Technical University of Varna
Annual Journal
https://doi.org/10.29114/ajtuv.vol3.iss2.114
Vol 3 Issue 2 (2019)
Published: 2019-12-31
ISSN 2603-316X (Online)

# Safety measures relating to carriage and transfer of liquid cargoes

*Ivaylo* Grancharov

Naval Academy "N. Y. Vaptsarov" - Varna, Faculty of Navigation, 9026, 73 Vasil Drumev Street, Varna, Bulgaria

Corresponding author contact: ivo_gran4a@abv.bg

***Abstract.*** The continuous growth in the volume of liquid cargoes, transported by sea, leads to increase of tankers' size and to implementation of appropriate shore facilities, which have to meet the relevant environmental requirements. In order to ensure safety during loading and discharging operations in shore terminals, it is necessary to make an assessment on the level of potential risk in port and on-board the vessel and to take all necessary steps to reduce the possibility for environmental impacts and occurrence of an accident especially when performing transfer operations to/from ships. The article presents some constructive decisions for building of shore tanks and their application for storage and transfer of petroleum products. The measures for ensuring safe cargo handling are systematized in accordance with the specific performance characteristics of all the relevant loading or discharging processes herein discussed. The precautions are defined in three critical points of action - operation on vessel systems, transportation of cargo using shore facilities and storage in tanks.

**Keywords:** cargo handling, safety, liquid cargo, storage

## 1 Introduction

The petroleum industry plays an important role in world economy. At the end of 2016 year, the gas processing and manufacturing industry registered a significant leap. The main reason for this is the extending exports of US petroleum products through the new locks of the Panama Canal to developing markets in Asia. The oil and gas market in the year of 2017 can be divided in section as follows: crude oil market with total amount of 1874,9 million tons (increased with 2,4% from previous year), liquefied natural gas – 293,8 million tons (increased with 9,6%) and liquefied petroleum gas – 89,3 million tons (increased with 2 %). At the end of 2018 the amount of produced petroleum product estimated more than 300 million tons, an increase of 3 % (WLPGA, 2018). According to the research of (UNCTAD, 2018) during 2017 year the tanker shipment estimates 3146 million tons, which is increased with 3,9% from previous year. The continuing growth in global production of liquefied petroleum gas (LPG), matched by an increase in consumption across a range of sectors. The result is a rising trend in exports from the United States and global refining activity, especially in Asia.

Changes in maritime trade produced by the development of the world fleet and by the building of new ships. In the beginning of 2011 the world fleet consisted of 12 803 tankers with a total deadweight tonnage of 523,6 million dwt. Comparing the 2007-2011 period the total increase in tonnage of the tankers is approximately 6,2% per year (Grancharova, 2012). In the year 2018 oil tanker fleet remains the second largest fleet after dry bulk cargo fleet and accounts for 14% of the world fleet with 29,2 % of total dead-weight tonnage (UNCTAD, 2018). Bearing in mind the above mentioned, the global trends in the business with petroleum products and the ever-increasing size of ships, there arises the problem of ensuring cargo safecarriage and transfer from/into the vessel. What comes to the foreground, thus, is the particular significance of the specific features of this type of cargo, the safety storage and efficient transfer at port terminals and all the other cargo handling operations.

With the introduction of important environmental rules, such as the creation of particularly sensitive shipping areas, where the usage of low-sulphur fuels is mandatory; the requirements for reduction of noise and vibration within port areas and those for air pollution by discharge of harmful substances, as a result of shipping activities, it is necessary to have much greater awareness of the assessment of the risk of liquid cargo maritime transportation and their impact on the marine life and habitats as well as a quick emergency response plan when leaks or spills occur. Undoubtedly, such an emergency plan

https://doi.org/10.29114/ajtuv.vol3.iss2.114
Vol 3 Issue 2 (2019)
Published: 2019-12-31
ISSN 2603-316X (Online)

should be devised in accordance with the requirements and principles set in the respective international normative documents.

International convention for the safety of life at sea (SOLAS) and International convention for the prevention of pollution from ships (MARPOL) are the main documents which are connected with vessel's stability and safety and cover the points concerning the prevention of marine pollution caused by ship operation. SOLAS Chapter II-2 contains regulations for all cargo ships, carrying dangerous cargo. Annex I and II of MARPOL provide rules, regarding the prevention of pollution, respectively, by oil and noxious liquid substances. Annex VI of MARPOL sets restrictions to the emissions of the main air pollutants: ozone-depleting substances, sulphur and nitrogen oxides and volatile organic compounds.

The article provides a systematic review of the safety precautions relevant to the carriage and transfer of liquid cargoes that should be followed when making and approving plans for bulk liquid cargo management. This imposes the performance of initial analysis of the critical points throughout the whole crude oil transfer process starting from the refinery, through the oil safe storage services and cargo handling operations.

## 2 Requirements connected with tank storage and shore facilities used for LPG

Liquefied petroleum gas (LPG) is a naturally occurring by-product of two origins: natural gas or crude oil. This is the well-known chemical appellation of propane and butane, from which approximately 60% are extracted from natural sources. The rest contain processed and refined ingredients (IMO, 2016a; IMO, 2018). After being chemically treated, they can be transported to the sea for overseas export by different modes of land transportation: pipeline, rail or road transport.

In nautical literature, the transportation of crude oil and petroleum products are classified as liquid bulk dangerous cargo. Due to their special features dangerous cargo may cause fire, explosion, demolition or damage to ships' holds or to port storage area. Compliance with various standards, in relation to the design, construction and equipment of the vessel is observed according to the nature of the product that is being carried. For example, the transportation of chemicals in bulk is covered by Chapter VII of SOLAS, MARPOL Annex II and International Code for construction and equipment of ships carrying dangerous chemicals in bulk (IBC code). According to listed in Chapter 17 hazardous chemicals and noxious liquid substances, IBC code divides vessels into three types. Article 16 and regulation 1.4 of MARPOL Annex II, concerned the procedure for amendment of IBC Code. The most recent amendments to Chapter 21 of IBC code, which comes into force next year, sets criteria in line with the degree of hazard of each individual product.

Petroleum products and gases can be transported in compliance with the requirements of the SOLAS 74, Chapter VII-part C, relative to gas tankers. These tankers as per IGC code are divided into 4 groups. Design, construction and equipment must fulfil the requirements of Annex I of MARPOL and the latest amendments of IGC code.

Different specialized tanks constructed specially for liquid cargoes can be used for storage at petrol terminals. Liquefied gases can be stored at terminal in pressurised, semi pressurised or refrigerated condition. The storage of liquids under pressure is arranged in spherical above-ground tanks, mounded horizontal tanks and underground tanks. In above-ground cylinders tanks and pipeline should be provided with fixed spray system, which protect tank surface and pipelines from thermal radiation using a film of cooling water. The tanks, pumps and all other shore facilities must be at a sufficient distance from ignition sources. Vapour emission control systems on board control accurately the amount of volatile substances escaped into the atmosphere. They must comply strictly with the actual international environmental requirements. Due to the fact that reservoirs are usually built underground, they do not need great shell thickness for protection from the sunlight radiation. This also reduces the need to provide greater free room between two contiguous tanks. The design pressure for storage of LPG can be set at about 12 bar.

The underground pressurised LPG is stored in underground caverns usually salt deposits or rock formations by means of submerged pumps. Storage in salt deposit in a depth of 600 to 1200 meters below sea level ground ensures preservation of its properties over a long period of time (Грънчарова, 2012a). For loads of more than 5 000 tones economically admissible are those the storage of which is

https://doi.org/10.29114/ajtuv.vol3.iss2.114
Vol 3 Issue 2 (2019)
Published: 2019-12-31
ISSN 2603-316X (Online)

carried out under pressure and at a low temperature around the point at which boiling occurs. For this purpose, single, double-walled or dual containment reservoirs are used (SIGTTO, 2001). Single-wall tanks are made of low-temperature steel and have an additional waterproof cover from the outside. The heating coils fitted on the tank ground avoid freezing of the bottom. Spray ring on the top is used for tank filling. The submerged pump on the bottom helps by discharging (Fig. 1).

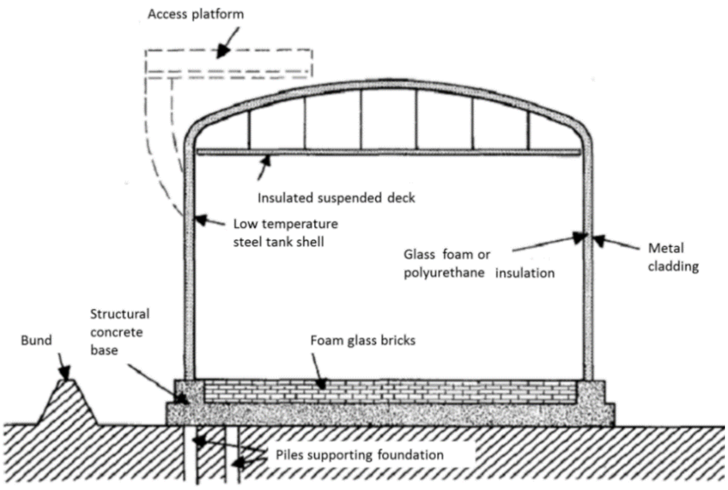


**Fig. 1.** Single-wall LPG storage tank (SIGTTO, 2001)

Provision of secondary containment controls accidental releases of liquid hazardous materials. Double containment storage tanks consist of additionally reinforced walls than the inner tanks, made from low-temperature steel which is safer against any leakage (Fig. 2). What is more, in this case, the outer shell prevents vapour to be released into the atmosphere. The mini bund is provided to retain minor leakage from pipeline. The double berm tank is equipped with an -auxiliary internal tank and enclosed outside from steel-concrete shell. The tank has a steel roof. The earth berm provides further assistance (Fig. 3). The purpose of this construction and design is to prevent the possibility of chemical interaction in case of fortuitous leak.

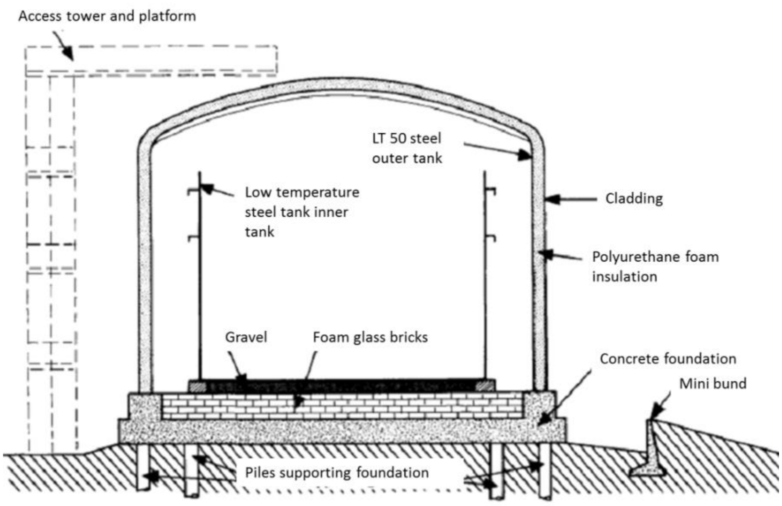


**Fig. 2.** Double containment LPG storage tank (SIGTTO, 2001)

Technical University of Varna
Annual Journal
https://doi.org/10.29114/ajtuv.vol3.iss2.114
Vol 3 Issue 2 (2019)
Published: 2019-12-31
ISSN 2603-316X (Online)

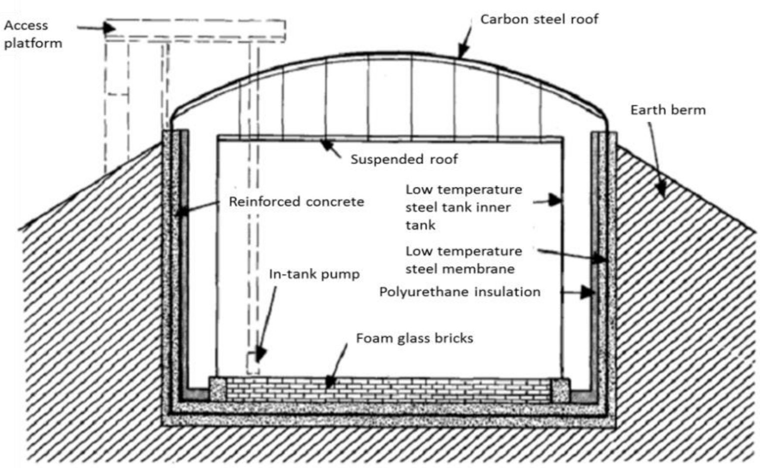


**Fig. 3.** Earth-berm LPG storage tank
(SIGTTO, 2001)

The two possible constructive solutions for bulk liquid cargo transportation between the storage tank and the vessel are connected with use of cargo hoses and loading arms. These handling facilities should follow the horizontal and vertical ship movements (Грънчарова, 2012b) and use should be made only of those pipelines or flexible pipes that are fully compatible for such cargos. Holes, pipes and other drains, where spillage can arise, have to be closed before commencement of the loading/discharging and after the completion of the process. The inscription with maximum working pressure on flexible pipe should be permanently and legibly fixed. It is recommended that each flexible pipe before commencement of any operation be visually inspected. The length of each flexible pipe has to allow operating envelope without overstressing the terminal connections. The transmission shore facilities must have valid documents pointing out the nominal internal diameter of the pipe, the maximum of flow velocity, the date of manufacture and the dates of regularly inspections done.

Pipes, new or fallen into disuse should be stored in dark, dry, and cool holds on shelves to prevent them from bending and torsion and under natural air ventilation. If they are not used for period more than 2 months, they should be handled with fresh water and have no traces of any substances. Short-term storage under the sheds is also applicable. Presented in Table 1 is the relation according to (SIGTTO, 2001) between throughput and nominal inside diameter by flow velocity of 12 m/s and 15m/s.

**Table 1.** The relation between throughput and nominal inside diameter by flow velocity

| | Flow velocity 12 m/s | Flow velocity 15 m/s |
|---|---|---|
| Nominal inside diameter [inches] | Throughput [ cub. m per hour] | Throughput [ cub. m per hour] |
| 6 | 788 | 985 |
| 8 | 1400 | 1750 |
| 10 | 2180 | 2730 |
| 12 | 3150 | 3940 |
| 16 | 5600 | 7000 |
| 20 | 8750 | 10900 |
| 24 | 12600 | 15700 |
| 30 | 19700 | 24600 |
| *Note*: 1 inch= 25.4 mm | | |

https://doi.org/10.29114/ajtuv.vol3.iss2.114
Vol 3 Issue 2 (2019)
Published: 2019-12-31
ISSN 2603-316X (Online)

As for design construction and building up the shore system transferring liquid cargo facilities it has to be mentioned that each transported or handled liquid bulk cargo should have procedures, concerning the following processes: tank inspection, drying, inert of holds, freeing of gases, cargo handling, performing of ballast operation and cleaning of cargo holds (Fig. 4). Drying the cargo handling system is necessary before commencement of loading in order for the water vapour and free water to be removed from the system and the correct dew point temperature to be achieved. The transhipment of liquefied petroleum products are done by temperature below -48 degree Celsius. If trapped moisture remains in the load/discharge system, it can trigger the formation of ice and water vapour. To prevent his from happening, dehydration with inert agents is performed. These operations avoid creation of explosive composites and lead to enhancement of pump efficiency during unloading. Inert gas systems are well-suited for use on land or aboard a ship Inert gas is produced by the combustion of gas oil or by shipboard nitrogen generators in case of gaseous nitrogen or, alternatively, by air dryer systems fitted on board. Prior to cargo transfer, the oxygen content in vessels' tank and vapours should be gauged. Oxygen content should not exceed 5 %. The content of hydrocarbons before aeration should be below 2 per cent. Only nitrogen of high purity taken from the shore is fully compatible with every liquefied cargo. After inerting procedures no antistatic precautions are necessary. Heating of highly viscous petroleum cargo enables reduction in the viscosity of the cargo and helps to flow better during the transfer to/from ship. In order to minimize the formation of wax sludge, it is necessary for the hold ventilation to be performed constantly. Each hold should have its individual systems, concerning ventilation and cargo load/unload.

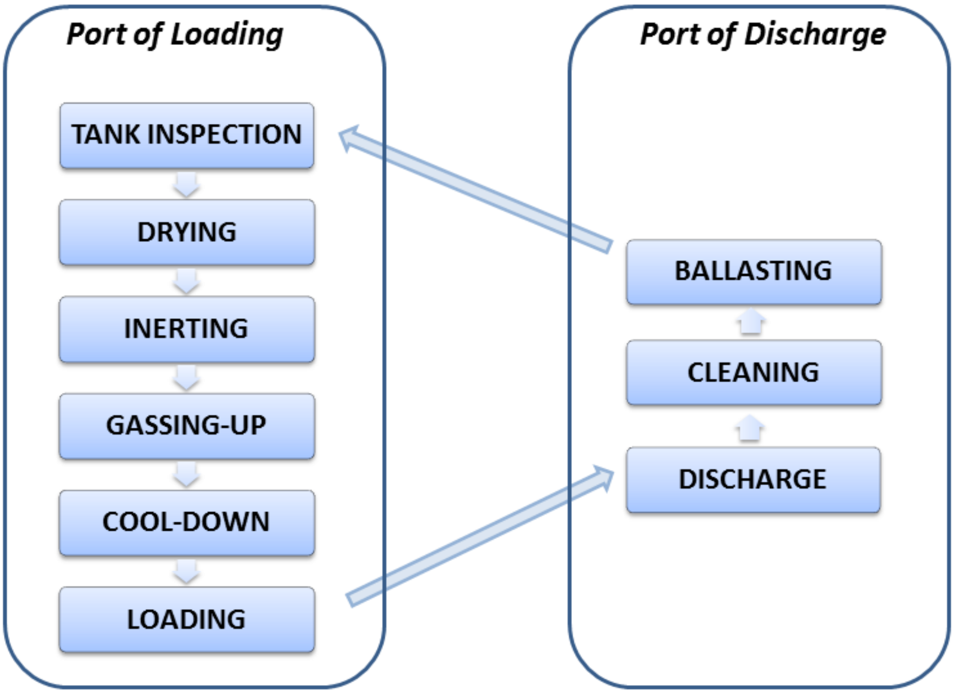


**Fig. 4.** Consequence of operations

For safe cargo handling operations, removing gases and cleaning cargo spaces, strict adherence to the ship's operating manuals is required. For instance, alkaline or acid fluids used for holds' preparation, have to be approved by IMO. If it is necessary to warm up them to a certain temperature of 70-80 degrees before implementation, the on-board heat exchangers may be applied. Some cleaning ingredients are used for direct injection. Distilled water under pressure can also be applicable. At the end of the cleaning process, all hatch covers must be locked. During cleaning it is strictly forbidden to command the loading spaces for temporary storage of waste. To ensure continuity of operation, the cargo holds should be prepared for the next carriage contingent upon the surface of the load compart-

Technical University of Varna
Annual Journal
https://doi.org/10.29114/ajtuv.vol3.iss2.114
Vol 3 Issue 2 (2019)
Published: 2019-12-31
ISSN 2603-316X (Online)

ment and the peculiarities (physical and chemical characteristics) of the previous and the subsequent shipment.

During transfer into/from vessel all scuppers have to be kept closed except when water needs to be drained off. Segregated ballast tank covers must be clearly marked and kept closed when cargo or ballast is being transferred to prevent petroleum gas from flooding into these tanks. Excess pressure does not develop in the vessel tank and in shore storage tank. Therefore, surrounding environment is under constant supervision via automatic system and gas detectors. They should be cooled including using of water spray (CCPS, 2008; Gauging, 2011). When tanker, which has previously carried crude oil or petroleum product, is shifted in berth other than the berth for liquid cargos and the vessel is not emptied from gases, the zone of 25 meters near vessel is marked as risky until completion of vessel tanks inerting operation. In order to prevent any spillage prior to removing any connections from the final faucet has to be checked for containing oil under pressure. Obviously, when unloading is carried out through a stern line, the area sprawled above 3 meters near the manifold danger zone must be strictly identified. During darkness the whole load areas should be adequately lit.

## 3 Assessment and measures for safety performance of cargo handling operation

All necessary mooring equipment should be ready for use before arrival at a port or a berth. Safe operations should be undertaken with careful observation of some basic rules regarding the approaching, manoeuvring, shifting and all the relevant preliminary actions with vessel systems and shore facilities. On approaching the master of the vessel must consider the actual size and direction of the wind, currents and sea waves. Steel are preferred for berthing in order to restrict vessel movements in the horizontal and vertical directions by strong wind or high waves. They should not be too loose or very tight. The preliminary actions, connected with loading, are based on the following information: the specific characters of the last shipped cargo; whether the cleansing performed is enough for approving the cargo holds for the next load; gathering of all technical and physical details concerning the transfer of liquid cargo with the help of the available shore facilities and ship systems and the necessity of additional facilities. Before commencement of transfer operation, the master of the vessel and the berth operator should agree in written form upon the following data:

- capacity and maximum allowable pressure both vessel and shore facilities including vapour venting systems;
- emergent signals and actions, which have to be taken;
- possible pressure arisen due to accidentally stop of load operation;
- eventual occurrence of electro-static stress;

The wide ranges of physical, chemical and transport characteristics of liquid cargo, as well as the incompatibility of most of them, require the use of a separate load pump and a separate pipeline for each tank. This eliminates the possibility of cargo mixing. To prevent the presence of static electricity and the occurrence of a spark in the explosive atmosphere of the tank, the maximum flow velocity on pipelines should not exceed 12 m/s for crude oil or 7-8 m/s for light petroleum products (Грънчарова, 2014a). Cargo handling is subject to verification of the shore facilities to confirm that they are designed in line with the relevant technical requirement and there are no possibilities for cargo mixing or running out into the land or sea. All precautions should be taken against inhaling of any gases during measuring or sampling on the part of the respective personnel. They must be dressed with protective clothes and wear personal life-protective equipment and while working they should face the wind directly the wind direction. Upon load completion the flow rates should be reduced in order fill the tank accurately.

Ship pipeline has to be drained and the remaining quantity to be delivered under pressure to land or by inerting the shore facilities to be delivered to the vessel holds. Then, the pipeline should be depressurised, manifold valves should be closed; cargo hose and loading arms should be disconnected from manifold range. In some ports, before disconnecting from manifold, it is necessary for all shore facilities to be purged free from flammable vapour. Chapter 15 of the IGC Code (IMO, 2016a) gives requirements for maximum allowable loading limits for cargo tanks:

Technical University of Varna
Annual Journal
https://doi.org/10.29114/ajtuv.vol3.iss2.114
Vol 3 Issue 2 (2019)
ISSN 2603-316X (Online)
Published: 2019-12-31

$$LL = FL\frac{\rho R}{\rho L}, \quad (1)$$

where

- LL – the upper allowance of loading;
- FL – allowance equal to 98 % of load;
- ρR – comparative cargo density at the actual temperature;
- ρL – comparative cargo density by initial temperature and pressure;

Occurred on land, reservoir drain valves should be blocked in order to allow direct outward flow. Only authorized personnel can operate with the starter control on transfer pumps. In case of non-working or in standby position, the shore facilities, including connections of pipelines, loading arms or transfer holes should be securely capped. The periodical gauge of vessel's tank during loading prevents cargo overfilling and spilling. Flanges connecting the ship to the shore facilities should be in accordance with the recommendations for equipment used by oil transfer, usually to fulfil requirements of ANSI B16.5, BS1560 Series 150 (OCIMF, 2017). Increasing the pressure, using additional pumps and heating should be taken into account for safe unloading. Bearing in mind that pressurising is ineffective and insufficient, in most cases, besides centrifugal pumps, additional pumps, are further employed. To reduce the turbulence by a side opening of land storage, the distance between the top of the opening and the free surface shall not exceed 0,6 m, and by the bottom opening the distance between the lower end of the pipe and the free surface shall be at least two times its diameter.

The valves of the land structures must be fully opened in direction to the storage that will be filled before the ones to be opened to the ship, and those on the shore tanks themselves shall be kept closed until the workable pressure is reached. The loading must start with slow speed and to be built up only to the agreed safe flow velocity. All outside holes shall be locked when performed on the vessel are any of the following operations: transfer of oil near or above its flash point or containing hydrocarbons, clean cargo holds, ballast/deballast manipulation, blowing through or leading out of gases (Shipley, 2011). The disconnection of flanges should not be undertaken unless it is clear that the connections are empty of cargo, depressurised and inerted with nitrogen or other suitable gas. Entering of air or any pollution in cargo pipeline should be avoided. If the number of shore pipeline systems don't tally with those on the ship, carefully check of these engaged in the process is preferable and those connections that are not in use should be firmly locked in order to eliminate their shaking and hitting to the board the vessel. Each loading arm after completion of the process must be cleaned from cargo and built upice.

## 4 Safety precautions for preventing environmental impacts

The handling and storage of liquid cargo set the matter of safe handling operations and reduced pollution and decreased amount of harmful impacts on the environment. They may be due to spillages during transmission of shore devices to/from the ship or by noxious air emissions emitted by harmful substances, or by noise and vibrations produced by mechanical systems under operation. The accidents with leakage of cargo and its spill and spread on sea water surface might be caused byshore or vessels system malfunctions or as a result of human error. In this regard, to prevent an ecological catastrophe, constant monitoring is required on the port area in which operations with bulk dangerous cargo are in progress.

During handling, all the necessary measures, concerning the control emission of vapour into the atmosphere and prevention of any flammable ingredient should be taken. The sources for environmental impacts such as noise and vibration pollution are likely to be emitted from hauling and rotating devices (ICS, 1996; ICS, & OCIMF, & SIGTTO, 1999). Problems and tasks related to the prevention of ports and marine aquatory from pollution by oil and other harmful substances have not been yet fully addressed (Недев & Димитрова, 2008). Methods applied to detect pollution with oil and oil products in sea water can be divided into direct methods for comparison and assessment and methods using biochemical analyses for comparison and assessment (Димитрова, 2005). One of the most commonly used passive sensors for monitoring oil spills is the infrared camera (IR camera). Among

https://doi.org/10.29114/ajtuv.vol3.iss2.114
Vol 3 Issue 2 (2019)
Published: 2019-12-31
ISSN 2603-316X (Online)

the directly measuring devices, the laser fluoro sensor (LFS) is preferred because of the remarkable ability to determine the presence of oil on the surface of water, soil, ice and snow (Димитрова, 2007).

Using risk assessment approach to assess the probable consequences allows hazards to be assessed not only in relation to their impacts on safety, but also on other areas that are considered essential for the proper utilization of the port itself (Vassilev & Grancharova, 2012). The contingency plan should include the organisation of the rapid systematization of the information about the surface-water condition, the meteorological environment and the characteristics of the oil spilled. These data are necessary to make the major decisions or countermeasures to prevent oil discharge into the environment (Димитрова, 2006). The development includes consideration of all the environmental factors of the region and the population of marine inhabitant and detailed Emergency Response Procedure and action plans in accordance with IFC, 2007.

The threats by carriage of petroleum products are complicated and can affect the environment. One of the main objectives is to reduce the human error during cargo handling. There is a big challenge for all IT Companies to design a solid manageable Terminal Operating System (TOS) (Grancharova, 2014a). Automation is a credible option offering new possibilities for operational control and visibility with reduced operating costs and enhanced service excellence. Introduction of effective terminal management system allow the operators to view the real-time vessel traffic in a single, convenient display, gain access to every aspect of an actively managed incident in user defined safety zones, and share real-time information and drafts reports with remote participants and other operation centers to ensure the required compliance and create incident reports (Grancharova, 2014b).

It can be summarized that automated control of the process will facilitate and allow instantaneous identification of any problem that has occurred. Thus, excluded is the possibility of a human mistake in assessing the related working system but sometimes a necessity for accidental stop emerges. Each operation alongside the quay might be under constant onboard and onshore supervision by the authorized personnel. It is a good practice to provide on terminal and on board the ship a life buoy at gangway entrances. The construction of an additional shell of impermeable materials on storage reservoirs and special substance for covering the work area and the surrounding with bones are parts of safety measures to prevent any probability of unexpected leakage or spill. On the other hand, it is necessary to give full details of the safety plans and the appropriate measures to be undertaken in the event of an accident. To this effect, in-depth analysis of the impact or magnitude of the damage, which is likely to occur as a consequence of these accidents, should be made and on this basis to provide the contingency measures for the location of the damage and remove the spill consequences. In addition, the protective clothing of the participants in the action must be in accordance with the actions taken and meet the rules of (IMO, 2016a). Water spray system designed for fire-fighting should be regularly tested. Emergency system ensuring safe “shut-down” in line with appropriate valve closure times in different critical cases such as reservoir brimming, braking the power flow or pressure, loss of electric power, fire in cargo area etc.

## 5 Conclusion

The safe carriage of liquid cargo is related to conformity of hydrological and meteorological situations during the voyage. By approaching and mooring of the vessel all changes in basic parameters of winds, waves and currents should be borne in mind in order to select the correct angle for manoeuver and safe berth and to prevent vessel grounding and environmental accidents such as spills.

An important requirement, connected with the safety, is ensuring possibility of manual control of all automated computerized processing systems (Грънчарова, 2014b). Analyzing the processes, connected with producing, tank storage and transfer into/from ship will help prevent environmental impacts by adopting appropriate measures and prevent accidents during cargo handling operations.

In view of the fact that liquefied petroleum gas is hazardous and noxious substanceby carriage, observed should be not only IGC Codes, but also the requirements of HNS Convention. Regarding the implementation of plans concerning safety operations, close attention should be paid to the fact that that some of the liquefied gas cargoes, listed in Chapter 19 of IGC code, have to fulfil the requirements set in the IBC Code.

Following the above mentioned and the analysis done for the entire process of loading, handling and storage and all the details in terms ofthe land and ship systems for transfer of liquid cargo as well as those of the storage tanks, it can be concluded that the provision of safe precautions when performing operations with such cargo relate to:

- the control of vapours and airborne harmful ingredients;
- the prevention of leaks and spills from shore-based facilities or on-board systems;
- accomplishment of mandatory inspections before the commencement and after cessation of operation of all the pumps, valves, carrying out a check on the strength of the connections and pipelines on shore and on ship;
- preliminary fixing and identifying the specific danger area on shore and restricting the access into the zone for authorized personnel only;
- surrounding the vessel with bones when performing oil transfer;
- detailed instructions and examples of the best course of action to be taken in case of accident occurrence and determining the appropriate necessary equipment, which should be positioned at the most critical sites locations;
- provision of continuous control in case of automated production process is, and the possibility of ensuring manual emergency break of transfer.

## References

CCPS (2008). *Guidelines for Hazard Evaluation Procedures-3rd edition*, American Institute of Chemical Engineers. ISBN 978-0-471-97815-2

Gauging R. (2011). *Increasing efficiency, accuracy, and safety at bulk liquid storage facilities*. Port Technology, 50, 127-128, London

Grancharova V. (2012). *Analysis of operations ensuring safe storage and maritime carriage of dangerous cargoes*. Science and Technologies, 2, 66-70. ISSN 1314-4111. (in Bulgarian). http://www.sustz.com/journal/VolumeII/Number2/Papers/ValentinaGrancharova2.pdf

Grancharova V. (2014a). *New technologies used for automation of container handling at terminals*. Journal of Marine Technology and Environment, VII/I, 41-48. ISSN 1844 – 6116.

Grancharova V. (2014b). *The challenge of building greenfield terminals.* Journal of Marine Technology and Environment, VII/II, 33-36. ISSN 1844 – 6116. https://issuu.com/jmte/docs/jmte-vol.2-2014

IMO (2016a). *IGC Code*, London. ISBN 9-28011-631-2

IMO (2016b). *International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea*, London. ISBN 978-92-801-1572-7

IMO (2018). *IMDG code*, London. ISBN 9-28011-682-7

ICS (1996). *International Safety Guide for Oil Tankers and Terminals-4th edition*, London. ISBN 1-85609-081-7

ICS, & OCIMF, & SIGTTO (1999). *Guide to Contingency planning for gas carriers alongside within port limits – 2nd edition*, London. ISBN 1-85609-173-2

https://doi.org/10.29114/ajtuv.vol3.iss2.114
Vol 3 Issue 2 (2019)
Published: 2019-12-31
ISSN 2603-316X (Online)

IFC (2007). *Environmental, Health, and Safety General Guidelines*. https://www.ifc.org/wps/wcm/connect/554e8d80488658e4b76af76a6515bb18/Final+-+General+EHS+Guidelines.pdf?MOD=AJPERES

OCIMF (2017). *Recommendations for Oil and Chemical Tanker Manifolds and Associated Equipment*. ISBN 10: 1-85609-741-2

SIGTTO (2001). *Guide to contingency planning for maritime terminals handling liquefied gases in bulk*. ISBN 978-1-85609-215-9

Shipley S. (2011). *Safe vapor handling during loading of volatile organic compounds*. Port Technology,52, 96-98. London

Vassilev, V. & Grancharova, V. (2012). *Safety and reliability in port*. IV International Scientific "Conference modern ports-problems and decisions"- Poland, 14-17. ISBN 978-966-7716-69-1

UNCTAD (2018). *The review of maritime transport*. ISBN 978-92-1-112928-1. https://unctad.org/en/PublicationsLibrary/rmt2018_en.pdf

WLPGA (2018). *Annual Report 2018*, France. https://www.wlpga.org/wp-content/uploads/2019/01/WLPGA-ANNUAL-REPORT-2018_FINALdt-amendment-p42.pdf

Грънчарова В. (2012a). *Иновационни методи за съхранение втечнени газове на територията на пристанището*. Известия. 92-100. ISSN 1314-3379. http://www.su-varna.org/izdanij/MNauki-12/Pages_92_100.pdf

Грънчарова В. (2012b). *Внедряване на съвременни брегови съоръжения и технологии за пристанищна обработка на течни товари*. Известия, 85-91. ISSN 1314-3379. http://www.su-varna.org/izdanij/MNauki-12/Pages_85_91.pdf

Грънчарова В. (2014a). *Товарознание – част I*, Стено. ISBN 978-954-449-719-4

Грънчарова В. (2014b). *Товарознание – част II*, Стено. ISBN 978-954-449-720-0

Димитрова В. (2005). *Методи за разпознаване състоянието на морските акватории*. Механика на машините, 57, 7-10. ISSN 0861-9727

Димитрова В. (2006). *Възможности за ограничаване разлива на масло по водната повърхност*, Механика на машините, 62, 80-83. ISSN 0861-9727

Димитрова В. (2007). *Използване на инфрачервена камера и лазерен флуоросензор за разпознаване на замърсявания с масла*, Механика на машините, 67, 108-111. ISSN 0861-9727

Недев, А., & Димитрова, В. (2008). *Сравнение на приложимостта на невронни мрежи при разпознаване на нефтопродукти*. Механика на машините, 77, 70-73. ISSN 0861-9727