



**TWO (2) QUAYSIDE CONTAINER CRANES**

**FOR**

**SPRC ,COLOMBIA**

**ZP16-2400**

**MAINTENANCE MANUAL**

**(MECHANICAL PART )**

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## CATALOGUE

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## Chapter 1 Brief introduction of quayside crane

### 1.1 Outline and main parameters for quayside container crane

This quayside container crane has twin-box section boom & girder, and a rope-towed

trolley.

The main parameters are below as table 1-1:

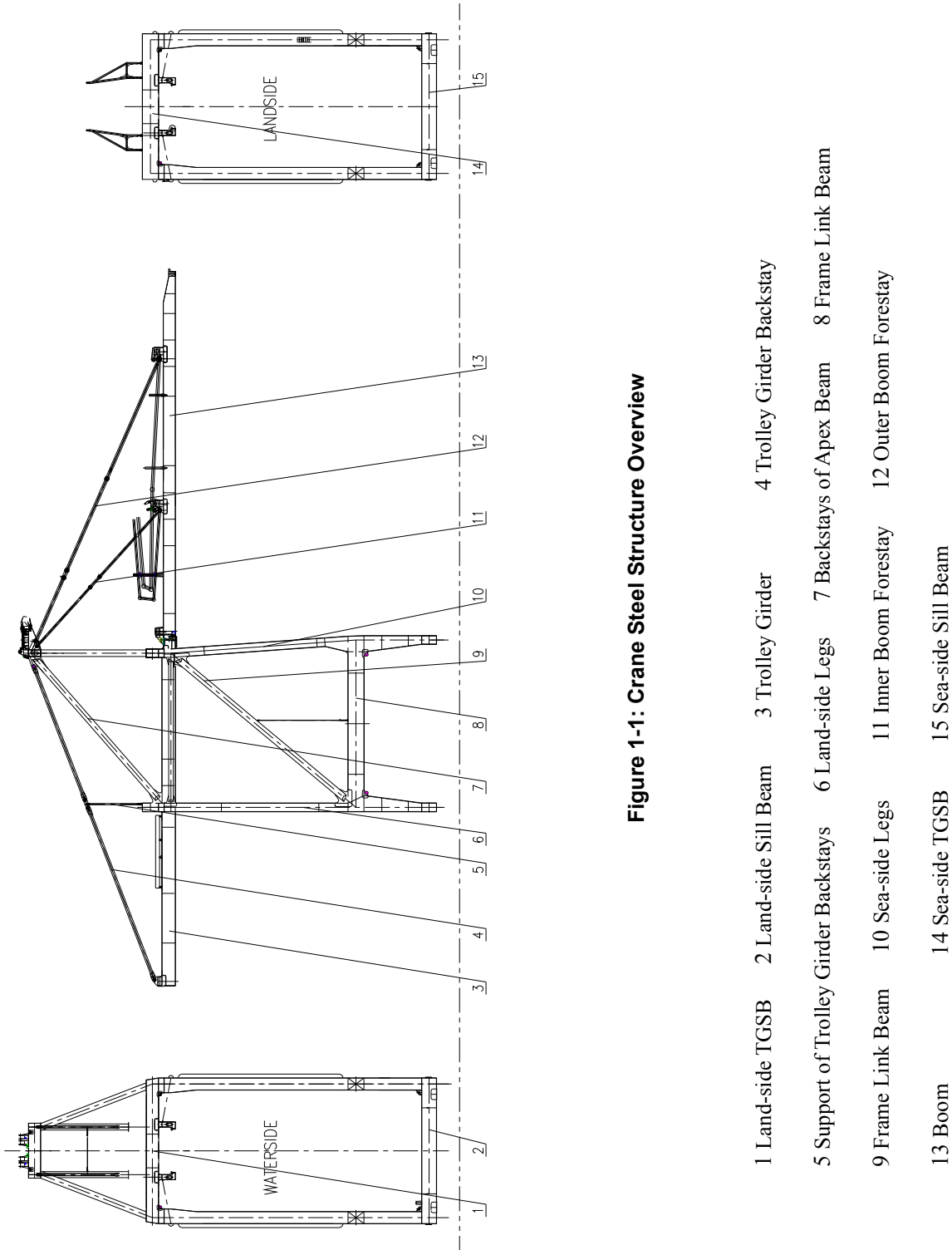
Table 1-1: Main Parameters for Quayside Container Crane

Basic Parameters	Rated Load Capacity(t)	Under Spreader	65	Speed	Hoist Speeds (m/min)	Full Load	90	
		Under Hook	80			Empty Load	180	
	Lift Height (m)	Above Rail	42		Trolley Travel Speed (m/min)		240	
		Total Lift Height	42+17		Gantry Speed (m/min)		45	
	Outreach (m)	61		Accelerating Speeds	Main Hoist Acceleration Time (sec)	Full Load	~2.1	
	Back reach (m)	13				No Load	~3.8	
	Max Operating Wheel Load (t)	Sea-side	85		Trolley Travel Acceleration Time (sec)		~6	
		Land-side	68		Gantry Travel Acceleration Time (sec)		~6	
	Max Stowed Wheel Load (t)	Sea-side	95.2		Boom Hoist time One Way (min) ≤	0°-80°(Stowed Position)		~5
		Land-side	76			0°-45°(Ship Clearance Position)		~3
	Inside Clearance Between Legs(m)		18		Motor Power	Quantity (pcs)		2
	Height Under Link Beam(m)		12.46			Hoist Motors	Power (Kw)	
	Overall Crane Width from Bumper to Bumper (m)		27.2	Rotating Speed (rpm)			900/1800	
	Crane Weight (t)		~1250	Trolley Motors		Quantity (pcs)		1
Setback of WS Trolley Girder Support Beam (m)		2	Power (Kw)			270		
Special Functions	Anti-Snag	Provided		Rotating Speed (rpm)		1750		
	Type of Anti-Sway	Electrical		Gantry Motors		Quantity (pcs)		16
Spreader Parameters	Trim	±3°				Power (Kw)		20
	List	±5°		Rotating Speed (rpm)		1400		
	Skew	±5°		Quantity (pcs)		1		
	Single 20'/40'/45' & Twin-20' Telescopic Spreader				Power (Kw)		280	
Trolley Main Data	Rail type		A75	Gantry Main Data	Rail type		CR175	
	Wheel Diameter(mm)		Φ630		Wheel Diameter(mm)		Φ800	
	Wheel Number		4		Wheel Number on Each Leg (pcs)		8	
	Weight(t)		23		Driving wheels (pcs)		4	
Stowage Pin Between Crane and Wharf			Manual	Double Boom Hinges Adopted between Boom and Trolley Girder				
Stowage Pin Between Boom and A-Frame			Manual	Power Supply on Wharf		13,2KV,60HZ,3/PE		

## 1.2 Configuration of the crane steel structure

With a huge volume profile and suffering severe impact and frequently start-up and braking, a crane is obliged to ensure container positioned accurately and handled efficiently at high speed during operation. All these are

ensured by the well-designed steel structure and the advanced control system. Most of the structure member section is trunk or box except some in tubular shape. The members of Main structure refer to Figure 1-1.



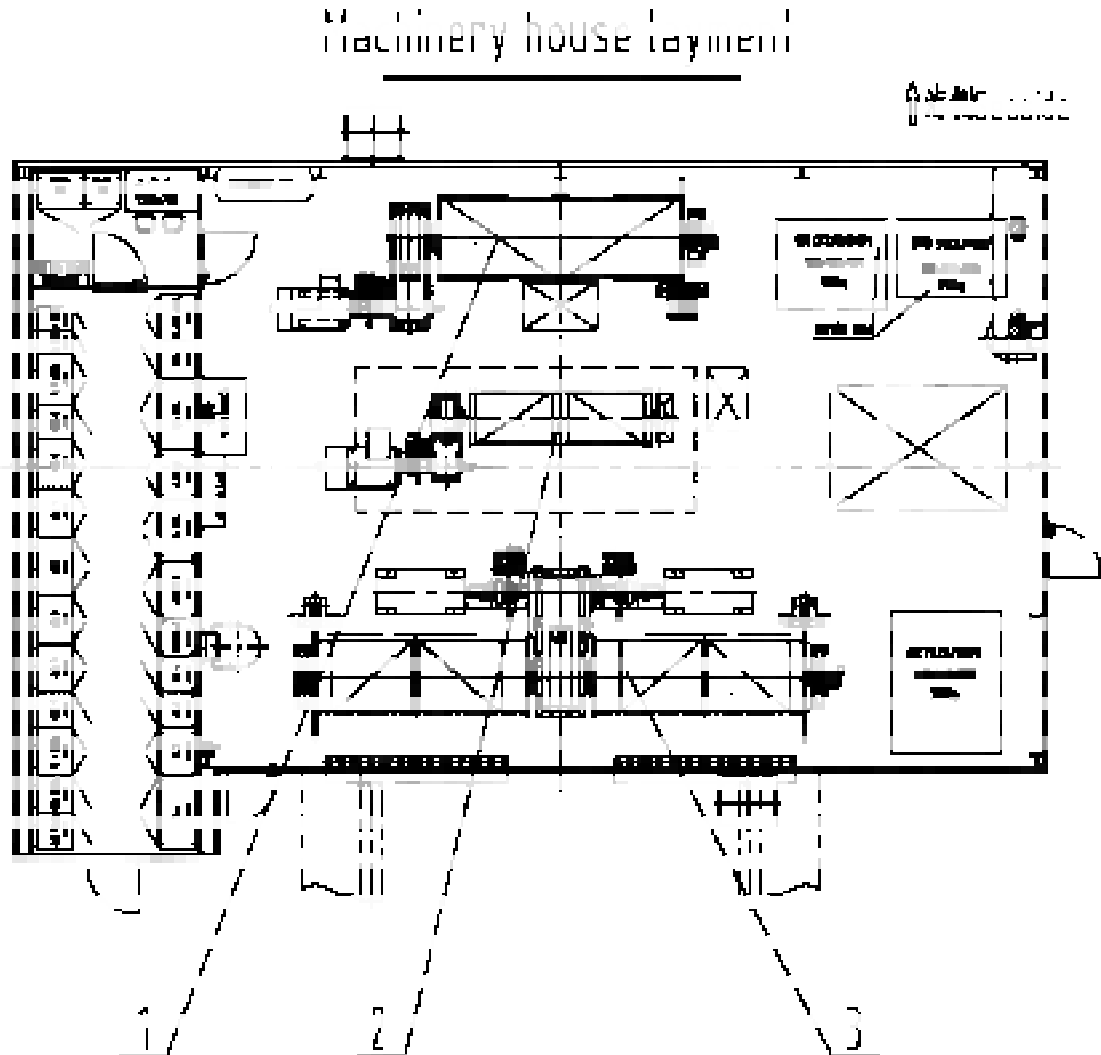
**Figure 1-1: Crane Steel Structure Overview**



### 1.3 Drive mechanism on crane

The four major drive mechanisms: Main Hoist Drive, Boom Hoist Drive, Trolley Travel Drive and Gantry

Travel are provided on the crane and sheltered in a weatherproof Machinery House except the Gantry Travel as shown in the below Figure 1-2.



**Figure 0-1: Major Drive Mechanisms Layout in Machinery Room**

1 boom hoist drive      2 trolley travel drive      3 main hoist drive

#### 1.3.1 Main hoist drive

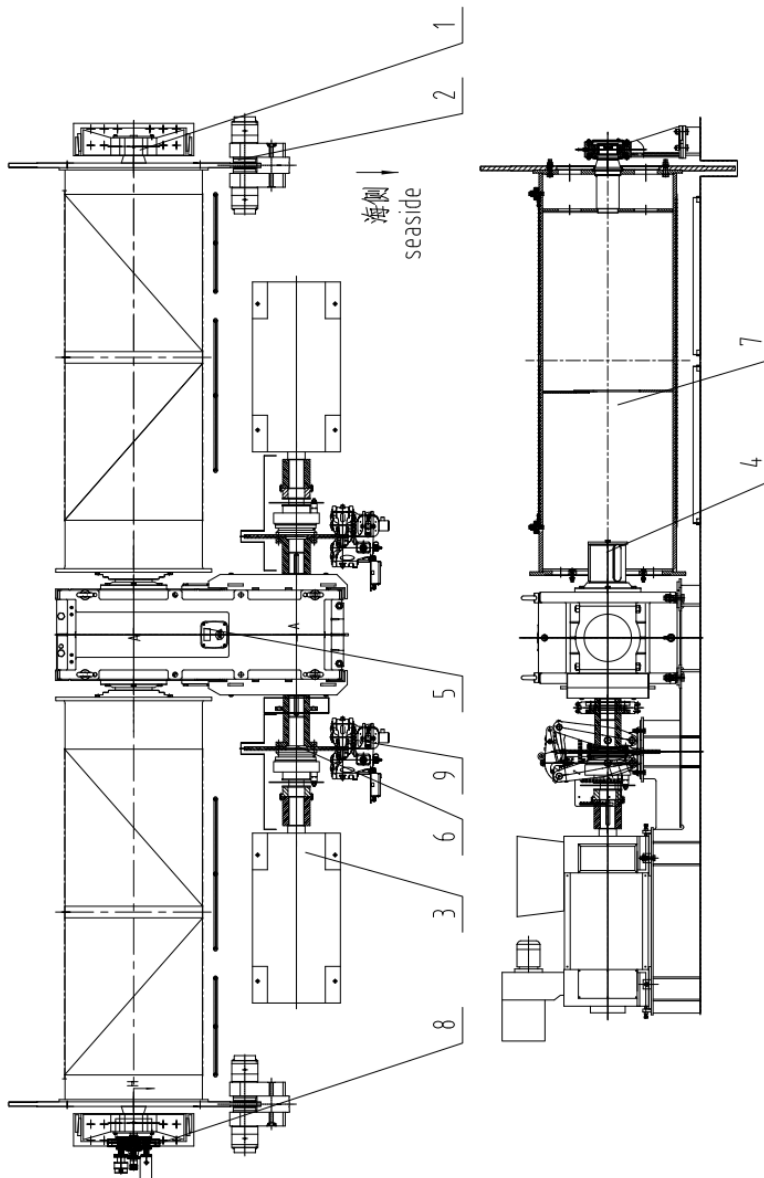
The main hoist drive is located in the machinery house. It is powered by two variable frequency AC motors connected to the reducer input shafts through the flexible elastomeric type couplings (high speed). Two rope drums are connected to the output shafts of the reducer through the two flexible gear couplings (lower speed). The driving force of this equipment is transmitted from the

motors to the drums by the high speed couplings and drum couplings and amplified through the reducer driving the drum and rope to lift or lower the cargo attached under the telescopic spreader or hook beam. The data of main components refers to Table 1-2.

**Table 0-1: Main Data of Major Components for Main Hoist Drive**

Motor	Type	AG 1PH8 356	Drum Brake	Type	SF24
	Power	2X705kw		Brake Torque	2X192kNm
	Rotating speed	900/1800rpm		Type	AKNXSE 0.88
Reducer	Type	PD63-R11-V25-18-Z2	Motor Coupling	Rated Torque	24kNm
	Ratio	18.7		Brake Torque	48kNm
	Rated Output torque	416kNm	Drum Coupling	Type	TTX21
Motor Brake	Type	SB28.3-BL450-8		Rated Torque	310kNm
	Braking Torque	2X25.6kNm	Wire Rope	Diameter	Φ30mm

**Note:** The braking torque of motor brake must be set according to required set torque on the drawing.



**Figure 1-3 Scheme and Photograph for Main Hoist Drive**

- 1 Drum Bearing Seat    2 Drum Brake    3 Motor    4 Drum Coupling    5 Reducer
- 6 Motor Coupling    7 Drum    8 Limit Switch Device    9 Motor Brake



Installed above the main reducer, an emergency drive is capable of hoisting or lowering the spreader slowly in case the hoist motor or drive control system failed and can not be fixed immediately. Upon the crane loss of high voltage power while hoisting or lowering, this emergency device can be plugged on the shore power and continue the operation till the container removed from the spreader or ready for next step.

### 1.3.1.1 Main hoist reeving system

The wire ropes reeled out from the drum, then run through the following route:

Drum → Trim/List/Skew/Snag System on girder rear end → Sheaves on trolley frame → Sheaves on head-block → back to Sheaves on trolley frame → Load cell at boom tip.

The rope ends are tied with four load cells which are mounted under the sheave blocks respectively at the boom tip (refer to Figure 1-4). The signal will be generated by the tension force along the wire ropes then transmitted to PLC (Programmable Logic Controller) and CMS (Crane Management System) so that the hanging load and its eccentricity information can be figured out and recorded.

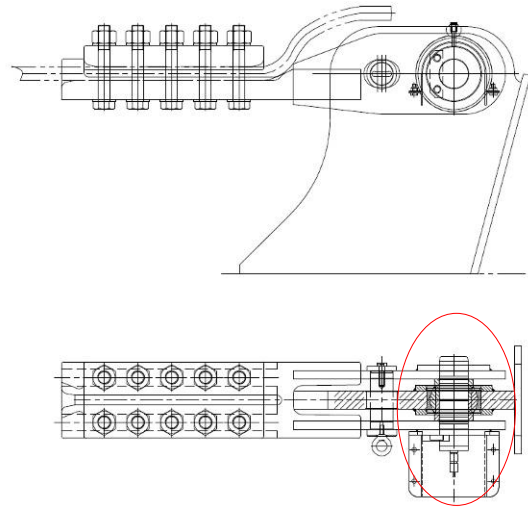


Figure 1-4: load cell location

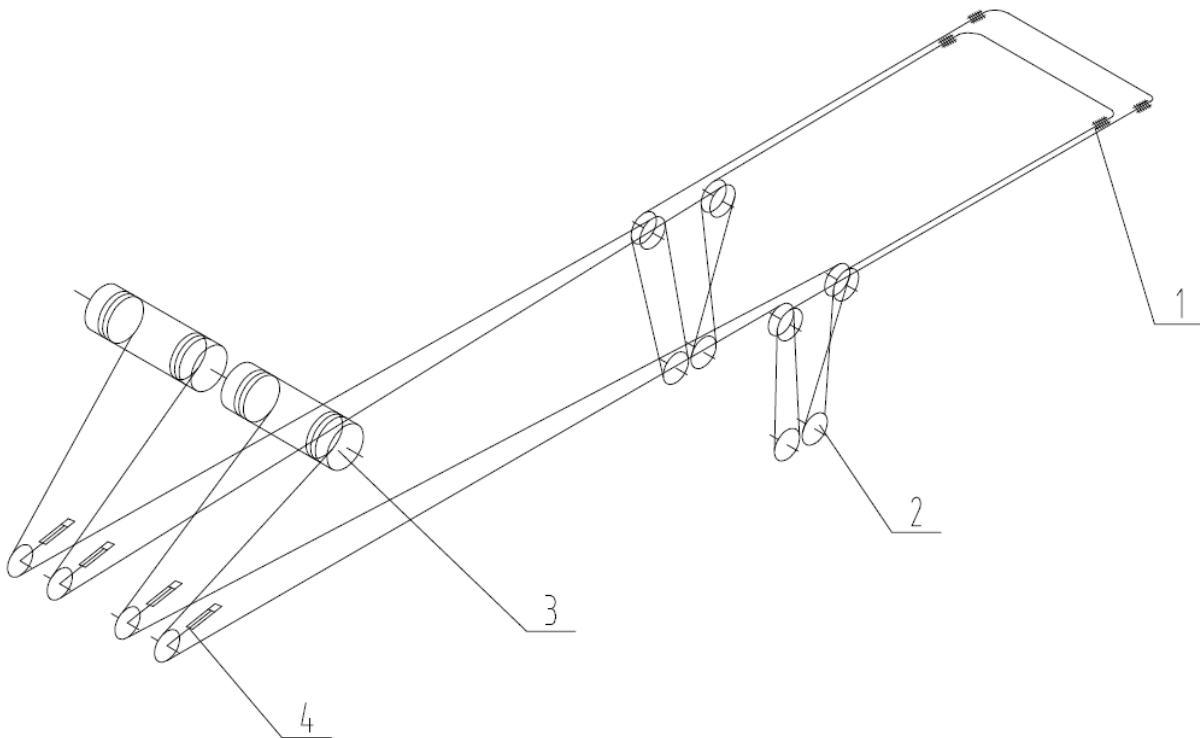


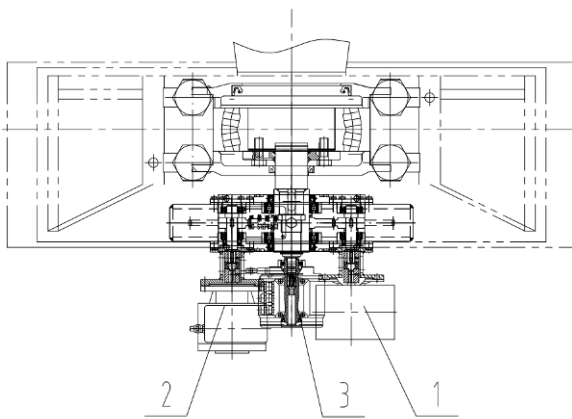
Figure 0-2: Main Hoist Rope Reeving System

- 1 Load Scaled Clamp Blocks on Boom Tip
- 2 Sheave Block on Head-block
- 3 Drum of Main Hoist
- 4 Trim/List/Skew & Anti-Snag on Girder Rear End

### 1.3.1.2 Interlocks for main hoist drive

#### 1) Over-speed switch

External over-speed protection for the main hoist is provided at the end of one drum. Actuation of the switch initiates an emergency stop. The theoretical trip speed setting for the switch is 110% of the motor maximum speed. In order to resume the crane operation, the switch must be manually reset from its back once it is tripped. (Refer to Figure 1-6) As an optional device, which is connected with the motor shaft end, the incremental encoder can transmit the real-time speed signal then PLC will evaluate over-speed or not. (Refer to Figure 1-7)



**Figure 1-6: Limit Switches at Drum End of Main Hoist Drive**

1 Cam Switch      2 Over-speed Switch      3 Absolute Encoder



**Figure 1-7: Absolute Encoder**

#### 2) Motor brake limit switch

Each of the two hoist motor brakes is monitored by a brake released limit switch (one normally open contact) and a brake manually-released limit switch (one normally-closed contact). Without signal of hoisting from joystick, the hoist motion is inhibited from operating as long as either switch is actuated.

#### 3) Drum brake limit switch

Each of the two hoist drum brakes is monitored by a brake released limit switch (one normally open contact). Without hoisting signal from joystick, the hoist motion is inhibited from operating as long as

either switch is actuated.

#### 4) Motor thermal switch

Each of the two hoist motors features an embedded over-temperature switch (one normally closed contact). Actuation of the switch indicates the motor temperature is at fault level. The hoist motion is inhibited from operating as long as either of the switches is actuated.

#### 5) Load weighing system

Information for the lifted load is provided by the weighing system. The hoist drives also provide overload indications. Refer to Section 1.3.1.1 for more detailed description.

#### 6) Anti-Snag system

When the snag occurs, the hydraulic system will enable the snagged cylinder to absorb the inertia energy of the mechanical moving parts through releasing its fluid and pressure. At the same time, an emergency stop will pause the hoist moving as long as the drive and PLC receives the signal sent from the electrical overload transducer or the pressure switches mounted on the snagged cylinders. The total snag event takes place in less than a second. Lowering the hoist is allowed at reduced speed after first resetting control power to release the strain on the ropes. No hoist raise motion is permitted until the event is cleared.

#### 7) Boom interlocks

If the boom is not fully at horizontal position (stowed or maintenance), the hoist motion is disabled. When the boom is raised the hoist functions at the reduced speed (empty spreader only)

#### 8) Spreader operation modes

The hoist and head-block / spreader system operates in three different modes, container, cargo and reeve.

#### 9) Spreader mode interlocks (Slack rope protection)

In case all the proximity switches around the twist locks are activated (means cargo already landed), further lowering motion of the spreader will be inhibited. These switches contribute to preventing the hoisting ropes from slacking. Hoisting motion is permitted when all these switches are released or activated.

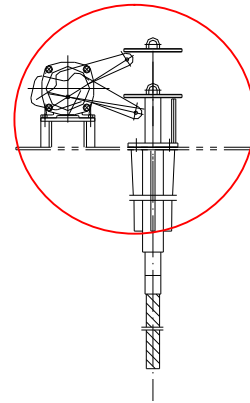
#### 10) Spreader cable reel interlock (for motorized cable reel only)

Whether improper tension, irrational position or selection of manual mode at the trolley top control station, the main hoist operation will be inhibited. The cable reel runs in two modes, auto and manual. Auto should be selected if operating from the cab and manual selected if from the local control station settled on the trolley. Hoist movement, raise and lower will be disable if the reel manual mode is selected in both container mode and cargo mode.

### 1.3.1.3 Positioning Limits for Main Hoist Drive

Normal hoist limits are controlled by the absolute encoder mounted on the main hoist motor. The home (or zero) position of the hoist is located at the upper limit of normal travel, while the hoist height indication is still counted from wharf ground level.

In addition to the absolute encoder limits, there is another weight operated lever switch (as shown in Figure 1-8) mounted on the bottom of the trolley and a third cam switch (as shown in Figure 1-6) installed on the hoist drum end. Such redundant design provides the over travel protection in a better and safer way.



**Figure 1-8: Trip Block under Trolley Frame for the Weight Operated Lever Switch**

### 1.3.1.4 Trim-list-skew and snag protection device

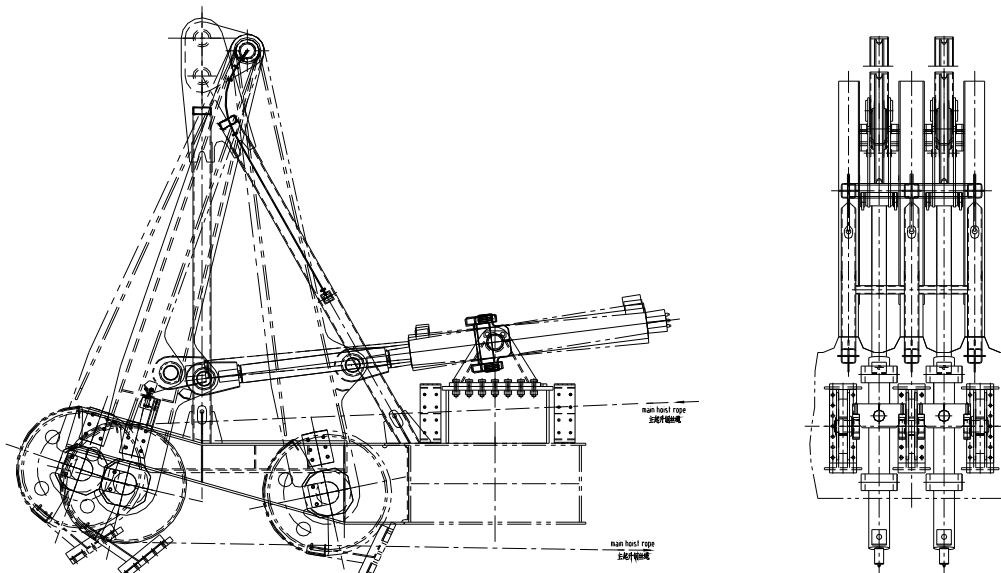
These functions are accomplished by the multi-functional hydraulic system at girder end tie, which is composed of four hydraulic cylinders and valves power-pack. The hydraulic cylinders are attached to the four hoist ropes by turning sheaves.

The hoist rope provides spreader positioning (trim/list/skew) and snag load protection through the multi-functional hydraulic system.

Spreader tilting is accomplished by manipulating the position of the cylinders, lengthening or shortening the rope falls to adjust the container tipping angle around its three orthogonal axes.

As snag event occurs, the kinetic energy of the hoist mechanism that is rotating at high speed is transformed into heat energy and releases it by the hydraulic system, which prevents the disaster such as wire rope broken, crane structure deforming or even whole crane overturning or collapsing.

The cylinder position is monitored by linear displacement transducers located inside each of the cylinder rods. Output from each of the cylinders is directly proportional to the 1200mm stroke of the cylinders. The initial home position, the minimum extruding under working condition, is at least 750mm for each of the cylinders. That is the stroke 0mm ~ 750mm for the snag protection, and stroke 750mm ~ 1200mm for the spreader Trim-List-Skew motions and/or compensating the length variety for the hoist wire ropes.



**Figure 1-9 Spreader Trim-List-Skew and Snag Protection Device on the Girder Tie End**

1) Trim, list and skew motions

By actuating combinations of hydraulic cylinders motions in different directions, this device adjusts the TRIM, the LIST and the SKEW.

- TRIM  
Tipping or rotating of the spreader around a horizontal axis perpendicular to the gantry rail. From the operator's perspective, trim raises and lowers the left or right end of the spreader as shown in Figure 1-10.

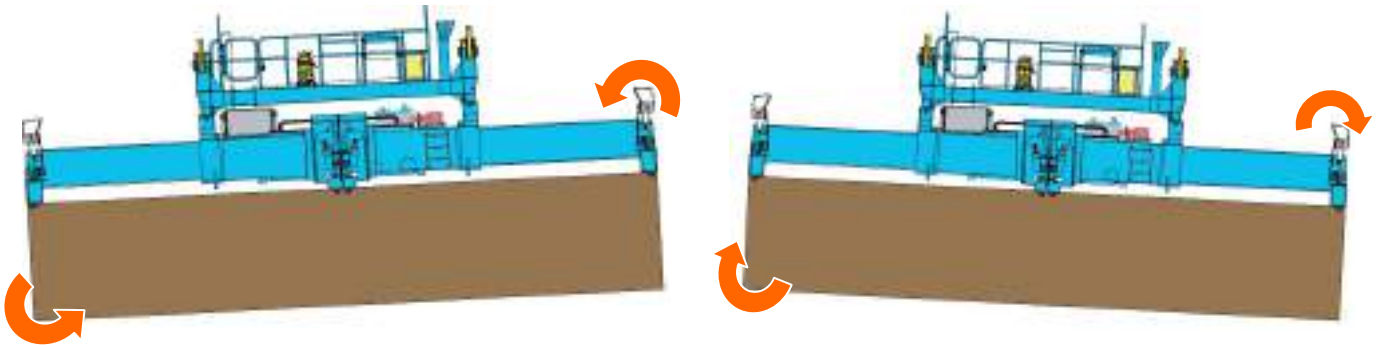


Figure 1-10 Spreader Left Trim ↖ and Right Trim ↗

- LIST Tipping or rotation of the spreader around an axis parallel to the gantry rails.



Figure 1-11 Spreader Forward List ↖ and Backward List ↗

- SKEW Rotation of the spreader around a vertical axis.

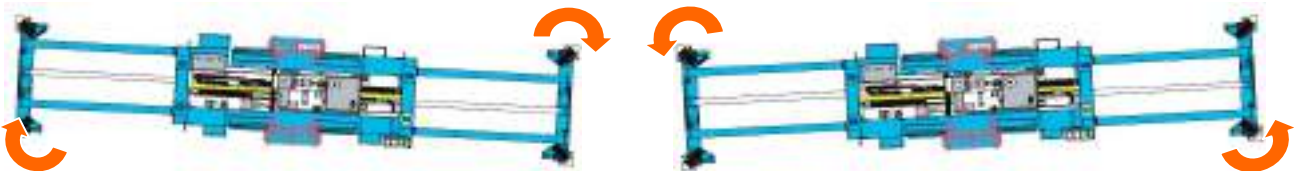


Figure 1-12 Scheme of Spreader Clockwise Skew ↖ and Counter Clockwise Skew ↗



When the Trim/List/Skew is at their maximum angles, the cylinders cannot actuate further. In such a case, operate the respective HOME switch on the operator's console to set it back to the HOME position.

## 2) Snag Protecting Function

Snag is a condition that typically occurs when a lifting spreader hooks or hits an obstruction such as the cell guides or hatch combings in the ship's cargo hold.

As snag occurs, the ropes' tension will increase rapidly and the hydraulic pressure of the snag cylinders increases correspondingly. When the pressure of any one of the four cylinders rises to the preset value of its pressure switch, a hardwired (fast) signal is sent directly to the hoist drives that initiates an emergency stop to the hoist motors. At the same time, the relief valve will open to blow the fluid and the cylinders will retract.

After the snag occurs, the snag indicating light will be on in the operator's cab, an audible warning will be sounded and the control power will be shut off. Meanwhile, only lowering the hoist is allowed at the reduced speed to release the strain on the ropes and no hoist raise motion is permitted.

In order to exit the snag condition, first the operator

must reset control power and lower the hoist to remove the load (hoisting is not permitted). The crane is then to be inspected for damage before the SNAG RESET key switch, located in the E Room is reset. Once reset full crane functionality is permitted.

## 1.3.2 Boom hoist system

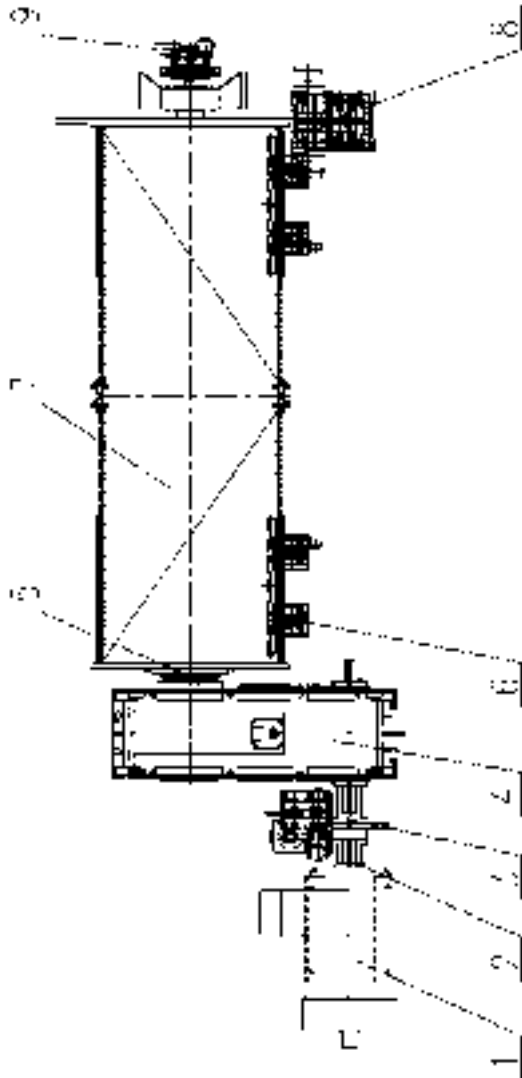
### 1.3.2.1 Boom hoist drive

The boom hoist drive is located in the machinery house. It is powered by a variable frequency AC motor connected to the reducer input shafts through a flexible elastomeric type coupling (high speed). A rope drum is connected to the output shaft of the reducer through the flexible gear coupling (lower speed). The driving force of this equipment is transmitted from the motor to the drum by the high speed coupling and drum coupling and amplified through the reducer driving the drum and rope to raise or lower the boom. The data of main components as following:

**Table 1-3: Main Data of Major Components for Boom Hoist Drive**

Motor	Type	1LL8 315	Drum Brake	Type	SF24
	Power	280kw		Brake Torque	2X172.8kNm
	Rotating speed	1750rpm		Type	K260-560x30
Reducer	Type	PD53-R11-V21-96.9	Motor Coupling	Rated Torque	3.98kNm
	Ratio	96.9		Brake Torque	11.94kNm
	Rated Output torque	239kNm	Drum Coupling	Type	TTX26
Motor Brake	Type	SB28-560x30-121/6		Rated Torque	390kNm
	Braking Torque	3.55kNm	Wire Rope	Diameter	Φ30mm

**Note: The braking torque of motor brake must be set according to required set torque on the drawing.**



**Figure 1-13 Scheme and Photograph for Boom Hoist Drive**

- 1 Motor    2 Motor Brake    3 Motor Coupling    4 Reducer    5 Drum Coupling
- 6 Rope Anti overlay Device    7 Drum    8 Drum Brake    9 Bearing Seat and Limit Switch



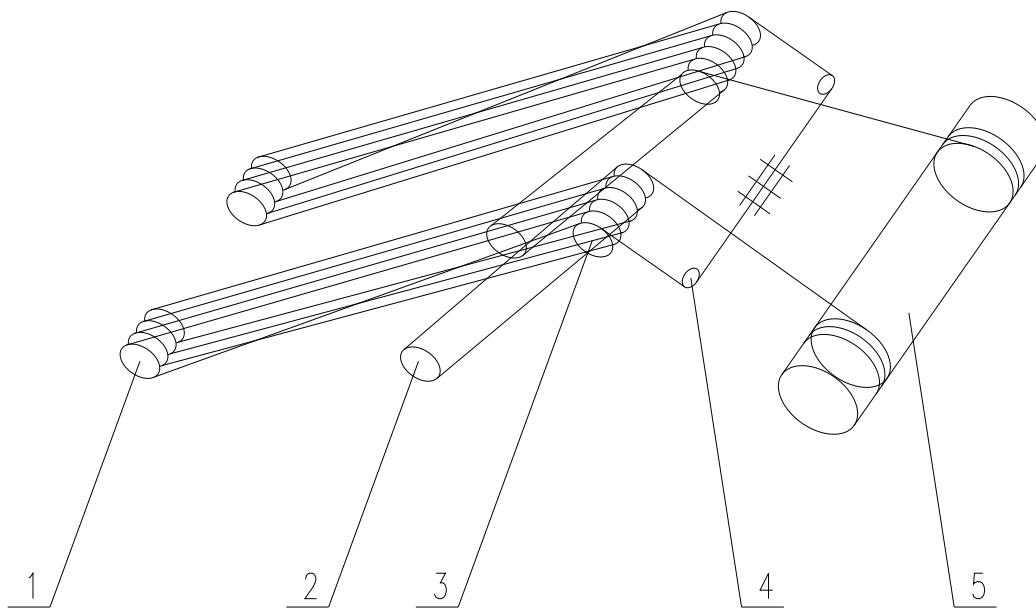
An emergency drive is located on the opposite side of main motor, its motor flanged onto the cycloidal planetary pin wheel speed reducer. Upon failure of the boom hoist main motor or drive/control system and can not be fixed immediately, this device can be used to raise or lower the boom at low speed. In case the crane loss of high voltage power, it is also capable of slowly raising or lowering the boom by plugged on shore power.



### 1.3.2.2 Boom hoist rope reeving system

The wire rope pays out from the drum, then runs through the following route: Boom hoist drum → Sheave block on top of A-frame → Inner single sheave on the boom → Sheave block on top of A-frame → Outer sheave blocks (4) on boom, rope runs 8 times to and fro between sheave block on top of sheave and outer sheave block on boom for either side reeving as shown in Figure 1-14.

The hoisting or lowering of the boom can be altered by changing the rotating direction of the motor. The boom hoist drive lifts the boom to the 45° stowed position or to the 80° maintenance position through the reeving rope. The boom hoist reeving includes two independent and equalized sets of falls. Either of them can catch the boom in the event of failure of one set. All sheaves contained with bearings and through covers are designed as a unit when removed or installed.



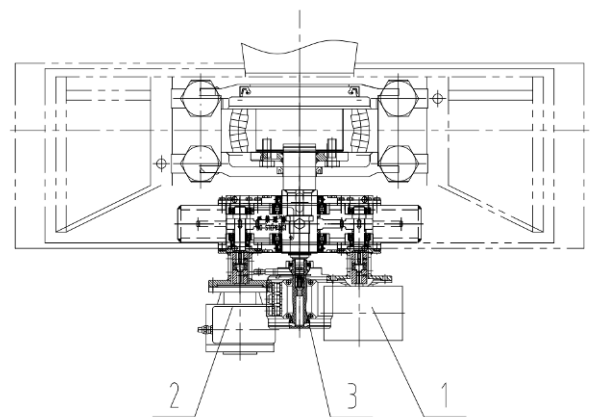
**Figure 1-14 Scheme of Boom Hoist Rope Reeving System**

- 1 Outer Sheave Blocks On Boom    2 Inner Single Sheave on Boom    3 Sheave Blocks on Top of the A-Frame  
4 Equalizer Sheave on Top of the A-Frame    5 Boom Hoist Drum

### 1.3.2.3 Boom hoist interlocks

#### 1) Over-speed switch

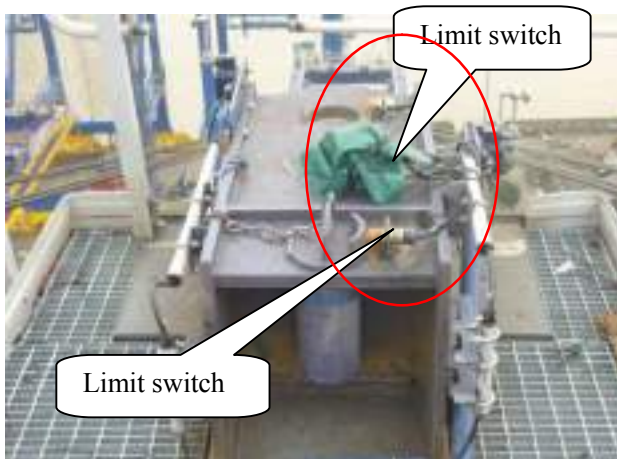
As shown in Figure 1-15, the external over-speed protection for the boom is provided at the end of the drum. Actuation of switch initiates an emergency stop. The theoretical trip speed setting for the switch is 110% of the motor maximum speed. In order to resume the crane operation, the switch must be manually reset from its back once it is tripped. (Refer to Figure 1-15) As an optional device, which is connected with the motor shaft end, the incremental encoder can transmit the real-time speed signal then PLC will evaluate over-speed or not.



**Figure 1-15 Limit Switches at Drum Shaft end**

- 1 Cam Switch    2 Over-speed Switch    3 Absolute Encoder

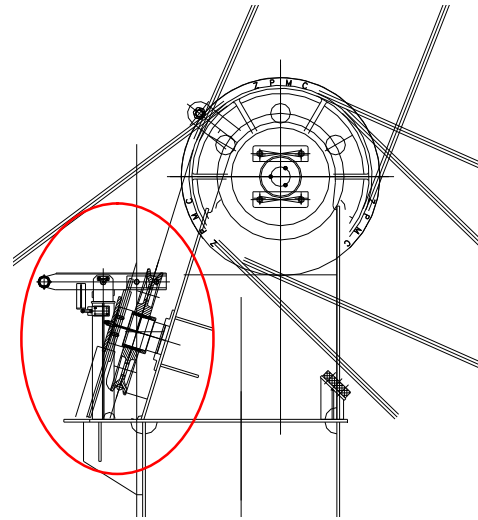
- 2) Motor brake limit switch  
The motor brake is monitored by a brake released limit switch (one normally open contact) and a brake manually released limit switch (one normally closed contact). Under no command of boom up or down, the boom motion is inhibited from operating as long as either switch is activated.
- 3) Drum brake limit switches  
Two boom drum brakes are monitored by a brake released limit switch (one normally open contact). Under no command of boom up or down, the boom motion is inhibited from operating as long as either switch is activated.
- 4) Motor thermal switch  
The motor features an embedded over-temperature switch (one normally closed contact). Actuation of the switch indicates the motor temperature is at fault level and the boom motion is inhibited.
- 5) Trolley park position check  
The trolley park position is monitored by a magnet-operated proximity switch. The boom motion is inhibited from operating as long as the trolley is not indicated to be in the park position.
- 6) Boom stowage pin stored in storage socket check  
The boom stow pins are monitored by proximity switches (As shown in Figure 1-16). Actuation of the switch indicates that the stow pin is rested in the storage socket and boom motion is permissive. Boom motion is inhibited from operation as long as either of switches is deactivated.



**Figure 1-16 Proximate switch for checking stow pin in storage socket**

- 7) Rope slack protection  
The boom ropes are monitored by two lever operated limit switches, one for each of the rope falls. The boom motion is inhibited from operation (only lowering direction) as long as either of the

switches is actuated.

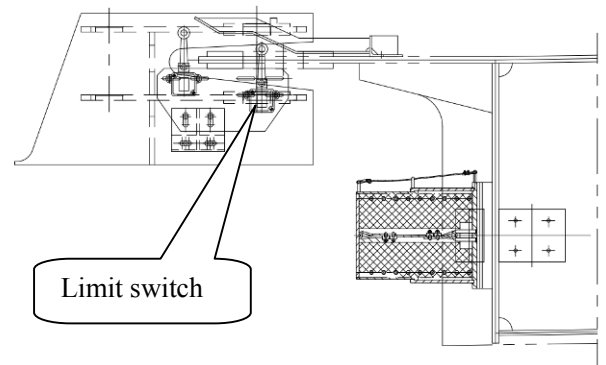


**Figure 1-17 Rope slack switch**

#### 1.3.2.4 Boom traveling limits

Normal boom hoist limits are controlled by the absolute encoder mounted on the drum shaft end. The home position of the boom hoist is set by lowering the boom to down stop position.

In addition to the absolute encoder limits, there is a lever operated limit switch mounted on the top of A-frame (As shown in Figure 1-18) and a multi-cam rotary limit switch mounted on the end of boom drum (As shown in Figure 1-15). This redundant design provides the over travel protection in a better way.



**Figure 1-18 Mechanical Limit switches for Boom stowage**



During the process of boom raising up, a spotter must stand on the seaside upper beams, carefully observe the whole process. The spotter must keep good communication with the operator. Once found anything abnormal, the operation should be stopped. In cases of emergency, immediately press the emergency stop switch. Before the recovery boom up operation, make a thorough check to ensure that the fault has been eliminated.

### 1.3.3 Trolley travel system

#### 1.3.3.1 Trolley travel drive

The trolley travel drive is located in the machinery house. It is powered by a variable frequency AC motor connected to the reducer input shaft through a flexible elastomeric type coupling (high speed). A rope drum is connected to the output shaft of the reducer through the

flexible gear coupling (lower speed). The driving force of this equipment is transmitted from the motor to the drum by the high speed coupling and drum coupling amplified through the reducer driving the drum and rope to propel the trolley forward (seaside) or backward (landside). The data of main components refers to Table 1-4.

**Table 1-4: Main Data of Major Components for Trolley Travel Drive**

Motor	Type	1LL831-4	Drum Brake	Type	Without equipment
	Power	270kw		Brake Torque	
	Rotating speed	1750rpm	Motor Coupling	Type	K260-560x30
Reducer	Type	PD40-R11-V24-19,7		Rated Torque	3.98kNm
	Ratio	19.7		Brake Torque	11.94kNm
Motor Brake	Rated Output torque	79KNm	Drum Coupling	Type	TTX6
	Type	SB28-560X30-80/7bb		Rated Torque	110kNm
	Braking Torque	3.07kNm	Wire Rope	Diameter	Φ22mm

**Note: The braking torque of motor brake must be set according to required set torque on the drawing.**

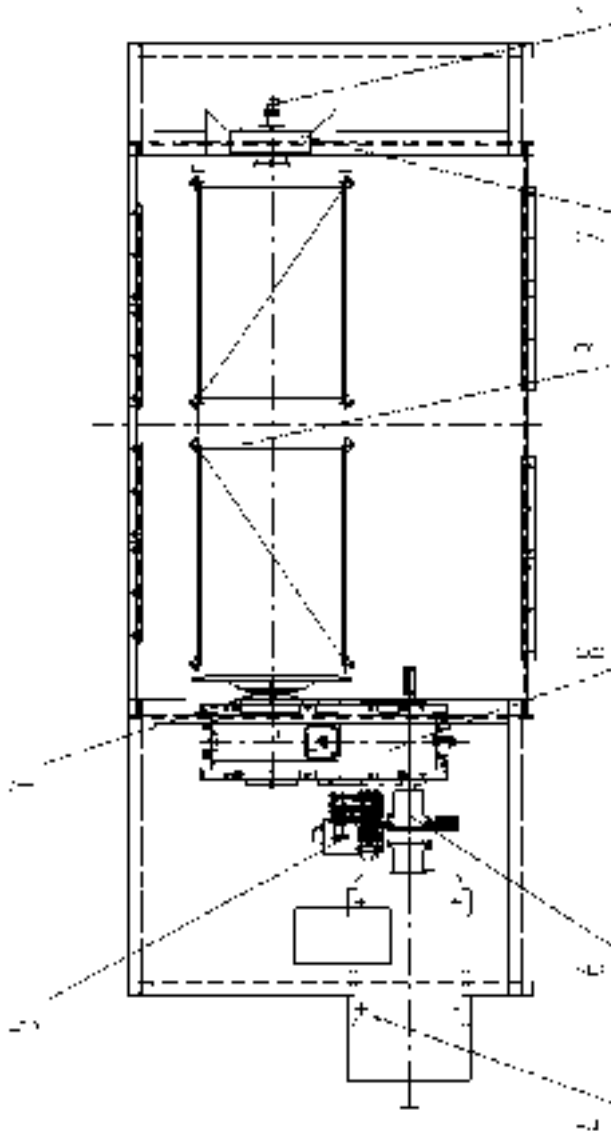


Figure 1-19 Scheme and Photograph for Trolley Travel Drive

- 1 Encoder
- 2 Bearing Seat
- 3 Drum
- 4 Motor
- 5 Motor Brake
- 6 Motor Coupling
- 7 Drum Coupling
- 8 Reducer



The trolley travel drive is equipped with an emergency drive. The device is capable of moving the trolley slowly forward or backward powered by the shore power in case the trolley motor or drive control system failed and can not be fixed immediately.

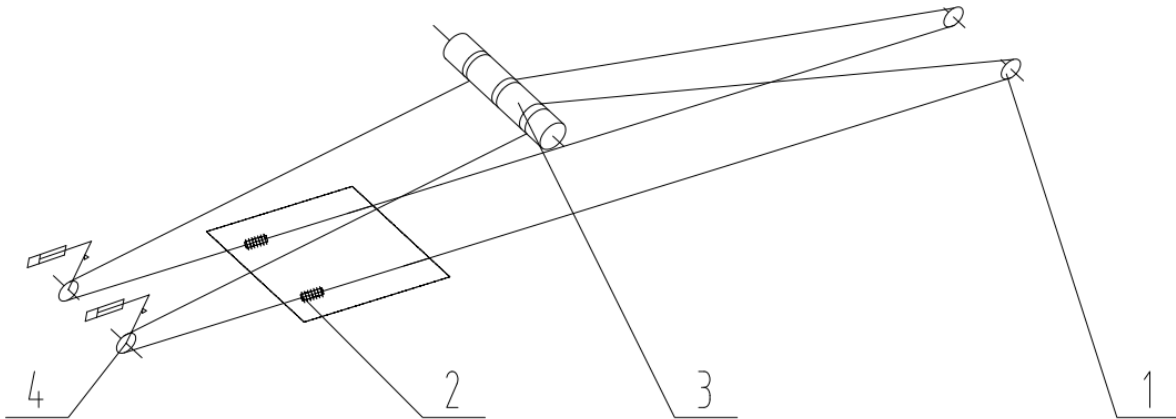
### 1.3.3.2 Trolley rope reeving system

By wire rope, drum, trolley, tensioning device and a series of related components linked together to form a trolley rope reeving system.

Two wire rope, four ends, clamp the rope on the drum firmly (see the main trolley drive device), and the midpoint of wire rope is fixed on the trolley, according

to the following route:

Drum → Boom tip sheaves assembly → Trolley → Boom tip sheaves assembly → Drum, Drum → Sheave of rope tensioning device at girder rear section → Trolley → Sheave of rope tensioning device at girder rear section → Drum (As shown in Figure 1-20); The trolley run back and forth by driving device.



**Figure 1-20 Trolley Rope Reeving System**

- 1 Boom tip sheave assembly    2 Dead end connection at trolley  
3 Trolley drum    4 Sheave of rope tensioning device at girder rear section

### 1.3.3.3 Trolley interlocks limits

- 1) Motor brake limit switch  
The brake is monitored by a brake released limit switch (one normally open contact) and a brake manually released limit switch (one normally closed contact). Under no trolley command from joystick, the trolley motion is inhibited from operating as long as the switch is activated.
- 2) Motor thermal switch  
The trolley motor features an embedded over-temperature switch (one normally closed contact). Actuation of the switch indicates the motor temperature is at fault level and initiates a ramp stop. The trolley motion is inhibited from operating as long as the switch is opened.
- 3) Boom hoist interlocks  
If the boom is not at right position (not fully lowered to level or fully up to stop position), the trolley motion will be disabled
- 4) Cab access gate  
Each of the two gates to the trolley, one on the portal frame and the other located on the trolley, is monitored by a gate closed proximity switch. Actuation of either of the switches indicates the respective gate is not closed well the trolley motion is to be inhibited.
- 5) Trolley rope tensioning limit switches  
This protection consists of four proximity switches, two for each utmost stroke of the rope tensioning cylinders. The trolley motion is inhibited from operation as long as either of them is activated.

### 1.3.3.4 Trolley traveling limits

- 1) Waterside over travel stop  
Controlled by Lever operated limit switch together with the absolute encoder mounted on trolley drum shaft end, actuation any of these limit initiates an emergency stop to boom hoist motor. The “limit back-out bypass” selector switch in the electrical house permits trolley traveling towards landside.
- 2) Waterside normal end stop  
Controlled by proximate limit switch together with the absolute encoder, actuation of this normal working end stop initiates a ramp stop.
- 3) Waterside slowdown check  
Controlled by magnetic inductive limit switch together with the absolute encoder attached on the motor end shaft, actuation of the proximate switch and trolley speed verified not slowdown to set range by the encoder will initiate an emergency stop.(As shown in Figure1-21)



**Figure 1-21:Roller Lever Operated and Magnetic Inductive Limit Switches around Boom Forward End.**

- 4) Waterside smart slowdown

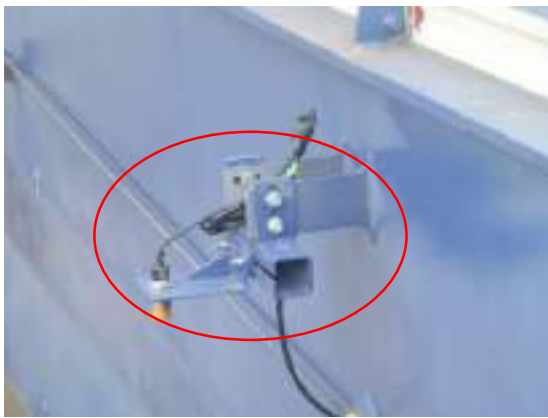
Under the control of the absolute encoder together with PLC software limit, the speed could be set in real-time way and slowdown to the setting value right within the slowdown distance in order to ease the tiredness caused by sudden stop.

- 5) Trolley Encoder Reset  
Actuation of the proximate switch initiates resetting a new position value for the absolute encoder.
- 6) Waterside normal end stop (boom stow position)  
Actuation anyone of the proximate switch together with absolute encoder indicates a ramp stop for the trolley(As shown in Figure 1-22).



**Figure 1-22 Magnetic Inductive Limit Switches nearby Boom Heel end.**

- 7) Park position  
Controlled by proximity switch together with the absolute encoder, actuation of this limit switches indicates trolley at park position and permits boom motions(As shown in Figure 1-23).



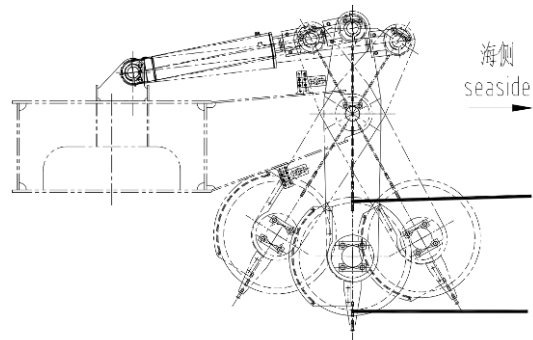
**Figure1-23: Trolley Parking Position Limit Switch**

- 8) Sill beam protection  
Under the control of the absolute encoder, actuation of any sill beam stop initiates a ramp stop in order that the spreader safely crosses over the sill beam.
- 9) Landside smart slowdown  
This is similar to the waterside smart slowdown.

- 10) Landside slowdown check  
This is similar to the waterside slowdown check.
- 11) Landside normal end stop  
This is similar to the waterside normal end stop.
- 12) Landside over travel stop  
This is similar to the waterside over travel stop.


**1.3.3.5 Trolley travel rope tensioner**

Trolley rope tensioners are located at the rear of the girder and apply appropriate tension to the trolley travel ropes by actuating two hydraulic cylinders attached to trolley sheave through the sheave arm. With this function, surging of the trolley due to the loosening of the wire rope during loading or unloading of the container will be minimized(As shown in Figure 1-24).



**Figure 1-24 Trolley Travel Rope Tensioner**

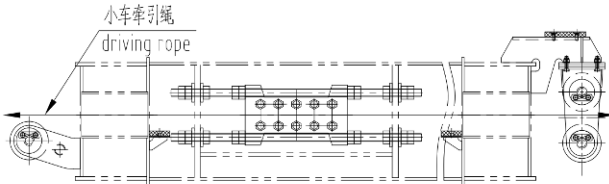
The cylinders are powered by the multi-function power unit with pre-set pressures to the hydraulic cylinders. The rope tensioning cylinders will retract to prevent the ropes from over-tensioning due to the changes of the waterside rope length as the boom rises. The cylinders will extend to keep the ropes under proper tensioning due to new ropes stretch after a period of operation.

	<p><b>In many cases, the wire rope length needs adjustment due to the stretching and slackening of the wire rope, and this variation is difficult to notice especially in continuous catenary roller support system.</b></p>
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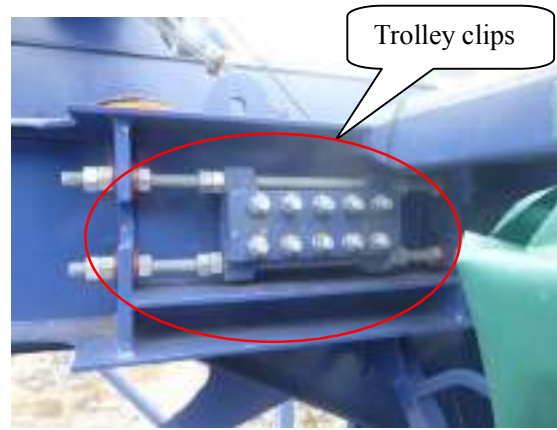
The position of the cylinder is monitored by two proximity switches and actual position is decided by the real presetting pressure / tension force. The desired position of the cylinder is that the sheave arm is almost vertical under the pressure of hydraulic system. The arm may offset from its original position and trolley motion is allowed until either of limit switches is activated. If limit switch tripped and cylinders in normal pressure wire rope length needs to be adjusted.

### 1.3.3.6 Trolley

The function of trolley is carrying spreader and container back and forth, in order to achieve the handling of containers. The movement of the car is achieved through the wire rope. As shown in Figure 1-25、1-26、1-27.



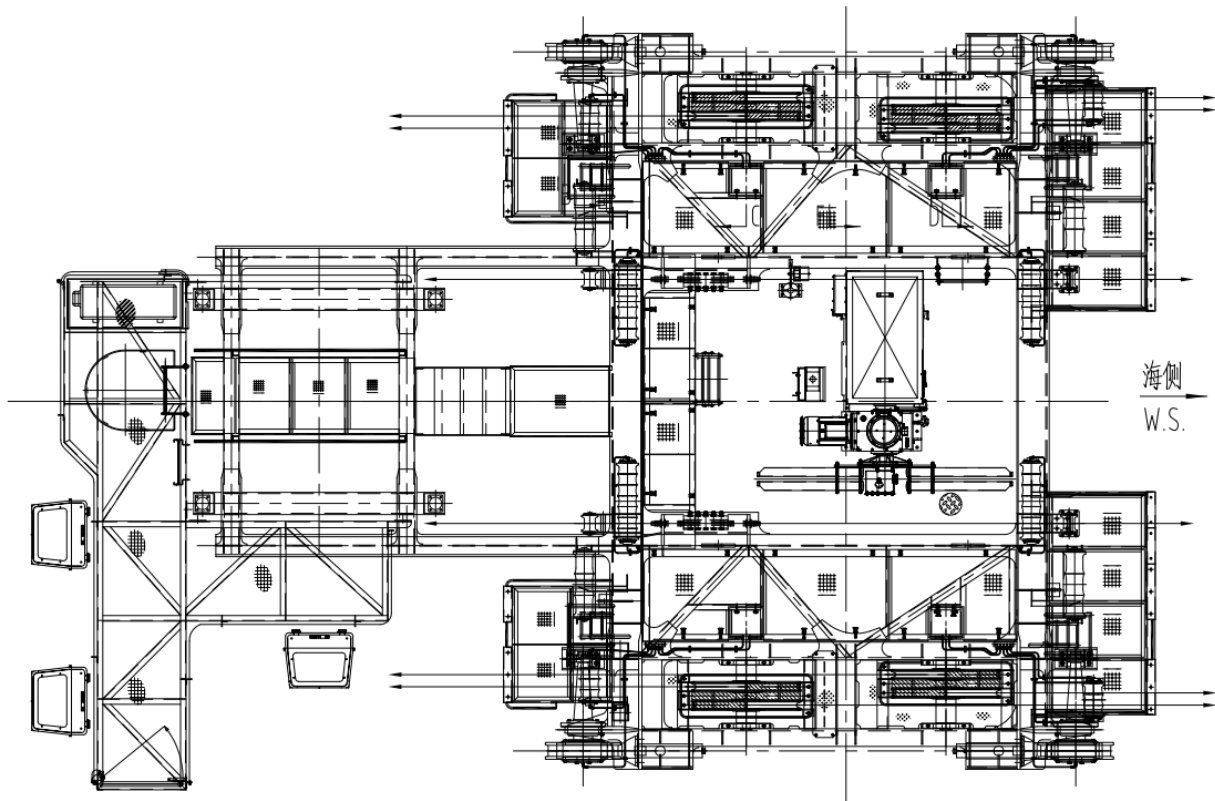
**Figure 1-25 Rope Guide Rollers on Trolley Frame**



**Figure 1-26 Rope Clamp with Adjustable Screw Rod**

Four traveling wheels are on the trolley frame corners. The wheels have anti-friction bearings with split pillow blocks for easy removal. The main hoist rope sheaves are mounted on the trolley frame. They accomplish the rope pickup and diverting.

The trolley frame has four pneumatic-hydraulic buffers at the seaside and the landside to minimize the impact on the end stop in case of an electrical control failure.

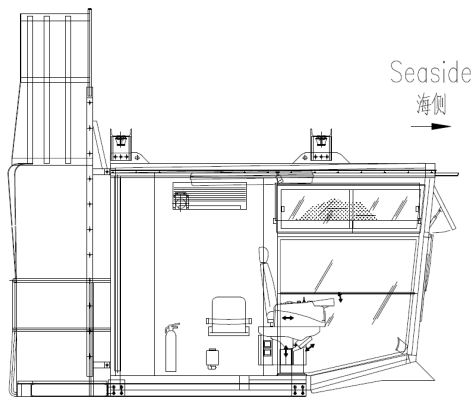


**Figure 1-27 Trolley Assembly Photograph**

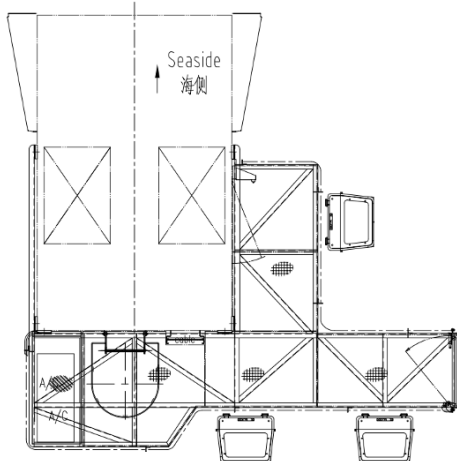
### 1.3.3.7 Operator's cab

The cab is purposefully and ergonomically designed to serve the crane operator. Attention was focused on providing comfort and convenience so that the operators can concentrate on the serious task of handling containers, and not be distracted or encumbered by uncomfortable surroundings.

All primary crane functions can be achieved in the cab. The cab is mounted to the trolley framework on its landside to provide the best possible view during loading or unloading operation.



**Figure 1-28 Operator's Cab Appearance**



**Figure 1-29 In View from Floor Window in Operator's Cab**

A seat with safety belts and shoulder harness, adjustable to accommodate a person's weight, height and distance from the front windows, is positioned so that the operator can reach all control switches comfortably.

All master switches, indicating lights, selector switches, joy sticks, and other control devices have been conveniently arranged on the left and right consoles, the auxiliary panel, twist lock indicating panel along the foot rest, and on the three computer and TV monitors, so the operator can access any of them without leaving your chair (As shown in Figure 1-28 & Figure 1-29).

### 1.3.4 Gantry

#### 1.3.4.1 Gantry travel drive

Gantry traveling devices drive the crane travel along the runway. Half wheels on each corner are driving wheels. Each drive device applies an AC inverter motor driving a wheel. Speed coordination between the two motions is controlled through a pulse tachometer mounted on each far left motor. To prevent the crane from shifting in storm wind (stowed wind), two sets of stowage pins are provided under the seaside and landside sill beams. In addition to motor mounted brakes which brake the driven wheels, hydraulic wheel brakes are mounted at each idler wheel to prevent the crane from moving in wind gusts during the operation (As shown in Figure 1-30 & Figure 1-31).

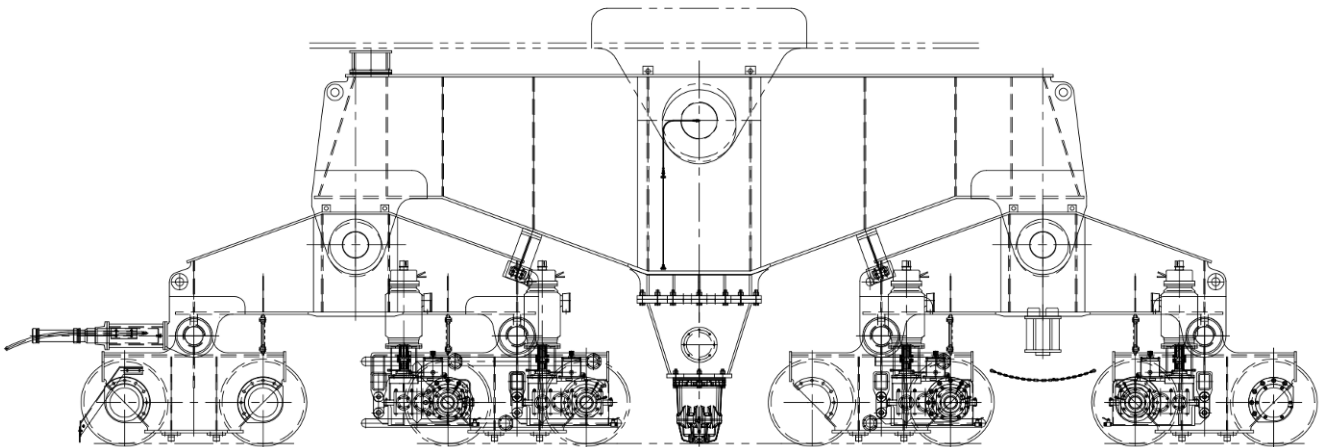
The driving force from the motor is transmitted through the gear coupling and gear reducer to the drive wheel. Travel direction of the gantry can be altered by changing the rotating direction of the motor. A thruster disc brake for each drive unit is provided between the motor and gearbox. The motor brakes are sufficient to stop the gantry. In addition to the motor brake, a wheel brake for each idler wheel is provided. The motor brakes combined with the rail brakes are sufficient to hold the crane at the wind speed 45m/sec. But if the forecasted wind speed is over 45m/sec, the stowage pin and tie down are required to be engaged in proper way. The data of main components refers to Table 1-5.



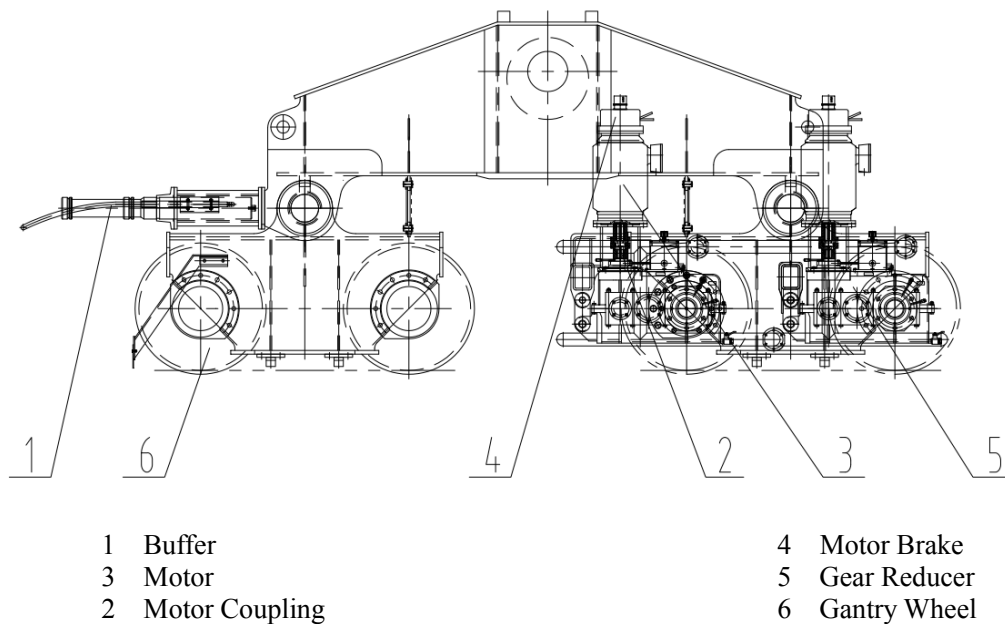
**Table 1-5: Main Data of Major Components for Gantry Travel Drive**

Motor	Type	1LP4-186-4CA91-Z	Rail Brake	Type	RBHS-DT-200-050
	Power	20kw		Clamping Force	222KN
	Rotating speed	1400rpm	Motor Coupling	Type	ML5
	Braking Torque	250Nm		Rated Torque	400Nm
Reducer	Type	TNR430.96.D2A.00	Buffer	Type	23MFZ140-17
	Ratio	95.954		Max Permissible Impact force	700KN
Motor Brake	Type	See motor		Stroke	400mm
	Braking Torque	250Nm		Wheel	Diameter $\Phi 800mm$

**Note:** The braking torque of motor brake must be set according to required set torque on the drawing.



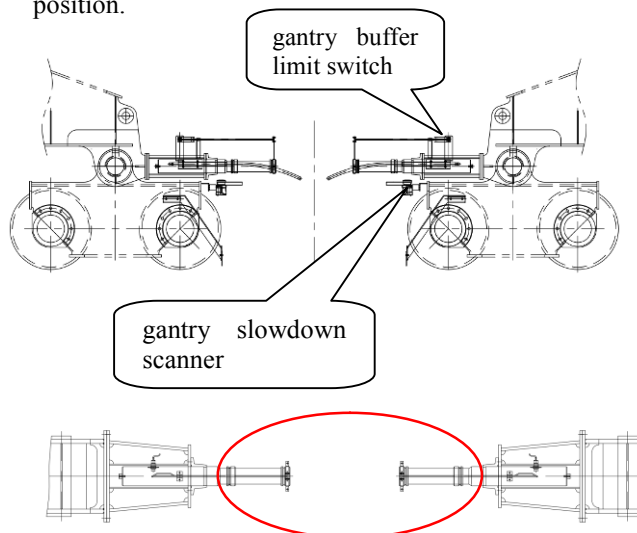
**Figure 1-30: Landside Gantry Full View**



**Figure 0-31: Scheme & Photography of Gantry Drive Unit**

### 1.3.4.2 Interlocks for Gantry Drive

- 1) Motor brake limit switches  
Each one of the 16 motor brakes is monitored by a proximate limit switch.
- 2) Gantry rail brake released check limit switches  
Each one of the 4 rail brakes is monitored by a proximate limit switch provided by Hillmar.
- 3) Gantry stow pins  
Each of the two stow pins on gantry, in both landside and waterside, is monitored and checked whether in released position by a proximity switch. As long as either pin is not in the retracted position, the gantry motion is inhibited from operating.
- 4) Gantry buffer limit switch & gantry slowdown scanner  
Each of the two gantry buffers located at waterside is monitored by a proximity switch. The gantry motion is inhibited from operating and a warning sounded as long as either side buffer is compressed to setting position.



### Gantry Buffer Limit Switches & Gantry Slowdown Scanner

- 5) Motor encoder  
The gantry motor frequency varying as well the speed are monitored and controlled by a pulse Tachometer which is attached on the motor end shaft.
- 6) Anemometer (wind speed) system  
Wind speed and direction monitoring for the gantry drive is provided by anemometer system. The anemometer transducer located on top of the A-frame, for measuring the wind speed and direction, a control module located in the electrical room, and an digital meter located in the operator's cab for displaying wind speed.

### 1.3.4.3 Gantry Maintenance Cab

There is a gantry maintenance cab installed in the Anchor & checker's cabin under the landside sill beam. The cab is provided with electric lock. Only those who have the mechanical key or the electronic key can access this cab. A ground control station and CMS terminal are mounted in this cab. This control station will help to maintain the spreader and stow the crane.

All functions of the spreader can be achieved on this station. The main hoist can be operated with empty spreader only (As shown in Figure 1-33).




Figure 1-33: Gantry Maintenance Cab

## 1.4 Crane safety facilities

### 1.4.1 Crane Stowage Device and Tie-Down Device

It is important and necessary to properly stow the crane safely on the designated site of dock (stowage and tie down pit). If not stowed, there will be a danger in the event of a sudden high wind condition. The motor brake and wheel brake can only guarantee locking the wheel with no rotation but can not prevent the crane from sliding along the rail. Once in motion, a crane can develop momentum and strike another crane or other obstacle and cause serious damage(As shown in Figure 1-34).

Each crane's anchoring device are installed at the centerline under the landside sill beam and seaside sill beam. Anchor plate of the anchor device can be lifted up or down by operating the handle. Lift anchor plate by a pin lock to guarantee not to interfere with the wharf surface of quayside walk properly; anchor plate down to insert embedded parts of the pier pit, to resist wind force along the rail(As shown in Figure 1-35).

	<p><b>No operation is allowed when wind exceeds 19.4m/sec! Crane must be stowed at its stowage position. Crane must be secured in tie-down condition when wind exceeds 40.2m/sec.</b></p>
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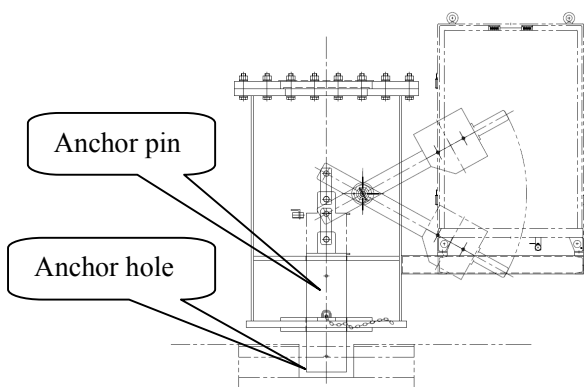


Figure1-34: Anchor Device

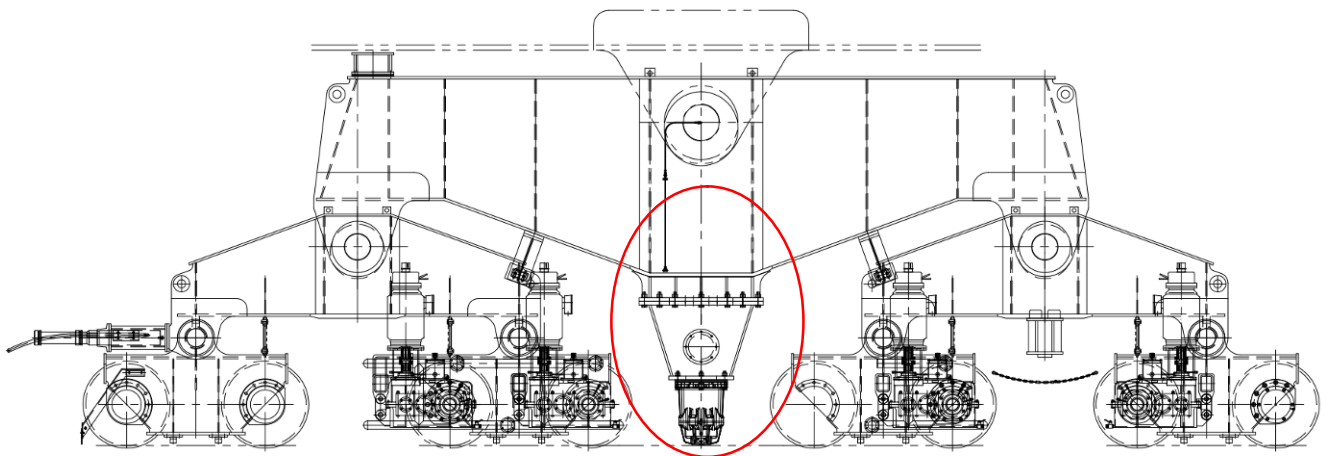


Figure1-35: Gantry Rail Brake Located under Equalizer Beam centered

### 1.4.2 Boom stowage device

This device is for securing the boom when the boom rises to the maintenance position (80°). It consists of two sets of pins and sockets, as shown in Figure 1-36. The pins are stored in the storage sockets under normal operation. The boom motion is inhibited from operation as long as either of the pins is not inside the storage sockets for safety.

The boom motion will ramp stop when the normal stop limit switch is activated. At that time, the latch hole on the boom is aligned with that on the stowage device. Pull pins out of the storage sockets and insert them into the latch hole. Insertion of an anchor pins must be done by manpower.

When trying to lower the boom, the pins must be

inserted back into the storage sockets. Otherwise there is no motion of the boom. There are limit switches to sense

the pins.



**Engaged in Storage Socket ↙**



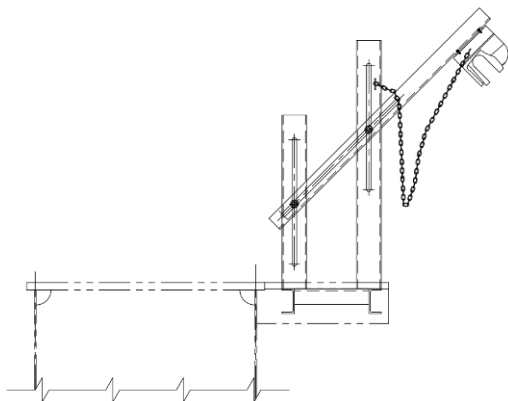
**Disengaged ↑**

**Figure 0-36: Boom Storage Pin Stored**

**1.4.3 Ship collision protection**

A stainless steel trip wire runs down each side of the boom to protect the lowest surface of the boom from contacting the ship structure. A LMS sick scanner switch is located on both sides of the boom. If either limit switch is activated, further travel toward ship will be inhibited and a warning signal will be sounded through the public address (PA) system. But the crane can only move away from the ship until the limit switch is de-activated. A bypass switch in the cab allows the gantry to travel in the detected direction. In this bypass mode, the warning light and the horn will activate.

and top of A-frame is equipped with an obstruction light to flash at night for warning the flying objects avoiding.



**Figure 1-37: Ship Anti-collision Device**

**1.4.4 Obstruction lights**

Each location of boom tip, trolley girder rear end



**Figure 1-38: Obstruction Light**

**1.5 Auxiliary equipments on crane**

**1.5.1 Power cable reel**

A cable reel device rides on the frame link beam to deliver the high voltage power for the crane. As crane traveling, the cable is wound or paid out by the cable reel, which is driven by the gearbox output torque transmitted from the motor through a magnetic hysteresis coupling. A guide roller device above the ground helps to lay the cable in a pit or pick up from it. On the opposite side of gearbox, a high voltage slip rings connected with the output shaft feeds H.V power to the crane(As shown in Figure 1-39).



**Figure 1-39: Power Cable Reel System**

### 1.5.2 Trolley festoon system

This project applies Wampfler chain assembly, please refer to Wampfler maintenance manual for detail.

## 1.6 Maintenance equipment

The maintenance equipments provided on the crane includes service crane inside machinery house, rope re-reeving device, service platform and tool kit, etc.

### 1.6.1 Machinery house service crane

A service crane with 8 tons rated capability is provided in the machinery house (As shown in Figure 1-40). Three motions of hoisting, transverse crossing and longitudinal traveling can cover the whole house. The service crane spans the machinery house and is capable of centering over, lifting and traveling with any component inside the machinery house as well as carrying components between the machinery house and wharf level. In order to position parts accurately, it is furnished with two stage hoisting speeds, one for fast and one for slow.



**Figure 1-40: Service Crane in Machinery House**

### 1.6.2 Service crane outdoors

Type of service cranes are provided outdoors on this crane, jib crane. One jib cranes located on the top of A-frame serve for replacing sheaves. Another on the girder, service crane is supplied to take care of the cylinders, sheaves on rear tie beam as well as the sheaves and wheels on trolley. Some handling tools such as plain trolley and chain blocks need to be put on temporarily while moving components during maintenance (As shown in Figure 1-41 & Figure 1-42).



**Figure 1-41: Jib Crane on the Top of A-frame**



**Figure 1-42: Jib Crane on Girder End**

### 1.6.3 Wire Rope Re-reeving Device

A re-reeving device is mounted over the main hoist drive in the machinery house (As shown in Figure 1-43). It consists of two cable drums including a motorized one equipped with brake device. During re-reeving procedure, the device winds the old rope on its take-up reel tightly and the new wire rope is on the feeder reel. For detailed rope re-reeving procedure, please refer to Chapter 4 of this manual.

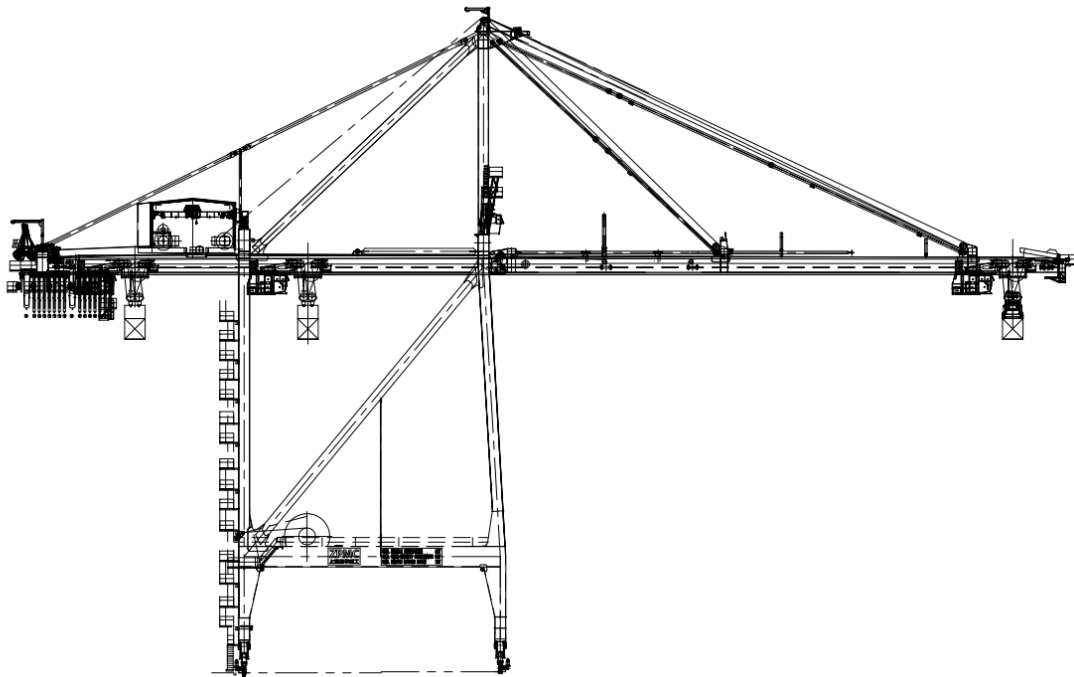


**Figure 1-43: Re-reeving Device Mounted Over the Main Hoist Drive**

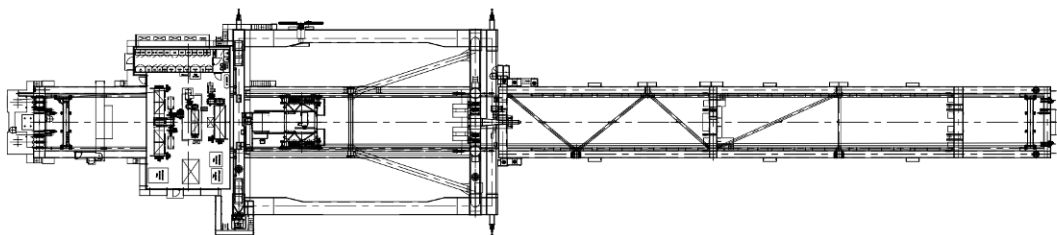
## 1.7 Walkways, access and elevator

### 1.7.1 Walkways and Platform

Each crane access to every part of the crane needing routine inspection or maintenance is provided with stairways, walkways, and ladders. The main access stairway is located on the landside left leg. Rest platforms are provided at various elevations along the stairways which can be used to access the portal tie beam, operator's cab parking position, or machinery house elevation (As shown in Figure 1-44 ; Figure 1-45 ; Figure 1-46 & Figure 1-47).



**Figure 1-44: Side View of Access General Arrangement**



**Figure 1-45: Top View of Access General Arrangement**



**Figure 1-46: Maintenance Platform for Festoon System**



**Figure 1-473: Maintenance Platform for Boom Forestays**

**1.7.2 Elevator**

On the same leg which the main access located at (crane stairway access), a man-carried elevator is installed for up and down. The main data of the elevator refers to Table 1-6 below.. For detailed maintenance instruction, please refer to an independent manual of Shen Yang .(As shown in Figure 1-48;Figure 1-49).

**Table 1-6: Main Data for Elevator**

Rated Capacity	400kg/4persons	Care Size (inside)	1000x1000x2150	
Type	SC40	Car Floor Area	~0.5m square meter	
Voltage	440V	1st Landing Elevation	5.7m	Landside Ladder Access
Frequency	60Hz	2nd Landing Elevation	15.03m	Access to the Portal Tie Beam
Rated Speed	0.6m/s	3rd Landing Elevation	45.153m	Access to the Operator's Cabin
Motor Power	12.7Kw	4th Landing Elevation	50.53m	Access to the Machinery House



**Figure 1-48: Elevator**



**Figure 1-49: Elevator Car**

## 1.8 Handling system

### 1.8.1 Spreader

As a “hand” of the crane, the spreader is the executive part of the crane to handle the containers. The spreader is designed to lift two 20’ containers separated to 1.6 meter, with 51 tons capacity in single 40’ mode and 65 (2x32.5) tons in twin operation(As shown in Figure 1-50).

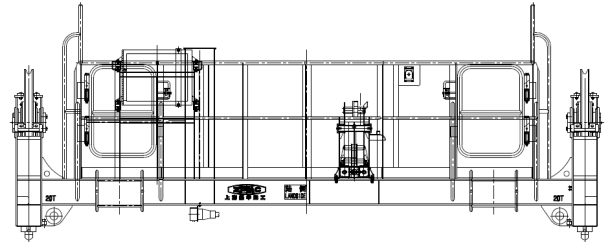


**Figure 1-50: Spreader**

### 1.8.2 Headblock

Four hoist sheaves mounted on the each corner of the headblock frame are the links between the hoist rope reeving system and the spreader and permanently reeved into the crane. It is a structural part of the crane and designed for specified crane capacity. The head block is

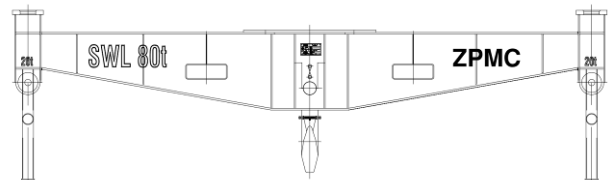
furnished with pins (twist locks or horizontal pins) for connecting to the spreader or the cargo beam. The engagement or disengagement of the pins is monitored by proximity switches (As shown in Figure 1-51).



**Figure 1-51: Headblock.**

### 1.8.3 Cargo beam

The Cargo beam of 80 tons rated capacity is designed to handle non-containerized loads (As shown in Figure 1-52).



**Figure 1-52: Cargo Beam**



## Chapter 2 Crane maintenance instructions

### 2.1 General

**Crane Maintenance** is composed of **Inspection, Routine Maintenance** and **Repair**. This Chapter basically expands upon the operating maintenance and routine inspection of the crane.

The inspection and routine maintenance is used to check whether the crane is in a safe state and to place the crane into a condition where a high confidence of reliable operation can be developed. The main work of the inspection and routine maintenance includes cleanliness, lubrication, fasteners and connections, spot-check and periodic inspection.

It is basically a visual inspection and some functional/detective tests. If, in doing so, an adequate assessment is not possible, a disassembly of crane parts has to be undertaken to get access to the hidden parts. Chapter 3 “The repair Instructions” will illustrate crane repair procedures in detail on components which need disassembly and disengagement.

The cautions and instructions about inspection and maintenance are outlined, aiming at giving a general idea on how to carry out an inspection and a routine maintenance.

Inspection of cleanliness

Inspection of fasteners and connections

Inspection of concentricity (alignment) periodically

Inspection of lubrication

Inspection and preventive actions

In addition to this maintenance manual, all subcontractors have manuals for their own components. To maintain such components, please refer to their manuals. The list of these manuals is in Table 2-1 as follows.

### 2.2 Cautions and safety notes

	<p><b>For repairing parts or replacing components safely, maintenance persons must follow the description in this manual and manuals it has mentioned. The relevant sections of this manual are to be studied carefully before every maintenance or repair.</b></p>
--	---

Before starting any maintenance or repair job, this

section should be read thoroughly and carefully in order to get clear general ideas on maintenance safety and instructions. Safety is always a first priority in any maintenance operation. When a crane is under maintenance, some of its parts may be disassembled or unstable, thus special attention should be paid. Operators and maintenance personnel should be familiar with the crane’s features. Before operating or maintaining the crane, maintenance and operation instructions have to be read carefully and understood by all maintenance and repair personnel. The crane should be put into operation only by authorized and trained specialists. Follow local safety laws and codes issued by the related authorities (i.e. Cal/OSHA, City of Long Beach, Pacific Coast Marine Safety Code, PCMSC, and others applicable). Safety requirements mentioned in this manual, as well as special safety cautions on the maintenance tasks are all valid.

	<p><b>Always read this manual thoroughly before operating, inspecting and maintaining the cranes. Before commencement of service work, the container crane must always be made free of load, set to maintenance position and in a LOCKOUT/TAGOUT condition on effected systems if no other note is given.</b></p>
	<p><b>Refrain from any working method that may inhibit safety!</b></p>
	<p><b>Danger of falling!</b></p>
	<p><b>Danger of tripping!</b></p>
	<p><b>Keep hands and body clear of moving or rotating parts!</b></p>
	<p><b>Wear protective clothing!</b></p>
	<p><b>Hazardous voltage!</b></p>
	<p><b>Keep away from suspended loads!</b></p>

The following are the safety instructions in maintenance:

### 2.2.1 Safety rules of operation

- 1) Follow the safety laws and codes issued by local government. Safety requirements mentioned by the user, manufacturer and fittings supplier of auxiliary materials are all valid.
- 2) Only qualified, trained, and designated personnel may carry out the repairs and maintenance on the crane.
- 3) The crane should be set to maintenance mode and safety methods should be adopted for such tasks.
- 4) Use safety harnesses and other safety gears as needed when working where you do not have a safe working platform and handrails to protect you. It is a good practice to work as a team of at least two persons when engaging in maintenance and repair work where there is potential danger.
- 5) Where inspections or work is being performed during the mechanism motion or rotation, enough spotters must be present watching each worker and ready to depress an Emergency Stop. Radios should be used to maintain communications with the operator. When a person stands on the trolley during maintenance, he must wear safety harness, and install safety chains near the rope inspection platform. When the trolley requires moving during the maintenance or inspection, even at a very slow speed, the person on the trolley must stay within designated platforms/hand-railing and pay special attention to any potential crush hazard.
- 6) Secure the repair area by closing a wider area and set striking signs and symbols about safety warning to prevent other idle person from entering.
- 7) During maintenance on the crane, be sure to close hatches on the machinery house and other places, or to protect them with fences. Where inspections or work is being performed without designated platforms/hand-railing, safety harness and other safety equipment should be used.
- 8) When handling parts from the hatches on the floor in the machinery house, install protection around the hatch with its fenders before opening it.
- 9) Conductive parts must be switched off and secured against reactivation.
- 10) Provide absorbing devices for leaking operating materials.
- 11) Wear protective clothing(oil and petrol-resistant gloves, protective clothing, eye goggle, helmet, protective footwear)
- 12) Handle operating and cleaning detergents and solvents cautiously.
- 13) Provide a safe and environmentally friendly release, storage and disposal of operating and auxiliary materials.
- 14) Do not use machine parts as climbing aids.
- 15) Reinstall and test safety devices (which have been disassembled during maintenance or test and repair work) immediately after the end of maintenance and repair work.
- 16) Inform the operating personnel before the commencement of special or maintenance work.
- 17) Tighten screw joints which were loosened during test and maintenance work correctly.
- 18) Replace fastening elements and seals (e.g. self-securing nuts, washers, split pins, O-rings and seals) which cannot be used again.

### 2.2.2 Safety Rules During repairing or maintenance

- 1) If hands will be on rope for inspection, lubrication or for any reason, they must be rope traveling away from pinch point.
- 2) The maintenance persons should pay particular attention to the moving/rotating parts.
- 3) An additional person is needed to act as a

### 2.2.3 Safety Rules after Maintenance / Repair Work

- 1) Update fault log and maintenance check list. The responsible maintenance personnel must make also assure that the occurred faults are logged and eliminated.
- 2) Put away tools, foreign parts and operating materials left lying around.
- 3) The cranes have been provided with non-slip grating walking surfaces where possible. Many of these walking surfaces are more than 40m high at the cab and machinery house elevation. An object, which falls from such a height to the ground, is traveling at high speeds that can cause serious injury or even death if it strikes a person on the ground. It is everyone's duty and responsibility to pick up any object or debris found on the crane to avoid accidents.
- 4) Test running and functional check of the components and safety devices. A functional test has to be carried out before starting operation and service again.

## 2.3 Cleanliness

The dust, oil dirt, water, impurity interfusing into the lubricant, rust and etc. may erode, speedup abrasion and depress even destroy partial original performance like reduce the braking moment, bring the electrical system short circuit or other malfunction, infect the leak-proofness of the hydraulic system and even destroy the hydraulic parts and bring severe result like system malfunction. Cleanliness is not only to keep a friendly environment but also to keep the machine super performance and prolong its lifetime. So in the routine maintenance the impassive contamination to the parts and equipments should be timely removed and keep the equipment leak tightness, without dust and oil dirt. The following are the routine methods and typical examples to keep the crane clean.

### 2.3.1 Major methods of cleanliness

#### 2.3.1.1 Dry cleaning

“Dry cleaning” used here means adopting physical methods to remove the contamination from the surface without water or solvent. Shown in figure 2-1, the main methods including:

- 1) The cleaner can directly remove the dust and small dirt from the body surface. To create a clean environment and improve the service life and stability of equipment, the place where mechanical and electric equipments concentrate like machinery house, electric house and cab should be cleaned periodically.
- 2) Air compressor and air blower can directly remove the powder, iron chipping and other waste falling off from body surface easily. Its

application including: cleanness of the faying face of the precision components such as bearing and deadeye, and wiping off dust from the surface of complicated shape part, electric element and other elements.

#### 3) Cleaning by machining:

- a. Use wire brush or electric polisher with copper brush. This method can remove the flotation rust or metal surface treatment before repairing paint.
- b. Cleanness by finish machining such as turning or grinding. This method only is adopted in renovating the defective surface such as bulge or sunken in the brake disc, brake lining and so on.

#### 2.3.1.2 Using cleanser

The cleanser is needed when the oil dirt on the surface is difficult to remove. In choosing the cleanser, advert to the problem that the solvent or cleanser based on halogenated hydrocarbon like trichloroethylene and dichloromethane will bring chemical reaction (injecting little water into the trichloroethylene, hydrochloric acid will generate) with the aluminum part, austenitic steel and galvanized part, and the part will be oxygenized. On extreme condition, such reaction will bring explosion. So the solvent or cleanser based on halogenated hydrocarbon shouldn't be used when cleaning the metal parts of the crane. In addition, the acid and alkali liquor shouldn't be used to clean the mental parts of the crane either, or it will destroy the parts directly. To cope with the common dirt, such cleanser as general gasoline bought in the market and industrial benzene can be used. As for the dogged dirt, use the cleanser such as dimethyl benzene.



Figure 2-1: Routine dry cleaning method



**Attention:** Necessary protective equipments such as the goggles, gauntlet and costume should be worn to prohibit hurting to the body by powder, scrap iron and even the cold wind.



**Attention:** Some cleansers such as methylbenzene, dimethyle benzene, acetone, and trichloroethylene are poisonous. The related instruction book should be read carefully before using it.

### 2.3.2 Main cleaning work

The following are some typical examples of cleanliness:

#### 2.3.2.1 Cleanliness of common parts

- 1) Braking disc (braking wheel) and the brake lining (braking shoe) must be kept clean on the surface **at all times**. No oil dirt, dust and rust, convex block, burr and painting coat will be permitted. Every rotating pin shaft of brake should be kept clean and free in rotation. No paint contamination and rust will be permitted (shown as Figure 2-2).



**Figure 2-2: Oil dirt and rust on the brake disc must be removed**

- 2) The cooling fan filter of the motor should be kept clean and properly ventilated (shown as Figure 2-3). As to the DC motor, the commutator should be kept clean.



**Figure 2-3: Fan and fan filter**

- 3) The internal of gear reducers should be kept clean. The bottom of the housing must be cleaned when oil is replaced.
- 4) The trolley running rail surface as well as both

sides of rail should be clean.

- 5) The gantry running rail surface as well as both sides of rail should be clean, and no foreign matter is permitted.
- 6) The elevator guiding rail should be clean. No foreign matter is permitted.
- 7) The position easy to be corroded by seawater should be cleaned periodically.
- 8) All glass in the operator's cab, main control room and boom control room should be cleaned frequently to ensure a good view for the operators (as Figure 2-4).
- 9) Indication lights should be cleaned if there are powder dust and other contamination to ensure that the operators and maintenance personnel can identify colorful lights clearly.
- 10) All rear mirrors should be kept clean.



**Figure 2-4: Operator's cab**

- 11) Remove excess grease and oil resulting from lubrication of the crane components, both as part of the lubricating activity and following a short period of operation.
- 12) The parts should be cleaned before reassembling.

#### 2.3.2.2 Cleanliness of the electric elements and system

- 1) Powder dust should be cleaned periodically for the high-voltage transformer to avoid leakage.
- 2) The electric control room should be kept clean. Doors and windows should be closed, and powder dust inside control panels and other places should be cleaned by vacuum cleaner. Pressure fan should be operated at all times.
- 3) Using dust collector to clean the place easy to

sorb dust like the controlling panels and computer screens in the electric and CMS house (as Figure 2-5).



**Figure 2-5: PLC controlling panel**

### 2.3.2.3 Cleanliness of the hydraulic system

Clean oil is the life of the hydraulic system. If impurity trespass the small damping holes or the gap in the precision component, the component will be pulled damaged and the oil roads will be jammed, which will bring danger to the safety running of the hydraulic system. Generally the impurity inbreak methods include: unclean hydraulic oil, unclean oil filling tools, carelessness in filling oil and maintenance, impurity slipping from hydraulic elements and air or water entered into the hydraulic system.

#### A. The way to prohibit the impurity from inbreak

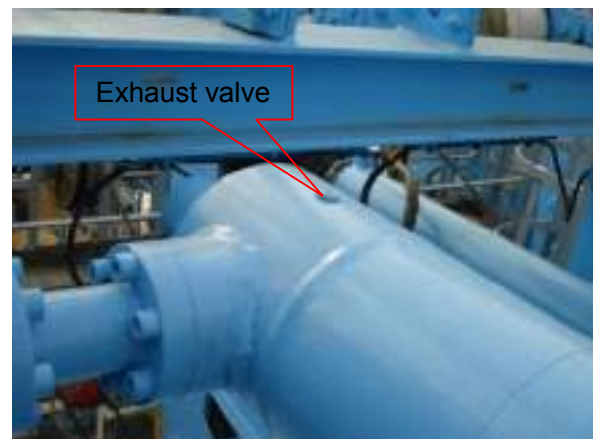
- 1) Before fill oil, the hydraulic oil should be filtered, the oil filling tools should be clean and the filter placed at the entry of the oil tank should not to be removed in order to speed up filling. To prohibit the solid or fibre impurity from inbreak, the oiler should keep the glove and clothing clean.
- 2) In maintenance when the oil filling cover, the filter cover, inspecting holes or the oil pipe is taken down, keep way from the flying dust. The cover of the oil tank can not be opened until the dirt around the tank cover has been removed and the impurity at the connection place has also been removed after loosening the bolts (to refrain the water from infiltration, the water can not be used to clean the impurity). Choose the cleaning materials without fibre impurity dropping off and hammer with rubber beating surface if they have to be used. Hydraulic elements and hoses should be cleaned and blow dry before assembling. The filter also should be cleaned when oil changes.
- 3) The type of cleaning oil should be the same as

that of the system, the oil temperature should be kept between 45 ~ 80°C. In order to completely remove the impurity in the system, keep cleaning oil flow in large capacity. Hydraulic system should be cleaned over three times and after each cleaning the cleaning oil used should be sent out completely before it cool down. Before—fill new oil, the filter should be cleaned and new filter element should be adopted.

#### B. Keep the air out of the hydraulic system

The entrained air in the hydraulics will cause elements cavitation erosion, make the compressibility increased and the operation instability, reduce the work efficiency and make the actuator “crawl”. In addition, the air will also make the oil oxidation and speeding up its metamorphism. To keep the air out of the hydraulics the following list should be paid attention to:

- 1) Random check should be conducted after maintenance and changing oil, and then begin normal work. As shown in the Figure 2-6 is the exhaust valve of the snag –protection cylinder used in the girder.



**Figure 2-6: Exhaust valve of the snag –protection cylinder used in the girder.**

- 2) The mouth of the inlet pipe in the pump can not come out of the oil lever and keep the inlet pipe being well sealed.
- 3) To keep well obturation for the driving axis of the lubropump, oil seal certified commended by the supplier should be adopted and ensure the function of airproof and oil proofing

#### C. Prevent water penetration into hydraulics

If the oil contains excessive water, that will make the hydraulic elements corroded, the oil emulsified and metamorphosed, the tenacity of lubricating film reduced and abrasion speedup up. If the water in the oil is super standard, the hydraulics needs to be clean thoroughly and

the oil should be replaced.

#### D. Inspection of the filter element

Filter is the cleaning equipment used in the hydraulic system. As shown in Figure 2-7 is the filter of the hydraulic power package located on the girder. Inspect the squalidity degree of the filter and the characters of the impurity on the filter element to provide evidence for further fault diagnosis.



**Figure 2-7: Filter of the hydraulic power package located on the girder**

## 2.4 Fastening

### 2.4.1 Grade of fasteners

Although all bolts used on the crane are based on Chinese standard, the Chinese standard for bolts is same as the ISO standard. The bolts are also equal to the American metric bolts in specification and have parallelism relation in grade. So it is very easy to find suitable bolts for replacement. TABLE 2-1 is another comparison table for bolt grade in different standards. The strength grade is usually marked in the head and end of the bolt (shown in Figure 2-8). Bolts used in the crane are usually greater than or equal to grade 8.8, so less bolts can not to be used in the maintenances.

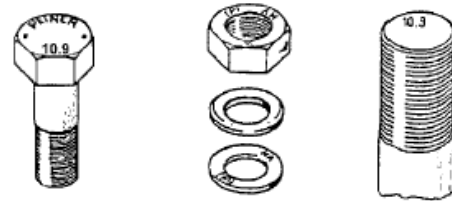
It must to be noted that the grade classification as mentioned above is suited for the bolts with the material carbon or alloy steel, and it is different from the stainless-steel bolts. Detail information please refers to other related data. Generally stainless-steel bolts with grade A2-70, nuts and washers are used when the bolts are less than M14 in the crane, so the same grade bolts shall be used in maintenances.

**Table 2-1: SAE Grade and ISO Grade**

ISO898-1 Bolt	SAE J429 Bolt	ISO898-2 Bolt	SAE J995 Bolt
Grade 4.8	Grade 1	4	
Grade 5.8	Grade 2	5	Grade 2
Grade 6.8		6	

Grade 8.8	Grade 5	8	Grade 5
Grade 9.8		9	
Grade 10.9	Grade 8	10	Grade 8

Fasteners used for metal structures should be ISO Grade 8.8 and 10.9 (ASTM A325 or ASTM A490) high-strength bolts. The bolt head and nut are usually bigger than the common ones and the matched bolt, nut and two washers are supplied as a complete set (shown in Figure 2-8, a set of bolt connection with grade 10.9). There are firm requirements on the bolt application, and only some simple knowledge is offered in this chapter, for more detail information please refer to the related criterion. As for the bolts ASTM A325 and ASTM A490, the 《Specification for structural joints using ASTM A325 or A490 bolts》 written by AISC can be referred to. Pretightening torque is required for many bolts and it is realized by using a calibrated torque wrench. As listed in Figure 2-9 are some typical torque wrenches.



**Figure 2-8: 10.9 Grade fastener for structure**



Hand torque wrench



Hydraulic torque wrench



Electric torque wrench

**Figure 2-9: Typical torque wrench**

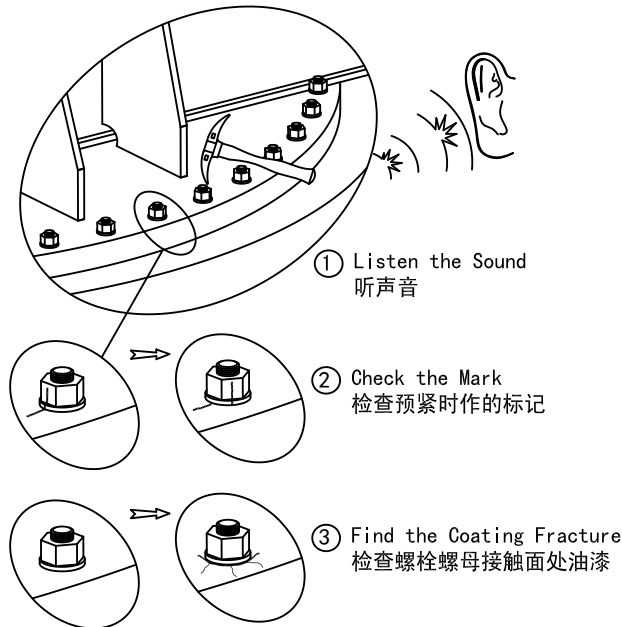
### 2.4.2 Inspection of bolts

For cyclic loading in working the bolts may be loosened. In order to reduce stress amplitude, the bolts shall be pretightened to set value. Periodic inspection is

aimed to insure the bolts loaded uniformly. Replace the bolts having yield and been lengthened or the deficiency-worried ones. Specification should be carried out during the downtime of the crane. There are two methods about the fastener specification: visual check and using wrest wrench, and visual check is mostly used.

### 2.4.2.1 . Visual check

Using the following methods to visually checking, refer to the Figure 2-10:



**Figure 2-10: Methods of Finding a Loosened Bolt**

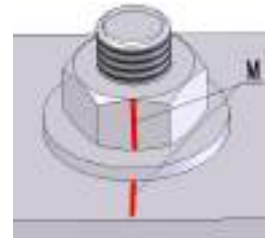
- 1) The sound of a pointed hammer hitting the head of a bolt can indicate the looseness /tightness of the bolt.
- 2) The position between the nut and the connecting part should be visually checked (during the fabrication in the ZPMC's facility, the positions between some critical nuts and connecting parts will be marked out with a marking pen). If the marking positions are deviated, it indicates that the bolts are loose.
- 3) The paint film of nuts and connecting parts can also be visually inspected. If the paint film has fracture, the bolts should be inspected.

### 2.4.2.2 Use the torque spanner

**A. Common fasteners (excluding the Fasteners used for metal structures)**

- 1) Before inspection, the crane should be off working and make the bolts idly without working stress.
- 2) If needed, remove all the dirt and paint on the fasteners. Spray a thin layer of oil-lubricant rust remover (CRC or other equate product) on the nut and washer. The lubricant rust remover is functioned after 10~20 minutes.

- 3) Mark the original location by a marking pen on the nut and on the joint surface of the structure and the washer (shown at Figure 2-11 ).



**Figure 2-11: Marked bolt**

- 4) An initial tension of 75% of the final tension shall be developed. Then the final tension shall be developed.
- 5) Check the nut: if the nut can be turned, make it out by a marking pen or painting and refasten or replace it later on.
- 6) If needed, the bolt joint should be replaced.
- 7) Repeat the process 3)-6) to inspect the other bolt joints.
- 8) The rotating nut should be refastened after the loosening the bolt and according to the methods mentioned in the section 2.4.3.3-A
- 9) The non-rotating nut should be refastened according to 10) ~11) step by step.
- 10) Turn the nut about 30° by a torque spanner to loosen the nut.
- 11) Refasten the nut to its pretightening torque requirement.
- 12) Remove all the dirt and use the proper solvent to clean bolts, nuts, washer and places around the joint surface of the structure, and then repair the damaged paints according to paint repairing process.

**B. Fasteners structures ( take the flanged connection as an example )**

- 1) Before inspection, make the crane under stopped state and make the bolts idly without working stress (without loading).
- 2) If needed, remove all the dirt and paint on the fasteners. Spray a thin layer of oil-lubricant rust remover (CRC or other equate product) on the nut and washer. The lubricant rust remover is functioned after 10~20 minutes.
- 3) Use a marking pen to mark out the original position on the nut and the surface between the



connection part and the washer (shown in the Figure 2-11 ).

- 4) An initial tension of 75% of the final tension shall be developed by a marked torque wrench.
- 5) Check the nut: if the nut can be turned, make it out by a marking pen or painting and refasten or replace it later on.
- 6) Repeat the process 3)-6) to inspect the other bolt joints.
- 7) Account all the nuts that marked rotation and should be replaced.
- 8) If the account of the bolts marked to be replaced exceeds 20%, use the same grade bolts to replace them according to the process mentioned in the section 2.4.3.3-B.
- 9) If the account of the bolts marked to be replaced under 20%, replace all the marked bolts and the bolts on both sides, and refer to the process in the section 2.4.3.3-B.
- 10) The non-rotating nuts should be refastened according to 11) ~13) step by step.
- 11) Turn the nut about 30° by a torque spanner to loosen the nut.
- 12) Refasten the nut to its pretightening torque requirement.
- 13) Use proper solvent to clean the bolt, nut, washer and the joint surface of the structure. Then repair the paint according to the “paint repair process” mentioned in the appendix A.

#### 2.4.2.3 Inspection period for the fasteners

**Table 2-2: Inspection Period for the Fasteners**

Inspection Type	Inspection Period (before the first maintenance) *	Inspection Period (after the first maintenance) *
Visually check	Per 3 months (except special sites)	Per 6 months (except special sites)
Use torque spanner	10% spot-checked (the sixth month or 50000 <sup>th</sup> hour in work circulation)	the 5th, 15th, 25th, 30th, 35 <sup>th</sup> year
Replace fasteners	If needed	If needed

\* The first maintenance here gives priority to the first expiration of the 6<sup>th</sup> month and 50000<sup>th</sup> hour in work circulation.

After the crane is put into operation for six months or 50000 hours work circulations, the tightness of bolts should be checked according to Table 2-2. Because the bolts are easy to be loosened in the primary stage, so an all-around inspection should be carried out. High-strength bolts should be spot-checked by 10% for each group. If any one bolt is found loose, all bolts within this group should be thoroughly checked. In addition, the bolts bearing vibrating or varying load and the effective anti-loosening methods have not been adopted, the inspection period should be shortened to avoid accidents. Electrical wiring and connecting bolts of small electrical parts, such as bar wiring connection in control panels, motor wiring, junction box wiring, various kinds of limit switches, encoders and cam limit switches (inside and outside), usually have smaller area and size. Impact and vibration during the operation of the crane may cause the bolts to loosen. Once the bolts are loose, the electrical control will fail. Therefore, the inspection of fastening condition for this kind of bolts must be carried out, and the wiring condition should be inspected periodically.

### 2.4.3 Process for bolt's replacement and tightening

#### 2.4.3.1 Replacement standard

The bolts under the following condition should be replaced:

- 1) The bolts required to be replaced mentioned in the above section.
- 2) The bolts with such defects like impairment, distortion, slide tooth, lacking tooth, corrosion, big change of the screw roughness and so on.
- 3) If the bolts following out the standard GB1228、GB1229、GB1230 ASTM325 and ASTM490 are hot dipped galvanizing, they are not allowed to be used repeatedly, and should be replaced once loosened after being final tightened. According to the standard AISC only the bolts by black finished can be used again with engineer's permission. In addition, when the adjacent bolts are loosened by tightening bolts, they are not needed to be replaced.

#### 2.4.3.2 Tightening torque for the bolts

As listed in the table 2-5 is the tightening torque for the bolts, studs and screws. if no special requirement, the data in the table can be used directly. Pretightening torque  $M_0 = K \cdot F_0 \cdot d$  ( $K$  is the torque factor,  $F_0$  is the pretightening force and  $d$  is the bolt diameter). The friction factor of the nut and washer, the nut and bolt changes will cause the torque factor change correspondingly, so even when the required pretightening force is unchanged, but the torque factor is changing.



Generally under dry connection, the torque factor  $K=0.145$ , if a little lubricant or MoS<sub>2</sub> is filled,  $K=0.12$ . For the important connection, the torque factor is got by spot-check of the each bolt or that of the same connection

and measuring through experiments. Before finishing tightening the fact torque factor of all the high-strength bolts or other similar connection should be measured.

**Table 2-3: Tightening Torque of Stainless Steel Bolts with Small Size (Grade A2-70)**

Size	M5	M6	M8	M10	M12	M14
Tightening torque (Nm)	3.2	5.5	13	26	46	74

**Table 2-4: Tightening Torque of Major Bolts**

Note : \* = without lubrication

 \*\* = with a little lubricant or MoS<sub>2</sub> lubrication

Size	Tightening torque (Nm)				Tightening force (N)	
	8.8s <sup>*</sup>	Grade 8.8s <sup>**</sup>	10.9s <sup>*</sup>	10.9s <sup>**</sup>	8.8s	10.9s
M 12	66	54	92	76	37766	53109
M 14	105	87	147	122	51520	72450
M 16	163	135	229	190	70336	98910
M 18	225	186	316	261	86016	120960
M 20	318	263	448	370	109760	154350
M 22	433	358	609	504	135744	190890
M 24	550	455	774	640	158144	222390
M 27	805	666	1132	937	205632	289170
M 30	1093	905	1537	1272	251328	353430
M 33	1488	1231	2092	1731	310912	437220
M 36	1911	1581	2687	2224	366016	514710
M 39	2473	2046	3477	2878	437248	614880
M 42	2851	2360	4009	3318	468168	658362
M 45	3818	3160	5369	4443	585109	822809
M 48	4593	3801	6459	5346	659973	928087
M 52	5937	4913	8349	6909	787401	1107282



The torque listed in the table is only suit for the connection surface without special requirements. The bolts in such connection are only bearing pretightening force, and the working force is vertical to the bolts and transferred through the friction from the connection surface. For those bolts bearing not only the pretightening force but also the working force, for example the bolts used in the bearing pedestal and the motor base, the pretightening force should be recalculated (the tightening torque is often less than the one listed in the table), please refer to the related drawing.

### 2.4.3.3 Bolt fastening and replacing process

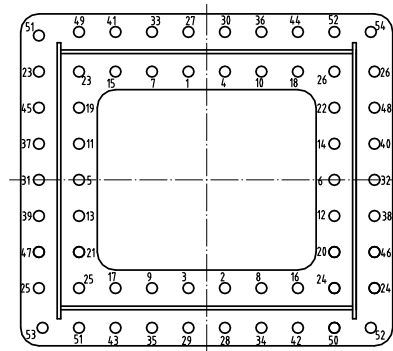
#### A. Fastening process of the general bolts (excluding the high strength bolts for structure) during the first installation or replacement.

- 1) Ensure the washer be planished and clean without oil dirt and burr.
- 2) Clean the connecting surface of the structure and washer and ensure the surface be smooth.
- 3) Clean the bolts and nuts.
- 4) Set well the washer and ensure the inclined plane touch the bolt head or the nut.
- 5) An initial tension of 75% of the final tension
- 6) Finally fasten the bolts to 100% required torque. The fastening order is similar to the first one. Generally use two kinds of color to distinguish the first and final fastening.

shall be developed. To ensure the flange bolts load equally, fasten the bolts in the order from the rigid joint to free end or from the center of the bolt group to around. If the connection steel plate warps and the connecting bolts are fastened from the two ends to the middle, the middle of splice plate may plump up and can not keep closely which will make friction forces lose partly. For detailed fastening process refer to figure 2-12. Make marks on the large hexagon head and high strength bolts to identify their first fastening to avoid missing.

**B. Replacement of the high strength bolts for structure (flange connection)**

- 1) To ensure the same torque factor, the bolts replaced one time should be the same batch products.
- 2) Ensure the bolts be enough in quantity, have the correct strength degree and tightening torque. Revise the torque wrench repetitiously before using.
- 3) Ensure the washer be planished and clean without oil dirt and burr.
- 4) Clean the joint surface of the structure and washer and ensure the surface be smooth.
- 5) Clean the bolts and nuts.
- 6) Use a new bolt to replace the old one which marked to be replaced and an initial tension of 75% of the final tension shall be developed immediately. Ensure the bolts to be replaced and fastened one by one.
- 7) The old bolts being taken down should be destroyed purposely to prevent from using again.
- 8) After all the bolts being replaced, the final tension shall be taken to all the new bolts in the order shown in figure 2-12.



**figure 2-12: Fastening order of the flange bolts**

**2.4.4 Anti-loosing methods for bolts**

It is very important to adopt some methods to prevent bolts from losing. If the bolts are loosened, the structure strength will be reduced and the downfallen bolts will bring danger to persons. Table 2-5 lists the main anti-loosening methods for the bolts used on the container crane.

**2.4.5 Pin connection**

Pins shall be well greased prior to each installation. After the installation, this process is to be repeated at all accessible spots of the pin.

**Table 2-5: Anti-loosening methods of the bolts used on the container crane**

METHODS	Instruction /application	Figure for example
using anti-loosing glue	The anti-loosing glue is often used in the fields with limited place, for example used on the fixing bolts of the anti-abrasion block for the wire rope.	
Lock washer and Fastening with wire rope	Both of these methods are comparatively reliable and have been widely used. Such methods are commended to be used in the fields without space restriction for example on the running or moving parts like braking disk, sheave and so on to prevent it from falling or flying off when the bolts are loosened.	<div style="display: flex; align-items: center;"> <span>Correct</span> </div> <div style="display: flex; align-items: center;"> <span>Wrong</span> </div>
Nylon anti-loosing nut	Nylon anti-loosing nut is the most widely used and it is reliable to anti-loose when matching with bolts.	
SPL nut	SPL nut has a strict requirement on the retightening torque and the nuts can be reused.	
Double nuts	Double nuts are not used commonly on the crane for inconvenience.	

METHODS	Instruction /application	Figure for example
Spring washer or anti-loosing washer	Spring washer is not very reliable and usually generates yellow water when used outdoors. Usually they are not used in ZPMC'S crane. But in some outsourcing or unimportant parts the stainless steel washers are still used.	

## 2.5 Lubrication

### 2.5.1 Summarization



**Attention: All used oil and grease must be collected and disposed properly!**

Lubrication is a very important maintenance task. It will determine the normal service and endurance life of the components. Proper lubrication practice will help to avoid premature wear and extend the endurance life of the components. Lack of lubrication will destroy the components. For example, if an anti-friction bearing is short of lubrication, it will be damaged in a very short time. It is very important to monitor the temperature and

sound level of the components to determine whether the components get enough lubrication. The lubrication of wire rope will be described in Chapter 4.

### 2.5.2 Lubricant

For well effect of lubrication, the type of lubricants must be selected properly. Consistency should be maintained on lubricants. Do not mix up different lubricants together. If the lubricant supplier, type or grade is changed, launder the bearing, reducer, pin, and other devices thoroughly to remove the previous lubricant. If different lubricants are mixed together, please contact the lubricants supplier.

The lubricants and grease used in the crane are listed in table 2-6~2-8. And the comparison of those products is also listed in the tables.

**Table 2-6: Gear lubricants**

40°C viscosity (mm <sup>2</sup> /s)		Place	code name
ISO VG 220	220	Gantry Reducer, Boom hoist Reducer, Hoist cable coil Reducer Rope re-reeving Reducer	A1
ISO VG 320	320	Main hoist Reducer, Trolley Reducer	A2

**Table 2-7: Hydraulic lubricants**

40°C viscosity (mm <sup>2</sup> /s)		Place	code name
ISO VG 32	32		B1
ISO VG 46	46	Motor room pumping station, Gantry Wheel brake pumping station, Back girder pumping station	B2

**Table 2-8: Grease**

drop point °C	Working point °C	Place	Code name
185 190	-20~+100 -25~+120	Low-speed and high-loading sliding bearing: Equalizer pin, other pin, hinge point, etc.	C1
185 190	-20~+100 -25~+120	Wire rope	C2
180 288	-30~+120	High-speed bearing: Bearing for Motor(the lubrication of motor should abide the standard afforded by the motor supplier)	C3

### 2.5.3 Lubricant replacement standard

The deterioration of the lubricant lies on the work frequency and the ambience.

In inspection of the lubrication or in the use of lubrication, replace the lubricant whenever sizable quantities of any of the following conditions are found:

- (1) Rubber-like deterioration
- (2) Impurity
- (3) Metal powder and badly discoloring
- (4) Emulsification
- (5) Separation of mineral oil and saponification radical (deterioration due to oxidation).

In addition, sample specimen termly as follows to determine whether the lubricant should be replaced: take approximate 20 milliliters of lubricant from the machine and consult the lubricant manufacturer or deliver it to lab to check .The detail of standard is listed in TABLE 2-9, replace lubricant or append additives according to the test result if any standard is met. Refer to sampling program to Section 2.6.5.

**Table 2-9: The standard of lubricant replacement**

Test items	the standard of replacement	Test method
kinematics viscosity variety (40 °C)	Increase 15% or decrease 20%	ASTM D 445

acid number	decrease 35% or increase $\geq 0.4\text{mgKOH/g}$	ASTM D 974
normal heptane thawless	$\geq 0.1\%$	IP 316
sheet copper erodibility	Less than Grade 2a	ASTM D 130
Chroma variety	Chroma $\geq 2$ than new lubricant	ASTM D 1500
humidity	$\geq 0.1\%$	ASTM D 1744

### 2.5.4 LUBRICATION PROCEDURE

- 1) When the reducer oil is changed, drain the used oil while it is still warm. The tank floor must be cleaned out with oil to remove deposited silt, metallic particles and oil residue. Use the same type of oil to keep normal operation.
- 2) When bearings are re-lubricated, pump the new grease into the oil pocket through grease fitting. Please clean out the old extruded grease after re-lubrication. During the first shift of operation after re-lubrication, the lubricating points should be cleaned.
- 3) For lubricating motor, emergency brake, reducer and other outsourcing parts, please refer to their manuals.
- 4) Wire ropes should be under good lubrication condition at all hours. Lubricating will prevent the wire rope from corrosion and reduce the friction in rope strands between the wire ropes and the sheaves and/or drums. The type of lubricant and application frequency varies with the rope construction, the operating conditions and its functional application. For details, please refer to TABLE B-1 in Addenda B.

- 5) The quantity of oil/grease should be suitable.
- 6) For gear reducers (splash lubrication), the oil level should be kept a little higher than the central level between the highest and lowest levels because the oil level will become lower when the gear reducer is working.
- 7) For bearings and other relatively sliding parts, it is natural that the old grease flows out of the seal from one side when the new grease is pumped in from other side.
- 8) Oil and grease complementary cycle. It has relationship with the ambience, sealing condition, working grade and operating frequency of each part. For details, please refer to TABLE B-1 in addenda B.
- 9) For reducers not used frequently, bottom valves should be opened termly to inspect the moisture content of the oil.
- 10) At the early stage of the crane is put into operation, three samples should be collected from the replaced old oil to analyze the percentage of metal powder in it. Compare and analyze the lubricant to find out the working status of machine.

### **2.5.5 Lubricating points layout**

Figure 2-13 and figure 2-14 gives the assembly to be lubricated, the amount of lubricating points and the style of bearing at lubricating point. There are relationship between the figures and Table 2-10.

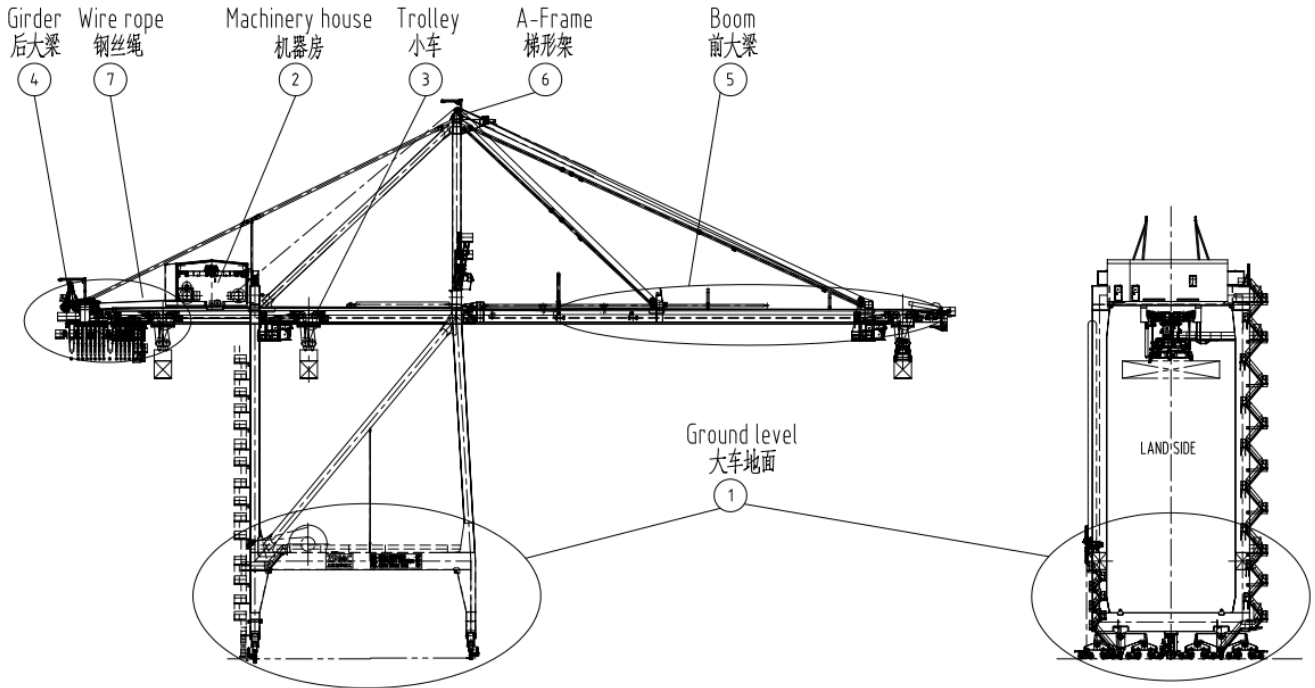


Figure 2-13: lubricating areas plot lubricating points layout

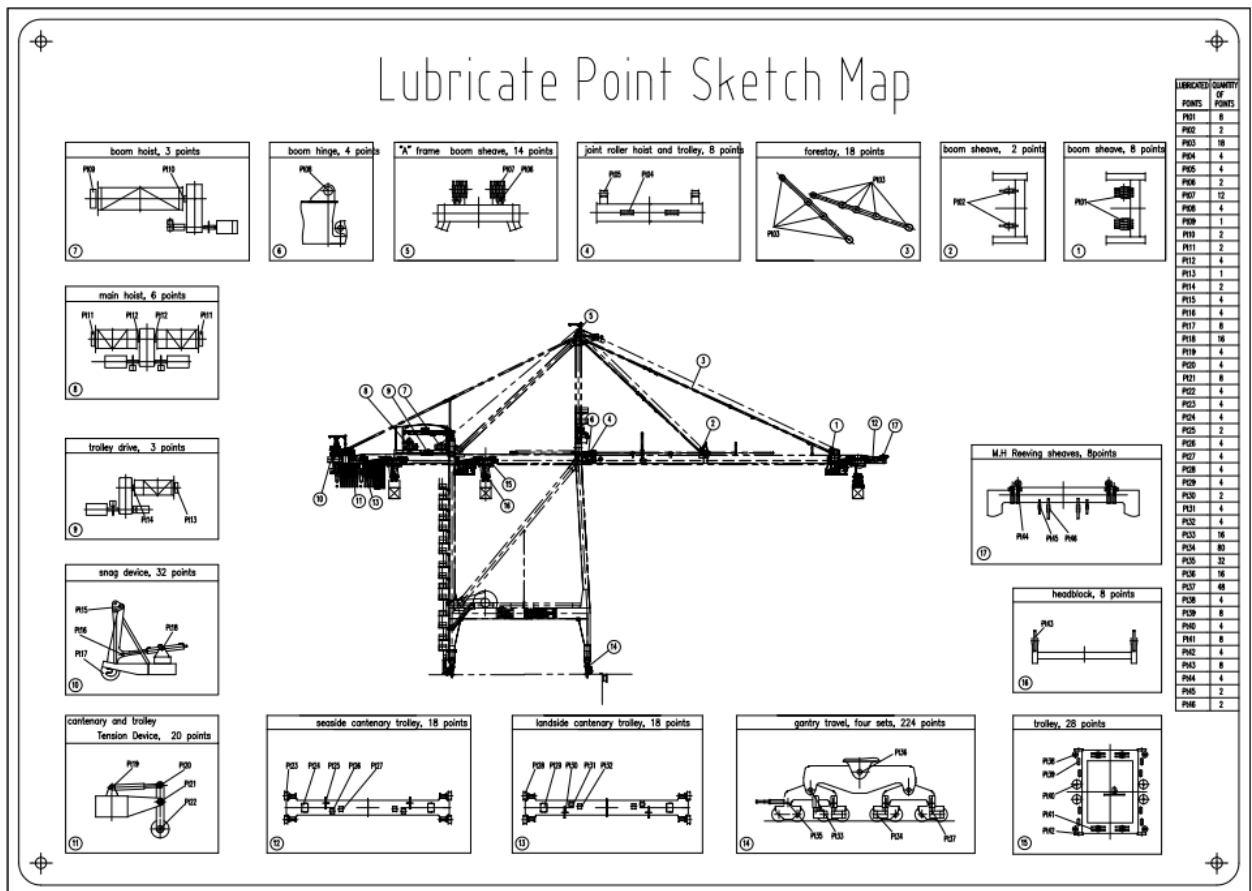


Figure 2-14: lubricating points layout



### 2.5.6 Lubricating frequency


The lubricants and lubricating frequency are listed in Table 2-11. Lubricating frequency has relationship with the weather such as temperature and rainfall, and the service condition of the crane at the terminal. The lubricating frequency listed in the table can be used in common

condition. The maintenance people should observe whether the lubricating is enough during the cranes service, to protract or shorten the lubricating periods properly. Refer to Figure 2-13: Lubricating areas plot and Figure 2-14 Lubricating points layout while using the table.

	The lubricating frequency listed is based on ZPMC's experience and common condition. Please keep an intact note or log. Based on the maintenance note and well lubricating condition, the lubricating frequency can be redefined or changed.
	The interval of lubrication is at most 4 years commonly. After this period, the lubrication should be changed even if the lubrication is not metamorphosed. Refer to the lubrication suppliers' recommendation.
	Sample the hydraulic oil and gear lubrication while the recommended replacing period listed in table 2-13 is reached. If the sample shows that the lubrication needn't be changed, the lubrication can be used while monitoring should be reinforced. What's more, gear lubrication should be sampled every 2 years even if the replacing period is not reached.
	The lubrication of forestay is very important for keeping well working status. If there is rust on the friction surface between the pin and stay bar, appended bending moment will be engendered in the stay bar while it is turning, and flaw can be engendered and expanded. So please remove ancient grease and add new grease every month.

**Table 2-10: Lubricating frequency**

symbol:			
D	Daily	3M	Every three month or ~1000 hours
W	Weekly	6M	Every six month or ~2000 hours
M	Monthly ~or 300 hours	A	Annually or ~4000 hours
H	According to working time (hour) or else		
Abbreviation of lubrication (Refer to Table 2-7 ~ Table 2-9)			
A1	Shell Omala S4 GX 220	A2	Shell Omala S4 GX 320
B1	---	B2	Shell
C1	Shell Omala S4 GX 220	C2	ChangCheng
C3	Refer to Motor manual		
Abbreviation Of Lubrication Points Types:			
I	Hydraulic	II	Gear
III	Common anti-friction Bearing	IV	Motor Bearing
V	Sliding Bearing	VI	Chain drive
VII	Gear Coupling or Spline	VIII	Wire Rope
IX	Others such as spring, seal...		
	Refer to drawing / correlative independent part maintenance manual		

Lubrication point P	period							lubricant (code name)	Lubrication point style / remark	amount	
	D	W	M	3M	6M	A	H				
1			●					C1	V /door hinge	4	
2			●					C1	V /hinge	1	
3			●					C1	IX/spring	2	
4				●				C1	III/hoist block bearing	4	
5			●					C1	V /crank handle	4	
6								---	Gantry cable coil	-	Refer to Gantry cable coil maintenance manual
7								---	Elevator	-	Refer to Elevator maintenance manual
8								---	Load handling device		Refer to Load handling device maintenance manual
9				●				C1	V /hook beam pin	2	
9a				●				C1	III/ hook beam thrust bearing	1	
9b				●				C1	V /high tower rotate pin	8	
10				●				C1	V /equalizer pin	112	
11						●		B2	I /gantry wheel brake pump	2	
11a						●		C3	IV/pump driving motor	4	Refer to motor specification
12			●					C1	V /spud pin	12	
13				●				C1	IV/wheel bearing	64	
13a				●				C1	V /motor pedestal pin	32	
14						●		C3	IV/gantry driving motor	32	Refer to motor specification
15							●	A1	II /gantry reducer: 400~500h for the first time, then 5000h	16	Refer to reducer maintenance manual
15a				●				C1	IX/reducer seal	32	
16						●		C1	II /toothed clutch & cam limit reducer	2	
17					●			C1	III/ boom hoist drum bearing	1	
18					●			C1	VII/drum coupling	2	
19				●				C1	IX/reducer seal <sup>1</sup>	4	
20								A2	II / boom hoist reducer: 400~500h for the first time, then 5000h	1	
21						●		C3	IV/ boom hoist driving motor	2	Refer to motor specification
22								A1	II / boom hoist emergency reducer: replacing per 4 years	1	Refer to reducer maintenance manual
23						●		C3	IV/ boom hoist emergency driving motor	2	Refer to motor specification



24						●		C3	IV/pump driving motor	2	Refer to motor specification
25						●		B2	I /drum brake pump	1	
26						●		C3	IV/trolley emergency driving motor	2	Refer to motor specification
27								A1	II / trolley emergency reducer: replacing per 4 years	1	Refer to reducer maintenance manual
28								C1	IX/ <sup>1</sup> trolley reducer seal	3	
29								A2	II / trolley driving reducer: 400~500h for the first time, then 5000h	1	
30						●		C1	VII/drum coupling	1	
31						●		C3	IV/ trolley driving motor	1	Refer to motor specification
32						●		C1	III/ trolley drum bearing	1	
33						●		C3	IV/ re-reeving device driving motor	1	Refer to motor specification
33a							●	A1	II / re-reeving device reducer, replacing per 4 years	1	Refer to reducer maintenance manual
34						●		C1	V/re-reeving drum sliding bearing	6	
35						●		C1	III/ traveling crane gantry wheel bearing	8	
35a						●		C1	III/ traveling crane trolley wheel bearing	8	
36							●	A1	II /maintain traveling crane gantry / trolley reducer, replacing per 4 years	4	Refer to reducer maintenance manual
37								C3	IV/ gantry / trolley driving motor	4	Refer to motor specification
37a						●		C2	VIII/ maintenance traveling crane wire	1	
38						●		C1	III/ hoist drum bearing	2	
39						●		C3	IV/ hoist driving motor	4	Refer to motor specification
40						●		C1	IX/ <sup>1</sup> hoist reducer seal	4	
41								A2	II/: hoist reducer: 400~500h for the first time, then 5000h	1	Refer to reducer maintenance manual
41a						●		C1	VI/ hoist emergency chain drive	1	
42							●	A1	II / hoist emergency reducer, replacing per 4 years	1	Refer to reducer maintenance manual
43								C3	IV/ hoist emergency driving motor	2	Refer to motor specification
44						●		C1	IV/ hoist drum bearing	2	
45								C3	IV/ fan motor	2	Refer to fan specification, self-lubricating bearing
46						●		C1	III/ electric jib crane bearing	1	
47						●		C1	III/ hoist level sheave bearing	8	
48						●		C1	V / equalizer pin	8	
49						●		C1	III/ hoist vertical sheave bearing	16	
50						●		C1	III/ main trolley wheel bearing	8	



51				•				C1	V / trolley guide sheave sliding bearing	16	
52								---	Sling cable ceil	1	Refer to sling cable ceil manual
53				•				C1	III/ idler bearing	70	
54				•				C1	V / level guide sheave	16	
55				•				C1	III / hoist sheave bearing	12	
56				•				C1	V / ball bearing	4	
57			•					C1	V / pin shaft	16	
58			•					C1	V / rocker pin shaft	2	
58a			•					C1	V / cylinder ball bearing	4	
59				•				C1	III/ trolley sheave bearing	2	
60						•		C3	IV/ pump driving motor	2	Refer to motor specification
61						•		B2	I / multifunctional pump	1	
62			•					C1	V / pull rod pin shaft	12	
63								-	Cable trolley	1	Refer to trolley maintenance manual
64			•					C1	V / pin ball bearing	4	
64a			•					C1	IX/ below pin shaft	2	
65			•					C1	V / pull rod pin shaft	4	
66					•			C1	III/ boom sheave bearing	8	
67					•			C1	III/ electric jib crane bearing	1	
68				•				C1	III/ trolley sheave bearing	2	
69			•					C1	V / pull rod pin shaft	2	
70					•			C1	III/ hoist sheave bearing	2	
71					•			C1	III/ electric jib crane bearing	1	
72				•				C1	III/ trolley sheave bearing	2	
73					•			C1	III/ hoist guide sheave bearing	4	
74					•			C1	III/ electric jib crane bearing	1	
75					•			C1	III/ electric jib crane bearing	1	
76			•					C1	V / pull rod pin shaft	4	
77					•			C1	III/ boom sheave bearing	2	
78					•			C1	V / back pull rod pin shaft	2	
78a					•			C1	V / back pull rod pin shaft	10	
79			•					C2	VIII / boom wire	1	
80			•					C2	VIII / hoist wire	2	
81			•					C2	VIII / trolley dragline	2	

Attention: To oil seal lubrication, add grease according to the direction of nameplate near the oil fitting, to avoid redundant grease come into the tank and mix with the gear lubrication.

## 2.6 Prevention and inspection

In order to ensure reliable crane operation and prolong the crane's life, each component on the crane must be operated correctly, and a proper maintenance schedule must be followed. To keep up the operating status and operational safety of the crane, please accomplish the maintenance of the crane at regular intervals listed in the rear of the chapter. The crane routine maintenance and inspection can be started with the following aspects.

### 2.6.1 Summarize

The inspection is used to judge whether the crane is in a safe and reliable state. It is basically a visual inspection and functional test. If an adequate assessment is not possible by this, further tests have to be taken, e.g. nondestructive testing. If necessary, disassemble the crane parts to observe the hid parts. The description of the crane components disassembly and re-assembly is listed in Chapter 3. When performing inspection and maintenance on the crane, the appropriate preventive actions **should be taken** according to Table2-11.

The abnormal temperature, sound, or libration can be the omen of failure, abrasion or mangle. The following sections list the detail.

**Table 2-11: Preventive action (mechanical)**

Inspection Items	Contents of Inspection	Preventive Action
Gear Gear coupling	Grease on gear Alignment Gear engagement and wear	Apply grease if poorly greased. Realign if out of tolerance Adjust the attachment if engagement is not proper. Replace excessive wear ones
Sliding surface of bearing, sheaves, wheel, pins, lever pins, etc.	Lubricating condition	Apply if necessary so that respective lubrication points are lubricated as required.
	Wear condition	Replace if wear is excessive
Bolts, nuts, keys, pins, shaft coupling bolts	Looseness, Attachment condition of split pin retainer	Tighten sufficiently. Replace if quality is deteriorated
Gear box	Lubrication Temperature sound	Add oil if the amount of oil is low. Replace if quality is deteriorated. Check abnormal sound
Wire ropes	Lubricating condition, broken wires, abrasion	Apply grease as necessary if grease is insufficient or degraded. See Section 3.4.9 for wire rope inspection.
Wire rope end termination	Condition of wire end	Tighten loose bolts with specified torque. See Section 3.4.7
High strength bolts, and welding for steel structure	Looseness Crack, damage	Replace if loose. Repair if crack or damage is observed.
Brake lining	Wear, fitness to brake disc	Replace if wear is excessive.
Brake disc	Wear of sliding surface	Repair if sliding surface is worn or rough.
Track and track clip	Bolt looseness, Track abrasion, Track distortion	Tighten loose bolts with specified torque, Replace excessive wear ones, Realign
Hook, headblock, lock pin in the spreader	Abrasion, crack	Replace excessive abrasion ones or ones with crack
Sheave, drum, idler	Abrasion	Replace if wear is excessive
Other consumable parts(such as seal, bulb)	Abrasion, damage	Replace if wear is excessive, Repair or replace damaged
Steel structure	Crack, paint, etc.	Refer to Steel structure maintenance manual
Safety device	Any abnormality	Repair while there is abnormality.



**The crane and its additional equipment, primarily the safety devices, have to be checked for proper condition and function depending on work use. It requires special supervision of: – emergency-stop button and control; – drive & brake; – electrical equipment; – limit switch and overload protection.**

### 2.6.2 Inspection of temperature rise

Temperature rise is a phenomenon. Maintenance personnel who well understand the temperature rise condition can judge the working condition of the crane. If there are no otherwise specifications, the temperature rise of the bearing should not exceed 60 °C (140°F) and the absolute temperature of the oil should be less than 85 °C (185°F). Infrared thermometer is in common use. See Figure 2-15. The following temperature raise locations on the crane should be carefully inspected:

- 1) High-speed rotation supporting locations, such as the motor bearings and the high-speed shaft bearing of reducers mainly used in main hoisting and trolley.
- 2) Heavy-load and slow speed supporting locations, such as reducer low-speed shaft bearing, drum bearing pedestal, wheel bearing and sheaves bearing.
- 3) Hydraulic actuator temperature rise, such as the hydraulic thruster of the brake (especially hydraulic thrusters of main hoist and trolley travel mechanisms), the relief valve and the throttle valve.
- 4) Hydraulic oil reservoirs, such as the multifunction pump, emergency brake, gantry wheel brake, and sling hydraulic units.

Normally, the inspection of temperature rise condition can be achieved by hand touch and judging if the temperature is abnormal. When there is abnormal temperature rise, it is often accompanied with abnormal noise. If there is abnormal temperature, specialized thermometer should be used to measure and to aid in finding the cause of temperature rise. Only after the problem is solved, should the operation be resumed.

Generally, the causes of temperature rising are:

- 1) Improper lubrication.
- 2) Improper gear meshing.
- 3) Bearing clearance is too loose or too tight (or bearing damage)
- 4) The alignment coupling can't meet standard.
- 5) Brake not fully released or not centered (one side released but the other side still touching

- the disc)
- 6) Hydraulic thruster oil internal leakage.
- 7) Abnormal operation of the relief valve.



**Figure 2-15:** Infrared thermometer

### 2.6.3 Inspection of abnormal noise

The main cause of mechanical noise is vibration, impact noise, friction noise and structural transmitting. Maintenance personnel who understand the noise change can judge the operating condition of the crane through daily noise observation. Generally, the abnormal noise may be caused by improper gear meshing, bearing damage, loose bearing clearances, shaft bending, loose bolts, interference or motor fan damage, lack of lubrication, etc.

Noise can be identified/isolated by using an industrial stethoscope.



**Noise measurement directly with ear may be harmful to ears, so only do this when necessary and for a short period.**

Generally, the abnormal noise and temperature rise happen simultaneously, such as when the bearing clearance is too big or the brakes are not fully released, and so on. Therefore timely noise inspections can avoid many equipment failures.

### 2.6.4 Inspection of abnormal vibration

Vibration is usually related to noise and element fatigue. Close attention should be paid to the abnormal vibration during crane inspection, such as for the motor base, gear reducer base and drum support rigidity, base rigidity, bolt pre-tightening, misalignment of motor and gear reducer, dynamic balance of coupling and static balance of drum.

The inspection sequence is generally started with the check of alignment (radial and axial vibrations). If the vibration still exists after adjustment, the coupling should be removed and the motor checked separately.

After causes of the motor and loose bolts are eliminated and dynamic balance of coupling are checked, the coupling can be connected and the high-speed shaft

bearing of the gear reducer and should be driven and checked. Generally, the problems caused by improper gear meshing and lack of adequate rigidity of the installation base can be found during test running.

If the vibration happens after the crane is put into operation for a certain period, loss of alignment, loose bolts, excessive bearing clearance or improper gear meshing usually cause the vibration problem.

### 2.6.5 Inspection of crack

Crack inspection sometimes can prevent failure or disaster of a crane at its early phase. The inspection of crack consists of inspection of the driving parts, the connecting parts and the structural parts. The cracks are normally caused by fatigue and happen on locations of fatigue source, stress concentration, and repeated stress effect.

Driving parts: such as driving shaft, wheel, gear, sprocket, sheave, coupling, braking wheel (disc), bearing and so on.

Connecting parts: such as fixed shaft, wheel shaft, sheave shaft, structural connecting pin shaft, headblock connecting pin, spreader twistlock and so on.

Structural parts: welding seam and base material.

The method of structural inspection can be visual inspection, which can be judged through the surface paint film. If the base material or welding seam is cracked, the paint film will be also cracked. Telescope can be used to

inspect pre-determined regularly inspecting locations. If there is any suspicion after visual inspection, MT or UT inspection can be applied. Please refer to the Steel Structure Maintenance Program for details. Driving or connecting parts can also be checked during maintenance when they are knocked down.

### 2.6.6 Inspection of rail & rail clips

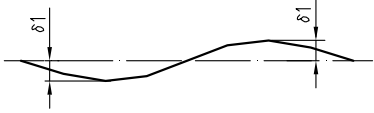
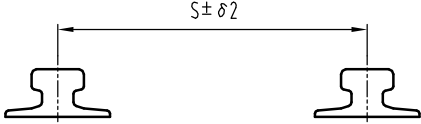
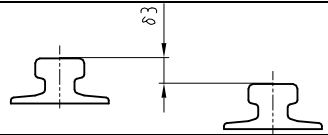
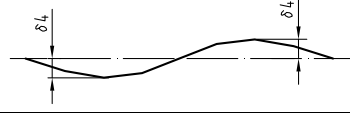
#### 2.6.6.1 RAIL INSTALLATION TOLERANCES

When designing a complete container handling system, the problems of the crane rail track never appear to be insignificant, and that is important to crane's using.

Failures of rails, to a great extent, can be attributed to improper lying of rail during foundation work or the crane or trolley may not be tracking accurately. If the crane is used with curved or uneven leveled runway rails, its structural members can be twisted causing high stresses. Accordingly, the bolts in joints may be loosened and the bases of the various machines on the steel structure may be distorted. Thus, crane performance may be impaired.

In order to prevent such troubles, at the time of annual inspection, measure the level, straightness, span, etc. of the trolley travel rail and gantry travel rail and keep their records. Also, carefully inspect the trolley travel rail and gantry travel rail for cracks. If measured dimensions are not within the allowable tolerance in Table 2-12 or Table 2-13, immediately repair or replace the gantry or trolley travel rail.

**Table 2-12 Allowable Tolerances for Gantry Rails**

Inspection items	Measuring Method	Maintenance tolerance
Straightness		Measured by a transit or piano wire $\delta 1 = \pm 10 \text{mm}$
Span (S)		Measured by a steel tape measure $\delta 2 = 5 \text{ mm}$ S-theoretic span=30500mm
Height difference between rails		Measured by a transit $\delta 3 = H_0 \pm 15 \text{mm}$ ( $H_0$ : original height difference = 0)
Bend of rail left and right		Measured by a transit or piano wire $LH + RH < \text{Tolerance}$ $\delta 4 = \pm 10 \text{ mm}$

Inspection items	Measuring Method	Maintenance tolerance
Levelness		$\delta 5 = \pm 25 \text{ mm}$  In the nominal span and wheel base of the crane no point on any rail will be greater than $\pm 25 \text{ mm}$ out of the common plane established by the other three corners of the crane.
Inclination		Measured by a transit  $\leq \frac{1}{400}$ (check every 10m/32.81ft)
Joint difference		Measured by a steel ruler  $\delta 6 = \pm 0.5 \text{ mm}$
Joint gap & deviation		Measured by a steel ruler  deviation $\delta 7 = \pm 0.5 \text{ mm}$ Gap $\delta 8 = 4 \text{ mm}$ or so No contact even in Summer

**Table 2-13: Permissible Tolerances for Trolley Travel Rails**

Inspection items	Measuring Method	Maintenance tolerance
Span (S)		Measured by a steel ruler  $\delta 2 = 3 \text{ mm}$ S-theoretic span = 6300mm
Difference in height		Measured by a transit or piano wire  $\delta 3 = \pm 9.45 \text{ mm}$ 0.15% of span
Slope or grade		Measured by a transit or piano wire  $\delta 4 = \pm 1 \text{ mm}$
Difference between boom and girder rail		Measured by a steel ruler  $\delta 6 = \pm 0.5 \text{ mm}$
Difference between boom and girder rail		Measured by a steel ruler  $\delta 7 = \pm 0.5 \text{ mm}$ $\delta 8 = 4 \pm 0.5 \text{ mm}$

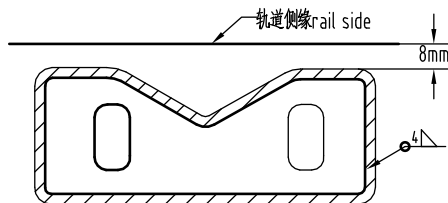


Inspection items	Measuring Method	Maintenance tolerance
Center distance between boom and girder rail		$\delta 9 \leq t/2 = \pm 6\text{mm}$
Levelness		0.1% of span $\delta 10 \leq 6.3$ [0.248 in]

### 2.6.6.2 TROLLEY RAIL CLIP INSTALLATION AND INSPECTION

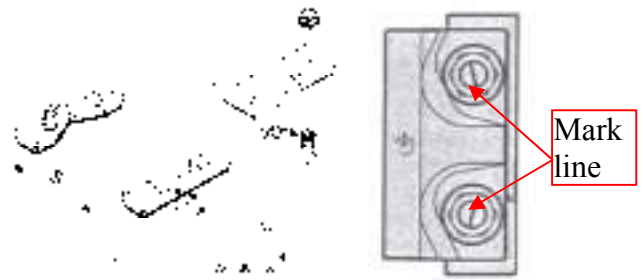
Inspect the bolts of rail clip to estimate whether they are loose. Screw down bolts if needed, and insure the exact position of stud. The process of installation about ZPMC trolley rail clip is listed hereinafter.

- 1) **Welding of base.** Weld the base all around with low hydrogen electrodes and 4mm fillet welding. Spot welding first, and then weld the base. Especially pay attention to clamp the base when welding to avoid the moving in upright direction and keep the contact of base. Refer to figure2-16.



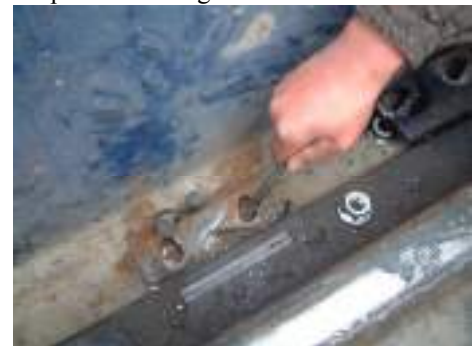
**Figure 2-16: Welding of base**

- 2) **Installation of bolts and clip.** Set the bolts into the holes of clip base, circumvolve it 90° and keep it lying in the wimble holes reliably. After confirming the bolts are oriented reliably (pay attention to the orientation line in the section of bolts), install clip and screw down nut manually. (It's important to screw down manually to ensure the correct location of the head of bolts in its head room.) Refer to Figure2-17. Paint immediately just after tightening the nut( do not stay overnight).



**Figure 2-17: Installation of bolts and clip**

- 3) **Cleaning up of base bolt hole.** Clean up the rubbish (with air pump) and slag (with welding hammer) in the base bolt holes before set up the clips. Refer to figure 2-18.



**Figure 2-18: Cleaning up**

- 4) **Tighten the clip.** Knock the clip slightly with hand hammer to keep the close contact of clip and rail side. Then, complete the tightening of the nuts to **200Nm**. In case of further painting protection, the use of solvent is prohibited. Refer to figure 2-19.

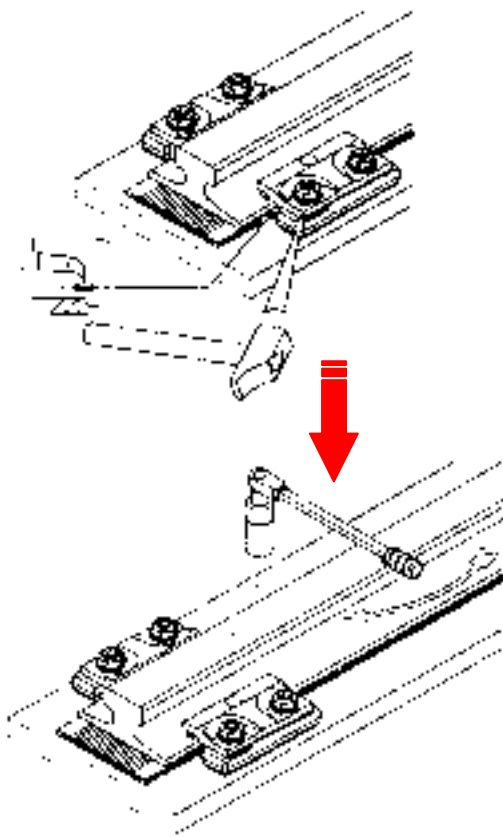


Figure 2-19: Tighten the clip



If, for any reason, a nut must be loosened after mounting, you must verify the correct position of the bolt shaft before re-tightening the nut.

### 2.6.7 Inspection of gantry & trolley travel wheel

The gantry travel and trolley travel are indispensable for operation by this machine. Therefore, it is important to maintain the travel wheels and rail in normal state all times. The following passages describe the inspection procedure of the wheel.

The following items should be checked during the daily, monthly, and annual periodical inspections.

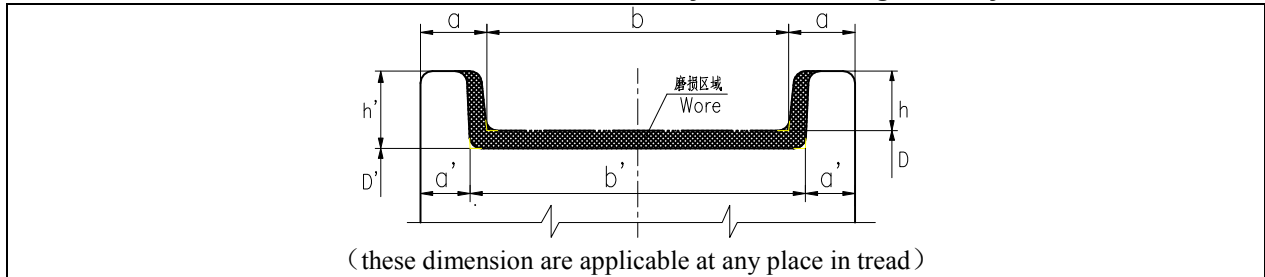
- 1) Wear in treads and flanges
- 2) No flanges riding on rail
- 3) During traveling, both sides moving smoothly in parallel
- 4) Abnormal noise or vibration
- 5) Wear in wheels, bearings, etc., developing evenly for both legs.
- 6) Cracks or repair welding cracks in wheels.
- 7) No break in rail flange. No condition of more than 3 places disfigurement with area over 3cm<sup>2</sup> and depth over 30% of the thickness of the rail.

After inspection, if the wear of the gantry or trolley travel wheel reaches the values indicated in Table 2-14 or Table 2-15, replace the wheel.

Table 2-14: Wear Limitation of Gantry Wheel

Original dimension		Wear Limitation		
		Driving wheel	Driven wheel	
D	800	D'	780 or the difference of the 2 driving wheel diameter is more than 1.6mm (0.2% D)	780 or the difference of the 2 driving wheel diameter is more than 4mm (0.5%D)
h	25	h'	35	
b	127	b'	145	
a	26.5	a'	17.5	

(these dimension are applicable at any place in tread)

**Table 2-15: Wear Limitation of trolley Wheel (draught trolley)**


Original dimension		Wear Limitation	
D	630	D	615 or the difference of the 2 wheel diameter is more than 3.2mm (0.5%D)
h	25	h'	32.5
a	26	a'	18.5
b	100	b'	115



**No wheel flange riding on rail is permitted. It will increase the travel resistance force up to 3 times as normal operation and will overload its driving system. If flange riding is observed, check the gantry drive coordination or the waterside trolley tow rope length agreement.**



**Severe wheel flange riding on rail will cause damage to the wheel and rail. Eliminate flange riding right away if it exist.**

## 2.6.8 Inspection of rope sheaves, drums, idler and slap block

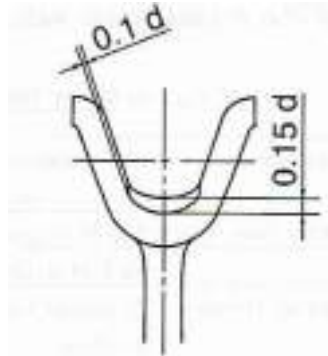
### 2.6.8.1 SHEAVE

If the following symptoms are found, check the wire rope for wear and replace the sheave at the same time of replacing the wire rope.

- 1) The flange is damaged or deformed.
- 2) The wear in the flange is 10% or more of the diameter of the wire rope used.
- 3) A trace of the wire

rope lay can be observed at the bottom of the sheave grooves.

- 4) The wear in the sheave groove is 15% or more of the diameter of the wire rope used. Refer to figure 2-20.

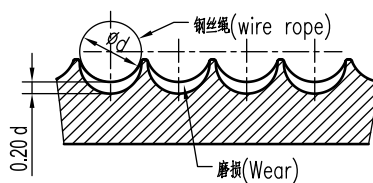


**Figure 2-20: limits of wear in sheave groove**



**Refer to Figure 2-20 for limits of wear in sheave groove. The symbol “d” indicates the diameter of the wire rope used.**

### 2.6.8.2 DRUM



**Figure 2-21: limits of wear in drum groove**

- 1) Periodically check the drum groove for corrugation and excessive wear.
- 2) The wear limit in the drum groove is 20% of the diameter of the wire rope used. Refer figure 2-21.
- 3) There should be no crack in drum groove, wire rope root point and drum axis.
- 4) Inspection of rope support roller and Slap Block

The inspection of the rope support roller is described as follows:

- 1) Verify that roller rotates freely.
- 2) Determine the anti-friction material is peeling, aged or worn out. The wear resistant roller ring shall be replaced when the amount of wear reaches 60% of its original thickness. Make sure that the worn roller ring has been replaced before the wire rope penetrates the thickness of the roller to expose the base metal of the roller shaft. If this happens, the wire rope will rub against the metal to cause the abrasion failure of both the wire rope and the roller shaft.

### 2.6.9 Inspection of the spreader

As a direct performer of loading container, the load handling device's reliability is very important. Please refer to the ZPMC load handling device manual to get the information about the detail of the load handling device's maintenance standard. Following routine inspection to the load handling device are suggested in handing over or taking over:

- 5) The reliability of lock pin or shaft pin connected with upper-hanger and load handling device.
- 6) Check the structure in the headlock and spreader to eliminate damage, incomplete fusion or weld crack in the parts easily to be stroked.
- 7) Check lubricating condition on the slide surface of flex arm and slide rail.
- 8) Lubricating and movement condition of key parts such as twist lock pin and peak-pin, reliability of twist lock pin locknut.
- 9) The tightness of all the limit-board of spreader, the integrity of limiter, the correctness of signal.
- 10) The reliability of cable used in spreader, and whether there is sudden damage.
- 11) The abrasion and damage condition of the head of twist lock of spreader.
- 12) The damage condition of guide-board of spreader.
- 13) The oil leakage condition of hydraulic system of spreader, and the oil surface location in the tank.

### 2.6.10 Inspection of hook and twist lock pin

The hook and twist lock pin become weaker against crack due to wear and hardening caused by extended use. Therefore, perform the following inspection once a year.

### 2.6.10.1 Hook

Perform the magnetic flaw or die check. After inspection, immediately make appropriate repairs or replacement. Refer to figure 2-22:

- 1) Any bending or twisting by 10°.
- 2) Any distortion causing an increase in throat opening of 15%.
- 3) Any wear exceeding 10% of the original section dimension of the hook or its load pin.
- 4) Any self-locking hook that does not lock.
- 5) Any latch that does not close the hook's throat.
- 6) Repair of cracks, nicks and gouges shall be carried out by designated person by grinding longitudinally; following the contour of the hook provided no dimension is reduced by

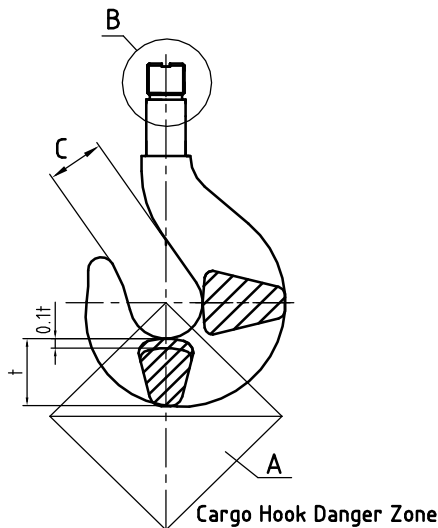


Figure 2-22: Annual check of cargo hook

more than 10%.

- 7) Deform or crack on the screw segment of the tail of the hook.

### 2.6.10.2 Twist lock pin

Perform the magnetic flaw detection or die check. Repair or replace the parts on condition listed hereinafter.

- 1) Crack, crevasse or hair-crack on the face of the head of twist lock pin, shaft and the connect root of the lock head;
- 2) Damage or wear of the head of twist lock pin;
- 3) Deform or crack on the screw segment of the tail of the pin.

**Always Inspect A and B area with special care Refer to figure 2-23!**

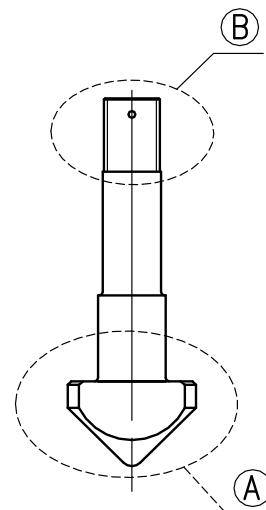


Figure 2-23: Annual check of Twist lock pin



**It's not permitted to repair the disfigurement in the hook and twist lock pin by welding. Replace the failure part if there is un-repairable disfigurement.**

### 2.6.11 Inspection of hydraulic handspike brake

Brake should be inspected periodically with items listed hereinafter:

- 1) Whether the brake lining and brake disk is



**Attention! Hydraulic handspike brake cylinder has especial structure inside and connecting proprietary technology. So don't disassembly it yourself and avoid belleville spring collapsing and hurting the people. Replace the fault cylinder as one piece.**

clean and not covered with oil dirt.

- 2) Whether the arm bars of the brake are flexible.
- 3) Inspect whether the belleville spring is broken or hydraulic oil is leaked to the belleville spring through inspection window of the brake cylinder. Repair or replace the failure part if the break or leak happened.
- 4) Inspect whether the push rod of the limit switch is loose and the action is right.


- 5) Inspect the abrasion condition of the brake lining. If the attrited thickness of the brake lining is over 40% of the original thickness of the friction material, a new brake lining should be set.

brake disc is contaminated. Any oil or grease on the disc must be cleaned with detergent or solvent immediately.

Also check the brake disc surface roughness. If the disc is damaged, scoring or cracked, if anything is found as shown in Table 2-16, the brake disc should be replace.

### 2.6.12 Inspection of brake disc

Inspection of the brake disc is very important to the safety of the crane operation. Periodically check if the



**DANGER! Any grease on the brake disc will cause the substantive drop of the brake torque.**

**Table 2-16: Standards for Brake Disk Changing**

	Main hoist	Trolley drive	Boom hoist	Boom hoist emergency brake	Main hoist emergency brake
Brake disc thickness	30mm	30mm	30mm	40mm	40mm
Wear limitation	27mm	27mm	27mm	36mm	36mm
Convex or concave on the disc surface	2mm	2mm	2mm	3mm	3mm
Brake lining wear limit	Attrited thickness should not more than 40% of base thickness. Interface between brake lining and brake disk should not less than 75%. The brake lining with adust face or aging should be replaced.				

### 2.6.13 Inspection of shaft and axle sleeve

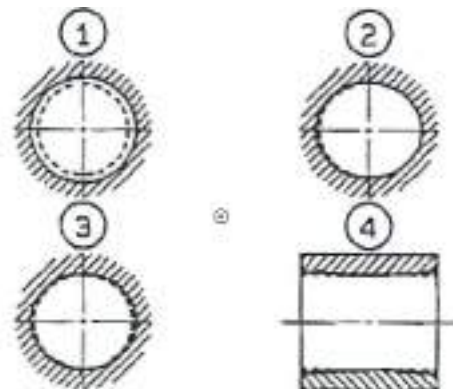
Some parts of the crane, such as stay bar pin and handle pin of gantry anchoring is equipped with shaft + axle sleeve (copper sleeve commonly, sometimes copper sleeve with plumbago lubrication). Check if the pin and bushing are well lubricated and rotates relatively freely. The relative rotation always happens between the bushing and the pin. The bushing should stand still in the housing, so no wear should occur on the outer diameter of the bushing. The abrasion form of the shaft and axle sleeve and the measure should be taken are listed hereinafter.

- (1) Sort according to the abrasion form which is shown in figure 2-24.

- 1) symmetrical wear ①
- 2) wear induced by unilateralism load ②
- 3) wear induced by bidirectional load ③
- 4) wear only on the both sides ④

- (2) Measure while the hole is worn.

- 1) replace the worn axle sleeve
- 2) deal with the worn shaft holes conform to the steps listed hereinafter
  - i. bore the hole after repair welding
  - ii. enlarge the diameter of pin, axle sleeve, and shaft hole
  - iii. replace axle sleeve



**Figure 2-24: Abrasion form of shaft hole**

If the wear of the bushing reaches the amount shown in Table 2-17, replace it.

**Table 2-17: The Wear Limits of Bushings**

D (mm)	Wear limitation of dia. (mm)	Location	Original dia.(mm)	Wear limitation of dia. (mm)
10~24	0.8	-	-	-
25~40	1.2	-	-	-
41~60	1.6	-	-	-
61~100	2.0	-	φ90/ φ70	~/ φ72
		-	φ85/ φ70	~/ φ72
101~160	2.5	-	φ180/ φ120	~/ φ122.5
161~250	3.0	-	φ200/ φ180	~/ φ183
		Stay Bar	φ220/ φ180	~/ φ203

**2.6.14 Inspection of oil seal**

Please check the oil seal if leakage is founded according as the description listed hereinafter.

- 1) whether there has been appropriate seal set in the leakage point;
- 2) Whether the brim seal is damaged by keyway, spring, screw, rough surface or the brim of shaft;
- 3) Whether the seal is set in reverse direction;
- 4) Whether the deformation of seal is caused by setting with unsuitable tool;
- 5) Whether the venthole is jammed.

**2.6.15 Bearing unit inspection**

In the crane’s working, judge the state of the bearing housing during operation, then take the following measures if abnormality is observed.

- 1) If vibration is found:

If the vibration is severe, first check the retaining bolts for looseness and verify that there is no looseness between the bearing unit and the installation base. Tighten the bolts as necessary. If the vibration remains after the above mentioned procedure, check if the causes of other rolling element vibration such as bent shaft exist. If no abnormal part is found, replace the bearing unit since the excessive clearance due to wear inside the bearing is suspected.

- 2) If abnormal temperature rise is found:

If the temperature of the housing rises over 20°C (36°F) after subtracting the ambient temperature,

carry out the inspections below.

- i. Check if any causes of the temperature rise exist, such as no relief clearance due to the one-side free bearing, overloading, etc;
  - ii. If no abnormal condition is found, replace the bearing since the severe condition such as an initial state of bearing damage etc. is suspected. Especially the temperature rise with abnormal noise is considered to be a sign of developing damage. Replace the bearing immediately in such a case.
- 3) If abnormal noise is found.

If abnormal noise is heard from the bearing unit, carry out the inspections below.

- i. Measure the bearing block temperature. If the temperature is less than 20°C (36°F) after subtracting the ambient temperature, check the retaining bolts for looseness and verify that there is no looseness between the bearing unit and the installation base. Tighten the bolts if necessary.
- ii. If the abnormal noise remains after procedure 1, the following causes are suspected. Immediately replace the bearing judging from the abnormal noise degree and the machine importance.
  - ◆ Slight wear appears on the track surface and/or rolling element of the bearing;
  - ◆ Inclination toward noise;
  - ◆ Foreign materials inside the bearing.
- iii. Measure the bearing block temperature. If the temperature is over 20°C (36°F) after subtracting the ambient temperature, replace the bearing unit

since the developing peeling of the track surface or rolling element is suspected.

### 2.6.16 Inspection procedure of key and keyway

The key and keyway suffer various kinds of damage according to the used condition. If and damage is found on inspection, immediately replace the key. The damage types and their cause are as follows:

#### 1) Shearing of key

The key may be sheared if the abnormal torque that is larger than key strength is applied in such a case. The keyway often may be deformed as well, so re-cut the keyway and install the key with hardness of superior grade.

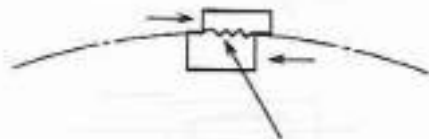


Figure 2-25: Shearing of Key

#### 2) Crack of keyway

The stress concentrates on the edges of the shaft or the keyway in the fillet engaged with the shaft. Therefore, cracks may be caused if the part suffers abnormal torque larger than their strength. If the condition remains, the crack may be enlarged, resulting in keyway damage of shaft failure.

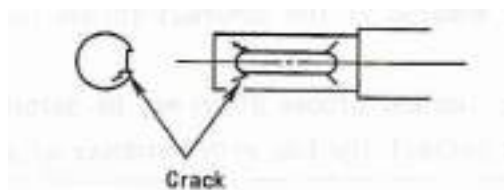


Figure 2-26: Crack of Key Groove

#### 3) Wear of keyway side

The fatigue and deformation may be caused if abnormal torque is applied to the keyway sides and abnormally high surface pressure is struck on the keyway sides repeatedly.

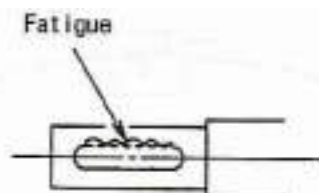



Figure 2-27: Wear of Key Groove Side

### 2.6.17 Inspection of consumable parts

Consumable-parts are those parts which may be depleted or worn out by use of the crane and **they do not belong to guaranty products**. During crane maintenance and inspection, pay special attention to the consumable parts listed as follows:

- 1) Inspection of wire rope for abrasion, wire breaks and other damage.  Refer to the relative provisions in Chapter 4.
- 2) Check if there is any oil leakage from gear seal rings.
- 3) Inspection of braking shoe abrasion.
- 4) Inspection of carbon brush of conducting ring (such as DC motor and spreader cable reel slip rings).
- 5) Inspection of kryptol for trolley rail and wheel lubrication.
- 6) Inspection of all lamp bulbs.
- 7) Make sure the spare fuses are available.
- 8) Inspection of filters.
- 9) Inspection of vulnerable parts, such as the spreader flippers.

### 2.6.18 Inspection of steel structural members




**The structural integrity of the crane requires that no attachments or fixtures of any kind be welded to any part of the crane without prior written approval of the responsible Structural Engineer.**



**Please refer to Steel Structure Maintenance Program for more inspection information.**

In order to maintain the crane in good condition, continuing inspection is very important. When damages occur to steel structural members, this crane may be unusable and require detailed inspection. Not only machine damage but also accidents including human injury may arise.

Deformation of the steel structure members may be caused by improper usage of the crane, development of cracks, and loose bolts. Therefore, always follow the operating procedures described in the container crane operation instruction manual  and conduct the



regular inspections as described in this manual.

Inspection and diagnosis methods for metal structure:

- 1) Inspect and judge the metal structure by human sense and experience:
  - Check to find out whether the hinge points and the interconnecting pieces run smoothly and flexibly, whether have abnormal sound and blocking phenomenon, whether have a good lubrication and a severe abrasion, whether the center axle have movement and so on.
  - Check the bolts connection to eliminate loosening.
  - Check the main connection pieces and welding to find out painting crimple, spalling or welding cracking.
  - Check the components to find out global or local deformation and bending, folding twisting and damage phenomenon.
- 2) Period inspection through non-destructive detection should be carried out for the welding of FCM pieces (for detailed information refers to STRUCTURE AND MAINTENANCE MANUAL for QUAYSIDE CONTAINER CRANES).
- 3) Use electrical logging stress method to test the strength and rigidity of the metal structure. Through careful and quantitative inspection to make a scientific judgment on the working condition of the metal structure.

The following things should be paid much attention to:

- 1) Check deformation, corrosion, crack, loose bolts, etc. at the time of regular inspection such as daily, monthly, and annual inspection.
- 2) The deformation of steel structure can degrade the alignment of the machinery installed on the structures, increasing operating noise, causing improper engagement of the gears, etc.
- 3) If some deformation of steel structures, development of cracks, loose bolts, etc. is observed, immediately report to the service office, and repair it under the supervision of

the structural engineers.

- 4) In order to prevent corrosion of the steel structure, clean clogged drain holes. Repaint areas if there is any indication of rusting. Corrosion will reduce the thickness of the structural members, increase members stress, and may create cracks. In order to inspect cracks in the structural members, thoroughly remove the rust and paints from the area, then conduct the indicated testing.
- 5) The lubrication of the stay bar pins is essential to keeping the stay bars sound. If the rusting of the pin occurs on the stay bar friction surface, the additional bending moment will be induced on the bar and may cause the initiation and propagation of cracks. Therefore, the lubrication must be made periodically to remove old grease and to refill the new grease.

### 2.6.19 Inspection of all safety protections

Safety protections should be checked before any work.

- 1) Regularly inspect if the braking torque setting-up of all brakes. Make a practical plan to periodically verify the braking torque. All slow-down limit switches and over-travel limit switches. Ensure that the positions of all encoders, functions of all interlock protections are correct.
- 2) Safety inspection of elevator according to its manual.
- 3) Regularly inspect the hoist over-travel limit switches and hook of service crane.
- 4) Visually inspect if all buffers mounting condition and wheel stoppers are reliable.
- 5) Replace any missing or illegible warning sign.
- 6) Refer to Chapter No.1 to find out the working condition of crane safety equipments like the boom stowage device, gantry anchor device, tie down device and so on.
- 7) Check the function of the operator's cab, and check the headblock to find out crack and losing parts. Check the ladder rails to find out the loosed or deformation bolts.



**Never tamper with any safety protection devices. It's about your own safety!**



## 2.7 Check list

This manual list the items that the crane need to check and maintain. Users can write down maintenance tasks for reference. Users have more experience than quay crane manufacturers on maintenance work, we welcome good maintenance advice or suggestions feedback to us, so that we can continue to improve maintenance tasks table, making it more practical operability.

The following inspection / maintenance tasks based on checks / maintenance interval are divided into 10 categories rating. These intervals determined depends on the main components of crane itself property and their wearing, damaging, and the level of failure frequency. According to the inspection / maintenance interval, 10 categories are defined as follows:

**Table 2-18: Description of Listed interval**

No.	Type	Description
1	running in period	Period after the overhaul of the trial run of the new purchase of quayside or shore bridge go together.
2	Dynamics	Execute before, during or after working. Permanent maintenance.
3	Weekly	Execute weekly or every 100 hours ( whichever comes first )
4	Every two weeks	Execute every two weeks or every 150 hours ( whichever comes first )
5	Monthly	Execute Monthly or every 300 hours ( whichever comes first )
6	Seasonly	Execute every three months or every 1000 hours ( whichever comes first )
7	Semiannually	Execute every six months or every 2000 hours ( whichever comes first )
8	Yearly	Execute yearly or every 4000 hours ( whichever comes first )
9	Every five years	Execute every sixty months or every 20000 hours ( whichever comes first )
10	Every ten years	Execute every 120 months or every 40000 hours ( whichever comes first )



**Table 2-19: Running-in Period Task List (For Queyside Container Crane)**

Equipment No. :		start time:	No.of checking sheet:	
Checked by :		finish time:	running hours:	
serviced by:		date:	technical confirmed by:	
no.	checking part	standard	result	process
<b>whole crane</b>				
1	cleaning	cleaning the dust and collecting the missing tools on the crane to avoid dropping		
2	marker	hang "running-in period) marker		
3	emergency	avoid emergency stop and other abnormal stop(electric power stop) in running-in period		
4	fastening	checking and testing every connecting parts. Do the fastenign or adjusting again if need.		
<b>machinery house</b>				
1	three main parts' motor	reduce 10%-15% of the rated load, low speed running for at least 50 hours, smoothly accelerate and brake. No emergency brake.		
2	emergenc brake (low speed brake)	Apply the brake several times under no load or 50% load, watch the stabilization. Check content in running-in period: 1. joint condition of bush and brake disc; 2. disc temperature should below 350°C;3. looseing of screw connector; 4. limit switch operation; 5. running and brake sounds should be normal;6. no leakage for the hydraulic system.		
3	high speed brake	Apply the brake several times under no load or 50% load, watch the stabilization. Check content in running-in period: 1. joint condition of bush and brake disc; 2. disc temperature should below 350°C;3. looseing of screw connector; 4. limit switch operation; 5. running and brake sounds should be normal		
4	hydraulic system	no leakage for the pipe and valve manifold, reading from the gauge should normal, cleaning the oil reservior, filter and other valves when changing oil.		
5	High coupling	no abnormal sound;bolts have no loosen		



6	Drum coupling	no abnormal sound;bolts have no loosen		
7	gear boxes for three main parts	no abnormal sound and glowing, cleaning the box and filters when changing gear oil		
8	electric boom	make sure no logic short-circuit or constraint. Checking the readings from the guage on the electric cabinet		
9	service bridge crane	running several times under no load or light load , make sure running and apply the brake smoothly		
<b>girder</b>				
1	multi-function hydraulic unit	no leakage for the pipe and valve manifold, reading from the gauge should normal, cleaning the oil reservior, filter and other valves when changing oil.		
<b>gantry</b>				
1	gantry hydraulic system	no leakage for the pipe and valve manifold, reading from the gauge should normal, cleaning the oil reservior, filter and other valves when changing oil.		
2	wheel brake	Apply the brake several times, watch the stabilization. Check content in running-in period: 1. joint condition of bush and brake disc; 2. disc temperature should below 350°C;3. looseing of screw connector; 4. limit switch operation; 5. running and brake sounds should be normal		
3	gear boxes	no abnormal sound and glowing, cleaning the box and filters when changing gear oil		
4	gantry motor	reducer 10%-15% of the rated load, low speed running for at least 50 hours, smoothly accelerate and brake. No emergency brake.		
5	gantry emergency stop	no abnormal sounds and glowing.		
The "result" column should be filled in : [√]pass; [0]fix/change; [×]rejected. The checking sheet should be collected after finish.				



**Table 2-20: mobile maintenance task list**

Equipment No. :		start time:	No.of checking sheet:	
Checked by :		finish time:	running hours:	
serviced by:		date:	technical confirmed by:	
no.	checking part	standard	result	process
<b>whole crane</b>				
1	communication system	keep all functions in good condition		
2	lighting	checking the walkway lighting, spot light and aviation alarm light. Make sure the function of the aviation alarm light.		
3	elevator	checking the smoothly running of the elevator, make sure the elevator stop at the correct floor.		
4	air conditioner (machinery house and driver cab)	checkin the function of the air conditioner		
5	emergency stop	checking the emergency stop function		
<b>machinery house</b>				
1	wire rope of three main parts (visual inspection)	well lubricated, no loosing for the press plate, reliable colligation for the redundant rope.		
2	brakes	keep reliable function, no loosing, distortion; keep correct clearance of the brake disc; no abnoamal abrasion ,cracks; keep polished surface and qualified brake toque. checking the compensate stroke.		



3	hydraulic system	no leakage for the pipe and valve manifold, reading from the gauge should normal, cleaning the oil reservoir, filter and other valves when changing oil. Checking the temperature rising abnormal sounds of the unit.		
4	drums of three main parts, high and low speed coupling.	keep in good condition(visual inspection)		
5	bearing base	keep in good condition, no losing bolts and keep limit switch mounted on correct location. (visual inspection)		
6	gear boxes of three main parts	keep gear oil at normal level, no abnormal sounds, glow and leakage.		
7	emergency stop for electric boom and machinery house	keep in good condition		
8	electric boom	make sure no logic short-circuit or constraint. Checking the noise and smell of the control panel;checking the CMS daily. inspect the electric current and voltage from CMS and PQM		
9	noise and vibration	checking the noise and vibration for motor, gear box, brake, drum, coupling and bearing		
10	motors for three main parts	keep motors and fans in good condition		
11	gates and windows for the machinery house	keep no broken for the doors and windows, shut them off after working.		
<b>boom</b>				
1	festoon	no twist for the wire rope, cable and elastic, no abnormal sound when the festoon running.		



2	trolley	no abnormal abrasion for all rollers on the trolley, rotate freely. Keep the wheel and level wheel in good condition without noise.		
3	wire rope	checking the wire rope for main hoist and trolley is at correct location.		
4	boom damper	no aging, loosening; no distortion and crack for the limit plate		
5	slap block for boom support	no distortion, loosening, blots, and bolts missing. (visual inspection)		
6	multi-function hydraulic system	no leakage for the pipe and valve manifold, reading from the gauge should be normal, cleaning the oil reservoir, filter and other valves when changing oil. Checking the temperature rising abnormal sounds of the unit.		
7	trolley and catenary tension cylinder	No leakage for connector, correct location for limit switches. No inner leakage for cylinders.		
8	sheave	No distortion, loosening and rotate freely for sheaves on the tip of boom and girder, sheaves for the trolley and for the boom.		
9	roller at joints (visual inspection)	no abnormal abrasion		
10	trolley rail (visual inspection)	No loosening, abrasion and separating for pressure plate and bolts on trolley rail. No impact on the rail connectors when the trolley drive through. No crack, tip-off, loosening for the connect plate and locate block on the short rail.		



11	clamp plate for hoist wire rope at the end of the boom	no loosening and distortion		
12	anti-bumping limit switch	checking the anti-bumping wire rope at the two side of boom		
13	the sheaves on tensioner and anti-sag device	checking the location of the sheaves on tensioner and anti-sag device		
14	spreader cable reel	make sure the cable in the groove , checking the noise and vibration for the motor and speed reducer.		
<b>top platform</b>				
1	limit switch plate	no distortion, crack, make sure the contract of limit switch		checking after "boom up"
2	limit switch	well wiring and no loosening bolts		
3	sheaves and bearings for boom	no noise, abrasion, distortion and loosening.		
<b>driver cap</b>				
1	control desk	for trolley:speed, acceleration, AI speed reduce, stop and cable festoon system. For boom and hoist: speed, acceleration speed reduce when up/down and stop;checkign the low speed hoist in ship clapboard. checking the lighting function in driver cab; checking the spreader guide and pin; checking the function of joystick and control panel		
2	air conditioner electric system	checking the function of air conditioner, air filter, lighting, defrost device and windshield wiper		
3	chair	checking the function of seat and shoulder safety belts.		
4	gate and window	clean the grease and dust, shut windows and doors off after using.		
<b>gantry cable reel</b>				





1	gantry cable reel	no missing, losing, distortion for bolts on the reel; no abrasion for cable and reliable motion for the reel. (visual inspection)		
2	speed reducer for gantry cable reel	normal oil level, no leakage and vibration		
<b>gantry</b>				
1	gantry hydraulic system	no leakage for the pipe and valve manifold, reading from the gauge should normal, cleaning the oil reservoir, filter and other valves when changing oil. Checking the temperature rising abnormal sounds of the unit.		
2	brake and pipe	no leakage and well fixed pipe, good brake function		
3	damper	no distortion, leakage and broken		
4	rail cleaner	correct position and nodistortion		
5	cable roller and guide	no losing and abnormal abrasion; no block for guide springs		
6	speed reducer	normal oil level, no leakage		
7	rail	check the obstacle on the rail or broken for of the rail		
8	high voltage cable groove	check the obstacle on the groove of high voltage cable or broken for of the groove		
9	motor	check the speed and acceleration		
10	emergency stop	keep function in a good condition		
11	stowage device	apply the stowage after working		
<b>spreader</b>				



1	spreader	check the spreader guide and pins, checking the drive chain's safety and tension;checking the position of 20,40 45 feet; checking the level and positive position of spreader; checking the gear oil in extend gear box; checking the connection of the cable plug.		
2	headblock	\checking the assembly and function of limit switches for hoist wire rope losing		

The "result" column should be filled in :[√]pass; [0]fix/change; [×]rejected. The checking sheet should be collected after finish.



**Table 2-21 scheduled maintenance task list (weekly)**

Equipment No. :		start time:	No.of checking sheet:	
Checked by :		finish time:	running hours:	
serviced by:		date:	technical confirmed by:	
no.	checking part	standard	result	process
<b>whole crane</b>				
1	lighting	check the function of all working spot lights		
1	limit switch	check the cable connection and bolts' fastening		
<b>machinery house</b>				
1	wire rope of three main parts (visual inspection)	well lubricated, no loosening for the press plate, reliable colligation for the redundant rope.		
2	brakes	keep reliable function, no loosening, distortion; keep correct clearance of the brake disc; no abnormal abrasion, cracks; keep polished surface and qualified brake torque. checking the compensate stroke.		Checking the boom brakes and gear box during "boom" motion; cooperate with driver when checking hoist brakes and trolley high speed brakes.
3	hydraulic system	no leakage for the pipe and valve manifold, reading from the gauge should be normal, cleaning the oil reservoir, filter and other valves when changing oil. Checking the temperature rising abnormal sounds of the unit; checking the filter pressure gauge		
4	drums of three main parts, high and low speed coupling.	no crack, abnormal abrasion and loosening of bearing base; no noise and vibration for bearing; no tip-off for lock block; reliable rope pressure plate.		
5	bearing base	keep in good condition, no loosening bolts and keep limit switch mounted on correct location. (visual inspection)		
6	gear boxes of three main parts	keep gear oil at normal level, no abnormal sounds, glow and leakage.		
7	high speed coupling for three main parts	no abnormal sound and loosening bolts		



8	low speed coupling for three main parts	no abnormal sound and leakage		
9	limit device on the tip of the bearing base.	no loosening and abrasion of encode coupling		
10	service bridge crane	keep in good condition; well lubricated; no loosening of pressure plate; keep wire rope in good condition.		
11	electric cabinet	make sure the aeration and fan working condition		
<b>girder</b>				
1	anti-sag platform	all wear block fixed; no distortion, loosening or abnormal abrasion for sheaves.		
2	anti-sag hydraulic system	no leakage for the pipe and valve manifold, reading from the gauge should normal, cleaning the oil reservoir, filter and other valves when changing oil. Checking the temperature rising abnormal sounds of the unit.		
3	joints	well lubricated and no abnormal abrasion		
4	wire rope tension hydraulic system	No leakage for connector, correct location for limit switches.		
5	fixing bolts for tension sheaves	no loosening and broken		
6	trolley tension cylinders	No leakage for connector, correct location for limit switches. No inner leakage for cylinders.		
<b>cable festoon</b>				
1	running wheel and level wheel	no dropping, distortion, abnormal abrasion; no decline when running		
2	rail	well lubricated		
3	fixing bolts and screw	no loosening; no screw broken.		
4	damper and pressure rubber	no loosening, aging, distortion and crack		
5	elastic and wire rope	no broken, dropping, aging; free rope tip		
6	cable clamping	no missing, loosening, distortion and broken; no broken for cable		
7	rubber protector for lamside tip cable	no moving, abrasion and missing		
<b>driver cab and trolley top</b>				
1	trolley festoon tractor	no distortion, loosening		
2	driver cab	。 Cleaning chair, slide freely and reliable fixing; gate for walkway and diving platform opens freely, the clearance for gate with locking plate is normal and no blocking.		



3	sheaves	no distortion, loosening and abnormal abrasion		
4	wire rope pressure plate	no distortion and loosening		
5	roller on the trolley top	no abnormal abrasion, loosening; rotate freely		
6	speed reducer for spreader cable reel	well fastened, enough oil; no noise and glowing; checking the chain		
7	rolling parts for spreader cable reel	well fastened and normal distance, no abnormal abrasion of cable		
8	trolley wheel and level wheel	no abnormal abrasion; the level wheel not touch the rail bolts; no loosening bolts for cover; well lubricated and no abnormal condition for wheel bearing.		
9	trolley damper	no distortion, leakage and broken		
10	linkage with trolley	well lubricated wire rope with no broken section. when wire rope diameter is 7% less than nominal diameter, even no broken wire found. 2. when 10% of the wires are broken in this bundle. No loosening, abrasion and separating for pressure plate and bolts on trolley rail. No impact on the rail connectors when the trolley drive through. No crack, tip-off, loosening for the connect plate and locate block on the short rail. no loosening or dropping wear block under the machinery house and boom. no abnormal abrasion for the boom joint's roller, and the roller rotate freely.		
11	limit switch for hoist gravity block	correct contact, reliable connection for limit switch. No loosening bolts		
<b>boom</b>				
1	boom sheaves and bearings at boom	no abnormal abrasion, loosening; reliable sheave function		
2	anti-bumping wire rope	normal tension and no broken		
4	joints between boom and girder	no abnormal sound and abrasion. Well lubricated bearing and fastened bolts		
5	roller for joints	no abnormal abrasion, loosening; rotate freely		
6	boom buffer	no loosening, aging, distortion and crack		
	boom stay bar	fasten the bolts lubricate the pin		
7	wire block for boom stay bar support	no distortion; no loosening and missing of bolts.		
8	wear block for wire rope	well fixed and no abnormal abrasion		



9	fixed roller	no abnormal abrasion, loosening; rotate freely; well fixed wear block		
10	trolley damper	no distortion, leakage and broken		
8	sheaves	no distortion for fixed sheaves at tips of boom and girder, and sheaves on the top of trolley; good condition for sheave shafts, well lubricated bearing		
<b>boom tip</b>				
1	clamp plate for hoist wire rope	no loosening and distortion		
2	wear block and bolts	well fastened		
3	trolley sheave	no loosening, distortion and abnormal abrasion		
<b>top platform</b>				
1	hook limit plate	no distortion, crack; good contact with limit switch		checking when "boom up"
2	rope-loosening limit switch shaft	well lubricated, sensitive and reliable		
3	sheaves and bearing for boom part	no noise, abrasion, distortion and loosening		
4	clamp plate and base for rope broken protection	no loosening, distortion and crack		
5	stay bar connect plate and bolts for lock plate	no distortion, tip-off, loosening and abrasion		
<b>gantry cable reel</b>				
1	gantry cable reel	no missing, loosening, distortion for bolts on the reel; no abrasion for cable and reliable motion for the reel. (visual inspection)		
2	speed reducer for gantry cable reel	normal oil level, no leakage and vibration		
<b>gantry</b>				
1	gantry hydraulic system	no leakage for the pipe and valve manifold, reading from the gauge should be normal, cleaning the oil reservoir, filter and other valves when changing oil. Checking the temperature rising abnormal sounds of the unit.		
2	brake and pipe	no leakage and well fixed pipe, good brake function		
3	disc of wheel brake	no grease, normal abrasion; no loosening bolts		
	coupling	no loosening and abnormal bolts		
4	damper	no distortion, leakage and broken		
5	steel boots	no distortion, rust; good support and chain		



6	stowage device	no distortion and tip-off, well lubricated, sensitive and reliable		
7	rail cleaner	correct position and nodistortion		
8	cable roller and guide	no loosing and abnormal abrasion; no block for guide springs		
9	speed reducer	normal oil level, no leakage		
<b>spreader and headblocks</b>				
1	hydraulic unit	hydraulic pressure should be 11Mpa		
2	hydraulic oil reservior	no leakage; reliable fixed and enough oil;		
3	bolts	checking the bolts at damper, speed reducer base and guide motor		
4	lubrication	checking the lubrication for drive reducer, extend chain, bearing and lock pin		
5	cleaning	clean and fasten the sn=ensor and limit switch		
6	connection between spreader anf headblock	make sure the limit switch function for separating or connecting the spreadr and headblock		
7	junction box and control desk on the headblock	checking the cable connecting and fastening of the bolts		
8	over-height adapter	well lubricated for lock pin and other moving parts.		
The "result" column should be filled in :[√]pass; [0]fix/change; [×]rejected. The checking sheet should be collected after finish.				



**Table 2-22 scheduled maintenance task list (bi-weekly)**

Equipment No. :		start time:	no. of checking sheet:	
checked by:		finish time:	running hours:	
service:		date:		technical confirmed by:
no.	checking part	content	result	process
<b>whole crane</b>				
1	brakes for three main parts in machinery house	cleaning the brake disc; checking the abrasion of bush for the brakes		
2	anti-bumping device for boom	checking the position for anti-bumping wire rope and its limit switch		
3	steel structure	no abnormal broken		
4	gantry wheel brake	cleaning the brake disc; checking the abrasion of bush for the brakes		
<b>spreader</b>				
1	motor and coupling	good condition; no vibration and noise		
2	gear box	good condition; no vibration and noise		
3	telescope motee	reliable function; no noise, leakage and loosing; enough oil		
4	hydraulic pump and valves	reliable function; no noise, leakage and loosing		
5	hydraulic piping and connector	reliable function; no noise, leakage and distortion		
6	all cylinders(extention, rotate lock, middle lock, hook)	reliable function; no noise, leakage and loosing; well lubricated		
7	oil reservior	well fixed; no leakage and loosing; enough oil		
8	filter	no leakage and correct display		
9	rotate locking device	reliable function, no distortion, crack for bush. No loosing bolts		
10	container landing lock	reliable function; no noise, leakage and distortion		
11	guide board	reliable function, no distortion, crack for bush. No loosing bolts		
12	drive chain and tank chain	reliable function, no distortion, crack for bush. No loosing bolts; keep the tention length for driving chain is 25mm(40 feet)		
13	middle lock slip slot (up and down, left and right)	well lubricated; no abnormal abrasion		
14	telescope beam	well lubricated; no abnormal abrasion		





15	main structure and parts structure	no distortio, tip-off, crack; no crack on the lock pin hole		
16	tip back-rotate wheel	well lubricated and reliable function		
17	wear block for guide and telescope beam	no abnormal abrasion and loosing		
18	bolts fastenning	spreader guide motor and gaer box base		
19	the sheaves, bearing and fastening for head block	no noise. Abrasion, distortion and loosing		
20	steel structure for head block	no distortio, tip-off, crack;		
21	rotate locking device for head block	reliable function, no distortion,crack for bush. No loosing bolts; keep the tention length for driving chain is 25mm(40 feet)		
22	portable bar and pin shaft	well lubricated; no abnormal abrasion		
23	spreader cable reel	well lubricated; no abnormal abrasion; no distortion for spring and no crack for bearings		
24	dooa for head block	neatly motion and lock plate		
25	protect cover for sheaves on head block	no distortion, tip-off and crack		
<b>electric parts for spreader</b>				
26	ternimal junction box	well fixed		
27	power box and fasst connect plug	well fixed and no broken		
28	terminal box on head block	well connected, no broken and inleakage		
29	limit switch	middle lock limit switch	good condition, well connected	
		middle lock position limit switch	good condition, well connected	
		open lock limit switch	good condition, well connected	
		close lock limit switch	good condition, well connected	
		container landing limit switch	good condition, well connected	
		middle lock limit switch	good condition, well connected	
		20FT limit switch	good condition, well connected	
		40FT limit switch	good condition, well connected	
		45FT limit switch	good condition, well connected	
		twin container limit switch	good conditon; well fixed and sealed	



		middle lock hook permitting limit switch	good condition, well connected		
30	solenoid valve plug	general valve	good condition and no leakage		
		guide up and down	good condition		
		telescoping	good condition		
		open and close locking	good condition		
		middle lock (up and down)	good condition		
		middle lock( telescope)	good condition		
31	limit switch connecting plate	well fixed and no broken			
32	power box and fast connect plug	well fixed and no broken			
33	terminal box for head block	well connected, no broken and inleakage			
The "result" column should be filled in :[√]pass; [0]fix/change; [×]rejected. The checking sheet should be collected after finish.					



**Table 2-23 scheduled maintenance task list (monthly)**

Equipment No. :		start time:	No.of checking sheet:	
Checked by :		finish time:	running hours:	
serviced by:		date:	technical confirmed by:	
no.	checking part	standard	result	process
<b>elevator and LS support beam</b>				
1	boom operating house	clean and no dust		
2	switches and limit switches	checking function for all the emergency stop switches and limit switches.		
3	lubrication for the elevator	checking the lubrication for all moving parts		
4	speed reducer and motors	normal running and no noise; no losing bolts		
5	control system	keep normal working		
6	bolts of the pressure plate cover for anti-sag sheave	no losing and broken		
7	support beam and its accessory	no distortion, crack, losing bolts and noise when running		
8	brake	clean the brake disc, checking the abrasion of brake bush		
9	cable	checking the twist and abnormal abrasion.		
<b>nachinery house</b>				
1	cleaning	no grease and dust		
2	bolts for motors, brakes, couplings and bearing base of the main parts	no losing and distortion		
3	wire rope clamper for three main parts			
4	gear box for three main parts	keep gear oil at normal level, no abnormal sounds, glow and leakage.		
5	emergency brake for three main parts	keep reliable function, no losing, distortion; keep correct clearance of the brake disc; no abnormal abrasion , cracks; keep polished surface and qualified brake toque. checking the compensate stroke.		
6	high speed brakes for three main parts	keep in good condition; no broken for the structure; correct brake torque.		
7	motors for three main parts	good working condition; no abnormal temperature; good aeration		
8	lighting	good working condition		
9	fan	good working and no noise		
10	service bridge crane	checking the abrasion, broken, lubrication for the wire rope; checking the hood abrasion, fastening the bolts; checking the running for cable trolley and cable.		



11	electric cabinet	checking the "fuse" and "shut-off"; checking the contract for relay and contactor		
<b>girder</b>				
1	oil nipple and lubrication piping	no leakage, distortion and rust		
2	main structure for anti-sag device	no distortion, tip-off and crack		
3	joints	well lubricated, no abnormal abrasion		
4	bolts for prssure plate cover of the anti-sag	no loosing and broken		
5	oil nipple and lubrication piping for tension device	no leakage, distortion and rust		
6	fixing bolts for tensioner sheaves	no loosing and broken		
7	main structure for tension device	no dsitortion, tip-off and crack		
8	wear blocks	well fixed, no abnormal abrasion		
9	outdoor service crane	no distortion, tip-off and loosing, correct position fo sliding trolley		
<b>cable festoon</b>				
1	cable	no broken		
2	structure for testeeon trolley	no distortion, crack and tip-off		
3	running wheel and level wheel	no dropping, distortion, abnormal abrasion; no decline when running		
4	rail	well lubricated		
5	bolts and screws	no loosing; no screw broken.		
6	damper	no loosing, aging, distortion and crack		
7	elastic and wire rope	no broken, dropping, aging; free rope tip		
8	cable clamper	no missing, loosing, distortion and broken; no broken for cable		
<b>boom</b>				
1	bolts and pressure plate for the rail	no loosing, dropping and abrasion		
2	connect plate and located block for short rail	no crack, tip-off and loosing		
3	the joint part of rail for boom abnd girder	no sunken area, the difference for level is normal		
4	rail for boom and girder	no sunken area, crack and abnormal abrasion		
5	furcation, guide wheel and slide rail	well lubricated; no abrasion, loosing and correct psition for guide wheel		
6	boom operating house	no tip-off, distortion, leakage of rain, good locking for the door; the lighting and switches is in good condition.		



7	lubrication piping	no leakage, rust and distortion		
8	boom sheaves and bearings for boom and girder	no abrasion, distortion and loosening		
9	bearing base	no distortion, tip-off, crack; well lubricated and no abnormal abrasion		
10	boom damper	no distortion, leakage and broken		
11	trolley damper	no distortion, leakage and broken		
12	joints shafts and their fastening	no abrasion, distortion and loosening and well lubricated		
13	joint base and shear block	no sliding, crack and loosening bolts		
14	roller	rotate freely and normal abrasion		
15	lubrication piping and nipples on joint upper beam	no leakage, rust and distortion		
16	air piping and reduce valve	no leakage, rust and distortion; good valve		
17	anti-bumping wire rope	normal tension, no broken; good limit switch		
18	wear block under beams	no abnormal abrasion		
20	sheaves at ends and its fastening	no abrasion, distortion and loosening		
21	limit switch for trolley running	good function; connected cable and no loosening bolts		
22	wire rope for trolley and main hoist	checking the abrasion and broken for the wire rope; lubricate the wire rope		
23	guide wheel for rope changing	no abnormal abrasion, distortion and loosening		
<b>boom tip</b>				
1	clamp plate for hoist wire rope	no loosening and distortion		
2	trolley sheave	no loosening, distortion and abnormal abrasion		
<b>top platform</b>				
1	connect plate shaft for front stay bar and the copper bush	no abnormal abrasion and noise		
2	shaft for front stay bar and the copper bush	no abnormal abrasion and noise		
3	boom sheaves and bearings	no abnormal abrasion, noise, distortion and loosening		
4	rope loosening device	sensitive and distortion		
5	rope broken protect plate and its base	no crack, distortion and loosening		
6	air piping and reduce valve	no leakage, rust and distortion; good valve		
7	lifting trolley	sensitive, no distortion and loosening		
8	bolts for connect plate shaft for front stay bar and lock plate	no abnormal abrasion, tip-off, distortion and loosening		



9	top lubrication piping and nipples for boom	no leakage, distortion and rust		
10	front and back top stay bar and joint base plate	no abnormal abrasion, tip-off, distortion and loosening		
11	sheaves base for boom	no abnormal abrasion, distortion and loosening		
12	boom wire rope	checking the abrasion and broken; well lubricated		
13	wind speed meter	make vane, cable connecting and function in good condition		
14	boom limit switches	good function, well connecting and no loosening bolts		
15	structure for boom stowage	no abnormal abrasion, noise, distortion and loosening		

**driver cab and trolley top**

1	lubrication piping and nipples	no leakage, rust and distortion		
2	upper limit switch	good function, well connecting and no loosening bolts		
3	sheaves	no distortion, loosening and abnormal abrasion		
4	wire rope pressure plate	no distortion and loosening		
5	roller and wear block on the trolley top	no abnormal abrasion, loosening; rotate freely		
6	trolley wheel base and its fastening	no abnormal abrasion, tip-off, distortion and loosening		
7	speed reducer for spreader cable reel	well fastened, enough oil; no noise and glowing; checking the chain		
8	rolling parts for spreader cable reel	well fastened and normal distance, no abnormal abrasion of cable		
9	trolley wheel and level wheel	no abnormal abrasion; the level wheel not touch the rail bolts; no loosening bolts for cover; well lubricated and no abnormal condition for wheel bearing.		
10	structure	no abnormal abrasion, tip-off, distortion and loosening		
11	trolley damper	no distortion, leakage and broken		
12	window and door for the cab	no dropping and broken, locker and seal is in good condition		
13	doors for the cab and diving platform	open freely, no block for lock plate		
14	control desk in the cab	good working for pushbuttons and joystick		
15	roller and wear block on the trolley top	no abnormal abrasion and loosening; no tip-off for the base		
16	trolley festoon tractor	no distortion, loosening		
17	cable reel	enough gear oil, no leakage, loosening bolts; no abrasion for cable		



<b>gantry</b>				
1	motors	good working and no noise		
2	gear box for three main parts	enough gear oil, no leakage, loosening bolts; no abrasion for cable		
3	stowage limit switches	good function, well connecting and no loosening bolts		
4	dock basing	no crack and broken for rail and base; cleaning the rail slot and stowage hole; no broken and loosening for gantry block. Checking the rail: linear, distance, level difference, sunken, clearance, wrong connection and slope		
<b>spreader, headblock and over-height adapter</b>				
1	mainstructure	no abnormal abrasion, no crack for welding line		
2	connecting bolts	no loosening		
3	upper rope-loosening limit switch for head block	good function, well connecting and no loosening bolts		
The "result" column should be filled in :[√]pass; [0]fix/change; [×]rejected. The checking sheet should be collected after finish.				



**Table 2-24 scheduled maintenance task list (quarterly)**

Equipment No. :		start time:	No.of checking sheet:	
Checked by :		finish time:	running hours:	
serviced by:		date:	technical confirmed by:	
no.	checking part	standard	result	process
<b>whoel crane</b>				
1	motor	no abnormal abrsion; fragment or nicks.good condition for cooler		
2	electric cabinet	good condition for contractor, relay and switches		
3	air conditioner	good condition		
4	cable	no broken ,checking with mega olm-meter		
5	limit switches	good condition, well connected and no loosing bolts		
6	hydraulic system	no leakage for connectora		
7	brake	no grease for brake disc, no abnormal abrasion for brake bush		
8	geaer box	no noise, abnormal temperature, leakage		
9	lubrication	bearing for sheaves,wheel, nearing base and joints; shafts for star bar pin and trolley pin		
10	coupling	checking the bolts connecting and elastic parts' abrasion		
11	drum and sheaves	no abrasion for groove		
<b>crane main structure; stair and platform</b>				
1	structure for stair, platform and handrail	no tip-off, distortion and rust		
2	stair footplate and fastenning	no distortion and loosing		
3	grating plate and fasten hook	no distortion, moving and loosing		
4	main structure	no tip-off, distortion and rust		
5	painting	no rust, cockle and big area of peel-off		
6	high strength bolts	no loosing and rust		
7	welding line for girder and upper beam (seaside and landside)	no tip-off and crack		
8	front and back stay bar	no distortion, crack; reliable function		
9	level stay bar	no distortion, crack; reliable function		
10	diagonal support of portal frame	no distortion, crack; reliable function		
11	limit switch bumping plate	no tip-off, distortion, rust and abrasion		





12	steel structure for gantry	no tip-off, distortion, rust and abrasion		
13	shaft lock plate and anti-cut block for equalizer shaft	no tip-off and loosening for bolts of shaft block		
14	check room	no tip-off, distortion, leakage and good lock		
15	air piping and reduce valve	no leakage, distortion, rust; good valve		
16	anti-wind bar and cable	neatly motion, well lubricated and fixed		
17	air compress system	good condition; no leakage		
18	emergency device	well fixed, no broken and leakage		
19	emergency transmission chain	no abrasion		
20	rope changer	no tip-off, distortion, rust and abrasion		
21	main structure for machinery house	no distortion, tip-off and leakage		
22	portal beam and rail for service crane	no tip-off, distortion, rust and abrasion		
23	pressure plate for trolley rail	no twist bolts and normal torque		
	boom joint	no tip-off, distortion, rust and abrasion		
24	wheels for gantry and trolley	no abrasion		
	block for trolley	no loosening and broken		
25	hoist motor and brake for indoor service crane	good condition; no rust and block for brake		
26	rope guide and rope changer	good condition, no slope bolts		
27	damper	no aging, crack and loosening		
28	main structure for anti-sag	no distortion, tip-off and crack		
29	outdoor lifting crane	no distortion, tip-off and loosening; good position for trolley		
30	structure for testoon	no tip-off, distortion, rust and abrasion		
31	structure for cab hanging	no tip-off, distortion, rust and abrasion		
32	hanging bolts for cab	no tip-off, distortion, rust and abrasion		
33	steel structure for the cab	no distortion, tip-off and inleakage		
34	structure for trolley frame	no tip-off, distortion, rust and abrasion		
35	support base for sheaves	no tip-off, distortion, rust and abrasion		



36	main structure for tension device	no tip-off, distortion, rust and abrasion		
37	outdoor lifting trolley	neatly; no distortion and loosig parting		
38	support base for boom sheaves	no tip-off, distortion, rust and abrasion		
39	steel structure for boo stowage	no tip-off, distortion, rust and abrasion		
40	spreader	well lubricated, good condition for sheaves and bearing; no crack for welding line		

The "result" column should be filled in :[√]pass; [0]fix/change; [×]rejected. The checking sheet should be collected after finish.



**Table 2-25 scheduled maintenance task list (semi-annually)**

Equipment No. :		start time:	No.of checking sheet:	
Checked by :		finish time:	running hours:	
serviced by:		date:	technical confirmed by:	
no.	checking part	standard	result	process
<b>general and elevator</b>				
1	lighting	keep reliable state for light base and rectifier, good condition for emergency lighting		
2	limit switch	coennection for limit switches; fastenning for bolts		
3	gear box for elevator	good condition, no noise and enough oil		
4	standard joint	no distorion and crack, no loosing bolts		
5	handrail, damper and elevator door	good condition, no distortion and abnormal abrasion		
6	the corect and safety function for elevator	no noise and abrasion for guide wheel; correct stopping		
7	he motor and electric system for elevator	clean the radiator of motor, checking the cable, connection and sealing		
8	alarm, lighting and communication system for elevator	good condition		
<b>machinery house</b>				
1	motor	clean the motor coil, checking the motor resistance by mega-ohm meter		
	electric cabinet	checking the connection for contactor and relay; checking the resistance and capacitnce for reactor and filter.		
2	brakes	checking the limit switch function, checking the abrasion and broken for the parts		
3	rope changer	lubricate the coupling, checking the abrasion		
5	bearing base	no noise and abnormal temperature for bearing, checking the fasten for bolts, well sealed		
6	gear box	well fixed and no leakage; enough oil		
10	service crane	well connected		
<b>back girder</b>				
1	outdoor beam crane	lubricate the bearing		
2	sheaves for tensioner and anti-srag	lubricate the bearing		
3	trolley tensioner cylinder	lubricate the bearing		
<b>cable festoon</b>				



1	rail	no crack for welding line; no distortion for rail and hanging part		
2	fixing bolts and screws	no broken and distortion		
<b>driver cab and trolley top</b>				
1	speed and acceleration for trolley and main hoist	good condition		
2	slip ring box for cable reel	clean; checking the connection of bolt, checking the abrasion of carbon brush; checking the sealing of box		
3	brake for cable reel	good condition		
<b>boom</b>				
1	joints between boom and girder	no abnormal abrasion and noise		
2	roller for the joints	no abnormal abrasion, rotate freely		
3	trolley damper	No distortion and broken		
4	weight sensor	well connected and no broken cable		
<b>top platform</b>				
1	wind speed alarm	good condition and correct display		
2	beam crane	lubricate the bearing, checking broken state		
<b>gantry</b>				
1	speed and acceleration	good condition		
2	motor	clean the motor coil, checking the motor resistance by mega-ohm meter		
3	coupling	lubricate the coupling, checking the abrasion		
<b>spreader and head block</b>				
1	oil reservoir	enough oil		
2	filter	good condition and correct display		
3	lock pin	no abnormal abrasion		
4	over-height adapter	well lubricated		
The "result" column should be filled in : [√]pass; [0]fix/change; [×]rejected. The checking sheet should be collected after finish.				



**Table 2-26 scheduled maintenance task list (annualy)**

Equipment No. :		start time:	No.of checking sheet:	
Checked by :		finish time:	running hours:	
serviced by:		date:	technical confirmed by:	
no.	checking part	standard	result	process
<b>general</b>				
1	crane and accessory (like air compressor)	certificate every year		
2	electric	checking the broken for limit switches, cable, ray cable, terminal, cable number, cable groove and cable guide; clean the connector for ray cable		
3	electric	checking the communication system, chagn the power for the emergency lights		
4	electric	make sure the fixing for terminal box, control panel and I/O equipment and control desk. No broken for cables		
5	electric cabinet	lubricate the knife switch; checking the function for indicator light, switch pushbutton and gauges. No broken cable, dust on risistance and over-heat. checking the setting for over heat; over-current and time relay. checking the insulation for reactance.		
6	electric parts	checkingt the abnormal state for printing board and electric parts, checking the weight sensor through standard load.		
7	transformer	checking no dust in the air; checking the transformer(main, light, control)checking the connection for cable connector		
	reactance	no fire tract for electric reactance, clean the parts, no broken. Good function for cooler.		
	electric	keep clean, fan, lights and temperature alarm in good condition		
8	service crane	certificate every year		
9	elevator	certificacate every year, exhaustively checking the abrasion for loading bearings and other parts under load.		
10	air conditioner ( electric boom and driver cab)	good condition		
<b>machinery house</b>				
1	motors	well cable connected, good condition for the rectifier, adjusting the current through the rated value on the nameplate		



2	brakes	checking the abrasion for brake bush, and decline abrasion; no distortion and crack for brake structure		
3	hydraulic system	checking the quality of hydraulic oil( hydrous rate)		
4	drums	checking the abrasion for drum rope groove		
5	emergency device	checking the limit switch, lubricate the chain and coupling		
6	gear boxes, motors and brakes for three main parts	checking the torque for base fixing bolts , checking the joggle for the gear inside		
7	low speed couplings	checking the abrasion and centralization for the coupling; fasten the bolts		
8	high speed couplings	checking radius and angle		
9	the limit device on the tip of bearing base	checking the abrasion and centralization for the limit switch coupling		
10	service crane	checking the rope guide, safety device, control cable, control panel, brake and hanging device for wire rope stowage. fasten all the bolts, checking the crack on the hook;checking the cold distortion, abnormal abrasion fixing for base and hook, emergency limit switches and coupling for low speed hoist. lubricate the wire rope		
<b>back girder</b>				
1	main structure for anti-slag	no crack on welding line		
2	hydraulic system	correct pressure setting for the valves		
3	sheaves for tension and anti-slag device	checking the press track on rope groove		
4	cylinders for tension and anti-slag device	no leakage and broken		
<b>driver cab and trolley top</b>				
1	spreader cable reel	lubricate the bearing, checking the joggle for gear		
2	wheels and horizontal wheel for trolley	no abnormal abrasion		
3	fixed roller	no abnormal abrasion, rotate freely; well fixed wear block and no crack on the roller base.		
<b>top platform</b>				
1	boom wire rope	well lubricated ,checking the abnormal		checking



		abrasion and broken		when "boom"
<b>gantry cable reel</b>				
1	gantry cable reel	lubricate the bearing, checking the joggle for gear		
	high voltage slip ring box	well sealed for the box, no inleakage; good contraction for slip ring and carbon brush; no broken and loosening.		
<b>gantry</b>				
	ground terminal box	clean the box; no distortion, leakage and broken, well cable connection		
	mobile high voltage cable	no distortion and broken		
1	wheel brake disc	checking the abrasion of brake bush		
2	lubrication	lubricate wheel bearings and pin shaft of equalizer		
3	gantry gear box	checking the quality of gear oil (hydraulic rate)		
4	hydraulic system	checking the quality of hydraulic oil (hydraulic rate)		
<b>spreader and head block</b>				
1	lubrication	lubricate the motor and bearings		
2	spreader, head block and over-height adapter	checkign the abrasion for the lock pin		
The "result" column should be filled in :[√]pass; [0]fix/change; [×]rejected. The checking sheet should be collected after finish.				



**Table 2-27 scheduled maintenance task list (every 5 years)**

Equipment No. :		start time:	No.of checking sheet:	
Checked by :		finish time:	running hours:	
serviced by:		date:	technical confirmed by:	
no.	checking part	standard	result	process
<b>whole crane</b>				
1	QC and accessory	certified every 5 years		
2	elevator	exhaustively check the motors, brakes and gears in gear box, change all the safety equipment		
<b>machinery house</b>				
1	motors for three main parts	changing the cooler and vane		
2	gear box for three main parts	exhaustively check the gear and gear joggle.		
3	low speed coupling for three main parts	exhaustively checking and heavy repair		
4	high speed coupling for three main parts	exhaustively checking and heavy repair		
5	high speed brake for three main parts	exhaustively checking and heavy repair		
6	low speed brake for three main parts	exhaustively checking and heavy repair		
7	service crane	certified every 5 years		
<b>driver cab and trolley top</b>				
1	cable	exhaustively checking and no broken		
2	speed reducer for spreader cable reel	exhaustively checking the gear interface and gear joggle		
3	wheels for trolley	exhaustively checking the abrasion for wheels		
4	cables for trolley festoon	exhaustively checking and no broken		
<b>cable reel</b>				
1	gear box for cable reel	exhaustively checking the gear interface and gear joggle		
<b>gantry</b>				
1	wheels	exhaustively checking the abrasion for wheels		
2	wheel brake	exhaustively checking and heavy repair		
3	gear box	exhaustively checking the gear interface and gear joggle		
<b>spreader and head block</b>				
1	lock pin	exhaustively checking the abrasion for wheels; no crack		
The "result" column should be filled in :[√]pass; [0]fix/change; [×]rejected. The checking sheet should be collected after finish.				





**Table 2-28 scheduled maintenance task list (every 10 years)**

Equipment No. :		start time:	No.of checking sheet:	
Checked by :		finish time:	running hours:	
serviced by:		date:	technical confirmed by:	
no.	checking part	standard	result	process
<b>whole crane</b>				
1	QC and accessory	certified every 5 years		
2	elevator	exhaustively check the motors, brakes and gears in gear box, change all the safety equipment		
<b>machinery house</b>				
1	motors for three main parts	exhaustively checking		
2	gear box for three main parts	exhaustively checking		
3	low speed coupling for three main parts	exhaustively checking		
4	high speed coupling for three main parts	exhaustively checking		
5	high speed brake for three main parts	exhaustively checking		
6	low speed brake for three main parts	exhaustively checking		
7	cooler and emergency motor	exhaustively checking		
8	main switch for high voltage cabinet	exhaustively checking		
<b>girder</b>				
1	sheaves for tensioner and anti-sag device	exhaustively checking		
<b>cable festoon</b>				
1	cable for festoon trolley	exhaustively checking		
<b>driver cab and trolley top</b>				
1	sheaves	exhaustively checking		
2	slip ring box	exhaustively checking		
3	cable for spreader	exhaustively checking		
4	trolley wheel	exhaustively checking		
<b>boom tip</b>				
1	trolley wheel	exhaustively checking		
<b>gantry cable reel</b>				
1	cable	exhaustively checking		
2	high voltage slip ring box	exhaustively checking		
<b>gantry</b>				
1	gear box	exhaustively checking		
2	wheel brake	exhaustively checking		
3	cable	exhaustively checking		
<b>spreader and headblock</b>				
1	spreader and headblock	exhaustively checking		

The "result" column should be filled in :[√]pass; [0]fix/change; [×]rejected. The checking sheet should be collected after finish.

## Chapter 3 Some important parts replacement

### 3.1 General:

#### 3.1.1 Attention

This chapter includes main components such as: bearing pedestal, motor coupling, drum coupling, motor brake, drum brake, gantry wheel brake, trolley wheel, gantry wheel, main hoist sheave, rope idler roller and so on. The personnel who takes part in the replacement procedure must be acquainted with the structure of components, control the operation step and have an ability of coping with the abrupt affairs. Before working, it is obligatory that set down the ethnics in detail according to this chapter, have a pre-work meeting, adopt to safety precautions, point someone who takes responsible for safe coordination, and strictly obeys the safety rule request in chapter 2.

	Danger of tripping!
	Keep away from suspended loads!
	Pinch Hazard!

### 3.2 Bearing pedestal replacement

#### 3.2.1 Preparation

The bearing pedestals are included in main hoist mechanism, trolley driven mechanism, boom hoist mechanism, which are all level form, shown in figure 3-1. Before replacement, carefully research the drawings, understand the bearings constitutes, the drawings about bearing pedestal on table 3-1. personnel and tools on table 3-2.

**Table 3-1: Drawings for bearing pedestal replacement**

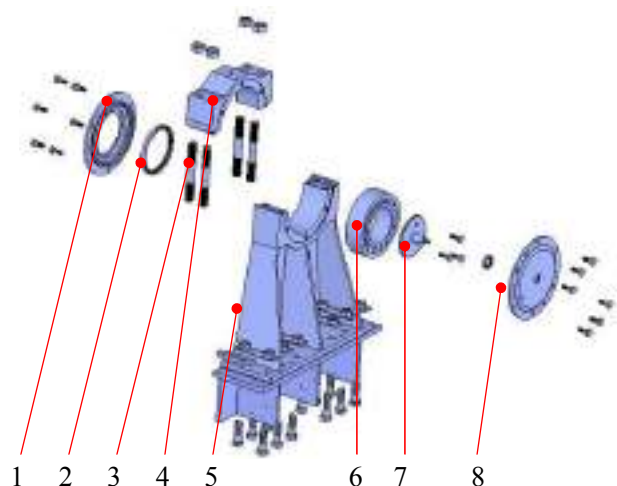
Main hoist bearing pedestal	J607A0300, HDS03a-800
Trolley bearing pedestal	J607A0400, ZM006500-J474B04
Boom hoist bearing pedestal	J607A0500, HDS03a-800

**Table 3-2 : personnel and tools for bearing pedestal replacement**

Personnel/quantity		Tools/quantity	
Lifting worker	3	Bottle gourd	1(10t)
welder	1	larma	1
fitter	1	Tension wrench	2
electrician	1	others	several



**figure 3-1: bearing pedestal appearance**



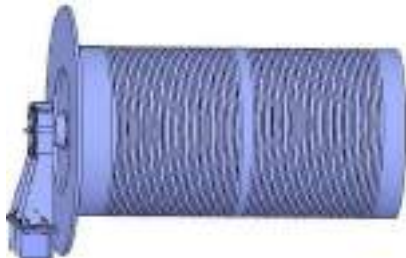
**figure 3-2: bearing pedestal sketch map**

1 end over1	2 seal	3 double screw bolt	4 upper seat
5 down seat	6 bearing	7 L.S shaft	8 end cover2

### 3.2.2 Replacement procedure

- 1) Lower the spreader to the ground and slacken the Main Hoist ropes. (or position the boom to the level and slacken the Boom Hoist ropes)
- 2) Lock out the crane's motion for the affected drives by performing lock-out and tag-out procedure.
- 3) Disconnect the coupling between the drum and the rotary limit switch, Use slings and softeners to connect the drum to the service crane.
- 4) Tie off each of the ropes in machinery house to remove the rope load from the drum.

Slacken enough rope, so that the drum can be moved slightly. Before replacement the whole appearance of mechanism are shown in figure3-3



**figure 3-3: The whole appearance of mechanism before replacement**

- 5) Remove the bearing pedestal end cover nuts.



**figure 3-4: Step 6**

- 6) Unfasten the stud nuts and screw.



**figure 3-5: Step 7**

- 7) Remove the bearing pedestal end cover 1



**figure 3-6: Step 8**

- 8) Remove the L.S shaft or shaft end plate.



**figure 3-7: Step 9**



**figure 3-8: Step 9**



The drum end is fasten on the support in machine house by ropes. Lift the drum up 50mm by bottle gourd, then move the lower bearing pedestal sideways from the drum shaft by the service crane, use a puller with a 10-ton capacity to pull out of the bearing.

- 9) Carry the bearing pedestal to the ground by the service crane, other procedure will do at workshop.



figure 3-9: Step 10



figure 3-10: Appearance after up pedestal removed

- 10) Remove the bearing and end cover 2.



figure 3-11: Step 11

- 11) Clean the drum shaft and bearing pedestal with solvent. Shaft seals should also be replaced if necessary.



figure 3-12: Step 12

- 12) Install a new bearing.



figure 3-13: Step 13

- 13) Re-assemble the bearing pedestal together in the reverse order mentioned above.
- 14) Realign the drum couplings. Refer to chapter 2 for alignment criteria. Verify the drum-mounted rotary limit switch setting and alignment.
- 15) Remove lock-out and tag-out devices and Pre-Op the crane. Startup and monitor the crane to verify its operation before returning it to service.

### 3.3 Motor coupling replacement

#### 3.3.1 Preparation

The motor couplings are included in main hoist mechanism, trolley driven mechanism, boom hoist mechanism, which are all flexible elastomeric type couplings, shown in figure 3-14 and 3-15. Before replacement, carefully research the drawings, understand the motor coupling constitutes, the drawings about motor coupling on table 3-3, personnel and tools on table 3-4; For Detail should be referenced by the manual of bubenzer.

table3-3:Drawings for motor coupling replacement

Main hoist motor coupling	J607A0300
Trolley driven motor coupling	J607A0400
Boom hoist motor coupling	J607A0500

table 3-4: Personnel and tools for motor coupling replacement

personnel/ quantity		tools/quantity	
Lifting worker	1	Bottle gourd	1 (10t)
welder	1	larma	1
fitter	3	Torque wrench	2
electrician	1	others	several



figure 3-14: Motor coupling appearance

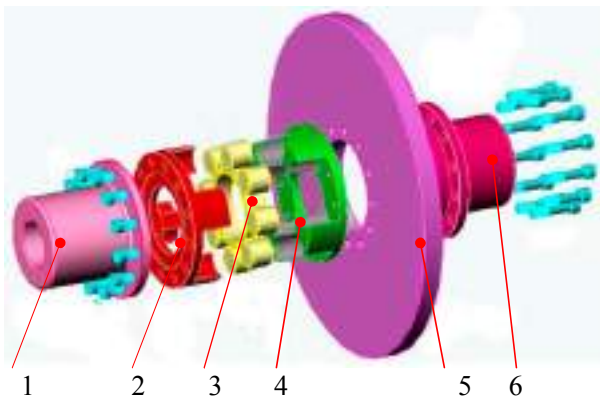


figure 3-15: Motor coupling sketch map

- |                       |                         |
|-----------------------|-------------------------|
| 1 motor side coupling | 2 motor side jaw        |
| 3 spider              | 4 reducer side jaw      |
| 5 brake disc          | 6 reducer side coupling |

### 3.3.2 Replacement procedure

- 1) Lower the spreader to the ground and slacken the Main Hoist ropes. (or position the boom to the level and slacken the Boom Hoist ropes)
- 2) Lock out the crane's motion for the affected drives by performing lock-out and tag-out procedure.
- 3) Disconnect the coupling between the drum and the rotary limit switch, Use slings and softeners to connect the drum to the service crane.
- 4) Tie off each of the ropes in machinery house to remove the rope load from the drum.
- 5) Remove the electrical connection from the motor brake, release the brake manually, then remove the brake by service crane.
- 6) Unfasten the nuts between motor side half coupling and motor side jaw; remove the motor and half coupling by service crane.



figure 3-16: Step 6

- 7) Take out the motor side jaw.



figure 3-17: Step 7

- 8) Take out the spider.



figure 3-18: Step 8

- 9) Remove the motor side half coupling by larma. Protect the motor shaft during the process.



figure 3-19: Step 9

- 10) Remove the reducer side half coupling. At first, remove the chain pulley on it.



**figure 3-20: Step 10**

- 11) Generally , the chain pulley is two half forms. Remove it by service crane.



**figure 3-21: Step 11**

- 12) Remove the driven side jaw.



**figure 3-22: Step 12**

- 13) Remove the brake disc.



**figure 3-23: Step 13**

- 14) Remove the driven side half coupling by larma, Protect the reducer shaft during the process.



**figure 3-24: Step 14**

- 15) Next is the procedure of re-align the new motor coupling. A bought coupling should be anti-corrosive treated, sealed well.



**figure3-25:Appearance of folded motor coupling**

- 16) After unfold the cover, clean the anti-rust oil, heating inset the two half couplings(or by oil bath heating)



**figure 3-26: Step 16**

- 17) When re-aligning, match the serial number between the half coupling and the brake disc.



**figure 3-27: Step 17**

- 18) Thread the heating half coupling into the, reducer shaft for blocking proof, the quicker the better, not overtime(ten minute).



figure 3-28: Step 18

	<p>Thread the heating half coupling into the, reducer shaft for blocking proof, the quicker the better, not overtime(ten minute).</p>
--	---

- 19) Realign the motor coupling according to the method in chapter 2, as for coupling allowable compensation rate, install separation, nuts torque, please refer to the coupling manual.



figure 3-29: Drum coupling appearance

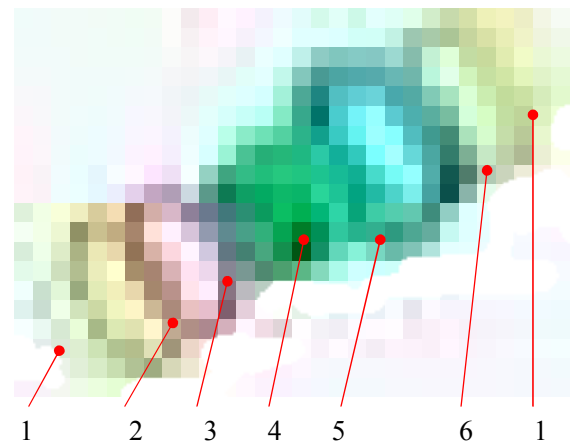


figure 3-30: Drum coupling sketch map

- |                   |                       |               |
|-------------------|-----------------------|---------------|
| 1 seal            | 2 out cover           | 3 load ring   |
| 4 out dental boss | 5 inner dental flange | 6 inner cover |

### 3.4 Drum coupling replacement

#### 3.4.1 Preparation

The drum couplings includes main hoist mechanism, trolley driven mechanism, boom hoist mechanism, which all are dental formula coupling, shown in figure 3-29 and 3-30 Before replacement, carefully research the drawings, understand the drum coupling constitutes, the drawings about drum coupling on table 3-5. personnel and tools on table 3-6.

For Detail should be referenced by the manual of Malmedie.

table 3-5: Drawings for drum coupling replacement

Main hoist drum coupling	J607A0300
Trolley driven drum coupling	J607A0400
Boom hoist drum coupling	J607A0500

table 3-6: Personnel and tools for drum coupling replacement

Personnel/quantity		Tools /quantity	
Lifting worker	2	Bottle gourd	2 (10t)
painter	1	larma	1 (200t)
locksmith	3	Torque wrench	2
electrician	1	others	several

#### 3.4.2 Replacement procedure

- 1) Lower the spreader to the ground and slacken the Main Hoist ropes. (or position the boom to the level and slacken the Boom Hoist ropes)
- 2) Lock out the crane's motion for the affected drives by performing lock-out and tag-out procedure.
- 3) Disconnect the coupling between the drum and the rotary limit switch, Use slings and softeners to connect the drum to the service crane.
- 4) Bind each of the ropes to machinery house to remove the rope load from the drum.
- 5) Hang the drum by service crane, remove the bearing pedestal, brake disc, and drop out the drum from the reducer shaft.



**figure 3-31: Step 5**

- 6) Disjoin the drum coupling step by step, and protect the out dental boss and inner dental flange.



**figure 3-32: Step 6**



**figure 3-33: Demounted inner dental flange**



**figure 3-34: Demounted out dental boss**

- 7) Then we will introduce how to demount the out dental boss and inner dental flange separately. For inner dental flange, at first place the drum in area near assembly. Then unfasten the nuts on it.



**figure 3-35: Step 7**

- 8) Suspended the inner dental flange by service crane, drop out it from the drum step by step.



**figure 3-36: Step 8**

- 9) Before demounting the out dental boss, at first estimate it if it is useful or not, If it is to be discarded as useless, plane it from the key slot by fire, then the coupling will drop out easily.



**figure 3-37: Step 9**

- 10) During the process, the reducer also can be set down (shaft upraise vertical), it is benefit to jacking up. Then fasten the double screw nut into the out dental boss.





**figure 3-38:** Step 10

- 11) Add an appropriate high mat slice, In order to make use of the shims of the jack to rise height well, (note all the shims should be stuffed).



**figure 3-39:** Step 11

- 12) Put the jack on the top of the shims steadily.



**figure 3-40:** Step 12

- 13) Put the raising flange at the peak, and make the double screw through the hole in flange.



**figure 3-41:** Step 13

- 14) Tighten nuts, assure the interface level up between the raising flange and jack, completely contact.



**figure 3-42:** Step 14

- 15) Start-up the jack. Normally, the whole procedure need one hour, more or less.



**figure 3-43:** Step 15

- 16) Next is the procedure of realign the new drum coupling. A bought coupling should be anti-corrosive treated, sealed well.



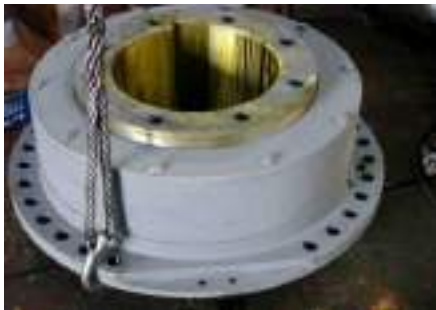
**figure 3-44:** Appearance of folded drum coupling

- 17) For cleaning rust inhibiting oil, benefit to next step, at first, take apart the inner dental flange, outer dental boss and abrasion indicator.



**figure 3-45:** Step 17

- 18) Clean the inner dental flange and outer dental boss carefully.



**figure 3-46:** Step 18

- 19) Heating inset the out dental boss,(or by oil bath heating)



**figure 3-47:** Step 19

- 20) When preparation ends, start up the installation, at first, telescope the abrasion indicator.



**figure 3-48:** Step 20

- 21) Telescope the out dental boss at the right place where is on the shaft of reducer, the quicker the better, for it will shrink in short time.



**figure 3-49:** Step 21

- 22) After the out dental boss fixed, telescope the abrasion indicator.



**figure 3-50:** Step 22

- 23) Realign the drum coupling according to the method in chapter 2, as for coupling allowable compensation rate, install separation, please refer to the coupling manual.

- 24) Remark line at the abrasion indicator, according to chapter 2.

## 3.5 Motor brake replacement

### 3.5.1 Preparation

The motor brake includes main hoist mechanism, trolley driven mechanism and boom hoist mechanism, which are

all electric hydraulic disc brakes., shown in figure 3-51 and 3-52, Before replacement, carefully research the drawings, understand the motor brake constitutes, the drawings about motor brake on table 3-7, the related personnel and tools on table 3-8.

For Detail should be referenced by the manual of bubenzer.

**table 3-7: Drawings for motor brake replacement**

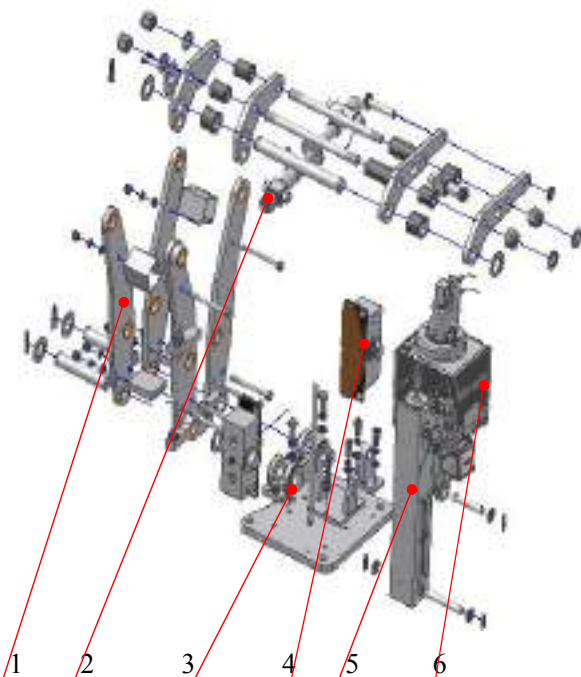
Main hoist motor brake	J607A0300
Trolley driven motor brake	J607A0400
Boom hoist motor brake	J607A0500

**table 3-8: Personnel and tools for motor brake replacement**

Personnel / quantity		Tools /quantity	
Lifting worker	1	bottle gourd	1 (5t)
welder	1	Fitter tools	several
locksmith	2	Tension wrench	1
electrician	1		



**figure 3-51: Motor brake appearance**



**figure 3-52: Motor brake sketch map**

1 brake arm      2 brake draw bar      3 equalization nut

4 brake gasket      5 brake spring subassembly      6 thruster

### 3.5.2 Replacement procedure

- 1) Lower the spreader to the ground and slacken the Main Hoist ropes. ( position the boom to the level and slacken the Boom Hoist ropes).
- 2) Avoid the crane's motions which affect safe driving by performing lock-out and tag-out procedure.
- 3) Only it is necessary, remove the whole brake., next we will introduce how to replace the whole brake and its ass.

#### 3.5.2.1 A whole brake replacement

- 4) Remove the power wire from the thruster, remove the L.S, and release the brake by hand.



**figure 3-53: Step 4**

- 5) Remove the nuts between the brake and support.



**figure 3-54: Step 5**

- 6) Suspend the brake away, mark the original position.



**figure 3-55: Step 6**

- 7) According to the mark, full install a new brake, relocation and adjustment is needed if necessary.



**figure 3-56: Step 7**

- 8) Remove LOTO devices and Pre-Op the crane. Startup and monitor the crane to verify its operation before returning it to service.

### 3.5.2.2 Thruster replacement

- 1) Take out the splint pin from up and down shaft on thruster.



**figure 3-57: Step 1**

- 2) Pull out the pin roll on thruster end, bend the thruster for laid aside firmly.



**figure 3-58: Step 2**

- 3) Pull out the pin roll on the support.



**figure 3-59: Step 3**

- 4) Suspend the thruster away. Thruster internal structure is more complicated, don't repair it in site. If it has any fault, please remove the whole thruster and give it to the professional person for repairing.
- 5) Install a new thruster.

### 3.5.2.3 Spring square tube replacement

- 1) At first, pull out the pin roll on thruster end, bend the thruster for laid aside firmly.



**figure 3-60: Step 1**

- 2) Turn the torque adjustable double screw bolt counter-clockwise, release the spring force.



**figure 3-61: Step 2**

- 3) Pull out the elastic cylindrical pin from groove nuts, Remove the groove nuts on square tube.



**figure 3-62: Step 3**

- 4) Pull out the splint pin from the spring support.



**figure 3-63: Step 4**

- 5) Pull out the pin roll.



**figure 3-64: Step 5**

- 6) Put up the set square.



**figure 3-65: Step 6**

- 7) Pull out the spring square tube.



**figure 3-66: Step 7**

### 3.5.2.4 Spring replacement

- 1) Screw the torque adjustable screw bolt to nut.



**figure 3-67: Step 1**

- 2) Turn the torque adjustable screw bolt clockwise, make sure that the screw bolt doesn't hold back the dummy plate under tube.



**figure 3-68: Step 2**

- 3) Pull out the dummy plate under spring tube by appropriate hammer.



**figure 3-69: Step 3**

- 4) Turn the torque adjustable screw bolt counter clockwise, until spring force disappear absolutely, wrest the nuts on the bolt up end. Pull out the bolt, spring support and spring. Install a new spring.



**figure 3-70: Step 4**

### 3.5.2.5 Auto compensate device replacement

- 1) Remove the compensate plate.



**figure 3-71: Step 1**

- 2) Remove the splint pin on shaft, loosen the holding screw on the pin roll.



**figure 3-72: Step 2**

- 3) Pull out the compensate screw bolt from cross square tube.



**figure 3-73: Step 3**

- 4) Loosen the nuts on screw bolt.



**figure 3-74: Step 4**

- 5) Pull out the screw shaft.



**figure 3-75: Step 5**

- 6) Pull out the pin roll.



**figure 3-76: Step 6**

- 7) Pull out the auto compensate device and set square assembly from the brake arm.



**figure 3-77: Step 7**

- 8) Remove the set square, take out the auto compensate device, install a new one.



**figure 3-78: Step 8**

### 3.5.2.6 Brake gasket replacement

- 1) Loosen the brake release device manually. Revolve the adjustable nut sufficiently.



**figure 3-79: Step 1**

- 2) Loosen the gasket binding bolt.



**figure 3-80: Step 2**

- 3) Move the gasket level for breaking away key. Then pull out it, and re-align a new gasket.



**figure 3-81: Step 3**

### 3.5.2.7 Hand release device replacement

- 1) Loosen the holding bolt on hand grip.



**figure 3-82: Step 1**

- 2) Pull out hand release grip.



**figure 3-83: Step 2**

- 3) Loosen the holding bolt on idler wheel.



**figure 3-84: Step 3**

- 4) Pull out the idler wheel.



**figure 3-85: Step 4**

### 3.5.2.8 Equalization nut replacement

- 1) Loosen the nuts under the screw bolt.



figure 3-86: Step 1

- 2) Loosen the adjustable nut to the screw end.



figure 3-87: Step 2

- 3) Loosen the adjustable screw bolt to the screw end and the top nuts.



figure 3-88: Step 3

- 4) Pull out the screw bolt, install a new one.



figure 3-89: Step 4

### 3.6 Drum brake replacement

#### 3.6.1 Preparation

The drum brake are included in main hoist mechanism,

boom hoist mechanism, which are all electric hydraulic disc brake, shown in figure 3-90 and 3-91, Before replacement, research the drawings carefully, understand the drum brake constitutes, the drawings about drum brake on table 3-9, related personnel and tools on table 3-10.

This chapter of drum brake is standard piece of ZPMC(hydraulic style); Drum brake of ZPMC in this project could refer to the bebenzer's manual for SB series Hydraulic Caliper Disc Brake.

table 3-9: Drawings for drum brake replacement

Main hoist drum brake	J607A0300
Boom hoist drum brake	J607A0500

table 3-10: Personnel and tools for drum brake replacement

Personnel/quantity		Tools /quantity	
Lifting worker	1	Bottle gourd	1 (5t)
Welder	1	Fitter tools	several
locksmith	2	Tension wrench	1
electrician	1		



figure 3-90: Drum brake appearance

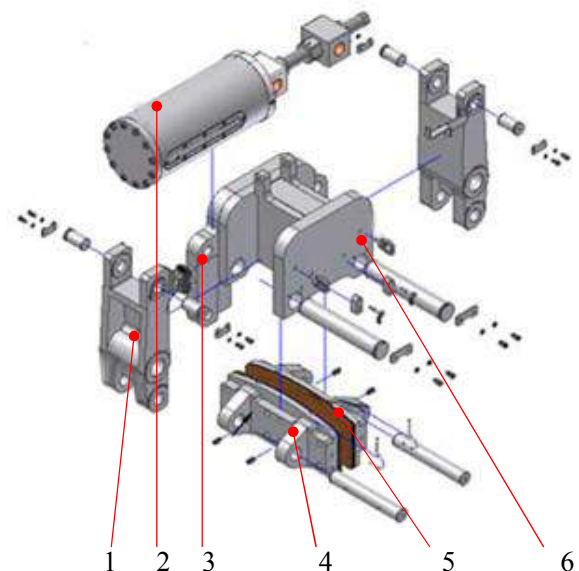


figure 3-91: Drum brake sketch map

- 1 brake arm    2 hydraulic cylinder    3 switch  
4 pedestal    5 brake gasket    6 support



### 3.6.2 Replacement procedure

- 1) Lower the spreader to the ground and slacken the Main Hoist ropes. (If change the drum brakes of the boom hoist mechanism, please position the boom to the level and slacken the Boom Hoist ropes)
- 2) Lock out the crane's motions which affect safe driving by performing lock-out and tag-out procedure.
- 3) If it is necessary, remove the whole brake., next we will introduce how to replace the whole brake and its ass.



figure 3-94: Step 2

- 3) Suspend the cylinder to safe place.

#### 3.6.2.1 Hydraulic cylinder replacement

- 1) Loosen the bolts on shaft end plate, remove the shaft end plate.



figure 3-92: Step 1



figure 3-95: Step 3

- 4) Install a new cylinder.

- 2) Pull out four pin rolls between hydraulic cylinder and brake arm one by one.



figure 3-93: Step 2



figure 3-96: Step 4



The hydraulic cylinder internal structure is more complicated, don not repair it in site, or it will be very dangerous, if cylinder has some failure, please replace the whole cylinder to professional person, and repair it in workshop.

#### 3.6.2.2 Pedestal spring replacement

- 1) Loosen the handing bolt, remove the pedestal.



**figure 3-97: Step 1**

- 2) Loosen two screws on spring.



**figure 3-98: Step 2**

- 3) Pull out the old pedestal spring, and install a new one, re-align it.



**figure 3-99: Step 3**

### 3.6.2.3 Brake gasket replacement



Generally, it isn't necessary to remove the whole drum brake, although this way is much safer and more effective.

- 1) Loosen the holding screw on pedestal pin.



**figure 3-100: Step 1**

- 2) Suspend the pedestal out.



**figure 3-101: Step 2**

- 3) Move the pedestal to a safer place.



**figure 3-102: Step 3**

- 4) Loosen the holding nuts on gasket.



**figure 3-103: Step 4**

- 5) Pull out the old gasket, install a new one.



figure 3-104: Step 5

### 3.7 Wheel brake replacement

#### 3.7.1 Preparation

The wheel brakes are included in the gantry mechanism, which are hydraulic disc brakes, see figure 3-105 and 3-106. Before replacement, it's very important to read the drawings on the wheel brake's structure. The drawings about wheel brakes see table 3-11, Personnel and tools placement see table 3-12.

This chapter of wheel brake is standard piece of ZPMC(hydraulic style); In this project we use the rail brake which could refer to the Hillmar 's manual .

table 3-11: The drawings on rail brakes

Wheel brakes	J607B0600
--------------	-----------

table 3-12: Personnel and tools

personnel/ quantity		tools/quantity	
Lifting worker	1	Handle gourd	1 (5t)
welder	2	Fitter tools	several
electrician	1	Tension spanner	1



figure 3-105: Wheel brake natural figure

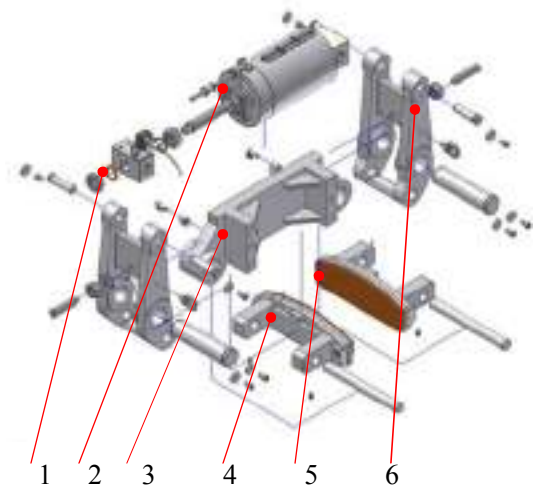


figure 3-106: Wheel brake abridged view

1 on-off key	2 fluid cylinder	3 base
4 pedestal	5 retaining piece	6 brake arm

#### 3.7.2 Replacement procedure

Only on special conditions, the whole wheel brake should be put apart. We introduce the replacement procedure of wheel brake and other unit mounts in the following parts.

##### 3.7.2.1 The whole wheel brake replacement

- 1) Lock out the crane's motions which affect safe driving by performing lock-out and tag-out procedure.
- 2) Remove the wire on the wheel brake L.S.
- 3) Hand releases the wheel brake through the hydraulic state.
- 4) Loosen the holding nuts, release the pressure in hydraulic state, loosen the adjustable nuts, and erase the spring force.



figure 3-107: Step 4

- 5) Remove the oil pipe on wheel brake, put the hose to a prepared case, warding for the hydraulic oil flowing to the ground.

- 6) Bracket the wheel brake by fork truck, and remove the bolts on its support.



**figure 3-108: Step 6**

- 7) Suspend the wheel brake by fork truck.
- 8) Install a new wheel brake by fork truck, connect the oil hose, and adjust it according to chapter 2.
- 9) Remove LOTO devices and Pre-Op the crane.
- 10) Startup and monitor the crane to verify its operation before returning it to service.

### 3.7.2.2 Hydraulic cylinder replacement



**Hydraulic cylinder is a main execute component on wheel brake, need special tools to assemble it, it is difficult to repair it in site. If there is failure in it, please replace the whole cylinder to professional person and repair it in workshop.**

- 1) Lock out the crane's motion which affect save driving by performing lock-out and tag-out procedure.
- 2) Disappear the spring force on wheel brake, and remove the wire and hose imitate last step.



**figure 3-109: Step 2**

- 3) Loosen the inner hexagon screw on brake arm using for holding the retainer ring.



**figure 3-110: Step 3**

- 4) Pull out the pin roll.



**figure 3-111: Step 4**

- 5) Pull out the whole cylinder.



**figure 3-112: Step 5**

- 6) Install a new, same type hydraulic cylinder, and re-assemble the L.S wire and hydraulic hose.



**figure 3-113: Step 6**

- 7) Adjust the wheel brake according to chapter 2.



figure 3-114: Step 7

### 3.7.2.3 Brake gasket replacement



When gasket thickness less than 2mm , you should replace the gasket.

- 1) Lock out the crane's motion for the affected drives by performing lock-out and tag-out procedure.
- 2) Open the brake to the most opening span.
- 3) Loosen the bolts on gasket.



figure 3-115: Step 3

- 4) Hold the gasket by hand, and sever it to the wheel side, make the gasket break away the key, and pull out it along the wheel radial.



figure 3-116: Step 4

- 5) Inspect the gasket surface clean or not, deform or not, and greasy dirt or not.
- 6) Install a new, same type gasket along wheel radial, and make the gasket groove aimed at join key groove.

- 7) Screw down all the bolts.
- 8) Adjust the wheel brake according to chapter 2.
- 9) Remove LOTO devices and Pre-Op the crane.

### 3.7.2.4 Pedestal spring replacement



Normally, pedestal spring will not failure, if find some abnormal condition, maybe the spring fall off or others.

- 1) Loosen the holding screw.



figure 3-117: Step 1

- 2) Loosen the holding pedestal, pull out the old spring, replace a new one and mount it firmly.



figure 3-118: Step 2

### 3.7.2.5 Pedestal replacement



Normally, pedestal will not failure, if find some abnormal condition, replace it according following procedure.

- 1) Lock out the crane's motions which affect driving by performing lock-out and tag-out procedure.
- 2) Loosen the spring.
- 3) Eliminate the fluid sealant on up and down pedestal holding screw hole.
- 4) Remove the holding pin.



figure 3-119: Step 4

- 5) Pull out the pedestal screw.



figure 3-120: Step 5

- 6) Pull out the old pedestal along the wheel radial.



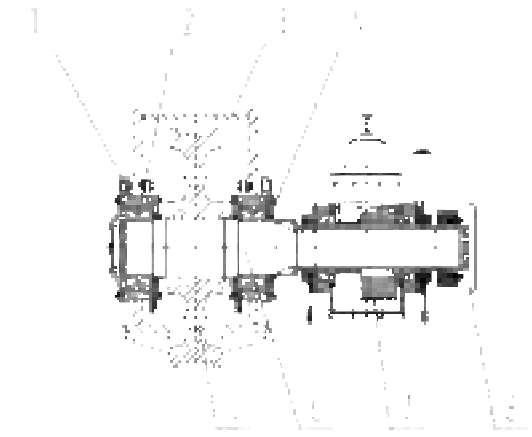
figure 3-121: Step 6

- 7) Install a new same type pedestal.
- 8) Install holding screws and wipe the fluid sealant.
- 9) Install the spring.
- 10) Remove LOTO devices and Pre-Op the crane.
- 11) According to chapter2, adjust the pedestal.

### 3.8 Gantry wheel replacement (8 wheels)

#### 3.8.1 Preparation

Gantry wheels are included in gantry mechanism, 8 wheels per corner, 32 wheels in total, then 24 driving wheels, other 8 are driven wheel. Before replacement, it's very important to read the drawings on the gantry wheel structure. The drawings about wheel brakes see table 3-13, Tools and personnel shown in table 3-14.



- 1 bearing block 2 bearing 3 frame 4 through cover  
5 driving wheel 6 driving shaft 7 reducer 8 plate

table 3-13 Drawings for gantry wheels replacement

Gantry wheels mechanism	J607B0600, J607B0604, J474B0605
-------------------------	---------------------------------

table 3-14: Personnel and tools for gantry wheels replacement

personnel/quantity		Tools /quantity	
Lifting worker	3	Chain block	1(5T)
welder	1	Bench tools	Several
Bench worker	2	Wrench	1
electrician	1	Cylinder 250t lift	1

#### 3.8.2 Replacement procedure

- 1) Jack up the crane with no suspended load in calm weather.
- 2) Lock out the crane's motion for the affected drives by performing lock-out and tag-out procedure.
- 3) Move the trolley to the following position:
  - At maximum outreach when the landside leg is jacked up.
  - At parking position when the waterside leg is jacked up.
- 4) The boom position is:
  - Raise the boom to the maintenance position when the waterside leg is jacked up
  - Set the boom to the operating position when the landside leg is jacked up.



At the jack point, use a Jacking-Up support connected with small equalizer beam by bolts where the replacement is located at and a 250t hydraulic jack with at least 500mm strokes on this support. The center line of jack should match the center line of rail. The wheel load value listed in chapter1.The jack capacity to jack up the lower equalizer beam is at least four times of the wheel load).

- 5) Align the hydraulic jack to center of lower equalizer beam. The jacking-up support contact with lower equalizer beam by bolts. Jack up the lower equalizer beam and have a forklift to hold the truck whose broken wheel is to be replaced. So there will be no load at truck pin.

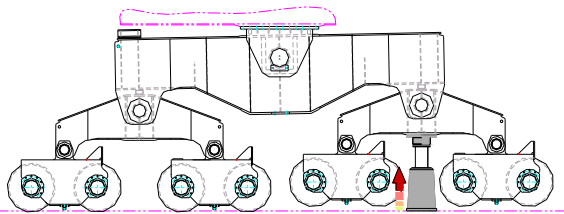


figure 3-109: Step 5

- 6) Jack up the equalizing beam by another jack, this procedure should match with big jack at the jack point, until the clearance between shaft and hole is equal.



figure 3-110: Step 6

- 7) Push the shaft by hand.



figure 3-111: Step 7



figure 3-112: Step 7

- 8) Fall the bogie on the rail slowly, then translate it laterally, move the bogie to the workshop by fork truck.

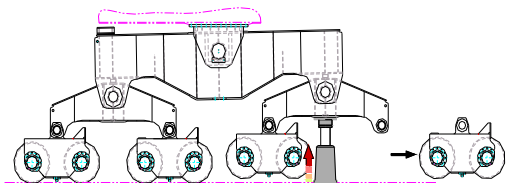


figure 3-113: Step 8

- 9) Remove the cover and pins of anti-torque plate out and loose and bolts of up-tight plate finally.

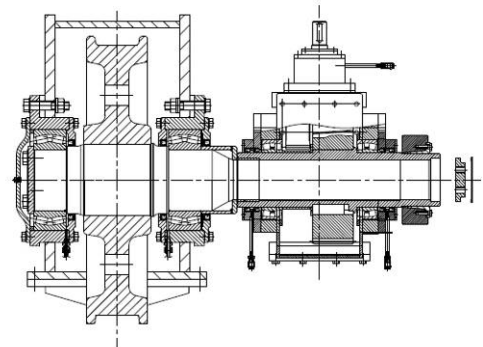


figure 3-114: Step 9

- 10) Remove the reducer.

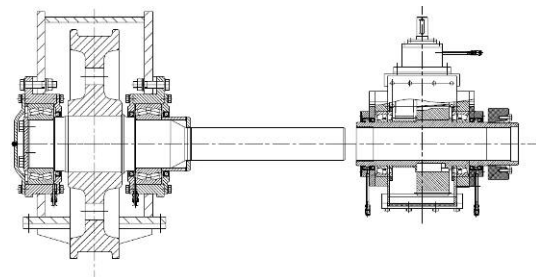


figure 3-115: Step 10

- 11) Remove the end-plate of wheel in the workshop



**figure 3-116: step 11**

- 12) Remove the bolts on bearing block.



**figure 3-117: Step 12**



**Figure 3-118: Driving shaft apparent after step 12**

- 13) Suspend away the wheel from the bogie by service crane.



**figure 3-119: Step 13**

- 14) Pull out the shaft from the bearing by larma. At

first, install additional pipe for larma on screw hole in bearing block.



**figure 3-120: Step 14**

- 15) Install the carrier rod of larma.



**figure 3-121: Step 15**

- 16) Install the hydraulic jack. Match the face between shaft end and jack. Then start up.



**figure 3-122: Step 16**

- 17) Pull out the bearing.



**figure 3-123: Step 17**



18) Pull out the bearing by hand.



**figure 3-124: Step 18**

19) Pull out the bearing pedestal.



**figure 3-125: Step 19**

20) Re-assemble the bearing and gantry wheel in contrary above on the gantry mechanism and equalizing beam.

21) Install the hollow shaft of reducer, install the

end-plate and bolts.

22) Adjust the bolts according to the requirements for up-tight plate of reducer, install the cover for up-tight plate.

23) Assemble onto the equalizer beam, and then finish the whole replacing process.

The procedures for driving wheel are same with driven wheel, except the details for reducer and up-tight plate.

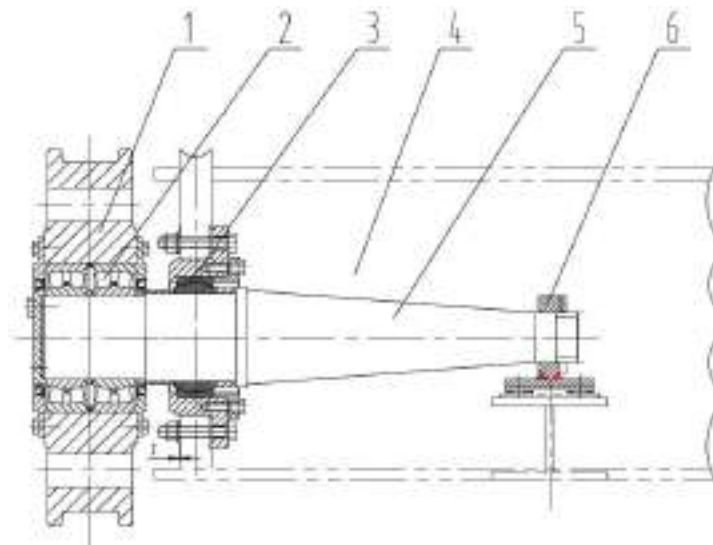
### 3.9 Trolley wheel replacement (4 wheels-rope towing)

#### 3.9.1 Preparation

Trolley wheels are included in the trolley ass, 1 wheels per corner, 4 wheels in total. For the pull type trolley, all the wheels are driven wheels. The wheels structure is shown in figure 3-126. Before replacement, it's very important to read the drawings on the trolley wheel's structure. See table 3-15&3-16

**table 3-15: Drawings for trolley wheels replacement**

Trolley wheel ass.	J607A0200&J474B0202
--------------------	---------------------



**figure 3-126: Trolley ass view**

1 wheel  
5 shaft

2 bearing  
6 pedestal

3 eccentric bearing

4 frame

**table 3-16: Personnel and tools for trolley wheels replacement**

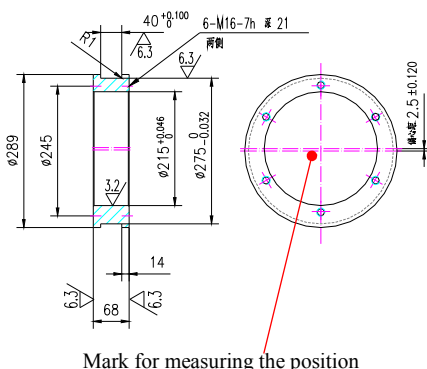
Personnel and tools placement are shown as below:

personnel/ quantity		Tools/quantity	
Lifting worker	3	Handle gourd	1 (5t)
welder	1	Fitter tools	several
Locksmith	2	Torque spanner	1
Llectrician	1		

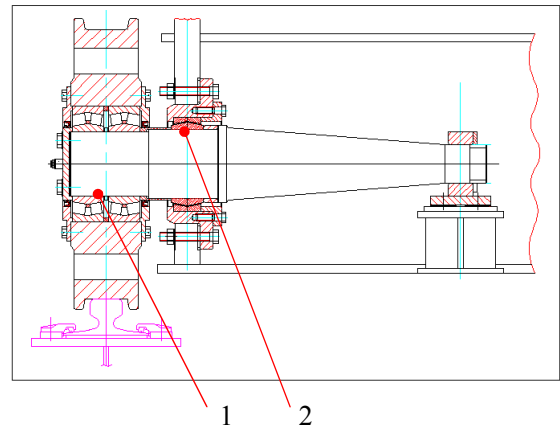
### 3.9.2 Replacement procedure

	<b>On running, if there is noise or splashing metal dust from the wheels, you should stop at once and check it, make an adjustable scheme.</b>
	<b>The checking of New QC during running-in time (150~300h), is very important. When built-in stress is released, trolley frame will deform appreciably, then check the trolley wheel and adjust it.</b>
	<b>On the end of adjusting, trail run with empty load, if well , then trail run with rated load.(20~30t, During this period, if there is anything wrong, adjust the wheel eccentric sleeve seat 2~5degree until acceptable.</b>

Trolley wheels replacement need many technologies, please read ZPMC method carefully. Each trolley wheel is supported by two anti-friction bearings which are housed inside two eccentric bearing sleeves, Both eccentric bearing sleeves are 1.5mm eccentricity.



**figure 3-127: Mark on trolley wheels**



**figure 3-128: Assay plan for wheel eccentric adjust**

1 trolley wheel 2 eccentric sleeve also bearing block

### 3.9.3 Eccentric sleeve assemble

- 1) The prepared eccentric sleeve.
- 2) Install the bearing on the wheel.
- 3) Install the seal on the end cover.
- 4) Install the end cover on the wheel.
- 5) Install the wheel on the shaft.
- 6) Install the bearing seat on the wheel shaft.
- 7) Install the whole wheel shaft on the support, adjust the sleeve and then tighten the bolts to fix the it. After adjusting the position of the wheel shaft, tighten the bolts on the cover.

### 3.9.4 Trolley wheel replacement

- 1) Move the trolley to the backreach (at its wheel maintenance position) and make sure the jack up point on the trolley frame.
- 2) Lower the spreader to the ground and slacken the main hoist ropes.
- 3) Perform the emergency stop to forbid all the process that influence the safety.
- 4) Install a 10T jack under jacking pads which are on the transverse centerline of the trolley (parallel to the

gantry rail). The gap between the top of the rail and the bottom of jack point is about 300mm. Rise the truck 10 mm. A timber block may be necessary between the trolley frame and rail top to prevent the trolley from tilting. The anti-lift plate may be removed from the trolley before jacking-up.



5) Loosen the bolts between the cover and sleeve thereby disconnecting the truck with defective wheel or shaft. Lift the truck up with the back reach overhead bridge crane, transfer to the electric jib hoist at the back reach and lower it to the ground.



**It is recommended that trolley wheel or axle repair work be accomplished in a workshop instead of on the crane.**

6) Disassemble the truck at the workshop. When disassembling the truck, first remove the wheel bearing end covers, and then make marks on the outside surface of bearing seats (eccentric sleeve) and truck.



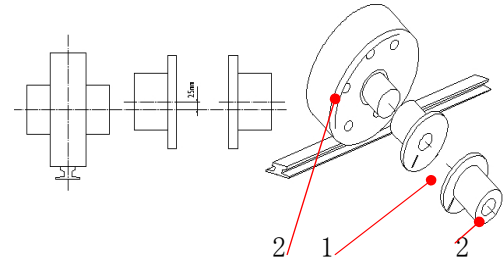
**The wheel bearing's seat is eccentric. The purpose of this design is that the axial alignment of trolley wheels on both sides of rails can be adjusted to proper value.**

- 7) Pull out the bearing.
- 8) Pull out the bearing.
- 9) Remove the old bearing.
- 10) Install the prepared bearing and bearing seat on the trolley wheel.
- 11) Suspend the new wheel into the shaft to assemble.
- 12) Install the sleeve on the shaft and then install the end cover and through cover.
- 13) Lift the new wheel and shaft by service crane at back reach, and translate them to the ground, re-assemble the pin roll.
- 14) Install the check plate and positioning bolts.
- 15) Install the bumper and other components, trail run the trolley.

### 3.9.5 Wheel adjustment analysis

Through different turning combinations of these two eccentric sleeves, the trolley wheels can be re-aligned in three conditions. 1) Horizontally Deviated; 2) Vertically leaned; 3) Vertical Lift-off.

1) Trolley Wheel in original position



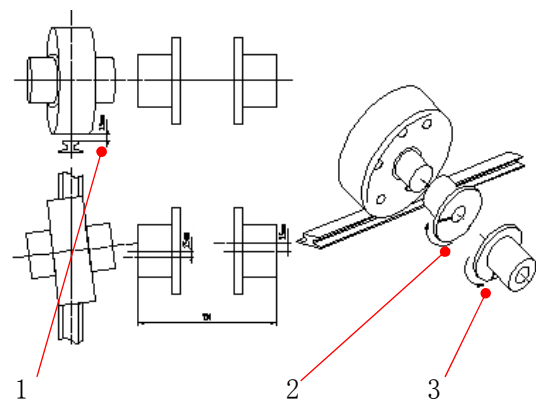
**figure 3-129: Trolley wheel in original position**

1 wheel 2 Original Pos. Mark on eccentric sleeve

Figure 3-129 shows the trolley wheel in its original position. The eccentricity of the bearing sleeve is exaggerated (not in scale, for a more clear view) **IMPORTANT!** Please locate the original position mark. If the mark is not there, make sure that you mark it before starting any disassembly. This will give you a definite direction of sleeve turning. You can return to the original position if the adjustment fails (gets worse after the adjustment).

2) Wheel Horizontally Deviate

Figure 3-130 shows how to make the wheel deviated horizontally. Turn the left sleeve 90 degree clockwise, and turn the right sleeve 90-degree counter clockwise. The wheel can be deviated horizontally to the left up to 0.97 degree. At the same time, the wheel will be elevated off the rail by 2.5 mm. If you turn the two sleeves in the opposite direction, the wheel will be deviated to the other direction.



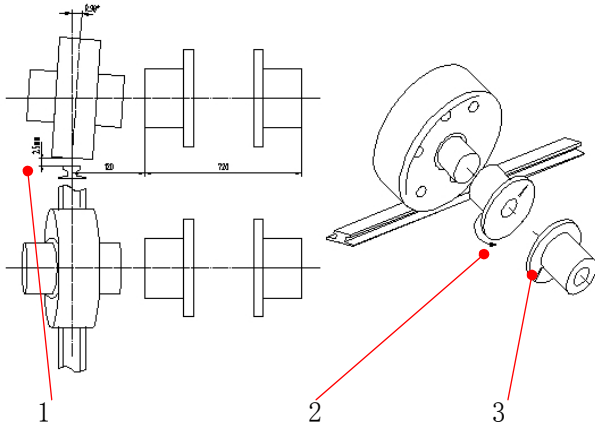
**figure 3-130: Wheel Alignment (Horizontal)**

1 wheel elevate 2.5mm 2 rotate 90 degree clockwise  
3 rotate 90 degree counter-clockwise

3) Wheel Vertically Leaned



When doing this adjustment, please gradually turn the eccentric sleeve. Every time, a 15~30 degree angle turning is recommended, then see if the trolley running condition has been improved. If necessary, turn another 15~30 degree.



**figure 3-131: Wheel Alignment (Vertical)**

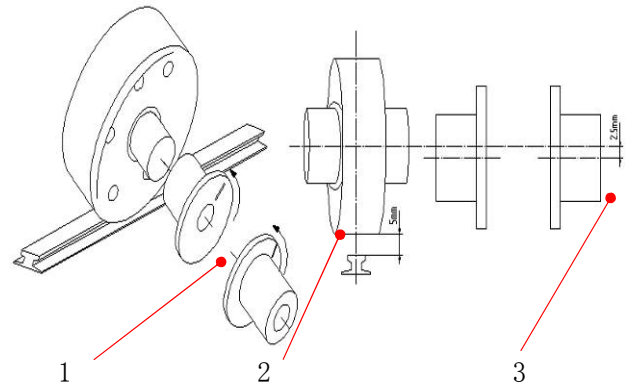
- 1 wheel elevate 2.5mm    2 rotate 180 degree clockwise  
3 not rotate

Figure 3-131 shows how to make the wheel leaned vertically. Turn the left sleeve 180-degree (either clockwise or counter clockwise), and the right sleeve stays un-turned. The wheel can be leaned vertically to the right up to 0.97 degree. At the same time, the center of the wheel will be raised the rail by 2.5 mm. If you do the two sleeves in the opposite direction, the wheel will be leaned to the other direction.



If turning one eccentric sleeve at 30, 60 or 90 degrees, the wheel will both leaned vertically and deviated horizontally. When one eccentric sleeve is turned 90 degree, half of the maximum deviation angle of 0.97 degree and half of the maximum leaning angle of 0.97 will be distributed evenly. You can do this if the wheel needs both deviation and leaning adjustment. Make sure the deviation and leaning direction is correct before doing this! (This decides which sleeve will be turned and what the turning direction is.)

- 4) Wheel Vertical Lift-off




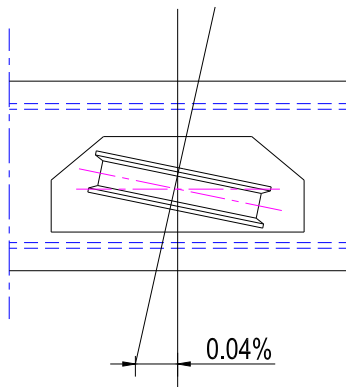

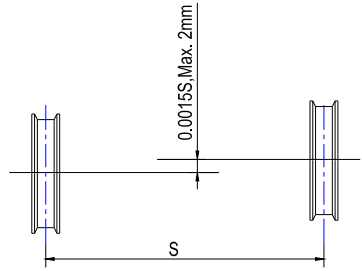
**Figure 3-132: Wheel Lift-off**

- 1 rotate 180 degree    2 rotate 180 degree  
3 wheel elevated 2.5mm

Figure 3-132 shows how to make the wheel vertically lift-off. Turn both the left and right sleeve 180 degree (either clockwise or counter clockwise). The wheel will be lifted vertically off the rail by 5 mm. If you do this by turning both sleeves 90 degree in the same direction, the wheel will be lifted off by 2.5 mm and there will be no wheel deviation and wheel leaning. The relationship between wheel alignment and eccentric sleeve turning is shown in table 3-17.

**table 3-17 : Wheel Alignment vs Eccentric Sleeve Turning Combination**

	Combination 1	Combination 2
Right Sleeve	90° ↺ ↻	Do not rotate
Left Sleeve	90° ↻ ↺	180° ↻ ↺
Wheel Alignment Results		
Horizontally Deviated	✓	
Vertically leaned		✓
Vertically lift-off	✓	✓
Wheel Alignment Results		
	Combination 3	Combination 4
Right Sleeve	180° ↻ ↺	Do not rotate
Left Sleeve	180° ↻ ↺	90° ↻ ↺
Wheel Alignment Results		
Horizontally Deviated		✓
Vertically leaned		✓
Vertically lift-off	✓	✓

	<p>The horizontal angular deviation of wheel axis to its theoretical position should be less than <math>\pm 0.04\%</math>.</p> 
	<p>The misalignment of the two opposite wheels' on two opposite rails. If the wheels are mounted on opposite bogie then the misalignment of opposite pins in the vertical plane should be less the 0.15% of the span, or a maximum of 2mm.</p> 

### 3.9.6 ILLUSTRATE FOR TROLLEY WHEELS ADJUSTMENT

1) Illustrate for Wheel Horizontally Deviate

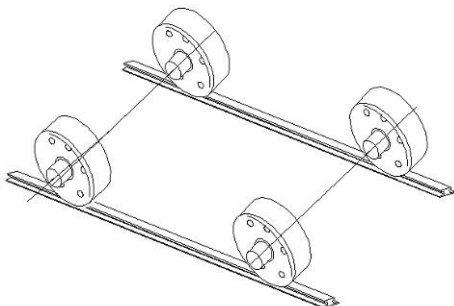



figure 3-133: Wheel horizontally deviate

The figure above shows seaside left wheel deflects horizontally. When trolley is running from landside to seaside, seaside horizontal wheels will extrude the left rail. Scream, or splash metal rust, then

try this way to settle it:

- If the wheel horizontal deflection angle is not big, near the permission offset, and wheels are rotated inside, then rotate the opposite wheels with same angle inside.
- If the wheel horizontal deflection angle is too big, or wheels are rotated outside, then according to the second method to adjust wheels.

	<p>Sometimes , two deflection wheels inside are better than two parallel wheels , just like a car, his two front wheels are deflectable inside to keep running straightforward,. And applicant the method in QC need more practice experience.</p>
---	--

2) Illustrate for Wheel Vertically Leaned

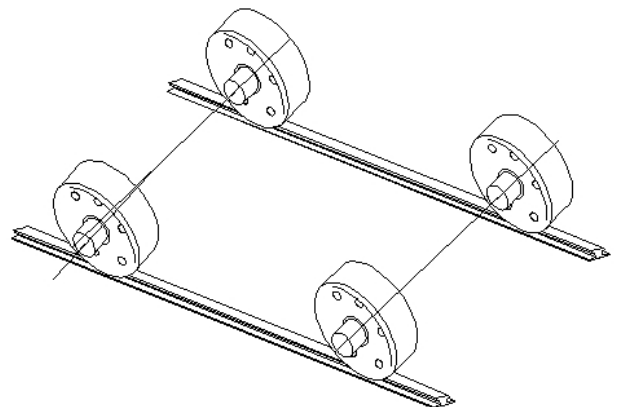


figure 3-134: Wheel Vertically Leaned

The figure above shows that wheel deflect vertically. Wheels will contact with inside rail. Normally it means rail side abrasion not asymmetry, and the other side rail will rusted, the wheels is the same condition, if the interface is caught down, the contact stress will increase, and the same to noise and vibration, then according to the third method in 3.9.5 to adjust wheels, but do not change the wheels in horizontal angle at same time.

3) Adjustment procedure:

- Remove the bolts on bearing block cover board.
- Loosen the half seat to rotate the eccentric sleeve.
- Find the peak on eccentric sleeve (three points).
- Lift the wheel until above rail 2-5mm.
- Measure the horizontal deviate.
- Fasten the bolts on eccentric sleeve, if necessary, rotate the eccentric sleeve to right angle by pontil

or other tools.

- g) Put the trolley down, resume it to the normal condition and trail run for check and adjustment effect.

### 3.10 Main hoist pulley replacement

#### 3.10.1 Preparation

The main hoist pulleys are included trolley frame, headblock, girder end, 18 in total. The nylon pulley at boom end which only for rope re-reeving needn't replaced, so the pulleys following are the forged one at other positions, 16 in total. The main hoist pulley pulleys constitutions are shown in figure 3-135& 3-136, before replacement, carefully research the drawings, understand the pulley constitutes, the drawings about pulley on table 3-18, personnel and tools on table 3-19.

**table 3-18: Drawings for pulley replacement**

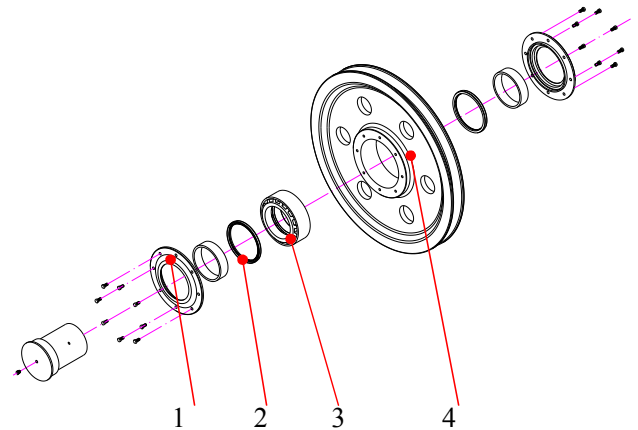
Main hoist pulley at trolley	J607A0200, TRSA07a-J474A, TRSA08a-J474A ZMHL900-Eb
Main hoist pulley at headblock	J607B1200, ZMHL900-Eb
Pulley in Anti-Snag device	J474A1000, ZMHL900-Eb

**table 3-19: Personnel and tools for pulley replacement**

personnel/quantity		tools/quantity	
Lifting worker	1	Bottle gourd	2 (0.5t)
Locksmith	2	Fitter tools	several
Electrician	1	Tension wrench	1



**figure 3-135: Main hoist pulley appearance**

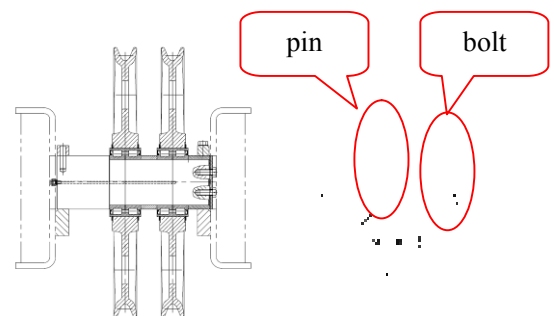


**figure 3-136: Main hoist pulley sketch map**

1 end cover    2 seals    3 bearing    4 pulley

#### 3.10.2 Replacement procedure

- 1) Move the trolley to backreach so that the sheaves which are to be replaced are accessible with the outside service crane at backreach.
- 2) Lower the headblock to the ground and slacken the main hoist ropes.
- 3) Lock out crane hoist and trolley motions by performing the lock-out and tag-out procedure.
- 4) Loosen the 4 bolts and pin connected the shaft upper seats with the structure of trolley frame.



**figure 3-137: Step 4**

- 5) Use two 0.5t chain hoists to remove the ropes from the sheaves which are to be replaced.
- 6) Remove the 2 shaft upper-seats and lift up the sheave assembly. Once the ropes are clear of the sheaves, place a timber across the opening where the sheaves were and released the rope wire onto the timber. Pull the bridge toward landside to let the sheave assembly be accessed by the electrical hoist on the jib.
- 7) Lower the sheave assembly to the ground and repair damaged sheave assembly parts in a workshop.



**figure 3-138: Step 7**

- 8) Tap out the shaft, don't damage the lubrication hole.



**figure 3-139: Step 8**

- 9) Suspend the shaft away by service crane in workshop.



**figure 3-140: Step 9**

- 10) Separate the two pulleys by service crane.



**figure 3-141: Step 10**



**figure 3-142: Dummy plate between pulleys**

- 11) After unfastening the pulley, remove the bolts on trouble pulley end cover.



**figure 3-143: Step 11**

- 12) Pull out up half bearing by larma.



**figure 3-144: Step 12**



**figure 3-145: Dummy plate between bearings**

- 13) Pull out the dummy plates.



**figure 3-146: Step 13**



**figure 3-147: outer dummy plate (brown part)**

- 14) Turn over the pulley, pull out another bearing by the same way.  
15) Re-assemble the pulley by reverse procedure.



## Chapter 4 wire rope



This chapter will introduce the common knowledge of the wire rope. If the conflict exists, the instructions provided by the wire rope supplier shall be preferential. There may be different regulations for the usage, maintenance, discarding of the wire rope that shall be strictly followed in different countries.

### 4.1 Basic knowledge of wire rope

#### 4.1.1 Construction

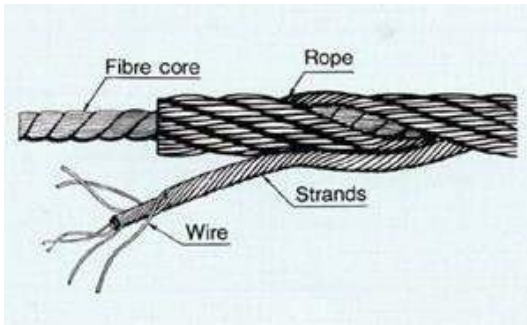
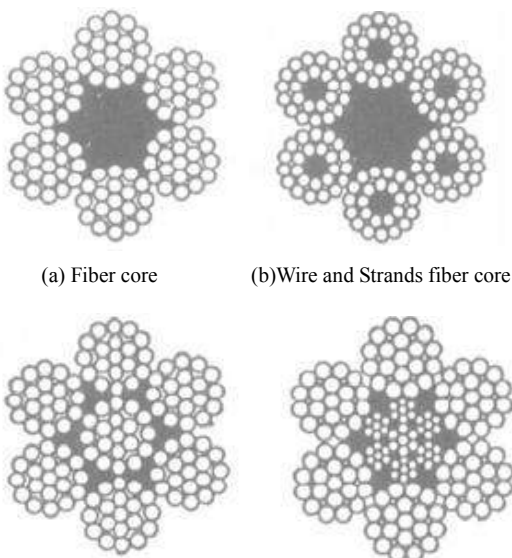


Figure 4-1: Wire rope appearance (example)

#### 4.1.2 Core

The core of the wire rope used for quayside container crane are shown in figure 4-2(d).



(c) Independent Wire Strand Cores(IWSC)      (d) Independent Wire Rope Cores(IWRC)

Figure 4-2: Core of wire rope

#### 4.1.3 Type of laying

##### 1) Direction of Laying

As concerns the direction of laying the rope and the strand, there is the Z lay and the S lay, as shown in Figure 4-3. in the case otherwise specified, the rope shall be made of Z lay and the stand products of the S lay.

##### 2) Laying of rope

There are two types of lay as shown in table 4-1:

- Ordinary lay(or regular lay): The lay of the rope and the lay of the strands are in opposite directions.
- Lang's lay: The lay of rope and the lay of the strands are in the same directions.

Table 4-1: Laying of wire rope

laying of rope	advantage	disadvantage
	Long silk on the surface, wear-resisting, soft and anti-fatigue, bend resistance	Big torque
	Hard and easy to operate, fixed tightly	Bad bend resistance

3) The length of a laying

Generally, The length of a laying (length of rope pitch) is usually 6.2~8.2 times of the wire rope diameter. The measurement of the length of a laying is shown in Figure4-3 (For a wire with 6 Srtands):



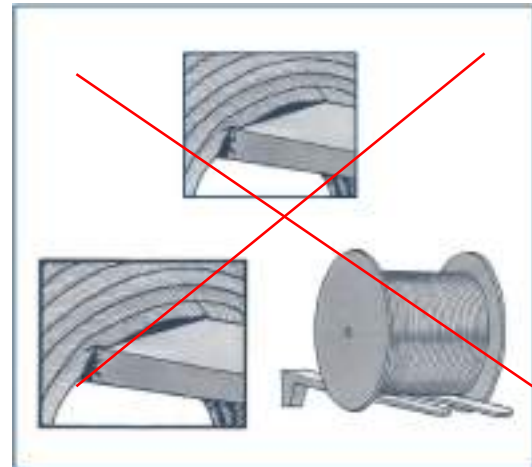
Figure 4-3: Measurement of a laying

## 4.2 Handling of wire rope

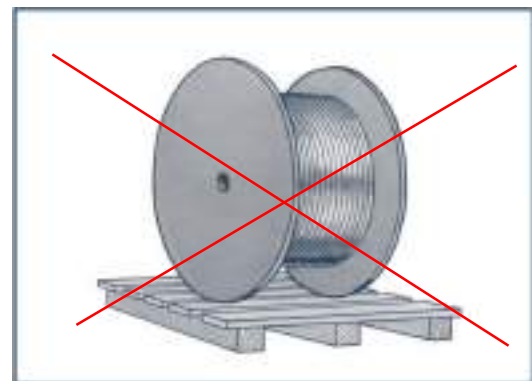
### 4.2.1 Transportation and storage

To prolong their life, the wire rope must be properly transported, stored, cleaned, inspected and installed. Wire ropes are easily affected by external damage. Therefore, they must be handled with utmost care during transport and unloading. All wire ropes should be stored clean, dry and cool and soil contact must be avoided anyway. Wire ropes must always be handled with equipment that will not damage the rope.

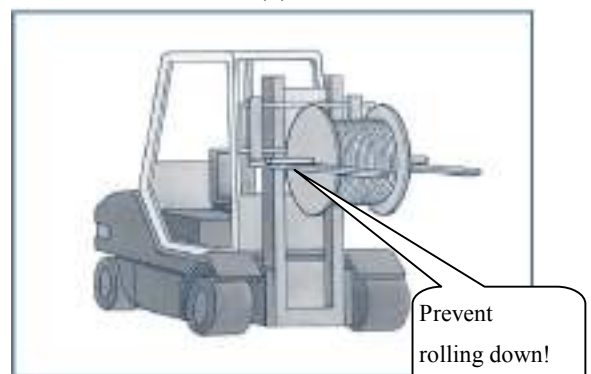
Reels of wire rope should be stored in an area where they will not be damaged by objects falling, chemical spills, excessive heat, open flames, welding, and excessive heat. Reels should be stored vertically on their flanges and covered to prevent dirt and debris from embedding into the wire. When storing reels, ensure that one reel will not roll into another. This will prevent one reel flange from hitting the wire rope surface of another reel. If necessary, reel flanges should be choked to prevent movement. The wrong method as shown in Figure4-4 shall be prohibited. For the correct method handing the rope, please refer to 错误! 未找到引用源。 5.



(a)



(b)



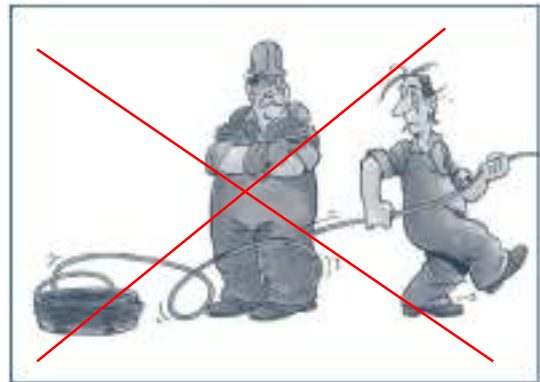
(c)

Figure 4-4: Un-recommend method

	<p><b>Do not store wire rope in atmosphere of volatile chemical or moisture. Wire rope will rust.</b></p>
	<p><b>Do not use any detergent oil to clean wire rope. Detergent oil soaks into and dissolves the lubricant inside the rope and will cause internal corrosion. Clean with a wire brush.</b></p>



(a)



(a)



(b)



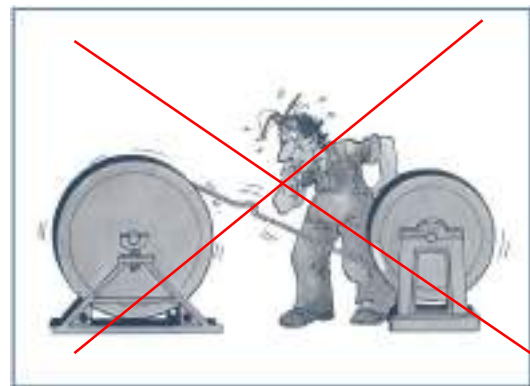
(b)

**Figure 4-5: Recommend method**

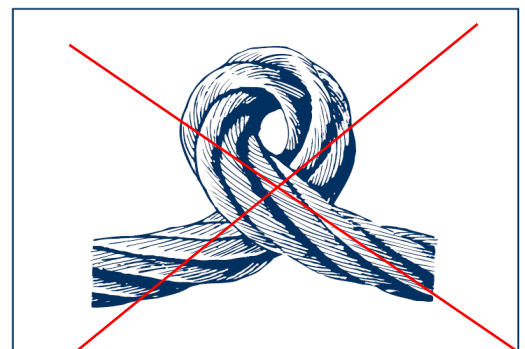
#### 4.2.2 Installation of wire rope

Proper/improper methods of unwinding a wire rope from a reel are separately introduced in Figure 4-6, Figure 4-7. Considerable care must be taken when unwinding a wire rope. Their operational performance is substantially influenced by the way they are handled. Bending or twisting wire rope can cause internal damage that will adversely affect the operational life of the wire rope. Avoid unwinding wire rope on the ground to protect the wire rope from debris. If there is no other option, make sure the ground is clean or covered with boards or plastic sheets.

Every wire rope bends in a particular direction based on the lay of the rope. So, the wire rope should always be uncoiled that coincides with their lay. As shown in Figure 4-8 the prohibited methods of unwinding a wire rope, wire rope should never be pulled out with the reel fixed.



(c)



(d)

**Figure 4-6: Improper method**



(a)



(e)



(b)



(f)



(c)

Figure 4-7: Proper method



If wire rope is unreeled with the reel fixed, wire rope will be tangled and will cause kink or deformation.

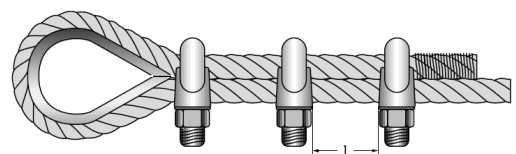


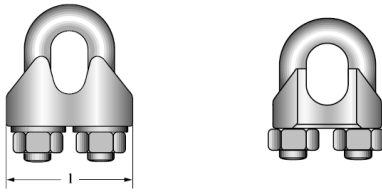
(d)

### 4.3 Termination and treatment of wire rope end

#### 4.3.1 The wire rope clip

##### 4.3.1.1 clips





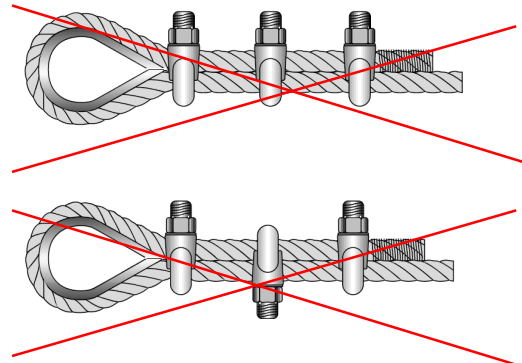
**Figure 4-8: Distance between clips**

Rope end connections using wire rope clips are very popular because they can be fabricated on-site with very little effort and they are also very cheap. Compared with many other end connections they are easily detachable and can be inspected without difficulties. The rope end is always laid around a thimble and the first clip is threaded on close to the thimble.

The distance between clips is approximately equal to the width of the clip as shown in Table 4-2. The minimal quantity of clips used for an end and the minimal tighten torque shall follow the values as shown in Table 4-2. The incorrect installation of clips such as shown in Figure 4-9 may reduce its breaking load considerably and results in unexpected accident.

**Table 4-2: Tightening torques for rope clips**

Nominal size	Torque [Nm]	clips number
5	2.0	3
6.5	3.5	3
8	6.0	4
10	9.0	4
13	33	4
16	49	4
19	67.7	4
22	107	5
26	147	5
30	212	6
34	296	6
40	363	6



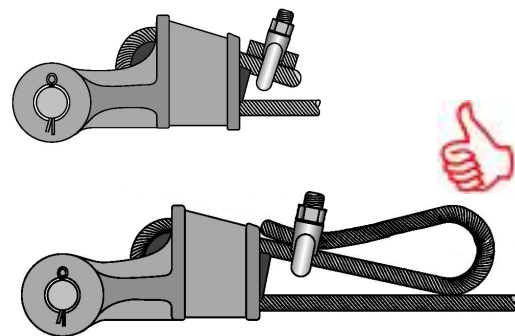
**Figure 4-9: End connections with rope clips fitted incorrectly**

#### 4.3.1.2 The asymmetrical wedge socket

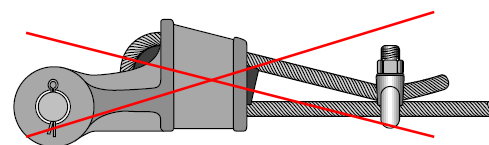
When terminating a rope end with a wedge socket, ensure that the rope tail can not withdraw through the socket by securing a clamp to the tail or by following the manufacturer's instructions. The tail length should be a minimum of 20 rope diameters for all Rotation Resistant wire rope and a minimum of 6 rope diameters for 6 and 8 strand ropes

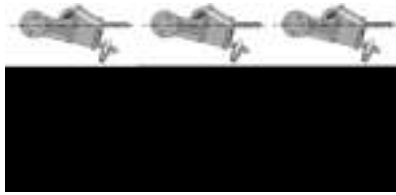
See Figure 4-10 for two recommended methods of securing the rope tail of a wedge socket termination.

The installation as shown in Figure 4-11 shall be prohibited in any case.



**Figure 4-10: Recommended clipping of the 'dead' line**

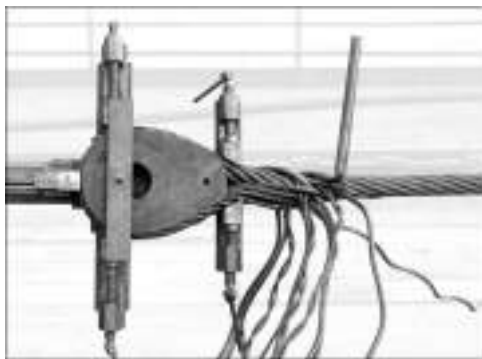




**Figure 4-11: Incorrect installation of a wedge socket connection**

#### 4.3.1.3 Other methods of rope end connection

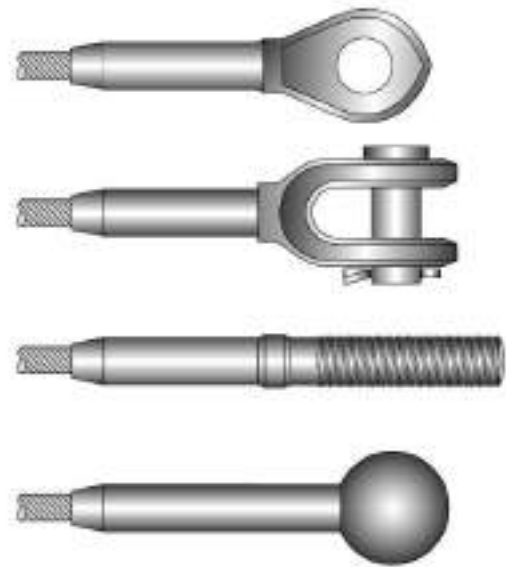
There are also many other methods for the rope end connection as shown in Figure 4-12 such as: (a) The splice, the oldest end connection for ropes, is not used very often and may only be limited to some wire ropes in very small size and used for secondary application in the container cranes. (b) The aluminum clamp that usually shall be fabricated by the specially machine. (c) swaged sockets and etc.



(a)



(b)



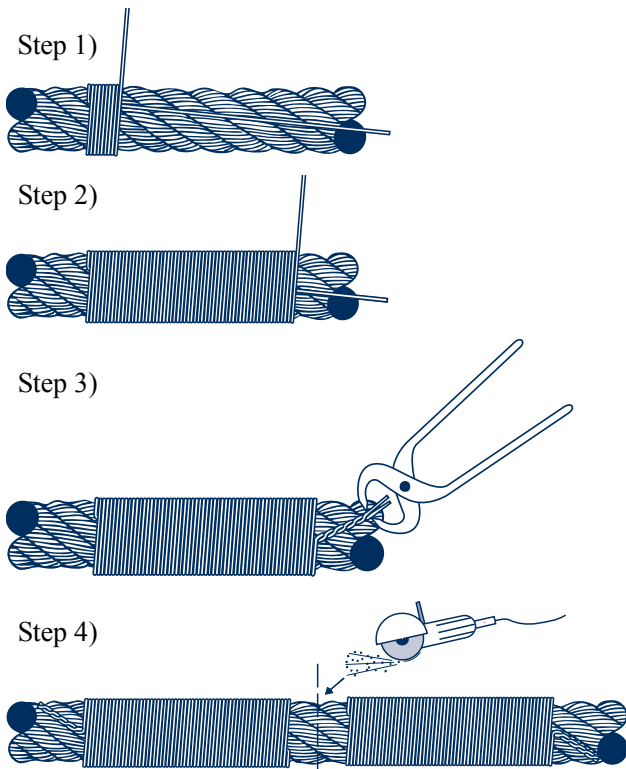
(c)

**Figure 4-12: Other rope end connections**

#### 4.3.2 Wire rope cutting and treatment of rope end

In every case, each side of the cut must be properly seized to prevent strand disturbance before cutting. After all the seizing are secure, then you may cut the rope. Normally, one seizing on each side of the cut is sufficient. For non-preformed or rotation-resistant ropes, a minimum of two seizing on each side is recommended. These should be spaced six rope diameters apart. The procedures of cutting are below:

- 1) The rope and this wire end are now wrapped moving away from the location of the intended cut. Keeping wraps parallel, close together and in tension. Twist ends of strand together by hand.
- 2) The rope is tightly wrapped for a distance of approx two three rope diameters.
- 3) Both ends of the seizing wire are then pulled tight and twisted together. The twisted connection is then hammered into a strand valley.
- 4) After preparing the other side of the intended cut accordingly the rope can now be cut. Please also see Figure 4-13 for details.



**Figure 4-13: Wire rope cutting**

Most ropes are shipped with the ends seized as they are prepared for cutting as shown in Figure 4-14(a). You can usually install seized ropes without further preparation. In some cases, though tight openings in drums and wedge sockets- or even complicated reeving systems – require special end preparation. Then, the strands must be tightly held without increasing the rope diameter. In such cases, the ends are tapered and welded as shown in Figure 4-15 (b) (c), or the ends fused as shown in Figure 4-15(d). It's sometimes necessary to provide a loop or link to which a lighter line is fastened to pull the rope into place or around sheaves. Some of these special end preparations are shown as follows:



(a) Seized end



(b) Tapered and welded end



(c) Seized and torch cut with ends fused



(d) Steel end link

**Figure 4-14: Treatment of rope end**

#### 4.4 Inspection of wire rope

A steel wire rope is a commodity with a limited lifespan. There are many factors that may influence the rope life and performance such as: the quality of the rope, load during the operating, operational environment, maintenance etc. Many properties will change and many damages may have during its service especially before the failure of the rope. Those changes and damage may be the premonition of the failure of a wire rope. So regular inspection is very necessary to eliminate any hidden defect to extent the rope life or find premonition of rope failure before rope changing. The factors influence the rope life, the properties changes and the damages are also recorded during the inspection so the reasons of rope failure can be analyzed and the deterring factor can be reduced to the minimal.



**The properties of wire rope will rapidly decrease before reaching the rope life time. So the inspection intervals need to be shortened before rope replacement for the safety.**

##### 4.4.1 The factors influence the rope life

There are many factors that may influence the rope life and performance including the condition of operating, maintenance, working environment etc. and is very complicate. To a rope on shore container crane, some main factors: are below:

- 1) The ropes are subjected to the changing load when running through drums and sheaves continuously so the ropes are bended constantly during all the operation and is easily fatigue.
- 2) The corrosion due to the humidity and salt spray in a marine environment: The air is mixed with humidity and salt which is liquefiable in water. The ions in water will speed up the diffusion of oxygen ion and that also speed up the oxidation reaction of wire rope and worse the corrosion of it.
- 3) Affect of foreign objects embed in the wire rope. The wire ropes are working on an opening adverse polluted environment. The wind are also very stronger that may bring the hard foreign objects such as graves, slag and etc to the surface of the wire rope and then go to the sheaves, drums, or even inside of the wire ropes that may cause wear and wire broken.
- 4) Affect of frequency operating: There is only a thin film of lubricant on the surface of the wire rope. The lubricant is squeezed out from internal of rope when the rope is tensioned and drawn in when the rope is loosed. This is frequency duplicated and not only causes the escape of the lubricant inside the rope but also speeds up the oxidation of the lubricant.
- 3) **Small diameter sheaves** can result in permanent set of the rope, and will certainly lead to early wire breaks.
- 4) **Oversize grooves** offer insufficient support to the rope leading to increased localized pressure, flattening of the rope and premature wire fractures. Grooves are deemed to be oversize when the groove diameter exceeds the nominal rope diameter by more than 15%.
- 5) **Undersize grooves** in sheaves will crush and deform the rope, often leading to two clear patterns of wear and associated wore breaks.
- 6) **Excessive fleet angle** can result in severe wear of the rope due to scrubbing against adjacent laps on the drum. Rope deterioration at the termination may be exhibited in the form of broken wires. An excessive angle of fleet can also induce rotation causing torsion imbalance.
- 7) Using the wire rope of incorrect size, construction, or grad.
- 8) Dragging rope over obstacles.
- 9) Having improper lubrication.
- 10) Operating over sheaves and drums with improperly fitted grooves or broken flanges.
- 11) Jumping off sheave.
- 12) Subjecting it to acid fumes.
- 13) Attaching fittings or installation improperly.
- 14) Subjecting it to severe or continuing overload.

Of course, there are many factors that may affect the life of the wire rope. Those factors may not only related to the design but also including a lot of abnormal factors such as:

- 1) **Multi-layers** of the rope on the drum can result in severe distortion in the underlying layers.
- 2) **Bad spooling** (due to excessive fleet angles or slack winding) can results in mechanical damage, shown as severe crushing, and may cause shock loading during operation.

#### 4.4.2 Inspection Method


The measurements shall be taken by the qualified people.

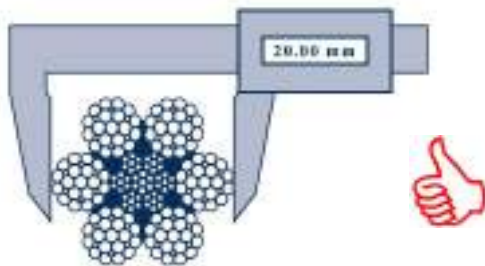
- 1) Measurement of diameter

The size of a wire rope is designated by its diameter. The diameter of a wire rope should be measured by a set of Venire calipers.

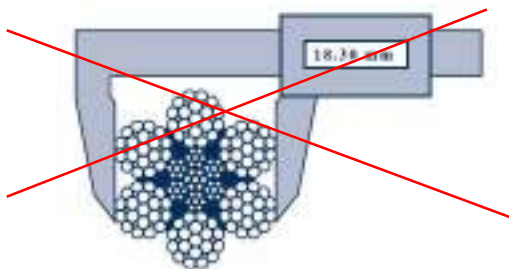


The correct measurement of the rope diameter is shown in Figure 4-16(a). The measurements as shown in Figure 4-16(b) are wrong.

 **The nominal diameter of a new wire rope must be measured and recorded before it is installed on the crane. The results of every subsequent check should also be recorded in the journal for that wire rope.**



(a) Correct measurement of the rope diameter



(b) Wrong measurement of the rope diameter

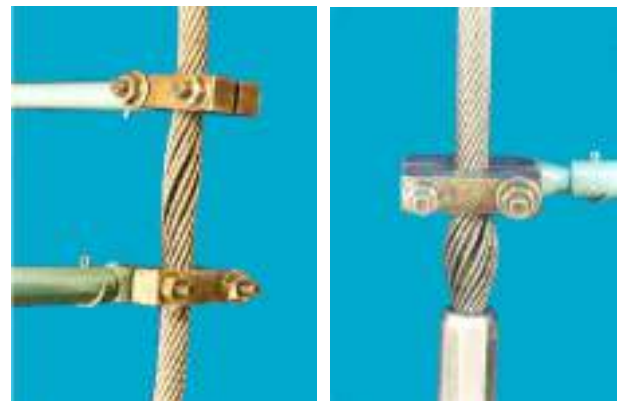
**Figure 4-15: Wire rope measurements**

2) Visual inspection

Visual inspection is the method most widely used. The wire rope surface shall be cleaned before inspection. Wire breaks of outer wire which do not occur at the crowns of the strands but at the contact points of two neighboring wires or even on the underside of the strands are very difficult to detect. With thin ropes, which can be completely unloaded, such wire breaks can be made visible by extreme bending of the rope as shown in Figure 4-16. The interior of wire rope can be examined according to Figure 4-17.



**Figure 4-16: Detecting wire breaks by bending the rope**



(a)

(b)

**Figure 4-17: Examine the interior of the wire rope**

3) Tactile inspection

The Tactile inspection is often used to detect the wire breaks by spooling the rope through your hand (only if the rope can be run slowly enough). This method is usually to be used together with the visual inspection simultaneously. When applying this method extreme care is necessary as protruding wires from the rope construction can cause severe injuries. In many cases the inspector will run a piece of wood along the rope which is then kicked back by the protruding wire break ends. Another useful technique is to hold a ring of cotton waste around the slow moving rope-any protruding broken wires will snag the cotton and thereby highlight the damaged area.

4) Magnetic testing of wire ropes (NDT)

There are some wire rope NDT machines to detect both surface and interior damages in the marketing. The advantages of this instruments are they good at detect the damages not visible or interior the wire rope and even can inform the inspector about the

extent of the rope deterioration. But the reliability of this kind of new techniques needs to be verified by the practice. For the details please reference the manuals of this kind of machine.



**NDT using electromagnetic means may be used to detect broken wires and loss in metallic area. This method complements the visual examination but does not replace it.**

#### 4.4.3 Where and when must wire ropes be inspected?

Generally speaking the whole wire rope length must be visually inspected. It goes without saying that critical zones require extra attention. For example, critical zones are: Those rope zones which are exposed to the highest number of cycles, rope end connections, loading points; rope zones on compensation sheaves; rope zone on rope drums and etc. The rope zones on compensation sheaves are easily to be ignored because it is usually wrongly though “this zone are static and compensation sheaves do not work (as everybody known’s) permit a smaller diameter for this very sheave.”. So, the piece of rope in this zone not only carries out more bending cycles (especially due to the jumping) than the others but also is on a sheave with a smaller diameter. Special care shall also be taken to the rope zones in the grooves of sheave and drums nearby rope out points.

As far as possible, all visible parts of any rope shall be observed each working day with the objective of detecting general deterioration and deformation. Particular attention shall be paid to the rope at points of attachment to the crane.

The wire rope shall be inspected one week after fisting using or the wire breaks firstly be found.

After first inspection, inspect the wire rope monthly.

After abnormal loading or whenever an accident

such as snag or in the case of presumed no-visible damage or installation of a new rope, the wire rope shall be inspected immediately. The intervals shall also be reduced after that.

The intervals shall also be shorted whenever any damage has occurred in connections with the reeving system especially before the period of the rope to be discarded.



**The intervals of inspection can be adjusted according to the previous inspection record.**

#### 4.4.4 What shall be inspected?

A thorough inspection should cover the following points:

To detect the abrasion and breaks early and on time, a schedule shall be set for each rope. A thorough inspection should cover the following points:

- 1) Determining the rope diameter: Measure the diameter of wire rope and check the reduction in rope diameter and the rate of the reduction.
- 2) Is there the rope corrosion? Is the rope properly lubricated?
- 3) Abrasion includes outer and interior of the rope.
- 4) Are there any visible break wires? What kind of break wire it is? The rope shall be discarded if the break wire reaches a specified numbers.
- 5) If there is a phenomenon that the wire rope has been crushed, abraded, flattened, Basket or lantern deformed kinked or has sustained any other damage that distorts it; the rope should be discard.
- 6) Inspection the rope connections and parts connected with the wire: What’s condition of the connection? Damaged connection shall be changed or corrected immediately. Is the abrasion of the drum and sheave grooves reach

allowable tolerance?

All inspection results shall be well recorded in the daily log and special record for wire ropes.



**The results of every visual inspection shall be recorded for tracking purposes.**

A Typical example of rope examination record is given in ISO 4309:2004(E) Annex B that could be referenced. The wire rope discard date and discard number of cycles could be predicted the series of wire rope inspection record. The records of inspection are also important material for analyzing the key factors affecting the rope life so the measures to improve the rope life can be found.

#### 4.4.5 Discard criteria

The safe use of wire rope is qualified by the following criteria:

- 1) Broken wires: the nature and number of broken wires; broken wires at the termination; localized grouping of wire breaks; the rate of increase of wire breaks.
- 2) The fracture of strands.
- 3) Reduction of rope diameter, including that resulting from core deterioration.
- 4) Decreased elasticity.
- 5) External and internal wear.
- 6) Deformation: waviness; Basket or lantern deformation, core or strand protrusion /distortion, Wire protrusion; local increase in diameter of rope, flattened portions, Kinks or tightened loops; bends.
- 7) Damage due to heat or electric arcing.
- 8) Rate of increase of permanent elongation.

All examinations shall take into account these individual factors, recognizing the particular criteria.

However, deterioration frequently results from a combination of factors, giving a cumulative effect which should be recognized by the competent person, and which reflects the decision to discard the rope or to allow it to remain in service. Particular attention shall be paid to the abnormalities that may damage the rope and shall be eliminated before rope changing.

The discard criteria can be found in ISO 4309:2004 (E), DIN15020, DIN3088 and etc. The local criteria shall be taken priority of those criteria.

The content of discard criteria of ISO 4309:2004 (E) is as below:

##### 4.4.5.1 Nature and number of broken wires

In the case of 6- and 8-strand ropes, broken wires usually occur at the external surface. In the case of rotation-resistant ropes, there is a probability that the majority of broken wires will occur internally and are “non-visible” fractures. Detail criteria are given in Table 4-3.

##### 4.4.5.2 Broken wires at termination

If there are broken wires at, or adjacent to the termination, the cause of this deterioration shall be investigated and, where possible, the termination shall be remade, shortening the rope if sufficient length remains for further use, otherwise the rope shall be discarded.

##### 4.4.5.3 Localized grouping of broken wires

Where broken wires are very close together, constituting a localized grouping of such breaks, the rope shall be discarded. If the grouping of such breaks occurs in a length less than  $6d$  or is concentrated in any one strand, it may be necessary to discard the rope even if the number of wire breaks is smaller than the maximum number shown in Table 4-3. Pictures 3 in Table 4-4 show the typical localized grouping of broken wires. They are usually the main damages to the main hoist and trolley towing ropes.

#### 4.4.5.4 Rate of increase of broken wires

In applications where the predominant cause of rope deterioration is fatigue, broken wires will appear after a certain period of use, and the number of breaks will progressively increase over time. In these cases, it is recommended that careful periodic examination and recording of the number of broken wires be undertaken, with a view to establishing the rate of increase in the number of breaks. This premise may be used to propose a future date for rope discard.

#### 4.4.5.5 Fracture of strands

If a complete strand fracture occurs, the rope shall be immediately discarded.

#### 4.4.5.6 Reduction of rope diameter resulting from core deterioration

Reduction of rope diameter resulting from deterioration of the core can be caused by:

- 1) Internal wear and wire indentation.
- 2) Internal wear caused by friction between individual strands and wires in the rope, particularly when it is subject to bending.
- 3) Deterioration of a fiber core.
- 4) Fracture of a steel core.
- 5) Fracture of internal layers in an rotation-resistant rope.

If these factors cause the actual rope diameter to decrease by 3 % of the nominal rope diameter for rotation resistant ropes, or by 10 % for other ropes, the rope shall be discarded even if no broken wires are visible.

#### 4.4.5.7 Decreased elasticity

Under certain circumstances elasticity decreasing is usually associated with the working environment, a rope can sustain a substantial decrease in elasticity and is thus unsafe for further use.

Decreased elasticity is difficult to detect. However, it is usually associated with the following:

- 1) reduction in rope diameter.
- 2) Elongation of the rope lay length.
- 3) Lack of clearance between individual wires and between strands, caused by the compression of the component parts against each other appearance of fine, brown powder between or within the strands.
- 4) Increased stiffness.

If any above phenomenon are observed or examiner has any doubt, advice shall be obtained from a specialist. Increased stiffness of a rope can lead to abrupt failure under dynamic loading and is sufficient justification for immediate discard.

#### 4.4.5.8 External wear

See picture 13 in Table 4-4 for the reference. Wear is promoted by lack of lubrication, or incorrect lubrication, and also by the presence of dust and grit. Wear reduces the strength of ropes by reducing the cross-sectional area of the steel strands. If, due to external wear, the actual rope diameter has decreased by 7 % or more of the nominal rope diameter, the rope shall be discarded even if no wire breaks are visible.

#### 4.4.5.9 External and internal corrosion

Corrosion occurs particularly in marine and polluted industrial atmospheres. It will diminish the breaking strength of the rope by reducing the metallic cross-sectional area, and it will accelerate fatigue by causing surface irregularities which lead to stress cracking. Severe corrosion can cause decreased elasticity of the rope.

Corrosion of the outer wires can often be detected visually. See picture 14 in Table 4-4.

See Picture 14 in Table 4-4 for the internal corrosion. It is more difficult to detect than the

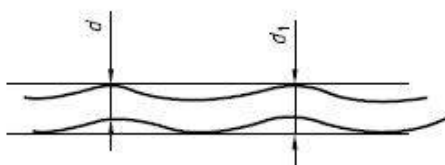
external corrosion which frequently accompanies it, but the following indications can be recognized:

- 1) Variation in rope diameter; in locations where the rope bends around sheaves, a reduction in diameter usually occurs. However, in stationary ropes it is not uncommon for an increase in diameter to occur due to the build-up of rust under the outer layer of strands.
- 2) Loss of clearance between the strands in the outer layer of the rope, frequently combined with wire breaks between or within the strands.

If there is any indication of internal corrosion, the rope should be subjected to internal examination as indicated in Figure. Confirmation of severe internal corrosion is justification for immediate rope discard.

#### 4.4.5.10 Waviness

See picture 11 in Table 4-4 for reference. In the case of waviness (see Figure 4-18), the wire rope shall be discarded if, under any load condition on a straight portion of rope that does not bend around a sheave or drum, the following condition is met:  $d_1 > 4d/3$  or  $d_1 > 1.1d$ .



**Figure 4-18: Waviness**

#### 4.4.5.11 Basket or lantern deformation

See picture 12 in Table 4-4. Basket or lantern deformation, also called “birdcage”, is a result of a difference in length between the rope core and the outer layer of strands. Different mechanisms such as excessive fleet angle that cause the rope touch the flange or the rope running over a “tight sheave”. The

rope shall be discarded if the basket or lantern deformation occurs.

#### 4.4.5.12 Core or strand protrusion/distortion

See picture 5, 7 in Table 4-4. Rope with core or strand protrusion/distortion shall be immediately discarded.

#### 4.4.5.13 Wire protrusion

See picture 4 in Table 4-4. In wire protrusion, certain wires or groups of wires rise up, on the side of the rope opposite to the sheave groove, in the form of loops. Rope with wire protrusion shall be immediately discarded.

#### 4.4.5.14 Local increase in diameter of rope

See picture 17 in Table 4-4. This condition usually relates to a deformation of the core such as in particular environments, a fiber core can swell up owing to the effect of moisture. If this condition causes the actual rope diameter to increase by 5 % or more, the rope shall be immediately discarded.

#### 4.4.5.15 Flattened portions

See picture 19 in Table 4-4. Flattened portions of rope which pass through a sheave will quickly deteriorate and may damage the sheave. In such cases the rope shall be discarded immediately. Flattened portions of rope in standing rigging can be exposed to accelerated corrosion, and shall be subject to inspection at a prescribed shortened frequency if retained in service.

#### 4.4.5.16 Kinks or tightened loops

See picture 18 in Table 4-4. Kink or tightened will cause imbalance of lay length, which will cause excessive wear, and in severe cases the rope will be so distorted that it will have only a small proportion of its strength remaining. Rope with a kink or tightened loop shall be immediately discarded.



#### 4.4.5.17 Bending

Bends are angular deformations of the rope caused by external influence. Rope with a severe bend will suffer similarly to flattened portions of rope and should be treated as in clause 4.4.5.15.

#### 4.4.5.18 Damage due to heat or electric arcing

Ropes that have been subjected to exceptional thermal effects, externally recognized by the colours produced in the rope, shall be immediately discarded.

**Table 4-3: Number, reached or exceeded, of visible broken wires in single-layer and parallel-closed ropes working in steel sheaves, signaling mandatory discard of rope<sup>1</sup>**

Rope category Number RCN <sup>2</sup>	Number of load –bearing wires in all outer strands of the rope <sup>3</sup> (n)	Number of visible broken wires <sup>4</sup>			
		Mechanism group of M1~M4		Mechanism group of M5~M6	
		in rope over a length of <sup>5</sup> 6d		in rope over a length of 30d	
01	$n \leq 50$	2	4	4	8
02	$51 \leq n \leq 75$	3	6	6	12
03	$76 \leq n \leq 100$	4	8	8	8
04	$101 \leq n \leq 120$	5	10	10	20
05	$121 \leq n \leq 140$	6	11	11	22
06	$141 \leq n \leq 160$	6	13	13	26
07	$161 \leq n \leq 180$	7	14	14	28
08	$181 \leq n \leq 200$	8	16	16	32
09	$201 \leq n \leq 220$	9	18	18	36
10	$221 \leq n \leq 240$	10	19	19	38
11	$241 \leq n \leq 260$	10	21	21	42
12	$261 \leq n \leq 280$	11	22	22	44
13	$281 \leq n \leq 300$	12	24	24	48
21	4- strand ropes, $n \leq 100$	2	4	4	8
22	3、 4- strand ropes, $n \geq 100$	2	4	4	8
23	At least 10 outer strands	2	4	4	8

1: Above values may also apply to ropes working in sheaves that are exclusively made of a polymer in combination with multi-layer coiling. They do NOT apply to ropes working in sheaves that are exclusively made of a polymer material in combination with single-layer coiling.

2: See ISO 4309:2004(E) Annex E for detail rope category number RCN. Where:

09-Including rope of 6X36WS-IWRC(line contract) / 6xK36WS-IWRC(compact strands) usually used for main hoist, trolley and boom hoist.





21~23-Rotation-resistant.

3: Filler wires are not regarded as load-bearing wires and are not included in the value of n. In ropes having a number of layers of strands, only the visible outer layer is considered in the value of n. In ropes having a steel core, this is regarded as an internal strand and is not considered in the value of n.






4: A broken wire will have two ends.






5: d=nominal diameter of rope.

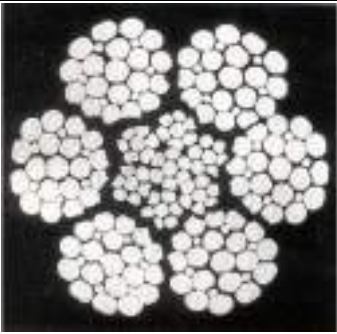



**Table 4-4 Typical examples of wire rope damages**


No.	Description	Picture
1.	Crown wire breaks Usually caused by fatigue	
2.	Valley wire breaks	
3.	Localized grouping of broken wires	
4.	Wire protrusion	







No.	Description	Picture
5.	Core protrusion-single-layer rope	
6.	Local reduction in rope diameter-sunken strand	
7.	Strand protrusion/distortion	
8.	Flattened portion	
9.	Kink (positive)	



No.	Description	Picture
10.	Kink(Negative)	
11.	Waviness	
12.	Basket deformation	
13.	External wear	
14.	External corrosion	

No.	Description	Picture
15.	Internal corrosion	
16.	Protrusion of inner rope of rotation-resistant rope	
17.	Local increase in rope diameter due to core distortion	
18.	Kink	

No.	Description	Picture
19.	Flattened Portion	

	<b>In case of wire rope abnormalities, the maker of the wire rope should be determined. A colored tracer thread is embedded in the core of the rope. The manufacturer can be found by this tracer thread.</b>
	<p><b>We are using right hand lay ropes on both right and left handed drums</b></p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  <p>Left hand lay</p> </div> <div style="text-align: center;">  <p>Right hand lay</p> </div> </div>

### 4.5 Wire rope lubrication

	<b>It has been proven that a well lubricated wire rope will last four times as many working hours as a non-lubricated wire rope.</b>
	<b>Always use wire rope manufacturer's recommended lubricant!</b>

#### 4.5.1 Importance of lubrication

The importance of periodic lubrication will never be overstressed. Mainly they are:

- 1) A wire rope is a machine, having many moving parts. Each time a rope bends or straightens the wires in the strands of the rope must slide on each other. Thus, a film of lubrication should be present on each moving part. When exposed to the same test condition a well-greased rope showed four times as many working cycles as a non-greased rope.
- 2) A second important reason for lubricating the wire rope is that it keeps away moisture which can cause interior corrosion under

simultaneous bacterial proliferation in the fiber core. The lubricant also prevents deterioration of the fiber core. A rusty rope is a liability, since there is no means of visual inspection, which can determine the remaining strength of a corroded rope.

#### 4.5.2 Selection of lubricant

The main lubricants for wire ropes used in a container terminal are below:

- 1) Grease: Mainly is lithium soap base grease. Sometimes are mixed with mineral oil for better penetrability.
- 2) Special lubricant for rope such as : ESSO SK(semi-liquid), FUCHS Ropelife (Grease),
- 3) Special synthetic base oil for rope such as: Ultrachem Chemlube 812(synthetic ester base oil), synthetic ester base oil supplied by PAO.

The grease that is one kind of protection of coving to rope may be most wildly used for the lubrication of the rope traditionarily because of convenience for using, economical efficiency and efficiency also good effectiveness. Compared to the

lubrication oil that is liquid and has better penetrability, the grease are more easily to be tainted with foreign grains in larger size such as dust, slag or grits. Those hard grains may also be pushed inside the wire rope and cause direct damages to rope. On the other hand, Oil lubrication also has better performance in resist the moisture, salt spray for the interior of rope than grease lubrication. Additionally grease lubrication is also making the visual inspection more difficult. Please reference section 2.6.2 for the lubricant used in this crane before it left the factory.

Below are some main requirements to the lubricant of the wire rope used in STS crane:

- 1) Better antioxidant capacity.
- 2) The better capacity to insulate the wires from moisture and salinity. That means the lubrication shall have a strong capacity of adsorbing and binding with the wires.

Usually ester oil has a better performance in Iron-binding capacity, permeability, film strength and water resistant. The user may determine the lubrication according to the actual condition of different terminal.

#### 4.5.3 The method of lubricant

Lubricant may be applied with an oil can, brush or any effective method. The objective is to apply a

uniform coating to the entire length of the wire rope. The detail scheme shall be make to assure the full length of wire rope can be lubricated. The wire rope may be lubricated by manually or Semi automatically or automatically. The typical manual lubricating is shown in Figure 4-19.

A semi automatic method is shown in Figure 4-20. This method may be more convenient and effective. The lubricant is easily to go inside the wire rope by the pressed air. Frequent and not too excessive lubrication of the wire ropes produces better results than only occasional but rich lubrication. As soon as the grease film vanishes in some areas of the wire rope, it has to be re-greased.

Greasing has to be done only when the wire rope is completely dry. Otherwise, the existing moisture will be contained in the rope and the corrosion be increased from the inside. Used wire rope should be cleaned with a wire brush to remove any accumulation of dirt, grit, rust, or other foreign matter. The purpose is to remove all old lubricant and foreign matter from the valleys between the strands and from the spaces between the outer wires. This gives newly applied lubricant ready penetrate into the rope.

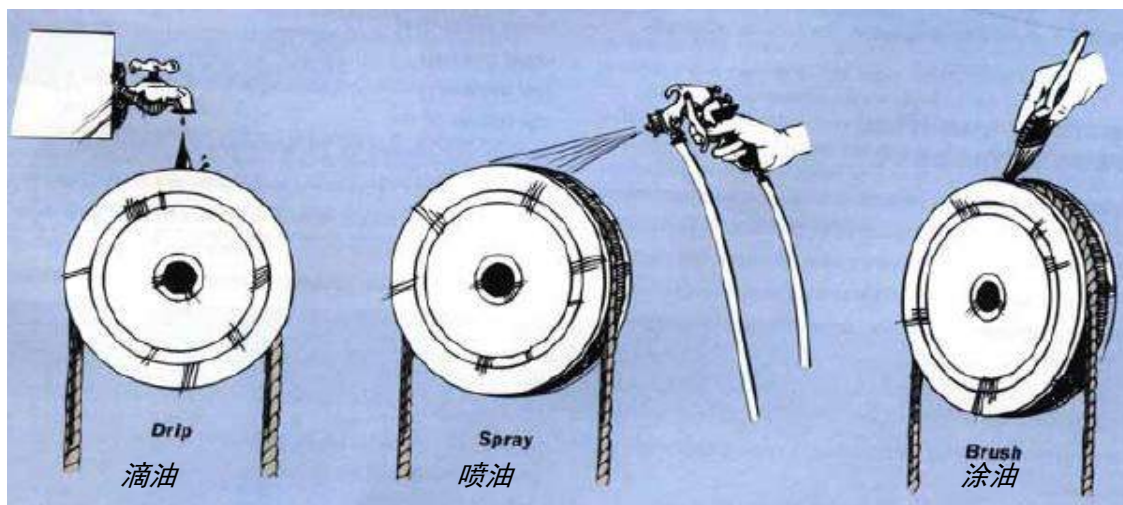


Figure 4-19: Method of manual lubricating

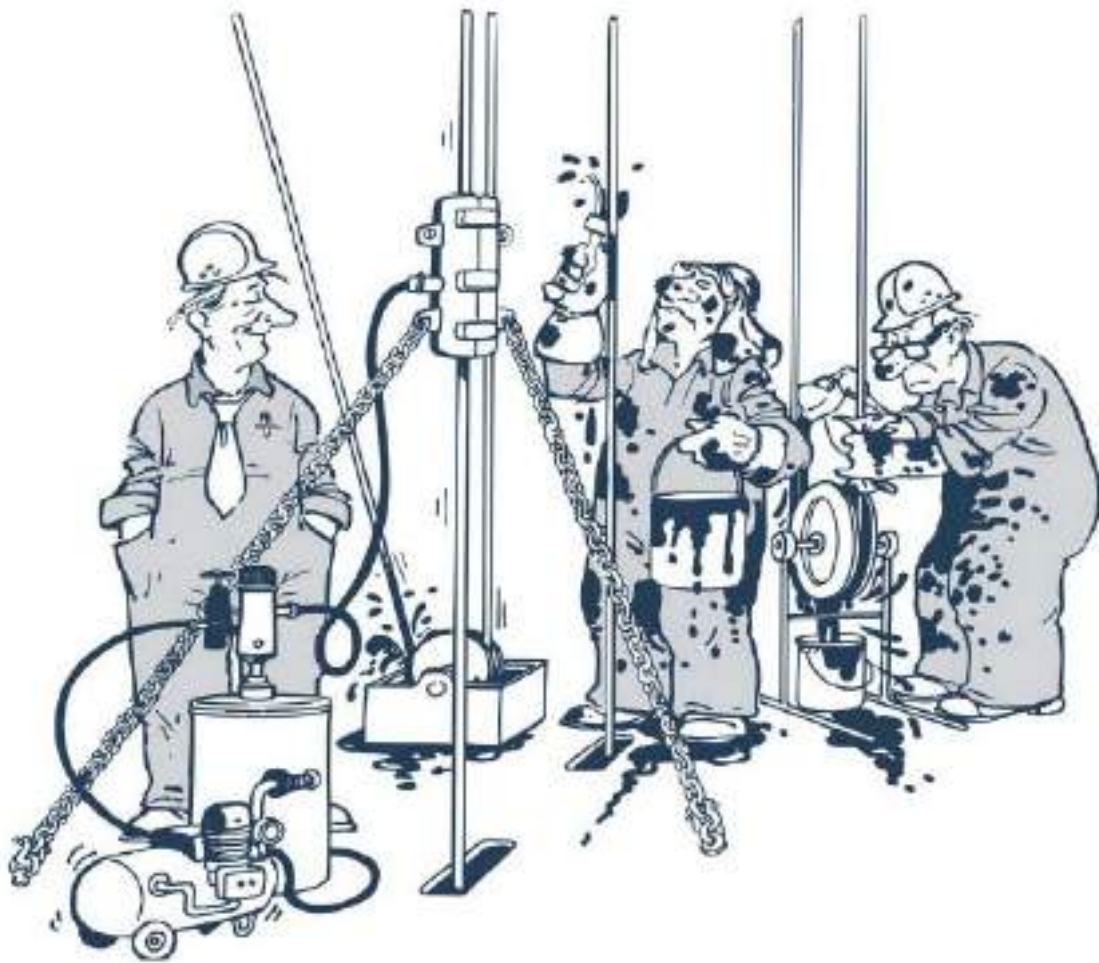


Figure 4-20:: Method of manual lubricating

#### 4.5.4 Lubricating of main hoist and trolley towing wire ropes

Introduction of wire lubrication below are based on the method of semiauto pneumatic lubricating. The procedure is similar if the other methods are used.

During the whole procedure, the boom shall be level and the crane must be in maintenance mode.

The necessary manpower and tools are shown in Table 4-5.

Table 4-5: Manpower and tools for the inspection of main hoist wire rope

Description		Quantity	Notes
Main power	Operator	1	With radio
	Examiner	1~2	With radio
	Supervisor	1	With radio
Tools	Duster cloth	several	For clean
	venire caliper	1	For measurement
	Chalk/tape	1	For marking
	Inspecting form	1	For recording
	Pen	1	
	Lubricant tools	1	
	Air pump	1	

- 1) Ensure that the boom is lowered and the crane is in Maintenance Mode.
- 2) Move the trolley to the suitable position such as boom tip so as to utilize the max distance of trolley travel.
- 3) Select a proper position to start the lubricating such as drum. Parts of the rope can be lubricated by rotating the drum slowly. Trolley is also a necessary good position to lubricate. Most of the remaining rope can be lubricated by moving the trolley slowly. There are always some dead ropes that could not reach on trolley or can not go into the drum. You have to manually lubricate it by the bushes with extension rods. Anyway, the full length of the rope shall be lubricated.

boom hoist ropes are below:

- 1) Boom shall be level and crane shall be in maintenance mode.
- 2) Operate boom in the boom operation cabin.
- 3) Clamp the lubricator onto the rope above the landside trolley girder support beam near the machinery house. See ① in Figure 4-21. Turn on the lubricator and hoist the boom to maintenance position at slow speed.
- 4) Clamp the lubricator on the lead-line rope just landside of the sheave group on the top cross tie beam of A-frame which leads to drum, and connect the lubricator air hose to the air quick disconnect. See ② in Figure 4-21.
- 5) Turn on the lubricator and lower the boom at slow speed until the freshly lubricated rope is at the waterside of the lubricator.
- 6) Clamp the lubricator on the rope reeving from 4th sheave (count from the centerline of boom) on the top cross tie beam to the third sheave (count from centerline of the boom) on the boom sheave group. See ③ in Figure 4-21.
- 7) Turn on the lubricator and lower the boom to the operating position at slow speed.
- 8) The last segment of wire ropes can be lubricated as shown in Figure 4-22. Connect the pneumatic lubricator with long hose in reels. Installed the sleeves of lubricator on the ropes. Then secure all the parts of lubricator connected with the sleeves by chain in case of falling down during the moving of lubricating later.
- 9) The lubricator is towed with a fiber rope at both ends. The fiber rope goes around a temporary. One mechanic can pull the rope on the walkway of boom while another mechanic hold other fiber rope at top of A frame, so the lubricator can move along the last segment of

	<b>Danger of falling!</b>
	<b>Danger of tripping!</b>
	<b>Keep hands clear of moving parts!</b>

#### 4.5.5 Lubricating of boom hoist wire ropes

There are some “dead ropes” between the sheaves on top of A frame and sheaves on boom tip and could not reached by normal access. These ropes are long and very difficult to be lubricated by the normal methods. To lubricate those ropes, additional tools listed in Table 4-5. are necessary besides the manpower and tool listed in Table 4-6.

**Table 4-6: Additional Tools to lubricate the boom hoist rope**

Description		Quantity	Note
tools	Fiber rope	140m	
	Air hose in reels	65m	

The recommended procedure to lubricated the

the wire ropes slow and then the rope to be lubricated simultaneous.

10) The dead wraps on both sides of the drum should be lubricated using a brush.

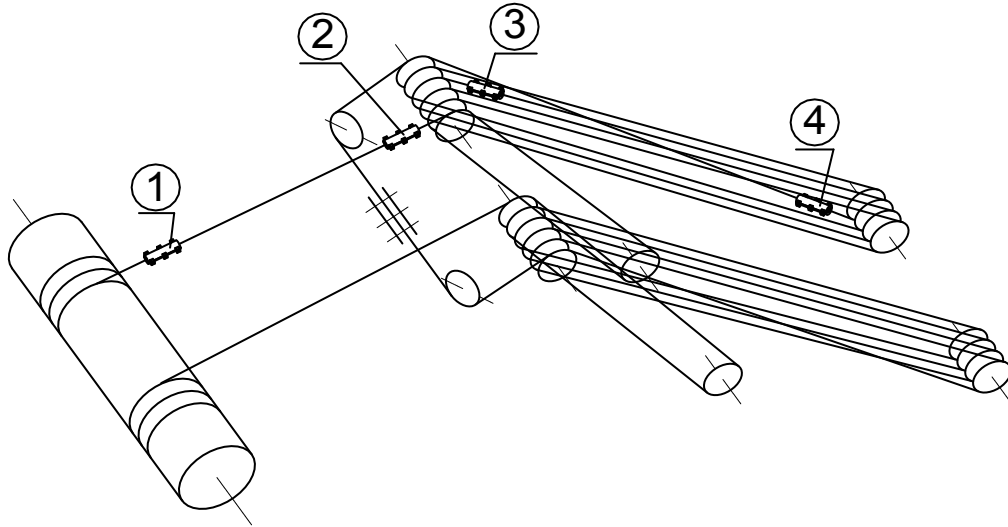


Figure 4-21: Operating position for boom hoist rope lubricating

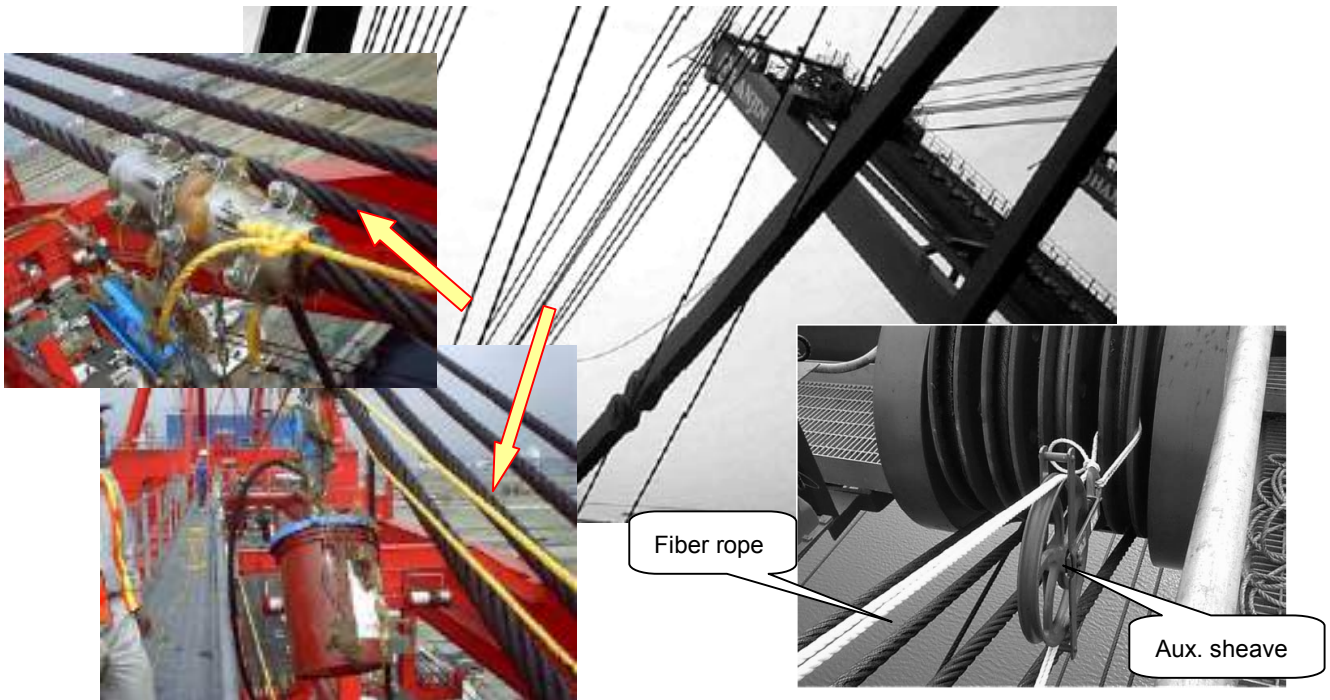









Figure 4-22: The lubricating of “dead rope” of boom hoist

	<b>Danger of falling!</b>
	<b>Danger of tripping!</b>
	<b>Keep hands clear of moving parts!</b>

#### 4.6 Rope re-reeving

The ropes reach the discard criteria shall be replaced by new one. The rope can be changed by the rope re-reeving device inside the machinery house. Please see section for the instruction of this device. The manpower and tools needed for the rope re-reeving are given in Table 4-7. The wire rope type and size are given in Table 4-8. Reference drawings are also given in Table 4-9.

Table 4-7: Manpower and tools needed

	Description	Quantity	Notes
Manpower	Mechanics	5	With radios. At least one person is qualified as a operator.
	Supervisor	1	With radios
	Duster cloth	Several	For cleaning
tools	Chisel	1	
	Torque wrench	1	
	Wrench	One for each size	M16, M20, M24, M30, M36
	Support for reel	1	Provided for maintenance staff
	Rope clamp	5	

2~3t chain block	5	Two chain block (3t) for boom hoist rope changing
Wood pad	1	Round and 80mm in diameter
Rubbers, wood plate, snap block	Several	
Wires, steel plate	Several	Secure the wire, plate, slap block, or tightening rope end.
Grinder or rope cutter	1	Cut wire rope
pincers	1	To colligate rope end
Chinese fingers	1	Connect the old and new ropes
electric welding machine	1	Welding temporize parts
Chalk/ punched tape	1	For marking
Note book and pen	1	For marking
Drawings and instructions of re-reeving	1 set	






**Table 4-8: Rope type and length**

Description	Note
Main hoist rope	Type: Verostar 8.8x26WS-EPIWRC, Grade 1770N/mm <sup>2</sup> Dia: 30mm Min Break load: 670.6KN Length: 600m 2/crane
Boom hoist wire ropes	Type: Veropro 8.8xK26WS-EPIWRC, Grade 1960N/mm <sup>2</sup> galvanized Dia: 30mm Min Break load: 790.3KN Length: 1338m 1/crane

Trolley towing rope	Type: Verostar 8.8x26WS-EPIWRC, Grade 1770N/mm <sup>2</sup> Dia: 22mm Min Break load: 360.6KN Length: 395m 2/crane
Catenary trolley wire ropes	Type: Verostar 8.8x26WS-EPIWRC, Grade 1770N/mm <sup>2</sup> Dia: 12mm Min Break load: 107.3KN Length: 160m/185m both 2/crane

**Table 4-9: Reference drawings**

Description	Note
J474A1500	Rope re-reeving system
WRR04A-J474A	Rope re-reeving device
J607A2000	Main hoist rope reeving system
J607A2100	Trolley towing rope reeving system
J607A2300	Boom hoist rope reeving system
J607A2200	Catenary trolley rope reeving system

	<b>Barricade the area under the crane where falling parts or rope may harm person and vehicle. Don't allow the person other than concerned to enter the procedure area.</b>
	<b>Keep away from suspended loads!</b>
	<b>Danger of falling!</b>
	<b>Danger of tripping!</b>
	<b>Keep hands clear of moving parts!</b>



Pay attention to the rotating direction of reels! The rotating direction(top of reel) shall towards the handle of the bind brake.(match the direction of brake torque)

#### 4.6.1 Re-reeving of main hoist rope

### Main Hoist Rope Rereewing

#### 起升钢丝绳换绳示意图

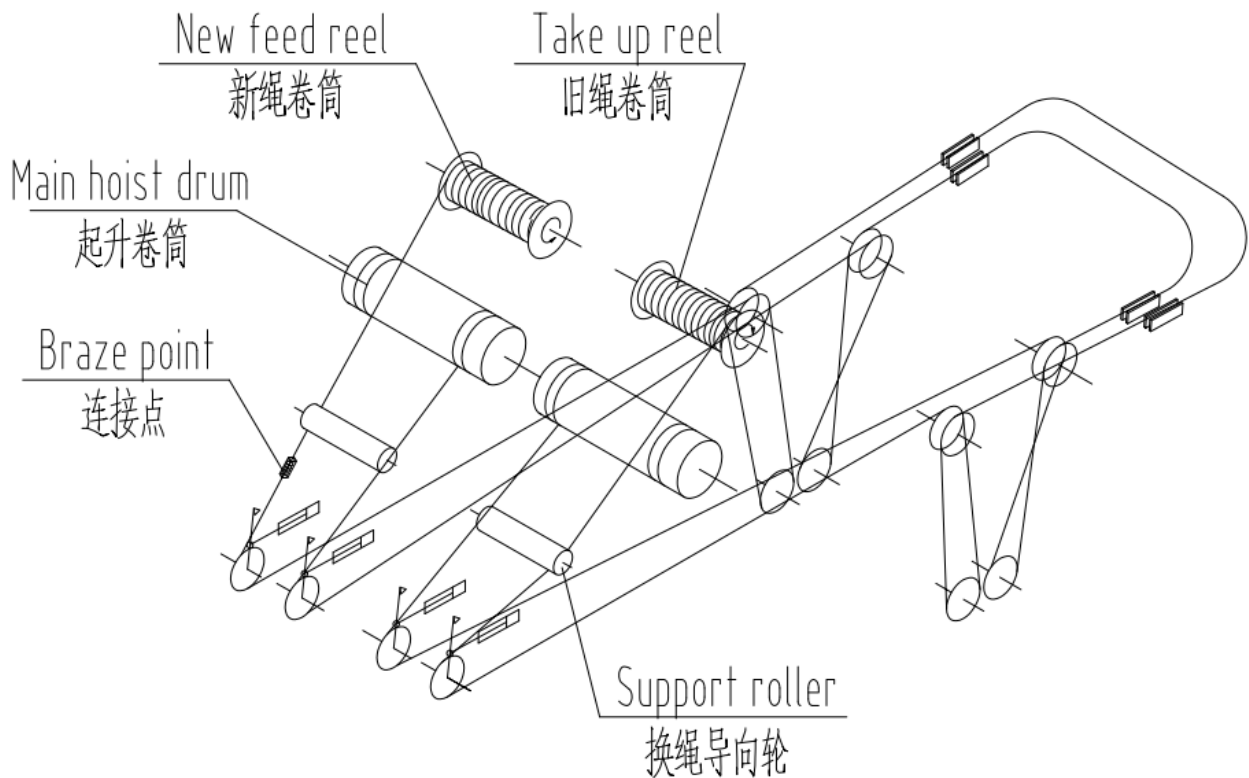
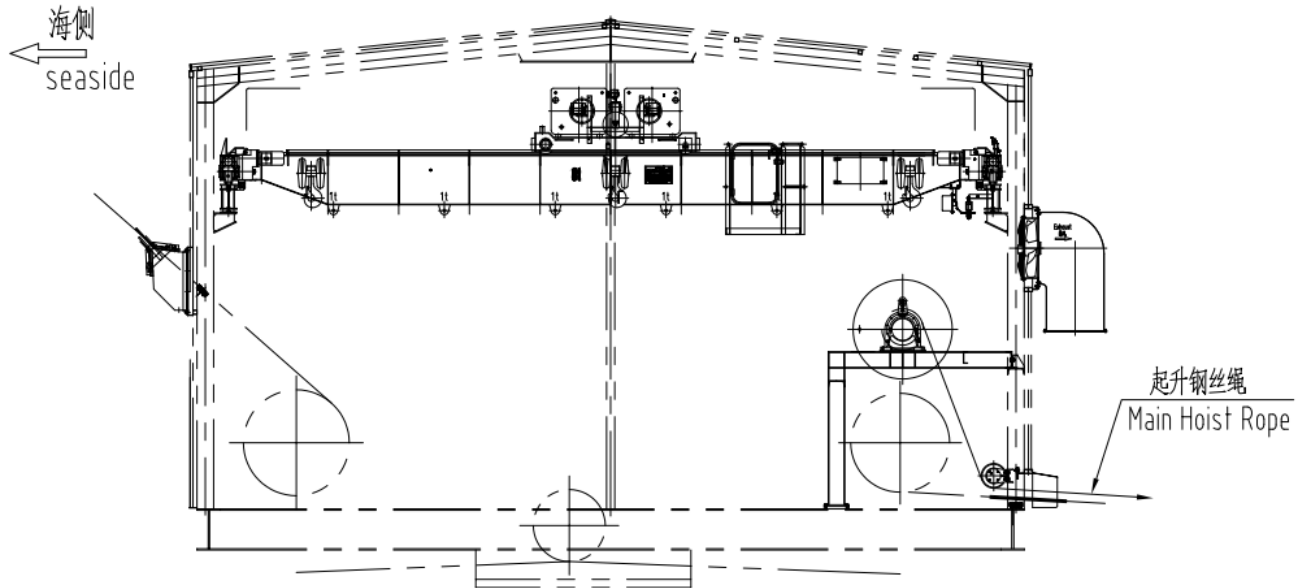


Figure 4-23: Main hoist rope reeving system ①

## Main Hoist Rope Rereeving

### 起升钢丝绳换绳示意图



**Figure 4-24: Main hoist rope reeving system ②**

- 1) Move the reels with new ropes into the machinery house by the service crane, and install it on the support of rope re-reeving device.
- 2) Install the empty reels at the same time.
- 3) Lower the boom to the level and move the trolley to the parking position, then lower the spreader to the ground to ensure no tension force on the rope.  
(bypass the limit switch of main hoist)
- 4) Retract the cylinder of TLS.
- 5) Bypass the main hoist encoder, decelerate the rope to the 10% of the rate speed.
- 6) Loosen the bolts of main hoist rope clips at the boom tip, make the ropes go through the guide pulley.
- 7) Operate main hoist device, rotate the drum to release the rope until there are 4 wraps only left on the drum. (2 wraps each side)
- 8) Loosen the clips of the old rope that would be changed.
- 9) Connect the end side of the old wire rope on the empty re-reeving reel by the guide pulley in the machinery house.
- 10) Set the torque of motor to the max value, connect the other side of the old wire rope with the new rope on the re-reeving reel by the guide pulley too.
- 11) Adjust the belt brake of the motor, ensure reel should not slip when operate.
- 12) Turn on the rope re-reeving device to wind the old rope on the empty reel and wind the new rope on the hoist drum.
- 13) Continue operating until there are 4 wraps remained on the re-reeving reel, and wind all the old rope on the empty reel.
- 14) Ensure to finish the changing.
- 15) Loosen the new wire rope on the reel, roll back the motor to release some ropes on the other reel, separate the new rope with the old one.
- 16) Fix the new wire rope on the hoist drum by the rope clips.
- 17) Change the other rope by the same way.
- 18) After finishing operating, reset the ropes and clips at the boom tips.

4.6.2 Re-reeving of trolley towing rope

# Trolley Rope Rereewing

## 小车钢丝绳换绳示意图

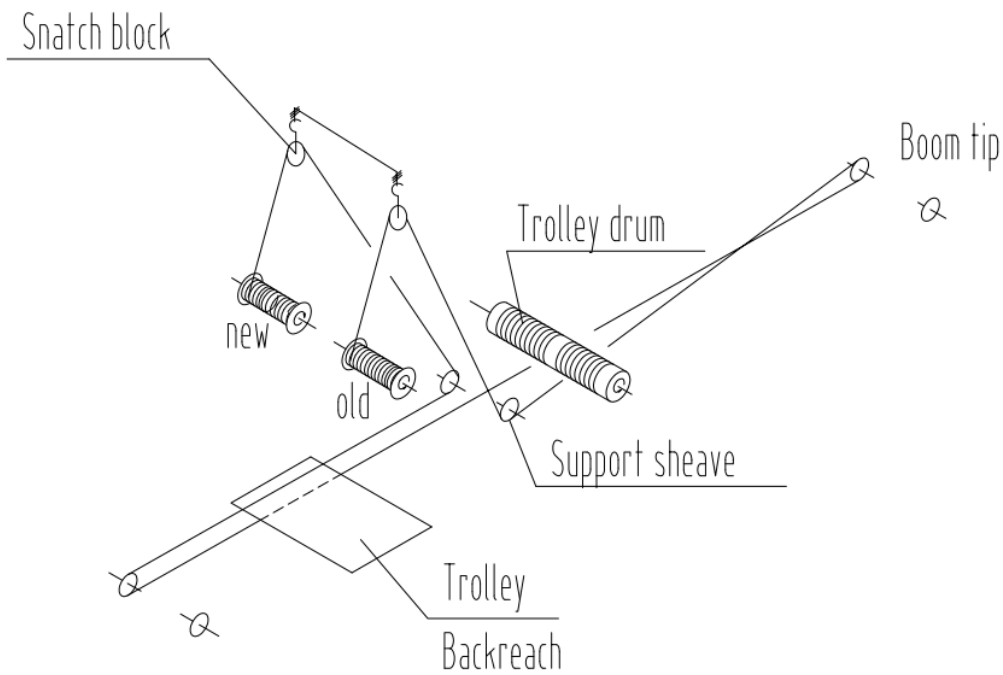


Figure 4-25: Trolley towing rope reeving system ①

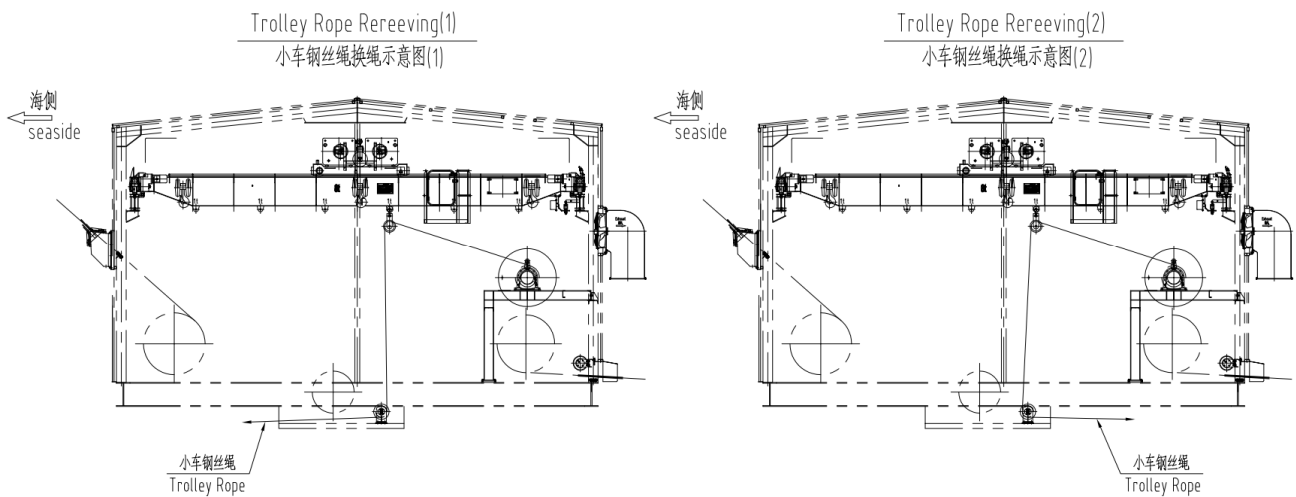


Figure 4-26: Trolley towing rope reeving system ②

- 1) Move the reels with new ropes into the machinery house by the service crane, and install it on the support of rope re-reeving device.
- 2) Install the empty reels at the same time.
- 3) Parking the trolley at the land side position when change the water side wire rope; parking the trolley at

the water side when change the land side wire rope.

4) Extend the cylinder of trolley tension device, and bypass the encoder to decelerate the trolley to the 10% of the rate speed.

5) Loosen the rope clips between the horizontal pulleys.

6) Choose the trolley wire rope should be changed in the machinery house.

7) Remove the rope clips on the trolley drum.

8) Connect the other side of the old wire rope on the empty re-reeving reel by the guide pulley in the machinery house.

9) Set the torque of motor to the max value, connect the other side of the old wire rope with the new rope on the re-reeving reel by the guide pulley too.

10) Adjust the belt brake of the motor, ensure reel should not slip when operate.

11) Turn on the rope re-reeving device to wind the old rope on the empty reel and wind the new rope on the trolley drum.

12) Continue operating until there are 4 wraps remained on the re-reeving reel, and wind all the old rope on the empty reel.

13) Ensure to finish the changing.

14) Loosen the new wire rope on the reel, roll back the motor to release some ropes on the other reel, separate the new rope with the old one.

15) Fix the new wire rope on the hoist drum by the rope clips.

16) Change the other rope by the same way.

#### 4.6.3 Re-reeving of boom hoist rope

### Boom hoist rope Re-reeving

### 俯仰钢丝绳换绳示意图

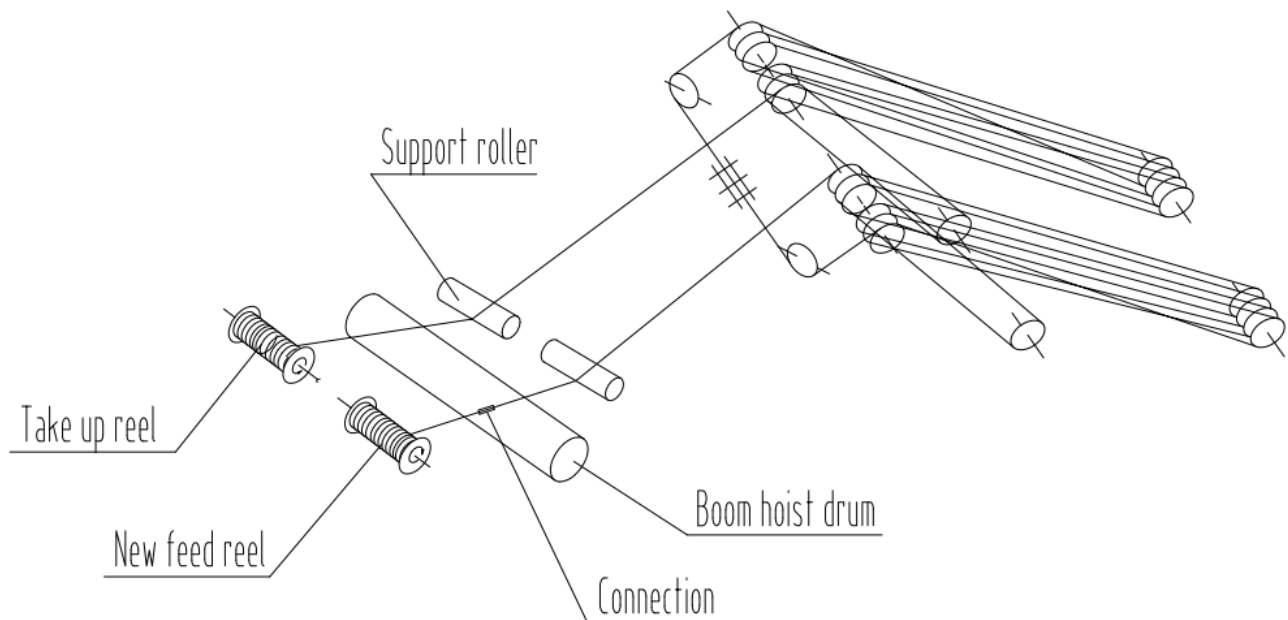


Figure 4-27: Boom hoist rope reeving system ①

## Boom Hoist Rope Rereving

## 俯仰钢丝绳换绳示意图

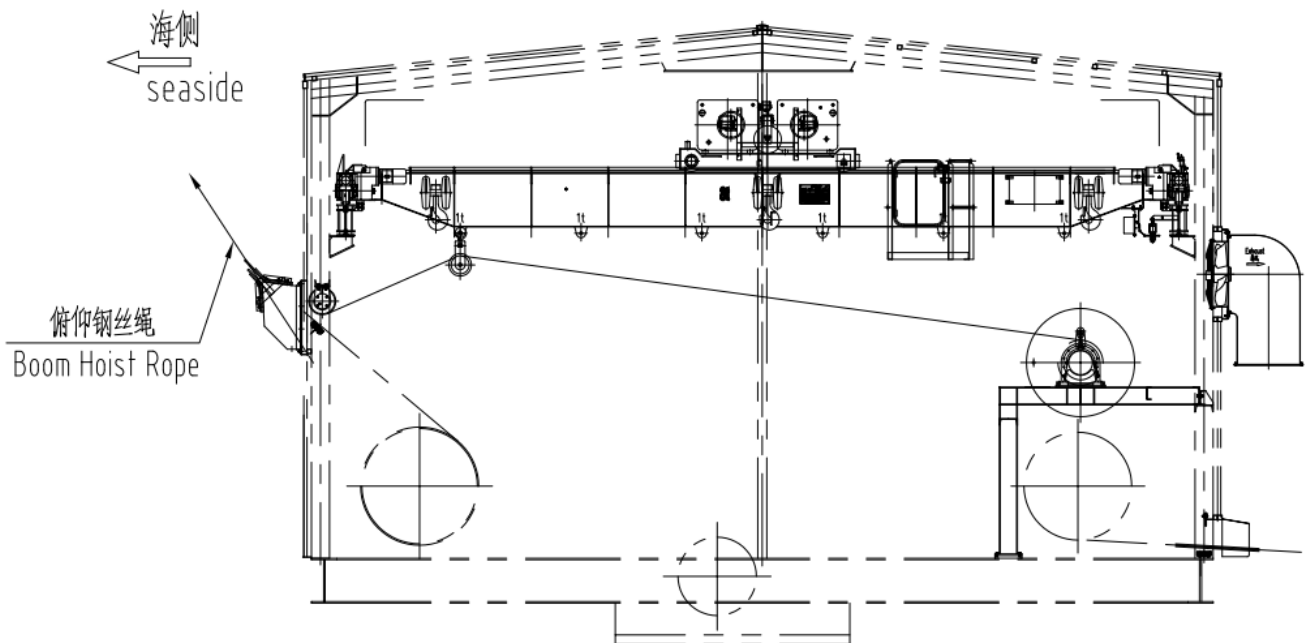


Figure 4-28: Boom hoist rope reeving system ②

- 1) Move the reels with new ropes into the machinery house by the service crane, and install it on the support of rope re-reeving device.
- 2) Install the empty reels at the same time.
- 3) Lower the boom to the level and move the trolley to the parking position, then bypass the encoder of boom hoist device to decelerate the boom drum to 30% of the rate speed.
- 4) Operate boom hoist device, rotate the drum to release the rope until there are 4 wraps only left on the drum. (2 wraps each side)
- 5) Loosen the bolts of boom hoist rope clips.
- 6) Remove the boom rope clips at the T-frame.
- 7) Connect the end side of the old wire rope on the empty re-reeving reel by the guide pulley in the machinery house.
- 8) Set the torque of motor to the max value, connect the other side of the old wire rope with the new rope on the re-reeving reel by the guide pulley too.
- 9) Adjust the belt brake of the motor, ensure reel should not slip when operate.
- 10) Turn on the rope re-reeving device to wind the old rope on the empty reel and wind the new rope on the boom drum.
- 11) Continue operating until there are 4 wraps remained on the re-reeving reel, and wind all the old rope on the empty reel.
- 12) Loosen the new wire rope on the reel, roll back the motor to release some ropes on the other reel, separate the new rope with the old one.
- 13) Fix the new wire rope on the boom drum by the rope clips.
- 14) After finishing operating, reset the rope clips at the T-frame.

#### 4.6.4 Re-reeving of catenary trolley rope

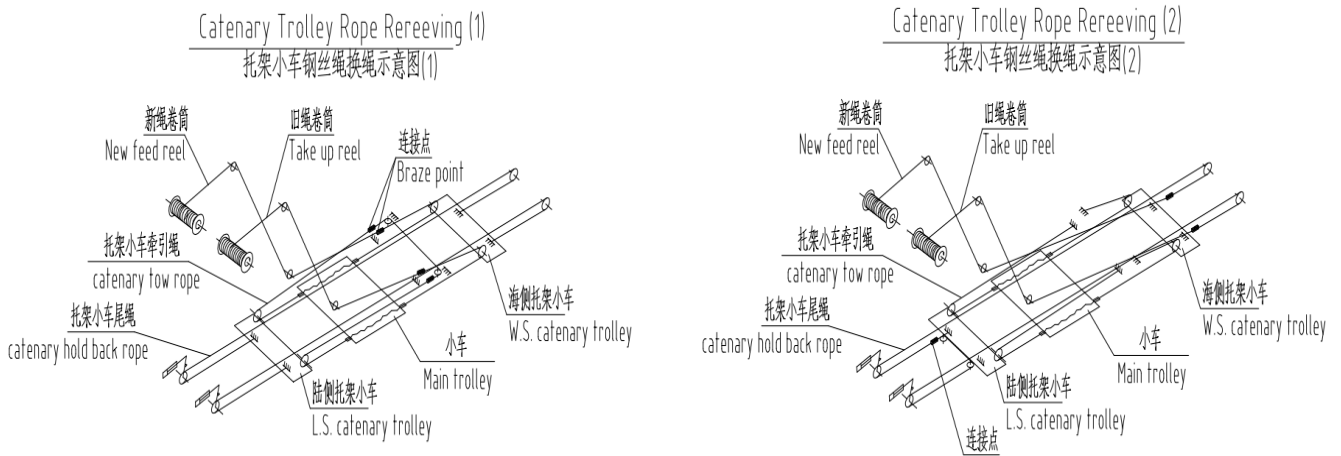


Figure 4-29: Catenary trolley rope reeving system ①

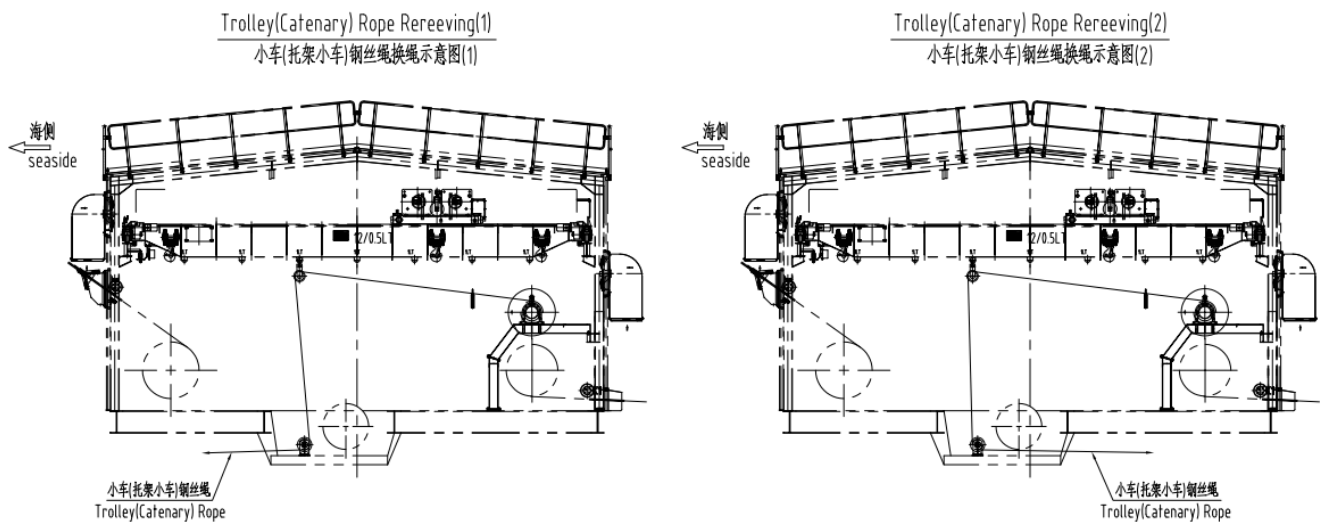


Figure 4-30: Catenary trolley rope reeving system ②

- 1) Move the reels with new ropes into the machinery house by the service crane, and install it on the support of rope re-reeving device.
- 2) Install the empty reels at the same time.
- 3) Lower the boom to the level and move the trolley to the parking position.
- 4) When change the wire ropes between land side and water side catenary trolley, remove the old rope from catenary trolley firstly, and then connect each end side

- with the new rope and empty reel.
- 5) Start motor to extract the old rope and feed the new one.
- 6) After all old ropes winded to the reel and the new rope go through its route, connect two end sides with fixed point on catenaery trolley.
- 7) When change the old rope between land upper beam and the fixed point on trolley, remove the old rope directly and install the new rope by hand.





#### 4.7 Rope Type & Size for cranes

Location	Type of wire ropes	Length / wire rope	Dimension (diameter) of wire rope (mm)	Brand name
Boom Hoist	8.8xK26WS-EPIWRC, Grade 1960N/mm <sup>2</sup> galvanized	1338m*1	30	Verope
Trolley	8.8xK26WS-EPIWRC, Grade 1770N/mm <sup>2</sup>	395m*2	22	Verope
Catenery (Outside)	8.8xK26WS-EPIWRC, Grade 1770N/mm <sup>2</sup>	160m*2	12	Verope
Catenery (Inside)	8.8xK26WS-EPIWRC, Grade 1770N/mm <sup>2</sup>	185m*2	12	Verope
Main Hoist	8.8xK26WS-EPIWRC, Grade 1770N/mm <sup>2</sup>	600m*2	30	Verope

## Chapter 5 Quayside container crane inspection requirements for high-altitude fall hazard

Quayside container crane is high mechanical equipment. The cranes include many parts. After the parts are used for a period of time, some connections may be loose. That will cause danger of falling. Under the crane, there are shuttling crane trucks and staff who frequently access to crane. Once the part falls from high, it poses a threat to personal safety. If it causes a major accident, it will cause significant loss to corporation and bring

misfortune to the family.

Therefore, the inspection of the high-altitude fall hazard source is necessary. Crane maintenance personnel must pay attention to it. Carry out the inspection work in accordance with the following table and make a record.

Maintenance personnel can print or copy the table below, fill in the date and name before the inspection. Pigeonhole them after checking.

Quayside container cranes altitude fall hazards key inspection items				
Inspectors				Date
Location	Item of Inspection	Frequency	Result	Note
Seaside A Frame	1.Bolt connections of boom sheave units;	Per 3 months		
	2.Clamp plates of boom sheave units;	Per 3 months		
	3.Pins of boom sheave units;	Per 3 months		
	4.All the connections of shield(Including pin shaft、 split pin, support welding and so on);	Per 3 months		
	5.Bolt connections of slack rope limit device;	Semiannually		
	6.Clamp plates of slack rope limit device;	Semiannually		
	7.Pins of slack rope limit device;	Semiannually		
	8. Counterweights' connection of slack rope limit device;	Semiannually		
	9.All support welding of slack rope limit device;	Semiannually		
	10.Bolt connections of service crane;	Semiannually		
	11.Location pin of service crane;	Semiannually		
	12.The pulley and the back plate of service crane;	Semiannually		
	13.Bolt connections of boom latch hook;	Semiannually		
	14.Clamp plates of boom latch hook;	Semiannually		
	15.Pins' installment of boom latch hook;	Semiannually		
	16. All counterweight's connection of boom latch hook;	Semiannually		
	17. All support welding of boom latch hook;	Semiannually		
Stay Bar Ass.	1. Bolt connections of stay bar ass. ;	monthly		
	2. Clamp plates' connections of stay bar ass. ;	monthly		
	3. Pins of stay bar ass. ;	monthly		



Boom	1.Bolt connections of boom latch support;	monthly		
	2.The connection of boom latch support's buffer;	monthly		
	3.Pins' installment of boom latch support;	monthly		
	4.The connection of anti-slap block of guide support;	monthly		
	5. Bolt connections of boom hoist reeving ass. ;	Per 3 months		
	6. Clamp plate's connection of boom hoist reeving ass. ;	Per 3 months		
	7. Pins' installment of boom hoist reeving ass. ;	Per 3 months		
	8.All the connections of boom hoist reeving ass.(Including pin shaft, split pin, support welding and so on);	Per 3 months		
	9.Bolts and pins of manhole cover;	Semiannually		
	10.Bolt connections of boom anti-collision device;	Semiannually		
	11.Clamp plates of boom anti-collision device;	Semiannually		
	12.Pins' installment of boom anti-collision device;	Semiannually		
	13.Bolt connections of service crane;	Semiannually		
	14.Location pin of service crane;	Semiannually		
	15.The pulley and the back plate of service crane;	Semiannually		
	16.The fix of flood light's cover;	Per 3 months		*
	17.The connection of trolley buffer;	Per 3 months		*
	18.Bolt connections in L/S/T device;	Per 3 months		**
	19.Clamp plates in L/S/T device;	Per 3 months		**
	20.Pins in L/S/T device;	Per 3 months		**
	21. Sheer plates in L/S/T device;	Per 3 months		**
	22. Bears in L/S/T device;	Per 3 months		**
	23. Supports of L/S/T device;	Per 3 months		**
	24. Bolt connections of trolley heaves ass. (includes sheaves, idles & anti-slap blocks) ;	Per 3 months		**
	25. Pin connections of trolley heaves ass. (includes sheaves, idles) ;	Per 3 months		**
	26. Clamp plates of trolley heaves ass.;	Per 3 months		**
	27. Bolt connections of catenary trolley heaves ass. (includes sheaves, idles & anti-slap blocks) ;	Per 3 months		**
	28. Pin connections of catenary trolley heaves ass. (includes sheaves, idles)	Per 3 months		**
29. Clamp plates of catenary trolley heaves ass.;	Per 3 months		**	
Boom Hinge Ass.	1. The bolt connections of boom hinge ass.	monthly		
	2. Clamp plates of boom hinge ass. ;	monthly		



	3.The cuneal plate of upper hinge support;	monthly		
	4.The cuneal plate of lower hinge support;	monthly		
	5.The bolt connections of trolley stop;	Per 3 months		
	6.Clamp plates of trolley stop;	Per 3 months		
	7.Pins of trolley stop;	Per 3 months		
	8.The wire rope of trolley stop;	Per 3 months		
	9. The fixation of seal gate of boom and girder near the hinge ass. ;	Semiannually		
	10. The fixation of hand-hole cover on boom and girder near the hinge ass. ;	Per 3 months		*
	11.The bolt connections of idle ass.(includes main hoist、trolley、catenary trolley) ;	Per 3 months		**
	12.The pins of idle ass.(includes main hoist、trolley、catenary trolley) ;	Per 3 months		**
	13.The supports of idle ass.(includes main hoist、trolley、catenary trolley) ;	Per 3 months		**
Girder	1.The connection between girder and machinery house(including bolt, pin and support welding and so on) ;	Per 3 months		
	2.The connection of trolley buffer;	Per 3 months		
	3.Bolts and pins of manhole cover;	Semiannually		
	4.The fixation of hoisting hole cap of machinery house;	Semiannually		
	5.The connections of all peripheral appendix of machinery house (including door, window, ventilation fan, nameplate and so on);	Semiannually		
	6.Bolt connections of service crane;	Semiannually		
	7.Location pin of service crane;	Semiannually		
	8.The pulley and the back plate of service crane;	Semiannually		
	9.The fixation of flood light's cover;	Per 3 months		*
	10.Bolt connections of snag protection device;	Per 3 months		**
	11.Clamp plates of snag protection device;	Per 3 months		**
	12.Pins of snag protection device;	Per 3 months		**
	13.Sheer plates of snag protection device;	Per 3 months		**
	14.Bears of snag protection device;	Per 3 months		**
	15.Supports of snag protection device;	Per 3 months		**
	16.Bolt connections of trolley tension device;	Per 3 months		**
	17.Clamp plates of trolley tension device;	Per 3 months		**
	18.Pins of trolley tension device;	Per 3 months		**



	19. Sheer plates of trolley tension device;	Per 3 months		**
	20. Bears of trolley tension device;	Per 3 months		**
	21. Supports of trolley tension device;	Per 3 months		**
	22. Bolt connections of catenary trolley tension device;	Per 3 months		**
	23. Clamp plates of catenary trolley tension device;	Per 3 months		**
	24. Pins of catenary trolley tension device;	Per 3 months		**
	25. Sheer plates of catenary trolley tension device;	Per 3 months		**
	26. Bears of catenary trolley tension device;	Per 3 months		**
	27. Supports of catenary trolley tension device;	Per 3 months		**
Trolley Rail	1. All rigid clamp and the flexible clamp of trolley rail;	monthly		
	2. The installment of cuneal plate near short rail;	monthly		
	3. The fix of rail pad;	monthly		
Festoon	1. Bolt connections of festoon rail;	monthly		
	2. The welding of supports of festoon rail;	monthly		
	3. The connection of festoon rail near boom hinge joint (including bolt, vertical bar's welding and so on);	monthly		
	4. All relative part of festoon sys (including to tow trolley, cable fix and so on);	monthly		
Frame	1. The bolt connection between seaside upper beam and legs;	Per 3 months		
	2. The bolt connection between landside upper beam and legs;	Per 3 months		
	3. The bolt connection of fixed tie links;	Per 3 months		
	4. The bolt connections of HV cable reel;	Per 3 months		
	5. Pin of HV cable reel;	Per 3 months		
	6. Clamp plates of HV cable reel;	Per 3 months		
	7. The fix of windproof strips (including bolt, steel wire and so on);	Per 3 months		
	8. The fix of nameplate on horizontal beam;	Semiannually		
	9. Bolts and pins of manhole cover;	Semiannually		
Trolley	1. Bolts connection of trolley horizontal wheel;	monthly		
	2. All bearing of trolley horizontal wheel;	monthly		
	3. All support welding of trolley horizontal wheel;	monthly		
	4. Bolts connection of operator's cab;	monthly		
	5. Bolt connections of cab suspending brackets;	monthly		



	6.Pins' installment of cab suspending brackets;	monthly		
	7.Clamp plates of cab suspending brackets;	monthly		
	8.The buffer of cab suspending brackets;	monthly		
	9.Bolt connections of trolley anchor device;	monthly		
	10.Pins' installment of trolley anchor device;	monthly		
	11.All supports' welding of trolley anchor device;	monthly		
	12.Bolt connections of spreader cable reel;	monthly		
	13.Pins' installment of spreader cable reel;	monthly		
	14.Clamp plates of spreader cable reel;	monthly		
	15.The cuneal plates of spreader cable reel;	monthly		
	16.The installment of bearing of spreader cable reel;	monthly		
	17.The chain wheel connection of spreader cable reel;	monthly		
	18.Bolt connections of MH stop limit switch;	monthly		
	19.Pins' installment of MH stop limit switch;	monthly		
	20.The clamp of wire rope of MH stop limit switch;	monthly		
	21.Bolt connections of main hoist sheaves;	monthly		
	22.Pins' installment of main hoist sheaves;	monthly		
	23.Clamp plates of main hoist sheaves;	monthly		
	24.The connections of all peripheral appendix of operator cab(including door, window, rear view mirror, air conditioning support, ventilating fan, floor window, window safety bar, rain shield and so on);	Per 3 months		
	25.Bolt connection of trolley drive device;	monthly		*
	26.Pins connection of trolley drive device;	monthly		*
	27.Clamp plate connection of trolley drive device;	monthly		*
	28.The cuneal plates of trolley drive device;	monthly		*
	29.Bearings of trolley drive device;	monthly		*
	30.All supports welding of trolley drive device;	monthly		*
	31. The bolt connections of idle ass. ;	monthly		**
	32. The pins of idle ass. ;	monthly		**
	33. The bolt connections of trolley equalized sheaves;	monthly		**
	34. The pins of trolley equalized sheaves;	monthly		**
	35. The bolt connections of trolley wheels;	monthly		**
	36. The pins of trolley wheels;	monthly		**
	37. The bears of trolley wheels;	monthly		**
	38. 11.The connection of trolley buffer;	Semiannually		**
Spreader &	1.Bolt connections of spreader and headblock;	monthly		



Headblock	2.Pins' installment of spreader and headblock;	monthly		
	3.Clamp plates of spreader and headblock;	monthly		
	4.Cuneal plates of spreader and headblock;	monthly		
	5.The bearings of spreader and headblock;	monthly		
	6.Bolt connections of main hoist sheaves;	monthly		
	7.Clamp plates of main hoist sheaves;	monthly		
Stairs, Ladders & Platforms	1. All fixed hook joints of platforms;	Per 3 months		
	2.Bolt connections and welding of stairs;	Per 3 months		
	3.Bolt connections and welding of ladders;	Per 3 months		
Hydraulic Sys. & Lubrication Sys.	1. The whole inspection of hydraulic sys. and lubrication sys. power station(including fastener and so on);	Per 3 months		
	2. The fixation of pipeline of hydraulic sys. and lubrication sys. (including pipe, clip, oil nipple and so on);	Semiannually		
Electric Sys.	1. The bolt connections of electric sys. ;	Per 3 months		
	2.The mounting of the cable-slot cover, junction boxes and limit switch;	Per 3 months		
	3.Check the fastener of walkway lights ,floodlights, etc.;	Per 3 months		
Addition Item				

**Note:**

1. The inspection requirement refers to the drawing. Insure the welding、bolts、pins meet the design requirement.
2. The inspection of potential falling hazards not only includes the above items .Other items can be added during the checking process.
3. The inspection of potential falling hazards is a special requirement. It can not be replaced by routine inspection.
4. “ \* ”refers to the application for MOT cranes; “ \*\* ”refers to rope driven cranes; not marked items are shared by these two kinds cranes.

## Chapter 6 Instruction for Drawing No.

Drawing No. is the basic information code and foundation of product designing for the company. It is also the basic of enterprise informatization data.

### 6.1 Drawing No.'s characteristics

6.1.1 Exclusive. It means one drawing no. represents only one product, or assembly, or part.

6.1.2 Affiliation. It can show the

subsidiary relation between assembly and parts;

### 6.2 The explanation of ZPMC drawing no. label

6.2.1 There is a title bar at the lower right corner of every drawing. There is drawing no. and drawing name of assembly or part on it.

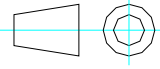

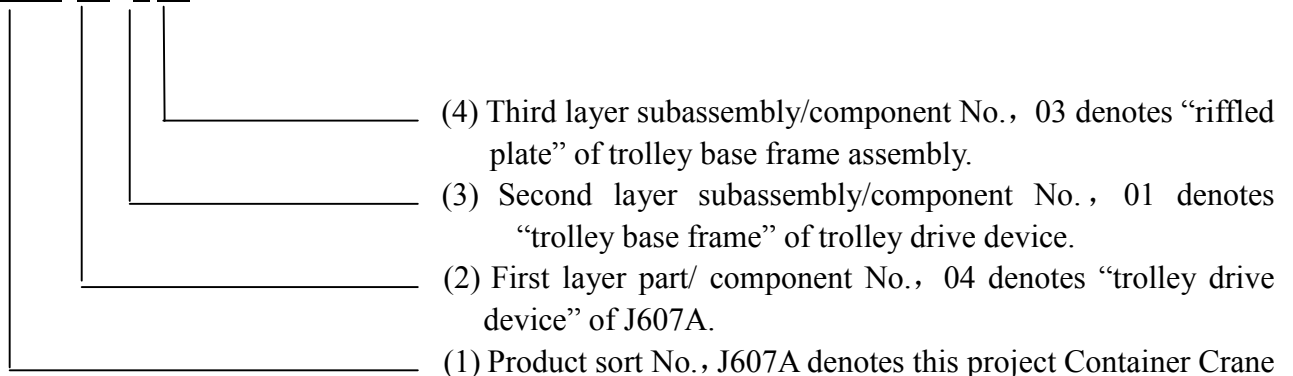
描述及日期/Description & Date	工号/JOB NO.		项目名称/PROJECT		
	设计/DSGN	校对/CHKD	审核/EXAM	审定/APPD	图幅/FORMAT
	日期/DATE	日期/DATE	日期/DATE	日期/DATE	
	材料/MAT	比例/SCALE	图名/DRAWING NAME		
单重/WEI (Kgl)					
修改标志/Sign	 上海振华重工集团		图号/DRAWING NO.	版本/REV	页号/PAGE

Diagram of title bar

### 6.2.2 Instruction for drawing no.

J607A 04 01 03



### 6.2.3 J607B SPRC Container Crane subsidiary list is as following:



No.	Drawing No.	Drawing Name
1	J607B0000	总图 General arrangement
2	J607B0100	钢结构总图 Structure general arrangement
3	J607A0200	小车总成 Trolley assembly
4	J607A0300	主起升机构 Main hoist mechanism
5	J607A0400	小车驱动机构 Trolley drive mechanism
6	J607A0500	俯仰机构 Boom hoist mechanism
7	J607B0600	大车行走机构 Gantry drive mechanism
8	J474A1000	挂舱倾转装置 Anti-slag and tilt device
9	J607B1200	吊具上架 Headblock
10	J607B1300	吊钩横梁 Cargo beam
11	J474B1400	应急装置 Emergency drive device
12	J474A1500	换绳装置 Rope re-reeving device
13	J607B1600	室内维修行车 Machinery house service crane
14	J607A2000	起升缠绕系统 Main hoist rope reeving system
15	J607A2100	小车缠绕系统 Trolley rope reeving system
16	J607A2200	托架小车系统 Catenary trolley rope reeving system
17	J607A2300	俯仰缠绕系统 Boom hoist rope reeving system
18	J607B3000	机器房 Machinery house
19	J607A3100	司机室 Trolley operator's cab
20	J474A3200	俯仰操作室 Boom hoist operator's cab
21	J607A4000	高压电缆系统 High voltage power supply system
22	J607A4100	小车电缆输送系统 Trolley cable conveying system
23	J607B5000	梯子平台 Walkway, stair, platform and ladder system
24	J607A5100	电梯 Personnel elevator
25	J607A6000	大车锚定 Gantry stowage pin assembly
26	J607A6200	大梁锚定装置 Boom stowage device
27	J607A6300	大梁防撞装置 Boom anti-collision device
28	J607A7000	空压机系统 Compressed air system
29	J607A7100	室外维修行车 Outdoor service crane
30	J607B7200	润滑系统 Lubrication system
31	J607B7300	铭牌 Nameplate
32	J607A7400	限位系统 Crane limit switch system
33	J607A7600	整机消防系统 Water piping system

## Chapter 7 Safety



















Safety is a priority either in operation or in maintenance and inspection. This chapter informs you of the possible hazards and necessary precautions to be taken when operating or maintaining the crane.

Before the operation or maintenance of cranes, maintenance or repair personnel must carefully read and thoroughly understand and strictly follow

the crane safety procedures described in this chapter.

### 7.1 WARNINGS AND SYMBOLS

The following signs and symbols are used in the manual to designate instructions of particular importance.

Symbol	Description	Symbol	Description
	Special information and/or orders and prohibitions directed towards preventing damage.		Hazardous voltage
	Warn of electric voltage.		Keep hands and body clear
	Stay clear		No standing on it
	No access		Keep hands clear of the moving parts.
	Do not enter, Authorized personnel only.		Danger of falling
	Refer to specified sections in the manual.		Special information for increasing efficiency
	Crush hazard		Keep away from suspended loads
	Refers to information in other parts of the Manual		Additional Information
	Wear protective clothing		Danger of tripping

In this manual, as well as on the crane, warnings or warning signs are categorized into four levels according to the severity of danger (or seriousness of accident) as shown in Table 7.1-1.

**Table 7.1-1**

Warnings	Definitions
<b>DANGER</b>	Refers to imminently dangerous situations. Used when serious injury or even death will occur if specified procedures or instructions are not followed.
<b>WARNING</b>	Refers to potentially dangerous situations. Used when serious injury or even death might occur if specified procedures or instructions are not followed.
<b>CAUTION</b>	Refers to potentially dangerous situations. Used when medium or slight injury will occur or when the machine or equipment will be damaged if specified procedures or instructions are not followed.
<b>NOTE</b>	Used when attention must be paid to or when information must be stressed.

## 7.2 GENERAL PRECAUTIONS

This crane embodies the latest and the best in structural, electrical, mechanical, and hydraulic systems and may only be put into operation by qualified or trained staffs.

Before operating or maintaining the crane, the operation and maintenance instructions have to be read carefully and understood by all maintenance and repair personnel.

This machine is also built according to the latest standards of technology and recognized safety technical rules, and is equipped with safety devices. It has been checked for function and safety before delivery and hand-over. However, in case of faulty operation, misuse, or use not in accordance with the instructions, dangers and/or damages could still arise and threaten the health of the operation personnel or third persons, the container crane or other material, and/or the efficient operation of the crane itself.

Always use safety harnesses and/or other safety gear as required whenever in an elevated working place. It is always a good practice to work in a team of at least two persons in a place where potential dangers may arise.

It must be observed strictly to secure the proper protection of staff whenever working on an equipment

that may release any form of hazardous energy including, but not limited to, electrical, rotational, mechanical, chemical, hydraulic, or pneumatic energy, while the equipment is shut down.

In addition to the operation and maintenance instructions provided herein, legal (generally valid) and other obligatory regulations issued by the local authorities for accident prevention and environmental protection must also be observed.

It is our admonition that working cautiously and carefully is the best protection from accidents.

None of us has all the expertise or training needed to complete every repair that may be required. Do not try to undertake a task on which you are lack of training or qualifications.



**IT'S ABOUT YOUR SAFETY!**

The manufacturer, Shanghai Zhenhua Heavy Industries Co. LTD. (ZPMC), has tried his best to assemble and make available a complete set of instructions in the form of manuals and data sheets to provide all necessary information for crane operation and maintenance. In case of uncertainties,

problems and additional requests, we will always be at your disposal. Please do not hesitate to contact our local representative and/or technical supporting staffs at the manufacturing base:

### 7.3 GENERAL RULES OF CONDUCT AND SAFETY REGULATIONS

The crane may only be operated in technically healthy condition and in compliance with the operating and maintenance instructions. Particular malfunctions that may impair the safety must be eliminated immediately. Before each commissioning, the crane must be checked for operational safety!

Uncompleted or illegible operation and maintenance must be replaced immediately.

Protection and safety devices (covers, safety barriers, etc.) must not be removed while operating the unit. The crane must not be operated without safety devices at any time.

Appoint personnel solely responsible for the crane operation and maintenance respectively. Also, do not permit unauthorized personnel to operate the crane.

The operating and maintenance staff has to be checked by the employer responsible for the operation. The person responsible for the operation is obliged to operate the crane only in proper condition and to instruct the operating and service staff to wear protective clothing, etc. whenever necessary or required by the regulations.

If there are any alterations concerning the safety of the machine or changes in the operational behavior, the machine has to be set to a standstill and the fault has to be reported to the relevant authority or person. Damages affecting the safety or malfunctions at the crane have to be eliminated immediately.

Arbitrary constructive modifications and the alteration of parameters beyond the operating and maintenance

instructions are not permitted for the sake of safety technical.

All maintenance and repair work must undergo a thorough review and inspection to ensure effective.



#### IMPORTANT SAFETY PRACTICE!

The following safety rules must be observed strictly in practice:

- (1) Verify that there is no danger to other related personnel before operating the machine.
- (2) Do not touch the rotating parts or the moving parts of the machine during operation.
- (3) Do not perform inspection and adjustment of the machine during operation.
- (4) Do not touch the live parts inside the control cabinets or terminal boxes. The internal live parts carry high voltage current and pose the risk of electric shock when touched.
- (5) Do not lubricate the components of the machine during operation.
- (6) Immediately press the emergency stop pushbutton to stop the machine when an accident has occurred or is likely to occur.
- (7) Always keep the machine and it's surroundings clean. Especially Keep the passageways at the elevated place clean so that personnel can walk safely.
- (8) Warn all the service personnel of an unsafe intended action that may endanger them.
- (9) Report any injury and make sure the wounded person can receive fast medical treatment.

(10) Installed in the safety device, no special circumstances shall not remove installed; often fully check the operation of each safety device is complete, the role of ability to meet the requirements of various devices.

(11) Measures should be taken to prevent crane moving when sudden wind occur during operation. Each driven wheel should be equipped with wheel brake. During operation, when the gantry motor brake action, wheel brake delay action. If the wind speed has reached more than 20m / s, the wheel brake automatic act. The wheel brake should meet the requirements that when the air pressure reach 551.7N / m (wind speed of 30m / s), the crane still will not move. However, if the wind speed is predicted to remain more than 20m/s for a long time, or in case of a storm, it must be fixed according to item (12). When the wheel brake action, since the limit switch and gantry motors are controlled by electrical interlock, you can not start gantry device. In addition, after the container handling operation, stop the crane by wheel brakes.

(12) The measures should be taken in the case of Storm. Storm means the heavy wind whose speed is more than 20m / s winds for a long time. In order to prevent the move of the crane when in storms, or when predict to the possibility of this phenomenon, we must take advantage of the seaside and the landside anchor device and tie-down to fix the crane onto the foundation. The anchoring device and fastening can ensure that the crane does not move when the air pressure reaches 1854.3N / m (i.e. wind speed of 55 m / s) as the boom is up. Anchoring device located under the seaside beam and land beam. Anchoring device is same as wheel brake and tie-down, it electrical interlock with the gantry device. So before running the crane must release the anchoring device firstly. If the crane won't run for a long time, fix the crane with anchoring devices and

tie-down.

(13) Daily inspection of the crane is to maintain the crane operate in the best state. You must always check the mechanical action status, the wearing of the various components, oil supply situation. Through routine inspections, if find any imperfections, take measures immediately to repair so as to make it in the optimal state.

## 7.4 SAFETY RULES FOR OPERATION

### Pre-service Precautions:

- (1) Before starting work at the crane, all persons have to be instructed in theoretic and practical use of emergency measures in case of an accident, the use of the emergency exits, and the use of rescue aids (fire extinguishers).
- (2) Unauthorized persons should not enter the crane.
- (3) All safety devices and facilities with protection functions must always be connected and operable. They must not be rendered ineffectively or used improperly.
- (4) The factory setting of the components must not be changed.
- (5) Observe the inspection procedure stated in this manual for the inspection of each component.
- (6) Make sure no irrelevant items collide with the crane, or are within the walking range of the crane. If there is such a situation, it is necessary to quickly move these items.
- (7) Confirm whether the anchoring device, the fastening devices are in a working state. Because the anchoring device, tie-down and gantry motor interlock, when they are in working condition the

crane is unable to walk.

- (8) Check if the oil supply for the mechanical devices is sufficient.
- (9) Check whether the switches and joystick of electric device are on the right position.
- (10) Check whether the power and voltage are normal.
- (11) Unlock the boom which is locked by boom storage device. Put it down to the working position (namely level position).
- (12) Run the crane under unloaded condition. Check the action of safety devices and limit switches are normal.

#### **Precautions during service:**

- (1) Do not step into an area below the cargo lifted when the crane is operating. It may result in a critical accident.
- (2) The lifting load and the reach during the loading or unloading operation must be within the limit values defined by the specifications of the crane. Excess reach or excess load may result in a critical accident such as a fall-down, a break-down or a damage of the crane.
- (3) Immediately stop operating the crane when an abnormal sound or vibration arises. Inform the responsible personnel immediately to eliminate the malfunctions or conduct maintenance.
- (4) Do not leave the crane with open hatch covers, or other openings into which a person could step or tools and objects could fall. And do not leave lubricants, paints, or other materials uncovered or un-attended.

- (5) Always operate the crane smoothly to prevent the shock of start-up or stoppage. Avoid operations such as abrupt loading or unloading at full speed with excess load or unnecessary repetition of start-up or stoppage.
- (6) When the crane encounters a strong wind over 31m/s, conduct the crane stowage procedure against wind.

#### **Precautions after service:**

- (1) Stop the crane at the registered position.
- (2) Stop the trolley at the registered position (namely the stop position).
- (3) Raise up the boom and lock it by boom stowage device. When the boom is hooked, the light in the operator's cab will be on.
- (4) Return the joystick in the operator's cab and switched to the registered position.
- (5) Return control cabin's switches in the machinery house back to the "OFF" position.
- (6) Check if wheel brakes are in working condition.
- (7) When predict to the possibility of strong storm, or the crane will stop for a long time, take advantage of the seaside and the landside anchor device and tie-down to fix the crane onto the foundation.
- (8) To assure keeping good condition for next operation, check if the oil supply for the mechanical devices is sufficient.
- (9) Check and repair the imperfection of devices.

(10) To prevent irrelevant person from entering the machinery house and operator's cab, equipped locker for these two places.

(11) Check whether the flight light on the boom and apex beam are on.

#### Quay foundation:

(1) The foundation is the most important part for the normal operation. After a long period of use, due to the sinking and moving of the foundation, such phenomena as horizontal error may occur. So regularly check the dimension of the foundation. If exceed the allowable value, you must adjust the basis.

(2) The rail should remain straight. Adjust the height difference of the connecting joint to the minimum. In addition, after long-term use, bolts may be loose, if so, must fasten them immediately.



**DANGER ZONE MUST BE BLOCKED BY SUITABLE MEASURES. HAZARD AREAS MUST BE INDICATED PERMANENTLY BY CLEAR INDICATIONS, SUCH AS COLORED SIGNS OR WARNING SIGNS.**

### 7.5 SAFETY RULES FOR MAINTENANCE AND REPAIR

The maintenance work is different from the ordinary operations. When the crane is under maintenance, some of its parts may be disassembled or unstable, thus special attentions should be paid to.



**BEFORE COMMENCEMENT OF SERVICE WORK THE CONTAINER CRANE HAS TO BE MADE FREE OF LOAD, SET TO MAINTENANCE POSITION AND SWITCHED OFF, IF NO OTHER NOTE IS GIVEN.**

Observe the following safety rules when conducting maintenance or inspection work on the crane:

(1) Personnel unauthorized by the person responsible for the crane should not perform maintenance or inspection work.

(2) Do not perform maintenance or inspection work when the crane is operating.

(3) Before conducting maintenance or inspection work, cut off the main power supply and all the power resources; then verify if the crane is stopped completely.

(4) Performing maintenance or inspection work before the release of the energy stored in all the relevant system. This also includes putting the spreader and head block on the dock, put down the boom so that it supported by the forestay or arise the boom to the maintenance position and lock it.

(5) Before conducting maintenance or inspection work, warn all the related workers of the work and prohibit entry of those unauthorized workers into the maintenance and inspection areas.

(6) The crane should be in maintenance mode for such a task.

(7) Secure the repair area by closing a wider area. During the maintenance of the crane, be sure to close hatches on the machinery house and other places, or protect them with fences.

(8) When inspecting one of the cranes on the same gantry rails, attach the mechanical stoppers or station a person to prevent collision of the cranes.

(9) Never fail to close the door to the walkways and the

- chains at the gate of the walkways.
- (10) When removing bolts, pins, wire ropes, and cables, warn workers other than the service personnel of the danger of attached parts falling.
  - (11) When relieving the residual pressure of the trim/list/skew and rope tensioning device, warn maintenance personnel of the device. The sheaves may move and each wire rope may loosen due to the relief of the pressure of the hydraulic cylinder. It may cause injury.
  - (12) Verify that there is no residual pressure left in the hydraulic equipment and the compressor. Residual pressure may cause injury.
  - (13) If hands will be on the rope for inspection, they must be away from the pinch point.
  - (14) The maintenance persons should pay more attention to the moving/rotating parts.
  - (15) Do not use the machine parts as climbing aids.
  - (16) Reinstall and test safety devices (which have been disassembled during the assembly or test and repair work) immediately after the end of the maintenance and the repair work.
  - (17) Correctly tighten the screw joints that were loosened during the test and the maintenance work.
  - (18) Replace the fastening elements and seals (e.g. self-securing nuts, washers, split pins, O-rings and seals) which cannot be used again.
  - (19) After the maintenance/repair work, update the fault log and the maintenance check list.
  - (20) Do test running and functional check of the components and safety devices before starting the operation and service again.

## 7.6 CONDUCT IN CASE OF ACCIDENTS AND EMERGENCY

- (1) All personnel must be trained and familiar with in particular emergency response procedures and incident response procedures. Employers should ensure that the version of the above procedures and training is latest.
- (2) In the case of an accident with injury to persons, damages to devices or other materials, immediately inform the supervisor after providing the injured with first aid. For well-directed rescue efforts, clearly give the degree of severity of the injury to persons and the damage to property.
- (3) In case of disasters (e.g. fire), all persons must leave the crane using the indicated emergency exits and/or other facilities.
- (4) Rescue actions may only be carried out by instructed operating and rescue personnel. Use the intended protective equipment.

(According to the calculation, this project have no need to set tie-down device )



## Chapter 8 Maintenance guide of the anticorrosion coating in port machinery equipments

As to port machinery equipments, the function of anticorrosion coating is not simply beautiful visually, but also which will protect steel structures out of natural corrosion. The anticorrosion capability of the exterior coating has very important effect on assuring the most durability of port machinery equipments.

ZPMC provide the certified painted production, which is designed according to the durability and considering the natural corrosion of coating in the correlative environment conditions provided by buyers. Reasonable application and coating system can actually assure the coating of steel structures to possess suitable anticorrosion function and life. While some undefined factors will dramatically restrict the durability of anticorrosion coating, such as without repairing coating damages and cleaning the grease of coating surface in

time etc. If exterior hidden disasters can not be eliminated in time, which will accelerate wearing down the coating and shorten anticorrosion life. Therefore, users should strictly execute the maintenance work in the process of using the Port machinery equipment, assuring the best anticorrosion capability of coating.

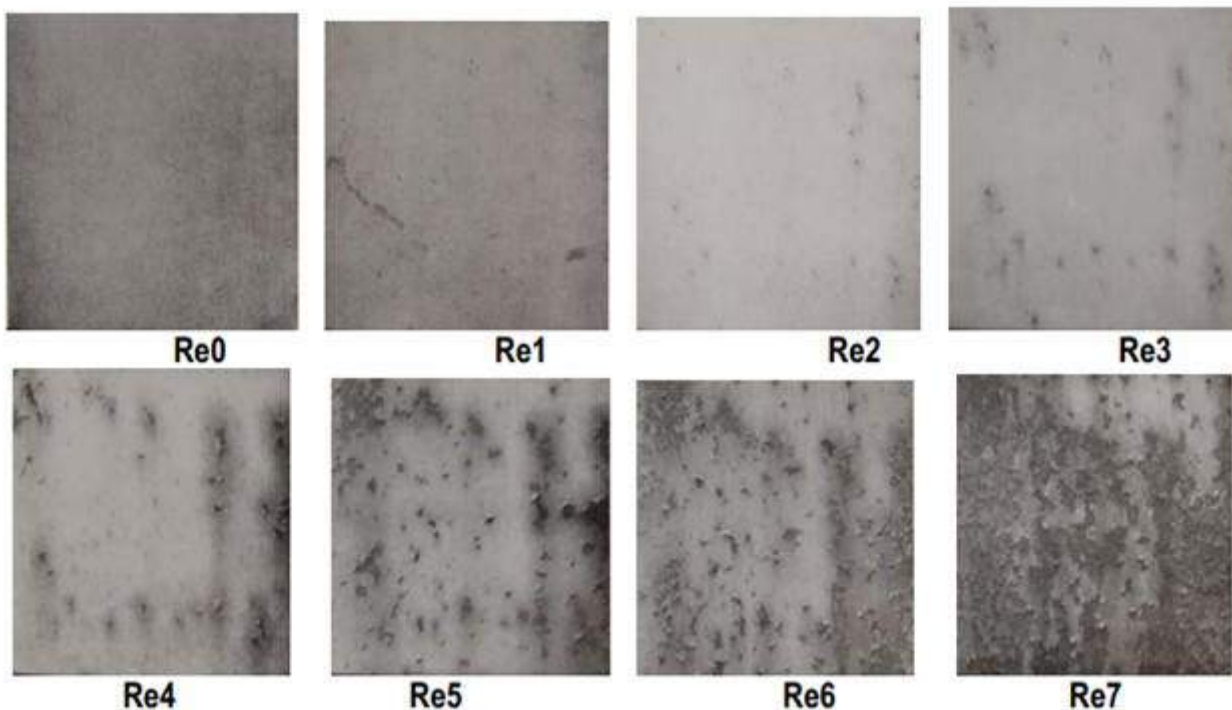
### 8.1 General principles

#### 8.1.1 Scope

This guide is applied to daily maintenance of anticorrosion coating in the process of using the Port machinery equipments.

### 8.2 Standard comparison of coating rust

Rust is corrosion from substrate to surface, as follows is European scale of degree of rusting for anticorrosive paints standard comparison:



The below table shows rust areas percent according to rust grades:

grades	Rust areas percent
Re1	0.05%



Re2	0.5%
Re3	1%
Re4	3%
Re5	8%
Re6	15~20%
Re7	40~50%

Note: when somewhere rust grade is more than Re4 or the single rust area is bigger than 0.25 square meters, the owners need to remove the rust and repair the coating. When the most scale of rust areas of Port machinery equipment is Re4, owners should remove rust and repair for the whole machine.

### 8.3 Inspection period and content of daily maintenance

#### 8.3.1 Inspection period

8.3.1.1 Inspection of coating in warranty period: After delivering the Port machinery equipment, owners should generally inspect the coating surface of Port machinery equipment every year.

8.3.1.2 Inspection of coating after warranty period: In order to assure the continuing effective anticorrosion coating capability, in the first half of the year of equipment coating warranty period expiration, owners should invite experts to evaluate anticorrosion effect for coating of the whole machine, and take corresponding measurements to assure anticorrosion effect according to evaluation results. We advise owners to inspect the whole machine surface condition once half a year after the warranty period.

8.3.1.2 If small local paint damage was found during crane inspection, users should take the initiative in repairing in accordance with the corresponding paint repair procedure to avoid damaging range widening. Even during the paint warranty period of crane manufacturer, the manufacturer should not be deemed to take the responsibility of those small local damage produced after handover, unless it is specified in

the main contract.

#### 8.3.2 Inspection content and measurement

Inspection content is generally inspecting coating surface of the whole machine, including inspection of surface cleanliness (grease and other contamination), surface salt deposit, surface water, local surface coating damage and some coating appearance etc, owners should take protective measurements for the different defects.

8.3.2.1 Inspect and deal with the contamination of coating surface

1) If the Port machinery equipment is contaminated by grease, dust and other contamination, the accumulation will directly damage the coating. If there are black or yellow adhesive objects, whose source should be inspected, then measurements should be taken to prevent contamination from increasing to continue, and surface contamination should be cleaned out by using cleanliness agent.

Note: The long-term accumulation and cover of grease contamination will easily cause the whole coating damage.

2) If there is much dust or corrosive salts covered the surface of steel structure, the owner should remove them by high-pressure water, the



pressure is not less than 2000psi.

#### 8.3.2.2 Inspections and treatments of salt deposit of coating surface

Salt deposit of coating surface can accelerate the loss of coating, so please immediately clean it out by water when you find a layer of white powder deposit.

#### 8.3.2.3 Inspections and treatments of the waterlogging on coating surface

During the operating, some drain holes may be jamed up, so that results in some places waterlogging occurs. The waterlogging of coating surface can accelerate corrosion, so the anti-corrosion life of coating will be shortened. Please inspect the state of the waterlogging on coating surface regularly, and dredge it in time.

#### 8.3.2.4 Inspections and treatments of local damage of coating

It is inevitable to collide or abrade during the operating, which makes the coating damaged. These coating damages must be repaired according to the repair standard regardless of whether the collision and abrasion damage the substrate of steel structure. During inspections, once found the coating is damaged, please pay attention to the coating damaged by blunt object. The coating scratches are not obvious, but the local peeling and loose phenomena may have happened. Therefore, these damages should be timely removed during repairing to avoid substrate corrosion. Coating damaged places must be repaired in time to avoid expanding the rust zone because of exposed for a long time.

#### 8.3.2.5 Inspections of paint powdering

It's a normal phenomenon that there is slight powdering and gloss loss of the finish paint after

the equipment is used for a time. The direct sunlight for a long time transforms the coating into powders or particles, it is a natural phenomena of coating attenuation.

#### 8.3.2.6 Inspections of paint color fading

It will be fading after the coating suffers from the erode-corrosion of ocean climate, the consistent exposure and the high heat and humidity of beach sunlight for a long time. So it is normal that port machinery equipment is operating after a long time.

#### 8.3.2.7 Inspections of the coating of galvanized steel surface

Galvanized steel has a good anti-corrosion performance. Zinc coating plays a nice role on protecting steel through sacrificing anode, because the potential of zinc is lower than steel. For the whole beauty, some galvanized parts such as handrails are also painted. But the adhesive force of the coating on the galvanized parts is less than the steel, so it may be peeled off after a long time. There is no need to be repainted when the red rust on the zinc coating. Because which indicates that substrates have not been eroded.

#### 8.3.2.8 Inspections of the coating on stainless steel

Stainless steel is a material of corrosion resistance, so it is not rusted in general. But some easy-rusted contaminants such as iron scraping attached to the surface of stainless steel would make the stainless steel surface rust. The owner can remove the rusts by power tools or sandpaper to get fresh surface exposed when the stainless steel surface is rusted.

### 8.4 Paint for maintenance

#### 8.4.1 Choice of paint brand

If the owner need purchase new paint to repair and maintain the coating of port machinery equipment, please choose the paint brand which same as original paint system as soon as possible. For convenience, purchasers also can choose heavy anti-corrosion protection paints of some famous paint brands nearby such as Hempel, Sigma, IP, Jotun, ZPMC and so on.

#### 8.4.2 Choice of coating

Coatings with convenient for application, high solid volume, fast curing or thicker film thickness is recommended for primer and intermediate coat. Inorganic rich zinc primer is not suitable for repairing, but epoxy rich zinc primer or high solid volume with surface tolerant coatings is proposed. The color and style of chosen top coat should accord with original top coat.

### 8.5 Coating system inspection and maintenance requirements

#### 8.5.1 Coating system inspection requirements

8.5.1.1 Users should arrange schedule for mechanical inspection and maintenance according to work amount.

8.5.1.2 Coating system inspection and maintenance are carried out at a rainless, dry and optimum temperature.

#### 8.5.2 Coating system maintenance requirements

##### 8.5.2.1 Substrate treatment

- 1) Surface contaminant such grease, oil should be removed prior to follow-up surface treatment.
- 2) Use power tool or hand tool to clean loose coatings and corrosion to minimum ST3 or SSPC-SP3. All surface to be renovated should be dry, and free from contamination harmful to coating system such as grease, dust etc.

##### 8.5.2.2 Painting application condition control

- 1) Painting shall be applied when weather is fine.

- 2) Carefully read the coating products specification before painting to understand environment control requirement of painting.
- 3) Ordinary condition control for painting as bellow: the temperature is no less than 5°C the relative humidity is no more than 85%, the surface temperature of steel is more than 3°C above the dew point. (particular demands on coating specification).

##### 8.5.2.3 Painting requirements

- 1) Carefully read coating products specification before painting to mix each compounds correctly. Note the pot life and forbid to use coatings exceeding the pot life.
- 2) Painting operations shall be performed in a proper application method according to the recommended instructions from coat producer integrated with practice situation. Brush and roller are recommended for the renovation of coating system.
- 3) The account of mixed coating should keep to principle of maximize the utilization to avoid waste and environmental pollution.
- 4) Spay is not recommended when wind speed is greater than 7 m/s.

##### 8.5.2.4 Inspection and control of dry film thickness

- 1) Need to recoat several times as dry film thick is too thin one coat when brush or roller.
- 2) The renovation should be according to the actual situation of area requiring renovation (from primer to top coat if primer is damaged, for example), and make sure every renovated coat should satisfy the required film thickness.
- 3) Make sure that the total film thick of renovated coating system no less than 220~250 μm.



#### 8.5.2.5 Appearance control requirement

- 1) Film faults must be ground feature to slope shape with 30° to make sure a fine smoothness of renovated film.
- 2) Grind the surface of intermediate and top coat by sandpaper (no more than 100 meshes are recommended) is not proposed to avoid marks.

#### 8.5.3 Special specification

If possible, waterborne or low VOC coatings are preferred to reduce environment pollution.

#### 8.6 Safety precautions

- 1) Climb equipment shall be prepared before maintenance work is carried out.
- 2) Scaffolds should be erected when climb equipment is absent and relative safety protection is followed.
- 3) Operator should give applicator necessary

safety education and training is recommended.

- 4) Learn Material Safety Data Sheet (MSDS) of coating before painting.
- 5) Protective measures such as safety belt, helmet and safety glasses etc must be taken for applicators.
- 6) No open flames and no cross operation in painting operation area.
- 7) Warning sign should be erected before coating dry totally.
- 8) Assistant materials should be recycled and uniform disposal.
- 9) Uniform disposal of abandoned coating and thinner, no littering and dumping.



## Attachment A Manuals for Subcontractors (Mechanical Part)

No.	Name	Subcontractors
1	Reducer(Main hoist Boom hoist &Trolley /Gantry)	PIV/ZPMC
2	High speed brake	Bubenzer
3	Drum brake	Bubenzer
4	Pump of drum brake	Bubenzer
5	Rail brake	Hillmar
6	Pump of wheel brake	Hillmar
7	Drum coupling	Malmedie
8	High speed coupling	Bubenzer
9	Head block	ZPMC
10	Spreader	Bromma/ZPMC
11	Cargo beam	ZPMC
12	Lift	ZPMC (Sheng Yang Long Chang)
13	Spreader cable reel	Cavotec
14	Gantry cable reel	Cavotec
15	Inside service crane	ZPMC
16	Wire rope	Verope
17	Air compressor	Shen Jiang
18	Buffer	Oleo
19	Fire extinguishing system	ZPMC
20	Emergency reducer/ motor	Guo Mao
21	Rope reeving reducer/ motor	Guo Mao
22	Festoon	Wampfler



## Special Explanation

Ports are the hubs of land and water transportation and also the distributing centers of various cargos. **Port handling operation not only needs the combination of people and machines, but also consists of heavy and complicated tasks which hide many potential hazards.** Therefore, it is the port's obligation to establish relevant safety regulations and procedures to prevent accidents from happening.

The quayside cranes are also potentially hazardous. To reduce the risks of injury or danger, please always follow the instructions in this manual when performing operation and maintenance work on the crane. **Shanghai Zhenhua Heavy Industries Co. LTD. (ZPMC) will not be liable for any damage or injury resulting from abuse or misuse of the crane.**

These quayside cranes are heavy duty, high-speed and very complicated machines with high degree of automation, so it is impossible to foresee every potential hazard. The manufacturer, Shanghai Zhenhua Heavy Industries Co. LTD. (ZPMC), can not envision every possible circumstance that might involve a potential hazard. The warnings in this manual and on the cranes are, therefore, not all inclusive. **When operating, inspecting, or maintaining the cranes, each person must be safety conscious and take all necessary precautions, in addition to following the instructions in this manual.**

## About Life-time Warranty

1. The lift-time warranty of quayside crane and its components will be based on the condition of **proper use, safe operation and timely maintenance** by the purchaser.
2. **Consumable components** such as limit switch, bulb, fuse, carbon brush, oil seal, brake lining, wire rope, lubricating oil etc. are not covered by this warranty.
3. **Non-ZPMC brand or Non-ZPMC recommended parts** are not covered by this warranty.
4. **Emergency stop** (especially full speed sudden stop) is abnormal working condition. Damages caused by that condition shall be classified to operation accident, which is not covered by this warranty. ZPMC may support to check and make renewing repairs.

Shanghai Zhenhua Heavy Industries Co. LTD  
December, 2016

# **MAINTENANCE MANUAL**

**SOCIEDAD PORTUARIA REGIONAL DE CARTAGENAS.A.**

TWO QUAYSIDE CONTAINER CRANES

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