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SAFETY OF MANOUVERING, MOORING AND UNLOADING OF LNG CARRIERS IN OUTER PORT OF SWINOUJSCIE

ABSTRACT

Safe entrance to the port of LNG carrier (vessel of length abt. 300m) to the terminal requires considering of technical and navigational aspects, as well as fulfilment of series of safety criteria related to manoeuvring, mooring and unloading of LNG carrier (LNGC). Complex manoeuvring, mooring and unloading safety assessment of LNG C in port, might be done as a assessment of particular types of manoeuvres and exploitation operations. Article copes with all this aspects.

Keywords: Manouvering, Safety, LNG.

INTRODUCTION

Safe entrance to the port of LNG carrier (vessel of length abt. 300m) to the terminal requires considering of technical and navigational aspects, as well as fulfilment of series of safety criteria related to manoeuvring, mooring and unloading of LNG carrier (LNGC).

Complex manoeuvring, mooring and unloading safety assessment of LNG C in port, might be done as a assessment of particular types of manoeuvres and exploitation operations.

As specific manoeuvres and operation of LNGC in port following can be characterized:

– turning of LNGC inside port area;
– mooring manoeuvres to the unloading terminal (mooring and unmooring);
– stay of vessel at terminal;
– unloading operations.

Safety of each of these operations and manoeuvres is assessed with different criteria. Fulfilment of these criteria relies on navigational and operational conditions, like type of vessel and area. These conditions might be different for particular types of operations.

SAFETY OF LNGC TURNING MANUVERS IN SWINOSUJSCIE PORT

Main safety of navigation condition during manoeuvre of turning can be formulated as follows:

$$\left.\begin{array}{ll} p(x,y)\in \mathbf{D}(t) & d_{ijk}\subset \mathbf{D}(t) \\ h(x,y,t)\geq T(x,y,t)+\Delta(x,y,t) & \end{array}\right\} \quad (1)$$

where: $\mathbf{D}(t)$ - accessible navigational area (meeting the condition of accessible depth at moment t),

$\mathbf{d}_{ijk}$ - accessible manoeuvring area (traffic lane) of the i-th vessel, performing the j-th manoeuvre in k-th navigational conditions,

$h(x, y, t)$ - the depth of the area at point with coordinates (x, y) at moment t,

T(x, y, t) - the draft of the vessel at area point with coordinates (x, y) at moment t,

$\Delta(x, y, t)$ - unerkeel clearance at area point with coordinates (x, y) at moment t.

Sets of points of the accessible navigational area $\mathbf{D}(t)$, as also the safe maneuvering area $\mathbf{d}_{ijk}$ can be identified with areas of definite linear parameters.

These criteria were applied to estimation of accessible area in outer port of Swinoujscie. Simulation method were developed for this purpose. Simulations were carried out at simulators in Marine Traffic Engineering Centre over Kongsberg's Polaris full mission simulator. Researches were conducted on 3 types of mathematical LNGC's models:

– s/v Exmar Excalibur capacity=138.000 cu.m., L_{oa}=277.0m;
– s/v Umm Bab capacity= 145.000cu.m., L_{oa} = 285.4m;
– m/v Al Gatarra (QFlex) capacity= 216.000 cu.m., Loa = 315.0m.

Manuvers of turning were conducted at wind conditions of 12.5m/s (different directions), with 4 tugs:

– 2 tugs of pulling force 48t (azipod drive);
– 2 tugs of pulling force 30t. (conventional drive).

Exemplary results from this researches (LNGC 138k cu.m., at wind N12m/s) are presented at figure 1.

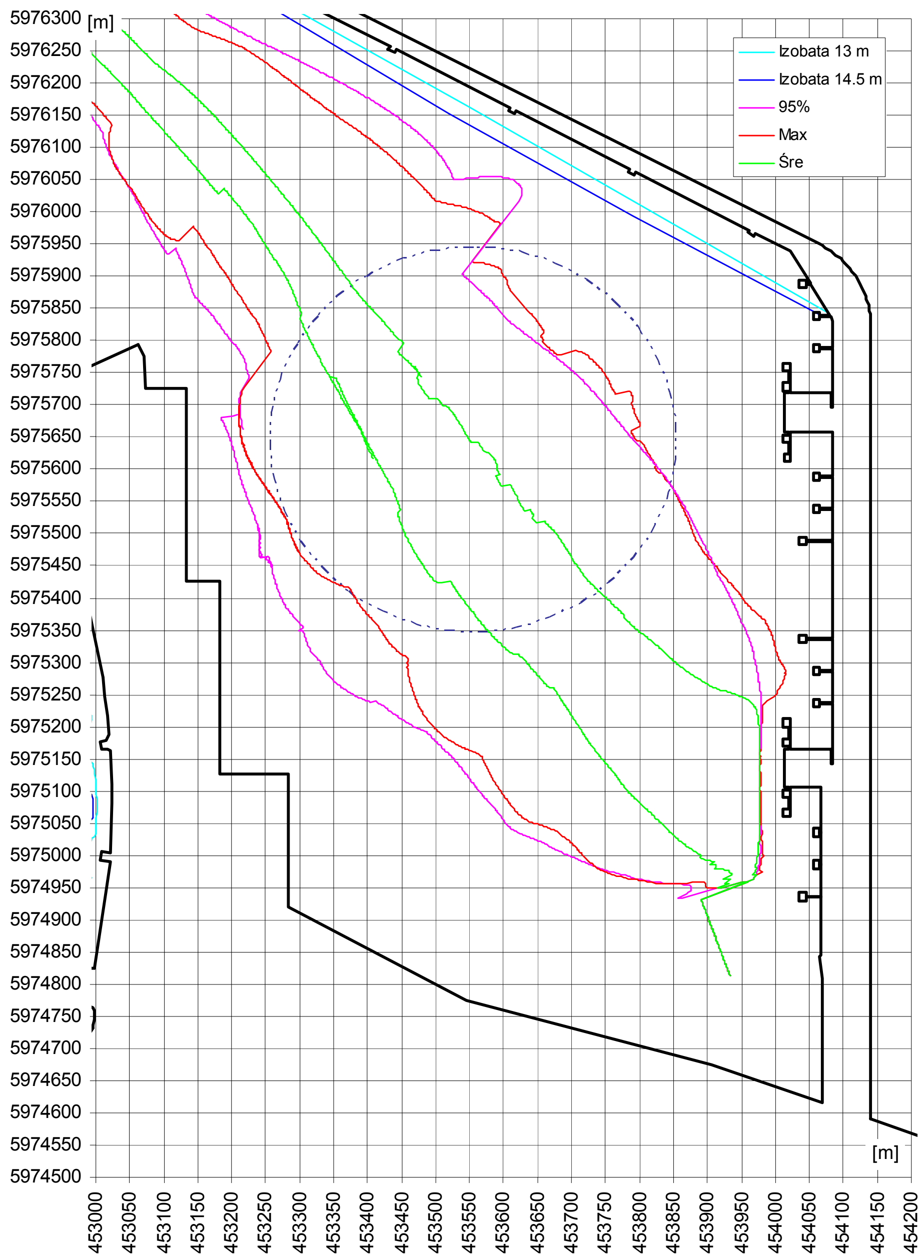

Fig. 1. Results from researches - traffic lane widths of turning LNGC 138k cu.m., in Oputer Port of Świnouujscie at wind N12m/s

SAFETY OF MANEUVERS OF MOORING LNGC IN OUTER PORT OF SWINOUJSCIE

Analysis of maundering tactics proved, that most crucial moment of manoeuvres is first contact of vessel's hull with structure. During this time kinetic energy is transformed into work of collision that affects on hull and fendering system. Energy induced in fendering system will affect potential damages, whilst second and following contacts wont induce that amount of energy as firs one. Keeping this assumption in mind it can be stated that safe mooring criteria is energy absorbed by fendering system E_a during first contact of vessel's hull and berth. It should be treated as a kinetic energy induced on berth.

Amount of absorbed by fendering-vessel system energy reflects reaction forces that decides over potential damage. Thus, criteria of navigation safety can be formulated as follow:

$$\left.\begin{array}{l} E_a(t_i) \le E_d^{nab} \\ E_a(t_i) \le E_d^{stat} \end{array}\right\} \qquad (2)$$

where: $E_a(t_i)$ - maximum kinetic energy of vessels contact absorbed by fendering-vessel system [kNm],

E_d^{nab} - permissible kinetic energy of vessels contact absorbed by fendering-vessel system [kNm],

E_d^{stat} - permissible kinetic energy, of which induced work will not deflects vessels hull permanently [nNm]

$$\delta \le \delta_d \qquad (3)$$

where: δ - singular maximum hull stress from fender reaction force[kN/m^2],

δ_d - permissible singular hull stress from fender reaction force[kN/m^2].

Parameters of kinetic energy distribution of 216 k cu.m. LNGC contact with terminal in Swinoujscie are presented on fig 2. These parameters were obtained from simulation researches. Fenders shall be selected for mooring energy induced by maximum vessel, which can be described by gamma distribution on confidence level. Area of contact between terminal and mooring vessel shall be taken into account for maximum allowable hull stress.

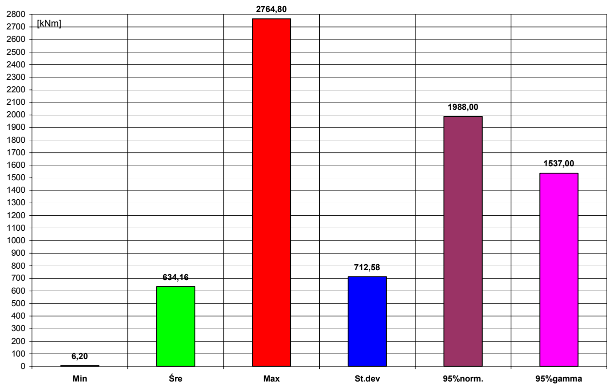

Fig.2. Energy induced during mooring of LNGC 216k cu.m.to terminal in Swinoujscie

SAFETY OF LNGC ALONGSIDE TERMINAL JETTY

Gas carrier can safely stay alongside at unloading terminal under conditions: that hull's flat body is in contact with fenders (with permissible forces as well as for hull and fender line); permissible tensions of all mooring lines is higher than longitude and traverse pull forces induced by maximal wind speed blows for given port. Thus, general conditions of safe stay alongside the unloading terminal can be as follows:

$$\left.\begin{aligned} l &\geq l_{wcd} \\ l &\geq l_{wcr} \end{aligned}\right\} \tag{4}$$

where: l - distance from C/L (centre line) of manifold (i.e. vapour return manifold line) to last fenders – this distance is measured on terminal;

l_{wcd}, l_{wcr} - length of flat body from C/L to bow and sterns directions, for ballast condition – this distance is specific to given vessel.

$$\begin{aligned} \sum_{i=1}^{n} P_{ib} &\leq Q_b \\ \sum_{i=1}^{n} P_{iw} &\leq Q_c \end{aligned} \qquad 5)$$

where: P_{ib}, P_{iw} - tension of i-th mooring line traverse and longitude respectively;
Q_b, Q_c - maximum pull force form wind blows traverse and longitude respectively.

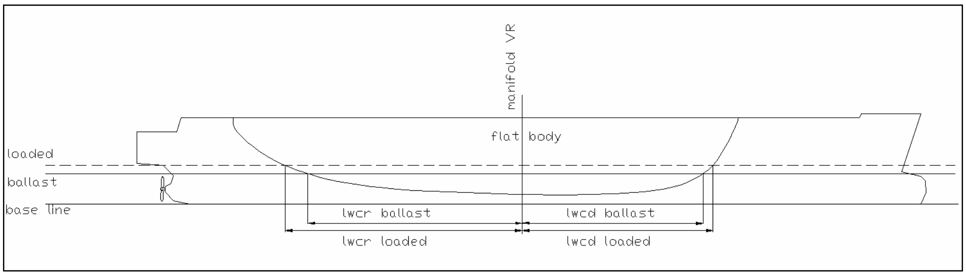

Fig.3. Flat body section

Additionally for location of fenders following shall be considered:

1. Stability of vessel during mooring will be fulfilled for distance of fenders from manifold minimum 1/3 of maximum vessels length.
2. Smmetrical fender distribution that will affect tensions on spring lines.

SAFETY OF UNLOADING OPERATIONS

Interconnection of vessels and land systems is performed by connecting adequate pipes flanges of unloading arm to ships manifold. Formulating this basic safety condition of unloading can be written as (fig.4)

$$\left.\begin{aligned} d_{\max} &\geq D - T_{bal} + \Delta h_{\max} \\ d_{\min} &\leq D - T_{lad} + \Delta h_{\min} \end{aligned}\right\}, \tag{6}$$

where: d_{max}, d_{min} - working range of unloading arms, max and min respectively, measured from reference line;
D - height of manifold from vessels base line;
T_{lad}, T_{bal} - draft of LNGC loaded and in ballast condition;
Δh_{max}, Δh_{min} - difference in water level in accordance to reference line (maximum and minimum for given period).

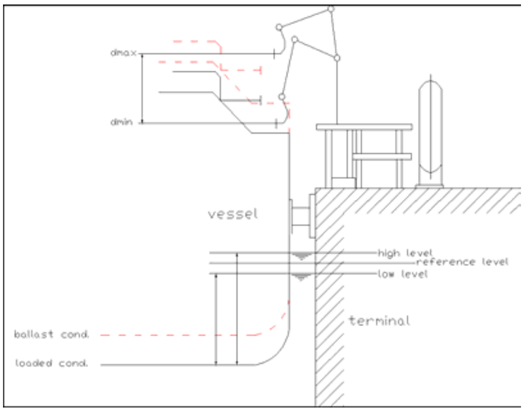

Fig.4. Loading arms working range

CONCLUSIONS

Safety of manoeuvring, mooring, alongside and unloading of LNGC inside port requires fulfilment of following criteria (conditions):

– manoeuvre of turning;
– berthing manoeuvre;
– mooring alongside unloading terminal;
– unloading of cargo.

All LNG tankers going inbound port must comply with these criteria. For designing process of outer port in Swinoujscie safety assessment has been conducted for typical LNG vessels within range of prospected operations inside the port. Vessels that will be delivering cargo to Poland are in ranges of capacities from 120.000 to 216.000 cubic meters.

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