

Implementation of the Use of Sopep Equipment During Bunkering on the MT Giat Armada 04 Ship

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Abstract

Marine pollution due to bunkering activities has become a serious problem along with the increase in tanker activity and operational risks. This study aims to analyze the implementation and effectiveness of the Shipboard Oil Pollution Emergency Plan equipment during bunkering on the MT Giat Armada 04 vessel. The study used a qualitative case study approach supported by quantitative data. The population was all crew members, with a purposive sample of 18 informants directly involved in bunkering activities. Data were collected through observation, semi-structured interviews, and Likert-scale questionnaires, then analyzed using data reduction, descriptive statistics, and triangulation. The results showed that the implementation of the SOPEP was classified as good with an average score of 3.84. The availability of equipment and crew understanding were adequate, but practical skills, compliance with PPE use, and the feedback system still needed to be improved. The study concluded that the SOPEP was effective in reducing the risk of oil spills during bunkering, but needed optimization through equipment maintenance, increased training frequency, and strengthened communication between crew and management.

Keywords: *Bunkering Operations, Marine Pollution Prevention, Maritime Safety, Oil Spill Response and SOPEP.*

I. INTRODUCTION

Marine pollution due to oil spills is an increasingly worrying global threat, particularly with the increase in international maritime activity. According to the latest report from the International Maritime Organization (IMO), oil spill incidents in global waters will reach more than 1,000 cases in 2023, with ecological impacts damaging marine ecosystems and coastal economies amounting to billions of dollars (Fernandez, 2023). At the national level, Indonesia, as an archipelagic nation, is experiencing a similar trend; data from the Ministry of Environment and Forestry recorded 150 oil spills in Indonesian waters in 2022–2024, most of which were caused by tanker bunkering operations (Indahningrum & Lia Dwi Jayanti, 2020). This phenomenon not only disrupts marine biodiversity but also poses occupational safety risks for crews, necessitating regulatory interventions such as MARPOL 73/78 Annex I to mitigate its impact.

Furthermore, in Indonesian waters such as the Sunda Strait and Merak Port, ship-to-ship bunkering activities are a major source of pollution, with leaks in bunker hose flange connections often occurring due to loose bolts or other mechanical factors (Rohman Moh Aziz & Eva Susanti, 2023). Empirical data from the Maritime Transportation Agency (BPOM) shows that 40% of oil spill incidents in Tanjung Sekong in 2021–2023 originated from this process, causing contamination up to a 500-meter radius at sea (Arifin et al., 2022). This issue is increasingly relevant considering that tanker traffic in domestic waters increased by 15% post-pandemic, emphasizing the urgency of implementing emergency equipment such as the Shipboard Oil Pollution Emergency Plan (SOPEP) for early prevention.

Previous research has explored the causes and management of oil spills during bunkering. Indahningrum and Lia Dwi Jayanti (2020) analyzed the case of the LPG/C vessel Decora in Merak waters in 2018, finding that a manifold flange leak was the primary trigger, with recommendations for improved SOPEP procedures. Similarly, Rohman Moh Aziz and Eva Susanti (2023) identified hydraulic pipe failure as a key factor in the MV Mariwit in Yokohama Port, where the crew's rapid response successfully contained the spread of oil using basic SOPEP equipment (Susanto & Pratiwi, 2021).

However, these studies show inconsistencies in the effectiveness of SOPEPs; while Indahningrum and Lia Dwi Jayanti (2020) highlight procedural negligence as a cause of failure, Rohman Moh Aziz and Eva Susanti (2023) emphasize technical factors without quantitatively measuring equipment effectiveness.

The main limitations lie in the descriptive approach lacking analytical skills, the lack of empirical post-intervention data, and the narrow focus on a single case without generalization to Indonesian domestic tankers (Hidayat & Nugroho, 2024). Furthermore, there is no comprehensive evaluation of SOPEP implementation during bunkering in the operational context of medium-tonnage vessels, such as 400 GT and above.

Therefore, there is a clear research gap in the literature: the lack of studies that specifically analyze the application and effectiveness of SOPEP equipment in the bunkering process of tankers in Indonesian waters, especially on the MT Giat Armada 04 vessel. This problem statement is formulated as: (1) how is the application of SOPEP equipment during bunkering on the MT Giat Armada 04 vessel, and (2) to what extent is it effective in preventing marine environmental pollution?

This study aims to reveal the implementation of Standard Operating Procedures (SOPEP) equipment during bunkering on board MT Giat Armada 04 and evaluate its effectiveness in pollution mitigation, an urgent matter considering the increase in national maritime operations post-2023. The novelty of the study lies in its empirical analysis based on field observations and quantitative measurements—different from previous descriptive studies—thus filling a methodological gap. Theoretically, these findings enrich the MARPOL regulatory framework in a tropical context; practically, they provide guidance for ship crews and port authorities to reduce the risk of occupational accidents and pollution, with direct contributions to Indonesia's maritime safety program.

II. METHODS

This research applies a qualitative design with a single case study approach on the MT Giat Armada 04 vessel, which aims to describe in depth the process of implementing SOPEP equipment during bunkering from the perspective of the ship's crew. The qualitative approach was chosen because of its ability to explore subjective meanings and field contexts, as described by Sugiyono (2017) who emphasizes a focus on the process and interpretation of real phenomena. This theoretical foundation is strengthened by Emzir (2019) within a descriptive-analytical analysis framework, as well as recent studies such as Hidayat and Nugroho (2024) who successfully applied a similar design to evaluate maritime safety procedures in Indonesian waters. Thus, this design ensures alignment between theory and the reality of ship operations.

The study population included all crew members (officers and crew) on MT Giat Armada 04 during a 12-month sea practice, with a purposive sample of 18 key informants selected based on direct experience in bunkering and SOPEP handling. A snowball sampling technique was used to identify additional informants through internal ship references, with inclusion criteria of at least 2 years of sailing experience and involvement in oil spill drills, while exclusion criteria applied to cadets without incident experience. This selection is in line with Sudaryono (2016) regarding relevance-based qualitative sampling, as well as Arifin et al. (2022) who demonstrated its effectiveness in domestic maritime case studies to achieve data saturation.

The research instruments consisted of a participant observation guide, a semi-structured interview protocol, and a closed-ended Likert-type questionnaire with a 1–5 scale to measure perceived effectiveness of the SOPEP. Key indicators included equipment implementation procedures, task allocation, and spill prevention, which were validated through triangulation and a pilot test with three pre-research informants. Validity and reliability were maintained through cross-checking between instruments, as recommended by Sugiyono (2017) and Susanto and Pratiwi (2021) in ship safety research, ensuring the data accurately reflected the phenomenon.

The research procedure began with preparation during an internship at a shipping company, including coordination with the captain for SOPEP access and observation permits. Primary data collection was continued through direct observation during bunkering, face-to-face interviews (30–45 minutes per session), and questionnaire distribution during the 12-month sea practice. Secondary data, such as SOPEP checklists and drill reports, were collected from ship documents, with the chronology recorded daily to maintain the chain of evidence. This step follows Emzir's (2019) protocol for field case studies, enhanced by Rohman Moh Aziz and Eva Susanti (2023) who emphasize chronological documentation for replicability in the ship's dynamic environment.

III. RESULTS AND DISCUSSION

Data Presentation

1. Observation Results

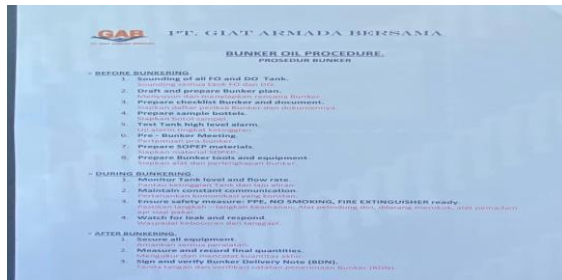


Fig. 1. Bunker procedure MT GIAT ARMADA 04
Source: Personal documentation (2025)

The bunkering procedures issued by PT Giat Armada Bersama emphasize the importance of paying attention to safety and security, especially preventing oil spills on the maindeck to prevent marine pollution. If an oil spill occurs, it can be handled using the SOPEP (Shipboard Oil Pollution Emergency Plan) equipment provided in accordance with MARPOL Annex I (Regulation 37). This regulation requires oil tankers above 150 GT and other vessels above 400 GT to have an emergency oil spill response plan. Every vessel, especially tankers, provides an SOPEP box containing oil spill cleanup equipment according to a predetermined list and quantity, so the availability of equipment must always be in accordance with the listed list. On the MT Giat Armada 04 vessel, an SOPEP box is also provided and contains the equipment needed for handling oil spills on board.



Fig. 2. SOPEP Equipment Box
Source: Personal documentation (2025)

The SOPEP box on the MT GIAT ARMADA 04 ship is located to the right of the cargo pipe near the loading and unloading manifold and fuel bunker above COT 5 S. The placement of this SOPEP box also makes it easier for the ship's crew to prepare SOPEP equipment during bunkering or loading and unloading. The SOPEP box contains a list of equipment determined by the company regarding the contents and quantity in the SOPEP box. The list of SOPEP equipment on the MT GIAT ARMADA 04 ship is as follows.

| INVENTORY RECORD | | | | | | | | | | |
|---------------------------|--------------------------|-----------|-----|---------------------|-----------|-----------|-----|-----|-----|-------------|
| VESSEL: MT GIAT ARMADA 04 | | | | Ref. No.: | | GAB | | | | |
| Deck: 30 APR 2025 | | | | Manufacturer: | | | | | | |
| Deck: | | | | Model / Serial No.: | | | | | | |
| SN | DESCRIPTION | PART NO | QTY | LAST ROB | DEC/ 2024 | JUN/ 2025 | QTY | QTY | QTY | REMARKS |
| | | | USE | | ROB | ROB | ROB | ROB | ROB | |
| (SOPEP EQUIPMENTS) | | | | | | | | | | |
| 1 | Waste Bags - Cotton | 30 kg | 30 | 30 | 30 | 30 | | | | SOPEP Store |
| 2 | Container - Plastic | 2 x 180Lp | 2 | 2 | 2 | 2 | | | | SOPEP Store |
| 3 | Flow Duct | 1 Baga | 1 | 1 | 1 | 1 | | | | SOPEP Store |
| 4 | Oil Absorbent Mat | 100Pcs | 100 | 100 | 100 | 100 | | | | SOPEP Store |
| 5 | Oil Spill Regament (ORB) | 20Lp A.S | 100 | 100 | 100 | 100 | | | | SOPEP Store |
| 6 | Plastic Blank | 10 Pcs | 10 | 10 | 10 | 10 | | | | SOPEP Store |
| 7 | Broom | 2Pcs | 2 | 2 | 2 | 2 | | | | SOPEP Store |
| 8 | Dust Pan - Plastic | 2Pcs | 2 | 2 | 2 | 2 | | | | SOPEP Store |
| 9 | Shovel - Plastic | 2Pcs | 2 | 2 | 2 | 2 | | | | SOPEP Store |
| 10 | Detergent | 3 Baga | 3 | 3 | 3 | 3 | | | | SOPEP Store |

NOTES: 1) All entries in the Inventory Record must be typewritten - no handwritten entries to allow
 2) A set of accurate and updated Inventory Record must be sent to Technical Dept. once every 6 months (June & Dec).
 3) Please note the physical condition of the items (new, used and/or reconditioned remaining on board in the Remarks column).
 Note: Retention Period of Completed Form is 2 years.

Prepared by: C/O
 Approved by: HENDRA KUSUMAH
 MASTER

Fig. 3. SOPEP Equipment List
Source: Ship documentation (2025)

In this case, addressing an oil spill on a ship also requires proper procedures to prevent the problem from escalating to a more serious situation. Therefore, there are also appropriate procedures for addressing an oil spill, as follows:

- A. Initial actions that must be taken when an oil spill occurs during bunkering on a ship:
- a) Stop the bunkering process immediately.
 - b) Activate the emergency alarm / general alarm.
 - c) Report the incident to the Master and Chief Officer.
 - d) Secure the spill site.
- B. Use of SOPEP equipment according to procedures
- a) The first thing to do is for the ship's crew to quickly close the scupper plug at the rear of the main deck if the spill is large enough.
 - b) Use a wilden pump to transfer the oil to the slop tank.
 - c) Use a shovel and bucket to help collect any remaining oil that the pump can't suck up.
 - d) Use absorbent pads to help absorb any remaining thin oil remaining at the spill site.
 - e) Use Sawdust on the area affected by oil, then sweep away the sawdust that is stuck to the oil.
 - f) Use Oil Spill Dispersant to break down the oil that is still stuck to the main deck.
 - g) The final step is to use detergent or soapy water to mop the area where the oil was spilled, so that the area is completely clean from the oil spill.
- C. Reporting and documentation
- a) Record the incident in the oil record book and log book
 - b) If a large spill occurs, report it to the company and port authorities.
 - c) Document photos and chronology of events
- D. Further evaluation and prevention
- a) Conduct an evaluation of the cause of the oil spill.
 - b) Improve procedures or SOPs in carrying out the bunkering process.
 - c) If any equipment is damaged in supporting the bunker process, it must be replaced immediately.
 - d) Carry out an oil spill drill for all ship crews so that they are more accustomed to dealing with oil spill problems.

On Monday, May 12, 2025, in the Anchor area of Makassar port MT GIAT ARMADA 04 carried out a ship to ship bunkering process with SPOB Bima 01. In this process, everything has been prepared according to the bunker procedures set by the company. At 09.24 preparation for the bunker process test when the oil began to transfer, a leak occurred in the manifold of the MT GIAT ARMADA 04 ship, the fastening of the flange by the bolt was not tight and precise enough, resulting in this. Because of this incident, oil spilled under the manifold so that the bunker process had to be stopped first. The oil spill was immediately cleaned using SOPEP equipment according to the procedure, the researcher also documented this incident which the researcher included in the form of images in the attachment. In this incident, the researcher examined how the crew implemented the use of SOPEP equipment during bunkering. The researcher also conducted interviews and gave questionnaires to the ship's crew to obtain valid data regarding the implementation of the use of SOPEP equipment during bunkering.



Fig. 4. Bunker hose flange leak
Source: Researcher Documentation (2025)

2. Interview results

A. The results of the researcher's interview with source 1 (Captain) the researcher obtained the following information:

Based on information provided by Capt. Hendra Kusumah as Captain on the MT GIAT ARMADA 04 ship, the implementation of the use of SOPEP equipment during the bunkering process has become a mandatory procedure on the ship. Before bunkering is carried out, the crew conducts a short briefing and prepares all SOPEP equipment such as oil booms, oil absorbents, waste drums, and personal protective equipment in the bunker station area. The Captain ensures that the equipment is placed in an easily accessible location to anticipate any oil spills. In addition, checks are carried out on the condition of the equipment to ensure that all equipment is ready for use during bunkering activities.

Captain It also explains that if an oil leak or spill occurs, the crew is required to immediately stop the bunkering process by closing the valve and turning off the pump. The spill area is immediately secured and the emergency alarm is activated. SOPEP equipment is used according to its function, namely an oil boom to contain the oil so it does not spread and oil absorbent to absorb oil spilled on the deck. SOPEP is very helpful for the crew in emergency situations because it provides clear written guidance on the roles of each personnel, handling procedures, and reporting flow to the company and related parties.

To ensure crew readiness, the Captain stated that SOPEP training and drills are conducted routinely, along with socialization for new crew through a safety familiarization program. Furthermore, after the bunkering process is completed, an evaluation of the effectiveness of the SOPEP equipment implementation is conducted, including monitoring crew discipline and equipment condition. Coordination with the fuel supplier is also carried out before bunkering activities begin to align safety procedures. Previous experience has shown that crew responsiveness and equipment readiness play a significant role in preventing marine pollution.

B. The results of the researcher's interview with source 2 (Chief Officer) the researcher obtained the following information:

Based on information provided by Chief Officer Freddy Yoppy, the field coordinator, the Chief Officer explained that preparations for the use of SOPEP equipment are always carried out before the bunkering process begins. The Chief Officer ensures that equipment such as oil booms, absorbents, waste drums, and PPE are available and placed in easily accessible locations. He also leads a toolbox meeting to assign tasks to the crew and explain safety procedures in detail.

In the event of an oil spill, the Chief Officer immediately halts the bunkering process by closing the valve and turning off the pump, and coordinates the crew to secure the area. The Standard Operating Procedure (SOPEP) equipment is immediately used as intended to prevent the spread of oil and clean the deck. The SOPEP facilitates the crew by providing written guidelines for emergency situations, including internal ship coordination.

To ensure crew readiness, the Chief Officer conducts regular briefings, familiarizes new crew, and conducts quarterly SOPEP drills. Additionally, equipment inspections are conducted before bunkering and evaluations are conducted after completion. Coordination with the bunker barge is also carried out through safety briefings. Previous experience has shown that equipment readiness and good coordination can prevent further contamination.

C. The results of the researcher's interview with source 3 (Boatswain) the researcher obtained the following information:

Based on information provided by Mr. Christiadi as Boatswain MT GIAT ARMADA 04, he explained that before the bunkering process was carried out, he was responsible for preparing SOPEP equipment such as oil booms, oil absorbents, shovels, and waste drums in the bunker station area. The Boatswain ensured that the deck was safe and free from fire sources and that the equipment was placed in strategic locations for easy access in an emergency.

In the event of an oil spill, the boatswain coordinates with the crew to immediately halt operations, secure hoses, and close valves. An oil boom is immediately deployed to contain the oil and prevent it from spreading into the sea, while oil absorbents are used to absorb the oil on deck. These procedures are implemented in accordance with the SOPEP guidelines outlined in the ship's emergency plan.

To ensure crew readiness, the boatswain provided a direct briefing before bunkering, demonstrating the location and use of SOPEP equipment to the crew, especially new crew members. He also inspected the equipment before use and evaluated the condition of the area after the activity was completed. Based on previous experience, the boatswain emphasized that crew responsiveness and

- f. I understand the function of each SOPEP equipment
- g. I know the storage location of the SOPEP equipment.
- h. I know what to do in case of a spill.
- i. I am able to operate oil boom and absorbent
- j. The briefing before bunkering explained my role.
- k. SOPEP procedures are implemented according to SOP
- l. Crew comply with the use of PPE
- m. Officer supervision is running well
- n. Effective coordination between crews
- o. I received SOPEP training
- p. I received SOPEP training
- q. Evaluation after bunkering is done
- r. Corrective actions are taken after evaluation
- s. Crew input is taken into account by management
- t. SOPEP effectively prevents pollution
- u. I believe SOPEP protects crew members
- v. I am ready to face an oil spill emergency.

Essay questions

A. The main obstacles in implementing SOPEP in your opinion:

B. Suggestions for improving the implementation of SOPEP:

Table 1. Summary of questionnaire answers

| No | Statement | STS(1) | TS(2) | R(3) | S(4) | SS(5) | Total | Average | Category |
|---|--|--------|-------|------|------|-------|-------|-------------|-------------|
| B. AVAILABILITY AND CONDITION OF SOPEP EQUIPMENT | | | | | | | | | |
| 1 | SOPEP equipment is fully available before bunkering | 0 | 0 | 3 | 6 | 9 | 18 | 4.33 | Good |
| 2 | The location of the SOPEP equipment is easy to reach | 0 | 0 | 5 | 8 | 5 | 18 | 4 | Good |
| 3 | The condition of the oil boom is suitable for use | 0 | 1 | 10 | 4 | 3 | 18 | 3.5 | Good |
| 4 | Oil absorbent is always sufficient | 0 | 0 | 2 | 13 | 3 | 18 | 4.06 | Good |
| 5 | PPE is always available before bunkering | 0 | 2 | 10 | 6 | 0 | 18 | 3.22 | Enough |
| Average Section: B | | | | | | | | 3.82 | Good |
| C. CREW UNDERSTANDING AND COMPETENCE | | | | | | | | | |
| 6 | I understand the function of each SOPEP equipment | 0 | 1 | 4 | 4 | 9 | 18 | 4.17 | Good |
| 7 | I know the storage location of the SOPEP equipment. | 0 | 1 | 4 | 6 | 7 | 18 | 4.06 | Good |
| 8 | I know what to do when a spill occurs | 0 | 1 | 4 | 9 | 4 | 18 | 3.89 | Good |
| 9 | I am able to operate oil boom and absorbent | 1 | 2 | 6 | 7 | 2 | 18 | 3.39 | Enough |
| 10 | The briefing before bunkering explained my role. | 0 | 0 | 9 | 6 | 3 | 18 | 3.67 | Good |
| Average Section: C | | | | | | | | 3.84 | Good |
| D. IMPLEMENTATION OF SOPEP PROCEDURES DURING BUNKERING | | | | | | | | | |
| 11 | SOPEP procedures are implemented according to SOP | 0 | 0 | 3 | 10 | 5 | 18 | 4.11 | Good |
| 12 | Crew comply with the use of PPE | 0 | 1 | 9 | 8 | 0 | 18 | 3.39 | Enough |
| 13 | Officer supervision is running well | 0 | 0 | 3 | 14 | 1 | 18 | 3.89 | Good |

| | | | | | | | | | |
|-----------------------------------|--|---|----|----|---|----|----|------|------------|
| 14 | Effective crew coordination | 0 | 0 | 8 | 9 | 1 | 18 | 3.61 | Good |
| Average Sexy: D | | | | | | | | 3.75 | Good |
| E. TRAINING AND EVALUATION | | | | | | | | | |
| 15 | I received SOPEP training | 0 | 0 | 1 | 5 | 12 | 18 | 4.61 | Very good |
| 16 | I gotSOPEP training (confirmation) | 0 | 0 | 0 | 3 | 15 | 18 | 4.83 | Very good |
| 17 | Evaluation after bunkering is done | 0 | 0 | 8 | 7 | 3 | 18 | 3.72 | Good |
| 18 | Corrective actions are taken after evaluation | 0 | 1 | 11 | 4 | 2 | 18 | 3.39 | Enough |
| 19 | Crew input is taken into account by management | 1 | 11 | 4 | 2 | 0 | 18 | 2.39 | Not enough |
| Average Section: E | | | | | | | | 3.79 | Good |
| F. OVERALL EFFECTIVENESS | | | | | | | | | |
| 20 | SOPEP effectively prevents pollution | 0 | 0 | 3 | 8 | 7 | 18 | 4.22 | Good |
| 21 | I believe SOPEP protects the crewboat | 0 | 0 | 9 | 5 | 4 | 18 | 3.72 | Good |
| 22 | I am ready to face an oil spill emergency. | 0 | 0 | 6 | 5 | 7 | 18 | 4.06 | Good |
| Average Section: F | | | | | | | | 4 | Good |

Source: Processed researcher data (2025)

Table 2. Category description

| CATEGORY DESCRIPTION | | |
|----------------------|-------------------|---|
| 4.50 – 5.00 | Very good | <i>The implementation is veryoptimal</i> |
| 3.50 – 4.49 | Good | <i>Implementation is good, there is room for minor improvements</i> |
| 2.50 – 3.49 | Enough | <i>Needs attention and improvement</i> |
| 1.50 – 2.49 | Not enough | <i>Needs significant improvement</i> |
| 1.00 – 1.49 | Very less | <i>Critical, requires immediate intervention</i> |

Source: Processed researcher data (2025)

Based on the description table, the categories can make it easier for researchers to use as a benchmark in determining the effectiveness of the implementation of the use of SOPEP equipment during bunkering on the MT Giat Armada 04 ship.

Table 3. Answers to open questions

| SUMMARY OF OPEN QUESTIONS | | |
|---------------------------|--|---|
| No | Q23. Main Obstacles to Implementing SOPEP | Q24.SOPEP Improvement Suggestions |
| 1 | The main obstacle is if the supply of SOPEP equipment is insufficient and the crew's minimal understanding also has an impact. | conduct training for the crew once a month to better understand |
| 2 | In my opinion, the quality of the SOPEP equipment must also be taken into account, so that it is not easily damaged when used. | conducting training for all ship crew and providing quality equipment |
| 3 | knowledgeship's crew regarding how to use sopep | the ship's crew needs to learn about sopep |
| 4 | Good condition of the sopep equipment helps facilitate oil spill cleanup | always pay attention to how to use sopep equipment |
| 5 | on the ship crew's knowledge of usesopep | do the drill several times so the crew understands |
| 6 | must understand about sopep | keep learning about sopep |
| | | The company must supply good quality sopep |

| | | |
|----|--|---|
| 7 | Sopep equipment must be good and complete | equipment |
| 8 | All ship crew must know the use of each function of the sopep equipment and its use. | training must be carried out according to schedule |
| 9 | must understand about sopep equipment | conduct training related to sopep |
| 10 | lack of knowledge of ship crew regarding sopep | have to do drill |
| 11 | ship crew must know how to use sopep equipment | learn about sopep so that the Japal crew understands better and carries out training more often |
| 12 | Quality equipment also helps in the usage process | maintain and send reports to the office regarding inventory sopep |
| 13 | large oil spills and equipment that is no longer suitable | understand howuse of sopep |
| 14 | understanding how to use Sopep properly according to existing procedures | take part in training on board |
| 15 | the ship's crew's lack of understanding of the function of the sopep equipment | take part in training and learn theory and practice about sopep |
| 16 | understanding of use of sopep equipment | conduct training and learn about sopep |
| 17 | not ad | learn more about drill sopep |
| 18 | All crew must understand so that there are no problems | crew should not play around during drills to better understand |

Source: Processed researcher data (2025)

Data analysis

1. Data reduction

A. Interview data reduction

Table 3. Interview data reduction

| Theme | Reduction results |
|---------------------|-------------------------------------|
| Equipment Readiness | Tools prepared before bunkering |
| Emergency stop | Bunkering stopped during spill |
| Use of Tools | <i>Oil absorbent & oil boom</i> |
| Crew Coordination | Clear roles |
| Training | Inconsistent |
| Evaluation | Undocumented |

Source: Processed researcher data (2025)

B. Questionnaire data reduction

Table 4. Questionnaire data reduction

| Sexy | Rated aspect | Average | Category | Information |
|------------------------|---|-------------|-------------|--|
| B | Availability and Condition of SOPEP Equipment | 3.82 | Good | Sufficient equipment is available, PPE needs to be increased |
| C | Crew Understanding and Competence | 3.84 | Good | Crew understanding is good, practical ability needs to be improved |
| D | Implementation of SOPEP Procedures during Bunkering | 3.75 | Good | SOP procedures are followed, PPE compliance is still sufficient |
| E | Training and Evaluation | 3.79 | Good | Training is very good, crew aspirations to management are lacking |
| F | Overall Effectiveness | 4.00 | Good | The effectiveness of SOPEP was assessed as good overall. |
| Overall Average | | | Good | The overall implementation of SOPEP is good |

Source: Processed researcher data (2025)

IV. DISCUSSION

Implementation of SOPEP Equipment During Bunkering on Ships Based on Interview Results

1. SOPEP Equipment Readiness

Interview results showed that all respondents stated that the SOPEP equipment had been prepared before the bunkering activity began. The Captain and Chief Officer explained that preparation was carried out by inspecting equipment such as oil booms, oil absorbents, shovels, waste drums, and personal protective equipment. This indicates that equipment readiness has been carried out according to the procedures stipulated in the SOPEP. However, the Boatswain and AB reported that on several occasions, equipment was still found to be worn out or had reduced absorbency. This condition indicates that although equipment availability is sufficient, maintenance and replacement of equipment needs to be tightened to ensure optimal SOPEP effectiveness.

2. Crew Understanding and Readiness

Captain stated that the Standard Operating Procedure (SOPEP) is a mandatory document that must be understood by the entire crew. The Chief Officer added that the crew received a briefing before bunkering and internal training. The Boatswain also played an active role in directing the field crew, while the crew members gained understanding through hands-on training. This demonstrates that the knowledge transfer system is working from officers to the operational level. However, there are differences in the level of understanding among the crew, indicating the need for structured training and more uniform training standards to improve the competence of all crew members.

3. Implementation of SOPEP Procedures during Bunkering

All sources emphasized that the SOP (SOPEP) is used as a guideline during the bunkering process. Officers supervise, and the crew carries out operational tasks according to instructions. Boatswains ensure that the crew installs oil booms and supplies oil absorbent. However, in practice, SOP implementation still relies heavily on crew discipline. If supervision is weak or the crew lacks discipline, the potential for negligence can increase. Therefore, active supervision by officers is a key factor in the success of SOPEP implementation.

4. Response to Oil Spill Incidents

Respondents' statements revealed that if a leak occurs, the first step is to stop bunkering and report it immediately. Standard Operating Procedures (SOPEP) equipment is immediately used to control the spill. The Chief Officer and Boatswain stated that a quick response is crucial to the success of the spill mitigation. The crew also stated that equipment readiness and coordination facilitated situation control. This demonstrates that the implementation of SOPEP has been effective in emergency response situations, although training is still needed to maintain crew skills.

5. SOPEP Training and Drill

Captain The Chief Officer and the Chief Officer stated that training and drills are conducted regularly. However, the Boatswain and AB stated that the exercises are more often informal. This discrepancy suggests that drills need to be standardized and formally scheduled to ensure that all crew members have equal learning opportunities.

The effectiveness of SOPEP equipment in preventing environmental pollution during the bunkering process on board the MT. GIAT ARMADA 04.

1. Availability and Condition of SOPEP Equipment (Section B)

Availability and condition of SOPEP equipment before bunkering was assessed as good, as seen from the average value of 4.33 (83.3% of respondents agreed or strongly agreed), indicating that the MT GIAT ARMADA 04 vessel had fulfilled the function of providing SOPEP equipment well before each bunkering operation. The availability of oil absorbent was also assessed as good with an average of 4.06 and 88.9% agreement, the highest percentage in the study. However, the condition of the oil boom only received a score of 3.50 (55.6% neutral), indicating that the suitability was still considered sufficient, while the availability of Personal Protective Equipment (PPE) received an average of 3.22 (sufficient), with 11% of respondents disagreeing and 33.3% agreeing, thus potentially reducing the effectiveness of the oil spill response. This finding is in line with the provisions of MARPOL Annex I which requires ships to ensure the availability and suitability of all SOPEP equipment before bunkering, and indicates the need for increased supervision of PPE inventory and oil boom maintenance schedules.

2 Crew Understanding and Competence (Section C)

Section B showed that the crew's understanding and competence were in the 3.84 (good) category, with theoretical knowledge rated as good: 72% of respondents understood the function of each SOPEP equipment (mean 4.17) and knew its storage location (mean 4.06). The crew's ability to determine actions during an oil spill was also in the good category (mean 3.89) with 72.2% positive responses, reflecting the success of the education and briefing program on board. However, the practical ability to operate oil booms and oil absorbents only obtained a 3.39 (sufficient), with 16.7% of respondents stating that they were unable to, thus indicating a gap between theoretical knowledge and practical skills that needs to be addressed by increasing the frequency of practical training. Several crew members in the open-ended question (Q23) highlighted the lack of a comprehensive understanding of how to use SOPEP and the importance of all crew members knowing the function of each SOPEP equipment as a major obstacle.

3. Implementation of SOPEP Procedures during Bunkering (Section D)

Implementation of SOPEP procedures during bunkering obtained an average of 3.75 (good), with the highest implementation of SOPEP procedures in this section (4.11; 83.3% agree or strongly agree), and officer supervision was assessed as good (3.89; 83.3% positive responses, even 77.8% only chose agree as the dominant answer), indicating that the role of officers in supervising bunkering has been effective. However, crew compliance in the use of PPE again became a serious concern with an average of 3.39 (sufficient), only 44.4% agreed and 50% were neutral, thus consistent with the finding of suboptimal PPE availability in Section B. This condition indicates structural constraints, including aspects of PPE availability to enforcement of discipline in its use. In addition, coordination between crews received 3.61 (good) with 55.6% positive responses, but 44.4% were neutral, indicating that team communication was running but still needed improvement in role clarity and communication flow between sections.

4. Training and Evaluation (Section E)

Training and Evaluation Section assessed the quality of the SOPEP training program and the consistency of post-bunkering evaluations, with an average of 3.79 (good), but showing the widest variation in scores among all sections. Acceptance of SOPEP training was the highest score in the study (4.83; 100% agree or strongly agree, Q16), indicating that the formal SOPEP training program had been running very well and was recognized by the MT GIAT ARMADA 04 crew as a strong foundation for SOPEP effectiveness in the field. However, the evaluation and follow-up aspects showed weaknesses: corrective actions after evaluation were only 3.39 (sufficient; 61.1% neutral), while management attention to crew feedback received the lowest score (2.39, poor), with 66.7% disagreeing or strongly disagreeing and only 11.1% agreeing. This revealed a gap between good training and a weak feedback loop, making technical problems such as declining equipment conditions or procedural weaknesses difficult to identify and systematically correct. Several crew members in the open-ended question (Q24) suggested the need for maintenance and reporting of SOPEP inventory to the office, as well as ensuring that training is carried out according to schedule, indicating the need for a more structured reporting and communication system.

5. Overall Effectiveness of SOPEP (Section F)

Overall effectiveness of SOPEP received the highest average score, 4.00 (good), indicating a positive crew perception of the SOPEP's ability to prevent environmental pollution and protect crew safety. The SOPEP's primary role in preventing pollution received a score of 4.22 with 83.3% positive responses, reflecting crew confidence that the procedures and equipment on MT GIAT ARMADA 04 significantly helped prevent oil spills from contaminating the sea during bunkering. Crew preparedness for oil spill emergencies was also rated as good (4.06; 66.7% positive), a direct reflection of the excellent training program in Section E. However, crew confidence that the SOPEP specifically protects crew safety only received a score of 3.72, with 50% choosing neutral, indicating that while crew acknowledged the effectiveness of the SOPEP in environmental aspects, some were not fully convinced that it provided optimal protection for personal safety, possibly related to issues of PPE availability and compliance in Sections B and D.

Analysis of Factors Inhibiting the Effectiveness of SOPEP

1. Inconsistent availability and condition of equipment.

Although equipment completeness was generally assessed as good, the condition of the oil boom was still adequate (mean 3.50) and the availability of inadequate PPE (mean 3.22) were infrastructure weaknesses that could hamper an effective response to an oil spill. As stated by several respondents, "large oil spills and equipment that is no longer suitable" and "the quality of SOPEP equipment must also be considered, so that it is not easily damaged when used."

2. The gap between theoretical knowledge and practical skills

MT. GIAT ARMADA 04 has a good understanding of SOPEP procedures, but their practical ability to operate oil booms and absorbents is still in the adequate category (mean 3.39). The majority of respondents in the open-ended statement stated that "lack of crew knowledge regarding SOPEP" and "how to use SOPEP equipment" were the main obstacles, with the dominant suggestion being increasing the frequency of training and drills.

3. Weak feedback system between crew and management

Management's attention to crew input received the lowest score in this study (mean 2.39, Poor). This condition hinders the identification and continuous improvement of operational problems and reduces crew motivation to actively participate in improving SOPEP implementation.

Discussion of the Effectiveness of SOPEP in Preventing Environmental Pollution

Overall, the effectiveness of SOPEP equipment in preventing environmental pollution during the bunkering process on the MT GIAT ARMADA 04 vessel is in the Good category with an overall average value of 3.84, which indicates that the pollution prevention management system has been running according to standards, but has not been fully optimal. The Overall Effectiveness (mean 4.00) and Crew Understanding (mean 3.84) sections showed the best performance, supported by an excellent formal training program (mean 4.83), so that the crew has adequate basic knowledge to prevent and deal with oil spills.

On the other hand, Procedure Implementation (mean 3.75) and cross-sectional issues related to PPE and evaluation systems are the areas that require the most attention because the effectiveness of SOPEP depends not only on the availability of equipment and crew knowledge, but also on the consistency of procedure implementation, completeness of safety equipment, and a continuous improvement cycle supported by effective communication between crew and management. This finding is in line with previous research which emphasized that the effectiveness of a ship's safety management system is determined by the synergy between technical aspects (equipment and procedures) and human aspects (competence, awareness, and organizational communication). To improve the effectiveness of SOPEP on board MT GIAT ARMADA 04 to the Very Good category, concrete steps are needed in the form of:

- a. Routine updates and maintenance of SOPEP equipment including PPE and oil booms
- b. Increase the frequency of practical drills to at least once per month.
- c. Establishment of a structured reporting and feedback mechanism between the crew and ship management.

V. CONCLUSION

This study shows that the implementation of SOPEP equipment during bunkering on board MT Giat Armada 04 is in the good category, with an average score of 3.84, which indicates that the pollution prevention management system has been running according to standards but is not yet fully optimal. The best performance is seen in the Overall Effectiveness and Crew Understanding Section, which is supported by a formal training program that is running very well. However, several areas still need to be strengthened, such as the availability and suitability of Personal Protective Equipment (PPE), compliance with its use during bunkering, and the consistency of post-operation evaluations and management responses to crew input. The findings also indicate a gap between the crew's theoretical knowledge and practical skills in operating equipment such as oil booms and oil absorbents, thus requiring increased drill frequency and hands-on skills training.

The main limitations of this study lie in the single-case study on a single vessel and the relatively small number of respondents, making the results infeasible for generalization to all other domestic tankers. Furthermore, data collection, which relied on crew perceptions and internal ship documentation, may introduce subjective bias. For future research, a multi-vessel comparative design and a more robust quantitative approach are recommended to measure the correlation between the implementation of SOPEP procedures, equipment condition, and the level of oil spill incidents. Practically, the results of this study can serve as a reference for shipping company management in developing SOPEP equipment maintenance programs, scheduling routine drills, and establishing structured feedback mechanisms to maximize SOPEP implementation in preventing marine pollution and improving crew safety.

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