eISSN: 2721-5717; pISSN: 2747-2124 https://journal.unhas.ac.id/index.php/zonalaut

ZONA LAUT

JURNAL INOVASI SAINS DAN TEKNOLOGI KELAUTAN

Analysis of Cargo Tank Preparation and Inspection to Support the Smooth Operation of Cargo Loading and Unloading on MT Dian Dina

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Abstract

The loading tanks is the main component of a tanker that must be properly prepared and thoroughly inspected before loading and unloading operations. Inadequate attention during these stages may cause residues, rags, or waste materials to remain inside the tank, obstruct cargo flow, and result in operational delays. This study aims to analyze the loading tank preparation process, the implementation of tank inspections, and the obstacles that affect the smooth operation of loading and unloading activities on MT. Dian Dina. This research employed a descriptive qualitative method. Data were collected through direct observation, interviews with the First Officer, Bosun, and Able Seaman, documentation, and literature studies. The data were analyzed through data collection, condensation, presentation, and conclusion drawing stages, while data validity was tested using source, technique, and time triangulation. The results showed that the loading tank preparation was carried out in accordance with the company's Standard Operating Procedure (SOP), including work planning, work team formation, tank ventilation, gas freeing, tank cleaning, drying, tank condition inspection, and inspection of cargo handling systems consisting of cargo lines, cargo pumps, valves, manifolds, and cargo pump filters. However, the final inspection was not fully optimal because rags and waste materials were still found in the bottom areas and corners of the tank that were difficult to access. These foreign materials were carried by the cargo flow and caused blockage of the cargo pump filter, resulting in delays during loading and unloading operations. Improvement efforts were carried out through multi-level inspections, recording and controlling work equipment, increasing supervision during tank cleaning activities, and conducting evaluations after completion. The implementation of these measures is important to ensure tank cleanliness and readiness while minimizing the risk of operational disruptions.

Keywords: loading tank preparation, loading tank inspection, loading and unloading operations.

1. INTRODUCTION

Tankers are among the principal components of the global maritime transportation system, playing a vital role in the distribution of liquid cargoes, including vegetable oils and their derivatives. The transportation of liquid cargoes by tanker requires a high level of precision, particularly during the cargo preparation stage, as errors at this stage may result in cargo contamination, operational delays, and occupational safety risks [1]. One of the critical stages in preparing a tanker for cargo operations is tank cleaning [1].

During vessel preparation prior to loading, particularly in relation to cargo tanks, various operational challenges may arise. These challenges become especially significant when tanks are intended for the carriage of specialized cargoes that must not be mixed with or contaminated by other substances or cargo residues. In liquid cargo transportation, dedicated compartments known as cargo tanks are required to accommodate the cargo. When cargo tanks are properly designed, prepared, and maintained, cargo transportation operations can be conducted more smoothly [2]. This is essential to ensure that the cargo remains safe and maintains its quality throughout storage and transportation within the tanks (Meliana, 2025).

Cargo tanks or cargo spaces must be in a suitable condition before they can be used to carry a particular type of cargo [4]. If the tanks are not ready, loading operations may be delayed. Following the discharge of the previous cargo, residual dirt, sludge, debris, and odours may remain inside the tanks. These residues may

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also contribute to cargo line blockages during subsequent discharge operations. Therefore, thorough tank cleaning and preparation are essential before loading begins. If the tanks are not adequately cleaned, they may fail the pre-loading inspection, preventing loading operations from commencing as scheduled [1].

Tank cleaning on tankers involves several stages, including stripping, washing using a Butterworth machine, rinsing, and drying, to ensure that no residual contaminants remain inside the tanks (Meliana, 2025). However, several factors may reduce the effectiveness of this process, including poorly maintained equipment, the selection of cleaning methods that are unsuitable for the characteristics of the previous cargo, and inadequate supervision by the vessel's crew [5], [6]. Environmental factors, such as low temperatures, may also affect cleaning effectiveness, particularly when the previous cargo has a high viscosity and is therefore difficult to remove [7]. Consequently, selecting an appropriate tank-cleaning method based on the characteristics of the previous cargo is essential to ensure that the tanks are sufficiently clean and ready for subsequent loading operations [8].

Accordingly, improvements are required through the consistent implementation of cargo tank preparation and inspection procedures in accordance with applicable standards [9]. These measures include enhancing crew members' understanding of standard operating procedures (SOPs), conducting comprehensive cargo tank inspections, and strengthening supervision at every stage of pre-loading preparation [10]. The implementation of appropriate procedures in accordance with applicable safety standards is expected to support smooth, safe, and efficient cargo handling operations at Gresik Port. Tank cleaning must only be carried out after the relevant conditions have been confirmed to be safe. The tank manholes are opened, and ventilation is operated for the prescribed period. Personnel entering the tank must wear complete personal protective equipment (PPE), while designated crew members remain on standby outside the tank to monitor the operation and maintain safety oversight. The cleaning process involves removing sludge and sediment manually or by using pumps, followed by cleaning the tank walls and floor with water, cleaning chemicals, or high-pressure washers, as required [11]. Gas measurements are conducted periodically throughout the operation to ensure that conditions remain safe. Once cleaning is completed, the tanks are rinsed thoroughly and dried naturally or with the assistance of blowers. A visual inspection is then performed to verify that no visible dirt or contaminants remain. A final gas test is conducted before the tanks are closed. After all activities have been completed and the area has been declared safe, the manholes are closed, the isolation arrangements are removed in accordance with the applicable procedures, and the permit for tank entry is formally closed. All activities are subsequently documented in a tank-cleaning report [12]. All waste generated during the cleaning process must be managed and disposed of in accordance with applicable environmental procedures [10].

Previous studies have demonstrated that cargo tank preparation plays an important role in ensuring the smooth execution of cargo handling operations on tankers. Earlier research has generally examined the factors contributing to cargo tank unpreparedness, the implementation of tank-cleaning procedures to prevent cargo contamination, and the readiness of cargo-handling equipment in relation to tanker operational efficiency. The findings indicate that inadequate tank preparation, non-compliance with tank-cleaning procedures, and insufficient technical readiness of cargo-handling equipment can adversely affect the continuity of cargo operations. These conditions may lead to operational delays, increased handling time, and potential safety risks during loading and unloading activities. Nevertheless, previous studies have predominantly focused on the causes of operational disruptions and the technical readiness of cargo-handling equipment. In contrast, the present study focuses on measures for preparing and inspecting cargo tanks before cargo handling operations to promote operational efficiency on board tankers. It also emphasizes a comprehensive evaluation of tank preparation, encompassing tank cleaning, tank inspection, and occupational safety supervision throughout cargo handling activities. This approach highlights the importance of systematic preparation and inspection procedures in minimizing operational disruptions and maintaining safe cargo-handling conditions.

Thus, the successful handling of liquid cargoes on tankers depends not only on the physical readiness of cargo tanks but also on the integrated implementation of safety management practices, regulatory compliance, crew competence, and appropriate technological applications. These elements must function cohesively to enable tanker operations to be conducted effectively, efficiently, and safely. Proper coordination among crew members and consistent adherence to operational procedures are also essential for maintaining the reliability of cargo-handling activities. Therefore, an investigation into cargo tank preparation and inspection before loading is essential. This study examines these aspects on board MT Dian Dina. The investigation is expected to provide practical insights into improving cargo tank readiness and supporting more efficient cargo-handling operations. Accordingly, the authors propose the research title: “Cargo Tank Preparation and Inspection to Support Efficient Cargo Handling Operations on Board MT Dian Dina.”

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2. METHODS

2.1. Research Design

This study employed a descriptive qualitative research method. According to Sugiyono (2022), qualitative research is conducted in natural settings (natural settings) and relies on descriptive information, narratives, and words as its primary sources of data. This approach emphasizes an in-depth and comprehensive understanding of a particular phenomenon [13]. It is used to investigate problems based on actual conditions in the field without manipulating the research object [14].

In this study, a descriptive qualitative approach was employed to describe and analyze cargo tank preparation and inspection procedures in supporting the smooth operation of cargo loading and unloading aboard MT Dian Dina. This approach enabled the researcher to obtain in-depth information regarding the implementation of cargo tank preparation procedures, the roles of crew members in the inspection process, and the operational challenges encountered during vessel operations.

2.2. Research Object and Data Sources

The object of this study was the process of cargo tank preparation and inspection aboard the tanker MT Dian Dina. The research was conducted from 11 May 2025 to 11 July 2025 through direct observation of tank-cleaning activities, gas freeing, tank condition inspections, gas concentration measurements, and cargo discharge operations aboard MT Dian Dina.

The research data consisted of primary and secondary data. Primary data were obtained directly from the research setting through observations and interviews with crew members involved in cargo tank preparation and inspection. The informants included the Chief Officer, pumpman, boatswain (bosun), Able Seafarers, and other crew members involved in these activities.

Secondary data were obtained from supporting sources, including reference books, scientific journals, previous research articles, vessel documents, tank-cleaning records, cargo operation manuals, and standard operating procedures (SOPs) relevant to cargo tank preparation and inspection. According to Sulung and Muspawi (2024), research data sources can be classified into primary and secondary data, both of which support the research process [15].

2.3. Data Collection Techniques

Data were collected through interviews, direct observation, documentation, and a literature review. According to Priatna et al. (2025), qualitative data collection involves in-depth and contextual approaches using multiple methods to enable researchers to develop a comprehensive understanding of the phenomenon under investigation [16].

Semi-structured interviews were conducted directly with informants involved in cargo tank preparation and inspection aboard MT Dian Dina. The interviews aimed to obtain information regarding the implementation of tank-cleaning procedures, tank inspection protocols, challenges encountered during cargo operations, and the measures taken by crew members to maintain smooth vessel operations.

Direct observations were conducted to examine cargo tank preparation and inspection activities, including tank cleaning, gas freeing, gas concentration measurements using gas detectors, tank condition inspections, the use of personal protective equipment (PPE), and cargo discharge operations.

Documentation was used to obtain supporting evidence in the form of tank inspection checklists, cargo operation manuals, tank-cleaning records, SOPs, photographs of operational activities, and vessel operational archives.

Meanwhile, the literature review involved examining relevant sources, including tanker operation textbooks, scientific journals, regulations issued by the International Maritime Organization (IMO), and the *International Safety Guide for Oil Tankers and Terminals* (ISGOTT). These sources were used to support the analysis of cargo tank preparation and inspection procedures and their relationship with the smooth execution of cargo operations.

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2.4. Data Analysis Techniques

The data were analyzed using a descriptive qualitative approach. Information obtained from interviews, observations, and documentation was examined in depth to develop an understanding of cargo tank preparation and inspection procedures and their contribution to the smooth operation of cargo loading and unloading aboard MT Dian Dina.

According to Miles and Huberman (2014), qualitative data analysis involves four stages: data collection, data condensation, data display, and conclusion drawing and verification [17].

During the data collection stage, information was gathered through observations, interviews, and documentation. Data condensation was subsequently conducted by selecting, focusing, and organizing information relevant to the research objectives. The selected data were then presented in a descriptive narrative format to facilitate systematic analysis and interpretation.

The final stage involved drawing conclusions based on the findings obtained from the data analysis. These conclusions were verified by comparing information from different data sources to assess the consistency and credibility of the findings.

2.5. Data Trustworthiness

Data trustworthiness was established to ensure that the information obtained in this study accurately reflected the actual conditions encountered in the field. Triangulation was employed to assess the credibility of the research findings. According to Sugiyono (2022), triangulation is a technique for examining the validity of qualitative research data through the use of multiple sources, data collection techniques, and collection times [13].

Source triangulation was conducted by comparing interview findings from the Chief Officer, pumpman, bosun, and other crew members with vessel documents, including tank-cleaning records, cargo operation manuals, and SOPs.

Methodological triangulation was performed by comparing findings obtained through direct observation, interviews, and documentation. Time triangulation was conducted by collecting data at different times during vessel operations to assess the consistency of the information obtained and determine whether the findings remained consistent across different operational periods.

3. RESULTS AND DISCUSSION

3.1. Cargo Tank Preparation Process Prior to Cargo Operations on MT Dian Dina

Based on observations conducted during the research aboard MT Dian Dina, cargo tank preparation prior to cargo operations was carried out in accordance with the company's Standard Operating Procedures (SOPs). The preparation process began with the development of a work plan by the Chief Officer, the formation of work teams, tank ventilation, gas freeing, tank cleaning, tank drying, tank condition inspection, and the inspection of cargo-handling systems. These stages were performed sequentially to ensure that the tanks were clean, dry, safe, and ready for cargo discharge operations. The observations indicated that each crew member performed their assigned duties in accordance with the established division of responsibilities and implemented occupational safety procedures throughout the activities.

Cargo tank preparation was intended not only to remove residues from previous cargoes but also to ensure that all supporting systems, including cargo lines, cargo pumps, valves, and manifolds, were in good working condition so that cargo operations could proceed without disruption. This procedure is fundamentally consistent with the guidance provided in the *International Safety Guide for Oil Tankers and Terminals* (ISGOTT), which emphasizes the importance of appropriate tank conditions before loading, particularly when the previous cargo differs in type or may cause contamination. ISGOTT also emphasizes gas testing and visual inspection as essential measures for preventing fire, explosion, and cargo contamination incidents. The research documentation showed that tank cleaning was conducted thoroughly, covering the tank bottoms, walls, and internal structures, which are areas where residues and foreign objects may remain. After cleaning was completed, the tanks were dried to prevent residual water from compromising the quality of the subsequent cargo [18].

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Figure 1. Tank-Cleaning Process Prior to Cargo Operations
Source: MT Dian Dina Documentation (2026)

Figure 1 shows crew members performing cleaning activities inside a cargo tank. The work focused on the tank bottom and internal structures because these areas are particularly susceptible to the accumulation of residues and foreign objects.

Interviews with the Chief Officer, bosun, and Able Seafarer indicated that the preparation stages were carried out in accordance with the company's SOPs. The Chief Officer explained that each stage was directly supervised to ensure that the tanks met the required cleanliness standards. The bosun added that re-inspections were routinely conducted after tank cleaning, while the Able Seafarer stated that all work was performed using personal protective equipment in accordance with occupational safety procedures. The consistency of information obtained from the three informants indicates that the tank preparation process was conducted systematically and in a coordinated manner.

These findings are consistent with the study by Andromeda and Ramadhan (2021), which emphasized that cargo tank readiness is influenced by the adequacy of work procedures, personnel coordination, and equipment condition. Therefore, cargo tank preparation aboard MT Dian Dina had covered the operational stages required before cargo discharge operations.

3.2. Challenges in Cargo Tank Preparation and Inspection on MT Dian Dina

Based on field observations, the main challenge identified during cargo tank preparation was the presence of residual cleaning rags and waste at the bottom of the tanks after the tank-cleaning process had been completed. This condition indicates that although the prescribed cleaning stages had been performed, the final inspection had not fully ensured the removal of all foreign objects from the tanks. These findings were particularly evident at the tank bottoms and corners, where limited accessibility made cleaning more difficult and allowed some foreign objects to remain. This condition is inconsistent with the principles of ISGOTT and the relevant IMO requirements, which emphasize that cargo tanks must be free not only from chemical residues but also from physical contaminants and foreign objects. The presence of cleaning rags and waste indicates deficiencies in housekeeping and tank-entry practices, potentially creating sources of cargo contamination and, under certain circumstances, ignition hazards if friction occurs against the steel tank structure.

The interview findings further supported these observations. The Chief Officer explained that a previous blockage of the cargo pump filter had been caused by cleaning rags carried along with the cargo flow during discharge operations. The bosun stated that the main reason cleaning rags remained in the tanks was that certain areas of the tank bottoms and corners were difficult to reach during cleaning. In addition, limited working time and weather conditions affected the effectiveness of tank-cleaning activities. The Able Seafarer added that whenever foreign objects were discovered during inspection, the cleaning process was repeated until the tanks were considered sufficiently clean. The triangulation results demonstrated consistency among the observations, documentation, and interviews. All three data sources indicated that the primary cause of the

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problem was not non-compliance with the SOPs themselves, but rather the insufficient effectiveness of the final tank inspection. Accordingly, the main issue concerned the verification of tank cleanliness before the tanks were declared ready for use.

These findings are consistent with the study by Magdalena et al. (2024), which explained that inadequate final inspections may result in tanks being declared ready despite the presence of residual substances or foreign objects [1]. Therefore, the final inspection stage is critical to ensuring the smooth execution of cargo discharge operations.

3.3. Measures to Address Challenges in Cargo Tank Preparation and Inspection on MT Dian Dina

Based on the observations, interviews, and research documentation, several measures were implemented by the crew to address challenges associated with cargo tank preparation and inspection. The first measure involved conducting a comprehensive re-inspection after tank cleaning had been completed. The inspection covered the tank bottoms, corners, walls, and internal structures to ensure that no cleaning rags, waste, or residues remained that could interfere with cargo discharge operations.

The second measure involved improving coordination among the Chief Officer, bosun, and Able Seafarer throughout the work process. Before work commenced, briefings were conducted to clarify task assignments, the use of personal protective equipment, potential hazards, and occupational safety procedures. After the work was completed, a joint evaluation was conducted to verify that all stages had been performed in accordance with the company's SOPs. The interview findings indicated that this coordination helped reduce the likelihood of errors during cargo tank preparation.

Another measure involved implementing a layered inspection system. Under this system, the Able Seafarer conducted the initial inspection as the person performing the work, the bosun carried out the second inspection as the work coordinator, and the Chief Officer performed the final verification as the person responsible for the operation. This approach is consistent with the concept of multiple barriers in safety management, as reflected in the guidance provided by ISGOTT and the International Maritime Organization (IMO) through the International Safety Management (ISM) Code, which emphasizes the importance of verification procedures at multiple levels to prevent human error. In addition, recording the number of cleaning rags and tools brought into the tanks is necessary to ensure that no foreign objects remain after the work has been completed.

The research findings indicate that enhanced supervision, greater attention to final inspections, and routine evaluations following cargo operations are important measures for preventing the recurrence of cargo pump blockages caused by foreign objects. These findings are consistent with the study by Andromeda and Ramadhan (2021), which emphasized that successful cargo tank preparation depends substantially on procedural discipline, supervision, and coordination among crew members. Therefore, implementing more rigorous final inspections is expected to improve the continuity of cargo discharge operations and minimize the risk of operational disruptions aboard MT Dian Dina.

4. CONCLUSION

Based on the findings of this study on cargo tank preparation and inspection to support the smooth operation of cargo loading and unloading aboard MT Dian Dina, it can be concluded that cargo tank preparation was conducted in accordance with the company's Standard Operating Procedures (SOPs). The process included work planning, the formation of work teams, tank ventilation, gas freeing, tank cleaning, tank drying, tank condition inspection, and the inspection of supporting cargo-handling systems, including cargo lines, cargo pumps, valves, manifolds, and cargo pump filters.

However, the final inspection process requires further improvement because cleaning rags and waste were found at the bottoms and in the corners of the tanks, where access is more difficult. These foreign objects may be carried along with the cargo flow and cause blockages in cargo pump filters, thereby disrupting cargo operations. Consequently, improvements are required in the implementation of layered inspections by crew members, supervision throughout the tank-cleaning process, control over the use of cleaning rags and work equipment, and post-operation evaluations to ensure that the tanks are thoroughly clean and ready for use.

The implementation of these measures is expected to minimize the risk of operational disruptions and support safer, more effective, and smoother cargo operations. Furthermore, the vessel's management and the shipping company are advised to conduct periodic evaluations of cargo tank preparation and inspection procedures by strengthening supervision systems, providing crew training and guidance on tank-cleaning

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procedures and tank inspections, and improving inspection checklists to ensure that the tanks are adequately prepared before cargo operations commence.

Future research could examine other factors affecting the smooth operation of tankers, including cargo-handling equipment readiness, human resource factors, and the implementation of occupational safety practices.

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