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Small craft — Hull construction and scantlings —

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

Petits navires — Construction de coques 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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 188, *Small craft*.

This second edition cancels and replaces the first edition (ISO 12215-5:2008, including its amendment ISO 12215-5:2008/Amd 1:2014), which has been technically revised.

One of the main reasons to achieve this revision, after a decade implementing the first edition, was to allow other scantlings calculation methods than those given in the 2008 edition, noting the huge development of finite element analysis methods and software, and the trend already applied in ISO 12215-9 (keels and appendages) and ISO 12215-7 (multihulls).

Therefore, in this new edition, like in many other scantlings standards, the design pressure loads, and the design stresses are given in the main body of the standard and, where needed, the scantlings calculation methods are detailed in Annexes.

The main changes compared to the previous edition are as follows:

— clarification of the scope and of many definitions, dimensions, and assessment;

— definition of a theoretical hull/deck limit height Z_{SDT} in Table 3;

— renaming of n_{GC} into k_{DYN} in Table 7;

— lowering of the values of k_L in the aft part of the craft in Table 8;

— deletion of k_{AR} min, to better consider large panels, mainly sandwiches, in Table 9;

— improvement of the values of k_{SUP} in Table 10;

— modification of design pressures for motor and sailing craft in Tables 12 & 13;

— modification of design stresses introducing k_{BB} and k_{AM} factors in Tables 15 to 17;

— incorporation of requirements for work boats in Table 2, Clause 12 and Annex J;

— possibility to use a wider range of assessment methods detailed in Table 18;

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— move of the previous assessment method (now called "simplified") in Annex A;

— improvements/clarification of the simplified method (panel assessment, hard chined sections, frameless sections, simple and double curvature, attached plating, requirements for core, etc.);

— development of Annex C for the determination of mechanical properties of composites;

— reminder in A.14 of the requirements of ISO 12215-9 on reinforcement of the hull in way of ballast keel attachment;

— new Annex I only recommending minimum thickness for single skin and sandwich that are no longer mandatory;

— new Annex J defining different types of commercial craft and workboats and their requirements;

— new Annex K defining loads induced by outboard engines;

— new Annex L proposing an application sheet of this document to explain how it has been used;

— for clarity, this edition generally uses tables to present formulas and requirements.

A list of all parts in the ISO 12215 series can be found in the ISO website.

NOTE The mechanical properties of ISO 12215-1 to -3 are largely superseded by the ones of this document.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This corrected version of ISO 12215-1:2019 incorporates the following corrections:

— errors in formulae, text and values in Clause 7, Clause 9, D.1.2, H.3.3, H.4, and Tables 12, 17, A.3, A.4, A.5, A.7, A.8, A.12, A.13, B.1, B.2, C.5, E.1, I.1 and K.1 have been corrected.

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Introduction

The reason underlying the preparation of this document is that standards and recommended practices for loads on the hull and the dimensioning of small craft differ considerably, thus limiting the general worldwide acceptability of craft scantlings. This document has been set towards the minimal requirements of the current practice.

The implementation of this document allows to achieve an overall structural strength that ensures the watertight and weathertight integrity of the craft. This document is intended to be a tool to determine the scantlings of a craft as per minimal requirements. It is not intended to be a structural design procedure.

It is also emphasized that this document should only be used to check the main structural features of a craft but should not be used as a scantlings guide. Users of this document should have practical and theoretical experience in strength of materials and engineering, even if calculation software are available. Many details can have a significant influence on the final stresses and strength of the structure, ISO 12215-6 shows "established practice".

The scantlings requirements aim at 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 in this document. The related criteria may need to be addressed by additional considerations, as deemed necessary by the users of this document.

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. Considering the future development in technology and the boat types and small craft outside the scope of this document, other methods than those described in this document exist, supported by appropriate technology, that can be used provided that they lead to equivalent results.

The dimensioning according to this document 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.

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Small craft — Hull construction and scantlings —

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

1 Scope

This document defines the dimensions, design local pressures, mechanical properties and design stresses for the scantlings determination of monohull small craft with a hull length (L_H) or a load line length (see NOTE 1) of up to 24 m. It considers all parts of the craft that are assumed to be watertight or weathertight when assessing stability, freeboard and buoyancy in accordance with ISO 12217.

NOTE 1 The load line length is defined in the IMO "International Load Lines Convention 1966/2005", it can be larger than L_H for craft with overhangs. This length also sets up at 24 m the lower limit of several IMO conventions.

The main core of this document determines the local design pressures and stresses for monohulls and details the possible scantlings methods derived from these pressures and stresses, both for monohulls and multihulls (see NOTE 2). The assessment process requires, where relevant, the application of Annexes.

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This document is applicable to small craft, in intact condition, of the two following types:

— recreational craft, including recreational charter vessels;

— small commercial craft and workboats, see Clause 12 and Annex J.

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It is not applicable to racing craft designed only for professional racing.

NOTE 2 Local pressures and stresses for multihulls are given in ISO 12215-7.

This document is applicable to the structures supporting windows, portlights, hatches, deadlights, and doors.

For the complete scantlings of the craft, this document is intended to be used with ISO 12215-8 for rudders, ISO 12215-9 for appendages and ISO 12215-10 for rig loads and rig attachments.

This document covers small craft built from the following materials:

— fibre-reinforced plastics, either in single skin or sandwich construction;

— aluminium or steel alloys;

— glued wood or plywood (single skin or sandwich), excluding traditional wood construction;

— non-reinforced plastics for craft with a hull length less than 6 m (see Annex D).

Throughout this document, unless otherwise specified, dimensions are in (m), areas in (m^2), masses in (kg), forces in (N), moments in (N.m), pressures in kN/m^2 (1 kN/m^2 = 1 kPa), stresses and elastic modulus in N/mm^2 (1 N/mm^2 = 1 Mpa). Max(a;b;c) means that the required value is the maximum of a, b, and c; and min(d;e;f) means that the required value is the minimum of d, e, and f.

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2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 8666:2016, *Small craft — Principal data*

ISO 12215-9:2012, *Small craft — Hull construction and scantlings — Part 9: Sailing craft appendages*

ISO 12217-1:2015, *Small craft — Stability and buoyancy assessment and categorization — Part 1: Non-sailing boats of hull length greater than or equal to 6 m*

ISO 12217-2:2015, *Small craft — Stability and buoyancy assessment and categorization — Part 2: Sailing boats of hull length greater than or equal to 6 m*

ISO 12217-3:2015, *Small craft — Stability and buoyancy assessment and categorization — Part 3: Boats of hull length less than 6 m*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

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3.1
design categories
description of the sea and wind conditions for which a craft is assessed to be suitable

Note 1 to entry: The design categories are defined in ISO 12217 (all parts).

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Note 2 to entry: The definitions of design categories are in line with the European Recreational Craft Directive 2013/53/EU.

3.2
loaded displacement
m_{LDC}
mass of water displaced by the craft, including all appendages, when in fully loaded ready for use condition

Note 1 to entry: The fully loaded ready for use condition is further defined in ISO 8666.

3.3
sailing craft
craft for which the primary means of propulsion is wind power

Note 1 to entry: It is further defined in ISO 8666.

Note 2 to entry: In this document, non-sailing craft are considered as motor craft.

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3.4
second moment of area
second moment
I
for a homogeneous material, 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

Note 1 to entry: The second moment of area is also referred to in other documentation as the moment of inertia.

Note 2 to entry: It is expressed in mm^4 or cm^4.

3.5
section modulus
SM
for a homogeneous material, second moment of area divided by the distance to any point from the neutral axis at which the bending stress is calculated, expressed in mm^3 or cm^3

Note 1 to entry: The minimum section modulus is calculated to the furthest point from the neutral axis.

3.6
craft speed
V
for motor craft, maximum speed in calm water and in m_{LDC} condition that is declared by the manufacturer, expressed in knots

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3.7
displacement craft
craft whose maximum speed in flat water and m_{LDC} condition, declared by its manufacturer, is such that $V < 5\sqrt{L_{WL}}$

3.8
displacement mode
mode of running of a craft in the sea such that its mass is mainly supported by buoyancy forces

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Note 1 to entry: This is the case where the actual speed in a seaway in m_{LDC} condition is such that its speed/length ratio makes the craft behave as a displacement craft.

3.9
planing craft
craft whose maximum speed in flat water and in m_{LDC} condition, declared by its manufacturer, is such that $V \geq 5\sqrt{L_{WL}}$

Note 1 to entry: This speed/length ratio limit has been arbitrarily set up in this document, but it may vary from one craft to another according to hull shape and other parameters.

3.10
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 to entry: A planing craft in calm water runs in planing mode, but it may be obliged to significantly reduce its speed when the sea gets worse, running in that case in displacement mode.

3.11
non-walking area
area of the working deck, cockpit or superstructures of a monohull at an inclination of more than 25° to the horizontal in the longitudinal direction or more than 55° to the horizontal in the transverse direction

Note 1 to entry: All other areas of the deck, cockpit bottom and superstructures are deemed walking areas.

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4 Symbols

Unless specified otherwise, the symbols shown in Table 1 are used in this document.

Table 1 — Data, factors, parameters

Symbol	Unit	Designation/meaning of symbol	Ref/sub clause
Linear Dimensions of the craft , principal lengths and beams			
B_C	m	Chine beam according to Figure 1, at 0,4 L_{WL} from of its aft end	Fig 1, Table 7
$GZ_{MAX<60}$	m	Maximum righting moment lever for light and stable sailing craft with all stability increasing devices active	Table 11
L_H	m	Length of the hull	1
L_{WL}	m	Length of waterline at rest, see Figure 2.	Tables 3, 7, 8, 11, etc.
T_C	m	Max depth of canoe body, see Figure 2.	Tables 12 & 13
Z_C	m	Local height of chine above W_L [see Figure 6 d)]	Fig 6 d, Table 12
Z_Q	m	Local height of a point Q, centre of a panel or stiffener above W_L	Fig 6, Tables 12 & 13
Z_{SDA}	m	Local height of actual side/deck limit above W_L, see Figure 2	Fig 6, Tables 12 & 13
Z_{SDT}	m	Local height of theoretical side/deck limit above W_L, see Figure 2	Fig 6, Tables 3, 12 & 13
Areas, displacement, angles, speed, accelerations			
V	knots	Maximum speed at m_{LDC} condition, used for motor craft with $V \geq 5\sqrt{L_{WL}}$ and for calculation of k_L for sailing craft with $k_{SLS}>1$	3.6 to 3.8 & Tables 7 & 8
m_{LDC}	kg	Mass in maximum load condition	3.2, Tables 7, 12 &13
$\beta_{0,4}$	degree	Deadrise angle at 0,4 L_{WL} from its aft end, taken as $10<\beta_{0,4}\leq 30$	Figure 1, 6.1, Table 7
Panel dimensions			
A_D	m^2	Design area under consideration (panel or stiffener)	Table 9
b	mm	Short unsupported dimension of a panel	Table 5, Figures 3 to 5
l	mm	Long unsupported dimension of a panel	Table 5, Figures 3 to 5
c_b	mm	Transverse camber of a curved panel	A.8.2.2 & Figure A.7
c_l	mm	Longitudinal camber of a curved panel	A.8.2.2 & Figure A.7
Stiffener dimensions			
s	mm	Small dimension (spacing) of a stiffener between axis	Table 5, Figures 3 & 4
l_u	mm	Large dimension (span) of a stiffener between axis	Table 5, Figures 3 & 4
c_l	mm	Camber of a curved stiffener	A.12.4 & Figure A.7
x	m	Distance of mid panel or stiffener from aft end of L_{WL}	Table 4 & Figure 2
b_b	mm	Base width of top hat stiffeners or equivalent	Figures 3 c), 4 & A.13
Stiffener characteristics			
b_e	mm	Effective breadth of attached plating connected to a stiffener	A.12.5 & Figure A.13
A_w	cm^2	Area of the shear web of a stiffener	Table A.9, H.4 & G.4
EI_{NA}	$N.mm^2$	Product of second moment by E modulus at neutral Axis	3.4, Table A.9, H.4
Q	N.mm	First moment of a stiffener	Table A.9, H.4
q	N/mm	Shear flow in the web of a stiffener	Table A.9, H.2.7 & H.4

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Table 1 *(continued)*

Symbol	Unit	Designation/meaning of symbol	Ref/sub clause
SM	cm^3	Section modulus of a stiffener	3.5, Table A.9, Annex G & H.4
Bulkheads, sandwich			
D_b	m	Depth of bulkhead	Table A.13
t_b	mm	Thickness of single skin plywood bulkhead	Table A.7, Annex E, H.4
t_c	mm	Thickness of the core of a sandwich	Table A.7, Annex E, H.4
t_i, t_o	mm	Thickness of inner skin and outer skin of a sandwich	Table A.7, Annex E, H.4
t_s	mm	Thickness of symmetrical skins of a sandwich	Table A.7, Annex E, H.4
Factors and ratios			
A_{RE}	1	Effective aspect ratio of a panel	Table A.2
A_{RG}	1	Geometric aspect ratio of a panel	Table A.2
k_{AM}	1	Assessment method factor	Tables 16 & 17
k_{AR}	1	Area pressure reduction factor	Table 9
k_{AS}	1	Actual/design shear force factor in a stiffener	Table A.12
k_{BB}	1	Boat building factor	Tables 15 & 17
k_{BM}	1	Bending moment factor for stiffener	Table A.8
k_C	1	Curvature correction factor for plating	A.8.2.2 & Table A.3
k_{CH}	1	Chine angle correction factor	A.5.4 & Figure A.2
k_{CS}	1	Curvature correction factor for stiffeners	Table A.10
k_{DC}	1	Design category factor	Table 6
k_{DYN}	1	Dynamic load factor (k_{DYN}; k_{DYN1}; k_{DYN2})	Table 7
k_G	1	"GREEN" factor for laminates see Note b in Table C.6	Tables C.6, C.9 & C.10
k_L	1	Longitudinal pressure distribution factor	Table 8 & Figure 7
k_R	1	Structural component and craft type factor	Table 9
k_{SF}	1	Stiffener shear force correction factor	Table A.8
k_{SH}	1	Panel aspect ratio factor for shear force (k_{SHb}, k_{SHl})	Table A.2
k_{SLS}	1	Slamming pressure factor for light and stable sailing craft	Table 11
k_{SM}	1	Actual/design bending moment factor in a stiffener	Table A.12.3
k_{SUP}	1	Superstructure pressure reduction factor	Table 10
k_2	1	Panel aspect ratio factor for bending moment (k_{2b}, k_{2l})	Tables A.2 & A.4
k_5 to k_{10}	1	Single skin minimum thickness or fibre factor	Table I.1
Pressures			
P_{BMD}	kN/m^2	Motor craft bottom pressure in displacement mode	Table 12
$P_{BMD\ BASE}$	kN/m^2	Motor craft base bottom pressure in displacement mode	Table 12
$P_{BM\ MIN\ PLT}$	kN/m^2	Motor craft bottom min plating pressure (displacement/planing)	Table 12
$P_{BM\ MIN\ STF}$	kN/m^2	Motor craft bottom min stiffener pressure (displ./planing)	Table 12
P_{BMP}	kN/m^2	Motor craft bottom pressure in planing mode	Table 12
$P_{BMP\ BASE}$	kN/m^2	Motor craft base bottom pressure in planing mode	Table 12
P_{DM}	kN/m^2	Motor craft deck and cockpit bottom pressure	Table 12
$P_{DM\ BASE}$	kN/m^2	Motor craft deck base pressure	Table 12

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Table 1 *(continued)*

Symbol	Unit	Designation/meaning of symbol	Ref/sub clause
P_{SMD}	kN/m^2	Motor craft side pressure in displacement mode	Table 12
P_{SMP}	kN/m^2	Motor craft side pressure in planing mode	Table 12
$P_{SMD\ MIN\ PLT}$	kN/m^2	Minimal motor craft side plating pressure (displ./planing)	Table 12
$P_{SUP\ M}$	kN/m^2	Motor craft superstructure pressure	Table 12
P_{BS}	kN/m^2	Sailing craft bottom pressure	Table 13
$P_{BS\ BASE}$	kN/m^2	Sailing craft bottom base pressure	Table 13
$P_{BS\ MIN\ PLT}$	kN/m^2	Sailing craft bottom minimal plating pressure	Table 13
$P_{BS\ MIN\ STF}$	kN/m^2	Sailing craft bottom minimal stiffener pressure	Table 13
P_{SS}	kN/m^2	Sailing craft side pressure	Table 13
$P_{SS\ MIN\ PLT}$	kN/m^2	Sailing craft side minimal plating pressure	Table 13
$P_{SS\ MIN\ STF}$	kN/m^2	Sailing craft side minimal stiffener pressure	Table 13
P_{DS}	kN/m^2	Sailing craft deck and cockpit bottom pressure	Table 13
$P_{DS\ BASE}$	kN/m^2	Sailing craft deck base pressure	Table 13
$P_{SUP\ S}$	kN/m^2	Sailing craft superstructure pressure	Table 13
P_{WB}	kN/m^2	Design pressure, watertight boundaries	Table 14
P_{TB}	kN/m^2	Design pressure, integral tank boundaries	Table 14
Stresses and other data			
σ_d, τ_d	N/mm^2	Design (direct or shear) stress for plate/stiffener	Table 17
σ_u, τ_u	N/mm^2	Ultimate (direct or shear) stress for plate/stiffener	Table 17
σ_{dco}, τ_{dco}	N/mm^2	Design (direct or shear) stress for sandwich core	Table 17
σ_{uco}, τ_{uco}	N/mm^2	Ultimate (direct or shear) stress for sandwich core	Table 17
E, G	kN/m^2	Elasticity or shear modulus for plate/stiffener	Table 17
E_{co}, G_{co}	kN/m^2	Elasticity or shear modulus for sandwich core	Table 17
w	kg/m^2	Dry fibre reinforcement mass per square metre	11.1 & Annexes A, C, H & I
F_d	N, N/mm	Design shear force (in plating, sandwich, stiffener)	Tables A.4 & A.8
M_d	Nm, Nmm/mm	Design bending moment (in plating, sandwich, stiffener)	Tables A.4 & A.8
The symbols are shown by group type and in alphabetical order. Unless otherwise specified, all dimensions, measured in m_{LDC} condition, are according to ISO 8666.			

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5 General

5.1 Materials

The materials considered in this document are the main modern building materials listed in Clause 1 and Table 17. This document may be used with other materials, including new fibres and resins, provided that they show similar cohesion, durability, resistance to marine environment and elongation at break as the ones quoted in Table 17.

5.2 Overall procedure for scantlings determination

Table 2 describes the overall procedure of this document for scantlings determination, by steps.

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