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Foreword

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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 World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 8, *Ships and marine technology*, Subcommittee SC 4, *Outfitting and deck machinery*.

Ships and marine technology — Marine cranes — Structural requirements

1 Scope

This document specifies the structural requirements for marine cranes of metal construction.

This document is applicable to the following types of marine cranes:

— deck cranes mounted on ships for handling cargo or containers in harbour or sheltered water conditions;

— floating cranes or grab cranes mounted on ships, barges or pontoons for operating in harbour conditions;

— engine room cranes and provision cranes, etc. mounted on ships (including floating docks) for handling equipment and stores in harbour conditions.

NOTE Marine cranes in other types can refer to this document.

This document is not applicable to the following:

— minimum ambient operating temperatures below −20 °C;

— maximum ambient operating temperatures above +45 °C;

— loads from accidents or collisions;

— lifting operations below sea level;

— transport, assembly, dismantling and decommissioning of cranes;

— lifting accessories, i.e. any item between the crane and the load;

— lifting operations involving more than one crane;

— hand powered cranes;

— emergency rescue operations;

— shore-side cargo handling cranes;

— portable cranes on board;

— lifting appliances for lifeboats, liferafts accommodation ladders and pilot ladders;

— launching appliances for survival craft and rescue boats;

— gangways, accommodation and pilot ladders and their handling appliances.

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 898-1, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs with specified property classes — Coarse thread and fine pitch thread*

ISO 5817, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections*

ISO 6157-1, *Fasteners — Surface discontinuities — Part 1: Bolts, screws and studs for general requirements*

ISO 8566-1, *Cranes — Cabins and control stations — Part 1: General*

ISO 8566-4, *Cranes — Cabins — Part 4: Jib cranes*

ISO 19354, *Ships and marine technology — Marine cranes — General requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3828, ISO 4306-1, ISO 8431 and ISO 19354 apply.

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

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

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

4 General requirements

4.1 General

4.1.1 The general requirements of the crane structure shall conform to ISO 19354.

4.1.2 Materials, structural types and construction means shall be selected properly in the design of the crane to meet the strength (including fatigue strength), stability, stiffness and safety requirements of the structural elements during transportation, installation and use, as well as the requirements of protection against fire and corrosion.

4.1.3 The composition and arrangement of the crane shall comply with the regulations of applicable organizations, such as classification societies, and satisfy the operational requirements of the marine crane to ensure the safety and reliability.

4.1.4 Types of steel and connecting materials shall be noted in the design document; for vital stressed elements, mechanical properties, chemical composition and other additional guarantee items required for steel products shall also be noted. Weld forms and quality grades required shall also be noted.

4.2 Materials

4.2.1 The materials shall be applicable to the use and manufacture of the marine crane. The selection of steel shall take into account such factors as the importance of construction, load characteristics, stress conditions, connection modes, ambient temperatures for the operation of the crane and steel thickness. The use of hull steel plates, forgings, and castings as elements shall comply with the applicable requirements, such as the requirements of classification societies.

4.2.2 The materials shall be manufactured by the approved manufacturer (e.g. approved by classification societies) with the required material quality certificate. The materials of the main structural elements shall be of batch member designations. Various tests on materials, such as the performance test, low-temperature impact test, test on the thickness direction of steel plates, ultrasonic inspection and surface quality inspection shall also comply with the applicable requirements; the test report and certificates shall conform to the regulation.

4.3 Welding

4.3.1 The welding process used in the crane shall conform to the regulations in ISO 5817 and be approved by applicable organizations, such as classification societies.

4.3.2 The manufacturer of the crane shall develop the specification for the welding, based on generally accepted standards.

4.3.3 The manufacturer shall assess the welding process in terms of steel types used for the first time, welding materials, welding methods, types of connection, welding positions, post-weld heat treatment processes, as well as combined conditions of various parameters, such as welding parameters, preheat or post-heat process.

4.3.4 The welding materials of the structural elements shall comply with the following requirements.

a) Types of electrodes and welding wires used for manual welding shall be adapted to the chemical composition and mechanical performance of the main body. Electrodes and welding wires shall conform to the regulations of generally accepted standards.

b) Welding wires and fluxes for automatic welding or semi-automatic welding shall be adapted to the chemical composition and mechanical performance of the main body and conform to the regulations of the standards.

c) The gas for gas shielded welding shall also conform to the applicable regulation.

4.3.5 For butt joints with the plate thickness difference more than 4 mm, the edge of the thick plate shall be beveled; the beveling width of the butt joint subjected to the dynamic load shall be not less than four times the thickness differences of the plate while the beveling width of other butt joints shall be not less than three times the thickness differences of the plate.

4.3.6 The quality level for imperfections of arc-welded steel joints shall comply with Grades B, C and D specified in ISO 5817.

4.3.7 Welding shall only be carried out by personnel who hold valid certificates of qualification issued by a recognized authority. A welder shall not carry out work for which they are not qualified.

4.3.8 Main welds shall be traceable after welding.

4.3.9 Welding inspection

4.3.9.1 The welding inspector shall have, as a minimum, a valid Welding Inspector's certificate. Personnel conducting non-destructive testing shall have a Certificate of qualification in non-destructive testing. Any non-destructive examination shall be conducted within the scope of the examiner's qualifications.

4.3.9.2 Visual inspection shall be carried out for all welds. The weld edge shall be smoothly transitioned to the base metal; the external dimensions of the weld shall comply with the requirements of the design drawing.

4.3.9.3 For the quenched and tempered steel with the yield strength bigger than or equal to 420 N/mm^2, the nondestructive examination of the weld shall generally be carried out 48 h after welding. When the postweld heat treatment is carried out for the weldment, the nondestructive examination shall be carried out after heat treatment.

4.3.9.4 The type and range of the nondestructive examination depend on the importance and loading of members. The nondestructive examination can be selected according to Table 1.

Table 1 — Range of the nondestructive examination

Structural type	Joint type	Examination method (%)			
		Visual inspection	RT	UT	MT or penetration
Special structure	Butt	100	10 ~ 20	100	100
	Cross/T, complete penetration	100		100	100
	Cross/T, fillet /deep penetration welding	100			100
Main structure	Butt	100	5 ~ 10	50 ~ 80	20 ~ 50
	Cross/T, complete penetration	100		50 ~ 80	20 ~ 50
	Cross/T, fillet /deep penetration welding	100			20 ~ 50
Secondary structure	Butt	100		2 ~ 5	2 ~ 5
	Cross/T, complete penetration	100		2 ~ 5	2 ~ 5
	Cross/T, fillet /deep penetration welding	100			2 ~ 5

4.4 High-strength bolt connection

4.4.1 The high-strength connecting bolt shall be inspected according to ISO 6157-1.

4.4.2 The contact surface of elements at the high-strength bolt connection shall be treated according to the design requirements, kept dry, clean, without any flash, burr, spatter, weld flash, scale and dirt; the contact surface shall not be coated with paint, except for design requirements.

4.4.3 The high-strength bolt shall be tightened with a torque-wrench or special tool according to the requirements of the instruction for installation of lifting appliances. The tightening sequence and initial torque of connecting assemblies shall conform to the design requirements and special regulations. The torque wrench shall be calibrated and recorded on a regular basis. The screwing record shall be made for high-strength bolts.

4.5 Cabin

4.5.1 If a cabin is provided, it shall conform to ISO 8566-1 and ISO 8566-4.

4.5.2 The cabin shall be located so that components of the crane, such as the jib or the load, cannot come into contact with it.

4.5.3 The field of vision, internal environment, safety protection, access route(s) and operational conditions of the cabin shall be compatible with the operational requirements of the marine crane to which it is fitted.

4.6 Access routes

4.6.1 If all operating positions and locations that require frequent examination and maintenance on the crane (including sheaves and movable parts on top of the jib) are more than 2 m above the bottom

footing, they shall be accessible through an inclined ladder (or stairs), platform, passage or vertical ladder. There shall be handrails or guard rails on both sides of the steps, as far as can practically be achieved. There shall be safety entrances for the passage, inclined ladder (or stairs) and platform.

4.6.2 The safety of the passage means its compliance with the regulations of the applicable international organizations, such as ILO and AWWF.

5 Structural strength check

5.1 General

The check on the strength of the crane and its structure shall comply with approved regulations of statics, dynamics and stress analysis.

5.2 Stress

5.2.1 The allowable stress of the structural members of the crane shall be calculated according to Formula (1):

$$[\sigma] = \frac{\sigma_s}{\beta n} \tag{1}$$

where

σ_s is the yield strength of the steel;

n is the safety factor, selected in Table 2.

Table 2 — Safety factor under different conditions

Condition	1	2	3	4
Safety factor, n	1,5	1,33	1,15	1,15
Condition 1: the crane is in a working condition without wind. Condition 2: the crane is in a working condition with wind. Condition 3: the crane is in a non-working condition. Condition 4: the crane withstands special loads.				

5.2.2 The effective stress, σ, of the steel shall be selected according to Table 3.

Table 3 — Effective stress, σ, of the steel

Stress state	**Tensile stress**	**Compressive stress**	**Shear stress**	**Bearing stress**
Symbol	σ_t	σ_c	τ	$1{,}0\sigma_{br}$
Failure stress	$1{,}0\sigma_s$	$1{,}0\sigma_s$	$0{,}58\sigma_s$	$1{,}0\sigma_s$

5.2.3 Where the normal stress, σ, and the shear stress, τ, on a certain position of the member are rather great, the combined stress shall be calculated, the allowable stress criterion shall comply with Formula (2):

$$\sigma_e = \sqrt{\sigma^2 + 3\tau^2} \leq [\sigma] \tag{2}$$

where

σ_e is the combined stress;

σ is the normal stress;

τ is the shear stress;

$[\sigma]$ is the allowable stress.

5.2.4 For members subjected to the combined stress, the allowable stress criterion shall comply with Formula (3):

$$\sigma_{cp} = \sqrt{{\sigma_x}^2 + {\sigma_y}^2 - \sigma_x\sigma_y + 3\tau^2} \leq 1,1[\sigma] \tag{3}$$

where

σ_{cp} is the combined stress after combination;

σ_x is the normal stress along the x-axis direction, $\sigma_x \leq [\sigma]$;

σ_y is the normal stress along the y-axis direction, $\sigma_y \leq [\sigma]$;

τ is the shear stress, $\tau \leq 0,58[\sigma]$;

$[\sigma]$ is the allowable stress.

5.3 Stability allowable stress of members subjected to pressure or bending

5.3.1 For the member only subjected to compressive stress, stability allowable stress is as given in Formula (4):

$$[\sigma_{st}] = \frac{\sigma_{cr}}{n} \tag{4}$$

where

σ_{cr} is the critical compressive stress of the member, based on generally accepted standards;

n is the safety factor, selected in Table 2.

5.3.2 For the member subjected to pressure and bending simultaneously, its stability shall be verified according to the tress criterion given in Formula (5):

$$\frac{\sigma_m}{\sigma_s} + \frac{\sigma_c}{\sigma_{cr}} \leq \frac{1}{n} \tag{5}$$

where

σ_m is the bending stress on the member;

σ_c is the compressive stress on the member;

σ_s is the yield strength of the steel;

σ_{cr} is the critical compressive stress of the member, the same as 5.3.1;

n is the safety factor, selected in Table 2.

Where the member is subjected to the bending stress along the *x*-axis and *y*-axis directions at the same time, σ_m shall be replaced by the sum of the bending stress, σ_{mx}, along the *x*-axis direction and the bending stress; σ_{my} along the *y*-axis direction in the formula.

5.4 Slenderness ratio (λ)

5.4.1 The slenderness ratio, λ, of the pressure member shall be not more than that specified in Table 4.

Table 4 — Slenderness ratio, λ, of the pressure member

Member type		Slenderness ratio (λ)
Main pressure member	**Chord of primary truss**	120
	Integrated member	150
Secondary pressure member (other members of primary trusses and chords of secondary trusses)		150

5.4.2 The slewing radius and slenderness ratio for members shall be calculated according to generally accepted standards or regulations (e.g. classification society regulations).

5.5 Overall stability check of crane jib

5.5.1 The stability check of the crane jib shall include the overall stability check of the jib, except for the local stability check of single members in the jib.

5.5.2 For the overall stability check of the crane jib, the stability in the jib plane and vertical plane shall be checked.

5.5.3 The stability of the crane jib shall be calculated according to generally accepted standards.

5.5.4 For the jib whose slenderness ratio is greater than that specified in Table 4 or the jib made of high-strength steel, special consideration shall be given to the calculation structure.

5.6 Local buckling stability of plate

It shall be calculated in accordance with the requirements of classification society or generally accepted standards or regulations (e.g. classification society regulations).

5.7 Welding

5.7.1 The allowable stress of the weld shall be taken from Table 5 according to the type of the weld. The physical properties of the welding materials shall be no lower than the base metal. The effective stress of the fillet weld shall be calculated according to the dimensions of the throat and shall conform to class societies' requirements.

Table 5 — Allowable stress of the weld

Type of weld	Allowable stress	
	Tension and compression	Shear
Penetration of butt joint ring	σ_s / n	$0,58\sigma_s / n$
Fillet	$0,7\sigma_s / n$	$0,58\sigma_s / n$
σ_S is the yield strength of the base metal. n is the safety factor, see Table 2.		

5.8 Bolt connection

5.8.1 The high-strength bolt connection shall be designed to withstand the stated static strength and fatigue strength in a pretensioned stress condition.

5.8.2 The high-strength bolt shall be of Grade 8.8, 10.9 or 12.9 specified in ISO 898-1. Special attention shall be paid to the use of the bolt of other grades.

5.8.3 The loose-fit bolt cannot be used for the linkage of vital joints or joints subjected to alternate loads.

5.8.4 When the joints are connected with fitting bolts, the allowable stress of the bolt calculated according to the external load shall not exceed the requirements specified in Table 6.

Table 6 — Allowable stress of the bolt

Load form	Allowable stress	
	Conditions 1 and 2	Conditions 3 and 4
Tension	$\sigma_s / 2,5$	$\sigma_s / 1,85$
Single shear	$\sigma_s / 2,6$	$\sigma_s / 2,0$
Double shear	$\sigma_s / 1,75$	$\sigma_s / 1,3$
Combined tension and shear $\sqrt{\sigma^2 + 3\tau^2}$	$\sigma_s / 2,1$	$\sigma_s / 1,56$
Bearing	$\sigma_s / 1,1$	$\sigma_s / 0,83$
NOTE The yield strength σ_S of the bolt material.		

5.8.5 For joints subjected to the alternate load, the connecting bolt shall be pretensioned to 70 % ~ 80 % of the yield strength.

Bibliography

[1] ISO 3828, *Shipbuilding and marine structures — Deck machinery — Vocabulary and symbols*

[2] ISO 4306-1, *Cranes — Vocabulary — Part 1: General*

[3] ISO 8431, *Shipbuilding — Fixed jib cranes — Ship-mounted type for general cargo handling*

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