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**Ships and marine technology —  
Deck machinery — Multifunctional  
manipulator**

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# Contents

|                                                                                                 | Page      |
|-------------------------------------------------------------------------------------------------|-----------|
| Foreword .....                                                                                  | iv        |
| <b>1 Scope .....</b>                                                                            | <b>1</b>  |
| <b>2 Normative references .....</b>                                                             | <b>1</b>  |
| <b>3 Terms and definitions .....</b>                                                            | <b>1</b>  |
| <b>4 Classification .....</b>                                                                   | <b>2</b>  |
| 4.1 Structural types .....                                                                      | 2         |
| 4.2 Product designation .....                                                                   | 3         |
| 4.3 Appearance .....                                                                            | 3         |
| 4.4 Basic parameters .....                                                                      | 3         |
| <b>5 Requirements .....</b>                                                                     | <b>4</b>  |
| 5.1 Design and structure .....                                                                  | 4         |
| 5.2 Material .....                                                                              | 8         |
| 5.3 Performance .....                                                                           | 8         |
| 5.4 Appearance quality .....                                                                    | 9         |
| <b>6 Test method .....</b>                                                                      | <b>10</b> |
| 6.1 No-load test .....                                                                          | 10        |
| 6.2 Rated load test .....                                                                       | 10        |
| 6.3 Over-load test .....                                                                        | 10        |
| 6.4 Safety protection inspection .....                                                          | 10        |
| 6.5 Power supply fluctuation .....                                                              | 11        |
| 6.6 Insulation resistance .....                                                                 | 11        |
| 6.7 Inspection of degrees of protection provided by enclosure (only for electrical cabinet) ... | 11        |
| 6.8 Appearance quality .....                                                                    | 11        |
| <b>7 Marking, packaging, shipping and storage .....</b>                                         | <b>11</b> |
| 7.1 Nameplate .....                                                                             | 11        |
| 7.2 Warning sign .....                                                                          | 12        |
| 7.3 Packaging .....                                                                             | 12        |
| 7.4 Transportation .....                                                                        | 12        |
| 7.5 Storage .....                                                                               | 12        |

## 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](http://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](http://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 of the voluntary nature of standards, 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 [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 4, *Outfitting and deck machinery*.

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](http://www.iso.org/members.html).

# Ships and marine technology — Deck machinery — Multifunctional manipulator

## 1 Scope

This document specifies the classification, requirements, test methods and inspection rules, as well as marking, packaging, shipping and storage requirements for multifunctional manipulators for deck operations (hereinafter referred to as “multifunctional manipulators”).

It is applicable to the design, manufacture and acceptance of double folding multifunctional manipulators for clamping and tidying the anchor chain and ropes in deck operations.

## 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 780, *Packaging — Distribution packaging — Graphical symbols for handling and storage of packages*

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

ISO 13849-1:2015, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

IEC 60529, *Degrees of Protection Provided By Enclosure (IP Code)*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3828 and the following 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/>

### 3.1

#### **jib**

second movable arm of the multifunctional manipulator used to lift and hook tension free ropes

### 3.2

#### **multifunctional head**

operating device of the multifunctional manipulator used to grasp, clamp and tidy the anchor chain and ropes

### 3.3

#### **multifunctional boom**

second movable arm of the multifunctional manipulator used to connect the *multifunctional head* (3.2)

### 3.4

#### **main boom**

first movable arm of multifunctional manipulator used to connect the slewing tower body and the second movable arm of the double folding boom

### 3.5 luffing

movement made by the *main boom* (3.4), *jib* (3.1) and *multifunctional boom* (3.3) of the multifunctional manipulator in changing the range in a reach direction

### 3.6 safe working load

#### SWL

maximum static load (kN) that the multifunctional manipulator can hoist or the *multifunctional head* (3.2) operates under design working conditions

### 3.7 travelling mechanism

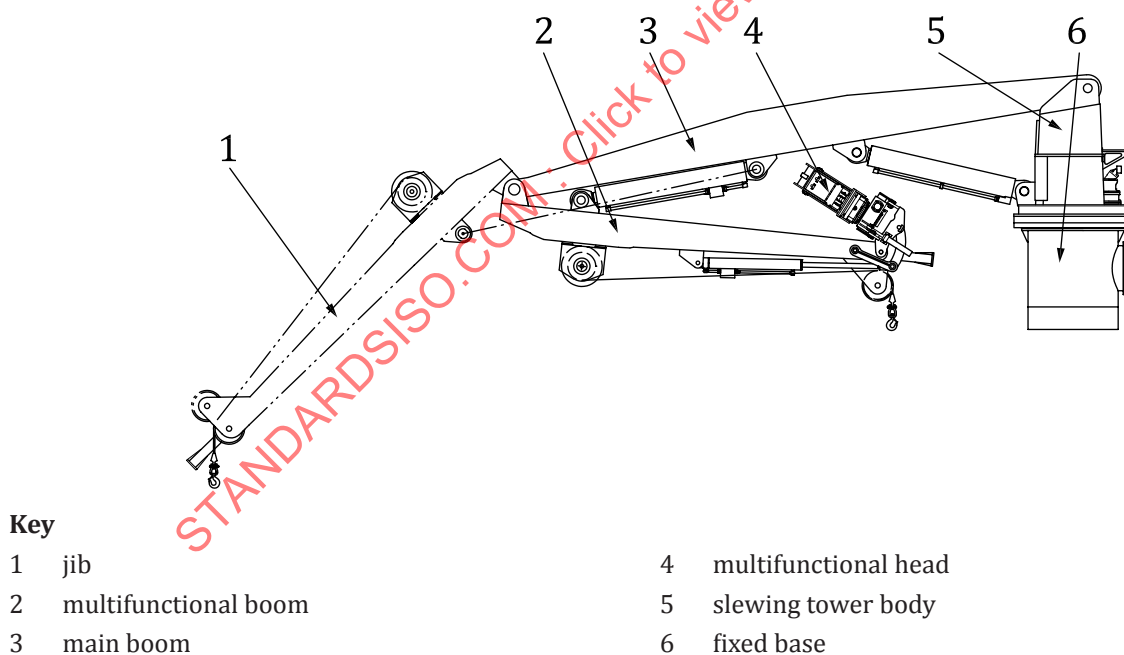
mechanism of the travelling multifunctional manipulator used to complete the movement with load along the guide rail, consisting of carrier, roller train, guide pulley set, travel driving unit, cable reel, pay-out stand, rail clamping device, speed control valve, buffer, and lubrication line

## 4 Classification

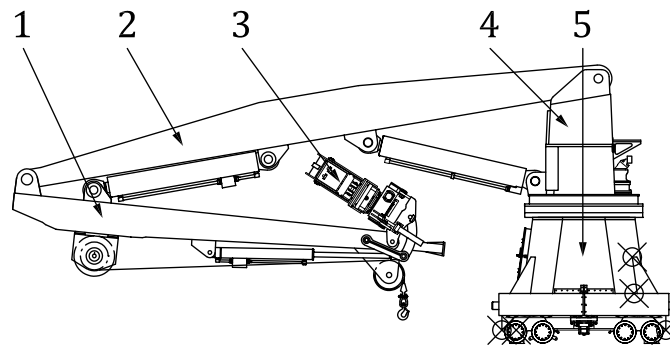
### 4.1 Structural types

**4.1.1** Multifunctional manipulators can be divided into fixed and travelling types, according to their structure (installation) form.

**4.1.2** Multifunctional manipulators can be divided into multifunctional boom only and combined multifunctional boom and jib, according to their composition. See [Figure 1](#) and [Figure 2](#).



**Figure 1 — Fixed multifunctional manipulator with combined multifunctional boom and jib**



#### Key

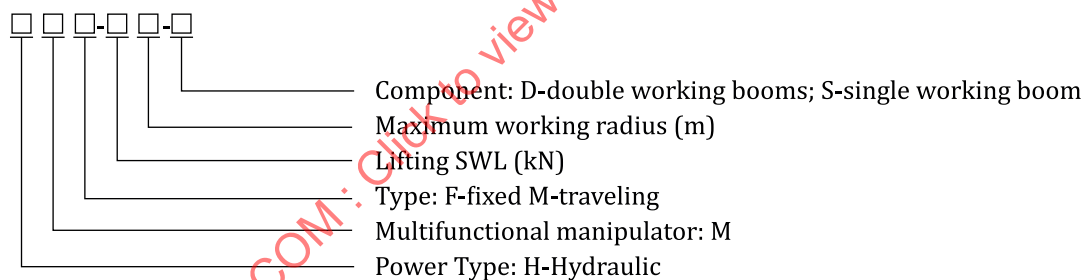
- |   |                      |   |                      |
|---|----------------------|---|----------------------|
| 1 | multifunctional boom | 4 | slewing tower body   |
| 2 | main boom            | 5 | travelling mechanism |
| 3 | multifunctional head |   |                      |

**Figure 2 — Travelling multifunctional manipulator with multifunctional boom**

## 4.2 Product designation

The multifunctional manipulator shall be designated as shown in the example in [Figure 3](#).

**EXAMPLE** Designation of a multifunctional manipulator with lifting SWL of 30 kN and maximum working radius of 12 m, hydraulic-driven, fixed type and double working booms: **Multifunctional manipulator HMF-3012-D**



**Figure 3 — Product designation example**

## 4.3 Appearance

The colour of the multifunctional manipulator surface shall be uniform, and the outer surface and the coating layer shall be free from scratching, peeling, cracks and rust. The safe working load (SWL) designation shall be clearly visible to the operator.

## 4.4 Basic parameters

The basic parameters of the multifunctional manipulator shall conform to [Table 1](#).

**Table 1 — Basic parameters of multifunctional manipulators**

| Type                                             |                                |      | HMF-2010-D | HMF-3012-D | HMR-3012-D | HMR-3014-D |
|--------------------------------------------------|--------------------------------|------|------------|------------|------------|------------|
| SWL                                              | Lifting                        | (kN) | 20         | 30         | 30         | 30         |
|                                                  | Multifunctional head operation | (kN) | 20         |            |            |            |
| NOTE $\varphi$ is the diameter of chain or rope. |                                |      |            |            |            |            |

Table 1 (continued)

| Type                                                        |       | HMF-2010-D        | HMF-3012-D | HMR-3012-D | HMR-3014-D |
|-------------------------------------------------------------|-------|-------------------|------------|------------|------------|
| Lifting speed                                               | (m/s) | 0,46              |            |            |            |
| Maximum working radius                                      | (m)   | 10,2              | 12,2       | 12,2       | 14         |
| Minimum working radius                                      | (m)   | 2,6               | 2,5        | 2,5        | 3,4        |
| Slewing angle                                               | (°)   | 360° full slewing |            |            |            |
| Main boom luffing                                           | (°)   | 0°to 60°          |            |            |            |
| Jib luffing                                                 | (°)   | 20°to 150°        |            |            |            |
| Multifunctional boom luffing                                | (°)   | 20°to 150°        |            |            |            |
| Swinging luffing of the multifunctional head along the boom | (°)   | 120°              |            |            |            |
| Self swinging of the multifunctional head                   | (°)   | ±40°              |            |            |            |
| Self slewing luffing of multifunctional head                | (°)   | 360° full slewing |            |            |            |
| Size range for multifunctional head clamping anchor chain   | (mm)  | φ50 to φ120       |            |            |            |
| Size range for multifunctional head clamping rope           | (mm)  | φ50 to φ84        |            |            |            |
| NOTE    φ is the diameter of chain or rope.                 |       |                   |            |            |            |

## 5 Requirements

### 5.1 Design and structure

#### 5.1.1 Environmental conditions

The multifunctional manipulator shall be able to work normally in the following environment:

- a) sea state: 4

NOTE According to Pierson - Moskowitz Sea Spectrum and Beaufort Force, sea state 4 means Beaufort wind force 5, under which condition the significant wave is 6 ft., significant range of periods is 2,5~8,5 s, average period is 5 s, and average length of waves is 80 ft.

- b) ambient temperature: -25 °C~45 °C
- c) vibration and shock generated during the normal operation of the ship.
- d) humidity greater than 95 % with oil mist, salt spray, and mildew.

#### 5.1.2 Steel wire rope

The steel wire rope shall be non-rotating steel wire, and the nominal tensile strength of a single steel wire shall be not less than 1 440 MPa and not greater than 2 200 MPa.

#### 5.1.3 Hook

The hook shall be of rotating type and shall reach the lifting capability of lifting SWL in the design sea state.



#### 5.1.4 Pulley

**5.1.4.1** There shall be a proper inclined angle, which is usually between 35° and 45°, at the pulley rope groove side and the inclined angle at the pulley rope groove side in Level 4 sea state shall be taken as 40°.

#### 5.1.5 Boom, slewing tower body, base and carrier structure

**5.1.5.1** The main boom, jib, and multifunctional boom shall adopt boom structure form with box shaped and variable section. The boom, slewing tower body, base and carrier shall be subjected to stress relief treatment after welding.

**5.1.5.2** The slewing tower body shall be subjected to watertight inspection.

#### 5.1.6 Slewing mechanism

**5.1.6.1** If there are special requirements for the slewing tower body to limit the slewing angle, the mechanical and electric limits shall be specified.

**5.1.6.2** The slewing angle measurement shall be measured using an encoder enclosed inside a hydraulic/electrical adapter.

**5.1.6.3** The slewing mechanism has two slewing hydraulic drive mechanisms which are respectively arranged on both sides of the lower plane of the slewing tower body. The slewing hydraulic drive mechanism is composed of a planetary speed reducer, a brake and a gear, and the brake is normally closed. The slewing hydraulic drive mechanism shall leave 1,5 mm eccentricity with the mounting axis to ensure that the slewing support meshes well with the slewing hydraulic drive mechanism gear and compensates for wear during use.

#### 5.1.7 Fixed base/travelling mechanism

**5.1.7.1** The fixed base shall be of sufficient rigidity to prevent the system from shaking due to excessive elastic deformation.

**5.1.7.2** For roller trains of the travelling mechanism, the two roller trains mounted on the front and rear ends of the lower portion of the carrier respectively shall be used, each roller train consisting of one mounting shaft, four positive rollers, four return rollers and two swing frames, to accommodate to the vertical plane motion and horizontal yaw of the ship. Travelling drive should adopt the pinion and rack driving mode.

**5.1.7.3** The cable length of the cable reel on the travelling mechanism is one-half of the travelling stroke of the travelling multifunctional manipulator plus the safety ring number.

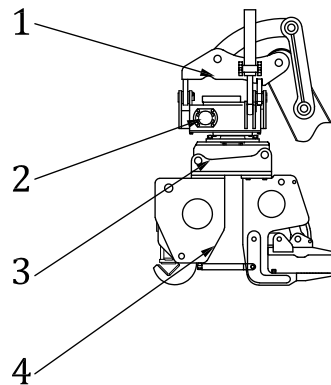
**5.1.7.4** The role of the speed control valve of the travelling mechanism is to automatically slow down and stop travelling near the stroke destination. The travelling mechanism of the hydraulic drive shall be equipped with a speed control valve to ensure the system travelling safety and buffers shall be installed at both ends of the travel stroke.

**5.1.7.5** The roller of travelling mechanism shall be of curved tread and the guide rail shall be of flat tread.

**5.1.7.6** The lubrication for the roller train and guide pulley set shall be carried out with wheel-side manual lubrication.

### 5.1.8 Multifunctional head

**5.1.8.1** The multifunctional head shall be mainly composed of an inverting mechanism, a slewing reduction box, a quick change mechanism and a fixture assembly. See [Figure 4](#) for the structural diagram.



**Key**

- |   |                       |   |                                     |
|---|-----------------------|---|-------------------------------------|
| 1 | inverting mechanism   | 3 | quick change device                 |
| 2 | slewing reduction box | 4 | rope/anchor chain fixture mechanism |

**Figure 4 — Structural diagram of multifunctional head**

**5.1.8.2** The multifunctional head shall integrate an anchor chain fixture/rope fixture, which can be flipped, oscillated, or fully slewed (see [Table 1](#) for parameters).

**5.1.8.3** The rope size that the multifunctional head can clamp shall be  $\phi 50$  mm to  $\phi 84$  mm, and the rope fixture shall have the function of extension and retraction; the size of anchor chain that can be clamped shall be  $\phi 50$  mm to  $\phi 120$  mm.

**5.1.8.4** The rope and anchor chain fixtures shall clamp the cylinder through the hydraulic slip ring installed on the slewing reduction box transmitting hydraulic power.

**5.1.8.5** The contact surface between the rope fixture and the steel wire shall be made of high-strength plastic non-metallic material with a tensile strength of more than 100 MPa and excellent wear resistance. There shall be anti-skid grooves on the surface.

**5.1.8.6** The anti-skid groove structure shall be adopted for the head of the anchor chain fixture. The wear resistance shall be considered when selecting metal materials, and the yield strength shall be greater than 500 MPa.

**5.1.8.7** The design of the multifunctional head shall ensure the rationality of the spatial arrangement of the pipeline under multi-degree of freedom motion.

**5.1.8.8** The design of the multifunctional head shall ensure that the direction change of the SWL of the anchor chain/rope tidying operation.

### 5.1.9 Braking system

The multifunctional manipulator braking system shall meet the following requirements.

- a) Each mechanism of a multifunctional manipulator shall be provided with brakes. The brakes for lifting and slewing mechanisms shall be normally closed and the safety factor (ratio of braking torque to rated torque) of the brake shall be not less than 1,5.

- b) The travelling multifunctional manipulator shall be equipped with a rail clamping device so as to prevent the equipment from self-sliding under the action of wind or ship tilting.
- c) The travelling multifunctional manipulator shall be equipped with an anchoring device for fixing when the equipment is shut-down.
- d) The braking system shall not produce impact loads that can cause damage to the structure and mechanism of the multifunctional manipulator.
- e) The mechanical brake shall be equipped with brake pads made of refractory material and such pads shall not affect the normal operation of the brake after they are heated and dampened.

#### **5.1.10 Electric control system**

**5.1.10.1** The control modes for the multifunctional manipulator shall include local control and wireless remote control.

**5.1.10.2** The control modes for the travelling multifunctional manipulator shall include wireless remote control and centralized control.

**5.1.10.3** The control speed for winch lifting and lowering, boom luffing, tower body slewing and multifunctional head extension and retraction shall be stepless adjustable.

**5.1.10.4** The travelling speed for the travelling mechanism shall be switchable between high and low speed positions.

**5.1.10.5** When the multifunctional manipulator requires multi-points control, all control points shall be interlocked. Only one control point is allowed for operation at any time and an emergency power off device shall be installed at each control point.

**5.1.10.6** The remote control system for the multifunctional manipulator shall normally operate within 150 m and shall be designed according to ISO 13849-1:2015, index class d.

**5.1.10.7** The remote control system shall have an active emergency stop signal and the system shall respond not later than 20 ms.

**5.1.10.8** The remote control system shall have a passive emergency stop signal. When the receiving system fails to receive continuous and valid transmission signals within 0,55 s (for example, the transmitting system has insufficient battery power, exceeds the effective service distance, is interfered with by the same frequency signal, or the signal is shielded), the receiving system shall cut off the output automatically.

**5.1.10.9** The receiving system shall use a very narrow band frequency modulation and only the required frequency shall be allowed to pass through. A remote control system with automatic frequency management is adopted. When the same-frequency interference occurs, the operating frequency of the transmitting system shall be capable of being automatically changed to adjust the receiving system to a non-interfering frequency automatically and simultaneously so that the remote controller can operate normally.

**5.1.10.10** The multifunctional manipulator shall be equipped with an emergency shut-down mechanism. When the operator conducts emergency shutdown, the emergency shutdown mechanism shall be capable of cutting off the power source of the multifunctional manipulator and stopping operation as well as making the automatic control brake system work. The emergency shut-down mechanism shall be placed in an obvious position easily accessible by the operator and that can avoid misoperation.

**5.1.10.11** The control system of the multifunctional manipulator shall be provided with zero position protection. Before starting the motor, it is necessary to ensure that all control handles and switches are in neutral position; where this is not the case, all actuators shall remain stationary and it shall not be possible to operate the multifunctional manipulator normally.

#### **5.1.11 Seat**

For the multifunctional manipulator of a centralized control mode, a seat shall be provided for the operator. The operating panel on the seat shall be capable of fully controlling the multifunctional manipulator functions with safety protection signal feedback. The seat shall be designed to be ergonomic with seat cushions and adjustable arm rests. The seat shall be fully adjustable, i.e., the height, front/rear and backrest angles can be adjusted. Arm rests shall be easy to move. The seat shall also be provided with an additional headrest to provide full support in the tilted position.

### **5.2 Material**

**5.2.1** The pulley shall be made of steel.

**5.2.2** The hook shall not be made of cast iron or cast steel.

**5.2.3** All bare tubes and accessories shall be made of stainless steel.

### **5.3 Performance**

#### **5.3.1 No-load**

When the multifunctional manipulator is operated under no-load conditions, there shall be no abnormality such as sticking, abnormal noise and leakage, and each limit function shall be normal, and the emergency shutdown shall be reliable.

#### **5.3.2 Rated load**

When the test stand has an angle of heel of 6° and a trim of 3° and the multifunctional manipulator is operated at the SWL, the performance parameters shall meet the requirements in [Table 1](#), and there shall be no abnormality such as sticking, abnormal noise and leakage, and each limit function shall be normal, and the emergency shutdown shall be reliable.

#### **5.3.3 Over-load**

When the test stand has an angle of heel of 6° and a trim of 3° and the multifunctional manipulator is slowly operated at 1.1 times the SWL, there shall be no abnormality such as sticking, abnormal noise and leakage, and each limit function shall be normal, and the emergency shutdown shall be reliable.

#### **5.3.4 Safety protection**

**5.3.4.1** The multifunctional manipulator shall have the following safety protection functions:

- a) lifting/lowering height protection;
- b) operation stroke protection (applicable to the travelling multifunctional manipulator);
- c) maximum/minimum boom range protection;
- d) slewing angle protection (applicable to the multifunctional manipulator with the slewing angle limit) and audible and visual alarm;
- e) buffer and end stop protection (applicable to the travelling multifunctional manipulator);

f) emergency stop and audible and visual alarm.

**5.3.4.2** The multifunctional manipulator shall have the lifting weight protection function and the lifting protection shall meet the following requirements:

- a) when the actual lifting weight exceeds 95 % of rated lifting weight, the system shall send an audible and visual alarm signal;
- b) when the actual lifting weight is between 100 % and 110 % of the rated lifting weight, the lifting weight limiter shall function and the lifting power source shall be automatically cut off, but the goods shall be allowed for lowering motion.

**5.3.4.3** The multifunctional manipulator shall have the function of lifting moment protection, which shall meet the following requirements:

- a) when the actual lifting weight exceeds 95 % of the rated lifting weight, the system shall send an audible and visual alarm signal.
- b) when the actual lifting weight is greater than the rated value of corresponding actual range but less than 110 % of the rated lifting value, the lifting moment limiter shall function and the power source in the insecure direction (rising, ranging expansion, boom extension or the combination of such actions) shall be automatically cut off, however, the mechanism shall be allowed to move towards a safe direction.

### **5.3.5 Electric performance**

#### **5.3.5.1 Power supply fluctuation**

Under normal operating conditions, the input voltage of the multifunctional manipulator shall be between -10 % and +6 % of the rated value.

#### **5.3.5.2 Insulation resistance**

When the ambient temperature is between 0 °C and 45 °C and humidity is between 20 % and 80 %, the insulation resistance between the motor, electrical cabinet and the ground shall be not less than 10 MΩ.

#### **5.3.5.3 Degrees of protection provided by enclosure (only for electrical cabinets)**

The degree of protection provided by the enclosure for the electrical equipment installed on the exposed deck shall be not lower than IP56, as specified in IEC 60529. and that for the electrical equipment installed on other place shall be IP44.

### **5.4 Appearance quality**

**5.4.1** The main bearing weld of booms, slewing tower bodies, bases and carriers shall be subjected to the flaw detection and 100 % qualified.

**5.4.2** The slewing tower body lower surface, base upper surface and carrier upper surface shall meet the slewing supporting planeness requirements.

**5.4.3** The interior of the steel tank shall be treated with an anti-rust that is compatible with the hydraulic fluid.

## 6 Test method

### 6.1 No-load test

**6.1.1** Under the no-load condition, conduct the action test on all the actuators through the console and the remote controller and check that all the actions are normal and consistent with the operation instructions, including main boom luffing, jib luffing, multifunctional boom luffing, multifunctional head launch and recovery, lifting winch lifting and lowering, tower body slewing, rail clamping device action, travelling mechanism travelling, towing hook opening and closing, multifunctional head swinging, multifunctional head slewing, rope fixture clamping/releasing, rope fixture launch and recovery, and anchor chain fixture clamping/releasing.

**6.1.2** Check the functions of each limit, including lifting/lowering height limit, main boom luffing limit, jib luffing limit, multifunctional boom luffing limit, tower body slewing limit and travelling limit.

**6.1.3** Check the function of emergency shutdown.

### 6.2 Rated load test

When the test stand has an angle of heel of 6° and a trim of 3°, complete all the action tests specified in [6.1.1](#) and the safety protection inspection at the SWL, and check the emergency shutdown function.

### 6.3 Over-load test

When the test stand has an angle of heel of 6° and a trim of 3°, slowly operate at 1,1 times the SWL and complete all the action tests specified in [6.1.1](#).

### 6.4 Safety protection inspection

**6.4.1** The following safety protection functions for the multifunctional manipulator shall be inspected:

- a) lifting/lowering height protection: lifting/lowering limit position protection for the lifting winch;
- b) operation stroke protection (applicable to the travelling multifunctional manipulator): when it travels to both ends, the hydraulic power shall be automatically cut off;
- c) maximum/minimum boom range limit protection: the luffing cylinder shall have the limit position protection at the limit stroke end;
- d) slewing angle protection (applicable to the multifunctional manipulator with the slewing angle limit) and sound and light alarm: when slewing to the limit angle, there is a slewing angle limit and audible and visual alarm;
- e) buffer and end stop protection (applicable to the travelling multifunctional manipulator): the buffer shall be provided at the end;
- f) emergency stop and sound and light alarm.

**6.4.2** Lifting weight protection shall meet the following requirements:

- a) when the actual lifting weight exceeds 95 % of rated lifting weight, the system shall send an audible and visual alarm signal;
- b) when the actual lifting weight is between 100 % and 110 % of the rated lifting weight, the lifting weight limiter shall function and now the lifting power source shall be automatically cut off but the goods shall be allowed for lowering motion.