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SECTION 5 STEERING SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. LAYOUT



- 1 Hole (connection to Forklift chassis)
- 2 Helical gear (3 stage)
- 3 Motor controller unit
- 4 AC Steering motor

- 5 Steering controller
 - Steering controller connection
- 7 Connection for angles-ofrotation sensor
- 8 Angle sensor
- 9 Axle carrier
- 10 Output flange

The steering operation by rotating the electric motor using the signal values from the steering sensor installed under the steering handle. EPS(Electronic Power Steering) system uses the electric motor for steering to achieve advanced functions such as operating force, lock to lock rev adjustment, and the correct system. Unlike traditional HPS(Hydraulic Power Steering) system, The electric motor only operates when the steering wheel is turned. And eliminating unnecessary energy consumption and noise. Without any hydraulic equipment, oil maintenance is unnecessary and environmentally friendly.

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2. STEERING UNIT STRUCTURE

1) Control Engine Unit



1 Control Unit

2 Sensor Kit

3 Control Engine Unit

2) Housing



- 1 Housing
- 2 Housing cover
- 3 Cap screw
- 4 Cylinder pin
- 5 Cover

- 6 Cap screw
- 7 O-Ring
- 8 Cup spring
- 9 Breather
- 10 Type plate

- 11 Sensor
- 12 Cap screw
- 13 Cap screw
- 14 V-ring

3) Input



- 1 Spur gear
- 2 Pinion shaft
- 3 Ball bearing
- 4 Spur gear
- 5 Pinion shaft

- 6 Ball bearing
- 7 Spur gear
- 8 Cup spring
- 9 Cup spring
- 10 Ball bearing
- 11 Ball bearing
- *-1 Input (Z=72)
- *-2 Input (Z=92)

4) Output



- 1 Output kit
- 2 Tapered roller bearing
- 3 Tapered roller bearing
- 4 Slotted nut
- 5 Locking nut
- 6 Output flange
- 7 Wheel stud
- 8 Tapered roller bearing

- 9 Nilos ring
- 10 Tapered roller bearing
- 11 Nilos ring
- 12 Shim
- 13 End shim
- 14 Hexagone srew
- 15 Protection cap
- 16 Retaining ring

17 Shaft seal

- 18 Fitty key
- 19 Shim ring
- 25 Magnet
- 26 Cap screw
- 27 Axial shaft seal
- 29 Hub

5) **OPERATION**

The steering system for this forklift truck is EPS. It stands for Electronic Power Steering. The EPS with integrated helical gear transmission is used in front-wheel-driven 3-wheel counter-balance lift trucks up to 2 tons lifting capacity for the steering of the rear axle. The EPS is connected with the vehicle chassis via fixing holes which are cast on the helical gear transmission. The torque for the steering is generated by an AC motor, which is firmly installed to the helical gear transmission. The AC motor is an integral part of the motor controller unit. The input pinion is directly mounted on the motor shaft of the AC motor (in overhung position) and is therefore the 1 st stage of the helical gear transmission. It is no longer necessary to mount the input pinion separately on the motor shaft.

The three-stage helical gear transmission of the EPS has got a high overall ratio. Fluid grease is used for lubrication of the gears of the helical gear transmission. Tapered roller bearings are used as axle carrier and wheel bearings. Ball bearings and tapered roller bearings of the transmission and the wheel bearing are designed for lifetime lubrication with roller and sliding bearing grease. This multi-purpose grease is a high-quality lithium-calcium-saponified grease with optimum lubrication properties for roller bearings.

The EPS is a joint project with the market leader for electronic controllers, ZAPI who delivers the electric controller unit consisting of AC motor, steering controller and steering software for it. The speed sensor for feedback of the speed to the steering controller is located directly under the cover of the AC motor. The angles-of-rotation sensor measures the actual value of the set steering angle or the angle position of the steering axle. It operates touchless in connection with a magnet located in the rotation axis of the axle carrier.

This steer-by-wire steering system, with the steering wheel motion being electrically transmitted to the steered axle, has the following advantages over the current hydrostatic steering system:

- Mechanical components are replaced by electrical ones. Advantages regarding space, significantly reduced installation effort during assembly.
- Low energy consumption compared with the hydrostatic steering system.
- It is no longer necessary that the hydraulic circuit for the steering is always active.
- Low-noise helical gear transmission by optimized gearing technology and excellent damping characteristics due to fluid grease lubrication.
- Wear-free helical gear transmission with high gear ratio.
- Variable adaptation of the steering ratio.
- Optimized sensor system.
- Plug & Play total system with mechanics, electrics, electronics and software functions from one source.

6) TIGHTENING TORQUE AND SPECIFICATION







TIGHTENING TORQUE : 35.6 ± 5.3kg.m





GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

Check item	Checking procedure	
Steering wheel 30-60mm (1.2-2.4 in)	 Set rear wheels facing straight forward, then turn steering wheel to left and right. Measure range of steering wheel movement before rear wheel starts to move. Range should be 30~60mm at rim of steering wheel. If play is too large, adjust at gear box. Test steering wheel play with forklift stopped. 	
Knuckle	Check knuckle visually or use crack detection method. If the knuckle is bent, the tire wear is uneven, so check tire wear.	
Steering axle	 Ask assistant to drive machine at minimum turning radius. Fit bar and a piece of chalk at outside edge of counterweight to mark line of turning radius. Min turning radius(Outside) : Refer to page 1-5 (Specifications) 	

2. TROUBLESHOOTING

1) STEERING SYSTEM

Problem	Cause	Remedy
Steering wheel drags.	Bearing faulty.	· Clean or replace.
	 Spring spool faulty. 	· Clean or replace.
	Reaction plunger faulty.	· Replace.
	Ball-and-screw assembly faulty.	· Clean or replace.
	· Sector shaft adjusting screw excessi-	· Adjust.
	vely tight.	
	 Gears poorly meshing. 	· Check and correct meshing.
	· Flow divider coil spring fatigued.	· Replace.
Steering wheel fails to return	Bearing faulty.	· Clean or replace.
smoothly.	Reaction plunger faulty.	· Replace.
	Ball-and-screw assy faulty	· Clean or replace.
	· Gears poorly meshing.	\cdot Check and correct meshing.

Problem	Cause	Remedy
Steering wheel turns unstea-	Lockout loosening.	· Retighten.
dily.	 Metal spring deteriorated. 	· Replace.
Steering system makes abn-	\cdot Gear backlash out of adjustment.	· Adjust.
ormal sound or vibration.	 Lockout loosening. 	· Retighten.
	Air in oil circuit.	· Bleed air.
Abnormal sound heard when	Valve	
steering wheel is turned fully	\cdot Faulty. (Valve fails to open.)	· Repair or replace.
Steering cylinder head	Packing foreign material.	· Replace
leakage (Piston rod)	 Piston rod damage. 	\cdot Grind surface with oil stone.
	 Rod seal damage and distortion. 	· Replace
	Chrome gilding damage.	· Grind
Steering cylinder head thread	· O-ring damage.	· Replace
(A little bit leak is no problem)		
Welding leakage	· Cylinder tube damage.	· Tube replace.
Rod	\cdot Tube inside damage.	· Grind surface with oil store.
	\cdot Piston seal damage and distortion	· Replace
Piston rod bushing inner	· Bushing wear.	· Replace
diameter excessive gap		

GROUP 3 DISASSEMBLY AND ASSEMBLY

1. STEERING UNIT

1)TOOLS

(1) Assembly truck assy



(3) Eye bolt

(4) Bushing

(5) Holding device











(6) Slotted nut wrench



(7) Pressure piece

(8) Forcing device

(9) Assembly lever set

(10) Extrator

(11) Counter support









(12) Inner extrator

(13) Basic tool

(14) Grab sleeve

(15) Inner extrator

(16) Removing tool

(17) Screwing device













(18) Driver tool

(19) Handle

(20) Holding device

(21) Driver tool

(22) Locating pin

(23) Press-in manderl

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2) DISASSEMBLY

- (1) Clamping of transmission
- ① Attach assembly fixture to the assembly truck.



② Install lifting device, consisting of eyebolt with bushing on the transmission as shown.



③ Transport transmission and position it in the assembly fixture.

Fix the transmission to the assembly fixture.

Removing lifting device.



- (2) Housing
 - # Electric control unit motor
- ① Separate plug connection from sensor on the wiring harness.
- 2 Loosen and remove cylindrical screw.

③ Remove electric control unit upwards.

④ Pay attention that the releasing V-ring does not drop.

⑤ Remove cup springs from the hole of the motor connection.

Angles of rotation sensor

 Loosen cylindrical screws on the Anglesof-rotation sensor. 2 Loosen cylindrical screws on the cover.



- ③ Remove cover. If required, remove O-ring.
- 4 Loosen cylindrical screw from solenoid.

5 Remove solenoid.

- (3) Input an output# Axle carrier bearing
- ① Unlock slotted nut on the locking plate on the axle carrier bearing.
- ② Position holding device onto the output flange and bolt it to the wheel stud by two wheel nuts.

Loosen and remove slotted nut.









③ Remove locking plate.

④ Loosen and remove cylindrical screws from housing.

- Locate suitable assembly mandrel on the casting noses of cylindrical pin.
 Loosen the housing cover by slightly hitting the two noses alternately.
- Place pressure piece on axle carrier.
 Locate forcing device and tighten it with screws.

Turn in screw and press off the housing cover.

O Remove bearing inner ring.

8 Remove bearing outer ring from the housing cover.













- # Helical gear transmission
- ① Turn around housing cover. Remove cup springs.
- 2 Remove cup springs.

3 Remove grease from helical gear transmission.

④ Pull ball bearing from the pinion shaft using a two-armed puller.

⑤ Unlock slotted nut on the locking plate on the axle carrier bearing.

6 Remove pinion shaft.













O Remove pinion shaft by hand.



8 Pull ball bearing off the pinion shaft.

9 Pull ball bearing off the pinion shaft.

- ① Use a suitable assembly mandrel to force pinion shaft out of the spur gear.
- Use a suitable assembly mandrel to force pinion shaft out of the spur gear.

- # Axle carrier
- ① Turn transmission on the assembly truck (horizontal position).









② Fit slotted nut.

Drive axle carrier out of the spur gear and remove it.

③ Force shaft seal out of the housing and remove it.

④ Rotate housing on the assembly truck by 90°. Remove bearing outer ring.

- ⑤ Rotate housing on the assembly truck by 180°. Pull ball bearing out of the hole of housing.
- 6 Place pressure piece upon axle carrier.

 \bigcirc Pull bearing inner ring from axle carrier.













8 If required, remove fitting key.

Breather

- For removal on detached housing cover, drive the breather out of the hole on the inner side of the housing cover using a pin punch and remove it.
- ② For removal on mounted unit, locate pincer head of the end-cutting pliers beneath the breather cap.

3 Pull the breather out of the housing cover.

- # Wheel hub bearing
- ① Rotate transmission on the assembly truck (horizontal position).

Use screw driver to lever out protective cap and remove it from the output flange.

② Loosen hexagon screw.













③ Remove hexagon screw, end shim and the releasing adjusting washer.

4 Remove output flange.

(5) Take Nilos ring and bearing inner ring out of the output flange.

⑥ Pull bearing outer ring (internal side of output flange).

 \bigodot Pull bearing outer ring (outside of output flange).

⑧ Pull bearing inner ring together with the Nilos ring off the axle.













9 Take out shim (see arrow) by hand.

Change wheel stud

Clamp output flange.

Heat up the wheel stud to be changed.

② Use removing tool to loosen wheel bolt and remove it.

③ Turn new wheel stud with the long thread side into the screwing device.

Afterwards turn in the short thread side of the wheel stud on the output flange.

④ Tighten wheel stud using a screwing device.











2) REASSEMBLY

- (1) Input and output# Wheel hub bearing
- ① Insert bearing outer ring (output flange outer face) until contact.
- ② Insert bearing outer ring (output flange internal side) until contact.

③ Place shim.

④ Mount Nilos ring.

- (5) Fill grease into bearing inner rings (each output side). Fill grease in the space between inner ring and bearing cage, until visible overflow. Do not rotate the cage for a complete filling, but slightly displace the bearing with the cage.
- ⑥ Install bearing inner ring which is filled with grease and bring it to contact position.



⑦ Slightly grease the track of the bearing outer ring.

Place output flange (with bearing outer ring) onto the bearing inner ring.

- 8 Fill bearing inner ring with grease. Proceed according to sequence of operation described in 5. Slightly grease the track of the bearing outer ring. Insert bearing inner ring into the bearing outer ring.
- (9) Insert Nilos ring.

Install adjusting washer, end shim and hexagon screw.

Tighten hexagon screw.
 Tightening torque = 245 Nm.

Check rolling torque of wheel hub bearing 1.0 ... 3.0 Nm. In case of deviations from the required rolling torque, correct with an appropriate adjusting washer. 1. Insufficient rolling torque – use thicker adjusting washer. 2. Excessive rolling torque – use thinner adjusting washer.















13 Press in protective cap until contact.

Axle carrier

key.





② Install heated bearing inner ring (85 ... 120°C) on the axle carrier until contact.

1 If removed or in case of a new part, mount fitting

③ Insert bearing outer ring into the housing.

④ Press the shaft seal into the housing with the sealing lip facing the grease chamber.

⑤ Richly grease the bearing rollers, inside and outside as well as front sides.









6 Install the ball bearing in the housing.

- ⑦ Rotate the housing by 180°.
 Insert complete axle carrier from above until contact position.
 Use a lashing strap to clamp the axle carrier tightly to the assembly fixture to secure it against falling out.
- 8 Rotate the housing back by 180°.
 Apply some fluid grease around the tapered roller bearing area.
- 9 Heat spur gear.

10 Install heated spur gear until contact.

1) Snap in retaining ring.













- # Helical gear transmission
- ① Press in pinion shaft until contact on the spur gear.



....

② Press in pinion shaft until contact on the spur gear.

③ Press ball bearing on the bearing inner ring onto the pinion shaft until contact position.

④ Press ball bearing on the bearing inner ring onto the pinion shaft until contact position.

5 Fill transmission chamber with fluid grease.

⑥ Insert preassembled pinion shaft with ball bearing.









⑦ Press in the preassembled pinion shaft until contact.

(8) Install heated ball bearing (85~120°C) on the pinion shaft until contact.

 ${\ensuremath{\textcircled{}}}$ Reset cylindrical pins in the housing cover.

① The opposite figure shows the installation position of cup springs, 4 pcs).

 Use fluid grease to fix cup springs into the hole of the housing cover.

① The opposite figure shows the installation position of cup springs, 6 pcs)













(3) Use fluid grease to fix cup springs into the hole of the housing cover.

5-30

- # Axle carrier bearing
- Turn around the housing cover. Install bearing outer ring (see arrow) and bring it into contact position.
- ② Fill transmission chamber with fluid grease. Install two locating pins.

③ Clean sealing surfaces on the housing and housing cover.

Evenly wet sealing surface of the housing cover with Loctite 574. Install housing cover and bring it to contact position. Flush-drive cylindrical pins.

- ④ Remove locating pins.
 Fix housing cover with cylindrical screws.
 Tightening torque (M8/10.9) = 34 Nm.
- (5) Fill bearing inner ring with grease, Proceed according to operation sequence.
 Install heated bearing inner ring (85~120°C) on bearing outer ring until contact.













6 Insert locking plate.

Hand-tighten slotted nut.
 Remove lashing strap.

- 8 Position the holding device on the gear shaft and fix it on the wheel bolt using two wheel nuts. Tighten slotted nut until the required rolling torque is obtained. Then force out bearing by means of slight hits and roll it in.
- ④ Check rolling torque of axle carrier bearing 10~15 Nm.

10 Secure slotted nut with locking plate.

- (2) Housing
 - # Angles of rotation sensor
- 1 Insert solenoid into the groove of the axle carrier.













② Fix solenoid by means of cylindrical screw.
 Tightening torque = 3 Nm.

③ Grease O-ring and insert it into the annular groove of the cover.

- Insert cover and bring it to contact position.
 Fix cover with cylindrical screws.
 Tightening torque = 5.5 Nm.
- ⑤ Place sensor observing the correct side.
 Fix sensor by means of cylindrical screws.
 Tightening torque = 4 Nm
 - # Electric control unit motor
- ① The opposite figure shows the installation position of cup springs.
- ② Insert cup springs into the hole of the motor connection













3 Install V ring on the motor.

- ④ Carefully mount control unit in the motor connection rotating it slightly.
 Simultaneously lower it until contact, when tooth engagement is noticeable.
- ③ Fix control unit using cylindrical screws. Tightening torque = 9.5 Nm.

4 Connect wiring harness to the sensor.

Breather

 If removed, or in case of a new part, use press-in mandrel to insert breather into the hole of the housing cover.









