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An Investigation on the Use of Enhanced Stripping Systems on Product Tankers as a Standalone Tank Preparation Method for Gasoline to Diesel Cargo Shifts

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Abstract

This study aimed to investigate the need for a better understanding of the appropriateness of using an enhanced stripping system as a standalone tank preparation method for gasoline to diesel cargo shifts. A qualitative research design was utilized to explore the experiences and perceptions of seven industry professionals, selected through purposive sampling to ensure a diverse range of perspectives. Semi-structured interviews were conducted, and thematic analysis was employed as the method of data analysis.

The key findings of this study revealed that decision-making, disadvantages of traditional tank preparation methods, and experience using an enhanced stripping system are the three main themes that influence the decision to use an enhanced stripping system as the main method of tank preparation for gasoline to diesel cargo shifts. The findings highlighted the importance of collaboration, consultation with other parties, access to accurate and relevant information, and compliance with regulations and guidelines in the decision-making process for using an enhanced stripping system as a standalone tank preparation method. The use of an enhanced stripping system was found to offer a more efficient, cost-effective, and environmentally friendly alternative to traditional tank preparation methods. This study also emphasized the importance of clear communication and coordination among parties involved in the shipment of cargo and tank preparation. Overall, this study contributes to a better understanding of the appropriateness of using an enhanced stripping system as the main tank preparation method for gasoline to diesel cargo shifts and highlights the need for further research in this area.

Language: English
Key Words: enhanced stripping, tank preparation, gasoline to diesel cargo shifts

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Appendix 1 Shell Ship Pre Cargo Matrix excerpt

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1 Introduction

Clean petroleum product (CPP) tankers are often faced with the challenge of having to prepare their cargo tanks for the carriage of their next cargo. Tank preparation may sometimes involve washing, mopping, and drying of cargo tanks, and this hazardous, resource intensive task is often carried out without much thought given to the negative consequences that may be brought about by this process. In today's world where safety, sustainability, and efficiency are top priorities, alternative methods and solutions are now always brought into consideration, and this trend applies to CPP tankers and their activities. Bearing this in mind, shipowners and other stakeholders in the tanker industry strive to keep up with innovation and advancement while keeping their business lucrative.

One of the cargo grade shifts carried out on CPP tankers is from gasoline to diesel cargoes and vice versa. When coming from diesel cargoes, gasoline can usually be loaded on top without any issue. However, when it is the other way around, tank preparation is required, and different methods are now recognized as appropriate cleaning procedures by various tank cleaning guides. Modern vessels are now equipped with enhanced stripping systems, and recently, the use of these systems has been acknowledged as an alternative to the conventional washing, mopping, and drying of ex-gasoline tanks that are to be loaded with diesel cargo. Figures 1 and 2 (FRAMO, 2022) in the following pages illustrate this system.

The process of washing, mopping, and drying of cargo tanks is not limited solely to these actions as several other factors need to be addressed before this can be carried out. Control of the atmosphere in the cargo tanks is required at almost every stage and various resources are consumed to ensure that the process is safe and compliant with regulations. If the necessity of having to supply inert gas to achieve appropriate atmosphere levels is present, the production of inert gas requires bunker fuel consumption, and this is one factor that impacts sustainability. Washing methods of cargo tanks vary from vessel to vessel. However, the production of oily slop wash water is a common result of this process, and the quantity produced may vary depending on factors such as equipment capacity and the extent of washing performed. The tank washing arrangements for each individual vessel can be found in its Procedures & Arrangements Manual or ship's particulars. Handling slop wash water is a challenging task and if one were to be concerned about

sustainability and operational costs, then producing slop wash water should be minimized or avoided as much as possible.

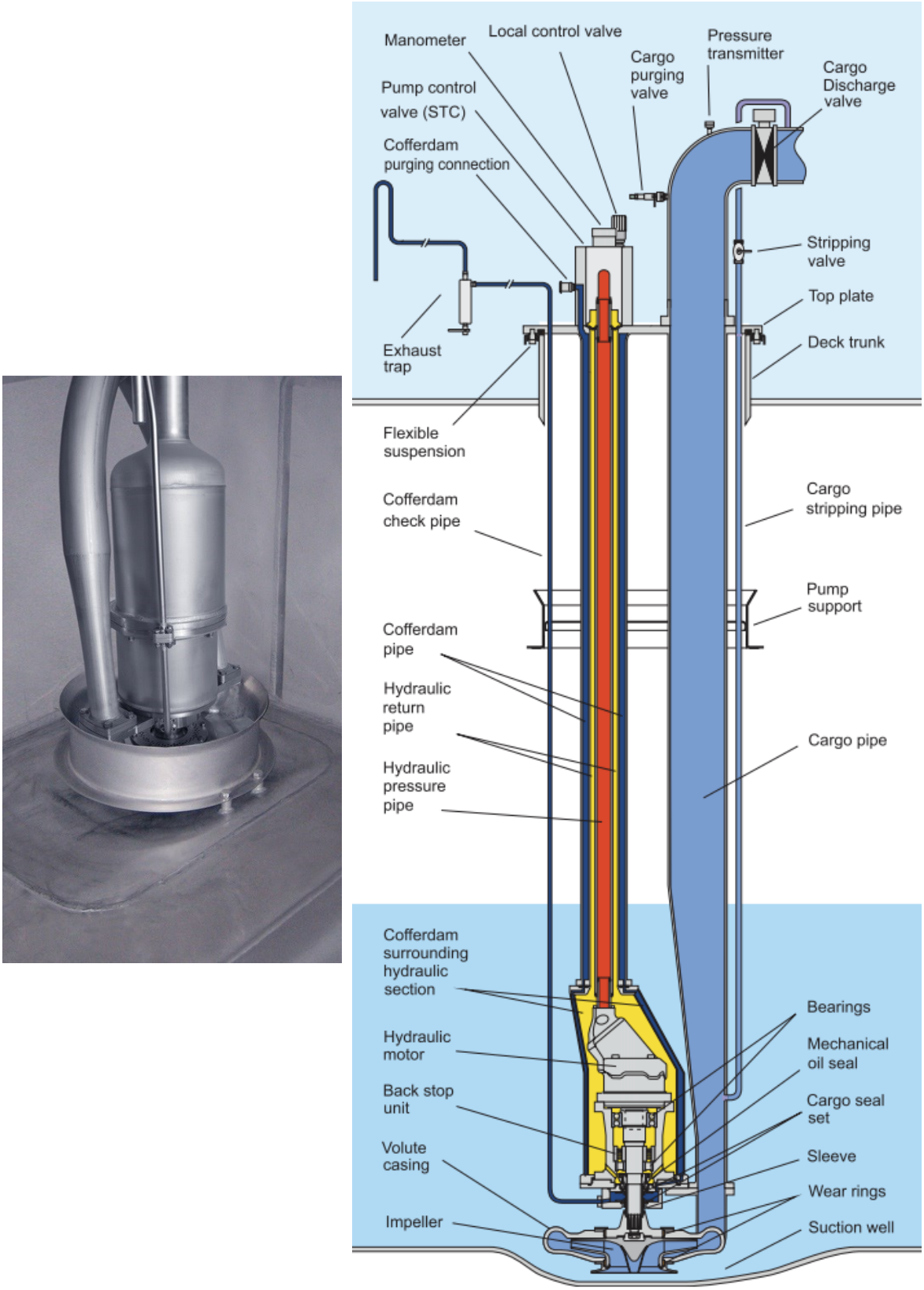

Figure 1. Photo of FRAMO cargo pump and its components (FRAMO, 2022)

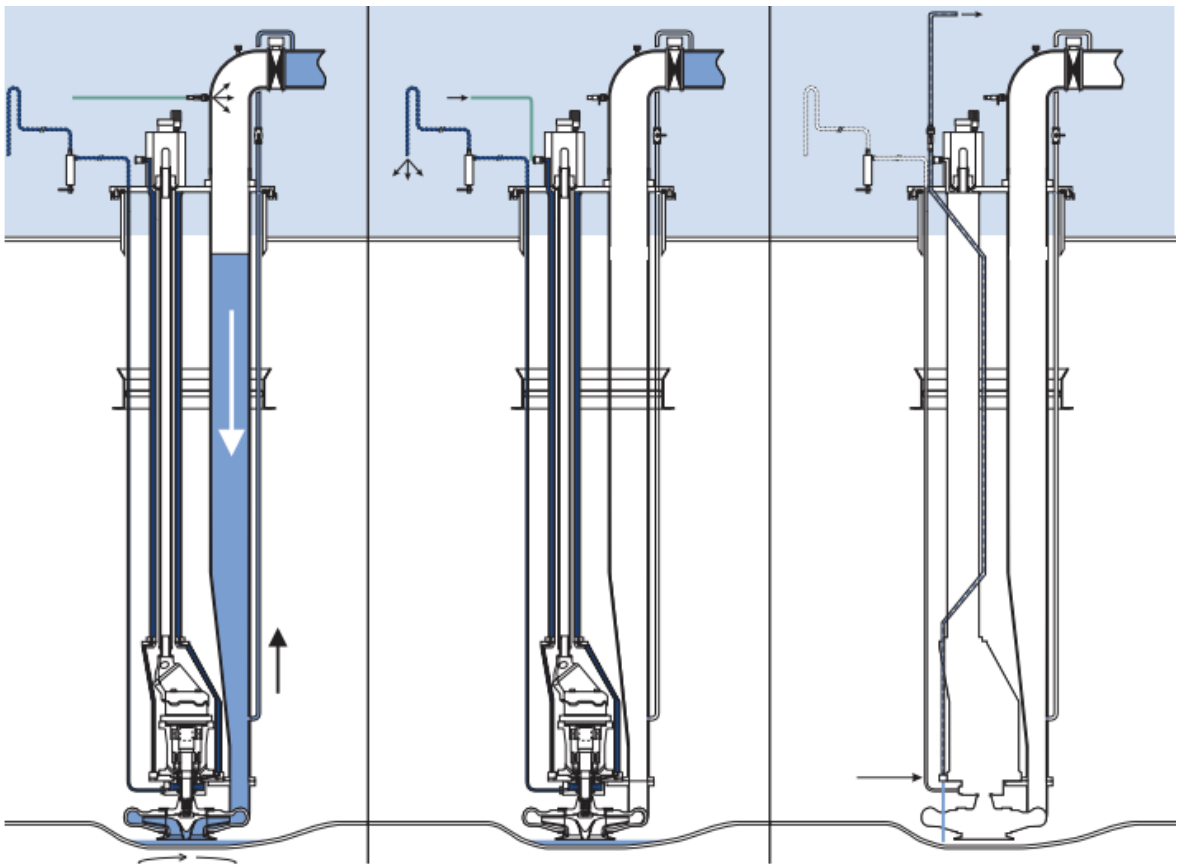

Figure 2. Illustration of submerged FRAMO cargo pump. Left: Conventional stripping. Middle: Cofferdam purging. Right: Vacuum drain / Enhanced stripping. (FRAMO, 2022)

To be able to mop and dry the tanks after washing, the atmosphere inside the cargo tank must be made safe for personnel entry. In order to achieve this condition, fresh air must be introduced into the tank, but this cannot be done immediately. The atmosphere in ex-gasoline cargo tanks after washing contains unsafe hydrocarbon (HC) levels that must be lowered before fresh air can be safely delivered into it. The safe hydrocarbon level is achieved by purging the hydrocarbon gases from the tank with inert gas and only when this is accomplished can fresh air be introduced for gas-freeing. Purging is a process wherein inert gas is introduced into a tank already in an inert condition with the purpose of reducing either the oxygen or hydrocarbon gas content in the tank. During the purging process, hydrocarbon gases are expelled from the tank into the atmosphere (International Chamber of Shipping [ICS], Oil Companies International Marine Forum [OCIMF], & International Association of Ports and Harbor [IAPH], 2006), and these gasoline vapors, according to the World Health Organization (2000), contain a variety of air pollutants such as Volatile Organic Compounds (VOCs) and Benzene. After purging the tanks of hydrocarbon gas, the inert gas used in the process is displaced by fresh air to ensure the tanks are gas-free for safe entry. Figure 3 illustrates the gas-freeing process. Once the tanks are gas-free and

confirmed to be safe for entry, personnel can then enter the tanks for mopping and drying. Once the cargo tank drying process is completed, the cargo tanks need to be re-inerted and this again takes a considerable amount of inert gas to achieve the desired condition. Almost every step in the tank cleaning process requires checking of the cargo tank atmosphere and this task is time consuming. Time spent on each activity should be considered, as time is a valuable resource that should be prioritized by those involved.

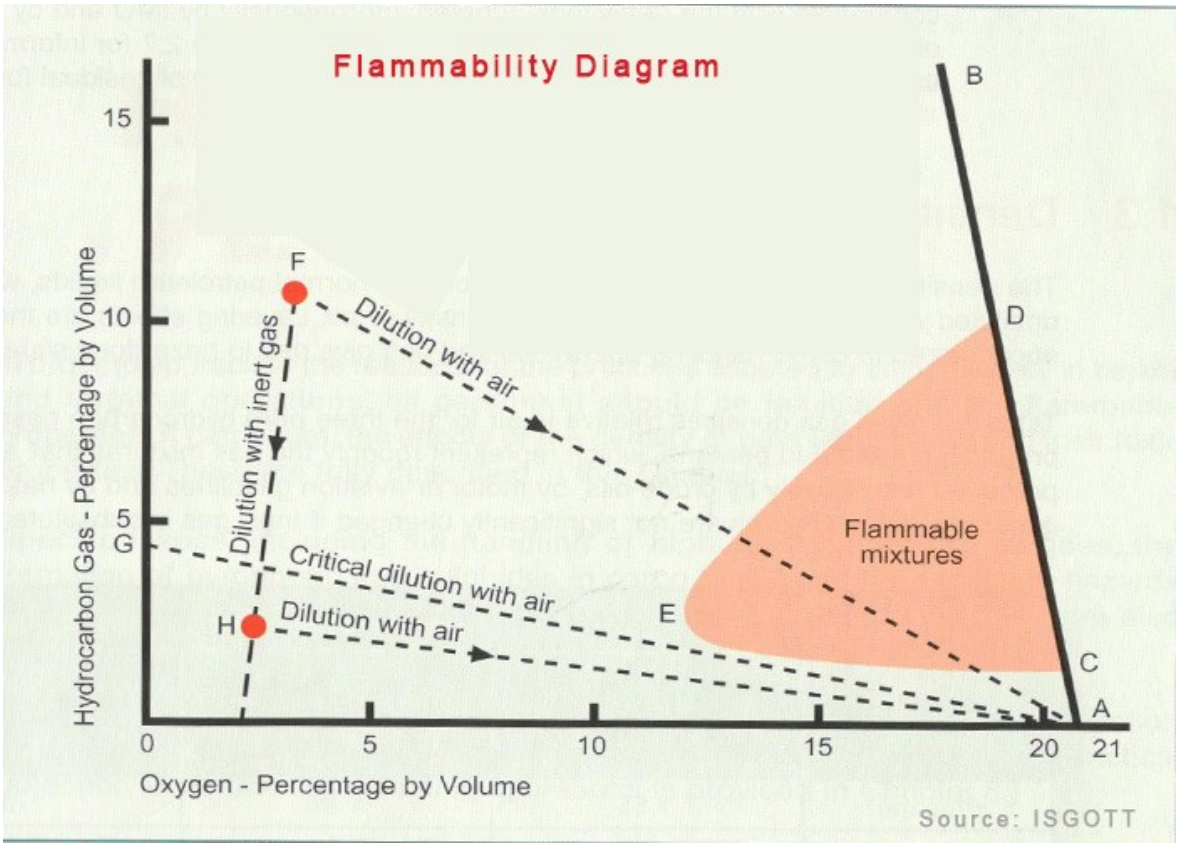

Figure 3. Flammability diagram (ICS, OCIMF, & IAPH, 2006)

The voyage instructions provided to vessels are often lacking in specificity and detail, typically only requiring that the cargo tanks be suitable for the next cargo. Figure 4 provides excerpts of clauses pertaining to tank cleanliness from voyage charter parties which are widely used in the industry. This leaves the final decision on the appropriate tank preparation method to the Master of the vessel. In many situations, when faced with uncertainty in handling gasoline to diesel cargo shifts, the typical course of action for the Master is to wash, mop, and dry the cargo tanks, as is widely practiced. This traditional tank cleaning method is resource-intensive and hazardous. Furthermore, this method may have negative consequences for sustainability. As such, there is a need for a better

understanding of the appropriateness of using an enhanced stripping system as an alternative tank preparation method for CPP tankers.

ASBATANKVOY

18. CLEANING. The Owner shall clean the tanks, pipes and pumps of the Vessel to the satisfaction of the Charterer's Inspector.

ExxonMobil VOY2012

3. TANK CLEANLINESS AND CARGO OPERATIONS.
(a) Owner warrants the tanks, pipes and pumps of Vessel are clean and suitable for the cargo specified in Part I (F) to the satisfaction of Charterer's representative(s).

"SHELLVOY 6"

Cleanliness of tanks — 2. Whilst loading, carrying and discharging the cargo the master shall at all times keep the tanks, lines and pumps of the vessel always clean for the cargo.

TANKERVOY 87

Cleaning — 5. (a) **The master shall exercise due diligence to keep the tanks, pipes and pumps of the vessel suitable for the cargo specified in Part I (C).**

Figure 4. Charter Party excerpts - ASBATANKVOY (Association of Ship Brokers & Agents, 1977), EXXONMOBIL VOY2012 (ExxonMobil, 2012), SHELLVOY 6 (Shell, 2005), TANKERVOY 87 (BIMCO, 1987)

Cargo tank preparation using solely an enhanced stripping system for gasoline to diesel cargo shifts is a relatively new method which a few tank cleaning guides have recognized. This method eliminates the need for traditional tank cleaning procedures and reduces the time and resources required to prepare cargo tanks for the next cargo. Despite its evident advantages, there is still apprehension about using the method due to its relative newness and uncommonness. The impacts on safety, efficiency, and sustainability of this alternative method need to be assessed and compared to traditional tank cleaning methods to strengthen its identity as an appropriate alternative.

1.1 Research problem

In recent years, the use of enhanced stripping systems for gasoline to diesel cargo shifts has gained increased attention due to its potential benefits in terms of safety, sustainability, and operational efficiency. However, despite its growing popularity, there is still apprehension about its use, and there is limited understanding of the appropriateness and feasibility of using such systems as a standalone method of tank preparation for these shifts. According to the Maritime Mutual Insurance Association (2020), there are currently no internationally agreed standard cleaning procedures for tanks which are specific to the CPP or any oil trades. However, comprehensive cleaning guides are available which have

been developed by both oil majors and independent experts and organizations. While some of these guides recognize the potential benefits of enhanced stripping, it appears that this method is not yet widely adopted in practice. Therefore, there is a crucial need for a better understanding of the appropriateness of the use of an enhanced stripping system as a standalone tank preparation method for gasoline to diesel cargo shifts.

This issue is particularly important given the potential environmental and economic impact of tank cleaning methods on the shipping industry. Traditional tank cleaning methods are resource-intensive and have been associated with significant costs and environmental consequences. These methods often require the use of large amounts of water and energy, which can lead to the generation of wastewater and air pollution. The disposal of these waste products can also be a significant challenge, as it can require specialized treatment facilities and incur additional costs. As the shipping industry continues to evolve and strive towards sustainability, there is a growing need for alternative tank cleaning methods that reduce the environmental impact and improve the operational efficiency of vessels. By reducing the use of resources and generating less waste, alternative methods can contribute to a more sustainable and cost-effective shipping industry.

Moreover, the impact on personnel safety should also be considered, as the risks of accidents and injury associated with traditional tank cleaning methods are quite high. Encountering numerous hazards, the most critical ones arise during enclosed space entry, including exposure to very low oxygen content or concentrations of toxic gases (Maritime and Coastguard Agency, 2015). According to the International Group of P&I Clubs (n.d.), 83 deaths have occurred in enclosed spaces during the period of 2015 to 2020, where 53% of deaths were due to oxygen depletion and over 60% of the incidents were located in the cargo hold. Utilizing an enhanced stripping system as the only form of tank preparation eliminates the need for tank washing and enclosed space entry, which reduces the risks to personnel and enhances their safety. The importance of personnel safety cannot be overstated, and any method that reduces the risks to personnel should be carefully evaluated and considered for adoption in the industry.

The use of an enhanced stripping system alone for gasoline to diesel cargo shift may have the potential to address these concerns and provide a safer, more sustainable, efficient, and cost-effective tank cleaning method. The potential impact of this research is significant,

as it has the potential to inform industry practices and regulations, as well as contribute to the development of more sustainable and efficient tank cleaning methods for gasoline to diesel cargo shifts.

1.2 Aim and delimitation

This study aims to explore the effectiveness and appropriateness of using enhanced stripping systems as a standalone cargo tank preparation method for gasoline to diesel cargo shifts, and to identify potential barriers to their use. The perceptions and experiences of industry professionals related to the use of enhanced stripping systems in gasoline to diesel cargo shifts will be explored to achieve this aim. The following objectives will be pursued:

- to identify any barriers to the adoption of enhanced stripping systems as a standalone method of tank preparation for gasoline to diesel cargo shifts in the shipping industry and suggest possible solutions;
- to evaluate the potential benefits and drawbacks of using enhanced stripping systems as the main tank preparation method for these shifts and how it is compared to traditional methods;
- to assess the effectiveness and appropriateness of enhanced stripping systems as a standalone method of tank preparation for gasoline to diesel cargo shifts; and
- to provide insights and recommendations for the development of more sustainable and efficient tank cleaning methods for gasoline to diesel cargo shifts.

The delimitations of this study include a focus on the perceptions and experiences of industry professionals related to the use of enhanced stripping systems in gasoline to diesel cargo shifts. This study will be limited to the CPP shipping industry, and only those who have experience in tanker operations and tank cleaning methods will be included in the sample. This study will not consider other types of tank cleaning methods or other cargo types. Additionally, this study will only focus on the potential benefits and drawbacks of using enhanced stripping systems as the main tank preparation method for gasoline to diesel cargo shifts, and will not cover the entire process of gasoline to diesel cargo shifting.

1.3 Research questions

To achieve this aim, the following questions need to be answered:

1. What are the key factors that influence the decision to use an enhanced stripping system as the main method of tank preparation for gasoline to diesel cargo shifts, as perceived by industry professionals?

2. How do industry professionals perceive the feasibility and appropriateness of using an enhanced stripping system as the main tank preparation method for gasoline to diesel cargo shifts, compared to traditional methods?

3. What are the experiences of industry professionals who have used an enhanced stripping system for gasoline to diesel cargo shifts, and how do these experiences inform their opinions on its appropriateness as a tank preparation method?

2 Theory and literature review

The purpose of this literature review is to provide an overview of the use of enhanced stripping systems for tank preparation in gasoline to diesel cargo shifts. The review draws upon related research materials to provide insights into different aspects of the topic, including the use of enhanced stripping systems as a standalone method for tank preparation, the perception of tank cleanliness standards in CPP trades, and various aspects relevant to CPP tankers, such as the control of tank atmospheres, cargo quality changes, and efficient cleaning methods.

These materials provide a valuable foundation for understanding the significance of this study. For example, the use of enhanced stripping systems is shown to be an effective method for substituting mopping procedures during tank preparation. Additionally, the lack of internationally agreed tank cleanliness standards highlights the need for a standardized approach. The materials also demonstrate the importance of controlling tank atmospheres to maintain safe conditions, and the need for sustainable and efficient cleaning methods to reduce environmental impact.

In summary, this literature review contributes to the current understanding of the use of enhanced stripping systems for tank preparation in the gasoline to diesel cargo shifts by

providing an overview of the different aspects of the topic and highlighting the potential benefits and drawbacks of this method.

2.1 Theoretical background

The theoretical background of this study consists of several key concepts, including enhanced stripping, traditional tank cleaning methods, safety, sustainability, and operational efficiency.

Enhanced stripping, which is also known as super-stripping (Svanehøj, n.d.) or vacuum drain (FRAMO, 2022), involves the use of specialized stripping systems and procedures to remove liquid cargo residue from the cargo tank sump. Furthermore, in the context of tank cleaning, enhanced stripping is recognized by some tank cleaning guides as a substitute to cargo tank mopping. These systems allow ships to comply with MARPOL Annex II Regulation 12 - Pumping, Piping, Unloading Arrangements and Slop Tanks (International Maritime Organization [IMO], 2017) which pertains to the carriage of substances in category X, Y or Z. The primary advantage of this approach when applied as a standalone tank preparation method for gasoline to diesel cargo shifts is that it can reduce the risks to personnel associated with traditional tank cleaning methods, while also improving operational efficiency by reducing the time and resources required for tank preparation.

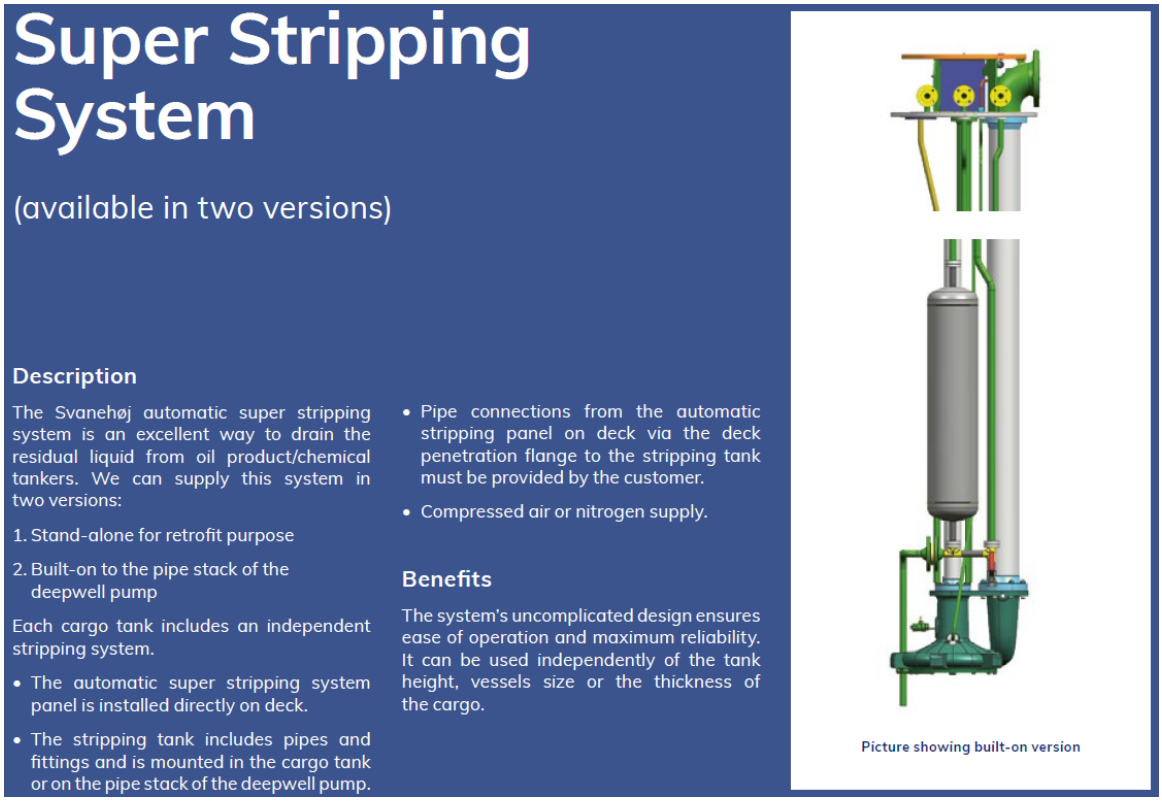

Figure 5. Svanehøj Super Stripping System (Svanehøj, n.d.)

Traditional tank cleaning methods involve the washing, mopping, and drying of cargo tanks, as well as the use of chemical agents on other types of cargo shifts. These can be complex and time-consuming, with details on procedures and precautions to be taken outlined in the International Safety Guide for Oil Tankers and Terminals (ICS, OCIMF, & IAPH, 2006). A paper by Stojan et al. (2011) explains the structural scheme of the system for washing tanks with sea water with a description of the main elements in the system. The complexity of traditional tank cleaning can also increase the possibility of prolonging downtime for the vessel.

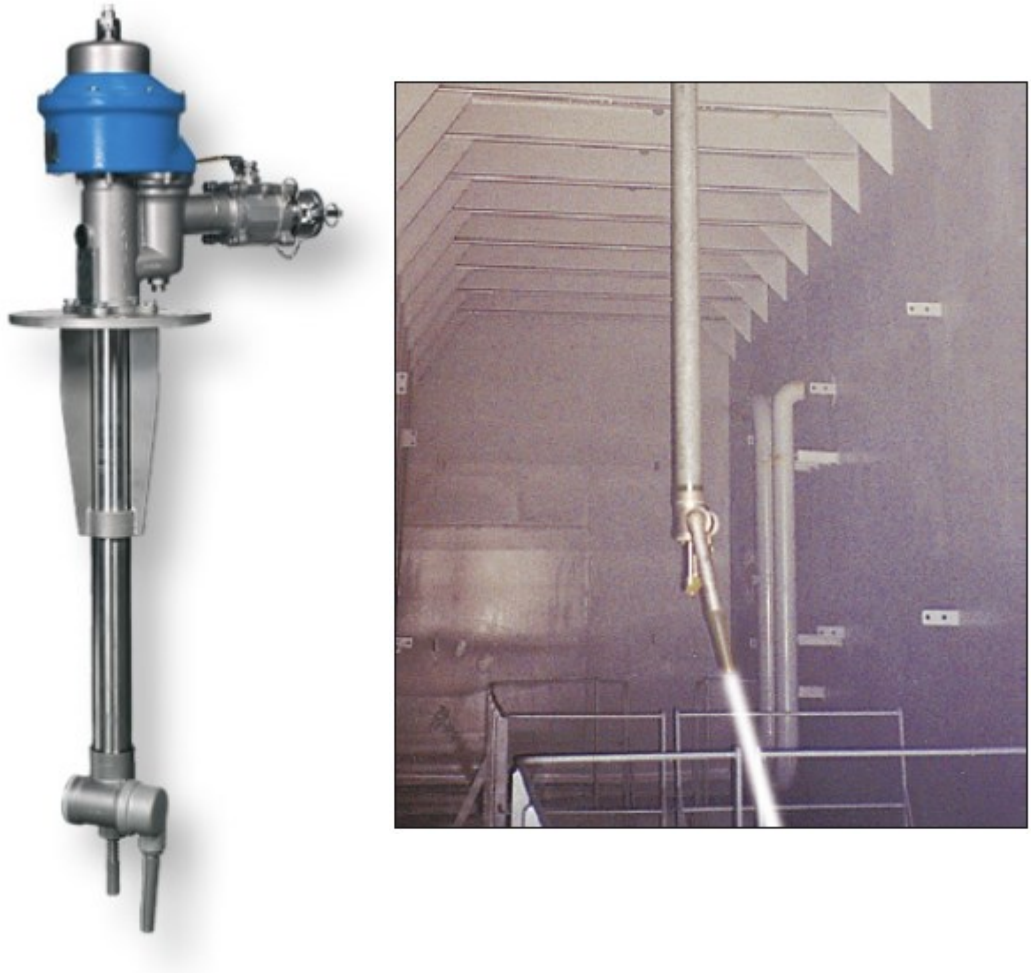

Figure 6. Left: Fixed tank cleaning machine (Scanjet, n.d.), Right: Photo of water washing (Scanjet, n.d.)

Safety is a critical consideration, as traditional tank cleaning methods are often associated with significant risks to personnel. The Code of Safe Working Practices for Merchant Seafarers 2015 edition (Maritime and Coastguard Agency, 2022) highlights these risks and its hazards, and states that “risks inherent in the working environment must be identified and evaluated, and measures must be taken to remove or minimize those risks, to protect seafarers and others from harm, so far as is reasonably practicable”. Mohit (2021) describes

the procedure for entering an enclosed space on a ship along with the associated dangers and hazards. The risks of accidents and injury associated with tank washing and enclosed space entry can be reduced by utilizing an enhanced stripping system as the only form of tank preparation for gasoline to diesel cargo shifts.

Sustainability is an essential consideration in the shipping industry, as it is becoming increasingly important to reduce the environmental impact of shipping operations. According to the Consolidated Guidance for Port Reception Facility Providers and Users (IMO, 2018), “Although not a direct requirement of MARPOL, minimizing the wastes/residues generated on board ships represents an environmental best practice, and should be considered in a ship's overall waste management practices.” (p. 7). A study by Bhandari (2020), highlights the impact of shipping on climate change and how emissions are expected to increase in the future. Conventional tank cleaning methods often require significant amounts of water and energy, and expulsion of cargo tank vapors into the atmosphere, which can lead to the generation of wastewater and air pollution. The disposal of these waste products can also be a significant challenge, as it may require specialized treatment facilities and incur additional costs. Alternative tank cleaning methods, such as the standalone use of an enhanced stripping system, can contribute to a more sustainable and cost-effective shipping industry by reducing the use of resources and generating less waste.

Operational efficiency is a critical factor in the shipping industry as it directly impacts the profitability and competitiveness of shipping operations. The conventional tank preparation process can be complex and time-consuming, leading to the possibility of delays. These delays, as Zárate (2009) stated, "will usually increase the costs of the operation," resulting in financial losses for all involved parties. Moreover, delays can cause missed voyage opportunities, especially if the ship is not cargoworthy at the commencement of the laycan (Plomaritou, 2014). Enhanced stripping systems can improve operational efficiency by reducing the time and resources required for tank preparation, enabling vessels to be loaded and unloaded more quickly which reduces downtime.

Through an analysis of the theoretical background of these key concepts, this study aims to provide valuable insights into the appropriateness and feasibility of using enhanced stripping systems as the main method of tank preparation for gasoline to diesel cargo shifts,

while also considering the potential impact on safety, sustainability, and operational efficiency.

2.2 Related research

The tank cleaning guides being referred to, wherein the use of enhanced stripping systems is recognized, are the independent tank cleaning matrix HM50 5th Edition published by the Energy Institute and the oil major tank cleaning matrix Shell's Ship Pre Cargo Matrix – White Oil Petroleum Products & Components 2018 (Shell, 2018). These guides are widely used on CPP tankers and are preferred over the stringent chemical-focused tank cleaning guides. The HM50 matrix (Energy Institute, 2018) is available to download from the internet, while the Shell matrix is provided to vessels chartered by Shell. Although the Shell matrix is intended for their own vessels, their cleaning matrix is being used by other vessels not associated with the oil major due to the fact that Shell is recognized as one of the leaders in the industry. Their matrix has circulated on different vessels and copies are also unofficially available on the internet. Excerpts of the Shell matrix and HM50 matrix are presented in Appendix 1 and 2, respectively.

Maritime Mutual NZ has published a bulletin discussing the standard tank cleaning procedures and cleanliness standards on CPP tankers with mention of these guides and how there is a lack of internationally agreed tank cleanliness standards specific to CPP trades. (Maritime Mutual Insurance Association, 2020)

The Standard Club also produced an article giving an overview of tank cleaning operations on tankers in general and mentions the importance of efficient cleaning and the avoidance of unnecessary over-cleaning. (Jager, 2016)

A dissertation for the World Maritime University covers in detail the control of tank atmospheres in oil tankers, which helps highlight the significance of this element in this study. (Gning, 1992) Individual companies have their own standards regarding this matter, but this dissertation provides a general overview and serves as a fine resource.

A study from Theseus about the cargo quality change on product tankers was published detailing the activities and systems on these types of vessels and a fair amount of information can be obtained from this resource. (Makkonen, 2014)

2.3 Gaps in literature

The literature review has revealed that while there are related materials that provide insights into the use of enhanced stripping systems for tank preparation and the various aspects of the CPP trade, there is limited research directly related to the use of enhanced stripping systems as a standalone tank preparation method for gasoline to diesel cargo shifts. As such, there are gaps in the literature that need to be addressed. Specifically, there is a need for further quantitative research that examines the prevalence of the use of enhanced stripping systems and its impact on factors such as safety, sustainability, and operational efficiency in gasoline to diesel cargo shifts. This research can build on the findings of this study and provide a more comprehensive understanding of the appropriateness and feasibility of using enhanced stripping systems as a standalone tank preparation method for gasoline to diesel cargo shifts.

In addition, further research can be conducted to investigate the experiences of industry professionals who have used enhanced stripping systems for tank preparation and how their experiences inform their opinions on its appropriateness as a tank preparation method. Such research can provide valuable insights into the practical applications of enhanced stripping systems and identify potential areas of improvement. By addressing these gaps in the literature, future research can contribute to the development of more sustainable, safe, and efficient tank cleaning methods for gasoline to diesel cargo shifts.

3 Methodology

The following section describes the research methodology used in order to investigate the need for a better understanding of the appropriateness of the use of an enhanced stripping system as the main tank preparation method for gasoline to diesel cargo shifts. This study utilized a qualitative research design to explore the experiences and perceptions of seven industry professionals. The lack of research on this matter warranted the need to conduct more studies in order to clarify whether the use of an enhanced stripping system as the main tank preparation method would be appropriate for gasoline to diesel cargo shifts. This study was guided by three research questions aimed at eliciting industry professionals' insights into the use of an enhanced stripping system as the main tank preparation method for gasoline to diesel cargo shifts.

Through this study, it has been sought to contribute to the existing knowledge on the use of enhanced stripping systems in the clean petroleum product industry and provide recommendations on the appropriate tank preparation methods for gasoline to diesel cargo shifts based on industry professionals' experiences and perceptions. The methodology section will describe the data collection process, data analysis procedures, and ethical considerations involved in this study.

3.1 Research design

This study employed a qualitative research design, which is appropriate for investigating complex phenomena that cannot be easily quantified. This approach was utilized to explore the appropriateness of using an enhanced stripping system as the main tank preparation method for gasoline to diesel cargo shifts. The qualitative research design allowed for the collection and analysis of data that is rich in detail, and provides insights into participants' experiences, attitudes, and beliefs.

The goal of the qualitative research design was to identify and understand the factors which affect the participants' opinions on the use of enhanced stripping systems for gasoline to diesel cargo shifts by examining their experiences and perspectives. This approach was deemed appropriate because it allowed for the exploration of the participants' attitudes towards the use of enhanced stripping systems, and how these attitudes were shaped by their experiences and perceptions.

According to Creswell (2014), qualitative research is particularly useful for exploring topics that have not been extensively studied or when the subject matter is complex and requires a more nuanced analysis. In his book on research design, Creswell emphasizes the advantages of using qualitative methods to gain a deep understanding of complex phenomena. In the case of this study, qualitative research is appropriate for exploring the complex and subjective perceptions, opinions, and experiences of industry professionals regarding the use of enhanced stripping systems as a standalone tank preparation method for gasoline to diesel cargo shifts. In this study, the participants were Senior Officers who had experience with both the traditional tank preparation methods and enhanced stripping systems. The use of a qualitative research design allowed for a deeper exploration of their

experiences and opinions, which would have been more difficult to achieve using a quantitative approach.

The data collected through the interviews were analyzed thematically to identify patterns and themes in the participants' responses. This approach was used to explore the factors that influence the participants' opinions on the use of enhanced stripping systems, and how their experiences and perspectives shape these opinions. The thematic analysis approach was chosen because it allowed for a systematic and in-depth exploration of the participants' experiences, attitudes, and beliefs.

3.2 Data collection

Participants were purposively sampled based on their experience with gasoline to diesel cargo shifts and their familiarity with the use of enhanced stripping systems as a standalone tank preparation method for these shifts. Given the specificity and complexity of the topic under investigation, a smaller sample size was deemed appropriate as it allowed for in-depth exploration of participants' experiences and perceptions. The use of purposive sampling allowed for the selection of participants who were most likely to provide relevant and insightful data on the topic of interest, ensuring a rich and varied dataset (Tongco, 2007). A total of seven participants were interviewed, which included six Captains and one Chief Officer. All participants were experienced in the maritime industry and had extensive knowledge of tank preparation methods for gasoline to diesel cargo shifts. The participants ranged in age from 42 to 58 years old, with a mean age of 49 years old. All participants had at least 19 years of experience in the tanker industry, with an average of 22 years of tanker experience.

The number of participants interviewed is considered sufficient for this study based on the concept of data saturation. Data saturation occurs when the collection of new data ceases to provide additional insights or information to the research questions or objectives (Guest, Bunce, & Johnson, 2006). Although Guest et al. (2006) suggest that data saturation is typically achieved after interviewing between 12 to 20 participants in qualitative research, other researchers such as Tongco (2007) argue that sample size in qualitative research is not solely based on numerical figures, but rather on the quality and richness of the data obtained. In this study, the rich and varied dataset obtained from the purposive sampling

of highly experienced industry professionals allowed for a thorough exploration of the research questions and objectives, and thus, the number of participants interviewed was deemed sufficient.

At the time of the interviews, all participants were on board handy sized CPP vessels trading mainly in Northern Europe, and their companies were involved in the transportation of petroleum products. The participants were selected from different companies and vessel types to ensure a diversity of perspectives on the use of enhanced stripping systems for gasoline to diesel cargo shifts. The participants were informed of the purpose of this study and had provided consent to participate in the interviews. The following provides a summary of the participants' demographic characteristics, including age and years of experience. To protect the anonymity of the participants, their names, nationalities, and specific vessel names have been omitted.

Participants' Demographic Characteristics:

1. Master 1 (M1): 57 years old, Captain of 19k DWT CPP tanker, 32 years tanker experience, 21 years as Chief Officer and 8 years as Master.

2. Master 2 (M2): 58 years old, Captain of 19k DWT CPP tanker, 29 years tanker experience, 4 years as Chief Officer and 23 years as Master.

3. Master 3 (M3): 46 years old, Captain of 14k DWT CPP tanker, 20 years tanker experience, 7 years as Chief Officer and 3 months as Master.

4. Master 4 (M4): 52 years old, Captain of 14k DWT CPP tanker, 28 years tanker experience, 6 years as Chief Officer and 12 years as Master.

5. Master 5 (M5): 47 years old, Captain of 16k DWT CPP tanker, 27 years tanker experience, 3 years as Chief Officer and 20 years as Master.

6. Master 6 (M6): 42 years old, Captain of 16k DWT CPP tanker, 19 years tanker experience, 12 years as Chief Officer and 4 years as Master.

7. Chief Officer 1 (CO1): 42 years old, Chief Officer of 19k DWT CPP tanker, 22 years tanker experience, 5 years as Chief Officer.

The interviews were carried out from May to August 2022 while the participants were on board their respective vessels. As the participants were unavailable during busy periods or when there was no mobile network coverage, interviews were conducted over the phone at times convenient for the participants and when mobile phone communication was possible. Prior to the interviews, the participants were informed about the purpose of this study and had provided consent for their participation.

Open-ended questions were used to guide the interviews, which lasted between 45 minutes and 1 hour. The questions covered a range of topics, including the participants' decision-making process when selecting a tank preparation method, their opinions with using traditional tank preparation methods, and their experiences with the use of enhanced stripping systems.

The interviews were not recorded or transcribed verbatim due to the limitation of mobile phones to record high-quality audio. Instead, detailed notes were taken using a computer during the interviews to capture the participants' responses and ensure that the key themes and patterns in the data were identified. Note-taking during the interview also allowed the researcher to stay more engaged with the participant and follow up on interesting points in real-time. The data collected through the interviews were then analyzed using thematic analysis.

3.3 Interview structure

Semi-structured interviews were used to collect data from the participants in this study. A semi-structured interview guide was used to ensure that all participants were asked the same questions, but also allowed for flexibility in the conversation to explore interesting themes that appeared during the interviews. Open-ended questions were used to allow the participants to express their thoughts and experiences in their own words, which is particularly important in a study focused on exploring subjective attitudes and perceptions.

The following is a summary of the interview questions which were used to guide the interviews:

1. What factors do you think are important to consider when deciding whether to use an enhanced stripping system as the primary method for preparing cargo tanks during gasoline to diesel cargo shifts?

2. In your experience, what do you believe are the advantages and disadvantages of using an enhanced stripping system for gasoline to diesel cargo shifts, compared to traditional tank preparation methods?

3. Can you describe your experiences using an enhanced stripping system for gasoline to diesel cargo shifts, and how have these experiences informed your opinions on its appropriateness as a main cargo tank preparation method?

The interview questions were developed to elicit detailed responses from the participants and to explore their experiences and perceptions regarding the use of enhanced stripping systems. The use of a semi-structured interview guide allowed for consistency and comparability across the interviews while also providing flexibility for follow-up questions and probing on interesting themes that arose during the conversation. The interview questions were selected based on the research questions and objectives of this study, and were refined through consultation with experts in the field to ensure that they were well-designed and appropriate for this study.

3.4 Data analysis

According to Braun and Clarke (2006), thematic analysis is ideal for examining qualitative data and identifying patterns and themes within the data set. Therefore, thematic analysis was employed as the method of data analysis for this study. Thematic analysis allowed for a systematic approach to analyzing the data collected from the semi-structured interviews.

The interviews were conducted in a private setting via mobile phone and were not recorded or transcribed verbatim. Instead, notes were taken during the interviews and used to identify key themes and patterns in the data. The notes were then reviewed to ensure that all relevant information had been captured, and to identify any emerging themes.

The data analysis process consisted of two main phases. In the first phase, the notes were reviewed to identify and code the key concepts and themes that emerged from the interviews. These codes were developed through an iterative process, with the notes

reviewed and refined until a final set of codes were developed. The codes were then applied to the data set to categorize and identify themes that emerged.

In the second phase of data analysis, the coded data were organized into categories and sub-themes. These categories and sub-themes were then reviewed and revised to ensure that they accurately reflected the data and were consistent with the research questions and objectives. This process allowed for a deeper understanding of the participants' experiences and perspectives related to the use of enhanced stripping systems for gasoline to diesel cargo shifts.

The analysis revealed several key themes related to the appropriateness of using and enhanced stripping system as the main tank preparation method for gasoline to diesel cargo shifts. These themes provided valuable insights into the factors that influence participants' opinions on the topic and helped to answer the research questions posed in this study.

3.5 Ethical considerations

Ethical considerations were an important aspect of this research, and all necessary measures were taken to ensure that the research was conducted in an ethical and responsible manner. Permission to conduct the research was obtained from the relevant organizations, and their support and cooperation were crucial to the success of this research. The identities of the organizations and their representatives have been kept anonymous in the reporting of the findings. All participants provided verbal informed consent prior to their involvement in this study, and the interviews were conducted privately over mobile phone, allowing participants to express their thoughts and experiences freely. It was established with all participants that their participation was voluntary and that they had the right to withdraw consent at any time. The utilization of data that would be obtained from the interviews was explained to all participants. Confidentiality and anonymity were maintained throughout the research process, and all data were stored securely and in accordance with the relevant data protection regulations.

4 Results and analysis

This section presents the results of the thematic analysis conducted on the data collected from the semi-structured interviews with the seven participating industry professionals. The aim of this study was to investigate the need for a better understanding of the appropriateness of the use of an enhanced stripping system as a standalone tank preparation method for gasoline to diesel cargo shifts, by exploring the experiences and perceptions of industry professionals on this matter.

The thematic analysis conducted on the data collected from the semi-structured interviews identified three main themes that captured the experiences and perceptions of the participants on tank preparation methods. The first theme, decision making, consisted of the factors that influenced the decision-making process on when to deem the use of an enhanced stripping system appropriate as the main tank preparation method for a gasoline to diesel cargo shift. The second theme, disadvantages of traditional methods, captured the shortcomings and limitations of traditional tank preparation methods. Finally, the third theme, experience using an enhanced stripping system as the main tank preparation method for gasoline to diesel cargo shifts, presented the participants' experiences and perceptions on the tank preparation method in question. Each theme had corresponding sub-themes that were used to analyze the data.

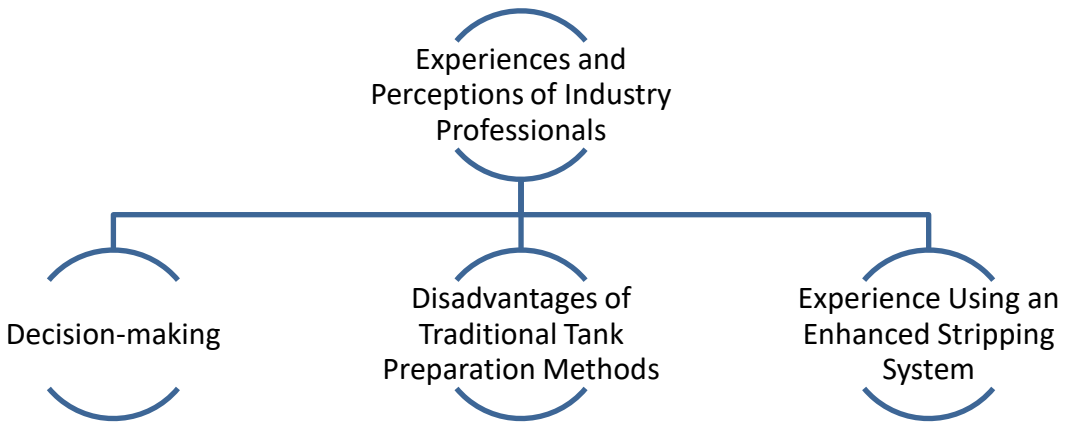

Figure 7. Key themes captured from the experiences and perceptions of industry professionals

The presentation of the results will follow a thematic organization, where each theme and its corresponding sub-themes will be presented and discussed. A detailed narrative description of the themes and patterns that emerged from the data is provided to offer context and support the findings. The following sections will provide a comprehensive analysis of the data collected from the semi-structured interviews and will discuss the implications of the findings for the use of enhanced stripping systems as the main tank preparation method for gasoline to diesel cargo shifts.

4.1 Decision-making

This theme encompasses the factors that industry professionals consider when deciding on whether the use of the enhanced stripping system as the main tank preparation method for a gasoline to diesel cargo shift would be appropriate. Sub-themes include experience with an enhanced stripping system as main tank preparation, knowledge of vessel capability, consultation with other parties, reliance on tank cleaning guides, compliance with voyage orders, characteristics of the previous gasoline cargo, and risk consideration. This study's findings provide insights into the factors that influence industry professionals' decisions and can inform best practices for improving safety and efficiency when performing gasoline to diesel cargo shifts.

Decision-making	Experience with Enhanced Stripping System as Main Tank Preparation
	Knowledge of Vessel Capability
	Consultation with Other Parties
	Reliance on Tank Cleaning Guides
	Compliance with Voyage Orders
	Characteristics of the Previous Gasoline Cargo
	Risk Consideration

Figure 8. Sub-themes of Decision-making

4.1.1 Experience with enhanced stripping system as main tank preparation

According to the data collected through the interviews, the participants' experience with situations that called for the use of an enhanced stripping system played a crucial role in their decision to use it as the primary tank preparation method for a gasoline to diesel cargo shift. They indicated that their past experiences with the system, in situations where it was offered as an option or where it was provided as an instruction, had influenced their decision-making process.

Participant M1, for instance, stated that they had gained confidence in their judgement over time due to their extensive experience with gasoline to diesel cargo shifts on different vessels with various charterers. They had encountered situations where the use of an enhanced stripping system was called for or given as an option, and this had helped them develop a level of familiarity with the method.

Similarly, participants M3 and M4 also shared similar views, citing their experience with their company's preference for using the enhanced stripping system over traditional methods for gasoline to diesel cargo shifts. The use of an enhanced stripping system for these shifts had been considered a standard practice, and this experience had influenced their decision-making process.

Overall, the data suggests that experience with situations that called for the use of an enhanced stripping system played a key role in the participants' decision to use it as the main tank preparation method for a gasoline to diesel cargo shift. Their past experiences with the system in these situations had influenced their decision-making process, and they had developed a level of familiarity and confidence in the method as a result.

4.1.2 Knowledge of vessel capability

The participants' knowledge of their vessel's capabilities, specifically the capabilities of its enhanced stripping system, emerged as a significant factor in their decision-making process. Several participants expressed that having this knowledge would support their ability to make informed decisions about tank preparation methods for a gasoline to diesel cargo shift.

Participants M5 and M6 mentioned the documented capability of their vessel's enhanced stripping system as per their vessel's Procedures and Arrangements manual. They noted that they would use this data in conjunction with tank cleaning guides to back their decision-making. The participants emphasized the importance of having access to accurate and relevant information about their vessel's capabilities to make informed decisions.

Furthermore, the participants noted that knowledge of their vessel's capabilities could also help them anticipate potential issues that may arise during the tank preparation process. By knowing the capabilities of their enhanced stripping system, they could better plan and prepare for any challenges that may occur, allowing them to make more informed decisions and avoid potential issues during the cargo shift.

The data suggests that knowledge of their vessel's capabilities, specifically the capabilities of its enhanced stripping system, plays a critical role in the participants' decision-making process. Participants M5 and M6's use of documented data from the Procedures and Arrangements manual to back their decision-making highlights the importance of having access to accurate and relevant information. Additionally, knowledge of the vessel's capabilities can help participants anticipate potential issues and better plan for the tank preparation process, ultimately leading to more informed decision-making and a smoother gasoline to diesel cargo shift.

4.1.3 Consultation with other parties

The participants in this study highlighted the importance of seeking advice or consulting with others when making a decision regarding tank preparation, especially to ascertain if using only the enhanced stripping system would be appropriate for the situation. They emphasized that seeking the opinion of other parties could provide them with valuable insights and help them arrive at a well-informed decision.

Participant M2 explained that when they are uncertain about whether to use their enhanced stripping system as the only form of tank preparation or to perform traditional tank cleaning, they would consult the vessel's operator. This consultation allowed them to leverage the operator's knowledge and authority, which they could then use to make an informed decision.

Similarly, Participant M4 mentioned that they would reach out to colleagues from sister ships for advice when faced with a situation where unfamiliar gasoline or diesel types were involved. They believed that their expertise could provide them with insights that they might have otherwise overlooked.

The participants in this study recognized the value of seeking advice from others when making decisions about the use of the enhanced stripping system as the main tank preparation method. They emphasized that these actions could help them make better-informed decisions and reduce the risks associated with cargo contamination during gasoline to diesel cargo shifts.

4.1.4 Reliance on tank cleaning guides

The interviews conducted during this study revealed that some participants would in some cases doubt if using only their enhanced stripping system as the only tank preparation method would suffice for a gasoline to diesel cargo shift. As a result, a few participants reported turning to tank cleaning guides to supplement their knowledge in this area.

Participant M2 shared that in cases where external consultation did not result in a conclusive decision, they would rely on the tank preparation method recommended by the tank cleaning guides. This highlights the perceived importance and trust that some participants placed on the information provided in these guides.

On the other hand, Participant M4 stressed the significance of examining various tank cleaning guides and determining which method is most efficient in terms of resource utilization. This suggests that some participants prioritized the optimization of resources when considering tank preparation methods for the gasoline to diesel cargo shift.

4.1.5 Compliance with voyage orders

Compliance with voyage orders was identified as a key factor in decision-making related to tank preparation for gasoline to diesel cargo shifts. Participant M5 expressed that compliance with voyage orders is their top priority when making decisions. However, if the voyage orders are unclear or lacking in specific details, they would refer to tank cleaning guides to help them decide on the appropriate tank preparation method. They brought up the availability of tank cleaning guides where the use of only the enhanced stripping system

for gasoline to diesel cargo shifts was deemed appropriate as a tank preparation method, with consideration to one of the guides requiring the vessel to have a tank emptying capacity within a certain limit to be able to meet the tank preparation criteria.

4.1.6 Characteristics of the previous gasoline cargo

Several participants cited the characteristics of the previous gasoline cargo as a crucial factor in the decision-making process. Participants M4 and M6 noted that the visual appearance and other characteristics of the previous gasoline cargo could impact their choice of using only their enhanced stripping system as the tank preparation method for a gasoline to diesel cargo shift.

Participant M4 stated that if the previous gasoline cargo was an unfamiliar variant or had questionable quality, and that they would not be able to confirm if using the enhanced stripping system alone would suffice, they would consider carrying out traditional tank preparation methods to ensure that their cargo tanks would be acceptable for the upcoming diesel cargo. Similarly, participant M6 noted that the visual appearance of the previous cargo may sometimes warrant the need for traditional tank preparation methods. This suggests that the characteristics of the previous cargo are an important consideration for participants when deciding whether the enhanced stripping system would be appropriate as the sole tank preparation method to be carried out for a gasoline to diesel cargo shift.

4.1.7 Risk consideration

In addition to the factors previously mentioned, participants also stressed the importance of considering the risks associated with opting to use only their enhanced stripping system when preparing cargo tanks for a gasoline to diesel cargo shift. Participant M6 emphasized that risk consideration should be given more weight. According to M6, the use of an enhanced stripping system as the sole method for tank preparation may result in residue remaining in the cargo tank due to errors, which can pose a risk to subsequent cargoes. Thus, adequate assessment and mitigation of these risks should be carried out.

4.2 Disadvantages of traditional tank preparation methods

The following section discusses the views of industry professionals on the drawbacks associated with traditional tank preparation methods. Through the thematic analysis of the interviews with the participants, several sub-themes emerged, including time consumption, avoidable costs, exposure to risk, the negative impact on the environment, personnel rest hour issues, and challenges with the presence of water. The findings shed light on the reasons why professionals may opt for alternative tank preparation methods and provide insight as to why the use of an enhanced stripping system is a favorable option.

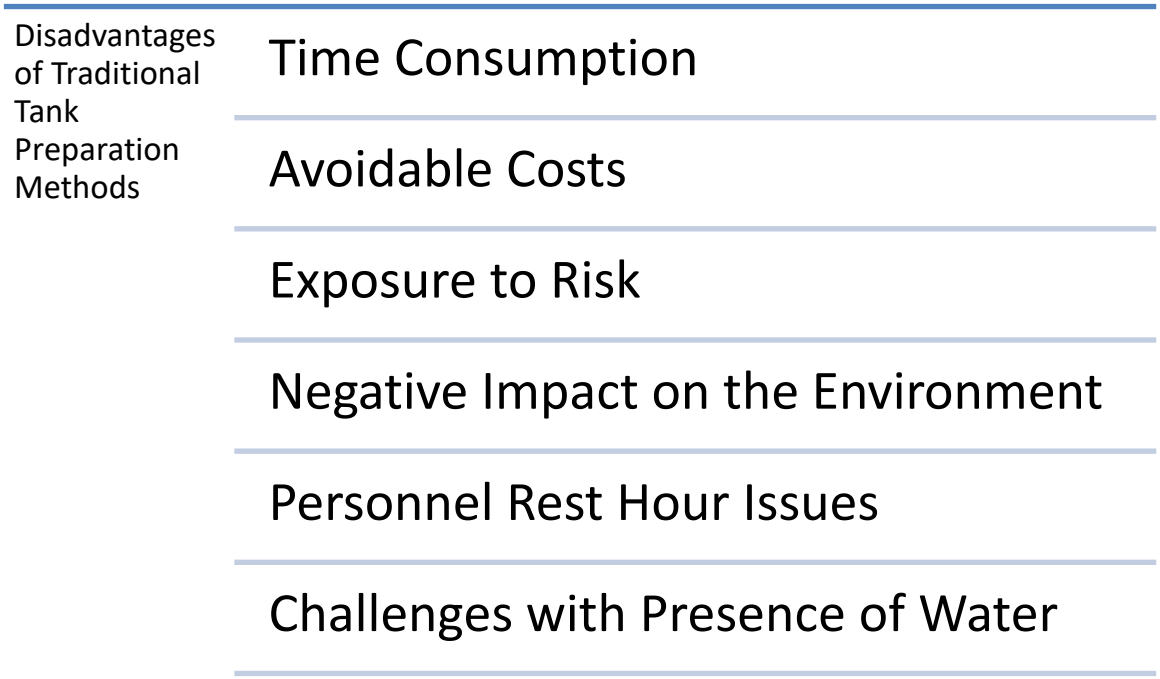

Figure 9. Sub-themes of Disadvantages of Traditional Tank Preparation Methods

4.2.1 Time consumption

Several participants highlighted the considerable time consumption associated with traditional tank preparation methods. They expressed that this process could take longer than anticipated, and unexpected situations may occur, causing significant delays. These delays can lead to a negative impact on business operations, such as missing crucial deadlines and incurring financial losses.

Participant CO1 shared their perspective on the matter, expressing concern over the extensive planning and paperwork required to comply with regulations and company procedures when performing traditional tank preparation. They emphasized that these

requirements can be time-consuming and cumbersome, leading to increased workloads and potentially affecting personnel's performance.

Similarly, participant M2 mentioned that washing and mopping may be unnecessary in some cases, but personnel would still comply if such orders or requirements are given. This highlights the issue of unnecessary procedures being carried out during tank preparation, which may contribute to longer processing times.

Participant M3 shared their belief that traditional tank preparation methods involve doing more than what is required, which could be avoided. They suggested that a more streamlined and efficient process could be developed, reducing the time and effort required to prepare tanks.

Overall, participants expressed concerns about the time consumption associated with traditional tank preparation methods, the extensive planning and paperwork required, and the possibility of unnecessary procedures being carried out. These issues can lead to delays, increased workloads, and negative impacts on business operations.

4.2.2 Avoidable costs

Appropriate tank preparation is necessary to ensure the safe and efficient transportation of cargo. The participants in this study who bear this responsibility, however, expressed their concern about the avoidable costs associated with traditional tank preparation methods. They suggested that using only the enhanced stripping system could be a more efficient and cost-effective option.

Participant CO1 pointed out that costs related to the disposal of slop washing water produced from washing the cargo tanks and bunker consumption from inert gas production for cargo tank atmosphere control could be avoided if vessels opted for preparing their tanks with only their enhanced stripping system.

Participant M4 echoed this sentiment, stating that traditional tank preparation procedures provided by most tank cleaning guides result in excessive resource consumption. They emphasized the need for a more streamlined approach to tank preparation that would reduce unnecessary costs.

Moreover, Participant M5 emphasized that consumption in general is lowered when traditional tank preparation methods are not utilized. This includes consumption of time, resources, and personnel effort. By using only the enhanced stripping system, vessels can reduce the costs associated with traditional tank preparation methods.

In summary, participants highlighted the potential cost savings associated with using only the enhanced stripping system for tank preparation. By avoiding the unnecessary costs associated with traditional methods, vessels can reduce their expenses and increase their efficiency.

4.2.3 Exposure to risk

During the interviews, it was revealed that several participants consider exposure to risk as one of the serious drawbacks of using traditional tank preparation methods. This observation was not surprising, given the complex and hazardous nature of the traditional tank cleaning process. The participants highlighted various risks, including slips, falls, toxic gas exposure, and confined space hazards, among others.

Participant CO1 expressed their concern about the risks associated with traditional tank preparation methods. They pointed out that despite the regulations and safety measures that companies have established, fatalities still occur due to the inherent dangers of the process. They emphasized that risk avoidance is always preferable over risk reduction, especially when it comes to the safety of personnel.

Another participant, M4, highlighted the risks of tank entry as one of the significant disadvantages of using traditional tank preparation methods and pointed out that tank entry is required to carry out some of the critical steps of the process, such as manual washing and mopping. They described how tank entry exposes personnel to a range of risks, such as oxygen deficiency, toxic gas exposure, and physical hazards.

Participant M5 shared a different perspective, stating that the use of an enhanced stripping system alone significantly reduces the amount of risk the vessel's crew would be exposed to. They pointed out that using an enhanced stripping system avoids the need for washing, mopping, and drying, which eliminates the risks associated with tank entry. This method

can also be performed remotely on some vessels, reducing the need for personnel to be in close proximity to the cargo tanks.

The interviews revealed that the exposure to risk is a major concern among participants who use traditional tank preparation methods. While safety measures and regulations are in place to mitigate these risks, the inherent hazards of the process cannot be entirely eliminated. The use of an enhanced stripping system offers a safer alternative that significantly reduces the amount of risk the vessel's crew would be exposed to.

4.2.4 Negative impact on the environment

Some participants expressed their concerns about the negative impact of traditional tank preparation methods on the environment. The participants shared their observations on the amount of emissions produced during the process, which can have a significant impact on the environment. Participants M3 and M5 voiced their concerns about the emissions being produced when performing traditional tank preparation methods.

Participant M3 pointed out that the amount of gas emissions produced during the process is significant, especially when cargo tanks need to be purged of hydrocarbons, gas-freed, and re-inerted. All these gases end up in the atmosphere while the vessel is at sea. Despite the lack of measurement of the emissions, the participant believes that the amount is so large that it contributes to the worsening of the environment.

Participant M5 also emphasized that the emissions from the production of inert gas are considerable. With the number of vessels doing the same for practically unnecessary tank atmosphere control, it would all add up to producing a significant negative impact on the environment. Additionally, the participant noted that aside from the gas emissions from cargo tank atmosphere control, other emissions are produced during the traditional tank preparation process, contributing to the negative impact on the environment.

The participants' concerns about the negative impact of traditional tank preparation methods on the environment are valid, and they highlight the need for alternative methods that would minimize environmental risks. The use of an enhanced stripping system alone, for example, could significantly reduce emissions, as well as the environmental impact, compared to traditional tank preparation methods. The participants' observations

underscore the importance of exploring alternative methods that are not only efficient but also environmentally friendly.

4.2.5 Personnel rest hour issues

The interviews conducted revealed that participants reported issues with personnel rest hours being compromised whenever traditional tank preparation methods are carried out. Participant CO1 raised concerns about the impact of these methods on personnel rest hours, noting that prolonged 6/6 watch schedules, short sea passages, and unexpected situations often resulted in reduced opportunities for adequate rest periods. These findings suggest that the use of traditional tank preparation methods may have negative implications for crew fatigue and overall safety, as reduced rest periods can impair cognitive function and decision-making ability, leading to an increased risk of accidents and injuries.

These results are consistent with previous research that has identified the importance of adequate rest and sleep in ensuring safe and effective task performance in high-risk industries, such as the maritime industry (Andrei, Griffin, Grech & Neal, 2020). The International Maritime Organization (IMO, 2019) has recognized the importance of rest and fatigue management for seafarers, mandating minimum rest hours and establishing guidelines for safe and effective rest periods. However, these guidelines may not be fully effective in mitigating the impact of traditional tank preparation methods on personnel rest hours and fatigue.

4.2.6 Challenges with presence of water

The interviews with the participants revealed challenges encountered during the process of tank preparation. One of these challenges was related to the possibility of the presence of water in the cargo tank. Participant M4 highlighted that in some instances where cargo tank washing is done without mopping and drying for gasoline to diesel cargo shifts, the potential for water to remain in the tank exists. The participant shared that this could pose a problem, particularly in load ports where water contamination is considered more problematic than contamination by the previous cargo.

Participant M4 added that the presence of water in the cargo tank is a significant concern because it could affect the quality of the cargo to be loaded. It can also result in significant expenses, as water contamination could lead to the rejection of the entire cargo, which could result in significant losses for the shipowner and the charterer.

In conclusion, the presence of water in the cargo tank poses a significant challenge during tank preparation for gasoline to diesel cargo shifts. The issue could result in cargo contamination and significant expenses for the shipowner and charterer.

4.3 Experience using an enhanced stripping system

In this section, we explore the experiences of participants who have used an enhanced stripping system as the main tank preparation method for gasoline to diesel cargo shifts. We examine various sub-themes related to the use of enhanced stripping systems, including the practices of instructing only enhanced stripping as tank preparation by charterers, the negotiations between owner and charterer on the use of only enhanced stripping, hydrocarbon purging and enhanced stripping as tank preparation, the responsibility of providing the appropriate tank preparation method, the coordination between parties for the implementation of enhanced stripping as the only tank preparation method, and the efficiency of enhanced stripping systems. Through an analysis of these sub-themes, we provide insight into the benefits and challenges of using an enhanced stripping system as the primary tank preparation method for gasoline to diesel cargo shifts.

Experience Using an Enhanced Stripping System	Standard Practice of Only Enhanced Stripping as Tank Preparation by Charterers
	Negotiations between Owner and Charterer on the Use of Only Enhanced Stripping
	Hydrocarbon Purging and Enhanced Stripping as Tank Preparation
	The Responsibility of Providing the Appropriate Tank Preparation Method
	Coordination between Parties for the Implementation of Enhanced Stripping as the Only Tank Preparation Method
	Efficiency of Enhanced Stripping Systems

Figure 10. Sub-themes of Experience Using an Enhanced Stripping System

4.3.1 Standard practice of only enhanced stripping as tank preparation by charterers

Several participants shared their experiences regarding the acceptance of using only enhanced stripping as tank preparation for gasoline to diesel cargo shifts as standard practice by charterers. Participant M1 mentioned that, based on their experience as a Master, the majority of charterers they worked with, particularly those from Northern Europe, had no issues with using the enhanced stripping system as the sole tank preparation method for gasoline to diesel shifts. Furthermore, some of these charterers would often themselves recommend the use of only enhanced stripping as preparation for a gasoline to diesel shift.

Similarly, Participant CO1, who worked on vessels chartered by various companies mostly based in Northern Europe, reported that traditional tank preparation was seldom done. Instead, tank atmosphere purging together with enhanced stripping or enhanced stripping alone, was the norm in most cases.

Participant M2's experience was different as they reported that traditional tank preparation methods were always carried out for gasoline to diesel cargo shifts during their early years as a Captain on oil tankers. Nonetheless, with the availability of enhanced stripping systems on newer tankers, traditional tank preparation methods were still being used, particularly when ordered by the charterers or the vessel's chartering department.

Participant M2 also reported instances where some charterers advocated the use of only the enhanced stripping system for gasoline to diesel shifts. This shift towards enhanced stripping as the sole tank preparation method is consistent with the trend observed in the maritime industry, where the use of traditional tank preparation methods is gradually being replaced by enhanced stripping systems.

In conclusion, the standard practice of using only enhanced stripping as tank preparation for gasoline to diesel cargo shifts is prevalent among charterers, particularly those from Northern Europe. The use of traditional tank preparation methods is not as widespread as it once was in certain areas, and in most cases, tank atmosphere purging and enhanced stripping are used together, or enhanced stripping is used alone. These findings are consistent with the trend in the maritime industry, which shows a gradual shift towards enhanced stripping as the primary tank preparation method for gasoline to diesel cargo shifts.

4.3.2 Negotiations between owner and charterer on the use of only enhanced stripping

During the interviews, Participant M1 mentioned that their current company's chartering department negotiates with charterers that traditional tank preparation is not necessary for gasoline to diesel cargo shifts, if such a situation presents itself. Instead, the vessel's enhanced stripping system is deemed sufficient to prepare the tanks.

This negotiation between owner and charterer on tank preparation methods is a significant occurrence, as it affects the vessel's efficiency and operational costs. Participant M1's experience highlights how the use of only enhanced stripping is becoming more prevalent in tank preparation for gasoline to diesel shifts.

Overall, this sub-theme shows that negotiations between owner and charterer on tank preparation methods may influence how methods other than traditional ones are utilized and that the use of only enhanced stripping is becoming more accepted as a standard practice for gasoline to diesel cargo shifts.

4.3.3 Hydrocarbon purging and enhanced stripping as tank preparation

The interviews revealed that some participants have experienced instances where charterers prefer that they prepare their cargo tanks by purging their atmosphere from hydrocarbons in conjunction with using their vessels' enhanced stripping system. Participants M1 and CO1 similarly shared that they have had experience with multiple charterers who preferred this method for such cargo shifts. They provided additional input saying that the method has been increasingly acknowledged more by load ports and external cargo surveyors, being seen as a compromise between traditional tank preparation and using only the enhanced stripping system.

Furthermore, participant M6 expressed a preference to always perform hydrocarbon purging in conjunction with the use of the enhanced stripping system. This preference could be due to the potential risks associated with cargo contamination if the tanks are not adequately prepared. The participant believed that the extra measure of hydrocarbon purging would increase the assurance of their cargo tanks being suitable for loading the next cargo.

In summary, the results of the interviews suggest that hydrocarbon purging in conjunction with the use of an enhanced stripping system is becoming a preferred method of tank preparation for some charterers. Furthermore, the method is increasingly acknowledged by load ports and external cargo surveyors. Participants also expressed their preference for this method, believing that it provides an extra level of assurance that the cargo tanks are suitable for loading the next cargo.

4.3.4 The responsibility of providing the appropriate tank preparation method

Participant M1 expressed their belief that the vessel's operator should advise the appropriate tank preparation method when giving out voyage orders. The participant believed that the operator is the entity situated between the cargo supplier and receiver and may have access to information that may not be readily available to the vessel.

This finding suggests that participants believe that the responsibility of providing the appropriate tank preparation method falls on the vessel's operator. This belief is supported by the understanding that the operator has access to information regarding the cargo and the voyage, which can inform the tank preparation method required.

4.3.5 Coordination between parties for the implementation of enhanced stripping as the only tank preparation method

Results from the interviews indicate that Participant M3 believes that proper coordination among all parties involved is necessary for the acceptance of enhanced stripping as the only tank preparation method for gasoline to diesel cargo shifts. This includes but is not limited to the vessel operator, cargo supplier, and cargo receiver, as each party might have different perspectives and priorities. The participant added that the perspectives of each party may vary due to factors such as their experience with enhanced stripping as the sole tank preparation method, their understanding of its effectiveness, and their concerns for the safety of the vessel and its cargo. Participant M3 emphasized that the uncertainty regarding using enhanced stripping as the only form of tank preparation due to this lack of coordination has always been an issue, and it is important to consider this matter. They expressed that coordination between the parties is crucial to ensure the acceptance of enhanced stripping as the sole tank preparation method, which could involve the sharing of information and data to enable an informed decision-making process and minimize potential disputes among the parties involved.

4.3.6 Efficiency of enhanced stripping systems

The findings of the interviews conducted with the participants revealed varying opinions regarding the effectiveness of an enhanced stripping system and its use as the only tank preparation method for gasoline to diesel cargo shifts. Participant M5 provided their perspective on the matter, stating that modern tankers equipped with enhanced stripping systems have been proven to be highly effective in emptying cargo tanks. They argued that any residue from previous gasoline cargo would not affect the quality of the following diesel cargo.

On the other hand, Participant M6 identified a potential drawback of using enhanced stripping systems for such shifts. They highlighted the possibility of cargo residue remaining in the tanks due to human errors which may occur during the tank preparation process, such as errors in setting up the vessel's list and trim or mistakes in lining up the system, and that this issue could potentially compromise the quality of the diesel cargo. Despite this drawback, Participant M6 acknowledged the effectiveness of enhanced stripping systems

when used correctly. They agreed with some tank cleaning guides which claim that the use of an enhanced stripping system can substitute mopping and drying of cargo tanks.

Overall, the results of the interviews suggest that enhanced stripping systems can be highly effective for emptying cargo tanks and preparing them for a gasoline to diesel cargo shift. However, the potential for human error during the preparation process and the resulting residue in the tanks from these cases should not be overlooked.

5 Critical review and discussion

This study aimed to investigate the need for a better understanding of the appropriateness of the use of an enhanced stripping system as a standalone tank preparation method for gasoline to diesel cargo shifts by exploring the experiences and perceptions of industry professionals. To achieve this aim, the research questions formulated to guide this study focused on identifying the key factors that influence the decision to use this method, exploring industry professionals' perceptions on its feasibility and appropriateness compared to traditional methods, and examining the experiences of those who have used it and how it informs their opinions. Utilizing a qualitative research design, the study collected data through semi-structured interviews with seven industry professionals and analyzed it thematically to identify patterns and themes in the participants' responses. Three main themes emerged from the data analysis: decision-making, disadvantages of traditional methods, and experience using an enhanced stripping system as the main tank preparation method. These themes were further explored through sub-themes and were used to analyze the data.

The first theme, decision-making, includes seven sub-themes. Participants considered their experience with an enhanced stripping system as a standalone tank preparation method, vessel capability, consultation with other parties, reliance on tank cleaning guides, compliance with voyage orders, the characteristics of the previous gasoline cargo, and risk consideration when deciding on tank preparation methods.

The second theme, disadvantages of traditional tank preparation methods, includes six sub-themes. Participants identified the time consumption, avoidable costs, exposure to risk, negative impact on the environment, personnel rest hour issues, and challenges with the presence of water as major disadvantages of traditional methods.

The third theme, experience using an enhanced stripping system, includes six sub-themes. Participants discussed the standard practice of using enhanced stripping as a standalone tank preparation method by charterers, the negotiations between owner and charterer on the use of only enhanced stripping, hydrocarbon purging and enhanced stripping as tank preparation, the responsibility of providing the appropriate tank preparation method, the coordination between parties for the implementation of enhanced stripping as the only tank preparation method, and the efficiency of enhanced stripping systems.

This review and discussion section will critically review the research findings, draw conclusions, and discuss their implications for industry professionals. Specifically, this section will explore: the key factors that influence the decision to use an enhanced stripping system, the industry professionals' views on the feasibility and appropriateness of enhanced stripping systems compared to traditional methods, and the experiences of industry professionals who have used an enhanced stripping system for gasoline to diesel cargo shifts. Additionally, this section will discuss the significance of the research and the limitations of this study. This review and discussion section aims to provide a comprehensive analysis and interpretation of the research findings, contributing to the ongoing discussion of the best practices for tank preparation for gasoline to diesel cargo shifts.

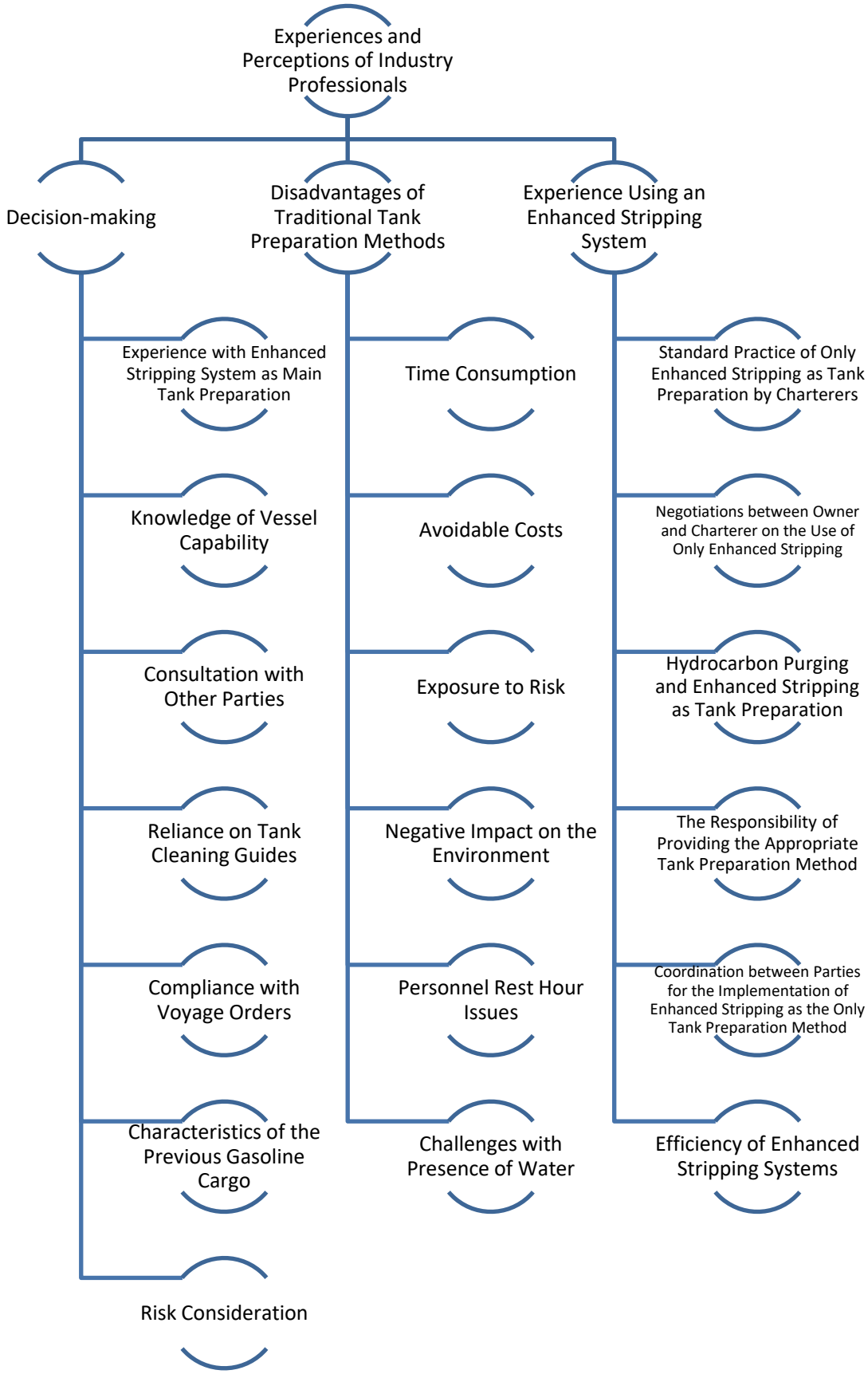

Figure 11. Key themes and sub-themes from the Experiences and Perceptions of Industry Professionals

5.1 Decision-making

The use of the enhanced stripping system as the primary tank preparation method for a gasoline to diesel cargo shift is a critical decision that industry professionals must make to ensure safe and efficient cargo transfers. This study's findings reveal that several factors, labeled as sub-themes in this study, influence the decision-making process, including experience with an enhanced stripping system, knowledge of vessel capability, consultation with other parties, reliance on tank cleaning guides, compliance with voyage orders, the characteristics of the previous gasoline cargo, and risk consideration.

The results from the first sub-theme suggest that experience with the enhanced stripping system plays a crucial role in the decision-making process when choosing the main tank preparation method for gasoline to diesel cargo shifts. The participants' familiarity and confidence with the method, gained from past experiences where it was offered as an option or provided as an instruction, influenced their decision to use it as the primary method. This finding highlights the importance of providing crew members with opportunities to gain experience with the enhanced stripping system in different situations, in order to increase their familiarity and confidence with the method. Furthermore, the participants' positive experiences with their company's preference for using the enhanced stripping system over traditional methods for gasoline to diesel cargo shifts suggests that standardizing the use of this system could be beneficial in increasing its adoption and improving the efficiency and safety of tank preparation. However, it is important to note that proper training and guidance should also be provided to ensure the safe and effective use of the enhanced stripping system.

The second sub-theme, knowledge of vessel capability, emerged as an important factor in the participants’ decision-making process when choosing a tank preparation method for gasoline to diesel cargo shifts. The participants noted that having access to accurate and relevant information about their vessel's capabilities could support their ability to make informed decisions. They emphasized the importance of using documented data from the Procedures and Arrangements Manual to back their decision-making. Furthermore, knowledge of the vessel's capabilities can help anticipate potential issues that may arise during the tank preparation process, allowing participants to make more informed decisions and avoid potential issues during the cargo shift. Therefore, it is crucial for crew

members to have a comprehensive understanding of their vessel's capabilities, specifically the enhanced stripping system, in order to make well-informed decisions and ensure a safe and efficient tank preparation process. Providing crew members with proper training and access to relevant information can increase their knowledge of their vessel's capabilities and ultimately lead to better decision-making.

The third sub-theme, consultation with other parties, plays a significant role in the decision-making process for tank preparation, especially when determining the appropriate use of the enhanced stripping system. The participants highlighted that seeking the opinion of other parties could provide valuable insights and help them arrive at a well-informed decision. Participant M2's explanation of consulting the vessel's operator is a prime example of the value of seeking advice. The consultation allowed them to leverage the operator's knowledge and authority, which they could then use to make an informed decision. Similarly, Participant M4 mentioned that reaching out to colleagues from sister ships for advice can provide valuable insights that they might have otherwise overlooked. The findings of this study suggest that crew members should be encouraged to seek advice and collaborate with others when making decisions about the use of the enhanced stripping system as the main tank preparation method. This can ensure that they make well-informed decisions that prioritize safety and quality of the transported cargo. However, it is important to note that seeking advice and consultation with other parties should not be seen as a substitute for proper training and knowledge of vessel capabilities, but rather as a complementary tool to enhance decision-making.

The fourth sub-theme, reliance on tank cleaning guides, emerged as a key factor in decision-making regarding whether to use an enhanced stripping system as the main tank preparation method. The interviews revealed that some participants doubted whether their enhanced stripping system alone would suffice for a gasoline to diesel cargo shift. In such cases, some participants turned to tank cleaning guides to supplement their knowledge in this area. Participant M2's reliance on tank cleaning guides when external consultation did not result in a conclusive decision highlights the perceived importance and trust that some participants placed on the information provided in these guides. This indicates that tank cleaning guides can serve as a valuable resource for crew members in making informed decisions about tank preparation methods. Participant M4's emphasis on determining the most efficient tank preparation method in terms of resource utilization

suggests that optimizing resources was an important consideration for some participants. This highlights the need for a balance between the guidance provided by tank cleaning guides and practical considerations, such as resource utilization when making decisions about tank preparation methods. The findings suggest that crew members can benefit from utilizing tank cleaning guides as a supplement to their existing knowledge and expertise. However, it is important to exercise caution and use their judgment when relying on the information provided in these guides, considering practical considerations and the unique conditions of each situation.

The fifth sub-theme, compliance with voyage orders, emerged as a major factor in decision-making related to the selection of the main tank preparation method for gasoline to diesel cargo shifts. Participant M5 highlighted that complying with voyage orders was their top priority, indicating the importance of adhering to established protocols and guidelines in the maritime industry. However, if the voyage orders were ambiguous or lacked specific details, participants would refer to tank cleaning guides to help them decide on the appropriate tank preparation method. The availability of tank cleaning guides provided a valuable resource for crew members, enabling them to make informed decisions about the most suitable tank preparation method. The interviews further revealed that the use of only the enhanced stripping system as a tank preparation method was deemed appropriate for gasoline to diesel cargo shifts in a few of the tank cleaning guides. However, consideration was given to the requirement for the vessel to have a tank emptying capability within a certain limit to meet the tank preparation criteria. This suggests that tank cleaning guides can serve as a reliable reference for crew members to select the most appropriate tank preparation method, considering various factors such as vessel capability and specific voyage orders.

The sixth sub-theme, the characteristics of the previous gasoline cargo, are an important consideration for participants when deciding on the appropriate tank preparation method for a gasoline to diesel cargo shift. Participants cited that the visual appearance and other characteristics of the previous cargo could impact their choice of using only the enhanced stripping system as the tank preparation method. If the previous gasoline cargo was an unfamiliar variant or had questionable quality, participants would consider carrying out traditional tank preparation methods to ensure the quality of the diesel cargo they will be transporting. These findings highlight the need for careful consideration of the

characteristics of the previous cargo in the selection of the appropriate tank preparation process to ensure the safety and quality of the transported cargo.

Lastly, the seventh sub-theme, risk consideration, emerged as a relevant factor during the decision-making process when opting to use an enhanced stripping system for gasoline to diesel cargo shifts. Participant M6 highlighted that residue remaining in the cargo tank due to errors during the process can pose a risk to subsequent cargoes, and therefore risk consideration should be given more weight. Adequate assessment and mitigation of these risks are necessary to ensure the safety and quality of the transported fuel. These findings emphasize the need for careful consideration of the risks associated with tank preparation methods to avoid potential hazards during subsequent cargoes.

This study's findings have important implications for industry professionals, vessel operators, and charterers involved in gasoline to diesel cargo shifts. The factors influencing the decision-making process suggest that industry professionals must have experience with the enhanced stripping system as the only form of tank preparation and a deep understanding of their vessel's capabilities to make informed decisions about the primary tank preparation method. The importance of consultation with other parties and reliance on tank cleaning guides also highlight the need for collaboration and access to accurate and relevant information to ensure safe and efficient cargo transfers. Additionally, this study's findings emphasize the need for compliance with voyage orders, consideration of the characteristics of the previous gasoline cargo, and risk management to mitigate potential issues during the cargo shift. The findings provide valuable insights into the decision-making process involved in the use of the enhanced stripping system as the primary tank preparation method for a gasoline to diesel cargo shift. The factors influencing the decision-making process suggest that industry professionals must have a broad knowledge base and work collaboratively to ensure safe and efficient cargo tank preparation with an enhanced stripping system.

5.2 Disadvantages of traditional tank preparation methods

Cargo tank preparation is a crucial step in ensuring the safe and efficient transportation of cargo. However, traditional tank preparation methods have several drawbacks, as revealed by the thematic analysis of interviews with industry professionals. In this study, six sub-

themes emerged, which are time consumption, avoidable costs, exposure to risk, negative impact on the environment, personnel rest hour issues, and challenges with the presence of water.

The first sub-theme, time consumption, was a significant concern among the participants. The participants highlighted that traditional tank preparation methods take a considerable amount of time and may even take longer than anticipated, leading to delays and increased workloads. The extensive planning and paperwork required to comply with regulations and company procedures also contribute to the time consumption. In addition, unnecessary procedures such as washing and mopping may be carried out, contributing to lengthening the process. Participants suggested that a more streamlined and efficient process could be developed to reduce the time and effort required for tank preparation. These findings suggest that the time consumption associated with traditional tank preparation methods is a critical issue that needs to be addressed to increase efficiency and reduce delays.

The second sub-theme, avoidable costs, is another significant issue associated with traditional tank preparation methods. Participants expressed concern about the unnecessary costs associated with traditional methods, such as the disposal of slop washing water, bunker consumption from inert gas production for cargo tank atmosphere control, and excessive resource consumption. The use of only the enhanced stripping system was suggested as a more efficient and cost-effective option. However, it is crucial to note that proper regulations and guidelines must still be followed to ensure the safe and efficient implementation of cargo tank preparation.

The third sub-theme, exposure to risk, was a significant concern among the participants. The complex and hazardous nature of the traditional tank cleaning process exposes personnel to various risks, including, for example, slips, falls, toxic gas exposure, and confined space hazards. Participants highlighted the need for risk avoidance rather than risk reduction, especially concerning personnel's safety. The use of an enhanced stripping system offers a safer alternative that significantly reduces the amount of risk the vessel's crew would be exposed to, as it avoids the need for washing, mopping, and drying, which eliminates the risks associated with tank entry. This method can also be performed remotely on some vessels, reducing the need for personnel to be in close proximity to the cargo tanks.

The fourth sub-theme, negative impact on the environment, was another concern among the participants. The amount of emissions produced during traditional tank preparation methods can have a significant impact on the environment. Participants expressed their concerns about the emissions produced during the process, especially when cargo tanks need to be purged of hydrocarbons or other harmful substances. The use of an enhanced stripping system may significantly reduce the amount of emissions produced, making it a more environmentally friendly option.

The fifth sub-theme, personnel rest hour issues, was a significant concern among the participants. Participants highlighted that the time consumption associated with traditional tank preparation methods can affect personnel's performance and rest hours, leading to increased workloads and potentially impacting personnel's performance. The findings suggest that the use of alternative tank preparation methods, such as enhanced stripping systems, may be beneficial in reducing the impact of tank preparation procedures on personnel rest hours and fatigue. By reducing the time and resources required for tank preparation, these methods may enable crew members to maintain adequate rest and sleep periods, enhancing their cognitive and physical abilities and ultimately contributing to a safer and more efficient maritime industry.

Finally, the sixth sub-theme, challenges with the presence of water, was a minor concern among the participants. Some participants highlighted that the presence of water in cargo tanks can lead to additional costs and complications in the tank preparation process. The issue of water contamination is not a new challenge for the shipping industry. Some shipping companies have invested in new technologies such as enhanced stripping systems and closed-loop tank cleaning systems to minimize the risk of water contamination. However, as participant M4 pointed out, the use of traditional tank preparation methods may increase the risk of water contamination in the cargo tank.

This study revealed that traditional tank preparation methods have several drawbacks, including time consumption, avoidable costs, exposure to risk, negative impact on the environment, personnel rest hour issues, and challenges with the presence of water. The findings suggest that the use of an enhanced stripping system can offer a more efficient, cost-effective, and environmentally friendly alternative to traditional tank preparation methods. By reducing the time and resources required for tank preparation, crew members

can maintain adequate rest and sleep periods, which enhances their cognitive and physical abilities and ultimately contributes to a safer and more efficient maritime industry. However, it is essential to note that proper regulations and guidelines must still be followed to ensure the safe and efficient implementation of cargo tank preparation.

5.3 Experience using an enhanced stripping system

In this section, we examine the experiences of participants who have used an enhanced stripping system as the main tank preparation method for gasoline to diesel cargo shifts. The sub-themes explored in this section include: the practices of instructing only enhanced stripping as tank preparation by charterers, the negotiations between owner and charterer on the use of only enhanced stripping, hydrocarbon purging and enhanced stripping as tank preparation, the responsibility of providing the appropriate tank preparation method, the coordination between parties for the implementation of enhanced stripping as the only tank preparation method, and the efficiency of enhanced stripping systems. Through an analysis of these sub-themes, we provide insight into the benefits and challenges of using an enhanced stripping system as the primary tank preparation method for gasoline to diesel cargo shifts.

The first sub-theme, the standard practice of only enhanced stripping as tank preparation by charterers, revealed that the use of enhanced stripping as the primary tank preparation method for gasoline to diesel cargo shifts is becoming increasingly prevalent. Participants reported that the majority of charterers they worked with, particularly the North European ones, had no issues with using the enhanced stripping system as the sole tank preparation method for gasoline to diesel shifts. Furthermore, some of these charterers would often themselves recommend the use of only enhanced stripping as preparation for a gasoline to diesel shift. Traditional tank preparation methods were not being used as often as they once were, and in most cases, tank atmosphere purging and enhanced stripping are used together, or enhanced stripping is used alone. This suggests that some charterers have accepted alternative methods for gasoline to diesel cargo shifts and are more open to exploring safer, more efficient, and more sustainable practices.

The second sub-theme, negotiations between owner and charterer on the use of only enhanced stripping, highlights an important trend in the industry towards using alternative

tank preparation methods for gasoline to diesel shifts. Participant M1's experience illustrates how the negotiations between owner and charterer on tank preparation methods may influence the utilization of traditional methods. The increasing prevalence of using only enhanced stripping as a standard practice for gasoline to diesel cargo shifts has significant implications for vessel efficiency and operational costs. This trend towards using more efficient and cost-effective tank preparation methods is indicative of a broader shift towards sustainability and eco-friendliness in the industry. By reducing the need for traditional tank preparation methods, which can be time-consuming and expensive, charterers and vessel owners can save money and minimize the environmental impact of their operations. Additionally, the use of only enhanced stripping as a standard practice may indicate a growing awareness and acceptance of safer and more sustainable practices in the industry.

The third sub-theme, hydrocarbon purging and enhanced stripping as tank preparation, indicated that some charterers prefer their vessels prepare their cargo tanks by purging their atmosphere from hydrocarbons in conjunction with using their enhanced stripping system, and this suggests a shift away from traditional tank preparation methods and towards more efficient and cost-effective methods. This method has also been increasingly acknowledged by load ports and external cargo surveyors, which is seen as a compromise between traditional tank preparation and uses only the enhanced stripping system. The recognition of this method indicates that it is steadily becoming an accepted practice in the industry. Participants expressed their preference for this method, believing that it provides an extra level of assurance that their cargo tanks are suitable for loading the next cargo. This highlights the importance of ensuring adequate tank preparation to prevent cargo contamination and related risks.

In the fourth sub-theme, the responsibility of providing the appropriate tank preparation method was found to be a concern among participants. Participant M1 expressed their belief that the vessel's operator should advise on the appropriate tank preparation method when giving out voyage orders, thus indicating that the operator should play a more active role in ensuring the safety and suitability of the cargo. This finding highlights the importance of clear communication and coordination between the operator, charterer, and vessel to ensure that the appropriate tank preparation method is selected. Although the final responsibility of cargo tank load suitability falls on the vessel’s master, the

operator's role in advising on the tank preparation method is significant in preventing cargo contamination and related risks. Moreover, it suggests that industry-wide guidelines and regulations may be needed to clarify the responsibilities of each party involved in the shipment of cargo and tank preparation.

In the fifth sub-theme, the importance of coordination between parties for the implementation of enhanced stripping as the only tank preparation method was highlighted. Participant M3 emphasized the necessity of proper coordination among all parties involved, including the vessel operator, cargo supplier, and cargo receiver. The participant noted that each party might have different perspectives and priorities, such as their experience with enhanced stripping as the sole tank preparation method, their understanding of its effectiveness, and their concerns for the safety of the vessel and its cargo. This finding highlights the need for clear communication and effective coordination among the parties involved to ensure the acceptance of enhanced stripping as the only tank preparation method. Furthermore, the lack of coordination and uncertainty regarding the use of enhanced stripping as the sole form of tank preparation was identified as an ongoing issue. Sharing information and data can enable an informed decision-making process and minimize potential disputes among the parties involved. This finding suggests that there is a need for industry-wide guidelines and regulations to standardize the use of enhanced stripping as the sole tank preparation method, and clarify the responsibilities of each party involved in the shipment of cargo and tank preparation to avoid misunderstandings and disputes.

In the sixth sub-theme, the findings regarding the efficiency of enhanced stripping systems as the only tank preparation method for gasoline to diesel cargo shifts were mixed. While some participants noted the effectiveness of modern tankers equipped with enhanced stripping systems, others identified potential drawbacks, such as the possibility of human errors during tank preparation leading to residue remaining in the tanks. Therefore, it is important to recognize the potential risks associated with the use of enhanced stripping systems and to take steps to minimize them, such as ensuring proper training and supervision of personnel involved in the tank preparation process. Additionally, further research could explore ways to improve the effectiveness of enhanced stripping systems and minimize the potential for residue remaining in the tanks. The findings of this study suggest that enhanced stripping systems have the potential to be a highly effective tank

preparation method for gasoline to diesel cargo shifts, but they should be used with caution and with proper training and supervision.

The use of an enhanced stripping system as a standalone tank preparation method for gasoline to diesel cargo shifts is becoming increasingly prevalent in the industry. Traditional tank preparation methods are being used less often by some vessels, and charterers are more open to exploring safer, more efficient, and more sustainable practices. This shift towards using more efficient and cost-effective tank preparation methods is indicative of a broader trend towards sustainability and eco-friendliness in the industry. The importance of clear communication and coordination among parties involved in the shipment of cargo and tank preparation was highlighted to ensure the appropriate tank preparation method is selected and to avoid misunderstandings and disputes. While the efficiency of enhanced stripping systems was found to be mixed, it is important to recognize the potential risks associated with their use and take steps to minimize them.

5.4 Significance of the research

This study contributes to the lack of existing literature regarding the appropriateness of an enhanced stripping system as the main tank preparation method for gasoline to diesel cargo shifts on oil tankers. Despite the increasing prevalence of this practice in the maritime industry, internationally agreed standards for using an enhanced stripping system as a standalone tank preparation method for gasoline to diesel cargo shifts have not yet been established. This study provides valuable insights into the factors that influence the decision to use an enhanced stripping system, the feasibility and appropriateness of using it compared to traditional methods, and the experiences of industry professionals who have used it.

By exploring the perceptions and experiences of industry professionals, this study highlights the need for a better understanding of the appropriateness of using an enhanced stripping system for gasoline to diesel cargo shifts. The findings of this study can inform the development of recommendations for tank preparation methods, which can enhance the safety and efficiency of this practice. Additionally, this study can serve as a foundation for future research on the topic, including quantitative studies to explore the prevalence of the

use of enhanced stripping systems and its impact on a multitude of factors such as safety, sustainability, operational efficiency, and much more.

This study has important implications for the maritime industry, as it sheds light on an important practice that affects the safety and quality of cargo transported on oil tankers. The findings of this study can be used to inform decision-making among industry professionals and policymakers, and can contribute to the development of best practices and standards for tank preparation methods.

5.5 Limitations of the study

One limitation of this study was the data collection method. The semi-structured interviews of the seven maritime industry professionals were not recorded or transcribed verbatim due to the limitation of mobile phones to record high-quality audio. Instead, detailed notes were taken using a computer during the interviews to capture the participants' responses. This could have resulted in a loss of information, as some nuances or subtleties in the participants' responses may have been missed during notetaking. Additionally, the use of notes instead of verbatim transcripts may have made it more difficult to fully capture the richness and complexity of the data.

Another potential limitation of this study was the use of thematic analysis as the analytical method. While thematic analysis is a widely used and accepted approach in qualitative research, it is important to acknowledge its limitations. For example, it is a subjective process that requires interpretation by the researcher, which may introduce bias or limit the reliability of the findings. Additionally, the identified themes may not represent the full range of perspectives or experiences of the participants, or they may be influenced by the researcher's preconceptions or assumptions. It is also possible that some relevant themes were not identified or were overlooked during the analysis.

While this study provides valuable insights into the understanding of the appropriateness of the use of an enhanced stripping system as a standalone tank preparation method for gasoline to diesel cargo shifts, it is important to recognize the limitations of the data collection and analytical methods used. Further research using alternative or complementary approaches may be needed to fully explore and understand this complex phenomenon.

6 Conclusion

This study identified the key factors that influence the decision to use an enhanced stripping system as a standalone tank preparation method for gasoline to diesel cargo shifts, as perceived by industry professionals. This study also explored the feasibility and appropriateness of using an enhanced stripping system for gasoline to diesel cargo shifts, compared to traditional methods, and identified the experiences of industry professionals who have used an enhanced stripping system for gasoline to diesel cargo shifts.

Decision-making highlights the importance of industry professionals having a broad knowledge base and working collaboratively to ensure safe and efficient cargo tank preparation with an enhanced stripping system. This study's findings emphasize the need for collaboration, consultation with other parties, access to accurate and relevant information, and compliance with regulations and guidelines. The decision-making process for selecting a primary tank preparation method involves several factors that require a deep understanding of vessel capabilities and the characteristics of the previous cargo.

The disadvantages of traditional tank preparation methods suggests that traditional tank preparation methods have several drawbacks, such as time consumption, avoidable costs, exposure to risk, negative environmental impact, personnel rest hour issues, and challenges with the presence of water. The findings indicate that the use of an enhanced stripping system offers a more efficient, cost-effective, and environmentally friendly alternative to traditional tank preparation methods. However, it is crucial to follow proper regulations and guidelines to ensure safe and efficient implementation of cargo tank preparation.

Experience using an enhanced stripping system highlights the shift towards using more efficient and cost-effective tank preparation methods in the industry, such as the increasing prevalence of using an enhanced stripping system as the primary tank preparation method for gasoline to diesel cargo shifts. The importance of clear communication and coordination among parties involved in the shipment of cargo and tank preparation was also emphasized. While the efficiency of enhanced stripping systems was found to be mixed, it is important to recognize the potential risks associated with their use and take steps to minimize them.

The findings of this study have important implications for the maritime industry, as they shed light on an important practice that affects the safety, sustainability, and efficiency of clean petroleum product tankers. This study provides valuable insights into the factors that influence the decision to use an enhanced stripping system, the drawbacks of traditional methods, and the experiences of industry professionals who have used an enhanced stripping system for gasoline to diesel cargo shifts.

Furthermore, the findings of this study can inform the development of recommendations for tank preparation methods, which can enhance the safety and efficiency of this practice. This study can also serve as a foundation for future research on the topic, including quantitative studies to explore the prevalence of the use of enhanced stripping systems and its impact on factors such as safety, sustainability, and operational efficiency.

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Shell Ship Pre Cargo Matrix excerpt

SHIP PRE CARGO MATRIX
WHITE OIL PETROLEUM PRODUCTS & COMPONENTS

KEY to DEFINITIONS FOR TANK PREPARATIONS

Key	Detail and Requirement
WD	Previous cargo is acceptable, so long as the cargo tank, pump columns and pipe lines are **"Well Drained"** by the ships stripping system to minimise the ROB - any ROB that does remain should only ever be in the pump well. Pump columns, pipe lines and drops should be cleared and drained free of all free-standing product and water. *An ROB volume in excess of 0.05% of the Individual Tank capacity does not meet the well drained criteria.* [1]
EWD	Previous cargo is acceptable, so long as the cargo tank, pump columns and pipe lines are **"Well Drained"** by the ships 'enhanced' stripping system to minimise the ROB - any ROB that does remain should only ever be in the pump well. Pump columns, pipe lines and drops should be cleared and drained free of all free-standing product and water. ***An ROB volume in excess of 0.0025% of the Individual Tank capacity does not meet the enhanced well drained criteria.(1)***
CW	First follow the **WD** procedure, then the cargo tank(s) and lines need to be **"Cold Water Washed"**, drained well to remove all free-standing water/product.[3]
CW-VP	First follow the **WD** procedure, then the cargo tank(s) and lines need to be **"Cold Water Washed"**, drained well to remove all free-standing water/product, and either *Ventilate or Purge* the tank atmospheres[2][3]
CWM	First follow the **WD** procedure, then the cargo tank(s) and lines need to be **"Cold Water Washed"**, drained well to remove all free-standing water/product, then Rendered Gas-Free and **Mop** the tanks dry.[3]
CFW	First follow the **WD** procedure, then cargo tank(s) and lines need to be washed with **"Cold Fresh Water"**. The bulk washing may be conducted with Cold Sea Water so long as a final wash with **"Cold Fresh Water"** is conducted. After washing the tank must be drained well to remove all free-standing water/product.[3]
HW	First follow the **WD** procedure, then the cargo tank(s) and lines need to be **"Hot Water Washed"**, drained well to remove all free-standing water/product, and either *Ventilate or Purge* the tank atmospheres[2][3].
HWM	First follow the **WD** procedure, then the cargo tank(s) and lines need to be **"Hot Water Washed"**, drained well to remove all free-standing water/product, then Rendered Gas-Free and **Mopped** dry.[3]
HFW	First follow the **WD** procedure, then cargo tank(s) and lines need to be washed with **"Hot Fresh Water"**. The bulk washing may be conducted with Hot Sea Water so long as a final wash with **"Hot Fresh Water"** is conducted. After washing the tank must be drained well to remove all free-standing water/product.[3]
NC	The last cargo is **"Not Compatible"** with the product to be loaded and therefore the product should not be loaded into the tank(s).

Shell Ship Pre Cargo Matrix excerpt (Cont.)

PREVIOUS CARGO

CARGO TO BE LOADED	UN1202 Diesels/Gasoils containing 0 - 5% FAME / Biodiesel	UN1202 Diesels/Gasoils containing 5 - 15% FAME / Biodiesel	UN 1202 10ppm - ULSD Diesel fuel ADO, AGO No bio component	UN 1202 50ppm - ULSD Diesel fuel ADO, AGO No bio component	UN 1202 Detergent Addivated 10ppm Diesel fuel V-Power Diesel	UN1202 & 1223 GTL Kero/Diesel Drilling Fluids Synthetic Distillate No bio component	UN 1202 Gas Oil DYED 500/2000 ppm S IGO No bio component	UN 1202 Gas Oil UNDYED 500/2000 ppm S IGO No bio component	UN 1203 10 or 50 ppm Gasoline PUL, SUL, ULG
UN 1202 ULSD - 10ppm Diesel fuel ADO, AGO 0 - 15% Bio	WD CWM if previous sulphur > 500ppm or if dyed	WD CWM if previous sulphur > 500ppm or if dyed	Same Grade	WD	WD	WD	CWM	CWM; WD if gas oil sulphur is <500ppm	CWM or EWD if applicable to vessel
UN 1202 ULSD - 50ppm Diesel fuel ADO, AGO 0 - 15% Bio	WD CWM if previous sulphur >2000ppm or if dyed	WD CWM if previous sulphur >2000ppm or if dyed	WD	Same Grade	WD	WD	CWM	WD	CWM or EWD if applicable to vessel
UN 1202 Detergent Addivated 10ppm Diesel fuel V-Power Diesel	WD CWM if previous sulphur > 500ppm or if dyed	WD CWM if previous sulphur > 500ppm or if dyed	WD	WD	Same Grade	WD	Very water sensitive. CWM	Very water sensitive. CWM. WD if gas oil suplur is <500ppm	Very water sensitive. CWM; EWD if applicable to vessel
UN 1223 & 1202 GTL Kero & GTL Diesel Drilling Fluids -DF Synthetic Distillate No bio comp	WD CWM if previous sulphur > 500ppm, if dyed or DF to load	WD CWM if previous sulphur > 500ppm if dyed or DF to load	WD CWM if DF to load	WD CWM if DF to load	WD CWM if DF to load	Same Grade	CWM	CWM	CWM
UN 1202 Gas Oil DYED 500 or 2000 ppm S IGO, GOCI 0 - 15% Bio	WD	WD	WD	WD	WD	WD	Same Grade	WD	CW-VP; CWM if to-load contain bio component. EWD if applicable
UN 1202 Gas Oil UNDYED 500 or 2000 ppm S IGO, GOCI 0 - 15% Bio	WD	WD	WD	WD	WD	WD	CW; CWM if to-load contain bio component	Same Grade	CW-VP; CWM if to-load contain bio component. EWD if applicable

HM50 Tank Cleaning Matrix excerpt

		Previous Cargo													
This Table to be used only with reference to the written recommendations of HM 50. See:	Cargo to be loaded	Aviation gasoline	Wide cut jet fuel, JP4, Jet B	Aviation jet fuel and components	Motor gasoline containing oxygenates (ethanol, MTBE, etc.)	Motor gasoline (unleaded)	Ultra low sulfur motor gasoline (unleaded)	Motor gasoline (leaded)	Naphtha (lead-free)	Natural gasoline (NGLs)	Kerosene (undyed)	Kerosene (dyed)	Gas oil (undyed)	Gas oil (dyed)	Ultra low sulfur gas oil/ diesel
2.11.2	Aviation gasoline #	1	1	2	2	1	1	1	2M	2M	2M	2M	2M	2M	2M
2.11.2	Wide cut jet fuel, JP4, Jet B #	2M	1	1	2M	2M	2M	2M	2M	2M	1	2M	1	2M	1
2.11.7	Aviation jet fuel and components #	2M	2M	1	2M	2M	2M	2M	2M	2M	1	2M	1	2M	1
2.11.4	Motor gasoline (unleaded) containing oxygenates (ethanol, MTBE, etc.)	2M	1	1	1	1	1	2M	1	1	1	1	1	2M	1
2.11.4	Motor gasoline (unleaded) †	2	1	1	1	1	1	2	1	1	1	1	1	2	1
2.11.5	Ultra low sulfur motor gasoline (unleaded) †	2M	2M	2M	2M	2M	1	2M	2M	2M	1 See Note 5	2M	1 See Note 5	2M	1
2.11.3	Motor gasoline (leaded) †	1	1	1	1	1	1	1	1	1	1	1	1	2	1
2.11.1	Naphtha (lead-free) †# See Note 8	X	1	1	2 See Note 8	1	1	X	1	1	1	1	1	1	1
2.11.1	Natural gasoline (NGLs) †	X	1	1	1	1	1	X	1	1	1	1	1	1	1
2.11.8	Kerosene (undyed)	2P	2P	1	2P	2P	2P	2P	2P	2P	1	2	1	2	1
2.11.8	Kerosene (dyed)	2P	2P	1	2P	2P	2P	2P	2P	2P	1	1	1	1	1
2.11.9	Gas oil (undyed)	2P	2P	1	2P	2P	2P	2P	2P	2P	1	2	1	2	1
2.11.9	Gas oil (dyed)	2P	2P	1	2P	2P	2P	2P	2P	2P	1	1	1	1	1
2.11.10	Ultra low sulfur gas oil/diesel	2M	2M	2M	2M	2M	2M	2M	2M	2M	1 See Note 5	2M	1 See Note 5	2M	1

HM50 Tank Cleaning Matrix excerpt (Cont.)

Table 1: Tank cleaning recommendations (continued)

Code	Cleaning recommendations
X	Not to be loaded without special cleaning instructions
X*	Not to be loaded without special cleaning instructions. Three clean and zero biological content intermediate cargoes recommended
1	Drain tanks, lines and pumps well. If previous cargo shows signs of instability or oxidation (dark colouring or broken down from sediment) then use code 2M
2	Wash with cold water and drain well
3	Wash with hot water and drain well
3M*	A stringent hot water wash, drain and mop may be sufficient if tanks are in good condition. As an alternative one clean product/ zero biological content intermediate cargo is recommended, followed by hot water wash, drain and mop. Fresh water rinse required if sea water is used. Consideration may be given to substituting mopping by enhanced stripping and drying, see 2.10
P	Purge to below 2 % hydrocarbon by volume
M	Gas-free, lift scale and mop. Consideration may be given to substituting mopping by enhanced stripping and drying, see 2.10
#	Fresh water rinse after any salt water wash when loading these products
LU	Reduced cleaning may be permitted depending on Lubricating Oil Specification. Otherwise apply code 3M
Notes:	1. Additional cleaning may be required for uncoated tanks, tanks with extensive coating breakdown or where specified by the charter party 2. † Benzene may be present in any petroleum product but may be present in higher concentrations in those products marked †. Refer to ISGOTT for precautions in handling cargo suspected of having a benzene content and prior to entering a space which has contained such a cargo 3. In cases where the FAME content in diesel is unknown, and in locations where reporting of FAME content is not required, it shall be assumed to be 15 % 4. Comments regarding FAME also apply to FAEE and other fatty acid esters 5. Where high sulfur kerosene or gas oil has been discharged Code 2 should be used 6. Refer to quality certificate: some condensates are of sufficient quality as to allow loading of clean products, including aviation fuel, following cleaning to code 2M 7. Lubricating oil should be loaded, carried and discharged under air or nitrogen only 8. Chemical grade naphtha is very sensitive to contamination by oxygenates. Stringent cleaning is required before loading this product. Some contracts require three oxygenate-free cargoes before loading chemical grade naphtha