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REMARKS ABOUT THE EUROPEAN PORTS' REGULATIONS OF NATURAL GAS BUNKERING

UWAGI DO ZASAD BUNKROWANIA GAZU NATURALNEGO W PORTACH EUROPEJSKICH

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Abstract: In the article there were presented examples of procedures of natural gas bunkering to ships in chosen ports according to approved regulations. The attention was paid to methane properties in liquid state and the threats during fuel transfer from bunkering boat to ship and cistern to ship. The research achievements for keeping the safety rules during LNG transport were indicated. The main task of approved regulations is minimizing the risk of dangerous accidents during fuel bunkering. There occurs a big similarity of fuel bunkering regulations in presented ports with their specificities. The author has submitted own remarks according to analyzed bunkering procedures

Keywords: natural gas, methane, LNG bunkering, port regulations, ship's fuel, safety of bunkering.

Streszczenie: W artykule przedstawiono procedury bunkrowania skroplonego gazu naturalnego na podstawie zatwierdzonych przepisów w wybranych portach. Zwrócono uwagę na właściwości metanu w postaci skroplonej oraz zagrożenia występujące podczas bunkrowania relacji bunkierka-statek i cysterna-statek. Wskazano na wyniki badań doświadczalnych nad zachowaniem zasad bezpieczeństwa podczas transportu LNG. Wydane przepisy regulujące zasady bunkrowania mają za zadanie minimalizować ryzyko zdarzeń niebezpiecznych podczas transferu tego paliwa. Występuje duże podobieństwo przepisów regulujących procedury bunkrowania uwzględniające jednak specyfikę portu, w którym ten proces ma zachodzić. Autor przedstawił własne uwagi dotyczące analizowanych procedur bunkrowania.

Słowa kluczowe: gaz naturalny, metan, bunkrowanie gazu naturalnego, regulacje portowe, paliwo okrętowe, bezpieczeństwo bunkrowania.

1. INTRODUCTION

Natural gas as a marine fuel has a big potential. The main reason is lower emission of toxic substances to the atmosphere in exhaust gases from engines and boilers. Due to lower content of coal (75% in comparison to 83–87% in liquid fuels) the emission of CO_2 (one of the GHG) is lower about 15%. Additionally the emission of particulate matters is about ten times lower, near zero emission of sulphur oxides, lower about 30% of nitrogen oxides, there is no need of using scrubbers that allows to compete with liquid marine fuels: diesel oils and heavy fuels [Herdzik 2012; Thompson 2015].

That is true but it ought to be mentioned in all natural gas (methane) production processes the leakage of CH_4 is about 2.4%, in some studies up to 9% [Rats 2013]. Methane leakage rates above 2-3% would probably offset the environmental gains of natural gas. It means the green-house effect may be higher than from liquid fuels.

Looking only on direct costs of switching the engines to LNG this way is often the most-efficient (Fig. 1) giving a long-term benefits higher than using scrubbers.

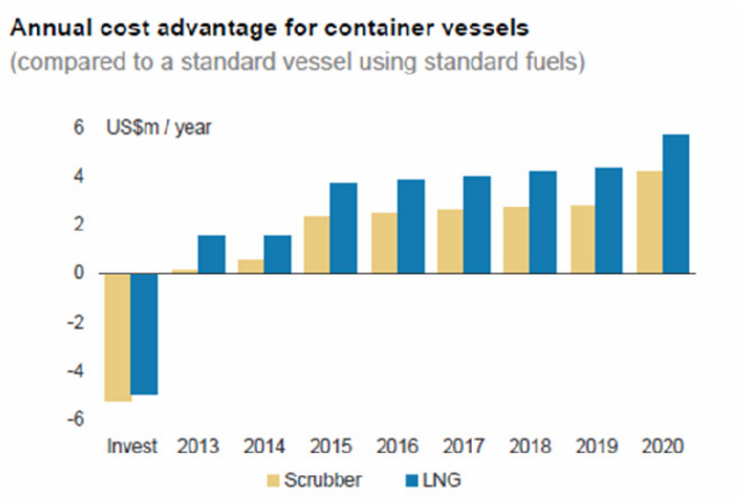

Fig.1. *Germanischer Lloyd and MAN analysis of switching the engines to LNG [Rats 2013]*

Rys. 1. Analizy Germanischer Lloyd i firmy MAN kosztów inwestycji i eksploatacji systemów oczyszczania spalin z płuczkami lub przystosowania silnika do spalania gazu LNG

Model assumptions: 2,500 TEU ship, 20 knots, 14,500 kW engine, 5,300 nm round trip, 65% ECA share, LNG tank volume gives vessel half-round-trip endurance, average cost of open/closed loop scrubber – $5/MWh, extra LNG operation costs 10% higher than standard, extra scrubber operation costs 20% higher than standard, continuous fuel price increase, starting year pricing scenario: HFO = 650 $/t, MGO = 900 $/t, LNG = 13 $/mm BTU (550 $/t equivalent to oil).

The transport ways of methane from source to customer have got a few possibilities: by pipelines; as liquefied natural gas (LNG), by change gas to liquid as fuel or methanol for chemical industry purposes, as methane hydrates, as compressed natural gas (CNG), by change gas to energy as electricity, directly gas to commodity [Herdzik 2011, 2013].

At present over 100 vessels are fuelled by LNG, mainly small ferries sailing in inland and territorial waters [*LNG in Baltic Sea Ports*].

Examples of LNG fuelled vessels are presented in Fig. 2.

Fig. 2. *LNG powered: barge on the Rhine (Dutch project 2013) (on the top) and offshore vessel „Viking Energy" (on the bottom) [Rats 2013]*

Rys. 2. Zasilane gazem LNG: barka na Renie (projekt holenderski 2013) (u góry) i statek obsługi platform „Viking Energy" (u dołu)

The possibility of LNG bunkering are presented in Fig. 3. Generally there are three ways: ship to ship (STS), truck to ship (TTS) and from tank via pipeline to ship (PTS). Conclusions of different bunkering solutions from a logistical and an operational perspective are presented in Table 1.

The main focus when developing a supply chain for LNG as a marine fuel is to create the most cost efficient supply chain as it is possible. The next ones are availability and price of LNG. For the scenario of 2030 the demand for LNG market as marine fuel will be 11% worldwide and about 29% for the Baltic Sea area [Herdzik 2012, 2013].

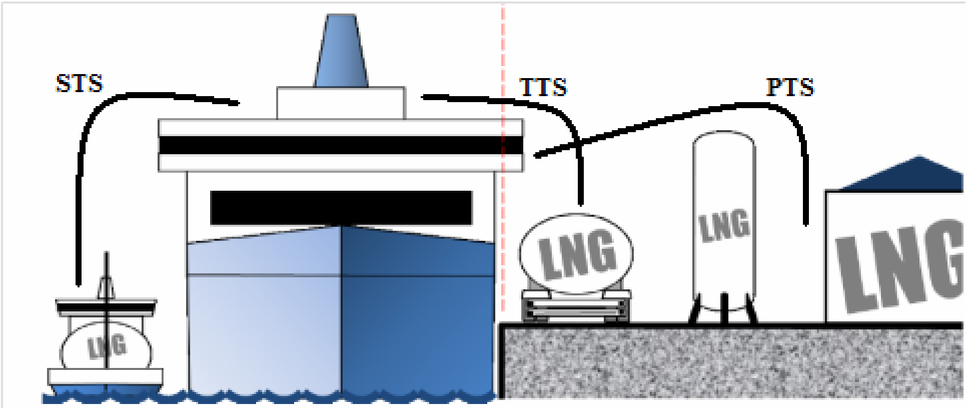

Fig. 3. *Possibility of LNG bunkering: STS, TTS, PTS [LNG in Baltic Sea Ports]*
Rys. 3. Możliwości bunkrowania LNG: statek/statek, cysterna/statek, terminal/statek

Table 1. *Different bunkering solutions from a logistical and an operational perspective [Gahnstrom 2012]*
Tabela 1. Sposoby bunkrowania (zalety i wady) z perspektywy logistyki i eksploatacji [Gahnstrom 2012]

	Ship to ship (STS)	**Tank truck to ship (TTS)**	**Tank to ship via pipeline (PTS)**
Advantages	flexibility	flexibility	availability
	high loading rate	low costs (investment and operation)	large bunkering volumes possible
	bunkering at sea (enlarged market)		
	large bunkering volumes possible		
Disadvantages	manoeuvrability in port basin	small quantity	fixed to certain quay
	high costs (investment and operation)	low loading rate	occupy terminal space
			sunk costs

2. LNG TRANSFER PROCEDURES PRINCIPLES

Where planning LNG activities, a number of rules and regulations need to be considered to get a permit approval, starting with EU regulations, through government and national authorities regulations [ISO Standard 28460 2010; Gahnstrom 2012; *Lloyd's Register LNG Bunkering Infrastructure Survey* 2014; *LNG Fuel Bunkering Procedures in Ports and Terminals in the South Baltic Region* 2014; *LNG Review of Regulations* 2014; ISO/TS 18683 2015]. There is a necessity of getting approval of a few permits like: building permit, environmental permit, permit for handling and storage of dangerous goods, municipal local plan etc. [*LNG in Baltic Sea Ports*]. For the maritime side, all installations need to fulfill the IMO regulations [*IGF Code*] and in states of EU the EMSA regulations [*Study on Standards and Rules for Bunkering of Gas-Fuelled Ships* 2013].

When the LNG bunkering is possible the port facility (bunker station) or bunker vessel and LNG fuelled ship ought to have onboard before operation following documents [Herdzik 2012]:

- MSDS of supplied LNG;
- certificates of all LNG transfer equipment, personal protective equipment and fire-fighting equipment;
- emergency response plan;
- class certificates of all vessels involved;
- crew training certificates.

The main goals of LNG bunker procedures and checklists are presented in Fig. 4. All mentioned four goals are important and all ought to be fulfilled.

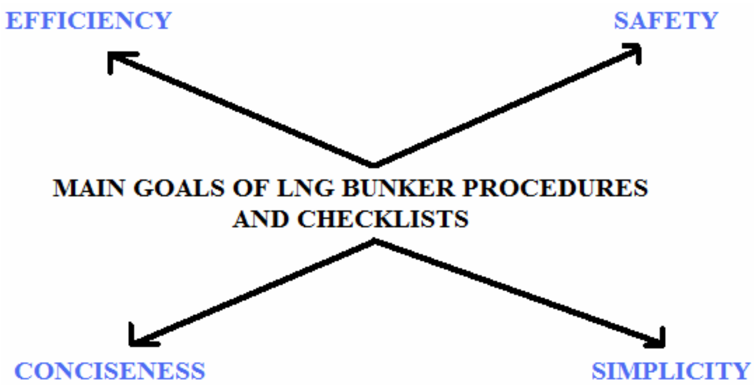

Fig. 4. *Main goals of LNG bunker procedures and checklists [LNG Bunkering in the Port of Antwerp 2015]*

Rys. 4. Główne zasady procedur bunkrowania LNG i list sprawdzających

3. EXAMPLES OF EUROPEAN PORT REGULATIONS

The possibility of LNG bunkering in European ports exists only in a few ports. The scale of LNG bunkering is small for internal market. A full scale bunker station needs a lot of money and ports still wait for EU or national decision (and finance) of that investment.

At first the future of LNG ship bunkering (the scale) and the demand from other internal consumers ought to be known. The port LNG bunkering solution depends on the size and type of vessel. The level suitability for different vessels are presented in Table 2. The number 1 means: best suitable LNG bunkering solution, number 2 means: suitable LNG bunkering solution, though not the best, number 3 means: unsuitable LNG bunkering solution for this vessel type.

Table 2. *LNG bunkering solutions and its level of suitability [Gahnstrom 2012]*

Tabela 2. Sposoby bunkrowania LNG i poziomy ich przydatności

Type of vessel/type of bunkering	STS	TTS	PTS
Ro-pax, ro-ro vessel	1	3	2
Tugboats	3	1	1
Coastal tankers, bulk carriers	1	3	3
Container feeder vessels	1	2	2
LNG feeder vessels	1	3	1
LNG bunker vessels	2	2	1
LNG tankers (>140,000 m^3)	2	3	1
Naval/ Coast Guard vessels	2	1	2
Offshore supply vessels	2	1	2
Smaller passenger vessels	2	1	1
Larger fishing vessels	1	2	1
VLCC	1	3	2

An example of LNG bunkering scenario for STS (ship to ship) scenario is as follows [*LNG Fuel Bunkering Procedures in Ports and Terminals in the South Baltic Region* 2014; *Development and Operation of Liquefied Natural Gas Bunkering Facilities* 2015; Jansen 2015; *LNG Operating Regulations Including LNG Bunkering* 2016]:

1. Preparations – establishing safety zones, fire equipment, personal protection equipment and emergency shutdown systems have to be prepared, checked and ready for use.
2. Checklists – both ships have to fulfill proper pre-bunkering checklists.
3. Communication – communication link have to be established, emergency signal and contingency plan have to be agreed.
4. Manoeuvring and mooring operations – after permission is granted manoeuvring and mooring operations can be carried out.
5. Hoses connection – dedicated hose handling equipment or typical hose crane can be used.
6. Checklist and documentation – pre-transfer checklist and documentation containing bunkering scheme and details have to be fulfilled by receiving ship and transferred to bunker ship.
7. Open manual bunker valves – remotely controlled valves have to be closed.

8. Ready signal from both ships.
9. Pump start sequence – during this stage possible leaks, hose and equipment behaviour and system functions should be monitored.
10. Bunkering operation – system pressure, tank volume and equipment behaviour should be monitored and checklist filled in during the bunkering process.
11. Pump stop sequence.
12. Pump must be stopped immediately in emerging or deviation cases.
13. Purging of bunker hoses – the liquid that remains in the bunker hoses after the pumps have stopped must be drained before disconnection.
14. Close manual and remote controlled valves – the valves, as both manifolds are to be closed when the hoses are purged. First, the remote valves are to be closed, and then the manual valves.
15. Disconnection of hoses.
16. Inerting of bunker lines – the receiving ship has to inert the bunker lines before departure, which means that the inerting sequence is to start as soon as the hoses are disconnected from manifold and run until lines are gas free.
17. Bunkering documentation exchanged.
18. Unmooring and manoeuvring.
19. Checklist and documentation – after LNG bunkering checklist and other documentation on both ships have to be carried out.

The scenario for other LNG bunkering solutions are similar to above mentioned according to specificity of installation.

An emergency shutdown system (ESD) on both manifolds is recommended for all LNG fuelled vessels, LNG bunker/feeder barges and small scale LNG terminals to be used when loading, discharging and bunkering LNG [Wang and Notteboom 2015]. An emergency Release Systems enables a rapid disconnection of arms/hoses when bunkering LNG in case of excessive drift of the vessel/barge or truck accidentally moving away from the operating area or design envelope. Suggested closing time of ESD valves is 5 seconds or less. The system when activated, initiates an emergency shutdown. As a result the system must be able to withstand the surge pressure that will be the result of the quick closing of ESD valves.

The existing rules demand a certain level of training for crews on LNG tankers. It is recommended that all persons involved in the LNG chain (crews of both vessels, bunker operators, port authority personnel etc.) are trained to a sufficient level (have certificates) in order to maintain the safety record for LNG handling.

For operation such as LNG bunkering, full mission simulator training of small vessels in very varying situations is not possible – the scope is too large. Some instructions of possible dangerous situations ought to be given.

4. CONCLUSIONS

The LNG bunkering chain in European ports ought to be built in maximal next ten years. Based on observations gathered, some recommendations can be made for next installations:

- LNG bunkering is feasible in terms of security, safety, environment protection and economics;
- Can be implemented in different mode (STS, TTS, PTS);
- LNG bunkering practices and procedures stay standards on international level;
- Prepared port regulations of LNG bunkering stay the pattern for new built installations in next ports;
- Acquired experience will facilitate the undertaking of next actions.

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