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Risk-Based Waste Control in Warehouses using FMEA and FTA Methods
(Case Study on CV. Roda Lintas Equator Sidoarjo)

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***Abstract*-Companiesthat have good management are companies that can manage risks that can occur so that the level of risk that occurs can be reduced or even eliminated. The risks that may occur can be managed by tracing beforehand so that information is obtained about the causes of these risks, and the analysis of risk assessment in the company serves as loss mitigation which will later be able to find out about the risks that will occur, the causes of the risks, the impact of these risks. as well as repair solutions to reduce waste in the warehouse. The risk assessment or risk assessment is carried out by the management, especially the head of the warehouse. The data obtained were then analyzed using the Failure Mode and Effects Analysis (FMEA) method and the Fault Tree Analysis (FTA) method. The analysis generates the value of the risk level (TR), and Risk Priority Number (RPN) and details the causes of a Top Event to a root cause failure. The results of the analysis obtained 25 risks for the entire process failure with the largest RPN value, namely the damaged network connection with a value of 40.74 while the smallest RPN value, namely the risk of lack of light intensity with a value of 4.89, the risk of damage to hardware with a value of 4.89.**

Keywords: Minimization, Repair, Production Process, Waste

I. INTRODUCTION

Of course, there are differences in the risks experienced by each company. A good company can manage risks that may be experienced, thereby reducing and eliminating the level of risk that occurs. Possible risks can be managed by obtaining information that leads to these risks so that companies can use this information to evaluate and analyze risks that may occur in the future (Mellisa, 2013). Risk management is an effort made to manage risk so that there is no accidental loss or accident (Ramli, 2010). Therefore, risk management can be used as an instrument for companies to take provisions, risk management can occur at any time (Ayu, 2016).

Companies that have a high level of risk in their management, one of which is a company engaged in retail distribution, in which there are inbound and outbound processes. Inbound and outbound processes include receiving, storing, replenishment, picking, packing, and shipping. In general, companies have warehouses where goods are stored. An example is a CV. The Equator Wheel. In the process of carrying out its activities, CV. Roda Lintas Khatulistiwa stores goods on selective pallet racking with stacked pallets and on material handling activities using hand lifts and forklifts. This condition poses many risks. The risks that may arise can interfere with the activities of the operator and can create unwanted risks to the company.

So far, because the company has not provided information about the risks that may occur in the operational process, risk management is carried out without any preparation. So that it can disrupt the production process when the risk occurs. Therefore, it is necessary to carry out a risk assessment analysis for the company so that losses do not occur in the future, the company can understand the risks that will occur, the causes of the risks, the impact of these risks, and solutions to reduce waste in the logistics department.

The problem in this study is related to the conditions of the work environment that are not paid attention to by the warehouse operator and cause waste in the logistics department. Many studies discuss risk management, but this research focuses on risk management-based waste control to control it. The aim is to analyze the risks that occur in the logistics department at CV. Roda Lintas Khatulistiwa and determine solutions for risks that may occur in the CV packaging section. The Equator Wheel.

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II. METHOD

The research conducted is descriptive quantitative research using FMEA and FTA methods to perform data processing. The sample used in the study were employees in a warehouse, totaling 12 people. The sampling method used is purpose sampling where respondents are taken based on what is the purpose of the study. The instruments used in this study were interview guides, observation guides, and questions on the questionnaire.

The data collected in this research are: 1). Interviews were conducted with the risk owner, to find out the risks that may occur in the production process that may occur. 2). Observation, field observations to get actual data. 3). Questionnaire, get data that is relevant to the research objectives.

The data obtained is used to identify process failure problems using a combination of two methods, namely Failure Mode and Effect Analysis (FMEA) and Fault Tree Analysis (FTA).

A. Failure Mode and Effect Analysis (FMEA)

At this stage, measurements are made of all process activities in the warehouse. The stages of the work carried out include:

1. Identifying the risk of failure in the Warehouse
2. Identify the cause of failure.
3. Determine the severity, occurrence, detection, and RPN values on the risk of failure

Table 1. Sub Identification of the Risk of Failure in the Warehouse

Failure	Risk	Risk Code
Inventory Management	The number of goods from the supplier does not match	R01
	Defective goods from supplier	R02
	Coming goods piled up in the area	R03
	Delay in goods from suppliers	R04
	The number of inventory items does not match the system	R05
Warehouse Supervision	Dirty environment	R06
	Low light intensity	R07
	Poor air circulation	R08
	The tool is out of place	R09
	Garbage piled up	R10
Goods Flow	No description of the item	R11
	Production of goods is not accompanied by evidence of documents	R12
	Lack of storage space	R13
	Damage to goods due to the value of goods	R14
	Demand for goods does not match inventory	R15
Technology Development	Broken computer software system	R16
	Damage to hardware	R17
	Missing files in the database	R18
	Broken network connection	R19
	Error entering data in a database	R20
HR Management	Limited employee skills	R21
	Less meticulous employees	R22
	Lack of employees	R23
	Low employee performance	R24
	Employees do not work discipline	R25

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B. Fault Tree Analysis (FTA)

The steps involved in making an FTA are:

a. Identify the root cause of failure in the warehouse, and create a table that classifies the causes of failure.
b. Making a Fault Tree, defining the problems that cause product failure, then making a Fault Tree, which is a simple analysis that can be described as an analytical technique.

III. RESULTS AND DISCUSSION

This risk assessment is carried out by the risk owner in each division in the production section. The risk owner will provide an assessment of the level of frequency (occurrence), the level of severity (severity), and the level of detection (detection) for each risk. Next, a Failure Mode and Effect Table will be made to calculate the value of the risk level and risk priority number (RPN).

A. Risk Analysiswith Failure Mode Effect and Analysis (FMEA) method

FMEA analysis is done by making a Failure Mode and Effect Table to find out the causes and effects of each risk. Table 2 calculation results based on calculations from the observations of researchers and the assessment of the head of the Logistics Department.

The calculation results based on table 2 provide several Risk Priority Numbers (RPN). The overall results of the Risk Priority Number (RPN) can be seen in table 2.

Table 2. Result of Calculation of Risk Priority Number (RPN)

Failure	Risk	Risk Code	Average value			RPN
			S	***O***	***D***	
Inventory Management	The number of goods from the supplier does not match	R01	2.67	1.00	3.67	9.78
	Defective goods from supplier	R02	3.33	1.33	3.00	13.33
	Coming goods piled up in the area	R03	3.33	2.67	3.00	26.67
	Delay in goods from suppliers	R04	3.67	2.67	3.33	32.59
	The number of inventory items does not match the system	R05	3.67	1.33	2.00	9.78
Warehouse Supervision	Dirty environment	R06	3.00	3.67	1.67	18.33
	Low light intensity	R07	3.67	1.00	1.33	4.89
	Poor air circulation	R08	4.33	1.00	2.33	10.11
	The tool is out of place	R09	2.33	4.67	2.00	21.78
	Garbage piled up	R10	3.67	5.00	1.33	24.44
Goods Flow	No description of the item	R11	2.33	3.33	2.67	20.74
	Production of goods is not accompanied by evidence of documents	R12	5.00	1.00	1.33	6.67
	Lack of storage space	R13	3.33	3.67	2.33	28.52
	Damage to goods due to the value of goods	R14	4.00	2.00	1.67	13.33
	Demand for goods does not match inventory	R15	3.33	2.33	1.67	12.96
Technology Development	Broken computer software system	R16	3.33	1.67	1.33	7.41
	Damage to hardware	R17	3.67	1.00	1.33	4.89
	Missing files in a database	R18	4.67	1.67	1.33	10.37
	Broken network connection	R19	3.33	3.67	3.33	40.74
	Error entering data in a database	R20	2.67	3.00	1.67	13.33
HR Management	Limited employee skills	R21	3.33	1.00	1.67	5.56
	Less meticulous employees	R22	4.33	3.33	2.00	28.89
	Lack of employees	R23	4.00	2.33	2.00	18.67
	Low employee performance	R24	3.67	1.33	1.33	6.52
	Employees do not work discipline	R25	3.00	1.33	2.00	8.00

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Tabel 3. Total Value of Risk Priority Number (RPN)

NO	Risk Indicator	RPN
1	**Inventory Management**	**92.15**
2	**Warehouse Supervision**	**79.55**
3	**Goods Flow**	**82.22**
4	Technology Development	**76.74**
5	HR Management	**67.62**
	Total RPN	**398.29**
	Critical Value	**79.65**

Table 3. shows the RPN value of all operational risk indicators and the critical value obtained from the total RPN value divided by the number of indicators assessed. Critical risk is not only influenced by the number of failures in it but also by the Severity, Occurrence, and Detection values. It can be seen in the risk indicators of inventory management, warehouse supervision, and the flow of goods, which have risk indicators that are categorized as critical.

B. Critical Risk Analysis With Fault Tree Analysis (FTA)

Critical risk indicators are used as top events and sub-indicators as sub-events and basic events determined through expert opinion.

There are 3 critical risks from the FMEA results which will then be searched for the basic events of each of the top events. The FTA process also involves correspondents from the FMEA questionnaires.

1. FTA Inventory Management Indicator

Sub-indicators of problems in the inventory management process include the number of goods from suppliers not matching, defective goods from suppliers, goods arriving piled up in the area, delays in goods from suppliers, and the number of inventory items not according to the system. Delay in goods from suppliers has a high-risk value which then makes it a top event in the inventory management section.

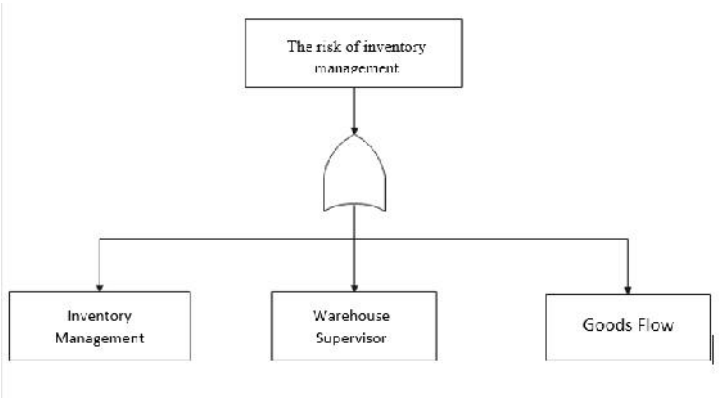

Figure 1. Department Critical Operational Risk

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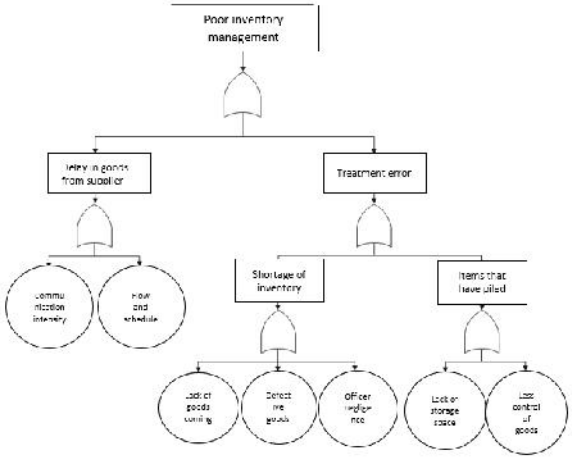

Figure 2. *InventoryFault tree*

The top event of the risk of inventory management indicators has 7 basic events, namely lack of quantity of goods, defective goods from suppliers, negligence of officers in counting goods, not preparing a place for goods to arrive, less control of incoming goods, less intensity of communication with suppliers, and inadequately planned schedule. applied. The solution for the handling is done by solving existing problems by collecting ideas from the heads of departments or experts.

2. FTA Warehouse Supervision Indicators

Sub-indicators of problems in Warehouse Supervision include a Dirty environment, Insufficient light intensity, Poor air circulation, Improper work tools, and Piled up the waste of goods. Garbage that has accumulated has a high-risk value which then makes it a top event in the warehouse supervision section.

Figure 3 shows some basic events from each of the existing top events. In the indicators of inventory management failure, there are 4 basic events, namely work accidents and lost items, disruption of the transfer and storage process, work tools that are not in place, and scattered cardboard waste. So that it can interfere with warehouse operational activities, this needs to be improved byincreasing supervision of employee performance and working environmental conditions.

3. FTA Goods Flow Indicator

Sub-indicators of problems in the flow of goods include: No description of the goods, Release of goods not accompanied by evidence documents, Lack of storage of goods, Damage to goods due to the value of goods, and Demand for goods does not match the inventory. The risk of lack of storage of goods has a high-risk value then makes it a top event in the flow of goods. Figure 3.3 is a Fault tree based on a predetermined flow of goods indicators

Figure 3.4 shows the top event results from the risk of goods flow indicators and 6 basic events from each existing top event. Some basic events from each top event are limited storage space, poor layout, inadequate warehouse service to customers,

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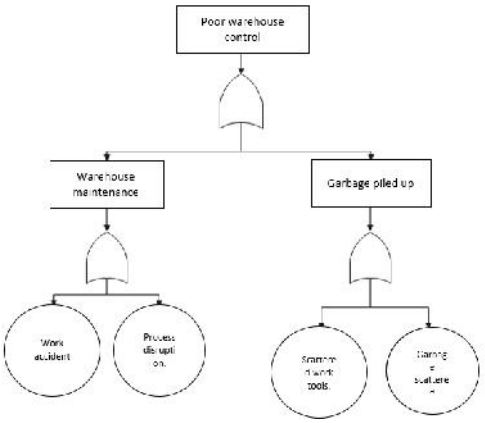

Figure 3. *Warehouse Monitoring Fault tree*

no label on goods, damage to goods, no field inspections. the process of flow of goods plays an important role.

From the basic critical risk events that exist, it is necessary to have a plan to overcome the identified risks and then create a plan at the Logistics Department in overcoming the risks that may occur, it can be concluded for the proposed improvement in table 4 as follows:

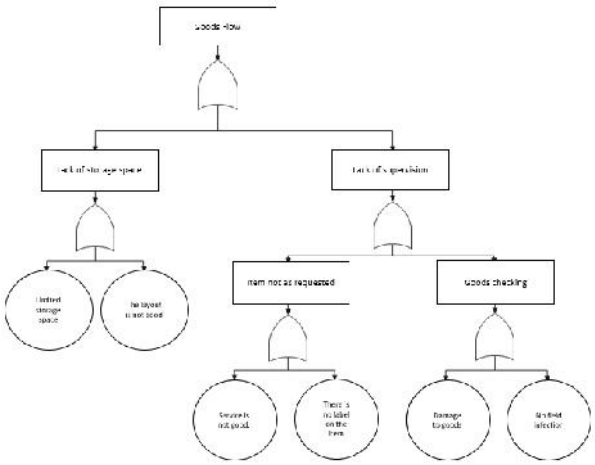

Figure 4 Item Flow Fault tree

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Table 4. Proposed Improvements

No	Failure	Possible Mode	The risk that occurs	Improvement Proposal
1	Inventory Management	Lack of amount of goods coming	The number of goods from the supplier does not match	Increase accuracy when measuring the weight of goods and checking random goods that come
		Product quality is decreasing	Defective goods from supplier	Carry out routine supervision and maintenance on incoming goods and immediately report if there are damaged goods
		Not preparing a place for goods to arrive	Coming goods piled up in the area	Controlling incoming goods by preparing a place for incoming goods and providing a maximum time limit on goods in the transit area
		Planned Flow and Schedule not applied	Delay in goods from suppliers	Increase the intensity of communication with suppliers and always maintain good relations
		The officer's negligence in counting the goods	The number of inventory items does not match the system	Calculating stock of goods periodically and making a schedule of stock-taking at a certain time
2	Warehouse Supervision	Lack of maintenance on warehouse	Dirty environment	Update the area picket schedule by creating a list of area responsibilities that did not previously exist
		The number of lights in the warehouse is less	Low light intensity	Arrangements on the layout so that the light is evenly distributed and replace the lamps with standard room lighting
		Improper air circulation in the warehouse	Poor air circulation	Ventilation settings and layout of raw materials because with an irregular layout will make the incoming air not optimal
		Limited tool storage space	The tool is out of place	Added space for tool storage and a dividing line for workers to place tools in an orderly manner
		Garbage leftover cardboard scattered	Garbage piled up	Require workers to clean the area according to a predetermined picket schedule and provide sanctions if they don't

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3	Goods Flow	No label on the item	No description of the item	Checking for items that don't have an article when the item arrives and sticking the barcode on the item before the packaging process
		The head of logistics does not know in writing	Production of goods is not accompanied by evidence of documents	Checking travel documents on each item to be issued more carefully
		Limited storage space	Lack of storage space	Arrangement of goods layout and addition of necessary goods shelves
		Release a new product while the old one is still stored in the warehouse	Damage to goods due to the value of goods	Making maintenance schedules on goods and prioritizing old stock
		Lack of synchronization of data on processed goods	Demand for goods does not match inventory	Correction of stock data of goods in and out of the warehouse based on actual conditions in the warehouse

IV. CONCLUSION

Based on the results of risk identification using the Failure Mode Effect and Analysis (FMEA) method, obtained 5 indicators of operational failure with 25 risks for the entire process failure with the largest RPN value, namely the damaged network

connection with a value of 40.74 while the smallest RPN value is the risk of light intensity that less with a value of 4.89 and the risk of damage to hardware with a value of 4.89. In risk analysis with (FMEA), the greatest risk does not become a critical risk because at that risk it has a high detection or control failure so it does not become a critical risk.

The root causes of each critical risk indicator include:

a. Inventory management the root of the problem is the intensity of communication with suppliers that are lacking, the planned flow and schedule are not applied, the lack of the number of goods arriving, defective goods from suppliers, negligence of officers counting goods, not preparing a place for goods to arrive, less control of incoming goods.
b. The root cause of warehouse supervision is work accidents and lost items, disruption of the transfer and storage process, work tools that are not in their place, and cardboard leftovers scattered.
c. The flow of goods at the root of the problem is limited storage space, poor layout, inadequate warehouse service to customers, no labels on goods, damage to goods, and no field inspections.

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