RUSSIAN MARITIME REGISTER OF SHIPPING

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RULES

FOR THE CLASSIFICATION, CONSTRUCTION AND EQUIPMENT OF MOBILE OFFSHORE DRILLING UNITS AND FIXED OFFSHORE PLATFORMS

PART IV

STABILITY

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RULES FOR THE CLASSIFICATION, CONSTRUCTION AND EQUIPMENT OF MOBILE OFFSHORE DRILLING UNITS AND FIXED OFFSHORE PLATFORMS

Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units (MODU) and Fixed Offshore Platforms of (FOP) 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 July 2022.

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

The Rules set down specific requirements for MODU and FOP, consider the recommendations of the Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU Code), as adopted by the IMO Assembly on 2 December 2009 (IMO resolution A.1023(26)).

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";
Part III "Equipment, Arrangements and Outfit of MODU/FOP";
Part IV "Stability";
Part V "Subdivision";
Part VI "Fire Protection";
Part VII "Machinery Installations and Machinery";
Part VIII "Systems and Piping";
Part IX "Boilers, Heat Exchangers and Pressure Vessels";
Part X "Electrical Equipment"
Part XI "Refrigerating Plants";
Part XII "Materials";
Part XIII "Welding";
Part XIV "Automation";
Part XV "MODU and FOP Safety Assessment";
Part XVI "Signal Means";
Part XVII "Life-Saving Appliances";
Part XVIII "Radio Equipment";
Part XIX "Navigational Equipment";
Part XX "Equipment for Prevention of Pollution".

These Rules supplement the Rules for the Classification and Construction of Sea-Going Ships and the Rules for the Equipment of Sea-Going Ships.

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 GENERAL

1.1 APPLICATION

1.1.1 The requirements of this Part of the Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units (MODU) and Fixed Offshore Platforms (FOP)[1] apply to:

.1 newly built MODU/FOP hereinafter referred to as "units", if in floating condition and if their hull form cannot be regarded as conventional for ships and barges;

.2 structural members of MODU/FOP hereinafter referred to as "units", if in floating condition;

.3 floating units with a ship- or barge-type displacement hull intended for drilling of seabed and operating in the floating condition;

.4 existing MODU/FOP and above-mentioned floating units hereinafter referred to as "units", if as the result of repair and/or conversion their stability is changed;

.5 MODU/FOP and/or above-mentioned floating units hereinafter referred to as "units" in service as far as it is reasonable and practicable.

[1] Hereinafter referred to as "the MODU/FOP Rules".

1.2 DEFINITIONS AND EXPLANATIONS

Definitions and explanations relating to the general terminology are given in Part I "Classification".

For the purpose of this Part the following definitions have been adopted.

1.2.1 General definitions.

Hull of a floating structure and a fixed structure is a watertight structure which ensures buoyancy and stability of a unit. The hull may be divided into one, two or more lower hulls (pontoons), as a rule, submersible, and upper hull which is usually above water.

Unit is a ship, MODU, FOP, other structures, a module and/or any their components covered by the requirements of this Part.

Openings considered to be open are openings in the weather decks, hull sides, columns and bulkheads of superstructures and deckhouses including chain lockers, the closing appliances of which do not comply with the requirements of Part III "Equipment, Arrangements and Outfit of MODU/FOP" as far as their strength, weathertightness and efficiency are concerned. Small openings such as discharges of ship systems and pipes which have actually no effect on stability in dynamical inclination are not considered to be open.

Floating structure is a unit which at all stages of its life cycle is in a floating condition and, while in service, may be exposed to extreme environmental conditions.

Among the floating structures are:

semi-submersible floating structure without excessive buoyancy positioned with the use of position mooring system and/or thrusters (dynamic positioning system);

semi-submersible floating structure with excessive buoyancy and pretensioned position mooring system;

self-elevating unit is a unit with movable legs resting on seabed, for which the floating condition may be regarded as short-time condition associated with outfitting and transit periods.

Floating unit is a unit with a ship- or barge-type displacement hull intended for drilling of seabed and operating in the floating condition.

Transit stores are fuel, fresh water, lubricating oil, provisions, consumable stores (ship's stores) intended for use during transit and minimum amount of drilling stores necessary for commencement of the operations.

Limiting angle of statical heel under the effect of the heeling moment is the lesser of the down-flooding angle φ_f and the angle φ_2 corresponding to the second intercept of the righting moment curve and the heeling moment curve.

Angle of inclination is the angle between a vertical and the line of intersection of the centerline plane and the midstation plane of the unit. The tangent of the inclination angle φ is determined by the formula $tg(\varphi) = (tg^2\theta + tg^2\psi)^{1/2}$ where θ is the angle of heel, is the angle of trim.

1.2.2 Design conditions.

Survival condition is an ultimate condition wherein in case of severe (design) storm or severe ice conditions the unit shall withstand environmental loads corresponding to such condition.

The stability criteria in the survival condition shall be, whenever possible, met by means of appropriate technical solutions incorporated in the design. The above criteria may be also met through:

interruption of an operation (e.g. bringing the unit to an anchor during transit, raising to the original position or grounding) if this improves the safety of the unit and if interruption of an operation may be effected within not more than three hours;

implementation of protective arrangements without interruption of an operation or coincidentally therewith (e.g. by means of ballasting).

Normal condition is a condition wherein work is performed in accordance with the purpose of the unit and with the Operating Manual.

Transit condition is a condition wherein a unit may be moved from one geographical location to another.

1.3 SCOPE OF SURVEYS

1.3.1 General provisions pertaining to the procedure of classification and surveys, as well as the aggregative list of the technical design documentation, to be submitted to the Register for review and approval are contained in Part I "Classification".

1.3.2 For every unit meeting the requirements of this Part, the Register may carry out the following:

.1 prior to commencement of the unit's construction — review and approval of technical documentation relating to the unit's stability;

.2 during the unit's construction, conversion and trials — technical supervision over the inclining tests or light-weight checks;

review and approval of the Stability Booklet and review of the Guidance for the ballast system arrangement plan;

.3 review and approval of the shipboard computer software by which monitoring of trim and stability is provided if any shipboard computer used;

.4 during special surveys for the purpose of class renewal and/or endorsement of the MODU Safety Certificate, as well as after repair or modernization — inspections to check for changes in the lightweight condition in order to conclude whether the Stability Booklet is still applicable.

1.4 GENERAL TECHNICAL REQUIREMENTS

1.4.1 Calculations.

All calculations shall be made by the methods approved by the Register. When using a computer, the methods of computation shall be approved and the programs certified by the Register. The copies of the programs shall have the authors' licenses.

1.4.2 Calculation of cross-curves of stability.

1.4.2.1 To be determined prior to the calculation of the cross-curves of stability are:

design modes and design conditions of the unit;

reasonable position of the unit's coordinate axes;

axes of inclination.

The cross-curves of stability shall be calculated for the most critical axes of inclination as regards stability. Where the position of such axes cannot be indicated without performance of an appropriate calculation, a circle stability diagram or a part thereof shall be constructed; for this purpose calculations shall be made for the condition when the unit is inclined about different axes with such a step that enables determination of the most critical axis of inclination in each design case.

1.4.2.2 When calculating the cross-curves of stability, account shall be taken of all watertight volumes of the units, as well as buoyancy/stability pontoons (if installed on the unit), deck wells, trunks, compartments of air cushion skirts, with due regard for the possibility for the water to spread over the spaces and compartments at the inclinations being considered.

1.4.2.3 Superstructures, deckhouses and similar structures may be taken into account in the calculations of the cross-curves of stability provided their strength meets the requirements of Part II "Hull", and the design and means of closing of openings meet the requirements of Part III "Equipment, Arrangements and Outfit of MODU/FOP". Openings which do not comply with the said requirements are considered to be open.

1.4.3 Arrangement of compartments.

Drawings of watertight compartments and compartments of air cushion skirts, tanks and wells shall contain data necessary to make stability calculations, including volumes and positions of the centres of gravity for tanks filled with liquid cargoes and values of corrections for the effect of free surfaces of liquids on stability.

1.4.4 Deck plans.

Deck plans included in the design documentation shall contain all data necessary to determine the centres of masses of deck cargoes. Where heavy deck cargoes are likely to be relocated in the process of operation, two extreme positions of these cargoes or equipment shall be indicated in the deck plans.

1.4.5 Arrangement of doors, companionways and side scuttles. Angle of flooding.

The arrangement plan of doors, companionways and side scuttles which shall be taken into account when calculating the cross-curves of stability shall include all openings in the decks, hull sides, columns, bulkheads of superstructures and deckhouses with indication of the degree of their tightness and with appropriate references to their design, as specified in Part III "Equipment, Arrangements and Outfit of MODU/FOP".

The flooding angle data, either in the form of a curve or in the tabular form shall be appended to the calculations of the cross-curves of stability.

1.4.6 Computation of free surface effect of liquids.

1.4.6.1 Tanks for each kind of liquid which according to the construction and service conditions may simultaneously have free surfaces, as well as stabilizing tanks shall be taken into account when determining the free surface effect of liquids on stability. The heeling moment δM_{φ}, kN m, due to liquid overflow shall be computed about the axis involved of the unit's inclination to an angle φ.

Besides, account shall be taken of the water on the deck during submergence/raising, as well as in other locations from which it cannot be removed.

Considering the number of tank combinations for the individual kinds of liquids or single tanks, likely to occur, only those developing the greatest total heeling moment δM_{15} due to liquid overflow at the unit's inclination of 15° shall be selected. In all cases the correction for free surfaces shall be calculated for each tank assumed to be filled to 50 % of its capacity.

1.4.6.2 The tanks to be taken into account shall be chosen in compliance with the Instructions on Loading and Consuming of Liquids.

The tanks complying with the following condition shall be not included in the calculation

$$\delta M_{15} \leq 0{,}02 g \Delta_{min} \qquad (1.4.6.2)$$

where g = gravity acceleration, in m/s²;
Δ_{min} = unit displacement corresponding to the minimum mass loading of the variants under consideration, t.

Total correction δM_{15} for tanks not included in the calculation is not to exceed $0{,}05 g \Delta_{min}$. Otherwise, appropriate corrections shall be taken into account in the computation.

1.4.6.3 Operations with liquids used as ballast (loading, discharge, transfer) shall ensure preservation of the allowable values of the metacentric height (in compliance with Section 3), draught and the unit's inclination angles.

1.4.6.4 Where sea valves are used to take in water provision shall be made for preserving the values of the metacentric height (in compliance with 3.1.3), draught and the unit's inclination angles.

1.4.7 Design data relating to stability checking.

1.4.7.1 The scope of the technical design documentation relating to stability to be submitted to the Register shall be agreed with the latter having regard to structural features and service conditions of the unit but is not necessarily to include the following documents to be submitted at the design stages:

.1 plan of subdivision showing all watertight structures and openings with indication of their arrangement, dimensions and types of closing appliances;

.2 lines drawing;

.3 calculation materials relating to verification of the unit's trim and stability in compliance with the requirements of this Part, including:

mass loading calculation;

arrangement of variable cargoes, including liquid cargoes and ballast;

plan of extreme positions of cargoes and equipment which may be stowed in different positions;

calculations and diagrams of windage area, icing and snow;

calculations of righting and heeling moments (having regard to the effect of drift ice, position-keeping systems, buoyancy/stability pontoons, influence of support reaction when in contact with the seabed);

calculation of corrections for free surface effect of liquids;

calculation of motion amplitudes;

metacentric diagrams for submergence/raising operations;

.4 Guidance for the ballast system arrangement plan.

1.4.8 Requirements for the Stability Booklet.

1.4.8.1 In order to assist the master of the unit in maintaining an adequate stability of the unit in service, and in order to render assistance to the control authorities, the Stability Booklet (the Booklet) approved by the Register shall be developed and issued.

The Booklet shall contain data on the unit's stability in compliance with the requirements of this Part.

Formal observance of the provisions contained in the Booklet does not relieve the master of the responsibility for the stability of the unit.

1.4.8.2 The format of the Booklet and the data included may vary dependent on the type and purpose of the unit, its operating area, stability reserve.

The Booklet shall contain in particular the following data:

.1 particulars of the unit;

.2 stability data for typical, predetermined loading conditions in order to provide stability of the unit in its design conditions: normal, transit, survival, as well as during submergence/raising;

.3 directions on restrictions proceeding from the hydrometeorological conditions for different loading conditions in order to provide stability of the unit, including instructions on necessary actions to be taken in the preparation condition (e.g. to pass from the normal condition to the survival one, etc) and time required to perform appropriate operations;

.4 or semi-submersible units the description, schematic diagrams and the directions on ballasting in compliance with the Guidance for the ballast system arrangement plan;

.5 tank and bulk material stowage space capacity tables showing capacity and the center of volume position (as far as tanks are concerned, values of capacity, center of volume position and free surface corrections in relation to the filling level shall be also specified) supporting diagrams, tables and other data to evaluate stability of the unit for any loading conditions not specified beforehand but likely to occur in service, as well as directions on use of such data with appropriate examples;

.6 recommendations on maintaining stability of the unit;

.7 data on recommended sources of hydrometeorological information;

.8 the location, type and quantities of permanent ballast installed on the unit;

.9 light ship data together with a comprehensive listing of the inclusions and exclusions of semi-permanent equipment;

.10 curves (tables) of the allowable heights of the unit's center of gravity in relation to its draught data or other parameters based upon compliance with the intact and damage stability criteria;

.11 description and limitations of any on-board computer used in trim and stability calculations;

.12 guidance for the maintenance of adequate stability and the use of data specified in the Stability Booklet;

.13 guidance for the routine recording of lightweight alterations;

.14 guidance for the calculation of loading which is different from the standard loading conditions, including the vertical components of the forces in the anchor cables;

.15 estimated time of transition to the survival condition from the normal or temporary condition and the actions of the crew recommended in this case.

When compiling the Booklet, the provisions of the Appendix 1 to Part IV "Stability" of the Rules for the Classification and Construction of Sea-Going Ships[1] shall be followed considering structural, operational and other peculiarities of a certain unit.

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

1.4.8.3 The Booklet shall be based on the unit's inclining test data. Where serial units are constructed at the same shipyard, the Booklet prepared for the first unit may be used for subsequent units provided the requirements of 1.5.2 are met.

1.4.8.4 The Stability Booklet may either be prepared as a separate document or as a part of the Operating Manual of the unit.

1.4.9 Requirements for the Guidance for the ballast system arrangement plan.

The format of the Guidance and information included may vary dependent on the unit type, purpose and operating area.

The Guidance shall contain, in particular:

.1 detailed instructions as regards operation of pumps, ballast system, preparation of tanks and air pipes for ballasting operations;

.2 instructions for prevention of over- and under-pressurization of tanks;

.3 information on free surface effect of liquids on stability and tankage in tanks that may be slack in any one time;

.4 information on weather conditions admissible for ballast exchange;

.5 weather routing in areas affected by cyclones, typhoons and hurricanes, or heavy icing conditions;

.6 instructions on maintenance of adequate intact stability during liquid ballast operations in accordance with an approved Stability Booklet;

.7 accepted values of minimum/maximum draughts;

.8 instructions for documented record of ballasting operations;

.9 instructions for contingency procedures for situations which may affect the water ballast exchange (including worsening of weather conditions, pump failure, de-energization of the unit, etc);

.10 information on time necessary to perform ballasting operations and sequence thereof;

.11 instructions for monitoring the amount of ballast water;

.12 list of manholes which may be left opened during ballasting with a notification that they shall be closed after completion of ballasting;

.13 instructions for ballasting under low temperatures;

.14 list of conditions and circumstances which do not allow ballasting and deballasting.

1.5 INCLINING TEST

1.5.1 An inclining test shall be required for newly built units referred to in 1.1.1.

1.5.2 On agreement with the Administration the following units may be exempted from the inclining test:

.1 series-built units which are identical by design. For them the light ship data of the prototype unit may be accepted; in this case the results of the light-weight check shall confirm that the difference in light ship displacement and horizontal position of the lightweight center of gravity does not exceed 1 % of the values of the light ship displacement and principal horizontal dimensions as determined for the first of the series;

.2 very big units for which an accurate inclining test is impractical; such a decision shall be based on comparison with similar units, proceeding from the experience in designing, building and operating thereof.

1.5.3 Where serial units are built at the same shipyard, the inclining test shall be required for:

.1 the first unit of the series;

.2 a unit for which the requirements of 1.5.2.1 are not fulfilled;

.3 unit whose centre of gravity height in light condition increases by more than $0{,}05\Delta_1 h/\Delta_0$ (where h = the least value of the corrected initial metacentric height at displacement Δ_1 of the unit t; Δ_0 = displacement of the first unit of the series during inclination, t) as compared with that of the first unit.

The Stability Booklet of a series-built unit shall take account of the correction for the difference in light ship displacement and in centre of gravity position as compared with the unit which has been subjected to the inclining test.

1.5.4 Where the inclining test results of a unit show that its actual displacement and/or centre of gravity height exceed the design value to the extent that involves non-fulfillment of the requirements of this Part, a unit's Inspection Record containing exhaustive explanation of the reasons of such differences shall be attached to the Inclining Test Report.

Based on review of the materials submitted or in case they are missing, the Register may require the repeated (check) inclining test of the unit. In this case both Inclining Test Reports shall be submitted to the Register for review.

1.5.5 Mass loading of a unit to be inclined shall be as far as practicable close to the loadings considered in the specific design conditions from among those referred to in 1.2.2.

1.5.6 The metacentric height of the unit in the process of inclining test shall be such as to ensure safety of the inclining test and in any event it shall be not less than 0,05 the centre of gravity height.

For the purpose of meeting this requirement and ensuring favourable trim of the unit necessary ballast shall be taken. When water ballast is taken, the tanks containing such ballast shall be carefully pressed up and their volumes and centres of gravity coordinates determined accurately.

1.5.7 **For column-stabilized units:**

.1 a lightweight survey or inclining test shall be conducted at the first survey for class renewal and/or for MODU Safety Certificate endorsement. If a lightweight survey indicates a change from the calculated light ship displacement in excess of 1 % of the operating displacement, an inclining test shall be conducted, or the difference in weight shall be placed in an indisputably conservative center of gravity and approved by the Administration;

.2 if the survey or lightweight check at the first survey for class renewal and/or for MODU Safety Certificate endorsement demonstrated that the unit was maintaining an effective weight control program, and at succeeding surveys for class renewal and/or for MODU Safety Certificate endorsement this is confirmed by the records in the light ship data alteration log, light ship displacement may be verified in operation by comparison of the calculated and observed draught. Where the difference between the expected displacement and the actual displacement based upon draught readings exceeds 1 % of the operating displacement, a lightweight survey shall be completed in accordance with 1.5.7.1.

1.5.8 An inclining test shall be carried out in the presence of a surveyor to the Register in compliance with the Guidance for the Conduct of an Inclining Test for a particular unit approved by the Register. This Guidance shall be prepared on the basis of model Guidance given in Appendix 2.

1.5.9 The results of the inclining test, or deadweight survey and subsequent inclining test, if conducted in conformity with 1.5.4, shall be indicated in the Stability Booklet.

1.5.10 Solid and water ballast shall be used as a heeling ballast during the inclining test. The heeling ballast may be moved from side to side with the help of the unit's own cargo cranes as well as shore-based cranes.

1.5.11 The total amount of heeling ballast shall be determined proceeding from the condition that when all heeling ballast are positioned on one side in their allocated places, the unit would be inclined to 1 — 5°, depending on its salient features, and that the waterline form shall not be changed and the hull counters and undercuts do not emerge, as this takes place.

The initial heel of the unit shall not generally exceed 0,3°.

In the Guidance for the Conduct of an Inclining Test to be prepared for a specific unit the said inclination angles may be finalized depending on the actual conditions wherein the inclining test is conducted.

1.5.12 When the unit is inclined by liquid ballast, it is essential to know the shape, volumes, volume centres of gravity of the tanks used for the heeling ballast, given in their calibration tables having regard to structure and equipment of these tanks. Preference shall be given to the side, symmetric about the inclination axis, sufficiently deep and narrow tanks, regular in shape, wherever possible. Compliance of the tanks with their drawings shall be verified on the spot.

Tanks containing heeling water ballast shall be efficiently pressed up or left slack within the wall-sided portion.

1.5.13 The Inclining Test Report, drawings and calculations associated with processing of the test data, as well as the unit's mass loading calculations shall be submitted to the Register.

2 GENERAL REQUIREMENTS FOR STABILITY

2.1 ALLOWANCE FOR THE POSITION-KEEPING SYSTEM

2.1.1 When making stability calculations in accordance with the requirements of this Part the unit is assumed to be a free-floating body. However, where a position-keeping system is provided it will be necessary to evaluate the possible detrimental effects on the stability, especially in case when the mooring line fairleads are lower than the centre of lateral resistance. The effect of the position-keeping system (mooring and/or using thrusters) shall be reviewed:

.1 in normal condition;

.2 in survival condition, if this results in the worse, as regards stability, estimations of criteria (e.g. in the event of failure of one, several or all positioning restraints) and if no means are developed for relieving the unit of the position-keeping system influence in time not more than 3 h.

2.2 LOADING CONDITIONS

2.2.1 Stability shall be generally checked for the whole range of possible loading conditions in all design conditions of the unit. Account shall be taken of the most unfavourable position of the cargoes and equipment to be moved.

2.2.2 The equipment and cargoes and consumables taken on the unit shall be so arranged that the survival condition can be achieved without the relocation or removal of solid consumables, equipment or other variable loads.

Removal of solid consumables and equipment on a unit when going to the survival condition may be allowed, provided:

.1 stability requirements stated in Section 3 are met;

.2 mass loads are handled within a short period of time that is well within the bounds of a favorable weather forecast.

Thus, the permissible weather conditions and loading conditions shall be identified in the Stability Booklet.

2.3 RIGHTING MOMENT CURVES

2.3.1 Curves of righting moments M_{φ} of a unit shall be calculated and plotted:

.1 covering all loading conditions under consideration, when the unit is inclined about the most unfavourable axis as regards stability;

.2 taking into account the free surface effect of liquids (cargoes, consumables, ballast, liquid in the stabilizing tanks, etc.) in conformity with the Guidance for the ballast system arrangement plan.

2.3.2 The curves of righting moments shall be calculated in accordance with methods approved by the Register for the volume displacement ∇, in m³:

.1 for a unit not kept by the position-keeping system

$$\nabla = \frac{1}{\rho_l}; \tag{2.3.2.1}$$

.2 for a unit kept by the position-keeping system

$$\nabla = \frac{1}{\rho_l}\left(\varDelta + \frac{\sum_1^n P_{Pi}}{g}\right). \tag{2.3.2.2}$$

The following symbols have been adopted in these formulae and in the subsequent text:

$\varDelta$ is the mass of the unit, in t;

P_{Pi} is the vertical component of the force due to the *i*-th element of the position-keeping system (*i* = 1,..,n), kN;

ρ_l is the sea water density, in t/m³.

Action of the said forces on the unit is illustrated schematically by Fig. 2.3.2 wherein:

the righting moment, weight and buoyancy forces are involved (Fig. 2.3.2, a);

the wind load is involved: V_{V_0} is the true wind velocity; V_l is the drift speed over seabed (sailing speed); V_V is the relative wind velocity (Fig. 2.3.2, b) which at low drift speed may be assumed as the design velocity (refer to 2.5.1.3);

the forces due to drift and current are involved:

$V_l \neq 0, V_R = V_l - V_S$, V_S is the current velocity (refer to Fig. 2.3.2, c);

the force due to current is involved: $V_l = 0$ (refer to Fig. 2.3.2, d);

the force due to the *i*-th element of the position-keeping system is involved (refer to Fig. 2.3.2, e).

(0 is the origin of coordinates in the unit's inclination plane, y_χ is the ordinate in the same plane).

In Figs. 2.3.2, a — 2.3.2, e apart from the specified forces and moments, the weight and buoyancy forces having no symbolic representation are involved.

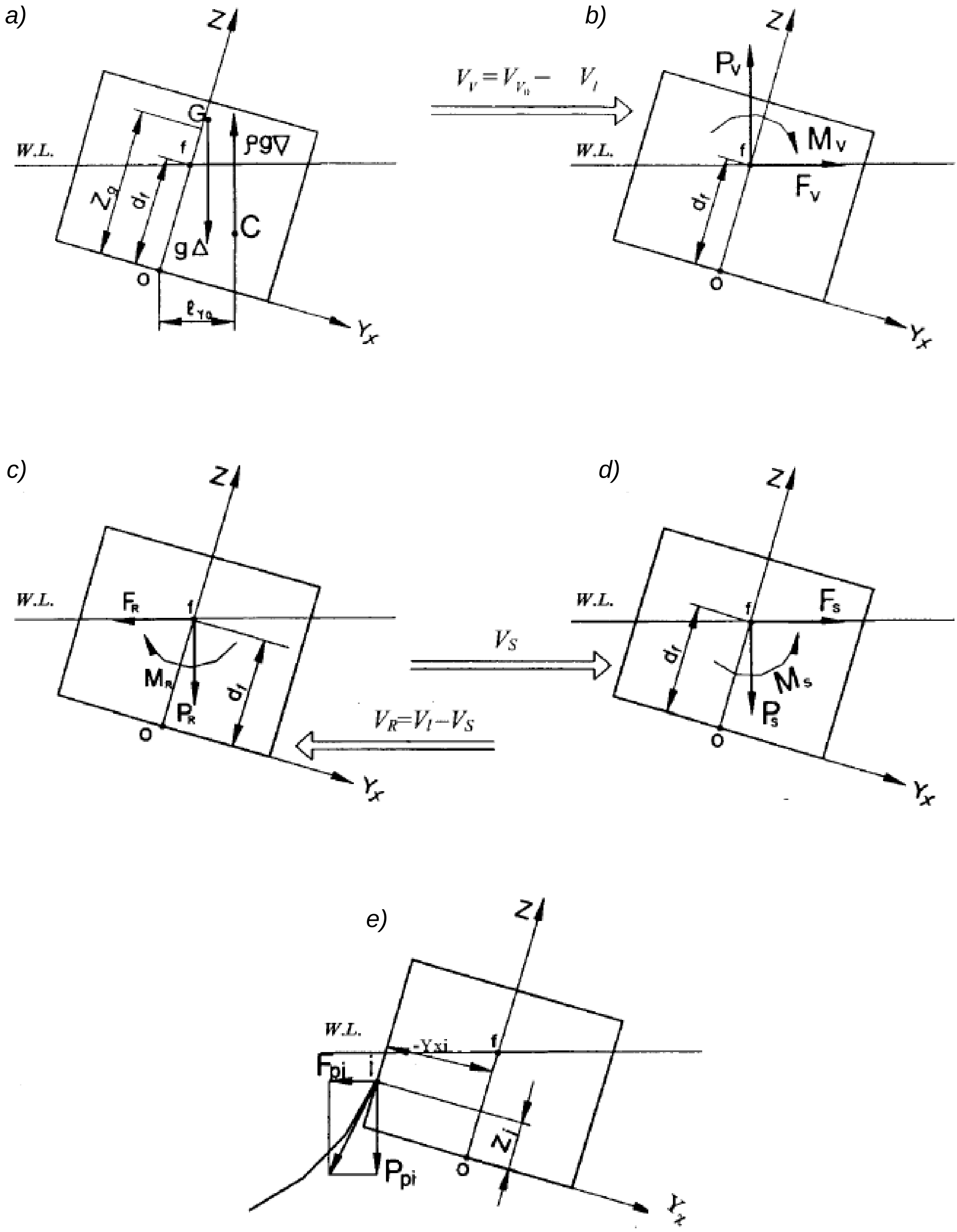


Fig. 2.3.2
Schematic illustration of the environmental effects in the unit's inclination plane

2.3.3 The righting moment M_φ, in kN·m, shall be calculated by the following formula:

$$M_\varphi = \rho_l g \nabla \left(l_{\varphi_0} - z_g \sin\varphi - y_{g\chi} \cos\varphi \right) \qquad (2.3.3)$$

where z_g, $y_{g\chi}$ = the unit's centre of gravity coordinates in the inclination plane, in m;
χ = heading angle of wind;
l_{φ_0} = the cross-curves of stability in the inclination plane about the origin of coordinates, in m;
φ = the inclination angle, in deg.

2.4 HEELING MOMENT CURVES

2.4.1 The heeling moment curve shall be calculated for a sufficient number of heeling angles to define the curve within the range which exceeds the second intercept with the righting moment curve. For the ship-shaped hulls the heeling moment curve may be assumed as the cosine function of the angle of heel.

2.4.2 Heeling moment components.

2.4.2.1 For all loading conditions under consideration the curves of heeling moments M_h, due to wind moment M_v, normal to the most critical axis of the unit inclination as regards stability shall be calculated, as well as:

.1 for the units assumed free-floating, in calculating the wind heeling moment the lever of the wind force application is assumed to be equal to the distance from the common pressure center of all surfaces defining the windage area to center of lateral resistance of the underwater body of the unit;

.2 for the units assumed floating free of mooring restraint, the heeling moment due to position-keeping system is determined by the formula (in the system of coordinates about the unit's center of gravity):

$$M_p = \sum_i F_{P_i}[(y_{\chi i} - y_{g\chi})\sin\varphi + (z_g - z_i)\cos\varphi] - $$
$$- \sum_i P_{P_i}[(z_g - z_i)\sin\varphi - (y_{\chi i} - y_{g\chi})\cos\varphi] \qquad (2.4.2.1.2)$$

where F_{P_i} = the horizontal component of the force due to *i*-th element of the position-keeping system;

z_i, $y_{\chi i}$ = coordinates of the force application points of the *i*-th element of the position-keeping system.

Where a current exists in the unit positioning location the moment of forces due to current M_S shall be taken into account in accordance with 2.5.3.

The horizontal force F_p acting on the object from the position-keeping system side is assumed to be equal to the sum of horizontal components of the wind force F_V and the current force F_S but reverse thereto in direction;

.3 for the moored units in the drift ice the heeling moment due to ice load M_i shall be evaluated using the procedures approved by the Register.

2.4.2.2 The heeling moments M_V, M_R, M_S, and relevant forces shall be generally determined by physical simulation methods using the procedures approved by the Register.

When no physical simulation data are available, the wind pressure and its lever with respect to the waterline, as well as the forces and moments due to drift and current may be determined by the method outlined in 2.4.3 and 2.4.4.

2.4.3 Wind heeling moment.

2.4.3.1 The wind force (horizontal component of the wind force) F_V, in kN, when the physical simulation data are used, shall be determined by the following formula:

$$F_V = C_V \frac{\rho_A}{2} A_V V_V^2 \qquad (2.4.3.1\text{-}1)$$

where C_V = the wind resistance coefficient F_V referred to the unit's windage area A_V, in m², and to the dynamic wind pressure – $\frac{\rho_A}{2} V_V^2$, in kPa, at the wind velocity profile V_V above the sea as given in 2.5.1.1;

p_A = air density (1,222 kg/m).

Note. Where the coefficient C_V is referred to the windage area in the position inclined to an angle φ, this shall be accounted for in the calculations.

2.4.3.2 To account for the windage area of small items which are not installed on the model used in the physical simulation, the wind force F_V and moment M_V shall be increased by 2 and 5 %, respectively. Under icing condition this increase shall be accepted in compliance with 2.5.5.3.

2.4.3.3 When no physical simulation data are available, a procedure outlined in Appendix 3, may be used to construct the circle diagram of the wind force. To do this, the wind force on the unit shall be previously determined for the wind flow in four directions differing by 90°, and then the wind force calculation shall be made following the instructions contained in Appendix 3. In the approximate calculations, the wind force and its lever shall be determined using the following formulae:

$$F_V = \frac{\rho_A}{2} A_{VA} V_V^2 \qquad (2.4.3.3\text{-}1)$$

where $A_{VA} = \sum_i C_{Si} C_{Hi} A_{Vi}$ (2.4.3.3-2)

where A_{VA} = assumed windage area, in m²;
A_{Vi} = area of the *ij*-th element of the unit windage, in m²;
$C_{Hj} = \left(V_{hj}/V_V\right)^2$ = height coefficient (zone coefficient) to be determined at $h_V = h_{Vj}$ by Formula (2.5.1.1) (h_{Vi} is the height of the center of area A_{Vi} above the waterline); at h_{Vi} 10 m the coefficient is assumed to be equal to 1 or obtained from Table 2.4.3.3-1 for characteristic wind velocities;
C_{Sj} = shape (aerodynamic flow) coefficient of the structural member; coefficients C_{Sj} for some windage area components are given in Table 2.4.3.3-2.

Table 2.4.3.3-1

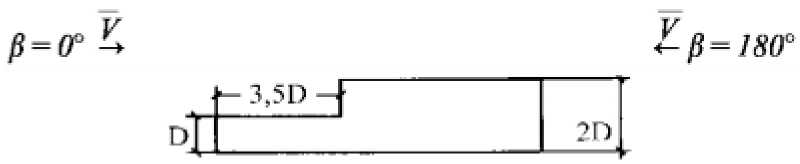
Height coefficient C_{Hj}

Height above sea level, in m	V_V, in m/s		
	25,8	36,0	51,5
10	1	1	1
20	1,182	1,208	1,242
30	1,296	1,339	1,396
40	1,379	1,435	1,510
50	1,446	1,513	1,602
60	1,502	1,578	1,680
70	1,550	1,633	1,746
80	1,592	1,682	1,805
90	1,630	1,726	1,858
100	1,664	1,766	1,905
110	1,695	1,802	1,949
120	1,723	1,836	1,990
130	1,750	1,867	2,027
140	1,775	1,896	2,062

Height above sea level, in m	V_V, in m/s		
	25,8	36,0	51,5
150	1,798	1,924	2,095
160	1,820	1,949	2,126
170	1,840	1,973	2,155
180	1,860	1,996	2,183
190	1,879	2,018	2,209
200	1,896	2,039	2,235
210	1,913	2,059	2,259
220	1,929	2,078	2,282
230	1,945	2,097	2,304
240	1,960	2,114	2,326
250	1,974	2,131	2,346
N o t e . The intermediate values of heights shall be determined by linear interpolation.			

T a b l e 2.4.3.3-2

Shape coefficient C_{Sj}

Windage area components	C_{Sj}
Spherical	0,4
Upper hull with that surfaces (hull shape in plan view):	
equilateral triangle when the wind flow is directed:	
along the bisectrix	0,65
normally to the side	1,01
square when the wind flow is directed:	
along the bisectrix	0,78
normally to the side	0,93
equilateral pentagon when the wind flow is directed:	
along the bisectrix	0,76
normally to the side	0,70
equilateral hexagon when the wind flow is directed:	
along the bisectrix	0,71
normally to the side	0,63
circle:	
with sharp edges of diameter R and height D	0,61
with rounded-off edges at a radius equal to half	0,32
the height rectangle with side ratio:	
$\lambda = B/L = 0{,}5$	0,89
$\lambda = B/L = 0{,}3$	0,96
(wind direction is normal to the face)	
Upper hull of rectangular shape in plan view with underdeck beams	1,1
Upper hull with a topside	
	0,63 ($\beta = 0°$) 1,2 ($\beta = 180°$)
Superstructures, deckhouses, cabins and other box-type structures located:	
along the perimeter of the upper deck	1,2

Windage area components	C_{sj}
in the centre part of the upper deck	0,7
Derrick substructure	1,2
Smooth cylindrical elements (bracing members, stability columns, cylindrical legs) depending of the product of the design dynamic wind pressure q, in Pa, by the pipe diameter d_1, in m, squared	
at $qd_1^2 \leq 10$ H	1,2
at $qd_1^2 \geq 10$ H	0,7
Legs of square section	1,4
Lattice-type structures consisting of tubular elements (load-bearing structure of drilling derrick, crane booms)	1,3
Lattice-type legs of self-elevating MODU:	
tetrahedral	1,6
trihedral	1,5
Drilling derrick consisting of tubular elements with the drill pipe stands, linings of landings and ladders	1,7
Lining of the entire structure of the drilling derrick (conical)	0,7
Helideck (cantilever)	1,5
Isolated shapes	1,5
Hand rails	1,2
Small windage area components	1,4
Ropes of cargo handling gear	
with ≤20 mm in diameter	1,2
with > 20 mm in diameter	1,0

N o t e s : 1. The windage area of the constituents of the unit A_{vj} is the characteristic area which is definitively related to the value of the unit resistance coefficient C_{sj}.

2. For structures with continuous surfaces (upper hull, superstructures, etc), the projected area of the hull to the vertical plane normal to the air flow velocity vector shall be taken as the characteristic area.

3. The projected area of lattice-type structures shall be obtained either by detailed calculations of the projected areas of the elements on the windward side having regard to unshielded areas inside the internal space (drill pipe stands, linings of ladders, etc) or by multiplying the projected block area on the windward side by a filling factor which is assumed equal to 0,45 for the drilling derricks and tetrahedral legs and 0,3 for trihedral legs, crane booms and other truss structures and tubular members.

4. When calculating the windage area of units with smooth cylindrical legs or stability columns of circular and square sections, exposed to head and beam wind, projected areas of legs and columns shall be included with a shielding allowance being made.

The shielding factor for legs and columns of circular section is determined by the formula:

$$K_3 = \exp(-0{,}002 + 1{,}033/\bar{l} - 20{,}4/\bar{l}^2),$$

where $\bar{l} = l/d_1$

l = the distance between the axes of legs or columns;

d_1 = the diameter of legs or columns.

The shielding factor for legs and columns of square section is determined by the formula:

$$K_3 = \exp(0{,}005 - 0{,}79/\bar{l} - 30{,}4/\bar{l}^2),$$

where $\bar{l} = l/b$

b = the breadth of leg or columns side.

The shielding factor for the trihedral truss-type legs is assumed as: $K_3 = l/6b$.

Windage area components	C_{sj}
The shielding factor for the tetrahedral truss-type legs is assumed as: $K_3 = l/9b$. 5. Where two similar structural elements of non-streamlined form (deckhouses and superstructures of box type) are located on the deck one after another in the direction of the wind effect, shielding allowance is made by multiplying the area of the windward element by the shielding factor $K_3 = l/12c$, where c is the least projection of the element on a plane normal to the wind direction. In this case, the overall projection are of the windward element is included in the windage area. Where the elements differ in size, the portion of the rear element not overlapped by the windward element is included in full. 6. Where no data is available, it is assumed then $K_3 = L/7c$. 7. For the intermediate values of qd_1^2, the values of C_{sj} is determined by linear interpolation. 8. The continuity factor is a product of the filling factor by the shielding factor.	

2.4.3.4 Where the hull above waterline incorporates structures which are likely to be subjected to vertical forces arising during inclination of the unit, as well as for the units with upper hull rectangular in the horizontal plane, without large cutouts and/or with a helideck, in case when no physical simulation data are available, the wind heeling moment shall be determined using the procedure outlined in Appendix 4.

2.4.4 Hydrodynamic portion of heeling moment.

2.4.4.1 For the unit not assumed floating free, the lever of the resistance force to drift are determined by physical simulation using the procedures approved by the Register.

2.4.4.2 Where the physical simulation data are not available, the lever of the resistance force to drift may be determined approximately:

.1 for the ship- or barge-shaped hull (at B/d = 2,0 – 6,0), the lever of the application of the resistance force to drift about the waterline in case where the unit is inclined about the longitudinal axis may be determined by the formula

$$h_R = d[B/d – 3{,}00 - 0{,}02(B/d - 5{,}35)^3] \qquad (2.4.4.2.1)$$

where d, B = hull draught and waterline breadth, respectively, in m;

.2 for the units with underwater hull body consisting of structural members of non-streamlined form j, having the projected area to the vertical plane A_{Rj}, in m², the lever of the resistance force to drift may be obtained by the formula

$$h_R = \left(\sum_j C_{R_j} A_{R_j} h_{R_j}\right) / \left(\sum_j C_{R_j} A_{R_j}\right) \qquad (2.4.4.2.2)$$

where the coefficients C_{R_j} may be taken equal to the coefficients C_{Sj} for the appropriate shapes of members. When considering members, a shielding allowance shall be made.

2.4.4.3 The moment (lever) and the components of the forces due to current for the unit kept from drifting by the position-keeping system are determined in a manner like that specified in 2.4.4.2 with allowance made for the differences in signs (refer to Fig. 2.3.2).

2.5 DESIGN ENVIRONMENTAL (NATURAL) CONDITIONS

When selecting parameters of the design models of the environmental effects on the unit, the designer (on agreement with the customer) shall take account of such factors as:

differences in the design modes;

differences in the design conditions;

salient features of the geographical locations and duration of the construction, transit, use of the unit;

seasonal fluctuations and local features of the environmental effects (wind, currents, waves, icing, etc);

sheltering of the water area;

possible restrictions due to hydrometeorological conditions;

accuracy of the weather forecasts;

peculiar features of the unit, etc.

2.5.1 Wind.

2.5.1.1 Height coefficient (zone coefficient) $C_{Hj} = (V_{hj}/V_V)^2$ considering increasing of wind velocity V_{hj} on the basis of h_{vj} is determined by the formula

$$C_{Hj} = (V_{hj}/V_V)^2 = \left[1 + 2{,}5\ln(h_{Vj}/10)\sqrt{(0{,}71 + 0{,}071V_V)10^{-3}}\right]^2 \quad (2.5.1.1)$$

where V_V = design wind velocity (an average over the 10 min period velocity of a wind at a height of 10 m above the sea level), in m/s;

V_{hj} = wind velocity at a height h_{Vj} above the sea level, in m/s.

2.5.1.2 The design wind velocity is specified by the designer on agreement with the owner of the unit on the basis of data from the recognized sources of the hydrometeorological information on the maximum value of the possible wind velocity at various stages of the unit life cycle:

.1 in the intended operating area:

in the normal condition — every year;

in the survival condition — every 50 years;

.2 in the temporary condition, transit condition, afloat building and preparation modes: with due account of their duration, location and season, sheltering of the water area (e.g. shore-side structures, configuration of terrain, lakes, bays, rivers, flooded areas, etc).

2.5.1.3 Where no data mentioned in 2.5.1.2 are available, the design wind velocity is assumed as follows:

in the normal condition in the open water areas: 36 m/s, and in the sheltered water areas: 25,8 m/s;

in the survival condition in conformity with Appendix 5, and where no data are contained therein: 51,5 m/s;

in the temporary condition, transit condition, in the afloat construction and preparation modes where the operation lasts not more than three hours, in conformity with the Shipyard's Instructions (with due account of the local and seasonal conditions), and in case of a longer period of the operation: 25,8 m/s in the sheltered water areas and 36 m/s in the open water areas.

2.5.2 Waves.

2.5.2.1 The effect of the waves is allowed for only in the seasons when there is no ice.

2.5.2.2 Waves are specified and described by the following design parameters:

$h_{3\%}$ which is the wave height with 3 % probability of exceeding level, in m;

T which is the mean period of heavy waves, in s;

χ which is the general wave direction.

The values of $h_{3\%}$, T and other parameters of the spectral wave density shall be taken consistent with the design wind force with due account of the local peculiarities of wave generation.

The design parameters of the waves shall be indicated in the Stability Booklet and in the Operation Performance Guidelines.

2.5.2.3 The design wave height (unless otherwise specified) shall be taken on the basis of the long-term probability (multi-year) distribution of heights $h_{3\%}$, as a height with 50 % probability of exceeding level at the design wind velocity (based on the principle of negligible probability for simultaneous occurrence of extreme values for the parameters of different phenomena — wind velocity and wave height).

2.5.2.4 In the temporary condition the design wave height is specified by the designer on agreement with the owner of the unit, but it shall not be taken lower than that given below:

in the sheltered water areas — 0,5 m;

in the open water areas — 2,0 m.

2.5.2.5 In the survival condition the design wave heights shall be taken for the area involved as the greatest heights from the multi-year observation data and where no such data are available, according to Appendix 5 to this Part, but on no account they shall exceed:

16 m for the seas of the Arctic Ocean (Russian sector) and the Pacific Ocean (Russian sector);

14 m for the Baltic and Caspian Seas;

12 m for the Black Sea;

6 m for the Azov Sea.

2.5.3 Current.

2.5.3.1 The effect of current is taken into account only in cases where the position-keeping system is used and where the total velocity of the components accounted for (of the wind, drift, gradient, tidal, discharge and other kinds of current) exceeds 0,5 m/s. The design velocities of the wind current and wave drift on the water surface shall be taken as having 50 % probability of exceeding level at the design parameters of wind and waves.

In case where the sum vector of the velocity of surface current does not coincide with the unit inclination plane for its orientation pattern adopted, the current velocity multiplied by the cosine of the angle between the wind and current directions is taken as the design current velocity.

2.5.3.2 The used data on currents shall be agreed with the customer (owner of the unit) and the procedure of calculating the current effects shall be approved by the Register.

2.5.4 Floating (drift) ice.

2.5.4.1 Stability of the object with a position-keeping system shall be evaluated with due account of the drift ice effect on the unit.

2.5.4.2 The following procedures shall be submitted to the Register for approval:

calculation of the effect of ice drift forces on stability;

physical modeling of the unit behavior in drift ice;

application of model test data for evaluating stability.

2.5.5 Ice and snow accretion.

2.5.5.1 Where a marine operation is performed in winter within winter seasonal zones set up by the Load Line Rules for Sea-Going Ships and the unit is operated within a winter seasonal zone, stability of the unit and supply vessels with due regard for ice and snow accretion shall be checked in addition to the main loading conditions.

2.5.5.2 When calculating stability with regard to ice and snow accretion in a first approximation use may be made of the following recommendations:

.1 for units operating within winter seasonal zones to the north of latitude 66°30'N and to the south of latitude 60°00'S, as also in winter in the Bering Sea, the Sea of Okhotsk and in the Tatarski Strait, the assumed rates of ice and snow accretion shall be as specified below:

the mass of ice per square metre of the horizontal projection area of exposed decks (irrespective of the availability of awnings) shall be 30 kg, if those decks are located at a height up to 10 m above the waterline, 15 kg, if the height is from 10 up to 30 m, and if the height above the waterline is more than 30 m, the mass of ice may be neglected;

the mass of snow per square metre of the area of the above-mentioned decks (irrespective of the height) shall be 100 kg for unmanned units and 10 kg for manned units, or with the geographical service area of the same units prescribed, the mass of snow shall be as given in Fig. 2.5.5.2.1;

the mass of ice per square metre of the windage area shall be 15 kg, if the height above the waterline is up to 10 m, 7,5 kg, if the height is from 10 up to 30 m, and if the height is more than 30 m, the mass of ice may be neglected;

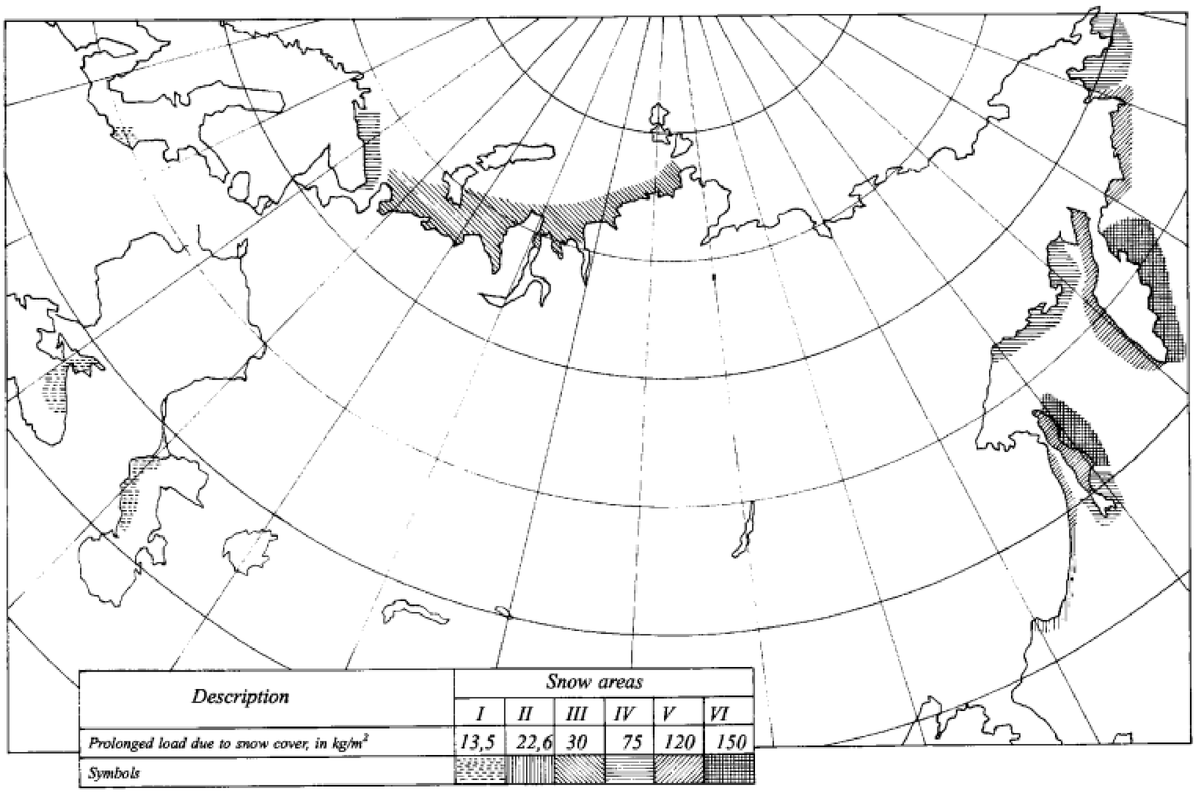


Fig. 2.5.5.2.1

.2 in other areas of the winter seasonal zone, as well as for the units operating in the Black and Azov Seas northwards of latitude 44°00'N and in the Caspian Sea northwards of latitude 42°00'N, the rates of ice and snow accretion shall be assumed to be equal to half those specified in 2.5.5.2.1.

2.5.5.3 To account for the projected lateral areas of discontinued surfaces of units subjected to icing the projected lateral area and its moment of continuous surfaces with respect to the base plane shall be increased by 10 and 20 % or 7,5 and 15 %, respectively, depending upon the rates of icing stated above.

2.5.5.4 Special facilities to reduce ice and snow mass shall be considered in the design of units.

3 STABILITY CRITERIA

3.1 GENERAL

3.1.1 The stability criteria given in this Section are determined in accordance with Fig. 3.1.1-1, if the unit motions are accounted for and in accordance with Fig. 3.1.1-2, if the unit motions are ignored.

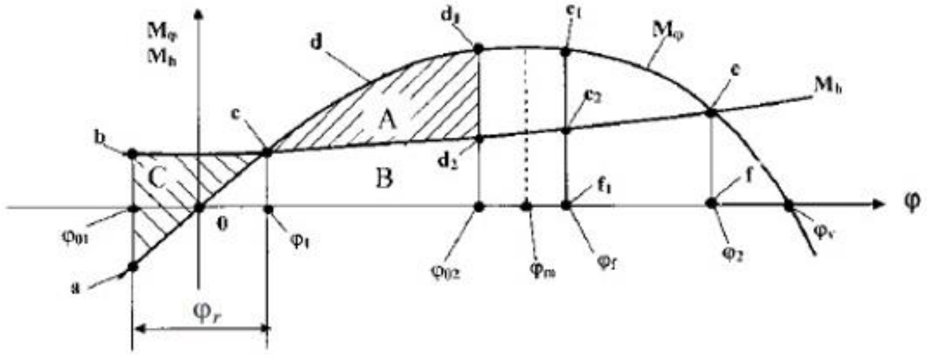


Fig. 3.1.1-1
Curve of statical stability with the motions allowed for:
M_{φ} = righting moment;
M_h = heeling moment;
φ_1 first intercept angle of the curves M_{φ} and M_h;
φ_{02} = angle of inclination due to combined action of the wind and waves on the leeward side;
φ_m = angle of maximum of the righting moment curve M_{φ};
φ_f = angle of flooding;
φ_2 = second intercept angle of the curves M_{φ} and M_h;
φ_v = angle of vanishing stability;
φ_r = motion amplitude

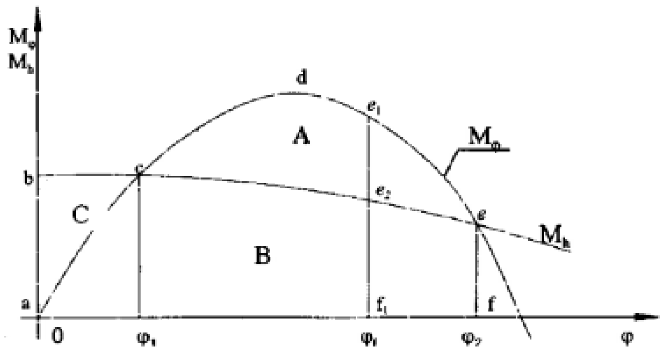


Fig. 3.1.1-2
Curve of statical stability with the motions ignored

The areas in above Figs. 3.1.1-1 and 3.1.1-2 are determined as follows:

area A — by figure cde (or cde_1e_2 if the angle of flooding φ_f is less than the angle of second intercept φ_2);

area B — by figure $ocef$ (or oce_2f_1, if $\varphi_f < \varphi_2$);

area C — by figure abc.

3.1.2 The corrected initial metacentric height h_0, corresponding to an inclination about any horizontal axis of the unit shall be not less than:

1,0 m — during operation of column-stabilized units in transit, normal condition and in survival condition;

0,3 m — in temporary condition (during submerging/emerging);

0,6 m — during operation of units of other types.

3.1.3 Where openings considered to be open, the following condition shall be met:

$$h_0 \geq 60 \frac{m}{\Delta} \frac{l_f}{\varphi_n^{\circ}} \text{, in m,} \quad (3.1.3\text{-}1)$$

where m/Δ = the ratio of the greatest load moved over the unit to the displacement of the loading condition under consideration, but not less than 0,01;

φ_n° = the permissible angle of inclination, in deg., equal to:

$$\varphi_n^{\circ} = \varphi_{\text{f}} - 35/l_f \quad (3.1.3\text{-}2)$$

but not more than 15° (φ_{f} is the least angle of flooding through the openings considered to be open; l_f is the horizontal distance from the inclination axshall the opening at the inclination angle equal to zero, m).

3.1.4 Design amplitude of motions.

3.1.4.1 The design amplitude of the unit's motion φ_{r} deg. (rad), is the amplitude of oscillation around the inclination axis, which is induced by wind waves running against the unit from a direction normal to the inclination axis. The design amplitude of motion has 1,1 % probability of exceeding level and is assumed equal to

$$\varphi_{\text{r}} = 3\sqrt{D_{\varphi}}; \quad (3.1.4.1)$$

where D_{φ} = the motion variance, in deg.² (rad.²).

3.1.4.2 The design amplitude of motion shall be determined with due account of the water depth (if the water depth is less than $0{,}03gT^2$), using the procedures approved by the Register.

3.1.4.3 Where physical simulation is used to determine the motion amplitude, the following procedures shall be submitted to the Register for approval:

procedure of the unit model tests;

procedure for using the model test data to evaluate the amplitude of motion.

3.1.4.4 The height of the lower edge of openings considered to be open above the wavy sea surface, h_f, in m, and to be taken as stated in the following formula, shall be not less than 0,6 m:

$$h_f = h_{f_0} - 3\sqrt{D_{h_f}} \quad (3.1.4.4)$$

where h_{f_0} = the height of the lower edge of the opening above the sea surface in calm water, in m;

D_{h_f} = the variance of relative vertical oscillations of the lower edge of the opening in waves, in m².

3.1.5 Requirements for the curve of statical stability.

3.1.5.1 The righting moment curve M_φ, in kN·m, shall be positive over the entire range of inclination angles from angle $\varphi = 0$ to the second intercept angle φ_2 of the above curve M_φ with the heeling moment curve M_h, in kN·m.

3.1.5.2 The area under the righting moment curve M_φ to the second intercept angle φ_2 (or to the angle of downflooding φ_f through an opening considered to be open, if $\varphi_f < \varphi_2$) without regard for the motion shall be not less than shall be not less than 1,3 or 1,4 times the area under the curve M_h to the same limiting angle, depending on the type of the unit; Additionally, the ratio between the areas with regard for the motions under the design wind and wave conditions shall be not less than 1,1.

3.1.5.3 The angle of inclination due to combined action of wind and waves on the leeward side φ_{02}, shall be determined on the assumption that the areas A (cd_1d_2) and C (abc) (refer to Fig. 3.1.1-1) are equal, shall not be in excess of the angle of maximum of the curve M_φ, that is φ_m.

3.2 ADDITIONAL REQUIREMENTS FOR STABILITY

3.2.1 Column-stabilized units.

3.2.1.1 In addition to the requirements of 2.2, stability of column-stabilized units shall be checked also for the following loading conditions (as applicable):

.1 in normal condition with maximum drilling stores in the upper hull, with complete set of drill pipes fitted in regular positions;

.2 in survival condition when the unit is disconnected from the well, drill pipes are secured in racks, the unit is changed to a new draught, the drilling stores are relocated (if necessary) to the pontoons and columns;

.3 in transit condition with maximum transit stores.

3.2.1.2 Stability of column-stabilized units is considered to be adequate provided the following requirements are met:

.1 under conditions and at loads referred to in 3.2.1.1 the ratio between the areas A, B, C with the motion ignored (refer to Fig. 3.1.1-2) meets the following condition:

$$(A+B) \geq 1{,}3(B+C); \qquad (3.2.1.2\text{-}1)$$

and where motions are allowed (refer to Fig. 3.1.1-1) the ratio between the areas meets the condition

$$(A+B) \geq 1{,}1(B+C); \qquad (3.2.1.2.1\text{-}2)$$

.2 in transit condition under loading referred to in 3.2.1.1.3 the angle of inclination corresponding to the maximum of the righting moment curve M_φ shall be greater than the amplitude of motion at sea state by 1 point in excess of that for which the transit is designed.

3.2.1.3 As an alternative to the criterion specified in 3.2.1.2.1, the stability of twin-pontoon column-stabilized units in the survival mode of operation which fall within the following range of parameters:

$$0{,}48 < V_p/V_t < 0{,}58;$$

$$0{,}72 < A_{wp}/(V_c)^{2/3} < 1{,}0;$$

$$0{,}40 < l_{wp}/[V_c(L_{ptn}/2)] < 0{,}70$$

where A_{wp} = waterplane area at the survival draught including the effects of bracing members, in m²;
wp = waterplane second moment of inertia at the survival draught including the effects of bracing members, in m⁴;
L_{ptn} = length of each pontoon, in m;
V_c = total volume of all columns from the top of the pontoons; to the top of the column structure, except for any volume included in the upper deck, in m³;
V_p = total combined volume of both pontoons, in m³;
V_t = total volume of the structures (pontoons, columns and bracings) contributing to the buoyancy of the unit, from its baseline to the top of the column structure, except for any volume included in the upper deck, in m³,

shall meet the following conditions:

.1 the areas A' and B' in Fig. 3.2.1.3 are in consistence with the following inequality:

$$B'/A' \geq 0{,}10 \qquad (3.2.1.3.1\text{-}1)$$

where A' = area under the righting arm curve measured from φ_1, to $(\varphi_1 + 1{,}15\varphi_{dyn})$;

B' = area under the righting arm curve measured from $(\varphi_1 + 1{,}15\varphi_{dyn})$ to the angle φ_2;
φ_1 = first intercept with the 51,5 m/s (100 knot) wind moment curve;
φ_2 = second intercept with the 51,5 m/s (100 knot) wind moment curve;
φ_{dyn} = dynamic response angle due to waves and fluctuating wind.

The dynamic response angle φ_{dyn} is determined by the following formulae:

$$\varphi_{dyn} = (10{,}3 + 17{,}8C)/(1 + h_1/(1{,}46 + 0{,}28r)); \quad (3.2.1.3.1\text{-}2)$$

$$C = (L_{ptn}^{5/3} A_{VA} h_V V_P V_C^{1{,}3})/(l_{WP}^{5/3} V_1) \quad (3.2.1.3.1\text{-}3)$$

where h_1 = initial metacentric height calculated about the inclination axis for which the ratio B'/A' is maximum. Typically, this axis is the diagonal axis because in case of inclination about it the value of the windage area is maximum;
r = metacentric radius of the unit in initial position, in m;
A_{VA} = effective windage area of the unit in initial position, in m²;
h_V = height of the center of the area A_{VA} above the waterline which corresponds to survival draught, in m.

.2 at the survival draught of the unit and during movements thereof relative to the static angle of inclination caused by wind at the velocity of 38,6 m/s, the following inequality is met:

$$h_{f0} - \delta h_f > 0{,}0 \quad (3.2.1.3.2\text{-}1)$$

where h_{f0} = height of the lower edge of the opening above the sea surface in calm water at the survival draught, in m;
δh_f = reduction in the distance h_{f0}, in m;

$\delta h_f = 1{,}1\ (kQSD_1 + RMW)$

$k = 0{,}55 + 0{,}08(a - 4{,}0) + 0{,}056(1{,}52 - h_2)$ at h_1 not more than 2,44 m;

$a = (h_d/d_s)\ /(b_{ptn}\ l_{cc})/A_{wp}$, but not less than 4,0 m;

$QSD_1 = h_{f0} - h_{f1}$, but not less than 3,0 m

where h_{f1} = height of the lower edge of the opening above the sea surface in calm water at the angle of inclination φ_1, in m,

RMW = amplitude of the oscillations in waves relative to φ_1, in m;

$RMW = 9{,}3 + 0{,}11(X - 12{,}19)$;

$X = d_s(V_t/V_p)\ (A_{wp}^2/l_{wp})\ (l_{cc}/L_{ptn})$, but not less than 12,19 m,

where h_2 = initial metacentric height measured about the inclination axis for which the height of the lower edge of the opening above the sea surface in calm water is minimum (i.e. the value of QSD_1 is the largest);
d_s = survival draught, in m;
h_d = vertical distance from the waterline to the top of the upper exposed weathertight deck at the side, in m;
b_{ptn} = transverse distance between the centerlines of the pontoons, in m;
L_{cc} = longitudinal distance between centers of the comer pontoons, in m.

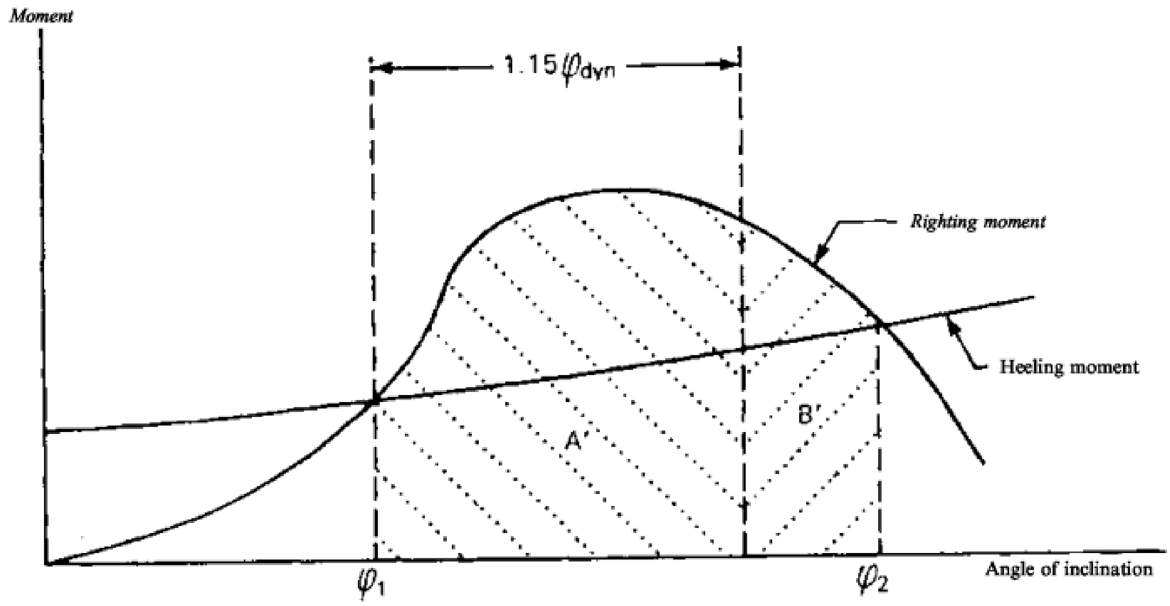


Fig. 3.2.1.3
Righting and heeling moment curves

3.2.2 Self-elevating units.

3.2.2.1 In addition to the provisions of 2.2, stability of self-elevating units shall be checked also in transit for the following loading conditions:

.1 with legs elevated to the utmost position with full stores and 10 % the stores;

.2 with legs lowered to 30 % of their length into water and with full stores.

3.2.2.2 Under loading conditions specified in 3.2.2.1 the ratio between areas A, B, C with motion ignored (refer to Fig. 3.1.1-2) meets the condition

$$(A + B) \geq 1{,}4(B + C); \quad (3.2.2.2\text{-}1)$$

and where the motions are allowed the above ratio meets the condition

$$(A + B) \geq (B + C). \quad (3.2.2.2\text{-}2)$$

3.2.3 Submersible MODU.

3.2.3.1 Stability of submersible MODU shall be checked in the transit condition, as well as during lowering and raising. In this case, the areas A, B, C shall meet condition 3.2.1.2.1.

3.2.4 Floating units.

3.2.4.1 Stability of floating units, to which provisions of 1.1.1.3 are applied, when in the normal condition under the worst loading condition, as far as stability is concerned, shall comply with the requirements of 3.2.2.2.

3.2.4.2 Stability of floating units with hull having geometrical proportions and forms of the sea-going displacement-type ship to which provisions of 1.1.1.3 are applied, in the transit and icing condition shall meet the requirements of Part IV "Stability" of the Rules for the Classification.

APPENDIX 1

STABILITY CALCULATION OF A UNIT

The information on calculations, including stability calculation, is recommended to be submitted in the following order and scope:

1. Introduction specifying the aim of the calculation.

2. Initial data listing the unit characteristics necessary to perform calculation.

3. Accepted methods and schemes of performing calculation; initial calculation formulas, coefficients etc. with references to the sources (the list of sources is set out at the end of calculation).

4. The list of software used and the information on its approval by the Register.

5. Calculation as such.

6. The results of calculation represented (as far as possible) as graphs, diagrams, charts, tables etc.

7. Conclusion.

8. Appendices with additional initial and calculation data (if necessary).

9. The list of sources.

APPENDIX 2

GUIDANCE FOR THE CONDUCT OF AN INCLINING TEST OF MODU/FOP AND THEIR MODULES

The Guidance for the Conduct of an Inclining Test of MODU/FOP and their Modules (hereinafter referred to as "the Guidance") sets forth requirements and recommendations for the preparation, conducting and processing of the results of the inclining test of MODU/FOP and their modules (hereinafter referred to as "units").

Inclining tests for the units having the ship hull form and ratio of dimensions shall be carried out in accordance with 1.5 of Part IV "Stability" of the Rules for the Classification.

The need for the inclining test of a unit is dictated by the criteria given in 1.5 of this Part.

1 GENERAL

1.1 The purpose of the inclining test of a unit is determination of its displacement and position of centre of masses (centre of gravity).

1.2 To conduct the inclining test, an Inclining Test commission is appointed, headed by the chairman. The commission incorporates representatives of the shipyard, designer and customer (owner of the unit).

1.3 The commission is in charge of the preparation, conduct and processing of the test results and is responsible for quality and accuracy of the test results.

1.4 The requirements of the commission applied to preparation, conduct and processing of the results of the inclining test are mandatory for all persons participating in and responsible for the test.

1.5 All departures from the requirements of the Guidance, unless they deteriorate quality of the inclining test, are adopted by the chairman of the commission, indicated and justified in the Inclining Test Report.

Form of the Inclining Test Report is given in Appendix 2.1 to the Guidance.

1.6 Prior to the inclining test, the commission shall:

detail and explain responsibilities of all persons directly involved in the inclining test;

assign time and place for the inclining test, having sufficient depth and protected from wind, waves induced by wind or passing ships, and currents;

work out the mooring method to allow unrestricted inclinations of the unit.

1.7 The water area in the location where the inclining test is conducted shall be free of ice and objects which hinder inclination of the unit and movement of craft around it when draught (freeboard) readings are taken.

1.8 The depth of water under the most immersed part of the unit's bottom during inclinations shall be not less than 2 m where there is no liquid mud in the water to that depth (Record according to the form given in Appendix 2.1.2).

1.9 Where there is a current, the unit is placed along the current.

1.10 The inclining test is conducted in calm weather, under ripple or smooth sea up to force 1 (wave height with 3 % probability of exceeding up to 0,25 m) conditions and at wind velocity not more than 2 m/s (Record according to the form given in Appendix 2.1.2).

1.11 The wind velocity and direction are measured at the beginning and at the end of the inclining test and also simultaneously with the heel angle measurements during inclination of the unit.

1.12 Prior to the inclining test, the analysis of parameters sensitivity affecting the test results shall be made. Such parameters are the draught, angle of inclination, sea water density, heeling weights and weight movement distances, varying wind velocity, accuracy of measuring equipment, etc.

The sensitivity analysis shall give the total expected error in determination of the position of centre of gravity and also to show what parameters shall be taken into account during the test.

2 LOADING OF THE UNIT DURING THE INCLINING TEST

2.1 The inclining test of a unit may be performed in the following loading conditions:
.1 loading condition corresponding to launching at the period when the unit was built;
.2 loading condition close to light-weight condition (as per design).

This is especially true where the design value of metacentric height is close to its minimum permissible value and where such condition results from the movement of heavy weights.

The repeated inclining test may be required if under the design change in the mass loading of the unit when passing from the condition 2.1.1 to the condition 2.1.2 the requirements of this Part are violated at:

$$Z_g = 1,2Z_{g2} - 0,2Z_{g1}$$

where Z_{g1} = design vertical centre of masses of the unit in condition 2.1.1;
Z_{g2} = design vertical centre of masses of the unit in condition 2.1.2 ($Z_{g2} > Z_{g1}$);
Z_g = assumed vertical centre of masses under test conditions.

2.2 The trim of the unit during inclining test shall be such that the actual waterline during inclinations of the unit does not intersect the bottom surface, for which purpose equalizing ballast may be taken, where required, in such an amount as to ensure specified position of the actual waterline.

Water ballast may be applied when the following conditions are met:
.1 tanks for inclining ballast shall be wall-sided, without stringers or any other internal members able to form air-pockets;
.2 tanks shall be located directly opposite one another;
.3 density of water used as inclining ballast shall be measured and registered;
.4 piping connected to the tanks used for inclining ballast shall be filled in;
.5 to prevent leakage of liquids during the inclining test, the ballast piping shall be plugged. During the inclining test the valves shall be continuously inspected;
.6 prior and after each movement the liquid level in the tanks used for inclining ballast shall be manually measured;
.7 for each movement, the position of gravity center in height, length and width shall be calculated;
.8 tables of tank level/ullage shall be provided. Prior to the inclining test, the initial heeling angle of the unit shall be determined to obtain the accurate volume values, position of the gravity center in width and height for the inclining weight tanks for each heeling angle. To establish the initial heeling of the unit the midship's displacement marks (portside and starboard) shall be used;
.9 moved quantities shall be evaluated by flowmeter or similar device;
.10 period of time required for inclining shall be determined. When wind change during the time required for inclining test may effect the results thereof, the inclining test using water inclining weight shall not be permitted.

2.3 Loading conditions of the unit consistent with its conditions during the inclining test shall be provided for in preliminary calculations for control and comparison with the results of the inclining test.

2.4 The total mass of missing loads may be not more than 2 % of the unit's displacement under test conditions Δ_{test}.

The mass of surplus loads exclusive heeling ballast and equalizing ballast according to 2.2 shall not exceed 4 % of the unit's displacement under test conditions Δ_{test}.

2.5 Personnel of firms and organizations together with their tools, equipment, except for persons directly involved in or responsible for the inclining test, all foreign objects (loads) which form no part of the mass loading of the unit during the inclining test, as well as debris and snow shall be removed from the unit.

2.6 No icing of the external and internal surfaces of the unit including the underwater body thereof shall be permitted.

2.7 The following items may be left on board the unit prior to the test:

liquids in the onboard machinery, apparatus, piping systems to keep them operating;

fuel and lubricating oil in the daily service tanks, boiler feed water to provide conduct of the inclining test and operation of boilers to meet the heating needs in winter;

fresh (drinking and washing) water in daily service tanks.

2.8 The inclining test commission in each particular case shall explore the possibility of leaving tankage and liquid cargo stock (refer to 5.3) on board the unit being subjected to the inclining test, and based on such exploration, the commission shall make a decision agreed with the surveyor to the Register who attends the test.

3 TEST WEIGHTS

3.1 To provide inclination of the unit, use shall be made of the following:
solid weights;
water ballast;
people running athwart ships in unison;
unit's own cargo cranes.
Inclination of the unit by water ballast may be performed by two methods:
.1 with heeling tanks pressed up;
.2 with heeling tanks being slack at all times.
When water ballast is used for inclination account shall be taken of the following:
tank shape, volume and volume center;
structural features of tanks intended for the heeling ballast;
possibility to eliminate effectively the free surfaces ("air pockets") when pressing up the heeling tanks.

3.2 Where the test weights are placed on one side of the unit, angle inclination to 2 to 4° shall be provided. For units with large displacement and excessive initial metacentric height of angle inclination may be reduced to 1°.

3.3 Where water ballast is used for inclination, provision shall be made for the most accurate determination of the volume and volume centre for each tank used for heeling ballast, arrangement and volumes of the internal stiffeners and equipment of these tanks, compilation of the tank calibration tables. Compliance of the tanks with their drawings shall be verified on the spot. The form of the Record of determination of the heeling water ballast mass is given in Appendix 2.1.8.

3.4 The levels and amount of the tankage in tanks, where inclination is made using the first method, shall be measured after each transfer of the heeling ballast. The effect of free surfaces of the tankage consisting of heeling ballast and liquid cargoes on the inclining test performance shall be negligible, which in each particular case shall be evaluated by the commission on the basis of the following criterion. The free surface correction to the design value of the metacentric height h, corresponding to the mass loading condition of the unit during the inclining test shall be at a time not more than:

$0{,}002h$ for each individual tank containing the tankage consisting of heeling ballast or liquid cargo;

$0{,}01h$ in total for all tanks containing the tankage consisting of heeling ballast or liquid cargo.

When determining the corrections, moments of inertia of the free surfaces are calculated at initial inclination of the unit with due account of the liquid density.

Inclination angles induced by cross-flooding of the tankage shall be so small that they cannot be recorded by instruments intended to measure the inclination angles during the inclining test.

3.5 Each time when tanks are filled with the heeling ballast, consideration shall be given to absolute absence of the air pockets after the heeling tanks have been pressed up.

3.6 If because of structural features of the tanks or for other reasons, the complete elimination of the air pockets from pressed up heeling tanks is impossible, the second method of inclination is used with transfer of the heeling ballast from side to side when free surfaces are present at all times.

The free surfaces shall be of rectangular shape and of the same size in the starboard and port tanks, invariable at the upper and lower levels of the heeling ballast being transferred.

The upper and lower levels of the free surface in a tank shall be set within the wall-sided portion of the tank. These levels at the tank comers shall be marked by clearly distinguishable lines accessible for observation through the upper manholes (hatches) with the use of portable lighting, or shall be determined by other reliable means.

3.7 Movement of the centre of mass of the test weights transferred from side to side shall be close to a transverse-horizontal one.

The amount of the heeling water ballast on board the unit during the inclining test shall remain constant and shall be necessarily checked just before and immediately after the inclining test.

3.8 To provide inclination of the unit, use shall be made, if possible, of tanks rather narrow breadthwise. Such tanks are beneficial for:

decrease of the error in determination of the heeling moment;

decrease of the free surface effect of the water ballast tankage when the first method of inclination is used;

more efficient elimination of the air pockets when the first method of inclination is used;

improvement of the accuracy in accounting for the free surfaces of heeling ballast when the second method of inclination is used.

3.9 The free surface correction to the initial metacentric height shall be accounted for in processing the results of the inclining test.

4 DEVICES FOR MEASUREMENT OF INCLINATION ANGLES

4.1 The dominant devices for measurement of inclination angles of the unit during the inclining test are U-tubes (three or more) or optical quadrants (two or more) to be located in different positions on the unit, longitudinally.

If there is a need to measure the angles of trim, three more U-tubes or two more quadrants located on the unit, transversely, shall be used.

4.2 Base length of the U-tube (distance between the measuring tubes) shall be sufficiently large to improve the accuracy of measurements of the inclination angles and shall be consistent with the length of the tubes themselves or of the measuring rules. In any case, the minimum base length of the U-tube shall be not less than 13 to 15 m.

Measurements of the inclination angles with the use of the U-tubes shall be made by persons who have experience in handling such devices.

4.3 The measuring rules with millimetric scale for taking the liquid level readings in the U-tubes shall be positioned vertically at the ends of the base length and attached securely together with the U-tubes to the fixed hull structures of the unit. In the initial position of the unit the water level in the U-tube shall be approximately at the mid-length of the tube (measuring rule).

The liquid level in the U-tube may be measured not by a measuring rule but by a declivity board (measuring batten) with a clean freshly planed surface provided instead. The form of the Measurement Record is given in Appendix 2.1.5.

4.4 To ensure adequate accuracy in measuring the inclination angles, the U-tubes shall be filled with a homogenous coloured liquid which does not freeze at sub-zero air temperatures during the inclining test.

When making measurements, no sharp bends of the U-tube hoses are permissible, the U-tube shall be free of air bubbles, solid particles and impurities.

4.5 In well-grounded cases, on the Inclining Test Commission's decision, the inclination angles may be measured by pendulums, inclinometers and other special devices, and in doing so, in each individual case use shall be made of devices of the same type or with identical accuracy of measurement.

Where pendulums are used, their length shall be at least 6 to 7 m.

5 PREPARATIONS FOR THE INCLINING TEST

5.1 Prior to the inclining test, the unit's trim shall be such that the requirements of 2.2 are met.

As a rule, the unit shall have no initial heel, or as a last resort, the heel shall not exceed 0,3°. Trim compensation is not required.

The initial heel shall be measured by devices referred to in Section 4 on reference lines (verification base) of the unit's hull, fitted before the unit is launched.

5.2 A careful preparation of the liquid cargo tanks for the inclining test is a central prerequisite for assuring its successful performance.

When pressing up tanks for liquid cargoes (including heeling ballast) measures shall be taken to prevent formation of air pockets. Not earlier than in 1,5 to 2,0 hours after pressing, the tanks shall be inspected, the air pockets detected in the process shall be completely removed. Methods to remove air pockets shall be established by the inclining test commission in each particular case. As directed by the commission, samples of liquid cargoes may be taken in order to determine density thereof.

5.3 Immediately prior to the inclining test of the unit, its spaces and containers: compartments, cofferdams, tanks (including small tanks and canisters), etc. are subject to inspection in order to ascertain whether they contain liquid cargoes, a Record of their readiness for the inclining test (in accordance with the form given in Appendix 2.1.6) is drawn up and a table of conditions of spaces and containers with liquid cargoes is compiled immediately prior to the inclining test (in accordance with the form given in Appendix 2.1.7).

All spaces and containers which, proceeding from the test conditions, shall not contain liquid cargoes are carefully dried. With permission of the inclining test commission, the hard-to-reach locations may contain some liquid cargo remains, which cannot be removed by standard means and do not affect the inclining test performance.

5.4 All variable loads included into the design loading condition of the unit during the inclining test are stowed in regular positions and secured. At the discretion of the commission, masses of these loads may be determined by weighing or according to the data of technical documentation.

For all loads which are surplus (missing) in relation to the design loading condition of the unit during inclining test, records are drawn up in accordance with the form given in Appendix 2.1.3.

5.5 The devices for measuring the inclination angles of the unit shall be positioned as specified in Section 4. Verification of their positioning shall be entered in a record to be prepared in accordance with the form given in Appendix 2.1.10.

Provision shall be made for an adequate illumination of measuring rules, scales of instruments and locations where freeboard (draught) readings are taken.

5.6 The following documents shall be submitted to the inclining test commission:

Record of acceptance of the principal dimensions of the unit to be drawn up in accordance with the form given in Appendix 2.1.1 (particular care shall be given to the depth measurement in those locations where freeboard readings are taken as the unit's trim is determined).

Record of acceptance of the draught marks (if any). The draught marks shall be cleaned and brightly coloured.

5.7 Small boats or rafts (at the commission's discretion) shall be available to aid in taking of freeboard and draught mark readings (if the draught marks are provided).

5.8 To take freeboard readings from the unit's deck, it is advisable to use a metal measuring tape which length exceeds the expected freeboard during the inclining test. A glass tube open at both ends, graduated in 5 mm, of at least 250 to 300 mm in length and not less than 5 mm in diameter shall be attached to the free end of the measuring tape. The lower end of the tube shall be fitted over a rubber hose of 3000 to 5000 mm in length. A plumb bob shall be suspended on the free end of the hose to impart an upright position to the hose in water. Under condition where there is ripple on the water surface, which does not rock the unit, such a hose makes it possible to measure in the tube, with an adequate accuracy, the level of calm water unsusceptible to the effect of surface wave fluctuations.

A similar device but without measuring tape may be used to take the unit's draught mark readings (if any).

The number of devices used for taking freeboard (draught) readings shall be not less than three, lengthwise. The freeboard readings taken shall be documented in the form of a record to be prepared in accordance with the form given in Appendix 2.1.4.

5.9 A plan of stationing of the participants in the inclining test shall be drawn up. The following commands (signals) shall be established:

"Stand by taking readings", "Start taking readings", "Stop taking readings". These commands (signals) shall be heard (seen) in all places on board where people stay during the test. The form of a record of stationing of the participants in the inclining test is given in Appendix 2.1.9.

5.10 Communications shall be provided between control station of the inclination test commission chairman and the U-tube (quadrant) observer stations, locations where freeboard and draught mark readings are taken, mooring line stations, etc.

5.11 Since the commencement of preparations for the inclining test, no loads shall be taken, removed or moved on board the unit without permission of the inclining test commission chairman.

6 INCLINING TEST PROCEDURE

6.1 To conduct the inclining test, a water area complying with the requirements of 1.6 to 1.10 shall be allocated.

6.2 The unit shall be held by lines at the bow and at the stem, secured at the centreline. The lines shall be as long as practicable. It is advisable to have not more than two (as a last resort, four) mooring lines. During the test, in the intervals between commands: "Stand by taking readings" and "Stop taking readings" the lines of the unit shall be as much slack as practicable. If there is a current, the bow line secured at the centreline need not be slacken to hold the unit against the current.

6.3 Immediately before the test, a survey shall be carried out to make sure that the unit is properly prepared for the test. The survey shall include also an inspection and check against the following records drawn up previously:

all tanks, compartments, machinery, piping, etc to verify preparation of the liquid cargoes for the test;

open decks and all spaces of the unit to verify presence and stowage of variable loads;

stationing of the participants in the test at the command (signal): "Stand by taking readings";

correctness of initial positioning of heeling ballast.

Immediately upon completion of measurements, condition of the unit shall be rechecked.

Prior to the test, a sample of sea water shall be taken from a depth equal to one-half the unit's draught in order to determine density of the water, and its temperature shall be measured.

6.4 All measurements of the unit's inclination angles, wind direction and velocity (Record in accordance with the form given in Appendix 2.1.2), the unit's direction in relation to current shall be taken only in the intervals between the signals: "Start taking readings" and "Stop taking readings".

6.5 The readings of freeboard and draught marks (if any) shall be taken twice: immediately before and immediately after the test.

At the discretion of the inclining test commission, measurements shall be taken either simultaneously on both sides in the same transverse plane or simultaneously at all measurement locations. Each boat or raft used to take measurements shall carry at least two observers.

With no water surface oscillation (or if its swing does not exceed 50 mm), only metal measuring tapes without additional fixtures referred to in 5.8 shall be used.

6.6 The need for an account to be taken of the unit's hull deflection when the unit's displacement and vertical centre of buoyancy are determined during the test, shall be identified by the inclining test commission on the basis of the unit's general strength calculations and actual freeboard and draught mark measurements (if the draught marks are provided).

6.7 The number of the test weight movements and, accordingly, of the heel angle measurements shall be such that of the total number of measurements, at least eight measurements meet the test quality criteria (refer to the Inclining Test Report). The end position of the test weights after all movements thereof shall be identical to their initial position.

6.8 When measuring the levers of the weight movements, only metal measuring tape shall be used; for the levers in excess of 20 m twenty-meter tape shall be used with transfer of same.

6.9 The liquid levels in the U-tubes (quadrants) shall be measured prior to movements of the test weights to an opposite side and after each movement.

The level measurements begin to be taken once the liquid oscillation swing has become not less than 20 mm, whereupon the level readings in both extreme positions (upper and lower) are recorded for at least three swings. Here, by the oscillation swing is meant the distance between two successive extreme positions (upper and lower) of the liquid levels in the U-tube.

After each measurement the observers at the U-tube (quadrant) stations shall report to the person in charge of the inclining test on completion of the measurements and inform of the results.

6.10 The accuracy of measurements made during the test shall not be lower than the values given below:

freeboard and draught, mm ········ 5
base length of U-tube, mm ········ 10
liquid level in U-tube, mm ········ 2
test weight mass, per cent ········ 1,0
position of test weight centre of mass, mm ········ 10
lever of test weight movement, mm ········ 10
solid and liquid cargoes forming part of the dead-weight capacity:
mass, t ········ 0,01
longitudinal centre of gravity, m ········ 0,10
transverse and vertical centre of mass, m ········ 0,05
water density, per cent ········ 0,1.

7 INCLINING TEST REPORT

7.1 The inclining test shall be documented as a Report and Records Nos.1 — 10 which in conformity with the forms given in Appendices 2.1.1 — 2.1.10 are an integral part thereof.

The Report shall be signed by all members of the Inclining Test Commission, and the Records — by the responsible persons appointed by the Inclining Test Commission Chairman.

7.2 The surveyor to the Register attending the test shall countersign the Inclining Test Report.

8 PROCESSING OF THE INCLINING TEST RESULTS

8.1 Measurements made during the test and the unit's technical documentation shall be taken as initial data in processing the inclining test results.

8.2 The displacement, coordinates of centre of buoyancy and transverse metacentric radius of the unit shall be determined from documentation which provides necessary accuracy of scales and measurements, accounts for the outstanding parts, etc. The hydrostatic curves shall be determined using a computer with required accuracy and with due account of the unit's trim if its value exceeds 0,005 its length ($0{,}005L$).

8.3 The arithmetic mean of the freeboard (draught) values before and after the inclining test, rounded off to 5 mm, shall be taken as their final value (refer to Appendix 2.1.4)).

In determination of the unit's underwater volume elements (displacement Δ, coordinates of centre of buoyancy X_c and Z_c) its sagging shall be accounted for by any sufficiently accurate method.

8.4 Not more than one measurement out of eight measurements referred to in 6.7 may be excluded from the calculation.

APPENDIX 2.1

INCLINING TEST REPORT

_______________ “_____” _____________200__
(test site)

1 Unit
Name, hull number ____
Purpose____
Shipyard, building year ____
Owner ____
Principal dimensions (design) actual:
length L (__________) ____________________ m
breadth B (__________) _____________________ m
depth D (__________) _____________________ m
(Refer to Record of acceptance of the unit's principal dimensions — Appendix 2.1.1 to the Inclining Test Report).

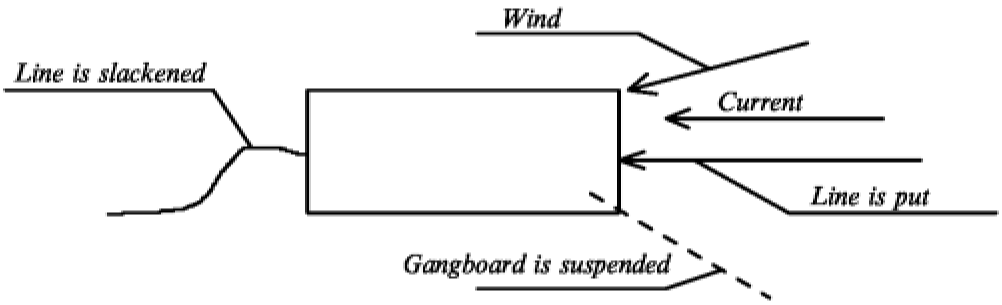
2 Arrangements for the inclining test
Inclining test objective____
____
The inclining test was conducted by the inclining test commission set up to consist of:
Chairman____
(position, full name)
members ____
(position, full name)
____
____
The results of the commission's activities were presented in the appropriate Records — Appendices ______________________________________
______________________________to the Inclining Test Report.
The inclining test was attended by the Surveyor to the Register ____________________
(position, full name)
The inclining test was performed at ____________________________________
(indicate location where the test was performed)
Time of the inclining test:
commencement: ________h ___________min "____"___________ 200___
completion: ________h ___________min "____"___________ 200___
The inclining test was conducted in conformity with _______________________________
____
(indicate guidance document, deviations therefrom)
____
____

3 Inclining test conditions
Wind velocity ____________________ m/s
(Detailed data on wind are given in Appendix 2.1.2 to the Inclining Test Report)
Current velocity ____________________ m/s
Water surface condition ____

Water density (refer to Appendix 2.1.2 to the Inclining Test Report) ρ_l________ t/m³
Water depth under the unit's bottom __________________ m
Air temperature __________________ °C
Precipitation ____
Ice conditions ____
(size of a lane and method to break it out)
____
____
(no contact with ice, etc)

4 Preparations for the inclining test

The unit is ready for the inclining test (refer to Appendices 2.1.6 — 2.1.10 to the Inclining Test Report)



Sketch showing position of the unit

Initial heel of the unit ______________ deg.
All foreign objects, debris and snow were removed from the unit.
External and internal surfaces of the unit, including those of the underwater body are free of icing.
All missing and surplus loads according to Table 1 (refer to Appendices 2.1.3, 2.1.7 — 2.1.9 to the Inclining Test Report) are taken into account.

Table 1

Missing and surplus loads during the inclining test

Loads including liquid loads, per cent of the unit's displacement during test Δ_{tl}	Mass, t	Levers, m			Moments, tm		
		X	Y	Z	M_X	M_Y	M_Z
Surplus loads: _______________ % of Δ_{tl} (sum from Appendices _______________) Missing loads: _______________ % Δ_{tl} (stun from Appendices _______________)							

Effects of liquid cargo free surfaces, running machinery on the inclining test performance
____
(indicate the free surfaces and machinery)
____were essentially eliminated.
Technical documentation listed in Table 2 was used for the test.

Table 2

List of technical documentation used

Document title	Document designation	Document developer

The unit is loaded with solid (water) ballast (to be filled in if the ballast is available)

____

(purpose of the ballast (righting, etc))

____

____

____

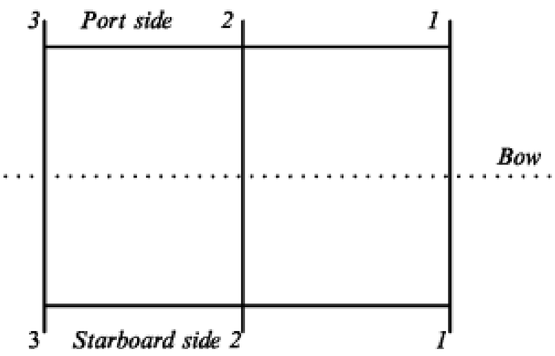
as indicated in Table 3.

Table 3

Data on ballast (righting, etc) loaded on board the unit

Position of solid (water) ballast	Mass, t	Coordinates of centre of mass, t		
		X	Y	Z
Grand total				

The transverse metacentric height during the test as per calculation ________________ was ensured and equal to ______________________________



Sketch showing locations (sections) of freeboard (draught) measurements

5 The inclining test

5.1 Account is taken of the unit's freeboard (draught) values given in Table 4 on the basis of design data from the Record of freeboard (draught) measurements, refer to Appendix 2.1.4 to the Inclining Test Report.

Table 4

Design values of the unit's freeboard (draughts) during the inclining test

Measurement location (fixed transverse plane, draught mark, etc)	Freeboard, mm	Draught, mm

The unit's deflection during the inclining test is ___________ mm.

5.2 Based on the data of Table 4, the following draughts were obtained by calculation on ____
(document title)
____

at aft perpendicular (transom) ____ m
at fore perpendicular (transom) ____ m
at the unit's mid-length (midsection) ___________________________________ m
Initial heel of the unit
to ___________ side ___________ deg.
Initial trim
by ___________ deg.(___________m)
For the unit's trim cited, the following data were obtained by calculation based on

____
(document title)
with regard to ____
in ____
(table, separate document)
volume displacement ∇ = ___________m^3,
weight displacement $\Delta = \rho_l \nabla =$ ___________ ,
coordinates of centre of buoyancy:
X_c= ___________ m,
Y_c= ___________ m,
Z_c = ___________ m;
transverse metacentric radius r= ___________ m.

5.3 During measurements of the of inclination angles the mooring lines were slackened and nothing could restrict free rolling of the unit.

Account is taken of the heeling angle values given in Table 5, based on the data of level measurements in U-tubes (optical quadrants), refer to Appendix 2.1.5 to the Inclining Test Report.

Table 5

Design values of heeling angles during the inclining test

Number of successive inclination (measurement)	Position of test weights (side)	Heeling angle by U-tube (quadrant), rad. (deg)		Accepted value of heeling angle, rad. (deg)
		No. 1	No. 2	
1				
2				
…				
$n-1$				
n				

5.4 Calculation of metacentric height h_h under the test condition was made in Table 6 and hereafter, where the value of h_h, was assumed as the mean of at least eight values of the metacentric height h_i obtained by individual measurements.

The mass of the heeling water ballast being transferred is _________ t.
Lever of movement of the heeling water ballast being transferred is_________ m.
Heeling moment due to transfer of the heeling water ballast is_________ tm.

In Table 6, increments in the heeling angles are used as their mean increments from Table 5.1 (5.2) of Appendix 2.1.5 for all the U-tubes (quadrants) used in the inclining test.

Table 6

Operation (measurement) No.	Increment in heeling moment M_h, tf·m	Increment in heeling angle θ_h, rad.	$h_i = M_h/\Delta\theta_h$, m	$h_i - h_h$, m	$(h_i - h_h)^2$, m²
2					Measurement is precluded
3					
4					
5					
6					
7					
8					
9					
Sum			$\sum h_i$	-	$\sum (h_i - h_h)^2$

From the data of Table 6:

$h_h = \sum h_i / n$, m,

where n = the number of sound measurements.

The inclining test was considered to be satisfactory performed, because:

.1 for each measurement the following condition was fulfilled:

$$|h_i - h_h| \le 2\sqrt{\sum (h_i - h_h)^2/(n-1)};$$

.2 probable error meets the condition

$$t_{an}\sqrt{\sum (h_i - h_h)^2/n(n-1)} \le \begin{cases} 0{,}02\left(1 + \frac{3}{2}\,h_h\right), & \text{at } h_h \le 2 \text{ m} \\ 0{,}04\,h_h & \text{at } h_h > 2 \text{ m} \end{cases}$$

where t_{an} = a coefficient accepted in accordance with 1.5.11 from Table 1.5.11 of Part IV "Stability" of the Rules for the Classification;

.3 taking h and l_{max} values as the most unfavourable design loading condition as regards their values, the following condition is fulfilled:

$$t_{an}\sqrt{\sum (h_i - h_h)^2/n(n-1)} \le 0{,}05h \text{ or } 0{,}10 l_{max},$$

whichever is less, but not less than 4 cm

where l_{max} = the maximum arm of statical stability curve under the most unfavourable design loading condition as regards its value, in m;
h = the corrected metacentric height under the most unfavourable loading condition as regards its value, in m.

Where anyone condition: 5.4.1, 5.4.2, 5.4.3 is not met, the value of metacentric height h_h less the probable error of the test may be taken for calculations:

$$h'_h = h_h - t_{an}\sqrt{\sum(h_i - h_h)^2/n(n-1)}.$$

Since during the test the water ballast tanks had free surfaces, the total correction for which was equal to $\sigma h = (\sum \rho_l i_x /\Delta)$, the metacentric height under test conditions was equal to $h_0 = h'_h + \delta h$.

In calculating free surface correction it is considered that for every tank with free surface the moment of inertia of free water surface taken as i_x value shall be selected corresponding to the actual tank filling level and tank inclination angle during inclining test.

5.5 Thus, the coordinates of centre of masses of the unit during inclining test were (at trim $\geq 0{,}005L$):

longitudinal centre of masses $X_g = X_{c\psi} - (r_\psi - h_0)\sin\psi$;

transverse centre of masses $Y_g = h_0 tg\theta$;

vertical centre of masses $Z_g = Z_{c\psi} + (r_\theta - h_0)\cos\psi$.

(The formulae are given with consideration for possible angles of heel θ and trim ψ).

The displacement Δ= _________ t (refer to 5.2).

5.6 Displacement and coordinates of centre of masses are given in Table 7.

Table 7

No	Elements of mass loading	Mass, t	Levers, m			Moments, tm		
			X	Y	Z	M_X	M_Y	M_Z
1	Unit under test conditions							
2	Surplus loads							
3	Missing loads							
Unit (1) – (2) + (3)								

6 Notes

At the discretion of the inclining test commission chairman.

7 Processing of test results

The results of the inclining test were processed by ________________________________

____
(name of the firm)

The original materials of the inclining test are held by ______________________________

____
(name of the holder)

Appendices 2.1.1 to 2.1.10 to the Inclining Test Report are an integral part ___________

____
(name of the unit)

of the present Report on inclining of the unit

8 Conclusions

The inclining test was well performed.

Based on the test results the following actual data of the unit ______________________

____
(name of the unit)

are considered to be established:

displacement Δ_0 = _________ t;

vertical centre of masses Z_g= _________ m;
longitudinal centre of masses X_g= _________ m;
transverse centre of masses Y_g= _________ m.

Inclining test commission chairman:

____
(signature, full name)

Members of the commission:
representative of the shipyard____
representative of the designer____
representative of the customer ____

____
(signature, full name)

The inclining test was attended by the Surveyor to the Register ____________________

____
(signature, full name)

APPENDIX 2.1.1

RECORD OF ACCEPTANCE OF THE UNIT'S PRINCIPAL DIMENSIONS

"_____" ____________200__ city ____________________
firm ____________________

Principal dimensions of the unit ____
(name, purpose)
were verified ____
(place of building, assembling, mounting)

length L — with the help of ____
breadth B — with the help of____
depth D — with the help of ____
The verification data are given in Table 1.1.

Table 1.1

Principal dimensions	As per design, m	Actual, m
Length		
Breadth		
Depth:		
port		
starboard		

The principal dimensions as per deviations from the drawing ____________________
are within tolerance.
Measurements were made by: ____
(position, full name)

APPENDIX 2.1.2

RECORD
OF MEASUREMENTS OF WIND VELOCITY AND DIRECTION,
WATER DENSITY AND UNIT'S POSITION DURING INCLINING TEST

Unit ______________________________ "_____" _____________200__
(name)

The measurement data are given in Table 2.1.

Table 2.1

Measurement No	Wind velocity, m/s	Wind direction in respect to unit		Unit direction	Measurement time, Hr., min
		Angle, deg.	side (port, starboard)		
1					
2					
…					
9					
10					

The wind direction was determined by the angle between centreline and velocity vector, considering from the bow to windward side.

Based on the samples taken from the depth of ____________ m,
the water density was ____________ t/m^3 at the temperature of ____________ °C.
Measurements were made by: ____
(position, full name)

____

____

APPENDIX 2.1.3

RECORD
OF SURPLUS (MISSING) LOADS

Unit ____________________________ "_____" ____________200__
(name)

All loads on the unit which are surplus (missing) in relation to the mass loading corresponding to the unit condition at the time of the inclining test are given in Table 3.1 (3.2)

Table 3.1 (3.2)

Load	Mass, t	Levers, m			Moments, tm		
		X	Y	Z	M_X	M_Y	M_Z
Liquid cargo remains in hull*							
Liquid cargo in machinery, apparatus, etc. to keep them running**							

* To be included into the Records of surplus (missing) loads according to data of Appendix 2.2.7.
** Design data shall be indicated.

Record was prepared by: ____
(position, full name)

____
____

APPENDIX 2.1.4

RECORD
OF THE UNIT'S FREEBOARD (DRAUGHT) MEASUREMENTS

Unit ______________________________ "_____" _____________200__
(name)

1. Measurements were taken with the use of _________ and are given in Table 4.1.
(name of devices)

Table 4.1

Measurement location (Section) acc.to Fig. 2	Time of measurement: before test, after test	Reference level: deck, (bulwark,), draught mark	Free board; draught mark, mm	Measurement from deck, draught mark		Value as obtained by measurement, mm		Deck stringer, keel thickness, mm	Theoretical value, mm		Theoretical, (mean) value, mm	Design value, mm
				Port	Stbd	Port (4)-(5)	Stbd (4)-(6)		Port	Stbd		
1	2	3	4	5	6	7	8	9	10	11	12	13
Freeboard												
Section 1-1	Before/ after	Upper deck		2290/2280	2270/2240			20	2270/2260	2260/2220	2265/2240	2252
Section 2-2	Before/ after	Ditto										
Section 3-3	Before/ after	Ditto										
Draught												
Section 1-1	Before/ after	Mark 60	6000	200/220	220/240	5800/5780	5780/5760	20	5780/5760	5760/5740	5770/5740	5760
Section 2-2	Before/ after	Mark 62	6200									
Section 3-3	Before/ after	Mark 64	6400									

(The numerical values are given in the Table as an example).

2. The design values of freeboard (draughts) were entered on ______________ (drawing title)

3. According to the measurements made the module hull sagged (did not sag) with a deflection of ______ mm.

Record was prepared by____
(position, full name)

____

____

APPENDIX 2.1.5

RECORD
OF U-TUBE LEVEL DEVIATION AND UNIT'S INCLINATION ANGLE MEASUREMENTS

Unit ____________________________ "_____" _____________201
(name)

Table 5.1

Heel measurements							
Operation (measurement) No.	Test-weight position (side)	Level measurement, mm				Heel angle increment, Rad.(deg)	
		U-tube No.1 Base length _____ mm		U-tube No.2 Base length _____ mm		U-tube No.1	U-tube No.2
		Stbd	Port	Stbd	Port		
1							
2							
…							
9							
10							
Trim measurements							
Operation (measurement) No.	Test-weight position (side)	Level measurement, mm				Trim angle increment, rad.(deg)	
		U-tube No.3 Base length _____ mm		U-tube No.4 Base length _____ mm		U-tube No.3	U-tube No.4
		Stbd	Port	Stbd	Port		
1							
2							
9							
10							

(When determining the unit's inclination angles with the use of optical quadrants tables which look like Table 5.2 shall be used).

Table 5.2

Operation (measurement) No.	Test-weight position (side)	Quadrant No.			Mean value of angle, deg.	Angle of heel, deg.	Heel angle increment	
		Angle of heel, deg.						
		Measurement 1	Measurement 2	Measurement 3			deg.	rad.
1								
2								
…								
9								
10								

Account shall be taken of the increments in the unit's inclination angles obtained from the data of all quadrants used for the inclination kind involved (heel, trim).

Measurements were made by____

(position, full name)

____

APPENDIX 2.1.6

RECORD
OF VERIFICATION OF AVAILABILITY OF COMPARTMENTS, LIQUID CARGO TANKS, CANISTERS AND COFFERDAMS FOR THE INCLINATION TEST

Unit ______________________________ "_____" _____________201
(name)

The inclining test commission verified the condition of compartments, liquid cargo tanks, canisters and cofferdams of the unit and found out that by the commencement of the test:

1) the compartments, tanks and cofferdams were drained, except for the tanks in which, on the commission's decision, liquid cargoes were left and which were pressed up (refer to Appendix 2.1.7 to the Inclining Test Report);

____
____
____
(special notes)

2) valves of the filling and daily service piping were shut off and sealed;

3) mass of the liquids in tanks was accounted for in the records of surplus (missing) loads.

Chairman of the commission_______________________________________
(signature, full name)

Members of the commission _______________________________________
(signature, full name)

APPENDIX 2.1.7

**REPORT
OF VERIFICATION OF CONDITION OF COMPARTMENTS,
LIQUID CARGO TANKS, CANISTERS AND COFFERDAMS**

Unit ____________________________ "_____" ____________201
(name)

Members of the inclining test commission _______________________________________
(full name)

____

____

verified carefully the liquid cargo tanks, including small daily service and other tanks and canisters, etc. Results of the verification are given in Table 7.1.

Table 7.1

Tank	Where water ballast is available							Filling pattern	Components of mass loading
	Mass, t	Levers, m			Moments, tm				
		X	Y	Z	M_X	M_Y	M_Z		
Fresh water No									Surplus load
Lubricating oil									Missing load
Water ballast No.									Surplus load
Fuel oil No.									Missing load
Surplus loads in total									
Missing loads in total									

Water ballast of ______ t was taken aboard in order to impart to the unit a draught of______ m, corresponding to the calculation.

Tanks Nos. _____________ were pressed up until liquid appeared in air pipes, with a previous time delay of ___________________ h.

(Included in Table 7.1 are all tanks, compartments and cofferdams available on the unit, which may contain liquid cargoes, regardless of their degree of filling. Column "Filling pattern" is used to note that the space was pressed up, filled completely, filled partly, contains liquid cargo remains, empty).

Members of the inclining test commission:
Signatures____
(full name)

____

APPENDIX 2.1.8

RECORD
OF DETERMINATION OF HEELING WATER BALLAST MASS
(model form)

Unit ____________________________ “_____” _____________201
(name)

Mass of the heeling water ballast was determined by calculation-based method (with the use of measuring vessels).

Schemes were given for the forms and volumes of ballast (and other) tanks or compartments (subsequently referred to as "tanks") used for heeling ballast. The schemes were constructed in three projections (or in axonometry) with indication of all geometric dimensions, arrangement of the metal framework and equipment in the tanks, references to the final plans of tanks (compartments) were made.

Determination of the volumes and volume centres of gravity of the tanks, as well as of the levels and store amount therein was carried out in tables (or by other ways); free surfaces and their effect on the inclining test performance were recorded.

Strict control was exercised over the condition of the heeling water ballast free surfaces in tanks after each transfer of the heeling ballast (or over the absence of free surfaces), to which effect relevant entries were made in the Record. (Form and number of tables, figures describing this process — at the discretion of the inclining test commission).

The free surfaces of the heeling water ballast in all tanks at all inclinations were of a regular rectangular shape.

During transfer of the heeling water ballast its upper and lower levels in tanks were within wall-sided portion of the tanks and were marked by clearly distinguishable lines (marks) on the battens fitted in the tank comers and accessible for observation through the manholes (hatches) with the help of an effective portable lighting (or by other reliable means).

Corrections for the free surfaces in the water ballast tanks were accounted for in determination of the initial transverse metacentric height from the inclining test data.

Procedures for preparation
of the present Record were executed by ____
(position, full name)
____

APPENDIX 2.1.9

RECORD
OF STATIONING OF THE PARTICIPANTS IN THE INCLINING TEST ON BOARD THE UNIT

Unit ______________________________ "_____" _____________201
(name)

The Record is given in Table 9.1.

Table 9.1

Space (station)	Number of persons	Mass, t	Levers, m			Moments, tm		
			X	Y	Z	M_X	M_Y	M_Z
Grand total								

Record was prepared by: ____
(position, full name)

____
____
____

APPENDIX 2.1.10

RECORD
OF MEASUREMENT OF U-TUBE BASE LENGTH, VERIFICATION OF POSITIONING OF MEASURING RULES (BATTENS) AND OPTICAL QUADRANTS

Unit ____________________________ “_____” _____________201
(name)

Base lengths of the U-tubes were measured by a steel measuring rule of ________ m long between glass tubes attached to the measuring rules (battens) at a height of ________ m above the upper deck of the unit.

It was found out through the verification that:

base length of the U-tubes was of __________ m;

measuring rules (battens) were so attached to the unit's hull that they do not shift when in use during the test;

rules (battens) were positioned normally to the base plane of the unit;

positioning of the optical quadrants was verified against the hull reference lines (verification bases) situated on __________________

The results of the measurements are given in Table 10.1.

Table 10.1

U-tube (quadrant) No	U-tube (quadrant) position	U-tube base length, mm			Note
		Measurement 1	Measurement 2	Design value	

Measurements were made by____
(full name)

Position ____

APPENDIX 3

PROCEDURE FOR CALCULATION OF WIND PRESSURE ACTING ON UNIT FOR ALL POSSIBLE WIND DIRECTIONS

This calculation procedure may be applied for determination of wind pressures acting on semi- submersible drilling units with rectangular-shaped upper hull, stability columns of different configuration and helideck outside the said hull at arbitrary angles of wind action.

In order to determine the wind pressure in case of arbitrary wind direction, it is necessary to obtain the wind pressures F_1, F_2, F_3, F_4 with the air flow normal to the midship section and the centre line of the unit (refer to Fig. 3.1).

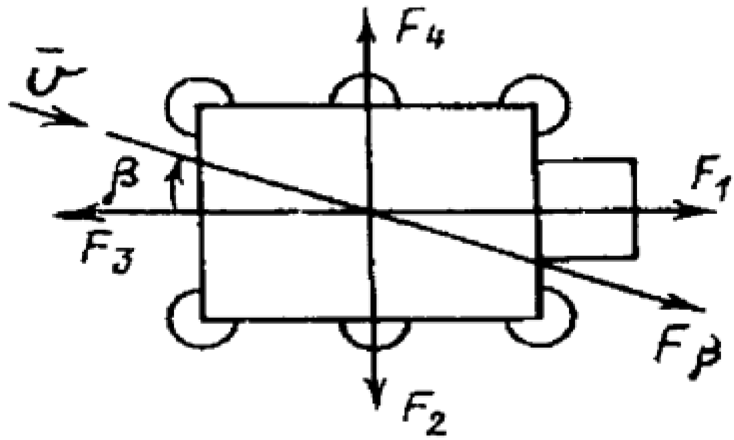


Fig. 3.1.

The values of wind pressure F_1, F_2, F_3, F_4 are calculated according to 2.4.2.

The intermediate values of wind pressure F_β, in deg., caused by the change of angle of air flow β from 0 to $\pi/2$ in each of the quarters are determined using the empirical dependence

$$F_\beta = F_i \cos^2\beta + F_{i+1}\sin^2\beta + \frac{1}{2}|\delta F| ctg 2\theta \sin 2\beta \qquad (3.1)$$

where	$\beta (0 \le \beta \le \pi/2)$	=	the angle to be determined on the basis of wind direction at which F_i was calculated; i = 1,2,3,4 (when F_β is determined in the last quarter $F_i = F_4; F_{i+1} = F$);
	$\delta F = F_i - F_{i+1}$	=	the difference in wind pressure in *i*-th and (*i*+1)- th positions of the unit;
	$\theta = 57{,}3k\sqrt{|\delta F|(F_i + F_{i+1})}$	=	the phase angle defining the value and position of the wind pressure maximum.

Factor $k = 0{,}66$ rad. is obtained from wind tunnel experiment on the unit models.

Where $|\delta F|(F_i + F_{i+1})100 > 7$ %, the wind pressure shall be obtained using the formula

$$F_\beta = \frac{F_i + F_{i+1}}{2}(1 + 0{,}25|\sin 2\beta|). \qquad (3.2)$$

The maximum value of wind pressure F_β obtained by the Formula (3.1) will be

$$F_{max} = \frac{F_i+F_{i+1}}{2} + \frac{1}{2}\frac{|\delta F|}{\sin 2\theta} \tag{3.3}$$

with $\beta = \begin{cases} \pi/4+\theta, & \text{at } F_i < F_{i+1}; \\ \pi/4-\theta, & \text{at } F_i > F_{i+1}. \end{cases}$

Where $|\delta F|(F_i + F_{i+1})100 < 7\,\%$, the maximum value of wind pressure with $\beta = \pi/4$ will be

$$F_{max} = 1{,}25\,\frac{F_i+F_{i+1}}{2}. \tag{3.4}$$

APPENDIX 4

PROCEDURE FOR CALCULATION OF WIND HEELING MOMENT FOR SEMI-SUBMERSIBLE AND SUBMERSIBLE UNITS WITH RECTANGULAR UPPER HULL

This calculation procedure takes into consideration the effect of vertical forces arising in the upper hull and helideck (outside thereof) in case of unit inclinations and shielding effect of the water surface on the heeling moment.

The procedure may be applied for determining the wind heeling moment of a semi-submersible or submersible unit with rectangular-shaped upper hull in pitching and rolling of the unit.

When a unit is inclined, the wind pressure acting on its components other than upper hull and helideck is considered proportional to the cosine of angle of inclination.

Additional horizontal forces caused by a lifting force acting on the hull and helideck of the unit when it is inclined are determined by the formula

$$\delta F = \frac{\rho_A V_v^2}{2} n_h (C_{Zh} S_h + C_{Zh.d.} S_{h.d.})\, tg\alpha \qquad (4.1)$$

where V_v = the mean velocity of steady wind flow at a height of 10 m above the sea level;
n_h = the coefficient of velocity head increase over the height Z_h equal to the distance of the upper hull centre from the sea surface;
C_{Zh} = the coefficient of lifting force of the upper hull at the arbitrary angle of unit inclination which shall be taken from Figs. 4.1 — 4.3 depending on the relative height of the upper hull projected area centre above the water surface:

$\overline{Z} = z_h / L_h$;

L_h = dimension of the upper hull in the direction of wind flow;
$C_{Zh.d.}$ = the coefficient of lifting force of the helideck at an arbitrary angle of unit inclination which is taken from Fig. 4.2 for the height $\overline{Z} = \infty$ (unlimited flow);
S_h, $S_{h.d.}$ = areas of the upper deck and helideck in plan, m² (these areas are assumed for calculation, since the values of coefficients of lifting force and heeling moment shown in Figs. 4.1 — 4.6 are obtained by dividing the forces and moments by the area in plan);
α = the angle of unit inclination (i.e. the angle of heel φ or trim ψ), deg.

The wind pressure in case of unit inclination caused by the horizontal components of wind forces is determined by the formula

$$F = \frac{\rho_A V_v^2}{2}\left[\cos\alpha \sum_j C_{Sj} C_{Hj} A_{Vj} + n_k tg\alpha (C_{Zk} S_k + C_{Zh.d.} S_{h.d.})\right] \qquad (4.2)$$

where A_{Vj} = the windage area of the *j*-th windage area component;
C_{Sj} = the shape coefficient of the *j*-th windage area component;
C_{Hj} = the height coefficient of the *j*-th windage area component.

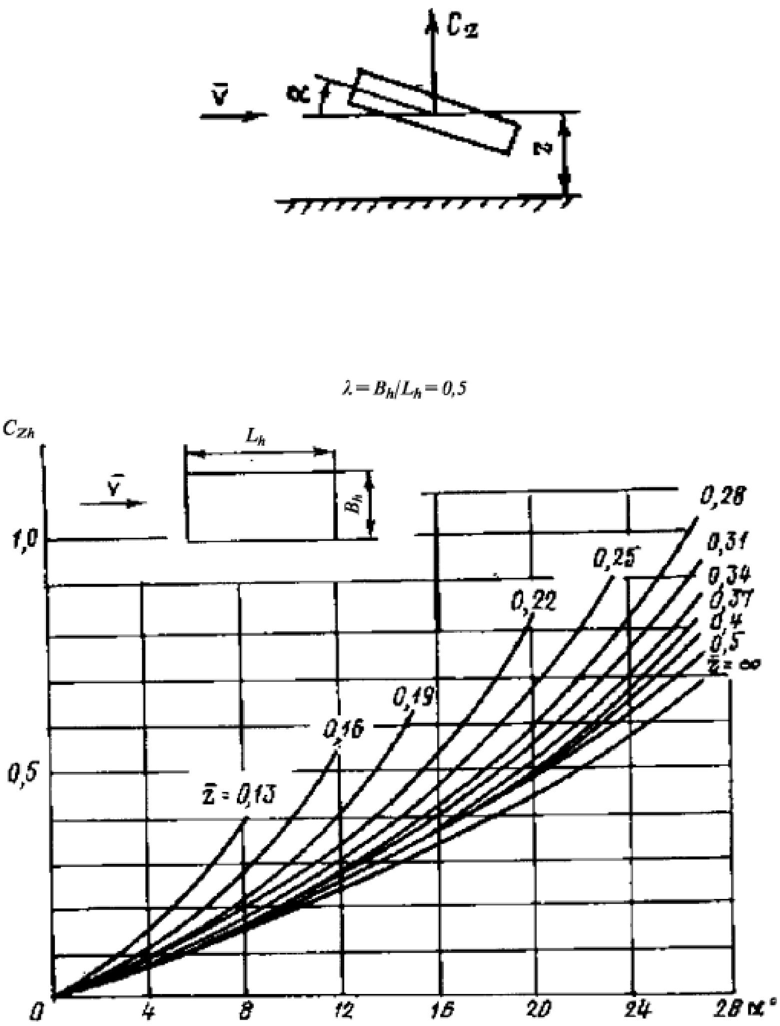

Cz
V̄
α
z
λ = Bh/Lh = 0,5
Czh
Lh
Bh
V̄
1,0
0,5
0
4
8
12
16
20
24
28 α°
z̄ = 0,13
0,16
0,19
0,22
0,25
0,28
0,31
0,34
0,37
0,4
0,5
z̄ = ∞

Fig. 4.1

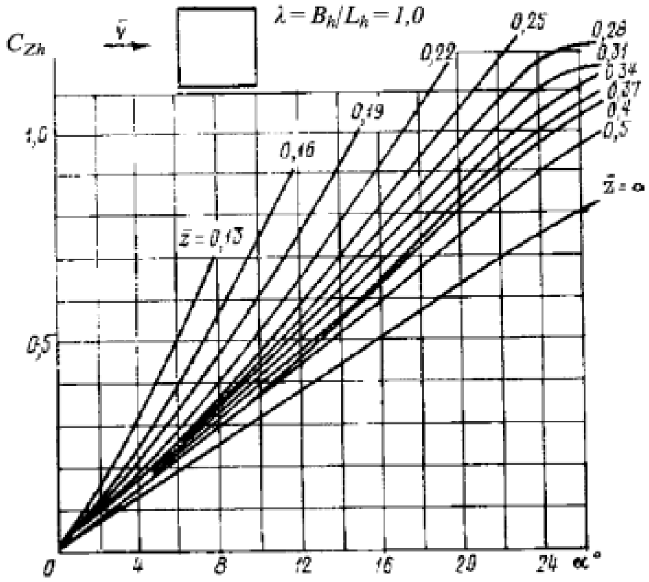

λ = B_h/L_h = 1,0
C_Zh
0,25
0,28
0,22
0,31
0,34
0,37
0,4
0,5
0,19
0,16
z̄ = ∞
z̄ = 0,13
1,0
0,5
0
4
8
12
16
20
24
α°

Fig. 4.2

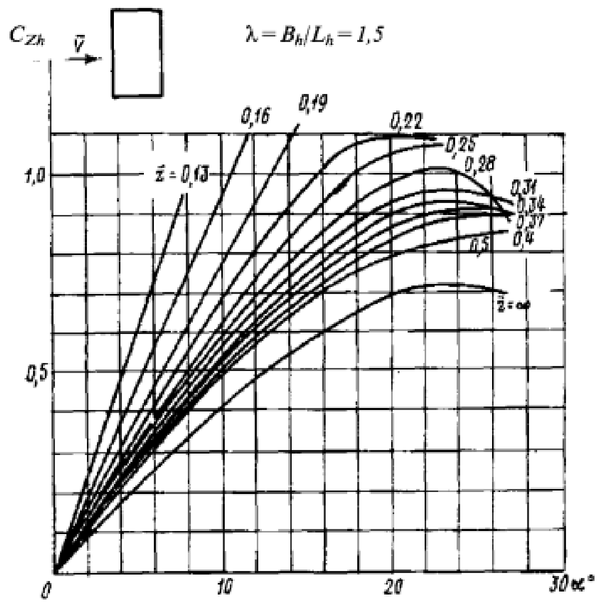
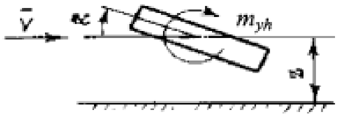

C_Zh
λ = B_h/L_h = 1,5
0,16
0,19
0,22
0,25
0,28
z̄ = 0,13
0,31
0,34
0,37
0,4
0,5
z̄ = ∞
1,0
0,5
0
10
20
30 α°

Fig. 4.3



$\lambda = B_h/L_h = 0,5$

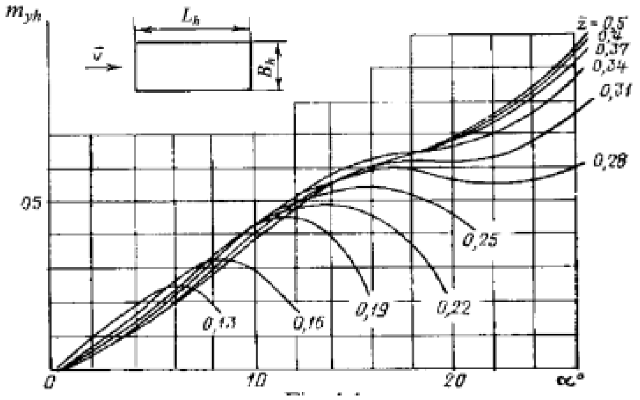


Fig. 4.4

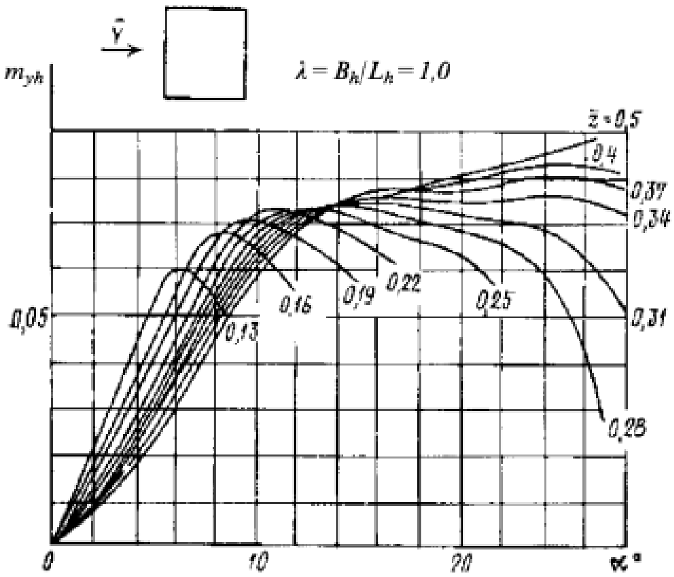


Fig. 4.5

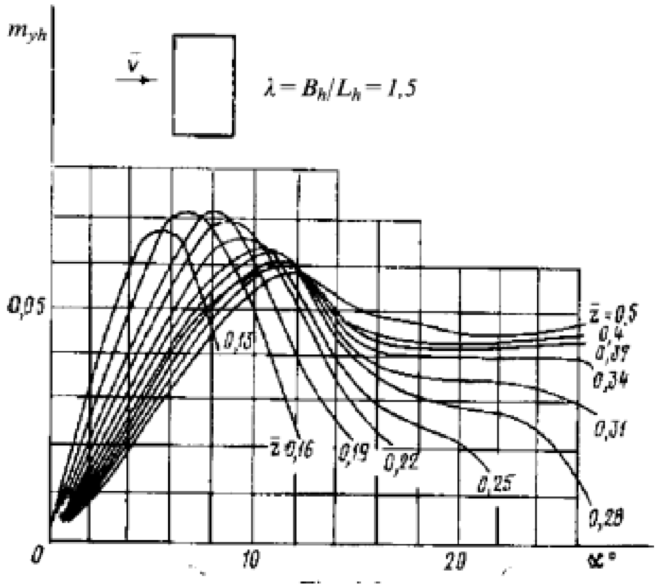


Fig. 4.6

The wind heeling moment relative to the centre of application of hydrodynamical forces is calculated by the formula

$$M = M_{H.F.} + M_{V.F.} + FZ_{\omega} \quad (4.3)$$

where $M_{H.F.}$ = the moment of horizontal forces relative to the origin of the wind coordinate system 0XYZ, which is the point of intersection of the vertical axis Z with the waterline plane (Fig. 4.7, point 0);
$M_{V.F.}$ = the moment of vertical forces relative to the point 0, the origin of the wind coordinate system 0XYZ;
F = the wind pressure determined by Formula (4.2);
Z_{ω} = the distance from the waterline to the centre of application of the resultant of hydrodynamical forces to be determined according to 2.4.3 of this Part.

The horizontal force moment is determined by the formula

$$M_{H.F.} = \frac{\rho_A V_v^2}{2}\left[\cos\alpha \sum_j C_{Sj} C_{Hj} A_{Vj} Z_j + n_k tg\alpha (C_{Zh} S_h z_h + C_{Zh.d.} S_{h.d.} z_{h.d.})\right] \quad (4.4)$$

where $z_{h.d.}$ = the distance from centre of the helideck (Fig. 4.7) to the sea surface, in m;
Z_j = the distance from windage area centre of the *j*-th element to the sea surface, in m.

The vertical force moment is determined by the formula

$$M_{V.F.} = \frac{\rho_A V_v^2}{2}\left(m_{yh} S_h L_h + C_{Zh.d.} S_{h.d.} X_{h.d.}\right) \quad (4.5)$$

where m_{yh} = the coefficient of vertical force moment arising on the hull to be determined using the relationships shown in Figs. 4.5 — 4.7;
$X_{h.d.}$ = the arm of vertical force arising at the helideck, m (assumed equal to the value of projection on the horizontal plane of the distance from the helideck centre to the upper hull centre refer to Fig. 4.7).

Formula (4.5) is used for the heel and trim of the unit if the helideck is on the windward side. If the helideck is on lee side, the effect of the vertical force arising at the helideck is not taken into account, since it is negligible.

The values of aerodynamical coefficients C_{Zh} and m_{yh} for hulls with intermediate values of elongation $\lambda = B_h/L_h$ are determined by interpolation with dependencies $C_Z = f(\lambda)$ and $m_{yh} = f(\lambda)$ being constructed for $\alpha = const$ and $\bar{z} = const$.

The values of aerodynamical coefficients C_{Zh} and m_{yh} for intermediate values of relative heights $\bar{z}$ shall be determined by interpolation $C_Z = f(\bar{z})$ and $m_{yh} = f(\bar{z})$ being constructed for $\lambda = const$ and $\alpha = const$.

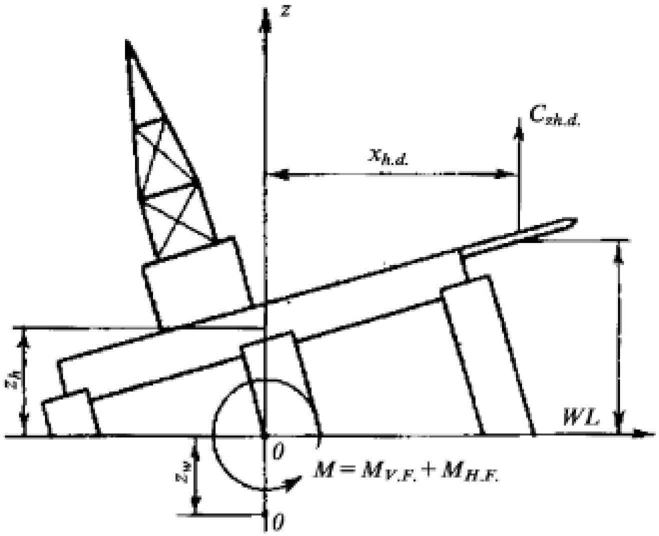


Fig. 4.7

APPENDIX 5

VALUES OF EXTREME WIND VELOCITIES AND WAVE HEIGHTS POSSIBLE ONCE EVERY 50/100 YEARS

Table 5.1

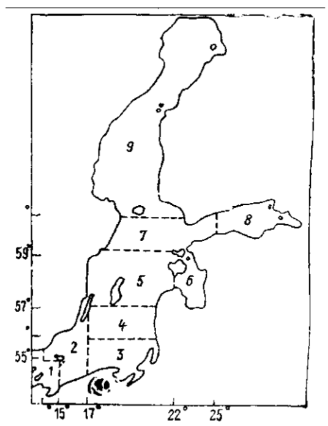
For Barents Sea			
Is not RF zone			
1			
2			
3	No data available	18/20	
4	Ditto	18/20	
5			
6	31-33/33-35	17/18	
7	31-33/33-35	15/16	
8	31-45/33-36	13/15	
9	31-33/33-35	14/16	
Entire water area:	Above 75°N		
up to 75°N		45/46	

Table 5.2

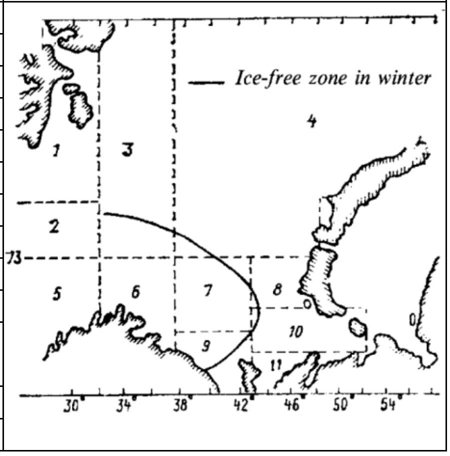
Area	Average wind velocity (averaging period 10 min), $\overline{\omega}_{50/100}$, m/s	Wave height with 3 % probability of exceeding level $h_{50/100}$, m	Map
10			
11	Ditto		
	Is not RF zone		
	For Caspian Sea		
No data available		Entire water area:	
	17/18		
	18/20		

Table 5.3

Area	Average wind velocity (averaging period 10 min), $\bar{\omega}_{50/100}$, m/s	Wave height with 3 % probability of exceeding level $h_{50/100}$, m	Map
For Okhotsk Sea			
1	34/36	8,5/9,5	
2	34/38	13/14	
3	34/36	12/13	
36/38	13/14	Entire water area:	

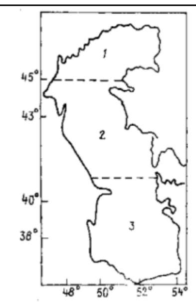


Table 5.4

Area	Average wind velocity (averaging period 10 min), $\bar{\omega}_{50/100}$, m/s	Wave height with 3 % probability of exceeding level $h_{50/100}$, m	Map
For Black Sea			
1 S, D	No data available	No data available	
2 S, D	44/46	17/19	
3 S	44/46	13/15	
4 D	No data available	18/20	
5 S, D	39/41	18/19	
6 S	40/42	10/11	
7 D	No data available	17/19	
8 S, D	44/46	12/13	
9	No data available	13/14	
in shelf zohes	44/46	17/19	
In the middle part (deep- sea zone)	No data available	18/20	

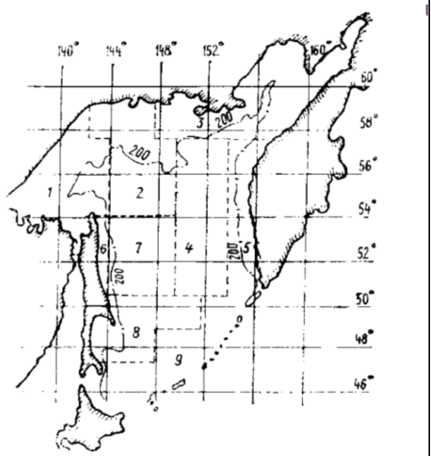
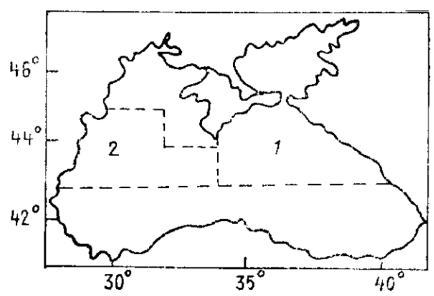


Table 5.5

Area	Average wind velocity (averaging period 10 min), $\bar{\omega}_{50/100}$, m/s	Wave height with 3 % probability of exceeding level $h_{50/100}$, m	Map
1	37/40	12,5/14,5	
2	36/39	13/14,5	
Entire water area:	37/40	13/14,5	



N o t e s : 1. Data on the wind and waves are given for the winter season and shall be considered as design data. Parameters of the transformed waves in shallow-water zones shall be recalculated on the basis of the deep water data.

2. Symbols: S means shelf zone, D means deep-sea zone.

In order to enhance the operational capabilities of the unit with due account of the seasons, it is necessary to use data of the Goskomgidromet, which account for seasonal fluctuation and zoning. When no such data are available, reduction coefficients given in Table 5.6 may be used.

Table 5.6

Hydrometeorological conditions	Season			
	Winter	Spring	Summer	Autumn
Wind	1,0	0,9	0,8	0,95
Waves	1,0	0,95	0,75	0,90

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