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Risk Mitigation on Metalworking Oil & Fluids Business Process by Integrated House Of Risk (HOR) and Fishbone Diagram Approach

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Abstract

Business processes take an essential role in creating strategic goals for every company. However, It is not easy things in current condition. In the business process, every company has many vulnerable activities to risk. This research was conducted in the company engaged in the manufacturing industry that produces and supplies metalworking oils & fluids. So far, the company has experienced risk events such as late production and late delivery. This research aims to analyse and design the risk mitigation strategies of the company's supply chain by using House of Risk and Fishbone Diagram approaches. By integrating these two methods, the root of the risk agent can be specifically identified and make it easier to design risk mitigation strategies. The purpose of this research is to analyse and design a risk mitigation strategy using the integrated HOR and Fishbone Diagram approach in the supply chain of a metalworking oils & fluids company. This research indicates twenty risk events, six priority risk agents, sixteen root of risk agents, and six priority mitigation strategies. The six priority mitigation strategies include implementing reward and punishment for better SOP, starting with briefing every day before activities, providing regular training to the employees, hiring great employees, establishing employee performance appraisal effectively, and maintaining machines preventively.

1. INTRODUCTION

The industrial sector plays a vital role in every nation's economic growth. Therefore, macro and micro scale industry players are trying to increase their competitiveness through excellence in terms of business processes. One of the challenges is minimising risk events from upstream to downstream. In the supply chain realm, business actors try their best to reduce risk events along the supply chain. During the past ten years, most companies reported the risk events they faced, as the company in the case study (Natalia et al, 2020), (Natalia et al, 2021) (Millaty et al, 2014), and (Pertiwi, 2017).

According to (Pujawan, 2017), Supply Chain Management can be defined as a unity of process and production activities starting from raw material obtained by the suppliers, value-added process which changes raw material into finished goods, storage process, inventory, until the process of delivering the finished goods to the consumers. In each supply chain activity in a company, various risk events may occur, which can affect the company supply chain, resulting in troubles during the process of the supply chain. According to Jüttner (2005), risk in the supply chain is the disruption of information flow and resources in the supply chain line because of variations and uncertain termination. A company has interconnected *supply chain* activities to fulfil consumer demand effectively and efficiently. In every supply chain activity in the company can be found various risks that can affect the business process or the company's supply chain activities; thus, the activities of the supply chain cannot run smoothly.

In minimising, resolving, and preventing the risks involved in the supply chain activities, analysis and risk mitigation need to be conducted strategies to minimise risk and risk agent arising in the company's supply chain with *House of Risk* (HOR) and *Fishbone Diagram* approach. According to (Pujawan, 2009), *House of risk* (HOR) is a method focusing on the formulation of a strategy to prevent, reduce, and handle the causes of the risks that may lead to more than one risk. The *House of risk* (HOR) approach is divided into two steps, namely HOR 1 and HOR 2. HOR 1 is performed to determine which risk agent priority should be given prevention

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action. Meanwhile, HOR 2 provides a priority mitigation strategy by looking at the cost and competent human resources. In this case, output from House of risk is the risk mitigation strategy proposed to be performed and implemented by the company.

The application of HOR methods has been made in many research. Based on the research results of Millaty et al (2014), five risk agents are identified: sudden demand from the customer, error in the recording of final products, raw materials not being available, raw materials to be processed have not come yet, and unavailability of an employee when required. In Kristanto and Hariastuti study (2014), four risk agents are identified: suppliers cannot fulfil orders, suppliers do not fulfil contracts, negligence labour, and damage to production equipment. Natalia et al. l (2020) had developed the supply chain risk management model by integrating HOR and ANP model, which ANP model was used to determine the correlation between risk mitigation and hence rank those mitigation based on the priorities. This study was conducted on three reputable manufacturing industries, and the result showed that risks apply differently to each company. Another implementation of the integrated HOR and ANP model has been studied in Natalia et al. (2021). The purpose of these integration methods was to identify and recognise interrelationships between the risk agent's mitigation strategies to reduce event risk. Furthermore, Natalia et al.(2020) integrated Interpretive Structural Modeling (ISM) and HOR to identify the relationship of risk and determine the mitigation to reduce the causes of the risk. The ISM approach is applied to solve problems related to risk linkages and produces key risks, which are the risks that most influence the occurrence of other risks. The key risks obtained are then processed using the house of risk (HOR) approach to determine the priority of risk mitigation actions.

According to Pertiwi and Susanty (2017), based on the results of their research, three risk agents are identified: raw material scarcity, poor raw material quality, and consumers cannot pay for orders. However, on this method, HOR has not been able to identify the roots of the risk agent, so it needs another method, such as a fishbone diagram that can identify the roots of the risk agent. According to Tague (2005), Fishbone Diagram is a method that combines brainstorming and concept maps. Fishbone Diagram can solve many problems, including risk management in the production and service of the company. This research integrates the methods of HOR and Fishbone Diagram to identify the roots of risk agent in specific and easy to design mitigation strategies that the company will prioritise.

2. METHOD

This research was conducted in the company engaged in the manufacturing industry that produces and supplies metalworking oils & fluids. This research aims to analyse and design the risk mitigation strategies of the company's supply chain by using House of Risk and Fishbone Diagram approaches.

In this research, the data used is primary data and secondary data. Primary data consist of risk events, risk agents, risk assessment, and risk mitigation strategies. After that, secondary data consist of risk events and mitigation strategies from the previous research. There are several ways to collect both data, namely brainstorming, interviews, observations, and questionnaires. Respondents of this research are five experts in the company. They are the assistant manager of PPIC Department is tasked with compiling a material procurement plan based on forecasts through monitoring the condition of the stock of goods to be produced, providing orders from the marketing department, compiling a production plan, and making a production process schedule; the assistant manager of Production and Warehouse Department is tasked with ensuring the production process runs according to the standard process, controlling the shipping/receiving documents of goods, and checking the Finished Goods that are prepared for delivery of goods on the D day; the assistant manager of the Technical Department is tasked with measuring and determining product quality and stability, verifying the measuring instruments used when checking product quality, examining and analysing the causes of production failures and discussing them with the relevant departments; the manager of the Purchasing Department that taking care of recording employee working time, attendance, leave, holidays, selecting workers according to company needs, managing costs related to facility maintenance, employee welfare benefits, and managing the procurement of goods or materials through comprehensive planning systematic and controlled; and manager of Sales Department in charge of coordinating all sales in order to meet sales targets, making company sales targets along with sales strategies, planning and formulating strategic policies related to marketing, providing input to the head of the principal director in deciding matters relating to marketing.

This research was conducted in several steps. First, identify metalworking oil & fluids business processes from plan to return. This area identification process seeks to identify all activities that can cause risk events to identify the causes of risk. Second, the potential risk events and the causes of the risks were assessed starting from an assessment of the impact (severity) of such risk

events with a scale of 1-10 where 1 means indicates no impact and 10 means indicates the impact is danger (Shahin, 2004). The assessment of each risk cause also uses a scale of 1-10 where 1 means almost never occurred and 10 means almost certain to happen (Shahin, 2004). From the identification of risk events and risk causes, a matrix of the relationship between each risk and risk cause was developed using a specific scale, namely 0.1, 3 and 9 where 0 is no correlation and 1, 3, 9 represent, respectively, low, moderate and high correlations (Pujawan and Geraldine, 2009). The results of using these scales were used to determine the aggregate risk potential of the agent (ARP), then the ranking was carried out. This stage is included in the HOR phase 1. The HOR 1 stage ends in the ARP ranking. Next, it forwarded to the fishbone diagram method. This fishbone diagram described the root causes of risk from the material, human, environmental and machine aspects. The root causes of the risk were identified and assessed to the HOR phase 2 to obtain priority mitigation strategy actions. All of these stages can be seen in figure 1.

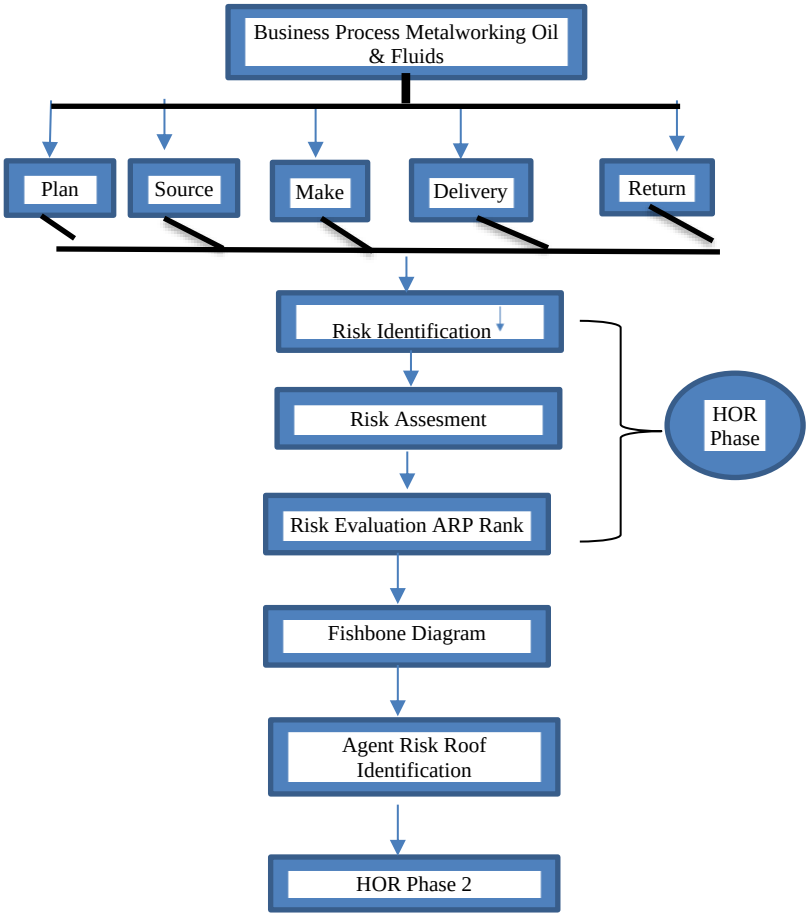

Figure 1.
Flow Diagram

3. RESULTS AND DISCUSSION

3.1 Risk Identification

The risk identification consist of risk events dan risk agents. Based on the interview result and brainstorming with company, there are 20 risk events and 25 risk agents that occurred in the company. The results of identifying risk events and risk agents can be seen in Table 1.

3.2 Risk Assessment

Risk assessment has been done by looking at how big the impact (severity) of risk event and the likelihood of occurrence of risk agent. The scale used to assess the level of impact (severity) and the level of the likelihood of occurrence using a scale of 1-10. Furthermore, an assessment of the correlation between risk events and the risk causes was also carried out by using a scale of 0,1,3,9. After the three values are obtained, we calculate the Aggregate Risk Potential (ARP). Next, we

determine the ranking of the ARP value. The results of the risk assessment can be seen in Table 2.

3.3 Risk Evaluation

Risk evaluations is carried out to find out priority risk agent and the root of risk agent. After determining and ranking the ARP value, the next step is to evaluate the risk using a Pareto diagram based on the result of ARP to determine priority risk agents from large to low values, and then identification roots of risk agent using a fishbone diagram with brainstorming.

Table 1.
Risk Event and Risk Agent

Major Processes	Sub Processes	Code (Ej)	Risk Events	Code (Aj)	Risk Agent
PLAN	Material inventory planning and control	E1	The different stock data between the system and the actual.	A1	Mistyped data input in the system
				A2	Mistyped data input in the worksheet
	Production planning and control	E2	Incorrect forecasting of demand	A3	Fluctuating demand
				A4	Improper forecasting method
		E3	A sudden change in production planning	A5	Customer impromptu request
				A6	Production machine damaged
SOURCE	Material order	E4	Delay on material order	A7	Fluctuating Material Price
		E5	Error in making a purchase order	A1	Mistyped data input in the system
	Scheduling Material Receipt	E6	Material Delay from supplier	A8	Lack of Coordination with supplier
				A9	No material stock available from the supplier
				A10	Only depend on one supplier
				A11	Natural Disaster Factor
	Material reception and checking	E7	Mismatch in the amount of material ordered	A8	Lack of Coordination with supplier
		E8	Error in giving material code received	A12	Limited Knowledge of the employee / the warehouse operator about the material
	Material storage	E9	Misplaced material in the material area	A13	There is a similarity in the colour of the material packaging
MAKE	Production implementation and control	E10	Late production	A6	Production machine damaged
				A14	Lack of availability of raw material
		E11	The product process stopped	A6	Production machine damaged
				A15	Power supply disruption
	Inspection of production result	E12	The product does not meet the specification	A16	Error in combining materials
				A17	Error in calculating material
	Product packaging process	E13	Error in labelling on product packaging	A18	The buildup product that will be labelled
DELIVER	Product Storage	E14	Product not included on the shelf	A19	Limited Storage shelf
	Scheduling product delivery	E15	Late delivery of products to consumers	A20	Damaged transport facilities
				A11	Natural Disaster Factor
				A21	Limited transport facilities
	Handling the product to be sent	E16	The difference in product location on the shelf between the system and the actual	A1	Mistyped data input in the system
				A2	Mistyped data input in examination sheet
	Product delivery to the customer	E17	Incompatibility of products sent to the customer	A22	Error in retrieving product
				A23	No inspection before shipment
RETURN	Receiving Customer's Complain	E18	A late response to customer's complain	A24	There is a queue in receiving customer's complain
	Repairing product return	E19	Delay on repairing product return	A25	There is the product return prioritised to be repaired
	Delivery Replacement Product	E20	Late delivery of replacement products	A20	Damaged transport facilities
				A11	Natural disaster factor
				A21	Limited transport facilities

Table 2.
House of Risk (HOR) 1

Risk Events (Ei)	Risk Agent (Aj)																									*Severity* (Si)
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24	A25	
E1	9	9																								7
E2			1	3																						4
E3					3	9																				8
E4							3																			5
E5	9																									7
E6								9	3	3	1															7
E7								9																		7
E8												3														6
E9													3													5
E10						9								3												9
E11						9									1											9
E12																9	9									9
E13																		3								6
E14																			9							5
E15											1									9	3					8
E16	9	9																								7
E17																						3	3			7
E18																								3		6
E19																									3	6
E20											1									9	1					8
Occurrence (Oj)	5	3	4	5	3	6	2	7	2	10	3	3	3	4	3	5	6	3	2	5	4	3	2	3	3	
ARPj	945	378	16	60	72	1404	30	882	42	210	69	54	45	108	27	405	486	54	90	720	128	63	42	54	54	
Rank (Pj)	2	7	25	15	12	1	23	3	21	8	13	16	20	10	24	6	5	17	11	4	9	14	22	18	19	

Table 3.
Priority Risk Agent

Code (Aj)	Risk Agent	ARPj	Pj	% ARP	% Cumm
A6	Production machine damaged	1404	1	21.80%	21.80%
A1	Input data error in the system	945	2	14.67%	36.47%
A8	Lack of Coordination with supplier	882	3	13.69%	50.16%
A20	Damaged transport facilities	720	4	11.18%	61.34%
A17	Error in calculating material	486	5	7.55%	68.89%
A16	Error in combining materials	405	6	6.29%	75.17%

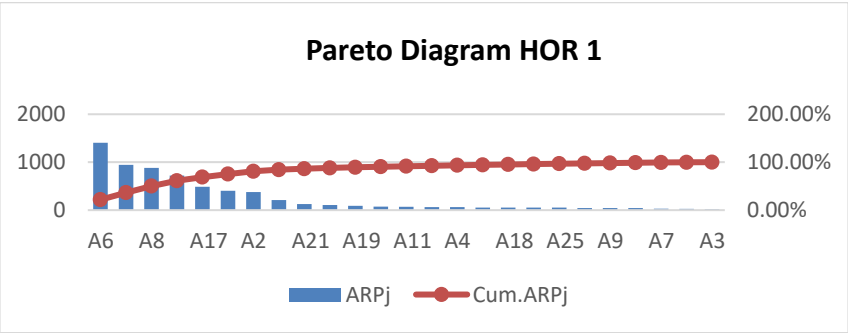

Figure 2.
Pareto Diagram HOR

Table 4.
The Recapitulation of Roots of Risk Agent with *Fishbone Diagram*

Category	Code (RAj)	Roots of Risk Agent
Workforce	RA1	Negligence in working
	RA2	Less ability in working
	RA3	Limited operator / employee
	RA4	Lack of communication
	RA5	Trainee Employee / Operator
Materials	RA6	The unclear information from the media
	RA7	Improper material
Machines	RA8	Old-aged machine
	RA9	Machines that are not regularly maintained
	RA10	Excessive engine usage
	RA11	Breakdown in IT office system
	RA12	Old-aged transport facilites
	RA13	Transport facilities that are not regularly maintained
	RA14	Broken digital scale
	RA15	No calibration at scale
Environment	RA16	Less conducive workspace

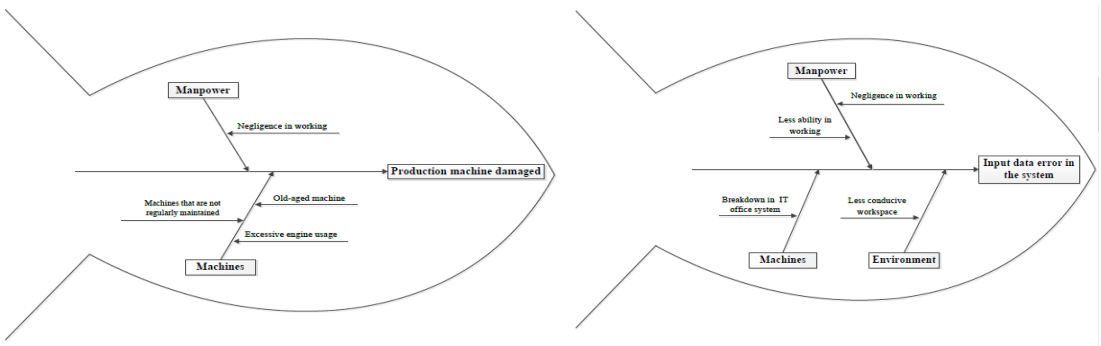

Figure 3.
Fishbone Diagram A6 dan A1

There are six priority risk agents from the pareto diagram, namely production machine damage (A6), input data error in the system (A1), lack of coordination with the supplier (A8), damaged transport facilities (A20), error in calculating material (A17) and error in combining materials (A16). Priority risk agents gained differ from previous research. The result of Pareto diagram HOR 1 and priority risk agents can be seen in Table 3 dan Figure 2.

In Millaty et al.(2014), there are five risk agents identified: sudden demand from customer, error in the recording of final products, raw materials not available, raw materials to be processed have not come yet, and unavailability of the employee when required. Furthermore, based on the research results of Kristanto and Hariastuti (2014), four risk agents are identified: suppliers cannot fulfill orders, and suppliers do not fulfill contracts, negligence labor, and damage to production equipment. According to Pertiwi and Susanty (2017), there are three risk agents identified: raw material scarcity, poor raw material quality, and consumers cannot pay for orders. From the Fishbone Diagrams in Figure 3 and Figure 4, and results of roots of risk agent, there are four categories: human, material, machine, and environment that can be seen in Table 4.

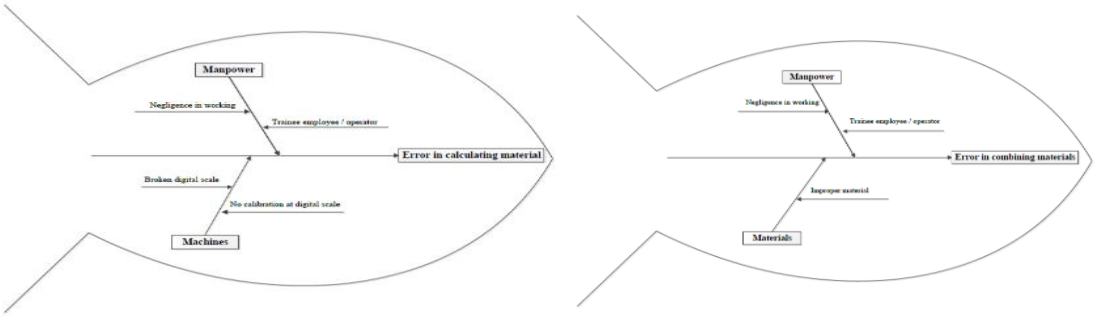

Figure 4.
Fishbone Diagram A17 dan A16

3.4 Risk Mitigation Strategy

HOR 2 started with designing risk mitigation strategy based on the root of risk agent from the results of Fishbone Diagram. An effective risk mitigation strategy aims to minimise the probabilities of risk agent and roots of risk agent. This can be seen in Table 5.

Then, assessment of the correlation between root of risk agent and the mitigation strategy, and the assessment of the difficulty level in carrying out the mitigation strategy as well as in calculating the ratio of total effectiveness to the level of difficulty have been done as the second step in HOR 2. The result can be seen in Table 6.

After calculating the ratio of total effectiveness to the level of difficulty (ETD), the next step is to draw ETD values using a Pareto diagram with the 80/20 principle to determine priority mitigation strategies to be carried out first by the company. A depiction of the HOR 2 pareto diagram and priority mitigation strategies can be seen in figure 5 and table 7.

Table 5.
Proposed Risk Mitigation Strategy

Code (PAj)	Mitigation Strategy	Code (PAj)	Mitigation Strategy
PA1	Reward and punishment are giving for carrying out the better SOP	PA11	Improving interdepartmental communication and coordination among departments before production
PA2	Intensive assistance during certain periods (ex: for 1 month)	PA12	Improving workspace layout
PA3	Doing preventive maintenance on the machine	PA13	Calibrate the scale regularly (once per 6 months)
PA4	Doing preventive maintenance on the transport facilities	PA14	Making the right standard time for machine usage
PA5	Doing preventive maintenance on the scale	PA15	Production machine replacement based on the age of machine
PA6	Provide training for employees / operators regularly.	PA16	Replacement or leasing of transportation equipment
PA7	Make a performance appraisals effectively	PA17	Arranging time to communicate with suppliers
PA8	Recruit operator / employee more strictly and only based on necessity (additional qualification)	PA18	Make complete media information details to the supplier (PIC supplier telephone number)
PA9	Improve communication with all suppliers.	PA19	Weigh tool replacement based on equipment age
PA10	Give briefing every day before activities	PA20	Employ the outsource to improve IT office system

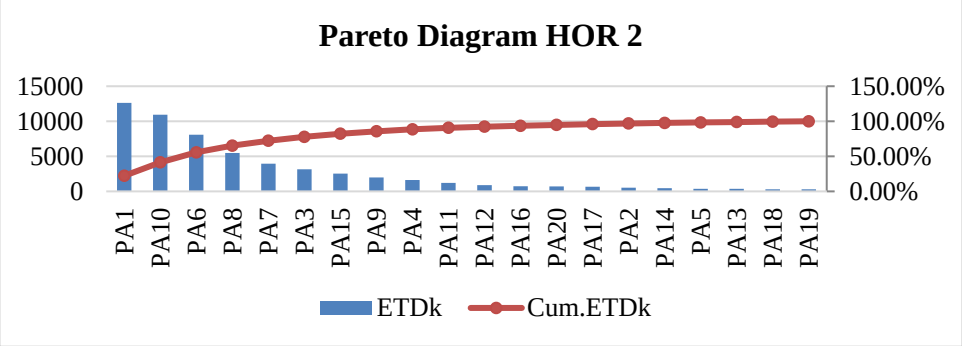

Figure 5.
Pareto Diagram HOR 2

Table 6.
House of Risk (HOR) 2

Risk Agent (Aj)	Roots of Risk Agent (RAj)	Preventive Action (PAk)																				ARPj
		PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	PA9	PA10	PA11	PA12	PA13	PA14	PA15	PA16	PA17	PA18	PA19	PA20	
A6	RA1	9					9	3			9											1404
	RA8															9						
	RA9			9																		
	RA10														1							
A1	RA1	3					9	3			3											945
	RA2						9		9		3											
	RA11																				3	
	RA16												3									
A8	RA3								9													882
	RA4	9								9								3				
	RA6																		1			
A20	RA1	9						3			9											720
	RA12																3					
	RA13				9																	
A17	RA1	9					3	3			9											486
	RA5		3																			
	RA14					3														3		
	RA15													3								
A16	RA1	9					3	3			9											405
	RA5		3																			
	RA7											9										
TEk		37908	2673	12636	6480	1458	32319	11880	16443	7938	32805	3645	2646	1458	1404	12636	2160	2646	882	1458	2835	
Dk		3	5	4	4	4	4	3	3	4	3	3	3	4	3	5	3	4	3	5	4	
ETDk		12636	535	3159	1620	365	8080	3960	5481	1985	10935	1215	882	364,5	468	2527	720	662	294	291,6	708,8	
Rank		1	15	6	9	17	3	5	4	8	2	10	11	18	16	7	12	14	19	20	13	

Table 7.
Priority Mitigation Strategy

Code (PAk)	Mitigation Strategy	ETDk	Rk	%ETDK	%Cumm
PA1	Reward and punishment are giving for carrying out the better SOP	12636	1	22,21%	22,21%
PA10	Give briefing every day before activities	10935	2	19,22%	41,43%
PA6	Provide training for employees / operators regularly	8079,75	3	14,20%	55,64%
PA8	Recruit operator / employee more strictly and only based on necessity (additional qualification)	5481	4	9,63%	65,27%
PA7	Make a performance appraisals effectively	3960	5	6,96%	72,23%
PA3	Doing preventive maintenance on the machine	3159	6	5,55%	77,79%

4. CONCLUSION

The House of risk method is a renewable risk analysis method that integrates FMEA and House of Quality. The advantage is that this approach focuses on mitigation strategies to minimise the probability of risk agents. However, the HOR method has not been able to identify the roots of the risk agent, so it needs another method, such as a fishbone diagram that can identify the roots of the risk agent. By integrating the HOR method and Fishbone Diagram, the roots of risk agent can be explicitly identified, and it is easier to design mitigation strategies. The integration of these two methods is a development framework model from previous research's results that are combined to form a unified development model. This model is an effort to reduce the impact of risk events that arise due to the root causes of risk. The results of this framework model get 20 risk events and 25 risk agents that have been successfully identified in the company's supply chain based on five major processes in the supply chain: plan, source, make, delivery, and return. Based on the result of the calculation of the ARP value and Pareto diagram, there are six priority risk agents, and also, sixteen roots of risk agent have been identified using Fishbone Diagram.

There is six strategy mitigation prioritised to be done by the company. They are reward and punishment for carrying out the better SOP, giving briefing every day before activities, providing training for employees regularly, recruiting employees more selectively and only based on

necessity (additional qualification), making an employee performance appraisals effectively doing preventive maintenance on the machine.

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