CHINA CLASSIFICATION SOCIETY

RULES FOR CONSTRUCTION AND CLASSIFICATION OF SEA-GOING HIGH SPEED CRAFT

AMENDMENTS

2017

Effective from 1 July 2017

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CHAPTER 2 SCOPE AND CONDITIONS OF CLASSIFICATION

Section 1 General Requirements

A new subparagraph 2.1.3.1(4) is added as follows:

“(4) Open sea service restriction means the service in the sea area within 300 nautical miles off the shore, and a passenger craft does not proceed in the course of its voyage more than 4 h, or a cargo craft 8 h, at operational speed from a place of refuge when fully laden. Where the sea state of some service areas above-mentioned is heavier, more stringent requirements may be made by CCS to the distance above-mentioned, depending on the specific cases. When special provisions for the service area are stipulated by the Administration of the flag State or by the coastal Authority in charge of the service area, the provisions are to be observed.”

The existing subparagraph 2.1.3.1(4) and the subsequent subparagraphs are renumbered accordingly.

A new subparagraph 2.1.3.1(14) is added after existing subparagraph 2.1.3.1(13) as follows:

“2.1.3.1(14)   A trimaran means a vessel with three hulls of displacement form, a main center hull stabilized by two much smaller side hulls, and three hulls are connected by cross deck structure. ”

The existing subparagraph 2.1.3.1(14) and the subsequent subparagraphs are renumbered accordingly.

Section 3 Characters of Classification and Class Notations

All descriptions related to CSAD and CSMD in this Section are deleted.

The explanation on the meanings of characters of classification in the existing paragraph 2.3.1.3 is revised as follows:

“The meanings of the characters of classification are:

★CSA ─ indicating that the structure and equipment of the craft have been constructed with plan approval by and under the supervision of CCS, and found to be in full compliance with CCS rules~~ and to comply with the requirements of the International Code of Safety for High-speed Craft~~.

★CSA ─ indicating that the structure and equipment of the craft have not been constructed with plan approval by and under the supervision of CCS, but they have been found after classification survey by CCS to be in compliance with CCS rules~~ and to comply with the requirements of the International Code of Safety for High-speed Craft~~.

★CSM ─ indicating that the product surveys for craft’s propulsion and essential auxiliary machinery have been carried out by CCS, the craft’s machinery and electrical installations have been constructed with plan approval by and under the supervision of CCS, and found to be in compliance with CCS rules ~~and to comply with the requirements of the International Code of Safety for High-speed Craft~~.

★CSM ─ indicating that the product surveys for craft’s propulsion and essential auxiliary machinery have not been carried out by CCS, but the craft’s machinery and electrical installations have been constructed with plan approval by and under the supervision of CCS, and found to be in compliance with CCS rules~~ and to comply with the requirements of the International Code of Safety for High-speed Craft~~.

★CSM — indicating that the craft’s machinery and electrical installations have not been constructed with plan approval by and under the supervision of CCS, but they have been found after classification survey by CCS to be in compliance with CCS rules~~ and to comply with the requirements of the International Code of Safety for High-speed Craft~~.”

The existing Table 2.3.2.3(1) is revised as follows:

“ **Table 2.3.2.3(1)**

No.	Type Notations	
	Chinese	English
1	高速单体船	Mono-Hull HSC
2	高速双体船	Catamaran HSC
3	高速三体船	Trimaran HSC
4	穿浪双体船	Wave Piercer Craft
5	高速水面效应船（侧壁气垫船）	Surface Effect Ship
6	全垫升气垫船	Air Cushion Vehicle
7	水翼船	Hydrofoil Craft

”

The existing Table 2.3.2.3(3) is revised as follows:

“ **Table 2.3.2.3(3)**

No.	Service Restriction Notations	
	Chinese	English
1	远海营运限制	**Open Sea Service Restriction**
2	近海营运限制	**Greater Coastal Service Restriction**
3	沿海营运限制	**Coastal Service Restriction**
4	遮蔽营运限制	**Sheltered Water Service Restriction**
5	平静水域营运限制	**Calm Water Service Restriction**

”

Section 5 Submission and Examination of Plans and Surveys

In the existing paragraph 2.5.1.1, the words “(in paper or electronic form)” are newly added after “plans and documents”.

Section 7 Assignment, Maintenance, Suspension, Cancellation and Reinstatement of Class

The existing subparagraph 2.7.2.1(4) ③a(d) is deleted.

A new subparagraph 2.7.2.1(4)④ is added as follows:

“④ when it is confirmed that the Surveyor has boarded the ship before the survey is due, but the ship is put into service before the satisfactory completion of the corresponding overdue survey.”

CHAPTER 3 MARINE PRODUCTS INSPECTIONS AND CRAFT’S SURVEYS

Section 1 Plan Approval

The content of subparagraph 3.1.2.1(1) is moved to paragraph 3.1.2.2 for information, i.e. a new subparagraph 3.1.2.2(9) is added as follows:

“(9) Strength calculations or scantling calculations according to the Rules, including hull girder strength, hull transverse strength and local strength;”

The words “and strength calculations” in subparagraph 3.1.2.1(19) are deleted and a new subparagraph 3.1.2.2(10) is added as follows:

“(10) Strength calculations of steering system.”

In the existing paragraph 3.1.2.1, “bow construction” is newly added.

The existing subparagraph 3.1.2.3(27) is deleted.

Section 2 Inspections of Marine Products

A new paragraph 3.2.1.4 is added as follows:

“3.2.1.4 The manufacturer’s certification of main engine foundation bolts of high speed craft submitted by the shipyard may be accepted by the Surveyor.”

Section 3 Surveys during Construction

New words “or welding” are added after “riveting” in subparagraph 3.3.4.1(1)④.

A new subparagraph 3.3.4.1(1)⑤ is added as follows:

“⑤ butt welds of steel-aluminum transition joints on exposed deck.”

Section 4 Surveys after Construction

The existing subparagraph 3.4.3.3(2)⑤ is deleted and a new subparagraph 3.4.3.3(3) is added as follows:

“(3) At periodical intervals not exceeding 5 years, a lightweight survey is to be carried out on all passenger craft to verify any changes in lightweight displacement and longitudinal center of gravity. The passenger craft is to be re-inclined whenever, in comparison with the approved stability information, a deviation from the lightweight displacement exceeding 2%, or a deviation of the longitudinal center of gravity exceeding 1% of L is found or anticipated.”

CHAPTER 4 STRUCTURE OF HULL

Section 1 General Requirements

The existing paragraph 4.1.1.1 is replaced by the following:

“4.1.1.1 This Chapter applies to hull structures made of aluminum alloy, steel and fiber reinforced plastics for monohull high speed craft, various high speed catamarans (including normal catamaran, wave piercer craft and SES), high speed trimarans, hydrofoil craft, ACV, etc., except for SWATH and WIG craft.”

A new paragraph 4.1.3.7 is added as follows:

“4.1.3.7 Stiffened plate means the structural member formed by combination of plate and single-direction member.”

Section 2 Structure Design Principles

The existing paragraph 4.2.1.1 is replaced by the following:

“4.2.1.1 Longitudinal framings are generally adopted for hull structures of monohull craft or hydrofoil craft. For hull structures of various catamarans, the two hulls are usually longitudinal framings. Transverse framings are generally adopted for two side hulls of trimarans. For side hulls contributing to hull girder strength complying with 3.1.1.2 of Appendix 4, longitudinal framings are to be considered.”

The existing paragraph 4.2.2.7 is replaced by the following:

“4.2.2.7 The span of the cross deck between two hulls of the wave piercer craft is relatively large so the transition is to be made by large brackets in the connections of the cross deck to two hulls and the symmetric positions of two hulls, to avoid stress concentration resulting from abrupt change in structure. The plate thickness and scantlings of members in such positions are to be appropriately increased. The scantlings may be determined by direct calculations in Section 10 of this Chapter. The cross deck and side hulls of trimaran are connected in accordance with the provisions for wave piercer craft.”

A new paragraph 4.2.2.9 is added as follows:

“4.2.2.9 The cross deck structure of trimaran is to comply with following requirements:

(1) Cross deck length structural arrangements are to be sufficient to provide effective integration of the side hulls to the main hull.

(2) Continuity of transverse structural strength is to be maintained. All primary transverse members are to be continuous through the side hull and integrated into transverse bulkheads or other primary structure within the main hull.

(3) Proper structural arrangements are to be made in way of the connection of the forward and aft ends of the cross deck to the main hull to ensure effective integration and good transition to eliminate welding. For cross deck and side hulls contributing to hull girder strength complying with 3.1.1.2 of Appendix 4, in order for the full breadth of the deck structure (including main deck, cross deck and side hull deck) to be effective in longitudinal bending, the taper ratio of cross deck connecting main hull to side hull, is to be 3:1 or greater.

(4) Effective connection between the wet-deck and hull is to be ensured with good transition to eliminate welding.”

Section 3 Watertight Integrity and Tests

The existing subparagraphs 4.3.3.2(6) is replaced by the following:

"(6) Rectangle windows are permitted to be fitted in walls of the spaces above the freeboard deck except in front wall of first tier superstructure for craft navigating in open sea and greater coastal service restriction (if side scuttles are fitted, requirements of above (5) are to be met), but they are to be fitted with portable deadlights according to Table 4.3.3.2. The deadlights are to be made of metal or composite material, the strength of which is to be the same as their surrounding structure, and to be stowed in such a way as to provide quick mounting.

Table 4.3.3.2

Service restriction	Number of deadlights/Number of windows	
	Superstructure front 1st tier	Superstructure side 1st tier Superstructure front 2nd tier
OSSR	No permission	One for each type of windows
GCSR	No permission	
CSR	50%	One for each type of windows①
SWSR	25%	
CWSR	—	

Note: ① If impracticable, other measures (e.g. provision of canvas) may be adopted to prevent windows from being damaged and protect personnel from wind and wave."

Section 4 Design Loads

The existing subparagraph 4.4.1.2(1) is replaced by the following:

"(1) For various type craft other than ACV:

$$a_{cg} = \frac{K_T}{426}\left(\frac{V_H}{\sqrt{L}}\right)^{1.4}\left(\frac{H_{1/3}}{B_{WL}}+0.07\right)(50-\beta)\left(\frac{L}{B_{WL}}-2\right)\frac{B_{WL}^3}{\Delta}g \qquad \mathrm{m/s^2}$$

where: g — acceleration of gravity, g = 9.81 $\mathrm{m/s^2}$

V_H — speed navigating at sea with significant wave height $H_{1/3}$, in kn;

$H_{1/3}$ — significant wave height, in m;

β — deadrise angle at LCG (°), β_{max} = 30°; β_{min} = 10°;

For trimaran, it is to be selected according to main hull.

The value β refers to Figure 4.4.1.2 (1). In the figure, (a), (b) and (c) are to be sharp chine craft, (d) and (e) are to be rounded chine craft;

K_T — hull type factor, determined according to the hull type:

K_T = 1 for monohull, normal catamaran, wave piercer craft and trimaran;
K_T = 0.8 for SES;
K_T = 0.7 for hydrofoil craft."

The existing paragraph 4.4.1.3 is replaced by the following:

"4.4.1.3 A series of significant wave heights $(H_{1/3})_1$ ~ $(H_{1/3})_i$ which may be encountered by the craft is assumed by design unit according to the craft's service restriction. The maximum value $H_{1/3\ \max}$ of the assumed wave heights is not to be more than the following values:

$H_{1/3\ \max}$ = 7.0 m for OSSR;
$H_{1/3\ \max}$ = 6.0 m for GCSR;

$H_{1/3\ \max} = 4.0$ m for CSR;
$H_{1/3\ \max} = 2.0$ m for SWSR;
$H_{1/3\ \max} = 1.0$ m for CWSR."

The existing paragraph 4.4.2.1 is replaced by the following:

"4.4.2.1 This provision applies to craft whose parts of hull immerse in seawater at high speed in fully laden condition, such as monohull craft, normal catamarans, wave piercer craft, trimarans and SES. Their bottoms will withstand the slamming force. The bottom means the area extending from the keel line to chine, upper turn of bilge or pronounced spray rail."

The existing paragraph 4.4.3.1 is replaced by the following:

"4.4.3.1 "Cross deck bottom" means the bottom surface of cross deck structure between two hulls of catamarans and the bottom of ACV or hydrofoil craft above water. For trimaran, cross deck bottom means the bottom surface of cross deck structure between two side hulls and main hull above water. This structure will withstand the slamming force when the craft sails at sea with high speed."

The existing paragraph 4.4.4.1 is replaced by the following:

"4.4.4.1 Pressure P_i acting on side is to be taken as:

$$P_i = 9.81h + 0.15P_{sl} \quad \text{kN/m}^2$$

where: h — vertical distance from the load point to upper deck, in m, which is not to be less than 0.8 m, but not more than 0.8 times the extent of side;
P_{sl} — slamming pressure on bottom in the same frame, in kN/m^2:
$P_{sl} = P_{sl2}$ for ACV and hydrofoil craft (see 4.4.3.2);
$P_{sl} = P_{sl1}$ for other craft (see 4.4.2.2).

Where the angle of forebody side flare at the considered point of trimaran is more than 22º, the pressure P_i is to be determined by the following formula:

$$P_i = 9.81h + K_h[64.6 - 0.95(90 - \alpha)]H_{1/3} \quad \text{kN/m}^2$$

where: h — vertical distance, in m, from the considered load point to upper deck, not less than 0.8 m, nor more than 0.8 times the height at side;
α — angle, in degrees, between vertical line and tangent of the transverse section line at the considered point;
k_h — coefficient, determined according to the longitudinal position of the considered point as follows:
$k_h = 0.85$ from $0.5L$ to $0.75L$;
$k_h = 2.0$ $0.85L$;
$k_h = 2.5$ from $0.95\,L$ to L;
For other area, k is to be obtained by linear interpolation;
$H_{1/3}$ — design significant wave height relating to service restriction area, in m, see 4.4.1.3."

The existing paragraph 4.4.4.2 is replaced by the following:

"4.4.4.2 Pressure P_{d1} acting on exposed deck is to be taken as:

$$P_{d1} = K_{l3}(0.2L + C) \quad \text{kN/m}^2$$

where: K_{l3} — longitudinal pressure distribution factor:
$K_{l3} = 1.0$ for forward of amidcraft,
$K_{l3} = 0.75$ for stern,
factors between midcraft and stern is to be obtained by linear interpolation;

C — service restriction coefficient:
$C = 10.6$ for OSSR,
$C = 7.6$ for GCSR and CSR,
$C = 4.6$ for SWSR and CWSR."

The existing paragraph 4.4.4.3 is replaced by the following:

"4.4.4.3 Pressure P_{d2} acting on unexposed freeboard deck, unexposed deck of first tier superstructure/ deckhouse and inner deck contributing to global strength is to be taken as:

$$P_{d2} = 0.1L + 4.6 \quad \text{kN/m}^2\text{"}$$

The existing paragraph 4.4.4.4 is replaced by the following:

"4.4.4.4 Pressure P_d acting on other unexposed deck is to be taken as:

$$P_d = 4.5 \quad \text{kN/m}^2\text{"}$$

The existing paragraph 4.4.4.6 is replaced by the following:

"4.4.4.6 Pressure P_{sd} acting on superstructures and deckhouses

(1) Pressure acting on end and side walls of superstructure and deckhouse is to be taken as:

$$P_{sd} = 15.6K_1K_2(CL + 0.8 - 0.3h) \quad \text{kN/m}^2$$

where: K_1 — location factor, to be taken as follows:
$K_1 = 1.0$ for fore end wall of first tier superstructure;
$K_1 = 0.75$ for fore end wall of second tier superstructure;
$K_1 = 0.5$ for side and aft end walls of superstructure and deckhouse.
K_2 — location factor, obtained according to the location of superstructure and deckhouse:
$K_2 = 1.0$ for area of forward amidcraft;
$K_2 = 0.75$ for area of aft amidcraft.
C — service restriction coefficient:
$C = 0.058$ for OSSR;
$C = 0.047$ for GCSR and CSR;
$C = 0.035$ for SWSR;
$C = 0.024$ for CWSR.
h — vertical distance from load point to full load water line, in m. For ACV, h is to be vertical distance from load point to skirt base line."

Section 5 Scantlings of Hull Structure Made of Aluminum or Steel

The existing paragraph 4.5.2.1 is replaced by the following:

"4.5.2.1 Minimum thickness t_{min} of plating is to be taken as follows:

~~$t_{\min} = K_0\sqrt[3]{L}$ mm for monohull craft and catamaran (excluding SES)~~

~~$t_{min} = 0.85K_0\sqrt[3]{L}$ mm for SES and hydrofoil craft~~

~~$t_{\min} = 0.8K_0\sqrt[3]{L}$ mm for ACV~~

$$t_{min} = \frac{K_0 K_1 \sqrt[3]{L}}{\sqrt{\sigma_s}} + 1.5 \qquad \text{mm}$$

where: K_0 — coefficient, obtained from Table 4.5.2.1. For trimaran, the value of strength deck contributing to longitudinal strength is to be taken as that of main deck plating;

K_1 — coefficient, $K_1 = s/s_b$, to be taken as not less than 0.5 nor greater than 1.0;

s — spacing of members, in m;

s_b — standard spacing of members, in m, $s_b = 0.0016L + 0.2$;

L — craft length, in m;

σ_s — yield strength of material, in N/mm^2, see 4.5.1.3 of this Section. For aluminum alloy, it is to be taken as not greater than 70% of tensile strength.

The minimum thickness of plate keel for monohull~~ and~~, catamarans and trimarans is to be increased by 2 mm over the above value. The width of plate keel is not to be less than 0.1B (for catamarans, B is the maximum molded width of one hull; for trimarans, B is the maximum molded width of main hull)~~, and is to be maintained over the whole length of the ship as far as practicable~~. Where it is impracticable for the bottom structure to be fitted with plate keel, other equivalent structures may be used as substitution.

Coefficient K_0 Table 4.5.2.1

Item		K_0	
		Steel	Aluminum
Bottom		12	15
Cross deck bottom		11	12
Side (up to 0.15 m above design waterline)		12	12
Side (more than 0.15 m above design waterline)		11	12
Main deck forward amidcraft		9	10
Main deck aft amidcraft		7	9
Unexposed deck plate		6	6
Collision bulkhead plate		8.5	11
Liquid tank bulkhead plate		8.5	9
Watertight bulkhead plate		8.5	8
Superstructure and deckhouse	Front	6.5	6.5
	Side, behind	5.5	5.5
	Top	4	3

The minimum plate thickness of main engine foundation (including face plate and web plate) of any type of high speed craft is to be calculated by $t_{min} = 1.9\sqrt[3]{L}$.

For craft with round chine, the bilge plating is divided by the point of intersection of the deadrise line β and round chine line (see Fig 4.4.1.2 (1)), the portion above the point is considered as the side plating, and the portion below the point is considered as the bottom plating."

Section 6 Scantlings of Hull Structure Made of FRP

The existing paragraph 4.6.1.1 is replaced by the following:

"4.6.1.1 This Section applies to the hull structure made of fabric reinforced plastics (FRP) (except for trimarans), in addition to the requirements of this Section, the scantlings of structural members are also to comply with the relevant requirements of Sections 8, 9 and 11 of this Chapter."

The existing paragraph 4.6.4.1 is replaced by the following:

"4.6.4.1 The total thickness t of a structural sandwich panel is not to be less than:

$$t = \frac{1.428}{K}\left(1+\frac{1}{\gamma}\right)\frac{sP}{\tau_C} \qquad \text{mm}$$

where: γ — ratio of the distance between centerlines of opposite skin laminates to the mean thickness of opposite skin laminates, ~~$6 \le \gamma \le 14$~~ $\gamma \ge 6$;
τ_c — ultimate shear stress of sandwich core material, in N/mm^2;
K — coefficient:
$K = 1.86 - 0.06\,\gamma$ and $K \nless 1$, for core of PU cellular plastic;
$K = 1.95 - 0.079\,\gamma$ and $K \nless 1$, for core of PVC cellular plastic;
$K = 1.0$ for core of plywood;
K is to be specially considered for core of other material."

The existing paragraph 4.6.6.2 is replaced by the following:

"4.6.6.2 The effective web plate area A_e calculated in accordance with the requirements of 4.6.6.1 above is not to be less than $A_{e\,\min}$ as follows:

~~$A_{e\,min} = \frac{25.5slP}{\tau_u}$~~

$$A_{e\,min} = \frac{25.5slP}{[\tau]} \quad \text{cm}^2$$

where: ~~τ_u — ultimate shear stress of member web, in N/mm^2.~~
$[\tau]$ — allowable shearing stress, in N/mm^2;
If the web plate is laminated plate, $[\tau]=\tau_u$;
If the web plate is sandwich panel, $[\tau]$ is the smaller of

$$[\tau] = 0.3\left(E_f^{45^0} E_c G_c\right)^{1/3}$$

$$[\tau] = 0.4\gamma G_c$$

Where: τ_u — ultimate shearing strength of laminate plate, in N/mm^2;
$E_f^{45^0}$ — compressing modulus of elasticity for the skin laminate of sandwich panel in 45° direction, in N/mm^2;
E_c — compressing modulus of elasticity of core material, in N/mm^2;
G_c — shearing modulus of elasticity of core material, in N/mm^2;
γ — see 4.6.4.1 of this Section."

Section 8 Hull Girder Strength

The existing paragraph 4.8.1.1 is replaced by the following:

"4.8.1.1 Monohull craft, catamarans, trimarans and ACVs with the length L not more than 50 m may be exempted from check of longitudinal strength of hull, provided that there is no ~~large~~ openings with breadth exceeding 0.25B (for trimarans, B is taken as the main hull breadth) on strength deck within 0.5L amidships (if several hatches are paratactic, B is the sum of breadth of each hatch), the ratio of L/D of the craft is less than 12 and local strength requirements for hull are complied with."

The existing paragraph 4.8.1.7 is replaced by the following:

“4.8.1.7 When the superstructure and deckhouse of a craft with notations OSSR and GCSR comply with the requirements specified in 4.8.7.1(2), it is considered that they make no contribution to the longitudinal strength of hull girder and their section modulus is not to be taken into account of the midcraft section modulus. And the measures to reduce the extent of contributing to the hull girder bending are to be adopted for the superstructure and deckhouse as practical as possible.”

A new paragraph 4.8.1.8 is added as follows:

“4.8.1.8 Check of overall strength of trimarans of more than 50 m in length is to be carried out in accordance with Appendix 4.”

In the existing paragraph 4.8.3.3, “v” is replaced by “V”.

The existing Table 4.8.6 is replaced by the following:

“ **Coefficient C_1, C_2 and C_3** **Table 4.8.6**

Service Restriction	C_1	C_2	C_3
Open Sea Service Restriction	0.182	0.250	0.125
Greater Coastal Service Restriction	0.155	0.200	0.100
Coastal Service Restriction	0.135	0.182	0.075
Sheltered Water Service Restriction	0.125	0.167	0.063
Calm Water Service Restriction	0.115	0.154	0.063

”

In the existing paragraphs 4.8.6.1 and 4.8.6.2, “M_t” is replaced by “M_{BX}”.

In the existing paragraphs 4.8.9.2(3), “τ_{cr} is critical shearing stress of the skin laminate of the sandwich panel” is replaced by “τ_{cr} is critical shearing stress of the sandwich panel”.

The existing paragraph 4.8.10.2 is replaced by the following:

“4.8.10.2 For a F.R.P craft, the moment of inertia I of midcraft section is to meet the requirements of the following formula:

~~$I > 4.0W_0L$~~ $I > 4.0K_EW_0L$ cm^4

where: $W_0 = \dfrac{M}{[\sigma]}$, in cm^3;

M — maximum longitudinal bending moment according to 4.8.2, 4.8.3 and 4.8.4, in kN·m;

$[\sigma]$ — the smaller of $[\sigma_p]$ and $[\sigma_b]$ specified in 4.8.9.2, in N/mm^2;

K_E — equivalent tensile modulus coefficient of material , $K_E = \dfrac{11000}{E_t}$.

where: E_t is equivalent tensile modulus of material, in MPa.”

Section 9 Stability of Structural Members

The existing paragraph 4.9.3.6 is replaced by the following:

“4.9.3.6 The allowable critical buckling stress $[\sigma_{cr}]$ for girder/web frame is to be calculated by the following formula:

$$[\sigma_{cr}] = \eta\sigma_{cr} \quad \text{N/mm}^2$$

where: σ_{cr} — critical buckling stress, see 4.9.3.4;

η — safety factor of stability, to be calculated as follows:

~~$\eta = \frac{K}{1+\frac{l}{r}}$~~ $\eta = \frac{K}{1+\frac{a}{r}}$

but η is not to be less than 0.3.
where: K — coefficient,
= 0.7, in general;
= 0.6, when design loads are primarily dynamic;
r — radius of inertia of section of girder/web frame, in cm;
~~l~~a — calculated span of girder/web frame, in m."

Section 10 Direct Calculation

The existing paragraph 4.10.1.1 is replaced by the following:

"4.10.1.1 In addition to complying with the Rule minimum plate thickness, hull structures of the following high speed craft ~~made of steel or aluminum~~ are to be subject to global structural strength verification by direct calculation in accordance with Appendix 2, Appendix 3 or Appendix 5 of the Rules as appropriate:

(1) Monohull craft ~~and~~, normal catamarans and trimarans of more than 50 m in length;

(2) Wave piercer craft;

(3) High speed craft of novel design or unusual form.

In addition to complying with the Rule minimum plate thickness, hull structures of the following high speed craft made of composite material are to be subject to global structural strength verification by direct calculation in accordance with Appendix 3 of the Rules:

(1) Monohull craft and normal catamarans of more than 30 m in length;

(2) Wave piercer craft;

~~(3) catamarans;~~

~~(4)~~ (3) High speed craft of novel design or unusual form."

The existing paragraph 4.10.1.4 is replaced by the following:

"4.10.1.4 The direct calculation is to be based on loads, combination conditions and allowable stresses as defined in Appendix 2, ~~or~~ Appendix 3 or Appendix 5 as appropriate."

Section 12 Weld Design for Metal Hull Structures

The existing paragraph 4.12.2.1 is replaced by the following:

"4.12.2.1 The arrangement of the weld ~~seam~~s is to take into account the structural continuity, and the restraint of the whole structure is to be minimized. Also, the weld ~~seam~~s are to be so arranged as to be convenient for the operation and inspection of welding."

The existing paragraph 4.12.2.2 is replaced by the following:

"4.12.2.2 The weld~~ seam~~s of hull structures are not to be arranged in the areas of maximum stress or areas liable to stress concentration. Sufficient transitional areas are to be arranged at positions where the section changes suddenly, and excessive concentration of weld~~ seam~~s are to be avoided. The parallel distance between butt welds and fillet welds is not to be less than 50 mm, and the parallel distance between butt welds is not to be less than 80 mm. "

A new paragraph 4.12.2.4 is added as follows:

"4.12.2.4 For welds connecting decks and boundaries for pantries, toilets, washrooms and battery rooms, continuous welding is at least to be used on the inside."

The existing paragraphs 4.12.2.4 and 4.12.2.5 are renumbered accordingly.

A new Section 14 is added as follows:

"Section 14 Supplementary Requirements for Aluminum Alloy Stiffened Plates

4.14.1 General requirements

4.14.1.1 In general, aluminum alloy stiffened plates are applicable to decks, bulkheads, superstructures and deckhouses.

4.14.2 Minimum plate thickness

4.14.2.1 Minimum plate thickness of stiffened plate structure of superstructures and deckhouses is not to be less than 2 mm, that of main hull deck in exposed area is not to be less than 3 mm, that in unexposed area is not to be less than 2.5 mm, that of main hull bulkhead is not to be less than 2.5 mm, and that of watertight bulkhead is not to be less than 3 mm.

4.14.3 Secondary members

4.14.3.1 The moment of inertia I of stiffened plate member is not to be less than the value calculated by the following formula:

$$I = 0.012Kl^2sP \qquad \text{cm}^4$$

where: K — see Table 4.5.3.1.

4.14.4 Suspended primary members

4.14.4.1 Primary members arranged in the vertical direction of stiffened plate member, if being suspended, are generally to use double side plate section (e.g. H-shaped aluminum, slot aluminum) rather than single side plate section (e.g. T section), and the effects of stiffened plate structure are not to be taken into account for section modulus calculation.

4.14.4.2 Primary members arranged in the parallel direction of stiffened plate member, if being welded with the face plate of stiffened plate member, may use single side plate section; if not being welded with stiffened plate member and being suspended, they are generally to use double side plate section (e.g. H-shaped aluminum, slot aluminum), and the effects of stiffened plate structure are not to be taken into account for section modulus calculation.

4.14.5 Weld design

4.14.5.1 For primary members arranged in suspension and in the vertical direction of stiffened plate member, the upper face plates are to be connected with the face plate of stiffened plate member by fillet welding (see Figure 4.14.5.1). The distance between both ends of weld and edges of the face plate of stiffened plate member is to be about 1 mm to 2 mm. The shear area of welds in way of throat (throat thickness h times weld length) is not to be less than that determined from the following formula:

$$A_e = 5.88SlP \qquad \text{mm}^2$$

where: S, P and l are the same as those in 4.1.3;

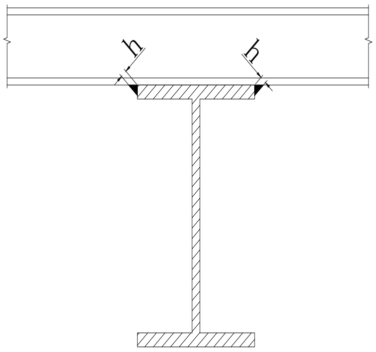

Figure 4.14.5.1 Connection of stiffened plate member and transverse primary member

4.14.5.2 If primary members arranged in the parallel direction of stiffened plate member are connected with the face plate of stiffened plate member by fillet welding, the welding coefficient within 0.2 span length at the end of primary member may be taken as 0.26; for other positions, it may be taken as 0.16. Web plates of primary member are to be in line with web plates of stiffened plate member as far as possible to ensure effective force transmission.

4.14.5.3 If stiffened plate structure is subject to longitudinal butt welding, the following requirements are to be complied with:

(1) When butt welds are on transverse primary members, one flat aluminum with equivalent height of stiffened plate member is to be welded on upper face plate of transverse primary member (see Figure 4.14.5.3a). Transverse primary members are to be connected with flat aluminum by fillet welding, and the welding coefficient is to comply with requirements for primary member web plate with the face plate. Welding of the face plate of stiffened plate member and the upper face plate on primary member is to meet the requirements of 4.14.5.1.The stiffened plate panel is to be beveled and welded with the flat aluminum, or the flat aluminum may be thickened or replaced by a small groove aluminum (see Figure 4.14.5.3b). Stiffened plate panels are to be subject to continuous plug welding.

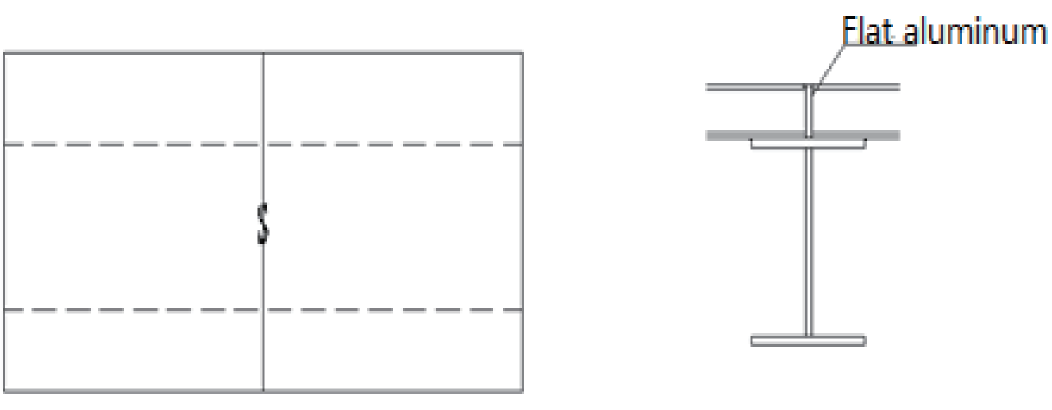

Figure 4.14.5.3a Connection of stiffened plate at transverse primary member (1)

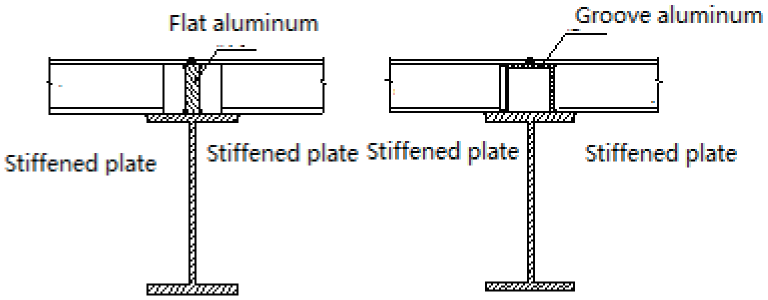

Figure 4.14.5.3b Connection of stiffened plate at transverse primary member (2)

(2) If butt welds are in way of transverse bulkhead, one flat aluminum lapped on the face plate of stiffened plate member is to be fitted on both sides of bulkhead plate respectively (see Figure 4.14.5.3c). Flat aluminum may be connected with bulkhead by single side welding. The face plate of stiffened plate member is to be welded with flat aluminum, with brackets fitted every 1 m, and the right angle side length of bracket is not to be less than 2 times member height. The stiffened plate panels are to be beveled and welded with the bulkhead. If the bulkhead uses a combination of suspended frame and bulkhead plate, the requirements of 4.14.5.3(1) are to be complied with.

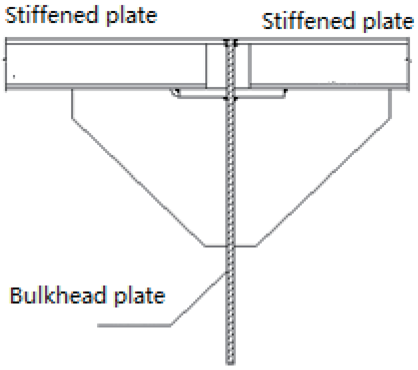

Figure 4.14.5.3c Connection of stiffened plate at transverse bulkhead

(3) If butt welds are not in way of transverse primary member or transverse bulkhead, one flat aluminum is to be used to connect stiffened plates. Stiffened plate members are to be connected with flat aluminum by fillet welding, and the welding coefficient is taken as 0.45. The stiffened plate panels are to be beveled and welded with the flat aluminum or the groove welding is used. Bridge brackets are to be fitted on each member between two stiffened plates (see Figure 4.14.5.3d). The bracket thickness is taken as the thickness of web plate of member, the bracket length is not to be less than 4 times the height of web plate of member, the bracket height is not to be less than the height of web plate of member, and the brackets are to be arranged evenly at both sides of connection as far as possible. The bridge brackets are to be connected with the face plate of member by fillet welding, and the welding coefficient is to be taken as 0.36.

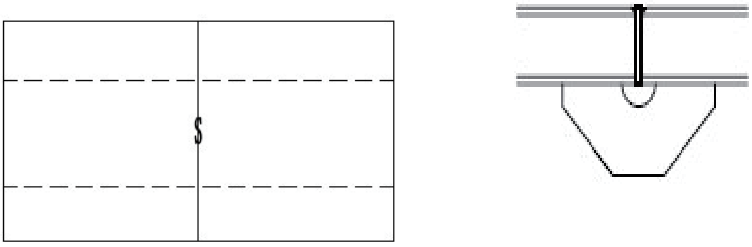

Figure 4.14.5.3d Connection of stiffened plate not at transverse primary member and transverse bulkhead ”

CHAPTER 5 EQUIPMENT AND OUTFITS

Section 1 Rudders

In the existing paragraph 5.1.2.1, “V – speed for calculation, V is to be taken as 0.9 times the service speed defined in 2.1.3.1(30), in kn;” is replaced by “V – maximum speed defined in 2.2.4.1, in kn;”.

The existing paragraph 5.1.2.3 is replaced by the following:

“5.1.2.3 When calculating the rudder force during backward running, the speed V in the formula is to be taken as the maximum astern speed of the craft.”

In the existing paragraph 5.1.8.1, “≮” in the formula is replaced by “≥”.

The existing paragraph 5.1.8.4 is replaced by the following:

“5.1.8.4 With metal bearings, clearances are not to be less than d_{b1} / 1000 + 1.0 mm on the diameter, where d_{b1} is inner diameter of bushing. If smaller clearance is used to maintain watertightness, bearings manufactured according to the standards accepted by CCS are to be used or the approval by CCS is to be obtained. If non-metallic bearing material is applied, the bearing clearance is to be specially determined considering the material’s swelling and thermal expansion properties. This clearance is not to be taken less than 1.5 mm on bearing diameter unless a smaller clearance is supported by the manufacturer’s recommendation and there is documented evidence of satisfactory service history with a reduced clearance.”

Section 2 of this Chapter is replaced by the following:

“Section 2 Anchoring and Mooring Equipment

5.2.1 Equipment number

The equipment number N is to be calculated by the following formula:

$$\cancel{N=\left(\Delta^{2/3}+2BH+\frac{A}{10}\right)K} \qquad \underline{N=\Delta^{2/3}+2BH+\frac{A}{10}}$$

where: Δ — fully loaded displacement, in t;

B — breadth, see 2.1.3.1(23), in m;

H — effective height from the waterline corresponding to Δ to the top of the uppermost deckhouse whose breadth exceeds $B/4$, in m, to be calculated as follows:

$$H=a+\sum h_i\sin\theta_i$$

a — vertical distance amidships from the waterline corresponding to Δ to the upper deck, in m;

h_i — height of each tier of the deckhouse whose breadth exceeds $B/4$, in m;

A — area in profile view of the hull, superstructures and the deckhouses whose breadth exceeds $B/4$ above the waterline corresponding to Δ, in m^2;

θ_i — angle (°) of inclination aft of the front bulkhead of each deckhouse tier corresponding to h_i;

~~K — coefficient, it is to be taken according to the service restriction:~~

~~K = 1.5 for greater coastal service restriction;~~

~~K = 1.2 for coastal service restriction;~~

~~K = 1.0 for sheltered water service restriction;~~

~~K = 0.7 for calm water service restriction.~~

For catamarans or trimarans, the cross-section area of the tunnel above the waterline is to be reduced from BH in the formula.

5.2.2 Anchoring equipment

5.2.2.1 At least an approved high holding power anchor is to be arranged at the bow. The weight of the anchor is not to be less than that obtained from Table 5.2.2 based on the equipment number. Where the anchor provided is ~~not high~~an ordinary holding power anchor, its weight is not to be less than 1.3 times the weight obtained from Table 5.2.2. An approved super high holding power anchor may be used in lieu of a high holding power anchor, and the weight of super high holding power anchor is not to be less than 2/3 times that of replaced high holding power anchor. Where two anchors are provided at the bow, the weight of each anchor is not to be less than 0.7 times the weight of the single anchor. High holding power anchor and super high holding power anchor are to meet relevant provisions of Chapter 10, PART ONE of CCS Rules for Materials and Welding.

5.2.2.2 For a craft navigating in greater coastal service restriction, the weight of high holding power anchor may be not less than 0.75 times the anchor weight obtained from Table 5.2.2 based on the equipment number. For a craft navigating in coastal service restriction, the weight of high holding power anchor may be not less than 0.55 times the anchor weight obtained from Table 5.2.2 based on the equipment number. For a craft navigating in sheltered or calm water service restriction, the weight of high holding power anchor may be not less than 0.45 times the anchor weight obtained from Table 5.2.2 based on the equipment number.

5.2.2.~~2~~3 Chain cables and anchor ropes

(1) The chain cables may be adopted in total length. The materials of chain cables are to be of Grade 2 chain steel (CCS AM2) or Grade 3 chain steel (CCS AM3) as listed in CCS Rules for Materials and Welding. However Grade 3 chain steel is not allowed to be used for the chain cables having a diameter less than 20.5 mm.

~~(2) The chain cables may be substituted by steel wire or synthetic fibre rope, where one of the following cases is complied with:~~

~~where $N < 440$, the chain cables may be substituted by the steel wire rope of equivalent breaking strength;~~

~~where $N < 80$, the chain cables may be substituted by the fiber rope of equivalent breaking strength.~~

~~In these cases, a short length of chain cables is to be fitted between the anchor and the rope. The length is to be taken at least as the distance between anchor in stowed position and windlass, and not to be less than 0.2L.~~

(2) The chain cables may be substituted by steel wire or synthetic fibre rope, and the breaking strength of the rope is not to be less than that of stud chains. A short length of chain cables is to be fitted between the anchor and the rope. The length is to be taken at least as the distance between anchor in stowed position and windlass or 0.2L, whichever is the lesser.

(3) The diameter of stud chains and the length of chain cables (or anchor ropes) are not to be less than the values obtained from Table 5.2.2 based on equipment number N. Where anchor weight is reduced according to service restriction in paragraph 5.2.2.2, the diameter of stud chain and the length of chain cable or anchor rope are not to be less than the value obtained from Table 5.2.2 based on reduced anchor weight. ~~Where stud chains are substituted by rope, the breaking strength of the rope is not to be less than that of the stud chains.~~The breaking strength of stud chains may be obtained from the following formula based on the diameter of chain cables:

CCS AM2: breaking strength $=13.73 d_c^2 \left(44-0.08 d_c\right) 10^{-3}$ kN

CCS AM3: breaking strength $=19.61 d_c^2 \left(44-0.08 d_c\right) 10^{-3}$ kN

where: d_c — diameter of chain cables, in mm, obtained from Table 5.2.2.

5.2.2.~~3~~4 The anchoring arrangements are to be such that any surfaces against which the chain cables may chafe (for example, hawse pipes and hull obstructions) are designed to prevent the chain cables from being damaged and folded. Adequate arrangements are to be provided to secure the anchor under all operational conditions.

5.2.2.~~4~~5 The craft is to be protected so as to minimize the possibility of the anchor and chain cables damaging the structure during normal operation.

5.2.2.~~5~~6 Where the weight of single anchor exceeds 50 kg, the anchoring arrangement is to be fitted.

5.2.3 Mooring equipment

5.2.3.1 The number, length and breaking strength of steel wires or fiber ropes for mooring are to be obtained from Table 5.2.2 based on the equipment number *N*. ~~However, the coefficient *K* in the formula of 5.2.1 to calculate *N* is to be taken as 1.~~ The diameter of fiber mooring ropes is not to be less than 15 mm~~.~~, and ~~T~~the total length ~~of mooring ropes~~ is not to be less than 4 times the length of craft in any cases.

Table 5.2.2

Equipment number N		Weight of high holding power anchor (kg)	Dia. of stud chains (mm)		Length of chains or ropes (m)	Mooring ropes	
Exceed	Not exceed		AM2	AM3		Number× length (m)	Breaking strength(kN)
—	10	37	8	—	90	2×25	30
10	20	48	9.5	—	97	2×25	30
20	30	67	11	—	108	2×25	30
30	40	93	12.5	—	115	2×40	32
40	50	119	12.5	—	115	2×40	32
50	60	146	12.5	—	130	3×40	34
60	70	171	12.5	—	130	3×40	34
70	80	198	14	—	130	3×50	37
80	90	224	14	—	130	3×50	37
90	100	251	16	—	150	3×55	39
100	110	276	16	—	150	3×55	39
110	120	303	17.5	—	150	3×55	44
120	130	329	17.5	—	150	3×55	44
130	140	356	17.5	—	165	3×60	49
140	150	383	17.5	—	165	3×60	49
150	160	408	19	—	165	3×60	54
160	175	441	19	—	165	3×60	54
175	190	480	20.5	—	180	3×60	59
190	205	521	20.5	—	180	3×60	59
205	220	560	22	20.5	180	4×60	64
220	240	606	22	20.5	180	4×60	64
240	260	659	24	22	200	4×60	69
260	280	711	24	22	200	4×60	69
280	300	764	26	24	215	4×70	74
300	320	816	26	24	215	4×70	74
320	340	869	28	24	215	4×70	78
340	360	926	28	24	215	4×70	78
360	380	974	30	26	230	4×70	88
380	400	1028	30	26	230	4×70	88
400	425	1086	32	28	230	4×70	98
425	450	1152	32	28	230	4×70	98
450	475	1226	32	28	230	4×70	108
475	500	1284	34	30	230	4×70	108
500	550	1403	34	30	248	4×80	123
550	600	1535	36	32	264	4×80	132
600	660	1694	38	34	264	4×80	147
660	720	1853	40	36	264	4×80	157
720	780	2012	42	36	281	4×85	172
780	840	2171	44	38	281	4×85	186
840	910	2329	46	40	281	4×85	201
910	980	2515	48	42	297	4×85	216
980	1060	2700	50	44	297	4×90	230
1060	1140	2912	50	46	297	4×90	250
1140	1220	3124	52	46	314	4×90	270
1220	1300	3335	54	48	314	4×90	284
1300	1390	3574	56	50	314	4×90	309
1390	1480	3812	58	50	330	5×90	324
1480	1570	4050	60	52	330	5×95	324
1570	1670	4315	62	54	330	5×95	333
1670	1790	4632	64	56	347	5×95	353
1790	1930	4950	66	58	347	5×95	378

”

CHAPTER 6 MACHINERY INSTALLATIONS

Section 4 Craft's Piping and Ventilating Systems

The existing paragraph 6.4.3 is replaced by the following:

"6.4.3 Bilge pumping system

6.4.3.1 The system is to be so arranged as to drain water effectively from any watertight compartment other than that intended for permanently storing liquid and prevent water flowing from one compartment to another.

6.4.3.2 ~~The system is to be so designed from the very beginning as to consider that it is to be capable of operating under all possible states of trimming or listing in case of flooding not damaging the craft's safety~~ The bilge pumping system is to be capable of operation under all possible values of list and trim after the craft has sustained the postulated damage in design. Necessary valves for controlling the bilge suctions are to be capable of being operated from above the datum①.

6.4.3.3 For individual compartment, the drainage can be exempted with the consent of CCS provided that the safety of the craft is not affected by drainage of this compartment through calculation or necessary demonstration.

6.4.3.4 At least two bilge suctions are to be provided in each machinery space. An independent bilge pump is to have one direct bilge suction from the space in which it is situated.

6.4.3.5 The bilge suctions in machinery space are to be arranged as follows:

(1) for monohull craft, the suction is to be arranged in the center longitudinal section;

(2) for ~~twin~~multi-hull craft, side-wall hovercraft, the suction is to be arranged in the center longitudinal section of each hull;

(3) for air-cushion vehicle, each machinery space may have only one su~~e~~ction.

6.4.3.6 The device for preventing rubbish from being sucked (such as mud box or strum) is to be provided for bilge suction in machinery space and it can be easily removed and replaced for cleaning.

6.4.3.7 At least one bilge suction is to be provided for each compartment in which bilge pumping system is necessary except machinery spaces and the said suction is to be so arranged as to drain the water effectively from the compartment.

6.4.3.8 The open ends of bilge suction pipes in those compartments other than the machinery space are to be enclosed in strum boxes, which can be easily removed and replaced for cleaning and the combined area of a box is not to be less than twice the sectional area of the bilge suction pipe.

6.4.3.9 For the accommodation used portable drainage pumping, raceways are to be provided to drain the bilge water facilitatedly in the aforesaid accommodation.

6.4.3.10 The internal diameter d_1 of the bilge main is to be calculated according the following formula. However, the actual internal diameter of the bilge main may be rounded off to the acceptable nearest standard size, but not less than the calculated value by 5 mm:

$$d_1 = 25 + 1.68\sqrt{L(B+D)} \quad \text{mm}$$

---

① Datum means a watertight deck or equivalent structure of a non-watertight deck covered by a weathertight structure of adequate strength to maintain the weathertight integrity and fitted with weathertight closing appliances.

where: L — length of craft defined in Chapter 2, in m;

Where the engine room bilge system is fitted only for serving the machinery space and they do not serve cargo hold or other spaces, L may be reduced by the combined length of the cargo holds or other spaces. In such cases, the cross sectional area of the main bilge line is not to be less than twice the required cross sectional area of the engine room branch bilge lines;

B — for monohull high speed craft, breadth of high speed craft as defined in Chapter 2; for multi-hull high speed craft, breadth of one hull or several hulls at or below the design waterline, in m;

D — molded depth of high speed craft to the datum, in m.

6.4.3.~~10~~11 In no case is the internal diameter of the bilge main to be less than that required for the largest branch bilge line.

6.4.3.12 The internal diameter d_2 of branch bilge suction pipes fitted in cargo and machinery spaces is not to be less than the value determined by the following formula, but the actual internal diameter of branch bilge suction pipes may be rounded off to the acceptable nearest standard size, but not less than the calculated value by 5 mm:

$$d_2 = 25 + 2.15\sqrt{l(B+D)} \quad \text{mm}$$

where: l — length of compartment, in m;

B — for monohull high speed craft, breadth of high speed craft as defined in Chapter 2; for multi-hull high speed craft, breadth of one hull at or below design waterline, in m;

D — molded depth of high speed craft to the datum, in m.

6.4.3.~~11~~13 In general, the internal diameter of the branch bilge line is not to be less than 25 mm.

6.4.3.~~12~~14 Screw-down non-return valves are to be provided in the following pipes or fittings to prevent water flowing coracle between watertight compartments, watertight compartment and machinery space, dry compartment and sea water or tank:

(1) direct bilge suction pipe;

(2) connection pipe of bilge pump to bilge main line;

(3) distribution bilge valve chest or bilge branch;

(4) bilge suction hose directly connected with bilge pump or bilge main line.

6.4.3.~~13~~15 The collision bulkhead between the bulkhead deck and inner bottom may be pierced by one pipe only for dealing with the fluid in the fore peak tank. The pipe is to be provided with a valve which can be operated above the bulkhead deck and an indicator to show the opening or closing state. The valve is to be secured to the bulkhead inside the fore peak. Hand pump may be used for drainage for the fore peak with the consent of CCS.

6.4.3.~~14~~16 The bilge main line is not to be arranged within the possible damaged penetration scope of the craft. ~~Provision is to be made to prevent the compartment served by and bilge suction pipe being flooded in the event of the breaking of the pipe, or otherwise damaged by collision or grounding in any other compartment.~~ Provision is to be made to prevent the compartment served by any bilge suction pipe being flooded in the event of the pipe being severed, or otherwise damaged by collision or grounding in any other compartment. For this purpose, where the pipe is at any part situated within the aforesaid damaged penetration scope, a non-return valve is to be fitted to the pipe in the compartment containing the open end.

6.4.3.~~15~~17 For the chain locker and the watertight compartment (if any), above the fore peak tank, steering gear compartments or other small enclosed spaces situated above the after peak tank, drainage is to be provided either by hand pump or power pump bilge suctions.

~~6.4.3.16 Necessary valves for controlling the bilge suctions are to be capable of being operated from above the datum①.~~

6.4.3.~~17~~18 All distribution boxes and manually operated valves in connection with the bilge pumping arrangements are to be in positions which are accessible under ordinary circumstances. The spindles of manually operated valves are to be easily accessible and all valves are to be clearly marked.

6.4.3.~~18~~19 The spindles of the sea inlet valves are to extend well above the ~~engine room~~ machinery space floor plates.

6.4.3.~~19~~20 All bilge suction piping up to the connection to the pumps are to be independent of other piping system.

6.4.3.~~20~~21 Spaces situated above the water level in the worst anticipated damage conditions may be drained directly overboard through scuppers fitted with non-return valves.

6.4.3.~~21~~22 Any unattended space for which bilge pumping arrangements are required is to be provided with a bilge alarm.

6.4.3.~~22~~23 All power bilge pumps are to be of the self-priming type, or with the self-priming arrangements.

6.4.3.~~23~~24 An emergency bilge suction is to be provided for each main machinery space. The suction is to be led to the largest available power pump other than a bilge pump, propulsion or oil pump, such as main cooling water pump which need not be of the self-priming type.

6.4.3.~~24~~25 The bilge pump complying with the following requirements is to be provided for each hull of ~~twin~~multi-hull craft ~~and~~or each monohull craft fitted with bilge main line:

(1) at least two bilge pumps are to be provided, one of them may be ~~pump~~ engine driven pump ~~engine~~;

(2) the bilge pump is to be of fixed type or portable type and to be driven by power. ~~For the craft with the length less than 20 m, only one power bilge pump is to be provided. However, a bilge pump with output of less than 1.5 m³/h may be hand pump~~;

(3) each bilge pump is to be capable of giving a speed of water through the required main bilge pipe of not less than 2 m per second, therefore, the output Q ~~of each bilge pump~~ is not to be less than the value calculated by the following formula:

~~$Q = 3.75(1 + L/36)^2 \quad \mathrm{m^3/h}$~~

$$Q = 5.66 d_1^2 \times 10^{-3} \qquad \mathrm{m^3/h}$$

where: ~~L — length of the rigid hull measured on the design waterline in the displacement mode, in m;~~
d_1 — internal diameter of bilge main, obtained from the formula in 6.4.3.10 of this Section, in mm;

(4) for ~~twin~~multi-hull craft, if bilge water of one certain hull can be drawn by the bilge pump of other hull, the aforesaid hull may only be provided with one bilge pump;

(5) independent power sanitary, ballast and general service pumps may be accepted as independent power bilge pumps, provided that they are of the required capacity of the self-priming type or with the self-priming arrangement and connected to the bilge main.

(6) an ejector with an adequate capacity may be accepted as an independent power bilge pump, and the spindles of the inlet valves for the ejector driving water are to extend well above the floor plates.

~~① Datum means a watertight deck or equivalent structure of a non-watertight deck covered by a weathertight structure of adequate strength to maintain the weathertight integrity and fitted with weathertight closing appliances.~~

6.4.3.26 The bilge pump complying with the following requirements is to be provided for each hull of multi-hull craft and each monohull craft where a bilge main is not fitted but bilge pumps are provided in each compartment independently:

(1) at least one fixed submersible pump is to be provided for each space;

(2) at least one portable bilge pump is to be provided supplied from the emergency supply, if electric, for use on individual spaces;

(3) for each hull of multi-hull craft and each monohull craft, the total output Q_t of bilge pump is not to be less than 2.4 times the calculated output of bilge pump specified in 6.4.3.25 (3);

(4) The output Q_n of each submersible pump is not to be less than the value calculated by the following formula, with minimum of 8 m^3/h:

$$Q_n = Q_t / (N - 1) \qquad \text{m}^3\text{/h}$$

where: N — number of submersible pumps;
Q_t — total output as defined in 6.4.3.26 (3), in m^3/h.

6.4.3.~~25~~27 The arrangement of bilge pumping system in the machinery space for hovercraft may be specially considered subject to agreement of CCS.

6.4.3.~~26~~28 The passenger craft of category B ~~are~~ is to comply with the following requirements.

(1) A monohull craft is to be provided with at least 3 power bilge pumps connected with bilge main (at least 2 for each hull of multi-hull craft with independent bilge main), one of which may be driven by the propulsion machinery, and the requirements of following (2) to (4) are to be complied with; As an alternative, requirements of 6.4.3.26 may be complied with;

(~~1~~2) The arrangement of bilge pumping system is to be so arranged that at least one power bilge pump is to be available for use in all flooding conditions which the craft is required to withstand as follows:

① one of the required bilge pump is to be an emergency pump of a reliable submersible type having an emergency source of power; or

② the bilge pumps and their sources of power are to be so distributed throughout the length of the craft that at least one pump in an undamaged compartment will be available.

(~~2~~3) Distribution boxes, cocks and valves in connection with the bilge pumping system are to be so arranged that, in the event of flooding, one of the bilge pumps may be operative in any compartment. In addition, damage to a pump or its connecting to the bilge main is not to put the bilge system out of action. When, in addition to the main bilge pumping system, an emergency bilge pumping system is provided, it is to be independent of the main system and so arranged that a pump is capable of operating in any compartment under flooding conditions. In that case only the valves necessary for the operation of the emergency system need to be capable of being operated from above the datum.

(~~3~~4) All cocks and valves referred to in 6.4.3.~~26~~28(~~2~~3) which can be operated from above the datum are to have their controls at the place of operation clearly marked and are to be provided with means to indicate whether they are open or closed."

Section 5 Machinery Piping Systems

The existing paragraph 6.5.3.3 is replaced by the following:

"6.5.3.3 Not less than two sea inlets are to be connected with the cooling water pump of sea-water cooling piping system or circulating system and to be fitted on both sides of the craft as far as practicable. For a multi-hull craft, if main engines or auxiliary engines are distributed in several hulls and each main engine or auxiliary engine is provided with independent sea-water cooling pump respectively, the pump may only be connected with one sea inlet."

Appendix 2 Direct Calculations of Hull Structure Strength of Steel/Aluminum High Speed Craft

The existing paragraph 1.4 is replaced by the following:

“1.4 This Appendix applies to monohull and catamaran high speed craft with aluminum alloy or steel hull structure.”

The existing paragraph 2.2.1 is replaced by the following:

“2.2.1 Longitudinal bending moment and distribution

The hull longitudinal bending moment is assumed to be distributed according to ~~sine~~ cosine curve along craft length as follows:

~~$M(x)=M_{BY}\sin(\frac{\pi x}{L})$~~ $M(x)=\frac{M_{BY}}{2}(\cos(\frac{x}{L}2\pi)-1)$ KN·m

where: x is the longitudinal ordinate of cross section from stern, and the amplitude of the distribution curve is the longitudinal bending moment, M_{BY}, of midsection. M_{BY} is to be calculated for the two cases of 4.8.2 and 4.8.3, Chapter 4 of the Rules respectively ($M_{BY}=|M_S|=M_h$). $M(x)$ can be obtained by applying the vertical force $q(x)$ distributed along craft length, and $q(x)$(positive upwards)can be determined by the following formula:

~~$q(x)=q_0(\sin\frac{\pi x}{L}-0.637)$~~ $q(x)=A\cos(\frac{x}{L}2\pi)$ KN/m

where: ~~$q_0=\frac{46}{L^2}M_{BY}$~~ $A=\frac{-2\pi^2 M_{BY}}{L^2}$ KN/m

The two conditions of hogging and sagging are to be calculated respectively, and $q(x)$ distributed along craft length or a series of equivalent concentrated forces are to be applied on calculation model. In order to avoid local bending stresses of structural members on which the force acts, the force is to be applied on longitudinal primary members, such as craft side, longitudinal bulkheads, bottom centre girders or other girders. The force acting on the same cross section may be divided into portions symmetrical to the longitudinal centerline at left and right sides. Where a series of concentrated forces are applied, each concentrated force is to be equal to the product of the distributed force multiplied by the length of areas loaded by the concentrated forces.

After loading, the resultant force all vertical forces acting on the model is to be zero and the error of its absolute value is not to be more than $0.005q_0L$.”

A new subparagraph 4.3(13) is added as follows:

“(13) M_{ty} condition”

Appendix 3 Direct Calculations of Hull Structure Strength of High Speed Craft Made of Composite Material

The following sentence is added at the end of the existing paragraph 2.5:

“CCS may also accept other types of strength criteria for composite material, e.g. Tsai-Wu and Tsai-Hill criteria. Relevant material and strength parameters are to be submitted to CCS for review.”

A new Appendix 4 is added as follows:

“Appendix 4 Method of Checking Longitudinal Strength of Steel/Aluminum High Speed Trimarans

1 General provisions

1.1 Application

1.1.1 Trimarans to which this Appendix applies are also to comply with the following requirements:

(1) Ship length: 50 m $\leq L \leq$ 180 m;

(2) Displacement of each hull is not more than 7% of total craft displacement;

(3) Longitudinal center-to-center distance between main hull and side hull X_{sm}, is not to exceed 0.1L towards stem, nor is it to exceed 0.3L towards stern.

1.1.2 Trimarans beyond the requirements of 1.1.1 are to be subject to special consideration and approved by CCS.

1.2 Symbols and definitions

1.2.1 Relevant definitions in this Appendix are as follows, and for those not defined in this Appendix, see paragraph 2.1.3.1, Chapter 2 of the Rules.

1.2.1.1 Design waterline length, L_{wl}, is the distance measured on a waterline at the design draught, from the fore side of the stem to the after side of the stern or transom of the main hull with no lift or propulsion machinery active, in m.

1.2.1.2 Design waterline breadth, B_{wl}, is the sum of greatest moulded breadth of the main hull and two side hulls on a waterline at the design draught, with no lift or propulsion machinery active, in m.

1.2.1.3 Total design waterline breadth, B_{wlt}, is the greatest breadth measured on a waterline at the design draught, from both ends of the hull, , with no lift or propulsion machinery active, in m.

1.2.1.4 Main hull design waterline breadth, B_{wlm}, is the maximum moulded breadth of the main hull on a waterline at the design draught, with no lift or propulsion machinery active, in m.

1.2.1.5 Side hull length, L_s, is the overall length of the underwater watertight envelope of the rigid hull, excluding appendages at or below the design waterline in the displacement mode with no lift or propulsion machinery active, in m.

1.2.1.6 Side hull design draught, d_s, is the vertical distance measured from the baseline to the design waterline of side hull at the midpoint of side hull length, L_s, with no lift or propulsion machinery active, in m.

1.2.1.7 Side hull design waterline length, L_{wls}, is the distance measured on a waterline at the design draught, from the fore side of the stem to the after side of the stern of the side hull, with no lift or propulsion machinery active, in m.

1.2.1.8 Side hull design waterline breadth, B_{wls}, is the greatest moulded breadth of a side hull on a waterline at the design draught, with no lift or propulsion machinery active, in m.

1.2.1.9 Total design displacement Δ is the total displacement of the side hull and the main hull on a waterline at the design draught, with no lift or propulsion machinery active, in ton.

1.2.1.10 Side hull design displacement Δ_s is the total displacement of one side hull on a waterline at the design draught, with no lift or propulsion machinery active, in ton.

1.2.1.11 Block coefficient C_b is a ship form coefficient calculated according to the following, if $C_b < 0.6$, it is to be taken as 0.6 :

$$C_b = \frac{\Delta / 1.025}{LB_{wlm}d + 2(L_{wls}B_{wls}d_s)}$$

1.2.1.12 Longitudinal center-to-center distance between main hull and side hull X_{sm} is the longitudinal vertical distance from mid-length section of side hull to mid-length section of main hull, in m.

2 Global load

2.1 Vertical acceleration when navigating in wave at high speed

2.1.1 The vertical acceleration a_{cg} at center of gravity of a high speed trimaran navigating in displacement condition is to be calculated according to 4.4.1.2, Chapter 4 of the Rules.

2.1.2 The vertical acceleration a_z at considered position of side hull is to be calculated according to the following formula:

$$a_Z = \sqrt{a_{cg}^2 + a_{rl}^2} \qquad \text{m/s}^2$$

where: a_{rl} — roll acceleration, in m/s^2, to be calculated according to following formula:

$$a_{rl} = 28y\frac{GM^{1.5}}{B_{wlt}^{2.5}}a_{cg}$$

where: y — abscissa of the position considered, in m;
GM — transverse metacentric height under loading condition considered, in m.

2.2 Still water bending moment and still water shear force of hull girder

2.2.1 The still water bending moments and shear force distributions may be derived using a suitable direct calculation method for a range of loading conditions which cover the operational envelope of the craft.

2.2.2 Still water bending moment M_S is to be taken as the maximum moment calculated from the loading conditions. If there is no sagging condition, the maximum sagging bending moment is to be taken as the minimum hogging bending moment.

2.2.3 Still water shear force Q_S is to be taken as the maximum value calculated from the loading conditions.

2.3 Vertical wave bending moment of hull girder

2.3.1 Hogging wave bending moment $M_W(+)$ and sagging wave bending moment $M_W(-)$ of each section of hull girder are to be calculated according to the following formulae:

$$M_W(+) = 0.19Cf_{sr}K_sL^2B_{WL}C_bD_M \qquad \text{kNm}$$

$$M_W(-) = -0.11Cf_{sr}K_sL^2B_{WL}(C_b + 0.7)D_M \qquad \text{kNm}$$

where: C — coefficient, to be calculated according to the following formulae:

$$C = 0.0412L + 4 \qquad \text{if } L < 90\text{m};$$

$$C = 10.75 - \left(\frac{300 - L}{100}\right)^{3/2} \qquad \text{if } L \geq 90\text{m};$$

f_{sr} — service area factor:

$f_{sr} = 0.80$ for OSSR;

$f_{sr} = 0.65$ for GCSR;

$f_{sr} = 0.30$ for CSR;

$f_{sr} = 0.18$ for SWSR;

$f_{sr} = 0.10$ for CWSR;

K_s — coefficient of side hull effect, to be calculated according to the following formulae:

$$K_s = 1.1 \quad \text{if } -0.1 \le \frac{X_{sm}}{L} < 0.05;$$

$$K_s = -0.6\frac{X_{sm}}{L} + 1.13 \quad \text{if } 0.05 \le \frac{X_{sm}}{L} \le 0.2;$$

$$K_s = -0.1\frac{X_{sm}}{L} + 1.03 \quad \text{if } 0.2 < \frac{X_{sm}}{L} \le 0.3;$$

D_M — bending moment distribution factor, to be calculated according to the following formulae:

$D_M = 0$ for both ends of ship length L;

$$D_M = 1 \quad \text{from } (0.4 - 0.25\frac{X_{sm}}{L})L \text{ to } (0.68 - 0.25\frac{X_{sm}}{L})L;$$

For other areas, it is to be determined by linear interpolation.

2.4 Vertical wave shear force of hull girder

2.4.1 Hogging wave shear force $Q_W(+)$ and sagging wave shear force $Q_W(-)$ of each section of hull girder are to be calculated according to the following formulae:

$$Q_W(+) = 0.3Cf_{sr}LB_{WL}\left(C_b + 0.7\right)D_{Q1} \quad \text{kN}$$

$$Q_W(-) = 0.3Cf_{sr}LB_{WL}\left(C_b + 0.7\right)D_{Q2} \quad \text{kN}$$

where: C — coefficient, see 2.3.1 of this Appendix;

f_{sr} — service area factor, see 2.3.1 of this Appendix;

D_{Q1}, D_{Q2} — shear force distribution factor, to be calculated according to the following formulae:

(1) for hogging wave shear force

$D_{Q1} = 0$ for both ends of ship length L;

$$D_{Q1} = 1.588\frac{C_b}{C_b + 0.7} \quad \text{from } (0.13 - 0.25\frac{X_{sm}}{L})L \text{ to } (0.26 - 0.25\frac{X_{sm}}{L})L;$$

$$D_{Q1} = 1.235\frac{C_b}{C_b + 0.7} \quad \text{from } (0.35 - 0.25\frac{X_{sm}}{L})L \text{ to } (0.45 - 0.25\frac{X_{sm}}{L})L;$$

$$D_{Q1} = 1.0 \quad \text{from } (0.65 - 0.25\frac{X_{sm}}{L})L \text{ to } (0.82 - 0.25\frac{X_{sm}}{L})L;$$

For other areas, it is to be determined by linear interpolation;

(2) for sagging wave shear force

$D_{Q2} = 0$ for both ends of ship length L;

$D_{Q2} = 0.92$ from $(0.13 - 0.25\frac{X_{sm}}{L})L$ to $(0.26 - 0.25\frac{X_{sm}}{L})L$;

$D_{Q2} = 0.715$ from $(0.35 - 0.25\frac{X_{sm}}{L})L$ to $(0.45 - 0.25\frac{X_{sm}}{L})L$;

$D_{Q2} = 1.729\frac{C_b}{C_b + 0.7}$ from $(0.65 - 0.25\frac{X_{sm}}{L})L$ to $(0.82 - 0.25\frac{X_{sm}}{L})L$;

For other areas, it is to be determined by linear interpolation.

2.5 Horizontal bending moment of hull girder

2.5.1 Horizontal bending moment M_H on each section of hull girder is to be calculated according to the following formula:

$$M_H = C_H f_{sr} L^2 D(C_b + 0.7) D_M \quad \text{kNm}$$

where: C_H — coefficient, to be calculated according to the following: formula

$$C_H = 0.005L - 0.07\left(\frac{L}{100}\right)^2$$

f_{sr} — service area factor, see 2.3.1 of this Appendix;
D_M — bending moment distribution factor, see 2.3.1 of this Appendix.

2.6 Longitudinal torsional moment of hull girder

2.6.1 Longitudinal torsional moment of hull girder is to be calculated according to the following formula:

$$M_{lt} = 0.765 f_{sr} \rho \left(V_s + V_c + \frac{V_m}{2}\right) y_{hc} a_{cg} D_{lt} \quad \text{kNm}$$

where: f_{sr} — service area factor, see 3.3.1 of this Appendix;
ρ — density of seawater, ρ =1025, in kg/m^3;
V_s — volume of one side hull, in m^3;
V_c — volume of unilateral cross deck, in m^3;
V_m — volume of main hull, in m^3;
y_{hc} — transverse distance from half section centroid divided by main hull central longitudinal section at mid-length of the side hull to the main hull central longitudinal section, in m;
a_{cg} — acceleration of center of gravity, see 2.1.1 of this Appendix;
D_{lt} — longitudinal torsional moment distribution factor, to be determined according to Table 2.6.1;

Longitudinal torsional moment distribution factor Table 2.6.1

Longitudinal position X(m)	D_{lt}	Longitudinal position X(m)	D_{lt}
0（stern）and L（bow）	0	$X_{sa}+5\Delta_{Xs}$	1.0
X_{sa}（intersection of main hull and aft end of cross deck）	0.13	$X_{sa}+6\Delta_{Xs}$	0.98
$X_{sa}+\Delta_{Xs}$	0.35	$X_{sa}+7\Delta_{Xs}$	0.91
$X_{sa}+2\Delta_{Xs}$	0.56	$X_{sa}+8\Delta_{Xs}$	0.80
$X_{sa}+3\Delta_{Xs}$	0.78	$X_{sa}+9\Delta_{Xs}$	0.68
$X_{sa}+4\Delta_{Xs}$	0.92	X_{sf}（intersection of main hull and fore end of cross deck）	0.56

Note: (1) $\Delta_{Xs} = (X_{sf} - X_{sa})/10$;
(2) For other areas, it is to be determined by linear interpolation.

2.7 Transverse vertical bending moment of cross deck

2.7.1 Two positions, i.e. the connection of cross deck bottom to main hull (near point 1) and the connection of cross deck bottom to side hull (far point 0) are to be selected to calculate transverse bending moment of cross deck. If the type of arc transition is used at such connections, tangent point position with an included angle of 45^o between the arc tangent line and the horizontal line may be taken as the calculation point.

2.7.2 Transverse hogging bending moment $M_{sp}(+)$ and transverse sagging bending moment M_{sp} (-) on longitudinal section of cross deck are to be calculated according to the following formulae:

$$M_{sp}(+) = 9.81 f_{sr} W_s \left(y_{sh} - y_o \right)\left(1 + 0.102 a_Z\right) \quad \text{kNm at bottom far point 0}$$

$$M_{sp}(+) = 9.81 f_{sr} W_s \left(y_{sh} - y_1 \right)\left(1 + 0.102 a_Z\right) \quad \text{kNm at bottom near point 1}$$

$$M_{sp}(-) = f_{sr} \frac{(\Delta - 2\Delta_s)}{2} \left(y_{sh} - y_o \right) a_Z \quad \text{kNm at bottom far point 0}$$

$$M_{sp}(-) = f_{sr} \frac{(\Delta - 2\Delta_s)}{2} \left(y_{sh} - y_1 \right) a_Z \quad \text{kNm at bottom near point 1}$$

where: f_{sr} — service area factor, see 2.3.1 of this Appendix;

W_s — total weight of one side hull, in ton;

y_{sh} — transverse distance from the centroid of one side hull section to main hull central longitudinal section, in m;

y_0 — transverse distance from far point 0 of cross deck bottom to main hull central longitudinal section, in m;

y_1 — transverse distance from near point 1 of cross deck bottom to main hull central longitudinal section, in m;

a_z — vertical acceleration at the centroid of side hull section, in m/s^2, see 2.1.2 of this Appendix.

2.8 Transverse vertical shear force of cross deck

2.8.1 Transverse hogging shear force $Q_{sp}(+)$ and transverse sagging shear force Q_{sp} (-) on longitudinal section of cross deck are to be calculated according to the following formulae:

$$Q_{sp}(+) = 9.81 f_{sr} W_s \left(1 + 0.102 a_Z\right) \quad \text{kN}$$

$$Q_{sp}(-) = f_{sr} \frac{(\Delta - 2\Delta_s)}{2} a_Z \quad \text{kN}$$

where: f_{sr} — service area factor, see 2.3.1 of this Appendix;

W_s — total weight of one side hull, in ton;

a_z — vertical acceleration at the center of gravity of side hull, in m/s^2, see 2.1.2 of this Appendix.

2.9 Transverse torsional moment of cross deck

2.9.1 Transverse torsional moment M_{tt} evenly distributed along breadth direction of cross deck is to be calculated according to the following formula:

$$M_{tt} = 0.382 f_{sr} \rho \left(V_s + V_c \right) L_s a_{cg} \quad \text{kNm}$$

where: f_{sr} — service area factor, see 2.3.1 of this Appendix;

V_s — volume of one side hull, in m^3;

V_c — volume of unilateral cross deck, in m^3;

a_{cg} — acceleration at the center of gravity, in m/s^2, see 2.1.1 of this Appendix.

3 Check of overall strength

3.1 Hull girder strength

3.1.1 General requirements

3.1.1.1 All trimarans to which the provisions of 1.1.1 of this Appendix apply are to be subject to check of longitudinal bending strength of hull girder, covering all ballast and full load conditions to determine hull girder strength required. For departure and arrival conditions, still water bending moment, wave bending moment and shear force are to be calculated. The midsection at the weakest part of the structure within ±10%L amidcraft is generally to be taken as the section for check in the calculation of longitudinal strength.

3.1.1.2 If the length of cross deck is greater than 0.4L, the cross deck structure and side hull beyond the breadth of main hull may be considered as contributing to the hull girder strength. In such case, hull girder sections under check are to include section at midpoint of side hull length and section at both sides of side hull which can represent transition area of side hull.

3.1.1.3 Calculation of hull girder section modulus is to meet relevant provisions of 4.8.7, Chapter 4 of the Rules and 2.2.4, Chapter 2 of PART TWO of CCS Rules for Classification of Seagoing Steel Ships.

3.1.2 Check of longitudinal strength

3.1.2.1 The longitudinal bending strength of hull girder of main hull is to be checked according to 3.1.1. The longitudinal bending stress σ of hull girder cross section may be calculated as follows:

$$\sigma = \frac{M}{W} \times 10^3 \qquad \text{N/mm}^2$$

where: M — vertical bending moment withstood by the hull girder, in kNm, to be calculated according to hogging and sagging conditions and to be taken as:

$$M = M_S + M_W$$

where: M_S and M_W — longitudinal bending moment calculated according to the provisions of 2.2.2 and 2.3.1 of this Appendix.

W — section modulus of deck and bottom calculated according to the provisions of 3.1.1.3 of this Appendix, in cm^3.

3.1.2.2 In addition, the shearing strength of hull girder is to be checked. The two cross sections with the maximum shearing force, i.e. hull cross sections at $L/4$ and $3L/4$ from the fore perpendicular, may be taken for check. If there is no longitudinal bulkhead at such sections, the maximum shearing force τ of side plating may be calculated by the following formula, and otherwise the shearing force is to be calculated according to thin wall shear flow theory:

$$\tau = 100 \frac{QS}{I_y t} \qquad \text{N/mm}^2$$

where: Q — gross shearing force of the section under check, in kN, to be calculated according to hogging and sagging conditions respectively and to be taken as:

$$Q = Q_S + Q_W$$

where: Q_S and Q_W — vertical shear force calculated according to the provisions of 2.2.3 and 2.4.1 of this Appendix;

S — static moment of the portion of the section above neutral axis, in cm^3;

I_y — moment of inertia of the section under check to its horizontal neutral axis, in cm^4;

t — total thickness of shell plating at horizontal neutral axis of the section under check, in mm.

3.1.2.3 The midcraft section modulus W in way of hull girder deck and keel is to meet following requirements:

$$W > f_{sr}CL^2B(C_b + 0.7)k_m \quad \text{cm}^3$$

where: f_{sr} — service area factor, see 2.3.1 of this Appendix;
C — coefficient, see 2.3.1 of this Appendix;
k_m — coefficient of material effects, for steel hull, $k_m=K$, K is material factor, see 1.3.1.7, Chapter 1, PART TWO of CCS Rules for Classification of Seagoing Steel Ships; for aluminum hull, $k_m=235/\sigma_{sw}$;
where: σ_{sw} — yield strength of aluminum material after welding, in N/mm^2, to be taken as yield strength $\sigma_{p0.2}$ of aluminum material in annealed condition, see relevant provisions of CCS Rules for Materials and Welding.

3.1.2.4 Moment of inertia I of hull girder midcraft section to its transverse neutral axis is to meet the requirements of the following formula:

$$I > 3f_{sr}CL^3B(C_b + 0.7)k_E \quad \text{cm}^4$$

where: f_{sr} — service area factor, see 2.3.1 of this Appendix;
C — coefficient, see 2.3.1 of this Appendix;
k_E — coefficient of material elasticity, for steel hull, $k_E= 1$; for aluminum hull, $k_E= 206/E_A$;
where: E_A — modulus of elasticity of aluminum material, in 10^{-3} N/mm^2。

3.1.3 Allowable stress

3.1.3.1 Allowable stress for check of overall strength is as follows:

(1) For steel hull, allowable bending stress of members $[\sigma]$ is to be taken as:

$[\sigma]=175/K$, N/mm^2, within 0.4L amidcraft;
$[\sigma]=125/K$, N/mm^2, within 0.1L from craft ends;
For other areas, it is to be determined by linear interpolation.

Allowable shear stress of members $[\tau]$ is to be taken as:

$[\tau]=110/K$, N/mm^2

where: K — material factor, see 1.3.1.7, Chapter 1, PART TWO of CCS Rules for Classification of Seagoing Steel Ships.

(2) For aluminum hull, allowable bending stress of members $[\sigma]=0.76\sigma_{sw}$, allowable shear stress of members $[\tau]=0.43\sigma_{sw}$.

where: σ_{sw} — yield strength of material after welding, in N/mm^2, to be taken as yield strength $\sigma_{p0.2}$ of aluminum material in annealed condition, see relevant provisions of CCS Rules for Materials and Welding.

3.2 Transverse strength of cross deck

3.2.1 General requirements

(1) Transverse strength of cross deck must be checked for all trimarans to which 1.1.1 of this Appendix applies. When calculating transverse strength of cross deck, longitudinal sections of two positions in way of the connection of cross deck bottom to main hull and the connection of cross deck bottom to side hull are to be taken as sections under check, see 2.7.1 of this Appendix.

(2) If the loading capacity of trimarans is distributed transversely with relatively large change in different loading conditions, transverse still water hogging and sagging bending moments under various loading conditions are to be considered.

(3) Calculation of section properties is to comply with the requirements of 3.1.1.3 of this Appendix.

3.2.2 Transverse strength

3.2.2.1 Cross deck bending stress σ_c due to transverse vertical bending moment of cross deck may be calculated as follows:

Hogging condition: $\sigma_{ch} = \frac{M_{sp}(+)}{W_c} \times 10^3$ N/mm^2

Sagging condition: $\sigma_{cs} = \frac{M_{sp}(-)}{W_c} \times 10^3$ N/mm^2

where: $M_{sp}(+)$, $M_{sp}(-)$ — transverse hogging bending moment and transverse sagging bending moment on longitudinal section of cross deck under check calculated according to 2.7.2 of this Appendix, in kNm;

W_c — the lesser of section modulus of bottom plate on section of cross deck under check and section modulus of deck, in cm^3.

3.2.2.2 Shear stress τ_c due to transverse vertical shear force of cross deck may be calculated as follows:

Hogging condition: $\tau_{cs} = 500 \frac{Q_{sp}(+)S}{I_y t}$ N/mm^2

Sagging condition: $\tau_{cs} = 500 \frac{Q_{sp}(-)S}{I_y t}$ N/mm^2

where: $Q_{sp}(+)$,$Q_{sp}(-)$ — transverse hogging shear force and transverse sagging shear force on longitudinal section of cross deck under check calculated according to 2.8.1 of this Appendix, in kN;

S — static moment of the portion of the section above neutral axis of section under check, in cm^3;

I_y — moment of inertia of the section under check to its horizontal neutral axis, in cm^4;

t — total thickness of shell plating at horizontal neutral axis of the section under check, in mm.

3.2.3 Allowable stress

3.2.3.1 Allowable stress for transverse strength check of cross deck is as follows:

(1) For steel hull, allowable stress $[\sigma]$ for bending stress of members is to be taken as:

$[\sigma]=168/K$, N/mm^2;

Allowable stress [τ] for shear stress of members is to be taken as:

$[\tau]=110/K$, N/mm^2。

Allowable stress $[\sigma]$ for equivalent stress of members is to be taken as:

$[\sigma]=210/K$, N/mm^2.

where: K — material factor, see 1.3.1.7, Chapter 1, PART TWO of CCS Rules for Classification of Seagoing Steel Ships.

(2) For aluminum hull, allowable stress for bending stress of members $[\sigma]=0.76\sigma_{sw}$, allowable stress for shear stress $[\tau]=0.43\sigma_{sw}$, allowable stress for resulting stress $[\sigma]=0.80\sigma_{sw}$

where: σ_{sw} — yield strength of material after welding, in N/mm^2, to be taken as yield strength $\sigma_{p0.2}$ of aluminum material in annealed condition, see relevant provisions of CCS Rules for Materials and Welding."

A new Appendix 5 is added as follows:

“Appendix 5 Direct Calculations of Hull Structure Strength of Steel/Aluminum High Speed Trimarans

1 General requirements

1.1 The purpose of direct calculation for trimaran structure is to verify hull longitudinal strength, transverse strength, torsional strength and local strength. Loading conditions, structural models and criteria for direct calculation are to comply with the provisions of this Appendix.

1.2 The wave load of trimarans may be determined by model test specified in this Appendix. If there is no model test information, the wave load may be determined by the formulae in 2.2 of this Appendix.

1.3 Wave loads may also be determined by direct calculation based on hydrodymic theory, provided that influences of wave conditions, ship speed and impact/slamming in respect to service restrictions of high speed craft are to be taken into consideration in calculation.

1.4 This Appendix applies to high speed trimarans with aluminum alloy or steel hull structure.

2 Load classification and equivalent application method

2.1 Longitudinal vertical bending moment

The hull longitudinal vertical bending moment is assumed to be distributed according to sine curve along craft length as follows:

$$M(x) = \frac{M_W}{2}(\cos(\frac{x}{L}2\pi) - 1) \qquad \text{kN·m}$$

where: x is the longitudinal ordinate of cross section from stern transom, and the amplitude of the distribution curve is the longitudinal bending moment, M_W, of midsection. M_W is to be calculated according to 2.3.1 of Appendix 4.

$M(x)$ can be obtained by applying the vertical force linear load $q(x)$ distributed along craft length, and $q(x)$(positive upwards) can be determined by the following formula:

$$q(x) = A\cos(\frac{x}{L}2\pi) \qquad \text{kN/m}$$

where: $A = \frac{-2\pi^2 M_W}{L^2}$ kN/m;

where: M_W — Rule calculation value of vertical bending moment of midcraft section of hull girder, in kNm, including two conditions of hogging and sagging.

The two conditions of hogging and sagging are to be calculated respectively, and the vertical force linear load $q(x)$ distributed along craft length or a series of equivalent concentrated forces are to be applied on calculation model. In order to avoid local bending stresses of structural members on which the force acts, the force is to be applied on longitudinal primary members, such as craft side, longitudinal bulkheads, bottom centre girders or other girders. The force acting on the same cross section may be divided into portions symmetrical to the longitudinal centerline at left and right sides. Where a series of concentrated forces are applied, each concentrated force is to be equal to the product of the linear load $q(x)$ multiplied by the length of areas loaded by the concentrated forces. For the calculation of concentrated force, refer to 2.2.

After loading, the resultant of all vertical forces acting on the model is to be zero and the error of its absolute value is not to be more than $0.005q_0L$.

2.2 Transverse vertical bending moment

The transverse vertical bending moment M_{SP} at the longitudinal centerline of cross deck of a trimaran is to be calculated according to 2.7.2 of Appendix 4 (y=0), the equivalent transverse split force F_y is calculated by the following formula:

$$F_{\mathrm{y}} = \frac{M_{sp}}{z + 0.5d} \qquad \text{kN}$$

where: M_{sp} — transverse vertical bending moment at the longitudinal centerline of cross deck, in kNm, including two conditions of hogging and sagging;

z — the distance from design waterline to neutral axis of midcraft section of cross deck, in m;

d —d esign draught, in m, including two conditions of hogging and sagging.

The transverse split force F_y acts on the model at the height of side hull keel, and is calculated in two separate load conditions as acting outward (sagging) and inward (hogging) respectively.

In actual calculation, F_y is applied as the load q distributed throughout the length of cross deck, acting on the hull:

$$q = \frac{F_y}{L_b} \qquad \text{kN/m}$$

where: L_b is longitudinal length of cross deck, in m.

The distributed load q is to be converted to the equivalent concentrated force P_i and applied at the transverse web framing of hull. The equivalent concentrated force P_i is to be determined by the following formula:

$$P_{\mathrm{i}} = q \cdot \left(\frac{S_1 + S_2}{2}\right) \qquad \text{kN}$$

where: S_1 and S_2 are the fore and aft spacing of transverse web framing respectively, in m.

2.3 Transverse torsional moment

For trimarans, the torsional moment M_{tt} about transverse Y-axis is to be calculated according to 2.9.1 of Appendix 4. Its equivalent may be the uniformly distributed load p which is asymmetrically distributed on half length of side hull. “Asymmetrically distributed” means that for the same side hull, the loading direction before midcraft section is opposite to that after midcraft section and the loading direction of left side hull is also opposite to that of right side hull. Such uniformly distributed equivalent load p can be obtained by the following formula:

$$p = \frac{4M_{tt}}{l^2} \qquad \text{kN/m}$$

where: M_{tt} — Rule calculation value of transverse torsional moment in breadth direction of cross deck, in kNm;

l — length of a distributed force or an equivalent concentrated force, in m.

A distributed force or an equivalent concentrated force may be applied on calculation model. In order to avoid local bending stresses of structural members on which the force acts, the force is to be applied on longitudinal primary members, such as craft side, longitudinal bulkheads, bottom centre girders or other girders. The force acting on the same cross section may be divided into portions asymmetrical to the longitudinal centreline at left and right sides. Where a concentrated force is applied, it is to be equal to the product of the distributed force multiplied by the length of areas loaded by the concentrated force.

After loading, the resultant of all vertical forces acting on the model is to be zero and the error of its absolute value is not to be greater than $0.01pL$.

2.4 Longitudinal torsional moment

Longitudinal torsional moment is to be applied on the nodes of each transverse bulkhead intersecting with hull enclosure in the form of vertically distributed couple, and the torsional moment due to resultant couple is to be equal to longitudinal torsional moment calculated according to 2.6.1 of Appendix 4.

$$T_\mathrm{i} = M_{lta} - M_{ltf}$$

where: M_{lta} — Rule calculation value of applied torsional moment corresponding to the mid position of a bulkhead and an adjacent one before the bulkhead;

M_{ltf} — Rule calculation value of applied torsional moment corresponding to the mid position of a bulkhead and an adjacent one after the bulkhead.

$$F_{ti} = \frac{2T_i}{b_t n} \qquad \text{kN}$$

where: T_i — moment applied on each transverse bulkhead, in kN;

F_{ti} — applied node force;

b_t — mean breadth at the nodes of forces applying on each section, in m;

n — number of nodes applying on each section.

Special consideration is to be given to other methods simulating torsional moment distribution.

2.5 Horizontal wave bending moment

A pair of longitudinal couples is to be applied on the side hull of each transverse bulkhead along ship length, and the bending moment due to resultant couple is to be equal to horizontal wave bending moment calculated according to 2.5.1 of Appendix 4.

$$F_{hi} = \frac{2M_H}{b_t n} \qquad \text{kN}$$

where: M_H — Rule calculation value of horizontal wave bending moment at each transverse bulkhead, in kNm;

F_{hi} — applied node force;

b_t — mean breadth at the nodes of forces applying on each section, in m;

n — number of nodes applying on each section.

2.6 Maximum heeling

Condition of maximum heeling angle that trimarans may obtain under static state is to be checked. Such condition corresponds to draught condition under maximum heeling angle, considering all hydrostatic pressure and hull weight load effects.

3 Calculation for check of overall structural strength

3.1 Global analysis model

3.1.1 Model extent

A global three-dimensional model is to be used for structural analysis, and hull shell, bulkheads, decks and platforms, primary members as well as superstructures are all to be represented in the model.

3.1.2 Applicable elements

The real structure is to be simulated by plate elements, beam elements and rod elements. For stiffeners on panels subject to lateral pressure, beam elements can be used for simulation, and the effects of eccentricity is to be considered. For stiffeners on girders and floors as well as face plates and stiffeners of primary members such as frames, rod elements can be used for simulation.

3.1.3 Mesh size of global model

Corresponding to similarity of load distribution, the mesh size of the global model may be taken as the spacing of transverse frames or primary members, whichever is the lesser, and quadrilateral elements with aspect ratio less than 3 are generally to be adopted.

3.1.4 Boundary conditions of global model

Six translation components are to be used to restrain rigid movement of the global model in space, without affecting relative deformation of each part of hull. It is recommended that one point be taken from stem and stern transom plate at the longitudinal centerline respectively for z restrain, one point be taken from midcraft bulkhead position as well as intersection of deck, keel and longitudinal centerline respectively for y restrain, and one point be taken from keel on midsection of two side hulls respectively for x restrain.

3.2 Load combination

Calculations are to be carried out in the following load combination conditions for overall strength check, see Table 3.2.

Load combination conditions **Table 3.2**

Wave direction	Condition	Still water bending moment		Wave bending moment		Horizontal wave bending moment	Transverse bending moment		Longitudinal torsional moment	Transverse torsional moment	Maximum heeling
		Hogging	Sagging	Hogging	Sagging		Hogging	Sagging			
Head sea	1	1.0	-	1.0	-	-	0.3	-	-	0.2	-
	2	-	1.0	-	1.0	-	-	0.3	-	0.2	-
Beam sea	3	1.0	-	0.1	-	-	1.0	-	0.2	-	-
	4	-	1.0	-	0.1	-	-	1.0	0.2	-	-
Oblique sea	5	1.0 (which is greater)		-	-	0.3	0.4	-	1.0	0.3	-
	6	1.0 (which is greater)		-	-	1.0	0.4	-	-	0.2	-
	7	1.0	-	-	0.2	0.2	0.6	-	-	1.0	-
	8	-	1.0	-	-	-	-	-	-	-	1.0

3.3 Strength criteria

The stress of structural members for strength calculation is to be not greater than the allowable stress listed in Table 3.3.

Allowable Stress for Overall Strength **Table 3.3**

	σ_{vm}	σ	τ
Global model (steel)	$0.80\,\sigma_{sw}$	$0.76\,\sigma_{sw}$	$0.43\,\sigma_{sw}$
Global model (aluminum)	$0.85\,\sigma_{sw}$	$0.83\,\sigma_{sw}$	$0.46\,\sigma_{sw}$

where: σ_{vm} is allowable equivalent stress of plate element;

σ is allowable normal stress of beam and rod elements;

τ is allowable shear force of plate element;

σ_{sw} is yield strength of parent material in welded condition. For steel, it is to be taken as yield strength of material, for aluminum, it is to be taken as yield strength $\sigma_{p0.2}$ in annealed condition, which is not more than 70% tensile strength. For the provisions for yield strength of aluminum material under different heat treatment, see 1.3.5, PART TWO of CCS Rules for Classification of Seagoing Steel Ships.

4 Local fine mesh analysis

4.1 Application

Areas in the vicinity of structural stress concentration points and other areas with great stress gradient as well as areas whose geometrical features can not be expressed correctly in global and local strength analysis models are to be subject to local structural fine mesh finite element analysis to determine the actual stress. Compared with the conclusions of global and local strength checks, the conclusion of this fine mesh analysis is to be as dominate.

In general, the following areas are to be subject to fine mesh analysis:

(1) Connection of the side hull to the end of cross deck;

(2) Connection of the main hull to the end of cross deck;

(3) Transverse bulkhead with maximum shear stress in global load analysis;

(4) Position of discontinuous structure such as opening or ends of primary member;

(5) Areas where the stress considered for the global coarse mesh model exceeds 95% of the allowable stress in global load analysis.

4.2 Analysis method

According to forces acting on local structures, one of the following methods is to be selected for local fine mesh analysis:

(1) Analysis by inserting fine mesh model

A local fine mesh model can be inserted into a coarse-mesh local structural model of global model, thereby carrying out calculation of local fine stresses while calculating global strength. In this condition, loads applied on fine mesh areas are to be consistent with those on the coarse mesh model. The calculation results indicate the stress condition of fine mesh areas in calculation for coarse meshes and apply to local positions without any special load.

(2) Fine mesh analysis by independent model

The local structure that needs fine mesh analysis is to be taken out for modeling separately, using displacements at the fine mesh model boundary provided by coarse mesh analysis as boundary conditions and applying local loads in the fine mesh area. The calculation results indicate the stress condition of high stress points of the structure under global deformation and local specific loads.

4.3 Meshes of fine model and criteria

For requirements for fine mesh size and criteria, see local fine mesh analysis in paragraph 6 of Appendix 2.

5 Buckling requirements

5.1 For requirements for buckling strength, see check of buckling strength in paragraph 7 of Appendix 2.”