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Article

Identification and Solutions for Cargo Loss on Self-Propelled Oil Barge (SPOB) Seroja V

Achmad Amin Firmansyah[1*], Sutoyo[2], Arleiny[3], Teguh Pribadi[4]

[1,2,3,4] Teknologi Rekayasa Operasi Kapal (TROK), Politeknik Pelayaran (Poltekpel) Surabaya

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E-mail *aminfirman0996@gmail.com (Corresponding author), Sutoyopoltekpel@gmail.com, arleiny@poltekpel-sby.ac.id, teguh.pribadi@poltekpel-sby.ac.id

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ABSTRACT

This study aims to identify the primary causes of cargo loss and to formulate effective solutions to address such losses aboard the Self Propelled Oil Barge (SPOB) Seroja V. The research employs a qualitative method with a descriptive approach to analyze operational discrepancies in the transport of Fatty Acid Methyl Ester (FAME). Data were collected through direct observation during onboard training (PRALA), semi-structured interviews with ship officers and cargo surveyors, and a comprehensive review of loading and discharging documentation. The findings reveal that cargo loss is driven by two distinct but interconnected factors: physical loss, characterized by evaporation, structural leakage, and residue accumulation; and apparent loss, resulting from measurement errors, calculation inaccuracies, and the use of uncalibrated measuring instruments. The study concludes that the unique physicochemical properties of FAME, combined with the aging infrastructure of the barge and the absence of automated monitoring systems, necessitate a robust intervention strategy involving technical remediation of tank integrity, stringent equipment calibration protocols, and the standardization of manual gauging procedures.

1. Introduction

The maritime sector constitutes the backbone of the global supply chain, facilitating the movement of approximately 80% of world trade by volume. For Indonesia, the world's largest archipelagic state, the maritime domain is not merely a conduit for trade but the fundamental fabric of national sovereignty and economic integration. Recognized internationally under the United Nations Convention on the Law of the Sea 1982 (UNCLOS 1982) and ratified through Law No. 17 of 1985, Indonesia's jurisdiction spans a vast maritime territory totaling 5.9 million square kilometers. This comprises 3.2 million square kilometers of territorial waters and 2.7 million square kilometers of Exclusive Economic Zone (ZEE). Within this sprawling aquatic geography, the distribution of energy resources—specifically liquid petroleum products and biofuels—is a critical logistical operation that demands precision, safety, and efficiency.

The strategic importance of sea transportation in Indonesia is paramount. It acts as the primary bridge connecting thousands of inhabited islands, ensuring price stability and the availability of essential commodities across the archipelago. As noted by Lasabuda (2013), the development of coastal and ocean areas is integral to the nation's economic resilience, yet the sector remains fraught with operational challenges. Among these, the phenomenon of "cargo loss"—the quantitative discrepancy between the cargo loaded at the port of origin and the cargo discharged at the destination—remains a persistent issue that erodes profit margins, disrupts supply chains, and complicates custody transfer protocols.

In recent years, the complexity of liquid cargo logistics has been compounded by the national mandate to integrate renewable energy sources into the fuel supply. The Indonesian government, through the Ministry of Energy and Mineral Resources (ESDM), has aggressively promoted the use of biosolar, a blend of fossil diesel and Fatty Acid Methyl Ester (FAME) derived from crude palm oil. Regulations such as the Minister of Energy and Mineral Resources Regulation Number 12 of 2015 explicitly outline the roadmap for biofuel utilization to support macroeconomic stability and reduce dependence on fossil fuel imports. This policy aligns with global trends toward decarbonization but introduces significant technical challenges. Unlike conventional hydrocarbons, FAME possesses unique physicochemical properties—such as hygroscopicity, solvency, and thermal sensitivity—that necessitate rigorous handling protocols to prevent degradation and physical loss during transport.

The vessel type central to this research is the Self-Propelled Oil Barge (SPOB). Unlike conventional ocean-going tankers, SPOBs are designed with flatter hulls and shallower drafts, allowing them to navigate the riverine and coastal waters that characterize Indonesia's remote distribution points. While operationally versatile, SPOBs often lack the advanced automated monitoring systems found on larger vessels, such as centralized Cargo Control Rooms (CCR) or sophisticated vapor recovery systems. This technological gap places a heavier burden on the crew's competence and the manual execution of Standard Operating Procedures (SOPs) to maintain cargo integrity.

The specific impetus for this research arises from operational irregularities observed aboard the SPOB Seroja V. On January 21, 2025, during a discharge operation at the Pertamina Plaju jetty in Palembang, significant cargo discrepancies were recorded. Following the connection of cargo hoses and subsequent gauging, calculations revealed a shrinkage in the FAME cargo volume that exceeded the tolerable industry standard of 0.5%. Such incidents are not merely statistical anomalies; they indicate potential systemic failures in the physical containment of the cargo or the procedural methodologies employed during custody transfer. The discovery of leakage from a cargo tank into the double hull structure further highlights the vulnerability of aging fleets handling corrosive biofuel cargoes.

Based on the background outlined above, several critical issues regarding cargo loss on the SPOB Seroja V have been identified. The problem of cargo loss is multifaceted, involving the interplay of physical infrastructure integrity, human error in measurement, and the physicochemical behavior of the cargo itself. The identification of problems includes:

High Frequency of Discrepancies: The vessel frequently experiences differences between ship figures and shore figures that exceed the 0.5% tolerance limit set by Pertamina and international standards.

Structural Integrity Issues: There are indications of physical failure in the containment systems, specifically leakage in cargo tanks leading to the migration of product into non-commercial spaces like the double hull.

Measurement Inconsistencies: The reliance on manual sounding and temperature measurement introduces human error, parallax issues, and inconsistencies between different watchkeepers.

Operational Deficiencies: The lack of a Cargo Control Room (CCR) necessitates manual valve operations, increasing the risk of "line content" retention and improper stripping due to communication latency between the deck and pump room.

Biofuel Handling Challenges: The specific characteristics of FAME, such as its cleaning effect on sediments and its corrosivity toward rubber seals and mild steel, contribute to both apparent and physical losses.

To ensure the research remains focused and achievable within the given timeframe, the scope of this study is limited to the following parameters:

Subject: The research focuses exclusively on the *SPOB Seroja V* and its operations.

Cargo Type: The study analyzes the handling of FAME (Fatty Acid Methyl Ester) cargo.

Operational Phase: The analysis covers the loading, transit (voyage), and discharging phases.

Context: The study investigates the specific incident of cargo loss identified during the voyage ending on January 21, 2025, and general operational practices observed during the author's onboard training (PRALA) period.

Focus: The research concentrates on the technical and operational aspects of "Identifikasi dan Solusi Loss Cargo" (Identification and Solutions for Cargo Loss), excluding deep financial analysis or legal liability claims beyond the operational context.

This study aims to provide a granular analysis of loss control management aboard the SPOB Seroja V. Specifically, the objectives are:

To rigorously identify and categorize the root causes of cargo loss, distinguishing between physical losses (e.g., evaporation, leakage, theft) and apparent losses (e.g., measurement inaccuracies, calculation errors).

To assess the effectiveness of the current cargo handling procedures and supervision systems employed by the deck officers and crew.

To formulate comprehensive, actionable solutions for technical maintenance, crew training, and procedural standardization to mitigate future losses and enhance the vessel's operational efficiency.

The findings of this research hold significant value for multiple stakeholders within the maritime and energy sectors:

For the Researcher: This study serves as a medium to apply theoretical knowledge of cargo handling and naval architecture gained during academic studies to real-world problems. It enhances the researcher's competency in analyzing complex operational failures and developing evidence-based solutions.

For the Ship Operator/Owner: The identification of specific loss mechanisms provides a basis for targeted maintenance (e.g., tank coating repairs) and crew training programs. Implementing the proposed solutions can directly reduce financial claims from charterers and improve the vessel's commercial reputation.

For Educational Institutions: This report contributes to the limited body of literature focusing on the specific challenges of transporting FAME via barge in tropical climates. It serves as a reference for future cadets and researchers in the field of Ship Operation Engineering, highlighting the intersection of vessel design and biofuel logistics.

For the Maritime Industry: The insights regarding "apparent loss" versus "physical loss" in the context of FAME transport are crucial for refining custody transfer contracts and tolerance thresholds, promoting fairer and more efficient energy distribution practices in Indonesia.

2. Literature Review

2.1 Theoretical Framework of Cargo Loss

In the maritime liquid bulk trade, "cargo loss" is rigorously defined as the discrepancy between the volume of cargo documented at the point of loading (Bill of Lading figures) and the volume received at the discharge port (Outturn figures). Industry standards, such as those maintained by the Energy Institute and the American Petroleum Institute (API), generally accept a trade allowance or tolerance of 0.5% to account for inherent measurement uncertainties and minor physical losses. However, losses exceeding this threshold trigger investigations and potential financial claims.

Losses are conceptually divided into two distinct categories: Physical Loss and Apparent (Paper) Loss.

2.1.1 Physical Loss

Physical loss refers to the actual reduction in the mass or volume of the cargo. This is an irreversible loss of product from the supply chain. Key mechanisms include:

Evaporation: Volatile organic compounds (VOCs) within liquid cargoes can vaporize, particularly when subjected to high temperatures or agitation during loading and transit. While crude oil is highly susceptible to this, biofuels like FAME have different volatility profiles but can still suffer volume reduction if tank integrity is compromised or if Pressure-Vacuum (PV) valves are malfunctioning.

Leakage: This occurs due to structural failures in the vessel's containment systems. Corrosion of hull plating, failure of gaskets in pipe flanges, or passing valves can allow cargo to escape into the sea, into segregated ballast tanks, or into void spaces such as the double hull or cofferdams. The SPOB Seroja V incident involving Tank 3P leakage into the double hull is a prime example of this mechanism.

Clingage and Sedimentation: Viscous cargoes may adhere to the walls of the tanks (clingage) or deposit sediments on the tank bottom, rendering a portion of the cargo unpumpable. This is often categorized as ROB (Remaining On Board) and is influenced by the tank coating condition and the effectiveness of the stripping system.

Theft and Pilferage: While less common in highly regulated terminals, the unauthorized removal of cargo—often disguised as sludge disposal or through bypass lines—remains a physical security risk in certain regions. SPOBs operating in remote riverine areas must be particularly vigilant against this form of loss.

Figure 1. Theft and Pilferage

2.1.2 Apparent Loss

Apparent loss, often termed "paper loss," arises from inaccuracies in data rather than an actual disappearance of the product. These losses are often reversible or reconcilable through recalculation. Causes include:

Measurement Errors: Inaccuracies in sounding (ullaging), temperature determination, or water cut gauging. On vessels like SPOBs that rely on manual open gauging, human error (e.g., misreading the tape, parallax error, improper bob contact) is a significant factor.

Calculation Discrepancies: Errors in applying Volume Correction Factors (VCF) derived from ASTM tables (e.g., Table 54 for product conversion to standard temperature). Incorrect density inputs or failure to calibrate shore versus ship tank tables can lead to substantial variance. For FAME, the density-temperature relationship is critical; using a standard mineral diesel table instead of a specific biofuel table can introduce error.

Figure 2. Calculation Discrepancies

Instrument Calibration: The use of uncalibrated or defective sounding tapes, thermometers, or flow meters can systematically skew volume readings. A stretched tape or a thermometer reading 0.5°C off can result in a calculated difference of thousands of liters over a full cargo load.

Figure 3. Instrument Calibration

2.2 Characteristics and Handling of FAME (Fatty Acid Methyl Ester)

Fatty Acid Methyl Ester (FAME) serves as the bio-component in Indonesia's B30/B35 diesel blends. Produced through the transesterification of vegetable oils (predominantly palm oil in Indonesia) with methanol, FAME possesses distinct physicochemical properties that differentiate it from mineral diesel.

Solvency and Corrosivity: FAME acts as a mild solvent. It can dissolve sediments deposited by previous fossil fuel cargoes, leading to filter clogging, and can degrade incompatible rubber seals, gaskets, and hoses, increasing the risk of leaks in the cargo system. This property necessitates the use of specific chemical-resistant gaskets (e.g., Teflon or Viton) rather than standard rubber.

Hygroscopic Nature: FAME has a high affinity for water. Absorption of moisture during transport can promote microbial growth at the fuel-water interface, leading to sludge formation and corrosion of tank bottoms (Microbiologically Influenced Corrosion or MIC).

Temperature Sensitivity: FAME has a higher cloud point and pour point than mineral diesel. If temperatures drop, wax crystals can form, leading to stratification or solidification, which complicates stripping and increases ROB quantities. Maintaining the cargo temperature within the ideal is crucial to prevent both solidification and excessive evaporation.

These properties necessitate stringent "closed loading" systems and specialized tank coatings, features that may be absent or degraded on older SPOB vessels designed originally for conventional heavy fuel oil or diesel.

2.3 Operational Profile of Self-Propelled Oil Barges (SPOB)

The SPOB is a specialized vessel class ubiquitous in the Indonesian archipelago. Designed with a flat-bottom hull similar to a towed barge but equipped with independent propulsion, SPOBs are optimized for shallow-water access, allowing them to navigate rivers and enter small depots inaccessible to larger tankers.

However, the SPOB design presents inherent challenges for loss control. The flat hull form can make effective stripping (draining the last residues of cargo) difficult, especially if the vessel cannot achieve a sufficient stern trim. Furthermore, many SPOBs, including the Seroja V, operate without a centralized Cargo Control Room (CCR), requiring crew members to manually operate valves on the open deck. This increases the latency in valve switching during loading/discharging and heightens the risk of human error or miscommunication. The structural integrity of older barges is also a concern; repeated groundings in shallow rivers can compromise hull plating, leading to undetectable leaks into double bottoms or void spaces.

2.4 Legal and Documentation Framework

Loss control is underpinned by a rigorous documentation trail. Key documents include:

Notice of Readiness (NOR): A legal declaration by the Master that the vessel has arrived and is in all respects ready to load or discharge. The timing of the NOR triggers the commencement of laytime and is critical for demurrage calculations. An invalid NOR due to cargo unreadiness (e.g., tanks not dry) can lead to significant commercial disputes.

Vessel Experience Factor (VEF): A historical ratio comparing the ship's measured quantity to the shore's measured quantity over previous voyages (typically the last 5-10 voyages). The VEF is used to validate the ship's figures and determine if a specific voyage's loss is consistent with the vessel's history. It is a critical tool for distinguishing between a physical loss and a shore-side measurement error.

Stowage Plan: A schematic diagram ensuring the vessel is loaded within stability limits and that cargo grades are segregated to prevent contamination. Proper stowage planning on an SPOB is vital to ensure optimal trim for stripping.

Compartment Log Sheet: A record maintained by the cargo officer tracking the contents, ullage, temperature, and volume of each tank at every stage. This document forms the primary evidence base for any loss investigation.

3. Research Methodology

3.1 Research Design

This study employs a qualitative research method with a descriptive approach. This methodology was selected to provide a deep, contextual understanding of the operational realities aboard the SPOB Seroja V. Unlike purely quantitative studies that might rely solely on statistical regression of loss data, the qualitative approach allows for the investigation of the *mechanisms* and *behaviors*—both mechanical and human—that lead to cargo loss. The descriptive nature of the study facilitates a detailed reconstruction of the events leading to the identified losses, specifically the leakage incident observed in January 2025.

Qualitative research is particularly appropriate here as it allows the researcher to explore the "how" and "why" of cargo loss, interpreting the social and technical interactions on board (e.g., communication between the Chief Officer and the pump operator, or the decision-making process during gauging).

3.2 Location and Object of Research

The primary locus of this research is the **SPOB Seroja V**, a self-propelled oil barge operated by PT. USDA Seroja Jaya. The vessel has a Gross Tonnage (GT) of 2,280 and a cargo capacity of approximately 3,500 MT. The research was conducted during a continuous onboard training period (PRALA - *Praktik Laut*) spanning 12 months, from January 29, 2024, to January 29, 2025. This extended duration allowed for the observation of multiple voyage cycles, providing a longitudinal perspective on vessel operations and maintenance standards.

The specific case study centers on the voyage discharging at the Pertamina Plaju terminal, Palembang, where significant discrepancies were noted.

3.3 Data Sources

Data were aggregated from two primary streams to ensure robustness:

1) Primary Data: Gathered directly from the operational environment.
   a. Informants: The researcher utilized purposive sampling to select key personnel for interviews. These included the Master (Nakhoda), Chief Officer (Mualim I), Second Officer (Mualim II), Boatswain (Bosun), and Cargo Surveyors. These individuals possess the direct authority and technical knowledge relevant to cargo operations.
   b. Direct Observation: The researcher participated in daily deck operations, including tank sounding, manifold connection, valve alignment, and stripping procedures. This hands-on involvement allowed for the verification of whether SOPs were being followed in practice versus in theory.
2) Secondary Data: Derived from vessel documentation and external literature.
   a. Vessel Documents: Ship's Particulars, Crew Lists, Stowage Plans, Ullage Reports (Ship Figures After Loading/Before Discharge), Time Sheets, and the Abstract Log.
   b. Literature: Academic journals, relevant laws (e.g., Permen ESDM), standard manuals (ISGOTT), and previous thesis works utilized to cross-reference findings.

3.4 Data Collection Techniques

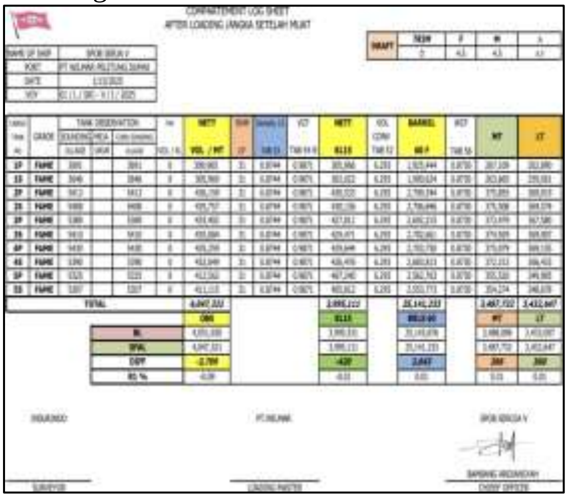
The triangulation of data collection techniques ensured the reliability of findings:

Observational Analysis: The researcher monitored the physical condition of the cargo tanks, the calibration status of sounding tapes, and the execution of the "dry tank" checks. Specific attention was paid to the "One Foot" sampling method and the final stripping phase to detect any procedural deviations.

In-depth Interviewing: Semi-structured interviews were conducted. Questions focused on the crew's understanding of loss control, their perception of the vessel's maintenance status, their rationale during critical decision-making points, and their explanation for the losses encountered. For example, the Boatswain was interviewed regarding the line-blowing procedures, while the Master was questioned on overall loss control strategy.

Documentation Review: A systematic analysis of the *Cargo Calculation Log* and *Compartment Log Sheets* was performed. This involved comparing the Ship Figures After Loading (SFAL) with Ship Figures Before Discharge (SFBD) to quantify the exact volume of "In-Transit Loss" and analyzing the VEF records to identify historical trends.

Table 1. Compartment Log Sheet - After Discharge



3.5 Data Analysis Technique

The analysis followed the qualitative flow model suggested by Miles and Huberman:

Data Reduction:

Selecting key incidents (like the Tank 3P leakage) and relevant interview excerpts from the mass of data collected during the 12-month period.

Data Display:

Organizing measurement tables, creating comparison charts of loading vs. discharge figures, and structuring interview transcripts into thematic categories (Physical vs. Apparent causes).

Conclusion Drawing / Verification:

Synthesizing the findings to answer the research questions and formulating recommendations. The conclusions were verified by cross-referencing interview statements with physical evidence (e.g., the visual confirmation of FAME in the double hull confirmed the Chief Officer's suspicion of leakage).

4 Results and Discussion

4.1 General Overview of the Research Object

The SPOB Seroja V is a dedicated FAME carrier owned by PT. USDA Seroja Jaya. Its design particulars are critical to understanding its loss profile. With a length overall (LOA) of 87.26 meters, a breadth of 15.60 meters, and a depth of 5.60 meters, the vessel operates with a relatively shallow draft, suitable for riverine terminals like Plaju. The vessel utilizes a cargo system comprising 10 main cargo tanks (1-5 Port/Starboard) with a total capacity of approximately 4,000 Kiloliters.

Figure 4. SPOB Seroja V

Notably, the vessel lacks an automated cargo monitoring system (such as radar gauging or a centralized computer in a CCR); all gauging is manual, performed via sounding pipes on the main deck. The crew complement consists of 15 personnel. The deck department, responsible for cargo operations, includes the Master, Chief Officer, Second Officer, Boatswain, and Able Seamen (AB). The absence of a Third Officer or dedicated Pumpman places the burden of cargo line setting and pump operation heavily on the Chief Officer and Boatswain, increasing the workload and potential for fatigue-induced errors.

4.2 Presentation of Data

4.2.1 The Leakage Incident of January 2025

On January 21, 2025, the SPOB Seroja V berthed at the Pertamina Plaju jetty to discharge FAME. The operation began with standard protocols: a key meeting between the Chief Officer and the Loading Master, followed by the connection of cargo hoses. The initial gauging (sounding) of all cargo tanks was conducted by the Chief Officer, witnessed by the surveyor and the cadet (researcher).

Table 2 below summarizes the measurement data recorded before discharge.

Table 2. Compartment Log Sheet - Before Discharge

COMPARTEMENT LOG SHEET
BEFORE DISCHARGE / ANGKA SEBELUM BONGKAR

NAME OF VESSEL	SPOB SEROJA V			
PORT	PERTAMINA PLAJU			
DATE	[illegible]			
VOY	[illegible]			
DRAFT	TRIM	F	M	A
	0	4,5	4,5	4,5

CARGO TANK NO	GRADE	TANK OBSERVATION SOUNDING	TANK OBSERVATION MEA	TANK OBSERVATION CORR ULLAGE	FREE WATER	OBS	TEMP	DENSITY 15	VCF	NETT KL15	VOL CONV	BARREL	WCF	MT	LT
1P	FAME	3855		3855	0	324.572	29	0,8757	0,9887	[illegible]	6,2[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1S	FAME	3883		3883	0	[illegible]	29	0,8757	0,9887	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2P	FAME	5307		5307	0	[illegible]	29	0,8757	0,9887	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2S	FAME	5304		5304	0	[illegible]	29	0,8757	0,9887	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3P	FAME	5303		5303	0	[illegible]	29	0,8757	0,9887	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3S	FAME	5309		5309	0	[illegible]	29	0,8757	0,9887	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4P	FAME	5326		5326	0	[illegible]	29	0,8757	0,9887	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4S	FAME	5307		5307	0	[illegible]	29	0,8757	0,9887	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5P	FAME	5320		5320	0	[illegible]	29	0,8757	0,9887	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5S	FAME	5302		5302	0	[illegible]	29	0,8757	0,9887	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL						[illegible]				[illegible]		[illegible]		[illegible]	[illegible]
						[illegible]				KL15		[illegible]		MT	LT
SFAL						[illegible]				[illegible]		[illegible]		[illegible]	[illegible]
SFBD						[illegible]				[illegible]		[illegible]		[illegible]	[illegible]
DIFF						[illegible]				[illegible]		[illegible]		[illegible]	[illegible]
R1%						[illegible]				[illegible]		[illegible]		[illegible]	[illegible]

Upon comparison with the loading figures from the port of origin (Pelintung), a discrepancy was noted. The Bill of Lading (B/L) figure was 4,051.030 KL, while the Ship Figure Before Discharge (SFBD) was 3,993.582 KL.

Table 3. Cargo Reconciliation

Remaining On Board (ROB)	0	0
Discharge Ratio (R3)		
Ship Figure Discharge (SFBD)	4.039.226	3.993.582
Received Figure	3.978.748	3.935.704
Difference	-60.478	-57.878
Percentage (%)	-1,50%	-1,45%
Supply Ratio (R4)		
Bill Of Lading	4.051.030	3.995.531
Received Figure	3.978.748	3.935.704
Difference	-72.282	-59.827
Percentage (%)	-1,78%	-1,50%

Remarks :
1. Quantity calculated was based upon ASTM Table 54
2. Bill of Lading was based upon Flowmeter / Shore Tank Ullage at PERTAMINA PLAJU

The variance of -1.13% (Ship to Ship) and -1.42% (B/L to Ship) significantly exceeded the 0.5% tolerance threshold commonly accepted in the industry. This triggered an immediate investigation.

4.2.2 Investigation and Interview Findings

The surveyor and ship's command initiated a "dry check" and internal inspection. This involved opening manhole covers. The visual inspection revealed a critical failure: FAME cargo was discovered in the double hull space adjacent to Cargo Tank No. 3 Port (3P).

To understand the context of this failure and other loss factors, interviews were conducted.

Interview with the Boatswain (Bosun):

Observation: The Bosun identified temperature and density and evaporation as common causes. Crucially, he highlighted the importance of "dry tank" checks and ensuring the "cargo line" is blown with Nitrogen (N2) to prevent residue.

Quote: Mismatch between tank and cargo character can erode plates... maintenance is required

Insight: The Bosun points to material incompatibility. FAME is corrosive; if the SPOB's tanks are mild steel without proper epoxy coating, the "character of the tank" is indeed mismatched, leading to the leak in Tank 3P.

Interview with the Chief Officer:

Observation: The Chief Officer attributed loss to "lack of supervision" and "equipment condition." He noted that poor sealing on manholes causes evaporation.

Quote: Evaporation causes significant shrinkage in figures

Insight: He emphasizes "Apparent Loss" factors like measurement accuracy ("Accurate Measurement") and "Physical Loss" factors like evaporation. He stressed that neglecting this leads to "sign off" or "off-hire," indicating high commercial pressure.

Interview with the Master:

Observation: The Master focused on the human element and the lack of automation.

Quote: Recent voyages show continuous losses... caused by officers being too aggressive during stripping)

Insight: "Aggressive stripping" sucks air into the line, causing cavitation and potentially leaving residue if the pump loses suction before the tank is dry. He estimates 50% of losses are due to measurement errors.

4.3 Discussion

The investigation confirms that cargo loss on the SPOB Seroja V is a composite issue involving both physical integrity and operational competence.

4.3.1 Analysis of Physical Loss

Structural Failure (Leakage): The discovery of FAME in the double hull adjacent to Tank 3P constitutes the most critical and massive physical loss identified in this operation. Comparing the Bill of Lading (B/L) volume to the Ship Figure Before Discharge (SFBD), the vessel experienced a significant discrepancy of approximately 57.4 KL. Visual inspections and internal soundings confirmed that the vast majority of this unrecoverable volume had migrated directly into the void space due to a structural breach. This validates the physical toll of FAME's corrosive and solvent properties on aging, potentially uncoated mild steel structures, presenting not only a severe financial deficit but also a major safety and environmental hazard.

Evaporation: While the Chief Officer raised concerns regarding worn manhole seals and vapor pressure in tropical conditions (cargo temperature at 29-30°C), volumetric calculations indicate that evaporative "breathing" losses account for a negligible fraction of the total cargo shrinkage. Compared to the massive structural leak in Tank 3P, evaporation is a highly secondary factor in this specific incident, though maintaining PV valves remains standard operational practice.

Residue (ROB): The Master's comment on stripping is critical. SPOBs have flat bottoms. To strip effectively, the vessel must have a significant trim by the stern to allow liquid to flow to the suction bell. If the "trimming" is not managed correctly by the duty officer (e.g., discharging tanks in the wrong sequence), pockets of cargo remain on the tank floor.

4.3.2 Analysis of Apparent Loss

Measurement Error: The Master stated that 50% of issues are measurement-related. On the Seroja V, sounding is manual. A "wet cut" reading error of just 1 cm on a large tank like Tank 3P (Capacity ~400 KL) can represent substantial volume. Rough waters or rolling during sounding exacerbates this.

Density Discrepancies: FAME density varies inversely with temperature. If the shore terminal uses a density of 0.875 kg/L (at 15°C) but the ship observes 0.8725 kg/L (at 29°C) without proper ASTM Table conversion, a "paper loss" appears. The document shows the ship used ASTM Table 54 , but slight errors in the input temperature (e.g., reading 29°C instead of 29.5°C) ripple through the calculation.

Equipment Calibration: The research implies that sounding tapes and thermometers are not always calibrated. A stretched tape reads a higher ullage (lower liquid level), artificially creating a loss record.

4.3.3 Operational Culture and Supervision

The interviews reveal a reactive rather than proactive safety culture. The leakage was found *after* a significant loss was noted, not during routine maintenance. The reliance on manual monitoring ("Pengawasan Manual") in the absence of a CCR requires high discipline. However, the "aggressive stripping" mentioned by the Master suggests a rush to complete operations, perhaps driven by pressure to minimize port time, which paradoxically leads to inefficiency (leaving cargo behind or damaging pumps).

5. Conclusions

Based The research findings indicate that the primary causes of cargo loss aboard the SPOB Seroja V are attributed to physical containment failures—specifically leakage from compromised valves, hoses, or connections—alongside natural evaporation and volumetric measurement errors. While previous studies acknowledge that evaporative and ullage losses are often inherent to oil transportation, this analysis identifies that specific operational deficiencies significantly exacerbate these discrepancies. Inaccurate cargo quantification typically stems from the use of uncalibrated or damaged sounding apparatus, inconsistent recording practices, and a lack of rigorous supervision during the measurement process, all of which contribute to widening the variance between documented and actual cargo volumes.

Furthermore, the study underscores the critical necessity of systematic maintenance and adherence to established international protocols, such as the International Safety Guide for Oil Tankers and Terminals (ISGOTT). Routine inspections of pressure-vacuum valves, tank integrity, and pump line cleanliness are essential for early leak detection, while the disciplined application of stripping techniques and manual sounding significantly mitigates the issue of cargo remaining on board (ROB). Failure to implement these technical and procedural safeguards results not only in documentation inaccuracies but also in tangible economic liabilities, including shortage claims, demurrage penalties, and increased insurance costs arising from discrepancies between bills of lading and outturn reports.

To address these challenges, the study recommends a targeted and comprehensive preventive strategy that prioritizes specific engineering interventions alongside operational rigor. From an engineering perspective, it is critical to resolve the material incompatibility between the SPOB's aging mild steel tanks and the highly corrosive nature of FAME. The primary recommendation is the immediate application of specialized chemical-resistant tank coatings—such as Epoxy Phenolic or Zinc Silicate formulations—which are specifically designed to withstand the aggressive solvency and hygroscopic properties of biofuels, thereby preventing future structural breaches like the one observed in Tank 3P.

Operationally, crew members must undergo intensive training aligned with the ISM Code. This training should emphasize the strict calibration of measurement instruments, the precise execution of loading and discharging sequences for optimal stripping, and the rigorous performance of "dry tank" inspections.

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