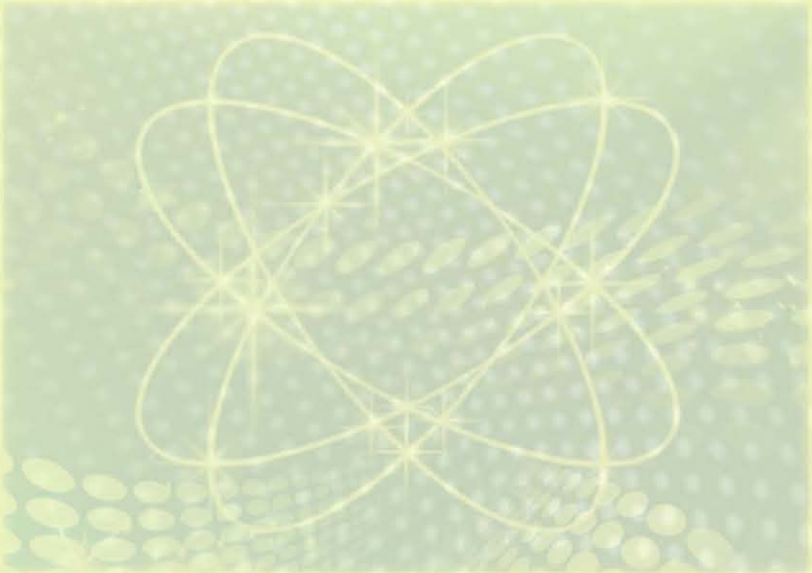
岸边集装箱起重机构造及维护手册(英语)



Preface

Shanghai Zhenhua Port Machinery Co. (ZPMC) is a world leader in heavy-duty machinery manufacturing, specializing in container handling cranes. Its main products, Quayside Container Cranes (QCs) and Rubber-Tired Gantry Cranes (RTGs) are in major terminals in 63 countries and areas (including Taiwan and Hong Kong) around the world. To date, ZPMC has captured more than 70% of the highly competitive world market in the industry, and its products are admired not only for their use of the latest technology, their quality and their reliability, but also for their competitive prices, timely delivery and complete after-sale customer service. ZPMC has become a world-famous brand name in the industry.

This manual has been in the planning stages for many years. As a company that has manufactured more than 1250 Quayside Container Cranes and 2000 RTGs, ZPMC has an obligation to produce an illustrated, useful and practical maintenance manual for port customers. ZPMC's recently-completed Quayside Container Crane Configuration and Maintenance Manual contains a brief introduction to crane maintenance, but the company felt that more detailed information was needed.

This manual focuses on the configuration and maintenance tasks important to quayside container cranes, especially on cleanliness, inspection of fastenings, adjustments, lubrication and replacement, which are the six basic aspects of maintenance. The manual covers mechanical, electrical and hydraulic parts, not only explaining basic theory and crane configuration, but also combining with port maintenance practice and experience, making it both useful and practical. The manual explains complicated tasks simply by using pictures and illustrations in over 50% of the descriptions, making it a truly illustrated maintenance manual that can provide both operating guidance and training material for port maintenance personnel.

If port customers closely follow the instructions in this manual, performing maintenance both correctly and timely, the life of ZPMC's highly reliable components can be significantly extended.

About Safety

Ports are the hubs of land and water transportation and also the distributing centers for various cargos. Port cargo handling operations require a combination of people and machines performing heavy and complicated tasks, many of which are potential dangerous. Therefore, it is the port's obligation to establish relevant safety regulations and procedures to prevent accidents from happening.

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 a crane. Shanghai Zhenhua Port Machinery Co. (ZPMC) will not be liable for any damage or injury resulting from abuse or misuse of its cranes.

Moreover, these quayside cranes are heavy duty, high-speed and very complicated machines with a high degree of automation; therefore it is impossible to foresee every potential hazard. The manufacturer, Shanghai Zhenhua Port Machinery Co. (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. In addition to following the instructions in this manual, when operating, inspecting, or maintaining a crane, each person must be safety conscious and take all necessary precautions.

Life-time Warranty

As of June, 2007, Shanghai Zhenhua Port Machinery Company(ZPMC)is offering a new life-time warranty on its quayside container cranes and RTGs.

This warranty is a concrete measure to protect user benefits. In the fifteen years since its establishment, ZPMC has been striving to achieve quality, high-technology and greater reliability for each individual component used on its cranes. ZPMC believes that today, its cranes are the most reliable in the world. Users are encouraged to understand the significance of this warranty and to co-operate with the company to realize its benefits.

1) The lifetime warranty of a quayside crane and its components is based on the conditions of **proper use**, **safe operation** and **timely maintenance** by the purchaser.

2) **Consumable components** such as limit switches, bulbs, fuses, carbon brushes, oil seals, brake linings, wire ropes, and lubricating oils are not covered by this warranty.

3) **Non-ZPMC brands** or **non-ZPMC-recommended parts** are not covered by this warranty.

4) **Emergency stops** (especially full-speed sudden stops) are abnormal working conditions: damage caused by emergency stops considered operation accidents and are not covered by this warranty. ZPMC may support checking and repairing.

Shanghai Zhenhua Port Machinery Co.

May, 2009

Contents

Chapter 1 The Quayside Crane

To a large extent, the lifespan of a crane and its components is determined by the principles of safe operation and proper periodic maintenance.

The opening chapter of this new edition of The Construction and Maintenance Manual for Quayside Container Cranes aims at providing fundamental knowledge about the construction, functions, performance and features of the crane for both operators and maintenance personnel in order that they can conduct operation and maintenance in proper and safe way.

This chapter will use figures, photographs and text to describe the Quayside Container Crane, including its general features, construction, components, layout, technical parameters, functions, and the characteristics of its mechanisms. The four main mechanisms (Main Hoist, Trolley Drive, Boom Hoist and Gantry Travel) will be the main focus and are described in detail. However, auxiliary components will be included as well.

1.1 Outline and main parameters for quayside container cranes

Since the construction of all the quayside container cranes is similar, all detailed information relating to the common mechanisms in this chapter will be based on a quayside container crane that was designed and manufactured by ZPMC for Tangier Terminal in Morocco and developed with assistance from APMT. This crane features double-box boom and girder, a rope-propelled trolley and a continuous catenary roller support system. It must be emphasized that all the parameters given in this chapter are unusual and relate to this project. The main parameters are shown in (Table 1-1).

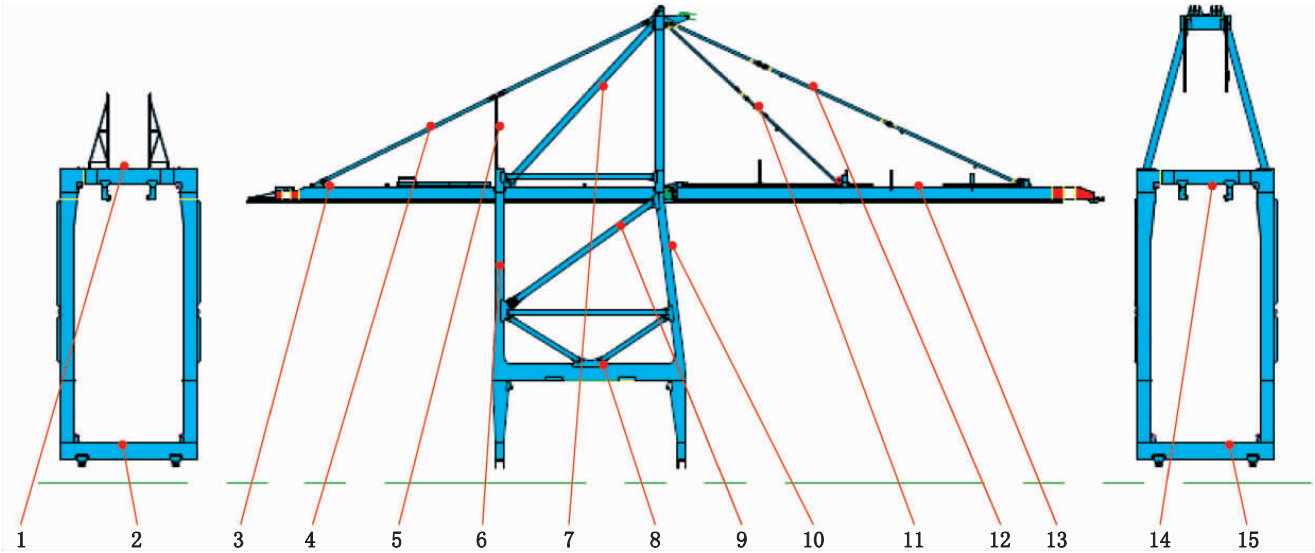
(Table 1-1) Main Parameters for Quayside Container Cranes

<table>
<tr><td rowspan="19">asic Parameters</td><td rowspan="2">rated load capacity (t)</td><td>under spreader</td><td>65</td><td rowspan="4">peed</td><td rowspan="2">hoist speeds (m/min)</td><td>full load</td><td>90</td></tr>
<tr><td>under hook</td><td>100</td><td>no load</td><td>180</td></tr>
<tr><td rowspan="2">lift height (m)</td><td>above rail</td><td>41+5.8</td><td colspan="2">trolley travel speed (m/min)</td><td>240</td></tr>
<tr><td>total lift height</td><td>58+5.8</td><td colspan="2">gantry speed (m/min)</td><td>45</td></tr>
<tr><td>outreach(m)</td><td colspan="2">63.5</td><td rowspan="5">ccelerating Speeds</td><td rowspan="2">main hoist acceleration time (sec)</td><td rowspan="2">full load</td><td rowspan="2">1.875</td></tr>
<tr><td>backreach(m)</td><td colspan="2">25</td></tr>
<tr><td rowspan="2">maximum operating wheel load(t)</td><td>seaside</td><td>97</td><td>no load</td><td>3.75</td></tr>
<tr><td>landside</td><td>75.2</td><td colspan="2">trolley travel acceleration time(sec)</td><td>5</td></tr>
<tr><td rowspan="2">maximum stowed wheel load(t)</td><td>seaside</td><td>86.5</td><td colspan="2">gantry travel acceleration time(sec)</td><td>5</td></tr>
<tr><td>landside</td><td>101</td><td rowspan="2">boom hoist time one way (min) ≤</td><td colspan="2">0°—80°(stowed position)</td><td>5</td></tr>
<tr><td colspan="3">inside clearance between legs (m)</td><td>18.276</td><td colspan="2">0°—45°(ship clearance position)</td><td>3</td></tr>
<tr><td colspan="3">height under link beam (m)</td><td>17</td><td rowspan="4">Motor Power</td><td rowspan="3">hoist motors</td><td>quantity(pcs)</td><td>2</td></tr>
<tr><td colspan="3" rowspan="2">overall crane width from bumper to bumper (m)</td><td rowspan="2">28</td><td>power (kW)</td><td>722</td></tr>
<tr><td colspan="3">crane weight(t)</td><td>1550.2</td><td>rotating speed (rpm)</td><td>900/1800</td></tr>
<tr><td colspan="3">setback of WS trolley girder support beam (m)</td><td>3.7</td><td>trolley motors</td><td>quantity(pcs)</td><td>1</td></tr>
<tr><td colspan="3"></td><td></td><td></td><td>power (kW)</td><td>350</td></tr>
</table>

Special Functions	anti-snag	provided	Motor Power		rotating speed (rpm)	1750
	type of anti-sway	electrical		gantry motors	quantity(pcs)	16
					power (kW)	25
					rotating speed (rpm)	1750
preader arameters	trim	±3°		boom hoist motor	quantity(pcs)	1
	list	±3			power (kW)	350
	skew	±3°			quantity(pcs)	1750
	single-20ft/40ft/45ft & twin-20ft telescopic spreader		antry Main Data	rail gauge (m)		30.48
rolley Main Data	rail gauge (m)	6.4		wheel base (m)		15.7
	wheel base (m)	4.4		wheel diameter (mm)		800
	wheel diameter (mm)	Φ500mm		wheels per leg (pcs)		8
	wheel number	8				
	weight (t)	40		drive wheels(pcs)		4
stowage pin between crane and wharf		manual	double boom hinges used between boom and trolley girder			
stowage pin between boom and A-frame		manual	power supply on wharf		2200kVA, 4160V, 60Hz	

1.2 Crane steel structure

Cranes have a large volume profile and they are exposed to severe impacts, frequent start-ups and braking; yet they must ensure that the container is positioned accurately and handled efficiently at high speed during operation. All these requirements are met by their well-designed steel structure and their advanced control system. Most of the structural member sections are trunk or box, although some are tubular (Fig. 1-1).

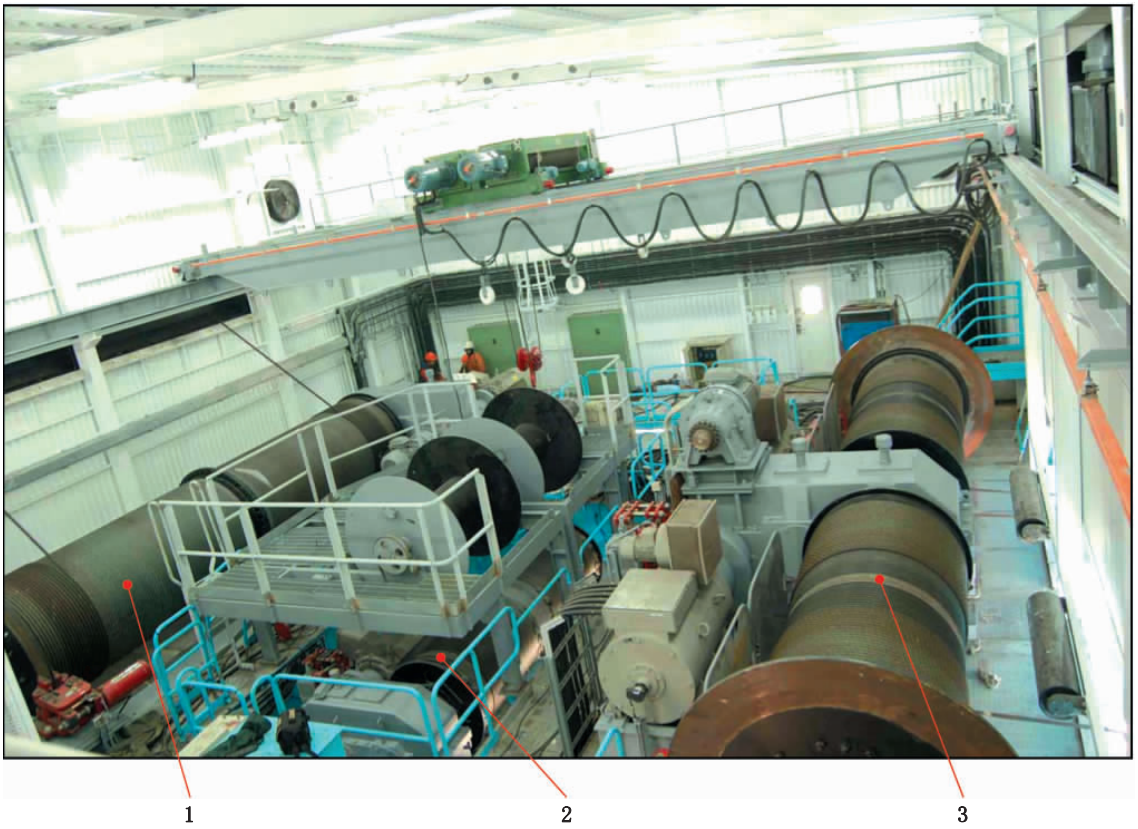


(Fig. 1-1) Crane Steel Structure Overview

1 Land-side TGSB 2 Land-side Sill Beam 3 Trolley Girder 4 Trolley Girder Backstay 5 Support of Trolley Girder Backstays 6 Land-side Legs 7 Backstays of Apex Beam 8 Frame Link Beam 9 Frame Link Beam 10 Sea-side Legs 11 Inner Boom Forestay 12 Outer Boom Forestay 13 Boom 14 Sea-side TGSB 15 Sea-side Sill Beam

1.3 Crane drive mechanisms

Three of the four major drive mechanisms (main hoist drive, boom hoist drive, and trolley travel drive) are located on the crane. The gantry travel drive is sheltered in a weatherproof machinery house (Fig. 1-7). In some cases, the trolley travel drive will be incorporated with the outdoor travelling trolley if it is a self-propelled type.



(Fig. 1-2) Major drive mechanisms in the machinery room

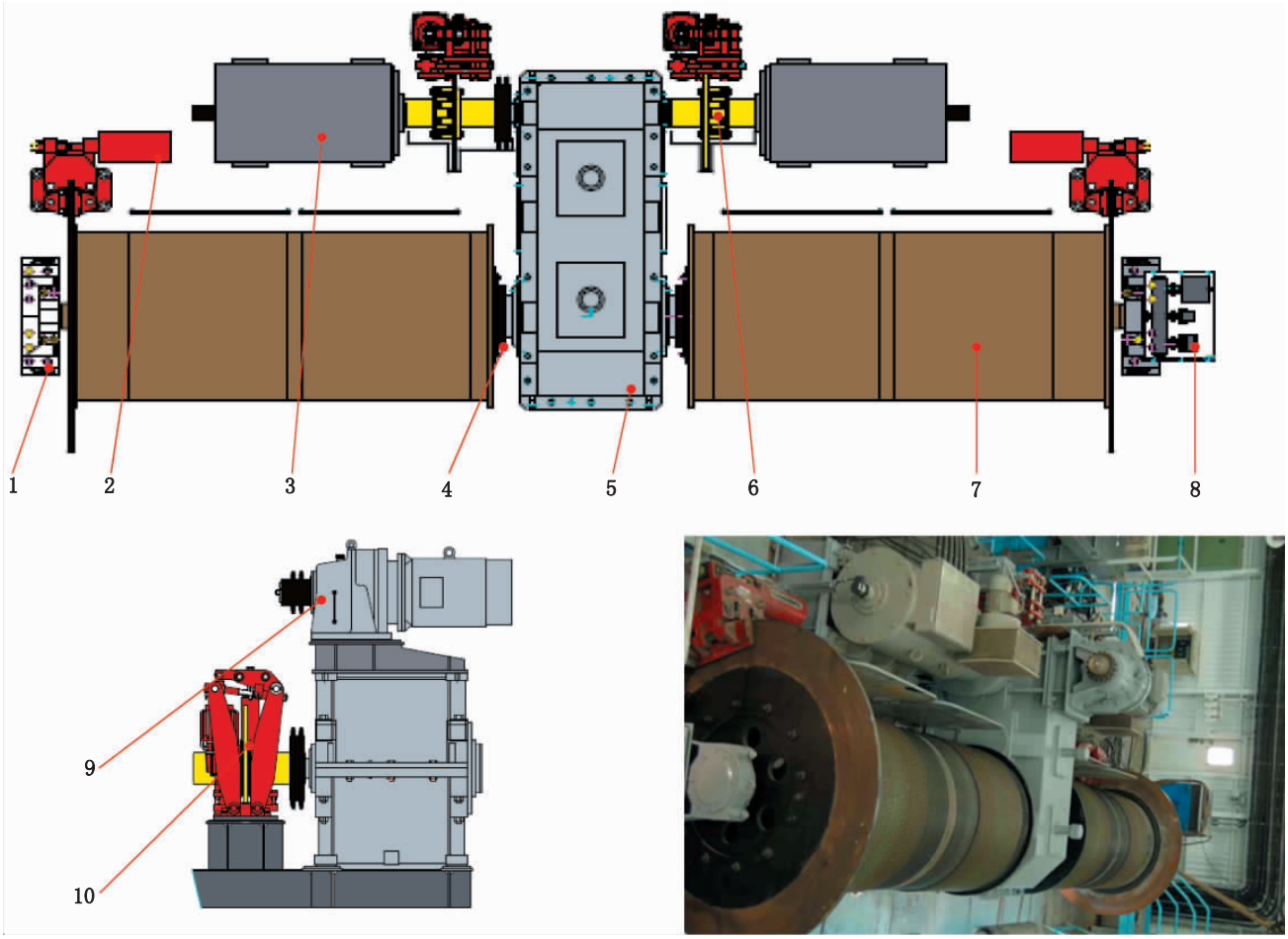
1. Boom hoist drive 2. Trolley travel drive 3. Main hoist drive

1.3.1 Main hoist drive

The main hoist drive, located in the machinery house, is powered by two variable-frequency AC motors connected to the reducer input shafts through flexible elastomeric couplings (high-speed). Two rope drums are connected to the output shafts of the reducer through two flexible gear couplings (lower speed). The drive force of this equipment is transmitted from the motors to the drums by high-speed couplings and drum couplings and is amplified by the reducer which drives the drum and rope to lift or lower the cargo attached under the telescopic spreader or hook beam. The data in (Table 1-2) main components refers to (Fig. 1-2).

(Table 1-2) Major Components of the Main Hoist Drive

Motor	type	ODRKF 400L	Drum brake	type	SBB365
	power	2×720kW		brake torque	2×229.2kNm
	rotating speed	900/1800rpm	Motor coupling	type	MLPK14 900×30
Reducer	type	FH1655.21.C2A		rated torque	16kNm
	ratio	21.389		brake torque	40.05kNm
	rated output torque	2×275kNm	Drum coupling	type	DC09B
Motor brake	type	YP41—4500—900×30		rated torque	450kNm
	braking torque	20×2kNm	Wire rope	diameter	Φ31.5mm



(Fig. 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 Emergency Device 10 Motor Brake

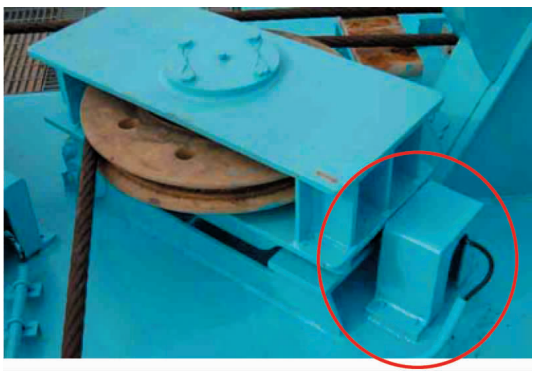
An emergency drive installed above the main reducer is capable of hoisting or lowering the spreader slowly in case the hoist motor or drive control system fails and cannot be repaired immediately. If the crane loses high voltage power while hoisting or lowering, this emergency device can be plugged into the shore power to continue the operation until the container is removed from the spreader to be ready for next step.

Warning: In case of sprocket wheel and chain used for emergency device, the two half sprocket wheels must be dismantled from main drive system in normal operation.

1.3.1.1 Main hoist reeving system (continuous catenary roller support system)

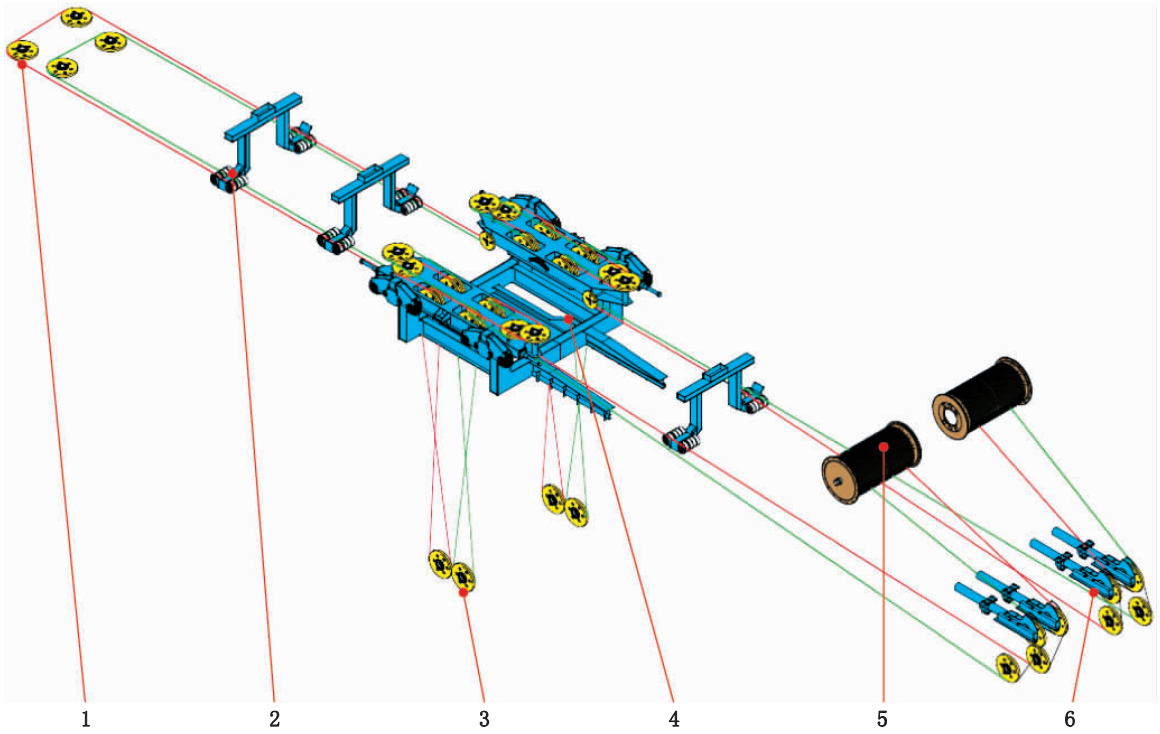
The wire ropes are reeled out from the drum, then are run through the following route:

drum→trim/list/skew/snag system on the girder rear end→sheaves on the trolley frame→sheaves on the head-block→return to the sheaves on the trolley frame →load cell at the boom tip.



(Fig. 1-4) Load cell location

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

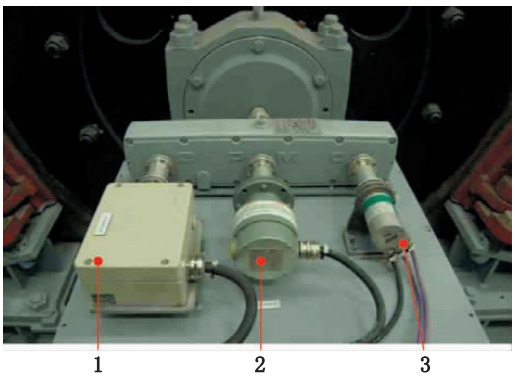


(Fig. 1-5) Main hoist rope reeving system (continuous catenary roller support system)

1. Load scaled sheave blocks on boom tip 2. Fixed support rollers 3. Sheave block on headblock
4. Traveling trolley 5. Drum of main hoist drive 6. Trim/list/skew & anti-snag on girder rear end

1.3.1.2 Interlocks for main hoist drive

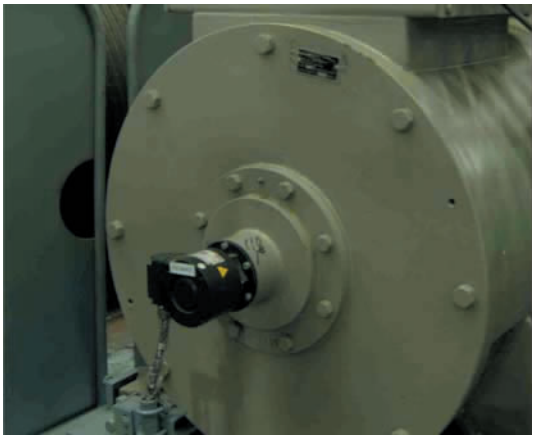
1) Over-speed switch



(Fig. 1-6) Limit switches at the drum end of the main hoist drive

1. Cam switch 2. Over-speed switch 3. Absolute encoder

External over-speed protection for the main hoist is provided at the end of one drum. Activation of the switch initiates an emergency stop. The theoretical trip speed setting for the switch is 110% of the motor maximum speed. Once the crane has been stopped, in order to resume crane operation, the switch must be manually reset (Fig. 1-6). An optional device, which can be connected to the motor shaft end, is an incremental encoder that can transmit a real-time speed signal enabling the PLC to evaluate the over-speed (Fig. 1-7).



(Fig. 1-7) Incremental encoder

2) Motor brake limit switch

Each of the two hoist motor brakes is monitored by a brake release limit switch (normally open) and a brake manual-release limit switch (normally closed). If there is no hoist signal from the joystick, the hoist motion is prevented from operating as long as either switch is activated.

3) Drum brake limit switch

Each of the two hoist drum brakes is monitored by a brake release limit switch (normally open). Without a hoist signal from the joystick, the hoist motion is prevented from operating as long as either switch is activated.

4) Motor thermal switch

Each of the two hoist motors features an embedded over-temperature switch (normally closed). Activation of the switch indicates the motor temperature is at a fault level. The hoist motion is prevented from operating as long as either of the switches is activated.

5) Load weighing system

Information for the weight of the lifted load is provided by the weighing system. The hoist drives also provide overload indication. (Refer to Section 1. 3. 1. 1 for a more detailed description.)

6) Anti-snag system

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

7) Boom interlocks

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

8) Spreader operation modes

The hoist and headblock/spreader systems operate in three different modes: container, cargo and reeving.

9) Spreader mode interlocks (slack rope protection)

If all the proximity switches around the twist locks are activated (cargo has already been landed), further lowering of the spreader will be inhibited. These switches help to prevent the hoist ropes from slackening. Hoisting is permitted only when all these switches are released or activated.

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

In the case of improper tension, incorrect position or the selection of the "manual" mode at the trolley main 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 operating from the local control station on the trolley. ***Hoist movement (raising and lowering) will be disabled if the "manual" mode is selected in both container mode and cargo mode.***

1.3.1.3 Positioning limits for main hoist drives

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 hoist height is calculated from wharf ground level.

(Fig. 1-8) Trip block under the trolley frame for the weight-operated lever switch

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

1) Hoist over-travel stop

The weight operated lever switch works together with the cam switch to control the hoist over-travel stop. Activation of either of these two limit switches will initiate an emergency stop to the main hoist motors, and will reset the absolute encoder (zero). The "limit back-out bypass" selector switch in the electrical house permits only lowering.

2) Hoist stop verification (cam limit switch)

The upper limit is controlled by the incremental encoder together with the cam switch. An emergency stop will be initiated as long as the hoist speed signal transmitted by the incremental encoder is not zero.

3) Normal hoist travel stop

A ramp stop of the hoist motors, controlled by the incremental encoder together with the cam switch, will be initiated by either switch activation. The absolute encoder can be reset manually from the CMS.

4) Hoist slowdown verification

An emergency stop controlled by the incremental encoder together with the cam switch will be initiated if the upper slowdown contact of the cam switch is activated. Meanwhile the hoist speed reflected by the incremental encoder will not slow down to the preset range.

5) Smart hoist slowdown

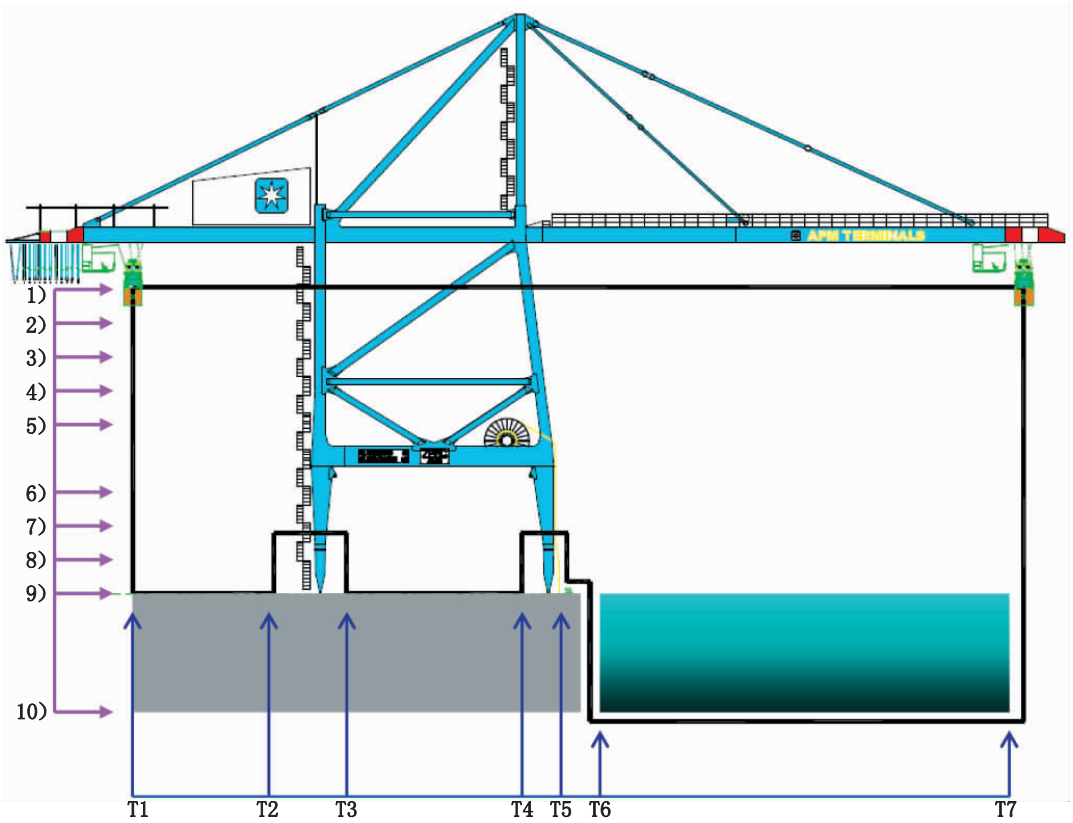
At the control of the cam switch and PLC program, the slowdown distance can be set based on the actual hoist speed so that the speed can be reduced to a set value at designated positions.

6) Smart lowering slowdown

Similar to the "smart hoist slowdown", the slowdown distance will be set and measured from the wharf level if the trolley is on the land-side.

7) Lowering sill beam stop

This protection is controlled by the absolute encoder and cam switch. To ensure the spreader travels safely across the sill beam upper surface, a designated stopping height will limit the spreader movement only when the trolley is over the waterside or landside sill beam (Fig. 1-9). When trolley travel is between T2—T3 or T4—T5, the hoist will be prevented from lowering above Level 7 (the actual height depends on whether a container is attached or not.



(Fig. 1-9) Hoist travel limit functions

8) Lowering slowdown verification (over the dock)

This is similar to the "hoist slowdown verification" (4).

9) Lowering normal end stop

This is similar to the "normal hoist travel stop".

10) Lowering over-travel verification

The absolute encoder and cam switch simultaneously control and protect the operation of lowering in the cell.

1.3.1.4 Trim/list/skew/snag protection devices

These functions are accomplished by the multi-functional hydraulic system at the girder end tie, which is composed of four hydraulic cylinders and a valve 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.

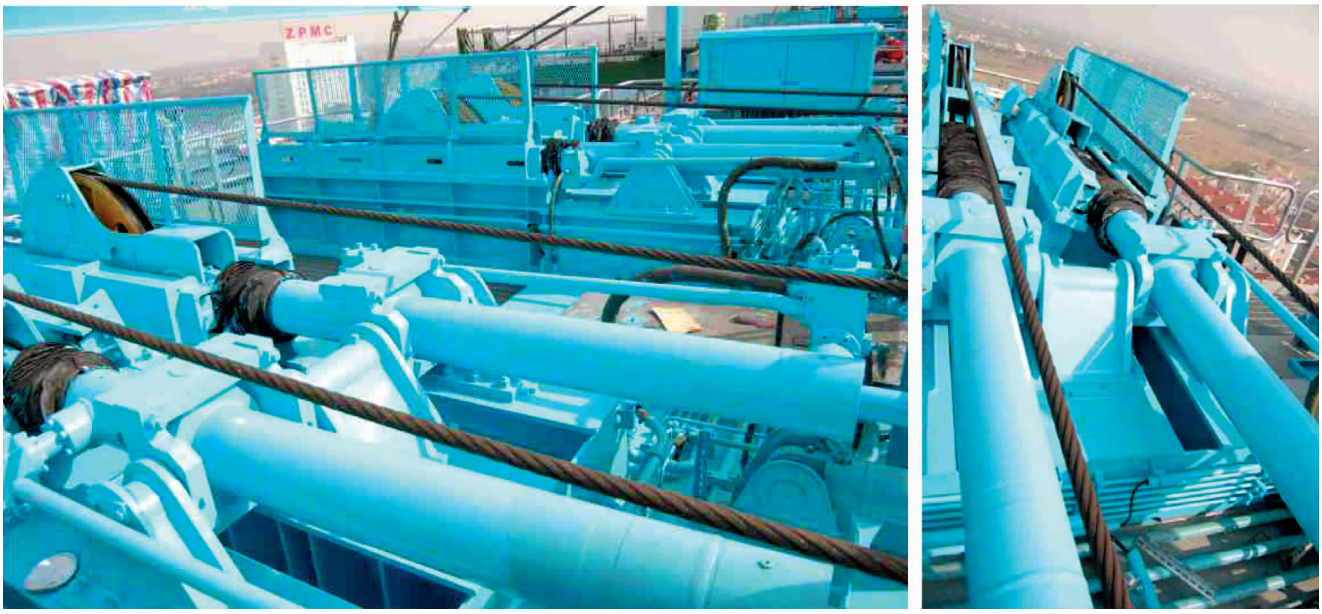
As a snag occurs, the kinetic energy of the hoist mechanism that is rotating at high speed is transformed into heat energy which is released by the hydraulic system, thereby preventing a disaster such as a wire rope breaking, a crane structure deforming, or even a crane overturning or collapsing.

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 1600mm stroke of the cylinders. The initial home position, the minimum extension under working conditions, is at least 800mm for each of the cylinders. That is, the stroke 0～800mm is for the snag protection, and 800～1600mm is for the spreader trim/list/skew motions and/or for compensating for the length variations in the hoist wire ropes.

1) Trim, list and skew motions

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

Tipping or rotating 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 (Fig. 1-11).



(Fig. 1-10) Spreader trim/list/skew and snag-protection devices on the girder tie-end