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Small craft — Hull construction and scantlings —

Part 5: Design pressures for monohulls, design stresses, scantlings determination

Petits navires — Construction de la coque et échantillonnage —

Partie 5: Pressions de conception pour monocoques, contraintes de conception, détermination de l'échantillonnage

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 12215-5 was prepared by Technical Committee ISO/TC 188, *Small craft*.

ISO 12215 consists of the following parts, under the general title *Small craft — Hull construction and scantlings*:

— *Part 1: Materials: Thermosetting resins, glass fibre reinforcement, reference laminate*

— *Part 2: Materials: Core materials for sandwich construction, embedded materials*

— *Part 3: Materials: Steel, aluminium alloys, wood, other materials*

— *Part 4: Workshop and manufacturing*

— *Part 5: Design pressures for monuhulls, design stresses, scantlings determination*

— *Part 6: Structural arrangements and details*

— *Part 7: Scantling determination of multihulls*

— *Part 8: Rudders*

— *Part 9: Sailing boats — Appendages and rig attachment*

Introduction

The reason underlying the preparation of this part of ISO 12215 is that standards and recommended practices for loads on the hull and the dimensioning of small craft differ considerably from one to another, thus limiting the general worldwide acceptability of boat scantlings. This part of ISO 12215 has been set towards the lower boundary of the range of current practice.

The objective of this part of ISO 12215 is to achieve an overall structural strength that ensures the watertight and weathertight integrity of the craft. It is intended to be a tool to assess the scantlings of a craft against lower bound practice and it is not intended to be a structural design procedure

The scantling requirements are based principally on providing adequate local strength. Serviceability issues such as deflection under normal operating loads, global strength and its connected shell and deck stability are not addressed. The criteria contained within may need to be supplemented by additional considerations deemed necessary by the designer of the structure.

The mechanical property data supplied as default values make no explicit allowance for deterioration in service nor provide any guarantee that these values can be obtained for any particular craft. The responsibility for the decision to use this part of ISO 12215 as part of the design procedure rests solely with the designer and/or manufacturer.

The design pressures given in this part of ISO 12215 are only used with the given equations.

Considering future development in technology and boat types and small craft currently outside the scope of this part of ISO 12215, provided methods supported by appropriate technology exist, consideration may be given to their use provided equivalent support for this part of ISO 12215 is achieved.

The dimensioning according to this part of ISO 12215 is regarded as reflecting current practice, provided the craft is correctly handled in the sense of good seamanship and operated at a speed appropriate to the prevailing sea state.

Important notice:

1) ISO/TC 188/WG 18 believes that this part of ISO 12215 is the best that can be achieved at the time of publication. It has therefore decided to publish this document as an ISO Standard. It is anticipated that wider usage may reveal a number of issues that require modification. It is for this reason that WG 18 has asked for a revision of the document at the same time as its publication. This revision agreement will enable the group to amend this part of ISO 12215 quickly should this prove necessary.

2) In furtherance of this, this part of ISO 12215 needs to be applied with a critical mind, and users are invited to report to the TC secretariat, or national standardization body, any items that are considered to require correction, together with supporting evidence, be that theoretical or based on satisfactory, long-term service experience with actual boats operating in the appropriate design category sea states.

Small craft — Hull construction and scantlings —

Part 5: Design pressures for monohulls, design stresses, scantlings determination

1 Scope

This part of ISO 12215 applies to the determination of design pressures and stresses, and to the determination of the scantlings, including internal structural members of monohull small craft constructed from fibre-reinforced plastics, aluminium or steel alloys, glued wood or other suitable boat building material, with a length of hull, L_H, in accordance with ISO 8666, between 2,5 m and 24 m. It only applies to boats in the intact condition.

It only applies to craft with a maximum speed $\leqslant$ 50 knots in m_{LDC} conditions.

The assessment shall generally include all parts of the craft that are assumed watertight or weathertight when assessing stability, freeboard and buoyancy in accordance with ISO 12217 and are essential to the safety of the craft and of persons on board.

For the complete scantlings of the craft, this part of ISO 12215 is used in conjunction with Part 6, for details, Part 7 for multihulls, Part 8 for rudders and Part 9 for appendages and rig attachment.

The scantling determination of windows, portlights, deadlights, hatches and doors, is in accordance with ISO 12216. The structure supporting these elements is in accordance with this part of ISO 12215.

NOTE 1 Scantlings derived from this part of ISO 12215 are primarily intended to apply to recreational craft including recreational charter vessels and may not be suitable for performance racing craft.

NOTE 2 This part of ISO 12215 is based on the assumption that scantlings are governed solely by local loads.

NOTE 3 The scantling requirements of this part of ISO 12215 are considered to correspond to the minimum strength requirements of motor and sailing craft which are operated in a safe and responsible manner, having due cognisance of the prevailing conditions.

Pressures and stresses are normally expressed in pascals, kilopascals or megapascals. For the purposes of a better understanding for the users of this part of ISO 12215, the pressures are expressed in kilonewtons per square metre ($1 kN/m^2 = 1 kPa$) and stresses or elastic moduli are expressed in newtons per square millimetre ($1 N/mm^2 = 1 MPa$).

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 178, *Plastics — Determination of flexural properties*

ISO 527-1, *Plastics — Determination of tensile properties — Part 1: General principles*

ISO 527-2, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*

ISO 844, *Rigid cellular plastics — Determination of compression properties*

ISO 845, *Cellular plastics and rubbers — Determination of apparent density*

ISO 1922, *Rigid cellular plastics — Determination of shear strength*

ISO 8666:2002, *Small craft — Principal data*

ISO 12215-3, *Small craft — Hull construction and scantlings — Part 3: Materials: Steel, aluminium alloys, wood, other materials*

ISO 12215-6, *Small craft — Hull construction and scantlings — Part 6: Structural arrangements and details*

ISO 12215-7, *Small craft — Hull construction and scantlings — Part 7: Scantling determination of multihulls*

ISO 12215-9, *Small craft — Hull construction and scantlings — Part 9: Sailing boats — Appendages and rig attachment*

ISO 12216, *Small craft — Windows, portlights, hatches, deadlights and doors — Strength and watertightness requirements*

ISO 12217 (all parts), *Small craft — Stability and buoyancy assessment and categorization*

ASTM C393, *Standard Test Method for Flexural Properties of Sandwich Constructions*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
design categories
sea and wind conditions for which a boat is assessed by this part of ISO 12215 to be suitable, provided the craft is correctly handled in the sense of good seamanship and operated at a speed appropriate to the prevailing sea state

3.1.1
design category A ("ocean")
category of boats considered suitable to operate in seas with significant wave heights above 4 m and wind speeds in excess of Beaufort Force 8, but excluding abnormal conditions, e.g. hurricanes

NOTE For the application of this part of ISO 12215, the calculation wave height is 7 m.

3.1.2
design category B ("offshore")
category of boats considered suitable to operate in seas with significant wave heights up to 4 m and winds of Beaufort Force 8 or less

3.1.3
design category C ("inshore")
category of boats considered suitable to operate in seas with significant wave heights up to 2 m and a typical steady wind force of Beaufort Force 6 or less

3.1.4
design category D ("sheltered waters")
category of boats considered suitable to operate in waters with significant wave heights up to and including 0,3 m with occasional waves of 0,5 m height, for example from passing vessels, and a typical steady wind force of Beaufort Force 4 or less

3.2
loaded displacement mass
m_{LDC}
mass of the craft, including all appendages, when in the fully loaded ready-for-use condition as defined in ISO 8666

3.3
sailing craft
craft for which the primary means of propulsion is wind power, having $A_S > 0{,}07(m_{LDC})^{2/3}$ where A_S is the total profile area of all sails that may be set at one time when sailing close hauled, as defined in ISO 8666 and expressed in square metres

NOTE In the rest of this part of ISO 12215, non-sailing craft are considered as motor craft.

3.4
second moment of area
I
for a homogeneous material, it is the sum of the component areas multiplied by the square of the distance from centre of area of each component area to the neutral axis, plus the second moment of area of each component area about an axis passing through its own centroid, and is expressed in centimetres to the fourth or millimetres to the fourth

NOTE The second moment of area is also referred to in other documentation as the moment of inertia and for brevity as "second moment" within this part of ISO 12215.

3.5
section modulus
SM
for a homogeneous material, it is the second moment of area divided by the distance to any point from the neutral axis at which the stress is to be calculated and is expressed in cubic centimetres or cubic millimetres

NOTE The minimum section modulus is calculated to the furthest point from the neutral axis.

3.6
displacement craft
craft whose maximum speed in flat water and m_{LDC} conditions, declared by its manufacturer, is such that

$$\frac{V}{\sqrt{L_{WL}}} < 5$$

3.7
displacement mode
mode of running of a craft in the sea such that its mass is mainly supported by buoyancy forces

NOTE This is the case if the actual speed in a seaway and m_{LDC} conditions is such that its speed:length ratio makes the craft behave as a displacement craft.

3.8
planing craft
craft whose maximum speed in flat water and m_{LDC} conditions, declared by its manufacturer, is such that

$$\frac{V}{\sqrt{L_{WL}}} \geqslant 5$$

NOTE This speed:length ratio limit has been arbitrarily set up in this part of ISO 12215, but it may vary from one boat to another according to hull shape and other parameters.

3.9
planing mode
mode of running of a craft in the sea such that its mass is significantly supported by forces coming from dynamic lift due to speed in the water

NOTE 1 A planing craft in calm water will run in planing mode.

NOTE 2 A planing craft may be obliged to significantly reduce its speed when the sea gets worse, running in that case in displacement mode.

4 Symbols

Unless specifically otherwise defined, the symbols shown in Table 1 are used in this part of ISO 12215.

NOTE The symbols are shown in alphabetic order, not in order of appearance.

Table 1 — Symbols, factors, parameters

Symbol	Unit	Designation/meaning of symbol	Reference/subclause concerned
Principal craft data			
A_S	m	Sail area in accordance with ISO 8666	ISO 8666
B_C	m	Chine beam	6.1
B_H	m	Beam of the hull	ISO 8666
B_{WL}	m	Beam of the fully loaded waterline at m_{LDC}	ISO 8666
D_b	m	Depth of bulkhead	11.8.1
L_H	m	Length of the hull	ISO 8666, 6.1
L_{WL}	m	Length of the fully loaded waterline at m_{LDC}	ISO 8666, 6.1
V	knots	Maximum speed at m_{LDC}	6.1
h_b	m	Load head for watertight bulkhead or integral tank	8.3
m_{LDC}	kg	Loaded displacement mass of the craft	3.2
$\beta_{0,4}$	°	Deadrise angle at 0,4 L_{WL} forward of its aft end	6.1, 7.3
Panel or stiffener dimensions			
A_D	m^2	Design area under consideration	7.5.1
b	mm	Shorter dimension of plate panel	9.1, 10
b_e	mm	Effective extent of plating connected to a stiffener	11.6
c	mm	Crown of a curved panel	10.1.3
c_u	mm	Crown of a curved stiffener	11.2.1
h	m	Height of centre of panel or mid stiffener above W_L	7.6
l	mm	Longer dimension of plate panel	9.1.2
l_u	mm	Unsupported span of stiffener or frame	9.2.2
s	mm	Stiffener or frame spacing	9.2.1
x	m	Distance of mid panel or stiffener from of aft end of L_{WL}	7.4
Z	m	Height of top of hull or deck angle above W_L	7.6
Calculation data: factor, pressures, parameters, stresses			
A_W	cm^2	Shear area cross-section	11.4.1
I	cm^4, mm^4	Second moment of area	11.4.2

Table 1 (*continued*)

Symbol	Unit	Designation/meaning of symbol	Reference/subclause concerned
k_{AR}	1	Area pressure reduction factor	7.5
$k_{AR\ MIN}$	1	Minimun value for k_{AR}	7.5
k_{AS}	1	Stiffener shear force correction in Table 21	11.7.2
k_C	1	Curvature correction factor for plating	10.1.3
k_{CS}	1	Curvature correction factor for stiffeners	11.2.1
k_{DC}	1	Design category factor	7.2
k_L	1	Longitudinal pressure distribution factor	7.4
k_R	1	Structural component and boat type factor	7.5
k_{SA}	1	Stiffener shear area factor	11.2.2
k_{SHC}	1	Shear strength aspect ratio factor	10.5.4
k_{SLS}	1	Light and stable sailboat pressure correcting factor for slamming	7.8
k_{SM}	1	Stiffener bending moment correction in Table 21	11.7.2
k_{SUP}	1	Superstructure pressure reduction factor	7.7
k_Z	1	Vertical pressure distribution factor	7.6
k_1	1	Bending stiffness factor for sandwich	10.1.1
k_2	1	Panel aspect ratio factor for bending strength	10.1.2
k_3	1	Panel aspect ratio factor for bending stiffness	10.1.2
k_4	1	Sandwich minimum skin location factor	10.5.6
k_5	1	Sandwich fibre factor	10.5.6
k_6	1	Sandwich care factor	10.5.6
k_7, k_8	1	Minimum thickness factors	10.6.2
n_{CG}	1	Dynamic load factor	7.3
$P_{BM\ MIN}$	kN/m^2	Motorcraft bottom minimum pressure (planing or displacement)	8.1.2, 8.1.3
P_{BMD}	kN/m^2	Motorcraft bottom pressure in displacement mode	8.1.2
$P_{BMD\ BASE}$	kN/m^2	Motorcraft base bottom pressure in displacement mode	8.1.2
P_{BMP}	kN/m^2	Motorcraft bottom pressure in planing mode	8.1.3
$P_{BMP\ BASE}$	kN/m^2	Motorcraft base bottom pressure in planing mode	8.1.3
P_{SMD}	kN/m^2	Motorcraft side pressure in displacement mode	8.1.4
P_{SMP}	kN/m^2	Motorcraft side pressure in planing mode	8.1.5
$P_{SM\ MIN}$	kN/m^2	Minimum motorcraft side pressure (displacement or planing mode)	8.1.4, 8.1.5
P_{DM}	kN/m^2	Motorcraft deck pressure	8.1.6
$P_{DM\ BASE}$	kN/m^2	Motorcraft deck base pressure	8.1.6
$P_{DM\ MIN}$	kN/m^2	Minimum motorcraft deck pressure	8.1.6
$P_{SUP\ M}$	kN/m^2	Motorcraft superstructure pressure	8.1.7
P_{BS}	kN/m^2	Sailing craft bottom pressure	8.2.1
$P_{BS\ BASE}$	kN/m^2	Sailing craft bottom base pressure	8.2.1
$P_{BS\ MIN}$	kN/m^2	Minimum sailing craft bottom pressure	8.2.1

Table 1 (*continued*)

Symbol	Unit	Designation/meaning of symbol	Reference/subclause concerned
P_{SS}	kN/m^2	Sailing craft side pressure	8.2.2
$P_{SS\ MIN}$	kN/m^2	Minimum sailing craft side pressure	8.2.2
P_{DS}	kN/m^2	Sailing craft deck pressure	8.2.3
$P_{DS\ BASE}$	kN/m^2	Sailing craft deck base pressure	8.2.3
$P_{DS\ MIN}$	kN/m^2	Minimum sailing craft deck pressure	8.2.3
$P_{SUP\ S}$	kN/m^2	Sailing craft superstructure pressure	8.2.4
P_{WB}	kN/m^2	Design pressure, watertight boundaries	8.3.1
P_{TB}	kN/m^2	Design pressure, integral tank boundaries	8.3.2
q	N/mm	Shear flow	H.2.1.7, H.3.2
Q	cm^3, mm^3	First moment of area	11.4.1
SM	cm^3, mm^3	Section modulus	11.4.1
σ_d	N/mm^2	Design direct stress	10
σ_u	N/mm^2	Ultimate strength (flexural, compressive, tensile)	10
τ_d	N/mm^2	Design shear stress	10.5.4, 11
τ_u	N/mm^2	Ultimate shear strength	10.5.4, 11
E	N/mm^2	Elasticity modulus (flexural, compressive, tensile)	10.5, 11
w	kg/m^2	Dry fibre reinforcement mass per square metre	10.2.2, 10.5.6
ψ	1	Glass content in mass	Annex A, Annex C
ϕ	1	Glass content in volume	Annex A, Annex C
Other variables contained in annexes are not listed in this table.			

5 General

The scantling determination shall be accomplished as follows:

— for craft with a length L_H of 2,5 m up to 24 m, in accordance with Clauses 6 to 11;

— for sailing craft with a length L_H of 2,5 m up to 9 m of design categories C and D, in accordance with Annex A for plating;

— for craft with a length L_H of 2,5 m up to 6 m and of single-skin construction, the drop test in Annex B may be used as an alternative to the main body of this part of ISO 12215.

NOTE 1 These scantling requirements are based on normal anticipated sea loads during normal usage. Compliance with these requirements does not eliminate the possibility of damage from accidental overloads, careless handling, trailing loads, chocking loads, grounding or berthing. In some instances the requirements may come out lower than fabrication requirements such as welding ability, and should therefore be increased accordingly. For craft < 6 m, in particular, robustness criteria may be the governing aspect for scantling determination, e.g. beaching, grounding, trailer and fender loads. See 10.5.6 and 10.6.

NOTE 2 Annex A is applicable mainly to small, lightweight inshore sailing boats and sailing dinghies that might otherwise find the scantlings from other sections too conservative, but is only available for plating thickness assessment.

NOTE 3 If an annex is used as an alternative to Clauses 6 to 11, the boat builder shall still refer to parts 7 (multihulls), 8 (rudders) and 9 (appendages and rig attachment) of ISO 12215, as appropriate, in addition to using the particular annex.

6 Dimensions, data and areas

6.1 Dimensions and data

All dimensions are measured, unless otherwise specified, in accordance with ISO 8666, with the craft in the fully loaded condition, with a mass m_{LDC} (expressed in kilograms) as defined in 3.2.

The main dimensions are

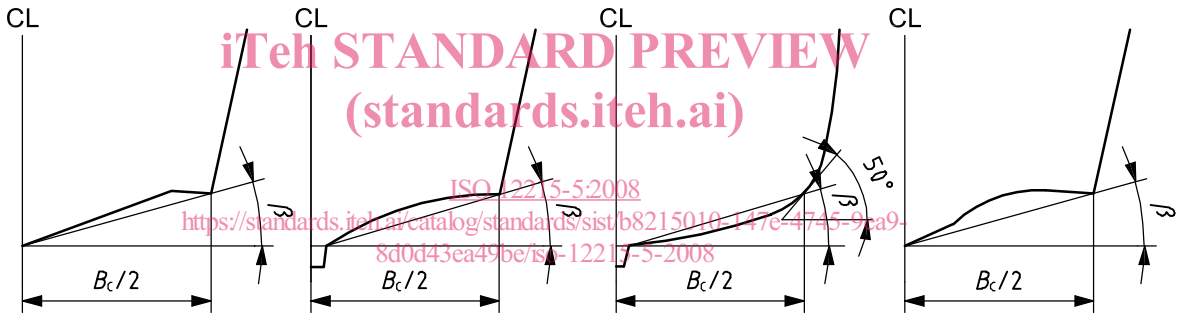
— L_H, the hull length in metres,

— L_{WL}, the length of the waterline, craft at rest in m_{LDC} conditions, in metres,

— B_C, the chine beam, measured in accordance with Figure 1, at 0,4 L_{WL} forward of its aft end, in metres,

— $\beta_{0,4}$, the deadrise angle at 0,4 L_{WL} forward of its aft end, measured according to Figure 1, not to be taken $< 10°$, nor $> 30°$, in degrees,

— V, for motor craft, the maximum speed in calm water declared by the manufacturer, with the craft in m_{LDC} conditions. This speed shall not be taken as $< 2{,}36\sqrt{L_{WL}}$. For sailing craft, speed does not need to be declared in knots.



NOTE For round bilge, the outer limit or chine is considered at the point where a tangent at 50° from the horizontal is tangent to the hull.

Figure 1 — Measurement of chine beam, B_C, and deadrise angle, β

6.2 Areas

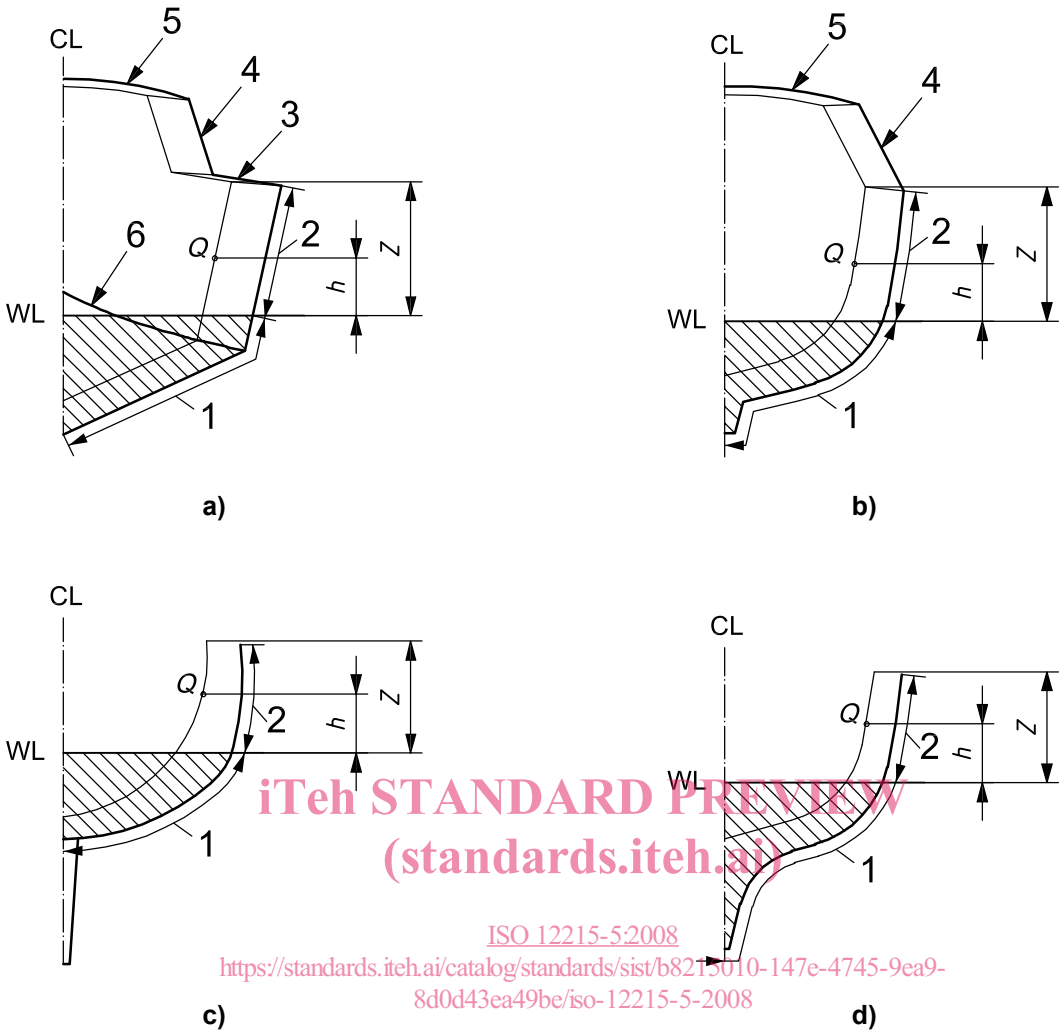
6.2.1 General

The hull, deck and superstructure are divided into various areas: bottom, side, decks and superstructures (see Figure 2).

6.2.2 Bottom areas

For all craft, bottom pressure applies up to waterline (see Figure 2).

The part of the transom following the above definition is considered as bottom.



Key

1 bottom (hatched area)
2 side
3 deck
4 superstructures
5 superstructure top
6 hard chine

Figure 2 — Definitions of areas, and panel height above waterline

6.2.3 Side areas

The extent of the side pressure area, which includes the transom, is the part of the hull not considered as belonging to the bottom area.

6.2.4 Decks and superstructures

Deck areas are parts of the deck exposed to weather and where persons are liable to walk. Cockpit bottom and top of benches and seating areas are included.

Superstructure areas include all areas above deck level. Table 4 lists the different superstructure types.

6.2.5 Panel fully in one area or across two areas

The general situation is as follows:

1) where the plate panel or stiffener is fully within a specified design area, e.g. bottom, side, deck, superstructures, etc., its design pressure shall be determined at the middle of the panel or at mid-length of the stiffener;

2) where the plate panel or stiffener extends over both bottom area and side area, its design pressure shall be determined as a constant pressure over the entire design area, calculated as a weighted average between the two pressures, as shown in the following example.

EXAMPLE For a sailboat panel that lies 30 % in the bottom area and 70 % in the side area, the average pressure is $0{,}3\ P_b + 0{,}7\ P_s$, where P_s is obtained at the midpoint of that part of the panel which lies above the waterline.

CAUTION — According to 8.1.1, for categories A and B planing motor craft, the side panels and stiffeners shall be analysed both in planing and displacement mode, using the worst case. If the chine is below waterline, the side panel is across side and bottom [see Figure 2 a)]. In that case, method 2) above shall be used.

For large panels, see also 10.1.4.

7 Pressure adjusting factors

7.1 General

Final design pressure is adjusted by a set of factors according to design, boat type, location, etc.

7.2 Design category factor k_{DC}

The design category factor k_{DC}, defined in Table 2, takes into account the variation of pressure loads due to sea with design category.

Table 2 — Values of k_{DC} according to design category

Design category	A	B	C	D
Value of k_{DC}	1	0,8	0,6	0,4

7.3 Dynamic load factor n_{CG}

7.3.1 General

The dynamic load factor n_{CG} is considered to be close to the single amplitude acceleration measured at the craft centre of gravity at the relevant frequency for a certain period of time. This factor is the negative acceleration supported by the craft, either while slamming in an encountered wave at speed or falling from the crest of a wave into its trough. n_{CG} is expressed in gs where $1g$ is the acceleration due to gravity (9,81 m/s^2).