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Mala plovila - Konstrukcija trupa in zahtevane lastnosti - 10. del: Obremenitve in pritrditve ladijske opreme na jadrnici (ISO/DIS 12215-10:2018)

Small craft - Hull construction and scantlings - Part 10: Rig loads and rig attachment in sailing craft (ISO/DIS 12215-10:2018)

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Kleine Wasserfahrzeuge - Rumpfbauweise und Dimensionierung - Teil 10: Takelagelasten und Takelagezubehör von Segelbooten (ISO/DIS 12215-10:2018)

Petit navires - Contruction de la coque et échantillonnage - Partie 10: Charges dans le gréement et points d'attache du gréement dans les bateaux à voiles (ISO/DIS 12215-10:2018)

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ICS:

47.020.10	Ladijski trupi in njihovi konstrukcijski elementi	Hulls and their structure elements
47.080	Čolni	Small craft

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DRAFT INTERNATIONAL STANDARD
ISO/DIS 12215-10

ISO/TC **188**   Secretariat: **SIS**

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Small craft — Hull construction and scantlings —

Part 10:
Rig loads and rig attachment in sailing craft

Petit navires — Contruction de la coque et échantillonnage —

Partie 10: Charges dans le gréement et points d'attache du gréement dans les bateaux à voiles

ICS: 47.080

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Foreword

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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).

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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*, together with CEN/BT/WG 69, *Small craft*.

This document is the 10th part of ISO 12215. A list of all parts in the ISO 12215- series can be found on the ISO website.

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Introduction

The reason underlying the preparation of ISO 12215- series is that scantlings rules and recommended practices for small craft differ considerably, thus limiting the general worldwide acceptability of craft.

This document determines the loads and design stresses on rig of sailing small craft and on the elements transmitting these loads to the rest of the structure (chainplates, mast step, etc.). It also gives, in Annexes, "established practice" methods for determination of mast step or chainplates, but other engineering methods may be used provided the design loads and design stresses are respected. This document has been set towards the minimal requirements of the current practice.

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 equipped and operated at a speed appropriate to the prevailing sea state.

This document is not a design standard and designers/builders are strongly cautioned from attempting to design craft such that nearly all structural components only just comply.

This document only considers the loads exerted when sailing. Any loads that may result from other situations are not considered in this document. The connection between the rig attachment and the structure is required to be stronger than the rig attachment itself. It is therefore considered that unforeseen overload will not entail its detachment from the structure, and that the watertight integrity will be maintained.

Like the other parts of ISO 12215, this document was developed to assess the structure of recreational craft up to 24 m L_H, but it may also be used for sailing craft of greater length and up to 24 m Load line length (See Note in the scope).

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Small craft — Hull construction and scantlings —

Part 10:
Rig loads and rig attachment in sailing craft

1 Scope

This part of ISO 12215 applies to the determination of:

— the loads in rig elements, and

— the load and scantlings of rig attachments and mast step,

on monohull and multihull sailing craft.

This document is not planned to be applicable to racing craft designed only for professional racing.

The scope of ISO 12215 was initially developed for craft below 24 m hull length L_H, but it may be applied for craft up to 24 m load line length (see Note) and beyond, with the necessary critical mind.

Scantlings derived from this International Standard are primarily intended to apply to recreational craft, including charter vessels.

Throughout this document, and unless otherwise specified, dimensions are in (m), Areas in (m^2), masses in kg, forces in (N), moments in (Nm), stresses and elastic modulus in (1N / mm^2 = 1 Mpa). Unless otherwise stated, the craft shall be assessed in m_{LDC} condition.

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

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, *Small craft — Principal data*

ISO 12215-5:2018, *Small craft — Hull construction and scantlings Part 5: Design pressures for monohulls, design stress, scantlings determination*

ISISO 12215- 6 *Small craft Hull construction-Scantlings —Part 6: Structural arrangements and details*

ISO 12215-7, *Small craft Hull construction-Scantlings —Part 7:Multihulls*

ISO 12215-8, *Small craft — Hull construction and scantlings — Part 8: Rudders*

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

3 Terms and definitions

For the purposes of this part of ISO 12215, the following terms and definitions apply.

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

Note 1 to entry: The characteristics for the different design categories are in line with the European Recreational Craft Directive 2013/53/EU.

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 12217

3.3
sailing craft
craft for which the primary means of propulsion is wind power, as defined in ISO 12217

Note 1 to entry: In ISO 12215, non-sailing craft are considered as motor craft.

3.4
monohull
craft with only one hull

3.5
multihull
craft with two or more hulls with a connecting wet deck/platform or beams above the loaded waterline, as opposed to a tunnel boat or scow

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3.6
mast step
element fitted at the bottom of the mast that supports the mast compression and transmits it to the rest of the structure

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3.7
pillar
compression post
in a deck stepped rig, element that transmits the mast compression to the rest of the structure

3.8
chainplate
rig attachment
component(s) to which the rig elements are attached and that transmit their load to the rest of the structure, this includes tie rods, where relevant

EXAMPLE Metal chainplate (see Annex D).

3.9
connection of mast step, pillar or chainplate to the structure
all elements or group of elements connecting the rig attachment to the structure of the craft. Some of these elements may be part of the chainplate

EXAMPLE Bolts, lamination.

4 Symbols

Unless specifically otherwise defined, the symbols, factors and parameters shown in Table 1 are the ones used in the main core or this document.

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Table 1 — Symbols, factors, parameters

Symbol	Unit	MAIN CORE - Designation/Meaning of symbol	Reference
1 - Main dimensions of the craft			
B_{CB}	m	Beam between centres of buoyancy: between centre of buoyancy of hulls, for catamarans and between C_B of centre hull and CB of float, for trimarans	Table 5
B_{CP}	m	Beam between chainplates (from port to starboard)	Table C.1
L_{WL}	m	Length of waterline in m_{LDC} conditions	7.5
m_{LDC}	kg	Mass of displacement in fully loaded condition according to ISO 8666	3.2 ,Clause 7
2 - Main dimensions of the rig and connected data			
A_i	m^2	Sail area, index i defining the sail name or combination	Table 5, etc.
F_i	N	Force, the index I defining which force it corresponds	7.5
$H_{M\,i}$	Nm	Heeling moment with index $_{UP}$, $_D$, etc	Table 5
$V_{A\,i}$	knots	Design apparent wind speed	Table 5, etc.
$R_{M\,i}$	Nm	Righting moment with index i=$_{UP}$, $_D$, etc	Table 5
See Table 8 for detailed dimension of rig , areas, etc			
3 - Factors			
k_{DC}	1	Design category factor	Table 3
k_{DYN}	1	Dynamic load factor	Table 10
k_{HFS}	1	Foresail centre of pressure height factor	Table 8
k_{HMS}	1	Mainsail centre of pressure height factor	Table 8
k_{LC}	1	Load case factor	Tables 3& 7
k_{MAT}	1	Material factor	Table 2
k_{ROACH}	1	Roach factor	Table 8
k_{θ}	1	Factor assessing heel angle of multihulls	Table 5
S_C	1	N° of sail configuration	Table 6
S_{Fi}	1	Safety factor against *i* , the index i being y (yield) or u (ultimate)	Table 6
s_i ,σ_i	N/mm^2	Stress, where i may be LIM, u, uw, yw,uc, ut, uf	5
V_{Ai}	knots	Design apparent wind speed	Table 5, etc.
θ_i	degree	Heel angle in sail configuration i	Table 5

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5 Purpose and application of the document

5.1 Purpose of the document

This standard defines the design loads and design stresses on rig elements of a sailing craft and allows to check the mast step and chainplates and their connection to the craft's structure:

1) by a simplified method or

2) by a developed method.

The developed method also allows the knowledge of the rig loads which are needed to assess the global loads in the structure of multihulls in ISO 12215-7.

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5.2 The simplified method

This method requires:

— the use of "Established practice" methods of Annex C for the calculation of the mast step/mast pillar and its connection;

— the use of "Established practice" methods of Annex D for chainplates (metal or FRP) and its connection.

In that case Annexes C and D are normative.

The use of the simplified method for chainplate avoids the calculation of rig loads to be made by the boat builder, but Clause 14 requires Mast/rig manufacturer to provide the design load of each rig element, dimensions of end fittings, etc. See Clause 14 for details.

5.3 The developed method

This method requires the full determination of the rig loads or mast compression. The assessment of the mast step/chainplates and their connection to the craft can then be checked either by the "established practice" methods of normative Annexes C & D or by any relevant engineering method, including finite elements method (FEM).

NOTE The actual dimensioning of mast and rig being a complex mast bending & buckling problem, where the tuning of rig elongation is paramount, it is voluntarily left out of the scope of this document, even if the values of the loads defined are useful information for this purpose.

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Table 2 sums up the steps to follow for either methods.

Table 2 — Choice of the assessment process

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Step	Applicable methods	Clause & Table
	1) SIMPLIFIED METHOD for Mast step or Chainplate Based on simple mast compression assessment or rig diameter/strength	
1.1	Design stress	Clause 6 &Table 3
1.2	For mast step and connection: use the "established" method of Annex C	Annex C
1.3	For chainplate and connection: use the "established" method of Annex D	Annex D
1.4	Checking compliance & fill the application declaration	Clause 12& Annexe A
1.5	Information in the owner's manual	Clause 13
1.6	Information to the boatbuilder	Clause 14
	2) DEVELOPED METHOD for Rig load, Mast step or Chainplate Computation of all the loads in the rig	
2.1	Design stress	Clause 6 &Table 3
2.2	Developed method : General assessments	Clause 7 &:
	HM_D Design moment upwind: heeling or righting	7.2 & Table 5
	F_{DOWN} & HM_{DOWN} Downwind Force and Heeling moment	Table 6
	Sail configuration, design heeling/righting moment & apparent wind speed	Table 7
	Rig dimensions and default values	Table 8
	Transverse forces in the mainsail and foresails	Table 9

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Table 2 *(continued)*

Step	Applicable methods	Clause & Table
2.3	Forces in rigging elements	Clause 8 &:
	Forces in forestay, inner forestay, mainsail leech and halyards	8.2 & Table 10
	Forces in backstay or running backstay or equivalent	8.3 & Table 10
	Loads on other rig elements	8.4
2.4	Structural components to be assessed	Clause 9
2.5	Rig attachment calculation	Clause 10 &:
	Mast step and its connection: use the "established" method of Annex C or another calculation method according to Clause 10	10.1 and/or Anne C
	For chainplate and connection: use the "established" method of Annex D or another calculation method according to Clause 10	10.2 and/or Annex D
	Design details of chainplates and their attachment	10.3
2.6	Calculation methods	Clause 11
2.7	Compliance to this document and application declaration	Clause 12 &: Annex A
2.8	Information in the owner's manual	Clause 13
2.9	Information to the boatbuilder	Clause 14

6 Design stresses

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6.1 General

The design stresses defined in Table 3 are the same as the ones used in ISO 12215-9, except that the dynamic factor k_{DYN} increases the loads for craft that are light and therefore have a "dynamic behaviour", see Table 10.

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This document differentiates two types of load cases: "Normal" and "Exceptional", see 7.1, which means two different design stresses.

The stresses are obtained by multiplying, where relevant (see Tables 2 & 3), the actual stress σ_{act}, τ_{act}, etc. by k_{DYN} , and they shall not be greater than the design stresses σ_d, τ_d, etc.

The values of st_{LIM} (i.e. σ_y ,σ_u ,τ_u for non-welded metals σ_{yw} ,σ_{uw} ,τ_{yw} ,τ_{uw} for welded metals in heat affected zones or σ_{tu} ,σ_{cu} , σ_{fu} , σ_{bu} or τ_u for wood and FRP) shall be taken:

— for rig element according to Annex D or written data provided by the rig manufacturer/provider;

— for other metals than the ones used in rig, according to Annex B for the listed metals, or documented values for other metals, from a recognized standard, or from tests made according to a recognized standard;

— for FRP or wood /plywood respectively according to Annex C or F of ISO 12215-5:2018.

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Table 3 — Design stress and adjustment factors

1 - Design stress					
st_d	$st_d = st_{LIM} \times k_{MAT} \times k_{LC} \times k_{DC}$ where *st* stands either for *σ* in direct stress or *τ* for shear stress, and where the adjustments factors are defined below				
2 - Adjustment factors					
Factor	**Material / designation**	**Value**			
st_{LIM}	Metals, unwelded or well clear of heat affected zones[a]	$\min\left(st_y ; 0{,}5 \times st_u\right)$ [b,c]			
	Metals, within heat affected zones, in welded condition[a]	$\min\left(st_{yw} ; 0{,}5 \times st_{uw}\right)$ [b,c]			
	Wood or FRP as dictated by sense of applied stress	$\left(\sigma_{uc}, \sigma_{ut}, \sigma_{uf}, \sigma_{ub}, \text{and } \tau_u\right)$ [c] as relevant			
3 - Stress factor for material k_{MAT}					
k_{MAT}	Metals with elongation at break $\varepsilon_R \geq 7$ %	0,75			
	Metals with elongation at break $\varepsilon_R < 7$ %	min.(0,0625ε_R + 0,3125;0,75)[d]			
	Wood and FRP	0,33			
4 - Values of load case factor k_{LC}, [e,f]					
k_{LC}		Mast/step/ connection		Rig/chainplate/connection	
		Normal	Exceptional	Normal	Exceptional
	Mast/pillar/rig Metal	(1,11)	(1,33)	(1,11)	(1,33)
	// Pure fibre	(0,86)	(1,03)	(0,86)	(1,03)
	// FRP or wood	(1,01)	(1,21)	(1,01)	(1,21)
	Step of (Mast/pillar), chainplate Metal	0,93	1,11	0,93	1,11
	// FRP	0,86	1,03	0,86	1,03
	// Strapped FRP chainplates			0,60	0,72
	Connection of above to structure Metal	0,77	0,93	0,77	0,93
	// FRP/wood (bolts, screws, etc)	0,70	0,84	0,70	0,84
	// FRP/secondary bond (wrapped chainplate)			0,20	0,24
Remark The values of k_{LC} for loads on mast/pillar/rig are given under brackets as this documents mainly deals with their attachment (chainplates) and their connection to the structure.					

a Generally the heat affected zone is considered 50 mm from welds.

b For metals $\tau = 0{,}58 \times \sigma$ often rounded to 0,6 as in EN 1993.

c Bearing stress depends on material type (Reference [10] in bibliography gives $\sigma_{ub} / \sigma_{uc}$ = 2,8 for Glass CSM and 0,91 for roving) Reference [8] gives 2,5 for steel. Row 4 of Table D.5 gives recommended values.

d The equation gives 0,75 for εR ≥ 7 % (e.g. lamellar cast iron) and 0,375 for εR ≥ 7 % and linear interpolation between.

e The load case for rig itself is normally not considered in this part of ISO 12215, but necessary for the global load of sailing multihulls in ISO 12215-7, and the values of kLC are given for comparison purposes.

f The values of k_{LC} correspond either to "normal" or "exceptional" cases in Table 7, the value for "exceptional" loads are 120 % the ones of "normal "loads. The values of k_{LC} for mast step/pillar or chainmplates are 120 % the ones for mast/rig, and the values of connection of mast step/chainplate to the structure is again 120 % of the mast step/chainplate i.e.144 % of mast/rig loads.

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Table 3 *(continued)*

5 - Design category factor k_{DC}		
k_{DC}	Craft of Design categories A and B	1,00
	Craft of Design categories C and D	1,25

a Generally the heat affected zone is considered 50 mm from welds.

b For metals $\tau = 0{,}58 \times \sigma$ often rounded to 0,6 as in EN 1993.

c Bearing stress depends on material type (Reference [10] in bibliography gives $\sigma_{ub} / \sigma_{uc}$ = 2,8 for Glass CSM and 0,91 for roving) Reference [8] gives 2,5 for steel. Row 4 of Table D.5 gives recommended values.

d The equation gives 0,75 for εR ≥ 7 % (e.g. lamellar cast iron) and 0,375 for εR ≥ 7 % and linear interpolation between.

e The load case for rig itself is normally not considered in this part of ISO 12215, but necessary for the global load of sailing multihulls in ISO 12215-7, and the values of kLC are given for comparison purposes.

f The values of k_{LC} correspond either to "normal" or "exceptional" cases in Table 7, the value for "exceptional" loads are 120 % the ones of "normal "loads. The values of k_{LC} for mast step/pillar or chainmplates are 120 % the ones for mast/rig, and the values of connection of mast step/chainplate to the structure is again 120 % of the mast step/chainplate i.e.144 % of mast/rig loads.

NOTE The lowering of k_{LC} (or increase of safety factor S_F) from rig load to mast step/chainplate, then their connection to structure ensures that the mast step/chainplate connection will be stronger that the mast compression/rig tension (i.e. the chainplate shall break after the rig), taking due consideration to the uncertainties of calculation of the connection effective stresses.

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6.2 Design load vs Safety factor

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The applicable limit stresses in the first row of Table 3 are multiplied by several factors like k_{DC}, design category factor, k_{MAT} material factor and k_{LC} load case factor. As many users or regulation speak of Safety factors, (S_F), and for comparison purposes Table 4 transforms the requirements of Tables 2 and 3 in terms of Safety factors or equivalent: it either give (highlighted grey) the value Ru element/Ru rig, or (not highlighted) Ru element /F rig, with special consideration whether $\sigma_y > 0{,}5\,\sigma_u$ or $\sigma_y \leq 0{,}5\,\sigma_u$.

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Table 4 — Values of the various safety factors computed from Table 3

Calculations made with k_{DC} = 1, modify k_{DC} = 1,25 for Cats C&D

CAUTION — F_{rig} other that mast in first column = Static load x k_{DYN}

Metallic structure (Aluminium or steel) are considered having $\sigma_y \leq 0{,}5\,\sigma_u$, whereas Metal rig is considered having $\sigma_y > 0{,}5\,\sigma_u$

"Norm" means "Normal load case and "Excp" means "exceptional" load case of k_{LC} in Table 3

					Metal				FRP		Metal rig where $s_y > 0{,}5\,s_u$				Ru Structure	
Load case description	k_{MAT}	k_{DC}	k_{LC}		SFy Metal $\sigma_y \leq 0{,}5\,\sigma_u$ $R_{y\ element} / F_{rig}$ $1/(k_{MAT}*k_{DC}*k_{LC})$		SFu Metal $\sigma_y > 0{,}5\,\sigma_u$ $R_{u\ element} / F_{rig}$ $/(k_{MAT}*k_{DC}*k_{LC})$		SF_U FRP $R_{u\ element} / F_{rig}$ $1/(k_{MAT}*k_{DC}*k_{LC})$		Ry structure/ Ru metal rig Metal structure		Ru structure/ Ru metal rig FRP structure		/Ru Fibre rig FRP structure	
			Norm	Excp	Norm	Excp	Norm	Excp	Norm	Excp	Norm	Excp	Norm	Excp	Norm	Excp
Rig/mast load																
Metal	0,75	1,00	1,11	1,33	1,20	1,00	2,40	2,00	/	/	1,00	0,83	/	/	/	/
Pure Fibre Rig	0,33	1,00	0,86	1,03	/	/	/	/	3,52	2,94	/	/	/	/	1,00	1,00
FRP Mast	0,33	1,00	1,01	1,21	/	/	/	/	3,00	2,50	/	/	1,25		0,85	0,85
Mast step or chain-plate					$\sigma_y \leq 0{,}5\,\sigma_u$		$\sigma_y > 0{,}5\,\sigma_u$				$\sigma_y \leq 0{,}5\,\sigma_u$					
Metal	0,75	1,00	0,93	1,11	1,44	1,20	2,88	2,40	/	/	1,20	1,00	/	/	/	/

[a] According to recommended "established practice",see D.5.