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Abstract

Due to large quantities of cargo transported by oil carriers, as well as the inability of many ports to accommodate such ships, the solution was found in the application of STS (Ship-to-Ship) operation. Opposite, LNG STS terminals are usually set up where the construction of a classic onshore terminal is impossible or economically unprofitable. However, such an operation is associated with increased risks which could be minimized by taking precautions, following the regulations, and having well trained officers and crew on board. Well trained and competent crews are indispensable in STS procedures to minimize the risks to which STS processes are exposed, especially those that can threaten the environment.
This paper elaborates LNG STS procedure and discusses the necessity for appropriate training of seafarers involved in such operations. Furthermore, it proposes education requirements for officers involved in LNG STS procedures based on relevant recommendations, practices, and perceived shortcomings.

Keywords: LNG STS operation, risk management, competencies, training requirements.

1. Introduction

In the nowadays maritime industry, large quantities of cargo are transported by oil and gas tankers. Unloading such cargo often involves more than a single port, particularly in the case of oil tankers. Ports can be limited by several factors such as draught, length, and height of a ship, as well as those related to the design of a ship. To overcome such issues, the technology of Ship-to-Ship (STS) cargo transfer operation

has been introduced. This technology is used primarily for the transhipment of liquid cargo. The ship-to-ship cargo operation is considered cost-effective in the context of cargo delivery to ports unable to provide mooring of ships or bunker operation to ships. In modern shipping, there is an increase in the variety of maritime processes and cargo operations related to STS cargo handling procedures [1,2]. STS procedures are on the rise, and that they follow the general increase in maritime transport.

Today's understanding of the STS procedures is related to the transfer of bulk cargo, either dry bulk, oil, or gas from one ship to another, both positioned alongside each other. STS procedures may or may not be conducted underway [1]. It includes not only the master's responsibility but also coordinated actions of all persons involved in the procedures, following the accompanying processes, all supported by appropriate equipment. Implementation of the procedure also requires valid authorization by the ship's classification society because procedures must be in line with the latest rules and regulations.

One of the specific STS procedures is LNG STS cargo operation. Due to the geographical position of ports and terminals located at different places, the STS procedures are widely applied worldwide, particularly in ports where onshore terminals are not economically feasible or landline infrastructure is not sufficient [3]. Far East countries such as China, Japan, Taiwan, Malaysia, and Singapore have a significant number of STS operations. Japan has firmly re-established itself as the world's leading buyer of LNG. After subdued demand related to COVID-19 related health measures' negative economic impact, the country's cargo offtakes have broadly returned to year-on-year levels [4]. Meanwhile, US LNG exporters are trying to return to growth, with exports growing rapidly [5].

It should be noted that the implementation of STS procedures and specifically of LNG STS procedures are associated with increased risks of accidents such as fire or explosion but also pollution. It is especially evident since the possibility of undesirable conditions is far more significant when the ship is not moored and exposed to unfavourable weather conditions (e.g., during STS operation at anchorage).

Safety and risk assessment of STS LNG transfer operation was the topic of research done by Daryanto et al. [6]. Ventikos and Stavrou [7] described the latest developments in STS cargo transfer procedures. Sultana et al. in [8] applied System Theoretical Process Analysis (STPA) and Hazard and Operability Studies (HAZOP) on an LNG STS cargo transfer operation to ascertain whether STPA can replace HAZOP. Englebert described the design, installation and operation of LNG STS transfer [9]. The author stated that before STS operation, extensive training covering all aspects of operation is given to the ship's crew by an experienced crewmember or STS Superintendent. Gilchrist in [10] described challenges for the LNG STS industry, including fendering systems, fender davits, mooring equipment, tugs usage, cargo transfer equipment, development of effective regulations and lastly, training requirements. The author explained using up-to-date simulators to transfer knowledge between experienced LNG Masters and experienced Mooring Masters. There was a benefit for both groups

of LNG experts, and such training involving a simulator could play an important role for various training involving LNG ship manoeuvring, including STS operations. Stokes et al. [11] elaborated on competencies required for seafarers involved in LNG bunkering operations. Implementing competencies for such critical operations might reduce human error and reduce incidents involving LNG bunkering. Changes in technology and procedures would require re-examining critical competencies required, ensuring a high level of safety during LNG bunkering operations. LNG vessels and cargo characteristics, including STS operations, were elaborated by previous research, but there is a gap in presenting characteristics and safety of LNG STS operations and accompanied training requirements.

This paper tries to fill the identified gap and elaborates LNG STS procedure, and discusses the necessity for appropriate training of seafarers involved in such operations. Furthermore, the paper proposes the development of models of educational programs for STS operation.

2. STS procedures and associated risks

In the tanker industry, there are some rules and recommendations that prescribe STS procedures [12]. One of them is the Ship to Ship Service Provider Management and Self Assessment Guide published by OCIMF, where the self-assessment programme encourages STS Service Providers to assess their safety management systems against key performance indicators [13]. Furthermore, following its SMS (Safety Management System), each company develops and implements safety procedures, seafarers' tasks and determines risks associated with the STS operation.

STS operation can be generally divided into the following stages [1,14]:

- Pre-Arrival stage,
- Approach and mooring stage,
- Cargo/bunker transfer stage, and
- Post-Transfer procedure.

The pre-arrival stage includes all the required preparations for moving towards the approached ship. At this stage, it is necessary to obtain permission from the appropriate national authorities to carry out the planned procedures. An essential element in this stage is creating a joint operation plan, considering all relevant risk assessment factors [6]. Risk factors may be different and may be related to, for example, environmental conditions, available marine or water space with an emphasis on known sea depths, sea conditions, tides, and various dynamic or some other restrictions. Also, lots of things should be considered, such as the level of crew training, communication issues, size of the vessels, as well as cargo specifics and cargo risk factors. It is recommended that the plan includes all regulatory requirements, primary and secondary communication plan, elaborated mooring and fendering issues, cargo transfer details, emergency response actions, roles and responsibilities of all parties involved in processes, a designated

POAC authority (Person in Overall Advisory Control), and, as a critical component, all ballast-related procedures being completed [14,15].

A Ship-to-Ship transfer operation should be under the advisory control of a designated Person in Overall Advisory Control (POAC). The POAC is usually one of the Masters of the vessels concerned or an STS Superintendent, Lightering Coordinator, or Mooring Master employed by an STS Resource Provider. It is not intended that the POAC in any way relieves the ships' Masters of any of their duties, requirements, or responsibilities [1,7,16].

In the approach and mooring stage, all calculations related to environmental conditions and the vessels' size should be conducted. A step-by-step approach with controlled speed should be used in checking the efficiency of available means such as tugboats, fenders, and boats. If the STS procedure is carried out at sea, then it should be clear which is the approaching ship that will manoeuvre to approach and which the approached ship, i.e., the one that is anchored. All mooring lines and securing points must follow the arrangement management plan and appropriate use of the fenders [14,15].

The cargo or bunker transfer stage is considered to be a crucial stage of the STS procedures. An effective and well-designed communication plan with good coordination is essential for a secure connection and transfer of cargo. It should be pointed out that all new procedures are coordinated and monitored by classification societies that provide recommendations for safer maritime operations. At this stage, ballast operations must be continuously monitored, and the movement of ships continuously supervised [14-16].

During the post-transfer stage and after the transfer, both ships must disconnect all cargo links such as hoses and secure cargo tanks. The procedure is considered to be equivalent to the procedure of a ship's departure from a terminal. Special care should be taken to avoid any possibility of hull damage between ships. Increasing the distance between the ships should be carried out gradually [14-16].

There is a series of important documents that support the implementation of the STS procedures. These documents refer to a number of checklists that confirm completion of information for each ship, information prior to STS commence, approaching and unmooring information, a list of commenced STS procedures, and the like. It is recommended that the documentation be made available for future use, especially to transfer knowledge and experience to reduce risk. It is considered important to have a detailed emergency response plan issued, such as planned pollution preventative measures, emergency breakaway with defined safe and quick unmooring in case of an emergency event, fire, and environmental protection measures, and awareness of roles and responsibilities for all persons involved [14-19].

Today, when modern shipping tendencies are to reduce harmful emissions, there are more and more solutions based on the use of natural gas as fuel. Today's cruise ships, bulk carriers, or container ships can be propelled by natural gas (LNG), which implies having adequate storage for that kind of fuel. In that sense, potentially on every ship that uses (LNG) natural gas as fuel, there is the same bunkering procedure as on

LNG tankers. Such a system is needed to ensure safety in manoeuvring, mooring, and transferring of LNG during transfer operation in Ship-to-Ship (STS) system between LNG powered ships and LNG bunker ships. Figure 1. gives an example of an organization of STS LNG transfer. The roles and duties of every person in this system are given in STS procedures. The prerequisite for an LNG bunker ship that has the objective of maintaining the integrity of the ship's safety management system for deploying LNG STS transfer is to acquire ISM (International Safety Management) on a voluntary basis [19].

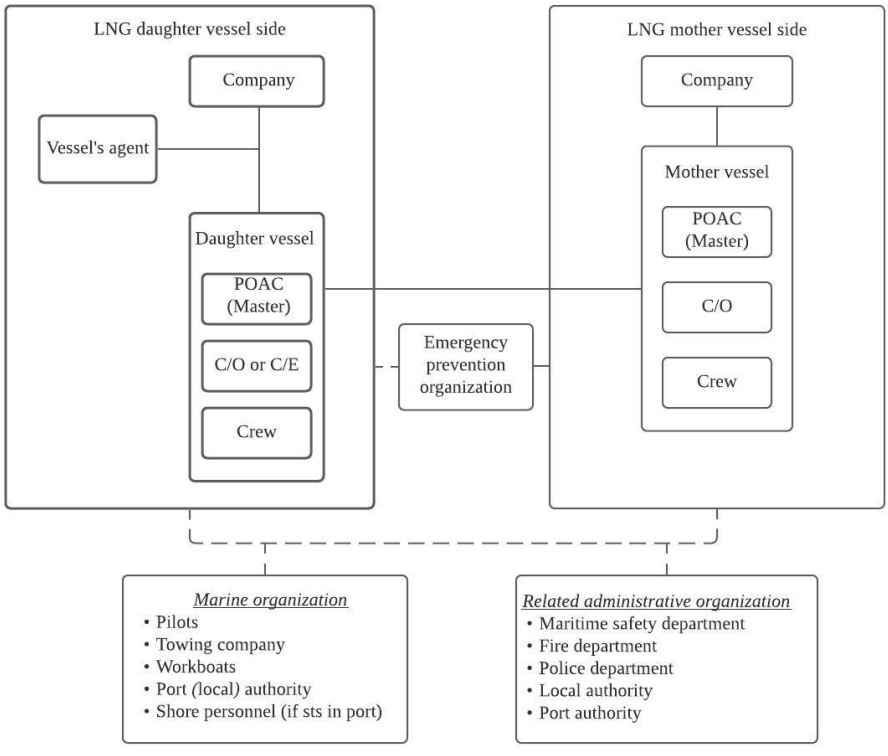

Figure 1 - Organization of Ship-to-Ship LNG transfer
Source: Authors adapted from [19]

The shipping industry has so far classified cargo vessels by ship design and their purpose, considering the type of cargo they are designed to carry. Conning such ships also required having experienced and skilled seafarers with maritime skills and regulations they had to comply with. With LNG STS operation on LNG FSRU ship as one of the most often LNG STS operation, LNG bunkering operations on LNG powered ships also require a crew adequately trained for that kind of work.

One of the most common international locations for STS transhipment operations is in Malaysia's maritime waters, where certain specific procedures and rules have been issued [20]. STS procedures and rules that are already in place could be taken as a basis for the implementation of training requirements.

The procedures and rules shall be designed to successfully allow appropriate coordination between the competent authority, terminal/ship operator, LNG supplier/ bunker infrastructure owner, or gas-fuelled ship. Due to that, all parties interested and related to LNG STS operation are jointly looking forward to furthering safety development, including good practise and recommendations [1].

These procedures should only take place if every party involved considering that the operation could be performed safely if:

- the risk assessment indicates a tolerable level of residual risk,
- all the mitigations requested have been provided,
- all personnel involved understand their roles and are adequately trained (approved by the administration/internationally),
- sufficient personnel shall be made available to ensure safe and effective STS transfer.

The aforementioned implies that LNG STS operation requires specialized competencies, knowledge, and understanding of the STS operation, not only those acquired throughout regular education and practice. Highly sophisticated and safety jeopardize operation inevitably require precise and well-educated crew, particularly those who manage the whole LNG STS operation.

3. Training and education requirements

To determine specific educational requirements for LNG STS operation, existing IMO and company tailored training need to be analyzed. Here the authors compared the existing IMO training requirements with company tailored STS training and synthesized them into competencies that could be considered as those needed for a safe and efficient LNG STS transfer operation.

IMO Model Courses are intended to support maritime training institutions and their teaching staff in organizing and implementing new training courses or amending existing training if they can be improved. Their goal is also enhancing seafarers' capabilities sailing on specialized types of vessels like liquefied gas tankers. The goal of the IMO Model Courses for liquefied gas carriers is to make seafarers aware of the peculiarities of shipboard operations unique to that type of vessel and prepare them for the responsibilities they will face once aboard a ship [21].

This proposed course training is designed for Masters, Chief Engineer Officers, Chief Mates, Second Engineer Officers, and any other person directly in charge of loading, discharging, transport, handling liquified gas cargo, tank cleaning, or other cargo-related operations on liquefied gas tankers. The coverage of the proposed training

is comprehensive in scope. It includes general onboard safety, fire safety measures and systems, prevention and control of environmental pollution, cargo operational practice, and obligations under applicable regulations, and covers all needed training. The planned training should also cover onboard leadership aspects, including risk assessments and safety management and emergency planning in line with the ISM Code.

It is assumed that seafarers in need for the completion of training for STS transfer operation have already had competencies required by STCW (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers) table A-V/1-2-1 and table A-V/1-2-2, both implemented in the training based on IMO Model Course on Basic Training for Liquified Gas Tanker Cargo Operations and Advanced Training for Liquified Gas Tanker Cargo Operations [21,22]. Furthermore, the competencies required by the STCW Convention for Master and Chief Engineer need to be taken into consideration, accompanied by the IMO Model Courses 7.01 (Master and Chief Mate) and 7.02 (Chief Engineer Officer and Second Engineer Officer) [23,24], as well as requirements of the IGF Code (International Code of safety for ships using gases or other low-flashpoint fuels)[25,26]. Competencies for the advanced level required by the STCW Convention excerpt are presented in Table 1.

Table 1. Competences for senior officers on a liquified gas tanker.

Competence	**Knowledge, understanding, and proficiency**
Safe performance and monitoring of cargo operations	LNG tanker design, characteristics, and knowledge of cargo transfer equipment (cargo pumps).
	Loading, unloading, cargo transfer, ship-to-ship transfer, and care during transportation.
	Safety culture skills and implementing safety management requirements, including safety procedures and cargo operations checklists.
	Knowledge of cargo measurements and calculations.
	Skills for management and supervision of personnel with cargo-related responsibilities.
Knowledge of liquefied gas cargoes' physical and chemical properties	Knowledge and understanding of the LNG's fundamental chemical and physical properties and the relevant definitions for safe transport.
	Interpreting the Material Safety Data Sheet (MSDS) information.

Knowledge of measures for prevention of hazardous occurrences	Knowledge of the hazards and control measures of LNG tanker cargo operations. Proficiency in checking and use monitoring and gas detection equipment. Knowledge and understanding of risks for non-complying with applicable regulations.
Knowledge of the application of occupational health and safety measures	Knowledge and understanding of safe working practices on LNG tankers.
Response to emergencies	Knowledge and understanding of LNG tanker emergency procedures.
Knowledge of environmental pollution prevention measures	Understanding of environmental pollution prevention procedures.
Knowledge of legislative requirements	Knowledge and understanding of applicable MARPOL stipulations and other applicable IMO instruments and local regulations. Proficiency in the usage of the IBC and IGC Codes and related regulations.

Source: Authors based on [21,27]

Ship to ship transfer is only mentioned as a small part of competence "Ability to safely perform and monitor all cargo operations," in Table A-V/1-2-2, "Specification of minimum standard of competence in advanced training for liquefied gas tanker cargo operations" [32]. However, more specific competencies and skills needed to safely and efficiently perform an STS transfer operation are not elaborated [21,27].

Furthermore, the authors researched company-tailored STS training subjects and compiled them in Table 2. The research included six STS training programs developed by different maritime training centers.

Table 2. Compiled subjects and topics of company-tailored STS training.

Subject	Topic
Rules and regulations applicable to STS transfer operations	Familiarization with all applicable international maritime legislation, specific local regulations, and industry best practices for LNG STS transfer operations.
Planning and risk assessment of STS transfer operation	Roles & responsibilities of persons involved.
	Planning of mooring/unmooring operations, including the associated risks.
	Planning safe STS transfer operation by using the appropriate size and number of fenders and certified and tested cargo transfer hoses.
	Risk assessment.
	Establishing an efficient framework for risk reduction.
STS transfer operation best practices	Familiarization with STS best practices, including a comparison between the industries, including case studies.
STS transfer operation environmental challenges	Understanding environmental risks and challenges.
	Emergency response planning.
	LNG spill response case study.
STS transfer operation equipment	Familiarization with LNG STS equipment.
	Enhancement of knowledge of STS transfer equipment, its' design, and maintenance.
Specifics of STS transfer cargo operation	Knowledge of specifics of STS-focused cargo transfer operations.

Authors based on [28-33].

Based on existing recommendations and practices while examining the procedures for implementation based on the competencies required by the STCW convention (Table 1) and company tailored training (Table 2), a proposal is made to develop a mandatory course for seafarers on management level involved in LNG STS transfer procedures. The following title of the training is proposed: Standard Operating Procedures (SOP) Course for LNG STS transfer operation. The general content of the course can be represented by the competencies and topics shown in Table 3.

Table 3. Course training - SOP Course for LNG Cargo and STS transfer

Competence	Topic
Implementation of applicable rules, regulations, and recommendations for STS transfer operation	Familiarization with publications concerning STS transfer operation.
	Notification to and approval from local authorities.
Planning and risk assessment	Identification of person in charge of STS transfer operation.
	Risk assessment of the STS transfer area.
	Ship to Ship Compatibility.
	Risk assessment of STS transfer, including vessels of similar lengths.
	Assessment of environmental conditions during the transfer operation.
	STS transfer check-lists usage and communication between vessels.
	Knowing hazards related to the usage of communication and navigation equipment. Manoeuvring, mooring, and unmooring phase risk assessment.
	Risk assessment for connecting and disconnecting cargo hoses.
	Cargo transfer operation risk assessment.
Familiarization with STS transfer equipment	Knowledge of fenders handling and usage.
	Knowledge of cargo transfer hoses characteristics, handling, and usage.
	Knowledge of mooring equipment for an STS transfer operation.
	Knowledge of lifting equipment used during STS transfer operation.
	Knowledge of lighting during STS transfer.
Precautions to prevent STS transfer operation specific hazards	The readiness of fire-fighting equipment.
	The readiness of pollution-prevention equipment.

Application of occupational health and safety precautions and measures	Training and familiarization of ship's personnel for STS transfer.
	Proficiency in usage of personal protective equipment and life-saving appliances.
Response to emergencies	Proficiency in contingency planning and knowledge of emergency response procedures.
	Examples of potential contingencies.
	Contingencies during manoeuvring.
	Actions in case of cargo leakage.

Source: Authors based on [16, 19, 21, 27-35].

Some of the topics included in the proposed SOP Course for LNG Cargo and STS Transfer seem generic and applicable for any LNG operation, however some differences exist. For example, cargo transfer hoses being used for an STS cargo operation are different from cargo hoses or loading arms at LNG terminals since they are supplied by support vessels and connected by the ship's crew. They have to be certified by an approved organization and in apparently good condition, and seafarers need to be aware of their characteristics and means of connecting. Because cargo transfer hoses and fenders are being pulled and lift by shipboard cranes, seafarers need to have adequate knowledge of using cranes for that specific purpose. Lighting arrangement is of great importance during an STS operation because there is no light from the shoreside, and operation safety during hours of darkness is solely dependent on shipboard lights. However, extra care must be taken, and not all lights should be switched on, especially ones pointed towards aft since they could blind the watchkeeper on the bridge. Also, special care must be taken to ensure that view of the watchkeeper on another ship is not impaired. As STS operation is a specific operation that could involves mooring operation and cargo transfer between two ships, seafarers need to take special precaution and use adequate protective equipment.

Publications concerning LNG STS transfer operations include Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases, International Safety Guide for Oil Tankers and Terminals (ISGOTT), Mooring Equipment Guidelines, Vessel Inspection Questionnaires for Oil Tankers, Combination Carriers, Shuttle Tankers, Chemical Tankers and Gas Tankers (sections applicable), and STS operations plan (shipboard plan). Masters of LNG vessels are responsible for notification of local authorities before commencement of LNG STS transfer [34].

Training should emphasize the importance of the STS transfer area risk assessment. Trainees should be able to understand and evaluate the specific area concerning the availability of a safe anchoring area, sea room for operation, traffic density, and safe water depth [15,16,19,34,35].

Another factor essential for STS transfer's safe performance, which should be covered by training, is communication between vessels involved. Before the STS operation commencement, the masters of the vessels involved should exchange information on the availability, preparedness, and compatibility of the equipment to be used. Hazards of different climates should be considered, and trainees should be familiarized with cold-weather precautions. MSDS should be elaborated, and seafarers should be able to use it in emergencies [15,16,19,34,35].

Safety precautions and risk assessments during LNG STS transfer operations should be processed, including helicopter operations, smoking policies, and naked lights. Hazards of using radio and satellite communication equipment should be covered, including Automatic Identification System (AIS) and radar usage during manoeuvring and cargo transfer phase [15,16,19,34,35].

Training should also cover hazards, development of risk assessments and emergencies during manoeuvring, including manoeuvring alongside with two vessels under power, manoeuvring a combined two-vessel system to anchor, STS transfer underway, manoeuvring with one vessel at anchor, and manoeuvring with one ship alongside a port terminal. Furthermore, mooring operations hazards and contingencies should be covered, including mooring plan, mooring equipment, underway mooring operations, STS mooring system's efficacy, and mooring operations in the port area. Seafarers need to have good knowledge of equipment used during STS transfer, including fenders (for example, selection of fenders, fenders requirements, low-pressure fenders, foam-filled fenders), cargo transfer hoses (for example, hoses standards, length, hose handling and connection, hose inspection, and testing requirements), lifting equipment (for example, the suitability of lifting equipment, personnel transfers at sea and in port operations), lighting, auxiliary equipment, and equipment noise level. One of the proposed topics is contingency planning, including emergency response procedures (for example, emergency signals, contingency situations, examples of potential contingencies, use of Shipboard Marine Pollution Emergency Plan (SMPEP) and Vessel Response Plan (VRP), actions in case of cargo leakage, and procedures in case of gas accumulation on open decks) [15,16,19,34,35].

Successful completion of proposed training should enable seafarers to safely and effectively manage and handle LNG STS transfer operations and improve their competencies and skills. Furthermore, proposed training should be discussed for implementation as mandatory for all seafarers at the management level involved in LNG STS transfer operation. A forthcoming (comprehensive) review of the STCW Convention is certainly appropriate timing for the implementation.

4. Conclusion

There is a relatively long history of using STS operations on oil tankers, while STS operation in the LNG industry has been introduced later and only in recent years it becomes widely used as a regular operation. These operations are particularly related to the growing use of LNG FSRU terminals and the fact that in an era of reducing emissions of air pollutants, LNG as cleaner fuel is increasingly used as ship's fuel.

The paper demonstrates the importance of having a well-educated and competent ship's crew performing STS operation on LNG ships, either as cargo or as a bunker operation. To achieve that, the introduction of mandatory specialized courses related to LNG STS operation is required.

The paper determines competencies for senior officers essential for safe performance and monitoring of LNG STS operations according to IMO requirements and a proposal for Standard Operating Procedures (SOP) Training Course for LNG STS operation. Due to the operation's complexity, seafarers on the management level involved in LNG STS transfer procedures should be required to demonstrate competencies by attending the proposed training.

In defining the course proposal, all previous experiences and training requirements with STS operations were considered and the STCW requirements, existing IMO Model Courses, and industry requirements for transhipment operations.

STS operation as highly sophisticated and dangerous operation put the risk on safety of crew and safety of ships' construction and inevitably needs to step forward in increasing safety standard onboard the ship. Proposed training indeed represents one of the steps that should be discussed for mandatory implementation.

Further research of the education associated with LNG STS operation should be on developing detailed Model Course and creating additional training course(s) for all shipboard personnel engaged in STS operation and not only on the management level.

Literature

1. Stavrou, D.I. & Ventikos, N.P. (2014) Ship to Ship Transfer of Cargo Operations: Risk Assessment Applying a Fuzzy Inference System. *Journal of Risk Analysis and Crisis Response*. 4 (4), 214-227, https://doi.org/10.2991/jrarc.2014.4.4.3
2. Marine Insight. Wankhede, A. *What is Ship-to-Ship Transfer (STS) and Requirements to Carry Out the Same?* Available from: https://www.marineinsight.com/maritime-law/what-is-ship-to-ship-transfer-sts-and-requirements-to-carry-out-the-same/ [Accessed 5th February 2021].
3. Jovanović, F., Rudan, I., Žuškin, S. & Sumner, M. (2019) Comparative analysis of natural gas imports by pipelines and FSRU terminals. *Maritime Affairs – Pomorstvo*. Vol. 33 No. 1.
4. International Transport Forum. *Fuelling Maritime Shipping with Liquefied Natural Gas. The Case of Japan.* Available from: https://www.itf-oecd.org/sites/default/files/docs/maritime-bunkering-lng-japan.pdf [Accessed 2nd February 2021].
5. U.S. Energy Information Administration. *Today in Energy. U.S. liquefied natural gas exports set a record in November*. Available from: https://www.eia.gov/todayinenergy/detail.php?id=46296# [Accessed 15th January 2021].
6. Daryanto, Maulana, M.A. & Kurniawan, F. (2020) Operational Risk Assessment Of Ship To

Ship Transfer In The FSRU Lampung Using Risk Matrix Method. *Maritime Safety International Conference. IOP Publishing. IOP Conf. Series: Earth and Environmental Science 557 012035*. doi:10.1088/1755-1315/557/1/012035.
7. Ventikos, N.P. & Stavrou, D.I. (2013) Ship to Ship (STS) Transfer of Cargo: Latest Developments and Operational Risk Assessment. *SPOUDAI Journal of Economics and Business*, Vol. 63, Issue 3-4, 172-180.
8. Sultana, S., Okoh, P., Haugen, S. & Vinnem, J.E. (2019) Hazard analysis: Application of STPA to ship-to-ship transfer of LNG. *Journal of Loss Prevention in the Process Industries*. Vol. 60, 241-252.
9. Englebert, P. (2009) Operational Experience with Ship to Ship Transfer. OTC 19854. *Offshore Technology Conference, Houston, Texas, USA, 4-7 May 2009*.
10. Gilchrist, R. (2008) Lightering the Load (LNG). OTC 19396. *Offshore Technology Conference, Houston, Texas, USA, 5-8 May 2008.*
11. Stokes, J. et al. (2013) Understanding the human element in LNG bunkering. *Proceedings of the ASME/USCG 2013. 3rd Workshop on Marine Technology and Standards. MTS2013. Arlington, USA, 24-25 July 2013.*
12. International Maritime Organization. (2009) *MEPC.186(59), Amendments to the annex of the protocol of 1978 relating to the International Convention for the Prevention of Pollution from Ships, 1973, (Addition of a new chapter 8 to MARPOL Annex I and consequential amendments to the Supplement to the IOPP Certificate, Form B)*. Resolution. London: IMO.
13. Oil Companies International Marine Forum. (2020) *Ship to Ship Service Provider Management and Self Assessment Guide*. 2nd Edition. OCIMF.
14. Safety4sea. *Procedures: Step-by-step stages of a proper STS transfer*. Available from: https://safety4sea.com/cm-procedures-step-by-step-stages-of-a-proper-sts-transfer/ [Accessed 10th February 2021].
15. Ship to ship operations plan. Available from: https://www.mavroudis.com.cy/media/cms/stsoperation_594A6B428D834.pdf [Accessed 20th January 2021].
16. American Bureau of Shipping (ABS). *STS Transfer Operations Plan*. Available from: https://ww2.eagle.org/content/dam/eagle/rules-and-resources/forms/STS-Transfer-Operations-Plan.doc [Accessed 5th February 2021].
17. International Chamber of Shipping, Oil Companies International Marine Forum, International Association of Ports and Harbors. (2020) *ISGOTT International Safety Guide for Oil Tankers and Terminals*. 6th Edition. Witherby & Co. Ltd.
18. McGuire, J.J. & White, B. (2000) *Liquefied Gas Handling Principles on Ships and in Terminals.* SIGTTO. 3rd Edition. Witherby & Co. Ltd.
19. Operation Guidelines for Ship to Ship LNG Transfer. Available from: https://www.mlit.go.jp/common/001173458.pdf [Accessed 17th January 2021].
20. Extracts from Malaysia Marine Department – Terms & Conditions for STS Operations. Available from: https://d1veykhimqea3r.cloudfront.net/johorport/files/10/1027028b-b17c-4380-bcb5-fb0e89c5a9b8.pdf [Accessed 20th January 2021].
21. International Maritime Organization. (2013) *Model Course 1.05 Advanced training for liquified gas tanker cargo operations*. London: IMO.
22. International Maritime Organization. (2013) *Model Course 1.04 Basic training for liquified gas tanker cargo operations*. London: IMO.
23. International Maritime Organization. (1999) *Model Course 7.01 Master and Chief Mate*. London: IMO.
24. International Maritime Organization. (2014) *Model Course 7.02 Chief Engineer Officer and Second Engineer Officer*. London: IMO.
25. International Maritime Organization. (2015) *MSC.391(95). Adoption of the International Code of safety for ships using gases or other low-flashpoint fuels (IGF Code)*. Resolution. London: IMO.
26. International Maritime Organization. (2015) *MSC.396(95). Amendments to the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978, as amended*. Resolution. London: IMO.
27. International Maritime Organization. (2010) *Final Act of the Conference of Parties to the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978*. London: IMO.

28. Tank Terminal Training. *2020 Ship to Ship Transfer (POAC/Superintendent) for Liquefied Natural Gas (LNG) (3 days)*. Available from: https://www.tankterminaltraining.com/downloads/2020/2020%20LNG%20Ship%20to%20Ship%20Transfer%20(STS)%20.pdf [Accessed 20th January 2021].
29. GTT Training. *LNG & Liquid Hydrocarbon STS Operations*. Available from: https://www.gtt-training.co.uk/sts-operations [Accessed 17th January 2021].
30. Abu Dhabi Maritime Academy. *Advanced LNG Vessel and STS/FSRU Operations, Methods and Handling*. Available from: https://www.admacademy.ae/short-courses-simulations/mice-global-partnership-management-operational-courses/advanced-lng-vessel-and-sts-fsru-operations-methods-and-handling/ [Accessed 17th January 2021].
31. Informa Connect Singapore. *LNG Transfer*. Available from: https://www.informaconnect.com.sg/event/lng-transfer/ [Accessed 17th January 2021].
32. KLAW LNG. *LNG ship-to-ship transfer systems*. Available online: https://www.klawlng.com/lng-applications/ship-to-ship/ [Accessed 17th January 2021].
33. ECA Group. *Training Course on Mistral 4000 Simulator for Ship-to-Ship (STS) transfer operations*. Available from: https://www.ecagroup.com/en/corporate/training-course-mistral-4000-simulator-ship-ship-sts-transfer-operations [Accessed 17th January 2021].
34. SKULD. *Ship to ship transfer safety*. Available from: https://www.skuld.com/topics/cargo/liquid-bulk/ship-to-ship-transfer-safety/ [Accessed 18th January 2021].
35. ICS, OCIMF, CDI, SIGTTO. (2013) *Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases*.