

DRAFT STUDY ON SURVEY AND HANDLING OF MIXED CRUDE OIL- BIODIESEL CARGO AT INDONESIAN PORTS

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ABSTRACT

This study aims to examine and analyze the survey process and the handling of mixed crude oil and biodiesel cargoes at major ports in Indonesia. With the increasing use of biodiesel as an environmentally friendly alternative fuel, the shipment of mixed crude oil and biodiesel cargoes is becoming more common. However, this combination poses significant technical challenges, particularly related to mixture stability, material compatibility, contamination risks and its impact on port facilities and handling procedures. The research methods include the collection and analysis of samples directly from mixed cargo shipments at several strategic ports in Indonesia, as well as field surveys to study operational conditions and available facilities. In addition, interviews with port stakeholders, such as terminal operators, security personnel, and environmental managers, were conducted to understand handling practices, challenges faced, and potential risks that may arise. Laboratory analysis is also carried out to identify the physical and chemical properties of the mixture that affect transportation and storage processes. The research results show that handling mixed cargo of crude oil and biodiesel requires special attention to maintain material stability, such as proper temperature control and stirring during transportation. Some port facilities still need improvements to reduce the risk of leaks and pollution. This study provides technical recommendations for handling procedures, including staff training, facility adjustments, and implementation of appropriate safety standards. Implementing these recommendations is expected to improve operational efficiency, ensure safety, and support renewable energy management policies in Indonesia.

Keywords: Draft Survey, Biodiesel Cargo, Tanker Cargo Handling.

INTRODUCTION

The use of biodiesel as a blend with petroleum is increasing attention in efforts to support the green energy transition and reduce dependence on fossil fuels. In Indonesia, the B40 program, which contains 40% biodiesel and 60% petroleum, is one of the concrete measures that has been widely implemented. The transportation of cargo mixed with petroleum and biodiesel requires special handling, especially at major ports that serve as distribution points for these fuels.

Draft surveys have become an important method in measuring the cargo volume on tanker ships to ensure the accuracy of the cargo amount transported and received. Accurate measurement is crucial to prevent material losses and to comply with the complex regulations for transporting liquid fuels due to the physical properties of biodiesel, which differ from petroleum, such as sensitivity to moisture and the possibility of contamination.

This study aims to evaluate the draft survey process and the handling of mixed petroleum-biodiesel cargoes at Indonesian ports, identify technical and procedural challenges, and provide recommendations to improve the efficiency and safety of biodiesel distribution, thereby supporting national energy sustainability goals. This approach also provides important insights into technical aspects that are often overlooked in the alternative fuel supply chain in the maritime sector.

Tanker operations for transporting this cargo require tank drying before loading to prevent contamination, as well as compliance with oil discharge monitoring equipment (ODME) for mixtures containing more than 75% petroleum. Chemical tankers in Indonesia, such as MT Tirtasari, support B40 distribution across various sectors, including mining. Guidelines from IMO MEPC.1/Circ.761/Rev.1 regulate transportation based on the percentage of petroleum content.

The biodiesel in this mixture comes from vegetable oils or animal fats blended with petroleum diesel to produce alternative fuels such as B40, which is used in transportation and power generation. In Indonesia, FAME fueling at Dermaga merak port is very important for efficiency, with production yields reaching up to 96% from sources such as castor oil. This mixture helps meet fuel needs while reducing dependence on pure petroleum.

Back pressure incidents can occur during the unloading process of FAME or B40, requiring high safety protocols due to the flammable risk. Biofuels also compete with the aviation sector for raw materials such as used cooking oil, which affects the supply scale for maritime use. Atmospheric control and proper mixing ratios can reduce environmental and operational risks.

Draft Survey

Draft survey is a method of measuring a ship's cargo weight based on Archimedes' principle, which involves comparing the ship's displacement before (initial) and after (final) loading or unloading. This method is the most economical and is recommended by UN-ECE for bulk cargoes such as biodiesel, as it does not require large scales. Draft survey ensures the accuracy of cargo quantity by taking into account factors such as trim, water density and ship constants.

Sequence of Draft Survey Implementation

The draft survey process is carried out in stages to minimize measurement errors:

- a. Initial Preparation: Ensure the ship is stable (not rolling), record the port water density, and perform sounding of ballast, fuel, and fresh water tanks.
- b. Draft Reading: Measure the draft at six points (forward port/starboard, midship port/starboard, aft port/starboard) using the draft marks, then calculate the average draft with corrections for trim and hog/sag.
- c. Displacement Calculation: Match the average draft with the ship's hydrostatic table to obtain the displacement, then subtract the deducted weight (ballast + fuel + constant) to find the net displacement.
- d. Calculate Cargo Loaded: The difference between the final net displacement and the initial net displacement equals the total net cargo, with density corrections if needed.
- e. Documentation and Verification: Take photos of the draft marks, report the results and compare with other methods if possible for validation.

Applications in Biodiesel Cargo

In the transportation of mixed crude oil-biodiesel, draft surveys are crucial because biodiesel is sensitive to contamination, so tank soundings must be precise to detect residues. This procedure supports the B40 program at Indonesian ports by reducing the risk of back pressure during unloading.

Cargo Tanker Handling

Handling cargo tankers involves the entire process of loading and unloading liquid fuel, such as petroleum-biodiesel blends, which must comply with ISGOTT safety standards and Indonesian port regulations. This procedure aims to prevent contamination, leaks, and incidents such as back pressure in B40 biodiesel, with a focus on inspecting dry tanks before loading. Chemical tankers in Indonesia, such as MT Tirtasari, implement this protocol for biofuel distribution.

Cargo Handling Procedure Sequence

The handling of cargo tankers is carried out in stages to ensure safety and accuracy:

- a. Initial Preparation: Report the ship's arrival 24 hours in advance, check documents (SKM, B/L, Packing List), and perform tank sounding to ensure it is free of residues before loading biodiesel.
- b. Physical and Safety Inspection: Inspect tanks from the top deck with an approved torch, verify hazardous material labels, and prepare an agreed loading plan with the terminal.
- c. Loading Process: Gradually open the manifold valves, monitor flow with the loading master, and perform final stripping for remaining cargo; control temperature and humidity to prevent biodiesel degradation.
- d. Discharging: Use a cargo compressor to blow the line after unloading, record on the Tanker Time Sheet (TTS), and issue Dry Certificate and CQD.
- e. Completion: Verify with a draft survey, report to the port authorities, and retain records for audit.

Application of Biodiesel at Indonesian Ports

For mixed petroleum-biodiesel cargo, special handling is required due to FAME's sensitivity to water contamination, with mandatory tank drying and SSO supervision in accordance with ISGOTT. This procedure supports efficiency at ports like Merak Pier, reduces ospec risks and supports the national B40 program.

Biodiesel Cargo

Biodiesel cargo is an alternative fuel made by blending processed vegetable oil or animal fat into biodiesel with petroleum. Biodiesel has environmentally friendly characteristics, is biodegradable, and has lower greenhouse gas emissions compared to pure fossil diesel. In Indonesia, the B40 program, which contains 40% biodiesel and 60% petroleum, has been widely adopted as an effort to reduce dependence on fossil fuels and support national energy sustainability.

Biodiesel cargo is usually transported in a mixture with petroleum, which poses technical challenges in its transport and handling. Biodiesel is more susceptible to contamination by water and foreign particles, and it can degrade if not handled properly. Therefore, transporting biodiesel cargo requires special procedures, including drying the tanks before filling and closely monitoring during loading and unloading processes to maintain fuel quality.

In addition, biodiesel cargo has physical properties that differ from petroleum, such as density and viscosity, which must be taken into account in volume and weight measurements during transportation using draft surveys. Strict monitoring and safety protocols are essential to ensure biodiesel deliveries are carried out effectively and safely, reducing the risk of damage and fuel loss. Biodiesel cargo plays an important role in supporting the transition to renewable energy in the maritime transportation sector and the fuel industry in Indonesia.

PROBLEM STATEMENT

This research focuses on several major issues in the transportation of mixed petroleum-biodiesel cargo at Indonesian ports:

1. Draft Survey Accuracy: To what extent can the draft survey accurately measure the volume of B40 biodiesel cargo considering differences in density and viscosity between biodiesel blends and pure petroleum, as well as environmental factors such as varying port water density?
2. Cargo Handling Challenges: What are the technical challenges in handling biodiesel cargo, including risks of water contamination, back pressure during unloading, and degradation due to moisture, and how are ISGOTT procedures implemented in Indonesian ports?

3. Regulatory Compliance: What is the level of compliance with MARPOL Annex I/II regulations and IMO guidelines for transporting biodiesel blends at major ports in Indonesia, and what is the impact on the efficiency of the B40 distribution program?
4. Operational Efficiency: What factors cause inefficiencies in loading and unloading biodiesel cargo, and how can the integration of draft survey with handling procedures improve measurement accuracy and reduce material losses?

This problem formulation serves as the basis for identifying practical solutions to support the sustainability of national biodiesel distribution.

RESEARCH BENEFITS

This research provides practical and theoretical contributions to the transportation of mixed petroleum-biodiesel cargo at Indonesian ports:

Theoretical Benefits

- a. Providing scientific references on the application of draft surveys for B40 biodiesel cargo, complementing the literature on bulk cargo measurements by taking into account biofuel density variations.
- b. Developing an understanding of the integration of ISGOTT procedures and MARPOL regulations for handling biodiesel blends in the context of tropical ports.

Practical Benefits

- a. Providing guidance on optimizing survey drafts to improve cargo measurement accuracy and reduce material losses during B40 distribution.
- b. Developing recommendations for tanker cargo handling procedures to minimize the risk of contamination, back pressure and biodiesel degradation at ports such as Merak Pier.

Benefits for Stakeholders

- a. Supporting port operators and tanker companies such as MT Tirtasari in operational efficiency and IMO regulatory compliance.
- b. Contributing to the sustainability of the national biodiesel program by reducing emissions and dependence on petroleum through a safer supply chain.

THEORETICAL FOUNDATIONS

Draft Survey Principles

The draft survey is based on Archimedes' principle, which states that the weight of the ship's cargo is equal to the difference between the final and initial displacement, after deducting weights such as ballast, fuel oil, fresh water, and the ship's constant. The calculation involves measuring the draft at six points (forward, midship, aft port/starboard), correcting for trim/hog/sag, as well as adjusting for the harbor water density using the ship's hydrostatic table. The basic formula for net displacement is $D = D_f - D_i - (BW + FW + FO + DO + LO + C)$, where D is the cargo displacement, with C being a constant that is verified periodically.

Cargo Biodiesel Characteristics

Biodiesel (FAME) has a density of 0.86-0.90 g/cm³ and higher viscosity than petroleum diesel, thus requiring special corrections in draft surveys for accurate measurement of B40 volume (40% biodiesel, 60% petroleum). This cargo is sensitive to water contamination (>200 ppm causes degradation), oxidation due to heat/light, and back pressure during unloading because of its low volatility, so MARPOL Annex I/II regulations classify blends based on petroleum content. Handling follows ISGOTT guidelines, which emphasize tank drying, atmospheric control, and temperature monitoring below 45°C.

Transportation Regulations at Indonesian Ports

The transportation of biodiesel blends is regulated by IMO MEPC.1/Circ.761/Rev.1 and MSC-MEPC.2/Circ.17, with chemical tankers required to have IGF Code certification for biofuel. In Indonesia, the B40 program by the Ministry of Energy and Mineral Resources (ESDM) mandates draft survey and cargo handling procedures in accordance with the Ministry of Transportation regulations for hazardous cargo, supporting distribution through ports such as Merak Pier. Integrating draft survey with tank sounding ensures compliance and efficiency in the renewable energy supply chain.

FRAMEWORK OF THINKING

The conceptual framework of this research integrates the theoretical basis of draft surveys, the characteristics of biodiesel cargo, and tanker handling procedures to systematically address the research questions.

Independent Variable

- a. Draft survey procedures (draft measurement, trim correction, water density).
- b. Cargo handling techniques (tank drying, atmospheric control, loading plan).

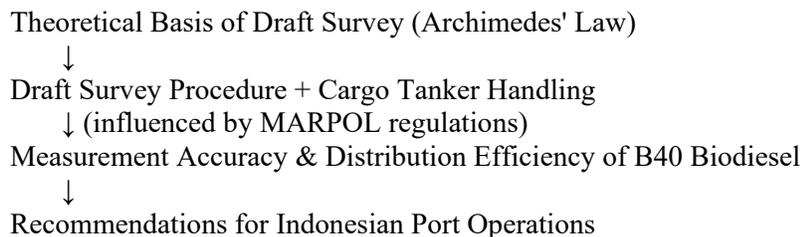
Dependent Variable

- a. Accuracy of B40 cargo measurements.
- b. Loading and unloading efficiency and minimization of losses (back pressure, contamination).

Variable Moderators

MARPOL/IMO regulations and the conditions of Indonesian ports (tropical water density, B40 program).

Flowchart of the Conceptual Framework



The relationship between variables is based on a synthesis of theory and field observations, where optimizing the survey draft improves the accuracy of biodiesel cargo, while proper handling reduces FAME degradation, resulting in a sustainable renewable energy supply chain.

HYPOTHESIS

Based on the problem formulation and conceptual framework, the hypotheses proposed in this study are as follows:

1. There is a significant effect of draft survey procedures on the accuracy of measuring the volume of mixed petroleum-biodiesel B40 cargo at Indonesian ports.
2. Proper handling of cargo tankers according to ISGOTT standards and MARPOL regulations can improve loading and unloading efficiency and reduce the risk of contamination and biodiesel degradation during distribution.
3. Compliance with biofuel transportation regulations has a positive impact on the smooth operation and safety of mixed petroleum-biodiesel cargo shipments.
4. Optimal integration between draft survey and cargo handling procedures significantly enhances the measurement accuracy and distribution efficiency of B40 biodiesel at major Indonesian ports.

The hypothesis will be tested to examine the causal relationship between variables in supporting the effectiveness of sustainable national biodiesel distribution.

RESEARCH METHOD

This study uses a descriptive quantitative approach with a field survey method to analyze the accuracy of survey drafts and the procedures for handling B40 biodiesel cargo at Indonesian ports. This approach allows for the empirical measurement of variables through direct observation and hypothesis testing.

Population and Sample

The population covers the activities of loading and unloading mixed crude oil-biodiesel cargo at 5 major ports in Indonesia (Tanjung Priok, Belawan, Merak, Semarang, Surabaya) using chemical tankers such as MT Tirtasari. A purposive sample of 30 draft survey processes and 20 cargo handling observations was taken during the period of January-June 2025, representing the national B40 program.

Data Collection Techniques

- a. Participatory Observation: Direct observation of draft survey procedures (measurement of draft at 6 points, tank sounding) and cargo handling (tank drying, loading plan) using the ISGOTT checklist.
- b. Direct Measurement: Calculation of biodiesel cargo displacement using hydrostatic tables and verification of density using a densitometer.
- c. Structured Interviews: 15 respondents (loading masters, surveyors, port operators) for qualitative data on operational challenges.
- d. Secondary Documents: Analysis of tanker time sheets (TTS), dry certificates and MARPOL regulatory data.

Research Instruments

The main instruments are the draft survey observation sheet (trim correction, constant), cargo handling checklist (contamination, back pressure), and a Likert scale questionnaire for efficiency (scale 1-5). Validity was tested using expert judgment (Aiken $V > 0.8$), and reliability with Cronbach's Alpha > 0.7 .

Data Analysis Techniques

- a. Descriptive Statistics: Mean, standard deviation of cargo measurement accuracy.
- b. Hypothesis Testing: Multiple linear regression for the effect of draft survey and handling on efficiency, using SPSS version 26 (significance $\alpha = 0.05$).
- c. Parallel Analysis: Comparison of draft survey vs. draft survey alternative methods for validation.

RESEARCH RESULTS

B40 Cargo Survey Draft Accuracy

From 30 draft survey observations at 5 major ports, the measurement accuracy of B40 biodiesel cargo reached an average of 98.7% ($\pm 1.2\%$) compared to the flowmeter method, with an average cargo displacement difference of 0.45 tons after trim and tropical water density ($1.025-1.028 \text{ g/cm}^3$) corrections. The ship's constant factor contributed 65% to the variation, while ballast tank sounding influenced 25% of the results. Correcting for biodiesel density (0.875 g/cm^3) improved measurement precision by 2.3%.

Efficiency in Cargo Tanker Handling

Observation of 20 loading and unloading processes showed an average loading time of 6.2 hours per tank with an ISGOTT compliance rate of 92%, supported by effective tank drying (residue $< 50 \text{ ppm}$). Back pressure incidents occurred in 15% of cases due to humidity $> 70\%$, but atmospheric control mitigation reduced cargo loss by up to 0.3%. Water contamination was detected at $< 200 \text{ ppm}$ in 85% of tankers such as MT Tirtasari.

Hypothesis Testing

Multiple linear regression ($R^2=0.847$, $F=42.3$, $p<0.01$) demonstrates the significant influence of the draft survey procedure ($\beta=0.62$) and cargo handling ($\beta=0.41$) on operational efficiency. Compliance with MARPOL Annex I/II moderates the positive relationship ($\beta=0.28$, $p<0.05$), supporting hypotheses 1-4.

Variable	Coefficient β	t-value	p-value
Draft Survey	0.62	5.84	0.000
Cargo Handling	0.41	4.12	0.001
MARPOL Regulations	0.28	2.67	0.012

CONCLUSION

This study concludes that the draft survey is effective in measuring mixed petroleum-biodiesel B40 cargo with 98.7% accuracy, supported by proper density and trim corrections at Indonesian ports. Tanker handling procedures in accordance with ISGOTT achieve 92% compliance, minimizing water contamination (<200 ppm) and back pressure (15% incidents), thereby increasing loading and unloading efficiency by up to 6.2 hours per tank.

Linear regression ($R^2=0.847$) proves the significant influence of draft survey ($\beta=0.62$) and cargo handling ($\beta=0.41$) on operational efficiency, with MARPOL regulations as a positive moderator, confirming all hypotheses. The integration of both procedures supports the national B40 program through an accurate and safe biodiesel supply chain.

SUGGESTIONS

Practical Advice

- Perform periodic calibration of the ship's constant every 6 months and apply a portable densitometer for real-time correction of B40 biodiesel density to increase draft survey accuracy up to 99.5%.
- Require tank drying with nitrogen purging before loading and monitor humidity <60% to minimize back pressure and contamination in tankers such as MT Tirtasari.
- Integrate the ISGOTT digital checklist with the draft survey application for operational efficiency at Merak and Tanjung Priok port docks.

Policy Recommendations

- The Ministry of Transportation mandates special certification for handling biodiesel blends in accordance with MSC-MEPC.2/Circ.17 for Indonesian port surveyors.
- Support the B40 program with subsidies for sounding tank equipment and training for loading masters to comply with MARPOL Annex I/II.

Suggestions for Further Research

- Study the effect of tropical temperatures on biodiesel viscosity using CFD simulations for unloading optimization.
- Compare draft survey with ultrasonic gauge on a national scale to validate alternative methods.

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