RUSSIAN MARITIME REGISTER OF SHIPPING

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RULES

FOR THE CLASSIFICATION AND CONSTRUCTION OF HIGH-SPEED CRAFT

PART IV

STABILITY

ND No. 2-020101-158-E

St. Petersburg
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RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF HIGH-SPEED CRAFT

Rules for the Classification and Construction of High-Speed Craft of Russian Maritime Register of Shipping (RS, the Register) have been approved in accordance with the established approval procedure and come into force on 1 March 2023.

The present edition of the Rules is based on the 2018 edition taking into account the amendments developed immediately before publication.

The procedural requirements, unified requirements, unified interpretations and recommendations of the International Association of Classification Societies (IACS) and the relevant resolutions of the International Maritime Organization (IMO) have been taken into consideration.

The Rules are published in the following parts:

Part I "Classification";
Part II "Hull Structure and Strength";
Part III "Equipment, Arrangements and Outfit";
Part IV "Stability";
Part V "Reserve of Buoyancy and Subdivision";
Part VI "Fire Protection";
Part VII "Machinery Installations";
Part VIII "Systems and Piping";
Part IX "Machinery";
Part X "Boilers, Heat Exchangers and Pressure Vessels";
Part XI "Electrical Equipment";
Part XII "Refrigerating Plants";
Part XIII "Materials";
Part XIV "Welding";
Part XV "Automation";
Part XVI "Live-Saving Appliances";
Part XVII "Radio Equipment";
Part XVIII "Navigational Equipment";
Part XIX "Signal Means";
Part XX "Equipment for Pollution Prevention";
Part XXI "Craft for Personnel Transportation".

REVISION HISTORY

(Purely editorial amendments are not included in the Revision History)

For this version, there are no amendments to be included in the Revision History.

1 SCOPE OF APPLICATION

1.1 This Part of the Rules for the Classification and Construction of High-Speed Craft[1] applies to the enclosed (decked) type craft.

1.2 The requirements of this Part do not apply to the light-craft loading condition.

[1] Hereinafter referred to as "these Rules".

2 DEFEINITIONS AND EXPLANATIONS

2.1 Definitions and explanations relating to general terminology are given in 1.1 of Part I "Classification" of these Rules and in Part IV "Stability" of the Rules for the Classification and Construction of Sea-Going Ships[1].

2.2 For the purpose of this Part, the following additional definitions are given.

Air-cushion skirt is a downwardly extending, flexible structure used to contain or divide an air cushion.

Multihull craft is a craft which, in any normally achievable operating trim or heel angle, has a rigid hull structure which penetrates the surface of the sea over more than one discrete area.

Monohull craft is any craft, which is not a multihull craft.

Fully submerged foil is a foil having no lift components piercing the surface of the water in the foil-borne mode.

Downflooding point is any opening, irrespective of size, that would permit passage of water through a water/weathertight structure (e.g. opening windows), but excludes any opening kept closed in compliance with the requirements of Section 6 of Part III "Equipment, Arrangements and Outfit" of these Rules at all times other than when required for access or for operation of portable submersible bilge pumps in an emergency (e.g. non-opening windows of similar strength and weathertight integrity to the structure in which they are installed).

Hull slope angle is an angle lying in the vertical plane perpendicular to the craft side or bow or stem and measured along the shortest arc between the base line and the lowest knuckle of the craft side or bow or stem (refer to Fig. 2.2).

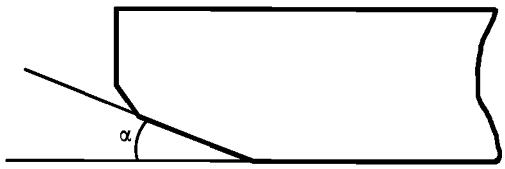


Fig. 2.2

[1] Hereinafter referred to as "the Rules for the Classification".

3 SCOPE OF SURVEYS

3.1 General provisions related to classification and survey procedures, as well as the requirements to technical documentation to be submitted to the Register for review and approval are specified in the General Requirements for the Classification and Other Activity and Part I "Classification" of the Rules for the Classification.

3.2 For each craft covered by the requirements of this Part, the Register performs the following:

.1 prior to construction and conversion of the ship — review and approval of technical documentation related to the craft stability;

.2 during construction, conversion and trials of the craft — supervision during inclining or weighting test;

review and approval of the Stability Booklet;

review and approval of Guidelines on the Safe Ballast Water Exchange at Sea;

.3 during special surveys for class reinstatement, as well as after repair and conversion of the craft — specifying the changes in the lightweight load to make a conclusion on further suitability of the Stability Booklet.

4 GENERAL TECHNICAL REQUIREMENTS

4.1 All craft shall be provided with stability characteristics and stabilization systems adequate for safety:

when the craft is operated in the displacement, operational (non-displacement) modes and during the transitional mode;

in transfer of the craft from any mode to the displacement mode in case of any system malfunction.

4.1.1 Stability may be verified by calculation and/or experimental methods.

Other means of demonstrating compliance with the requirements of this Part may be accepted, provided that the method chosen can be shown to provide an equivalent level of safety. Such methods may include:

mathematical simulation of dynamic behaviour;

scale model testing;

full-scale trials.

The adequacy of mathematical simulations shall be demonstrated by correlation with full-scale or model tests for the appropriate type of craft. It may be appropriate to use mathematical simulations to help to identify the more critical scenarios for subsequent physical testing.

Model or full-scale trials and/or calculations (as appropriate) shall also include consideration of the following known stability hazards to which high-speed craft[1] are known to be liable, according to craft type:

.1 directional instability, which is often coupled to roll and pitch instabilities;

.2 broaching and bow diving in following seas at speeds near to wave speed, applicable to most types;

.3 bow diving of planing monohulls and catamarans due to dynamic loss of longitudinal stability in relatively calm seas;

.4 reduction in transverse stability with increasing speed of monohulls;

.5 porpoising of planing monohulls, being coupled pitch and heave oscillations, which can become violent;

.6 chine tripping, being a phenomenon of planing monohulls occurring when the immersion of a chine generates a strong capsizing moment;

.7 plough of air-cushion vehicles, either longitudinal or transverse, as a result of bow or side skirt tuck-under or sudden collapse of skirt geometry, which, in extreme cases, can result in capsize;

.8 pitch instability of SWATH (small waterplane area twin hull) craft due to the hydrodynamic moment developed as a result of the water flow over the submerged lower hulls;

.9 reduction in effective metacentric height (roll stiffness) of surface-effect ship (SES) in high speed turns compared to that of straight course, which can result in sudden increase in heel angle and/or coupled roll and pitch oscillations; and

.10 resonant rolling of SES in beam seas, which, in extreme cases, can result in capsize.

Verification procedures and calculation programmes shall be approved by the Register.

4.1.2 Stability characteristics of the designed HSC in the displacement mode may be determined using calculation methods; in the operational and transitional modes, by calculations or experimentally by testing a model of the designed craft or on the basis of the results of full-scale trials of the craft prototype.

[1] Hereinafter referred to as "HSC".

For craft having a distinguishing mark **AUTstab** in the class notation, data proving sufficient stability of the craft in case of possible failures in the stabilization controls and their drives shall be presented.

4.1.3 Stability characteristics of the craft shall be finally corrected in the displacement mode in accordance with the inclining test results (refer to 5.1), in the operational and transitional modes according to the experimental data.

An ability of the craft to keep the operational and transitional modes under the worst intended conditions shall be proved experimentally during delivery seaworthiness trials of the craft.

Suitable calculations shall be carried out and/or tests conducted to demonstrate that, when operating within approved operational limitations, the craft will, after a disturbance causing roll, pitch, heave or heel due to turning or any combination thereof, return to the original attitude.

Where calculations are employed, it shall first be shown that they correctly represent dynamic behaviour within the operational limitations of the craft.

4.2 HSC stability shall be verified for the loading conditions referred to in 13.1.1, 13.1.2 and 13.2.1.

4.3 If in the process of normal service of a craft the worse loading variants with regard to stability are intended in comparison with those mentioned in 4.2, the stability for those loading variants shall be verified also.

4.4 The requirements of 1.4.1, 1.4.2.1 — 1.4.2.3, 1.4.2.5 — 1.4.7, 1.4.9 and 1.4.10 of Part IV "Stability" of the Rules for the Classification apply to HSC in the displacement mode. Calculations of HSC stability levers shall be carried out with respect to accompanying trim.

4.5 Unless provided otherwise, the requirement of 12.2 shall be met in the transitional mode under conditions referred to in 3.2; the maximum angles of heel shall not exceed 15°.

4.6 When computer programs are used on board the craft to determine trim and stability, the requirements in 1.4.12 of Part IV "Stability" of the Rules for the Classification.

5 INCLINING AND STABILITY INFORMATION

5.1 Ships stated in 1.5.1 of Part IV "Stability" of the Rules for the Classification shall be subject to the inclining test.

Inclining test shall be carried out in compliance with the requirements in 1.5 of Part IV "Stability" of the Rules for the Classification and Appendix 11 to Part V "Technical Supervision during Construction of Ships" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

5.2 Where an accurate inclining experiment is impractical owing to the height of the centre of gravity (KG) being less than one third of the initial transverse metacentric height (GM_T), the Register may accept estimation of KG by detailed calculation in place of a inclining test. In such a case, the light-weight check shall be undertaken to confirm the calculated light-ship characteristics, including the longitudinal center of gravity of the craft. The calculation results may be accepted as true if the data resulting from the lightweight check differ from the measured ones for not more than 2 % by the light-ship displacement and for not more than 1 % of the ship's length between perpendiculars by the light-ship longitudinal centre of gravity. The provision shall apply to craft constructed on and after 1 July 2002.

5.3 The master shall be supplied by the owner with reliable information relating to the stability of the craft in accordance with the provisions of this Section. The Stability Booklet shall, before being issued to the master, be submitted to the Register for approval, together with a copy thereof for their retention.

The Stability Booklet of a HSC shall incorporate the information on provision of stability of the craft in different modes of operation, as well as all the restrictions specified for the craft, such as distances allowed to proceed from a place of refuge and navigation seasons, sea state and wave height, angles to safely put the rudder over from one side to the other, etc. In compiling the Stability Booklet, one shall be guided by Appendix 1 to Part IV "Stability" of the Rules for the Classification, having regard to specific features of HSC and the requirements of these Rules.

5.4 To provide stability of the craft in service, each craft shall be provided with the RS-approved Stability Booklet in compliance with the requirements in 1.4.11 and Appendix 1 to Part IV "Stability" of the Rules for the Classification.

5.5 Every craft shall have scales of draughts marked clearly at the bow and stern. In the case where the draught marks are not located where they are easily readable, or operational constraints for a particular trade make it difficult to read the draught marks, then the craft shall be also fitted with a readable draught-indicating system by which the bow and stem draughts can be determined.

For amphibious air-cushion vehicles this may be achieved by the use of draught gauges in conjunction with deck datum plates.

5.6 The owner or builder, as appropriate, shall ensure that the positions of the draught marks are accurately determined and that the marks are located on the hull in a permanent manner. Accuracy of the draught marks shall be demonstrated to the Register prior to inclining experiment.

5.7 The requirements of 1.5 of Part IV "Stability" of the Rules for the Classification, apply to HSC.

5.8 Other methods of determining the displacement and centre of mass coordinates of the lightweight craft may be used upon agreement with the Register.

6 CONDITIONS OF SUFFICIENT STABILITY

6.1 In the worst loading condition in respect of stability out of those referred to in 3.2, stability of the craft shall meet the following requirements:

.1 a craft without capsizing in the displacement mode and without losing the mode in the operational mode shall withstand simultaneous action of a dynamically applied wind pressure and rolling the parameters of which shall be determined in accordance with the requirements given below;

.2 numerical values of parameters of static stability curve in the displacement mode and the value of the corrected initial metacentric height in all modes shall not be lower than those indicated in this Part;

.3 icing effect shall be taken into account in compliance with Section 11;

.4 stability in service shall comply with the requirements of Section 12;

.5 craft stability shall meet the additional requirements contained in Section 13.

7 PASSAGE OF CRAFT FROM ONE PORT TO ANOTHER

7.1 The requirements of Part IV "Stability" of the Rules for the Classification apply to HSC.

8 GENERAL REQUIREMENTS FOR STABILITY

8.1 WEATHER CRITERION

8.1.1 In the displacement mode stability of HSC other than hydrofoils and multihull craft is considered sufficient as regards weather criterion if the craft can withstand the combined effects of steady wind and rolling with reference to the following:

.1 the craft is subjected to a steady wind pressure acting perpendicular to the craft centreline which results in a steady wind heeling lever HL_1 (refer to Fig. 8.1.1.1);

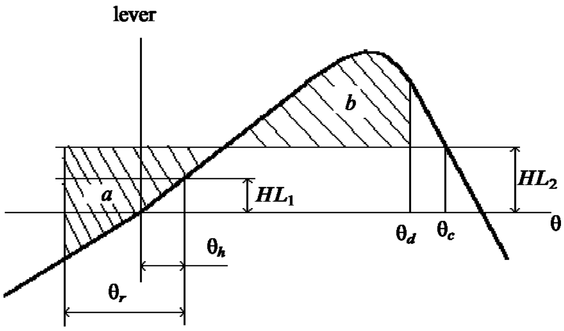


Fig. 8.1.1.1:
θ_h = angle of heel under action of steady wind;
θ_r = angle of rolling;
θ_d = angle of downflooding;
θ_c = angle of second intercept between a straight line HL_2 and GZ curve;
HL_1 = steady wind heeling lever;
HL_2 = gust wind heeling lever

.2 from the resultant angle of heel 0_h, the craft is assumed to roll owing to wave action to an amplitude of rolling θ_r to windward;

.3 the craft is then subjected to a gust wind pressure which results in a gust wind heeling lever HL_2,

.4 the areas a and b are compared (shaded areas in Fig. 8.1.1.1). The area b is bounded by the righting lever curve, a straight line corresponding to lever HL_2 and an angle of heel:

50° or angle of heel 0_c which corresponds to the second intercept between wind heeling lever HL_2 and the righting lever curve; or

angle of heel θ_d corresponding to the angle of downflooding, whichever is less.

The area a is bounded by the righting lever curve, a straight line HL_2 and an angle of heel corresponding to amplitude of rolling θ_r.

Craft stability is considered sufficient as regards weather criterion if area b is equal to or greater than area a;

.5 the permissible angle of heel 0_0 due to steady wind shall not exceed 16° or the angle equal to 0,8 times the angle of deck edge immersion, whichever is less. In this case, where the angle of heel exceeds 10°, efficient non-slip deck surfaces and suitable holding points shall be provided as specified in 4.4.1.1 of Part V "Reserve of Buoyancy and Subdivision" of these Rules;

.6 the wind heeling lever HL_1 in m, is assumed to be a constant value at all angles of inclination and shall be calculated as follows:

$$HL_1 = \frac{PAZ}{1000g\Delta} \quad (8.1.1.6)$$

where $P = 500(\frac{V_w}{26})^2$ — steady wind pressure, in N/m²;

V_w= wind speed corresponding to the worst intended conditions, in m/s;

Z = windage area lever; it is assumed equal to the vertical distance from the centre of windage to the centre of the waterline lateral area or approximately to a point at one half of the draught, in m;

A = windage area, in m²;

A = displacement of the craft, in t;

g = 9,81 m/s².

The heeling lever HL_2 is equal to 1,5 HL_1.

In assessing the roll angle θ_r account shall be taken of the roll damping characteristics of individual craft, which may alternatively be derived from model or full-scale tests using the procedure for determining the angle θ_r given in 13.3.1.2.1.5.3. Hulls with features, which greatly increase damping, such as immersed sidehulls, substantial arrays of foils, or flexible skirts, are likely to experience significantly smaller magnitudes of roll angle. For such craft, therefore, the roll angle shall be derived from model or full-scale tests or, in the absence such data, shall be taken as 15°.

8.1.2 Amplitudes of rolling are determined in the following manner:

.1 amplitudes of rolling for the displacement and operational modes shall be calculated using the procedures agreed with the Register or obtained from the data of experimental studies;

.2 if calculations or the data of experimental studies are lacking, the amplitude of rolling is assumed to be equal to θ_r= 15°;

.3 in determining the amplitude of rolling by means of experiments, it shall be determined as an amplitude of irregular rolling with 2 % of exceeding level and craft beam to the waves the intensity of which corresponds to:

in the operational mode — the worst intended conditions;

in the displacement mode — critical design conditions;

.4 the amplitude of rolling of an air-cushion vehicle in the operational mode is assumed equal to that in the cushion-borne mode; for all types of HSC in the displacement mode it shall be determined for the craft without motion.

8.1.3 The assumed design moment of losing the operational mode M_c' shall be determined by a method approved by the Register. The recommended procedure for determination of M_c' is given in Appendix 1 to this Part.

9 STATIC STABILITY CURVE

9.1 The area under the righting lever curve (GZ curve) shall not be less than 0,07 m·rad up to θ = 15° when the maximum righting lever (GZ) occurs at θ =15° and 0,055 m·rad up to θ = 30° when the maximum righting lever (GZ) occurs at θ =30° or over. Where the maximum righting lever occurs at angles of heel between θ =15° and θ = 30°, the corresponding area under the righting moments curve shall be not less than:

$$A = 0{,}055 + 0{,}001(30° - \theta_{\max}), \mathrm{m \cdot rad}, \quad (9.1)$$

where $\theta_{\max}$ = the angle of heel, in deg., at which the righting lever reaches its maximum.

9.1.1 The area under the righting lever curve between θ = 30° and θ = 40° or between θ = 30° and the angle of flooding θ_f, if this angle is less than 40°, shall not be less than 0,03 m·rad.

9.1.2 The righting lever GZ shall be at least 0,20 m at an angle of heel equal to or greater than 30°.

9.1.3 The maximum righting lever shall occur at an angle of heel not less than 15°.

9.2 Characteristics of static stability curves of air-cushion vehicles in the cushion-borne mode shall be determined according to the methods approved by the Register.

10 METACENTRIC HEIGHT

10.1 The corrected initial metacentric height under all loading conditions and in all modes shall be not less than 0,15 m.

11 ALLOWANCE FOR ICING

11.1 Substantiation of the HSC possible operation in icing conditions shall be submitted to the Register.

Allowance for icing shall be taken in compliance with 2.4 of Part IV "Stability" of the Rules for the Classification.

12 STABILITY IN SERVICE

12.1 The stability of the craft in the displacement mode shall be such that, when in still water conditions, the inclination of the craft from the horizontal in any direction would not exceed 10° under all permitted cases of loading and uncontrolled passenger movements as may occur.

Hydrofoil craft fitted with surface-piercing and/or fully submerged foils shall have sufficient stability under all permitted cases of loading to comply with the relevant provisions of 13.3 and maintain a heel angle of less than 10° when subjected to the greater of the heeling moments referred to in 13.3.1.2.

12.2 Under weather conditions up to the worst intended conditions, the time for HSC to pass from the displacement mode to the operational mode and vice versa shall not exceed 2 min.

12.3 It shall be proved by calculations or by tests that in the operational and transitional modes within the approved operational limitations, the craft will, after a disturbance causing heel, pitch, heave, roll or any combination thereof, return to the original attitude without occurrence of natural oscillations.

12.4 It shall be proved that no forces will arise in the operational mode on surface-piercing structures or appendages subsequent to collision with floating or submerged objects which might result in dangerous heel, trim or loss of stability.

12.5 It shall be proved that in case of any fault of the craft that can adversely affect stability in the transitional and operational modes provision is made for the safe transition of the craft into the displacement mode.

12.6 An inward angle of heel due to turning shall be provided in still water in the operational mode. The heel due to turning shall not exceed 8°.

12.7 Stability of the craft in the following sea in the operational mode shall be proved by testing a full-scale craft. In the following and quartering seas under the worst permissible conditions and the worst loading condition as regards stability as well as in case of turning under such conditions from the following sea to the head sea, the maximum angle of heel shall not exceed the angle of flooding or 0,6 of the angle corresponding to the lever HL_2 according to 8.1.2 or 12°, whichever is the less.

For the verification of characteristics of stability under the worst permissible conditions model tests shall be used. The method of model tests shall be approved by the Register.

12.8 The verification methods under 12.1 — 12.7 and the restrictions set up shall be agreed with the Register.

12.9 For the verification of stability of craft in service the instructions of Guidelines for uniform operating limitations of high-speed craft shall be taken into consideration (refer to Collection of regulating documents. Book Twenty, 2010).

13 ADDITIONAL REQUIREMENTS FOR STABILITY

13.1 REQUIREMENTS FOR PASSENGER CRAFT

13.1.1 Stability of HSC shall be verified for the following loading conditions:
the craft with full muster of passengers and cargo, and with full stores;
the craft with full muster of passengers and cargo and 10 % of stores;
the craft without passengers and cargo, and with 10 % of stores.

The distribution of passengers, their mass and the position of their centre of gravity shall be assumed in compliance with the guidelines given below:

.1 the distribution of passengers is 4 persons per square metre;
.2 each passenger has a mass of 75 kg;
.3 vertical centre of gravity of seated passengers is 0,3 m above the seat;
.4 vertical centre of gravity of standing passengers is 1,0 m above the deck;
.5 passengers and luggage are considered to be in the space normally at their disposal;
.6 passengers shall be distributed on available deck areas towards one side of the craft on the decks where assembly stations are located and in such a way that they produce the most adverse heeling moment;
.7 passengers assumed to be occupying seats shall be taken as having a vertical centre of gravity corresponding to being seated, with all others standing;
.8 on the decks where assembly stations are located, the number of passengers on each deck shall be that which generates the maximum heeling moment. Any remaining passengers shall be assumed to occupy decks adjacent to those on which the assembly stations are located, and positioned such that the combination of number on each deck and the total heeling moment generate the maximum static heel angle;
.9 passengers shall not be assumed to gain access to the weather deck nor be assumed to crowd abnormally towards either end of the craft unless this is a necessary part of the planned evacuation procedure;
.10 where there are seats in areas occupied by passengers, one passenger per seat shall be assumed, passengers being assigned to the remaining free areas of the deck (including stairways, if appropriate) at the rate of four per square metre.

13.1.2 Stability of passenger HSC in all modes shall be additionally verified in still water for the loading condition with full muster of passengers and cargo, and with 10 % of stores but with 50 % of passengers seated on one side from the centreline of the craft. The other 50 % of passengers are accommodated in fore-and-aft passages between the seats according to 3.1.6 — 3.1.8 of Part IV "Stability" of the Rules for the Classification.

13.1.3 The experimental checking of the lateral stability of a full-scale HSC in still water shall be made by moving solid ballast.

During checking at least two different heeling moments are applied to the craft and the corresponding angles of heel and trim in the displacement, transitional and operational modes are measured.

The maximum heeling moment shall be not less than the moment, which corresponds to the loading condition according to 13.1.2.

The checking procedure shall be submitted to the Register for approval.

13.1.4 The requirement of 12.1 shall be met for each passenger craft.

13.1.5 Stability of a craft in the non-displacement mode:

.1 the total angle of heel in still water due to the effect of passengers movements or due to beam wind pressure as per 13.3.1.2.1.4 shall not exceed 10°;
.2 under all loading conditions, the outward angle of heel due to turning shall not exceed 8°, and the total angle of heel due to beam wind pressure as per 13.3.1.2.1.4 and due to turning shall not exceed 12° outward.

13.1.6 Verification of the effects produced by the passenger heeling moment calculated as given in 13.1.1.1 — 13.1.1.10, or by a defined beam wind pressure when at speed, shall be carried out by comparing results of a trial or model test with an equivalent heeling moment applied by test weights. Passenger movement may only be neglected on craft where the safety announcement expressly requires passengers to remain seated throughout the voyage.

13.1.7 Inclining tests and Stability Booklet.

13.1.7.1 At periodical intervals not exceeding 5 years, a light-weight check shall be carried out on all passenger craft to verify any changes in lightweight displacement and longitudinal centre of gravity. The passenger craft shall be re-inclined whenever, in comparison with the approved Stability Booklet, a deviation from the lightweight displacement exceeding 2 %, or a deviation of the longitudinal centre of gravity exceeding 1 % of L is found or anticipated.

13.2 REQUIREMENTS FOR CARGO CRAFT

13.2.1 Stability of cargo craft shall be verified for the following loading conditions:
.1 the craft with full cargo and full stores;
.2 the craft with full cargo and 10 % of stores;
.3 the craft without cargo and with 10 % of stores.

13.3 SPECIAL REQUIREMENTS FOR STABILITY OF HYDROFOILS, AIR-CUSHION VEHICLES AND MULTIHULL CRAFT

13.3.1 Hydrofoils.

13.3.1.1 The stability of these craft shall be considered in the hull-borne, transitional and foil-borne modes under all permissible loading conditions. The stability investigation shall also take into account the effects of external forces.

The requirements of this Section shall be applied on the assumption that any stabilisation systems fitted are fully operational.

The roll and pitch stability on the first and/or any other craft of a series shall be qualitatively assessed during operational safety trials. The results of such trials may indicate the need to impose operational limitations.

13.3.1.2 Hydrofoils fitted with surface-piercing foils.

13.3.1.2.1 Displacement mode:

.1 hydrofoils fitted with surface-piercing foils shall have sufficient stability under all permitted loading conditions to comply with the relevant provisions of this paragraph and specifically to maintain an angle of heel of less than 10° when subjected to the greater of the heeling moments referred to in 13.3.1.2.1.2 and 13.3.1.2.1.4;

.2 the heeling moment developed during manoeuvring.

The heeling moment developed during manoeuvring of the craft may be derived from the following formula:

$$M_R = 0{,}196(V_0^2/L)\Delta KG \qquad (13.3.1.2.1.2)$$

where M_R= heeling moment, in kN·M;
V_0= speed of the craft in the turn, in m/s;
Δ= displacement, in t;
L= length of the craft on the waterline, in m;
KG= height of the centre of gravity above keel, in m.

This formula is applicable when the ratio of the radius of the turning circle to the length of the craft is 2 to 4;

.3 weather criterion.

The stability of a hydrofoil in the displacement mode shall be verified for compliance with the weather criterion K according to the formula

$$K = M_C/M_v \geq 1 \qquad (13.3.1.2.1.3)$$

where M_c= minimum capsizing moment as determined when account is taken of rolling;
M_v= dynamically applied heeling moment due to the wind pressure;

.4 heeling moment due to wind pressure.

Heeling moment due to wind pressure M_v, in kN/m, is determined by the formula

$$M_v = 0{,}001 p_v A_v Z \qquad (13.3.1.2.1.4)$$

where P_v= wind pressure, in N/m^2, = 750 (V_w/26)^2;
A_v= windage area, in m^2, including the projections of the lateral surfaces of the hull, superstructure and various structures above the waterline;
Z = windage area lever, in m, (the vertical distance to the geometrical centre of windage area from the waterline);
V_w= wind speed corresponding to the worst intended conditions, in m/s.

The value of the heeling moment is taken as constant during the whole period of heeling;

.5 evaluation of the minimum capsizing moment M_c in the displacement mode.

The minimum capsizing moment is determined from the static or dynamic stability curves taking rolling into account;

.5.1 when the static stability curve is used, M_c is determined by equating the area under the curves of capsizing and righting moments (or levers) taking rolling into account as indicated by Fig. 13.3.1.2.1.5-1, where 0_r is the amplitude of rolling and MK is a line drawn parallel to the abscissa axis such that the shaded areas S_1 and S_2 are equal.

$M_c = \mathrm{OM}$, if the scale of ordinates represents moments;

$M_c = \mathrm{OM} \times displacement$, if the scale of ordinates represents levers;

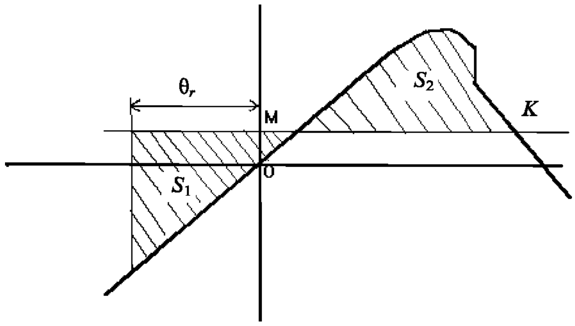


Fig. 13.3.1.2.1.5-1

.5.2 when the dynamic stability curve is used, first an auxiliary point A shall be determined. For this purpose the amplitude of rolling is plotted to the right along the abscissa axis and point A' is found (refer to Fig. 13.3.1.2.5-2). A line AA' is drawn parallel to the abscissa axis equal to the double amplitude of heeling ($\mathrm{AA}' = 20_r$) and the required auxiliary point A is found. A tangent AC to the dynamic stability curve is drawn. From the point A the line AB is drawn parallel to the abscissa axis and equal to 1 radian (57,3°). From the point B a perpendicular is drawn to intersect the tangent in the point E. The distance BE is equal to the capsizing moment if measured along the ordinate axis of the dynamic stability curve. If, however, the dynamic stability levers are plotted along this axis, BE is then the capsizing lever, and in this case the capsizing moment M_c is determined by multiplication of ordinate BE, in metres, by the corresponding displacement in tonnes:

$M_c = 9{,}81\Delta\mathrm{BE}$, kN·m; (13.3.1.2.1.5.2)

Moment or lever

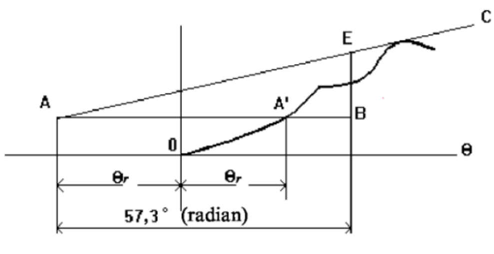


Fig. 13.3.1.2.1.5-2

.5.3 the amplitude of rolling 0_r shall be determined by means of model and full-scale tests in irregular seas as a maximum amplitude of 50 oscillations of a craft travelling at 90° to the wave direction in sea state for the worst design condition.

If such data are lacking the amplitude of rolling is assumed to be equal to 15°;

.5.4 the effectiveness of stability curves shall be limited to the angle of flooding.

13.3.1.2.2 Transitional and foil-borne modes:

.1 the stability in the transient and foil-borne modes shall be verified for all cases of loading for the intended service of the craft. Under all weather conditions up to the worst intended conditions, the time to pass from the displacement mode to the foil-borne mode and vice versa shall be minimized unless it is demonstrated that no substantial reduction of stability occurs during the transition;

.2 stability in the transitional and foil-borne modes may be determined either by calculation or on the basis of data obtained from model experiments and shall be verified by full-scale tests by imposition of a series of known heeling moments by off-centre ballast weights, and recording the angles of heel produced by these moments. When taken in the displacement, take-off and steady foil-borne and settling to the displacement mode, these results will provide an indication of the values of the stability in the various situations of the craft during the transitional condition. Procedures for determination of static stability curve characteristics shall be submitted to the Register for approval;

.3 the angle of heel in the foil-borne mode caused by the concentration of passengers at one side is not to exceed 8. During the transient mode the angle of heel due to the concentration of passengers on one side is not to exceed 12. The concentration of passengers shall be taken in accordance with the provisions of 13.1.1;

.4 one of the possible methods of assessing foil-borne metacentric height *(GM)* in the design stage for a particular foil configuration as given in Fig. 13.3.1.2.2.4 is as follows:

$$GM = n_B(L_B/2tanl_B - S) + n_H(L_H/2tanl_H - S) \qquad (12.3.1.2.2.4)$$

where n_B= percentage of hydrofoil load borne by front foil;
n_H= percentage of hydrofoil load borne by aft foil;
L_b= clearance width of front foil;
L_H= clearance width of aft foil;
a= clearance between bottom of keel and water;
g= height of centre of gravity above bottom of keel;
l_B= angle at which front foil is inclined to the horizontal;
l_H= angle at which aft foil is inclined to the horizontal;
S= height of centre of gravity above water.

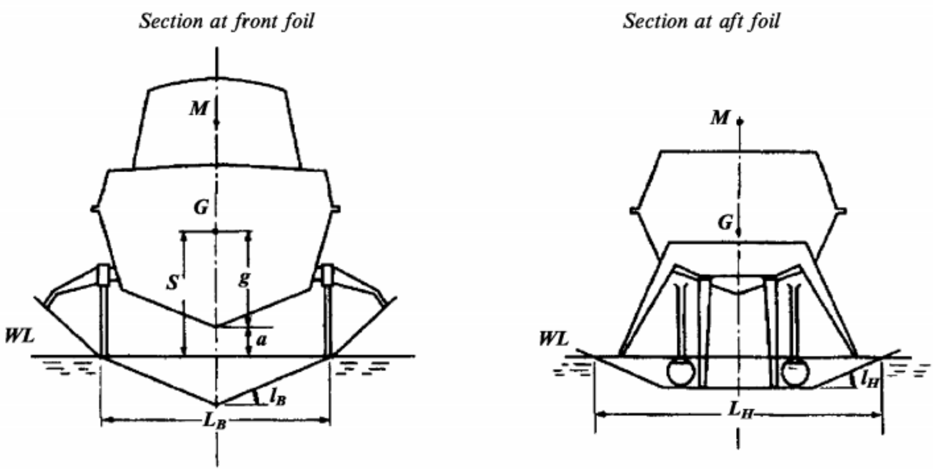


Fig. 13.3.1.2.2.4

13.3.1.3 Fully submerged hydrofoils.

13.3.1.3.1 Displacement mode.

Requirements 13.3.1.2.1.1 — 13.3.1.2.1.5 shall be applied to this type of craft in the displacement mode.

13.3.1.3.2 Transitional mode.

The stability shall be examined by numerical simulation with the use of the Register-approved computer program which allows to evaluate the craft's behaviour under the normal and limited conditions of operation, as well as its response under the influence of any malfunctions.

Stability conditions resulting from any potential failures in systems or operational procedures during the transitional stage which could be hazardous to the craft watertight integrity and stability shall be examined.

13.3.1.3.3 Foil-borne mode.

Craft stability in the foil-borne mode shall be in compliance with provisions of Section 12 and 13.3.1.3.2.

Requirements of 13.3.1.2.2.1 — 13.3.1.2.2.4, 13.3.1.3.2 and 13.3.1.3.3 shall be applied to this type of craft as appropriate and any computer simulations or design calculations shall be verified by full-scale tests.

13.3.2 Multihull craft.

13.3.2.1 A multihull craft, in the intact condition, shall have sufficient stability when rolling in a seaway to withstand successfully the effect of either passenger crowding or high-speed turning as described in 13.3.2.2.

13.3.2.2 The following stability criteria shall be met:

.1 the area under the GZ curve.

The area (A_1) under the GZ curve up to angle 0 shall be at least:

$$A_1 = 0{,}055 \times 30°/0, \mathrm{m} \cdot \mathrm{rad}, \qquad (13.3.2.2.1)$$

where Θ is the least of the possible angles:
the downflooding angle;
the angle at which the maximum GZ occurs;
30°;

.2 the maximum value of righting lever GZ.

The maximum GZ value shall occur at an angle of at least 10°;

.3 heeling due to wind.

The wind heeling lever shall be assumed constant at all angles of inclination and shall be calculated as follows:

$$HL_1 = \frac{P_i AZ}{9800\Delta}, \text{ in m}, \qquad (13.3.2.3.3)$$

$HL_1 = 1{,}5HL_1$, in m (refer to Fig. 13.3.2.2),

where P_i= wind pressure, in N/m^2, to be obtained from the formula
P_i= 500 $(V_w/26)^2$;
V_w= wind speed corresponding to the worst intended conditions, in m/s;
A= projected lateral area of the portion of the craft above the lightest service waterline, in m^2;
Z= vertical distance from the centre of A to a point one half the lightest service draught, in m;
Δ= displacement, in t;

.4 heeling due to passenger crowding or high-speed turning.

Heeling lever due to the crowding of passengers on one side of the craft or to high-speed turning, whichever is the greater, shall be considered in combination with the heeling lever HL_2 due to wind (regarding the gust);

.4.1 heeling due to passenger crowding.

When calculating the heel a heeling lever due to passenger crowding shall be determined. The calculation shall be made with regard to provisions of 13.1.1 and 3.1.6 — 3.1.9 of Part IV "Stability" of the Rules for the Classification;

.4.2 heeling due to high-speed turning.

When calculating the heel a heeling lever due to high-speed turning shall be determined using the following formula:

$$TL = \frac{1}{g}\frac{V_0^2}{R}(KG - d/2) \qquad (13.3.2.2.4.2)$$

where TL= turning lever, in m;
V_0= speed of the craft in the turn, in m/s;
R= turning radius, in m;
KG= height of vertical centre of gravity above keel, in m;
d= mean draught, in m;
g= acceleration due to gravity.

Alternatively, another method of assessment may be employed as provided for 3.1.1;

.5 rolling in waves (refer to Fig. 13.3.2.2).

The effect of rolling in a seaway upon the craft stability shall be demonstrated mathematically. In doing so, the residual area (A_2) under the GZ curve, i. e. beyond the angle of heel θ_h, shall be at least equal to 0,028 m·rad up to the angle of rolling θ_r. In the absence of model tests results or other data θ_r shall be taken as 15° or as an angle of (θ_d – θ_h), whichever is less.

The determination of θ_r from the model test or other data shall be carried out using the procedure for determining θ_r given in 13.3.1.2.1.5.3;

.6 for the purpose of intact stability calculations and application of Fig. 13.3.2.2, the following heeling levers shall be used:

.6.1 wind heeling lever (including gusting effect) — *HL*2;

.6.2 total heeling lever equal to the sum of heeling lever due to wind (+ gusting) and heeling lever due to either passenger crowding or turning, whichever is the greater.

The angle of heel due to the wind heeling lever (*HL*2) shall not exceed 10°.

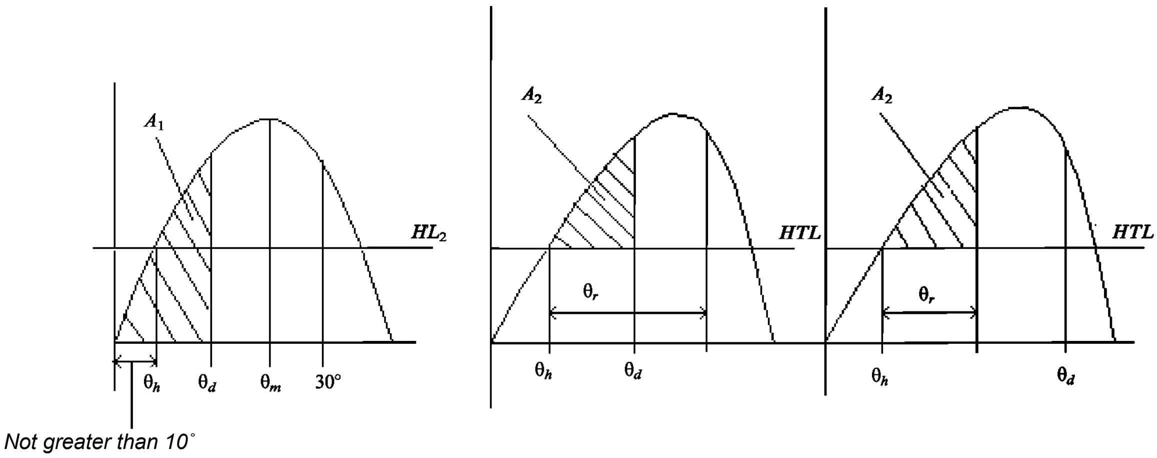


Fig. 13.3.2.2:

HL_2 = heeling lever due to wind + gusting;
HTL = heeling lever due to wind + gusting + (passenger crowding or turning), whichever is the greater;
θ_h = angle of heel due to heeling moment with lever HL_2. or HTL;
θ_r= angle of roll;
θ_d = angle of downflooding;
θ_m = angle of maximum GZ

13.3.3 Air-cushion vehicles.

13.3.3.1 These requirements apply to air-cushion vehicles of all types.

13.3.3.2 Air-cushion vehicles in the displacement mode are covered by the requirements of 13.3.1.2.1.2. The angle of heel due to the combined effect of turning and passenger crowding shall be determined experimentally.

13.3.3.3 Stability of air-cushion vehicles in the transitional mode shall be such that the inclination of the craft from the horizontal in any direction will not exceed 8° under all possible loading conditions and passenger movements as may occur.

13.3.3.4 Stability of air-cushion vehicles in the operational and transitional modes shall meet the requirements of 13.3.1.2.2. The total angle of heel due to passenger crowding and wind pressure or due to passenger crowding and turning shall be determined on the basis of model tests of the designed craft or prototype craft.

The total angle of heel due to passenger crowding and turning shall be determined experimentally in a more accurate way during delivery trials of the full-scale craft.

13.3.3.5 Where an air-cushion vehicle shall go to a shore, which is not protected against waves, it shall be demonstrated to the Register that the craft stability is sufficient when it passes the tidal area under the worst permissible conditions.

The substantiation submitted shall confirm that the air-cushion vehicle has sufficient stability to meet the stability criteria given in Part IV "Stability" of these Rules with regard to stability decrease in a seaway.

The substantiation shall be confirmed during delivery trials of the first craft of the series.

13.3.3.6 The following structural requirements shall be met to ensure stability of an air-cushion vehicle:

.1 the shape of the rigid hull in the forward end shall provide the hydrodynamic righting moment in water landing with a bow trim in still water and in a seaway. The hull slope angle shall be not less than 12°;

.2 for air-cushion vehicles fitted with flexible skirts it shall be demonstrated that flexible skirts will not lose stability in the modes allowed by the operational manual and in all possible loading conditions. The height of flexible skirts and hull structure shall be such that in the cushion-borne mode the contact of the main hull with the supporting surface (water, land) can occur at a heel angle not less than 9° and trim 3°. The opening angle of flexible skirt shall be not less than 30°;

.3 in designs where periodic use of cushion deformation is employed as a means of assisting craft control, or periodic use of cushion air exhausting to atmosphere for purposes of craft manoeuvring, the effects upon cushion-borne stability shall be determined, and the limitations on the use by virtue of weather conditions, mode and loading condition of the craft shall be established. These limitations shall be indicated in the Stability Booklet.

APPENDIX 1

DETERMINATION OF ASSUMED DESIGN MOMENT AT WHICH HIGH-SPEED CRAFT LOSES OPERATIONAL MODE

The assumed design moment M_c taking rolling into account when HSC loses the operational mode and is transferred into the displacement mode may be determined from the dynamic and static stability curves.

For air-cushion vehicles the curves cut short at an angle of heel which corresponds to the point of intersection of the static stability curve in the displacement mode (curve 1) and that in the cushion-borne mode (curve 2) determined in still water without motion (refer to Fig.).

For hydrofoil craft the curves cut short at the angle of heel corresponding to the limiting angle of heel for which hydrodynamic characteristics of the foil system are calculated at the specified speed.

Moment M_c shall be determined (as in the case when the curve cuts short at the flooding angle) by one of the methods described in Appendix to Part IV "Stability" of the Rules for the Classification.

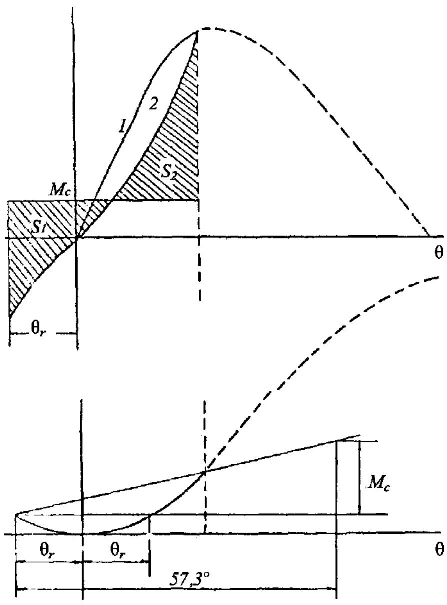


Fig.

APPENDIX 2

ICING AS APPLIED TO ALL TYPES OF CRAFT

1 ICING ALLOWANCES

1.1 For craft operating in areas where icing is likely to occur, stability calculations shall be made considering the following:

.1 icing allowances:

30 kg/m^2 on exposed weather decks and gangways;

7,5 kg/m^2 of projected lateral area of each side of the craft above the water;

.2 the projected lateral area of discontinuous surfaces of rail, sundry booms, spars (except masts) and rigging and the projected lateral area of other small objects shall be computed by increasing the total projected area of continuous surfaces by 5 % and the static moments of this area by 10 %;

.3 reduction of stability due to asymmetric ice accumulations in cross-structure.

1.2 For craft operating in areas where icing may be expected:

.1 within the areas defined in 2.1, 2.3, 2.4 and 2.5 and known to have ice conditions significantly different from those specified in 1.1, ice accretion requirements of one half to twice the required allowance may be applied;

.2 within the area defined in 2.2, where icing twice exceeding the allowance required by 2.2 may be expected, more severe requirements than those given in 1.1 may be applied.

1.3 Information shall be provided in respect of assumptions made in calculating the condition of the craft in each of cases set out in this Appendix for the following:

.1 duration of the voyage in terms of the period spent in reaching the destination and returning to port;

.2 consumption rates during the voyage for fuel, water, stores and other consumables.

2 AREAS OF ICING CONDITIONS

2.1 In the application of 1, the following icing areas shall be considered:

.1 the area north of latitude 65°30'N, between longitude 28°W and the west coast of Iceland; north of the north coast of Iceland; north of the rhumb line running from latitude 66°N, longitude 15°W to latitude 73°30'N, longitude 15°E, north of latitude 73°30'N, between longitude 15°E and 35°E, and east of longitude 35°E, as well as north of latitude 56°N in the Baltic Sea;

.2 the area north of latitude 43°N bounded in the west by the North American coast and the east by the rhumb line running from latitude 43°N, longitude 48°W to latitude 63°N, longitude 28°W and thence along longitude 28°W;

.3 all sea areas north of the North American continent, west of the areas defined in 2.1 and 2.2 of this paragraph;

.4 the Bering and Okhotsk Seas and the Tatary Straight in winter;

.5 south of latitude 60°S.

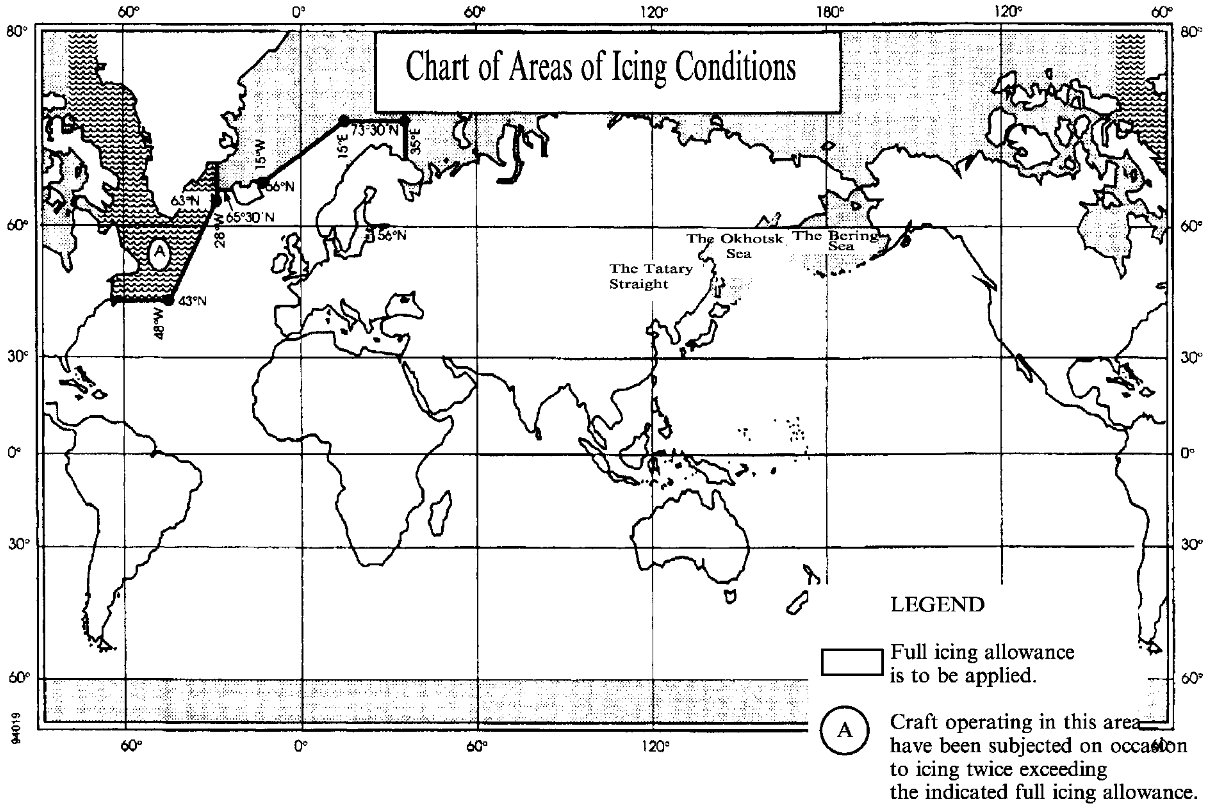
The chart to illustrate the areas is attached.

3 GENERAL REQUIREMENTS

3.1 Craft intended for operation in areas where icing is likely to occur shall be:

.1 designed to minimize the accretion of ice;

.2 equipped with means for ice removing.



Russian Maritime Register of Shipping

Rules for the Classification and Construction of High-Speed Craft
Part IV
Stability

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