ASSESSMENT OF OCCUPATIONAL SAFETY AND HEALTH RISKS BASED ON A RISK MANAGEMENT SYSTEM AND THE SELECTION OF ALTERNATIVE IMPROVEMENTS

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ABSTRACT

Work accidents, especially in the industrial world, must be an essential concern because they involve and individual health and safety in the surrounding environment. At Squadron 900 / Fasharkan Puspenerbal Juanda, there were quite a lot of work accidents. The causes of work accidents vary, from mechanical aspects (equipment and machines) to parts of hazardous materials. The use of Hazmat mainly causes work accidents in squadron 900/Fasharkan, primarily in department IV. Therefore in this study only discuss hazardous materials as a cause of work accidents. The research conducted is the identification of risks in department IV (Department of Frame, AKP and Motor) Squadron 900 / Fasharkan, especially the Division of Frame and Mechanical Division using the approach of Risk Management System. In this approach, a risk ranking is carried out using FMEA, and further efforts a made to make improvements to reduce the risk of hazards. The improvement efforts-selected from several alternative solutions that have made using the NPV approach. With the Net Present Value approach, it is possible to compare the existing alternative solutions financially.

Keywords: Risk Management, Occupational Health and Safety (K3), Hazardous materials, Net Present Value (NPV)

1. INTRODUCTION

Work accidents have become a classic problem in the industrial world, especially in the manufacturing industry such as Squadron 900, a maintenance workshop for the Juanda Puspenerbal aircraft whose position is under the maintenance and repair facility of the Juanda Penerbal. Squadron 900 / Fasharkan still involved many dangerous tools and materials that could cause accidents for workers. However, that does not mean that the company management can ignore this classic problem because it involves the safety of its workers.

At Squadron 900 / Fasharkan Juanda's Puspenerbal, especially department IV (the frame, Aviation and Motorcycle safety equipment) there are many dangerous chemicals, such as flammable paint and toxins from rusty equipment, residue from the painting process in the form of flying powders. In the air and some other hazardous materials. Some of the consequences of these dangerous substances can cause skin burns, skin cancer, shortness of breath, lung cancer and even death.

Work accidents that often occur are caused by human error. Still, it is also necessary to anticipate correctly and carefully the use and layout of tools or materials that can cause accidents or what is commonly known as HAZMAT.

Personnel can be anticipation efforts can be started by identifying the causes of accidents to determine what deserves attention for later repairs. In designing repairs, it is also necessary to do a financial analysis of the costs incurred for these repairs and the benefits that can be obtained from the implementation of these improvements so that later we will get the results of repairs as well as reduce the risk of work accidents and the design is feasible to implement in the company concerned (Squadron 900 / Fasharkan)

2. LITERATURE REVIEW

2.1 K3

The definition of occupational health and safety, safety is related to the acute effect of a hazard, while health is related to the chronic result of a Hazard (Ashfal, 1999)

Work accidents consist of categories ranging from minor work accidents to work accidents that can have fatal consequences (causing death). The following are some types of work accidents based on the Safety Report (2005):

a. Fatality

   Work accidents that cause death.

b. Lost Time Injury

   Work accidents- interfere with the health of workers, so they cannot carry out work activities.

c. Restricted Work Day Case

   Work accidents disrupt the health of workers so that the work performance given is not optimal.

d. Medical Treatment Case

   Work accidents that can handle by medical personnel only.

e. First Aid Case

   Work accidents with consequences that can overcome with first aid in work accidents can not only- done by medical personnel.

f. Near Miss Incident

   Work accidents with minimal consequences on human, material, environmental and media aspects.

g. Anomaly

   Conditions or actions that are unsafe and may result in accidents.

Hammer (1989) defines Hazard as a potential condition to cause injury to personnel, damage to equipment or building structures, loss of material or reduced ability to perform a predetermined function. Hazard can also- define as the characteristics of materials, conditions or potentially detrimental to property, humans and the environment (ICF Consulting, 2000).

Following are some of the Hazard categories in the Industry:

a. Physical Hazards

   Noise, radiation, lighting, heat.

b. Chemical Hazards

   Hazardous and toxic materials, dusts, chemical fumes, chemical solutions.

c. Biological Hazards

   Viruses, Bacteria, Fungi, Parasites.

d. Mechanical Hazards

   Machinery, equipment.

e. Ergonomic Hazards

   Narrow and limited space, lifting goods, pushing, pulling, inadequate lighting, little body movement.

f. Psychosocial Dangers

   Work shift patterns, work organization, long working hours, trauma.

g. Behavioral Hazards

   Non-compliance with standards, lack of skills, new or irregular assignments.

h. Environmental Hazards

   Dark, uneven surfaces, slopes, muddy and wet surface conditions, weather, fire.

According to the US Department of Transportation (1998), the classification of hazardous materials is explosive, gas (flammable/nonflammable), flammable liquids (flammable liquids), oxidizers, radioactive materials, corrosives, poison (poisons from corroded equipment). Infectious substances (dispersible elements) and miscellaneous materials. The following is an explanation of some of these hazardous materials (Hammer, 1989):

a. Fuel is an element that acts as a "reducing agent" giving electrons to the oxidizer in a chemical combination. Examples of Fuel

include carbon, hydrogen, magnesium, methane, rubber, and so on.

b. oxidizer is an element that gets electrons from Fuel in a chemical reaction. Examples are oxygen, chlorine, halogens, nitrates, nitrites, peroxide and several other strong acids such as sulfuric, hydrochloric, etc. This oxidizer must be handled carefully to prevent contact with the Fuel.

c. Flammable Material (flammable materials) consists of Fuel for heating, internal combustion engines, welds, rocket engines, solvents and cleaning agents, lubricants, paints, varnishes, coolants, plastics and polymers, rubber, metal materials (sodium, potassium, cesium, rubidium, metal dust, powders, fibres, ribbons).

d. Both flammable and non- flammable materials, the air is not volatile. Still, it will burn when it reacts with a strong oxidizer, high oxygen concentration, very high temperature or ignition material. Examples are halogenated hydrocarbons, soaps and silicone rubbers, plastics and polymers, metals in solid form, mixtures of lubricants with hydraulic fluids.

e. Gases. There are limits and ranges of gas levels in the air to stay in safe conditions.

f. Flammable and Combustible are Liquids. It is a flammable liquid but previously changed its phase to free gas.

2.2 Risk Management System

Risk Management is applying a process of mathematical assessment and supervision of policies, practices and resources that can affect human health, safety, and the environment (USDOT, 1989). According to the European Union (1999), risk management is a formal process for managing risks. The process consists of system definition, hazard identification, identification of accident scenarios, quantification of the probability and consequences of risk assessment, identification of a risk control system, a decision to go to the stage implementation, and slip and management of the residual risks that exist.

a. Options Generation.

Identification of alternative options available for decision- making, identifying factors that may influence the decision, and risk factors.

b. Select Methods / Tools.

It is choosing the correct - method or tools for analyzing decision making. Usually by using benefit-cost analysis.

c. Analyze / Evaluate.

Perform a specific analysis, including benefit-cost and comparison of existing options.

d. Select Options.

Select and recommend alternative approaches for the implementation of risk management strategies and measures.

e. Identify Residue Risks.

Identify the risks that will occur and make ways to handle them.

2.3 FMEA

Kmenta (2002) cites Omdahl (1998) defines Failure Modes and Effect Analysis as a technique used to identify, prioritize, eliminate the possibility of system, design or process failures before reaching the customer. Furthermore, Hammer (1989) explains that FMEA is used to determine how long - equipment can operate correctly - and determine what effects the failure of the equipment component will produce.

The steps of the FMEA are as follows:

a. Define the system.

Defining a system of a process or product, and identifying its components, by creating a

modelling system can be a block diagram or a fault

tree diagram.

b. Identify Potential failure modes and their causes, identify the possibility of failure, along with the effects that will cause.

c. Evaluate the effect on the system of each failure mode. The consequences of possible failure can identify using the Severity Index, which indicates the seriousness of the impact due to the type of failure. Some of the commonly used classifications include four levels, namely 1 Catastrophic, 2 Critical, 3 Major, 4 Minor.

d. Identify failure detection methods / corrective actions, identify strategies for detecting failures and identify the presence of disciplinary actions, for example, alarms, inspection activities. These things need- to correct failures and provide a backup system to reduce breeding risk in the existing system.

2.4 NPV

Dharsono (2007) cites Joesron (2001) defines NPV as the value of the project in question, which is obtained based on the difference between the resulting cash flow and the investment issued. A proper NPV is a positive NPV, where the cash flow generated exceeds the amount invested.

NPV calculation is by discounting all cash inflows and outflows during the project life (investment) to present value, then calculating the difference between the present value of the inflows and outflows. NPV shows the lump sum amount, which with a specific discount flow (WACC) gives a figure of how much the current business value (IDR) is (Gunarta, 2006). If it is written with the equation, it will be:

$$NPV = \sum_{t=0}^{n} \frac{(C)t}{(1+i)^t} - \sum_{t=0}^{n} \frac{(Co)t}{(1+i)^t}$$

Where,

NPV = Net Present Value

(C) t = Cash inflow in year t

(Co) t = Cash Outflow in year t

n = The age of the investment yield business unit

i = Flow of Return (rate of return)

t = Time

3. RESEARCH METHODS

This research is conduct in four stages: the preliminary stage, data collection, data processing, analysis and finally, the Conclusion and Suggestion Stage. Shown in the flow chart as follows:

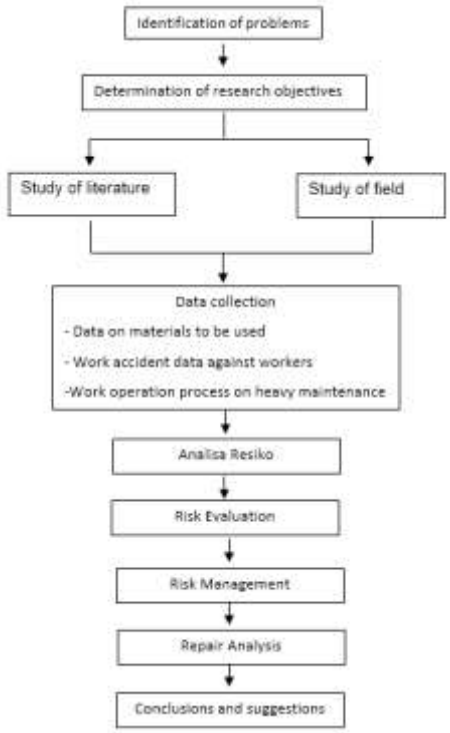


Figure 3.1 Flow Chart of Research Methods

The preliminary stage consists of problem identification, research objective setting, literature study, field study. At the data collection stage, namely, data that supports the data processing process. In the data processing stage, steps are carried out for risk analysis, risk evaluation and risk management. In the Analysis Phase, an investigation is carried out from the results of the improvement efforts that have been made. In the conclusions and suggestions stage, conclusions are drawn from the research that has been carried out as well as suggestions for further research that are related to this research

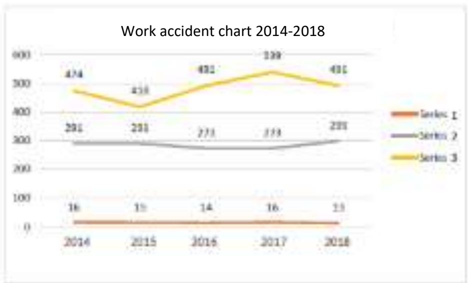
4. RESULT AND DISCUSSIONS

Table 4.1 data on occupational accidents for 2014-2018

Other diseases (fractures,muscle pain,etc)					
Month	Year				
	2014	2015	2016	2017	2018
1	3	2	2	2	2
2	0	2	1	0	2
3	4	0	0	2	1
4	2	0	3	0	1
5	0	0	1	0	3
6	3	0	0	2	0
7	0	4	2	3	1
8	2	1	2	0	0
9	0	2	1	2	1
10	1	0	0	1	1
11	0	0	1	3	1
12	1	4	1	1	0
total	16	15	14	16	13
averageper year		14,8=15			
averageper month		1,23=1			

Skin irritation					
Month	Year				
	2014	2015	2016	2017	2018
1	38	25	24	25	22
2	27	15	17	35	25
3	21	29	15	16	12
4	17	14	23	19	34
5	30	27	26	24	21
6	17	34	27	22	16
7	12	15	22	24	31
8	15	26	19	29	41
9	18	28	24	18	25
10	23	25	22	17	21
11	36	39	23	20	32
12	37	13	31	24	19
total	291	290	273	273	299
average per year		285,2=285			
average per month		23,78=24			

Respiratory diseases					
Month	Year				
	2014	2015	2016	2017	2018
1	51	41	29	55	58
2	34	53	36	54	65
3	42	26	32	53	41
4	37	23	43	48	42
5	43	41	52	54	36
6	51	48	69	59	34
7	52	40	44	47	48
8	43	42	27	32	13
9	32	32	30	21	34
10	26	30	53	45	27
11	28	19	45	36	39
12	35	23	31	35	54
total	474	418	491	539	491
average per year		482,6=483			
average per month		40,22=40			



From the tables and graphs, it can be seen that a large number of squadron 900/ fasharkan who suffer from health problems due to work accidents is almost the same every year if you take the monthly average it is found that respiratory diseases and skin diseases get pretty high scores, namely 40 and 24. Mean while other condition such as fractures and muscle pain scored a puny average of 1 per month.

Hazard identification in the frame division using FMEA can be displayed in the table as follows:

Table 4.2 FMEA in the Order Division

Table 4.3 FMEA in the Mechanical Division

Tabel 4.4 Recap of potential Hazard in the Frame Division

Rank	Types of potential hazards in the Mechanical Division
1	Hazardous materials
2	Steam from paint during the painting process
3	Paint material during the mixing process
4	The occurrence of physical contact with hazardous materials
5	The occurrence of physical contact with the paint material during the mixing process
6	There was a fire
7	The occurrence of physical contact with the paint material during the painting process

Table 4.5 Recap of potential hazards in the Mechanical Division

Level	Likelihood Class	Incident
A	Frequent	Probability (≥ 17 failures per month)
B	Probable	Often occurs (11 ≤ x ≤ 16 failures per month)
C	Occasional	Occurs multiple times (5 ≤ x ≤ 10 failures per month)
D	Remote	Occurs Occasionally (2 ≤ x ≤ 4 failures per month)
E	Very Unlikely	Very rare chance (≤ 1 failure per month)

Table 4.6 Occurance (O) Evaluation of Criteria

Rank	Types of potential hazards in the Order Division
1	Inhalation of steam from Hydrolic fluid skydrol
2	The occurrence of physical contact of hazardous substances on the skin, eyes or into the mouth
3	The occurrence of fire

Table 4.7 Occurance (O) Evaluation of Criteria for each type of failure

No	Type of Failure	Likelihood Class
1	Inhalation of dangerous chemicals enter the respiratory tract	Frequent
2	Physical contact with hazardous chemicals	Probable
3	Fire	Veru Unlikely

Table 4.8 Severity (S) Evaluation of criteria

Level	Severity Class	Information
I	Catastrophic	Accidents that cause fatal injury or death of workers / operators
II	Critical	Accidents that cause an injury that does not result in death
III	Mayor	Low level accidents on operators / workers
IV	Minor	Damage to the system or environment but does not affect workers /operators

Table 4.9 Severity (S) Evaluation of criteria for each type of failure

No.	Type of Failure	Severity Class
1	Inhalation of dangerous chemicals enter the respiratory tract	Major
2	Physical contact with hazardous chemicals	Critical
3	Fire	Catastrophic

From the results of categorizing the occurrence and severity of each failure, a matrix will be made to determine the position of the type of failure and to find out what steps to take next.

Table 4.10 Risk Matrix

Likelihood / Occurance	Severity			
	Minor	Major	Critical	Catastrophic
A (Frequent)		1		
B (Probable)			2	
C (Occasional)				
D (Remote)				
E (Very Unlikely)				3

Information :

■ = Unacceptable (must be mitigated to a lower level)

■ = Undesirable

■ = Acceptable with control

■ = Acceptable as is, the risk is acceptable, no need to take action.

Process activities in the frame division generally use relatively few hazardous materials compared to the Mechanical Division so that they are not so dangerous to personnel outside the frame division. Still, overall, the process of activities in the Frame Division and the Mechanical Division can be hazardous. Personnel in the hangar room. Its

surroundings, so there is a need for an alternative solution to cover it all.

The alternative solutions offered for this problem:

1. Do Nothing
2. Renovation of the painting room
3. Development of a particular painting room

3 Alternative explanations for this type of risk 1. For type 2 risk, there are two alternative solutions, first Do nothing and the second is to impose sanctions and the installation of a safety sign. As for the type of risk 3, the alternative solutions are Do nothing and Safety equipment and Safety sign.

NPV calculation Alternative solutions to the risk of inhalation of vapours from hazardous materials shown using the following table:

Solution 1 for Risk 1	
Cost of Lost Working Days	
Wages / day	Rp. 45.000,00
Amount average Work accident / year	483
Lost work day / accident	1
Cost of lost working days / year = wages / day X average amount Work accident / year X days lost work / accident	Rp. 21.735.000,00
Overtime cost personel	
Overtime pay / day	Rp. 125.000,00
Average Overtime days	104
amount of Overtime personel	7
Overtime expenses / year = overtime pay / day X average overtime / year X amount of personnel overtime	Rp. 91.000.000,00

Solution 2 for Risk 1	
Cost Savings on lost work days	
Percentage of savings / year	80%
Total savings in loss working day/year	Rp. 17.388.000,00
Cost Savings in personnel overtime	
overtime cost savings personnel / year = overtime costs personel/year	Rp. 91.000.000,00
Renovation Costs	
Purchase and installation costs pvc partition curtain	Rp. 30.000.000,00
Sewer construction costs	Rp. 55.000.000,00
Cost of manufacture / m	Rp.100.000,00
Circumference of channel in hangar (m)	544
Go around the channel in the painting room	6
Total cost of renovation	Rp.85.000.000,00
Maintenance costs I	
Estimated cost of treatment / month	Rp. 200.000,00
Maintenance costs / year	Rp. 2.400.000,00
Cost of Lost Working Days	
Percentage of lost work days	20%
Cost of lost working days / year	Rp. 4.347.000,00

Solution 3 for Risk 1	
Cost Savings on lost work days	
Percentage of savings / year	95%
Total savings in loss working day/year	Rp. 20.648.250,00
Cost Savings in personnel overtime	
overtime cost savings personnel / year = overtime costs personel/year	Rp. 91.000.000,00
Development Costs	
Development Costs	RP. 430.289.484,00
Equipment Costs	Rp. 50.000.000,00
Total Development costs	Rp.480.289.484,00
Maintenance costs II	
Estimated cost of treatment / month	Rp. 1.000.000,00
Maintenance costs / year	Rp. 12.000.000,00
Cost of Lost Working Days	
Percentage of lost work days	5%
Cost of lost working days / year	Rp. 1.086.750,00

Solution 1 for Risk 1						
year	0	1	2	3	4	5
Cash In						
Cash Out	112.735.000	112.735.000	112.735.000	112.735.000	112.735.000	112.735.000
Cash Flow	-112.735.000	-112.735.000	-112.735.000	-112.735.000	-112.735.000	-112.735.000
NPV	-568.847.834					

Solution 2 for Risk 1						
year	0	1	2	3	4	5
Cash In	108.388.000	108.388.000	108.388.000	108.388.000	108.388.000	108.388.000
Cash Out	89.347.000	6.747.000	6.747.000	6.747.000	6.747.000	6.747.000
Cash Flow	19.041.000	101.641.000	101.641.000	101.641.000	101.641.000	101.641.000
NPV	430.268.787					

Solution 3 for Risk 1						
year	0	1	2	3	4	5
Cash In	111.648.250	111.648.250	111.648.250	111.648.250	111.648.250	111.648.250
Cash Out	493.376.234	13.086.750	13.086.750	13.086.750	13.086.750	13.086.750
Cash Flow	-381.727.984	98.561.000	98.561.000	98.561.000	98.561.000	98.561.000
NPV	17.040.501					

Solution 1 for Risk 2	
Cost of Lost Working Days	
Wages / day	Rp. 45.000,00
Amount average Work accident / year	285
Lost work day / accident	2
Cost of lost working days / year = wages / day X average amount Work accident / year X days lost work / accident	Rp. 25.650.000,00

Solution 2 for Risk 2		
Cost Savings on lost work days		
Period	Percentage savings	Savings in lost costs Working hours
year 0	98%	Rp. 25.137.000,00
year 1	100%	Rp. 25.650.000,00
year 2	100%	Rp. 25.650.000,00
year 3	100%	Rp. 25.650.000,00
year 4	100%	Rp. 25.650.000,00
year 5	100%	Rp. 25.650.000,00
Purchase Costs Safety Sign		
Price / Safety Sign		100000
amount Safety Sign		8
Biaya Pembelian		Rp. 800.000,00
Costs Lost hours of work		
Period	Percentage savings	Savings in lost costs Working hours
year 0	2%	Rp. 530.000,00
year 1	0%	Rp.0
year 2	0%	Rp.0
year 3	0%	Rp.0
year 4	0%	Rp.0
year 5	0%	Rp.0

Solution 1 for Risk 2						
year	0	1	2	3	4	5
Cash In						
Cash Out	25.650.000	25.650.000	25.650.000	25.650.000	25.650.000	25.650.000
Cash Flow	-25.650.000	-25.650.000	-25.650.000	-25.650.000	-25.650.000	-25.650.000
NPV	- 129.426.948					

Solution 2 for Risk 2						
year	0	1	2	3	4	5
Cash In	25.137.000	25.650.000	25.650.000	25.650.000	25.650.000	25.650.000
Cash Out	1.313.000	0	0	0	0	0
Cash Flow	23.824.000	25.650.000	25.650.000	25.650.000	25.650.000	25.650.000
NPV	127.600.948					

Solution 1 for Risk 3	
Cost of Lost Working Days	
Wages / day	Rp. 45.000,00
Amount average Work accident / year	250
Lost work day / accident	63
Estimated working days lost	13
Cost of lost working days / year = wages / day X average amount Work accident / year X days lost work / accident	Rp. 35.437.500,00

Solution 2 for Risk 3	
Cost Savings on lost work days	
Wages / day	Rp. 45.000,00
Working day/year	250
amount labor	63
Non-lost work day / year 3% X work day/year	8
Cost savings lost work day /year = wages/day X amount labor X day work is not lost	Rp. 21.262.500,00
Purchasing costs Safety Equipment	
amount Safety Cabinet	2
price/Safety Cabinet	Rp. 800.000,00
amount Safety cans	7
price/Safety Cans	Rp. 456.000,00
purchasting costs Safety Equipment	
purchasing costs Safety Sign	
price/Safety Sign	Rp. 100.000,00
amount Safety Sign	8
purchase costs	Rp. 800.000,00
Cost of Lost Working Days	
Wages / day	Rp. 45.000,00
Working day/year	250
amount workforce	63
Non-lost work day / year 3% X work day/year	5
Cost savings lost work day /year = wages/day X amount labor X day work is not lost	Rp. 14.175.000,00

Solution 1 for Risk 3						
year	0	1	2	3	4	5
Cash In						
Cash Out	35.437.500	35.437.500	35.437.500	35.437.500	35.437.500	35.437.500
Cash Flow	-35.437.500	-35.437.500	-35.437.500	-35.437.500	-35.437.500	-35.437.500
NPV	-178.813.546					

Solution 2 for Risk 3						
year	0	1	2	3	4	5
Cash In	21.262.500	21.262.500	21.262.500	21.262.500	21.262.500	21.262.500
Cash Out	19.767.000	14.175.000	14.175.000	14.175.000	14.175.000	14.175.000
Cash Flow	1.495.500	7.087.500	7.087.500	7.087.500	7.087.500	7.087.500
NPV	30.170.709					

5. CONCLUSIONS

From the research that has done, the following conclusions can draw:

a. Most of the causes of work accident hazards in the 900 / Fasharkan squadron are jobs that use hazardous materials, which are generally flammable, toxic and can cause irritation.

b. The risks arising from the use of hazardous materials include: Burns or skin irritation, disruption of the respiratory tract, digestive system, and brain (memory) system and can also cause a fire.

c. The frequency of probability of work accidents varies, depending on the conditions, time, and type of work carried out in each activity process.

d. The risk of danger with the highest ranking in the skeleton division is the risk of inhalation of vapours from hazardous materials, followed by the threat of physical body contact with hazardous materials and the risk of fire. Whereas in the Mechanical division, the risks that are ranked 1-3 are the risk of inhalation of vapours and hazardous materials, then ranking 4-5 is the risk of physical contact with the body with hazardous materials, and the 6th position is the occurrence of fire

e. To reduce the risk 1, 3 alternative solutions designed, namely:

   1) Do nothing
   2) Renovation of hangars and halls painting
   3) Development special room painting

   To reduce the risk of 2, two alternative solutions designed, namely:

   1) Do nothing
   2) Giving sanctions and using a safety sign

   To reduce the risk of 3, the design of 2 alternative solutions, namely:

   1) Do nothing
   2) Use of safety equipment and safety sign

f. To reduce the risk 1, the second-best alternative solution chosen, to minimize the risk 2, the second-best alternative solution is chosen, and to reduce the risk 3 the second-best alternative solution is chosen

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