

Navigational safety of LNG tankers in emergency situations

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Abstract

LNG import terminals are under construction in the Baltic Sea ports Klaipeda and Świnoujście and should start operations in 2014. LNG tankers in Klaipeda port should cross port up to the end of the port. Probability of possible emergency situations with LNG tankers is very low, but in the same time it is necessary to take all possible precaution measures to avoid accidents with LNG tankers in any cases, especially in port areas.

“Black out” on the LNG ships is very dangerous in ports areas, because there is very limited channel’s width and other port water areas, and it is necessary to steer vessel in such situations as well. Theoretical calculations of the precaution measures, simulations and practical training of the ship and tugs masters, port pilots and VTS operators should help in such emergency situations.

This article is oriented to explain theoretical calculation methods for the LNG tankers steering by tugs in case of “black out” situations, simulations’ results and practical recommendations for the Port Authorities, port pilots, ships’ and tugs’ masters that will be possible to minimize LNG ships’ incidents and accidents probability in port areas.

Introduction

LNG as energy for industry, for people requirements, for transport as a fuel and many other tasks is very important and LNG demand increase every year in many countries. In many countries and regions LNG import terminals are constructed or are under construction or planning. In the Baltic Sea are under construction LNG terminals are in Klaipeda and Świnoujście and should start to operate in 2014. LNG tankers in Klaipeda port must sail up to end of the port (about 6 miles by port waters). LNG Carriers are built up under very strict requirements by the authorities, but the in same time it is impossible to have 100% navigational safety guaranty [1, 2, 3]. Emergency situations with LNG tankers probability is very low, but in the same time it is necessary to take all possible precaution measures to avoid accidents with LNG tankers in any cases, especially in ports.

“Black out” on any ship is very dangerous in the ports areas, because there is very limited channels width and other port water areas, but it is necessary to steer vessel in such situations as well. Theoreti-

cal calculations of the precaution measures, simulations and practical training of the ship and tugs masters, port pilots and VTS operators should help in such emergency situations [4, 5, 6, 7].

Theoretical calculations methods for the LNG tankers steering by tugs in case of “black out” situations, simulations results and practical recommendations for the Port Authorities, port pilots, ships’ and tugs’ masters that will be possible to minimize LNG ships accidents probability in port areas [1, 6, 8, 9].

Navigational situations in planning LNG import ports and terminals

In the world there are more than 50 LNG import terminals. In the Baltic Sea there are under construction two LNG import terminals: in Klaipeda offshore LNG terminal and in Swinoujście onshore LNG terminal. In mentioned LNG terminals navigation has specific conditions, that means navigational channels (approach and inside ports) have limited width, there are bends in the channels, navigational channel in Klaipeda port is located close

to the oil and other terminals, which is visited by big ships, there are some public places close to the navigational channel [2, 3, 9, 10, 11].

In depending of the very high requirements to LNG tankers, in the same time nobody can guaranty that nothing happens with LNG tanker during passing navigational channel. In this case should be taken additional precaution measures to avoid big losses in case of incidents or accidents on LNG tanker. In any case, ships should be checked on “black out” situations. In this case in 30 s emergency generator must start to work, which is supplying the energy steering equipment (rudder machine). In the same time tugs’ assistance should guaranty to keep LNG tanker in the channel up to hydro meteorological limitation conditions, that means LNG tanker at any time should be under control and should avoid touching moored to quay walls ships or waterfront constructions (quay walls, etc.) [1, 3, 5, 8, 9, 12].

On figures 1–3 there are shown Klaipeda port important places, which are located close to the navigational channel and cannot be touched by LNG tanker at any time [10, 13, 14].

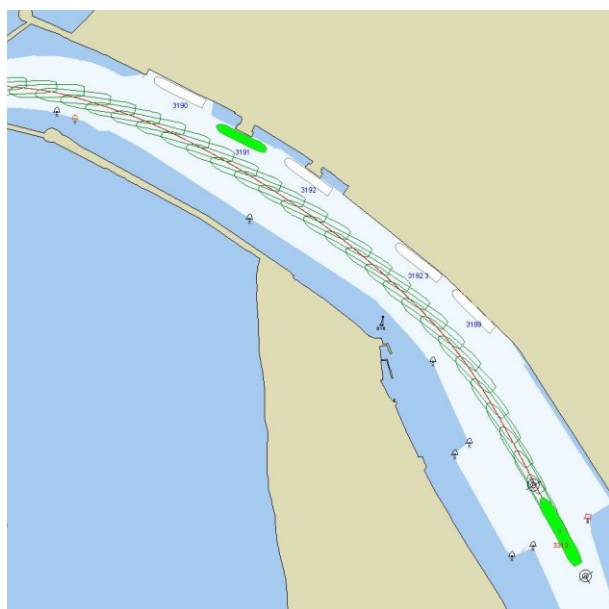


Fig. 1. LNG tanker sailing pass near Klaipeda oil terminal

In the same time other terminals, which are located close to the navigational channel are important for the port as well. Navigational passes are always important for the port navigational channels, terminals’ design, that would be possible to guaranty safe navigation in ports [1, 3, 8, 9, 12]. As the example LNG terminal in Klaipeda port is located in south part of the port and LNG tanker must cross all the port until it reaches mooring place [10].

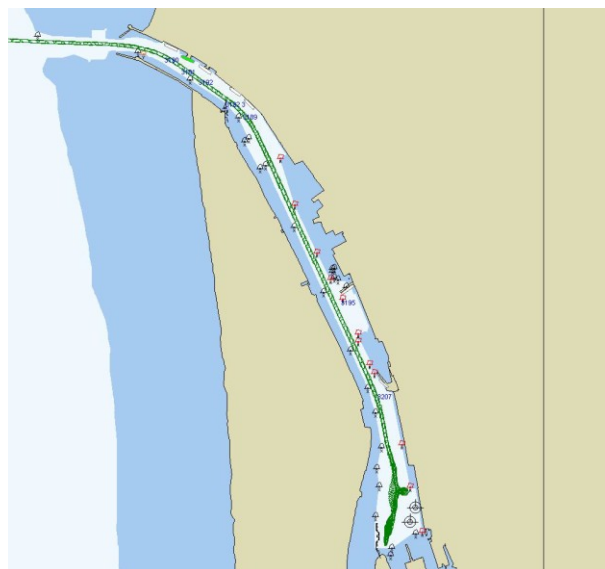


Fig. 2. LNG tanker sailing trajectory from entrance to the port until the mooring place

LNG terminal is located in the south part of Klaipeda port and ships turning basin is located close to the LNG terminal jetty.

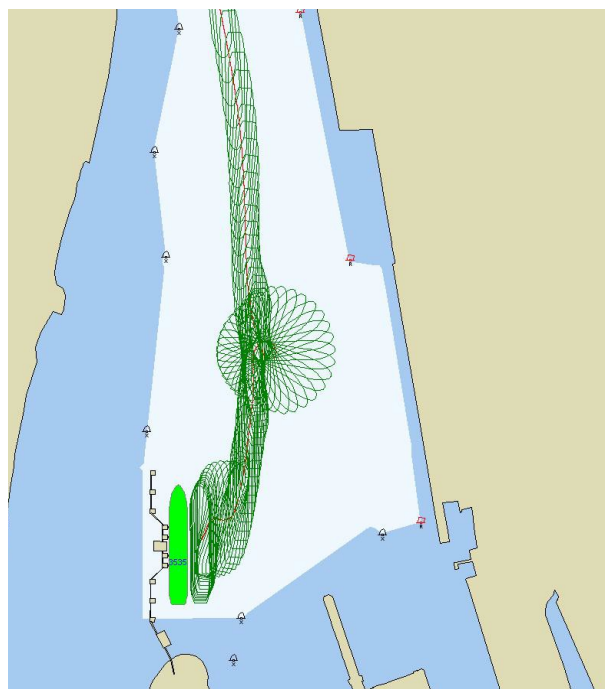


Fig. 3. Ships turning basin and LNG tanker mooring jetty

In typical navigation situation LNG tanker could sail to or from port entrance to the mooring place and from mooring place to the port gates. Klaipeda port entrance and inside navigational channels are wide and deep enough for typical LNG tankers (capacity up to 150,000–200,000 m³) in normal navigation conditions. In the same time there are always at least minimum probability of the failures, such as engine or steering system brake and etc.

In emergency situations LNG tanker must be safely steered by tugs until LNG tanker is reaching the safe place (anchoring or mooring place, etc.).

Very similar navigation situations are in other LNG ports and terminals.

Theoretical basis for the LNG tankers steering in emergency situations

LNG tanker steering in emergency conditions moments should be managed by tugs (in case of failure ship's propulsion equipment). In general moments, which are created by the ship and environment could be calculated as follows [2]:

$$M_{in} + M_k + M_{\beta} + M_p + M_N + M_a + M_{sr} + M_b + M_{sek} + M_T + M_{vil} + \dots = 0 \quad (1)$$

where: M_{in} – inertia moment; M_k – moment on ship's hull; M_{β} – ship's hull as wing moment; M_p – ship's helm moment; M_N – moment which is created by ship's thrusters; M_a – aerodynamic moment; M_{sr} – moment which is created by current; M_b – moment which is created by waves; M_{sek} – shallow depths created moment; M_T – ship's propeller created moment; M_{vil} – moment created by tugs.

In the emergency conditions, in case of failure of ship's propulsion equipment for example in "black out" situation, ship cannot create moments by propulsion system, that means formula (1) could be expressed as follows:

$$M_{in} + M_k + M_{\beta} + M_a + M_{sr} + M_b + M_{sek} + M_{vil} + \dots = 0 \quad (2)$$

For mentioned tasks, (in port conditions) formula (2) can be expressed as follows:

$$(I + \lambda_{66}) \frac{d\omega}{dt} \cdot \sin \beta \cdot \cos \beta + M_R + M_a + M_{sr} + M_{vil} = 0 \quad (3)$$

where: V – ship's mass; λ_{ω} – added water mass; dv/dt – ship's acceleration; β – ship's drift angle; I – ship's hull inertia moment; λ_{66} – added moment; $d\omega/dt$ – angle velocity acceleration.

Finally, moment which is created by tugs should be equal or bigger as other moments. For the ship's steering possibilities it is necessary calculate moments. In case, if it is created moments by tugs are bigger as other moments, ship is able to steer, that means should be [2]:

$$M_{vil} \geq M_{in} + M_R + M_a + M_c + M_{\beta} + \dots \quad (4)$$

where: M_{vil} – moment created by tug or tugs.

Mentioned moments could be calculated by the ship's theory or other methods, for example could be used numerical methods [2].

Practical calculations and testing of LNG tankers steering in emergency situations

For the practical calculations and testing was used LNG tanker, which length – 288 m, width – 49 m, draft 11.8 m, capacity – 150,000 m³ LNG.



Fig. 4. LNG tanker "Arctic Princess" (Norway): $L = 288$ m, $B = 49$ m, $T = 11.8$ m, DWT = 74,400 t

Calculation results receive by formula (4) showed, that four tugs with bollard pull 50 T are enough to steer LNG tanker with capacity of 150,000–170,000 m³ LNG in Klaipeda port in limited hydro meteorological conditions (wind up to 12–14 m/s, current up to 1.5–2.0 knots, waves on port entrance up to 1.5–2.0 m high).

Tests were made on SimFlex Navigator full mission Simulator [14] by Klaipeda port pilots in FORCE TECHNOLOGY (Denmark) during pilots' training session and by other ship masters and pilots. In case of training port pilots and good cooperation between ship's master, port pilots and tugs masters, it is possible to steer LNG tanker up to limited entrance to the port for such size ships hydro meteorological conditions. In the same time it is necessary to point out, that constant education and training of port pilots and tugs' masters is extremely important.

Some examples of the LNG tankers steering in emergency conditions in Klaipeda port tests are presented on figures 5–7.



Fig. 5. LNG tanker sailing pass on departure in emergency situation (wind SW – 12 m/s, current out 1.2 kn, waves SW – 1.5 m) used four 50 T bollard pull tugs

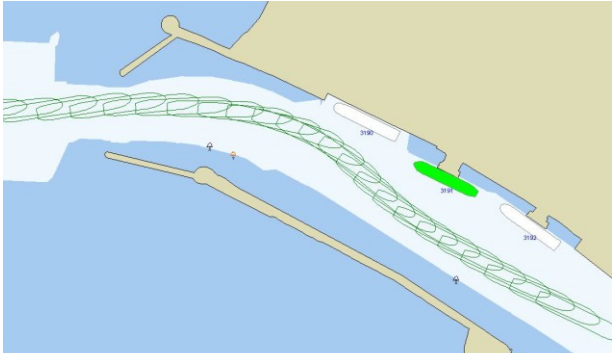


Fig. 6. LNG tanker sailing pass on entrance to the port in emergency situation (“black out” happens just before port gates, wind SW – 12 m/s, current out 1.2 kn, waves SW – 1.5 m), used four 50 T bollard pull tugs

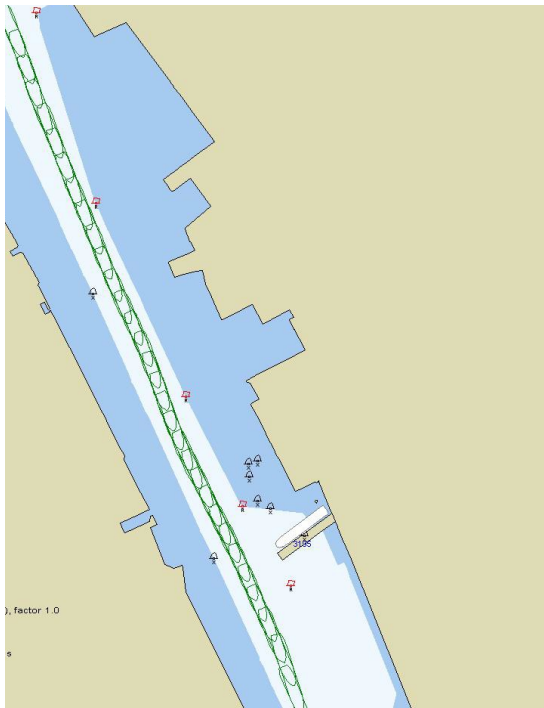


Fig. 7. LNG tanker sailing pass inside port navigational channel in emergency situation (“black out” happens during sailing in port inside navigational channel (wind SW – 12 m/s, current out 1.2 kn) used four 50 T bollard pull tugs

Conclusions

Emergency situations with LNG tankers probability is very low, but in the same time it is necessary to take all possible precaution measures to avoid incidents and accidents with LNG tankers in any cases, especially in ports.

In the emergency situations LNG tanker must be safely steered by tugs until LNG tanker reaches safe place (anchoring, mooring place, etc.).

Forces and moments, which are acting during ship’s movement, could be calculated by the naval theory or other methods, for example numerical methods.

On the basis of LNG tanker’s steering in emergency conditions calculation and testing results, as shown in the article, it is possible to consider that in case of good preparation of the port structures (VTS operators, port pilots, tug masters), education and training, there is possible to have successful steering of LNG tankers in emergency situations and avoiding incidents and accidents in port areas in any cases.

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