RUSSIAN MARITIME REGISTER OF SHIPPING

CIRCULAR LETTER	**No. 314-14-1911c**	dated 22.03.2023

Re:
amendments to the Rules for the Cargo Handling Gear of Sea-Going Ships, 2023, ND No.2-020101-179-E

Item(s) of supervision:
Ship's Cargo Handling Gear

Entry-into-force date:
01.05.2023

~~Cancels / amends / adds Circular Letter No.~~ ~~dated~~

Number of pages: 1 + 24

Appendices:
Appendix 1: information on amendments introduced by the Circular Letter
Appendix 2: text of amendments to the Rules for the Cargo Handling Gear of Sea-Going Ships

Acting Director General Sergey A. Kulikov

Text of CL:
We hereby inform that the Rules for the Cargo Handling Gear of Sea-Going Ships shall be amended as specified in the Appendices to this Circular Letter.

It is necessary to do the following:

1. Bring the content of this Circular Letter to notice of the surveyors of the RS Branch Offices, as well as interested organizations and persons in the area of the RS Branch Offices' activity.
2. Apply the provisions of this Circular Letter in the process of review and approval of technical documentation and in technical supervision of manufacture of cargo handling gear, whose technical documentation was submitted for review on or after 01.05.2023.

List of the amended and/or introduced paras/chapters/sections:
Paras: 1.2.1, 1.6.2, 2.1.3, 2.3.1 – 2.3.4, 3.1.1, 5.5.5 and 6.4.2.2
Section 7
Appendices I–IV

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Information on amendments introduced by the Circular Letter
(for inclusion in the Revision History to the RS Publication)

Nos.	Amended paras/chapters/ sections	Information on amendments	Number and date of the Circular Letter	Entry-into-force date
1	Para 1.2.1	New definitions have been introduced according the technique of a calculation for strength based on the limit state method	314-14-1911c of 22.03.2023	01.05.2023
2	Para 1.6.2	New para 1.6.2 has been introduced determining the application area of the FRP cranes	314-14-1911c of 22.03.2023	01.05.2023
3	Para 2.1.3	New para 2.1.3 containing the requirements for calculation methods of the FRP cranes has been introduced	314-14-1911c of 22.03.2023	01.05.2023
4	Chapter 2.3	Chapter 2.3 has been renamed	314-14-1911c of 22.03.2023	01.05.2023
5	Paras 2.3.1 – 2.3.3	Paras have been amended using the technique of a calculation for strength based on the limit state method	314-14-1911c of 22.03.2023	01.05.2023
6	Para 2.3.4	New para 2.3.4 has been introduced using the technique of a calculation for strength based on the limit state method. Existing paras 2.3.4 – 2.3.6 have been renumbered 2.3.5 – 2.3.17, accordingly	314-14-1911c of 22.03.2023	01.05.2023
7	Para 3.1.1	Section 3 has been supplemented by the reference to new Section 7	314-14-1911c of 22.03.2023	01.05.2023
8	Para 5.5.5	Para has been amended to specify the types of control posts	314-14-1911c of 22.03.2023	01.05.2023
9	Para 6.4.2.2	Para has been amended to specify the dimensions of the proof load	314-14-1911c of 22.03.2023	01.05.2023
10	Section 7	New Section 7 containing the requirements for members of ship's FRP cranes has been introduced	314-14-1911c of 22.03.2023	01.05.2023
11	Appendix I	The existing Appendix has been numbered "I" due to the introduction of new Appendices II–IV	314-14-1911c of 22.03.2023	01.05.2023

Nos.	Amended paras/chapters/ sections	Information on amendments	Number and date of the Circular Letter	Entry-into-force date
12	Appendices II─IV	New Appendices II─IV have been introduced using the technique of a calculation for strength based on the limit state method	314-14-1911c of 22.03.2023	01.05.2023

RULES FOR THE CARGO HANDLING GEAR OF SEA-GOING SHIPS, 2023,

ND No. 2-020101-179-E

1 GENERAL

1.2 DEFINITIONS AND EXPLANATIONS

1 **Para 1.2.1** shall be supplemented with the following definitions and Figure 1.2.1-6-6. Figures 1 ─ 5 have been renumbered 1.2.1-1 ─ 1.2.1-5, accordingly.

"Asymmetric stress cycle means a cycle, in which the maximum and minimum stresses have different absolute values.

Maximum stress per cycle σ_{max} means the greatest stress per cycle in terms of algebraic value.

Minimum stress per cycle σ_{min} means the smallest stress per cycle in terms of algebraic value.

The first group of limit states means the states, in which the bearing capacity (strength, stability or fatigue strength) of structures becomes exhausted under corresponding combinations of loads, which may also be accompanied by failure of any kind (ductile, fatigue, brittle), cracking, etc.

Symmetric stress cycle means a cycle, in which the maximum and minimum stresses are equal in absolute value, but opposite in sign.

Crack resistance means resistance of a structure to the crack propagation.

Cycle of stresses (strains) means a set of successive values of stresses (strains) for one period of their change under regular loading.

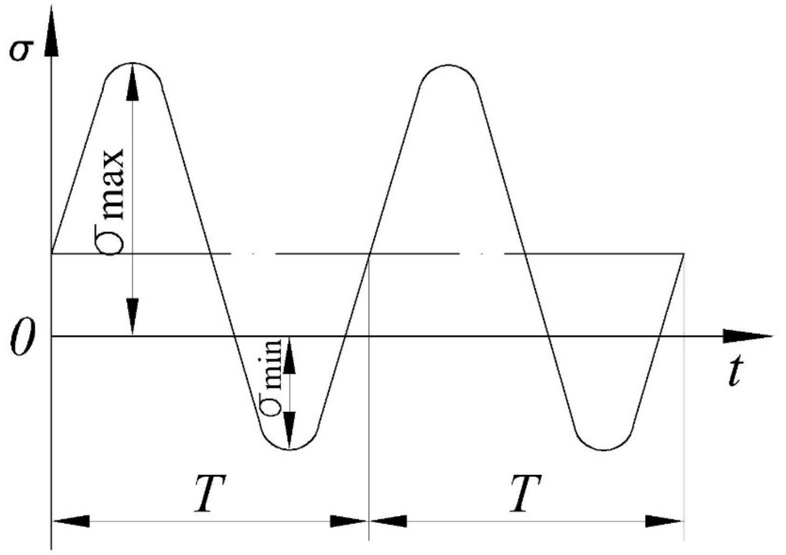


Fig. 1.2.1.6-6".

2 **New para 1.6.2** is introduced reading as follows:

"**1.6.2** The cranes with SWL of no more than 2.8 tons and the boom length of no more than 10 m, which include load-bearing stressed members made of fiber-reinforced plastic (FRP), shall comply with the requirements of Section 7 "Ship's FRP cranes".".

2 CALCULATIONS

3 **New para 2.1.3** is introduced reading as follows:

"**2.1.3** The requirements for calculation methods, allowable stresses, safety factors and stability for crane structures made of FRP are set out in Section 7 "Ship's FRP cranes".".

4 **Chapter 2.3** is renamed as follows:

"**2.3 ALLOWABLE AND ULTIMATE STRESSES, SAFETY FACTORS AND STABILITY MARGIN**".

5 **Paras 2.3.1—2.3.3** are replaced by the following text:

"**2.3.1 Methods for determining allowable and ultimate stresses.**

2.3.1.1 Under the action of design loads, the stresses in the metal structures of ship's cargo handling gear shall not exceed the allowable values determined using the limit state method in accordance with 2.3.2, 2.3.3 and 2.3.4 or, as agreed with the Register, the allowable stress method in accordance with 2.3.1.2.

The calculation method for allowable stresses is recommended to be used only in the case of a linear relationship between loads and stresses in a structure, as well as for preliminary calculations as the structures calculated by this method often turn out to have excessive safety factors.

The limit state method can be used for any design cases.

2.3.1.2 The stresses in metal structures of ship cargo handling gear under the effect of the design loads shall not exceed the allowable values given in Table 2.3.1.2.

Table 2.3.1.2

SWL, t	Allowable stresses as fractions of yield strength of material s/R_{eH}	Safety factor R_{eH}/s	Dynamic factor, c_H=0.7R_{eH}/s	Maximum cargo hoisting or lowering speed at which check calculation c_H is not mandatory, m/s
5 and less	0.40	2.50	1.75	1.00
10	0.42	2.38	1.67	0.89
15	0.44	2.27	1.59	0.78
20	0.46	2.18	1.52	0.69
25	0.48	2.08	1.46	0.61
30	0.50	2.00	1.40	0.53
40	0.54	1.85	1.30	0.40
50	0.57	1.76	1.23	0.31
60	0.59	1.70	1.19	0.25
75 and more	0.60	1.67	1.17	0.22
Note. Intermediate values shall be determined by interpolation.				

For masts with several light-weight single derricks used simultaneously, the allowable stresses may be assumed equal to 0,5 of the yield strength R_{eH} of the material.

The allowable stresses in stayed masts shall be taken by 10 % less than the above values.

For manually operated cargo handling gear the allowable stresses may be taken equal to 0,6 of the yield strength R_{eH} of the material.

The values of allowable stresses specified in Table 2.3.1.2 include the following dynamic load factors:

$$\psi_H = 0{,}7R_{eH}/\sigma; \qquad (2.3.1.2\text{-}1)$$

where ψ_H the standard dynamic factor obtained as the ratio of the maximum anticipated dynamic load to the static stress under the action of the design load;

R_{eH}/σ safety factor according to Table 2.3.1.2.

When the maximum cargo hoisting or lowering speed is more than 1.33 $(\psi_H - 1)$, m/s, the dynamic load factor shall be checked by calculation, using the formula:

$$\psi = 1 + 0{,}318\frac{v}{\sqrt{f_{cm}}} \qquad (2.3.1.2\text{-}2)$$

where ψ = dynamic load factor obtained as the ratio of the dynamic load to its static value;
v = maximum speed of load movement, m/s;
f_{cm} = calculated vertical shifting of the load suspension point (including variation in the rope length) under the action of a static force induced by cargo weight equal to the safe working load, m.

If the calculated dynamic load factor ψ exceeds ψ_{H}, the allowable stresses indicated in 2.3.1.2 shall be multiplied by ψ_H/ψ; if the calculated dynamic load factor is equal to, or less than c_H, the allowable stresses are assumed equal to those given in 2.3.1.2.

Other methods may be used for the calculation of dynamic load factor in case the substantiation for the application of these methods is provided.

2.3.1.3 The safe working load (*SWL*) of ropes (wire, natural fiber and synthetic ropes) shall not exceed the guaranteed breaking load F_{guar} established by a specimen testing (with the above ropes) divided by the safety factor given in Table 2.3.7 and Table 2.3.8.

2.3.2 Calculation of structural strength.

2.3.2.1 Stresses in metal structures from any loads for the first group of limit states shall meet the following requirement:

$$\sigma_{us} \leq \sigma_{\text{ult}} \qquad (2.3.2.1\text{-}1)$$

where $\sigma_{пс}$ = design stress. When calculating it, the acting loads are taken in accordance with factor γ_{fi} given in Table 2.3.2.1-1:
$\sigma_{пр}$ = ultimate stress in a metal structure is calculated by the formula:

$$\sigma_{\text{ult}} = \frac{\gamma_n \gamma_d R_n}{\gamma_m} \qquad (2.3.2.1\text{-}2)$$

where σ_i = design stress in metal structure from the *i*- th type of load;
γ_n = reliability factor by purpose of the structure (refer to Table 2.3.2.1-2);
γ_d = service factor (refer to Table 2.3.2.1-3);
γ_m = reliability factor by material (refer to Table 2.3.2.1-2);
R_n = characteristic resistance $R_n = R_{eH}$ where R_{eH} – yield strength of material.

Overload factor γ_{fi} is determined for stresses from a specific type of loading (load from dead weight, dynamic loads, wind loads, etc.) in accordance with Table 2.3.2.1-1.

Table 2.3.2.1-1

Values of overload factor γ_{fi}

Type of loads	Load cases[1]			
	I normal loads in working condition	II maximum loads in working condition		III maximum load in non-working condition
	Load combinations			
	-	IIa	IIb	-
Dead weight of structure (taking into account the roll and trim of the ship)	1,22	1,16	1,16	1,22
Weight of cargo and removable equipment (taking into account the roll and trim of the ship)	1,34	1,22	1,22	-
Horizontal inertia forces of crane masses from the acceleration and deceleration of mechanisms	1,34	-	1,22	-
Vertical inertia forces from lifting and lowering of cargo	1,34	1,22	1,22	-
Horizontal inertia forces from rolling in waves	1,22	1,16	1,16	1,22
Vertical inertia forces from rolling in waves	1,22	1,16	1,16	1,22

Type of loads	Load cases[1]			
	I normal loads in working condition	II maximum loads in working condition		III maximum load in non-working condition
	Load combinations			
	-	IIa	IIb	-
Wind pressure on structure	1,0	1,22	1,22	1,1
[1]Types and cases of loads are determined in accordance with 6.2.1 and 6.2.2 of these Rules				

Table 2.3.2.1-2

Reliability factor by purpose of the structure γ_n

Key condition of calculation	Consequences of damage	
	major	minor
Strength (restriction of plastic strain)	0,95	1,0
Stability	0,90	0,95
Fatigue resistance	0,95	1,0
Crack resistance	0,85	0,95

Table 2.3.2.1-3

Values of service factor γ_d

Confidence level of calculation model	Stress condition	
	Simple[1]	Combined[2]
Satisfactory[3]	0,90	0,80
Unsatisfactory[4]	0,80	0,70

[1]Simple stress state of beams, beam structures and trusses if their members have a length of at least five times the cross-sectional dimensions.
[2]Combined stress state if the members and nodes consist of short and wide beams of low height (for example, the caps of four-post portals), which have an irregular shape and are shells or joints of beams or rods.
[3]Satisfactory is considered to be the reliability of simulating the loading of beams, frames and trusses that take up weight, inertial, and wind loads.
[4]Unsatisfactory is simulating the loading of members loaded mainly by misalignment that directly take up local moving loads, supporting members of moving structures with a statically indeterminate support arrangement, bars subject to significant local bending, etc.

Table 2.3.2.1-4

Values of reliability factors by material γ_m

State standard or specifications for rolled products and pipes	Reliability factor by material γ_m
GOST 27772 (except for steels S590 and S590K) and other regulatory documentation using the procedure to control the properties of rolled products in accordance with GOST 27772	1,025
For rolled products with yield strength over 380 N/mm^2 in accordance with GOST 19281, for pipes in accordance with GOST 8731	1,100
For other rolled products and pipes that meet the requirements of these standards	1,050
For rolled products and pipes supplied according to foreign regulatory documents	1,100
Steel ropes	1,600

2.3.2.2 Stresses in welded joints.

2.3.2.2.1 Butt welds.

The design stresses on the metal of the butt weld σ_{us}^W shall satisfy the following requirement: provided that the weld is subject to 100 % non-destructive test:

$$\sigma_{us}^W \le \sigma_{\text{ult}}; \qquad (2.3.2.2.1\text{-}1)$$

in other cases

$$\sigma_{us}^W \le 0{,}85\ \sigma_{\text{ult}}. \qquad (2.3.2.2.1\text{-}2)$$

where σ_{ult} = ultimate stress in metal structure (determined by Formula 2.3.2.1-2)

2.3.2.2.2 T-joints and overlap joints.

The calculation is based on shear stresses.

The design shear stresses on the weld metal τ_{us}^{W} shall satisfy the following requirement:

$$\tau_{us}^{W} \leq \tau_{\text{ult}}^{W}; \qquad (2.3.2.2.2\text{-}1)$$

where $\tau_{пр}^{шва}$ = ultimate shear stress on the weld metal is calculated by the formula:

$$\tau_{us}^{W} = \frac{\gamma_n \gamma_{Wd} R_{Wn}}{\gamma_{Wm}}; \qquad (2.3.2.2.2\text{-}2)$$

where γ_n = reliability factor by purpose of the structure (refer to Table 2.3.2.1-2);
γ_{Wd} = service factor (refer to Table 2.3.2.2.2-1);
γ_{Wm} = reliability factor by weld metal (at R_{Wn} ≤ 490 MPa γ_{Wm}=1.25, at R_{Wn} ≥ 590 MPa γ_{Wm}=1.35);
R_{Wn} = characteristic resistance of weld metal by tensile strength $R_{Wn} = 0{,}55 \cdot R_m$ where R_m —tensile strength of weld metal, MPa.

The design shear stresses on the metal of the fusion boundary $\tau_{us}^{\text{г.с}}$ shall satisfy the following requirement:

$$\tau_{us}^{\text{г.с}} \leq \tau_{\text{ult}}^{\text{г.с}} \qquad (2.3.2.2.2\text{-}3)$$

where $\tau_{us}^{\text{г.с}}$ = ultimate shear stress on the metal of the fusion boundary is calculated by the formula:

$$\tau_{us}^{\text{г.с}} = \frac{\gamma_n \gamma_{Wd} R_{Wn}}{\gamma_{Wm}} \qquad (2.3.2.2.2\text{-}4)$$

where γ_n— reliability factor by purpose of the structure (refer to Table 2.3.2.1-2);
γ_{Wd} = service factor (refer to Table 2.3.2.2.2-1);
$\gamma_{Wm} = 1{,}0$ = reliability factor by weld metal;
R_{Wn} = characteristic resistance of weld metal by tensile strength $R_{Wn} = 0{,}45 \cdot R_m$
where R_m = tensile strength of weld metal, MPa.

Table 2.3.2.2.2-1

Values of structure service factor γ_{Wd}

Joint type	γ_{Wd}
attachment of beams to flanges[1]	$0{,}7 \div 0{,}8$
connection of bracket to beam web stiffened by web plate	$0{,}65 \div 0{,}7$
overlap joints[2]	$0{,}8 \div 0{,}9$

[1]lower values are for thin flanges without stiffeners;
[2]lower values for joints with long side fillet welds, higher values are for combined joints with end fillet and side fillet welds of shorter length

2.3.2.3 Stresses in bolted and riveted joints.

2.3.2.3.1 Flange joints with high-strength bolts.

The calculation applies to the bolted connections with a specified tightening torque.

Stresses in the most loaded bolt from any loads for the first group of limit states shall satisfy the following requirement:

$$\sigma_b \leq \frac{u \mu \gamma_n \gamma_{bd} R_{bn}}{\gamma_{bm}} \qquad (2.3.2.3\text{-}1)$$

where u = number of friction or shear surfaces;
μ = friction factor (refer to Table 2.3.2.4-1)
γ_n = reliability factor by purpose of the structure (refer to Table 2.3.2.1-2);
γ_{bd} = service factor (refer to Table 2.3.2.3-2);
$\gamma_{bm} = 1{,}4$-= $\gamma_{bm} = 1{,}4$ = reliability factor by bolt material;
$R_{bn} = 0{,}7 \cdot R_m$= characteristic resistance of high-strength bolt, R_m – tensile strength of bolt material.

Table 2.3.2.3-1

Friction factor μ

Method of friction surface cleaning	μ
Shot blasting	0,58
Flame blasting	0,42
Steel brushes	0,35
Without treatment	0,25

Table 2.3.2.3-2

Factor γ_{bd}

For dedicated cleaning or preservation of surfaces to be bolted	$0{,}8 \div 0{,}85$
Without surface treatment (lower values are for connections with a number of bolts less than 10)	$0{,}7 \div 0{,}8$

2.3.2.3.2 Connections with longitudinal joint.

Connections with a longitudinal joint are designed to transfer loads of all types acting in the plane of the joint.

The bolts installed in the hole by fit and rivets are calculated for bolt (rivet) shear and for crushing of side contact surfaces.

Design stresses by shear condition

$$\tau_b \leq \frac{u\gamma_n\gamma_{bd}R_{bs}}{\gamma_{bm}} \qquad (2.3.2.3\text{-}2)$$

where factors u, γ_n have the same values as in formula (2.3.2.3-1); $\gamma_{bd} = 1{,}0$; $\gamma_{bm} = 1{,}2$; $R_{bs} = 0{,}4 \cdot R_m$;
R_m = tensile strength of bolt (rivet) material.

Design stresses by the crushing condition of sheets to be joined

$$\tau_b \leq \frac{u\gamma_n\gamma_{bd}R_{bp}}{\gamma_{bm}} \qquad (2.3.2.3\text{-}3)$$

where – factor γ_n has the same value as in formula (2.3.2.3-1)
$\gamma_{bd} = 1{,}0$; $\gamma_{bm} = 1{,}2$; $R_{bp} = k_p \cdot R_{eH}$; $k_p = 1{,}0$ when joining a single shear surface;
$k_p = 1{,}4$ when joining multiple surfaces;
R_{eH} = yield strength of metal of sheets to be joined.

2.3.2.4 In calculation of the ultimate stresses in metal structures, the characteristic resistance (design yield strength) guaranteed by the standard or specifications shall be taken as a basis for calculations; in all cases, however, the characteristic resistance shall be taken no greater than 0,70 of the minimum ultimate strength (tensile strength) guaranteed by the standard or specifications. ".

2.3.3 Validation of structural member stability.

2.3.3.1 Check for overall stability

To provide the overall stability of structural members, stresses in metal structures from any loads for the first group of limit states:

$$\sigma_{us} \leq \sigma_{\text{ult}} = \phi\frac{\gamma_n\gamma_d R_n}{\gamma_m} \qquad (2.3.3.1\text{-}1)$$

where– γ_n = reliability factor by purpose of the structure (refer to Table 2.3.2.1-2);
$\gamma_d = 0{,}8 \div 0{,}95$ – service factor;
γ_m= reliability factor by material (refer to Table 2.3.2.1-4);
R_n= characteristic resistance of structural member equal to yield strength $R_n = R_{eH}$;
ϕ = stability factor, calculated by the formula:

Stability factor:

$$\phi = \frac{0{,}5\left(\delta - \sqrt{\delta^2 - 39{,}5\bar{\lambda}^2}\right)}{\bar{\lambda}^2} \leq 1 \text{ at } \bar{\lambda} \leq 5 \qquad (2.3.3.1\text{-}2)$$

$$\phi = \frac{7,6}{\bar{\lambda}^2} \text{ at } \bar{\lambda} \geq 5 \qquad (2.3.3.1\text{-}3)$$

where $\delta = 10 \cdot (0,96 + \beta\bar{\lambda}) + \bar{\lambda}^2$ = correction factor;

$\bar{\lambda} = \lambda\sqrt{\frac{R_{eH}}{E}}$ = conditional flexibility of steel member;

$\beta = 0,9$ = for bars of closed section and symmetrical open section (tees, I-beams, pipes);

$\beta = 0,14$ = for bars of asymmetric section made of single and double rolled sections (channels, angle pieces);

λ = ultimate flexibility of steel member (refer to Table 2.3.3.1-2);

E = Young's modulus.

Table 2.3.3.1-2

Ultimate flexibility of steel members λ

Members of metal structures	Flexibility of members	
	Compression	Tension
Chords of main trusses	120	150
Single-beam structure of derricks, posts and masts	150	180
Other beams of main trusses and chords of auxiliary trusses	150	250
All other beams	250	350

2.3.3.2 Check for local stability.

Thin-walled members of compressed bars and compressed vertical walls, and compressed chords of beams working in transverse bending are subject to check for local stability. Such members are panels mainly loaded with forces acting in the middle plane.

The local stability condition of the *i*-th panel, which is under combined conditions of loading with normal stresses from bending, compression and with shear stresses from shear, shall satisfy the following requirement:

$$\left(\frac{\gamma_d\sigma_i}{\gamma_m\sigma_{ci}} + \frac{\gamma_d\sigma_z}{\gamma_m\sigma_{zci}}\right)^{q_i} + \left(\frac{\gamma_d\tau}{\gamma_m\tau_{zci}}\right)^2 \leq 1 \qquad (2.3.3.2)$$

where σ_i = maximum value of longitudinal normal (compressive) stresses σ within the *i*-th panel;

σ_{ci} = critical stress for the *i*-th panel loaded only with longitudinal normal stresses σ (refer to Appendix F1, GOST 33169-2014);

σ_z = design value of longitudinal normal (compressive) stresses;

σ_{zci} = critical stress for the *i*-th panel loaded only with transverse normal stresses σ_z (refer to Appendix F3, GOST 33169-2014);

τ = design value of longitudinal shear stresses τ within the *i*-th panel;

τ_{zci} = critical stress for the *i*-th panel loaded only with longitudinal shear stresses τ (refer to Appendix F2, GOST 33169-2014);

γ_d = service factor, $\gamma_d = 0,85 \div 0,95$;

γ_m = reliability factor by material (refer to Table 2.3.2.1-4);

q_i = exponent for the *i*-th panel is calculated by the formula:

$$q_i = 0,8 + 0,15{\gamma_i}^3;$$

where γ_i = loading parameter (refer to Fig. 2.3.3.2-2);

$\gamma_i = 1 - \sigma_2/\sigma_1$;

where σ_1 and σ_2 = normal stresses in the upper and lower parts of the *i*-th panel, respectively.

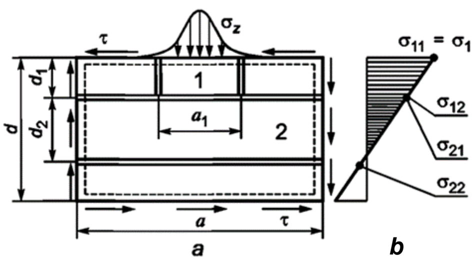


Fig. 2.3.3.2-1

Diagram and geometric parameters of plate with stiffeners:

a – diagram of plate with stiffeners; *b* – normal stress distribution diagram σ (σ_{11} and σ_{12} – design stresses for panel 1; σ_{21} and σ_{22} – design stresses for panel 2)

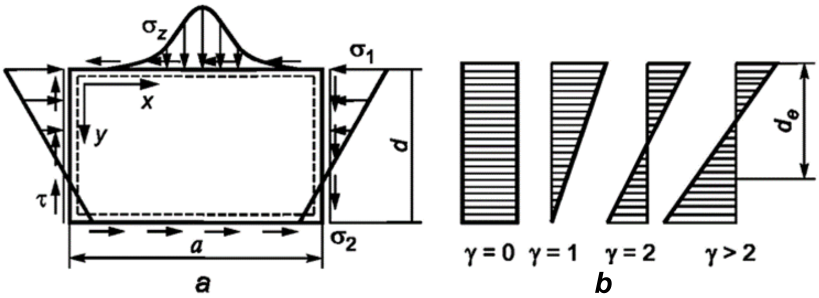


Fig. 2.3.3.2-2
a – general case of plate loading; *b* – normal stress distribution diagrams σ".

6 **New Para 2.3.4** is introduced reading as follows. Existing paras 2.3.4 – 2.3.16 are renumbered **2.3.5 –2.3.17**, accordingly.

"**2.3.4 Validation of fatigue strength of structural members of cargo handling gear.**

2.3.4.1 The metal structures of cargo handling gear shall be tested for fatigue strength.

2.3.4.2 The calculation for fatigue strength shall be made in accordance with the requirements of this section.

2.3.4.3 The calculation for fatigue strength is a checking calculation and made for nodes located in the most loaded main sections. Based on the analysis of the designed cargo handling machine, sections are selected where high time-dependent loads act. In these sections, nodes with a high concentration of stresses subject to high tensile loads are selected (welding areas of stiffeners, pads, nodes with fillet welds, etc.).

2.3.4.4 During the calculation, the nodes of metal structures are divided into groups with approximately the same values of stress concentrators (refer to Table 2.3.4.4). Examples of nodes of metal structures, indicating the numbers of groups, to which they are assigned according to the fatigue strength level, are given in Appendix 1. Nodes and members of group 1–3 do not contain welded joints, groups 4–10 include nodes with welded joints.

Table 2.3.4.4

Values of basic fatigue strength (MPa)

Value σ_{-1K}, MPa	Node group (see Appendix 1)									
	1	2	3	4	5	6	7	8	9	10
$\sigma_{-1K} \leq 420$	130	105	90	75	63	52	43	36	30	25
$420 < \sigma_{-1K} \leq 540$	150	130	105							
$540 < \sigma_{-1K} \leq 700$	185	150	105							
$\sigma_{-1K} > 700$	225	185	130							

2.3.4.5 It is recommended to first make the calculation for unlimited fatigue strength (based on a number of loading cycles N_0=2·10[6]). If the calculation shows a negative result, then repeat the calculation for limited fatigue strength (for a given number of loading cycles *N*).

The purpose of the fatigue strength calculation is to determine the ultimate stress σ_{ul} for the calculated joint.

2.3.4.6 Ultimate stress when calculating for fatigue resistance is determined by the formula:

$$\sigma_{us} \leq \sigma_{ult};$$

$$\sigma_{ult} = \frac{\gamma_n \gamma_d \sigma_{-1K}}{\gamma_m} \sqrt[m]{\frac{N_0}{z_e}} \qquad (2.3.4.6\text{-}1)$$

where γ_n = reliability factor by purpose of the structure or its member (see Table 2.3.2.1-2);

γ_d = service factor takes into account the simulation inaccuracy of the processes of loading and accumulation of cyclic damage, γ_d = 0.75 + 0.85;

γ_m = reliability factor by material (refer to Table 2.3.2.1-4);

σ_{-1K} = fatigue strength of design node in symmetrical loading cycle based on $N_0 = 2 \cdot 10^6$ cycles, it is calculated by the formula:

$$\sigma_{-1K} = k_t \sigma_{-1KB}, \qquad (2.3.4.6\text{-}2)$$

where $k_t = \left(\frac{t_0}{t}\right)^{0,2}$ = factor of influence of main member thickness of welded node;
σ_{-1KB} = basic fatigue strength, Table 2.3.4.4;
z_e = base of cycles when calculating for limited fatigue strength;
m = exponent of fatigue curve, $m = \frac{3,3}{lg\sigma_B - lg\sigma_{-1K}}$;

2.3.4.7 Ultimate stress in calculation of fatigue resistance in asymmetric loading cycle.

$$\sigma_{ult} = \frac{\gamma_n \gamma_d \sigma_{RK}}{\gamma_m} \sqrt[m]{\frac{N_0}{z_e}} \quad (2.3.4.6\text{-}3)$$

$$\sigma_{RK} = \frac{2\sigma_{-1K}}{(1-R)+(1+R)\psi_k} \quad (2.3.4.6\text{-}4)$$

where for $\sigma_{RK} > R_{eH}$; , the value $\sigma_{RK} = R_{eH}$ is taken into account.
$R = \sigma_{min}/\sigma_{max}$, factor of cycle asymmetry (σ_{max} and σ_{min} – maximum and minimum stresses of loading cycle);
ψ_K – factor of metal sensitivity to cycle asymmetry, it is calculated by the formula:

$$\psi_K = 0,57\sigma_{-1K}/R_m \quad (2.3.4.6\text{-}5)$$

where R_m = tensile strength of material, MPa,
σ_{-1KB} = basic fatigue strength of similar joint with a thickness of t_0=20 mm. (refer to Table 2.3.4.4)
t = thickness of node member where fatigue failure occurs, mm.

2.3.4.7 Ultimate stress based on limited number of loading cycles *N* is determined by the following formula:

$$\sigma_{ult} = \frac{\gamma_n \gamma_d \sigma_{RKN}}{\gamma_m} \quad (2.3.4.6\text{-}6)$$

where γ_n = reliability factor by purpose of the structure or its member (refer to Table 2.3.2.1-2);
γ_d = service factor in combined stress state (refer to Table 2.3.2.1-3);
γ_m = reliability factor by material (refer to Table 2.3.2.1-4);
σ_{RKN} = fatigue strength for a given number of cycles *N*, it is calculated by the formula:

$$\sigma_{RKN} = \sigma_{RK} \sqrt[m_R]{N_0/N} \quad (2.3.4.6\text{-}7)$$

where m_R = exponent of fatigue curve, it is calculated by the formula:

$$m_R = \frac{3,3}{lg\sigma_B - lg\sigma_{RK}},$$

σ_{RK} = fatigue strength at $N_0 = 2 \cdot 10^6$, MPa. (refer to formula 2.3.4.6-4).
$\sigma_B = R_m$ = tensile strength of material.".

3 MATERIALS AND WELDING

7 **Para 3.1.1** is replaced by the following text:

"**3.1.1** The materials used in the manufacture of stress-bearing metal structures, machinery and gear of cargo handling gear, as well as heat treatment of forged and cast items, where not covered by the specific requirements of these Rules, shall comply with the appropriate requirements of Part XIII "Materials" of the Rules for the Classification.

The materials used in the manufacture of stress-bearing structures of cargo handling gear installed on fixed offshore platforms, mobile offshore drilling units as well as on the ships operated under low temperatures shall be covered by the additional requirements of Part XII "Materials" of the Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units and Fixed Offshore Platforms.

If the conformity of steel to the requirements set forth in this Section is confirmed, it is allowed to use steel manufactured in compliance with the international or national standards, as well as to the standards of firms (organizations) specified in the technical documentation for materials and products approved by the Register and agreed by the Register in accordance with the requirements of Part II "Technical Documentation" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

The load-bearing stressed members of ship's cranes may be made of FRP. In this case, the requirements set forth in Section 7 "Ship's FRP cranes" shall be met taking into account the class and mode of operation.".

5 SHIP'S CRANES AND HOISTS

8 **Para 5.5.5** is replaced by the following text:

"**5.5.5** Cargo handling gear fitted with the control cabin or remote control shall be provided with a pneumatic/electrical audible warning alarm, which can be put into operation by the operator at any time. The audible warning alarm shall be clearly heard and be distinctive among other audible signals and operation noises.".

6 UPPER STRUCTURES OF FLOATING CRANES AND CRANE SHIPS. CRANES ON FLOATING DOCKS

6 TESTS

9 **Para 6.4.2.2** is replaced by the following text:

"**.2** with a proof load, whose mass shall be no smaller than the value specified in Table 10.3.4 in the scope specified in 10.3.4.".

10 **New Section 7** with the subsequent Sections renumbered is introduced reading as follows:

"7 FIBER-REINFORCED PLASTIC (FRP) SHIP'S CRANES

7.1 GENERAL

7.1.1 The requirements of this Section apply to the cranes specified in 1.6.2.

7.1.2 The cranes, which include the load-bearing stressed members made of FRP, shall be designed as follows:

using FRP based on carbon fibers – for operating conditions no higher than class U_3 (according to the classification of ISO 8686 – 1:2012/GOST 32579.1-207);

using FRP based on glass fibers – for operating conditions no higher than class U_1 (according to the classification of ISO 8686-1:2012/GOST 32579.1-207).

7.1.3 The definitions and explanations related to the general terminology are given in 1.2 "Definitions and explanations". For the purposes of this Section, the terminology of 1.2.2, Part XVI "Structure and Strength of Fiber-Reinforced Plastic Ships" of the Rules for the Classification shall also apply taking into account the following:

Fiber-reinforced plastic (FRP) means structural materials that consist of reinforcing fibers, polymer binder (matrix) and is formed directly during the manufacture of CHG (cargo handling gear) members.

Vacuum infusion method means a method related to closed molding methods, which consists in the impregnation of the reinforcing material with a binder by creating a vacuum in a sealed cavity formed by a mold where the dry reinforcing material is placed, and a sealed film that fits tight to the mold.

Robot-based spatial-rebar winding technology (RSW) means a continuous roving winding technology that produces a FRP truss structure using industrial robotic manipulators with a built-in reinforcing material impregnation system.

7.2 TECHNICAL DOCUMENTATION

7.2.1 In addition to 1.4, the Technical Documentation shall contain:
program of test samples for specimens of FRP used;
list of allowable process defects and operational damage;
test reports for FRP coupon samples;
results of research and tests (in case of using FRP other than carbon fiber composite and fiberglass based on epoxy binders, refer to 6.11.2.2, Part XVI "Structure and Strength of Fiber-Reinforced Plastic Ships" of the Rules for the Classification);
technological instruction for FRP manufacture.

7.3 REQUIREMENTS FOR STRENGTH CALCULATION OF FRP CRANES

7.3.1 When calculating the acting stresses in the construction of FRP cranes, the finite element method (FEM) shall be used as the main calculation method.
7.3.2 External operational loads on the crane are determined in accordance with 2.2 "Design loads and stresses" taking into account the accepted dynamic factors.
7.3.3 When forming the design combinations of loads, ISO 8686-1:2012/ GOST 32579.1 207 shall be followed in accordance with the type of crane and operating modes.
7.3.4 Validation of the serviceability, durability and reliability of the designed FRP crane structure is the design-basis justification for the strength and stability of the structure taking into account the influence of the cyclic nature of the impacts in accordance with the crane operating modes according to ISO 8686-1:2012/GOST 32579.1-207.
7.3.5 When assessing the strength of a FRP structure, the strength assessment criterion shall be applied based on allowable stresses. Allowable stresses shall be determined as follows:

$$[\sigma]_{perm} = \sigma_{ult}/K_{comp} \quad (7.3.5)$$

where σ_{ult} = ultimate strength of FRP under the loading condition being studied (tension, compression, shear, etc.);
K_{comp} = complex safety factor for FRP taking into account the expected impact of operational factors throughout the entire life of the crane.

7.3.6 When calculating structural members for stability, factor K_{comp} is used as a safety factor in relation to critical Euler forces or stresses.
7.3.7 Factor K_{comp} shall be determined as follows:

$$K_{comp} = K_f \cdot \gamma_n \cdot (\gamma_f/1.1) \quad (7.3.7)$$

where K_f = factor of external influences on the physical-mechanical properties of FRP taking into account cyclic influences over the entire service life (refer to 7.3.8);
γ_n = importance factor of crane and the analyzed structural member according to ISO 8686-1:2012/ GOST 32579.1-207;
γ_f = reliability factor according to ISO 8686-1:2012/GOST 32579.1-207, which takes into account all possible load deviations for the analyzed combination of loads.

7.3.8 The values of factor K_f for plate and bar elements of structure are given in Table 7.3.8

Table 7.3.8

Value of factor of external influence

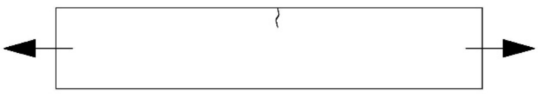
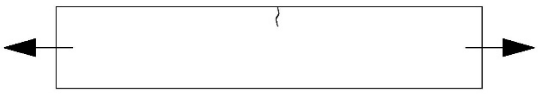
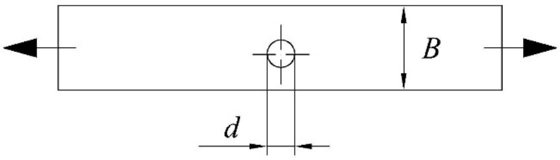
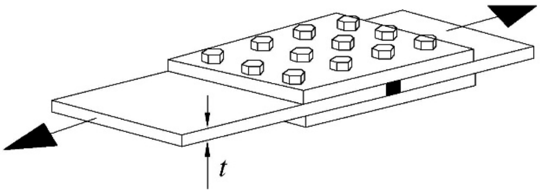
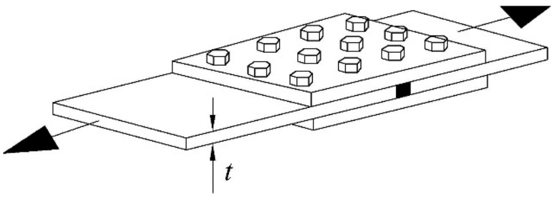
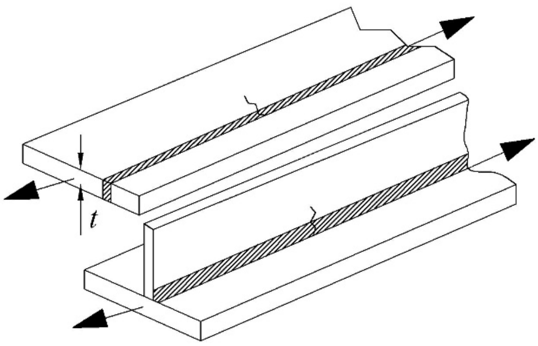
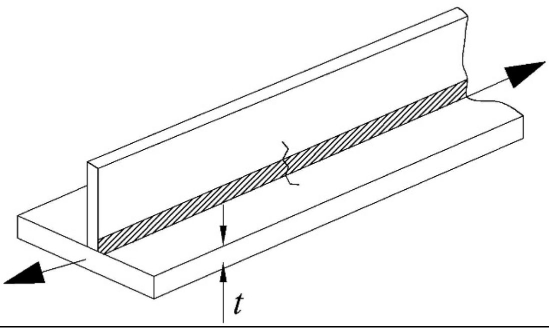
Complex factor of external influence	Plate elements		Bar elements
	Carbon fiber composite	Fiberglass	Carbon fiber roving
K_f	1,6	2,2	1Ю3

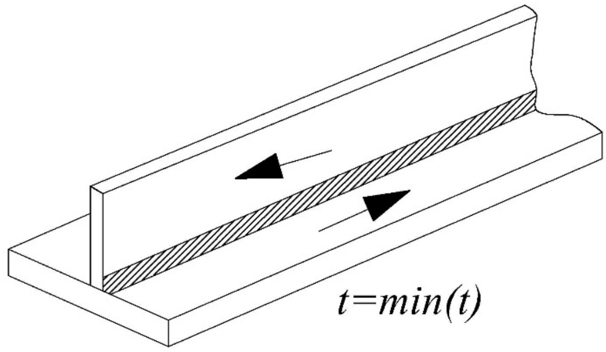
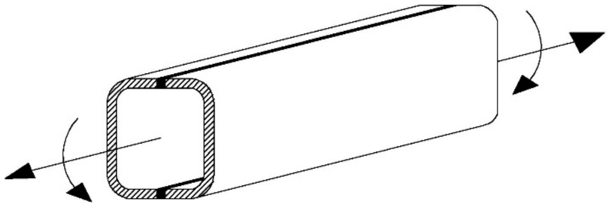
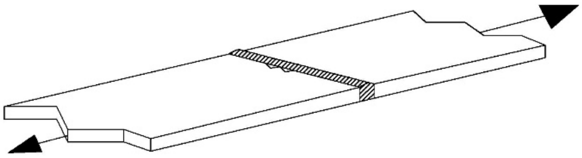
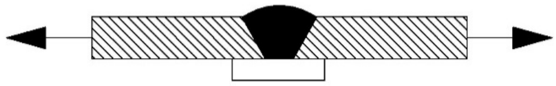
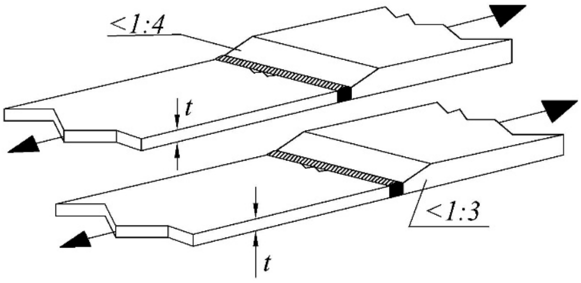
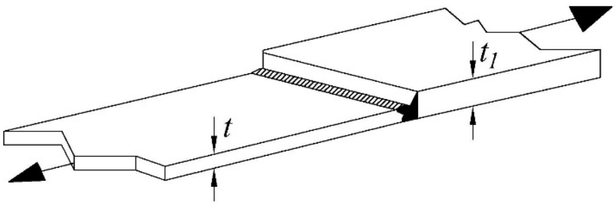
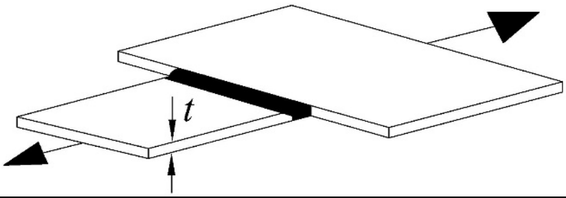
".

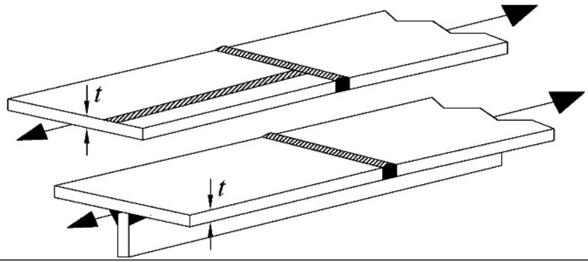
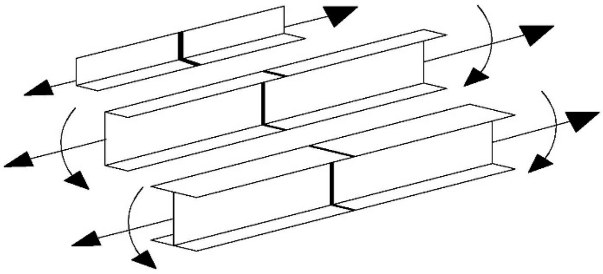
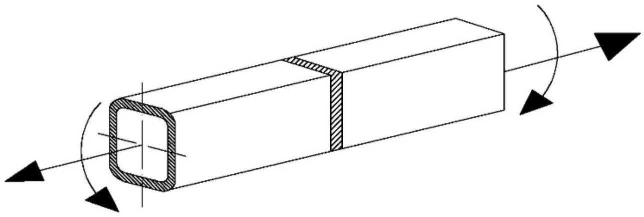
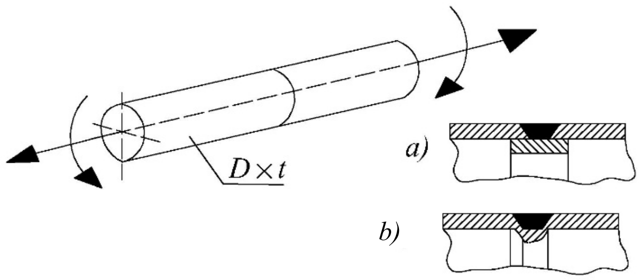
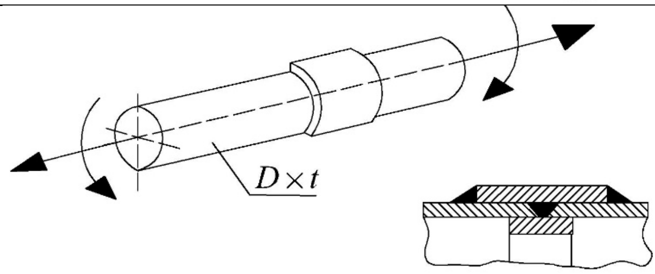
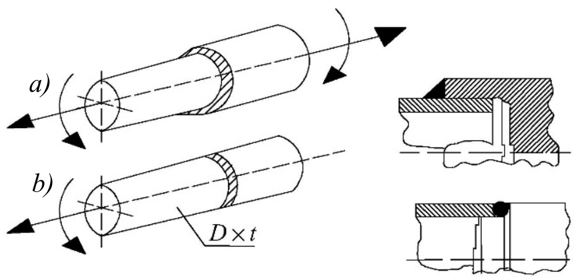
11 **APPENDIX.** The existing **Appendix** is renumbered "**I".**

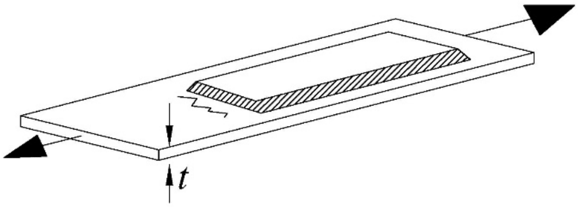
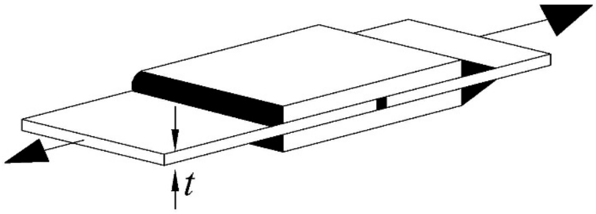
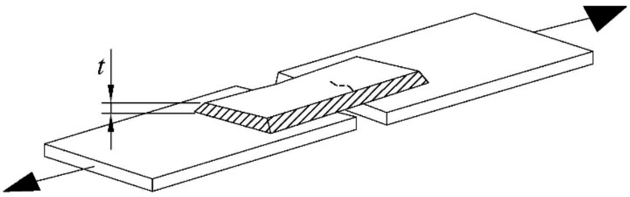
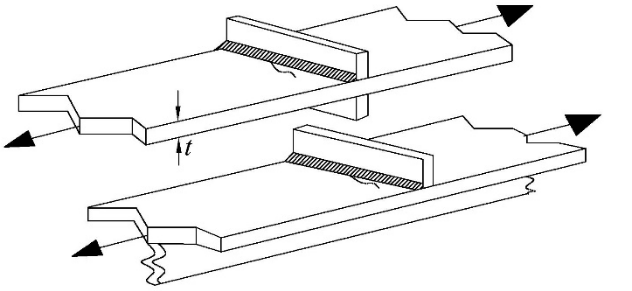
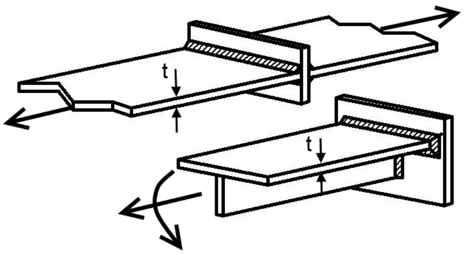
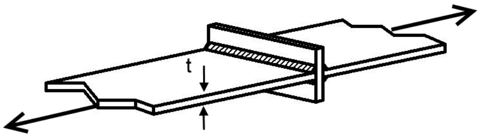
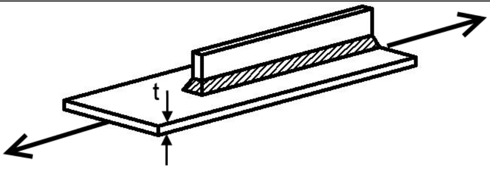
12 Three **new appendices** are introduced reading as follows:

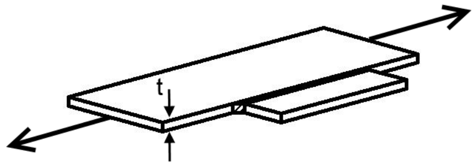
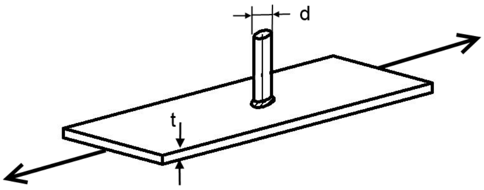
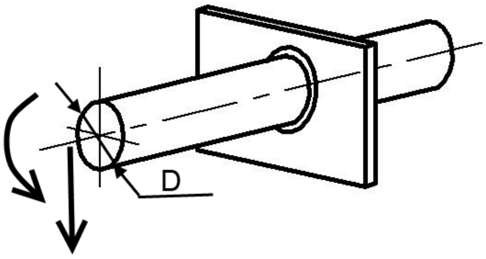
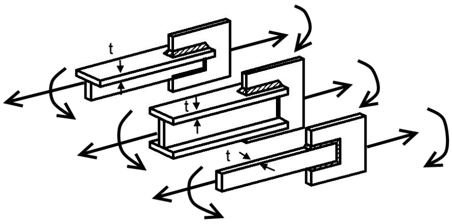
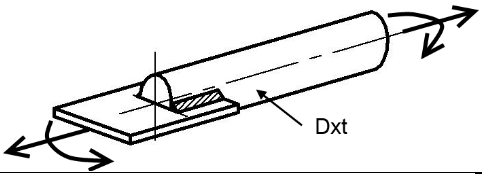
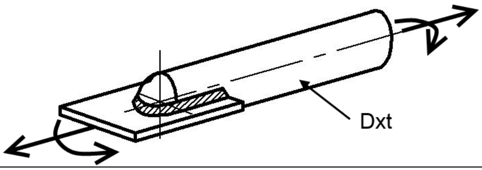
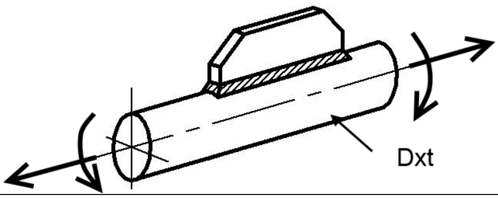
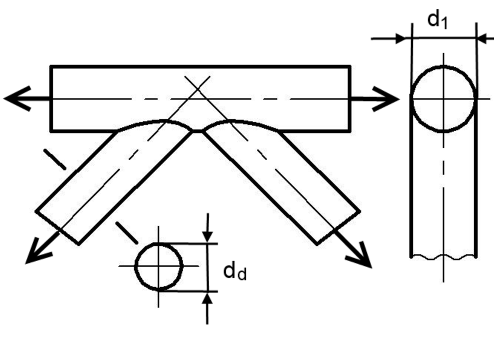
CLASSIFICATION OF METAL STRUCTURAL COMPONENTS BY FATIGUE STRENGTH LEVELS

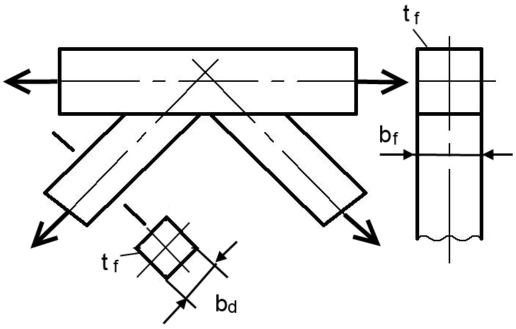
1		Edge of rolled plate after gas cutting (QN = machine gas and plasma-arc cutting)	QL	5
			QN	4
			QH	3
2		Edge of rolled plate cut by shearing or guillotining	-	5
3		Drilled hole. Effective section stresses	-	4
4		Bolted connection using high-strength bolts	-	5
5		Bolted connection using shear bolts	-	7
6		Longitudinal butt joint or T-joint groove weld (QN = automatic welding)	QL	4
			QN	3
			QH	2
7		Longitudinal joint of plates by fillet square welds	-	4

8		The same at fillet weld failure (τ_{-1K})	-	7
9		Longitudinal joint of roll-formed sections by butt square welds	QL	6
			QN	5
			QH	4
10		Butt joint of plates of the same thickness and width	QL	5
			QN	4
			QH	3
11		Backing butt joint of plates	-	6
12		Bevel butt joint of plates of different thickness	QL	6
			QN	5
			QH	4
13		Square butt joint of plates of different thickness at $t_1/t \leq 1{,}2$	-	7
14		Butt joint of plates of different width	QL	8
15		Butt joint crossed by longitudinal butt or fillet weld	QL	6

			QN	5
			QH	4
16		Butt joint of members of rolled shape	QL	6
			QN	5
			QH	4
17		Butt joint of rectangular hollow sections	QN	7
18		Butt joint of pipes on backing ring (*a*), joint with rolling of edges (*b*)	QL	7
			QN	6
19		Thimble joint (solid or two halves)	QL	7
			QN	6
			QH	5
20		Attachment of pipe to forging	Option *a*	8
			Option *b*	7

21		Pad welded with end fillet welds	QL	8
			QN	7
			QH	6
22		Overlap joint with end fillet welds or end-and-slide lap welds (end fillet + side fillet)	QL	8
			QN	7
			QH	6
23		Overlap joint of plates with side fillet welds	QL	10
			QN	9
24		Cross member	QL	7
			QN	6
			QH	4
25		T-joint, double-sided with root penetration. Parent metal failure	QL	8
			QN	7
			QH	6
26		Square T-joint, double-sided. Parent metal failure	-	9
		Weld failure (τ_{-1K})	-	7
27		End of longitudinal member with seal welding of butt	QL	8
			QN	7

28		Gusset welded to edge of loaded strip	QL	8
29		Welding of bar to plate at $d/t \leq 2$	-	7
30		Bar welded into wall hole	QL	7
			QN	6
			QH	5
		The same at fillet weld failure (τ_{-1K})	-	7
31		Attachment of shaped sections to gusset with side fillet welds or end-and-slide lap welds	QL	10
			QN	9
32		Attachment of pipe with right-angled end to gusset. Pipe failure	-	10
33		Attachment of domed pipe to gusset. Pipe failure	-	9
34		Attachment of gusset to pipe. Pipe failure	-	9
35		Chord of tube truss at $d_d/d_f = 0{,}6 \div 1$; d – diameter, t – thickness, index f – chord, index d – brace	$t_f/t_d = 1$	10
			$t_f/t_d \geq 2$	8

36		Chord of tube truss at $b_d/b_f = 0,6 \div 1$	$t_f/t_d \geq 2$	10

First category (QL) is low-quality welded assemblies. This category includes the assemblies that meet the specified requirements, i.e., made with high-quality welding materials, without unacceptable defects, with butt welds going onto run-off tabs, however, having the maximum allowable convex shape of the welds, with undercuts and offset edges of acceptable size, welded without stripping the surface of rolled products from scale in the pass area. The quality control of these joints is carried out by visual inspection.

Second category (QN) is quality welded assemblies. This group includes welded assemblies with fine-grain surface of welds having a slightly convex, straight or concave (for fillet welds) shape, without undercuts and edge offsets. The ends of the longitudinal fillet welds (for example, the end of the longitudinal stiffener) are seal-welded around the end face of the member to be welded without detaching the electrode. Welds are made on the rolled product surface cleaned from scale, the absence of internal defects is confirmed by flaw detection or by regular testing of the welding technology.

Third category (QH) is high-quality welded assemblies. This group includes welded assemblies that meet the requirements of category (No.), after welding subjected to additional technological treatment aimed at increasing fatigue resistance, for example, mechanical, surface-plastic or argon-arc.

ASSESSMENT PROCEDURE FOR TECHNICAL CONDITION OF METAL STRUCTURES OF CARGO HANDLING GEAR BASED ON CRITERION OF FATIGUE CRACK PROPAGATION TO CRITICAL SIZE IN TERMS OF STRENGTH (HEREAFTER REFERRED TO AS CRACK RESISTANCE ASSESSMENT)

1 This procedure is designed to assess and provide the crack resistance margin of steel structures of cargo handling equipment under operational loading at design stage, as well as when diagnosing equipment in operation.

2 The application of the procedure is limited to structural members of simple sections: strip, angle piece, channel, provided that the crack does not extend beyond one member of the chord or wall, and also when ratio $\alpha = a/B$ (a – crack length, B – member width) is limited (see Fig. 6.1). For structural members with more complex sections, numerical solutions (finding *K*-calibration) shall be used.

3 Structural members may be assessed that have more complex sections: box-shaped or I-section beams, provided that the crack does not extend beyond one member (chord or wall of width *B*) and its size does not exceed ratio $\alpha = a/B < 0.1$.

4 The assessment of crack resistance is made for nodes located in the most loaded main sections.

5 The assessment of crack resistance includes the determination of the critical size (length) of crack a_C and the crack resistance margin under cyclic loading expressed as a number of loading cycles Z_a until the crack reaches the critical size.

6 Determination of K-calibration factor ξ_K.

6.1 To assess crack resistance, factor ξ_K (K-calibration) shall be calculated that depends on $\alpha = a/B$ (where a – current crack length, B – width of structural member) and loading conditions (refer to Fig. 6.1).

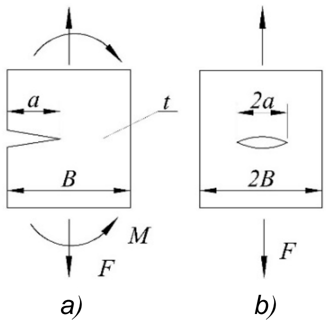


Fig. 6.1
Diagram for calculation of factors ξ_K in bodies with cracks

6.2 In structural members of simple sections in the form of strip, angle piece, channel, the following approximate analytical formula may be used subject to limited values of ratio $\alpha = a/B$. Ratio α is necessary to calculate the nominal stresses and K-calibration.

Also, Formulas (6.1-1.2, 6.2) may be used for structural members with more complex sections: box-shaped or I-section beams if the crack does not extend beyond one member (chord or wall of width *B*) and its size does not exceed $\alpha = a/B < 0.1$, or numerical solutions of the problem may be used.

6.2.1 For a strip with an edge crack with ratio $\alpha = a/B < 0.7$ (refer to Fig. 6.1, a):
under tension by force *F*:

$$\xi_K = 1{,}12 - 0{,}231\alpha + 10{,}55\alpha^2 - 21{,}72\alpha^3 + 30{,}39\alpha^4 \quad (6.2.1\text{-}1)$$

under bending by moment M (refer to Fig. 6.1, *a*):

$$\xi_K = 1{,}12 - 1{,}40\alpha + 7{,}33\alpha^2 - 13{,}08\alpha^3 + 14{,}0\alpha^4 \quad (6.2.1\text{-}2)$$

6.2.2 For a strip with a central crack under tension conditions with ratio *α* = *a/B* < 0.8 (refer to Fig. 6.1, *b*)):

$$\xi_K = cos^{-0,5}(0,5\pi\alpha), \tag{6.2.2}$$

where *α* = *a/B*,

here *a* = half the crack length, *B* - half the width of calculated member (Fig.6.1).

7 Critical crack size a_C under single loading is calculated by selecting its value until the inequality is satisfied

$$\xi_K \sigma_{MAX}\sqrt{\pi a_C} \leq \gamma_n \gamma_{dc} K_C \tag{7-1}$$

where ξ_K = factor of K-calibration (refer to para 6);

σ_{MAX} = maximum cycle stress, MPa;

γ_n = reliability factor by purpose of the structure or its member (to be taken according to Table 2.3.2.1-2);

K_c = stress intensity factor is calculated by the formula:

$$K_C = [1 + c(T_Э - T_0)]K_{C*}\left(\frac{t_0}{t}\right)^{0,2} \tag{7-2}$$

where $T_э$ = operating temperature of structure, °C; T_0 =20^{0}C test temperature of a steel sample;

c = factor depending on material properties (refer to Table 7);

K_c^2 = critical value of the stress intensity factor determined during testing of a steel sample with a thickness of t_0 = 20 mm at a temperature of T_0 = 20 °C (refer to Table 7);

Table 7

Values of crack resistance characteristics

Steel grade[1]				K_c^2, MPa m$^{0.5}$	*c*
Russia	Germany	Japan	China		
Ст3кп	USt 37-2, USt 37-2 G, RSt37-2	-	A3, Q235A, Q235A-F	80	0.009
Ст3нс				80	0.006
Ст3сп	St 37-3, St 37-3 G, UZSt 37-2	SS34	-	80	0.005
1ОГ2С1	10MnSi7, 11MnSi6			90	0.003
О9Г2С	13Mn6, 9MnSi5	SB49	12Mn	100	0.003
14Г2АФ[1]				110	0.002
10ХСНД		S355J0WP		110	0.002

[1]When using steel of other grades, it is necessary to provide the validated values of factors K_c^2 and *c*.
[2]Rolled after heat treatment.

γ_{dc} = reliability coefficient of the calculation method (if the crack develops along the base metal of the structure, refer to Fig. 7, *a*–*c*, then γ_{dc} =0.85, if the crack passes through the weld or near-weld zone, then γ_{dc} = 0,75 refer to Fig. 7, *d* and *e*.

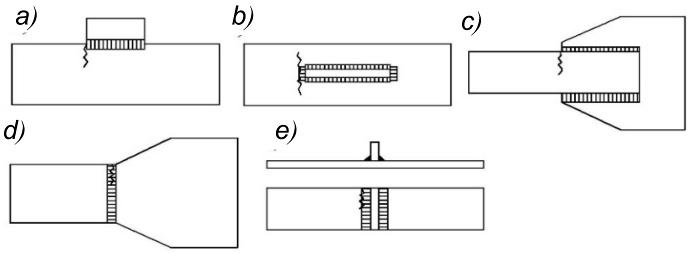


Fig. 7 Examples of joints with cracks propagating through parent metal (*a* - *c*) and along welded joint (*d*, *e*)

8 Calculation of crack resistance margin under cyclic loading.

8.1 When $\alpha = \alpha_C / B < 0.2$, a number of loading cycles until the critical state is reached is determined by the formula:

$$Z_a = \frac{\gamma_{dn}(\gamma_n \gamma_m \Delta K_*)^q}{(0,5q-1)\zeta_{ea} V_*(\xi_K \Delta\sigma\sqrt{\pi})^q}\left[\frac{1}{a_0^{0,5q-1}} - \frac{1}{a_C^{0,5q-1}}\right] \tag{8.1-1}$$

where γ_{dn} = reliability factor of calculation procedure (for crack passing through weld γ_{dn} = 0.80–0.95, along heat effected zone γ_{dn} = 0.60–0.75);

γ_n = reliability factor by purpose of the structure or its member (to be taken according to Table 2.3.2.1- 2);

q =3 = exponent of fatigue curve;

a_0 = initial size of crack, m;

a_C = critical size of crack, m;

ΔK = stress intensity range, it is determined experimentally depending on the steel grade, if it is impossible to conduct an experiment, according to the formula:

$$\Delta K_* = 0{,}05\sigma_в - 9 \qquad (8.1\text{-}2)$$

where $\sigma_в$ = ultimate strength of material, MPa.

ζ_{ea} = cyclic loading factor for structural member with crack is determined by Formula (8.1-3), which can be used in the absence of direct experimental data:

$$\zeta_{ea} = \sum_i \left[\left(\frac{\Delta\sigma_i}{\Delta\sigma_I}\right)^q Z_i\right] \qquad (8.1\text{-}3)$$

where i = sequential number of loading block;

$\Delta\sigma_i$ = stress range of individual stage of non-stationary loading block, MPa (refer to Fig. 8.1);

Z_i = number of cycles corresponding to stress range $\Delta\sigma_i$;

$\Delta\sigma_I$ = greatest stress range in non-stationary loading block, MPa. (refer to Fig. 8.1);

q =3 = exponent of fatigue curve.

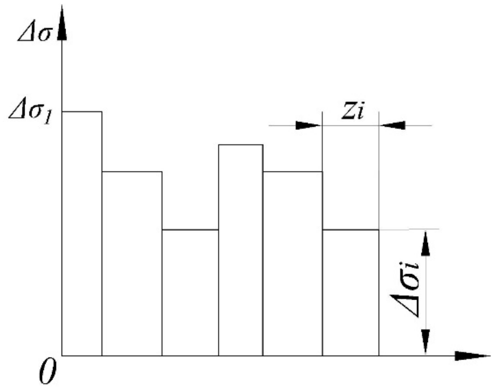


Fig. 8.1
Diagram of ultimate stresses

8.2 The general dependence of the calculation of a number of loading cycles required for crack growth from size a_O to a_C at $\alpha > 0.2$ is calculated by numerically integrating the following equation:

$$Z_a = \frac{\gamma_{dn}(\gamma_n\gamma_m\Delta K_*)^q}{\zeta_{ea}V_*(\Delta\sigma_1\sqrt{\pi})^q}\int_{a_0}^{a_C}\frac{da}{[\xi_K(\alpha)\sqrt{a}]^q} \qquad (8.2)$$

ASSESSMENT PROCEDURE FOR TECHNICAL CONDITION OF METAL STRUCTURES OF CARGO HANDLING GEAR WHEN CORROSION WEAR EXCEEDS MORE THAN 10 % IN TERMS OF STRENGTH

1. This procedure is designed to assess the technical condition of metal structures subjected to continuous uniform corrosion.

2. When preparing for the assessment, it is necessary to calculate the minimum load-bearing capacity of the structural member being studied in accordance with 2.3 of these Rules in order to determine and compare the effective and ultimate stresses:

for compression members according to the buckling failure criterion in accordance with 2.3.3 of these Rules;

for tension members according to the structural strength criterion in accordance with 2.3.2 of these Rules and, if necessary, fatigue strength (based on unlimited fatigue strength $N_0=2\cdot10^6$) in accordance with 2.3.4 of these Rules;

calculate the minimum allowable member thickness t_{min} corresponding to the minimum bearing capacity.

3. Measure the section thickness at least 8–10 times on one member in the corrosion damage zone;

Using the obtained measurements, calculate the arithmetic mean of section thickness t_y.

4. Corrosion damage $K_П$ is determined by the formula:

$$K_d = \frac{A_n - A_{cor}}{A_n} \times 100\% \qquad (4\text{-}1)$$

where A_n = nominal cross-sectional area of the member, mm^2;
A_{cor} = calculated cross-sectional area of structural member in case of surface corrosion, [mm^2], it is calculated by the formula:

$$A_{cor} = (1 - k_{cs}\Delta_{el})A_n \qquad (4\text{-}2)$$

where k_{cs} = section unification factor equal to a ratio of perimeter to cross-sectional area of the member, mm^{-1};
Δ_{el} = average thinning value of the member (thickness loss by member), [mm], it is determined by the formula:

$$\Delta_{el} = t_0 - t_y, \qquad (4\text{-}3)$$

where t = arithmetic mean of section thickness based on measurement results;
t_0 = initial section thickness, mm;

5. Assessment of the technical condition is made by determining remaining life T_r according to the formula:

$$T_r = \frac{t_{min}}{V_{cor}}.. \qquad (5\text{-}1)$$

where t_{min} = minimum allowable thickness of the member, mm;
V_{cor}= average corrosion rate, [mm/year], it is determined by the formula:

$$V_{cor} = \frac{\Delta_{el}}{T_0} \qquad (5\text{-}2)$$

where T_0 = service life of the structural member by the time of the survey, year.".