宝鸡市盟泰石油机械有限公司
BAOJI MENGTAI PETROLEUM MACHINERY CO.,LTD

F-1600HL Drilling Pump
Operation & Maintenance Manual

(US System 2016)

Model: F-1600HL Mud Pump

BAOJI MENGTAI PETROLEUM MACHINERY CO.,LTD

Safety Rules

—— Requirements of Health, Safety and Environment (HSE)

Normally, the drilling pump is installed in the environment of the oil drilling rig and such environment has certain danger for operation of the drilling pump. Correct operation and maintenance are very important for the reliable operation of the drilling pump.

1 Basic Safety Requirements

Although the representative of the drilling pump manufacturer may be available at site, it will not represent that the operator of the drilling pump can be exempted from the responsibilities of installation, operation and maintenance according to requirements of this operation manual.

Warning: Before performing the operations of the drilling pump such as the installation, operation, maintenance, repair and so on, please carefully read the following instructions to avoid the accident or the damage to the equipment.

- While the drilling pump is in operation, it is strictly forbidden to perform the maintenance and repair. While performing the installation, operation, maintenance or repair for the drilling pump, ensure the drilling pump is at stationary state.
- The operator must wear the personnel protective equipment in complete according to the specification.

2 Parts Replacement

While assembling or disassembling the drilling pump, the parts involved shall be properly marked and numbered so that they will not be incorrectly installed during the assembly. Please use the parts of good quality or manufactured by the original manufacturer (BOMCO), otherwise it may result in the accident such as the damage to equipment or the personal injury.

3 Maintenance

The periodical routine maintenance shall be performed for the drilling pump, otherwise it may result in the accident such as the damage to the equipment or the personal injury.

4 Hazard Identification and Risk Control

4.1 Environmental Pollution

a) Oil seeping and oil leakage may appear at the sealing parts of drill pump power end and rear cover, extension part of pump input shaft and pony rod sealing part etc. which may pollute the environment. It is required to ensure that Seals at all parts is reliable in using, and it is required to inspect and maintain at regular interval.

b) For chain drive pump unit, oil seeping and oil leakage may appear at the contact surfaces of chain box cover and chain box body which may pollute the environment. It is required to ensure that ventilation cap is without plugging and seals at contact surfaces are reliable in using, and it is required to inspect and maintain at regular interval.

c) When the valve assembly or piston of cylinder liner is replaced, the effluent could drop on the ground or flow into ocean. Therefore, the effluent collector shall be provided and regularly cleared.

4.2 Personal Injury

a) Relief line of relief valve could get loose or fly off when it is relieving, which may cause the mechanical accident and /or casualty accident. The following requirements for installationshall be followed:

- Relief lineshall keep a downward dip angle from the horizontal direction;
- Angle of line at the bending shall be not less than 135°;
- Fixing pipe clamp on the solid control tank must be secure and reliable;
- Safety ropes or chains shall be set at both ends of relief pipeline.

b) When the drilling pump is running, do not open the safety shield on the relief valve to avoid accidental personal injuries.

c) Before the cover of pulsation dampener is removed or the bladder of pulsation dampener is replaced, gas in the bladder of pulsation dampener must be exhausted to avoid casualty accident which is due to expansion of residual gases.

d) The pulsation dampener can only be charged with nitrogen or air. Flammable and explosive gases such as oxygen or hydrogen are not allowed to avoid explosive accident of pulsation dampener and personal injury accident.

e) For replacement of piston of cylinder liner, make sure the power machine and drilling pump are at the closed state to prevent the casualty accident.

f) During running of drilling pump, inspect the fluid end quickly to avoid or reduce personal injuries caused by leaked high pressure liquid.

g) Operators could touch the reciprocating parts and even fall into the draw bar box. It will result in casualty accident. Therefore, before using, inspect whether the shield on the upper part of draw bar box is under the correctly closed state to ensure the protection effective.

h) Fasteners on the rotational parts might get loose, drop and even fly off, which can cause casualty accident because operator could touch the rotational parts. Therefore, inspect whether the fasteners on the rotational parts are secure and reliable and whether safety shields on the rotational parts are under the effective protection on a regular basis.

4.3 Damage to Equipment

a) Confirm the lubricating oil quality of power end is good, otherwise will cause guide plate scratched, gear pitted, bearing damaged etc. make the drilling pump cannot work normally. Mainly check the following items:

- When the sealing ring of pony rod damaged, the slurry or water will enter the oil pool, causing lubricating oil quality changed, so the sealing ringshall be replaced timely.
- Regularly drain and clean the sediment from pollution discharge flanges that on the sides of the rack, to insure the lubricating oil keep clean.
- After long time running of pump, in case there is abrasive grain or corrosiveness compound in lubricating oil, it is required to replace with new lubricating oil;
- The type of lubricating oil shall be adjusted properly according to the operating manual or nameplate specification based on the change in environment temperature.

b) Make sure that oil levels of lubricating oil in equipment are within the specified range and cannot be lower than the lowest one particularly, or it will result in failure.

c) Make sure that the lubricating oil pump can be operated normally, or it will result in failures such as bearing failure.

d) Inspect the overflow holes at sealing locations of fluid ends on a regular basis. If the fluid is seeping, the operation of drilling pump shall be stopped and sealing ring shall be replaced timely.

e) Correctly install and use the valve seats with a qualified quality to avoid the taper hole damage of hydraulic cylinder by puncturing.

f) Correctly use the relief valve and make sure the safety pin is inserted into the correct position; do not use the iron wire or welding electrode to replace the safety pin.

g) When the drilling pump is running, do not open the angle stop valve on the top of pulsation dampener to avoid the damage of pressure gage. Charge pressure of pulsation

dampenershall be inspected under the closed state of pump (discharge pressure of pump shall be zero).

5 For the other safety matters to be noted, please follow the related content specified in different chapters of the context.

Foreword

Thanks for purchasing F-1600HL drilling pump manufactured by CNPC Baoji Oilfield Machinery Co., Ltd.

F-1600HL Drilling Pump Operation & Maintenance Manual includes one set of complete data provided to users. The manual provides the corresponding guides for the installation, use, maintenance and service of the product. This manual is prepared for F-1600HL drilling pump (US system), all connecting thread of this pump adopts US system thread in principle except for main bearing bolts.

This operation &maintenance manual is used by operating personnel and technicians who have certain knowledge and are familiar with drilling equipment (or other equipment), so that the manual is not expected to cover every situation you may encounter.

Parts of equipment operation and maintenance information are from manufacturer's manual. If the manufacturer publishes a updated operation and maintenance manual or the old and new manuals have contradiction, the manufacturer's data has precedence over the information given in this manual.

Our company reserves the right to revoke (or change) product model and design at any time without prior notice and bears no liability or obligation.

Please carefully read this operation & maintenance manual before installing and using the products.

For the imperfection of this manual, we sincerely welcome your valuable advice and suggestions!

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1 New Pump Operation

F-1600HL drilling pump is an important equipment of drilling rig. The application is that transmit drilling fluid to the well bottom by high pressure manifold of circulating system to cool the drill bits, clean the bottom of well, break stone, bring cuttings and balance pressure of stratum etc.

The design and manufacturing of F-1600HL drilling pump conforms to the requirements of API Spec 7K *Drilling and Well Servicing Equipment*.

1.1 Technical Specification and Performance Parameters

1.1.1 Technical Specification

F-1600HL Drilling Pump	
Type	Three cylinder single acting piston pump
Maximum bore diameter of liner (mm)	7 1/2"
Rated power kW (HP)	1193(1600)
Rated stroke (r/min)	120
Stroke length (mm)	304.8(12")
Gear ratio	4.206： 1
Valve chamber	API 7
Weight (kg)	30925(68177lbs)

1.1.2 Performance Parameters

The performance parameters of the F-1600HL pump are shown in Table 1. **It is strictly prohibited to use it with overload!** If the overload is more than 10%, the service life of its bearing will be reduced by 27% compared with the design life. If the overload is more than 20%, the service life of its bearing will be reduced by 46%. If the overload is 100%, the service life of its bearing will be reduced by 90%. It is recommended to use it under 80% load for long-term, and the service life of its bearing will be increased by 110%.

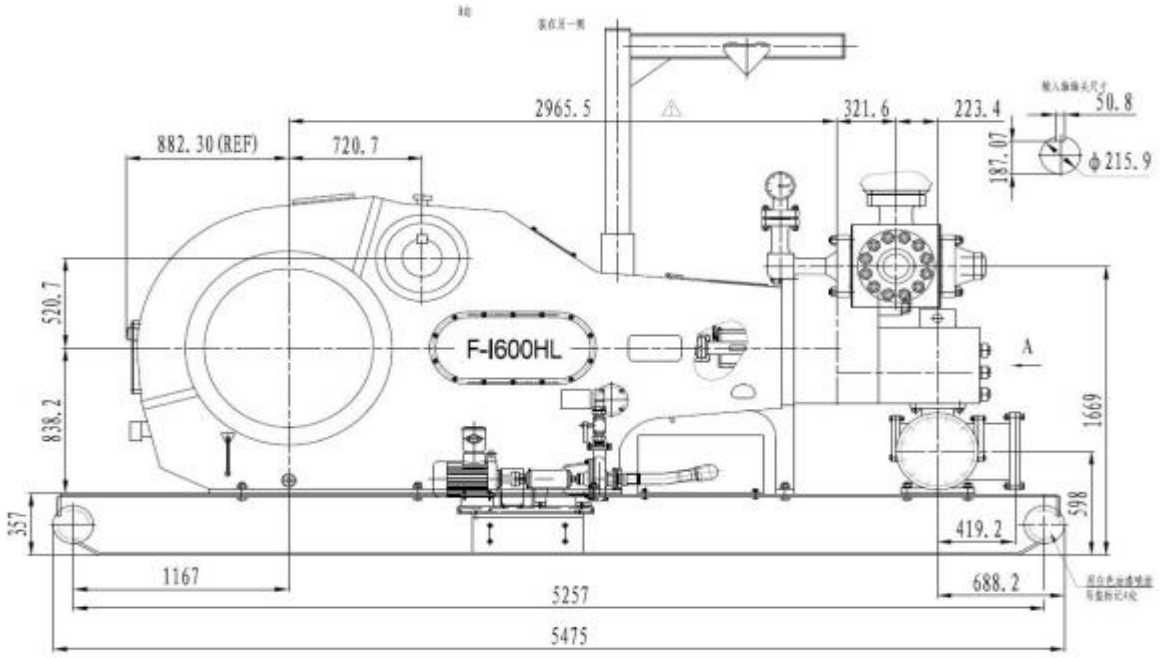
Table 1 F-1600HL Performance Parameters (Inch cylinder liner)

Stroke	Rated power		Dia. of cylinder liner (in) & Rated pressure (MPa / PSI)							
			7 1/2	7	6 3/4	6 1/2	6	5 1/2	5	4 3/4
			20.6	23.6	25.4	27.4	32.2	38.3	46.4	51.4
	kW	HP	2990	3430	3690	3980	4670	5555	6725	7450
			Displacement (L/s)							
120	1193	1600	52.12 826	45.41 720	42.22 669	39.15 621	33.36 529	28.03 444	23.16 367	20.91 331
110	1094	1467	47.78 757	41.62 660	38.70 613	35.89 569	30.58 485	25.70 407	21.24 337	19.17 304
100	994	1333	43.44 689	37.84 600	35.18 558	32.63 517	27.80 441	23.36 370	19.31 306	17.42 276
90	895	1200	39.09 620	34.05 540	31.67 502	29.36 465	25.02 397	21.02 333	17.37 275	15.68 249
80	795	1067	34.75 551	30.27 480	28.15 446	26.10 414	22.24 353	18.69 296	15.44 245	13.94 221
1			0.4344 6.885	0.3784 5.998	0.3518 5.576	0.3263 5.172	0.2780 4.406	0.2336 3.703	0.1931 3.060	0.1742 2.762

Note: 1. Calculate in accordance with volume efficiency of 100% and mechanical efficiency 90%.
2. Maximum working pressure 51.4MPa (7450psi).

1.1.3 Overall Dimension

The overall dimension of F-1600HL drilling pump is detailed in Fig. 1.



Dimension of input shaft end

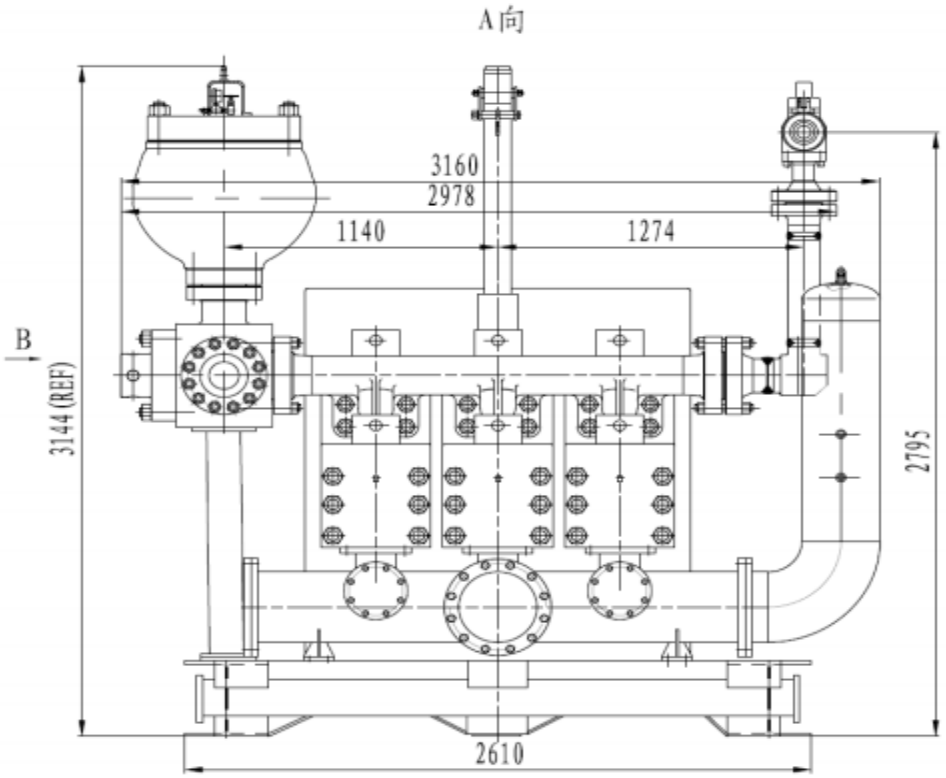


Fig. 1 Overall Dimension of Drilling Pump

1.2 New Pump Installation

When Ex-work, the following parts of F-1600HL drilling pump have been dismantled and packed into the accessory box, air filter (connecting part shall be plugged tightly), 5" auxiliary piping, pulsation dampener and relief valve, etc. And the pump shall be subject to loading test and the lubricating oil will be discharged from power end. Preventive measures shall betaken to operate and check it before operation. The equipment must be powered off and stopped and all the protective shield device on prime mover and drive device must be in safety position in case of occurrence of human injury during maintenance and check.

The foundation under BOMCO F-1600HL drilling pump shall be suitable for all types of installation. However, the supporting foundation under the pump must be in horizontal position and shall be with adequate strength so as to support the net weight of the pump and strength occurred during rotating.

1.2.1 Hoisting Requirement

In order to ensure the hoisting safety, it's advised to use 4 individual steel wire ropes, the length shall not shorter than 8 meters, and the breaking force of each individual steel wire ropes shall not less than 40T.

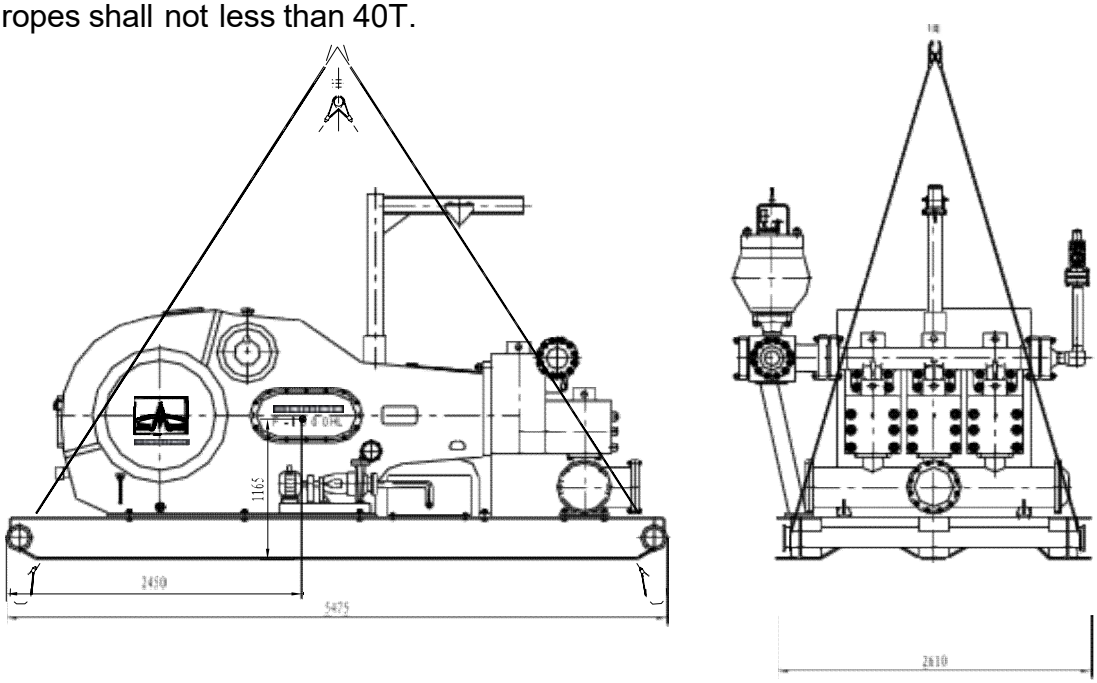


Fig. 2 Hoisting Diagram

1.2.2 Installation on Ground

At least 8 spacers with dimension of 76×305mm shall be applied on the foundation of pump while ground installation. Positions are shown as Fig. 3. The foundation under the

bottom plate must be 300mm(11.8in) wider than the main body of base beam of the pump. More stable foundation is needed for damp or swamp area.

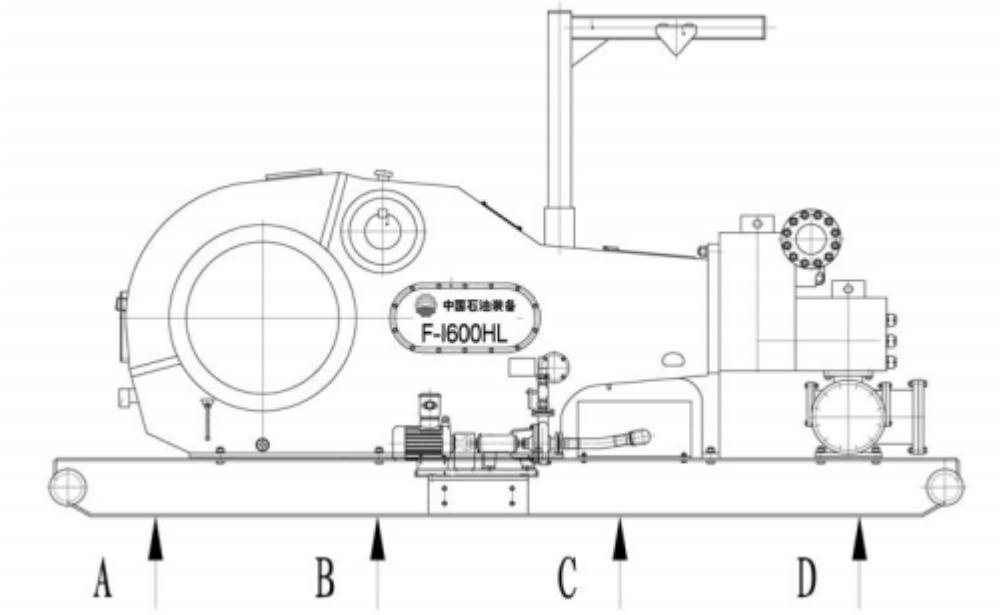


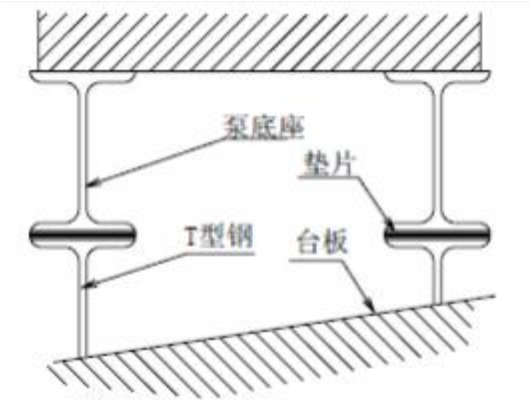
Fig. 3 Ground installation diagram

1.2.3 Permanent Installation

The pump shall be installed on the structural or cement foundation on drilling ship or drilling platform and the foundation of pump be fixed by bolts. It must be bedded by spacer of the foundation in case of possible distortion or inclination of rack at power end and the foundation of pump must be firmly on all spacers when the bolts are loosening.

When it is installed on the ship, the base of pump is always connected on T-type beam by bolts and the installation of spacers on each point is detailed in Fig. 3 and Fig. 4. Proper plates shall be added in case of distortion and inclination. All spacers must be over the width of the projecting edge of base beam with min length of 305mm (12").

When the prime mover, drive device and base of pump are installed as integral part, the pump shall be installed on the base of T-beam with stopping block and bolts shall not be applied. It could allow “floating” of the pump and largely reduce the possibility of distortion of rack due to distortion of shipboard or platform.



泵底座: Foundation of pump

垫片: Spacer

T 型钢: T-type steel

台板: Plate

Fig. 4 Foundation of New Pump

1.2.4 Installation of Drive Device

V-belt or multi-row chain could be applied for driving of pump and prime mover. It must be accurately installed to ensure the max operating life and min frequency of stopping machine due to driven faults.

When drive belt or chain wheel is installed, anti-rusting agent or grease on the mating hole and shaft head shall be cleaned. Clean fin, protuberance on the key, keyslot and shaft head to ensure that the key is closely matching with the key slot on the shaft and driven components.

Apply light lubricating oil or anti-coherероil on the pinion shaft head and install the belt hub or chain hub, screw the bolts as per the following description:

Screw torque N·m (lbfft)	Length of wrench mm (in)	Strength on the wrench N (lbfft)
810(597)	900(35.4)	900(202.3)

When wrench or extension bar is applied to screw the bolts, it may cause over torque. Therefore, we shall continuously screw the bolts as per the torque values given above. It is important to do that because the strength for screwing bolts for installation of wheel hub will be increased sometimes due to effect of conical surface and the strength will force the wheel hub to tightly wrap the wheel hub. When the strength of fasten bolt is over, it will create more expansion strength and cause broken of wheel hub. Thus, the bolts for wheel hubshall be screwed by symmetrical, crossing, uniform and successive methods.

1.2.4.1 Driven by V-belt

1) Check the state of groove of pulley

Check if the groove of pulley becomes round after abrasion before installation. V-belt will be damaged by the groove after abrasion. The wall of groove must be straight without sewage or projecting part inside.

2) Check the centering of pulley

3) Adjusting the pre-tightening force of V-belt

Move the central distance of pulley to adjust the tension of belt until the tensioning side of the belt is not down and the belt at loosen side will also be tensioning and increase a certain central distance. For example, after the central distance is adjusted to 2540mm (100″), increase 13mm (1/2″). When the central distance is 3810mm (150″), increase 19 mm (3/4″) for the central distance after adjustment.

Do not gain tension of belt by means of padding the end of pump and low down the pump end on the ground to tension the belt by net weight of the pump.

1.2.4.2 Driven by Chain

1) Installation

Right installation and maintenance are necessary methods for gaining better service life of chain driven and chain driven device. For many reasons, such as width of chain, central distance, speed and load, that shall be taken into account for confirming the tolerance of centering of chain wheel. However, there is not a completed “Practice Rules” could be applied. Therefore, centering for chains must as accurate as possible. The more accurate method for centering is that tensioning on one surface alongside the two chain wheel by two steel wires (piano string), one is on the center line and one is under it, move one chain wheel to make the two steel wires contact with the four point of chain wheel, it could be confirmed that the two chain wheels driven are centering and the center line is parallel and it is vertical to the shaft line.

2) Lubrication of driven chain

Chain lubricating system in the chain driven device of F series pump is a separate system with its own lubricating pump, oil tank and driven. The lubricating oil will filled into the chain box to reach the indicated height of fluid level. Selection for brand of lubricating oil could refer to ***Selection Guideline for Lubricating Oil of BOMCO Product.***

When the temperature is less than -18℃ (0°F), consult supply department of lubricating oil and take their advices.

The applied lubricating oil shall be in accordance with relevant norms of lubricating oil and lubricating manual compiled as per the specifications.

Chain lubricating system is a separate system. Thus, it need to be repaired and maintained as other machinery equipment. It includes:

——Check oil level every day;

——Check status of lubricating oil every day;

——Check oil pressure 0.035 MPa～0.103 MPa（5psi～15psi）

——Supply certain mount oil for the chain;

——Check the working condition of oil nipple on the spray pipe;

——Check the working condition of driven of oil pump (V-belt or chain).

Note: ① Relief bolt behind the pump foundation is used to adjust the oil pressure.

② When the oil pressure reduces or is too high, the filter screen for suction shall be cleaned.

1.3 Requirements for Suction System

The design for suction system of pump shall meet the requirements of separate installation. F series pump must be with positive pressure head (positive pressure) so as to get satisfying suction performance. The preferred pressure of suction manifold is 0.14~0.21MPa (20～30psi) so that the pump will have maximum volume efficiency and longest life of wearing parts. The pressure head could be gained by 6×8 charge pump. The charge pump shall be started prior to drilling pump. Stimulate the electromagnetic starter by one signal gained on D.C control panel on the drilling rig driven by D.C motor.

The charge pump could be driven by belt and the driven force is originated from the pinion shaft of drilling pump.

Suction pipeline shall be arranged to connect the bypass of charge pump. When the charge pump is with faults or is repaired, the drilling pump could continue working. When there is no charge pump and the drilling pump works, some suction valve springs can be replaced to improve the suction performance.

Suction pulsation dampener is a very effective auxiliary device and it could improve suction performance and eliminate the liquid flow pulse of suction pipeline to stably discharge liquid flow. The following operation and check must be conducted before operation of the pump.

Note: Do not connect the back-flow pipeline of shear pin relief valve to the suction pipeline, because when the shear pin relief valve is opened, the pressure inside the system will suddenly rising. When it is higher than the rated pressure of suction system, the manifold, suction pulsation dampener and centrifugal pump will be damaged.

1.4 Preparation for Power End

F-1600HL pump must be completely assembled and subject to frame running test and the lubricating oil inside the power end shall be discharged before delivery. The following operation and check must be conducted before operation of the pump.

Note: When delivery, air filter C-M60×2 on the top of rack is dismantled and packed into accessory box, and plugged by plug. So the plug shall be removed, and reinstall air filter C-M60×2 before use.

1.4.1 Lubrication of Power End

Open the inspection door on the cover, to check if lubricating oil inside the power end is altered before filling lubricating oil, if altered, open the pipe plug besides the pump (Fig.8-No. 2) and discharge all stored oil and clean it. The lubricating oil with specified brand number and quantity (nameplate on rack) must be filled into the power end.

After 15min operation of the pump, check the oil level again. Stop the pump for 5min to stabilize oil and check the oil mark (Fig.8-No. 1). More than 10L (3 gallons）lubricating oil must be supplemented for there is a certain amount of oil in the crosshead and cavity of rack.

1.4.2 Installation for sealing of pony rod and packing box

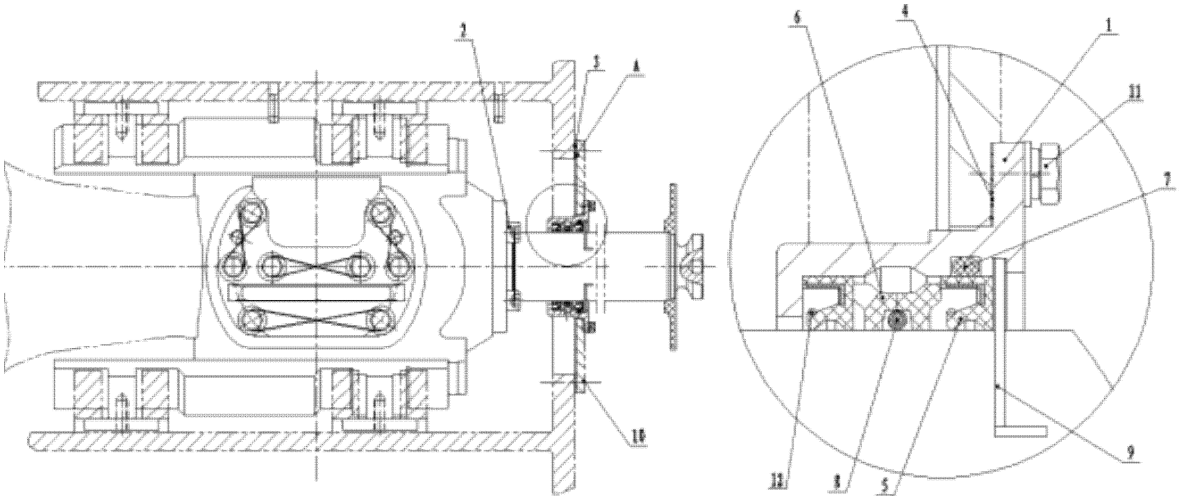


Fig. 5 Packing box seal installation

(1) Packing box (2) Bolt (3) Spacer (4) Gasket (5) Double-Lips oil seal (6) Oil seal ring
(7) O-ring (8) O-ring (9) Locking spring (10) Bolt (11) Bolt (12) Spring

As the Fig. 5 shown, remove the packing box (1), rotate the pump manually to make the crosshead is in the frontend of the stroke. Thoroughly clean the forepart of crosshead and the end surface of the pony rod, and then mount the positioning boss of the pony rod to the hole of crosshead. Tighten the bolt (2) with the torque of 566N.m(415lbf. ft),and then lock up with iron wire. Thoroughly clean the end surface between fender plate and rack, mount sealing gasket (3) (Fig.5 - “A”) and bolt (10), screw the bolt with torque of 68N•m (50lbf•ft).

Clean the outer surface and flange surface of the packing box, apply the outer surface of the packing box with light oil and install the gasket. Fill the packing box onto the fender, tighten the bolt (11).

Packing box assembly includes: lips oil seal (5), oil seal ring (6) and O-ring (7), O-ring (8), lock spring (9), spring (12) and so on. The method of installing the assembly is as follows,

Method 1:

1) Remove the spring (12) from the double lipped oil seal (5), mount the oil seal to the external of the pony rod. The main lip is towards to the power end, and then the spring (12) is mounted to the oil seal lip, push them to the packing box. Refer to the Notes below.

2) Install O-ring (8) into the sealing ring (6) and install it on the bar and then install it inside the hole of packing box.

3) Install O-ring (7) into the slot of packing box.

4) Install the double lipped oil seal (5) in Fig. 5. The method is the same as step 1).

Note: the double lipped oil seal (5) on the side of the power end could be replaced by single lipped oil seal. But single lipped oil seal could not be applied to the outside (fluid end) one.

5) Install locking spring (9).

Method 2:

1) Take off the packing box (1) from the rack. Pack the double lipped oil seal (5), sealing ring (6) and O-ring (7), O-ring (8) and locking spring (9) in the packing box (1) according to the partial enlarged drawing in Fig. 5, and then cover the gasket (4) in the outer cylindrical surface of the packing box (1).

Install the guide sleeve (attached tools) at the frontend of the pony rod as shown in Fig.

5, and then apply the light lubricating oil on the external surface of the pony rod and the guide sleeve.

Mount the packing box assembly on the pony rod through the guide sleeve, and push in place manually, and then install the packing box (1) on the fender plate with the spring washer and bolt (11).

Note: It is necessary to guarantee that the pressure spring (12) will not be slipped out of the oil seal lip when the crosshead rod is seriously scratched. Apply the draw rod with light oil so that the packing box assembly is easily installed.

1.5 Spray Pump Assembly

Spray pump assembly includes spray pump, water tank and nozzle, etc. The function is to clean and cool cylinder liner, piston and seals during operation to improve its service life.

Spray pump is the centrifugal pump, driven by the AC motor. Recommend cooling fluid is consisted of 10% JH-I water base lubricating coolant and 90% clean water. Then stir well.

The nozzle is fixed on the frame above the cylinder liner. When the piston moves, the nozzle does not move, called "fixed" type.

F-1600HL metric drilling pump adopts the fixed spray pipe as shown in Fig. 6, including nozzle (1), steel pipe (2) and spray pipe (3) which fixed on the frame. It shall spray the cooling liquid to the cylinder liner and piston. Adjust the water supply of manifold and often check the nozzle to let the sprayed fluid directly on the piston.

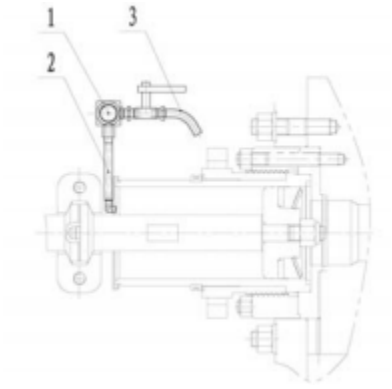


Fig. 6 Spray Pipe
(1) Main Spray pipe (2) Spray pipe (3) Nozzle

The cooling fluid is transmitted to the manifold located at the left (right) wall of rack from spray pump (Fig. 8, No. 3) to water tank (Fig. 8, No. 5). The regulating valve (Fig. 8, No. 4) shall provide water for spray on the piston of cylinder liner as much as possible. It is preferred that it not spray on the draw bar of crosshead and avoid that litter water will return the power end and pollute the lubricating oil.

The cooling fluid will return to the sediment chamber of water tank from the front chamber. When the cooling fluid flow from the strainer, the solid substrates as mud water will become sediment and the foreign matters will be blocked by the strainer as shown in Fig. 7.

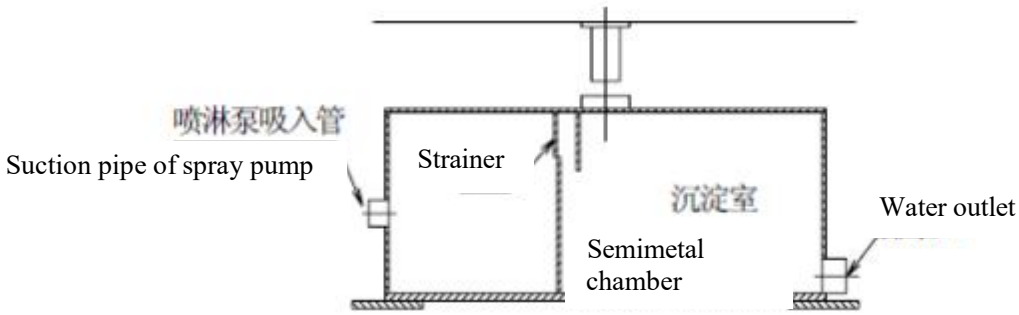


Fig. 7 Water Tank of Drilling Pump

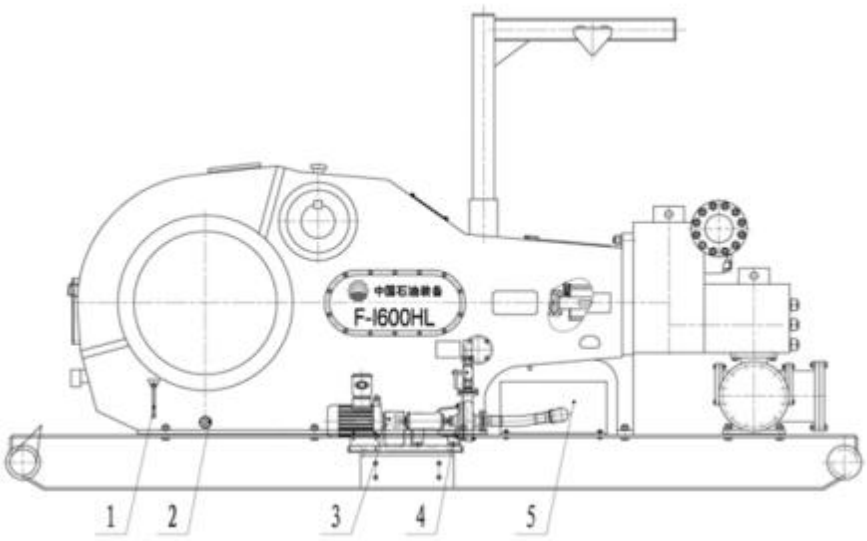


Fig. 8 Spray System of Drilling Pump

(1) Oil level indicator (2) Pipe plug (3) Spray pump

(4) Regulating valve (5) Water tank

Regularly check the cleaning situation of cooling liquid. Clean and wash the water tank and change the cooling fluid as per requirements. Due to increased sand of polluted fluid, piston and cylinder liner will be worn or the spray pipe will be blocked.

1.6 Assembling of Fluid End Components

Cross-section of fluid end of F-1600HL is shown in Fig. 9. Clean and assemble the components of fluid end as per the following methods.

Note: Metal to metal installation is designed for many components at fluid end. It could reduce wearing by high pressure fluid flow during operation of high pressure pump. For this reason, it is necessary to require that all the components must be clean before installation. It shall be without vices as fin, scrap and rust that could influence the quality of products to ensure the reliable sealing of fluid end.

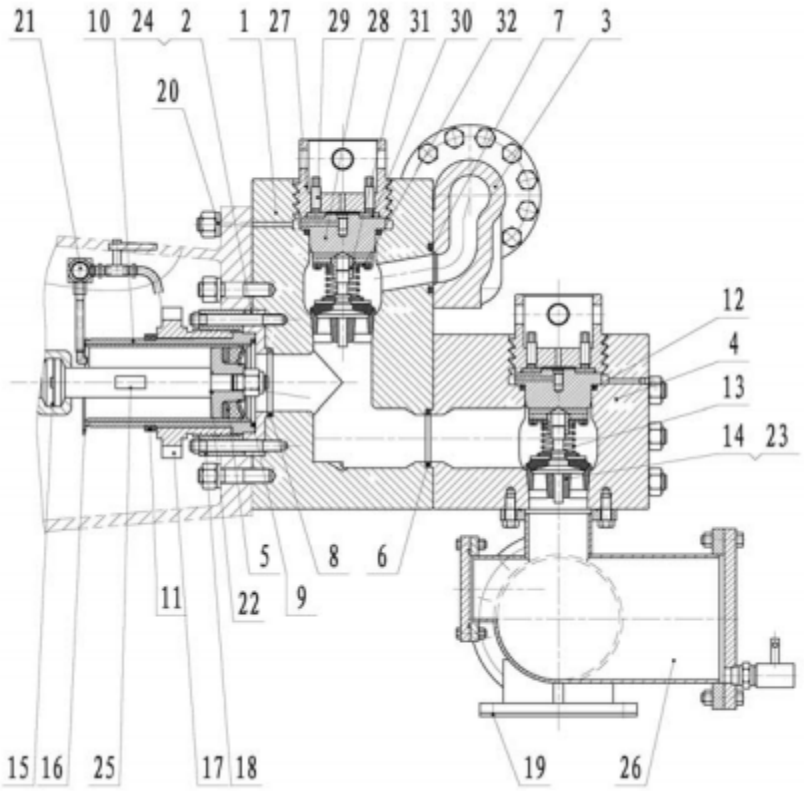


Fig. 9 Fluid End Assembly of F-1600HL Drilling Pump

(1)Discharge hydraulic cylinder (2)Wear plate (3)Discharge pipeline (4)Suction hydraulic cylinder (5)Piston (6)Cylinder seals (7) Discharge pipe seals (8) Wear pleas seals (9) Liner seals (10) Cylinder liner (11) Liner locking ring (12) Bonnet seals (13)Valve spring(14) Valve assembly API 7 (15) Clamp assembly (16) Liner end cover (17)Liner cover (18) Liner flange (19) Spacer unit (20) Gasket 39 (21) Spray pipe assembly (22) Piston Seals (23) High pressure valve assembly（24）Wear plate (25) Piston rod (26)Suction pipeline (27)Bonnet (28)Bonnet plug (29)Screw M24 (30)Gasket (31)Valve stem guider (32) Baffle

1.6.1 Valve, valve seat

Assemble the valve body, valve rubber into a whole by plate and locking spring. Clean the external conical surface of the valve seat, and confirm the external conical surface without nick or burr. Put the valveseat into a cleaned cylinder valve cone hole.

When assembling the valveseat, it is better to find an old valve body to keep on it. Hit three times with an iron bar, and then take out the valve body and check whether the valve seat is fixed or not. If there is no old valve body, shall hit around top edge of the valveseat evenly with a copper bar to make it closely fit the hydraulic cylinder.

Note:

1.When assembling, it is strictly prohibited to coat oil or grease on the external conical surface of the valve seat and the internal surface of the valve seat hole.

2.The old valve body shall not be used on the newly replaced seat.

1.6.2 Bonnet

Install the valve assembly (14) on the seat. Make the valve spring in the central position of the valve body and compress it with the bonnet (27).

Install the bonnet seals (12) coated with grease on the shaller of cleaned hydraulic cylinder. After assembling the bonnet and the valve stem guider (31), coat the thread surface of the bonnet (27) with grease, and then screw tightly with the round bar.

Before installing the bonnet (27), put the cushion and the valve stem guider into the bonnet. The valve stem guider is composed of a guiding body and an inner sleeve. Check the inner sleeve during the replacement of the bonnet seals. And replace with a new inner sleeve, when the old one is worn or damaged. When replacing, cut and take out the old inner sleeve, and then use the attachment tools (bolts, nuts and washers) to press the new inner sleeve in, as shown in Fig. 10.

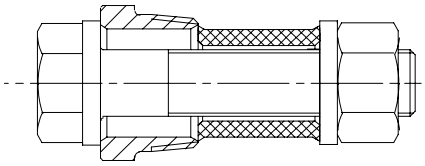


Fig. 10

The suction and discharge valves are interchangeable.

When the working pressure is no more than 35MPa, shall use the ordinary valve (API 7 #). When the working pressure is greater than 35MPa, shall install the high pressure valve (API 7H).

1.6.3 Assembling of piston and its assembly with the cylinder liner

Clean the piston (5) and piston rod (25) to ensure there is no burr or scratch. Install the piston seal (22) into the groove of the piston core. Install the piston (5) on the piston rod (25), and be careful not to let the O-ring slip. Rotate the nut on the piston rod with a torque of 2152N • m (1587 lbf • ft).

Coat the grease on the inner circle of the cylinder liner and the outer circle of the piston. Check the piston rod (25) and the pony rod end to ensure themclean without burr. Put the

piston rod (25) into the cylinder liner, so that the piston rod keeps in the middle at the backside of the cylinder liner. Hit the piston into the cylinder liner with hardwood or special tools. Note that hold the piston rod to make it into the positioning hole and not to damage the positioning boss at the end of the piston rod, when approaching the pony rod.

Shall install the piston with the cylinder liner outside the pump body in advance, and then lift them together onto the hydraulic cylinder. The assembly and disassembly procedures are the opposite steps. When installing the piston with the cylinder liner, must coat the inner surface of the cylinder liner and the outer surface of the piston with calcium base grease in advance, and then install the clamp of the piston rod and the pony rod.

1.6.4 Installation of cylinder liner

The wear plate seal (8) is fitted into the counter bore of the discharge cylinder (see Figure 9). Install the wear plate (2) with the studs in place. And install the flange(18), in the assembly to make the starting point of the thread on the lower right corner, equivalent to the clock on the 5 o'clock position, with 566 N • m (420lbf • ft) torque tightening liner flange nuts.

Note: The starting point of the thread at 5 o'clock position is to make the cylinder cover gland thread easier to engage.

Install the wear plate seal (8) into the counter bore of the wear plate (2). Coat the grease on the inner surface of the liner cover gland (17) and then cover the cylinder liner (10) from the rear. Place the halves liner locking ring (11) in the liner groove with O-rings. Lock the lock ring of halves liners with O-ring. The rack is equipped with a small crane for lifting cylinder liner. The maximum lifting capacity is 500kg. Use a spreader to lift the cylinder liner (10) from the top. Coat grease on the cylinder gland thread. Make the starting point of liner cover thread equivalent to the position of 7 o'clock on the timepiece, put the cylinder liner into the cylinder liner flange (18), tighten the cylinder liner gland (17) so that cylinder liner seat is in place. Tighten the cylinder liner cover with hammer.

1.6.5 Piston rod clamp

The whole clamp is divided into two pieces after processing. Two pairs are marking with a pairing number and linked together with the chain. The two parts with the same pairing number shall be used together for a group of clamps on the piston rod and the middle tie rod flange. Tighten the bolt with a torque of 566 N · m (420 lbf • ft).

If both the piston rod and the clamp are new, the gap between the two halves of the clamp has a gap greater than 5.5 mm. So that the piston rod end faces a good metal-to-metal connection. When worn, the two halves will tend to approach. If the gap does not appear, the clamp does not work, shall replace the clamp. Install the baffle at the rear of the cylinder to prevent water splashing.

1.6.6 Discharge pipeline

The flanges of the discharge lines and the discharge ports are 5 1/8 "API 10000 psi. After removing the discharge flange and the gasket ring, the flange is welded to the discharge line (the welding methodshall be selected by the user). With 843N • m (620 lbf • ft) torque, tightening flange coupling bolts. Tighten nuts with a crossed manner.

1.6.7 Suction pipe flange

There are three 305mm (12") connecting flanges on the suction pipe. Normally, according to the well site situation, one flange is connected to the suction pipe inlet. One flange is connected with the suction dampener. The last one is with blind plate. And flange connection shall be sealed with O-ring. F. Before connecting, clean O-ring groove and flange end face, then tighten the bolt with 266N • m (195lbf • ft) torque.

1.6.8 Auxiliary pipeline

The auxiliary pipe is shown in Fig. 11. Can be installed in the discharge pipe on the opposite side of the discharge. This pipe can be connected with WY75-52 pulsation dampener (1), shearpin safety valve (3) and pressure gauge (2).

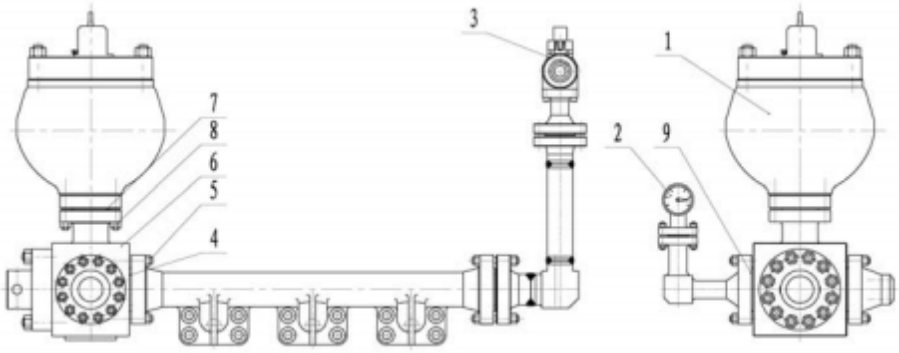


Fig. 11 Auxiliary pipeline

(1) Pulsation dampener (2) Pressure gauge (3) Shear pin safety valve (4) Rim (5) Flange bolt (6)5-wany discharge (7) Rim (8) Nut (**9)** Rim

The auxiliary and the discharge pipelines are connected by flange. Before installation, thoroughly clean the sealing groove on the flange, put the rim (4) and tighten the flange bolts (5) with the tightening torque of 843N • m (620 lbf • ft), to ensure uniform tightening of

the rim connector. The gap of the flange end shall be uniform and used cross-tightening.

The auxiliary pipeline is also equipped with shearpin safety valve (3). When the pump pressure exceeds, the specified value rapidly blows off to ensure the safety of drilling pumps. The safety valve must be installed correctly and contact directly with the mud. And any type gate shall not be allowed between the discharge line and the safety valve. Connect the safety valve outlet with a seamless steel pipe directly to the mud pool. This seamless steel pipe shall be bent as little as possible. It is advisable to direct the discharge end of the safety valve to the suction pipe of the pump.

The flange at the bottom of WY75-52 pulsation dampener is equipped with a gasket ring of BX155. Before installation of pulsation dampener, thoroughly clean the rim and groove. Then tighten the nuts (8) with a 1193N · m (880 lbf • ft) torque. Use a crisscross pattern to tighten it evenly.

Both sides of the 5-way discharge (6) are the flanges of the rim BX-169. Before installation, thoroughly clean the rim and groove, the coupling bolts and nut with torque of 843N • m (620lbf • ft) to use the cross-way evenly tightened.

Before starting the pump, pre-charge the pulsation dampener with air or nitrogen. See the description of *"pulsation dampener assembly"* section.

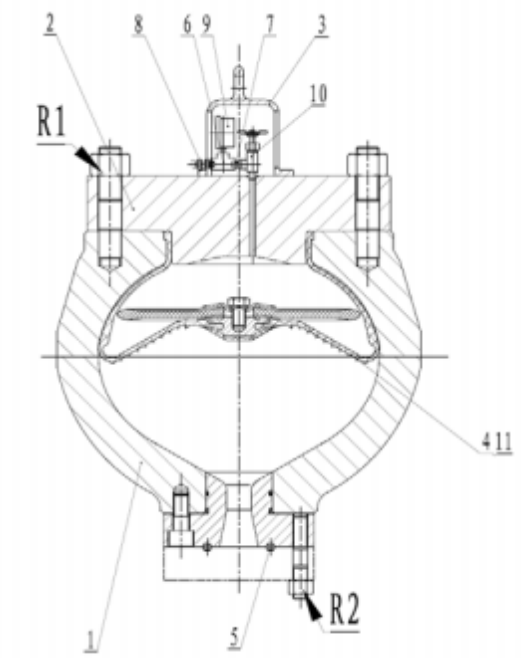


Fig. 12 WY75-52 pulsation dampener assembly

(1)Shell assembly (2) Cover (3) Pressure gauge cover assembly (4) Bladder assembly (5) Rim (6) Tee (7)Joint (8) Exhaust valve (9)Pressure gauge (10)Stop valve (11) High temperature bladder assembly (R1)Nut (R2) Nut

1.7 Pulsation Dampener Assembly

Correct installation and application of pulsation dampener could effectively reduce the pressure fluctuation of exhaust system to gain more uniform fluid flow. Often keep recommended proportion of pump pressure and pre-charging pressure of bladder in order to gain longer life of bladder. Generally, it will not be over 2/3 of exhausted pressure of the pump. However, it shall not be over 8.6Mpa(1250psi). Both the capacity and the compressive strength of the dampener meet the requirements of the drilling pump. The dampener shall be filled with nitrogen or air. But oxygen, hydrogen and other flammable and explosive gases are not allowed.

The stop valve of pulsation dampener shall be closed after charging. The pre-charge pressure is 8.6MPa (1250psi). Close the stop valve to protect the pressure gauge after filling. Long-term work under low pressure cycle pressure, the baldder usually exhausr the pre-charge pressure.

1.7.1 Installation

Structure of WY75-52 pulsation dampener is as shown in Fig. 12. The lifting lugs installed on the pressure gauge enclosure (3) are used to hoist pulsation dampener assembly. The sealing groove, rim and sealing groove of coupling flanges must be completely cleaned before installation and coated with grease.

Hoist the pulsation dampener to the corresponding position of drilling pump discharge pipe, and screw the bolts (R2) with the torque of 1193N.m(880lbf. ft). Keep the connecting part straight and centering when screw and therefore, crossing methodshall be applied to screw bolts.

1.7.2 Inflation

The pump is equipped with gas-filling (Dampener inflatable hose assembly) Ex-work. It shall be operated as per the following steps and shown in Fig. 13.

1.Remove the pressure gauge enclosure of pulsation dampener, rotate 1/4-1/2 circle of exhaust valve and exhaust the gas pressure in the pressure gauge and take off the valve bonnet of exhaust valve.

2.Connect the hose to the switch of nitrogen cylinder and gas-filling valve of pulsation dampener.

3.Open the gas-filling valve of pulsation dampener.

4.Slowly open the nitrogen cylinder valve and adjust the gas in the pulsation dampener

by this valve.

5.When the pressure of pulsation dampener indicates the necessary pressure, close the cylinder valve.

6.Close valve of pulsation dampener.

7.Remove the hose, cover the pressure gauge enclosure and install exhaust valve.

The filling pressure of pulsation dampenershall not be over 2/3 of exhausted pressure in order to get best results. But the maximum filling pressure is 8.6MPa(1250psi).

Warning!

1. When charging, only the compressed nitrogen or air can be used – the oxygen or hydrogen and other flammable gases cannot be used.

2. The pump must be stopped when maintaining the pulsation dampener, and ensure that the gas in the pulsation dampener is discharged off. Do not judge them with the pressure gauge, since the residual pressure is small, which cannot be displayed in the pressure gauge. But the low pressure will also cause an accident!

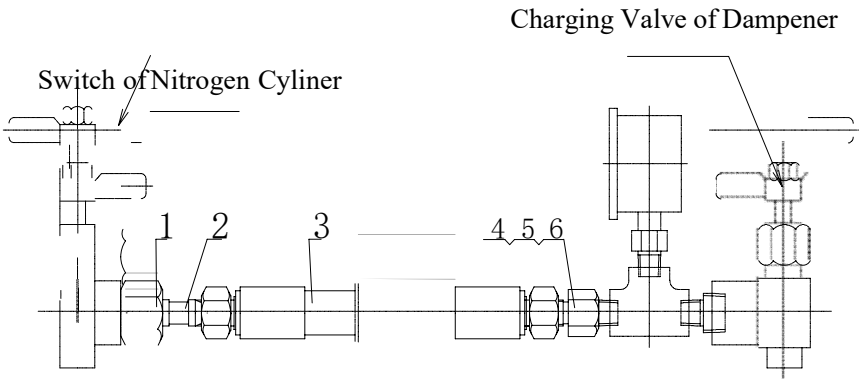


Fig. 13 Dampener inflatable hose assembly

(1)Nut (2)Seals joint (3)Hose (4)Joint (5)Gasket (6)Plug

1.8 Shear Pin Relief valve

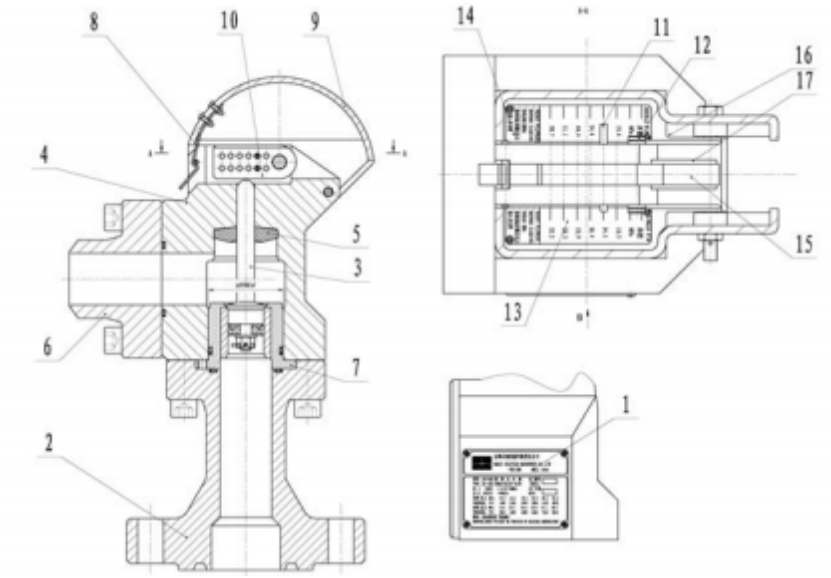


Fig 14 Shear Pin Relief valve

(1) Nameplate (2) Inlet flange (3) Piston rod (4) Valve body (5) Cushion (6) Outlet flange (7) Transition sleeve assembly (8) Locking spring (9) Safety cover (10) Shear pin plate (11)Shear pin (12) Pin (13) Label Ⅰ (14) Label Ⅱ (15) Gasket (16) Piston assembly (17) Gasket

The JAF-3×52 flange type shear pin relief valve is shown in Fig. 14. When the pump pressure exceeds the rated value, the acting force on the piston assembly (16) will jack up the shear pin plate (10) to compel the shear pin (11) broken, and the liquid is rapidly emptied.

JAF-3 flange type shear relief valve can change the discharge pressure by changing the position of the shearpin. It's easy to operate and reliable to work.

At the shear plate of the shearpin type relief valve is marked with the working pressure of each grade. When regulating the pressure, just insert the safety pin to the appropriate hole according to the pressure. Note: Maximum 2 pins could be inserted into the shear plate. When the cylinder liner is changed in size, the position of the safety pin must be adjusted accordingly so that the pressure corresponding to the safety pin is slightly higher than the pressure that the cylinder liner can withstand.

Steel wire, electrode or other materials are not allowed to be used to replace shearpin. It could influence the pressure value of relief valve and could cause accident.

There are three sizes of relief valve inlet: 2 1/16" flange type, 3 1/16" flange type, 3″-1502 union type for selection of users.

2 Lubrication

It is important to lubricate the moving components, because it directly influences the life limitation of machinery components. It must carry out maintenance and check to gain the longest life without faults of the pump and ensure that suitable clean lubricating oil shall be on the surface of every moving component.

F-1600HL drilling pump is equipped with the oil bath splash lubrication and pressure lubrication system to lubricate the entire power end, and various types of pressure lubrication control the minimum stroke per minute of the pump in operating. That is to say, the minimum speed of the pump only makes pressure lubrication for the main bearing and pinion bearing is 40 strokes / min. But as to the pump makes pressure lubrication for parts such as bull gear bearing and pinion shaft bearing, crosshead bearing and crosshead, etc., if the minimum oil supply pressure is 0.035 MPa（5psi）, the minimum operating speed is 25 strokes / min.

2.1 Minimum Operating Speed

The F-1600HL drilling pump adopts the oil bath splash lubrication and pressure lubrication system for the entire power end. The form of pump pressure lubrication limits the minimum stroke of the pump in operating, and the F-1600HL drilling pump can work at the speed of 25 strokes / min (if the oil pressure is 0.035 MPa).

Note: The pressure lubricating oil pump can be installed outside the mud pump driven by AC Motors, or installed inside the pump (driven by the bull gear of the pump). When using the latter oil pump for lubrication, the direction of rotation of the pinion shaft shall be as shown in Fig. 15.

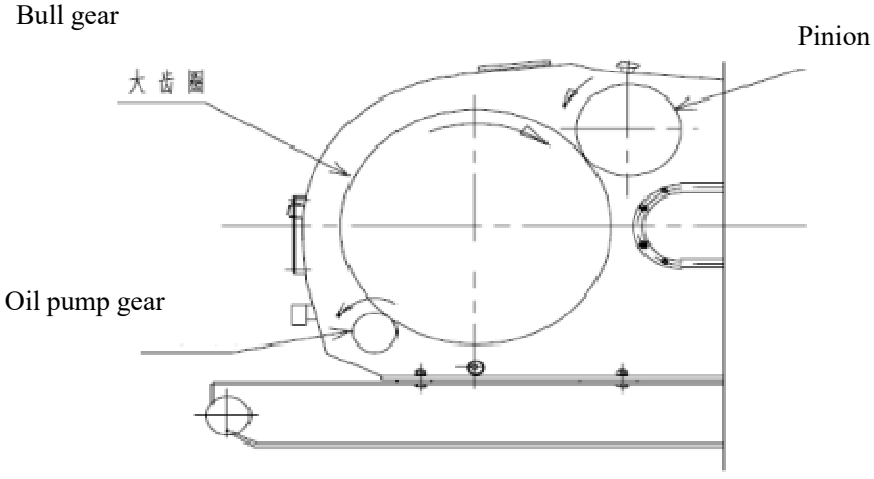


Fig. 15 Drilling pump power end rotation

2.2 Splash Lubrication for Controlling Fluid

In the splash lubrication system that control the fluid flow, bring the oil from the pool with the bull gear. When the bull gear and pinion is engaged, the oil will be splashed into the sump and the chamber of rack. As shown in Fig. 17, when the oil is thrown to the oil sump (7), it will pass through the oil pipe (8) to flow to the bearings of two bearings of pinion shaft.

Flow into the oil passage of crosshead bearing from the top plate of crosshead is detailed in Fig. 16. The lubricating oil will accumulate in the chamber on top of crosshead, and will flow into the baffle of crosshead by nipple (1) and into the oil passage (5) to lubricate the crosshead pin bearing. As shown in Fig. 16, the cross pin has two oil passages (5) that allow the crosshead pinto rotate without having to worry about the alignment of the oil hole, so that the crosshead can be loaded from either direction during installation.

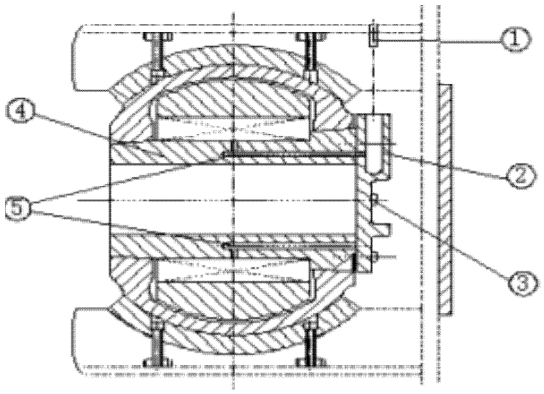


Fig. 16 Crosshead Lubricating Oil Passage

(1) Oil nipple (2) Baffle (3) Bolt (4) Crosshead pin (5) Oil passage

2.3 Pressure Lubricating System

The pressure lubricating system of F-1600HL drilling pump is equipped with lubricating pump as shown in Fig. 17. In this system, the filtered oil shall flow into the pump through the suction filter (1), and thendrainto the oil separator (2) and nozzle (3A). Besides, it also enters the oil pipe of main bearing oil pipe (4) and crosshead chamber oil separator (4A). This oil separator can distribute the oil to the crosshead, crosshead bearing and piston rod. The pressure gauge (5) is mounted on the back wall of the rack to indicate the oil pressure of the oil separator. The pressure varies with the pump speed. However, if the oil pressure suddenly reduces or rises, refer to the *“maintenance of lubricating system”*, to identify possible causes and exclude them in a timely manner.

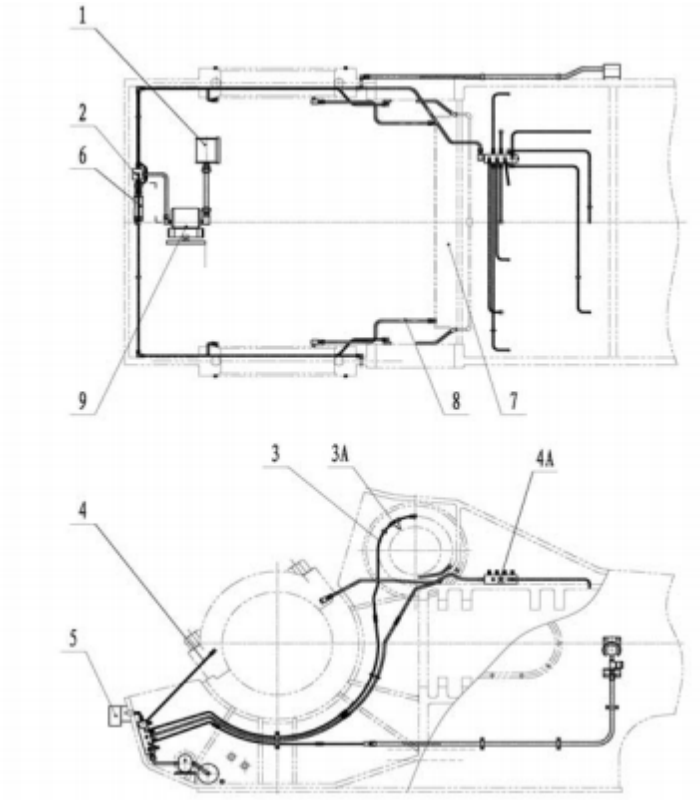
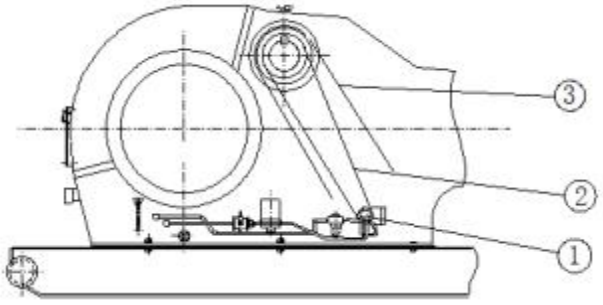


Fig 17 Pressure Lubricating System

(1) Filter (2) Oil separator (3) Oil pipe (3A) Nozzle (4) Main bearing oil pipe (4A) Oil separator (5) Pressure gauge (6) Relief valve (7) Oil sump (8) Oil pipe (9) Lubricating pump

A relief valve (8) is mounted on the oil separator (2) to prevent damage to the transmission of oil pump due to excessive pressure. The working pressure of relief valve is 0.5MPa（72.5psi）, and shall be locked (to prevent the change of the regulated pressure).

When installing the internal assembly type lubricating pump (9), position the oil pump. Make the back of the transmission gear parallel and level to the side of the bull gear of the mud pump, and there shall be 2.0 mm ~ 2.5 mm （0.079"~0.098"） clearance between teeth.



(1) Lubricating pump (2) V-belt (3) Shield

Fig.18 External Power End Lubrication

A typical external lubrication pump is shown in Fig. 18. Through oil pump (1) to use pipe connecting pipeline of lubrication system by suction and discharge joint at the bottom of left and right wall panel of power end. V-belt (2) do not adjust too tightly to prevent early damage to the pump. To prevent possible incident, install the belt guard (3) before operation.

2.4 Maintenance of Lubricating System

It is a key factor for extending the service life of pump by complete lubrication of moving machinery components. It is necessary to carefully maintain the lubricating system by the operators and lubricating situation will decide the period of service life without faults of the pump.

2.4.1 Lubricating Specification

Recommendation of lubrication is shown below and also could be referred to *Selection Guideline of Lubricating Oil of BOMCO Products*. This information can be found in the nameplate on the side of the pump. The documents are based on the long-term test results of oilfield. The replaced oil could only be applied in emergency situation.

2.4.2 Oil Tank

Capacity of oil tank is 379L (100 U.S. Gallons)

Note: After 100 hours of drilling pump operation at the first time, lubrication oil shall be replaced timely to drain out the foreign substance from new pump chamber.

2.4.3 Routine Check

Check one time for ever shift. To check the oil level and keep it on the full mark of the oil standard. The pump must be shut down for about 5 minutes to stabilize the oil level before check.

Check it every six months. If there is abrasive particle or corrosive matters in the oil, it must be discharge one time and clean the oil tank and then add new one. Drain port is at side of pump rack. During spraying, completely clean all oil sumps and chamber on the guide plate of crosshead. Simultaneously clean or change the filter element of respirator and clean the suctionstrainer. Before adding new oil, to remove the sewage flange, remove sediment.

Periodically check the condition of lubricating oil. The oil shall be often changed due to entry of damp, moisture, dust and mud.

The sediment chamber is located at the crosshead guide plate section of the power end, and the oil dirt spilled into the chambershall be precipitated. The oil discharging cover of the sediment chamber is located at the two sides of the rack under the crosshead inspection door, and you shall open the cover to discharge sediment.

Check it every month and remove the oil-discharge cover of both sides, the oil with sediment will be discharged and about 15-gallon oil will loss. Therefore, certain amount oil shall be added to supplement the lost oil.

Check it ever week and remove 1/2″ plug of the bottom part of flange and drain the accumulated water.

Check by every shift. Check the oil level in the main oil tank to keep the oil level is on the full mark. If pressure is decreasing, check the following items,

-If the strainer is blocked

-If the oil level is lower

-If the V-belt is slipping

-If the joint is loosened or broken

-If the oil pump is broken or damaged

-If the relief valve has faults

If the oil pressure is increasing abnormally, check the following items,

-if the oil passage is blocked

-if the sediment with oil-coherence

-if the relief valve does not work

-if the pressure gauge is damaged

-other conditions.

3 Maintenance

3.1 Power End

Routine checks of the power end are the most important way of preventive maintenance, which can help discovery of various defects. Necessary check is required for the existing faults or during rig movement.

3.1.1 Check Pre-tightening force of main bearing bolt

Tightening torque of main bearing bolt is 13210 N. m(9750lbf. ft).

3.1.2 Locking wire

Check all bolts (including the main bearing cap bolts, the locking wire of bearing baffle bolt end of crankshaft. After re-tightened the bolts, replace the wire. For the requirements for the tightening torques, please refer to the chapter of crankshaft assembly).

3.1.3 Oil pipe

Check all oil pipes to ensure that they are intact and unblocked. Check whether the pump suction hoses are damaged or pressed flat.

3.1.4 Suction filter

Check filter. If necessary, please clean or replace it.

3.1.5 Main bearing cap

Remove the main bearing cap, check the conditions of main bearing stop bolt fastening, roller bearings and so on. Clean and remove any scum and foreign matter, because they will accumulate to the bottom of the bearing area.

3.1.6 Teeth of bull gear and pinion

Check whether the bull gear and pinion have abnormal wear. During the running-in period, there will be some spots on the tooth surface. This is the "initial pitting",which has no impact on the gear life. However, if the pitting is discovered expanded in the routine inspection, it is necessary to immediately contact with the pump OEM to conduct a thorough inspection of the gears.

3.1.7 Crosshead pin bolts and crosshead guide plate

Remove the crosshead hole cap and check the crosshead pin bolts and locking wires (when checking the middle crosshead pins, remove the back cap and switch the linkage to

the outside dead point). Tighten the crosshead pin bolt with torque of 290～310 N. m （215～230lbf. ft）.

When using the torque wrench, do not exceed the above values.

If abnormal wear and tear of crosshead or guide plates occurs, replace them immediately. Since may cause damage to bearings and other parts, and excessive wear will accelerate the wear and tear of pistons and cylinder liners.

3.1.8 Lubricants and oil tanks

Check the oil condition and cleanliness of the tank and conduct maintenance and services on the lubricating systems according to the measures in the chapter of “Lubrication”.

3.2 Rolling Bearing

F-1600HL pump adopts the rolling bearings, which are precision mechanical parts. To extend the service life, it is required to carry out maintenance on the rolling bearings.

Main bearing is spherical roller bearing. The pinion shaft bearings are cylindrical roller bearings. There are ribs on both sides to keep the connecting rod on centerline. The crosshead pin bearings are double row cylindrical roller bearings. Bearing needs no special adjustment.

The outer and inner ring of all bearings shall match the holes or shafts precisely. The outer and inner ring of bearings shall be installed in pairs with pair numbers. Therefore, when re-installation of bearings, it is required to keep the inside and outside rings match correctly.

It is necessary to replace the defective bearings. Even if only one parts fails, the whole set (inside and outside rings, rollers and holding rack) must be replaced. The movement clearance of these bearings is very small, if there is a large clearance, and channel or abrasion of seat retainer or any defects like pitting or peeling, it indicates that the bearings failand it is required to change them as soon as possible.

The coordination of all rolling bearings and journals shall be shrinkage fitting (refer to each assembly for bearing coordination data). The damaged or worn bearings or seat retainers can be knocked down from the shaft with a copper bar or a hammer, or taken down by gas cutting, but be cautious not to damage the shafts. The assembly bearings are usually heated by oil bath and the temperature shall be lower than 149℃(284°F). The oil

and tank must be clean. If directly heat with fire from the lower part of the tank, the bearing outer ring must be padded up when placing in the oil tank. The time for oil bath of bearings shall be no more than 3 min.

Generally, do not heat the bearings with flames. If flame must be used under special circumstances, just experienced welder can operate them. The flame shall be at least 150mm (6") from the bearing, which can be tested with a temperature-test pen. Do not overheat the bearings. After overheating bearing tempering, the bearing becomes soft.

After the bearings are mounted on the shaft by heating, naturally cool down them at the location. Do not cool down the bearings with water or other liquids. Fast cooling will make the inside and outside rings and rollers “heat crack” and rejected.

Do not directly hit the bearing with a hammer. And if required to install the bearings in place, slightly hit them with a wood hammer.

Generally, the journals and installation holes are coated with lubricants prior to the bearing installation. The best lubricant is white lead oil, that is, a type of anti-adhesion oil.

After the bearing is taken out from the package, prevent the dusts and foreign matters into the bearing. Before assembly, it is required to clean the rust oil for packaging. The cleaning agents must be clean kerosene or other solvents.

3.3 Pinion Shaft Assembly

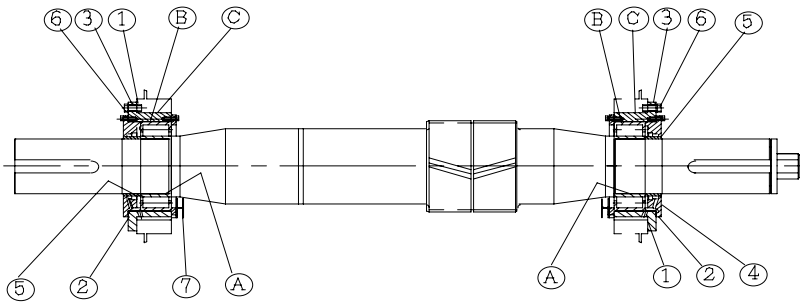


Fig. 19 Pinion Shaft Assembly

(1) Washer (2) End-cap washer (3) Bearing sleeve (4) End-cap (5) Wear sleeve (6) Bolt

Table 3 Main Matching Sizes of Pinion Assembly mm （inch）

Description	Position	Coordination
Inner ring and journal	A	T0.050～T0.109 (T0.002～T0.004)
Outer ring and hole	B	L0.115～L0.018 （L0.005～L0.001）

Bearing sleeve and Frame hole	C	L0.203～L0.076 （L0.008～L0.003）

Note: T is the interference and L isthe clearance

The gear and shaft as a whole structure, so as long as the assembly of the bearing and wear sleeve of oil seal is complete (see Figure 19).

The bearing clearance shall be determined by the matching precision of front shaft and the inner holes of bearing sleeve. When maintenance or repair, ensure that its coordination shall meet the requirements as set forth in Table 3.

When mounting the pinion assembly to the pump, comply with the following,

1) Ensure that the bearing sleeves washer (1) of the pinion and end cap washer (2) are intact and correctly installed.

2) The location of the oil sump (7) and the oil return hole shall be aligned when installation of bearing sleeve (3) and end cap (4).

3) Clear off the burrs, scratches and sump on the outer surface of wear sleeve (5) and then install the end cap (4) in place. When assembly, be careful. And when the oil seal lip passes through the shaft keyway, prevent the keyway from being scratched by the sharp edges. Note that when the oil seal is mounted to the wear sleeve, do not rotate theseallip at the edge of the wear sleeve.

4) Tighten the bearing bolt (6) with torque of 194N•m (145lbf•ft)

5) Check the inner and outer rings of the pinion bearing and the rollers and if there is any abrasion peeling, scratching, or the radial internal clearance exceeding 0.24 mm (0.0094"), it is recommended to replace with new bearings.

3.4 Crankshaft Assembly

The crankshaft assembly is composed of the crankshaft, bull gear ring, linkage (with bearings) and main bearings, etc. The clearance between bearings shall be pre-determined by the precision of the shaft and the holes. For maintenance or repair, be sure to meet the requirements as set forth in Table 4.

Table 4

Description	Postion	Date（mm）	Date（inch）
Inner ring and journal	A	T0.098～T0.165	(T0.0039～T0.0065)
Outer ring and hole	B	L0.108～0	L0.0043～0
Inner ring and shaft	C	T0.175～T0.300	T0.0069～T0.0118
Outer ring and hole	D	T0.112～L0.044	T0.0044～L0.0017
Gear ring and crankshaft	E	T0.026～T0.236	T0.0010～T0.0093
Bearing seat and rack hole	F	L0.050～T0.050	L0.0020～T0.0020
Outer ring and hole	G	T0.016～T0.083	T0.00063～T0.0033
Inner ring and pin	H	T0.05～T0.109	T0.0020～T0.0043

Note: T is the interference and L isthe clearance.

The assembly of crankshaft follows the methods below (Fig. 20),

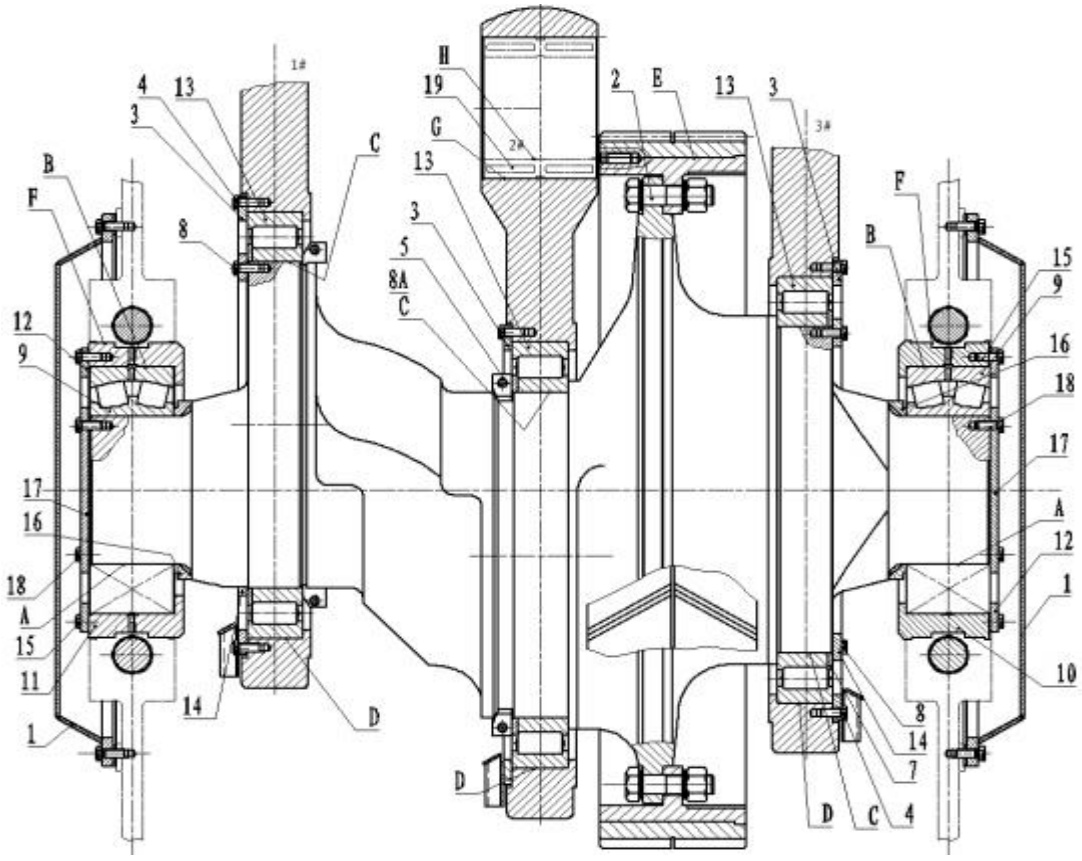


Fig.20 Crank Assembly

(1) End cap (2) Bolt (3) Retainer (4) Bolt (5) Bearing Retainer (7) Baffle ring (8) Bolt (8A) Hex Bolts (9) Main bearing (10) Bearing Sleeve-Right (11) Bearing Sleeve-Left (12) Outer retainer (13) Linkage Bearing (14) Inner retainer (15) Bolt (16) Main bearing retainer (17) Inner baffle plate (18) Bolt (19) Crosshead bearing

1) Install the gear ring and check the jumping.

Thoroughly clean the coordination face of the gear ring and the crankshaft flange and tighten the bolts for gear ring. Tighten the bolt with torque of 2152 N.m（1590lbf. ft）.

Install one set of roller bearings at both ends of the crankshaft and measure the gear ring face runout with a dial indicator. Due to the impact of the roller bearing clearance, it is required to measure them at the shaft end and the gear face with a dial indicator synchronously. The actual runout at any point is the difference of two indicators. If the runout exceeds 0.224mm（0.0088"）, shall takeoff the bull gear ring and check the reasons of tolerance.

2) The outer ring and the outer retainer (3) of the linkage bearing (13) are respectively mounted on three linkages. The outer retainershall be mounted as such, when the pump is at the middle stroke, the oil catch-ring shall be at the bottom. Tighten the bearing retainer ring bolt (4) according to the toque of 75N·m(55lbf•ft), then lock it with wires.

Note: Inner ring, outer ring and roller of the linkage bearing are matched in groups with the pairs number. Cannot be mixed.

3) Put the outer ring of the crosshead bearing into three small ends of linkages. It is preferred to cool them down with "dry ice" (CO_2), that is, assembly by a deep freezing method. Under emergency conditions, heat the small linkage heads with flames (do not exceed 149 ℃（300°F), which can be measured with a temperature pen.

Do not cool down the linkage head with water.

Note: The inner and outer rings of the crosshead bearings are matched in groups, with the matching number, cannot be mixed.

4) The inner rings of the crosshead bearing are fitted to the crosshead pin. And mark them with the corresponding labels (such as 1, 2, 3 or left, right and middle). Before installation, remove all the burrs and scratches. Tolerances are shown in Table 4, position H.

5) The inner rings of the middle eccentric bearingshall be mounted on the shaft. Mount the middle linkages in place, and then mount the inner retainer (5), tighten the hex bolt (8A) with toque of 75N·m (55lbf•ft), then lock it with wires.

6) Install baffle ring (7) in the slot of right eccentric bearing. Install the inner ring at the eccentric bearing of shaft. After installing linkage, mount the bearing inner retainer (14). Tighten the bolt (8) with the torque75N·m (55lbf•ft).

7) Mount left eccentric bearing and linkage (Refer to Clause 6 above).

8) Install the main bearing (9) in the bearing sleeve (the serial number (10) is the right side and the serial number (11) is left). And mount the outer retainer (11). Fastened the bolts (15) with a torque of 75 N · m (55 lbf • ft).

9) After mounting two main bearing retaining rings (16), install main bearing (9) on both sides of shaft. Install inner baffle (17) and bolt (18). Tighten the bolt with 75N·m (55lbf•ft).

3.5 Mount the Crankshaft Assembly on the Rack

In order to acquire precision fit between main bearing sleeve of F-1600HL pump and rack hole, please carry out installation according to the following procedures (Refer to Fig.21).

1) Insert one woodblock (See Fig.22) between the small end of linkage and crosshead guide plate to prevent the guide plate from damage caused by the sliding of linkage.

2) Rotate main bearing sleeve and make its two plane points (in 180 degrees' position respectively) parallel to the bolt hole of main bearing. Slowly lay down crankshaft assembly and put it in place (Reserve clearance between two plane points to allow main bearing bolt pass through it.).

3) After mounting crankshaft assembly on rack, check the roller of main bearing before installing main bearing cap (2). Ensure that each row of rollers of two bearings can support identical loads. The specific measures are as follows, rotate each row of rollers by hand. It is normal that 4-6 rollers will be seized due to gravity. However, it is not allowed of having the phenomenon that a certain row of rollers can be rotated. In addition, two sides of outer ring of floating bearingshall have approximately equal axial clearance. Main bearing cap (2) shall only be installed after check.

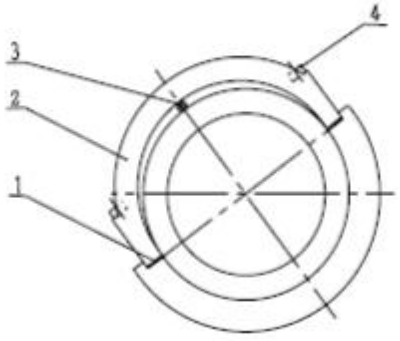


Fig. 20 Installation of Main Bearing Cap

(1) Washer (2) Bearing Cap (3) Lead wire (4) Main bearing bolt

4) Adjust the washer under bearing gland and make it to have pressing thickness of 0.06-0.10mm (0.0024"~0.0040") to acquire pre-tightening force. This pre-tightening force is acquired according to the appropriate total thickness of gasket. The final thickness of gasket is determined by the following methods,

a) Put **1.00 mm (0.0394")** original washer under bearing gland (at No.1)

b) Put a piece of lead wire (the approximate diameter is 0.8mm) or plastic clearance gauge between outer circle of bearing sleeve and inner circle of bearing gland. It shall be pressed in the middle position of bearing gland as much as possible.

c) Tighten the main bearing bolt. Torque is shown in Table 5;

d) Dismantle bearing gland to determine the clearance between gland hole and outer circle of bearing sleeve. It can be obtained by measuring depth at the flattening position of lead wire or compressed dimension (maximum dimension) of plastic clearance gauge with a micrometer.

e) Calculate total thickness of washer with this dimension. The calculation methods are as follows,

Final washer thickness= original washer thickness (it is 1.00mm (0.0394") in this manual) - flattening thickness of lead wire - (0.06-0.10) mm（0.0024"～0.004"）(amount of pressing interference).

Note: Because dimensional tolerance of left and right sides after machinery may not be same, left and right main bearing caps shall be measure respectively. Calculate washer thickness according to the measured values.

5) Put the washer with final thickness (as mentioned above) under main bearing gland. Tighten the bolt with the torque shown in Table 5.

6) Check the loads of inner and outer rows of roller on both sides of bearing every time (as mentioned above) to ensure that each bearing still has equal load.

Table 5 Main Bearing Bolt Torque Value

Description	Torque	Thread Specification	Wrench Specification
	N·m（lbf.ft）		mm（in）
Data	13210（9750）	3”-8UN	92.0（3-5/8″）

3.6 Installation of the Crosshead Guide Plate

1) Clean chamber of the rack and remove oil dirty and sundries on the surface of the guide plate, and remove burr and rough edge and corner.

2) If the old guide plate is used again, check whether the friction surface is worn or scratched. If yes, please replace them with new plates.

Note: The upper and lower guide plate of F-1600HL pump are different. So they are not interchangeable. The lower guide places the crosshead on the centerline of the frame, while the upper guide is machined to provide some clearance between the crosshead and the guide. Upper guide plate is thinner. There is a big bevel in the rear position and an oil hole in the middle position of upper guide plate.

3) Assemble the upper and lower guide plates and the tighten torque of its bolt is 257 N•m(190lbf•ft).

4) Check the tightness between the frame and the guide plate, with a 0.05 mm (0.002 in.) feeler gauge not inserted.

3.7 Installation of Crosshead

Crosshead can be installed from the frontend (fluid end) or the rear end of guide plate. See Fig. 22. The following notes shall be followed when installing the crosshead.

1) Completely clear off all dirt, remove the burrs and sharp edges on the surface of the crosshead circle, crosshead pinhole and the guide plate inner hole, etc., dry the crosshead pintaper hole to form metal-metal contact.

2) Keep the small end hole (eye) of the linkage at the side hole position of the crosshead. Pad the linkage with a woodblock to keep the crosshead to slide to the location where the crosshead pinhole is aligned with the small end hole of linkage.

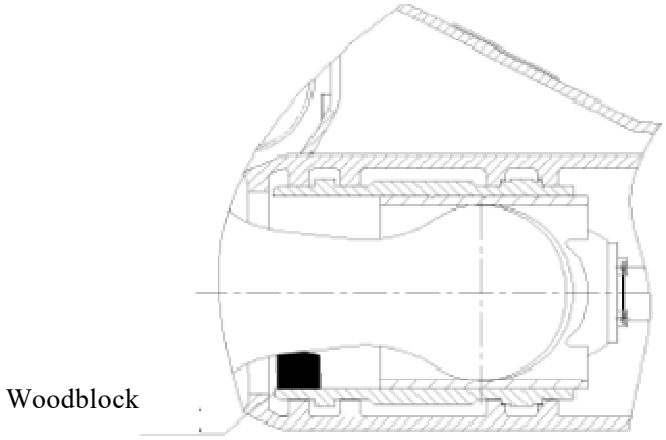


Fig. 22 Crosshead Assembly

3) Firstly install the left crosshead and then rotate the crankshaft assembly to keep the small end of the middle linkage into the middle of the crosshead. At this time, withdraw the right side of linkage hole, takeoff the fender plate, and push the right crosshead to the front chamber of the rack, and thus reserve sufficient space for installation of the middle crosshead, and then install the right crosshead.

Note: If the old crosshead is used again, check whether the slide surface of the crosshead is worn or scratched. And if necessary, install the crosshead at the opposite side of the pump, that is, the exchange position of the left and right crossheads and adjust 180 ° to allow the smooth surface at the bottom of the crosshead. The middle crosshead can also be adjusted for 180°, at this time, the crosshead pin shall be installed at the opposite direction. But remember not to insert the crosshead pin into the taper hole before the crosshead pin baffle is installed.

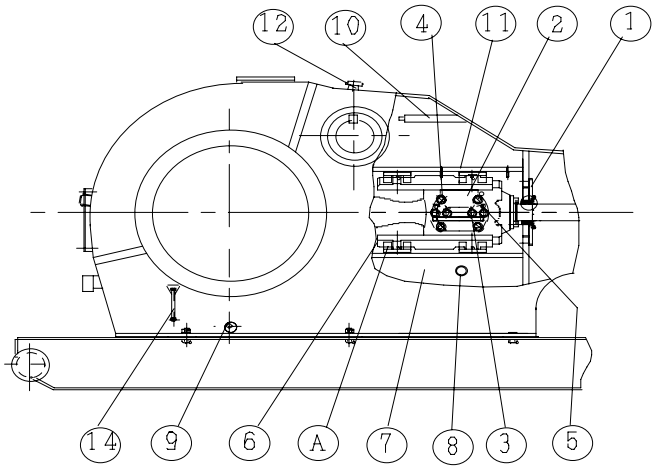


Fig. 23 Installation of Crosshead Assembly

(1) Fender plate (2) Crosshead pin baffle (3) Bolt (4) Bolt (5) Screw hole (6) Lower guide plate (7) Rack (8) Drain hole (9) Pipe plug (10) Oil collector (11) Upper guide plate (12) Vent cap (14) Oil level meter

4) Install the crosshead pin baffle (2) and bolt (3). At this time, rotate the crosshead pin to align the four bolt holes (4). Install the four bolts and tighten them with hands, as referred to Fig. 23, the oil sump shall be upward.

Lightly stick the large end of the crosshead pin and make them into the taper hole. Tighten the baffle bolts (3) and (4) and fix safety wire. Tighten bolt with torque of 290～310 N. m（215～230lbf. ft）.

Use torque wrench to tighten the bolts, don't exceed the above torque.

Note: The steps for pulling-out of the crosshead pins, take off four baffle bolts (4) and two of them are screwed into the top wire hole "(5)". Tighten the two "jack" bolts until the pins are loosened. Completely remove the crosshead pin plate (2) and take out the crosshead pin from the holes.

5) Put a long feeler gauge between the upper surface of the crosshead and the guide plate to check its moving clearance. This clearance shall be 0.62mm ～ 0.75

mm(0.024~0.03in). Check the whole surface of the crosshead with a long feeler gauge.

Note: The over-tightening of the crosshead pin baffle bolts (4) will cause the crosshead arc deformation, increase the opportunities for eccentric wear. At this time, it is required to loosen the crosshead pins and re-tighten them with a torque wrench according to the description as above 4).

3.8 Inspection of Crosshead Centering

To make the pistons correctly move in the cylinder liner, the crosshead must have a movement in a straight line along the horizontal axis of the rack. Check and adjust the centering of the crosshead according to the following steps,

1) Dismantle the end cover from cylinder liner and piston-nut, piston, spray pipe and hose clamp from piston rod, while clamp assembly is still used to connect piston rod and pony rod intently (Fig. 24).

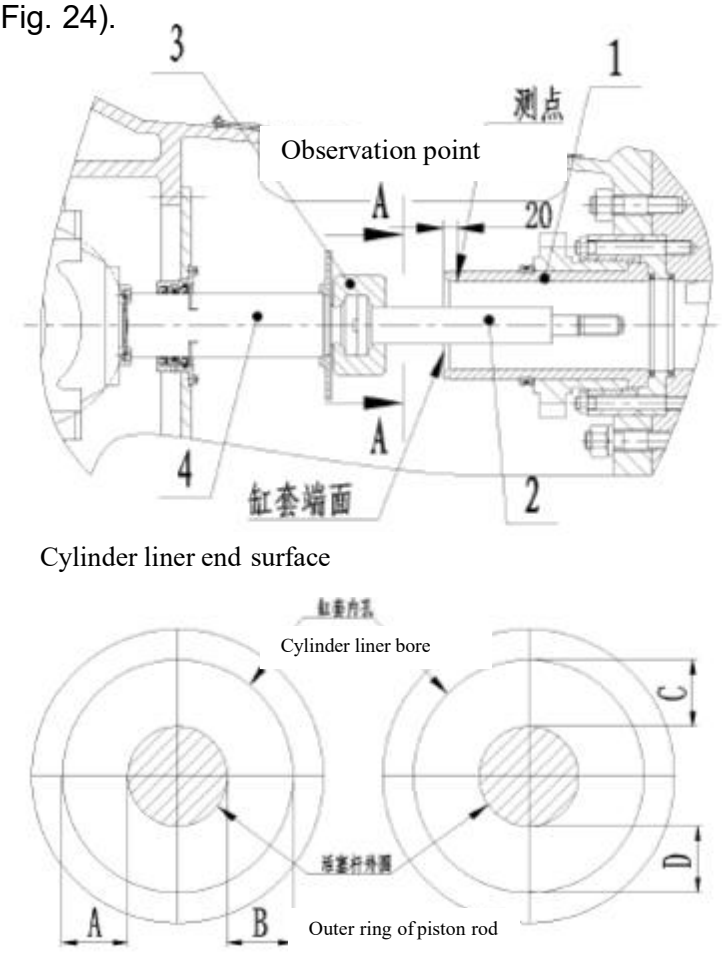


Fig. 24 Concentricity Measurement Diagram

(1) Cylinder liner (2) Piston rod (3) Clamp assembly (4) Pony rod

2）Horizontal distances from inner bore of cylinder liner to outer ring of piston rod are measured as A and B while vertical dimensions are measure as C and D, coaxially between the cylinder liner and piston rod is required to be:

Horizontal direction ±0.50 mm (±0.020"), namely｜A-B｜=1.00 mm (0.0394").

Vertical direction ±0.40 mm (±0.016"),that is ｜C-D｜=0.80 mm (0.0315").

Two positions required to check, crosshead places rear dead point (nearest to crankshaft center) and crosshead locates at front dead point as far as possible.

3) If there is sufficient clearance between the upper part of the crosshead and the upper guide plate, make the above adjustment. Since the angle between linkage, the lower guide plate has a heavy load, and the force at the back is relatively larger, so the wear and tear is larger, therefore, the guide plate is well padded.

4) After the concentricity is adjusted, clearance between crossheads of upper guide plates shall be modified, which shall be 0.62～0.75 mm(0.0244"~0.0295") for F-1600HL pumps. The clearance is expected to be reviewed after complete assembly and the minimum clearance shall be more than 0.50 mm (0.0197"). and it also shall be checked after long-term use of drilling pump and the maximum clearanceshall be less than 1.00 mm (0.0394").

5) The steel spacer shall be cut sufficiently long to pass the guide plate completely. Cut into a protruding part at the side and exceed the support of the rack. Refer to the sections (3) and (4) of “Installation of crosshead guide plate”.

3.9 Maintenance of Fluid end

Over the years, hydraulic cylinder has been regarded as a non-loss part, because it cannot be punctured by the erosion of liquid like other parts. However, nowadays the enhancement of pressure of drilling equipment adopted cause occasional occurrence of damage to hydraulic cylinder. However, regular good maintenance will enable parts at fluid end to get reasonable service life.

Some major maintenance items are described as below,

1) All valves in one end of outlet port must be opened before operation. Impact load on the pump will lead to fatigue crack when the valve is closed. And it is possible to have fissure cracked and the small crack will start the course of *Corrosive Fatigue Fracture*.

2) Do not close the clutch when the prime mover (diesel engine, motor and its transmission) runs at high speed, because this will cause impact load that we do not expect, which is bad for both motive power end and fluid end.

3) Proper maintenance shall be given to the relief valve to ensure it can be opened when the adjusted nominal pressure is exceeded, and the adjusted pressure is related to the dimension of the cylinder liner, and see introduction in *ShearPin Relief valve* for details.

4) When serious hydraulic impact happens, do not use the pump for a long time.

Perform proper maintenance of fluid end. When the pump is not in use or cease operation for more than 10 days, it is suggested to dismantle some parts such as piston, piston rod, cylinder liner from the fluid end, rinse the power end thoroughly with water, wipe up after washing,and then coat the machined surfaces such as sealing end, cylinder liner flange screw, valve bonnet screw, valve seat with protective grease. Of course, the parts removed from the pump including cylinder liner, piston shall also be taken protective treatment. Doing in this way not only extends the service life of the fluid end but also protects wearing parts removed from the pump so that they are in good condition and can be installed for use when the pump restarts.

The fluid end assembly of triplex pump consists of three forged hydraulic cylinders, cylinder liner, valve bonnet and cylinder head, suction pipe and discharge pipe.

3.9.1 Hydraulic cylinder

For the structure of suction, discharge hydraulic cylinder see Fig. 25. And the size see Table 6.

The fluid end consists of three pairs of interchangeable suction and discharge cylinders. The discharge cylinders are connected to the metal by studs with power-end frame, through the holes of the power end frame and the wear plate to ensure that the power end and discharge cylinder alignment. In the same way, the suction and discharge hydraulic cylinder are positioned through the metal boss of the suction hydraulic cylinder and connected by bolts. For accurate alignment, groove marks, burrs and dirt on the combination surface of the rack hole and hydraulic cylinder, wear resistant plate must be removed, otherwise “warping” or deflection will be produced after the three are connected.

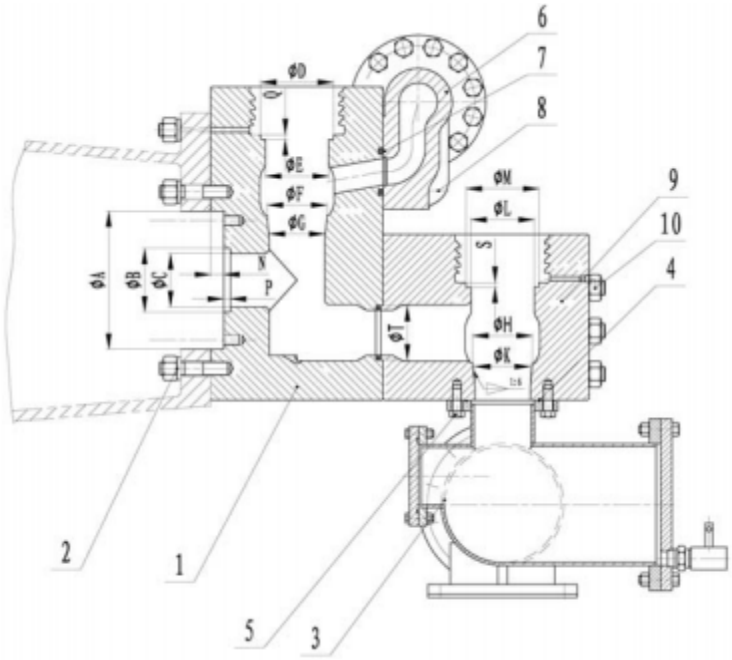


Fig. 25 **Hydraulic Cylinder**

(1) Discharge hydraulic cylinder (2) Bolt (3) Suction pipe (4) O-ring (5) Bolt (6) Discharge pipe (7) O-ring (8) Bolt (9) Suction hydraulic cylinder (10) Bolt

Table 6

Position	Dimensions(mm)	Dimensions(inch)
A	368.275-368.325	14.499-14.501
B	170.063-170	6.695-6.693
C	143.25-143	5.640-5.630
D	187.46-187.33	7.380-7.375
E	168.66-168.53	6.640-6.635
F	158.8-158.67	6.252-6.247
G	148.02-147.82	5.827-5.820
H	158.8-158.67	6.252-6.247
K	148.02-147.82	5.827-5.820
L	168.66-168.53	6.640-6.635
M	187.46-187.33	7.380-7.375
N	33.9-33.7	1.335-1.327
P	15.85-15.75	0.624-0.620
Q	12.8-12.6	0.504-0.496
S	12.8-12.6	0.504-0.496
T	Hole：140.000～140.063 Shaft：139.894～139.957	Hole：5.512-5.514 Shaft：5.508-5.510

3.9.2 Suction pipe

Suction pipe (3) connects each hydraulic cylinder (9) by bolts, seal the combination surface of flange with O-ring (4). Rinse thoroughly O-ring groove and the O-ring seal at the bottom of hydraulic cylinder, put in the O-ring before installing the suction pip, flange must

be a metal-to-metal connection to ensure the seal of O-ring. Therefore, any nicking groove or punctured part on the sealing surface must be repaired before installation. See section (3.10) Repair Welding and Repair in this manual for repair procedures.

Before tighten discharge pipe nuts (5), first screw bolts in the three hydraulic cylinder (do not tighten when it looses), and then tighten the nuts connecting pump head with the rack according to the torque value shown in Table 7 with torque wrench. (See the description below)

3.9.3 Discharge pipe

Tighten the bolt (8) of the exhaust pipe on every hydraulic cylinder and use O-ring (7) to seal on connecting flange. Clean the O-ring recess and adjoining plane on the hydraulic cylinder thoroughly before the installation of the exhaust pipe. It must be metal-to-metal connection to press O-ring. So any notch, groove and puncture on the sealing faceshall be renovated before the installation (See repair welding and repair section of this manual for details).

Before tighten discharge pipe nuts (5), first screw bolts in the three hydraulic cylinder (do not tighten when it looses), and then tighten the nuts connecting pump head with the rack according to the torque value shown in Table 7 with torque wrench.

3.9.4 Suction hydraulic cylinder

The replaceable suction hydraulic cylinder (9) is tightened on the discharge hydraulic cylinder (1) by bolts, and the suction hydraulic cylinder must form a metal to metal connection, in order to ensure the axis on the end face and hydraulic cylinder vertical. Therefore, make sure that the burrs, salient points and foreign bodies on the joint surface are removed before installation. Tightening torques of nuts (10) are shown in Table 7.

Table 7 Tightening Torque

Position	No. in the picture	Torque N•m	Torque lbf•ft
With the rack	2	2152	1590
Suction pipe	5	195	145
Discharge pipe	8	2786	2055
Suction hydraulic cylinder	10	3538	2610

3.9.5 Valve seat disassembly

The disassembly tools and method used for the suction and discharge hydraulic cylinder are consistent.

First, remove all parts such as the bonnet, valve spring, valve body assembly above dimension of machined hole shall comply with the data specified in Table 6. Furthermore, the shoulder of hole (installing cylinder liner, bonnet and cylinder head, etc.) shall make an angle of 90 degrees with the axis of hole in all conditions.

3.10.1 Welding procedures

Welding is usually divided into two types: (A) "punctured"(include normally worn and punctured), (B) crack. The basic information of repair is listed as below.

A Punctured (include normally worn and punctured)

Clean area to be given repair welding: clean welding zone by gouging or grinding method to expose the medal.

Procedures for repair welding of puncture are as follows,

a) Welder shall observe requirements of safety, qualification and technology related welding process.

b) Adopt shielded metal arc welding method, welding material shall be electrode conform to AWS A5.1 E7018 or GB/T5117 E5018.

c) Using of welding material shall execute the requirements of product instruction of manufacturer.

d) The range of preheating of repair welding area shall be at least 75mm(3″) at all directions, heating temperature is not less than 200℃ (392℉) , layers temperature is 200°~350℃ (392℉~662℉) .

e) After one course welding finished, shall clean carefully. When confirm there is no defect, weld next. After welding completed, heat welding area and surrounds to 350℃ (662 ℉) and keep 10 minutes, then cool naturally.

B Crack

Clean of repair welding area: remove all cracks by mechanical means. If gas cutting is anticipated to use for removal of crack, it only leads to speed of crack propagation more than metal ablating velocity, so the method is not advised.

Preheating: The purpose of preheating is to enlarge the welding zone so that the cooling of preheating zone is more consistent with that of weld repairing area in the cooling process. Eliminating hot cracking when welding can prevent forming hard points between solder and basic metal, obviously, this kind of hard point is the position easy to cause fatigue crack.

Procedures for repair welding of crack are identical with that for above-mentioned puncture.

3.11 Repair of Bonnet Hole

When repairing erosive (punctured) of bonnet hole, the most important thing is to keep the plane of the valve bonnet seat completely flat and at the angle of 90 ° with the axis of the thread when turning or grinding, as shown in Fig. 27. Valve bonnet retainer ① mounted in the sink hole at the top of the valve bonnet hole form a metal-to-metal connection. Obviously, high points formed on the valve bonnet during any welding or low points formed due to over-grinding on the welding point will form clearance between the bottom of valve bonnet and the plane of hydraulic cylinder, obstructing ring will be extruded or punctured under pressure. High or low points will also form a "tilting" on the valve bonnet, since the two thread axises are not perpendicular, its consequence is to lead to serious damage to screw thread.

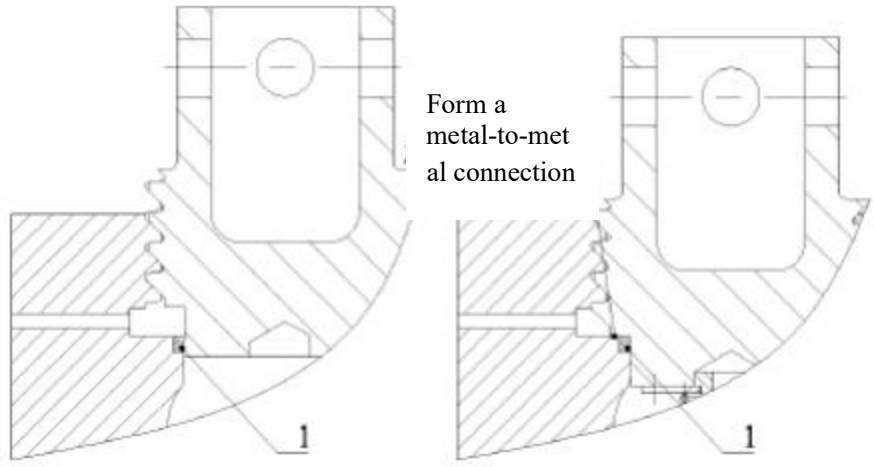


Fig. 27 Bonnet Repair

3.12 Replacement of Bladder

Replacement of bladder can be carried out in accordance with the following procedures (refer to Fig. 12):

1) Confirm that the system has been decompressed completely (refer to 1.7 Pulsation dampener assembly).

2) Dismantle the cover (2), you can use three dismantle screw to push it out, if stud is screwed out from the Enclosure when disassembling, first remove the nut (R1), then rinse the bolt and screw, then screwed in the stud (with a special stud wrench or tighten two nuts

with a common wrench), with tighten torque of 1600N.m(1180lbf•ft).

3) Remove the bladder.

Insert a bald bar without burrs, edges and corners from the middle of the bladder and Enclosure, flatten the bladder and take it out from the top.

4) Check if the bladder is damaged. If the bladder is damaged due to be punctured, inside the Enclosure and then check whether there is lump or foreign substance in the Enclosure and damage-related position resulting in the damage, factors caused the damage must be eliminated.

5) Intall a new bladder.

Flatten the bladder and roll it into a spiral shape so that it can be put in from the opening on the top of the pulsation dampener, then stretch it and adjust the bladder to make it touch with the Enclosure, finally push obstructing ring on the neck of the bladder to the opening of the Enclosure and apply lubricating grease to inner side of the neck.

Bend the balance disc and put it into the bladder, compress with pressing plate, spring washer and bolts.

6) Install top cover (2).

7) Tighten nut (R1) with tighten torque of 4418N.m(3260lbf.ft)

8) Inflate according to the methods described in section 1.7.2.

3.13 Approximate Weight of Each Assembly

Name	Pinion Shaft Assembly	Crankshaft Assembly	Crosshead	Crosshead Pin & Baffle	Rear Cover	Suction Manifold	Connection part of 1/3 fluid end
Weight: kg	1319	7534	200	92	245	366	1965

Note: The 1/3 connection part of fluid end refers to one pump head (including suction and discharge hydraulic cylinder, etc.). Triplex pump has three pump heads in total. Each pump head can be regarded as one part.

4 Maintenance and Inspection Point

Proper and timely maintenance of drilling pump is a necessary measure to ensure normal operation of the pump and extend its service life, which shall be paid attention at the time of using any of the pumps.

4.1 Daily Maintenance

(1) Check oil level at power end at least once a daywhen oil surface is stable. If chain drive is used, shall also check oil level of chain box.

(2) Check the oil pump pressure gauge changes. If the pressure is found to be very small (less than 0.035MPa) or no pressure, shall promptly check the suction and discharge filter whether the phenomenon of blocking.

(3) Check whether the work of the suction dampeneris normal.

(4) Check the exhaust dampener inflation pressure, whether to meet the operating conditions.

(5) Check the reliability of the safety valve, if necessary, shall be replaced.

(6) Observe the cylinder and piston working condition. There is a small amount of mud dragged out by the piston, is the normal situation. If the occurrence of a thorny situation, the timely replacement of the piston and check the cylinder liner hole wear, such as wear and tear is larger, the cylindershall also be replaced.

(7) Check the front chamber, if there is a large number of mud, oil precipitation, shall be cleaned.

(8) Check the water tank of spray pump, water shall be added to the insufficiency, and pollution shall be replaced, but also need to clean the tank.

(9) Loosen the piston rod clamp every day to check whether the clamp cone and the piston rod, the pony rod is clean, and the piston rod is rotated by a quarter turn. In this way, the wear surface of the piston can be evenly distributed to extend the service life of the piston and the cylinder liner.

(10) Before installing the cylinder head and bonnet, coat grease to the surface of the thread. Check every 4 hours whether there is a loose phenomenon.

(11) Often observe the bonnet seal, cylinder seal (including wear between the disk and the cylinder seal) alarm hole, if the mud discharge, it shall promptly replace the corresponding ring.

4.2 Weekly Maintenance

(1) Remove the bonnet and liner once a week, remove the sludge and clean it. Coat extreme pressure (composite) lithium grease.

(2) Check the inner sleeve of the stem guide, if it has been obviously worn (the gap between the valve guide rod and the guide is more than 3mm) shall be replaced so as not to damage the guide to the steering effect.

(3) Check service condition of valve and valve seat, replace seriously worn or punctured valve, valve rubber and valve seat (shall also pay attention to replace valve at the same time of replacing valveseat), check valve spring, replace broken spring or spring losing elasticity.

(4) Check lock nut of piston, in case of corrosion or damage, it shall be replaced (because the O-ring inside the nut has lost its ability to lock in general after the nut has been fastened three times).

(5) Discharge water from the plug of sewage flange once until oil can be seen.

(6) Check and clean strainer in the pipeline of grease pump once.

4.3 Monthly Maintenance

1) Check all studs and nuts at fluid end, such as flange nuts on cylinder cover, nuts connecting hydraulic cylinder and the rack, coupling bolts and nuts on suction manifold and exhaust manifold, etc. If there is looseness, tighten according to the stipulated torque values.

2) Check sealing ring in the packing box of pony rod, replace it if it has worn, usually replace at least once every three months, shall pay attention to direction of oil seal upon replacement. (inward main seal lip)

3) Dismantle and clean filter drum installed in the discharge screen.

4) Replace dirty oil in oil sump at motive power end and crosshead sedimentation oil sump once every six months, then clean up the oil sumps at the same time.

4.4 Yearly Maintenance

(1) Check the crosshead and guide surface wear, check the cross head guide is loose, crosshead operation gap is in line with the requirements. Spacer can be added under the guide plate to adjust the clearance. Can also rotate the crosshead at 180 ° and use it (for easy operation, you can change the position of the crosshead).

Crosshead shall be discarded when the outer surface of crosshead is worn more than 2mm （0.079"）or 3mm (0.118") marks are more than 5 place or taper hole reformatted;

Guide plate shall be discarded when guide plate has crack, or inner surface of guide plate is worn more than 2mm （0.079"）or 3mm (0.118") marks are more than 5 places;

(2) It is recommended to carry out a comprehensive inspection on the pump once every two years or three years. Check if main bearing, linkage bearing, crosshead bearing, input shaft bearing are worn or damaged, if cannot continue to be used, shall replace by a new one.

The discard clearance of each bearing: main bearing 0.40 mm (0.0157"); Input shaft bearing 0.24(0.0094") mm; crosshead bearing 0.35 mm (0.0138"); eccentric bearing 0.50 mm (0.0197").

(3) Check wear condition of gear pair, if badly worn, shall make U-turn installation for driven shaft and driving shaft simultaneously to make use of tooth surface without wear.

Gear shall be discarded when has crack, broken tooth and open pitting corrosion on gear surface of more than 2mm（0.079"）.

For easier reference, above maintenance check points are now shown in Table 8 and Fig. 28, please execute carefully.

4.5 Other Matters to be Paid Attention during the Maintenance

(1) Before mounting the clamp of pony rod and piston rod, the tapered surface must be wiped clean.

(2) When replacing cylinder liner, sealing ring of the liner must be replaced together.

(3) After the pump is stopped in winter or temporary stoppage of the pump for more than ten days, must discharge mud in valve chamber and cylinder liner and rinse them completely.

(4) All inspection windows and holes of pump shall be covered in a right way to prevent dust from mixing into lubricating oil inside.

(5) Discharge pulsation dampener can only be filled with nitrogen or air, it is prohibited to fill with inflammable or explosive gases such as oxygen, hydrogen and so on.

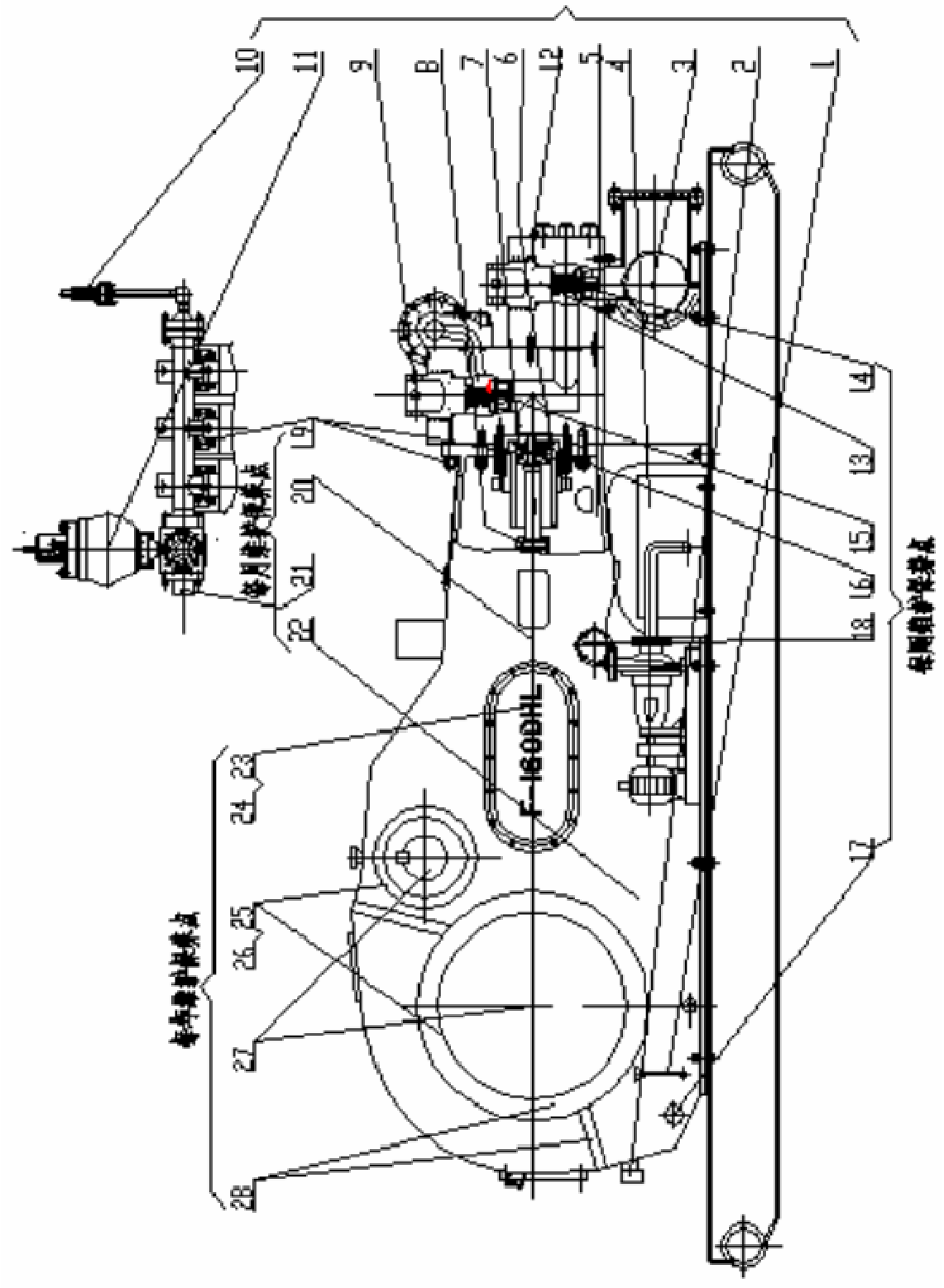


Fig. 28 Routine Maintenance

Table 8 Routine Maintenance List

Period	No.	Routine Maintenance Contents
Daily	1	Stop the pump to check oil level, if the oil level is too low, increase it to

		the desired height
Daily	2	If the reading of lubrication pump pressure gauge is normal, if pressure is too low, check the cause timely
Daily	3	Check that the air dampeneris working properly
Daily	4	If cooling lubricant in water tank of spray pump is in shortage, fill it up; if goes bad, replace it.
Daily	5	Check the cylinder liner of the rack, if there are a large number of slurry or oil deposits, shall clean up
Daily	6	Observe if the seals of piston and cylinder liner has leakage, make replacement if serious
Daily	7	Observe if piston and cylinder liner has leakage, make replacement if serious
Daily	8	Loosen the clamp on piston rod once a day, tighten the clamp after turn the rod by a quarter of a circle
Daily	9	Check whether the bonnet is loose once every 4 hours, and often coat with lubricating grease on the screw thread.
Daily	10	Check if relief valve is reliable
Daily	11	Check if pre-charge pressure in discharge pulsation dampener is normal n when stopping the pump
Daily	12	Observe indicator hole, if there are slurry discharged, replace the corresponding O-ring timely Judge whether the pump valve operates normally by means of hearing, and check it if not.
Weekly	13	Remove the bonnet, clean the mud, coated with molybdenum disulfide composite calcium-based grease
Weekly	14	Check the inner sleeve of valve stem guider, if the wear and tear exceeds the requirement, it is needed to be replaced
Weekly	15	Check suction and discharge valve, valveseat, valve rubber and valve springs. Make replacement if there is any damage
Weekly	16	Check if piston locknut has corrosion or damage. If so, make replacement (generally can be used three times)
Weekly	17	Check if filter screen in lubrication system is clogged. If so, it shall be

		cleaned up
Weekly	18	Unscrew plug from sewage flange to discharge dirt and water accumulated in the oil pool
Monthly	19	Check if bolts and nuts at fluid end loose or damage, if any, tighten or replace as required
Monthly	20	Check O-ring in the packing box, replace it if worn, make replacement at least once every three months
Monthly	21	Check whether the filter in the discharge pipe is blocked by sundries and so on, and clean it if it is blocked.
Monthly	22	Replace dirty oil in oil pool of power end and cross head sedimentation oil tank every six months and rinse completely
Yearly	23	Check the wear condition of cross head and surface of guide plate, if necessary, can rotate the cross head 180 ° for reuse
Yearly	24	Check if guide plate has looseness, if cross head clearance meets the requirements, if not, they shall be checked and regulated
Yearly	25	Check the pinion shaft, crankshaft tooth surface wear and tear, if necessary, use the surface
Yearly	26	Check if pinion shaft assembly, crankshaft assembly are intact, measures shall betaken if there is anomaly
Yearly	27	Check if bearing at the power end has damage, if so, make replacement
Yearly	28	Check seal condition of back cover, crankshaft cover and other parts, if fail to achieve a good seal effect, make replacement

5 Possible Failures and Solutions

If failure occurs when drilling pump is in operation, shall find out the cause and clear the failure timely. Otherwise, it may cause damage to the parts and affect the normal drilling work.

5.1 Failure of Fluid end

Table 9 Troubleshooting of Fluid end

Failures	Causes	Troubleshooting
1. The value of pressure gauge drops, discharge amount reduces or no discharge of mud.	1.Suction manifold are not sealed tightly, resulting in the entering of air into the pump 2.Suction filter is blocked.	1.Tighten the flange bolts of suction manifold or replace the gasket. 2. Stop the pump to clear debris off the suction filter.
2. The liquid discharge is uneven with suddenly large or suddenly small impact. Amplitude of swing of pressure gauge pointer is too big. Suction manifold have whirs.	1.One of the pistons or valves is badly worn or damaged. 2. Air enters into the pump cylinder.	1. Replace damaged piston, check if pump valve is damaged or stuck. 2. Check if suction manifold and valve bonnet are sealed tightly.
3. There are drastic beats at the cylinder liner.	1. Piston nut loose. 2. Cylinder liner gland loose. 3. Poor suction cause water hammer.	1. Tighten the piston nut. 2. Tighten the cylinder liner gland. 3. Check the cause for poor suction.
4. Indicator holes at valve bonnet, cylinder cover and cylinder liner seal have mud leakage.	1. Valve bonnet is not tightened. 2. O-ring is damaged.	1.Tighten the valve bonnet. 2. Replace the O-ring.
5. Discharge pulsation dampener cannot be filled in the gas or the air leaks soon after filled.	1. Gas-filling joint is blocked. 2. Capsules in the pulsation dampener have been broken. 3. Needle valve is not sealed tightly.	1.Remove debris off the joint. 2. Replace the capsules. 3. Repair or replace needle valve.
6. Diesel engine has heavy load.	Discharge filter cartridge is blocked.	Remove the cartridge for clearing debris away.

5.2 Failure of Power End

Table 10 Troubleshooting of Power End

Failure	Cause	Troubleshooting
1. Temperature of bearing is high	1. The oil pipe or oil hole is blocked 2. The oil is too dirty or deteriorated 3. The rolling bearing is worn or damaged 4. Too much or too little oil	1. Clean the oil pipe and oil hole 2. Replace the oil 3. Repair or replace bearings 4. Make the amount of oil appropriate
2. The power end with percussion sound	1. The crosshead guide plate has been seriously worn 2. The bearing is worn 3. The guide plate is loose 4. The fluid end with water hammer phenomenon	1. Adjust the gap or replace the worn guide plate 2. Replace the bearing 3. Tighten the bolts of guide plate 4. Improve the suction performance
3. Oil leakage at the pony rod packing box	1. The seals are damaged 2. The lower guide plate is seriously worn	1. Replace the seals, and it is recommended to replace them every three months 2. Examine and repair the crosshead guide plate

5.3 In addition to the above possible failures

Such as the discovery of other anomalies, due to the location of the failure to find the reasons carefully, until the cause identified and excluded after the drilling pump can be normal operation.

6 Storage Precautions

When drilling pump doesn't use or shut down for a long time, protect and store according to following requirements:

6.1 Protection of Fluid end

6.1.1 Drilling fluid of fluid end (inclusive of pulsation dampener and relief valve) shall be drained before stored and wash with clean water, and remove dirty of all parts and components of fluid end and cylinder liner cavity. Takeout parts, such as valve body, valve spring, valve guide, cylinder liner, piston, piston rod, bonnet, and cylinder cover, plug, hydraulic liner gland, etc. Dry these parts and inner cavity of cylinder in open air and wipe cleanly, and then let finished surface of them are coated with rust-preventative lubricating oil for bearings with dynamic viscosity (40℃) no less than 100 mm2/s. And connecting threads of bonnet and cylinder, and connecting threads of flange of cylinder liner shall be coated with lithium base grease. All these parts shall be put in cylinder successively and tighten up bonnet, cylinder liner gland.

6.1.2 For discharge screen, pressure gauge, discharge five-way assembly or connector of relief valve, mutual mating surface and ring groove of sealing gasket shall be provided with rust-preventative lubricating oil for bearings with dynamic viscosity (40℃) no less than 100 mm2/s.

6.1.3 Faces of discharge flange on both side of fluid end and ring groove of sealing gasket shall be provided with rust-preventative lubricating oil for bearings with dynamic viscosity (40℃) no less than 100 mm^2/s.

6.1.4 Suction inlet and outlet port shall be blocked with blind plate.

6.1.5 Exhaust pulsation dampener completely.

6.2 Protection of Power End

6.2.1 Drain water tank of spraying pump entirely and keep it dry.

6.2.2 Discharge engine oil at the bottom of gear case of power end.

6.2.3 Open sewage flange for draining sedimentation basin.

6.2.4 Bearing, crosshead, guide plate, gear, pony rod on power end shall be coated

with rust-preventative lubricating oil for bearings with dynamic viscosity (40℃) no less than 100 mm^2/s to form a coating of protective oil film.

6.2.5 Mount piston rod and pony rod and coat exposed parts of the pony rod with rust-preventative lubricating oil for bearings with dynamic viscosity (40℃) no less than 100 mm^2/s, and wrap up with oil paper.

6.2.6 Cover, rear cover, eyehole cover of crosshead shall be sealed tightly.

6.2.7 Dismantle air filter on upper part of rack and block with screwed plug tightly.

6.2.8 Shaft extension of pinion shall be coated with rust-preventative lubricating oil for bearings with dynamic viscosity (40℃) no less than 100 mm^2/s or lubricating grease and protective measures.

6.3 Storage

The drilling pump shall be stored at dry, clean, less dust and vibration-free site. It shall be placed on flat position. It is advisable to store at storeroom and cover it with waterproof cloth for outdoor storage. Riser vent of the waterproof cloth shall be opened after rain to dry vapors within it, and then cover the riser vent tightly. If drainage of storage site has been blocked, the pump shall be raised with cushion block, the position of cushion block is shown as Fig. 29. The distance from ground shall be no less than 100 mm (4") to avoid soaking and rusting.

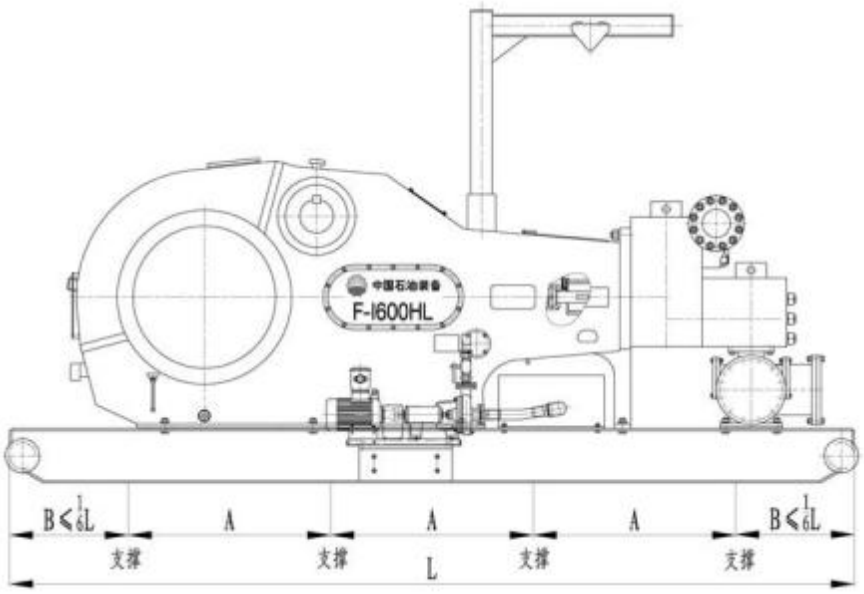


Fig. 29 Schematic Diagram of Position of Cushion Block

Surrounding and top of drilling pump shall be protected sufficiently to avoid damages

arising from other articles' falling or collision. Accessory case of the drilling pump is filled up with rubber articles, so it shall be stored at dry environment to avoid contact with sun directly, fluid and ozone, as well as radioactive substance.

7 Ordering Information

7.1 Single pump range

Single pump includes: pump body, spray pump, pulsation dampener, relief valve, auxiliary tools and disposable rubber seal for replacement.

Single pump does not include pulley, skid.

Spray pump adopts motor drive, if need shaft head belt drive spray pump, users shall specify when ordering.

Lubrication oil pump at drive side adopts built-in structure. If users require other drive types,it needs to specify them.

When users have not special requirements, pumps will be assembled with φ 260-cylinder liner piston when out of factory.

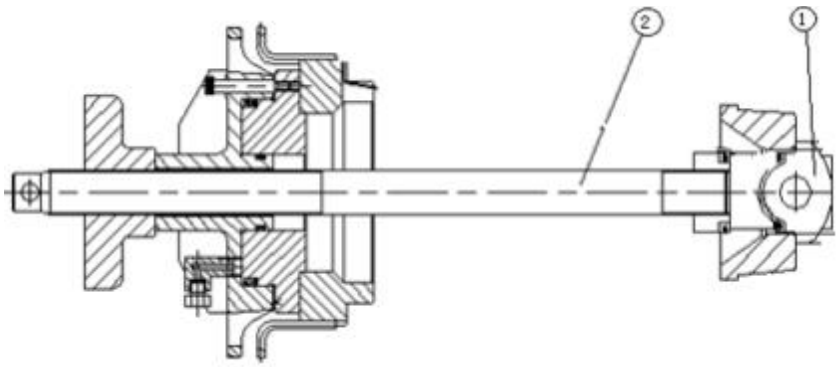
7.2 Metric and imperial products

F series pump metric system, the British two types, by the user choice.

Metric pumps are made of metric threads. British pump with US-made thread.

8 Use of Special Tools

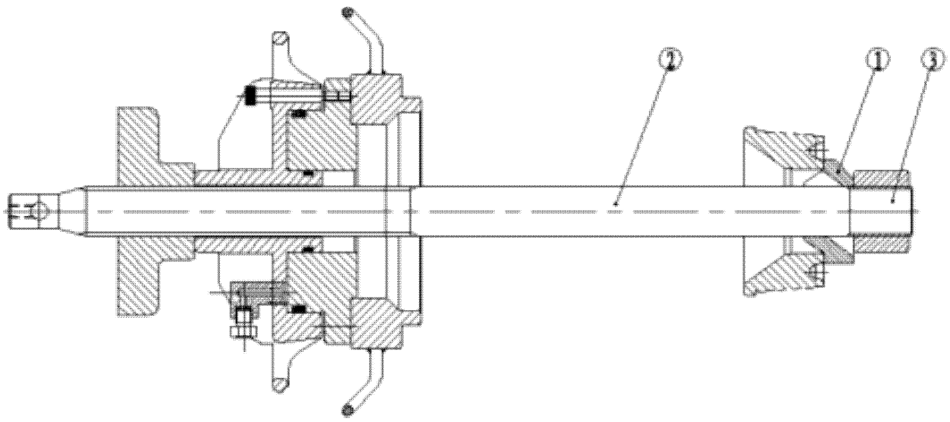
8.1 Ordinary Valve Seat Extractor - Hook Type (When using ordinary valve assembly)



(1) Hook assembly AH130101-16060200

(2) Screw AH160201-090101

8.2 High Pressure Valve Seat Extractor - Tray Type (When using high pressure valve assembly)

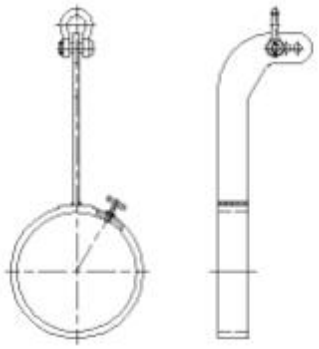


(1) Hook AH160201-0908B1

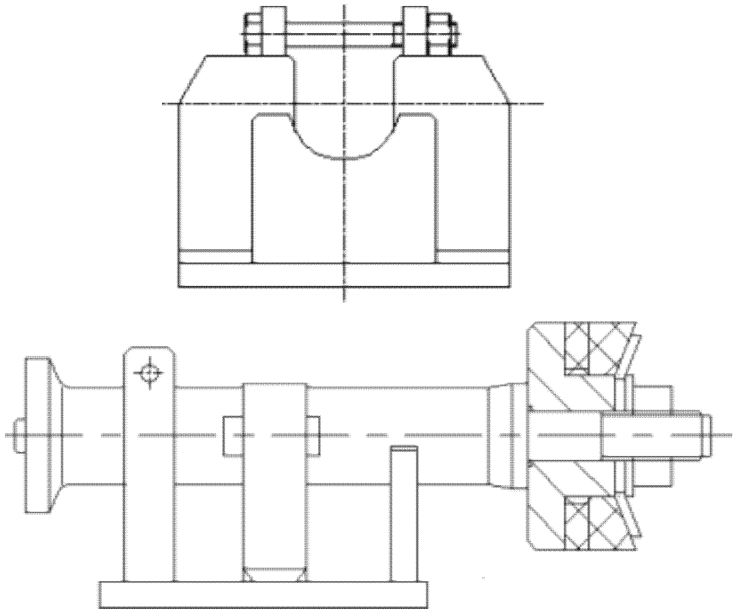
(2) Lengthen screw AH160201-0907B2

(3)Thick Nut M48×3（AH160201-0911）

8.3 Hoisting Tools of Cylinder Liner AH130102-100100



8.4 Dismantlement Frame of Piston Nut AH130101-161400

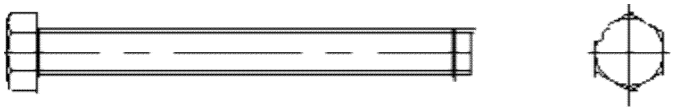


8.5 Conversion coupling (AH100102-1302)

Conversion coupling used for dismantling connection bolts of pony rod and crosshead.

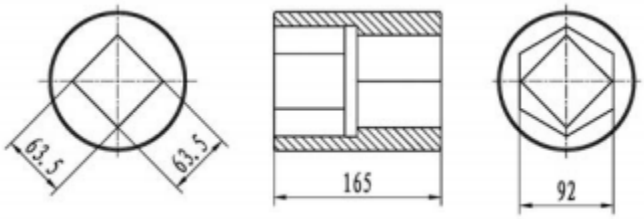
8.6 Bolt 1"-8UNC×8 3/4 (AH130102-1002)

Used for dismantling the wear plate

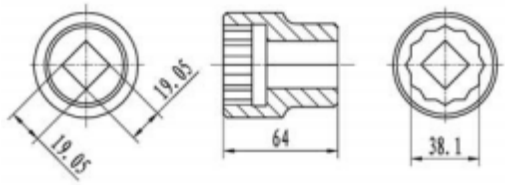


8.7 Sleeve-- Tool for Dismantling Nuts of Fluid end

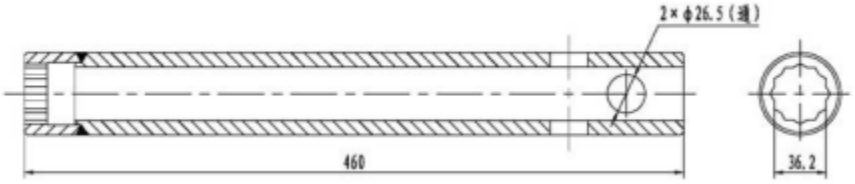
8.7.1 Sleeve 3 5/8（AH130101-1602）



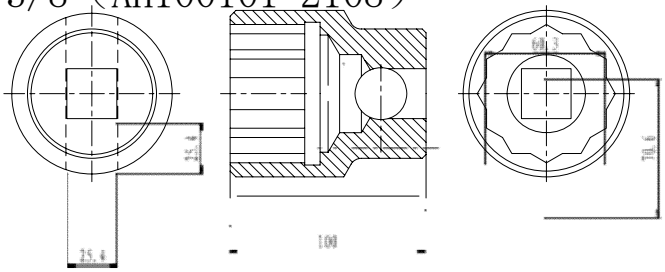
8.7.2 Sleeve 1 1/2（AH130101-1603）



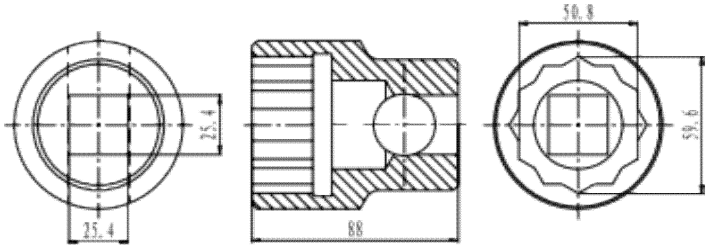
8.7.3 Long Sleeve（AH130101-161000）



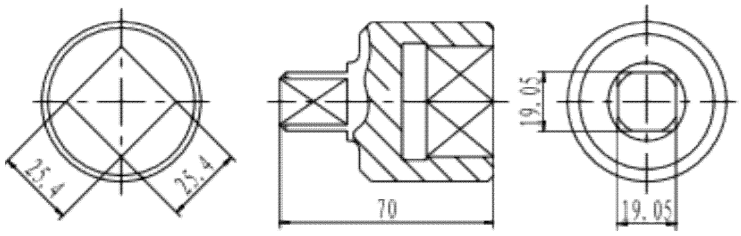
8.7.4 Sleeve 2 3/8（AH100101-2108）



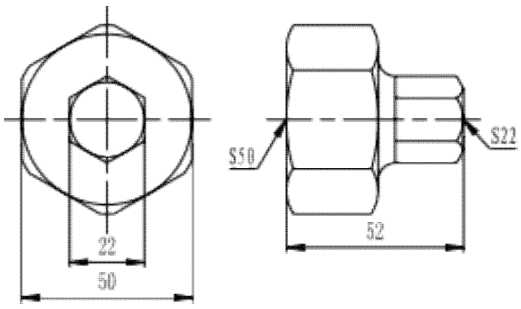
8.7.5 Sleeve 2″（AH100101-2109）



8.8 Conversion adapter (Used to transition the sleeve from 19.05 to 25.4)



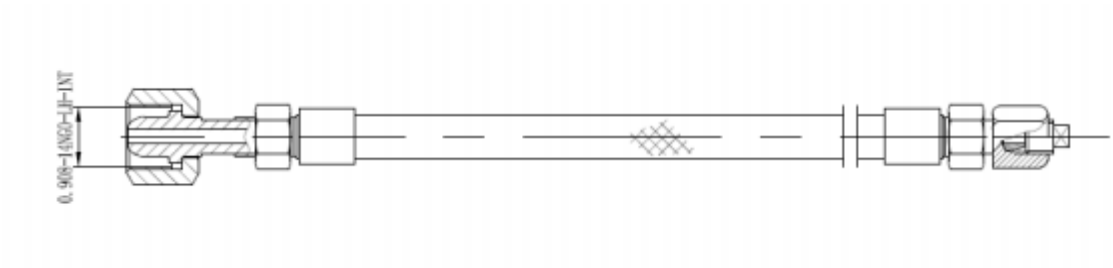
8.9 Conversion adapter（Use to remove the hexagon screw of the discharge flange）



8.10 Cylinder head rod AH100101-210100

For disassembly cylinder head, bonnet.

8.11 Gas-filling Hose Assembly of Pulsation dampenerAH100102-130100



9 Guide for Selection of Lubricating Oil

Lubricating Position and Description	Ambient Temperature	Oil Specifications	Recommended Oil Products		
			Kunlun	Changcheng	Mobil
Mud pump gear box (Note: the oil contains antirust and anticorrosion, foam-inhibiting and parathion-based extreme pressure wear-resisting additives)	+10°C～+68°C	AGMA Mild EP # 7 * L-CKD 460 Industrial Enclosed Gear Oil (GB5903)	KG460 Heavy-duty Gear Oil CKD460 Gear Oil	L-CKD 460 Industrial Enclosed Gear Oil	Mobilgear 634
	-7°C～+38°C	AGMA Mild EP # 6 * L-CKD 320 Industrial Enclosed Gear Oil (GB5903)	KG320 Heavy-duty Gear Oil CKD 320 Gear Oil	L-CKD 320 Industrial Enclosed Gear Oil	Mobilgear 632
	-29°C～+16°C	AGMA Mild EP #2 * L-CKD 68 Industrial Enclosed Gear Oil (GB5903)	KG68 Heavy-duty Gear Oil	AP-L 68 Industrial Gear Oil	Mobilgear 626
	-40°C～+27°C	L-CKT 220 Synthetic Extreme Pressure Industrial Gear Oil	KG/S220 Heavy-duty Gear Oil	L-CKT 220 Synthetic Heavy-duty Industrial Gear Oil	Mobilgear SHC 220
Grease-lubricated bearings (for spray pump, drive shaft, cardan shaft) Bonnet thread, and discharge filter cover thread, etc.	-50°C～+16°C	L-CKT 150 Synthetic Extreme Pressure Industrial Gear Oil	KG/S150 Heavy-duty Gear Oil	L-CKT 150 Synthetic Heavy-duty Industrial Gear Oil	Mobilgear SHC150
	Above 0°C	NLGI 2 Extreme Pressure Lithium Base Grease	2# Extreme Pressure Lithium Base Grease	2# Extreme Pressure Lithium Base Grease	Mobilux EP 2
	Below 0°C	NLGI 1 Extreme Pressure Lithium Base Grease	1# Extreme Pressure Lithium Base Grease	1# Extreme Pressure Lithium Base Grease	Mobilux EP 1