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Ships and marine technology — Marine cranes — Technical requirements for rigging applications

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National foreword

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Foreword

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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 — Technical requirements for rigging applications

1 Scope

Rigging used for marine cranes is mainly wire rope rigging. This document specifies the technical requirements of the selection and application of running rigging and standing rigging used for wire rope rigging of marine cranes.

This document specifies the minimum requirements of the allowable strength and performance level for wire ropes of marine cranes according to the design, application and maintenance requirements of cranes.

This document specifies the implementation criteria of installation, maintenance, inspection and discards for running rigging and standing rigging of marine cranes.

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

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

— floating cranes or grab cranes mounted on barges or pontoons for operating in harbour conditions or sheltered water conditions;

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

This document does not apply to the following:

— loads from accidents or collisions;

— lifting operations below sea level;

— cranes which are supposed to be included in the class of the vessel and where the vessel receives a crane class notation; the contents of this document may be used however, as recommendation or guidance;

— other items where there is the danger that they might be considered in-scope are excluded from this document, such as

  — loose gear items, such as the hook block, and

  — ropes and fittings;

— cranes which are to be included in class by the class society;

— minimum ambient operating temperatures no less than −20 °C;

— maximum ambient operating temperatures above +45 °C;

— 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 4309:2010, *Cranes — Wire ropes — Care and maintenance, inspection and discard*

ISO 2408, *Steel wire ropes for general purposes — Minimum requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3828, ISO 4306-1, ISO 17893 and the following 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

3.1
stable status of wire rope
status when the elongation measurement of the wire rope stays stable during repeated loading and unloading of wire rope within two ranges of the specified force value

3.2
standing rigging
supporting and non-operating wire rope that maintains a constant distance between the points of attachment to the two components connected by the wire rope

3.3
running rigging
operating wire rope used to change the distance between the points of attachment to the two components connected by the wire rope under outside force

3.4
rigging termination
rigging end for being connected with wedge socket

4 Form of rigging

The running rigging and standing rigging chosen for marine cranes shall comply with the requirements in ISO 2408; the wire rope, running rigging and standing rigging not specified in ISO 2408 can also be chosen, but the manufacturer shall provide the customer with technical documents of rigging strength and performance level related to mechanism design, equipment operation and maintenance. Running rigging which functions as hoisting of the marine crane shall give preference to the rotation-resistant wire rope type in ISO 2408. Three strand form of rigging shall not be used.

5 Selection method for wire ropes

5.1 Safety factor for running rigging

5.1.1 For crane with the safe working load SWL ≤ 100 kN, safety factor $n = 5$.

5.1.2 For crane with the safe working load SWL > 100 kN, safety factor of wire ropes shall be calculated according to Formula (1), in which the minimum shall be not less than 3:

$$n = \frac{10^4}{0,9\text{SWL} + 1\ 910} \quad (1)$$

where

SWL is the safe working load of crane, in kN.

5.2 Safety factor for standing rigging

Standing rigging shall not be wound on a drum or sheave, but fixed at both ends. Safety factor for standing rigging shall be determined according to design and inspection rules for the crane used in operational environment. If rules correspond, the safety factor for standing rigging should be the same as the one for running rigging.

5.3 Minimum breaking strength of wire rope

The minimum breaking strength, Q, of the marine crane rigging is calculated from Formula (2), in N:

$$Q = nW \quad (2)$$

where

n is the safety factor required for running or standing rigging;

W is the static load of the single wire rope, including friction effects of the wire rope running over sheaves (as applicable), in N.

See Annex A for examples of selection of wire ropes.

5.4 Rigging technical requirement

Select the nominal breaking strength, F_0, of the wire rope and the corresponding nominal diameter (d) according to the minimum breaking strength, Q, which is calculated from Formula (2). The following factors shall be taken into account when selecting the nominal breaking strength, F_0, of the wire rope.

a) Structure of the wire rope (see the related information from ISO 2408 or the data provided by the manufacturer of wire rope).

b) Nominal tensile strength of the wire rope (see the related information from ISO 2408 or the data provided by the manufacturer of wire rope).

c) Anticorrosion coating protection requirement for the wire rope should be taken into account.

d) Sockets of rigging, together with the wire rope shall be selected and installed as a whole by rigging manufacturer.

6 Extension of rigging

6.1 General

When the rigging is subject to tension, its length will be increased because of the rope structure and material of the rigging. When selecting the wire rope rigging, the influence of the rigging length change (length changes due to two stages: construction stretch and elastic stretch) on the operation of the crane shall be considered. Other factors of rigging extension, such as temperature, free rotation of one end of the wire rope, friction, are not taken into account unless customer particularly mentions these factors.

6.2 Original extension

Original extension of the rigging is not elastic and cannot be obtained precisely through calculation, and can only be determined by pretensioning force. Necessity of pretension and pretensioning force shall be decided appropriately between the manufacturers of rigging and marine cranes.

6.3 Elastic extension

When the rigging is at stable status under the tension, wire rope realizes elastic extension generally complying with Hooke's law. Elastic extension, L_0, shall be calculated according to Formula (3), in mm:

$$L_0 = \frac{WL}{1\ 000EA} \tag{3}$$

where

W is the static load of the single wire rope, including friction effects of the wire rope running over sheaves (as applicable), in N;

L is the wire rope rigging length, in mm;

E is the ultimate elastic modulus of wire rope, in GPa;

A is the nominal metal cross section of wire rope, in mm^2.

Different form of wire rope has different elastic modulus, E, the elastic modulus, E, shall be provided according to section cross form of rigging by the rigging manufacturer.

7 Torsion of the rigging

Wire rope rigging, when loaded, will cause torsional force due to its self-rotation feature of the wire rope. The torque is related to load through "torque coefficient" due to wire rope rigging load. In the hoisting reeving system of marine crane, hook sheave produces angular displacement under the influence of torque caused by load, and the angular displacement increases with the hoisting height goes up. Running rigging of marine crane hoisting reeving system ensure that the angular displacement of rigging stay in a safe range when marine crane reaches the upper limit of hoisting height. Since there are different marine crane hoisting reeving systems, the upper limit of hoisting height of wire rope rigging and angular displacement also differ. Annex B provides an example for torsion of the rigging.

It is recommended that angular displacement should be calculated approximatively according to Formula (4):

$$S^2 = \frac{4\ 000 \times L \times k \times d}{\sin\theta} \qquad (4)$$

where

- L is the upper limit of hoisting height of hoisting wire rope rigging, in m, (see Figure 1);
- S is the distance between hoisting wire rope rigging centers, in mm (see Figure 1);
- θ is the angular displacement for the upper limit of hoisting height of wire rope rigging, in degrees (°);
- k is the torque coefficient of 20 % wire rope breaking strength, the coefficient is provided by the rigging manufacturer;
- d is the nominal diameter of wire rope, in mm.

NOTE 1 Torque value = $k \times d$.

NOTE 2 Formula (4) is based on the assumption that wire rope rigging is in a state of free torsion and with no load. The torque from reeving system will generate during or after wire rope rigging installation. It can influence calculation result reversely.

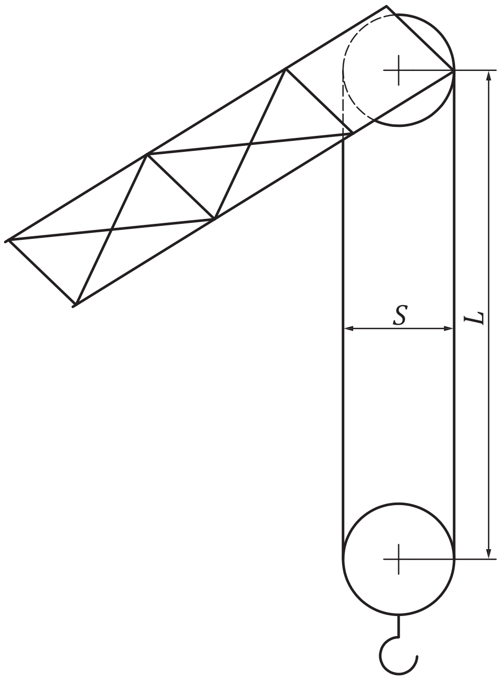


Figure 1 — Distance between rigging hoisting height and rigging center

When the angular displacement is beyond 90° (that is, sinθ = 1), instability situation is appeared and the wire rope can intertwine each other in reeving system. Judge condition for instability of reeving system is as given in Formula (5):

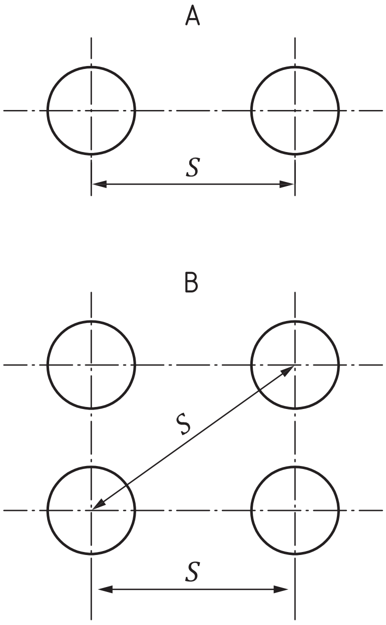
$$S > \sqrt{4\ 000 \times L \times k \times d} \qquad (5)$$

Formula (5) is for single two falls of reeving system.

For complicated reeving system, the similar calculation method can be used if different distance *S* is considered. Calculation method is as follows.

When the number of wire rope rigging in the hoisting reeving system is even number, see Figure 2.

NOTE Take two falls and four falls, for example, in Figure 2.



Key

A for 2 falls

B for 4 falls

Figure 2 — Distribution maps of even number riggings

When the number of wire rope rigging in the hoisting reeving system is odd number, see Figure 3.

NOTE Take 3 falls, for example, in Figure 3.

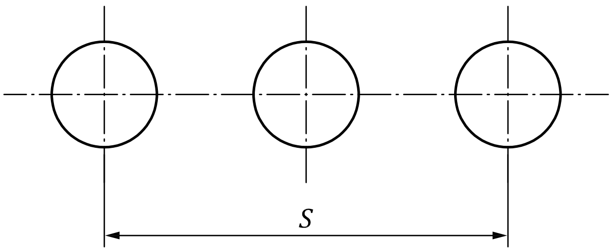


Figure 3 — Distribution maps of odd number riggings

If the distance *S* is effective and the hoisting reeving system is stable, Formula (5) can be corrected according to Formula (6):

$$S > \sqrt{6\ 000 \times L \times k \times d} \quad (6)$$

NOTE 1 Torque value = $k \times d$.

NOTE 2 The torque mentioned above is caused by load. This document does not include the residual torque caused during manufacturing, installation and some other conditions. Conduct additional analysis on complicated wire rope arrangements.

NOTE 3 The calculation data above is based on the constant torque value. It is an effective assumption that new rigging, abrasion and use of rigging will have obvious influence for torque value. Actually, torque value can be reduced gradually during practical use and it can improve the instability of reeving system. When rigging arrangement is very complicated in some reeving system, the instability of reeving system cannot be calculated precisely. Finite element analysis can be taken to calculate.

8 Rigging termination

8.1 U-bolt and clamp clips

Pay particular attention to the positioning of type U bolt clip. Joints of type U bolt shall be in contact with the dead end of wire rope. Positioning direction, distance, torque and number of all clamp clips shall meet the requirements of the crane manufacturer.

8.2 Eye splice

There are at least three fastening sections of the eye splice; the other specific requirements shall be determined by the crane manufacturer. Some requirements from rigging manufacturer can be considered.

8.3 Wedge socket

Wedge sockets shall be installed with the live-load-side of the wire rope in line with the wedge socket pin. Wire rope clips used in conjunction with wedge sockets shall be attached to the unloaded (dead) end of the rope as shown in Figure 4 (other options are provided by various vendors). Wedge socket assemblies shall withstand wire rope failure.

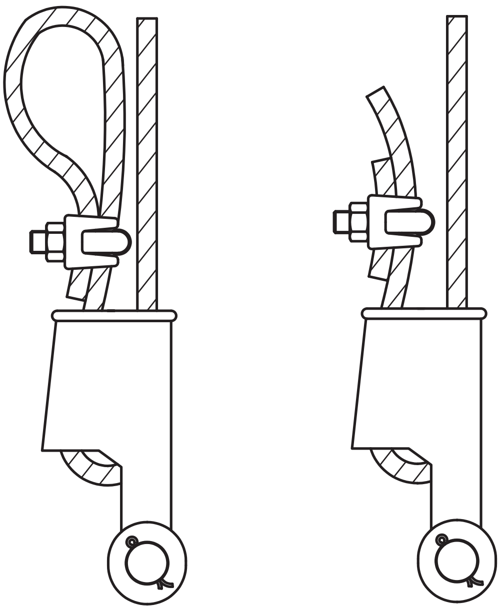


Figure 4 — Fixing method of the rigging end by using wedge socket

8.4 Connecting efficiency of rigging head

Rigging head connection chosen shall not reduce the rigging strength to 80 % of the nominal breaking strength of rigging wire rope.

8.5 Procedures of installation

Detailed installation procedures of the rigging termination shall be specified by the crane manufacturer.

9 Installation, maintenance, inspection and discard of rigging

9.1 General

Riggings of marine crane chosen according to this document cannot ensure their safe operation in the indefinite term; installation, maintenance, inspection and discard of the rigging shall be conducted according to the following requirements.

9.2 Installation of the wire rope rigging

During the installation of the wire rope rigging, torsion to the wire rope shall be avoided or reduced. Keep the rigging clean as much as possible, avoid contacting water and dust.

The rigging cutting-off shall be done under the guidance from professional manufacturer and it adopts proper method for avoiding wire rope rigging looseness. Especially for the resistant rotation wire rope rigging, cutting-off shall be safe, reliable and anti-loose. If any part of marine crane rubs against wire rope rigging during installation, effective protection method shall be adopted at the contact position.

When rigging has been installed on the marine crane, make sure to keep all devices being related to wire rope rigging running under normal condition before coming into service. After the installation of moving rigging, conduct several running cycles of the mechanism at about 20 % rated speed and about 10 % rated load and adjust rigging and its corresponding accessories to practical operation condition.

9.3 Maintenance of the rigging

Keep the rigging of marine cranes in well state of lubricating at all times and avoid appearance of its dryness and rusting.

The rigging should be lubricated sufficiently before every operation of the marine crane. For the rigging lubricant select and use, consult the rigging manufacturer and adopt the one being the same as the recommended lubricant from the rigging manufacturer. When lubricating the rigging, pay particular attention to the parts of the rigging through sheaves and the parts specified by the inspection procedures.

The maintenance of the rigging also meets the requirement from rigging manufacturer.

9.4 Inspection of rigging

9.4.1 Normal visual inspection

During every working day of the marine crane, all visible parts of the rigging shall be observed as much as possible and the common damage and deformation are found out timely. Attention shall be given to the connecting position of the marine crane. Any suspicious change of rigging shall be reported and inspection is conducted by director personnel according to ISO 4309:2010, 5.3.3. If rigging discard is necessary according to ISO 4309, there should be no any work delay.

9.4.2 Periodical inspection

The wire rope rigging shall be inspected before each operation of marine crane. The person in charge has the right to conduct several inspections during the usage of marine crane.

9.5 Discard of the rigging

The discard criterion of marine crane wire rope rigging shall refer to ISO 4309:2010, Clause 6.

Annex A
(normative)

Examples for selection of wire ropes

A.1 Example 1

For a marine crane with an SWL of 40 kN and a static load, *W*, of the single wire rope of 21 kN, the 6 × 29*F*i + IWR wire rope with nominal tensile strength of 1 770 MPa shall be selected.

According to 5.1.1, safety factor of the wire rope is $n = 5$ with SWL less than 100 kN.

The minimum breaking strength of the wire rope is calculated as given in Formula (A.1):

$$Q = n \times W = 5 \times 21 \text{ kN} = 105 \text{ kN} \quad \text{(A.1)}$$

Based on the actual operational requirement, selected structural type and nominal tensile strength of the wire rope, the Φ13 mm wire rope with the minimum breaking strength of 106 kN is selected from the samples of the wire rope as the hoisting running rigging.

A.2 Example 2

For marine crane with SWL of 360 kN and static load *W* of the single wire rope of 189,4 kN, the 6 × 36WS + IWR wire rope with the nominal tensile strength of 1 770 MPa shall be selected.

According to Formula (1), as given in Formula (A.2):

$$n = \frac{10\ 000}{0,9 \times 360 + 1\ 910} = 4,476 \quad \text{(A.2)}$$

The minimum breaking strength of the wire rope is calculated from Formula (2), as given in Formula (A.3):

$$Q = n \times W = 189,4 \text{ kN} \times 4,476 = 847,75 \text{ kN} \quad \text{(A.3)}$$

Based on the actual operational requirement, selected structural type and nominal tensile strength of the wire rope, the Φ38 mm wire rope with the minimum breaking strength of 910 kN is selected from the samples of the wire rope. When the designer intends to use the wire rope with the smaller diameter, the Φ36 mm wire rope with the nominal tensile strength of 1 960 MPa may be selected as the hoisting running rigging.

Annex B
(normative)

Example for torsion of the rigging

For marine crane with two falls of wire rope rigging of hoisting reeving system, the 7 × 34Fi + IWR wire rope with the nominal tensile strength of 1 960 MPa shall be selected.

Selected nominal diameter of wire rope rigging is $d = 20\ \text{mm}$.

Tension coefficient of wire rope rigging is $k = 0{,}018$.

The distance between hoisting wire rope rigging center which is block sheave diameter is $S = 360\ \text{mm}$.

Hoisting height of hoisting wire rope rigging is $L = 30\ \text{m}$.

If the wire rope rigging is new and without block weight and friction, the angular displace is calculated according to Formula (B.1):

$$\sin\theta = \frac{4\ 000 \times L \times k \times d}{S^2} = \frac{4\ 000 \times 30 \times 0{,}018 \times 20}{360^2} = 0{,}333 \qquad \text{(B.1)}$$

Since $\sin\theta < 1$, the hoisting reeving system is stable and the wire rope cannot intertwine each other in the reeving system.

It is assumed that the wire rope intertwining each other can appear (that is, $\sin\theta = 1$) when hoisted to certain height. The limit hoisting height, L, is calculated according to Formula (B.2):

$$L = \frac{S^2}{4\ 000 \times k \times d} = \frac{360^2}{4\ 000 \times 0{,}018 \times 20} = 90\ \text{m} \qquad \text{(B.2)}$$

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