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Strategy for Improving the Quality and Effectiveness of Work on the Storage Tank Construction Project in Indonesian Oil Refinery

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Abstract - *Refineries have important role on processing crude into fuel. Damage and failures still found in the technology in refinery then can be effected to environmental pollution, asset losses, and incident fatality. Based on the fuel demand in Indonesia, a refinery plan to increase the capacity, so more storage tanks have to build. To achieve the qualified of quality, evaluation of Project Quality Management also needed to find problems effected to unqualified storage tanks and strategy to improve them are needed to prevent same issues. Authors used expert preliminary interview to find some existing problems and the result shows there are five problems (availability of quality standard documents, standard measurements and references used, safety standards applied, implementation of quality control in the field, and responsibilities of stakeholders). Methods used in this research are The Delphi Study combined with Kendall's W, both are used to evaluate project quality management existing and define strategy to improve project quality management.*

Keywords – *Storage Tank Project, Quality Management, Delphi Study, Kendall's W*

I. INTRODUCTION

Refineries have important role to provide energy needs, especially by its function to process crude oil into fuel products, non-fuel products and also petrochemical. Indonesia plans to increase the capacity of oil refinery to fulfil the needs of fuel consumption, tank is a part of refineries that have to be increase cause its function are very vital as a storage of the fuel products before it transferred to retail. In the process of developing it, quality is the main focused. Every process from supplying the material, choosing certified manpower to work in the project, and also methods that used should be considered well to meet quality standard and to prevent failures or equipment damage while its used.

Project Quality Management has big role as a guidance to control the project construction. PQM focus from quality planning, quality assurance and quality control. Quality plan is begin by indentify the quality required and ensure the quality is acceptable and comply to the standard. Quality Assurance is process checking that quality if your deliverables meet the requirements. Quality control is monitoring quality through every phase of the process and have matrix to make sure quality standards are being met, if it is not meet the expectations, adjustment are needed to set the quality standards.

Project Quality Management should be evaluate to find the obstacles that cause the quality doesn't meet the criteria. After conducting an evaluation and finding the obstacles, so quality of the storage tank construction work can be maintained. On the project of storage tank construction, PQM also have to be evaluate to meet the project standard and prevent unqualified of quality. So, the storage tank constructed. Methods that can be applied to evaluate the implementation of PQM are Delphi Methods, Focus Group Discussion and mix with Kendalls W Methods. After finding the evaluation, strategy can be define to improve PQM on storage tank construction project and aims to prevent unqualified quality while doing the construction storage tank.

II. LITERATURE REVIEW

The results show that the combined contractors and architects agree that the highest important factors affecting quality are: human resource management, customer satisfaction, and construction-specific factors. The results also show that strategic planning, continuous improvement, and resources are the lowest important factors. A conceptual framework covering the main quality factors was also developed[1]. And also good preparation and organization of implementation is considered as a key success factor [2].

According to the literature, there are three main obstacles to the success of quality management in construction projects: poor implementation, the nature of construction work, and the industry itself. The success of quality management is enhanced through the combined efforts of all parties involved in a project. Integrating safety and quality management is a possibility, but requires more research before it truly becomes a reality [3].

Quality Management is very useful in the construction process because it can improve and

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eliminate the possibility of major problems that can cause major losses to the project. With Quality Management, you can also map the source of problems that may occur in the project so that prevention can be carried out [4].

The biggest factor causing a decline in the quality of construction projects is the lack of project regulations or procedures [5]. Based on this research, 13.1% of all construction project failures are caused by the lack of standards and procedures in project planning.

The largest factors influencing Quality Management in a construction project are Design and Execution, with a percentage weighting of 13.20% [6]. The study stated that 11.37% of design and execution factors that can lead to quality degradation are due to the project's implementation not complying with applicable standards and procedures.

The availability of quality standards and documentation was recognized by the panelists of the Delphi survey and group interviews as a problem when implementing quality control as early as possible in the pre-construction stage, as well as the issue of project team competency.

III. METHODOLOGY

Research Approach

The study utilizes mixed methods approach by using preliminary interviews and Delphi Method. Quantitative methods to count percentage of each subcriteria based on respondents' opinion that involve their experiences and understanding. Qualitative methods matter in this research because data sources come from interviewing the expert to know their opinion about project quality management and considering each opinion to arrange the questionnaire. Opinion from the expert will be classified into a few aspects. So that, each aspects would contains 5-10 questions based on the opinion from all experts. The questionnaire contains some aspects that consist of some questions. After that, questionnaire can be used on Delphi Method.

Population and Sampling

The term population refers to the whole set of people, events, or subjects that researcher is interested in studying and hopes to draw conclusions from. This research contains 2 targeted audiences to be studied, there are Project Owner and the Main Contractor. All respondents are expert in tank construction project who has 5 years work experience in the same sector. Research population on Delphi Study both round 1 and Round 2 are stakeholders that related to tank construction project in Indonesian Refinery. Number of respondents in this research are five respondents, there are Quality Control Manager, Senior Engineer Mechanical, Head of Safety from Project Owner, Engineering Manager and Quality Control Manager from the Main Contractor. All respondents sufficient for the research proposed because all respondents are expert in their sector, so their answer of each question on questionnaire can be accounted for.

Research Indicators

The present study's variables that are measured from the indicators, include readiness quality standard documents, references and standard used in the project, safety standard applied, quality control implementation on the site, and role and responsibility of stakeholders. Indicators. Successful indicator of each aspects are some which achieve above 90% of agreement [7]. Some aspects that doesn't achieve 90% of agreement may have potential of error, then the question should be asking in the next round.

Methods

Based on researcher's knowledge after literature study phase, they note some highlight from each paper about project quality management and confirmed it to the expert. This phase called **Expert Preliminary Interview**. After researcher got the confirmation from all experts that have been interviewed, they arrange questionnaire to be used on next phase.

Delphi Methods

The Delphi method has been widely used in recent decades and is now regarded in academic research as a valuable technique for reaching consensus about specific issues when empirical evidence is scarce or contentious. The method aims to achieve consensus about a specific topic by using several rounds of questionnaires to collect data from a panel of selected experts on the topic of interest [8]. On this research contain 2 stages, that is **Round 1** and **Round 2**. Round 1 used the questionnaire that has been prepared, but Round 2 used questionnaire in Round 1 that has not agree yet. All rounds use anonymity technique to reduces the effect of dominant individuals on participants response. Response given to each item can vary across rounds, thereby favoring the convergence of opinions [9]. After all rounds finished, researcher process the data using quantitative methods to give summary of statistics using percentage of agreement [10].

Kendall's W (Coefficient of Concordance)

Kendall's W has been used to identify groups of significantly associated species in field survey data [11]. On interpreting level of aggrement from Kendall's w coefficient to level of aggrement using criteria:

1. $0.00 < w < 0.2$ = Slight Agreement
2. $0.2 < w < 0.4$ = Fair Agreement
3. $0.4 < w < 0.6$ = Moderate Agreement
4. $0.6 < w < 0.8$ = Substantial Agreement
5. $W > 0.8$ = Almost Perfect Agreement

In analyzing the level of inter-rater agreement using Kendall's W, the data used must be ordinal, that is, in the form of rankings. Therefore, the original Likert-scale questionnaire scores must first be converted into rankings. This conversion process is essential to fulfill the basic assumption of the Kendall's W test, namely that each rater provides ratings in the form of a relative order between the items being assessed.

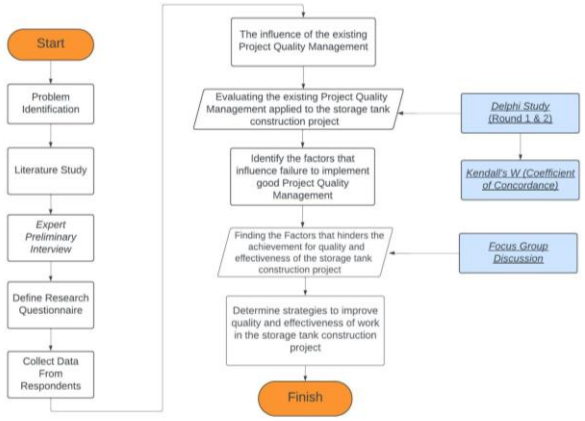

Figure 1 Research Framework

IV. FINDINGS AND DISCUSSION

Preliminary Interview Results

Based on the result of preliminary interview from five expert respondents, there are **30 questions** form that are related to construction project in Indonesian refinery. Questions classified into **five aspects**, there are readiness quality standard documents, references and standard used in the project, safety standard applied, quality control implementation on the site, and role and responsibility of stakeholders. These questions below used on the Round 1 Delphi Study.

Table 1 The Study Questionnaire

Aspects	Code	Questions
A. Readiness quality standard documents in the Project	A1	Availability of technical procedure documents, quality guidelines and quality planning
	A2	Availability of technical documents that have been agreed upon and signed jointly by the Project Owner and Contractor
	A3	There is a checklist to ensure that the implementation is in accordance with the guidelines, planning and scope of the contract
	A4	Existence of document hierarchy provisions as a reference for work guidelines
	A5	Availability of daily and weekly implementation reports
B. References and standards used in the project	B1	There is a mutual check activity at the start of the project to ensure that the work plan/drawings match the actual conditions
	B2	Availability of standard documents, drawings and general references at every stage of work
	B3	Project Owner and Contractor quality policy documents are aligned with the project quality plan
	B4	There are records for reporting any quality defects/gaps in work against standards
	B5	Standards and guidelines used clearly define the quality to be achieved
C. Safety standard applied	C1	Steps of project work are carried out based on Construction Safety Procedures
	C2	Steps of project work are carried out in compliance with environmental policies
	C3	Availability of appropriate safety and personal protective equipment to ensure safety during construction
	C4	There are safety checks and labeling of work equipment to be used
	C5	There are daily checks and assurances regarding the health level of workers on tank construction projects
D. Quality control implementation the site	D1	QC personnel ensure that each step of work meets quality standards

Aspects	Code	Questions
	D2	QC personnel ensure that every material used meets specifications
	D3	Quality planning documents are implemented in every stage of construction
	D4	There are personnel who carry out control not only on quality aspects but also costs, time and scope
	D5	QC personnel carry out checks and understand the technical procedures for testing material samples
	D6	There are inspection methods to control the construction process so it can meet specifications
	D7	Supervisory personnel periodically evaluate work performance, work quality and safety aspects during construction
	D8	There is a reporting system for non-conformities found in the field by QC personnel from both the Project Owner and Contractor
E. Role and responsibility of stakeholders	E1	High awareness of project implementers regarding the quality of work
	E2	Project Owner and Contractor understand the objectives and benefits of the tank construction project
	E3	Project Owner and Contractor communicate in making important decisions during project construction
	E4	Level of competence of QC personnel in the organization is considered satisfactory
	E5	Project Owner and Contractor understand construction quality and safety when designing and controlling the project implementation
	E6	All stakeholders in the project actively learn from quality and safety mistakes in construction
	E7	Project Owner and Contractor are committed to implementing a quality management system and project safety system

Delphi Study Round 1 Results

On this phase, questions will be given to five stakeholders expert on this project. And the results will show the satisfaction/agreement level of respondents (level of how much they agree) to each question.

Table 2 Delphi Study Round 1 Result

Q	R1	R2	R3	R4	R5	% Satisfy
A1	5	5	5	5	5	100%
A2	5	5	5	5	5	100%
A3	5	4	4	5	4	88%
A4	3	4	4	3	4	72%
A5	5	5	5	5	5	100%
B1	4	5	4	5	5	92%
B2	3	4	4	3	5	76%
B3	5	5	5	5	5	100%
B4	5	4	4	5	5	92%
B5	5	5	5	5	5	100%
C1	5	5	5	5	5	100%
C2	5	5	5	5	5	100%
C3	5	5	5	5	5	100%
C4	5	5	5	5	5	100%
C5	5	5	5	5	5	100%
D1	5	5	5	5	5	100%
D2	4	4	4	5	5	88%
D3	5	4	5	4	5	92%
D4	5	5	5	5	5	100%

Q	R1	R2	R3	R4	R5	% Satisfy
D5	4	4	5	4	5	88%
D6	5	4	4	4	4	84%
D7	5	5	5	5	5	100%
D8	5	5	5	5	5	100%
E1	4	4	4	5	4	84%
E2	5	5	5	5	5	100%
E3	5	5	4	4	4	88%
E4	4	4	3	3	5	76%
E5	5	5	5	5	5	100%
E6	5	5	5	5	5	100%
E7	5	5	5	5	5	100%

Based on the table, all questions have satisfaction percentage more than 70%, means that all questions still on the range of Delphi Consensus [12].

But there are nine questions with satisfaction percentage under 90%, there are existence of document hierarchy provisions as a reference for work guidelines, availability of standard documents, drawings and general references at every stage of work, there are inspection methods to control the construction process so it can meet specification, high awareness of project implementers regarding the quality of work, and level of competence of QC personnel in the organization is considered satisfactory.

The lowest satisfaction level is 72% on the question A4 "Existence of document hierarchy provisions as a reference for work guidelines", Most of respondents answer 4 out of 5, from there we know that document hierarchy provisions didn't apply well as reference for work guidelines. There must be agreement of guideline or standard that must be applied during the project from owner and contractors before starting the work project, whether contractor can freely choose International standard that can be applied or the owner have their specifically standard used for the guideline, or even the owner has their own standard. So, during the project, there will not be confusing standard that should be applied because both owner and contractor know document hierarchy provisions.

In question A3 shows percentage of agreement is 88%, means some of respondents did not know about the checklist to ensure that the implementation is in accordance with the guidelines, planning and scope of the contract, may it caused by less of comunication or socialization about that checklist.

Question B2 shows 76% of agreement means low agreements from the experts about there is Availability of standard documents, drawings and general references at every stage of work. Which means standard documents did not available at every stage at work, may they should create or adopt document standard for every stage at work.

In question D2, D5, and D6 mostly about QC personnel, which means the QC personnel in this project did not meet the expectations for doing some of the task such as ensure every material used meets specifications, carry out checks and understand the technical procedures for testing material samples, in the next project we should hire more qualified QC personnel and brief them before the project start.

In Role and responsibility of stakeholders aspects there are 3 questions E1, E3 and E4 that have agreement level below 90% which are High awareness of project implementers, Stakeholder communication in making importance decision and level of competence for Quality control personnel.

Kendall's W (Coefficient of Concordance) Result

Table 3 Kendall's W Result

Aspects	Kendall's W	P-value	Level of Agreement	Significancy
A	0,815	0,003	High	Highly Significant
B	0,539	0,029	Moderate	Significant
C	0,508	0,038	Moderate	Significant
D	0,516	0,012	Moderate	Significant
E	0,647	0,004	Moderate to High	Significant

The level of agreement among respondents across all aspects (A–E) showed significant results, with Kendall's W values ranging from 0.508 to 0.815. Dimension A had the highest agreement ($W = 0.815$, $p = 0.003$), while the other dimensions showed moderate but significant agreement. Thus it can concluded the assessment from the respondent are consistent and reliable.

Delphi Study Round 2 Results

Delphi study round 2 is follow up step from questions that have satisfaction percentage under 90%, which means they are not agreed yet. Delphi round 2 aims to make sure the agreement from those all questions. All respondents option using Yes or No question. Yes, means satisfaction for the question and No means unsatisfied. Results from Delphi Study Round 2 shown from the table below.

Table 4 Delphi Study Round 2 Result

ID	R1	R2	R3	R4	R5	%Satisfy
A3	Yes	Yes	Yes	Yes	Yes	100%
A4	No	Yes	No	No	No	20%
B2	No	Yes	No	No	No	20%
D2	Yes	Yes	Yes	Yes	Yes	100%
D5	Yes	Yes	Yes	Yes	Yes	100%
D6	Yes	Yes	Yes	Yes	Yes	100%
E1	Yes	Yes	Yes	Yes	Yes	100%
E3	Yes	Yes	Yes	Yes	Yes	100%
E4	Yes	No	No	Yes	No	40%

Based on the table 3, Question A3, D2, D5, D6, E1 and E3 shows that 100% respondents agree with the question and satisfied. In the other question, question A4, B2, and E4 shows that respondents answer No for satisfaction on each question.

On Round 1, their satisfaction shows more than 70%, so there are different results on Round 1 and Round 2, it because there are changes in actual condition in the field. Question A3 'There is a checklist to ensure that the implementation is in accordance with the guidelines, planning and scope of the contract' shows that respondents satisfied with the availability of checklist, it can help workers to make sure that their work comply with the guidelines, planning and scope of contract that aims to enhance project quality management. On question D2 'QC personnel ensure that every material used meets specifications' in round 2, shows that respondents satisfied with the performance of QC personnel in duties on checking and make sure the materials used has meet the specifications. Also on Question D5 'QC personnel carry out checks and understand the technical procedures for testing material samples' shows that respondents satisfied with performance of QC personnel responsibility on checking and also the QC personnel have to understand technical procedures for testing material samples, so that the materials that have been checked and qualified can be trusted. D6 'There are inspection methods to control the construction process so it can meet specifications' results on the Delphi round 2 shows that respondents satisfied with implementation of inspection and control methods during process construction, while on Delphi Round 1 respondents unsatisfied. It can happen because the contractors improve their inspection methods to fulfill the owner expectations. It also impacts to quality of work awareness of project implementers, so the question E1 'High awareness of project implementers regarding the quality of work' also get 100% satisfaction on Delphi Round 2. In question E3 'Project Owner and Contractor communicate in making important decisions during project construction' also shows that respondents satisfied, good communication between project owner and contractor can help the contractor improve their works.

There are 3 questions that did not satified the respondents yet, there are question A4, B2, and E4. On the question A4 'Existence of document hierarchy provisions as a reference for work guidelines' shows that respondents unsatisfied yet, it means there is no document hierarchy provisions as a reference for work guidelines. On question B2 'Availability of standard documents, drawings and general references at every stage of work' shows respondents has not satisfied yet, because until Delphi round 2, there is no standard documents, drawings and general references. On question E4 'Level of competence of QC personnel in the organization is considered satisfactory' shows 40% of respondents satisfaction. It means that level of competence of QC personnel have to be improve.

One of the questions is Question A4, which is the lowest results on the Delphi Round 1, it means consistency of respondent's opinion. Until Delphi round 2, the project didn't have document hierarchy provisions yet.

Based on all rounds of Delphi Study, we can conclude that respondents most agree to all questionnaire, only 3 question they didn't agree yet, there are Existence of document hierarchy provisions as a reference for work guidelines, Availability of standard documents, drawings and general references at every stage of work, and Level of competence of QC personnel in the organization is considered satisfactory

V. CONCLUSION

This study evaluate problem in project quality management tank construction project in Indonesian Oil Refinery, it has been found that existing project quality management in the Storage Tank Construction Project has 5 (five) important aspects that affect the level of quality and effectiveness of the project. The five aspects are: Availability of Quality Standard Documents in the Project, Standard Size and References Used, Safety Standards Applied in the Project, Implementation of Quality Control in the Field and Duties and Responsibilities of Stakeholders. Of the five aspects, there are 25 factors that are already satisfactory in terms of implementation in the field, but there are still 5 factors that are further narrowed down to 4 factors that are considered unsatisfactory and can be an obstacle to achieving the quality and effectiveness of the storage tank construction project. Based on the results of the Preliminary Interview and Delphi Study confirmed through Round 1 and Round 2 activities, factors were obtained that inhibited the achievement of quality and effectiveness of the storage tank construction project. These factors are: The absence of a document hierarchy as a reference for work guidelines, The unavailability of standard documents, drawings and general references in each stage of work (for example, Basic design documents, shop drawings and incomplete field investigation data) and Lack of competence of Quality Control personnel (some personnel in the organization are inexperienced and less competent) [5]. In addition, there are several other factors that are considered obstacles, namely the Change order proposal approval process which takes time and has an impact on delivery time, Lack of performance and communication of local subcontractors which affects project performance, and Miscommunication between Management, the Quality Control team and the executor team in the field [3].

Based on the research results obtained, suggestions for both Project Owner and Contractors are Stakeholders are expected to discuss and agree to determine the document hierarchy and detail it for each stage of work during the project, companies are expected to update guidelines, standards and technical procedures related to storage tank construction projects and to create a checklist of implementations that have been carried out in the field regarding their suitability with the scope of work, and

The company can provide training and certification to critical personnel such as Quality control, Engineer, Safety officer, as well as assign them to other projects to increase their work experience [6].

As an action to improve quality and effectivity on storage tank construction project, there are several strategies should be implemented, there are : determine the implementation of a document hierarchy at the beginning of the project, which has been evaluated and approved by stakeholders; collect, complete, and create a checklist of standard documents, drawings, and other supporting data before project execution; select personnel within the project's organizational structure, primarily responsible for quality control, engineering, and safety officers; prioritizing certified personnel with experience in similar projects; and the last, improve communication patterns by holding joint meetings outside the project site without discussing technical issues to strengthen relationships.

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REFERENCES

[1] Jraisat, et al., *Quality in construction management: an exploratory study*, (2015)
[2] Ingason, *Best Project Management Practices in the Implementation ISO 9001 Quality Management System* (2014)
[3] Loushine, et al., *Quality and Safety Management in Construction,* (2007)
[4] Nowotarski, P., Szymanski, P. and Rzepecka, P., *DMAIC (Define Measure Analyze Improve Control) Method of Quality Improvement of Ground Work Process: Case Study*, (2002)
[5] Attarzadeh., *Project Management Practices: The Criteria for Success or Failure*, (2008).
[6] Jasim, N.A., *Diagnosing the Causes of Poor Quality Management in Iraqi Construction Projects Using Technique of Root Cause Analysis*, (2020)
[7] Choi, S.Y., Ok, S.M., Jeong, S.H., Ahn, Y.W., Jeon, H.M., Ju, H.M., *The Potential of Percent Agreement as an Adjunctive Diagnostic Tool for Acute Temporomandibular Disorder*, Pusan National University, Republic of Korea (2024)
[8] Barrios, M., Guilera, G., Nuno, L., and Benito, J.G., Consensus in Delphi Method: *What Makes a Decision Change*, University of Barcelona, Spanyol (2021)
[9] Dajani J.S., Sincoff, M.Z., and Talley, W.K., *Stability and Agreement Criteria for the Termination of Delphi Studies*, Technol Forecast Soc Change (2011)
[10] Boulkedid, R., Abdoul, H., Loustau, M., Sibony, O., and Alberti, C., *Using and Reporting the Delphi Method for Selecting Healthcare Quality indicators: a Systematic Review*, Plos One (2015)
[11] Legendre P., *Species Associations: The Kendall Coefficient of Concordance Revisited,* American Statistical Association and the International Biometric Society Journal of Agricultural, Biological, and Environmental Statistics, Volume 10, Number 2 (2005)
[12] Vernon, W., *The Delphi technique: a review*, International Journal of Therapy and Rehabilitation, Vol. 16 No. 2 (2013)