Delay Identification of the HVAC Project on West Madura Offshore Oil Company Using the House of Risk Method

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Abstract—This research is focused on the analysis of delays or risks to the implementation of the "Procurement and Installation HVAC Installation" contract at West Madura Offshore Oil Company, which has a working area in the Offshore area. This study uses the HOR (House of Risk) method as an alternative to the ISO31000: 2009 risk management method that has been used internally by West Madura Offshore Oil Company. The basis for selecting the HOR (House of Risk) method is the existence of a tool to see the impact (severity) and relations (relations) between the event of a delay and the method used namely Poor-quality shop and quality of HR (contractors and subcontractors), Absence of coordination drawings, weather constraints, limited quantity and quality of HR (contractors and subcontractors), Absence of duct fabrication workshops at the site and lack of communication between contractor and subcontractor.

Keywords—Risk Management, House Of Risk, HVAC, Delay Analysis, Offshore.

I. INTRODUCTION

PROJECT risk is an uncertain event or condition which, if it occurs, has a positive or negative effect on the project objectives [1]. Projects with broad complexity and strategic importance occur in oil and gas industry construction projects. Risk of conditions in the Oil and Gas field which is a hazardous area, which requires special requirements both for electrical mechanical construction and installation. In NFPA and ICEE there are HVAC (Heating Ventilation Air Conditioning) cooling system requirements as a cooling system as well as a pressurized system. and consists of several subsystems, primarily: thermodynamic processing and filtration, water separation, hot, cold, steam, or water supply for humidification, air duct installation, automatic adjustment subsystem [2].

West Madura Offshore Oil Company is one of the Indonesian Oil and Gas PSC Contractors, one of West Madura Offshore Oil Company Platforms require the work "Procurement and Installation of HVAC" which has been carried out from 2016 to 2018. In its implementation, there was a delay of 382 days. The loss resulted from the delay in the work of "Procurement and Installation of HVAC" in terms of West Madura Offshore Oil Company, namely in terms of lost opportunity cost recovery valued at IDR 9,574,600,000. This delay is caused by delays in the Manufacturing Heating Ventilation Air Conditioning (HVAC) unit, Fabrication Ducting, and Installation processes in the Offshore area.

Risk management always begins with risk identification, which may be considered the most important phase of the risk management process. The aim of risk factor identification is to comprehensively identify all significant sources of factors affecting a certain project's objective, as well as the causes of those factors [6].

That's why this study utilized Focus Group Discussion. Focus Group Discussion were conducted by Internal Expert from West Madura Offshore Oil Company for the purpose of identifying the risk which is part of risk management process. The risk management process begins by setting the scope of the “Procurement and Installation of HVAC Project” to be managed at risk. Furthermore, risk identification activities are carried out to determine the potential hazards that may arise.

II. METHOD

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and also do historical data collection from the project in the 2016-2018 implementation period. In this stage a list of delays will be generated that can be obtained from the identification of the source of the delay, what are the factors of delay (what), where the delay factor appears / is found (where), how the delay arises (how) and why the delay arises (why), which delay has an impact on the achievement of company goals and objectives within the scope of the "Procurement and Installation of HVAC" projects.

A. Data Collection

Data collection will be divided into two with detail:(1)Primary Data, starting with setting the scope of the "Procurement and Installation of HVAC Project" to be managed at risk, then conducting Focus group discussions and Internal Expert Judgments using secondary data as a basis for discussion;(2)Secondary data, the collection of similar project history data (HVAC) at West Madura Offshore Oil Company in the period of 2016-2018 as secondary data.

In determining the weighting criteria in this study will be carried out through an expert judgment process with the profile of respondents can see Table 1. Respondents in table 1 are internal stakeholders involved in the HVAC project in the 2016-2018 period and are also experts at WEST MADURA OFFSHORE OIL COMPANY have experience in fields related to the HVAC project.

After conducting a focus group discussion, the researcher does the re-recording for further re-verification so that the definition of the researcher from the results of the focus group

| Stakeholder | Number of Respondents | Work Experience (years) |
|-------------|-----------------------|-------------------------|
| Engineering | 1                     | 5-10                    |
| Project Executor | 3             | 10-15                   |
| QA&QC Project | 2                | 5-10                    |
| Process Safety | 1               | 5-10                    |
| Field Engineer | 2                | 5-10                    |
| Line Manager Technical Maintenance | 1 | 10-15 |

Table 1. Profile of Respondents as Internal Experts

| Business Process | Risk Event (Ej) | A1 | A2 | A3 | A4 | A5 | A6 | A7 | Severity of Risk Event i (Si) |
|------------------|-----------------|----|----|----|----|----|----|----|------------------------------|
| Plan             | E1              | R11| R12| R13| .. | .. | .. | .. | S1                           |
| Source           | E2              | R2 | .. | .. | .. | .. | .. | .. | S2                           |
| Make             | E3              | R31| .. | .. | .. | .. | .. | .. | S3                           |
| Deliver          | E4              | R41| .. | .. | .. | .. | .. | .. | S4                           |
| Occurence of Agent j | O1            | .. | .. | .. | .. | .. | .. | .. | S5                           |
| Aggregate Risk Potential | ARP1       | .. | .. | .. | .. | .. | .. | .. | ARP2                          |
| Priority Rank of Agent j |          |    |    |    |    |    |    |    | ARP3                          |

Table 2. HOR Model 1

| Risk Factors classification | RFIT | Rank | RFIC | Rank | Group |
|-----------------------------|------|------|------|------|-------|
| Poor selection of valves that might cause more damage | 0,449 | 1 | 0,459 | 1 | B |
| Lack of specialized laborers | 0,417 | 2 | 0,355 | 5 | D |
| Poor-quality shop and coordination drawings | 0,417 | 3 | 0,371 | 3 | D |
| Wrong selections that might cause future rectification | 0,406 | 4 | 0,415 | 2 | C |
| Poor safety regulations | 0,385 | 5 | 0,344 | 8 | D |
| Wrong work procedure between different disciplines | 0,367 | 6 | 0,318 | 12 | D |
| Equipment sizes clash with provided spaces | 0,363 | 7 | 0,358 | 4 | C |
| Wrong selection of dampers and plenum boxes | 0,339 | 8 | 0,337 | 11 | A |
| Power/Chilled/Duct connection might not match with the equipment | 0,338 | 9 | 0,34 | 9 | C |
| Openings missing in the concrete and wall for horizontal and vertical penetration | 0,337 | 10 | 0,278 | 15 | D |
| Selecting fittings that might not be compatible with the pipe thickness | 0,336 | 11 | 0,352 | 6 | B |
| Weak connection/ joints (threaded/ groove/ welded etc.) between two chilled water pipe pieces | 0,334 | 12 | 0,347 | 7 | B |
| Inappropriate storage of the duct, which might cause damage to the duct | 0,329 | 13 | 0,254 | 22 | A |
| Unsafe handling of the equipment | 0,312 | 14 | 0,338 | 10 | C |
| Installation without following the standard procedure | 0,312 | 15 | 0,275 | 16 | D |
| Extreme weather conditions | 0,311 | 16 | 0,27 | 18 | D |
| Shortage of power supply for machine's operation | 0,311 | 17 | 0,252 | 24 | D |
| Lack of water supply and drainage for testing | 0,308 | 18 | 0,253 | 23 | B |
| Abnormal floor height that might require special scaffolding | 0,304 | 19 | 0,26 | 21 | D |
| Inappropriate fixing methods | 0,301 | 20 | 0,278 | 14 | D |
discussion can be believed to be in accordance with the objectives and research objects.

B. Risk Identification or Delay Stage

Risk identification activities carried out to determine the potential hazards that may arise. The common tools and techniques used are:

a. **Review** documents: Input documents in the pre-project stage (Pre-FS / FS documents, economic models, risk evaluation results, and other supporting documents).

b. **Information Gathering Techniques** which will be used are: Focus Group Discussion.

c. **Analysis Checklist**

d. **Root Cause Analysis**, which will be used is FTA basis from the Internal Expert Judgment of West Madura Offshore Oil Company. After getting the risk based on the risk identification process, next step is using House of Risk (HOR) method for the identification of the delay stage. The detail step are:

- Identification of possible delays that may occur for each stakeholder, obtained from the focus group discussion.
- Give a rating on a scale of 1 to 5 regarding the severity due to factors that occur delays
- Identify agents of delays and assess their likelihood.
- Develop a linkage matrix (relations) between each of the delay factor agents with each delay.

### III. RESULT AND DISCUSSIONS

#### A. Identification of Late Events

The primary data obtained from this identification came from group discussions with internal expert judgment consisting of engineering, project executors, QA & QC projects, process safety, field engineers, and Line Manager Technical Maintenance as Contract Holder in the "Procurement and HVAC Installation "Button. And secondary data obtained from the literature review and historical data of the company must be able to describe events, risk agents (include sources of risk), potential consequences, and key risk indicators.

The Literature Review that will be used is a paper entitled "Procurement and HVAC Installation - Button. And secondary data obtained from the literature review and historical data of the company must be able to describe events, risk agents (include sources of risk), potential consequences, and key risk indicators.

#### B. Identification of Agents

| Code | Delay Event                                      | Severity |
|------|--------------------------------------------------|----------|
| E1   | Delay in HVAC Manufacturing Units                | 4        |
| E2   | Delay in Fabrication Ducting                     | 4        |
| E3   | Delay in the HVAC Assembly Control Panel         | 3        |
| E4   | Delay in installation of the Control Panel unit  | 3        |
| E5   | Delay in ducting installation                    | 4        |
| E6   | Delay in installation of HVAC and PFU Units      | 4        |

#### C. Likert scale for severity used in the HOR (House of Risk) approach

| Scale | Remark                          |
|-------|---------------------------------|
| 5     | Very serious impact and cause project failure |
| 4     | Serious impact on project completion     |
| 3     | Moderate impact on project completion   |
| 2     | Little impact on project completion     |
| 1     | The impact on the completion time target can be ignored |

#### D. Likert scale for probability used in the HOR (House of Risk) approach

| Scale | Remark                          |
|-------|---------------------------------|
| 6     | Probabilities inevitably occur and cause project failure |
| 5     | The probability of occurrence is very high so it is very common for projects |
| 4     | High probability of occurrence   |
| 3     | Probability of moderate occurrence |
| 2     | Low probability of occurrence    |
| 1     | the probability of occurrence will almost certainly not occur |

#### E. Calculation of Aggregate Delay Potential (ADPj)

Calculate the Aggregate Delay Potential of Agent j (ADPj) which is the result of the possible emergence of the delay factor j agent and the aggregate effect of the delay caused by the delay factor agent.

\[ \text{ARP}_j = \sum \text{ARP}_i \times \text{Probability}_i \]

#### F. Pareto Chart

Use Pareto Chart 80:20 with ARP, as basis calculation using formula :

\[ \text{Pareto} = (\text{ADPj}/\text{TotalADP}) \times 100\% \]

#### G. HOR Model 1

See Table 2.
The FGDs result that have been carried out with Fault Tree Analysis (FTA) are events and agents and sub-agents of delays related to delays from the project "Procurement and Installation of HVAC (Heating Ventilation Air Conditioning)" which show in figure 1 and 2. From Figure 1 and 2 we can know factors that cause (can be called a Delay Event) of the project "Procurement and Installation of HVAC (Heating Ventilation Air Conditioning)", namely:

1) Delay "Project Management & Installation & Termination"
   Delay "Project Management & Installation & Termination" including cable installation and accessories", which has a delay agent:
   a. Delay in the installation of the Control Panel unit
   b. Delay in ducting installation
   c. Delay in the installation of the HVAC Unit (Heating Ventilation Air Conditioning) and PFU (Pressurize Fan Unit).

2) Delay "Provide HVAC Unit Complete with accessories"
   Delay "Provide HVAC Unit Complete with accessories", which has a delay agent:
   a. Delay in HVAC (Heating Ventilation Air Conditioning) Manufacturing Unit both AHU (Air Handling Unit), ACU (Air Conditioning Unit) and PFU (Pressurize Fan Unit).
   b. Delay in Fabrication Ducting
   c. Delay in HVAC (Heating Ventilation Air Conditioning) Assembly Control Panel

Furthermore, the probability or occurrence value of delay agent and severity or impact severity of each event delay can be seen in table 6 and 7. From the table 6 and 7 it is known that the HOR (House of Risk) method uses table 4 and 5 as a scale to determine the severity impact and that will be used to obtain risk ratings through Aggregate Delay Potential (ADP) calculations which the matrix is shown in table 2.
B. Identification of Agents Causing Delays

After finding the event or event causing the delay, the next step is to find the agent and sub-agent causing the delay. With primary and secondary data obtained. Then get several agents and sub-agents causing delay using the FTA (Fault Tree Analysis) method and Focus Group Discussion (FGD), the result are shown in the following Table 8, 9, 10, 11, 12 and 13.

C. Analysis of Research Result Based on the Method Used

Based on the results of the research that has been done in the previous sub-chapter both about the significant potential

### Table 11.
Listing or listing of agents causing delays in the delay event with the E4 code that will be used in the HOR (House of Risk) Method

| No | Event Delay                                      | Delay Agent                                                                 |
|----|--------------------------------------------------|-----------------------------------------------------------------------------|
|    | Delay in the installation of the Control Panel unit | Limitations of POB (Personal on Board) on PT.XYZ's Offshore Platform       |
|    |                                                 | Safety Regulations for Offshore work                                         |
|    |                                                 | Weather Constraints                                                         |

### Table 12.
Listing or listing of agents causing delays in the delay event with the E5 code that will be used in the HOR (House of Risk) Method

| No | Event Delay                                      | Delay Agent                                                                 |
|----|--------------------------------------------------|-----------------------------------------------------------------------------|
|    | Delay in ducting installation                    | Limited quantity and quality of human resources (contractors and subcontractors) |
|    |                                                 | Safety Regulations for Offshore work                                         |
|    |                                                 | Weather Constraints                                                         |
|    |                                                 | Poor-quality shop and coordination drawings                                  |
|    |                                                 | Absence of duct fabrication workshop at the site                            |
|    |                                                 | Difficulties in "horizontal and vertical penetration" against the walls of the room |

### Table 13.
Listing or listing of agents causing delays in delay events with code E6 that will be used in the HOR (House of Risk) Method

| No | Event Delay                                      | Delay Agent                                                                 |
|----|--------------------------------------------------|-----------------------------------------------------------------------------|
|    | Delay in the installation of HVAC and PFU Units  | Limitations of POB (Personal on Board) on PT.XYZ's Offshore Platform       |
|    |                                                 | Safety Regulations for Offshore work                                         |
|    |                                                 | Weather Constraints                                                         |
|    |                                                 | Difficult access in "horizontal and vertical penetration" of the walls of the room |
|    |                                                 | Lack of storage space for ducts, pipes, and equipment at the site           |

### Table 14.
ADP (Aggregate Delay Potential) results on the HOR (House of Risk)

| Business Process                  | Risk Event (Ei) | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | Severity of Risk Event i (Si) |
|----------------------------------|----------------|----|----|----|----|----|----|----|----|----|-----|-----|-----------------------------|
| Provide HVAC unit               | E1             | 3  | 0  | 0  | 3  | 0  | 3  | 0  | 9  | 9  | 0   | 4   | 4                           |
| E2                              | 0  | 0  | 0  | 3  | 0  | 0  | 3  | 0  | 9  | 9  | 0   | 4   | 4                           |
| E3                              | 0  | 0  | 0  | 3  | 0  | 0  | 3  | 0  | 9  | 9  | 0   | 4   | 4                           |
| E4                              | 0  | 9  | 0  | 3  | 0  | 0  | 0  | 0  | 0  | 0  | 1   | 3   | 3                           |
| E5                              | 0  | 9  | 0  | 3  | 0  | 3  | 0  | 0  | 0  | 9  | 1   | 4   | 4                           |
| Project Management and Installation | E5            | 0  | 9  | 0  | 3  | 0  | 3  | 0  | 0  | 0  | 9   | 1   | 4                           |
| E6                              | 0  | 9  | 1  | 3  | 0  | 0  | 3  | 0  | 0  | 0  | 1   | 4   | 4                           |
| Occurrence of Agent i           | 2  | 5  | 2  | 4  | 3  | 6  | 5  | 6  | 4  | 5  | 2   | 2   | 2                           |
| Aggregate Risk Potential j      | 24 | 495| 8  | 264| 99 | 216| 165| 72 | 144| 675| 22  | 22  | 22                          |
| Priority Rank of Agent j        | 9  | 2  | 11 | 3  | 7  | 4  | 5  | 8  | 6  | 1  | 10  | 10  | 10                          |

### Table 15.
Ranking or ranking of Pareto results from the ADP (Aggregate Delay Potential) on the HOR (House of Risk) method

| Agent Code | Aggregate Risk Potential j | Priority Rank of Agent j | Cumulative Percent | Delay Agent                                                                 |
|------------|-----------------------------|--------------------------|--------------------|-----------------------------------------------------------------------------|
| A10        | 675                         | 1                        | 31%                | Poor-quality shop and coordination drawings                                 |
| A2         | 495                         | 2                        | 54%                | Weather Constraints                                                          |
| A4         | 264                         | 3                        | 66%                | Limited quantity and quality of human resources (contractors and subcontractors) |
| A6         | 216                         | 4                        | 76%                | Absence of duct fabrication workshop at the site                            |
| A7         | 165                         | 5                        | 83%                | Lack of communication between contractors and subcontractors                |

B. Identification of Agents Causing Delays

After finding the event or event causing the delay, the next step is to find the agent and sub-agent causing the delay. With primary and secondary data obtained. Then get several agents and sub-agents causing delay using the FTA (Fault Tree Analysis) method and Focus Group Discussion (FGD), the result are shown in the following Table 8, 9, 10, 11, 12 and 13.
risks that cause delays in the Project "Procurement and Installation of HVAC (Heating Ventilation Air Conditioning)" on the WEST MADURA OFFSHORE OIL COMPANY Offshore Platform or risk mitigation to deal with it using the Risk Management method The ISO31000: 2009 approach and HOR (House of Risk) are obtained potential significant risks that cause delays in the Project "Procurement and Installation of HVAC (Heating Ventilation Air Conditioning)" on the Offshore Platform of PT.XYZ, like seen in table 14 and 15. From table 15, we can resume:

1) Poor-quality shop and coordination drawings

"Poor-quality shop and coordination drawings" which have the largest quantitative impact of five hundred twenty-two thousand USD, an RPN (Risk Priority Number) of fifteen (15) or in the category of High Impact, and a percent value of Pareto diagram of 31%. Thirty-one percent (31%) shows the largest contribution compared to other risks. The delay agent "Poor-quality shop and coordination drawings" ranks third of the twenty list of risk factors causing delays in the HVAC project [7].

2) Weather constraints

Weather constraints "which have an RPN (Risk Priority Number) of sixteen (16) or with the High Impact category, and a percent value of a pareto diagram of 23%. The value of twenty-three percent (23%) shows the second largest contribution compared with other risks. This is caused by the transportation and accommodation system in the offshore area which is very dependent on weather conditions.

3) Limitations on the quantity and quality of human resources (contractors and subcontractors)

"Limitations on the quantity and quality of human resources (contractors and subcontractors)" which have an RPN (Risk Priority Number) of twenty (20) or with a High Impact category, and a percent value of a pareto diagram of 12%. The value of twelve percent (12%) shows the third largest contribution compared to other risks. This is caused "Limited quantity and quality of human resources (contractors and subcontractors)" is common or often occurs in every construction project and were identified as the factors most causing project delay [6].

4) Absence of duct fabrication workshop at the site

"Absence of duct fabrication workshop at the site" where the RPN (Risk Priority Number) value is twenty (20) or with the category of High Impact, the percent value of the pareto diagram is 10%. The value of ten percent (10%) shows the fourth largest contribution compared with other risks. Delay agent "Absence of duct fabrication workshop at the site" is the uniqueness of HVAC construction work in Oil and Gas companies located in offshore areas, in addition to limited space, hazardous area location is another factor that causes no duct fabrication workshop ".

5) The lack of communication

"The lack of communication between the contractor and the sub-contractor which has an RPN (Risk Priority Number) of nine (9) or with the Moderate Impact category, and the percent value of the Pareto diagram is 7%. A value of seven percent (7%) shows the fifth largest contribution compared with other risks, this is in the correlation between three (3) delay events with codes E1 through E3 with a correlation value of three (3) or with categories according to the Likert scale "low". This is caused "Limited quantity and quality of human resources (contractors and subcontractors)" is common or often occurs in every construction project.

IV. CONCLUSION

After numerous proses including FGD (focus group discussion), this study has identified the risk factors that affect the duration and cost of the identified activities for the purpose of high-lighting the key risks that can significantly influence the delivery of HVAC systems in offshore construction projects. The outcome of the study is a list of five (5) significant risk factor which fall to category Manufacturing or Fabrication and Installation. A summary of the specific conclusions drawn from this study is as follows:(a)The result from FGD regarding the ranking of risk factors were determined based on three indices related to the probability of occurrence, impact and the inherent quantitative impact . The experience of the respondents was taken into consideration; (b)Severity scales were developed based on a combination of the probability of occurrence and the impacts of risk factors on time and cost to describe the key risk factors affecting HVAC system activities; (c)"Poor-quality shop and coordination drawings" was considered the most important risk factor that affected both time and cost. With 31% shown as the largest contribution compared to other risks, this is due to the high correlation value (9, "high correlation") to the most delay events; (d)Correlation or relationship between risk agents each other are important factor that can determine the risk priority which can lead to accurately risk treatment.

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