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Risk Management for Backlog Work Order in Petrochemical Company

Saefullah[1], **Muhammad Asrol**[2]

[1] Industrial Engineering Department, BINUS Graduate Program – Master of Industrial Engineering,
Bina Nusantara University, Jakarta, Indonesia, 11480
Saefullah001@binus.ac.id

[2] Industrial Engineering Department, BINUS Graduate Program – Master of Industrial Engineering,
Bina Nusantara University, Jakarta, Indonesia, 11480
muhammad.asrol@binus.ac.id

***Abstract*: Backlog work order in petrochemical company is potentially to increase risk and reduce competitive advantages. This study aims to assess the risk potential related to backlog work order and propose preventive actions for risk mitigation. This research applied failure mode and effect analysis (FMEA) framework in risk assessment and house of risk (HOR) framework in formulating risk mitigation. To support the analysis, expert judgement, in-depth interview, and field observation were applied in data acquisition. The result showed that backlog work order was potentially to increase number of risks in petrochemical operations from six risk categories, resource, planning, method, materials, environment, and system. Using FMEA, this study found twenty risk potential that affect the backlog work order. Six risk potential were prioritized to mitigate since donated highest impact to petrochemical business process, including: lack of manpower, unavailability of spare parts, lack of employee skills. This research has also succeeded in formulating risk mitigation actions and providing input to companies to improve the ability of employees both in knowledge and in managing work orders, so that the number of work order backlogs decreases every year.**

***Keywords*:** Backlog work order, Expert judgement, Mitigation, Petrochemical company, Risk management, Risk mitigation.

I. Introduction

During economic turmoil caused by the fall in oil prices in 2015, petrochemical company launched program to identify, evaluate and optimize production processes, materials, structures, and business process [1]. The program aims to develop a platform to enhance competitiveness and business sustainability. The company's management must encourage Departments to deliver excellent performance with efficiency in cost management. It is necessary to transform the business into petrochemical company, evaluate the performance and activities to achieve goals in optimization.

The Maintenance Department holds an important role which is responsible for guiding many employees and resources in a Petrochemical Company. The Maintenance Department must support the operation department in maintaining and improving production machines and equipment in top performance condition. The work partnership of the departments aims to meet the production targets to finalize 90% of work orders. To provide its services, the Maintenance Department needs to manage resources and operate well to achieve the target.

As part of the business transformation that makes the main objective of the efficiency program, the management of the Maintenance Department must analyze its activities to produce superior performance. One of the areas of improvement that needs to be done is maintenance work order backlog management or Maintenance management. Refer to Ref. [2], backlog is all work orders list that have been planned and will be completed eventually. The backlog is measured in hours but is more often also determined in a matter of weeks, calculated based on the time it takes to complete the work according to the number of labor and other resources planned to complete the work. Generally, a work order backlog is a number of work orders that delays in implementation due to internal problems, involve shortage manpower, unavailability of spare parts, work order priority, problem in planning and communication.

Petrochemical companies must focus on reducing the work order backlog effectively by managing many pending work orders and identifying the required resources to complete all work order backlogs. Maintenance Work Order or better known as maintenance work order is defined as maintenance activities, repair, monitoring, checking work that must be completed at the scheduled time using existing resources / manpower. Work Order can be done manually through the request process from the operation department or user or can also be done through the SAP system by making Preventive maintenance planning. When the work order has been released then cannot be completed on time, then the work order is categorized as a work order backlog.

The workorder backlog is categorized as risk that vulnerable to petrochemical business process. Risk has positive and negative impact to business process and risk management aims to minimize the impact [3]. Risk management is a requirement to reduce the work order backlog at the petrochemical company. A risk management organized by identify risk, assess risk, and formulate risk mitigation [4], [5]. In other research, Ref. [5] suggest the needs of knowledge sharing between actors to reduce the potential risks. A risk management is defined as an approach to minimize the potential of vulnerability along business process and management [6][7]. The risk management in this research is focused on the effort to minimize the work backlog order at the petrochemical company to increase company's productivity.

Risk assessment and mitigation has largely been discussed in previous research. At the first stage, risk identification is required to know current potential risk at the business process. In this stage, some methodology has been proposed, involved using supply chain operation reference (SCOR) framework [8], [9], conducted an in-depth interview [10] or risk mapping. At the second stage, the risk assessment is proposed. Some methodology that has been largely used at the previous research include: Analytical Hierarchy Process [11], Failure Mode and Effect Analysis (FMEA) [12], Bayesian Belief Networks [13], project risk management using fuzzy approach and develop a decision support system [3], [14], House of Risk [8] and fuzzy assessment approach [15]. At the final stage, risk mitigation aims to minimize potential risk effect with the formulated activities to achieve the goal. In this stage, some methodologies are possible to apply, including House of Risk [8], Interpretative Structural Modeling [16] or analytical hierarchy process [17].

To manage potential risks that arise since the uncompleted numbers of backlog order, a comprehensive risk management from assessment to recommend mitigation activities is required. As far as authors knowledge, considering risk management to minimize backlog work order in the literature is limited. Backlog work orders factors are identified and assessed using the risk management framework which is supported by principal experts. This research applied a combination of FMEA and HOR model to assess and mitigate risk which arises by the uncomplete backlog work order.

The objective of the research is to identify risk and formulate risk mitigation to minimize backlog work order at the petrochemical company. A complete risk management with risk analysis, assessment and mitigation are conducted to minimize the risk and proposed risk mitigation activities.

The paper is organized as follows: Section 2 describes step-by-step methods to analyses, assesses, and formulates risk mitigation in reducing backlog work order impact to petrochemical company. Section 3 served the result of data analysis and provided discussion in minimizing the risk impact to the petrochemical business based on the priority risk. Section 4 provides the conclusion and limitations.

II. Research method

A. Research stages

According to the research objective this study aims to identify the main problem of backlog work order and formulate mitigation activities at petrochemical companies. The first step is to brainstorm and develop the potential causes map of the work order backlog. One common scheme is to break down the main causes into groups consisting of materials, methods, machinery, measurements, labor, and the environment [18].

Risks are assessed through expert discussion to determine the most priority risk to be mitigated. In this study, the backlog of work orders was deemed to fail to fulfill orders. Determination of priority issues/risks for mitigation is determined through risk assessment. Risk items with the highest score from the expert assessment must be mitigated immediately. Further, formulating risk mitigation provides recommendations for efforts to reduce work order backlog. The research stage is depicted in Figure 1.

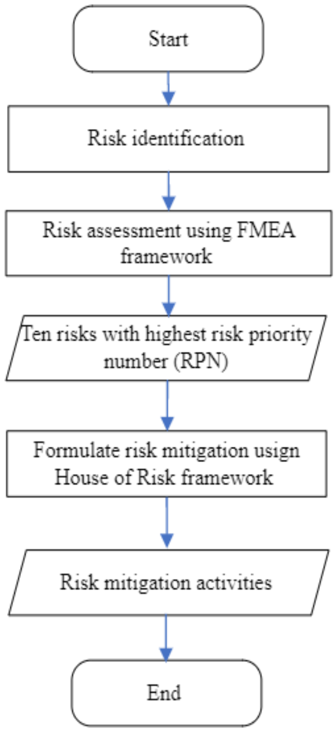

Figure 1. Research stage

B. Data acquisition

Data was collected from primary and secondary sources. The primary data was extracted by the in-depth interview and field observation to identify, assess, and formulate risk management strategy. Expert judgement from the principal practitioner in the petrochemical company is involved in the data acquisition. This study accomplishes in-depth interview with ten respondents from maintenance, production, and planner department of the petrochemical company.

In the primary data source acquisition, the work order backlog data is obtained by filtering all work orders in the SAP system. Based on data from the SAP system shows that the work order backlog always goes up in number every year. An illustration of the work order backlog data can be seen in Table 1. This data is further analyzed to find the main root cause of the risk potential arising by the backlog work order problems.

Year	Numbers of work order backlog
2016	2,777
2017	2,988
2018	5,608
2019	7,837
2020	5,608
2021	1,410

Table 1. Numbers of work order backlog

C. Data Analysis

1) Failure Mode and Effect Analysis (FMEA) for risk assessment

A comprehensive risk assessment in risk management practice that has been largely applied in various fields is Failure Mode and Effect Analysis (FMEA) [19], [20]. FMEA comprises a systematic method to identify and assess risk in process problems to minimize the occurrence. Hardware-oriented or bottom-up approaches are emphasized in FMEA. FMEA frameworks examines processes and products to determine possible failures by identifying potential failures, consequences as well as their possible occurrence. This approach is suitable in reducing backlog work order which is a process-oriented system.

FMEA requires experienced expert opinion and judgement to provide assessments of severity, occurrence, and problem detection. Expert judgement produces risk priority number (RPN) which is obtained by multiplying three indicators namely S (severity), O (event), and D (detection). Failure mode with high RPN is more critical and given higher priority than low RPN mode. The severity, occurrence, and detection use ranges from 1 to 5, then RPN value score is between 1 and 125. Risk Priority Number (RPN) is calculated through Equation 1.

$$RPN = S \times O \times D \quad (1)$$

2) Formulate risk mitigation activities.

Risk mitigation is the final stage to reducing risk impact in risk management. This study applied a house of risk (HOR) framework which is developed by a combination of QFD quality function deployment (QFD) and failure modes and effect analysis (FMEA) framework for managing risk [8]. In this study used HOR 2 model for risk mitigation is adopted. The priority risk mitigation activities are formulated based on the highest risk RPN value from previous stages. HOR-2 framework is described in Table 2.

Risk priority from FMEA	**Preventive actions**					**RPN**
	PA_1	**PA_2**	**PA_3**	**PA_4**	**PA_n**	
Risk 1	R_{11}					RPN 1
Risk 2						RPN 2
Risk *n*						RPN 3
Total effectiveness	TE_1	TE_2	TE_3	TE_4	TE_n	
Degree difficulty	D_1	D_2	D_3	D_4	D_n	
Effectiveness	ETD_1	ETD_2	ETD_3	ETD_4	ETD_n	
Rank	R_1	R_2	R_3	R_4	R_n	

Table 2. HOR 2 framework

In the first stage of analysis, the priority risk that ranked at the FMEA stage is provided. These risks are the most priority risks which has highest risk priority number to be mitigated in reducing work backlog order. Experts are encouraged to formulate preventive actions in mitigating risk through discussion and in-depth interview. The relationship between priority risk and preventive actions (PA) are assessed by expert group and stated at the R_{11}. According to Ref. [8], the total effectiveness of the preventive actions is calculated using Equation 2.

$$TE_k = \sum_j RPN_j \times R_{jk} \quad (2)$$

Experts are also required to provide an assessment of the degree of difficulty *(D)* to implement the preventive actions. Finally, the effectiveness of the preventive actions to mitigate risk is found by $ETDk = TE_k / D$.

III. Result and Discussion

The decline in world oil prices in 2015, a lot of petrochemical companies in middle east even around the world make efficiencies in various fields including contract and permanent labor, review of potential parts in warehouse departments and the priority of work orders. From the 3 efficiencies carried out petrochemical company arises a variety of problems in the company, especially in the maintenance department where every work requested by the operation department cannot be done on time because of internal problems such as lack of labor, lack of spare parts and so on related to maintenance activities to production equipment.

Work orders from the operation department received by the maintenance department always experienced as rework because of the problem so that the production process is disrupted and in the end the operation cannot meet the customer's curiosity on time because of the limitations of capability department maintenance. Each work order that is set to be completed at a certain time experiences a very long delay due to the many problems in the maintenance department called a work order backlog. So, what is meant by work order backlog is all work that has been planned in the last time to experienced job delays due to internal problems of the company such as lack of labor, lack of spare parts and so on that hinder the work.

In 2019 is a very risky year for the company because of the many backlog work orders that occur that require special attention from management companies. Based on data extracted from SAP system it is known that from January to December 2019, the total work order backlog has reached 7,837 out of 48,647 work orders released which have a completion rate of only 84%. While Key Performance Indicator (KPI) has been set by the company, the completion rate must be estimated at 90% which means a maximum of 10% work order backlog allowed. Based on the data, the maintenance department is only able to complete about 84% of the number of Work orders and the remaining 16% of backlogs occur, as shown in Table 3.

Status	Number of backlogs	%
Completed	40,810	84
Backlog	7,837	15
Total	48,647	100

Table 3. work order performance in petrochemical company

Some of the problems that can be identified in this petrochemical company are the number of work order backlog that resulted in disruption of the production process, work order completion time is long enough to increase the work order backlog and limitations of capabilities of the Department of Maintenance to meet the work order of the

Department of Operation. The impact of work orders is very large on the efficiency of the company, so it needs to be identified and mitigation efforts are made so that it does not happen again in the future. Figure 2 below is data on the increasing work order backlog from 2016 to 2019 and decreasing in number in July 2021 after mitigation efforts from the company.

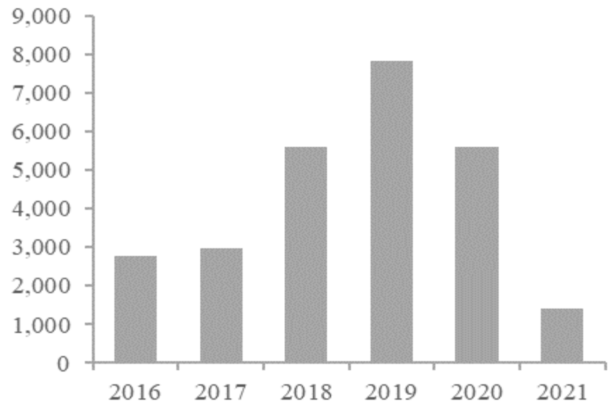

Figure 2. Number of work order backlog 2016 – 2021 at a Petrochemical Company

Such conditions have a huge impact on the survival of employees or workers and companies. Termination of employment for permanent employees continues to this day. In January 2020, employee survival is increasingly concerned with the trimming of all incentives and company facilities for all employees, the absence of salary increases, no annual bonus and trimming all incentives such as housing facilities, transport facilities and so on. This condition attracts the attention of all employees of the company to conduct analysis or research conducted by various engineers in all departments including the author himself that the case of work order backlog needs to be mitigated and given solutions to reduce the number so that the production process runs smoothly and company KPIs can be achieved every year.

Risk management is a comprehensive approach to minimize risk in the production process. Generally, risk management organized by risk identification, risk assessment, risk mitigation and knowledge sharing among stakeholders [5], [6]. In the following parts, the risk management and stages are explored to mitigate risk at the petrochemical company and reduce backlog work order.

A. Risk identification

This study uses descriptive quantitative methods that collected data and identified risk by conducting interviews and group discussion. In this study, the work order backlog is experiencing risks that have a major impact on employee survival and the development of the company in the future which needs special attention.

In 2019, there is a customer asking for large quantities of products, the operation coordinates with maintenance that will increase the amount of plant production up to 100% to meet the needs of these consumers within 5 months. Before increasing the production capacity, it is required to repair the production machines to minimize problems in the 5 months. The time set for maintenance of these production machines is set for 20 days. Due to the limited number of skilled employees and inadequate parts, as well as other problems, the maintenance process takes a very long time so that the 20 days that have been determined but retreated to 2 months. Finally, the production capacity has failed to increase on time and the needs of the customers cannot be met. This illustration reaps many complaints from various companies that need products and decide to postpone cooperation.

Risks in petrochemical companies are huge in numbers. We identify these risks based on in-depth interview and field observation. This study found twenty potential risks that disrupt petrochemical production and efficiency. Risk identification is focused on 6 aspects of potential risk at the company and described by risk potential. Risk identification showed that resource, planning, and method aspects are the greatest number of potential risks in petrochemical company. After that, according to [21] suggest to provide code for each risk items to supporting the analysis. Finally, the result of risk identification is described at Tabel 4.

No	Category	Code	Risk potential items
1	Recourses	R1	Lack of Manpower
2		R2	Lack of skilled contractor workforce
3		R3	Low surveillance
4		R4	Lack of vendor support
5	Planning	P1	There is no priority work order.
6		P2	Poor planning
7		P3	Not exactly scheduling
8		P4	The command in work order is unclear
9	Method	M1	Poor communication
10		M2	A convolute permit system
11		M3	Reduction in overtime work
12		M4	High level of repair work
13	Materials	T1	Spare parts not available
14		T2	The process of procuring goods is late
15		T3	Parts are not suitable
16	Environment	E1	Short working hours in Ramadhan
17		E2	Weather Conditions
18	System	S1	Unavailability of procedure
19		S2	High Employment Order
20		S3	Difficulty working procedure

Table 4. Risk identification result

B. Risk assessment

The identified risk needs to be assessed to determine which risk is the most potential to affect business operations. In this stage, this study exploit expert's judgement to assess risk using FMEA methodology. Ten respondents from all sections in the maintenance department are encouraged to provide opinions and judgment into the potential risk. Department that involves in the risk analysis and assessment of the potential risk are Senior Maintenance Manager, Planning Manager, rotating equipment engineer, electrical Head division, Instrument head division, rotating equipment head division, head of workshop, warehouse manager, instrument engineer and rotating supervisor.

According to FMEA methodology, experts provide assessment of the level severity (S), occurrence (O), and detection (D) of each potential risk. The result of risk assessment from each respondent is provided in Table 5.

No	Category	Code	Risk Item	Respondent 1			Respondent 2			Respondent 3			Respondent 4			Respondent 5			Respondent 6			Respondent 7			Respondent 8			Respondent 9			Respondent 10		
				S	O	D	S	O	D	S	O	D	S	O	D	S	O	D	S	O	D	S	O	D	S	O	D	S	O	D	S	O	D
1		R1	Lack of Manpower	3	5	3	3	3	4	2	3	4	2	4	4	3	3	3	3	4	4	3	3	3	2	4	4	2	4	3	3	4	4
2	Resources	R2	Lack of skilled contractor workforce	3	3	1	2	3	4	2	4	3	1	4	4	2	3	3	1	3	4	2	4	3	1	3	4	2	4	3	1	4	4
3		R3	Low surveillance	2	3	2	1	2	2	2	3	3	1	2	2	2	3	3	1	2	2	2	3	3	3	2	2	1	3	3	1	2	3
4		R4	Lack of vendor support	1	2	2	2	2	1	2	3	2	1	2	1	2	3	2	1	2	1	2	3	2	1	2	2	2	2	2	2	2	2
5		P1	There is no priority work order.	2	4	3	2	4	1	3	3	2	2	3	1	3	4	2	3	3	1	2	4	2	2	3	2	2	4	2	3	3	1
6	Planning	P2	Poor planning	2	5	3	2	2	2	3	2	2	3	3	3	3	2	2	2	3	3	3	3	2	2	3	2	3	2	2	3	3	2
7		P3	Not exactly scheduling	2	3	3	3	2	2	3	2	1	3	2	2	4	2	1	3	2	1	4	2	1	3	2	2	4	3	2	3	3	2
8		P4	The command in WO is unclear	1	2	2	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	1	1	2	1	1	3	1	2	2	2	1	3
9		M1	Poor communication	2	2	3	2	3	2	3	3	3	2	3	2	2	3	3	3	3	2	2	1	3	3	3	2	3	3	3	2	2	3
10		M2	A convolute permit system	1	2	3	2	2	3	1	2	3	1	2	2	1	2	3	1	3	3	1	3	4	1	3	4	1	3	2	2	3	3
11	Method	M3	Reduction in the amount of overtime work	3	2	2	4	3	2	3	3	3	4	3	2	3	3	3	5	4	2	3	4	3	3	4	2	4	3	3	3	4	2
12		M4	High level of repair work	2	3	2	4	4	1	3	3	2	3	4	2	3	4	2	3	3	2	4	3	2	2	4	1	3	3	2	3	4	1
13		T1	Spare parts not available	4	3	3	3	2	3	3	3	2	3	3	2	3	3	4	3	2	4	3	4	4	4	3	4	4	2	4	3	2	3
14	Material	T2	The process of procuring goods is late	2	3	1	3	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	2	3	3	3	4	2	2	4	2	4
15		T3	Parts are not suitable	2	2	3	3	2	3	4	3	2	5	3	1	3	3	2	4	2	2	5	3	1	3	2	1	4	3	2	5	2	2
16	Environment	E1	Short working hours in the month of fasting month	2	2	2	3	2	2	2	2	1	2	2	2	3	3	1	2	2	2	3	2	1	1	3	2	2	3	1	2	2	2
17		E2	Weather Conditions	2	3	3	1	4	3	2	5	4	1	5	4	2	4	4	2	5	4	2	3	4	2	5	3	2	5	4	1	4	4
18		S1	Unavailability of procedure	1	2	2	1	2	2	2	3	3	2	3	3	2	2	3	2	3	3	2	2	2	1	2	2	1	3	3	1	3	2
19	System	S2	High Employment Order	2	3	1	2	3	2	2	3	1	2	3	2	2	3	1	2	3	2	2	3	1	2	3	2	2	3	1	3	2	3
20		S3	Difficulty working procedure	2	2	3	1	3	3	1	3	3	1	3	3	2	3	3	3	2	3	3	2	2	3	2	2	2	2	3	2	3	3

Table 5 Risk assessment by experts

No	Category	Code	Risk items	Expert judgement modes			RPN
				S	O	D	
1		R1	Lack of Manpower	3	4	4	48
2	Resources	R2	Lack of skilled contractor workforce	2	3	4	24
3		R3	Low surveillance	1	3	2	6
4		R4	Lack of vendor support	2	2	2	8
5		P1	There is no priority work order.	2	4	2	16
6	Planning	P2	Poor planning	3	3	2	16
7		P3	Not exactly scheduling	3	2	2	12
8		P4	The command in WO is unclear	2	1	3	6
9		M1	Poor communication	2	3	3	18
10	Method	M2	A convolute permit system	1	2	3	6
11		M3	Reduction in the amount of overtime work	3	3	2	18
12		M4	High level of repair work	3	3	2	18
13		T1	Spare parts not available	3	3	4	36
14	Material	T2	The process of procuring goods is late	2	2	2	8
15		T3	Parts are not suitable	3	2	2	12
16	Environment	E1	Short working hours in the month of fasting month	2	2	2	8
17		E2	Weather Conditions	2	5	4	40
18		S1	Unavailability of procedure	1	2	2	4
19	System	S2	High Employment Order	2	3	1	6
20		S3	Difficulty working procedure	2	2	3	12

Table 6. Risk priority number (RPN) of the potential risk in petrochemical company

From the risk assessment of ten respondents, the risk priority number is calculated. The RPN score from various expert is obtained by some method, for example: using arithmetic, fuzzy approach [15], mode technique or order weighted average [22]. This study uses mode technique since it is appropriate with the SOD numbers that provided by the experts. Using mode technique to provide the RPN in risk assessment was also applied by [23]. The result of risk RPN calculation for each risk potential is served in Table 6.

The RPN calculation has showed that the most highest RPN is lack of manpower, weather condition during the operations and spareparts. As mentioned before, manpower readiness and utility may ensuring productivity. Appropriate numbers of manpower may improve the peroformance and reduce work order backlog. In-depth interview and field observation show that lack of manpower in the maintenance department may increasing the number of work order backlog. After that, the company's that analysed as the case of this study is located at the middle-east which has extrem weather condition. Expert agreed that weather condition is the most potential risk that may distrupt petrochemical operations. For the spareparts problems also donates higher number of backlog work order since it is disrupting machine maintenance during operations. Some solutions must be made to reducing spareparts problem, it is not only the avaialability but also the storage condition in the warehouse to supporting the maintenance goals [24].

From the twenty risk potential at the petrochemical company, it found that there are twelve risks that has RPN more than score ten. It is indicated that these risk need to be mitigated immediately. In the following section, the risk mitigation are formulated using HOR-2 to recommend the preventive actions in reducing backlog work order.

C. Formulate risk mitigation.

The House of Risk method for assessment is a combination of FMEA and QFD (Quality Function Deployment) methods. This method is used to solve problems around the relationship between risk events, the relationship between the causes of risk, the relationship between risk and the cause of risk and risk mitigation actions that will be carried out. Moreover, this study applies FMEA for risk assessment, while risk mitigation is formulated by HOR type 2.

Based on the identification of risks that the impact of this work order backlog is very large on the production process. In general, the risk mitigation is focus on the high RPN which contributes to the high damage of the operations. Ref. [15] decide to mitigate potential risk by limiting to the risk score by expert, while [8] choose the risk potential to mitigate using pareto diagram. In this study, we apply Pareto diagram analysis to capturing risk with the highest score and impact to the petrochemical company. The pareto diagram of the potential risk is depicted at Figure 3.

Based on the risk identification that the author has explained above, there are 20 risks that need to be addressed with different RPN values. In this case the author prioritizes handling risks that have high priority that must be resolved immediately to mitigate the workorder backlog. Pareto diagram analysis shows that the first six risk potential contributes to more than 50% total risk in the petrochemical company. Due to cost limitation of the risk mitigation, this study suggests focusing the risk mitigation into the first six risk potential. The potential risk that is prioritized to mitigate is described in Table 7.

To mitigate risk priorities, it should formulate preventive actions. According to HOR framework, risk potential can deal with one preventive action, while one preventive action may reduce more than one risk priority simultaneously. In this stage the RPN for specific risk is provided at the right side of the HOR model. A RPN with FMEA for risk assessment is possible to be applied for the professional at the company. For mapping on HOR 2 this can be seen in Table 8.

This study proposed five preventive actions to mitigate risk potential based on expert discussion and judgement. The proposed preventive actions are: Communicate continuously to all departments to monitor work order status (PA1), coordinate to stakeholders in managing weather condition using Computerize Maintenance Management System (CMMS) (PA2), Investment in warehouse management system to manage spare parts for maintenance and production using CMMS (PA3), Improve the quality of employee in providing a scheduled training and monitor the employee regularly (PA4), Investment in communication facility, alarm system and deliver coordination before, during and after work project (PA5), and provide a comprehensive planning management system that discussed in the early periods (PA6).

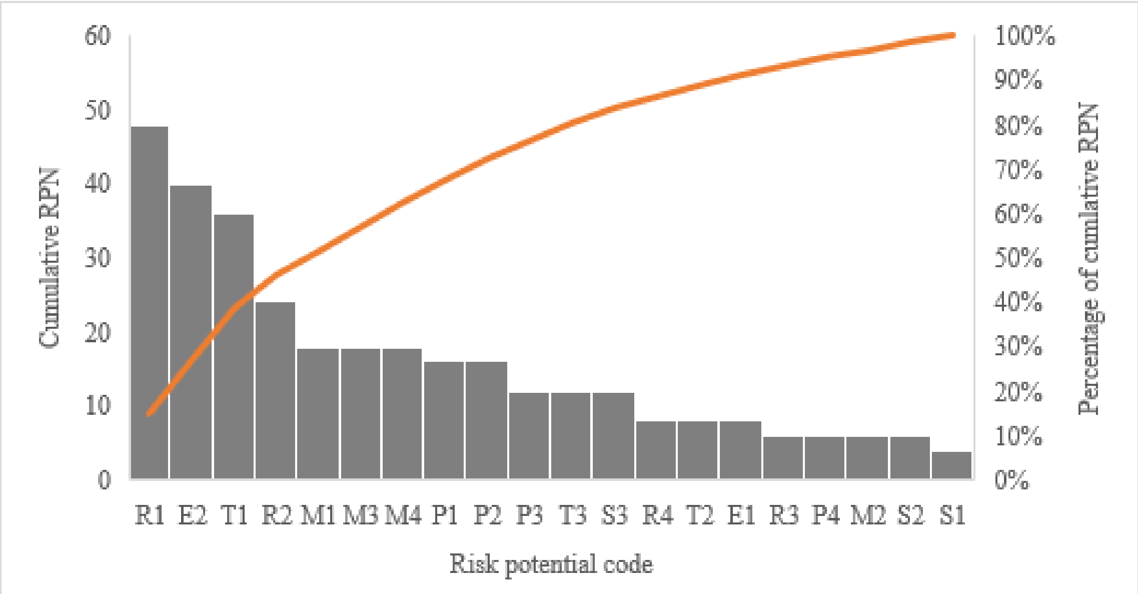

Figure 3. Pareto diagram of the RPN

No	Risk priority items	RPN	Percentage (%)	Cumulative Percentage (%)
1	Less workforce	48	15%	15%
2	Weather condition	40	12%	27%
3	Spare part not available	36	11%	39%
4	Lack of skilled contractor workforce	24	7%	46%
5	Lack of communication	18	6%	52%
6	Poor planning	16	6%	57%

Table 7. Risk priority to mitigate

Risks	Preventive actions (PA)						RPN
	PA 1	PA 2	PA 3	PA 4	PA 5	PA 6	
Less Manpower	4	5	3	3	3	3	48
Weather condition	3	3	3	1	4	2	40
Spare Part Not Available	3	3	3	3	2	4	36
Un-Skilled Employee	4	3	1	2	3	3	24
Lack of Communication	2	2	3	2	3	2	18
lack of planning	1	4	3	2	4	2	16
Total Effectiveness	472	640	498	408	566	568	
Difficulties	5	4	2	3	2	2	
ETD	98	160	249	136	283	284	

Table 8. HOR 2 mapping calculation

No	Risk priority items	Proposed mitigation activities
1	Less manpower	1. Communicate continuously to all departments to monitor work order status. 2. Utilize experienced old employees to complete a new or urgent Work Order. 3. Send a work order backlog report to the supervisor regularly every week to remind the supervisor that all work orders are executed properly and on time. 4. Place and update the availability of labor and resources in CMMS. 5. Increase the number of skilled employees. 6. Utilize skilled new employees to complete delayed WOBs.
2	Weather condition	1. Increase the number of members of the work force so that the work on the ground can be done alternately, at least 2 technicians and 2 helpers. 2. For work that is short work time can make shade or temporary cover if the work is done in the field 3. If the work can be done in the workshop, then the equipment that will be maintained is dismantled and brought to the workshop. The process of assembling and replacing spare parts can be done in the workshop. 4. If the work is not foam done in the workshop, then provide a cooler fan and drinking water station in the field. 5. Coordination with the safety department about the weather every day to find out the weather conditions directly. 6. Pressure production to use priority matrix in criticizing and participating and applying it in CMMS.
3	Spare parts problems	1. Create communication channels and meetings on an ongoing basis with the procurement team and inventory team about the needs of spare parts and stock of empty goods in the warehouse. 2. Predicting the number of spare parts requirement and demand for preventive maintenance 3. Ensure the CMMS program records all required parts. 4. Develop and effective communication with good procurement and inventory. 5. Review the standard operational procedure of procurement to deliver efficient and effective process and control. 6. Make sure the parts are always available in the warehouse by buying them directly if the stock is already in a minimum position. Don't wait until it's over.
4	Lack of skilled contractor workers	1. Training programs on priority matrix and checking regularly. 2. Develop an effective communication of management and power providers regarding the requirements. 3. Create a training program to improve the skills of contract workers. 4. Improve the quality of the contract recruitment process more selectively.

No	Risk priority items	Proposed mitigation activities
		5. The process of receiving contract employees must be selective and comprehensive to know the level of knowledge of those employees. 6. Add qualified contractors.
5	Lack of communication	1. Communicate continuously to all departments to monitor work order status. 2. Ensuring duplicated data for the availability of existing workforce within SAP 3. Improve lines of communication to execute the schedule and activities in enabling business process. 4. Ensure quality reports and scheduling. 5. Develop lesson learner problems and solutions to avoid issues in the future. 6. Send a work order backlog report to the supervisor regularly every week to remind the supervisor that all work orders are executed properly and on time.
6	Poor planning	1. Develop an effective communication with organizing maintenance plan meeting sessions to brainstorm the planned activities and schedules. 2. Identifying the breakdowns periodically and the required parts should be available if time is needed. 3. Predict early the needs of each work order, especially work orders for preventive. 4. Training programs on priority matrix and checking regularly. 5. Increase the active communication of planners with other departments so that there is no miscommunication between departments, especially maintenance departments. 6. Improve planning skills with specialized training in the company.

Table 9. Risk mitigation activities

Risk priority for each risk and activity is determined by the value to action difficulty ratio (ETDk). Risk mitigation activity with the highest ETDk ratio is cost-effective and proposed as preventive actions. In this case, the preventive actions to mitigate the work order backlog are preventive actions (PA) 5 and preventive actions (PA) 6 with total effectiveness of 566 and 568. Further, this study also provides practical solutions to reduce the number order backlog as found in Table 9.

The optimal number of work order backlog does not interfere with the production process. The production meets the needs of consumers that must meet 10% of the total work orders released every year. In this study, the analysis found that the Petrochemical Company reached 16% of the total work orders reduced every year.

IV. Conclusion

The petrochemical company must be able to answer on how to reduce work order backlogs in improving performance due to global oil price dynamism. A high backlog of work-level orders creates a major problem for petrochemical companies as reflected in the data and interviews conducted at the company. The analysis concluded the backlog of work orders is a real problem and the percentage reaches 16%. This research has found 20 potential risks to be managed in a petrochemical company. Our analysis recommends focusing on six risks which have the highest risk priority number. With the analysis comes the conclusion of the cause of the backlog work order is manpower, weather factors that occur in middle eastern countries, spare parts availability problem, contractor skills and competencies, lack of communication and poor planning to complete the order. Based on analysis of root cause, existing data, literature review, expert opinion during the interview there are several recommendations proposed as mitigation or solutions to reduce work order backlog in petrochemical companies.

This research has provided a complete analysis of risk potential in petrochemical companies. However, the risk assessment and mitigation are delivered by expert judgement in the petrochemical company. For further research, it needs risk mitigation activity implementation in the field for validation.

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Author Biographies

Saefullah was born in Serang Banten Province, Indonesia in 1981. He received his bachelor's degrees in 2019 and master's degrees in 2021 from Industrial engineering department of Bina Nusantara University, Indonesia with predicate "CUMLAUDE". He worked with PT. Polyprima Karyareksa (PT. Indorama right now) from 2001 until 2005 located in Ayer Cilegon, Banten province as mechanical Rotating Equipment technician. He joined with PT. Transpacific Petrochemical Indotama located in TUBAN, East Java from 2005 to 2008 as Rotating Equipment Foreman. Since 2008, he moved to Qatar and joined a Petrochemical company as Senior Rotating Equipment and Condition Monitoring in maintenance section. During master's degrees education, his research interest is in maintenance management of work order backlog mitigation to avoid and reduce the number of maintenance backlogs which affect the key Performance Indicator (KPI) of the maintenance section.

Muhammad Asrol was born in Riau Province, Indonesia in January 1994. He received his PhD and master's degrees at Agro-industrial Technology Department - IPB University by the scheme Master leading to Doctor Education program for brilliant undergraduate degree holder from Indonesian Government supervised by Prof Marimin. In 2018 he also joined Prof Taira laboratory at University of the Rykyus, Japan to finish their current project on Sugarcane Agroindustry. Since 2020 he joined as faculty member at master's in industrial engineering, Bina Nusantara University, Indonesia. His research interests include supply chain management, decision support system, artificial intelligence, and business process modeling.