Polski Rejestr Statków

RULES

PUBLICATION NO. 19/P

ZONE STRENGTH ANALYSIS OF HULL STRUCTURES IN TANKERS

2010

Publications P (Additional Rule Requirements) issued by Polski Rejestr Statków complete or extend the Rules and are mandatory where applicable.

GDAŃSK

Polski Rejestr Statków

RULES

PUBLICATION NO. 19/P

ZONE STRENGTH ANALYSIS
OF HULL STRUCTURES IN TANKERS

2010

GDAŃSK

Publication No. 19/P – Zone Strength Analysis of Hull Structures in Tankers – 2010 is an extension of the requirements contained in *Part II – Hull* of the *Rules for the Classification and Construction of Sea-going Ships*.

The *Publication* was approved by the PRS Board on 9 November 2010 and enters into force on 25 November 2010.

The present *Publication* replaces *Publication No. 19/P – Zone Strength Analysis of Hull Structures in Tankers – 1995.*

PRS/AW, 11/2010
ISBN 978-83-7664-144-7

CONTENTS

page

1 GENERAL

1.1 Application

The requirements of the present *Publication* apply to zone strength analysis of hull structure of tankers other than double hull oil tankers having the length $L_0 \geq 150$ m.

For double hull oil tankers having the length $L_0 \geq 150$ m, the requirements specified in *Publication No. 85/P – Requirements Concerning the Construction and Strength of the Hull and Hull Equipment of Sea-going, Double Hull Oil Tankers of 150 m in Length and above*, apply.

1.2 General

1.2.1 For design of tankers, the technical documentation of which is subject to PRS' approval, the PRS *Rules for the Classification and Construction of Sea-going Ships* (hereinafter referred to as the *Rules*) require a zone strength analysis of the hull structure to be carried out.

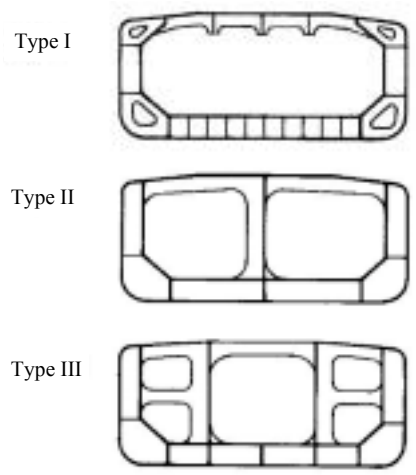
1.2.2 The zone strength analysis is to show that in all, described below, design load conditions (LC), the stresses in the specified sections of the structure will not exceed the values prescribed by the *Rules*, *Part II – Hull*.

1.2.3 Acceptable results of zone strength analysis carried out in accordance with the procedure given in the present *Publication*, as well as compliance with the requirements of the relevant Chapters of *Part II – Hull* will be the basis for approval, by PRS, of hull documentation.

1.2.4 For zone strength analysis, any calculation method or computer program, approved by PRS, may be applied, provided the effects of bending, shear, axial and torsional deformations are considered.

1.2.5 The present *Publication* contains guidelines for carrying out the stress analysis of girders of three basic structure types of tankers shown in Fig. 1.2.5.

Tankers with other structural arrangement (e.g. containing 'tweendecks or platforms in the cargo area) are subject to special consideration by PRS.



Centreline longitudinal bulkhead of ship type II may be a watertight or wash bulkhead. In the latter case, design loads as for ship type I are to be taken.

Fig. 1.2.5 Types of tankers

1.2.6 The design loads to be applied to analysis of the individual structural members may be derived from the load conditions given in Chapter 2.

Load conditions LC1, LC2 and LC3 are assumed to be service conditions (sea – going conditions).

Load conditions LC4 and LC5 are assumed to be harbour conditions.

Additional load conditions may be required for special cargoes or a special loading arrangement, as well as for ships with special hull geometry.

1.2.7 At determining load conditions (see Chapter 2), crude oil or crude oil products density, ρ, equal to sea water density, i.e. $\rho = 1.025$ t/m^3, is to be taken.

The structure of tanks intended for the carriage of liquids other than those mentioned above, with the density $\rho > 1.025$ t/m^3, is subject to special consideration by PRS.

Standard and additional load conditions need not, in general, be considered for parts of the structure where other conditions are obviously decisive for the scantlings.

1.3 Definitions

1.3.1 Symbols not mentioned in the following list are given in connection with the relevant formulae.

L_0 – scantlings length of the ship, [m];
B – breadth of the ship, [m];
H – depth of the ship, [m];
T – draught, [m];
T_m – the minimum design draught of the ship, [m];
g – standard acceleration of gravity; $g = 9.807$ [m/s^2];

h_a – cargo (ballast) head, [m], (the vertical distance from the load point to the top of the tank);
S_A – amplitude of the relative hull motion, [m];
a_v – combined vertical acceleration, [m/s^2];
Φ_A – roll angle, [radians];
ρ – stowage rate of cargo, [t/m^3]; for crude oil, crude oil products and ballast water $\rho = 1.025$ is to be taken;
p_0 = 25 kPa, but is to be not less than p_v ;
p_v – pressure at which safety valve operates, [kPa].

2 LOAD CONDITIONS

2.1 Design Load Conditions

The calculations are to be based on the most severe realistic load conditions, with the ship:
– fully loaded, at draught T ,
– partly loaded, at draught T_m, in the upright and heeled conditions,
– loading or discharging (harbour conditions).

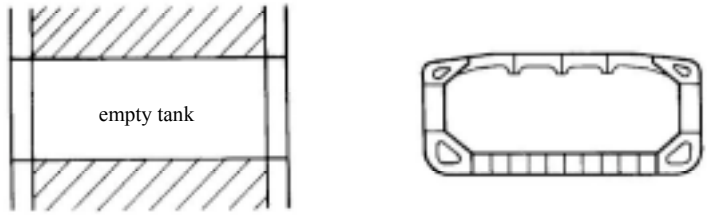
The detailed description of the above-mentioned load conditions is given in paras. 2.2 ÷ 2.6.

2.2 Fully Loaded Ship, Some Tanks Empty (LC1)

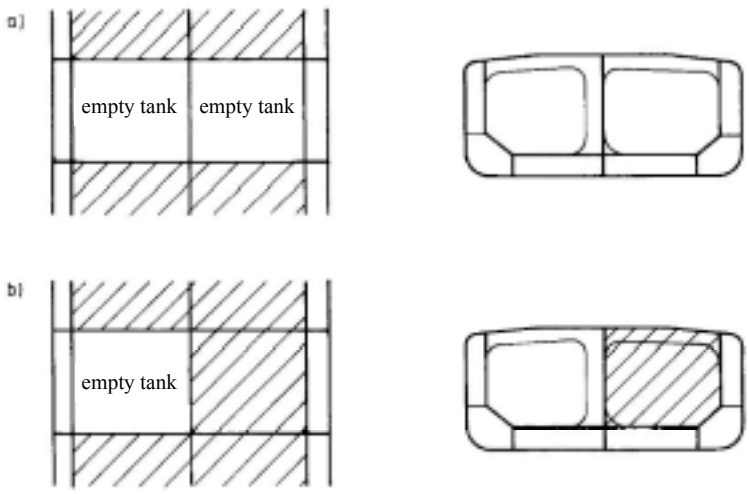
2.2.1 Load conditions to be considered in the strength analysis of the respective ship types are shown in Fig. 2.2.1.

The loads may be decisive for the scantlings of longitudinal and transverse bulkheads girders, sides and bottom girders in way of empty tanks.

Type I



Type II



Type III

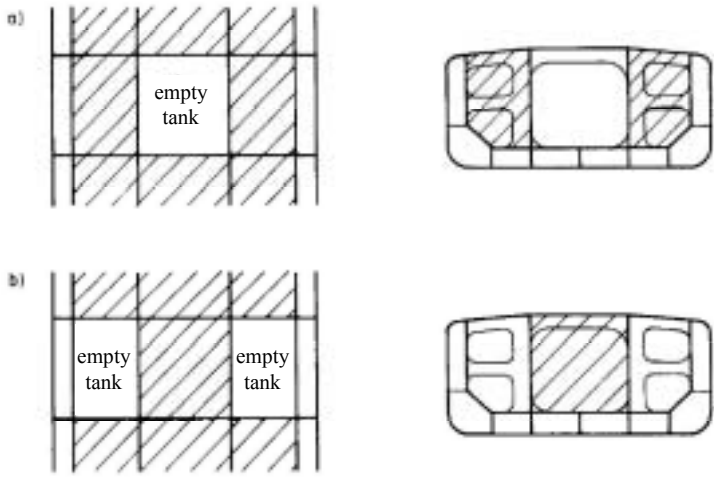


Fig. 2.2.1

2.2.2 The design sea pressure is to be determined for the full ship's draught T, including dynamic sea pressures, according to formulae given in *Part II – Hull*.

2.2.3 The design liquid (cargo) pressures in tanks are to be determined from the following formula given in *Part II – Hull* for fully loaded tanks:

$$p = \rho \cdot g \cdot h_a + p_o, \text{ [kPa]} \qquad (2.2.3)$$

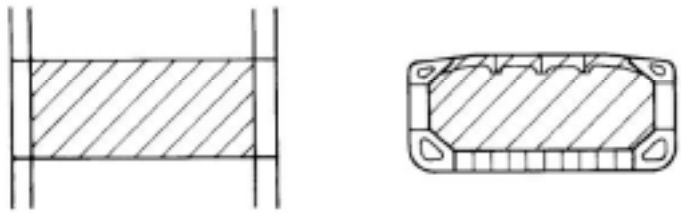
2.3 Ship in the Upright Condition, Partly Loaded (LC2)

2.3.1 Load conditions for the respective ship types I, II and III to be taken into account in the strength analysis are shown in Fig. 2.3.1.

The ship's draught equal to T_m is to be taken.

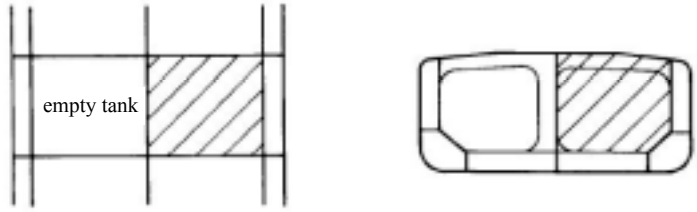
These loads may be decisive for the scantlings of the bottom, longitudinal and transverse bulkheads girders, as well as the side girders in way of full tanks.

Type I

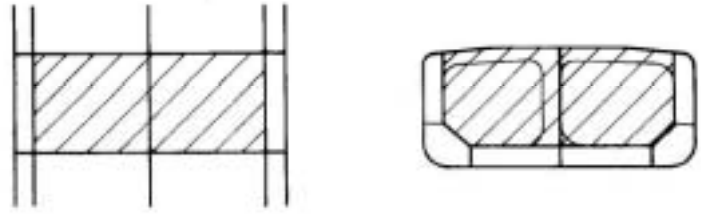


Type II

a)



b)



Type III

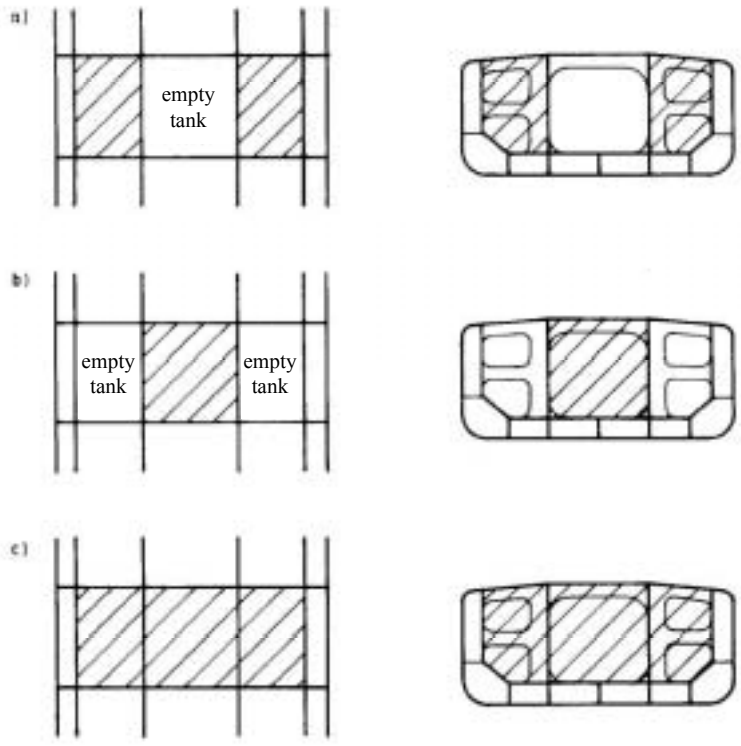


Fig. 2.3.1

2.3.2 The design sea pressures are to be determined as follows:

a) dynamic sea pressures acting on the ship's bottom and side at the level of waterline corresponding to draught T_m are to be determined according to formulae given in *Part II – Hull*, substituting, into the formulae, draught T;

b) the design side pressure at the level of the upper deck and the pressure on the upper deck are to be determined as specified in a) substituting, into the formulae for pressure, draught T_m. S_A and a_v are to be calculated for draught T;

c) when determining the design pressures distribution along the frame, static pressures, calculated for T_m, are to be added to the pressures according to a). Linear interpolation is to be applied using the values of pressures determined above.

2.3.3 The design liquid (cargo) pressure is to be determined as for LC1, i.e. as specified in para. 2.2.3.

2.4 Ship in Heeled Condition, Partly Loaded (LC3)

2.4.1 Load condition, shown in Fig. 2.4.1, is to be applied to all ship types: I, II and III. The ship's draught in calm water is equal to T_m.

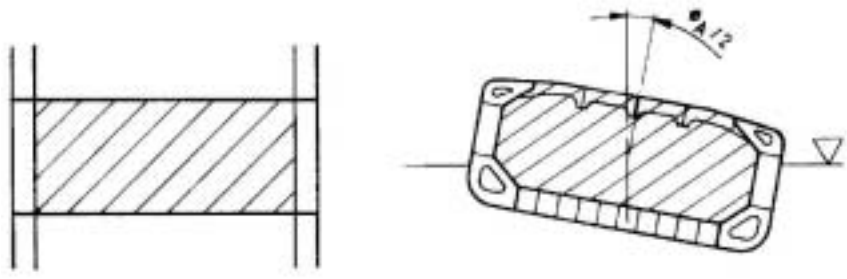


Fig. 2.4.1

2.4.2 The design sea pressures are to be determined as follows:

a) on the emerged side
   - the pressure at the bilge is to be calculated from the formula:
   - $$p = 10T_m - 5 \cdot B \cdot tg\frac{\Phi_A}{2} \qquad (2.4.2\text{-}1)$$
   - at the distance equal to $T_m - 0{,}5 \cdot B \cdot tg\frac{\Phi_A}{2}$ [m], above the base line $p = 0$ is to be taken;

b) on the submerged side
   - the pressure at the bilge is to be calculated from the formula:
   $$p = 10T_m + 3{,}3 \cdot B \cdot tg\frac{\Phi_A}{2}, \qquad (2.4.2\text{-}2)$$
   - at the distance equal to $T_m + 0{,}33 \cdot B \cdot tg\frac{\Phi_A}{2}$, [m], above the base line $p = 0$ is to be taken;

c) to determine the pressure, p, at any point of the side, linear interpolation is to be applied.

2.4.3 The design liquid (cargo) pressures in cargo tanks are to be determined from the formula:

$$p = \rho \cdot g \cdot h_0, \text{ [kPa]} \qquad (2.4.3\text{-}1)$$

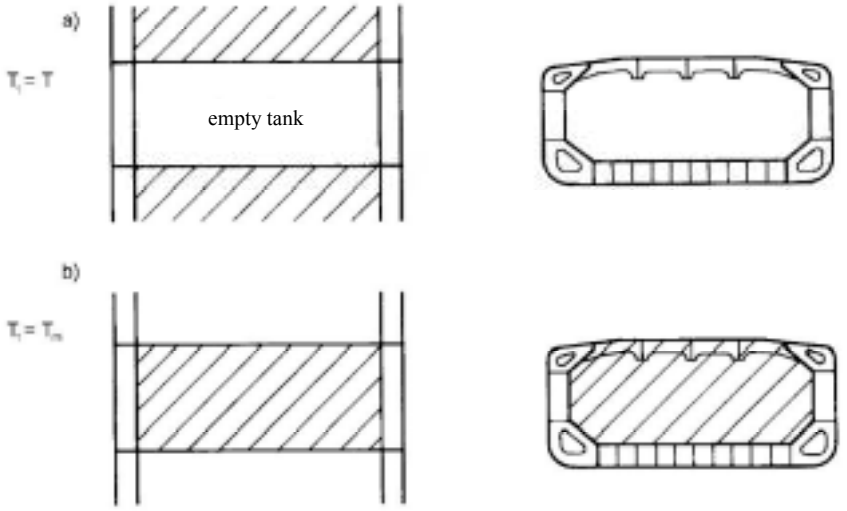
where h_o denotes vertical distance, [m], from the top of the tank (including hatch coaming) to the considered point of structure for the ship heeled to an angle of $\frac{1}{2}\Phi_A$.

2.5 Ship in Loading or Discharging Condition (LC4)

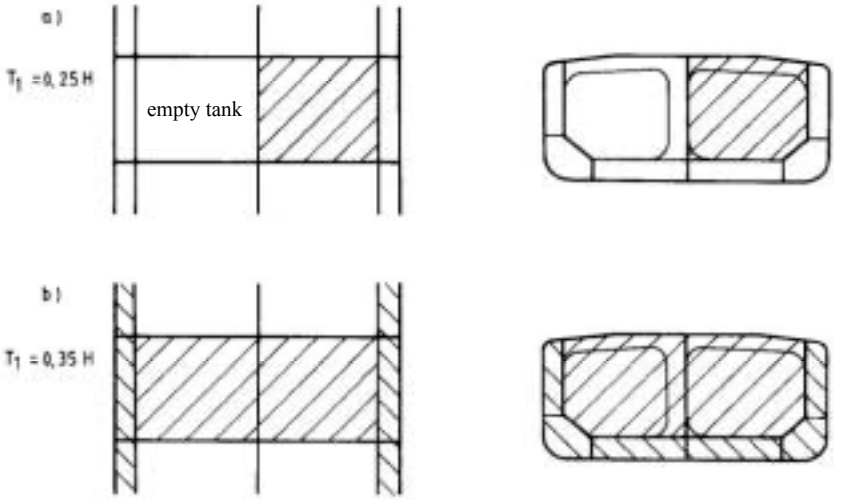
2.5.1 Load conditions for the respective ship types I, II and III to be considered in the strength analysis are shown in Fig. 2.5.1.

The values of the ship's draught T_1 are also given in Fig. 2.5.1.

Type I



Type II



Type III

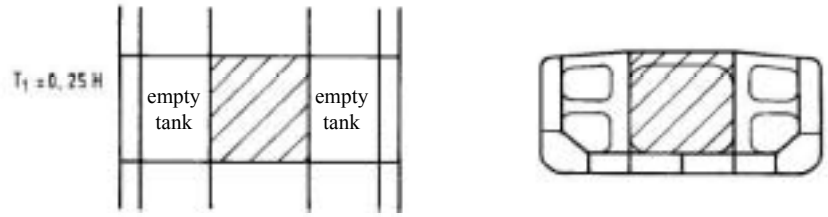


Fig. 2.5.1

2.5.2 The design sea pressure is to be taken as static pressure, i.e. the pressure calculated from the formula:

$$p = 10(T_1 - z)\,, \text{[kPa]} \qquad (2.5.2)$$

but is to be not less than $p = 0$.

T_1 – the ship's draught given in Fig. 2.5.1, [m],

z – vertical distance from the base line, [m].

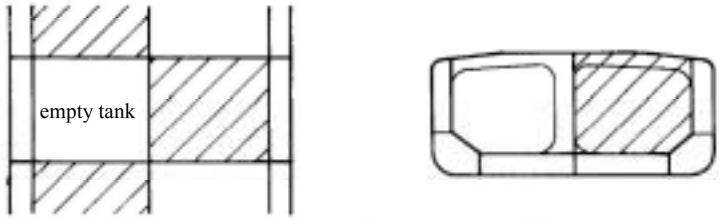
2.5.3 The design liquid pressure in cargo and ballast tanks is to be taken as given in para. 2.2.3.

2.6 Ship in Loading or Discharging Condition, Alternate Loading (LC5)

2.6.1 Load conditions to be considered in the strength analysis of transverse bulkheads of ship types II and III are given in Fig. 2.6.1.

The ship's draught is to be taken equal to $0.25\,H$.

Type II



Type III

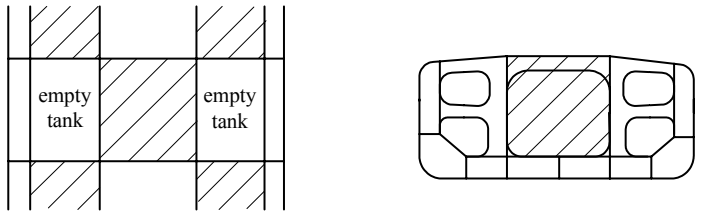


Fig. 2.6.1

2.6.2 The design sea pressure is to be determined as specified in para. 2.5.2.

2.6.3 The design liquid pressure in cargo tanks is to be determined as specified in para. 2.5.3.

3 STRUCTURE MODELLING

The applied method of zone strength analysis should take into account the effects of bending, shear, axial and torsional deformations.

Zone strength analysis using 3D FE model not shorter than three cargo holds lengths, applied to the midship region, is recommended.

The results of such analysis will normally be considered applicable also outside of the midship region.

Calculations are to be performed using 3D frame or shell and rod FE models.

These models are to comply with the requirements set forth in Chapter 14, *Part II – Hull*.

4 STRESS ANALYSIS

The values of permissible stresses are to be taken in accordance with Chapter 14, *Part II – Hull*; buckling strength criteria are to be applied in accordance with Chapter 13, *Part II – Hull*.