RUSSIAN MARITIME REGISTER OF SHIPPING

TECHNICAL REQUIREMENTS

FOR THE ARRANGEMENT AND SECURING OF THE INTERNATIONAL STANDARD CONTAINERS ON BOARD THE SHIPS INTENDED FOR CONTAINER TRANSPORTATION

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Saint-Petersburg
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The present Technical Requirements have been developed on the basis of the 1997 edition of the same name taking into account additions and amendments appeared in 2007. They have been approved in accordance with the established approval procedure and come into force on the date of their publication.

The requirements of the Register current normative documents have been taken into consideration in the Technical Requirements.

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CONTENTS

1 GENERAL

1.1 APPLICATION

1.1.1 Russian Maritime Register of Shipping[1] carries out technical supervision based on the present Technical Requirements[2] for the arrangement and securing of the international standard containers on board the ships intended for container transportation, as well as supervision of containers securing devices.

Performance of the present TR is mandatory for the ships having in their Classification Certificate as required by 2.3.1, Part I "Classification" of the Rules for the Classification and Construction of Sea-Going Ships[3] an additional characteristic stating that the ship is intended for containers transportation, and is also mandatory for container ships carrying containers on the open deck.

The present TR apply to the ships of unrestricted area of navigation and restricted area of navigation **R1**. Degree of reduction of the said requirements for the ships of restricted area of navigation **R2-RSN**, **R3-RSN** and **R3** is subject to special consideration by the Register in each particular case.

1.1.2 The present TR have been developed as applied to the ISO series 1 containers (set forth in the Register Rules for the Construction of Containers).

Other types containers securing is subject to special consideration by the Register taking into account their strength and rigidity.

1.1.3 As a rule, fully loaded containers shall be considered. It is permitted to provide containers arrangement and calculate containers securing based on their partial loading. In these cases, the submitted plans of containers arrangement and securing shall specify permissible loading of all containers.

1.1.4 The present TR do not apply to the methods of containers securing in the container ship cargo holds equipped with cellular guide members (see the definition of "container ship" in 1.1, Part I "Classification" and 8.4.8, Part III "Equipment, Arrangements and Outfit" of the Rules).

[1] Hereinafter referred to as "the Register".
[2] Hereinafter referred to as "TR".
[3] Hereinafter referred to as "the Rules".

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 For the purpose of these TR the definitions and explanations given in Part I "Classification" and Part III "Equipment, Arrangements and Outfit" of the Rules are adopted. Additionally, the definitions and explanations mentioned below have been adopted in the present TR.

1.2.2 Safe working load for containers securing devices (SWL) is a permissible load for the securing device established upon results of the ultimate load testing of the test and prototype specimens of the above device by taking into account prescribed safety factor.

1.2.3 Proof load (PL) is a test load which the securing device shall be capable of withstanding without permanent set.

1.2.4 Breaking load (BL) is a test load used for determination of ultimate bearing capacity of the considered containers securing device which is not subject to fracture.

1.2.5 Removable containers securing devices are various buttresses, bridge fittings, cones, lashings and equally efficient means attached to the containers, ship structures and fixed containers securing devices by detachable joints.

1.2.6 Fixed containers securing devices are various padeyes, deck fittings, weld-in sleeves, sockets and equally efficient means permanently fixed on the hatch covers, decks and other ship hull structures.

1.2.7 Lock is a removable device for containers securing which function is to prevent either horizontal or vertical movement of a container. Regardless of the design, a lock (automatic and semiautomatic twistlocks, stacking cones with inserted pin) is designated and shall be tested for the action of horisontal shear load and vertical tensile load.

Double twistlocks, except stated one, are designated for interconnecting two adjacent stacks and shall be tested additionally with horizontal tensile and compressive load.

1.2.8 Stacking cone is a removable containers securing device which function is to prevent horizontal movement of a container (shall be tested with horisontal shear load).

Double stacking cones, except stated one, are designated for interconnecting two adjacent stacks and shall be tested additionally with horisontal tensile and comprehensive load.

1.2.9 Lashing is a removable containers securing device which design and method of connection with a container and fixed containers securing device shall provide the capability of taking up tensile forces only. Lashings normally contain arrangements for their length regulation (for example, a turnbuckle).

1.2.10 S t r u t is a removable device for containers securing which design and method of connection with a container, fixed containers securing device or ship hull structures shall provide the capability of taking up both tensile and compressive forces acting along the strut centre line.

As a rule, a strut shall be provided with a length regulator.

1.2.11 B u t t r e s s is a removable device for containers securing which design and method of connection with a container and ship hull structures shall provide the capability of taking up compressive forces acting along the buttress centre line.

As a rule, a buttress shall be provided with a length regulator.

1.3 TECHNICAL DOCUMENTATION

1.3.1 For the ships intended for container transportation the following documentation shall be submitted to the Register:

.1 containers arrangements and securing plan (drawing). The plan shall clearly indicate containers type and size, maximum gross masses permissible for arrangement in different parts of the ship and illustrate securing method for each container, as well as provide main data on each container securing device (i.e. assembly drawing number or technical specifications on the securing device, its name, and value of the safe working load for each load case);

.2 calculations determining forces in the containers securing devices and structural elements carried out in compliance with the present TR;

.3 assembly drawings and drawings of the main parts of the containers securing devices, containing data on material of the parts, their heat treatment, safe working load (*SWL*), proof and breaking load tests.

1.3.2 Where it is supposed transportation of containers different from ISO series 1 containers, additionally, technical documentation specified in 5.2 of the present TR shall be submitted to the Register.

1.3.3 Where the documentation specified in 1.3.1 is not included in documentation concerning technical design, detailed design or technical detailed design such documentation (or its extracts) previously approved by the Register as a part of the similar ship design or working documentation containing information on the approved (in this ship design) plan of containers arrangement and securing in holds, on decks and on cargo hatch covers, as well as data on the mass of containers being arranged, shall be submitted to the Register.

2 CONTAINERS ARRANGEMENT AND SECURING

2.1 GENERAL

2.1.1 Containers carried on deck or on cargo hatch covers shall be located mainly in the longitudinal direction of the ship.

2.1.2 Containers shall be arranged in such a way that they do not project beyond the ship side. In cases when containers project beyond the hatch covers or other ship structures on which these containers have been placed, special deck supports shall be provided under each projecting corner of the container.

2.1.3 Arrangement of containers approved for transportation in cargo holds, on decks, on hatch covers; number of their tiers, their mass shall be determined taking into account conditions to provide ship's stability and strength of ship structures and cargo hatch covers (with regard to the requirements of Part II "Hull", Part III "Equipment, Arrangements and Outfit" and Part IV "Stability" of the Rules), as well as conditions to provide strength of containers securing devices and containers themselves in compliance with the present TR and containers technical characteristics.

2.1.4 Arrangement and securing of containers shall provide free passage to all parts and spaces of the ship access to which is required while at sea.

2.2 CONTAINERS SECURING

2.2.1 Containers shall be secured using one of the following methods or their combinations:

application of container corner locks;

application of lashings (chain, steel wire rope or rod);

application of struts, buttresses or similar devices.

Other containers securing methods may be subject to special consideration (see also 1.1.4).

2.2.2 Selection of containers securing method for a particular ship is carried out by the documentation developer upon agreement with the shipowner (with regard to 2.2.1) providing the following:

.1 the locks fitted in each container bottom corner, regardless the calculation results, are mandatory in case when containers are stacked in one tier on the open parts of the decks, hatch covers and if the containers are not secured with the lashings;

.2 in case when the lock is not fitted in this corner the stacking cone (or double stacking cones) for each container bottom corner is mandatory.

2.2.3 In case of containers stowage in blocks or semi blocks in the hold (see 4.1.1) to avoid a possibility of containers compression as a result of ship hull deformation in waves the following shall be met:

.1 in case of using buttresses (see Fig.4.1.1-3) guaranteed clearances between the buttresses and the block shall be provided (v_j);

.2 in case of using struts (see Fig. 4.1.1-4) two independent semi blocks with the clearance v_{bl} between them shall be provided in the hold. These semi blocks shall not be interconnected on any level with double stacking cones, double twistlocks or bridge fittings.

3 DESIGN LOADS

3.1 Containers securing devices and containers elements shall be tested for capability of withstanding forces caused by the loads F_{yi} and $F_{zi}^{(trans)}$ affecting the gravity centre of each container in the transverse plane and by the loads F_{xi} and $F_{zi}^{(long)}$ in the longitudinal plane simultaneously with the wind load W_i acting upon the windward surfaces of containers.

3.2 Combined loads F_{yi} and $F_{zi}^{(long)}$ in the transverse plane are determined by the formulae:

$$F_{yi} = m_i g a_{yi} \, , \tag{3.2-1}$$

$$F_{zi}^{(trans)} = m_i g a_{zi}^{(trans)} . \tag{3.2-2}$$

Combined loads F_{xi} and $F_{zi}^{(long)}$ in the longitudinal plane are determined by the formulae:

$$F_{xi} = m_i g a_{xi} \, , \tag{3.2-3}$$

$$F_{zi}^{(long)} = m_i g a_{zi}^{(long)} , \tag{3.2-4}$$

where F_{xi} — horizontal load parallel to the center line of the ship, in kN; the cases when the load is directed both forward and aft shall be considered;

F_{yi} — horizontal load parallel to the midship section plane, in kN; the cases when the load is directed both to the nearest shipside and the opposite side shall be considered;

$F_{zi}^{(trans)}$ and $F_{zi}^{(long)}$ — vertical loads, in kN, directed downward when their values are positive, directed upward when their values are negative. Combined action of maximum values of loads $F_{yi(\max)}$ and $F_{zi(\max)}^{(trans)}$ and respectively $F_{xi(\max)}$ and $F_{zi(\max)}^{(long)}$ — with maximum values of dimensionless accelerations $a_{yi(\max)}$, $a_{xi(\max)}$, $a_{zi(\max)}^{(trans)}$ and $a_{zi(\max)}^{(long)}$ shall be considered. Combined action of minimum values of loads $F_{yi(\min)}$ and $F_{zi(\min)}^{(trans)}$ and respectively $F_{xi(\min)}$ and $F_{zi(\min)}^{(long)}$ — with minimum values of dimensionless accelerations $a_{yi(\min)}$, $a_{xi(\min)}$, $a_{zi(\min)}^{(trans)}$ and $a_{zi(\min)}^{(long)}$ (see 3.3) shall be considered.

m_i — mass of the considered container, in t;

g — acceleration due to gravity equal to 9,81 m/s^2;

3.3 The dimensionless accelerations are determined by the formulae:
for the transverse plane of the ship

$$a_{yi(\max)} = (0{,}3 + 23/L_1)(1{,}27 + 0{,}91x_i^2/L^2 + 0{,}44Z_i/B), \qquad (3.3\text{-}1)$$

$$a_{zi(\max)}^{(trans)} = 1{,}26\sqrt{L_1}/(1{,}14 + \sqrt{L_1}) + \left[11{,}95/(\sqrt{L_1} - 1{,}10)\right] \cdot \frac{|x_i|}{L}, \qquad (3.3\text{-}2)$$

$$a_{yi(\min)} = (0{,}3 + 23/L_1)(1{,}27 + 0{,}91x_i^2/L^2 + 0{,}44Z_i/B)\ , \qquad (3.3\text{-}3)$$

$$a_{zi(\min)}^{(trans)} = 1{,}18\sqrt{L_1}/(3{,}83 + \sqrt{L_1}) - \left[11{,}95/(\sqrt{L_1} - 1{,}10)\right] \cdot \frac{|x_i|}{L}; \qquad (3.3\text{-}4)$$

for the longitudinal plane of the ship

$$a_{xi(\max)} = (31{,}9/\sqrt{L_1} - 0{,}59)(0{,}132 + Z_i/L) - 0{,}054\ , \qquad (3.3\text{-}5)$$

$$a_{zi(\max)}^{(long)} = 1{,}3 + 20/L_1 + (38/\sqrt{L_1}) \cdot \frac{x_i^2}{L^2}\ , \qquad (3.3\text{-}6)$$

$$a_{xi(\min)} = a_{xi(\max)}\ , \qquad (3.3\text{-}7)$$

$$a_{zi(\min)}^{(long)} = 0{,}7 - 20/L_1 - (38/\sqrt{L_1}) \cdot \frac{x_i^2}{L^2}\ , \qquad (3.3\text{-}8)$$

where L — ship length between perpendiculars;
L_1 — ship length between perpendiculars but not less than 100 m;
B — ship breadth;
x_i — distance between the gravity centre of the considered container and the midship section plane, in m;
z_i — vertical distance between the summer load waterline and the gravity centre of the considered container, in m, is assumed as positive where the gravity centre is above the waterline and negative where the gravity centre is below the waterline.

The gravity centre of a container is assumed as positive at a distance of 0,4 of its height from the container bottom base.

3.4 Wind load W_i, in kN, affecting the windward surface of container is determined based on the effect of the wind pressure p =1,5 kPa.

3.5 Forces occurring in the containers securing devices due to the loads specified in 3.1 and 3.2 shall not exceed the value of the safe working load (*SWL*) prescribed for the considered device (see 6.2.1) while the forces occurring in the container elements shall not exceed the permissible value specified in 5.1.

4 DETERMINATION OF FORCES OCCURRING IN THE CONTAINERS SECURING DEVICES AND STRUCTURAL ELEMENTS

4.1 DETERMINATION OF FORCES OCCURRING IN LASHINGS, STRUTS AND BUTTRESSES (CONDITION OF CONTAINER RACKING CONSIDERATION)

4.1.1 Two or more adjacent container stacks may be considered as constituting a single block (semi block) providing that these stacks are interconnected with double stacking cones, double twistlocks or bridge fittings on all the levels where buttresses, struts shall be provided or where the upper ends of the lashings shall be secured. Specific types of the blocks (semi blocks) used are shown in Figs (4.1.1.-1) — (4.1.1.-4); the tiers numbering in the stacks (i) and the levels numbering (j) adopted in the TR are shown in these figures.

Where the container stacks are adjacent but not interconnected, as mentioned above, they are considered as separately standing.

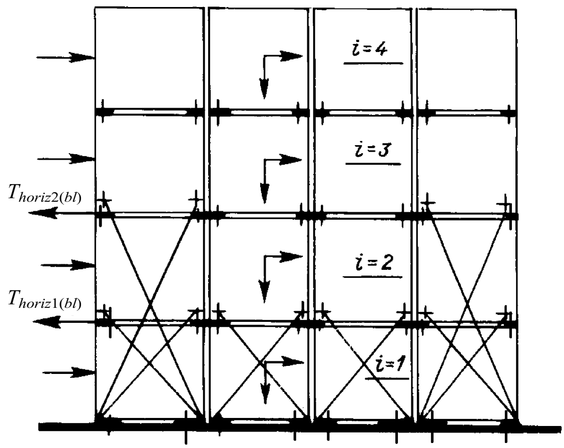


Fig. 4.1.1-1
Block with diagonal lashings, $n_{tier} = 4$, $n = 4$, $n_{load1} = 4$, $n_{load2} = 2$

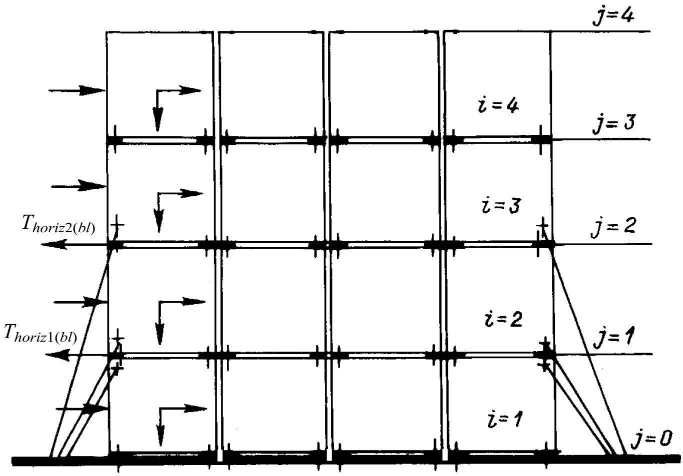


Fig. 4.1.1-2
Block with external lashings, $n_{tier} = 4$, $n = 4$, $n_{load2} = 1$, $n_{load1} = 1$ (double) or $n_{load1} = 2$ (single)

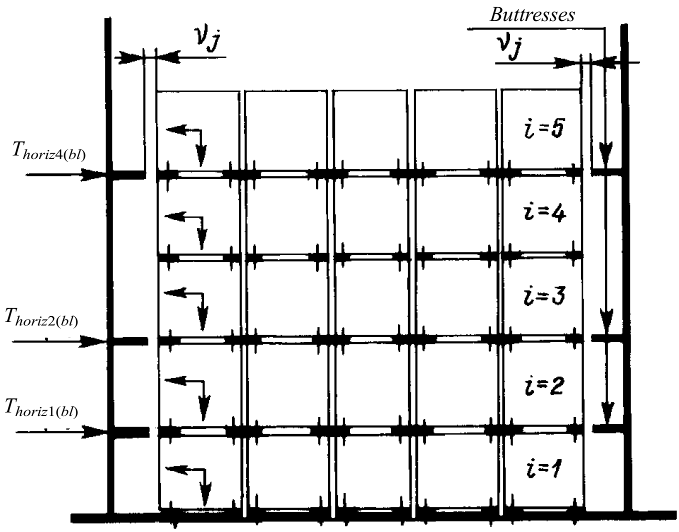


Fig. 4.1.1-3
Block with buttresses, $n_{tier} = 5$, $n = 5$, $n_{load1} = n_{load2} = n_{load4} = 1$

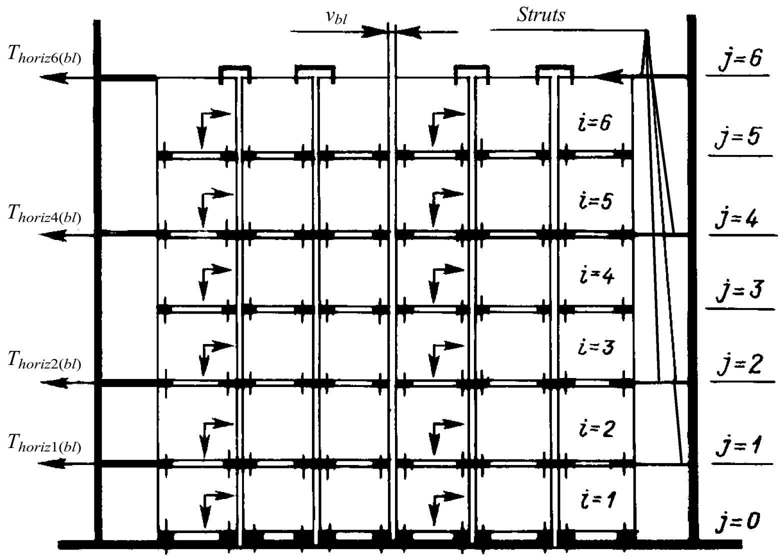


Fig. 4.1.1-4
Two semi blocks each with struts, $n_{tier} = 6$, $n = 3$, $n_{load1} = n_{load2} = n_{load4} = n_{load6} = 1$

4.1.2 Horizontal components of forces occurring in lashings, buttresses or struts $T_{horiz\ j(bl)}$, in kN, for a block (semi block or stack) are determined on the basis of solving a linear system of equations which quantity is equal to the number of levels where buttresses, struts are fitted or the top ends of the lashings are secured.

To build up the system of equations for a particular containers securing plan such equations shall be selected out of the universal equation system (see 4.1.3) which numbers (j) correspond to the level numbers (j) where struts, buttresses are fitted or the top ends of the lashings are secured on the particular containers securing plan.

4.1.3 The universal linear equation system for $n_{tier} \leqslant 6$ consists of the following:

for $j = 1$

$$(1 + nc_1/n_{load1}c)T_{horiz1(bl)} + T_{horiz2(bl)} + T_{horiz3(bl)} + T_{horiz4(bl)} + T_{horiz5(bl)} + T_{horiz6(bl)} = M_1; \quad (4.1.3\text{-}1)$$

for $j = 2$

$$T_{horiz1(bl)} + (2 + nc_2/n_{load2}c)T_{horiz2(bl)} + 2T_{horiz3(bl)} + 2T_{horiz4(bl)} + 2T_{horiz5(bl)} + 2T_{horiz6(bl)} = M_2; \quad (4.1.3\text{-}2)$$

for $j=3$

$$T_{horiz1(bl)}+2T_{horiz2(bl)}+(3+nc_3/n_{load3}c)T_{horiz3(bl)}+3T_{horiz4(bl)}+3T_{horiz5(bl)}+3T_{horiz6(bl)}=M_3\ ; \quad (4.1.3\text{-}3)$$

for $j=4$

$$T_{horiz1(bl)}+2T_{horiz2(bl)}+3T_{horiz3(bl)}+(4+nc_4/n_{load4}c)T_{horiz4(bl)}+4T_{horiz5(bl)}+4T_{horiz6(bl)}=M_4; \quad (4.1.3\text{-}4)$$

for $j=5$

$$T_{horiz1(bl)}+2T_{horiz2(bl)}+3T_{horiz3(bl)}+4T_{horiz4(bl)}+(5+nc_5/n_{load5}c)T_{horiz5(bl)}+5T_{horiz6(bl)}=M_5; \quad (4.1.3\text{-}5)$$

for $j=6$

$$T_{horiz1(bl)}+2T_{horiz2(bl)}+3T_{horiz3(bl)}+4T_{horiz4(bl)}+5T_{horiz5(bl)}+(6+nc_6/n_{load6}c)T_{horiz6(bl)}=M_6; \quad (4.1.3\text{-}6)$$

The values of M_j entering into the universal equation system (4.1.3-1) — (4.1.3-6) are determined by the formulae:

$$M_1=\frac{ng}{2}(0{,}4m_1a_1+m_2a_2+m_3a_3+m_4a_4+m_5a_5+m_6a_6)+$$
$$+\frac{(2n_{tier}-1)}{4}W-\frac{nv_1}{c}\ , \quad (4.1.3\text{-}7)$$

$$M_2=\frac{ng}{2}\left[0{,}4m_1a_1+1{,}4m_2a_2+2(m_3a_3+m_4a_4+m_5a_5+m_6a_6)\right]+$$
$$+(n_{tier}-1)W-\frac{nv_2}{c}\ , \quad (4.1.3\text{-}8)$$

$$M_3=\frac{ng}{2}\left[0{,}4m_1a_1+1{,}4m_2a_2+2{,}4m_3a_3+3(m_4a_4+m_5a_5+m_6a_6)\right]+$$
$$+\frac{(6n_{tier}-9)}{4}W-\frac{nv_3}{c}\ , \quad (4.1.3\text{-}9)$$

$$M_4=\frac{ng}{2}\left[0{,}4m_1a_1+1{,}4m_2a_2+2{,}4m_3a_3+3{,}4m_4a_4+4(m_5a_5+m_6a_6)\right]+$$
$$+2(n_{tier}-2)W-\frac{nv_4}{c}\ , \quad (4.1.3\text{-}10)$$

$$M_5 = \frac{ng}{2}(0{,}4m_1a_1 + 1{,}4m_2a_2 + 2{,}4m_3a_3 + 3{,}4m_4a_4 + 4{,}4m_5a_5 + 5m_6a_6) +$$

$$+ \frac{5(2n_{tier} - 5)}{4} W - \frac{nv_5}{c} \ , \qquad (4.1.3\text{-}11)$$

$$M_6 = \frac{ng}{2}(0{,}4m_1a_1 + 1{,}4m_2a_2 + 2{,}4m_3a_3 + 3{,}4m_4a_4 + 4{,}4m_5a_5 + 5{,}4m_6a_6) +$$

$$+ 3(n_{tier} - 3) W - \frac{nv_6}{c} \ , \qquad (4.1.3\text{-}12)$$

where n_{tier} — number of containers tiers in one stack;

n — number of stacks in a block — for lashings and buttresses; number of stacks in a semi block — for struts; for a separately standing stack n = 1;

$n_{load\ j}$ — number of loaded buttresses, struts and lashings fitted or secured on the considered level;

m_i — container mass of the relevant tier, in t. Where within the limits of a single block or semi block tier the containers masses of different stacks are not identical the average value of m_i is assumed for this tier;

a_i — appropriate values for a_i are assumed as:
$a_{yi(\max)}$ or $a_{yi(\min)}$ — in the transverse plane of the ship;
$a_{xi(\max)}$ or $a_{xi(\min)}$ — in the longitudinal plane of the ship;

W — appropriate wind load on one container, in kN. For blocks (semi blocks, stacks) protected against the wind it is assumed that $W = 0$;

v_j — structural clearance between the thrust surfaces of buttresses or struts and containers, in mm, (where provided — see 2.2.3.1). For the lashing equipped with the length regulating device it is assumed that $v_j = 0$;

c — container flexibility factor to racking, in mm/kN. For ISO series 1 containers this factor may be assumed as:
c = 0,278 mm/kN — in the plane of container end wall with a door;
c = 0,0625 mm/kN — in the plane of container end wall without a door;
c = 0,17 mm/kN — in the plane of container side wall;
For blocks and semi blocks in the plane of containers end walls the average value of c may be assumed as c = (0,278+0,0625)/2 = 0,17 mm/kN;

c_j — flexibility factor of one buttress, strut or another support or lashing secured (fitted) on the considered level, in mm/kN, and determined in accordance with 4.1.5, 4.1.6 and 4.1.7.

4.1.4 In the equations selected for a particular containers securing plan (in compliance with 4.1.2) it is assumed that:

$T_{horiz\ j(bl)} = 0$ — for all the forces $T_{horiz\ j(bl)}$ whose index "j" is equal to the level "j" where neither buttresses nor struts are fitted and where the top ends of the lashings are not secured;

$a_j = 0$ — for the terms of equations (4.1.3-7) — (4.1.3-12) whose indexes "j", "y", "a_i" are greater than the number of tiers in a stack ($i > n_{tier}$).

4.1.5 The flexibility factor of the lashing c_j, in mm/kN, is determined by the formula:

$$c_j=\frac{l_j\cdot 10^6}{E_jS_j sin^2 a_j}\ , \qquad (4.1.5\text{-}1)$$

where l_j — full length of the lashing including turnbuckle and couplings, in m;
S_j — cross section area of the lashing, in mm^2. It is assumed as 5 for:
total cross section area of all the wires of the rope (in a steel wire rope lashing);
cross section area of one branch of the chain link (in a chain lashing);
cross section area of the main rod (in a lashing bar);
E_j — modulus of inelastic buckling of the lashing in tension. In the absence of actual results of the tests it may be taken as:
$E_j=0{,}8\times10^5$ MPa — for a chain lashing;
$E_j=1{,}0\times10^5$ MPa — for a steel wire rope lashing.
The value of E_j, MPa, for a lashing bar (rod) is determined by the formula:

$$E_j=3\cdot10^5(1-1/\sqrt{l_j})\ , \qquad (4.1.5\text{-}2)$$

providing that Ej shall not be less than $1{,}0\times10^5$ MPa and more than $2{,}0\times10^5$ MPa irrespective of calculation results determined from the formula (4.1.5-2);
a_j — see Figs 4.2.2. and 4.2.3.

4.1.6 For struts and buttresses under 1.5 m in length the flexibility factor c_j is determined by the formula (4.1.5-1) with $\alpha_j=90^\circ$ and $E_j=1{,}2\times10^5$ MPa.

The application of struts and buttresses over 1,5 m in length and their flexibility factor are subject to special consideration by the Register.

For struts and buttresses of 0,2 m in length and less being fitted on the rigid hull members of the ship it is permitted to assume their flexibility factor as $c_j=0$;

4.1.7 For the buttress fitted on a single span steel rail simply supported at both ends (as shown in Fig. 4.1.7 for level j = 4) the buttress flexibility factor is assumed as:

$$c_j=\frac{10^{12}lh^2(1-h/l)^2}{3EJ}\ , \qquad (4.1.7)$$

where l — distance between the supports (span) of the rail where a buttress is fitted, in m;
h — vertical distance from the upper support of the rail to the level where a buttress is fitted, in m;
E — modulus of elasticity of the rail material; assumed as $E=2\times10^5$ MPa;
J — moment of inertia of the rail cross section, in mm^4.

The application of container securing plans with buttresses fitted on two levels and more on a single span rail (similar to that shown in Fig. 4.1.7) is not permitted.

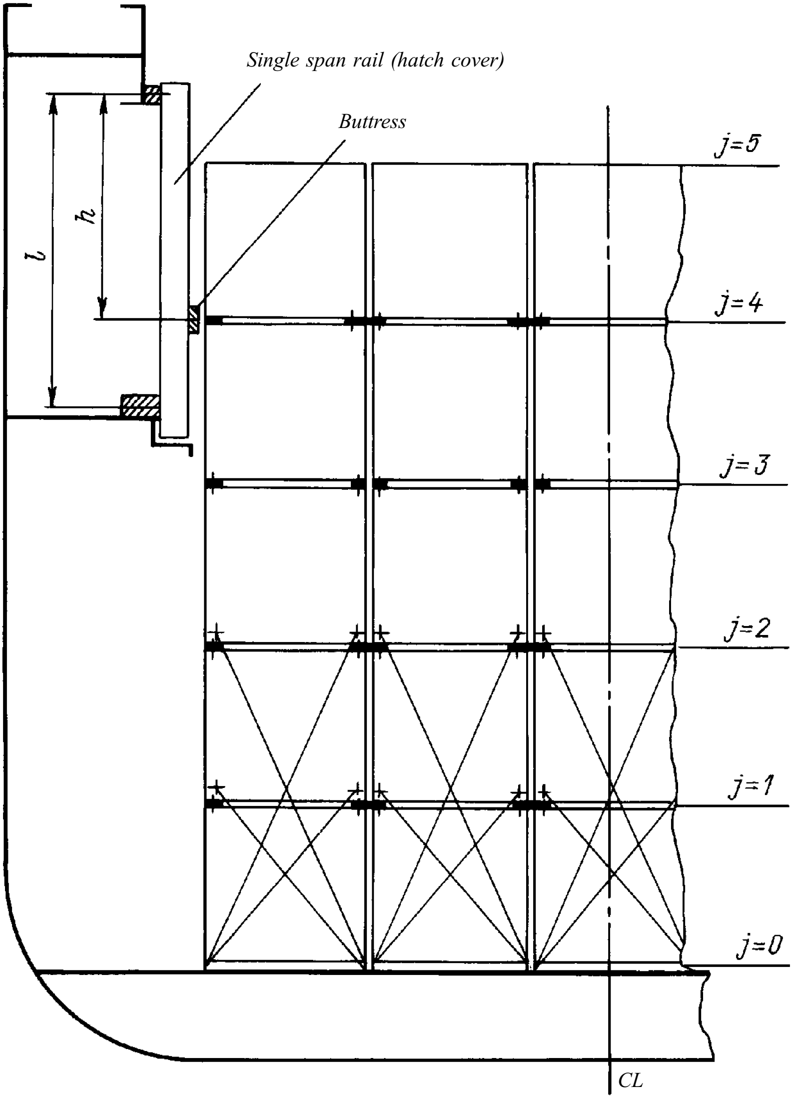


Fig. 4.1.7

4.2 DETERMINATION OF VERTICAL COMPONENTS OF REACTIONS AND FORCES OCCURRING IN THE CONTAINER POSTS AND LOCKS (CONDITION OF STACK TIPPING CONSIDERATION)

4.2.1 The applicable in the present Chapter values for vertical and horizontal components of forces in lashings, buttresses and struts $T_{horiz\ j}$ and $T_{vert\ j}$ transmitted to the separately standing stack under consideration are determined by the formulae:

$$T_{horiz\ j} = T_{horiz\ j(bl)}/n\ , \qquad (4.2.1\text{-}1)$$

$$T_{vert\ j} = T_{vert\ j(bl)}/n_{load\ j}\ , \qquad (4.2.1\text{-}2)$$

where $T_{horiz\ j(bl)}$, n, $n_{load\ j}$ are determined according to Chapter 4.1;

$$T_{vertj(bl)} = \frac{T_{horiz\ j(bl)}\cos\alpha_j}{\sin\alpha_j}\ . \qquad (4.2.1\text{-}3)$$

At that, forces $T_{vert\ j}$ are considered as applied to the stack to which the lashings are secured directly; where on a considered level the lashing is not secured to the considered stack it is assumed that $T_{vert\ j} = 0$.

(For example, in Fig. 4.1.1-1 forces $T_{vert\ 2}$ are applied only to the extreme stacks in the block, for the stacks located in the middle of the block $T_{vert\ 2} = 0$)

4.2.2 For the containers stack secured by diagonal lashings (see Fig. 4.2.2) vertical components of reactions $R_{Aj\ vert}$ and $R_{Bj\ vert}$, in kN, at the points A_j and B_j for any level considered shall be determined by the formulae:

$$R_{Aj\ vert} = \frac{1}{4}\sum_{i=j+1}^{n_{tier}} F_{zi} + \frac{1}{2e}\sum_{i=j+1}^{n_{tier}} F_{horiz\ i}h_{ji} + \frac{1}{2e}\sum_{i=j+1}^{n_{tier}} W_i h_{wji} - \frac{1}{e}\sum T_{horiz\,j}h_{horiz\,jj_1} + \sum T_{vert\,j}\ , \qquad (4.2.2\text{-}1)$$

$$R_{Bj\ vert} = \frac{1}{4}\sum_{i=j+1}^{n_{tier}} F_{zi} - \frac{1}{2e}\sum_{i=j+1}^{n_{tier}} F_{horiz\ i}h_{ji} - \frac{1}{2e}\sum_{i=j+1}^{n_{tier}} W_i h_{wji} + \frac{1}{e}\sum T_{horiz\,j}h_{horiz\,jj_1}\ , \qquad (4.2.2\text{-}2)$$

where $F_{horiz\ i}$ — depending on the load condition considered it is assumed as:
$F_{yi(\max)}$ or $F_{yi(\min)}$ — for the transverse plane of the ship;
$F_{xi(\max)}$ or $F_{xi(\min)}$ — for the longitudinal plane of the ship;
e — depending on the container plane;
a — distance between the centres of apertures for the container fittings, in m, in the container end wall plane under consideration; for ISO series 1 containers a = 2,26 m;
$vert$ — distance between the centres of apertures in the container fittings, in m, for the case when the container side wall plane under consideration; for ISO series 1 containers $vert$ = 5,85 m (20 ft) and $vert$ = 11,985 m (40 ft);
h_{ji} — vertical distance from the considered level (j) to the gravity centre of the considered container (i), in m; container gravity centre is assumed as located at a distance of 0,4 of its height from the container bottom base;
h_{wji} — vertical distance from the considered level (j) to the centre of wind pressure on the considered container (i), in m; the centre of wind pressure is assumed as located at a half of the container height from its bottom base;
$h_{horiz\ jj1}$ — vertical distance from the line of action of the considered force $T_{horiz\ j}$ to the considered level (j_1), in m;
$\Sigma_{Thoizr\ j}h_{horiz\,jj_1}$ — sum of the moments of all forces $T_{horiz\ j}$ which lines of action are located above the considered level (j_1);
$\Sigma T_{vert\ j}$ — sum of all forces $T_{vert\ j}$ acting on lashings which upper mounting points to the containers are located above the level considered.

4.2.3 For the containers stack secured by external lashings (see Fig. 4.2.3) vertical components of reactions $R_{Aj\ vert}$ and $R_{Bj\ vert}$, in kN, at the points A_j and B_j for any level considered shall be determined by the formulae:

$$R_{Aj\ vert}=\frac{1}{4}\sum_{i=j+1}^{n_{tier}}F_{zi}+\frac{1}{2e}\sum_{i=j+1}^{n_{tier}}F_{horiz\,i}h_{ji}+\frac{1}{2e}\sum_{i=j+1}^{n_{tier}}W_ih_{wji}-\frac{1}{e}\sum T_{horiz\,j}h_{horiz\,jj\,1}, \quad (4.2.3\text{-}1)$$

$$R_{Bj\ vert}=\frac{1}{4}\sum_{i=j+1}^{n_{tier}}F_{zi}-\frac{1}{2e}\sum_{i=j+1}^{n_{tier}}F_{horiz\,i}h_{ji}-\frac{1}{2e}\sum_{i=j+1}^{n_{tier}}W_ih_{wji}+$$
$$+\frac{1}{e}\sum T_{horiz\,j}h_{horiz\,jj_1}+\sum T_{vert\,j}\ . \quad (4.2.3\text{-}2)$$

4.2.4 For the containers stack secured by vertical lashings (see Fig. 4.2.4), as well as containers stack secured without lashings (struts or buttresses), vertical components of reactions $R_{Aj\ vert}$ and $R_{Bj\ vert}$, in kN, shall be determined by the formulae of 4.2.2 or 4.2.3 with the following values:

$$\sum T_{horiz\,j}h_{jj_1}=\sum T_{vert\,j}=0\ . \quad (4.2.4)$$

4.2.5 Where buttresses or struts are used instead of lashings the formulae of 4.2.2 and 4.2.3 are applicable, at that, for the level where buttress or strut is fitted $T_{vert\ j}$ = 0 (see formulae (4.2.1-2) and (4.2.1-3) with α_j = 90°).

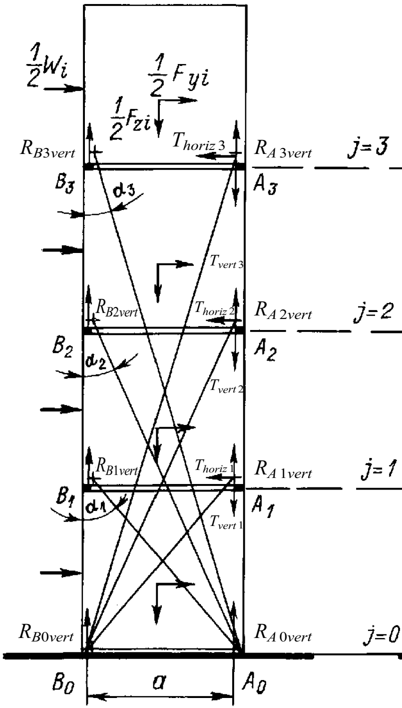


Fig. 4.2.2

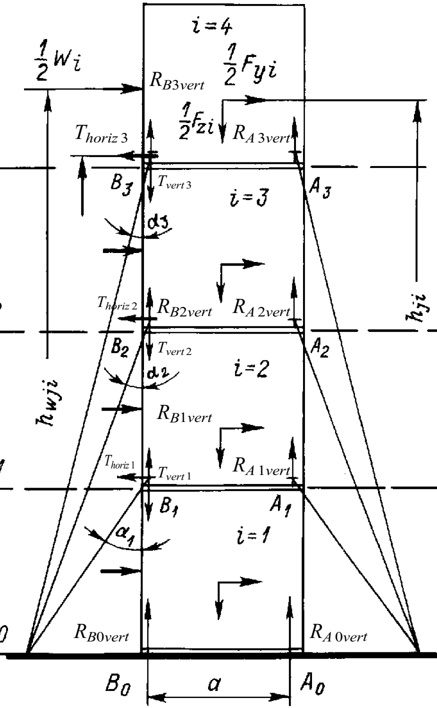


Fig. 4.2.3

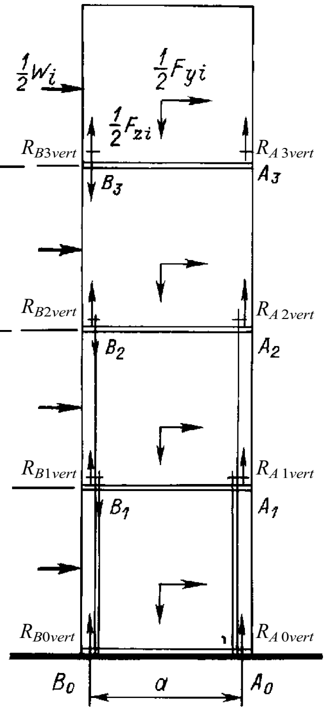


Fig. 4.2.4

For stacks protected from wind the formulae of 4.2.2 or 4.2.3 shall be assumed with $W_i = 0$.

4.2.6 Maximum value of reaction $R_{j\ vert(\max)}$ and minimum value of reaction $R_{j\ vert(\min)}$ are determined for each stack level upon calculation results of $R_{Aj\ vert}$ and $R_{Bj\ vert}$ according to 4.2.2 — 4.2.5 and with regard to the provisions of 3.2.

4.2.7 The value of $R_{j\ vert(\max)}$ is a vertical design force being transmitted to the relevant container bottom corner fittings and supporting structures, as well as compressing the relevant container corner post ($R_{j\ vert(\max)}$ is compared with the allowable values of P_{bott} and P_{com} given in Table 5.1).

4.2.8 Negative value of minimal reaction $R_{j\ vert(\min)}$ indicates that there is a tendency to the stack tipping on the considered level.

Where the locks are provided on this level the negative value of $R_{j\ vert(\min)}$ is a vertical tensile force in the lock, as well as a force lining up relevant corner fittings of containers (they are compared with P_{bott} and P_{top} given in Table 5.1).

Where the stacking cones are provided on this level and vertical lashings are used the negative value of $R_{Bj\ vert(\min)}$ (at the point B_j) is a force taken by vertical lashings (see 4.3).

Where external or diagonal lashings, struts or buttresses are used and stacking cones are provided on the considered level the negative value of $R_{Bj\ vert(\min)}$ (at the point B_j) is a force which shall be taken into account when the values of forces in the lashings, struts or buttresses are subject to clarification and whose values have been previously determined according to 4.1 (see 4.4); where the value of $R_{Aj\ vert(\min)}$ (at the point A_j) on this level is negative the locks shall be provided while the installation of cones is subject to special consideration by the Register in each case.

4.3 DETERMINATION OF FORCES OCCURRING IN VERTICAL LASHINGS (CONDITION OF STACK TIPPING CONSIDERATION)

4.3.1 For the containers stack secured by two pairs of vertical lashings (see Fig. 4.2.4) in cases, when minimum values of reactions $R_{Bj\ vert(\min)}$ (at the point B_j) determined according to 4.2.6 and 4.2.8 have negative values on all or some levels and where on these levels the stacking cones are fitted the tensile forces in lashings T_1 and T_2, in kN, are determined by the formulae:

$$T_1 = \frac{-\sum R_{Bj\ vert(\min)}}{(n_1 + n_2 k_1)}, \qquad (4.3.1\text{-}1)$$

$$T_2 = k_1 T_1\ , \qquad (4.3.1\text{-}2)$$

$$k_1 = \frac{l_1 E_2 S_2}{l_2 E_1 S_1}\ , \qquad (4.3.1\text{-}3)$$

где $R_{Bj\ vert(\min)}$ — vertical components of reactions (at the point B_j) having negative values, in kN;

$\sum R_{Bj\ vert(\min)}$ — summing-up over all the stack levels located below the mounting point of the top end of a longer lashing; at that, $R_{Bj\ vert(\min)}$ having positive values are not considered;

n_1 and n_2 — number of levels located below the mounting point of the top end of the relevant lashing where $R_{Bj\ vert(\min)}$ has a negative value;

l_1 and l_2 — full length of the relevant lashing, in m;

E_1, E_2, S_1, S_2 — determined according to 4.1.5.

4.3.2 For the containers stack secured by a pair of vertical lashings under the conditions similar to those indicated in 4.3.1 the tensile force in the lashing T_1, in kN, is determined by the formula (4.3.1-1) with $n_2 = 0$.

4.4 SPECIFICATION OF FORCES OCCURRING IN THE EXTERNAL AND DIAGONAL LASHINGS, STRUTS OR BUTTRESSES

4.4.1 For the containers stack secured by two pairs of diagonal or external lashings (see Figs 4.4.1-1 and 4.4.1-2) in cases, when minimum values of reactions $R_{Bj\ vert(\min)}$ (at the point B_j) determined according to 4.2.6 and 4.2.8 have negative values on all or some levels and where on these levels the stacking cones are provided the additional values of the tensile forces ΔT_1 and ΔT_2, in kN, occurring in lashings as a result of the tendency to stack tipping are determined by the formulae:

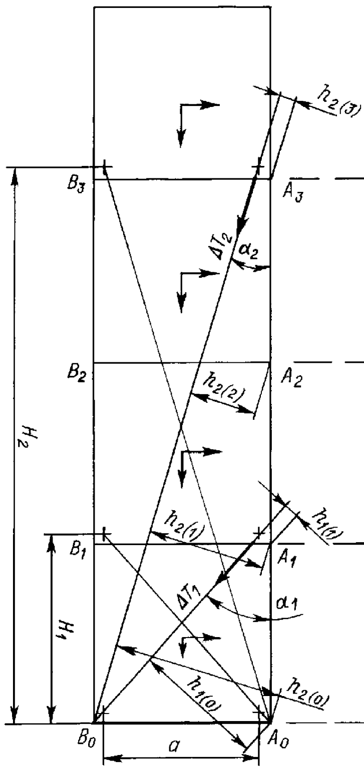


Fig. 4.4.1-1

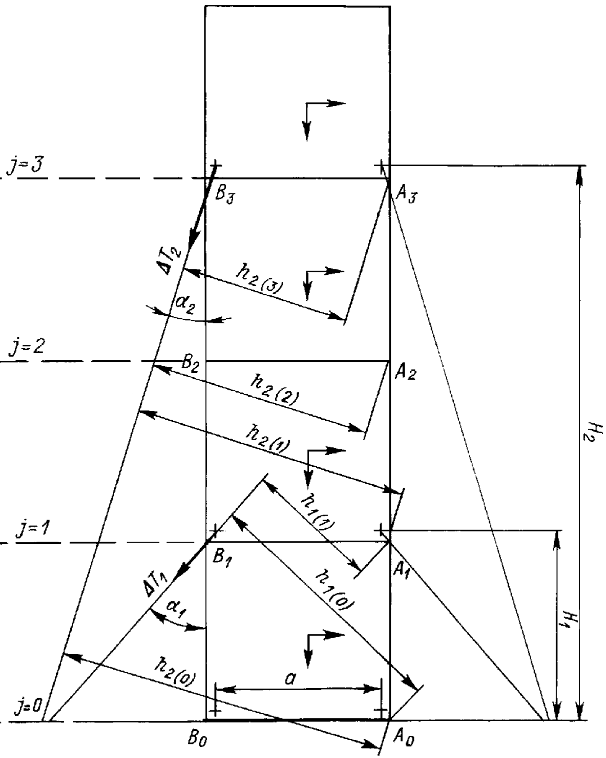


Fig. 4.4.1-2

$$\Delta T_1 = \frac{-a\sum R_{Bj\,vert(\min)}}{\sum h_{1(j)} + k_2 \sum h_{2(j)}}, \tag{4.4.1-1}$$

$$\Delta T_2 = k_2 \Delta T_1 , \tag{4.4.1-2}$$

$$k_2 = \frac{H_2 c_1 sin\, \alpha_1}{H_1 c_2 sin\, \alpha_2}, \tag{4.4.1-3}$$

where $h_{1(j)}$ and $h_{2(j)}$ — shoulders, in m, of the appropriate forces ΔT_1 and ΔT_2 relative to the points A_j of the levels j located below the mounting point of the top end of the relevant lashing and where $R_{Bj\ vert(\min)}$ has a negative value; for levels j where $R_{Bj\ vert(\min)} \geqslant 0$ it is assumed that $h_1(j) = h_2(j) = 0$;

$\Sigma h_{1(j)}$ and $\Sigma h_{2(j)}$ — summing-up the shoulders $h_{1(j)}$ and $h_{2(j)}$ over all the levels which points A_j are located below the mounting point of the top end of the relevant lashing;

H_1 and H_2 — vertical distance, in m, between the mounting point of the top end of the relevant lashing and the base of the stack;

c_1, c_2 and $\Sigma R_{Bj\ vert(\min)}$ — see 4.1.5 and 4.3.1 respectively.

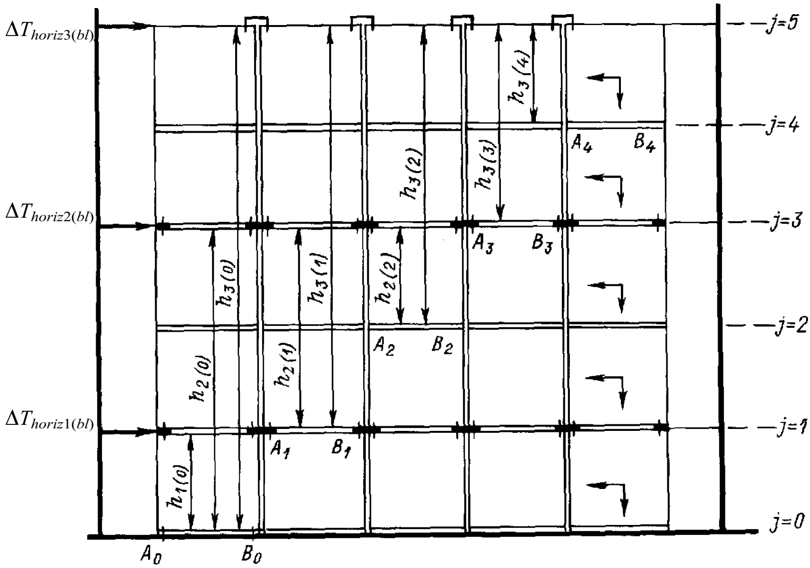
4.4.2 For the containers stack secured by a pair of diagonal or external lashings under the conditions similar to those indicated in 4.4.1 the additional tensile force in the lashing ΔT_1 is determined by the formula (4.4.1-1) with $\sum h_{2(j)} = 0$.

4.4.3 For the containers block secured by diagonal or external lashings (see Figs 4.1.1-1 and 4.1.1-2) the provisions and formulae of 4.4.1 and 4.4.2 shall be applicable taking instead of $R_{Bj\ vert(\min)}$ of the relevant level the sum $\Sigma R_{Bj\ vert(\min)}$ over all the stacks on this level j; at that, instead of the forces ΔT_1 and ΔT_2 the total block forces $\Delta T_{1(bl)}$ and $\Delta T_{2(bl)}$ are determined.

4.4.4 For the containers block or semi block secured by three pairs of buttresses or struts (see Fig. 4.4.4) in cases, when the minimum values $R_{Bj\ vert(\min)}$ (at the point B_j) determined according to 4.2.6 and 4.2.8 have negative values on all or some levels and where on these levels the stacking cones are provided the values of additional forces $\Delta T_{1(bl)}$, $\Delta T_{2(bl)}$, $\Delta T_{3(bl)}$, in kN, occurring in the buttresses or struts as a result of the tendency to stack tipping are determined by the formulae:

$$\Delta T_{1(bl)} = \frac{-a\sum R_{Bj\ vert(\min)}}{\sum h_{1(j)} + k_3 \sum h_{2(j)} + k_4 \sum h_{3(j)}}, \tag{4.4.4-1}$$

$$\Delta T_{2(bl)} = k_3 \Delta T_{1(bl)} , \tag{4.4.4-2}$$



$$\Delta T_{3(bl)}=k_4\Delta T_{1(bl)}\ , \qquad (4.4.4\text{-}3)$$

$$k_3=\frac{h_{2(0)}c_1}{h_{1(0)}c_2}\ , \qquad (4.4.4\text{-}4)$$

$$k_4=\frac{h_{3(0)}c_1}{h_{1(0)}c_3}\ , \qquad (4.4.4\text{-}5)$$

where $R_{Bj\ vert(\min)}$ — see 4.3.1;

$\Sigma R_{Bj\ vert(\min)}$ — summing-up over all the levels (of all the stacks) of the block or semi block located below the highest buttress or strut; at that, $R_{Bj\ vert(\min)}$ having positive value is not considered;

$h_{1(j)}$, $h_{2(j)}$, $h_{3(j)}$ — shoulders, in m, of the appropriate forces $\Delta T_{1(bl)}$, $\Delta T_{2(bl)}$ and $\Delta T_{3(bl)}$ relative to the levels j where even in one of the stacks $R_{Bj\ vert(\min)}$ has negative value; for the levels j where over all the stacks $R_{Bj\ vert(\min)} \geqslant 0$ it is assumed that $h_{1(j)} = h_{2(j)} = h_{3(j)} = 0$;

$\Sigma h_{1(j)}$, $\Sigma h_{2(j)}$, $\Sigma h_{3(j)}$ — summing-up the relevant shoulders $h_{1(j)}$, $h_{2(j)}$, $h_{3(j)}$ over all the levels located below the line of action of the appropriate forces $\Delta T_{1(bl)}$, $\Delta T_{2(bl)}$ and $\Delta T_{3(bl)}$;

c_1, c_2, c_3 — see 4.1.6 and 4.1.7.

4.4.5 For the containers block or semi block secured by two pairs of buttresses or struts the forces $\Delta T_{1(bl)}$, and $\Delta T_{2(bl)}$ are determined by the formulae (4.4.4-1) and (4.4.4-2) with $\Sigma h_{3(j)} = 0$. For the containers block or semi block secured by one pair of buttresses or struts the force $\Delta T_{1(bl)}$ is determined by the formula (4.4.4-1) with $\Sigma h_{2(j)} = \Sigma h_{3(j)} = 0$.

4.4.6 Considering a tendency to tipping the specified value of horizontal component of forces in lashings, buttresses or struts on the block level j — $T'_{horiz\ j(bl)}$, in kN, is determined by the formula:

$$T'_{horiz\ j(bl)} = T_{horiz\ j(bl)} + \Delta T_{j(bl)} \sin \alpha_j , \qquad (4.4.6)$$

where $T_{horiz\ j(bl)}$ — see 4.1 and 4.2.8;

$\Delta T_{j(bl)}$ — depending on the level j one of the forces $\Delta T_{1(bl)}$, $\Delta T_{2(bl)}$ or $\Delta T_{3(bl)}$ (see 4.4.3 — 4.4.5) located on that level j of the block or semi block is assumed in the index of force $T_{horiz\ j(bl)}$. For buttresses or struts it is assumed that $\alpha_j = 90°$.
The value of $T'_{horiz\ j(bl)}$ is a design tensile and/or compressive force for a strut or a buttress, as well as the force upon which the design forces acting in the container transverse structural elements, double stacking cones, double twistlocks or bridge fottings (see Chapter 4.5) are assumed.

4.4.7 The design value of specified force acting in the lashing T'_j, horizontal and vertical components $T'_{horiz\ j}$ and $T'_{vert\ j}$ of the above force, in kN, are determined by the formulae:

$$T'_j = \frac{T'_{horiz j(bl)}}{n_{load j} \sin \alpha_j} , \qquad (4.4.7\text{-}1)$$

$$T'_{horiz j} = T'_j \sin \alpha_j , \qquad (4.4.7\text{-}2)$$

$$T'_{vert j} = T'_j \cos \alpha_j , \qquad (4.4.7\text{-}3)$$

where $n_{load\ j}$ — см. 4.1.3.

The forces $T'_{horiz\ j}$ and $T'_{vert\ j}$ are compared with the values of T_{horiz} and T_{vert} given in Table 5.1.

4.5 DETERMINATION OF FORCES OCCURRING IN THE CONTAINER TRANSVERSE STRUCTURAL ELEMENTS THAT CONSTITUTE BLOCK OR SEMI BLOCK, IN DOUBLE STACKING CONES, DOUBLE TWISTLOCKS AND BRIDGE FITTINGS

4.5.1 Maximum value of the force P_j, in kN, occurring in the double stacking cones, double twistlocks or bridge fittings fitted on the levels where the containers block (or semi block) is secured with buttresses, struts or lashings shall be determined by the formula:

$$P_j = \frac{(n-1)}{n} T'_{horiz\ j(bl)}\ , \qquad (4.5.1)$$

where n — see 4.1.3;
$T'_{horiz(bl)}$ — see 4.4.6.

Force P_j is a shear force for double stacking cones and double twistlocks. Besides, in case of application on the considered level of:

lashings, the force P_j is a tensile force;

buttresses, the force P_j is a compressive force;

struts, the force P_j is a tensile/compressive force applied to the relevant double stacking cones, double twistlocks or bridge fittings.

4.5.2 Maximum value of the compressive force $P^{(comp)}_{com(j)}$, in kN, occurring in the transverse structural elements of the container end wall on the level where the block or semi block is secured with a buttress or a strut shall be determined by the formula:

$$P^{(comp)}_{com(j)} = \frac{(n-1)}{n} T'_{horiz\ j(bl)}\ . \qquad (4.5.2\text{-}1)$$

Maximum value of the tensile force $P^{(tens)}_{com(j)}$, in kN, occurring in the transverse structural elements of the container end wall on the level where the block or semi block is secured with lashings or a strut is determined by the formula:

$$P^{(tens)}_{com(j)} = T'_{horiz\ j(bl)}\ . \qquad (4.5.2\text{-}2)$$

On the roof level of the top tier in the containers stack the force $P^{(comp)}_{com(j)}$ or $P^{(tens)}_{com(j)}$ is taken by the top transverse structural element of the container end wall ($P^{(comp)}_{com(j)}$ or $P^{(tens)}_{com(j)}$ is compared with $P_{horiz\ top}$ given in Table 5.1).

On the level between the tiers the force $P^{(comp)}_{com(j)}$ or $P^{(tens)}_{com(j)}$ is taken by the two transverse structural elements (top and bottom) directly adjoining the considered level ($P^{(comp)}_{com(j)}$ or $P^{(tens)}_{com(j)}$ is compared with the sum $P_{horiz\ top} + P_{horiz\ bott}$ given in Table 5.1).

4.6 DETERMINATION OF HORIZONTAL COMPONENTS OF REACTIONS AND FORCES (CONDITION OF CONSIDERATION OF CONTAINERS RACKING IN A STACK)

4.6.1 Horizontal components of reactions $R_{Aj\ horiz}$ and $R_{Bj\ horiz}$, in kN, for any considered level j (see Figs 4.2.2 — 4.2.4) are determined by the formula:

$$R_{Aj\,horiz}=R_{Bj\,horiz}=\frac{1}{4}\sum_{i=j+1}^{n_{tier}}F_{horiz\,i}+\frac{1}{4}\sum_{i=j+1}^{n_{tier}}W_i-\frac{1}{2}\sum T'_{horiz\,j(stack)}\ , \qquad (4.6.1\text{-}1)$$

where $T'_{horiz\ j(stack)}$ — specified value of horizontal force component in the lashing, buttress or strut for a stack, in kN, determined by the formula:

$$T'_{horiz\,j(stack)}=\frac{T'_{horiz\ j(bl)}}{n}; \qquad (4.6.1\text{-}2)$$

$\Sigma T'_{horiz\ j(stack)}$ — sum of all the forces $T'_{horiz\ j(stack)}$ which lines of action are located above the considered level. For the containers stack secured by vertical lashings (see Fig. 4.2.4), as well as when the stack is secured without lashings, struts and buttresses it is assumed that $\Sigma T'_{horiz\ j(stack)} = 0$;

$F_{horiz\ i}$ — see 4.2.2;

n and n_{tier} — see 4.1.3;

$T_{horiz\ j(bl)}$ — see 4.4.6.

For the stack protected from the wind it is assumed that $\sum_{i=j+1}^{n_{tier}} W_i = 0$.

Forces equal to $R_{Aj\,horiz}$ and $R_{Bj\,horiz}$ in the opposite direction are shearing forces applied to the stacking cones or locks and for level j = 0 they are also design horizontal load applied to the supporting structures of the stack.

4.6.2 Design value of horizontal racking force of the i-th container Q_i, in kN, applied to its roof level is determined by the formula:

$$Q_i=\frac{1}{5}F_{horiz\ i}+\frac{1}{4}W_i+\frac{1}{2}\sum_{k=i+1}^{n_{tier}}(F_{horiz\ i}+W_i)-\sum_{j=i}^{n_{level}}T'_{horiz\ j(stack)}\ , \qquad (4.6.2)$$

where $F_{horiz\ i}$, n_{tier}, $T'_{horiz\ j(stack)}$ — see 4.6.1;

n_{level} — number of levels in the stack where buttresses or struts are fitted or where the top ends of diagonal or external lashings are secured.

For the containers stack secured by vertical lashings (see Fig. 4.2.4), as well as when the stack is secured without lashings, struts and buttresses it is assumed that $\sum_{j=i}^{n_{level}} T'_{horiz\ j(stack)} = 0$.

For the stack protected from the wind it is assumed that W_i = 0.

(Values of Q_i calculated by the formula (4.6.2) are compared with the values of Q_{end} or Q_{side} given in Table 5.1).

5 PERMISSIBLE FORCES IN THE CONTAINER STRUCTURAL ELEMENTS

5.1 For ISO series 1 containers manufactured according to the requirements prescribed for their approved transportation on sea-going ships when containers with allowable gross mass R established during manufacture are stacked in 6 tiers, the forces acting in the container elements determined in compliance with the provisions of Sections 3 and 4 shall not exceed the permissible values of the appropriate forces given in Table 5.1.

Table 5.1

Nos.	Forces	Containers		
		20 ft		40 ft
		R = 20 t	R = 24 t	R = 30 t
1	Force transmitted to the container corner fittings from the lashing (parallel to the container end or side wall): horizontal component of force, T_{horiz} vertical component of force, T_{vert}	 150 kN 300 kN	 150 kN 300 kN	 150 kN 300 kN
2	Horizontal container racking force applied to the container top corner fitting: in the plane of container end wall, Q_{end} in the plane of container side wall, Q_{side}	 150 kN 100 kN	 150 kN 100 kN	 150 kN 100 kN
3	Vertical support reaction transmitted to the container bottom corner fitting (directed upward), R_{bott}	540 kN	635 kN	810 kN
4	Vertical compressive force for the container corner post, P_{com}	450 kN	530 kN	675 kN
5	Vertical force tensioning corner post and lining up corner fittings from a container: for the top fitting, P_{top} for the bottom fitting, P_{bott}	150 kN 200 kN	150 kN 200 kN	150 kN 200 kN
6	Horizontal forces acting in the plane of container end wall, tensioning or compressing container transverse structural element: at the level of top corner fittings, $P_{horiz\ top}$ at the level of bottom corner fittings, $P_{horiz\ bott}$	 225 kN 350 kN	 270 kN 420 kN	 340 kN 500 kN

5.2 Permissible forces for the container elements other than containers specified in 5.1 shall be established upon agreement with the Register based on the technical documentation which determines the requirements for strength, rigidity and tests of the said containers.

6 CONTAINERS SECURING DEVICES. MANUFACTURE. TESTING. TECHNICAL SUPERVISION DURING MANUFACTURE

6.1 GENERAL INSTRUCTIONS ON MANUFACTURE

6.1.1 Selection of material for parts of containers securing devices, necessity of their heat treatment after manufacture, heat treatment procedure are set forth by the documentation developer and the manufacturer taking into account part designation and the loads affecting the part, as well as prescribed safety factors.

Information on selected material, heat treatment is recorded in the documentation of containers securing devices and submitted to the Register for approval.

6.1.2 Special attention shall be given to the weldability of parts of fixed containers securing devices with regard to their chemical composition and steel grades used in the ship structures to which the said parts are welded and the requirements of Part XIV "Welding" of the Rules shall be met.

6.1.3 For the containers securing devices application of materials other than steel is subject to special consideration by the Register.

6.1.4 The faults in steel forgings or castings may be repaired by welding only when the steel in question has been previously checked for weldability with regard to the operation peculiarities of the product.

Repairing of faults by welding shall be carried out prior to the final heat treatment. The surface subject to repair shall be grounded to the sound metal so as to provide for full penetration throughout the welded area.

Repetitive faults in forgings or castings are not permitted for repair by welding.

6.1.5 Steel ropes and chains used in lashings shall satisfy the requirements of 3.15 and Section 7, Part XIII "Materials" of the Rules.

Wires of the steel ropes shall be galvanized in compliance with the recognized standards.

6.1.6 For containers securing devices considered in the present TR and being, as a rule, typical standard products the issue of a Type Approval Certificate in accordance with the procedure established by the Register shall be mandatory.

6.2 SAFETY FACTOR. PERMISSIBLE STRESSES

6.2.1 Main characteristic of any containers securing device is its safe working load (*SWL*) set forth (confirmed) by the Register proceeding from positive results of the breaking load (*BL*) test carried out in accordance with the provisions of 6.3.4, 6.3.5 (see also 6.3.8). *SWL* is determined by the formula:

$$SWL = BL/K\ , \tag{6.2.1}$$

where *SWL* and *BL*, in kN, respectively;
K — safety factor taken from Table 6.2.1.

Table 6.2.1

Nos.	Types of containers securing devices	Safety factor, *K*
1	Wire rope lashings; assembled	3,0
2	Chain-lashings; assembled	2,5
3	Lashing bar; assembeled	2,0
4	All containers securing devices, except lashings, which have been capable of withstanding testing with breaking load $BL \leqslant 800$ kN	2,0
5	All containers securing devices, except lashings, capable of withstanding breaking load test $BL > 800$ kN	1,5

6.2.2 Equivalent stresses occurring in the metal structures elements applicable for containers securing (supports, foundations, etc.) under the effect of loads specified in 3.1 shall not exceed 0.7 times the yield stress of their material.

6.2.3 Equivalent stresses (σ_{eq}) specified in 6.2.2 shall be determined by the formula:

$$\sigma_{eq} = \sqrt{\sigma^2 + 3\tau^2}\ , \tag{6.2.3}$$

where σ — normal stresses in section under consideration;
τ — shear stresses in section under consideration.

6.3 TESTS FOR TYPE APPROVAL CERTIFICATE

6.3.1 For each type and size of container securing device submitted to the Register for the first time the following specimens shall be manufactured in accordance with documentation approved by the Register:

two specimens for a proof load (*PL*) test;

two specimens for a breaking load (*BL*) test.

6.3.2 Specimens of fixed containers securing devices (Nos. 10 — 14, Table 6.3.4) shall be welded to the metal structure segments so that to imitate to the extent possible the ship structure to which the considered fixed containers securing device is welded. Welding technique and basic requirements for welding shall be included as the installation instructions in the documentation on the containers securing device.

6.3.3 The value of breaking load for containers securing devices (for each type of load) shall be assumed by the documentation developer for these devices proceeding from customers' requirements, considerations on typing and unification of such type of devices, standards requirements and with regard to the required safety factor (see 6.2.1);

6.3.4 The two specimens shall be tested with the breaking load of all the types specified in column 4, Table 6.3.4.

Scheme of loads application (see column 3, Table 6.3.4) to the maximum extent possible shall correspond to the operation of the considered device.

The time under load shall be not less than 10 s. Containers securing device is considered to have passed the test if both specimens are not subject to failure due to the breaking load; at that permanent set may be accepted, wherein there is still a possibility of removing the device from its proper location.

6.3.5 Where the results of the specimens breaking load tests carried out in compliance with the requirements of 6.3.4 are unsatisfactory the value of breaking load specified in 6.3.3 shall be reduced and retesting shall be conducted as per 6.3.4 with the reduced value of breaking load which at positive test results shall be accepted as the initial value in the determination of safe working load (*SWL*) according to 6.2.1. It is permitted to perform the initial breaking load tests with the values less than those indicated in 6.3.3 gradually approaching to the value stated in 6.3.3.

6.3.6 Containers securing devices tested with the breaking load are not permitted for further use.

6.3.7 The two specimens shall be tested with the proof load (*PL*) of all the types specified in column 4, Table 6.3.4.

Scheme of loads application (see column 3, Table 6.3.4) to the maximum extent possible shall correspond to real operation conditions of the considered device.

Table 6.3.4

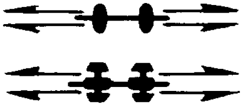
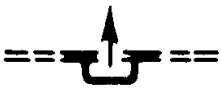
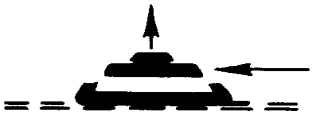
Nos.	Type of containers securing devices	Scheme of load application at testing	Type of load	Symbol of safe working load
1	Lashings (chain, steel wire rope, rod)		Tension	*SWL*(*T*) = ...kN
2	Turnbuckle		Tension	*SWL*(*T*) = ...kN
3	Single stacking cone		Shear	*SWL*(*S*) = ...kN
4	Double stacking cones, double twistlocks		Shear	*SWL*(*S*) = ...kN
			Tension — Compression (along the plate)	*SWL*(*TP*)= ...kN
5	Twistlock (automatic, semi automatic); Stoppers; Stacking cone with inserted pin (keyhole stacker)		Shear	*SWL*(*S*) = ...kN
			Tension	*SWL*(*T*) = ...kN
6	Inserted hook		Shear	*SWL*(*S*) = ...kN
7	Strut		Tension — Compression	*SWL*(*TP*) = ...kN
8	Buttress		Compression	*SWL*(*P*) = ...kN
9	Bridge fitting		Centerless	*SWL*(*T*) = ...kN
10	Weld-in socket, flush with the floor		Tension	*SWL*(*T*) = ...kN
11	Weld-on socket protruded		Tension	*SWL*(*T*) = ...kN
			Shear	*SWL*(*S*) = ...*kN*

Table 6.3.4 — continued

12	Deck fitting semi circular		Tension	*SWL*(*T*) = ...kN
13	Lashing pad eye		Tension	*SWL*(*T*) = ...kN
14	"Dove tail" locks socket		Tension	*SWL*(*T*) = ...kN
			Shear	*SWL*(*S*) = ...kN

The time under load shall be not less than 5 min. The value of the proof load (*PL*) for the appropriate type of load shall be assumed not less than determined by the formula:

$$PL=k_1 SWL, \text{ кН} , \quad (6.3.7)$$

where *SWL* — safe working load for the containers securing device determined in compliance with the provisions of 6.2.1, 6.3.4 and 6.3.5;

k_1 — coefficient equal to:

1,25 — for containers securing devices with $SWL \leqslant 400$ kN;

1,15 — for containers securing devices with $SWL > 400$ kN.

Containers securing devices are considered to have passed the test providing that after the proof load application both specimens are not subject to permanent set or other faults affecting their operability.

6.3.8 Where the results of the specimens proof load tests in compliance with the requirements of 6.3.7 are unsatisfactory the value of proof load (*PL*) specified in 6.3.7 shall be reduced and retesting shall be conducted as per 6.3.7 with a reduced value of proof load (*PL′*) which at positive test results shall be accepted as the initial value to specify previously determined value of the safe working load (*SWL*).

The final value of the safe working load (*SWL*) in this case shall be determined by the formula:

$$SWL=PL'/k_1, \text{ kN} . \quad (6.3.8\text{-}1)$$

In this case to specify the value of breaking load (*BL*) in all technical documentation previously approved by the Register is mandatory, the *BL* value shall be specified by the formula:

$$BL=PL'k/k_1, \text{ kN}. \qquad (6.3.8\text{-}2)$$

6.3.9 Functional tests of containers securing device shall be carried out to determine the compliance of the above device with its designation. Special attention shall be given to the reliability of stopping devices designed to prevent self-releasing or loosening of tension of containers securing devices.

6.3.10 In case of positive results of specimens testing according to 6.3 a Type Approval Certificate shall be issued in accordance with the established approval procedure for each type and size of containers securing devices. Issue of Type Approval Certificate for several types and sizes of containers securing devices of the same type may be permitted.

In Section "Technical Data" of Type Approval Certificate it is mandatory to indicate the safe working load (*SWL*) for the considered device for each type of load in full compliance with its symbol given in column 5, Table 6.3.4.

6.3.11 Type Approval Certificate shall be issued by the Register Head Office or Branch Offices. In accordance with the established approval procedure Branch Offices shall send copies of issued Type Approval Certificates to the Register Head Office.

6.4 TECHNICAL SUPERVISION DURING SERIAL MANUFACTURE

6.4.1 Containers securing devices shall be submitted in batches for survey and testing. A batch shall consist of not more than 50 containers securing devices of the same type and size. A batch of cast parts shall be stocked with the devices of the same type and size made from metal of one cast, heat treated in the same furnace charge or by the same type of continuous furnace heating.

6.4.2 All containers securing devices composing a batch are subject to survey for ascertaining their compliance with the approved documentation, at that, certificates for material or any other document confirming that material of the parts meets the requirements of material specifications shall be submitted.

6.4.3 From each batch of removable containers securing devices, except lashings and turnbuckles, one specimen is selected and shall be subject to the proof load testing in accordance with the provisions of 6.3.7. Where the specimen test results are unsatisfactory two additional specimens selected from the same batch shall be re-tested. In case of unsatisfactory results of the second test each containers securing device of this batch shall be tested. The devices which have failed the test specified in 6.3.7 shall be rejected.

6.4.4 Each lashing and turnbuckle included in the batch shall be subject to the proof load (*PL*) testing in accordance with the provisions of 6.3.7. The lashing and turnbuckles which have failed the test specified in 6.3.7 shall be rejected.

6.4.5 Containers securing devices shall be subject to marking. The scope and types of marking are set forth upon agreement with the Register during development of documentation on the devices; in any case marking of the batch distinctive number shall be mandatory (see 6.4.1 and 6.4.6).

6.4.6 In case of positive results of survey and testing according to 6.4 each containers securing device included in the batch surveyed shall be subject to the Register branding.

Certificate (see form 6.5.30) for the batch of containers securing devices which has passed the survey shall be issued by the Register.

In the Register Certificate (see form 6.5.30) an entry concerning the safe working load specified in column 5, Table 6.3.4 shall be made.

7 TECHNICAL SUPERVISION OF CONTAINERS SECURING DEVICES IN SERVICE

7.1 GENERAL

7.1.1 The system of surveys, examinations and tests of containers securing devices in service sets forth the procedure of their periodical submissions to the Register for ensuring their safe operation in compliance with the present TR.

7.1.2 Submission of containers securing devices for surveys, examinations and tests within the time established by the present TR, as well as performance of all necessary preparations on conducting the tests shall be a responsibility of the shipowner.

7.1.3 The Register surveyor shall refuse to supervise the testing, as well as perform a survey or an examination where the containers securing devices are not sufficiently prepared for the test, survey or examination.

7.1.4 During surveys of containers securing devices carried out by the Register, administration of the ship or enterprise preparing the above devices for survey shall report on all the faults revealed, as well as repairs, parts and ropes replacements which have been performed since the last survey.

7.1.5 Logbook on Recording and Examination of Reusable Fastening Facilities for Cargos in the form prescribed by the shipowner and filled up in compliance with the requirements set forth for such documents shall be available on board the ship and presented to the surveyor at any time.

7.2 SURVEYS, EXAMINATIONS AND TESTS

7.2.1 Periodical surveys.

7.2.1.1 All containers securing devices in service are subject to initial, annual and special surveys so that to ascertain their fit conditions and that they are provided with all necessary documents. Survey results shall be indicated in Report on Survey of the ship (form 6.3.10).

7.2.1.2 During special survey the certificates of the Register (form 6.8.3, form 6.5.30) or certificate of other classification society — IACS member, Certificate of Test and Survey of Reusable Fastening Facilities (RFF) for General Cargos (form 5.1.7) (where necessary) and Logbook on Recording and Examination of Reusable Fastening Facilities for Cargos shall be presented to the surveyor.

7.2.1.3 Availability of manufacturer's markings and brands of the Register or a body authorized by it for substitution shall be checked during survey.

7.2.1.4 Containers securing devices not subject to defects or wear exceeding permissible values preventing them from further use shall be considered as approved for service.

7.2.1.5 Where during special survey the defects affecting safe use as well as the wear exceeding the permissible values are found in containers securing devices the worn out or defective devices shall be replaced or repaired with the method approved by the Register and the faults shall be eliminated. Repaired containers securing devices shall be subject to the proof load test.

7.2.2 Survey of containers securing devices in service, manufactured without supervision of the Register or other classification society — IACS member.

7.2.2.1 In cases when containers securing device are not provided with the Register certificates or certificates of other classification society — IACS member, as well as with the brands of the Register, other classification society or manufacturer the shipowner submits them for the survey to meet the requirements specified in 14.12.1.3, Part II "Technical Supervision of Ships in Service in Compliance with the Register Rules" of Guidelines on Technical Supervision of Ships in Service.

7.3 LIMITS OF WEAR

7.3.1 The present standards of wear are tentative and may be altered depending on the specific operation conditions and the type of securing device. The present standards refer to the places liable to the maximum wear.

7.3.2 Containers securing devices having parts with 10 per sent wear and more regarding of thickness and diameter, as well as with cracks, fractures or permanent set shall not be permitted for use.

7.3.3 Steel wire rope lashings shall not be used if:

5 per sent and more of the total number of wires in the rope are broken in any length equal to ten times the rope diameter;

there is any tendency towards birdcaging (i.e. separation of the strands or wires);

a strand broken;

it shows signs of corrosion, particularly of the internal corrosion;

the wires are broken only in one strand, or in the length of less than 10 times the rope diameter, or in the wire hinges with metal clips.

more than one torn wires nearest to metal clips are broken.

7.3.4 Wear of welded or punched chains links shall not exceed 10 per sent of the initial diameter (allowance is not considered).

7.3.5 Containers rods shall not be subject to curvature with a bend more than 1/50 of the rod length unless the curvature has been designed.

7.3.6 The containers securing devices having threaded details with damaged thread shall not be permitted for use.

7.3.7 All movable or rotating parts shall move without gripping, jamming or use of extra force.

7.3.8 Availability of corrosion pits or spots shall not exceed 15 per sent of overall surface area of metal parts.

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