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Analysis of the Implementation of Tank Cleaning to Support Smooth Loading and Unloading

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ABSTRACT

Effective and efficient tank cleaning is essential in tanker operations to maintain cargo quality, ensure operational safety, and support the smooth loading and unloading of subsequent cargoes. Tank cleaning involves removing cargo residues and contaminants from ship tanks after the transportation of specific substances. This study aims to analyze the procedures for implementing effective and efficient tank cleaning aboard MT Bahari Maju II and identify factors that influence its successful implementation. The study employed a quantitative research approach, with data collected through observation and case studies. The collected data were used to examine tank cleaning procedures and the factors affecting their implementation. The findings provide guidance for ship crews in carrying out tank cleaning systematically and efficiently while improving their understanding of the factors that influence the process. The study highlights the importance of proper procedural implementation and operational awareness in achieving effective tank cleaning. Its practical contribution lies in providing operational guidance to support improvements in tank cleaning practices aboard MT Bahari Maju II. These findings are expected to help ship crews improve cleaning efficiency, maintain tank readiness for subsequent cargo operations, and support safer and more reliable tanker operations.

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1. INTRODUCTION

Tank cleaning is an essential operation on liquid cargo tankers because it prepares cargo tanks, pipelines, and associated equipment for the next cargo. Effective cleaning helps remove previous cargo residues, reduce the risk of cross-contamination, and maintain the quality of subsequent cargoes. Wu et al. (2023) explain that tank cleaning connects successive voyages and that its effectiveness is influenced by operational safety, cleaning performance, and the time required to complete the process. Therefore, tank cleaning must be planned and performed systematically to support the smooth loading and unloading of liquid cargoes.

In palm oil transportation, cargo preparation is particularly important when vessels carry crude palm oil (CPO), crude palm kernel oil (CPKO), or other palm oil derivatives. These products have different physical and chemical characteristics and may have specific requirements concerning temperature, cleanliness, and acceptable contamination levels. Residues from a previous cargo, remaining wash water, or foreign substances can affect cargo quality if the tank is not prepared according

to the requirements of the next cargo. Consequently, the required tank cleanliness should be determined by considering the previous cargo, the next cargo, the vessel's cargo-handling procedures, and the applicable cargo specifications.

Tank cleaning involves several interconnected activities, including planning, removal of remaining cargo, preparation of equipment, washing, removal of residual cleaning water, drying where required, ventilation or gas freeing when applicable, and inspection of the tank's condition. The exact sequence depends on the type of cargo, tank design, cleaning system, and safety requirements. Wu et al. (2023) review the factors affecting the safety and efficiency of tank cleaning on liquid cargo tankers, emphasizing that the process requires attention to both operational timing and the conditions necessary for effective cleaning. This means that tank cleaning performance should not be evaluated solely by the time taken but also by the cleanliness achieved and compliance with safety procedures.

The preparation stage is an important determinant of tank cleaning performance. Planning should identify the previous and next cargoes, required cleanliness standards, cleaning methods, personnel assignments, equipment, estimated duration, and relevant safety controls. Equipment such as tank-cleaning machines, pumps, hoses, ventilation equipment, gas detectors, and personal protective equipment should be inspected before work begins. Equipment failure or inadequate preparation can interrupt the cleaning process and extend the time needed to make the tank ready for loading. Accordingly, equipment readiness, preventive maintenance, and clear task allocation should be included in an evaluation of tank cleaning effectiveness.

Safety is another fundamental consideration because tank cleaning may expose personnel to toxic vapours, flammable atmospheres, oxygen deficiency, chemical hazards, and other operational risks. Şenol and Yaşlı (2021) developed a risk-analysis approach for chemical cargo tank cleaning using a Fuzzy Bayesian Network, demonstrating the usefulness of systematic risk assessment in identifying factors that may contribute to unsafe conditions. Dhani and Novitrie (2023) also examined safety risks during crude oil tank cleaning using the Task Risk Assessment method and identified personnel entry as a high-risk stage in their case study. These studies indicate that risk identification, assessment, and control should be incorporated into the tank cleaning plan rather than treated as separate activities.

The International Maritime Organization (IMO, 2025) adopted revised recommendations for entering enclosed spaces aboard ships through Resolution MSC.581(110). These recommendations emphasize systematic hazard identification, risk assessment, atmosphere testing, entry procedures, and emergency preparedness. The guidance is particularly relevant whenever tank cleaning involves entry into a cargo tank or another enclosed space. Personnel should not enter a tank until the required safety conditions have been verified and the appropriate authorization and safeguards are in place. The vessel's Safety Management System and applicable procedures should govern the operation.

Environmental protection must also be considered during tank cleaning. Residues and tank washings should be collected, retained, transferred, or discharged in accordance with the applicable requirements. The IMO's International Convention for the Prevention of Pollution from Ships

(MARPOL) establishes controls on ship-generated pollution, including provisions for oil and noxious liquid substances. The applicable requirements depend on the previous cargo, the relevant MARPOL annex, the vessel, and the circumstances of the operation. Therefore, disposal of tank washings or cargo residues must not be treated as an unrestricted step in the cleaning process.

In addition to safety and environmental compliance, time management is important because delays in tank cleaning can affect vessel schedules and the planned commencement of subsequent cargo operations. Inefficient cleaning methods, equipment problems, insufficient preparation, unclear task allocation, and repeated cleaning due to unsatisfactory inspection results may increase operational time. Wu et al. (2023) identify safety and timeliness as two important dimensions in evaluating tank cleaning operations. A practical evaluation should therefore consider preparation time, actual cleaning duration, equipment availability, inspection results, and the reasons for any interruption or repetition of work.

At the operational level, tank cleaning effectiveness depends on the coordination of the master, deck officers, crew members, and other personnel involved in cargo preparation. A clearly communicated work plan can help ensure that personnel understand their responsibilities, the required cleaning sequence, the equipment to be used, and the safety precautions that must be followed. Pre-operation briefings, checklists, supervision, and documentation of completed work can also help identify deviations from the planned procedure and support continuous improvement.

This study focuses on the implementation of tank cleaning to support smooth loading and unloading operations on MT. Bahari Maju II. The issues identified in the initial research framework include delays in completing tank cleaning, limited time, and work methods that may not be sufficiently efficient. These issues require further examination through observation, interviews, and shipboard documentation to establish their actual causes and operational effects.

Previous studies have examined tank cleaning safety, risk assessment, cleaning effectiveness, and operational timeliness. However, the factors affecting tank cleaning may differ according to vessel characteristics, cargo types, equipment condition, working procedures, and the availability of personnel. Therefore, a vessel-specific analysis is needed to understand how tank cleaning is implemented on MT. Bahari Maju II and how its execution affects readiness for subsequent loading operations.

Based on this background, this study aims to analyze the implementation of tank cleaning on MT. Bahari Maju II, identify the factors that cause delays or reduce operational effectiveness, and formulate recommendations to improve the process. The analysis focuses on preparation, execution, equipment readiness, safety compliance, cleaning results, and time management. The findings are expected to provide practical recommendations for improving tank cleaning procedures while maintaining cargo quality, personnel safety, environmental protection, and operational efficiency.

2. METHODS

This study employed a qualitative descriptive approach to examine the implementation of tank cleaning procedures aboard MT *BAHARI MAJU II* and their role in supporting safe and efficient cargo

loading and unloading operations. The qualitative approach was selected because the research focused on operational practices, crew experiences, and safety-related procedures that required direct observation and in-depth interpretation within the vessel's working environment.

Tank cleaning was defined in this study as the systematic process of removing cargo residues and other contaminants from a tank to achieve the cleanliness required for the subsequent cargo, in accordance with applicable procedures and safety requirements. The analysis focused on the implementation of cleaning procedures, the adequacy of preparation and equipment, compliance with established standard operating procedures (SOPs), and factors affecting the effectiveness of tank cleaning. Particular attention was given to the prevention of cargo contamination, the efficient use of time and resources, and the protection of crew members during cleaning operations.

The vessel was selected as the research setting because tank cleaning is an essential activity in preparing cargo tanks for subsequent loading operations. Data collection focused on the procedures implemented by the crew, the equipment and resources used, the challenges encountered during cleaning, and the measures adopted to ensure that the tanks met the required cleanliness standards.

The research informants consisted of crew members directly involved in or responsible for tank cleaning operations aboard MT *BAHARI MAJU II*. Potential informants included the Chief Officer, other deck officers, and crew members assigned to cleaning, inspection, or related safety duties, depending on their actual involvement in the operation.

Informants were selected using purposive sampling based on their responsibilities, experience, and knowledge of tank cleaning procedures. This technique was appropriate because the study required information from personnel with direct experience of the activities under investigation.

The research instruments consisted of an observation guide, an interview guide, and a documentation checklist. The observation guide was used to record the sequence of tank cleaning activities, preparation of equipment, implementation of cleaning procedures, and compliance with applicable safety requirements. The interview guide contained open-ended questions about the procedures followed, operational difficulties, cleaning effectiveness, time and resource constraints, and measures taken to prevent cargo contamination. The documentation checklist was used to review relevant SOPs, tank cleaning records, inspection reports, risk assessments, and other available vessel documents, subject to authorization.

The principal analytical focus was the implementation of tank cleaning procedures, examined through the following indicators:

1. Preparation and planning: Readiness of equipment, cleaning materials, personnel, and operational arrangements.
2. Procedural compliance: Implementation of cleaning steps in accordance with the vessel's SOPs and applicable requirements.
3. Cleaning effectiveness: Evidence that cargo residues and contaminants had been removed and that the tank met the cleanliness requirements for the intended subsequent cargo.

4. Time and resource utilization: Documented cleaning duration and use of labor, equipment, and cleaning materials, where records were available.
5. Cargo contamination prevention: Measures implemented to reduce the risk of residues or incompatible materials contaminating the next cargo.
6. Occupational safety: Implementation of applicable risk assessments, personal protective equipment requirements, ventilation, atmospheric testing, and enclosed-space entry controls, where relevant to the specific cleaning operation.

These indicators served as qualitative analytical guides rather than standardized numerical scales. The credibility of the findings was strengthened by comparing observations, interview responses, and documentary evidence. Formal validity or reliability tests should be reported only if they were actually performed.

Data were collected through direct observation, interviews, and documentation. First, direct observations were conducted to examine the tank cleaning process, including preparation, implementation of cleaning procedures, use of equipment, and compliance with applicable safety requirements. Observations were recorded systematically to identify operational practices and potential obstacles affecting cleaning effectiveness. Second, interviews were conducted with selected crew members to obtain detailed information about their responsibilities, the procedures followed, challenges encountered, and measures taken to achieve the required tank cleanliness. Open-ended questions allowed informants to explain their experiences and clarify issues identified during observation. Third, relevant documents were reviewed to support and verify the information obtained from observations and interviews. These documents included tank cleaning SOPs, cleaning records, inspection reports, risk assessments, and other available technical or operational documentation, where applicable and authorized.

Primary data consisted of information obtained through observations and interviews, while secondary data consisted of vessel records, technical documents, applicable safety requirements, and relevant literature. Information from these sources was organized and compared to identify consistencies, discrepancies, and potential areas for improvement.

All observations and data collection activities were conducted with the necessary authorization and in accordance with vessel safety procedures. The research did not require the researcher to undertake unsafe tank entry or interfere with cargo operations.

The data were analyzed using qualitative descriptive analysis based on the framework proposed by Miles, Huberman, and Saldaña (2014), comprising data condensation, data display, and conclusion drawing and verification. First, data condensation involved selecting, organizing, and coding relevant information from observation records, interview responses, and documents. The data were grouped according to themes such as preparation, procedural compliance, cleaning effectiveness, operational constraints, contamination prevention, and occupational safety. Second, data display involved organizing the findings into descriptive narratives, thematic summaries, or tables to illustrate how tank

cleaning was implemented and what factors influenced the process. Third, conclusion drawing and verification involved interpreting the identified patterns and comparing information from different data sources. The findings were evaluated against the vessel's applicable SOPs, available technical documentation, and relevant safety requirements. This process was used to identify procedural gaps, explain operational challenges, and formulate recommendations for improving tank cleaning practices.

The analysis aimed to determine how tank cleaning procedures were implemented, identify factors that affected their effectiveness, and assess how the documented practices supported cargo readiness, contamination prevention, and crew safety.

The study was conducted with due consideration for participant confidentiality, vessel operational safety, and the protection of confidential information. Permission to conduct observations and access relevant vessel documents was obtained from the authorized vessel or company representative, where required. Informants were informed about the purpose of the research, and informed consent was obtained before interviews.

Participants' identities and confidential operational information were protected in the research report unless explicit authorization for disclosure had been provided. Photographs, internal records, tank cleaning documents, and other non-public materials were included only where the necessary permission had been obtained. Institutional ethics committee approval was obtained where required by the applicable institutional policy. If applicable, the committee's name and approval number should be provided in the final manuscript.

3. RESULTS AND DISCUSSION

3.1. The Research Results

a. Lack of ability and insight of the Crew in carrying out tank cleaning activities.

The initial process of tanker loading operations begins with the preparation of the loading chamber (tank *cleaning*) which is very crucial. Especially for sensitive cargoes such as CPKO used in the production of cooking oil, the cleanliness and integrity of the loading space must be strictly maintained. Contamination by other cargoes or water can cause severe damage to the CPKO, changing its content and quality. Therefore, a professional and experienced workforce is needed to carry out tank preparation, supported by a skilled crew.

In charter ship operations, time efficiency is essential. Careful planning, in-depth knowledge of the ship, and crew skills are key factors in maximizing limited time. The entire process must be carried out with attention to the safety aspects of the ship and the entire crew.

Load damage during the loading process can be caused by a variety of factors, among other things.

1) There are indications of procedural errors in the arrangement of the loading space that lead to contamination of the cargo by foreign substances or other cargoes.
2) Due to the suboptimal tank cleaning process, there are still remnants of the previous load left behind.

3) There was a leak in the cargo storage tank. The researcher's analysis showed that the cargo damage that occurred was caused by a combination of the limited time factor and the lack of competence of the ship's crew. The short time pressure to carry out the tank cleaning, as well as the lack of technical skills and knowledge among the crew, has created sub-ideal conditions. As a result, the cleaning process is not carried out optimally, thus causing damage to the cargo.
4) Lack of information. Although the number of deck personnel on tankers is adequate, there is a gap in the mastery of technical knowledge related to their work. One example is the lack of understanding of optimal and standard tank cleaning methods. This can hinder the operational efficiency of the ship, especially when there is a time limit due to the lease contract. Generally, preparations for tank cleaning only begin after the ship officer receives information about the cargo to be transported. Furthermore, Mualim I will give orders to the bosun or other crew members to carry out the task based on the established procedures.

b. Less time interval in the tank cleaning process

The tank *cleaning* process ideally requires sufficient time to achieve optimal results. However, in this voyage, time constraints are the main challenge. The relatively short sailing schedule, which is about 2 days and 12 hours from the unloading port to the loading port, severely limits the duration of cleaning.

With the CPKO loading plan on four tanks, each tank takes about 4 hours to be thoroughly cleaned. Thus, the total time required to clean the four tanks is about 16 hours. It is clear to see that the available time allocation is very limited compared to the actual needs.

In addition to time constraints, the presence of a new crew in the helm position also complicates the situation. Helmsman 1, who has just joined the tanker and previously had experience on a container ship, as well as helmsmen 2 and 3 who have no experience in a tanker at all, need time to adapt to understand the procedures and techniques of tank cleaning. This is of course an additional burden in an effort to achieve a good and timely cleaning target.

Based on the experience of sea practice on the MT. BAHARI MAJU II, the researcher concluded that the allocation of time allocated for the implementation of tank cleaning still needs to be evaluated. The optimal tank cleaning process requires sufficient time to ensure that the entire tank surface is thoroughly cleaned. Unfortunately, in the existing conditions, time constraints are the main inhibiting factor in achieving maximum cleaning results.

3.2. Discussion

In this study, the author conducted an interview conducted at MT. Bahari Maju II about how *the tank cleaning* procedure on the ship, the author made the results of the interview to see *the crew deck*'s understanding of the effective and efficient *tank cleaning* procedure as follows:

Interview with *chief officer*, Muhammad Basri, what is the main purpose of *tank cleaning* on the ship?

The chief officer said that it was to clean the tank of the old remaining load, to prepare the tank for the new load, and to prevent corrosion of the tank.

Interview with *chief officer*, Muhammad Basri, what is the *most common method of tank cleaning* on ships?

The chief officer said that *the tank cleaning* methods used on the ship are *Dry cleaning*, *Wet cleaning*, *Chemical cleaning* and a combination of two or more methods.

Interview with *the second officer*, Aswandi, what are the main tools used to spray water or cleaning chemicals into the tank during *tank cleaning*?

The second officer said that the tools used to spray water/cleaning chemicals into the tank were *Hose, Nozzle*, and Pump.

Interview with Driver I Jufri is what is the main personal protective equipment to use during *tank cleaning*?

Driver I said that the tools that must be used are respiratory masks, protective goggles, and gloves

Interview with Driver II Achmad Fahrul is who is responsible for ensuring that *tank cleaning* is carried out safely and according to procedures?

Helmsman II said that those responsible for safe and procedural tank cleaning are the ship's Captain, *Chief Officer* (CO), and *Chief Engineer* (CE)

Interview with driver III Andi Achmad Dhani is who is authorized to give permission to close the air and ventilation vents after *the tank cleaning* is completed?

Helmsman III said that the authority to give permission to close the air and ventilation holes is the Port Authority that gives the permit.

Preparation of the loading space is a crucial step in ensuring the smooth operation of the ship, especially in terms of loading and unloading of cargo. However, various technical and operational obstacles often hinder the smooth running of the process. Thus, this study seeks to identify and evaluate various alternative solutions that can be applied to overcome problems that arise during the loading room preparation process, so as to increase the efficiency and effectiveness of ship operations.

a. Improved deck crew performance in tank cleaning tasks

Tank cleaning procedures require close supervision from a deck officer to ensure that all safety measures and established cleaning procedures are followed. Without effective supervision, there is a potential risk of cargo contamination due to debris such as sand or rust left in the tank, especially in the *bellmouth* section. To prevent this, the Mualim should periodically conduct direct inspections into the tank, especially if the crew does not have sufficient experience in carrying out this task.

b. Increasing the active role of Mualim I in closely supervising the process of cleaning the ship's tank.

In general, ship officers, especially Mualim I who is assisted by other Mualim, play the role of direct leaders in the implementation of duties on deck. In addition to facilitating harmonious cooperation between the crew, the officer is also responsible for directly supervising the performance of all crew members. In this context, the officer is considered the party who best understands all the technical

aspects of the ship. This supervisory task, while crucial, is also complex considering the human nature that is sometimes resistant to criticism and suggestions. In fact, constructive feedback is essential to improve the competence and professionalism of the crew. Based on the terms of the task, the First Mualim plays an important role in supervising the ship's cargo and the entire process of preparing the cargo tank. As a responsible officer, the First Mualim is required to cooperate effectively with *the Bosun*, the Helmsman, and the Cadets in ensuring smooth operations. Good cooperation practices are necessary, especially in a limited work environment such as on a ship. One concrete example is in the implementation of the cleaning of the cargo tank. The First Mualim must be actively involved in every stage of the process, including conducting direct inspections to the work site to ensure that all safety and quality standards are met. Thus, the risk of errors such as the discovery of water residues in the cargo suction tank can be minimized. Through solid cooperation, all crew members can contribute optimally to achieving the common goal, which is to maintain the cleanliness and safety of the ship.

c. Finding skilled personnel

Shipping companies have a crucial role to play in improving the competency of the onboard workforce through a rigorous selection process. Effective selection will result in qualified crew members, particularly in terms of analytical thinking abilities and technical skills relevant to onboard tasks.

To illustrate, the incident that occurred on board the MT. BAHARI MAJU II shows the importance of careful selection. When a helmsman fails to fully open the faucet on the manifold, resulting in unstable pump pressure during the loading and unloading process, this indicates a lack of adequate discipline and competence. The incident underscores the importance of better selection to ensure that all crew members, especially deck crew, are qualified to meet company standards.

In order to achieve optimal ship operational efficiency, companies are advised to place deck crews who have high competence. This is a key factor in supporting the smooth running of all activities on board.

4. CONCLUSION AND RECOMMENDATIONS

This study concludes that the tank cleaning process on board MT. BAHARI MAJU II requires improvement to ensure that cleaning activities are carried out effectively and efficiently. Limited time for tank cleaning and the potential for unexpected operational difficulties may hinder the completion of cleaning procedures and contribute to delays in loading and unloading operations. These findings highlight the importance of proper planning, adherence to established procedures, and effective coordination among deck crew members to achieve the required tank cleanliness within the available time without compromising safety or operational standards.

To improve tank cleaning performance, the deck crew should conduct regular pre-operation meetings to review cleaning procedures, clarify individual responsibilities, assess operational risks, and establish realistic time schedules before commencing the work. The crew should also prioritize

compliance with safety requirements and cleaning standards rather than focusing solely on completing the task quickly. This study is limited to the operational conditions examined on MT. BAHARI MAJU II; therefore, the findings may not be directly generalizable to other vessels with different cargo types, equipment, and operating conditions. Future research should examine tank cleaning practices across multiple vessels and investigate how planning, crew competence, equipment condition, and time management influence cleaning effectiveness, operational efficiency, and loading and unloading delays.

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