



用户手册
User Manual
Руководство пользователя

HH2400 Mud Pump

NB019-SC

Nov. 2017

四川宏华石油设备有限公司
SICHUAN HONGHUA PETROLEUM EQUIPMENT CO., LTD.
Сычуаньская компания нефтяного оборудования ХунХуа



HH2400 Mud Pump

Installation, Operation, and Maintenance Manual

Part Number:

Serial Number:

Customer:

End User:

SO Number:

PO Number:

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Revision: 01

Private

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Foreword

HH2400 drilling pump is designed and manufactured by Sichuan honghua petroleum equipment co.,LTD company. Each pump has an ex-factory serial number, and users shall point out the model and the ex-factory serial number of the pump when ordering spare parts or inquiring relevant things.

This manual provides general instructions to install, commission, operate, maintain, and repair HH-supplied mud pumps. The information is intended for operators and service personnel who are familiar with drilling equipment. It will not cover every situation that may be encountered. The operators of drilling pump must read this manual of pump carefully before installation, operation or maintenance. Improper installation, using or repair may cause personal injury or equipment damage.

To determine the right hand and left hand side of a pump, stand at the power end and look toward the fluid end. Right hand and left hand are indicated in parenthesis following the part name, i.e. (RH) & (LH), when appropriate.

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1. Introduction

1.1 Overview

This manual provides general instructions to install, commission, operate, maintain, and repair HH-supplied mud pumps. The information is intended for operators and service personnel who are familiar with drilling equipment. It will not cover every situation that may be encountered.

This manual provides information pertaining to the basic mud pump design. Each mud pump is a combination of a basic design and optional features and accessories. Information on optional features and accessories can be found in manufacturers' service manual that accompanies each mud pump.

Specifications are in accordance with engineering design and should be followed in all repairs. Operation and maintenance information for equipment other than HH products is taken, in part, from various manufacturers' service manuals. In the event of conflict between this manual and component manufacturer's information, the manufacturer's information will take precedence over this manual unless specifically stated otherwise.

The material used in the construction of each mud pump is satisfactory for use in a sour gas (Hydrogen Sulfide) environment, if the drilling fluid condition is maintained as specified in NACE Standard ISO 15156-01. This NACE standard specifies the practice of one of the following:

1. Maintaining a PH of 10 or higher, to neutralize Hydrogen Sulfide (H₂S) in the drilling mud
2. Using chemical sulfide scavengers
3. Using a drilling fluid in which oil is the continuous phase

WARNING

Failure to control the drilling fluid as specified by NACE Standard ISO 15156-01 can result in sulfide stress cracking of certain components and result in serious personal injury or loss of life.

HH reserves the right to change, discontinue, or modify mud pump models at any time without notice and without incurring any obligation.

1.2 Abbreviations and Acronyms

The abbreviations and acronyms used throughout this publication are defined in Table 1.

Table 1: Abbreviations and Acronyms

Term	Meaning	Term	Meaning	Term	Meaning
degC	Degrees Celsius	kPa	Kilopascal	MPa	Megapascal
degF	Degrees Fahrenheit	kW	Kilowatt	psi	Pounds Per Square Inch
galUS	Gallon (US)	L	Liter	RIC	Radial internal Clearance
h	Hour	lbm	Pounds (mass)	Spm	Strokes Per Minute
hp	Horsepower	m	Meter	TIR	Total Indicated Runout
in	Inch	mm	Millimeter		
kg	Kilogram	min	Minute		

1.3 Conventions

Signal words and accompanying messages are formatted and used in compliance with ANSI Z535.6-2011.

American National Standard for Product Safety Information in Product Manuals, Instructions, and Other Collateral Materials. These messages may be used throughout this document to emphasize important and critical information relating to the handling, installation, operation, and maintenance of the equipment.

DANGER

Danger signal word indicates a hazardous situation that, if not avoided, will result in death or serious injury. The use of this signal word is limited to the most extreme situations.

WARNING

Warning signal word indicates a hazardous situation that, if not avoided, could result in death or serious injury.

CAUTION

Caution signal word indicates a hazardous situation that, if not avoided, could result in minor or moderate injury.

NOTICE

Notice signal word indicates information considered important, but not hazard-related (e.g. messages related to property damage).

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**SAFETY
INSTRUCTIONS**

Safety instructions signal words indicate specific safety-related instructions or procedures .

1.4 Contact Information

Mailing Address: Sichuan honghua petroleum equipment co.,LTD
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+86 158-8384 9729 (24 Hour Local)

Web Resources: daij@hhcp.com.cn (Product Services Sales Email)
huangsj@hhcp.com.cn (Technical Support Email)

1.5 Warranty and Liability Information

Equipment warranties are specified in the purchase contract. Failure to follow operation and maintenance instructions or making aftermarket modifications may invalidate third party certifications and void the equipment warranty.

1.6 Owner and Operator Responsibilities

It is the responsibility of the owner and operator to obtain proper instructions and to train personnel in the safe installation, operation and maintenance of this equipment.

This product is supplied in accordance with the purchase specifications and does not necessarily include all safety devices required to put this product into operation. Safety devices, including but not limited to rotating equipment guards, chains, cables, and wrenches, are the responsibility of the owner / operator.

1.7 Health, Safety, and Environment Provisions

1.7.1 General Safety Provisions

The following general safety precautions and provisions should be followed at all times. All

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provisions or all the possible eventualities of events cannot be listed here. Proper training, precaution, and good judgment should always be followed when operating, maintaining, inspecting, or repairing equipment.

- Never start a task without being completely familiar with applicable safety techniques.
- Obey WARNING signs. WARNING signs and provisions help to prevent accidents. Remind others to obey WARNING signs as well.
- Never disable guards, safety systems, or switches to any equipment for any reason.
- Wear proper eye protection, such as safety glasses or goggles.
- Remove jewelry, such as rings, watches, necklaces, etc.
- Wear appropriate Personal Protective Equipment (PPE) such as steel toe footwear, hard hat, etc. Ensure PPE clothing is available if the task requires such protection.
- Wear and properly secure a safety harness when working at elevations above 5 ft (1.5 m).
- Turn off and lock out any power prior to performing any task on electrical equipment.
- Never check for leaks with your hands or any other body part. Oil under pressure coming from a hole can be close to invisible and can penetrate skin causing serious injury. Always check for leaks with a piece of wood or similar material.
- Use caution when draining lubricants and fluids. They can be very hot and may cause personal injury upon contact.
- Avoid working with loose tools or components directly above other people.
- Ensure heavy and/or overhead components are moved and lifted with the proper equipment and the equipment is properly secured. Never position any part of the body beneath a hanging component attached to a crane.
- Never use a tether that will stretch when pulling on components during removal.
- Ensure a stable support before beginning work.
- Never use a tool for a purpose it is not designed for, and never modify any tool.
- Follow all safety and environmental procedures and regulations when applying preservation compounds and materials.
- It is the responsibility of each individual to heed all warnings and cautions regarding the proper use and containment of potentially hazardous chemicals. Use of chemicals for purposes other than the intended purpose is not recommended. A copy of the latest

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versions of applicable Safety Data Sheets (SDS) or Material Safety Data Sheets (MSDS) must be maintained and made accessible for reference during the performance of a task where chemicals are used.

1.7.2 Mud Pump-Specific Safety Provisions

Prior to performing maintenance or service on the mud pump:

1. Read this manual in its entirety.
2. Shut down or disengage the equipment's power source. Failure to shut down power before servicing can result in damage to equipment and serious injury or loss of life to personnel.
3. Relieve (bleed off) all pressure from the pump fluid end module(s). Failure to relieve pressure before servicing can result in serious personal injury or loss of life to personnel.
4. Do not use a high-pressure air or a nitrogen source for charging the suction dampener. Use only a hand-operated air pump. Over-pressure can result in damage to components, serious injury, or loss of life to personnel.
5. Do not pipe the relief valve by-pass line into the pump suction system piping. High-pressure surges can result in damage to components, serious injury or loss of life to personnel.
6. Prior to lifting ensure there is sufficient clearance to other items and structures, and verify all bolted connections on the equipment are properly secured.
7. Always use properly rated lifting equipment that accommodates the actual weights given in the freight documents.
8. Always use the rig hoist, lifting appliance, or jib crane to lift items over 40 lbm (18 kg). Failure to use such devices could cause serious injury or loss of life to personnel. The jib crane capacity is noted on the jib crane and is matched with the capacity of the chain hoist. Never exceed the rating of the jib crane or the chain hoist.
9. Always wash the inside of a pump fluid end if the pump is to be idle for an extended period, especially with fluid over PH 10. Fluids with a PH over 10 may result in serious injury or loss of life to personnel.
10. If the mud is stagnant and confined, microbiological action in certain drilling muds can produce harmful quantities of sulfides.

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2. General Assembly and Parts List

The component descriptions and general assembly diagrams featured in this section are intended to highlight the main components that are available for all mud pumps and should be used for reference only. Refer to the project specific assembly and subassembly drawings and parts lists for a given mud pump.

2.1 Parts List

The components listed in Table 2 are called out by item number on the general assembly reference diagrams in Section 2.2.

Table 2: General Assembly Parts List

Item	Component	Description
1	Power End	Area of the mud pump where mechanical rotary input motion is converted to reciprocating output motion for powering the pistons
2	Electric Drive Motors	AC variable frequency motor
3	Drive Mechanism	Top mounted AC motor direct drive, gear type, No belt, the motor shaft is working as the pinion shaft
4	Gear case assembly (LH)	Gear case that allows access to the pinion gear , main gear and crankshaft in the left
5	Gear case assembly (RH)	Gear case that allows access to the pinion gear , main gear and crankshaft in the left
6	Gear case Inspection Cover	An opening used to inspect the pinion gear and main gear tooth contact, used to manually rotate the pinion shaft during service
7	Frame Rear Cover	An opening cover that allows access to the connecting rod bearing
8	External Lube Oil Pump	Electric powered pump providing lubrication to the power end of the mud pump, one working, one stand by
9	Lube Oil Heat Exchanger	A heat exchanger used to cool the lube oil
10	Lube Oil Filters	External filters to clean the lube oil on the discharge side of the lube oil pump

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Table 2: General Assembly Parts List

Item	Component	Description
11	Oil Level Dipstick	An oil level stick (on the pump skid for the oil sump) used to check the oil level when the mud pump is idle
12	Lube Oil Sump	A sump used to storage lube oil
13	Inlet and outlet for cooling water	Inlet and outlet for cooling the lube oil and liner wash fluid
14	Oil Drain	A drain used to remove oil from the oil sump
15	Pump skid	Support the pump also used to lube oil sump and spray water tank
16	Fluid End	Area of the mud pump containing three modules (fluid cylinders): suction and discharge valves, suction and discharge manifolds, and liners and pistons
17	Crosshead Cover	Inspection An opening for access to the crossheads, crosshead guides, Crosshead Pins, and crosshead bearings
18	Crosshead Plugs	Clean Out Plug on left side of the mud pump frame used to drain off contamination that has settled in the crosshead compartment
19	Liner Wash Tank	Storage for the liner wash fluid that is divided into two sections: a settling section, and a reservoir section
20	Liner Wash Pump	An electric powered centrifugal pump used to circulate liner wash and cooling fluid from the liner wash tank to the liner spray nozzles
21	Liner Wash Exchanger	Heat A heat exchanger used to cool the liner wash fluid
22	Service Crane / Jib Crane	A light duty crane mounted on the mud pump for handling equipment, liners, etc. when servicing the mud pump, ex. liners, liner retaining ring, crosshead assembly, etc.
23	Suction Manifold	A distribution pipe bolted to the inlet openings of the fluid end modules used to supply drilling fluid to the fluid end (this manifold may contain the suction dampener)
24	Discharge Cross	A flanged cross with an optional strainer screen connected to the discharge manifold. If equipped, the strainer is used to remove large pieces of debris from the mud pump discharge manifold.
25	Discharge Manifold	Provides connections for the strainer cross including the pressure relief valve, and discharge pressure gauge

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Table 2: General Assembly Parts List

Item	Component	Description
26	Discharge Pulsation Dampener(optional, no shown)	Pressure container mounted on the discharge manifold for smoothing the pulsations in the discharge piping
27	safety valve seat (optional)	Mounted on the discharge manifold to provides connections for the Pressure Relief Valve
28	Pressure Relief Valve (optional, no shown)	Mounted on the opposite side of the mud pump from the discharge strainer to protect the system against damage from over pressurization.
29	Suction Dampener(optional, no shown)	An elastomeric device used to smooth suction pressures (also known as a suction desurger or a suction stabilizer)

2.2 General Assembly Diagrams

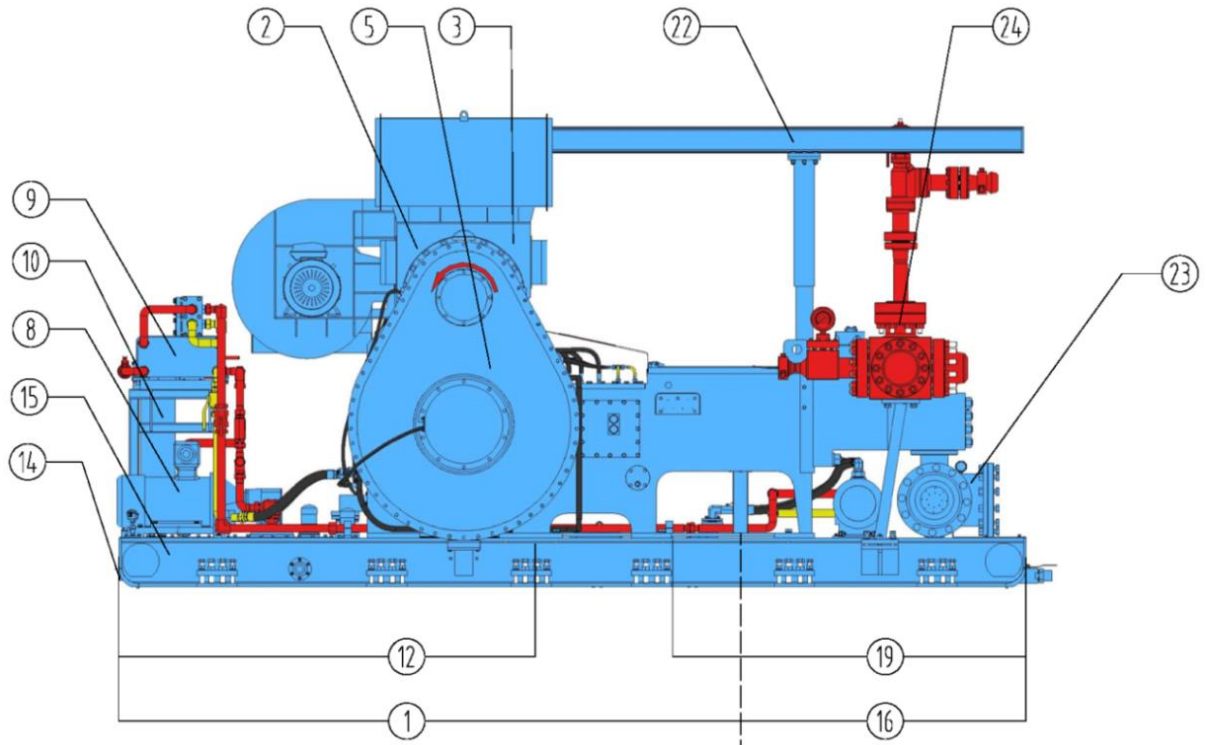


Figure 1: Mud Pump General Assembly Diagram - Right Side View

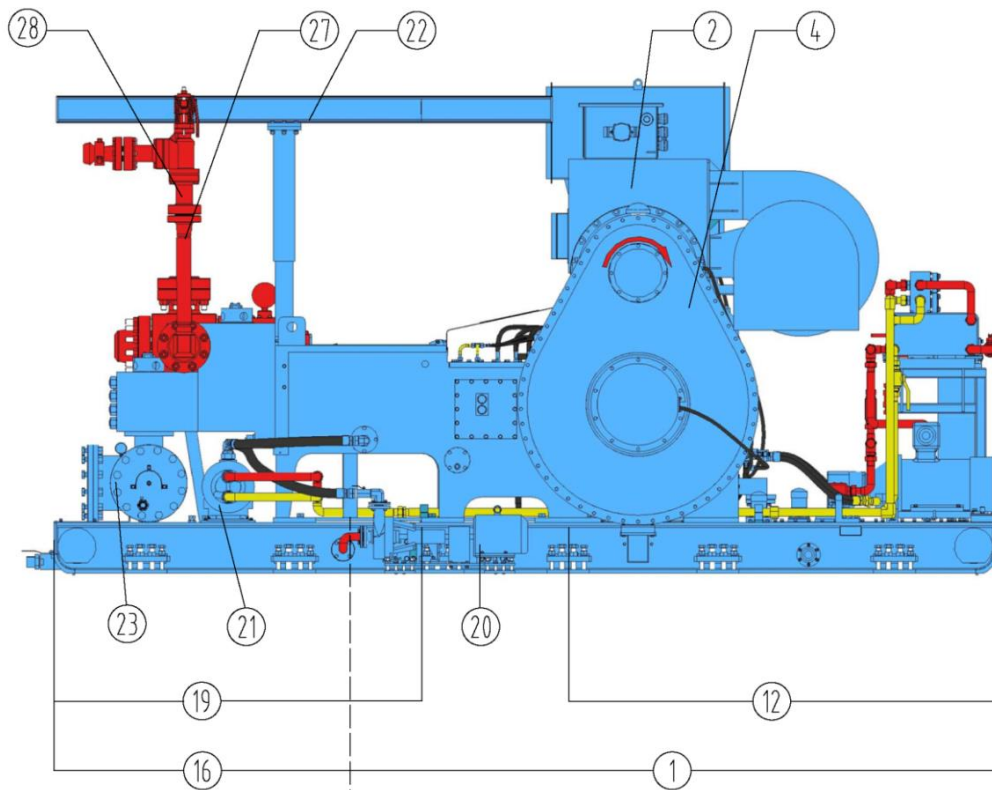


Figure 2: Mud Pump General Assembly Diagram - Left Side View

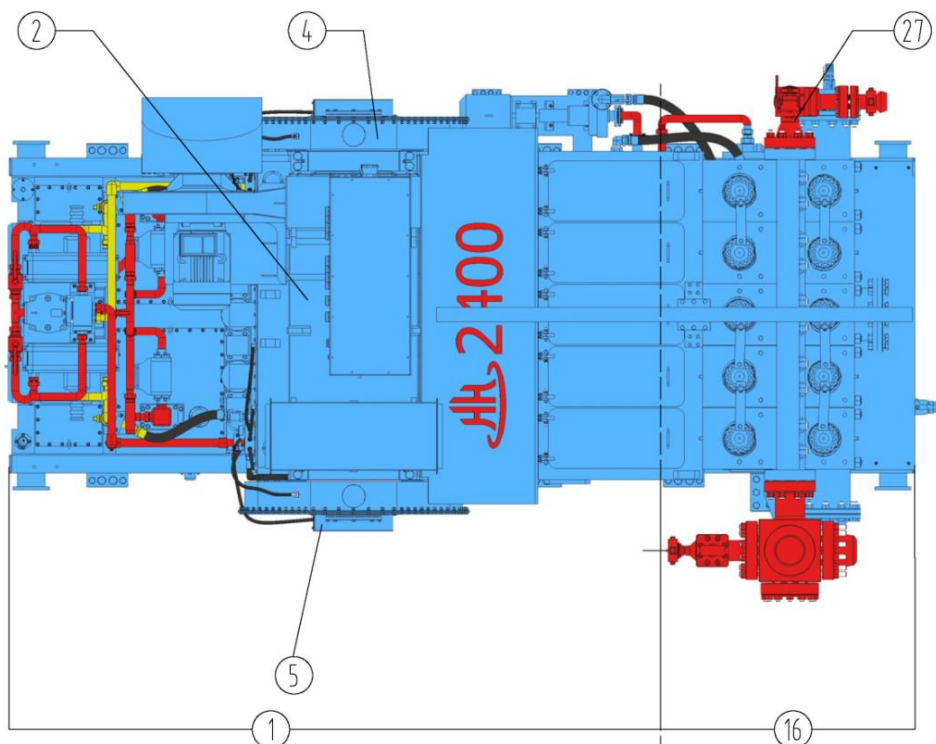


Figure 3: Mud Pump General Assembly Diagram - Top View

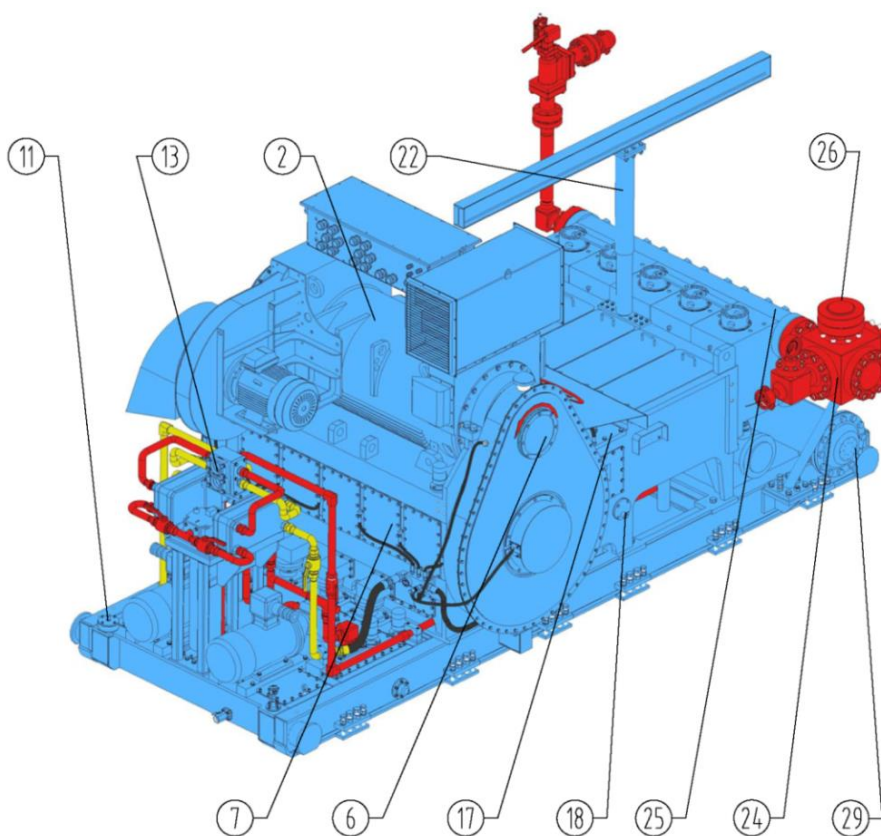


Figure 4: Mud Pump General Assembly Diagram – 45°View

3. Specifications

All specifications are subject to change. Information important to a particular application should be verified by HH. For all performance data, maximum input ratings are based on 90 % mechanical efficiency and output values are based on 100 % volumetric efficiency

3.1 Performance Data

3.1.1 HH2400 Quintuplex Piston Model Continuous Duty Performance Data

Table 3: HH2400 Quintuplex Piston Model Continuous Duty Performance Data

HH7"×12"/2400-7500psi-Stroke12"(304.8mm)										
Liner Size	inch	7	6	5-1/2	5	4-3/4	4-1/2	4-1/4	4	
	mm	177.8	152.4	139.7	127	120.7	114.3	108.0	101.6	
Max. Discharge Pressure	psi	2452	3337	3967	4805	5319	5914	6643	7500	
	bar	169	230	274	331	367	408	458	517	
Volume Per Stroke	US Gallons	9.99	7.34	6.17	5.10	4.6	4.13	3.68	3.26	
	Liters	37.82	27.79	23.35	19.30	17.4	15.63	13.94	12.35	
Pump Speed SPM	Max. Input Power		Discharge Flow US Gallons/min							
	kW	HP	Discharge Flow Liters/min							
150	1775	2415	1500	1102	925	765	690	620	552	490
			5678	4172	3502	2896	2612	2347	2090	1855
140	1657	2254	1399	1028	864	714	644	578	516	457
			5295	3890	3269	2701	2438	2188	1952	1729
130	1539	2093	1299	954	802	663	598	537	479	2045
			4917	3612	3035	2508	2264	2032	1812	1605
120	1420	1932	1199	881	740	612	552	496	442	392
			4538	3334	2802	2315	2089	1876	1673	1482
110	1302	1771	1099	808	679	561	506	454	405	359
			4160	3056	2568	2123	1915	1719	1534	1358
100	1184	1610	999	734	617	510	460	413	368	326
			3782	2779	2335	1930	1741	1563	1394	1235

Pump Speed SPM	Max. Input Power		Discharge Flow US Gallons/min Discharge Flow Liters/min							
	kW	HP								
90	1065	1449	899	661	555	459	414	372	331	294
			3404	2501	2101	1737	1567	1407	1255	1111
80	947	1288	799	587	493	408	368	330	295	261
			3026	2223	1868	1544	1393	1250	1115	988
70	829	1127	699	514	432	357	322	289	258	228
			2647	1945	1634	1351	1219	1094	976	864

Type	Quintuplex, single acting, piston pump
Rated input power	2400HP (1800kW)
Max. strokes	150SPM
Stroke of piston	12" (304.8 mm)
Maximum liner diameter	7" (177.8mm)
Maximum working pressure	7500 psi (51.7MPa) (4"liner)
Maximum displacement	1500GPM (95L/s)
Drift diameter of suction pipe	12" (305mm)
Drift diameter of outlet pipe	5 1/8" (130mm) Welding journal flange
	10000psi
Gear ratio	4.87
Valve pot	API 6#
Liner Dia.	optional 4", 4- 1/4", 4- 1/2" , 4- 3/4", 5", 5 -1/2", 6", 7"
Lubrication system	Forced lubrication
Lubricating Oil cooling	Water-cooling
Environment temperature	0°C~+55°C
Overall dimensions(L × W × H)	18.3ft × 8.7ft (10.5ft with block)×9.5ft (5587mm × 2637mm (3152mm with block) × 2910mm)
Weight (with traction motor)	35570kg(78,418lbs)

3.1.2 HH2400 Quintuplex Piston Model Pump Main Component Weight

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Table 4: HH2400 Quintuplex Pump main component weight

Item	Component	Weight/ lb (Kg)
1	Frame assembly	17178lb (7792Kg)
2	Crankshaft and Main bearings	5882lb (2668 Kg)
3	Bull gear	1534lb (696 Kg)
4	Crosshead and connecting rod assembly	829lb (376Kg)
5	Pinion gear and main motor assembly	12963lb (5880 Kg)
6	Pinion gear	127lb (58 Kg)
7	Discharge module	1863lb (845 Kg)
8	Suction module	893lb (405 Kg)
9	Discharge Cross assembly	1900lb (862 Kg)

3.2 Clearance and Tolerance Data

Table 5: Non-Bearing Clearance, Maximum Total Indicated Runout (TIR), and Backlash

Parameter	Acceptance Criteria
Crosshead (Upper Guide) Clearance	0.0118 in to 0.0158 in (0.3 mm to 0.4 mm)
Piston / Liner TIR (Crosshead Alignment)	0.0051 in (0.13 mm)
Pony Rod TIR	0.0039 in (0.1 mm)
Main to Pinion Gear Backlash	0.0126 in to 0.0232 in (0.32 mm to 0.59 mm)
Main to Pinion Gear Synchronism (RH&LH)	≤0.0059 in (0.15mm)

Table 6: Main Bearing Installed Radial Internal Clearance (RIC)¹

Model	Bearing P/N	Acceptance Criteria
HH2400	1200508349	0.002 in to 0.0079 in (0.05mm to 0.20mm)
HH2400	1200508347	0.002 in to 0.0079 in (0.05 mm to 0.20mm)

1. All main bearing Installed RICs apply to China manufactured bearings. Contact HH for all other manufacture's or unlisted mud pump models.

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Table 7: Pinion Bearing Installed Radial Internal Clearance (RIC)

Model	Bearing P/N	Acceptance Criteria
HH2400	1300032598	0.0017 in to 0.0047 in (0.043mm to 0.119mm)
HH2400	1300016094	0.0034 in to 0.0079 in (0.087 mm to 0.2mm)

Table 8: Connecting rod Bearing(slide bearing) Installed Radial Internal Clearance (RIC)

Model	Bearing P/N	Acceptance Criteria
HH2400	1200370220	0.0055 in to 0.009 in (0.14mm to 0.229mm)

Table 9: Crosshead Pin Bearing Installed Radial Internal Clearance (RIC)

Model	Bearing P/N	Acceptance Criteria
HH2400	1200367175	0.0055 in to 0.0089 in (0.14 mm to 0.225 mm)

Table 10: Used Bearing Installed Radial Internal Clearances (RIC)

Bearing	HH2400
Main	0.0197 in (0.5mm)
Pinion	0.0087/0.0122 in (0.22/0.31 mm)
Connecting Rod	0.0142 in (0.36mm)
Crosshead Pin	0.011 in (0.28mm)

Table 11: New Main Bearing Bench RIC, RIC Reduction

Manufacturer / Model	HH P/N	Bench RIC	RIC Reduction
China/Timken/SKF			
HH2400	1200508349	0.0106 in to 0.013 in (0.27mm to 0.33 mm)	0.0051 in to 0.0087 in (0.13 mm to 0.22 mm)
HH2400	1200508347	0.0106 in to 0.013 in (0.27mm to 0.33 mm)	0.0051 in to 0.0087 in (0.13 mm to 0.22 mm)

4. Lifting and Handling

4.1 Shipment Preparation

All equipment and ship-loose items are inspected for damage, deterioration, or other signs of non-conformance prior to shipment. As applicable, preparation may include the removal of all fluids used for final factory acceptance testing prior to shipment. Upon delivery and installation, supply and fill all fluid systems prior to operating the equipment.

The mud pump is secured to a master skid during manufacturing and crated according to customer specifications. The electric motors, chamber guards, lube oil pumps, liner wash pumps, heat exchangers, and any other component that projects from the mud pump or contains an opening is be covered with protective crating or sealed if the mud pump is not packed in a fully enclosed crate. The pulsation dampeners may also be heat shrunk prior to shipment. Ship-loose items are secured to a skid and packaged in a fully enclosed crate.

Based on the weight and dimensions of the mud pump, licensed personnel load the equipment using machinery of appropriate capacity. The receiving representative is provided copies of all paperwork, as well as all customer copies.

HH personnel retain copies of all shipping paperwork according to HH document retention protocols. Shipment documentation may be obtained upon customer request.

4.2 Lifting Recommendations

Use lifting machinery and accessories with capacities exceeding the maximum required loads by a factor of safety according to local practice (typically 2 to 3 times maximum expected loads). All operations must be compliant with international standards. Lifting capacity of the machinery used for lifting this equipment must exceed the weight of the equipment as specified on the freight documents.

Recommended lifting configuration and specifications for estimated dimensions, center of gravity (COG), and weight for the equipment, less packing materials, are provided in the project-specific lifting arrangement and/or general arrangement drawings. Refer to the weight specified on associated freight documents for the measured weight of the equipment including packing materials.

Verify the capacity and condition of all lifting gear before use according to inspection procedures obtained from the lifting gear manufacturer.

Before attempting any lift operations, verify that the total hook load, including the weight of lifting gear and accessories, does not exceed the maximum safe lifting capacity of the available equipment. All necessary lifting gear, including slings and spreader bars, must be provided by the customer or a third party according to purchase specifications.

Ship-loose items should be handled with a forklift of sufficient load capacity according to the weight of the ship- loose crate on the freight documents.

4.3 Transport

Safe transport requires shipment of equipment in an upright, secure, and dry means of conveyance without exposure to excessive vibration, submersion in water, or collision with other equipment or property. Contact the transport or freight forwarding vendor for specific procedures or requirements appropriate for transportation of this equipment.

4.4 Acceptance and Inspection

Upon customer receipt of the equipment, HH advises that qualified personnel immediately inspect all equipment for damage that may have occurred during transport. Pay special attention to parts that became unprotected at any time during shipment, making them particularly susceptible to damage. Inspect all surfaces and correct any damage prior to installation. Also inspect ship-loose items for damage and missing parts.

Following inspection and correction of any shipping damage, HH recommends prompt installation and commissioning or repackaging and storage until needed.

CAUTION

Disruption of the packaging without proper repackaging may result in exposure of the equipment and its components, which could cause damage and result in substandard performance or hazardous operation.

5. Installation

Use the following procedure to help plan installation of a HH-supplied mud pump. Improper installation may cause unnecessary and expensive corrections to piping, pulsation dampener mounting, and equipment tie-down after installation.

5.1 Foundation

Use plank or beam foundation matting to temporarily support the mud pump. Be sure that the mud pump is evenly supported under its entire length to prevent unnecessary strain on the frame. For fixed or permanent installations, the foundation must be level and evenly support the mud pump under its entire length.

Follow the mounting locations shown on the project-specific assembly drawing. Ensure the foundation is level to within 3.175 mm (0.175 in) per 2,540 mm (100 in) of mud pump frame length.

NOTICE

Make sure that the mud pump is level. If the mud pump is not level, the lubricating oil in the power end will not be distributed properly during mud pump operations.

5.1.1 Mud Pump Installation (Trailer Foundation)

1. Adjust the 12 tie down plates (1) of height adjustment devices higher than the below surface of pump skid main beams (RH&LH) (2) before installing the mud pump. Be sure that the tie down plates (1) will not ahead of contact the trailer main beam surface.
2. Be sure that the below surface of pump skid main beams(RH&LH) (2) contact the trailer main beam support surface. Follow the mounting locations shown on the project-specific assembly drawing. Maybe the below surface of pump skid main beams (2) can't fully contact the trailer main beam support surface. Secure the 12 tie down plates (1) fully contact the trailer main beam through adjust the bolts, the lock the plates with locking bolts.

- 3. Welding the 12 tie down plates (1) to the trailer main beam surface, welding position is shown in (3), fillet weld height is 10mm, weld length of two sides is 62mm. As shown in Figure 5.

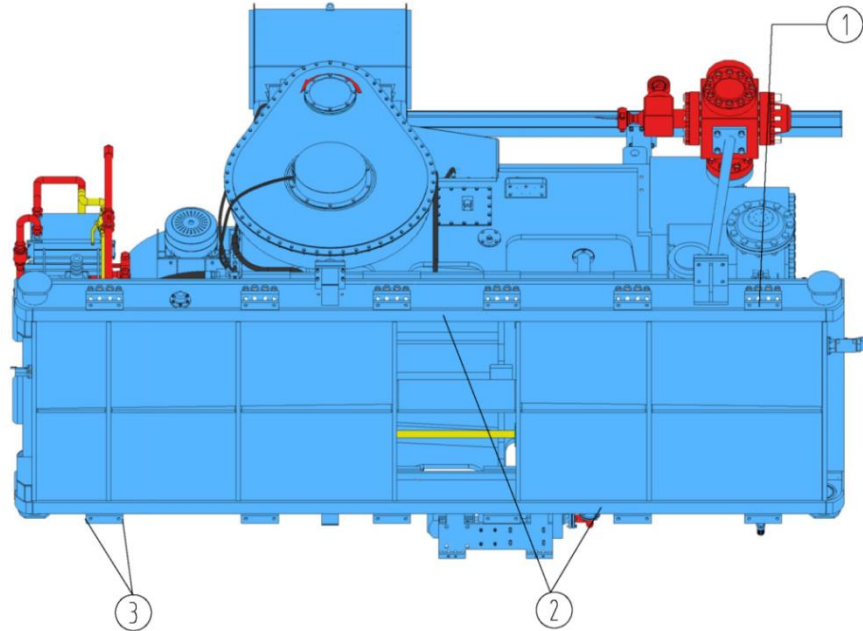


Figure 5: Mud Pump Installation (Trailer Foundation)

- 4. It is not necessary to remove the welding seam if the mud pump is transported with the trailer together. If need to separate the mud pump and the trailer, burnish the welding seam with the flapper wheel or fine grain grinder (4) . As shown in Figure 6.
- 5. Following the above procedure when reinstalling the HH Mud Pump.



Figure6: Flapper wheel or fine grain grinder

5.1.2 Mud Pump Installation (Concrete Foundation)

1. Adjust the 12 tie down plates (1) of height adjustment devices higher than the below surface of pump skid main beams(RH&LH) (2) before installing the mud pump. Be sure that the tie down plates (1) will not ahead of contact the concrete surface.
2. Be sure that the below surface of pump skid main beams(RH&LH) (2) contact the support beam or concrete surface. Follow the mounting locations shown on the project-specific assembly drawing. Maybe the below surface of pump skid main beams (2) can't fully contact the concrete surface. Secure the 12 tie down plates (1) fully contact the concrete surface through adjust the bolts , the lock the plates with locking bolts. As shown in Figure 7.

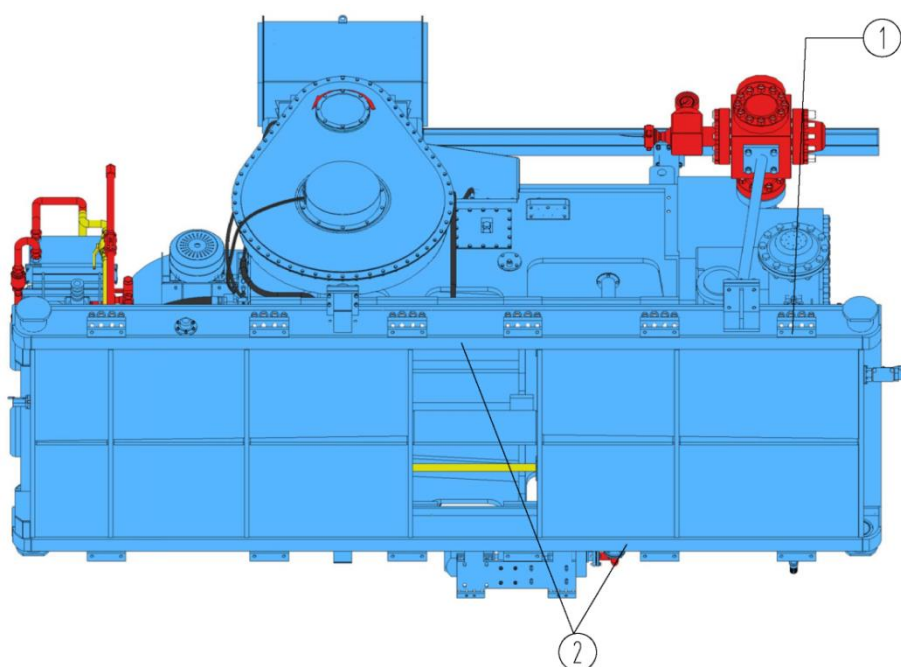


Figure7: Mud Pump Installation (Concrete Foundation)

5.2 Suction System

5.2.1 Suction Dampener Location

Always install the flanged suction dampener directly inside the suction manifold. When a welded-in suction dampener is used, mount it as close to the suction manifold flange as possible. To insure satisfactory performance, never place valves or turns between the suction dampener and the suction manifold inlet.

5.2.2 Suction Dampener Pressure (optional)

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Pre-charge the suction dampener to 15 psi (103.42 kPa). Adjust the dampener charge pressure, either up or down, as necessary to obtain the smoothest operation for the specific suction conditions of the mud pump. Refer to Section 5.2.3 for more information regarding operating conditions.

5.2.3 Suction Piping Arrangement

When equipped with a properly installed suction dampener, HH-supplied mud pumps will satisfactorily operate without a charging pump when the following conditions are met:

- The fluid level in the tank is higher than the top of the liners.
- The pumped fluid has a low viscosity.
- The suction line is short and straight with a diameter that is at least as large as the diameter of the suction manifold.

When the conditions listed above are not met, the operator must use a dual piping design that permits both natural and charged suction operation.

Natural suction piping must meet the requirements previously stated. The line from the charging pump discharge to the suction manifold may violate these restrictions if the suction dampener is installed directly inside the suction manifold.

The minimum required operating suction pressure is 29 psi (0.2MPa). HH recommends a suction pressure operating range of 58 psi to 116 psi (0.4MPa to 0.8MPa).

5.2.4 Common Suction Manifold

Multiple mud pumps may have their suction connections made to a common manifold. The common manifold must have a cross-sectional area greater than the sum of the individual mud pump inlet areas. If a common manifold with a smaller area is used, mud pump efficiency will decrease and the mud pump may cavitate causing the discharge lines to jump and vibrate with detrimental results.

5.2.5 Suction Pressure Relief Valve

NOTICE

A suction pressure relief valve is an optional accessory, providing protection for the charging pump and suction dampener in the event of a high pressure surge in the suction line. Consult HH to determine if a suction pressure relief valve is required for a particular application.

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If required, the relief valve should be installed on the top of the suction line near the suction dampener between the charging pump and the mud pump suction inlet. This valve should be set at approximately 75 psi (517.11 kPa), but may be set up to the maximum operating pressure of the suction manifold and piping.

The suction pressure relief valve should not be used to control the suction pressure.

5.3 Discharge System

5.3.1 Discharge Cross

The discharge system may be equipped with an optional discharge cross available from HH, as shown in Figure 8. This discharge cross provides two outlets for mud lines, a top mount for a discharge pulsation dampener, and a side mount for a pressure gauge.

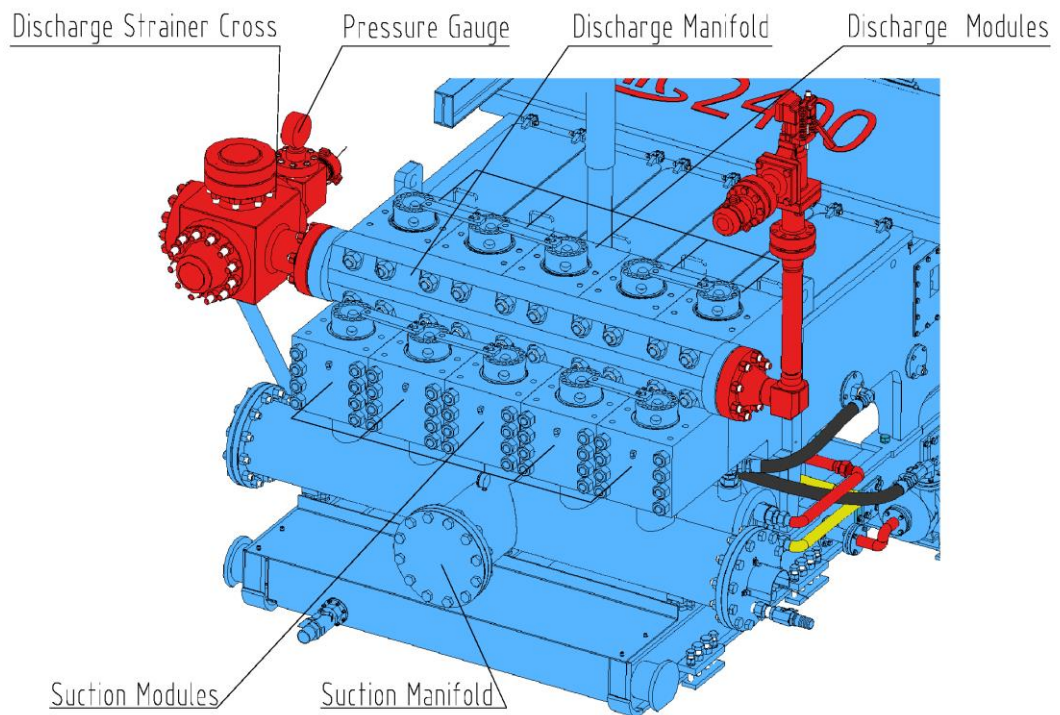


Figure 8: Discharge System Diagram

The discharge cross can be connected directly to the discharge manifold or the discharge modules either on the right or left sides of the mud pump. Integral supports from the mud pump frame to the discharge cross help carry the weight of the discharge cross and any equipped components. Refer to the project-specific assembly drawings for torque values. If torque values are not provided on the assembly drawings, refer to the fastener torque specifications

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provided in Table 18.

5.3.1.1 Discharge Strainer

An optional discharge strainer can be installed into a discharge cross to remove large pieces of debris from the drilling mud during operation. The strainer should only be installed into the discharge cross connected to the relief valve discharge line. Do not install a strainer into a discharge cross equipped with a pressure relief valve.

WARNING

Installing a strainer into a pressure relief valve equipped discharge cross could prevent the relief valve from sensing and relieving excessive mud pump discharge pressures if the strainer becomes clogged and lead to serious personal injury and damage to equipment.

5.3.1.2 Discharge Pulsation Dampener (optional)

To HH2400 mud pump, a unique five cylinder design, reduced pump operating pulsation by 15% compared to traditional triplex mud pump, results in smoother operation and reduced vibration downstream. It is not necessary to install the discharge pulsation dampener if working pressure is less than 5000psi (34.48MPa). It is optional for customer to install the dampener if working pressure is more than 5000psi (34.48MPa), the flow vibration can be controlled in 2%~5%. The dampener must be mounted onto the discharge cross. Refer to the project-specific assembly drawings for torque values. If torque values are not provided on the assembly drawings, refer to the fastener torque specifications provided in Table 18.

There are multiple options for the bladder that is used in the discharge pulsation dampener, depending on the expected operating pressures and type of mud used. Refer to the discharge pulsation dampener component product manual for additional information on available bladders for specific applications.

The dampener only allows filling nitrogen, oxygen、 compressed air or other combustible gas is strictly prohibited. Only a small amount of gas is charged when the dampener is supplied for storage. When used in the field, the pre-charge pressure shall be increased according to the nitrogen pressure required in the user's manual.

1. All combustible gases can't be added, such as hydrogen, compressed air, etc.
2. The nitrogen pressure must be filled in accordance with the nitrogen pressure value requirements described in the user's manual.

5.3.1.3 Discharge Pressure Relief Valve

Always use a full-opening reset type pressure relief valve to protect the system against damage

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WARNING

from over pressurization. The discharge pressure relief valve must be on the opposite side of the mud pump from the discharge strainer.

Do not connect the discharge pressure relief valve to the same discharge cross equipped with a discharge strainer. A plugged strainer could prevent the relief valve from sensing and relieving excessive pump discharge pressures and lead to serious personal injury and damage to equipment.

Do not install any type of shut-off valve between the discharge pressure relief valve and the discharge manifold/modules or at any place in the discharge valve relief line.

Connect the discharge valve relief line to the same discharge cross as the discharge strainer. The line should be the same size as the relief valve opening. The piping should be short, straight, securely anchored, and provide an escape path for the fluid to return to the mud tank. The line must slope downward at least 0.25 in (6.35 mm) per 12 in (304.8 mm) to prevent solids from settling in the line.

It is important to equip your mud pump with a by-pass line to allow bleed off of drilling mud back to the mud tanks prior to performing maintenance and servicing tasks. Although the by-pass line can be connected to a discharge cross equipped with or without a discharge strainer, HH recommends installing the by-pass line to the discharge cross opposite the discharge strainer. This will prevent the by-pass line from interfering with strainer removal during regular maintenance.

The following are recommendations for setting the actuation pressure of Retsco, RR, and Oteco relief valves. All adjustments should be made with the valve at normal operating temperature. Also reference the component product manual included with the mud pump product documentation.

RR Valve

The RR Valve has a variance of ± 150 psi (1,034.21 kPa), regardless of the actuation pressure. The actuation pressure should be set to 150 psi (1,034.21 kPa) greater than the maximum pressure rating of the liner used. The last mark on the indicator's scale is 7500 psi (51.71 MPa), and a quarter turn of the adjusting nut represents approximately 500 psi (3.45 MPa). At a maximum operating pressure of 7500 psi (51.71 MPa), the valve should be set to 7,500 psi (51.71 MPa) on the indicator's scale and then the adjusting nut should be rotated 1/8 of a turn.

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Retsco Valve

The Retsco valve has a variance of $\pm 3\%$, regardless of the actuation pressure. The actuation pressure should be set to 1.03 times the maximum pressure rating of the liner used. The last mark on the indicator's scale represents 8,000 psi (55.16 MPa). If the operating pressure is 7500 psi (51.71 MPa), then the actuation pressure should be set to 7725 psi (53.26 MPa).

Oteco Valve

Oteco valves are pressure relief valves that use shear pins to determine the operating pressure. The nominal operating pressure listed on the valve nameplate was determined in laboratory conditions using Oteco shear pins. The actual operating pressure of the valve will vary. Refer to the manufacturers' service manual for more information.

6. Operation

6.1 Preparation

6.1.1 Control System Integration

Ensure the control system is properly integrated with the mud pump and its component systems. Proper control system integration is critical to the safe and efficient operation of the mud pump in accordance with the equipment specifications.

Control system integration is the responsibility of the owner/operator and the manufacturer of the chosen control system. HH is neither responsible nor liable for any damage or injuries that may result from the use of the mud pump without proper control system integration.

WARNING

Failure to properly integrate the chosen control system with the mud pump can result in damage to the equipment, severe personal injury, or loss of life.

Ensure equipment operators are properly trained in the use of the chosen control system. Even if the mud pump is properly integrated with the chosen control system and the control system functions properly, errors in operation or operating in a manner other than in strict conformance with the control system manufacturer's instructions, may result in unpredictable operation or failure of the mud pump. HH is not responsible for any damage or injuries resulting from malfunctions or errors in the operation of the control system.

Control features, such as warnings and stoppings are determined by the control system manufacturer. As such, HH is not responsible for ensuring the necessary stopping notifications are programmed or operational. However, equipment operating limits are provided in Section 6.3 and may be used as a guide when determining the appropriate control system stopping and/or warning parameters.

6.1.2 Suction Dampener(optional)

Before initial start-up, ensure the suction dampener is charged to approximately 15 psi (103.42 kPa) to provide a cushion for the diaphragm when the charging pump is started.

6.1.3 Power End Lubrication

Open the lube oil sump oil drain, shown in Figure 9, and remove the drain plug from the

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crosshead compartment. Drain any moisture or contamination that has accumulated.

When starting a pump for the first time or after storage, fill the lube oil sump with applicable lube oil, the oil level should fall between the marks on the dipstick, refer to table 12 and 13.

Ensure the external lube pump (electric) is operational and pumping oil through all the internal lube lines.

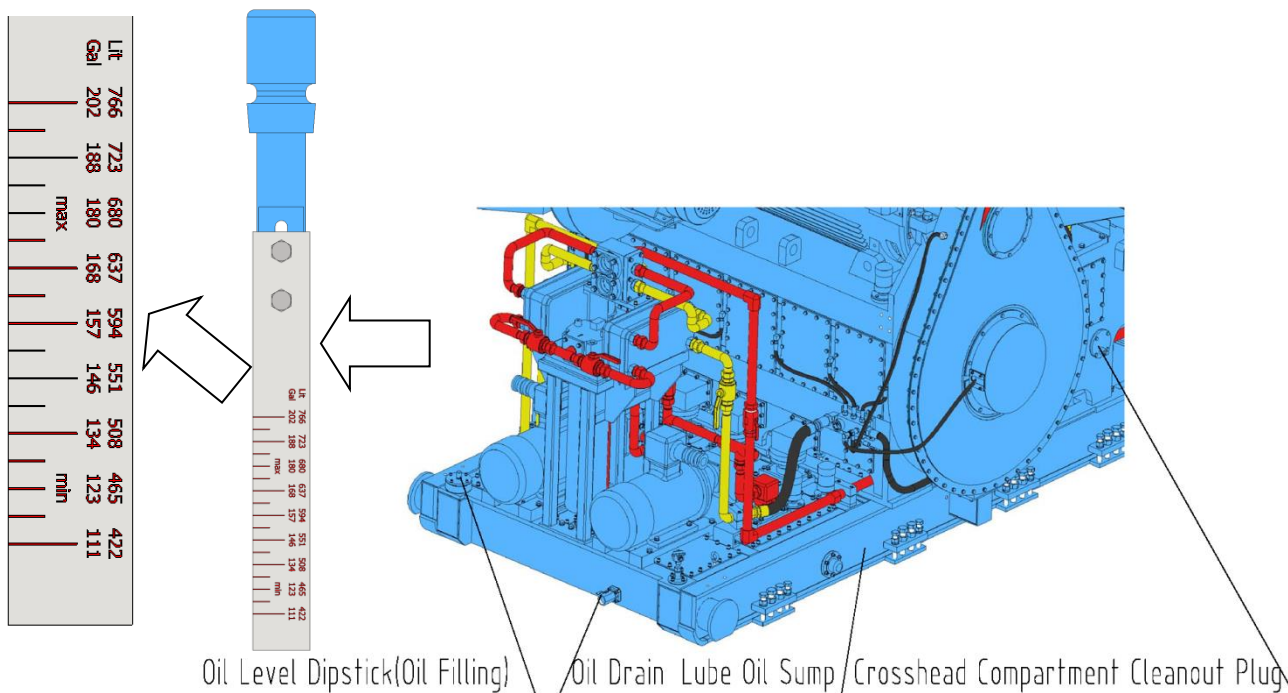


Figure 9: Power End Lubrication Components

6.1.3.1 Gear Drive

HH 2400 is gear drive type mud pump, no belt or chain drive. All friction pairs in power end including crankshaft main rolling bearings, connecting rod big and small end sliding bearings and the friction pairs between the crosshead and the crosshead guide.

Fill the mud pump lube oil sump with synthetic lubricant. Refer to Table 12 and select recommended synthetic lubricant for the appropriate ambient conditions. For example: Mobil SHC Series Synthetic lubricant or other brand oil.

Table 12: Recommended Synthetic Lubricant by Operating Temperature

Temperature	Recommended Lubricant	Viscosity at 104degF (40degC)	Heating Temperature When Cold
32degF to 131 degF (0 degC to 55 degC)	ASTM/ISO-VG Grade 1000 Non-Corrosive, Anti-Foaming Synthetic lubricant, for example Mobil SHC639	1000cst	64.4 degF (18 degC)
20 degF to 95 degF (-7 degC to 35 degC)	ASTM/ISO-VG Grade 680 Non-Corrosive, Anti-Foaming Synthetic lubricant, for example Mobil SHC636	680cst	55.4 degF (13 degC)

6.1.3.2 Oil Capacity

With the pump at rest, use the dipstick as show in Figure 9, to measure the oil level. The oil level should fall between the marks on the dipstick. Refer to Table13 for mud pump oil capacity. Also you can determine the amount of lubricant according to the oil dipstick identification data.

Table 13: Oil Capacity

Model	Oil Capacity
HH2400	Max.180 gal US (680 L) Min.123gal US (465 L)

6.1.3.3 Heating the Lubricant

The lube oil needs to be heated when the ambient temperature is below the allowable minimum temperature. The heating method is: Fully close the ball valve (6), adjust the safety valve (3) and (4) to the highest pressure, and the safety valve (5) to the lowest pressure. Start the heater and the oil pump, the oil is sucked from the oil tank then return back to tank follow the line shown in figure10 (the low temperature high viscosity lube oil does not pass the filter to protect the filter), heat the oil during the cycle. The lube oil need to be heated to 64.4deg F when using 1000# lubricant (the oil need to be heated to 55.4deg F when using 680# lubricant). Open the ball valve (6) then adjust the safety valve (5) to 1.1MPa after heating the oil to specific temperature .Ensure run the lube pump and pump oil through all the internal lube lines before starting the mud pump.

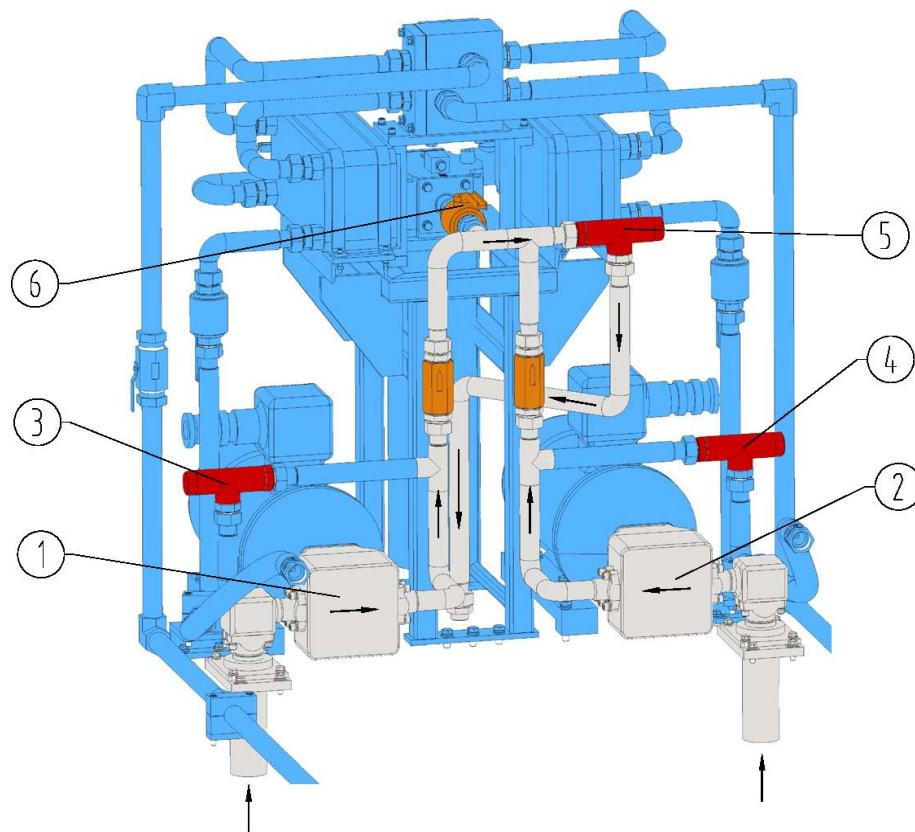


Figure 10: Lube Oil Heating Line

6.1.3.4 Adjust oil pressure relief valves to recommended setting:

Use Figure 10 to reference component locations. The specific method is:

1. Adjust the safety valve (5) be the max limit (above 1.2MPa, the screw completely tightened), adjust the safety valve (3) and the safety valve (4) to the low pressure (only thread the screw 2~3 turns).
2. Close 2# (2) oil pump, start the 1# (1) oil pump, and adjust safety valve (3), set the oil pressure between 1.2 and 1.6MPa. See the corresponding 1# pressure gauge indication on the main manifold. Close 1# (1) oil pump, start the 2# (2) oil pump, and adjust safety valve (4), set the oil pressure between 1.2 and 1.6MPa. See the corresponding 2# pressure gauge indication on the main manifold.
3. Adjust the safety valve (5), set the oil pressure to be 1.1MPa.
4. In drilling yard, mud pumps can run continuously with only one lubricating pump, the second lubrication pump can be standby pump. Back-up lubrication pump kicks in at 0.75 MPa, the lubricating pressure will increase above 1.1 MPa meanwhile.
5. The oil pressure on main manifold $0.75\text{MPa} \leq p \leq 1.15\text{MPa}$; the pressure on crosshead $0.65\text{MPa} \leq p \leq 1.05\text{MPa}$.

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6.1.4 Liner Wash System

6.1.4.1 Liner Lubrication

Fill the liner wash system with clean water and either a surfactant fluid, such as Castrol Syntilo 9951; an equivalent; or water-soluble oil. A surfactant fluid is best when mixed with clean water. Liquid soap is another suitable material for reducing the surface tension of the liner wash water, thus lubricating the piston in the liner.

Depending on the corrosiveness of the water and/or drilling mud, water-soluble oil can also be used for cooling. HH recommends a mixture of 10 to 20 % surfactant fluid or soluble oil with clean water, depending on the size of the liner wash tank.

If water is used without a mixture of oil, the operator must exercise greater care and perform additional maintenance to prevent heat and corrosion damage to the parts in and adjacent to the piston liner chamber. Coating the clamps and all exposed surfaces with a thread compound will minimize the effects of corrosion.

When a liner spray manifold system is used, the operator must make sure that the spray nozzles are properly positioned for the size of the liner being used. The spray system must start either before, or at the same time, as the mud pump to prevent damage to the piston and liner.

To effectively cool the piston and the liner, the temperature of the coolant must be below the temperature of the drilling mud. In some circumstances, it may be necessary to provide an external means to cool the coolant fluid, such as a heat exchanger.

6.1.4.2 Liner Wash Pump

An electrically driven centrifugal pump is used on all HH-supplied HH2400 quintuplex mud pumps for supplying coolant to the liners and pistons. The centrifugal liner wash pump oil reservoir must be kept filled to the proper level with SAE 20 motor oil to protect the oil-lubricated bearings.

NOTICE

The seal on the centrifugal liner wash pump will be damaged if it is allowed to run dry or to cavitate. Maintain a flooded suction to the centrifugal liner wash pump at all times to prevent damage to the equipment.

6.1.5 Fluid End

Inspect the fluid end to verify the following:

- The liners and pistons have been properly installed;
- The rod and liner clamps have been tightened;

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- The valves have been installed;
- The valve covers have been tightened.

6.1.6 Line Valves and Charging Pump

Open all valves in the suction and discharge lines and ensure the suction charging pump is starting either at the same time or before the mud pump. Never start the mud pump ahead of the charging pump, as this will result in cavitation, incomplete filling, and damage to the fluid end parts.

6.2 Initial Operation

6.2.1 Speed Adjustment

Bring the mud pump up to speed gradually. This allows the fluid flow velocity in the suction line to match the flow requirements to the mud pump without cavitation.

The maximum mud pump speed when operating with a natural suction is limited by the pump's ability to completely fill during the suction stroke. This limiting speed will differ for each installation, as it depends on the design of the suction piping and available head as well as the condition of the mud (i.e. weight and/or amount of entrained air or gas and the mud pump model).

The operator may determine this limiting speed by listening to the mud pump. As the limit is approached, the mud pump will begin to knock, indicating cavitation and incomplete filling. At this point, the suction charging pump should be brought into the system until operating conditions change and a natural suction can again be used.

Do not run the mud pump in excess of the maximum design speed.

6.2.2 Suction Dampener Charge Adjustment

Before initial start-up, use a hand-operated air pump to charge the dampener to approximately 15 psi (103.42 kPa). This will provide a safety margin to prevent accidental damage to the diaphragm when the charging pump is started. The proper charge and final adjustment must be determined with mud pump in operation. The dampener charge level will differ for charged suction operation and for natural suction operation. This is easily adjusted using an ordinary, hand-operated air pump.

⚠ WARNING

Use a hand-operated air pump to charge the suction line pulsation dampeners. Do not use a high-pressure air source or nitrogen bottle. Charging the suction dampener with high-pressure sources can result in serious personal injury and equipment damage.

6.2.3 Lubrication

Do not operate the mud pump without the external lubrication system. HH2400 mud pumps are all equipped with external lubrication system, no internal lube oil pump. Refer to Section 6.3 for variation specifications.

6.3 Operating Limits

Table 14: Mud Pump Operating Limits

Parameter	Value
Lube Oil Temperature ¹	(1) SHC639 lube oil Optimal: 95degF to 131degF (35degC to55degC) Maximum: 158degF (70degC) Warning Setting (Recommended): 149degF (65degC) Stopping Setting (Recommended): 158degF (70degC) (2) SHC636 lube oil Optimal: 77degF to 113degF (25degC to 45degC) Maximum: 131degF (55degC) Warning Setting (Recommended): 122degF (50degC) Stopping Setting (Recommended): 131degF (55degC)
Suction / Charge Pump Pressure	Recommended: 58 psi to 116 psi (0.4MPa to 0.8MPa) Required Minimum: 29 psi (0.2MPa)
Suction Pressure Relief Valve Setting	116 psi (0.8MPa)
Liner Wash System Fluid Pressure	≥15 psi (0.1MPa)

Table 14: Mud Pump Operating Limits

Parameter	Value
Heat Exchangers	(lube oil exchanger spare tool P/N 1300044536 /spray water exchanger spare tool P/N 1300128506)
Flow Rate	40galUS/min (9 m ³ /h) for1300044536 88galUS/min (20 m ³ /h) for 1300128506

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Cooling Water Temperature Range	5degC to 30degC (41degF to 86degF) for spare tool P/N 1300044536 1300124619
Maximum Pressure	232psi (1.6MPa) for P/N 1300044536 232psi (1.6MPa) for P/N 1300128506
Pressure Drop	7 psi (0.05MPa) for spare tool P/N 1300044536 7 psi (0.05MPa) for spare tool P/N1300128506

Mud Pumps Equipped with External Lubrication System Only (two lube oil pump, one working , one stand by, the second pump will auto start working when the main manifold lube oil pressure dropped to 108psi)

Crosshead and Main Manifold Lube Oil Pressure ²	(1) Main manifold lube oil pressure Optimal: 108 psi to 138 psi (0.75MPa to 0.95MPa) Acceptable: 101 psi to166 psi (0.7MPa to 1.15MPa) Warning Setting (Recommended): 108 psi (0.75MPa) Stopping Setting (Recommended): 101 psi (0.7MPa)
	(2) Crosshead lube oil pressure Optimal: 94 psi to 123 psi (0.65MPa to 0.85MPa) Acceptable: 87 psi to152 psi (0.6MPa to 1.05MPa)

Driver motor

Winding temperature	Warning Setting (Recommended): 302degF (150degC) / Stopping Setting: 329degF (165degC)
Bearing temperature	Warning Setting (Recommended):194degF (90degC) / Stopping Setting: 203degF (95degC)

1. In colder environments, a low lube oil temperature during startup can result in higher lube oil pressures. Lube oil temperature should increase and pressures should stabilize as the mud pump friction heat is increased during start-up. It is acceptable to run the mud pump between 149degF (65degC) and 158degF (70degC) for short periods. However, HH does not recommend running the mud pump above 158degF (70degC) for any length of time.

2. It is acceptable to run the mud pump between 101 psi (0.7 MPa) and 108 psi (0.75 MPa) for short periods. However, HH does not recommend running the mud pump below 101 psi (0.7 MPa) for any length of time.

7. Maintenance and Inspection

The following sections provide information necessary to maintain a HH-supplied mud pump through regular maintenance and inspection activities. All issues identified during inspection should be corrected promptly to prevent abnormal wear and possible / further equipment damage.

7.1 Initial

A new mud pump requires expanded maintenance and inspection procedures during the first 500 hours of operation in addition to the regular daily maintenance and inspection tasks.

7.1.1 Net type Oil Filter

HH2400 mud pump is equipped with a net type oil filter on the external lubrication system. Additional information on the net type oil filter can be found in the manufacturers' service manual.

7.1.2 Lubricating Oil

Check the usability of the power end lubricating oil by taking monthly samples from the oil drain after 300 hours of operation for oil analysis. Drain and replace oil if analysis results indicate that it is not suitable for continued use, for example, the water content is more than 1% or viscosity more than the limit of $\pm 10\%$. It is necessary to clean the oil sump and the crosshead compartment before replacing the oil.

7.1.3 Main Gear and Pinion Gear

Regularly inspect the main gear and pinion gear for pitting during the first 500 hours. Some corrective pitting of the gear is expected during the initial operation period. These pits should be small and circular and dispersed along the pitch line of the gear teeth. They should not expand and form larger, single pits. Pitting activity should slow to a halt during the initial operation period.

7.2 Daily

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Perform the following maintenance and inspection activities every calendar day.

7.2.1 Pump Threads

Inspect all threads that are exposed to the atmosphere to ensure they are coated with rust inhibitor.

7.2.2 Power End

Inspect the pressure gauges at the main manifold and crosshead lube oil lines.

Check the oil level in the lube oil sump. The level should be checked with the pump at rest.

7.2.2.1 Net type Oil Filter

HH2400 mud pump is equipped with a net type oil filter on the external lubrication system. Additional information on the net type oil filter can be found in the manufacturers' service manual. There is a CMS type pressure difference switch on the oil filter, if the pressure differential is greater than 50 psi (0.35MPa) when the pump is at operating temperature, check the filter strainer for debris and clean or replace if necessary.

7.2.3 Auxiliary Pumps

Lubricate the shaft and packing of auxiliary pumps (lube oil pumps and spray pump) according to the manufacturers' service manual.

7.2.4 Auxiliary Heat Exchangers

Perform maintenance on the liner wash and lube oil heat exchangers according to the manufacturers' service manual.

7.2.5 Pistons and Liners

Inspect the condition of the liners and pistons. Smooth wear on the liners normally indicates smooth wear on the pistons. A small amount of the drilling fluid is washed from the liners on each stroke. This does not necessarily indicate worn out pistons or liners. Pistons and liners should be replaced when drilling fluid by-pass becomes excessive.

7.2.6 Liner Chamber Coolant

Check the liner-piston coolant. Add coolant as required. If coolant appears dirty, flush the sump with fresh water before adding clean coolant.

NOTICE

Dirty coolant will increase wear of the liners and pistons and will shorten the life of the coolant pump.

7.2.7 Spray Manifold

Inspect the spray water on the liner spray manifold. If the amount of spray water is obviously too small, please check whether there is cavitation or blocked , clean as necessary to ensure an adequate coolant / lubricant supply is provided for the liners and pistons.

7.2.8 Rod and Liner Clamps

Check the liners and rod clamps for proper tightness after the first few hours of operation following assembly.

This allows the taper locking assembly to become seated. Proper tightening will ensure minimum movement of the rod components.

7.2.9 Valve Covers

After the first few hours of operation, check to make sure the valve covers are tight.

7.2.10 Suction Dampener (optional)

Verify the suction dampener pressure is operating at approximately 15 psi (103.42 kPa).

7.2.11 Pony Rod Seals

Lubricate the pony rod seals with EP1 or EP2 multipurpose lithium grease while the pump is in operation.

Pump grease until it becomes visible on the inside diameter of the seal. Make sure that the grease appears around the entire seal.

7.3 Bi-Weekly

Perform the following maintenance and inspection activities every 14 calendar day.

7.3.1 Valve Cover Threads

Remove all valve covers and carefully clean all drilling mud and debris from the cover screw

threads and in the bolt rings. Completely grease the cleaned threads with a drill collar anti-seize thread compound.

NOTICE

It is important that an anti-seize compound be used to provide the necessary protection against corrosion, galling and seizing. Do not use an ordinary tool joint thread dope, as they will not effectively protect the joint.

7.3.2 Valve Guide Bushing

Inspect the bushing in the valve stem guide and replace if visible signs of wear are found. A worn bushing will cause increased valve wear.

7.3.3 Valves and Seats

Inspect the valves, seats and inserts for wear. Replace if necessary.

7.3.4 Piston Hub Seal

The piston hub seal is a compression seal that fits against the flange and radius on the piston rod.

Verify the seal is correctly seated in the piston hub groove.

Verify the seal is not altered or damaged.

7.3.5 Piston Rod Lock Nut

Replace the piston rod lock nut if it has been damaged or corroded, or if the locking nylon has lost its ability to effectively grip the threads. Do not reuse nuts that have been used three times.

7.4 Monthly

Perform the following maintenance and inspection activities every 30 calendar days.

7.4.1 Cross Strainer Cage

Clean the cross strainer cage.

7.4.2 Studs and Nuts

Tighten any loose fluid cylinder studs and nuts. This includes cylinder to frame studs, discharge pipe to module, liner pilot bushing studs, and discharge to suction studs.

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7.4.3 Gaskets and Seals

Inspect the power end for leaking gaskets or loose cap screws and replace and tighten as necessary.

7.4.4 Power End Lubrication

Check the usability of the power end lubricating oil by taking monthly samples from the oil drain, located on the oil sump, for oil analysis. Samples should be taken while the pump is in operation or soon after the pump is turned off. This is to ensure that the lubricating oil is well mixed when the sample is taken.

Sample intervals may be extended up to three months if the results of monthly sample analysis consistently show the lubricating oil to be suitable for use. Sample intervals may also be adjusted at the operator's discretion, based on recommendations from the party performing the oil analysis.

Mud pump oil lubrication cleanliness should be at NAS class 8 (or ISO 19/17/14) specification with water content less than 200 ppm (0.02 %) prior to use. Drain and replace oil if analysis results indicate that it is not suitable for continued use, for example, the water content is more than 1 % or viscosity more than the limit of $\pm 10\%$. It is necessary to clean the oil sump and the crosshead compartment before replacing the oil.

Clean and inspect the net type oil filter strainer. Replace if damage is found.

7.5 Semi-Annually

7.5.1 Power End Lubrication

Perform the following maintenance and inspection activities every 6 calendar months.

Drain and clean the power end oil sump and the settling area under the crossheads. Refill with the proper grade of Synthetic Lubricant specified in Table 12.

NOTICE

Semi-annual oil changes may not be necessary if monthly oil sample results consistently show suitable oil results.

7.6 Annually

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Perform the following maintenance and inspection activities every calendar year or every 3,000 operating hours.

7.6.1 Clearances

Measure the clearance for all bearings (main, pinion, connecting rod, and crosshead pin). Record measurements for future reference.

Compare each measurement with those taken at the time of manufacture and any previous recorded measurements. During typical mud pump applications wear may occur over time. Table 10 provides values for maximum used bearing clearances. These values should be used only as a general guideline for bearing replacement. Lubrication oil samples, bearing roller / race inspection, and trends in the bearing clearances should also be considered to determine the need for bearing replacement.

Measure the crosshead clearances at the power end. Crosshead clearance acceptance criteria are provided in Table 5.

7.6.2 Crossheads

For the pistons to run true in the liners, the crosshead must be aligned so that they travel in a straight line along the horizontal centerline of the frame bore.

To perform crosshead alignment, use the following procedure:

1. Remove the piston rod, piston, and sub-rod. Inspect the face of the pony rod and make sure there are no burrs or disfigurements;
2. Install new liners and make sure that all components are clean to ensure proper indication;
3. Using a new rod clamp to install the piston;
4. Rotate the crosshead to the forward stroke position;
5. Measure the piston / liner runout (crosshead alignment). The total indicated runout (TIR) should be less than the maximum TIR specified in Table 5 which is the total clearance of the piston and liner. If total TIR exceeds the value specified in Table 5, the crosshead must be reinstalled to bring the TIR within tolerance. No shim is required just changing the standard crosshead guide.

7.6.3 Crosshead Guides

Inspect the crosshead guides for grooves. Grooved crosshead guides indicate improper

lubrication or particulate matter on guides.

Inspect the lubrication system and the condition of the stuffing box / pony rod seals. Replace if severely worn or scarred.

7.6.4 Bolts

Check the tightness of the main frame mounting bolts, and crosshead pin retainer bolts. Tighten loosened bolts.

Check the safety wires on all the bolts. If wires are broken, determine the cause and correct. Replace broken safety wires.

Check the tightness of the main bearing cap bolts.

For pumps with super nuts, the torque for the tightening bolts is stamped on the top of the nut. For other hardware, refer to the project-specific assembly drawings for the appropriate torque value. If the torque value is not supplied on the assembly drawing, refer to the fastener torque specifications provided in Table 18.

7.6.5 Main Gear and Pinion Gear

Inspect the condition of the main gear and pinion gear teeth. Some minor pitting may occur during the initial operation period of the pump. This initial, or corrective, pitting should be light and limited to an area near the pitch line of the gear teeth and extend across the length of the teeth. Scoring, significant pitting, or continued increase of pitting should be thoroughly inspected and the source of the problem removed.

Measure the synchronism of main and pinion gear of two sides. The acceptance criteria is provided in Table 5.

8. Storage and Preservation

When a HH-supplied mud pump is placed in storage, measures must be taken both before and during storage to protect mud pump components from damage due to corrosion and deterioration.

Failure to perform the steps outlined in this document may result in damage to mud pump components during storage and result in costly repairs.

8.1 Storage Environment

HH recommends storing a mud pump in a climate controlled facility, where it can be protected from the elements. The storage environment must be kept free of contaminants, including but not limited to blowing sand, salt spray, welding / grinding / media blasting operations, and painting operations. The mud pump must be wrapped in a suitable greaseproof / waterproof material to protect the mud pump from dust and other debris.

If a climate controlled environment is not utilized for storage, extra care must be taken to ensure the pump is adequately preserved and maintained.

8.2 Equipment Preparation

Perform all activities while the mud pump is not operating and power is turned off unless specifically stated otherwise for a particular task.

8.2.1 Power End

1. With power connected to the mud pump, run the external lube oil pump for a minimum of 2 minutes to fill the lines and bearings with lube oil. Once lines are lubricated disconnect power to the mud pump. If the power end has been drained or is empty, skip this step.
2. Remove dirt and debris from gear case, crosshead, and frame rear covers and cover bolts to prevent the ingress of contaminants into the mud pump.
3. Remove the gear case, crosshead, and frame rear covers and inspect the inside of the power end for corrosion.
4. Remove the oil drain plug and drain all fluid from the oil sump. Properly dispose of drained fluid.

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5. Clean the inside of the mud pump power end, removing all potential contaminants.
6. Using a grease gun apply grease to each of the pony rod seal grease fittings until clean grease appears from the grease relief fittings.
7. Apply rust inhibiting oil as indicated in Table 12 to bearings, gears, and any unpainted surfaces inside the power end. Using a pinion turning tool, rotate the pinion shaft as necessary to ensure complete coverage.
8. With the crankcase oil drain plug in place, fill the bottom of the oil sump with approximately 2 in (50.8mm) of clean gear oil as specified in Table 13.
9. Install a heater in oil sump. If heaters are not available, use desiccant. The amount of desiccant required is dependent on storage conditions and the type of desiccant used.

NOTICE

Heaters must be installed in the oil sump to allow the pinion shaft to be rotated during storage maintenance without damaging the mud pump.

10. Visually inspect gear case, crosshead, and frame rear covers gaskets and replace if damaged. Undamaged gaskets can be reused during storage.

NOTICE

Do not use silicone sealer as silicone could contaminate the lubrication system and result in costly damage.

11. Reinstall the gear case, crosshead, and frame rear covers.
12. Apply rust inhibiting oil to the exposed surface of each pony rod.

8.2.2 Fluid End

1. Remove the valves, pistons, piston rods, and liners as outlined in the disassembly instructions.
2. Clean and visually inspect the inside of the fluid end modules and all fluid end components.
3. Coat the inside of each fluid end module and any other unpainted surfaces with rust inhibiting oil.

NOTICE

Heaters must be installed in the oil sump to allow the pinion shaft to be rotated during storage maintenance without damaging the mud pump.

4. Drain all water from the liner wash system tank.
5. Clean and visually inspect the liner wash system tank.
6. Use compressed air to dry the liner wash system lines and hoses. Disconnect and

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reconnect hoses as needed to ensure all water is removed from the system.

7. Once dry, coat the accessible parts of the inside of the liner wash pump with rust inhibiting oil. Turn the liner spray pump by hand while applying oil to ensure coverage.
8. Coat the tank and exposed liner wash system components with rust inhibiting oil.
9. Coat any exposed surfaces in the liner area with rust inhibiting oil and plug the liner openings to prevent debris from entering the fluid end.
10. Block, cap, or plug any open ports on the suction and discharge manifolds.

8.2.3 Drive Motor

See the manufacturers' service manual for more information regarding drive motor preservation. Motor heaters should be powered as described in the component manual during storage to prevent moisture buildup.

8.2.4 Accessories

See the manufacturers' service manual for more information regarding preservation.

8.3 Inspection and Preservation

A proper inspection and preservation schedule should be followed when storing the mud pump. This will ensure that corrosion is kept to a minimum and the mud pump will be maintained in sufficient operating condition. It is recommended that notes from these inspections be captured for record retention purposes.

8.3.1 Weekly Inspection

If the mud pump is not stored in a climate controlled facility, the integrity of the mud pump cover must be inspected weekly (every 7 calendar days). If damage to the covering is found, repair or replace as required.

If the mud pump is kept in a climate controlled environment inspect the integrity of the mud pump cover monthly (every 30 calendar days).

8.3.2 Periodic Inspection

For mud pumps kept within a climate controlled environment perform the following inspection and preservation activities quarterly (every 90 calendar days).

If a climate controlled environment is not utilized for storage, extra care must be taken to ensure

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the pump is adequately preserved and the following inspection and preservation activities must be performed monthly (every 30 calendar days).

1. Clean dirt and debris from the gear case, crosshead, and frame rear covers and cover bolts.
2. Remove gear case, crosshead, and frame rear covers and visually inspect the inside of the power end for corrosion. If any corrosion is found, it must be addressed immediately and the periodic inspection interval shortened to prevent future occurrences.
3. Verify proper operation of the oil sump heaters.
4. Using a grease gun apply grease to each of the pony rod seal grease fittings until clean grease appears from the grease relief fittings.
5. Ensure the lube oil level in the oil sump is approximately 50.8 mm (2 in). Add lube oil if needed as specified in Table 13.
6. Using a pinion turning tool, rotate the pinion shaft five complete revolutions to coat the pinion shaft with lube oil.
7. Reapply rust inhibiting oil to all bearings, gears, and unpainted surfaces inside the power end.
8. Visually inspect gear case, crosshead, and frame rear covers gaskets and replace if damaged. Undamaged gaskets can be reused during storage.

NOTICE

Do not use silicone sealer as silicone could contaminate the lubrication system and result in costly damage.

9. Reinstall the gear case, crosshead, and frame rear covers.
10. Apply rust inhibiting oil to the exposed surface of each pony rod.
11. Visually inspect the inside of each fluid end module for corrosion. Reapply rust inhibiting oil as necessary.
12. Visually inspect the liner wash system and the inside of the liner wash pump for corrosion. Reapply rust inhibiting oil to the inside of the liner wash pump as necessary.
13. Verify the integrity of all plugs, block offs, and caps. Replace if damaged.
14. Inspect all junction boxes for moisture. If moisture is found address appropriately.

8.3.3 Quarterly Inspection

The following inspection and preservation activities must be performed quarterly (every 90 calendar days).

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1. Perform an insulation resistance test on drive motor. If the measured resistance falls outside the specifications found in the component manual, repair or replace the motor(s) in accordance with the component manual.
2. Perform an insulation resistance test on the lubrication motor. If the measured resistance falls outside the specifications found in the component manual, repair or replace the motor in accordance with the component manual.
3. Perform an insulation resistance test on the liner wash motor. If the measured resistance falls outside the specifications found in the component manual, repair or replace the motor in accordance with the component manual.

8.4 Storage Removal Procedure

The following instructions are provided as a guideline for removing a HH-supplied mud pump from storage and placing it into operation. This section assumes that the mud pump was stored, and inspection and preservation was performed in accordance with guidelines outlined by HH.

Any damage, missing parts, or issues found during this procedure must be addressed before returning the mud pump to service.

8.4.1 Power End

1. Remove the gear case, crosshead, and frame rear covers.
2. Remove the oil drain plug and drain all fluid from the oil sump. Properly dispose of drained fluid.
3. Visually inspect the inside of the power end for corrosion. Remove corrosion using an appropriate method.
4. Visually inspect all bearings and ensure they are in good condition.
5. Fill the oil sump with clean synthetic lubricant as specified in Table 13.
6. Replace the gear case, crosshead, and frame rear covers gaskets.

NOTICE

Do not use silicone sealer as silicone could contaminate the lubrication system and result in costly damage.

7. Replace the gear case, crosshead, and frame rear covers.

8.4.2 Fluid End

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1. Remove the fluid end covers.
2. Visually inspect all parts that were removed from the mud pump, prior to storage, for corrosion or damage. Repair or replace as necessary.
3. Reinstall all removed fluid end parts.
4. Inspect all gaskets and replace if needed.
5. If valve seats were removed, replace as described in the mud pump Assembly Procedure using new valve seats.
6. Tighten all fasteners in accordance with the torque specifications in Table 18.
7. Reinstall the fluid end cover gasket.
8. Reinstall the fluid end cover.

8.4.3 Drive Motor

Perform an insulation resistance test on the drive motor(s) as specified in the component manual to ensure resistance falls within the allowable tolerance range.

8.4.4 Accessories

8.4.4.1 Liner Wash System

Perform an insulation resistance test on the liner wash pump motor as specified in the component manual to ensure resistance falls within the allowable tolerance range.

8.4.4.2 External Lube Pump

Perform an insulation resistance test on the lube oil pump motor(s) as specified in the component manual to ensure resistance falls within the allowable tolerance range.

9. Disassembly and Assembly

Instructions outlined in this section apply only to the extent necessary to disassemble and assemble a HH- supplied HH2400 mud pump for the purpose of maintenance and repair. Contact HH if further mud pump disassembly is required.

NOTICE

Ensure that the parts of every cylinder are all labeled and kept together during disassembly. These must be reassembled in the same positions.

9.1 Fluid End Disassembly

System pressure must be relieved before attempting any work on the fluid end. Close the shut-off valves in the suction and discharge lines and open the by-pass line to the mud tanks to relieve the pressure and eliminate the danger of opening a valve cover, or removing a liner clamp while the component is still under load.

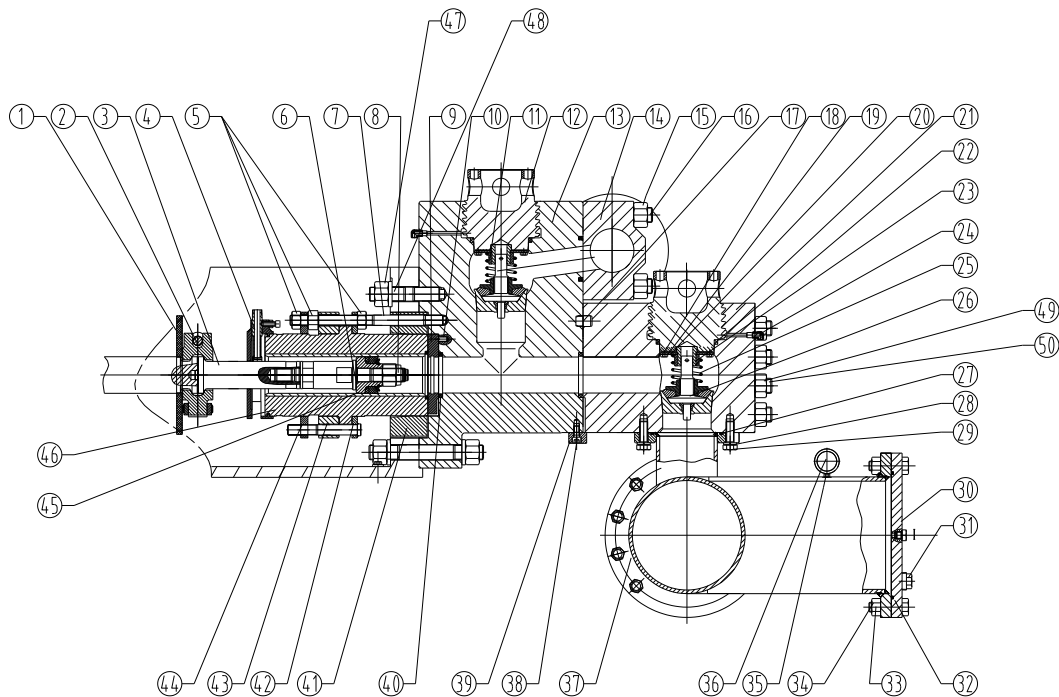


Figure 11: Fluid End Diagram

WARNING

Failure to relieve system pressure can result in severe personal injury.

For component locations identified by numbers in parentheses refer to Figure 11 for fluid end

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disassembly procedures unless specified otherwise.

9.1.1 Suction and Discharge Modules

The suction module portion (21) of the two-piece fluid modules can be removed without disturbing the discharge module. The discharge module portion (13) of the two-piece fluid end can also be removed without disturbing the adjacent modules.

1. Remove the bolts (29) connecting the suction module to the suction manifold.
2. Remove the nuts (49) from the studs holding the suction module to the discharge module.
3. Slide the suction module (21) off of the studs (50).
4. Remove the liner (46), piston (45), locking plate (44), liner lock ring (43), and the discharge manifold (14).
5. Remove the nuts (47) holding the discharge module to the frame and slide it out until the studs clear the frame and lift up.

9.1.2 Suction Manifold

It is not necessary to remove the suction manifold (37) except to replace the manifold.

Remove sufficient suction piping to allow removal of the manifold.

Remove the bolts (29) connecting the manifold to the suction modules and replace it with the new manifold.

It is good practice to also replace the gaskets and seals (27) connecting the manifold to the suction modules and the suction piping.

9.1.3 Pistons and Liners

The two-piece piston rod permits removal of a piston without disturbing the liner. The pressure in the system must be relieved before taking the pistons and liners apart.

Close the shut-off valves in the suction and discharge lines and open the by-pass line to the mud tanks before attempting any work on the fluid end modules, liners, pistons, or valves. This relieves the pressure in the modules and eliminates the danger of opening a valve cover, or removing a liner clamp while the part is still under load.

9.1.3.1 Rod Clamps

The rod clamp (2) is equipped with a loose joint bolt and a nut, it may be easily removed with air or ordinary wrenches.

9.1.3.2 Piston Removal with the Liner in Place

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1. Remove the rod clamp (2) and rotate the pump to position the pony rod in the rear stroke position.
2. Remove the sub-rod of the two-piece piston rod (3) near the power end.
3. Remove the piston rod (3) and piston (45) from the liner (46) by using the piston rod connecting tool (spare tool P/N1200535656) and rod clamp tool (spare tool P/N1200566956).

9.1.3.3 Piston and Liner Removal as a Unit

1. Remove the rod clamp (2), the four nuts(5) outside of the locking plate(44)
2. Rotate the pump to place the pony rod in the rear position.
3. Install the 2 nuts (5) at 12 and 6 o'clock on the studs of the liner returning plate assembly (42).
4. Move the liner (46) , liner lock ring (43), liner returning plate assembly (42) ,piston rod (3) and piston (45)(as a unit) out of the liner pilot bushing (41) by loosening the two nuts(5) at 12 and 6 o'clock.
5. Lift the piston and liner (as an assembly) up and out of the liner chamber by using the liner lifting tool (spare tool P/N1200533153).

9.1.3.4 Piston Cups (For Non-Bonded Style Pistons)

It is possible to change the piston cup without removing the hub from the rod. Remove the snap ring in the front of the hub and the end plate to permit removal of the piston cup.

9.1.3.5 Pistons/Pistons Hub Seal

1. Remove the piston rod nut (8).
2. Slide the straight bore piston hub off the rod.

NOTICE

A pressure-actuated seal fits in a counterbore in the hub and seals against the radius and shoulder on the rod. Do not alter or damage this seal. Doing so can result in damage to the overall equipment.

9.1.3.6 Liner Sealing Wear Plate

In HH2400 mud pumps with wear plates (9), the wear plate is retained by the liner (46). It is possible to replace the wear plates (9) without removing the liner pilot bushing (41).

1. Remove the liner with the liner pilot bushing (41) in place, remove the wear plate (9) from the fluid end to replace the wear plate by using the pulling wear plate tool (spare tool P/N1200533157).
2. A wear plate seal (40) is located under the wear plate. Always replace this seal.

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9.1.3.7 Liner Retaining Water Device

In HH2400 mud pumps, the liner retaining water device (4) is a split type that located at the end of the liner (46). It is possible to remove liner retaining water device (4) without removing the liner (46) and the two-piece piston rod (3).

9.1.4 Valves and Seats

9.1.4.1 Valve Stem Guide

1. Remove the valve cover (12) by using the valve cover installing tool (P/N1300121197).
2. Remove the valve cover seal (22) from the fluid end bore.
3. The valve stem guide (23) is attached to the valve cover (12). Remove and replace the upper valve stem guide (23) or the bushing (11) as necessary.

9.1.4.2 Valves and Seat

1. Lift out the valve spring (25) and the valve of valve assembly (26).
2. The valve seat can now be removed. Always use the hydraulic valve seat puller (P/N1300128788) and the manual pump when pulling a valve seat. This avoids the possibility of damaging the fluid end modules with a torch.

9.2 Fluid End Assembly

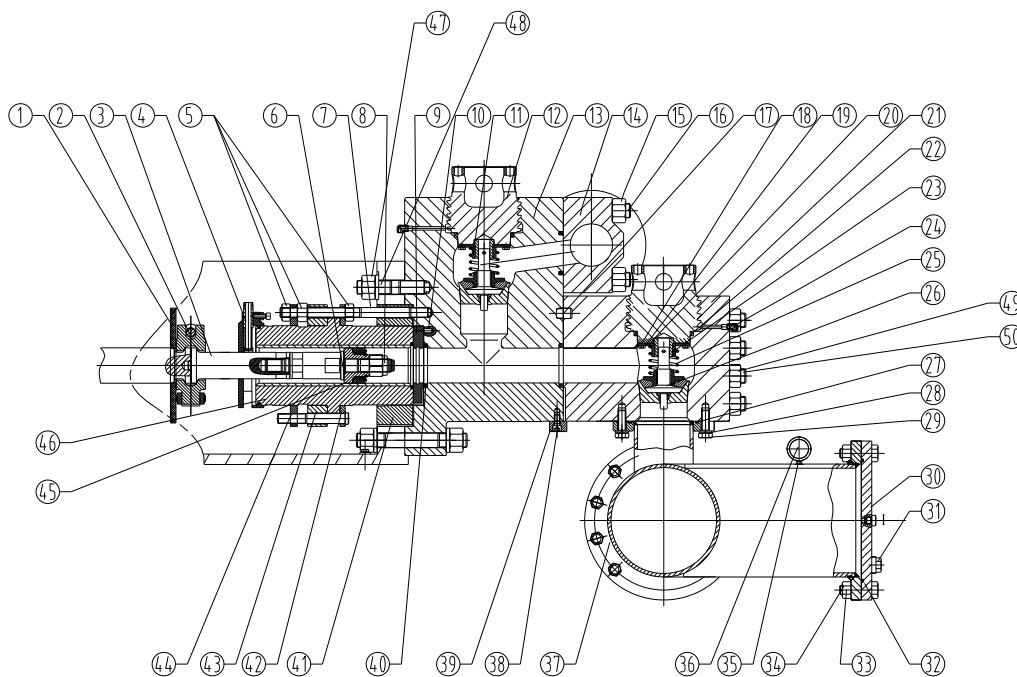


Figure 12: Fluid End Diagram

For component locations identified by numbers in parentheses for fluid end assembly

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procedures refer to Figure 12 unless specified otherwise. Refer to Table 18 for proper fastener torque specifications.

9.2.1 Preparation

Parts should be clean and free of burrs, nicks, and raised metal on the mounting and sealing faces and bores. All parts used in an assembly should be available and ready to install before starting the assembly process. Refer to Table 18 for proper fastener make-up torque values.

9.2.2 Suction and Discharge Modules

9.2.2.1 Liner Sealing Wear Plate

Install the wear plate seal (40) in its counterbore and follow with the wear plate (9).

9.2.2.2 Liner Retainer to Discharge Module

The liner retainer pilot bushing (41) is interference fit with the pump frame bore. Install the liner retainer pilot bushing to the frame using the special tool.

9.2.2.3 Discharge Module to Frame Face

Install the discharge module to the frame and tighten the nuts (47). Use a rotating "X" pattern of tightening to tighten the nuts (47) holding the discharge modules to the frame. Tighten to the proper torque value according to Table 18.

9.2.2.4 Suction Module to Discharge Module

1. Install the suction module (21) to the discharge module (13), the cylinder seal (same as wear plate seal) (40) in its counterbore.
2. Slide the suction module (21) over the studs (50) and tighten the nuts (49) to the proper torque value.

9.2.2.5 Suction Modules to the Suction Manifold

Tighten the bolts (29) evenly to the proper torque value, and always use new seals (27) between the suction manifold (37) and the suction modules.

9.2.2.6 Discharge Manifold

Always use new seals (40) between the discharge manifold (14) and the discharge modules (13). Tighten the bolts (15, 16) evenly to the proper torque value according to Table 18.

9.2.3 Pistons and Liners

9.2.3.1 Pistons and Piston Rods

These pistons have a straight cylindrical bore and are made up to shoulder on the rods. A seal

is used to seal the piston hub against the shoulder on the rods.

1. Install the pistons (45) on the piston rods (3).
2. Make up the shoulder on the rod and make sure the seal is positioned in the hub as the assembly is made up.

9.2.3.2 Piston Rod Lock Nut

1. Inspect the piston rod nut (8) and replace it if the nut shows signs of corrosion, thread damage, or the crushing effects of tightening with an improper wrench.
2. Tighten the piston rod nut to the proper value. Refer to the fastener make-up torque values in Table 18.

NOTICE

All piston rod lock nuts must be replaced after being made up three times. The locking nylon in the end of the nut loses its ability to grip the threads and prevent back off. Failure to regularly replace the piston rod nuts can lead to damaged pistons, rods, cylinders, as well as other parts.

9.2.3.3 Piston and Liner Assembly

1. Grease the inside of the liner (46) and the outside of the piston (45).
2. Install the piston in the liner so the piston rod nut and the end of the liner with the counterbore for the liner seal are on the same end. Make sure that the fastening screw on the front and rear ends of the two-piece piston rod is facing upwards to ensure that the fastening screw face is parallel to the top of the module when installing the piston and liner assembly.

NOTICE

Use grease for the inside of the liner and the outside of the piston. Do not use tool joint compounds on the piston.

9.2.3.4 Piston and Liner Lock ring Installation

1. Grease the inside of the liner returning plate assembly (42) and liner lock ring (43).
2. Grease the outside of the liner (46).
3. Install the liner returning plate assembly (42), liner lock ring (43) and the liner (46) according to the project-specific fluid end assembly drawings.

9.2.3.5 Piston and Liner Installation

1. Clean and dry the face of the wear plate (9).
2. Install the corresponding liner seal in the end of the liner.
3. Coat the inside of the liner retainer (41) with a thin coat of corrosion-resistant grease.
4. Turn the pump so that the pony rod and sub-rod are in the rear position.

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5. Install the 2 nuts (5) on the above 2 studs (7). (the bottom 2 studs don't install nuts)
6. Then slide the liner and piston assembly according to 9.2.3.3 and 9.2.3.4 to the 4 studs (7) in the liner retainer (41) and against the wear plate (9).
7. Tighten the 4 nuts locking the liner lock ring to the proper value by using the air wrench (spare tool P/N1300128798) and torque wrench (spare tool P/N1300121632). Refer to the fastener make-up torque values in Table 18.
8. Install the locking plate (44) and tighten the 4 nuts (5). Refer to the fastener make-up torque values in Table 18.

NOTICE

Leakage at the liner seal may wash out the wear plate or damage the fluid end block, costing down time and expense.

9.2.3.6 Piston Rod and Piston Installations with Liner in Place

1. Turn the pump so that the pony rod is in the rear position, remove rod clamp and the rear part of two-piece piston rod.
2. Connect the piston rod connecting tool (spare tool P/N1200535656) to the front part of two-piece piston rod.
3. Turn the pump to place the pony rod in the front position ,connect the pony rod and the piston rod connecting tool by using the rod clamp tool (spare tool P/N1200566956) in the spare tools.
4. Turn the pump to place the pony rod in the rear position. Move the front part of two-piece piston rod equipped with piston out of the liner.
5. Hang the front part of two-piece piston rod and the piston rod connecting tool. Disassemble the rod clamp tool (spare tool P/N1200566956) to apart from the pony rod.
6. Separate the front part of two-piece piston rod with piston from the piston rod connecting tool.
7. Replace the new piston on the piston installing device (spare tool P/N1200532029) on the pump skid.
8. Connect the front part of two-piece piston rod with new piston to the piston rod connecting tool (spare tool P/N1200535656) .
9. Hang the front part of two-piece piston rod and the piston rod connecting tool and connect to the pony rod with the rod clamp tool (spare tool P/N1200566956).
10. Grease the outside of the piston (45) and the inside of the liner (46).

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11. Turn the pump to place the pony rod in the front position to place the piston in the liner, make sure the connecting hexagon of the front and rear part of the piston rod outside of the liner.
12. Disassemble the rod clamp tool to apart the piston rod connecting tool from the pony rod.
13. Turn the pump to place the pony rod in the rear position. Disassemble the piston rod connecting tool.
14. Check the connecting face of the front and rear part of the piston rod for upsets, burrs, or any other defects or blemishes. Remove any raised metal on the contacting faces.
15. Connect the front and rear part of the piston rod and lock it with locking screw. Make sure that the fastening screw on the front and rear ends of the two-piece piston rod is facing upwards.

9.2.3.7 Piston Rod Clamps Installation

NOTICE

The rod clamps must be inspected and installed using the following procedure. Failure to follow this procedure could result in serious equipment or part failure.

1. Before installation, inspect both clamps and rod ends to make sure they are free from any cracks, burrs, dings, or foreign material.
2. Clean any burrs or dings with a flapper wheel or fine grain grinder.
3. Immediately discard and replace any rod ends or clamps that show any cracks.
4. With the rod ends clean and inspected, coat the clamps with Kopr-Kote or similar products to resist corrosion.
5. Install the rod clamps at the pony rod -piston rod rear part connection.
6. Once the clamps are fitted over the connection, tighten the nut at the end of the loose joint bolt evenly, according to the specified torque value in Table 15.

Table 15: Piston Rod Clamp Fastener Torque

Bolt Size	Thread Series	Torque Range (Lubricated)
25.4mm (1 in)	1-8UNC	331 ft.lbf (450N·m)

7. While tightening the bolts, repeatedly tap both halves of the clamp lightly with a small (3lbm [1.36 kg]) hammer to ensure proper seating.
8. Make sure the ends of the clamps are not being deformed when compared to the center of the clamp. See Figure 13 for the correct and incorrect clamp orientation.
 - 8.1. After repeated use and wear, the top and bottom clamps will start coming closer

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together. When the clamp halves start to touch, the clamps should be taken out of service and replaced with new clamps.

8.2. With new clamps, the approximate nominal gap between the clamps is 0.6 in (15 mm).

This dimension is for reference only and should not be used to determine if a part will or will not work correctly. The most important factors are:

There must be a gap between the two clamp halves.

The surfaces must run parallel to each other.

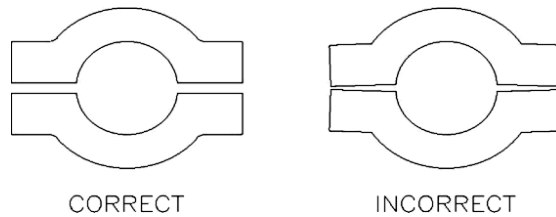


Figure 13: Piston Rod Clamp Orientation

9.2.3.8 Liner Retaining Water Device

In HH2400 mud pumps, the liner retaining water device (4) is a split type that located at the end of the liner (46). It is possible to install the liner retaining water device (4) without removing the liner (46) and the two-piece piston rod (3).

9.2.3.9 Liner Spray Manifold (Equipped With Spray Pump)

1. Connect the liner spray manifold to the inlet of the liner retaining water device.
2. Connect the hose to the outlet at the bottom of the liner chamber. The hose can be connected to RH side.

9.2.4 Valves and Seats Installation

9.2.4.1 Valve and Valve Insert

The valve insert is removable and is held in place with a valve lock.

1. Make sure the insert is securely held to the valve. If it is loose, the insert will rapidly wear and cut (wash) the valve.
2. Replace the valve if a new insert extends more than 1/16 in (1.5875 mm) beyond the valve or if the valve is cut (washed).

9.2.4.2 Valve Seats

NOTICE

Never reuse valve seats. Previously installed valve seats may not seal properly if reused, leading to fluid end module damage.

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1. Make sure that the taper in the module and the outside of the seat are clean, dry, and free of nicks and burrs immediately prior to assembly. Any oil, grease, or preservative must be removed from both mating surfaces prior to assembly.
2. Position the seat in the taper and ensure it is leveled and centered.
3. Install the valve in the seat, position the valve seat bushing (P/N1200510290) in the spare tools on the body, the seat will be sealed by tightening the valve cover.
4. Take out the valve seat bushing and valve body, proceed the leakage test on the ring space between the seat and the module, if no leak, to the next step.

NOTICE

Do not strike the valve seat directly. This can damage the valve seat.

5. Once the mud pump is installed but prior to normal operation, set all valve seats.

9.2.4.3 Valve Spring

Install the valve in the seat and center the valve spring (25) on the valve (26).

9.2.4.4 Valve Stem Guide

1. Install a new valve stem guide bushing (12) when the old one is worn enough to permit 1/8 in (3.175 mm) clearance between the valve stem and guide.
2. Lubricate the bore of the valve stem guide prior to installing the valve guide bushing.
3. The valve stem guide bushing is to be installed using a method as to not permanently deform the bushing. One acceptable method is to warm the bushing by placing it in boiling water for approximately five minutes to make it flexible for easy installation.
4. Allow the guide bushing to cool making sure that it has returned to its original shape.

NOTICE

Valve stem guide bushings should be stored at a temperature less than 100 degF (40 degC).

9.2.4.5 Valve Cover Seal

1. Replace the seal if it is cut or broken down at the outer edges.
2. Clean the seal (22) seat in the module.
3. Lightly grease the valve cover seal.
4. Place it in the counterbore in the module.

9.2.4.6 Valve Cover

1. Coat the threads of the valve cover with grease.
2. Use a 2ft bar through the valve cover and tighten with four blows of a 16 lb (7.26 kg) sledgehammer.

3. Install the valve cover installing tool (optional P/N1300121197) in the spare tools.
4. Tighten the valve cover with a small air wrench.
5. Check the actual torque with the torque wrench. As long as the torque wrench reaches 183ft.lbf~220ft.lbf (250N.m~300N.m) can increase to 30000lbf (40500N.m).
6. Locking the valve cover with the locking device (spare tool P/N1300121203).
7. Cover the valve cover with the guard (spare tool P/N1300121204).

9.2.4.7 Suction Dampener (optional)

This dampener is pre-charged using air. Refer to Section 5.2.2.

1. Charge the suction dampener to 15 psi(103kPa).
2. Adjust the dampener charge pressure upward or downward as necessary to obtain the smoothest operation for the specific suction conditions of the pump.

9.3 Power End Disassembly

Use Figure 14 to reference component locations for the power end crosshead assembly disassembly procedures.

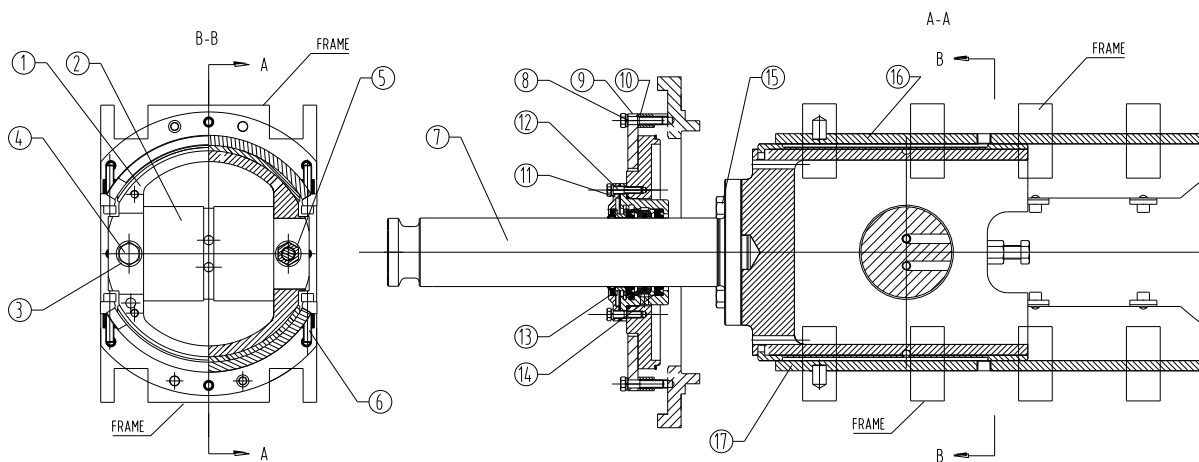


Figure 14: Power End Crosshead Assembly Disassembly Diagram

9.3.1 Pony Rods

9.3.1.1 Pony Rod Stuffing Box

1. Remove the bolts (12) mounting the pony rod stuffing box (11) to the diaphragm plate (9).
2. Slide the stuffing box (11) off the pony rod (7).

9.3.1.2 Crosshead Diaphragm Plate

Unbolt the bolts (10), remove the press plate (8) and diaphragm plate (9) can replace the diaphragm plate gasket.

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It is not necessary to remove the diaphragm plate unless replacing the gasket.

The crosshead (1) to be taken through the upper crosshead cover on the pump frame rather than the diaphragm plate opening.

9.3.1.3 Pony Rod

1. The pony rod (7) can be removed without removing the diaphragm plate (9).
2. Remove the pony rod bolts (15) and separate the pony rod (7) from the crosshead (1).

9.3.2 Crosshead, Crosshead Pin and Connecting Rod Assembly

9.3.2.1 Removal of Crosshead Assembly with Liner In Place

The crosshead, crosshead pin and connecting rod assembly of every chamber can be removed by removing the corresponding upper crosshead cover and rear cover on the pump frame without disturbing the adjacent chamber.

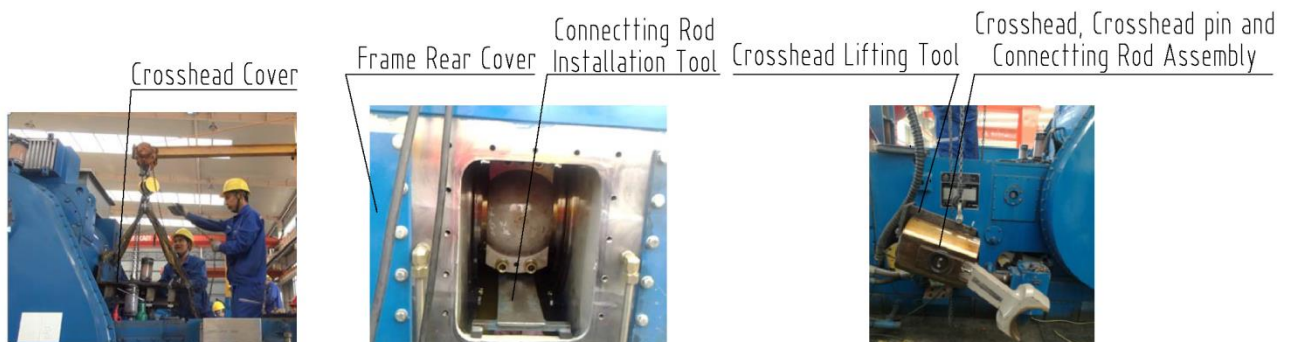


Figure 15: Crosshead Disassembly Reference Diagram

9.3.2.2 Crosshead Assembly

The disassembly of the crosshead assembly (1) is totally different from the traditional triplex mud pump. The crosshead assembly of every chamber can be removed by removing the corresponding upper crosshead cover and rear cover on the pump frame without disturbing the adjacent chamber. It is very easy to disassemble the crosshead assembly.

9.3.2.3 Crosshead Pin

Remove the two locking bolts (3) and (5) on the crosshead, the crosshead pin can be removed.

9.3.2.4 Connecting Rod Assembly

1. The connecting rod assembly consists of connecting rod body, big end bearing bush (connecting rod slide bearing) and small end copper bush (crosshead slide bearing).
2. The connecting rod big end and small end cover can be detached from the body.
3. The connecting rod big end slide bearing is two –piece structure.

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9.3.2.5 Crosshead Assembly Removal Guides

1. Remove the gear case inspection cover and install the pump rotating tool (spare tool P/N 1200510276).
2. Disconnect the lube lines on the upper crosshead covers.
3. Remove the corresponding taper dowel pin and screws, the dowel pins can be removed with the pin removal (spare tool P/N 1300100716).
4. Remove the rod clamp between the pony rod and the piston rod.
5. Turn the pump to remove the pony rod bolts and separate the pony rod from the crosshead.
6. Open the corresponding rear cover of the pump frame, turn the pump to place the pony rod in the rear position ,put the connecting rod big end installing tool (spare tool P/N 1200510248) under the connecting rod in the crankshaft compartment .
7. Remove the connecting rod big end body cover and the upper slide bearing by removal of the big end bolts. Hang the crosshead, crosshead pin and connecting rod assembly with the crosshead lifting tool (spare tool P/N 1200510269) .
8. Remove the crosshead pin, disconnect the crosshead and the connecting rod assembly.
9. Remove the connecting rod small end holding screw, disconnect the crosshead bearing and the connecting rod body.

9.3.2.6 Crosshead Guides

NOTICE

The top and bottom crosshead guides is different part numbers from each other for HH2400 mud pump. The top guide should not be used in the lower position or the lower guide in the top position. Only allow inserting the shims between the upper crosshead guides and the support seats.

1. The crosshead upper guides (16) and lower guides (17) are bolted to upper guide support seats and the main frame with the socket head screws (6). Unbolt the socket head screws (6).
2. The lower guides are standard interchangeable parts, no need for shims between the lower guides and the main frame to meet the requirements of assembling. This is the biggest advantage of HH2400 mud pump.
3. If a new guide or crosshead is to be installed, it requires check the crosshead clearance and alignment according to table 5 to avoid abnormal situations (burrs, or foreign material),

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the first inspection after assembly is acceptable under normal circumstances.

9.3.3 Crankshaft and Main Bearings

9.3.3.1 Crankshaft and Main Bearings Removal

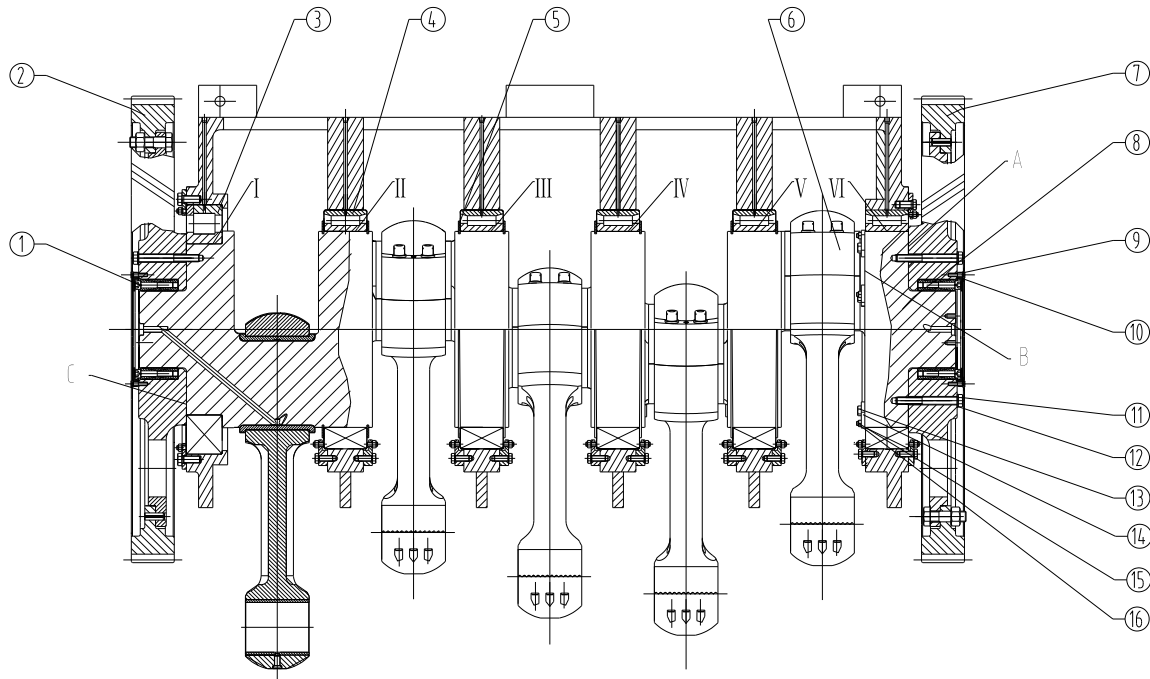


Figure16: Crankshaft and Main Bearing Reference Diagram

Do not remove the crankshaft or main bearings unless they are to be replaced, or removal is required for further disassembly. If necessary, use the following procedure to take off the crankshaft and main bearings. Use Figure 16 to reference component locations for the gear, crankshaft and main bearing disassembly procedure.

1. Remove the crosshead, crosshead pin and connecting rod assembly with liner in place according to section 9.3.2.
2. Remove the pinion shaft assembly with crankshaft and main bearings in place according to section 9.3.3.2.
3. Remove the two bull gear according to section 9.3.4.
4. Remove the hold down plates of six main rolling bearings ((3) and (4)) outer race, (3) is location bearing, only 1 piece, (4) have 5 pieces.
5. The crankshaft (8) with inner bearing race assembly can be removed with careful handling from one side of the frame (location bearing side) . Support the crankshaft with inner bearing race assembly to eliminate the downward load on the main bearings. This leaves outer bearing race in the bearing seat hole of frame, it is a clearance fit, remove the outer

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bearing race.

- Apply uniform heat to the inner bearing race using the torch. Be sure to keep torch moving. Once there is adequate heat to the inner bearing race, it will expand and the inner race and roller assembly will begin to slide through the crankshaft .(install the slide device on the crankshaft journals)

9.3.3.2 Removal of Pinion Shaft Assembly With Crankshaft and Bull Gear In Place

NOTICE

The drive motor shaft is working as pinion shaft.

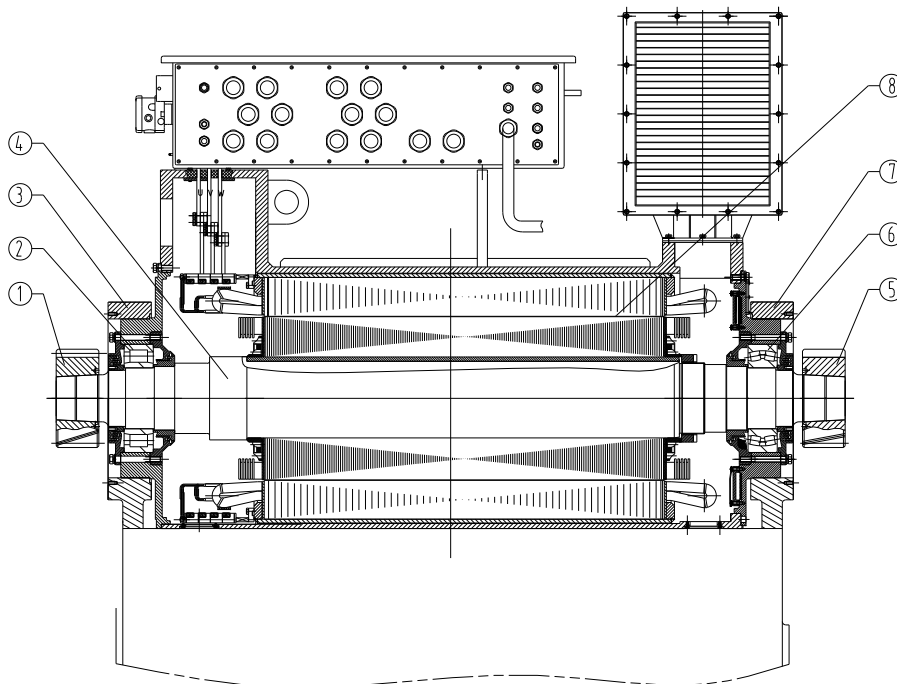


Figure 17: Pinion Shaft Assembly Reference Diagram

- Remove the gear case cover plate, the cover plate is one piece, but the internal part is two pieces, it is convenient to disassemble the pinion shaft assembly. Figure 17 to reference component locations for the pinion shaft assembly disassembly procedure.
- Remove the motor base upper cover (3, 7) on the frame.
- Lift the pinion shaft assembly.

9.3.3.3 Removal of Pinion with Pinion shaft in place Pinion Bearings

The pinion has a shrink fit to the pinion shaft. Connect a high pressure puller to the connection on the end of the pinion shaft. Apply pressure until the pinion free (loose on the shaft).

9.3.3.4 Removal of Pinion Bearings

The pinion bearings (2, 6) can be replaced by removing the pinion shaft assembly.

- Remove the pinion shaft assembly according to section 9.3.3.1 support the shaft to prevent

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it from moving.

2. Remove the two outer bearing cover to pull the rotor assembly.
3. Pull the outer bearing race from the front end plate by using the special bearing disassembling tool.
4. Use a puller to remove the inner bearing race and spherical roller from the rotor.

9.3.4 Removal of Main Gear

The two main gears are bolted to the both ends of the crankshaft through the expansion sleeve. The main gears should not be removed unless the gears, crankshaft or the main bearings are being replaced. Figure 16 to reference component locations for the main gear disassembly procedure.

1. Remove the press plates (10) and connection screws (9).
2. Remove the expansion sleeves (1) between the main gear and the crankshaft.
3. Remove the main gears (2, 7) by removing the screws (11).

9.4 Power End Assembly

NOTICE

Refer to the project-specific assembly drawings for proper torque value and tighten all nuts, bolts, and studs to the specification listed unless specifically noted otherwise. If torque values are not shown on the assembly drawing, refer to the fastener torque specifications provided in Table 18. Nut and bolt connections located inside the pump use lock nuts. Bolts in tapped holes inside the mud pump are wired for security after the proper torque is applied.

Make sure that all the fitting surfaces are clean, dry, and free of nicks and burrs immediately prior to assembly.

9.4.1 Crosshead Guides

Use Figure 18 to reference component locations for the power end crosshead assembly disassembly procedures.

The crosshead upper and lower guides are bolted to upper guide support seats and the main frame with the socket head screws. The torque is 74ft.lbf (100N.m). Special attention: The fitting area between the support seats inner surface and the crosshead guides outer surfaces is more than 85%, unfitted area is dispersed, the largest concentration area is less than 10% inner surface of

support seats.

NOTICE

The top and bottom crosshead guides is different part numbers from each other for HH2400 mud pump. The top guide should not be used in the lower position or the lower guide in the top position. Only allow inserting the shims between the upper crosshead guides and the support seats. The lower guides are standard interchangeable parts, no need for shims between the lower guides and the main frame to meet the requirements of assembling.

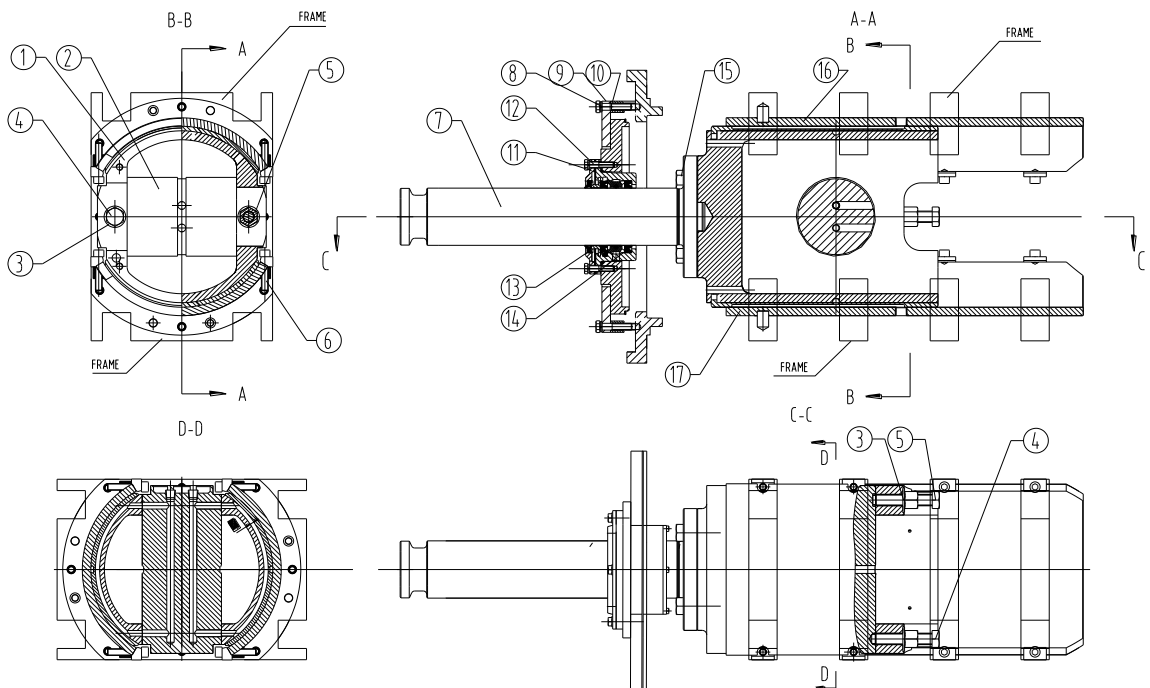


Figure 18: Power End Crosshead Assembly Disassembly Diagram

9.4.2 Crosshead, Crosshead Pin and Connecting Rod Assembly

9.4.2.1 Crosshead Assembly and Crosshead Pin

1. The crosshead pin and crosshead assembly of every chamber can be installed independently without disturbing the adjacent chamber.
2. Put the connecting rod small end in the crosshead, install the crosshead pin after the copper bush centering the crosshead pin hole.
3. Tighten the machine retention screw (5) and conical head retention screw (7) to lock the crosshead pin. Tighten to the proper torque value according to Table 18.
4. The crosshead pin bearing installed radial internal clearance is 0.0055 in ~ 0.0089 in (0.14 mm ~0.225 mm) shown in table 9. If installed RIC measurements fall outside of the acceptable range, contact HH for assistance.

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9.4.2.2 Connecting Rod Assembly

Check the contact area of connecting rod bearing bush and crankshaft journal.

After coating thin detecting agent for red lead powder and engine oil on the surface of connecting rod journal of crankshaft, install connecting rod bearing bush on connecting rod journal as per specified torque, rotate for 8~10 turns, disassemble connecting rod bearing bush from connecting rod journal to check the fitting condition of inner hole of connecting rod bearing bush, the fitting area in right circle of connecting rod bearing bush is above 90%, unfitted area is dispersed, and the maximal unfitted area cannot exceed 10% of the area of the right circle of connecting rod bearing bush, otherwise, find out reason until the fitting area meets requirement.

Disassemble checked connecting rod bearing bush and connecting rod from crankshaft, mark cylinder number, and respectively store for later use during general assembly.

Refer to Figure 19 for component locations identified by numbers in parentheses for the connecting rod assembly procedures.

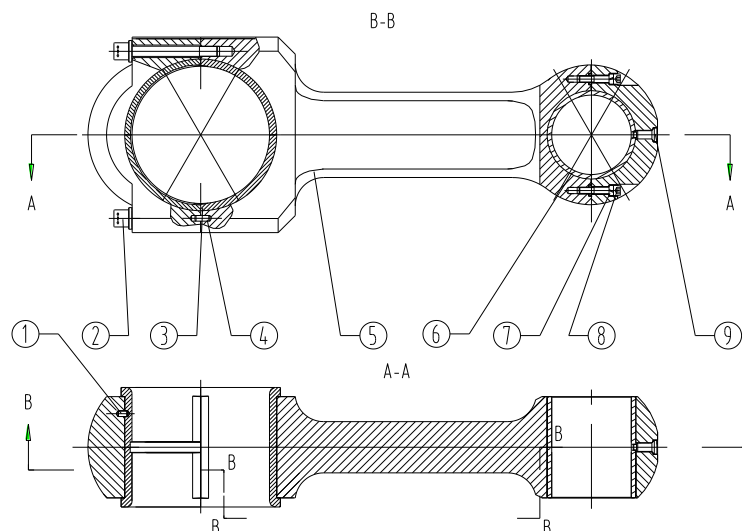


Figure 19: Connecting Rod Assembly Diagram

1. The connecting rod big and small end bearings are two-piece sliding bearings. Don't need to heat the connecting rod body or cool the sliding bearings.
2. Put the connecting rod dowel pin (4) and big end bearing dowel pin (1) in the connecting rod body(5), coat a thin anaerobic adhesive (GY-280)in pin hole, install the other parts after the pin to be hard.
3. Put the small end bearing dowel pin (9) in the body after positioning the small end bearing.
4. Install the big end bearing (3) and small end bearing (6) in the connecting rod body. Tighten the connecting rod bolts (2) and the socket head screws (8) to the proper torque value

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according to Table 18.

9.4.2.3 Crosshead, Crosshead Pin and Connecting Rod Assembly

The crosshead, crosshead pin and assembly of every chamber can be installed independently without disturbing the adjacent chamber.

1. Open the corresponding rear cover of the pump frame, put the connecting rod big end installing tool (spare tool P/N 1200510248) in the crankshaft compartment . Hang the crosshead, crosshead pin and connecting rod assembly with the crosshead lifting tool (spare tool P/N 1200510269) into the lower crosshead guide , the connecting rod body put on the connecting rod big end installing tool.
2. Turn the pump by the pump rotating tool (spare tool P/N 1200510276) to make centers of crankshaft journal and connecting rod big end at the same horizontal plane, push crosshead to make connecting rod big end is closed to the crankshaft journal, and then fix connecting rod big end (with bearing shell) and connecting rod body on the crankshaft by the connecting rod big end installing tool.
3. Install the upper crosshead cover with the upper crosshead guide on the frame.
4. Crosshead and guide shall have no interference during moving:
Fill lubrication oil into upper and lower guide, rotate the pump and make sure there is no interference during crosshead moved in the guide back and forth.
5. Install the pony rod (7). Tighten the bolts (15) to the crosshead (1) to the proper torque value according to Table 18.
6. Check contact condition between crosshead and the lower guide:
After the crosshead is installed on the lower guide, check the crosshead and the lowest place of lower guide for no gap, when the crosshead is at front and rear dead points, check lowest position by 0.02mm feeler gauge without passage, otherwise, find out reasons and treat it correspondingly.
7. Check the clearance between the crosshead and the upper guide:
Always check the crosshead clearance after the final crosshead to the frame alignment. Use a long feeler gauge and check the clearance in front and rear several places.
8. Crosshead clearance acceptance criteria are provided in Table 5. The first inspection after assembly is acceptable under normal circumstances. Otherwise, find out reasons and treat it correspondingly.
9. Measure the pony rod runout using a dial indicator on the vertical and horizontal axes at the bore end of each pony rod. Maximum TIR acceptable criteria are provided in Table 5

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9.4.3 Stuffing Box Seal

Use Figure 18 to reference component locations for stuffing box assembly procedure.

1. Place the two-lip seal (14) and dust-proof seal(13) in the stuffing box (11). Coat grease on oil seals.
2. Make sure the seal on the power end side is facing the power end, and the seal on the fluid end side is facing the fluid end.
3. Slide the stuffing box (11) on the pony rod (7).
4. Slide the stuffing box (11) against the diaphragm plate (9).
5. Tighten the bolts(12) to the proper torque value according to Table 18

9.4.4 Pinion Shaft Assembly

The pinion shaft assembly with pinion bearings can be installed with or without the crankshaft and gear in place.

1. Check internal conical surface of pinion and external conical surface of motor shaft by coloring method to ensure that contact area of conical surfaces is exceeding 80%.
2. Push the pinion into the motor shaft by hand in room temperature, when hands can not push, record the distance from outer end surface of pinion to shaft end surface , it should be 0.33~0.41in (8.4~10.35mm).
3. Take down the pinion, Heat the pinion to 518~554deg F, keep temperature for 5 hours, then push the pinion into the motor shaft with the pinion installing tool (P/N 1200510258), the distance from outer end surface of pinion to shaft end surface should be 0.15~0.29in (3.89~7.35mm) at this moment, so as to ensure the magnitude of interference to be 0.012~0.018in (0.3~0.45mm).
4. Lift the pinion shaft assembly into the mounting seat of frame. Install the mounting seat cover of motor, screw on eight pieces of M36 bolts, Tightening torque of each bolt is 1323 ft.lb (1800N.m) according to Table 18.

9.4.5 Main Bearings

Use Figure 16 to reference component locations for main bearings assembly procedure.

Main bearings should not be removed from their protective wrapping until ready to be mounted. Do not remove protective rust preventative oil from new bearings. Keep bearings covered with plastic until ready to begin mounting procedure.

1. Inspect bearing carrier for burrs and defects and remove with emery paper or file, as

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necessary.

2. Clean debris from bearing carrier with a clean cloth and light oil based solvent.
3. Coat inner diameter of carrier and outer diameter of bearing with a light coating of oil to facilitate installation.
4. If necessary, a light coating of oil may also be sprayed on housing and bearing to reduce friction during installation.

9.4.5.1 Install Outer Bearing Race In the Bearing Seat Hole of Frame

1. The outer diameter of bearing and inner diameter of carrier of frame is a clearance fit. It is easy to install the outer bearing race. Make sure the groove on the outer race is aligned with the groove on the frame.
2. Install the hold down plates of main bearings outer race. Tighten the bolts and screws to the proper torque value according to Table 18.

9.4.5.2 Mounting Main Bearing (with inner race, roller, retainer) on Crankshaft

1. Use an electric oven or oil bath to warm the main bearings (3, 4) inner race and retainer to 230~248 degF (110~120degC).
2. Before installing the inner bearing race of No. II, III, IV and V on crankshaft , first install elastic retainer ring (5) in one edge slot of four crankshaft main journals, after the inner bearing races are installed in position, install another elastic retainer ring in another side. when the inner bearing race of No.VI is installed, install the surface of hold down plates (14) without step on the surface A of No.VI main journal, tighten three hold down plates by three bolts M16X150, ensure that the end surface of the inner bearing race is level with surface A , but is not higher than surface A, when the inner bearing races are cooled to room temperature, disassemble three hold down plates (14), install plates (14) on the end surface B of No.VI main journal, tighten the inner bearing race, ensure the correct position of the axial position of the roller bearing during shrinkage fit. When the inner bearing race of the No. I main journal is installed, ensure that the end surface of inner bearing race cannot be higher than surface C. Roller bearing outer race should be aligned with end surface of inner race during installation.

9.4.6 Mounting Crankshaft assembly (with main bearings) on the Outer Bearing Race of Frame

1. The outer diameter of bearing and inner diameter of carrier of frame is a clearance fit. It is easy to install the outer bearing race. Make sure the groove on the outer race is aligned

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with the groove on the frame.

2. Check and record the main bearing Installed Radial Internal clearance, the minimum and maximum mounted clearance listed in Table 6, if recorded Installed RIC does meet the requirements listed in Table 6, contact HH for further assistance.

9.4.7 Main Gear

1. Install the left and right main gears (2, 7). Make sure that the tooth surface marked with "0" of pinion is assembled into tooth space marked with "0" of bull gear. Tighten the bolts (11) to the proper torque value according to Table 18.
2. Check left and right main to pinion gear synchronization after installation. The steps of synchronization adjustment are shown in section 9.4.8, the tolerance acceptance criteria are provided in Table 5.
3. Install the expansion sleeves (1) and press plates (10). The bolts (9) on the press plates should be wired for security after the proper torque is applied. Tighten all the bolts to the proper torque value according to Table 18.
4. Check the main-pinion gear backlash. Backlash tolerance acceptance criteria are provided in Table 5.

9.4.8 The Steps of Synchronization Adjustment for Main to Pinion Gear

Assuming install left bull gear firstly.

Stand at the power end of the pump and look toward the fluid end, the left hand side is left gear.

1. The tooth surface for left pinion has a mark "0" and find the mark "0".
2. Install the corresponding bull gear (in contrast with the pinion rotation), the tooth surface for the bull gear also has a mark '0', must ensure the two marks meshing with each other during installation.
3. Fasten the left bull gear by 6×M20 bolts and torque with 370ft.lbf (500N.m), then install the left expansion sleeve.
4. The right bull gear is mounted to the crankshaft according to the step 2.
5. Install 6×M20 bolts, but not tightened by torque wrench, ensure that the mating face between the gear face and crankshaft has no gap so as to the bull gear can be slight rotation through the six shaped holes on the hub.
6. Manually turning the pump as per the pump turning rotation, make sure the force face

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between the left bull gear and pinion has no gap (0.02mm feeler cannot pass), then the unstressed side is stoppered by the feeler.

7. Hammering the shaped hole on the right bull gear hub with the copper rod, make the bull gear rotate a slight angle (note: the pinion cannot rotate), until the force face between the right bull gear and pinion has no gap, then the unstressed side is stoppered by the feeler.
8. Fasten the right bull gear by 6×M20 bolts and torque with 370ft.lbf (500N.m).
9. Manually turning the pump as per the pump turning rotation, check left and right main to pinion gear synchronization, every 36 °as an inspection point, totally require 11 inspection points and make a record.
10. If the inspection data of step 9 can satisfy the following standard, the data can satisfy design required, otherwise continue adjustment as the step 5~7, until satisfy the design required, then install right sleeve. Acceptance criteria as follows:
 - (1) At least, 1~2 points of left and right mesh at the same time in the 11 inspection points, means the force face has no gap;
 - (2) The left and right main to pinion gear synchronization difference cannot exceed 0.008in (0.15mm) in the 11 inspection points, means one side gear force face has no gap , the other side gear force face cannot exceed 0.008in (0.15mm) at the same time;
 - (3) In the same side, the gear force face clearance difference for starting point and end point (the same point) cannot exceed 0.003in(0.08mm).

10. Special Tools

Special tools described in this section are available for order from HH's Product Services Sales department.

Special tools of HH 2400 drilling mud pump are listed in Table 16.

Table 16: Special tools of HH 2400 drilling mud pump

Item	P/N	Description
1	1200510258	Pinion Installing Tool
2	1200510276	Pump Rotating Tool
3	1200510248	Connecting Rod Big End Installing Tool
4	1200510269	Crosshead Lifting Tool
5	1300128788	Hydraulic Valve Seat Puller (API-6#)
6	1300121197	Valve Cover Installing Tool

10.1 Pinion Installing Tool

Refer to Figure 20 for pinion installing tool.

Part number: 1200510258

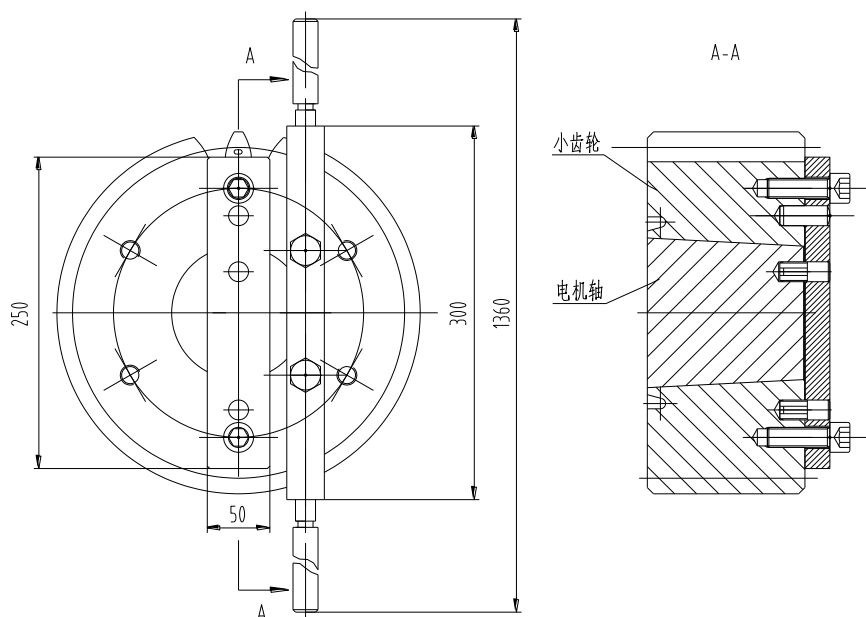


Figure 20: Pinion Installing Tool

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It is used to install the pinion to the motor shaft (as pinion shaft) to ensure correct fixed position.

Heat the pinion to 518~554deg F, keep temperature for 5 hours, then install this tool to the pinion according to installation instruction and use pin to fix position, push pinion into the motor shaft, the magnitude of interference between pinion and motor shaft should be 0.012~0.018in (0.3~0.45mm).

NOTICE

Push the pinion into the motor shaft by hand in room temperature, when hands can't push, record the distance from outer end surface of pinion to shaft end surface, it should be 0.33~0.41in (8.4~10.35mm). After the pinion is heated, the pinion is mounted on the motor shaft with the pinion installing tool, the distance from outer end surface of pinion to shaft end surface should be 0.15~0.29in (3.89~7.35mm) at this moment, so as to ensure the magnitude of interference to be 0.012~0.018in (0.3~0.45mm).

10.2 Pump Rotating Tool

Refer to Figure 21 for pump rotating tool.

Part number: 1200510276

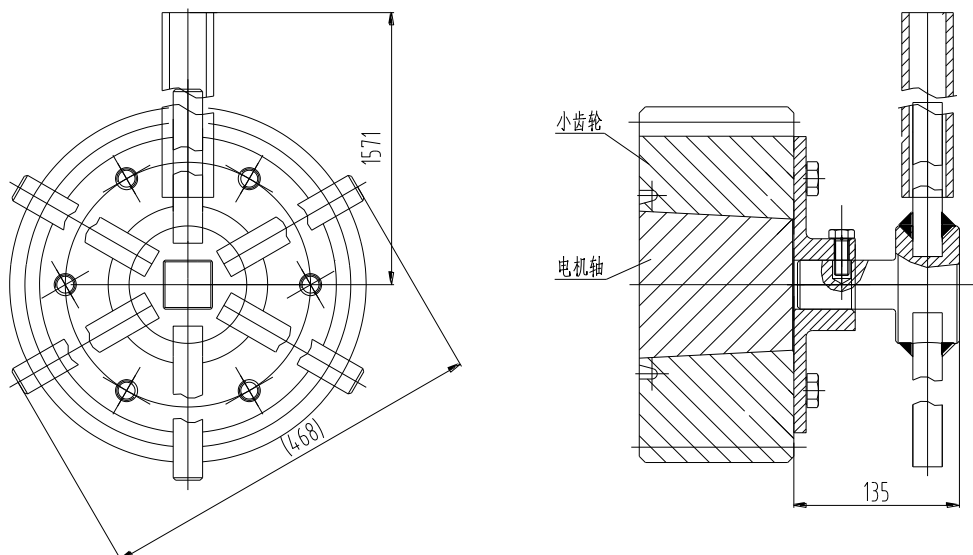


Figure 21: Pump Rotating Tool

This is a hand-operated tool for rotating the pinion. Put this pump rotating tool on the end face of the pinion, the pump will be manual operation.

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10.3 Connecting Rod Big End Installing Tool

Refer to Figure 22 for connecting rod big end installing tool.

Part number: 1200510248

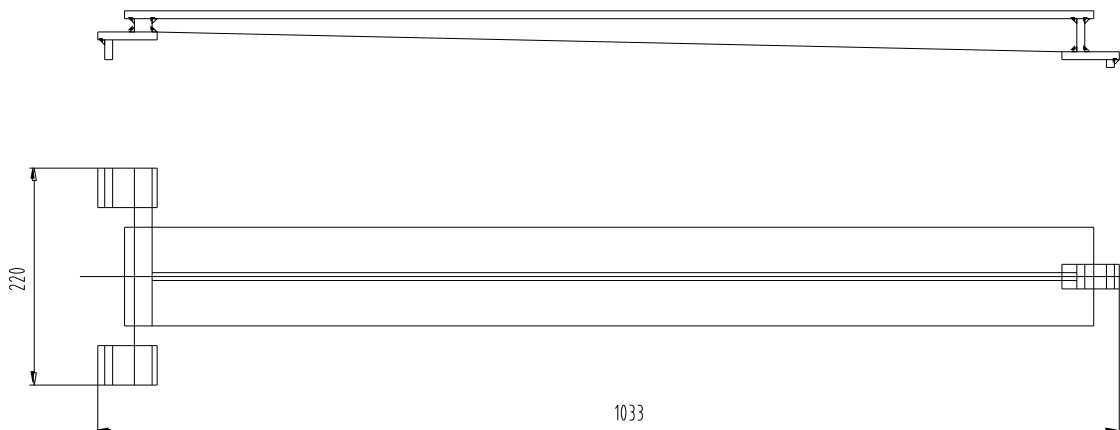


Figure 22: Connecting Rod Big End Installing Tool

Connecting rod big end installing tool is used for assembling and disassembling the connecting rod component. Just open the corresponding rear cover of the pump frame, put this tool under the connecting rod in the crank shaft compartment to assemble or disassemble the connecting rod big end.

10.4 Crosshead Lifting Tool

Refer to Figure 23 for crosshead lifting tool.

Part number: 1200510269

Crosshead lifting tool is used for assembling and disassembling the crosshead components. Just open the corresponding crosshead upper cover of the pump frame, install this tool to the connecting face between the crosshead and pony rod to assemble or disassemble the crosshead components.

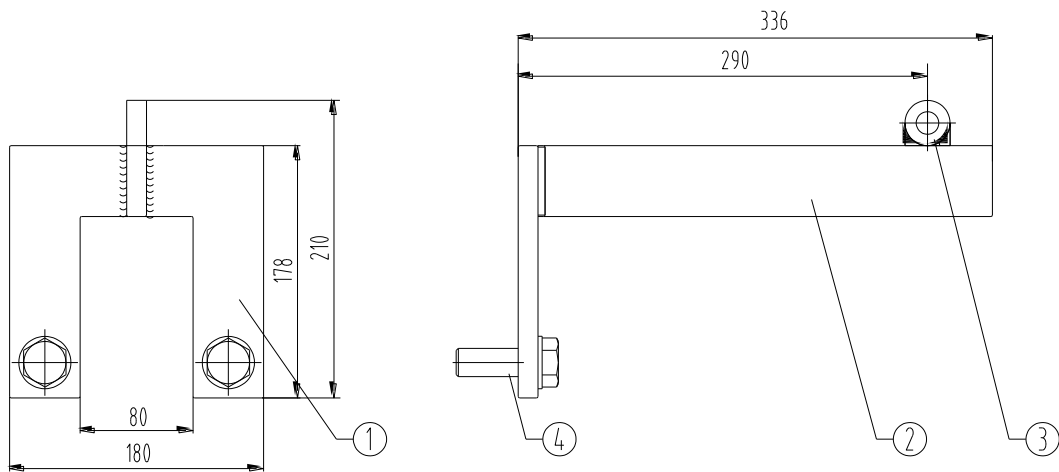


Figure 23: Connecting Rod Big End Installing Tool

10.5 Hydraulic Valve Seat Puller (API-6#)

Refer to Figure 24 for hydraulic valve seat puller.

Part number: 1300128788

This hydraulic valve seat puller is patented product for pulling the valve seat of HH2400 mud pump.



Figure 24: Hydraulic Valve Seat Puller (API-6#)

10.6 Valve Cover Installing Tool (API-6#)

Refer to Figure 25 for valve cover installing tool.

Part number: 1300121197

This tool is patented product for assembling and disassembling the valve cover of HH2400

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mud pump.

The torque for locking the valve cover can reach up to 30000lbft (40500N.m), it will not loosen under the 7500psi high pressure, it is safe and reliable.

1. Install this tool on the valve cover;
2. Tighten the valve cover with a small air wrench.
3. Check the actual torque with the torque wrench. As long as the torque wrench reaches 183ft.lbf~220ft.lbf (250N.m~300N.m) can increase to 30000lbft (40500N.m)



Figure 25: Valve Cover Installing Tool

11. Troubleshooting

Table 17: Troubleshooting

Problem	Possible Cause	Solution
Knocking Fluid End	Improper pulsation dampener pre-charge (optional)	Keep discharge pulsation dampener pre-charged with nitrogen at the correct pressure for the application (see the manufacturers' service manual for instructions on how to determine the correct pre-charge pressure)
	Improper suction dampener operation	Keep the suction dampener pre-charged with air at 15 psi (103 kPa)
	Loose or washed out valves or valve seats	Check for loose valve seats by pulling up sharply on the bottom of the seat with a jerk hammer
	Valves cocked in seats	Examine valves for uneven wear, fluid cuts, and loose valve inserts
	Loose piston hubs	Check piston nut for proper tightness and nylock wear
	Charging pumps output too low	Charge pressure in the suction manifold should be 50 psi to 60 psi (345 kPa to 414 kPa) with the mud pump in operation
	Charging pump packing loose or worn out permitting air to be drawn into suction	Hose water over the packing area while running the charge and mud pumps; if knocking stoppings, adjust or replace packing
	Restriction in suction line or plugged suction line strainer (if one is used)	Remove restriction
	Air or gas in mud	Examine mud pits for excessive bubbles Check that mud return lines terminate below mud level Check degassing equipment

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Table 17: Troubleshooting (Continued)

Problem	Possible Cause	Solution
Knocking Fluid End (Continued)	Loose or worn piston rod clamps	Replace the clamps if the two faces meet metal-to-metal Tighten the clamps; there should be no relative movement between the rod and the clamp
	Discharge cross strainer plugged preventing proper discharge dampening	Clean the cross strainer cage
	Missing or worn valve springs	Replace valve springs
	Swollen valve stem guide inserts causing valves to stick	Replace the valve stem guide inserts
	Suction manifold sediment build-up (causing bladder to clock ports)	Remove the cling flange and clean suction manifold
	Suction bladder damaged, blocking inlets	Remove the suction bladder and inspect for damage. Replace if damage
	Discharge line (relief line or shear) to the mud pits is open	Reset relief valve
	Downhole issue with the drill string or drill bit	Choke the discharge manifold (preferably at the standpipe). If pressure increases, the issue is downhole in the well.
	Gate valve seat destroyed	Choke the discharge manifold (preferably at the standpipe). If pressure does not increase replace the gate valve seat.
	By-pass on suction piping line is open (pressure gauge will fluctuate, indicating a suction piping / valve by-pass issue)	Ensure valves are set correctly
Impellers damaged causing cavitation	The net positive suction head may be too low for viscosity and specific gravity Increase the fluid in mud tanks	

Table 17: Troubleshooting (Continued)

Problem	Possible Cause	Solution
Knocking Power End ¹	Crosshead pin is too tight	Loosen the crosshead pin, remove Crosshead Pin tightening screws, and bump pin lightly; if pin moves easily in crosshead, re-torque
	Upset on crosshead guide	Replace guide
	Excessive clearance (>0.014in [0.36 mm]) in connecting rod bearing	Replace worn bearing
	Excessive clearance (>0.011in mm [0.28]) in crosshead bearing	Replace bearing
Vibration	Inadequate pump support	Resize pump supports
	Inadequate discharge strainer cross support	Resize the support
	Loose connecting bolts between pump frame and skid	Retighten the bolts
	Improper pulsation dampener pre-charge(optional)	Keep discharge pulsation dampener pre-charged with nitrogen at the correct pressure for the application
	Improper suction dampener operation	Keep the suction dampener pre-charged with air at 15 psi (103kPa)
Rapid Piston and Liner Wear	Insufficient coolant sprayed into liner causing overheating	Insufficient coolant sprayed into liner causing overheating
	Coolant too hot (> 100 degF [37.8 degC])	Use a larger coolant sump or heat exchanger or switch to a non-recirculating clean water system
	Coolant contaminated with trash and mud	Decontaminate or change coolant
	Mud has high concentration of sand or solids which generally results in streaked liner bores	Check desanders and clean mud tanks

1. Most pump knocking problems are fluid end related. All checks on the fluid end of the pump should be performed before investigating the power end.

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Table 17: Troubleshooting (Continued)

Problem	Possible Cause	Solution
Rapid Piston and Liner Wear (Continued)	Deterioration of piston cups and valve disc when aniline point of oil-based muds is less than 150 degF (65.5 degC)	Check with suppliers and use special pistons and valve discs
	Corrosive mud attacks liner	The mud PH should be above 8.5; use premium liners with corrosive muds
Liner Difficult to Install in Liner Bushing	Paint on the two pilot diameters of the liner	Remove paint with emery cloth
	Liner bushing egg-shaped	Replace liner bushing
	Burr on piloting diameters inside liner bushing	Remove burr
	Trash on wear plateClean the plate; the wear plate and liner end must be clean and dry	Clean the plate; the wear plate and liner end
Liner wash fluid temperature exceeds recommended operating limits	Low cooling water flow rate	Increase heat exchanger cooling water flow to recommended rate (Section 6.3)
	Heat exchanger clogged	Clean heat exchanger
	Heat exchanger damaged or not connected properly	Ensure heat exchanger is connected properly
		Repair or replace components as necessary
Liner wash pressure is below recommended operating limits	Low liner wash fluid level	Check liner wash fluid level
		Use a larger liner wash fluid sump
	Leaks in liner wash system hoses or gaskets	Check for leaks in the liner wash system; repair or replace components as necessary
	Wear on liner wash pump	Repair or replace pump

Table 17: Troubleshooting (Continued)

Problem	Problem	Problem
Liner wash fluid pressure is above recommended operating limits	Blockages or buildup in liner wash system hoses	Check for obstructions in the liner wash system piping; clean, repair, or replace
		Obstruction(s) or buildup in liner wash system strainer
Lube oil temperature exceeds recommended operating limits	Low cooling water flow rate	Increase heat exchanger cooling water flow to recommended rate (Section 6.3)
		Clean heat exchanger
	Heat exchanger damaged or not connected properly	Ensure heat exchanger is connected properly
		Repair or replace components as necessary
Crosshead and/or main manifold oil pressure is below recommended operating limits ¹	Obstruction(s) or buildup in lube oil system filters, strainers, or piping	While the pump is not running, check for obstructions in the lube oil system filters, strainers, and piping; clean, repair, or replace components as necessary
		Low crankcase oil level
	Leaks in lube oil system hoses or gaskets	Check for leaks in the lube oil system; repair or replace components as necessary
	Wear on lube oil pump	Repair or replace pump
	Oil pressure relief valve set improperly	Adjust oil pressure relief valve to recommended setting ²
	Crosshead and/or main manifold oil pressure exceeds recommended operating limits ¹	Oil being used does not match operating environment
Blockages or buildup in lube oil system piping		Check for obstructions in the lube oil system piping; clean, repair, or replace components as necessary

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Table 17: Troubleshooting (Continued)

Problem	Problem	Problem
Crosshead and/or main manifold oil pressure exceeds recommended operating limits ¹ (Continued)	Oil pressure relief valve set improperly	Adjust oil pressure relief valve to recommended setting ²

1. In drilling yard, mud pumps can run continuously with only one lubricating pump, the second lubrication pump can be stand-by pump.
 - a. Main manifold low oil pressure warning setting is 0.75 MPa.(Warning and stopping setting to be tied into Drillview)
 - b. Back-up lubrication pump kicks in at 0.75 MPa, the lube oil pressure will increase above 1.1 MPa meanwhile.
 - c. The oil pressure on main manifold $0.75\text{MPa} \leq p \leq 1.15\text{Mpa}$; The pressure on crosshead $0.65\text{MPa} \leq p \leq 1.05\text{Mpa}$;
 - d. The oil pressure on main manifold stopping setting value is 0.7MPa.
2. Adjust oil pressure relief valves to recommended setting. (Use Figure 10 to reference component locations). The specific method is:
 - a. Adjust the safety valve (5) be the max limit (above 1.2MPa, the screw completely tightened), adjust the safety valve (3) and the safety valve (4) to the low pressure (only thread the screw 2~3 turns).
 - b. Close 2# (2) oil pump, start the 1# (1) oil pump, and adjust safety valve (3), set the oil pressure to be 1.2~1.6MPa, see the corresponding 1# pressure gauge indication on the main manifold.
 - c. Close 1#(1) oil pump, start the 2# (2) oil pump, and adjust safety valve (4), set the oil pressure to be 1.2~1.6MPa, see the corresponding 2# pressure gauge indication on the main manifold.
 - d. Adjust the safety valve (5), set the oil pressure to be 1.1MPa.

12. Torque Specifications

Table 18: Steel Fastener Torque Specifications (Lubed)

Steel Fastener Torque Specifications (Lubed) ¹			
Thread	Torque ft.lbf (N·m)	Type	Location
1-5/8-8UN-2B	2073 (2820)	Nut	Discharge module to frame /discharge manifold
1-5/8-12UNF-2A	926(1260)	Stud	In discharge module
1-1/2-8UN-2B	1592 (2165)	Nut	Suction to discharge module
1-1/2-12UNF-2A	728 (990)	Stud	In discharge module
1-1/2-8UN-2B	1103 (1500)	Nut	Piston rod lock nut
1-1/8-7UNC-2A	294 (400)	Stud	In discharge module/pipe/ cross
1-1/8-7UNC-2B	757 (1030)	Nut	Tight liner lock ring
1-1/8-7UNC-2B	294 (400)	Nut	Lock plate
1-1/8-8UN-2B	625 (850)	Nut	Discharge strain cross /pipe/safety valve seat
1 -8UN-2B	331 (450)	Nut	Piston rod clamp
3/4-12UN-2B	331 (450)	Nut	Discharge strain cross to pressure gauge seat
3/4-12UN-2A	110 (150)	Stud	In discharge strain cross
7/8-9UNC	220 (300)	Bolt	Suction pipe to module
NPT3/8	184 (250)	Plug	Plug on crosshead pin
M48	3088 (4200)	Bolt	Drive motor to frame
M36	1323 (1800)	Bolt	Pinion bearing basket to frame
M20×2	220 (300)	Screw	Crosshead pin conical / hexagonal socket head bolt
M20×2	368 (500)	Nut	Crosshead pin lock nut
M20	368 (500)	Bolt	Pony rod to crosshead/holddown main bearing bolt
M16	184 (250)	Bolt	Crosshead cover to frame, horizontal
M12	74 (100)	Bolt	Crosshead cover to frame, vertical
M16	184 (250)	Nut	Liner retaining water device
M20	368 (500)	Bolt	Connecting rod bearing bolt
M12	74 (100)	Screw	Crosshead guide/ bearing/holddown main bearing
M16	184 (250)	Screw	Crosshead bearing locating screw
M16	261 (355)	Screw	Expansion sleeve

1. All torque values given are for fasteners lubricated with 30 weight motor oil.

2. All torque values on HH2400 mud pumps fasteners are for specific grades according to the drawing

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