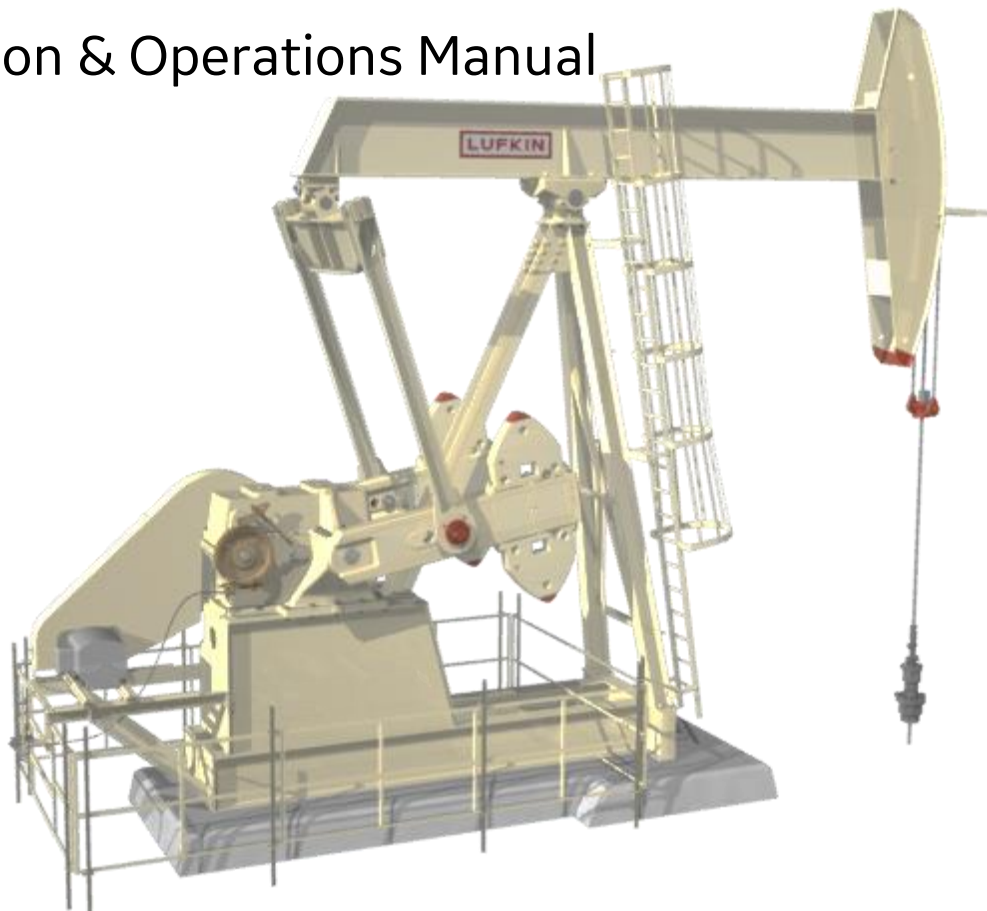




Lufkin Beam Pumping Units

Conventional & Reverse Mark

Installation & Operations Manual



LEGACY CONVENTIONAL & REVERSE MARK UNITS ONLY
ORIGINAL TRANSLATION

THIS DOCUMENT CONTAINS IMPORTANT SAFETY INFORMATION AND INSTRUCTIONS. DO NOT DISCARD.

This manual is provided as a reference guide for the operation of a Lufkin Beam Pumping Unit (BPU). It does not cover all aspects of transportation, installation, operation, decommissioning, and safety, or replace the need for trained BHGE service personnel to help ensure proper setup and performance of this unit.

Some of the photographs and illustrations used in this manual are representative and may not look exactly like the parts with which you are working.

A spare parts list for your BPU is available upon request.

The LUFKIN Conventional crank balanced pumping unit is a rear mounted geometry Class I lever system having crank counterbalance. LUFKIN's Reverse Mark unit is a conventional style pumping unit with forward shifted rear working center and phased counter-balance. The Reverse Mark is designed for operation in a clockwise direction of rotation only, when viewing the unit from the side with the well head to the right, while the Conventional unit may be operated in either direction. The four-bar lever system converts rotational motion at the crank to reciprocating motion at the horsehead and in turn to the downhole pump.

LUFKIN pumping units have been designed to rigid LUFKIN standards and exceed API (American Petroleum Institute) standard requirements for pumping unit design. In addition, all individual components of the unit and the unit as a whole represent the very best engineering design, production facilities, quality, and field experience that almost a century of LUFKIN INDUSTRIES' experience can bring to you. Your LUFKIN unit will give many years of dependable service when properly installed, maintained, and operated within its load and torque ratings.

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1 Frequently Used Terms

To avoid confusion, some of the more common terms used concerning pumping units and operations are defined as follows. Pumping unit component naming conventions are illustrated in Figure 2.

BPU: abbreviation for Beam Pumping Unit.

Front: is the well head (horsehead) end.

Rear: is the prime mover end.

Left & Right: are determined by standing at the rear of the pumping unit and facing the well head.

Crank Sweep or Crank Swing: is the circular area centered about the crankshaft where the cranks and counterweights will rotate when in motion.

Crank Orientation: is the location of the cranks using the analogy of a 12-hour clock to describe angles and directions when viewed from the right side. For example, cranks oriented vertically downwards are at the 6 o'clock position.

Direction of Operation: Determined based on direction of rotation observed from the right side as seen in Figure 1. Clockwise operation, the cranks descend towards well head.

Lockout/Tagout: Abbreviated as "LOTO." The process in which the equipment is shut-down and all energy sources are isolated to prevent the release of potentially hazardous energy or motion while work is being performed.

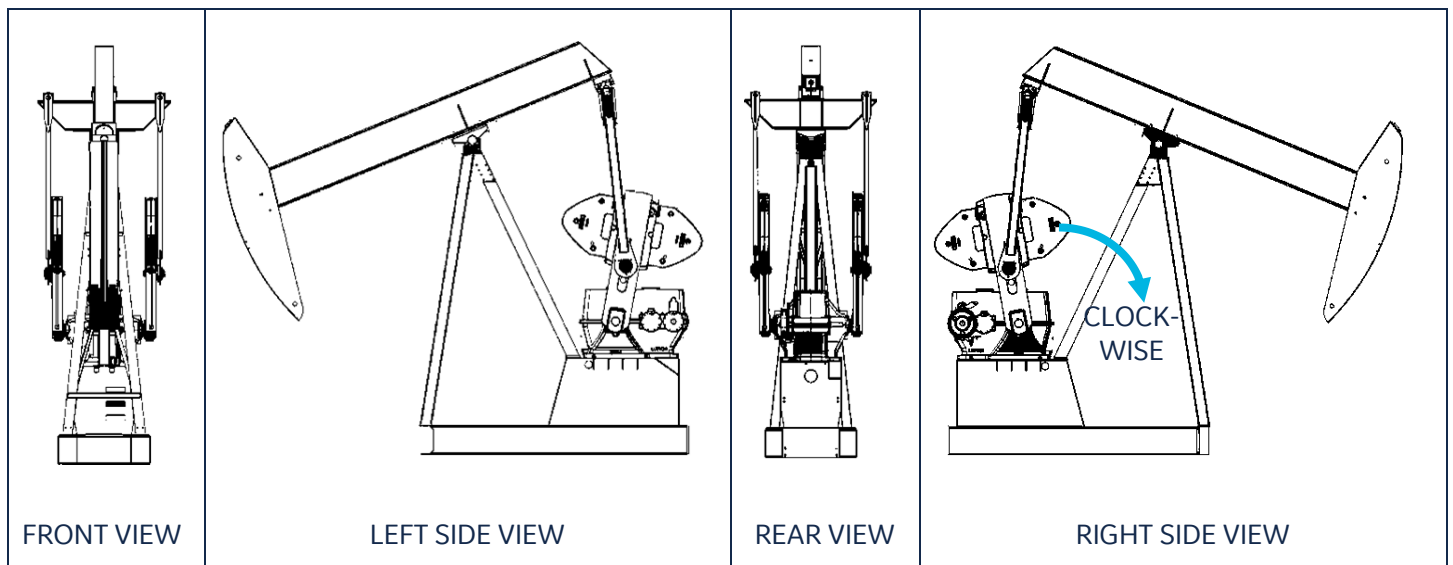


Figure 1: Pumping unit orientations

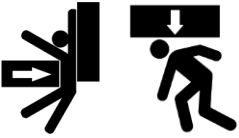



Figure 2: Conventional and Reverse Mark component names

2 Important Safety Instructions

Before proceeding with the installation, operation or maintenance of a pumping unit, identify all the site regulations and statutes associated with Federal, State and Local law including but not limited to, Electrical codes, Zoned area requirements, EMC, Noise and Air Emission Regulations, Environmental concerns, and Health and Safety regulations along with specific BPU hazards identified in this Operators Manual. For your protection and to prevent equipment damage, please heed the product safety signs attached to the pumping unit.

The LUFKIN Conventional and Reverse Mark Pumping Units are designed to give many years of dependable service. Like all machines with moving parts, there are “potential” hazards associated with its use. These hazards can be reduced if the machine is properly installed, operated, and maintained. All personnel who install operate or maintain the unit must read this manual and must be trained to use the machine in an appropriate and safe manner. Follow all pumping unit site safety procedures. Other potential hazards are listed in Section 2.2, “Potential Product Hazards.” Should any questions arise concerning the maintenance or operation of the machine, contact LUFKIN Industries, LLC. at 1 (936) 634-2211.

POTENTIAL HAZARD	EFFECT	PREVENTION
 <p>Moving Loads or Parts</p>	<p>Can cause severe injury or death.</p>	<p>Do not allow personnel to stand under moving loads or parts.</p> <p>Set brake, engage pawl, and chain brake drum during installation and maintenance to prevent movement of counterweights and cranks.</p> <p>Keep clear of counterweight and crank swing area and other parts that may start moving.</p> <p>Do not operate pumping units without proper guards in place.</p> <p>Do not service well without removing the horsehead.</p> <p>Properly install the horsehead components: latch bolt, safety bar, and/or hinge pin.</p>
 <p>Electrical Contact</p>	<p>Can cause severe injury or death.</p>	<p>Keep pumping units at least 10 feet away from all overhead wires.</p> <p>LOTO ALL energy sources.</p> <p>All electrical work must be performed by a qualified electrician. Refer to federal, local, and company regulations and requirements.</p>

2.1 Hazard Identification

The United States Department of Labor, Occupational Safety and Health Administration - In the United States, the Lufkin pumping unit will use the ANSI Z535 standard as the norm for all Signal Word signs with conformity to color, font type, and size. Country of final destination must be identified and submitted to Lufkin prior to order to ensure that all applicable regulations are met.



Indicates an imminently hazardous situation that, if not avoided, will result in serious injury or death.



Indicates a potentially hazardous situation that, if not avoided, could result in serious injury or death.



Indicates a potentially hazardous situation that, if not avoided, could result in a minor to moderate injury or damage to the unit.



Indicates information considered important, but not hazard related, such as possible machine damage, environmental or site or facility signage.

2.2 Potential Product Hazards

Failure to heed the following WARNINGS could result in severe bodily injury or death to personnel.

2.2.1 Mechanical Systems Hazards

- It is recommended that all personnel not directly involved in installing the unit remain outside the zone of operations to ensure no interference with the crew on site. All personnel must be trained with regards to regulatory lifting practices.
- Pumping units have large and heavy rotating parts. Even a temporarily stationary pumping unit has components that can start moving from the effect of gravity. Times of increased danger include unit installation, stroke change, counterbalance change, general unit maintenance, well servicing, and while taking dynamometer card readings. Whenever performing maintenance on, or working around the pumping unit, always lockout/tagout (LOTO) all energy sources and secure the cranks against rotation. All personnel must stay alert and keep clear of the crank swing area and other potential moving parts. It is the responsibility of the site management to develop appropriate LOTO procedures and train all employees/personnel to follow them. Refer to EU directive 89/391/EEC or US OSHA

Section 1910.269 Subpart S for LOTO recommendations. The product user should adhere to these requirements and familiarize themselves with energy isolation methods identified in API RP 11G.

- Do not assume a stationary unit is not operational. Automatic timers can start units in motion without warning.
- Inspect all lifting devices (chains, beam clamps, etc.) prior to lifting and ensure they are properly sized, certified, and have no defects before use.
- Do not stand under moving parts or loads being lifted. Always attach tag lines to parts to aid in initial alignment of parts or assemblies.
- Never stand under the horsehead during installation or removal of the horsehead. Double check the horsehead for proper installation on the walking beam, including the installation of the safety bar, hinge pin, and/or the latch bolt before rotating the unit. Remove the horsehead before servicing the well, remembering to first remove safety bar, hinge pin and/or latch bolt.
- Use of appropriate fall protection is recommended when working at heights. Follow applicable site and company requirements.

2.2.2 Electrical System Hazards

- All electrical work must be performed by a qualified electrician. Regularly inspect and maintain electric motors, automatic timers or any other electrical device.
- In many cases, pumping units are connected to rod pump controllers, motor control panels, and other electrical devices. Consult equipment manufacturers' recommendations regarding safety practices for their equipment. Additionally, follow any site specific electrical safety procedures that exist.

2.2.3 Site and Environmental Hazards

- Conduct a pre job walk around and make note of any and all site specific hazards.
- Use of H2S monitors is recommended.
- Be aware of power line locations, keeping unit and service equipment at least ten feet away.
- Be aware of piping on and around the well site during the unit installation and maintenance.
- LUFKIN does not recommend installation of or maintenance on pumping units during thunderstorms. Exercise extreme caution during icy conditions and other inclement weather.

2.3 Securing the Cranks



Do not enter the crank swing area to chain the drum or engage the pawl.

2.3.1 Shut off Power to the Pumping Unit

Disengage power source from pumping unit.

2.3.2 Engage the Brake



Abrupt braking may damage the gear teeth in the reducer, deform keys, and possibly slip cranks. A slow, even pull on the brake lever is recommended.



Lockout of control panel from power source should be done after pumping unit is completely at rest to prevent any potential energy feedback.

After the pumping unit power source has been disengaged and the unit is slowing, engage the friction brake by applying a slow, even pull to the brake control lever. LOTO all energy sources. Never use the brake alone as a safety stop. Always use as many other methods as possible for back ups along with your company's lockout/tagout procedure.

When possible, stop the cranks at the 6 o'clock position.

2.3.3 Engage the Brake Drum Pawl



Do not enter the crank swing area to engage the pawl.



Do not allow the well load to rest on the pawl. If this is done, you will need a crane to lift the load to disengage the pawl. Do not use a hammer to disengage the pawl. Doing so may damage the pawl and/or brake drum to the point that they are not reusable.

Once the unit is at rest, engage the Brake Drum Pawl. Figure 3 shows the Brake Drum Pawl in the open position, on the left, and the engaged position, on the right. In the engaged position, the pawl is resting on the cylindrical body. The pawl does not need to be nested into one of the notches.

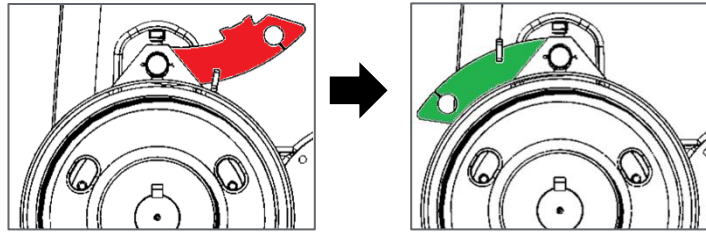


Figure 3: Brake pawl, disengaged and engaged position

If the brake pawl has a hole, as shown in Figure 3, a tool may be used to rotate the pawl from a distance.

2.3.4 Chain the Drum



Do not enter the crank swing area to engage the drum.



Faulty chains and slings could fail and cause severe bodily injury or death.

After the friction brake is engaged and the brake pawl is set against the cylindrical body, chain the drum. When chaining the brake drum, there are two primary options that may be used. For both methods, use a ½” Grade 80 chain, the minimum size and strength combination.

Configuration 1: The first option is a double leg configuration chain and binder from the brake drum to the high-prime bracket with the chain in the plane of the brake drum. See Figure 4.

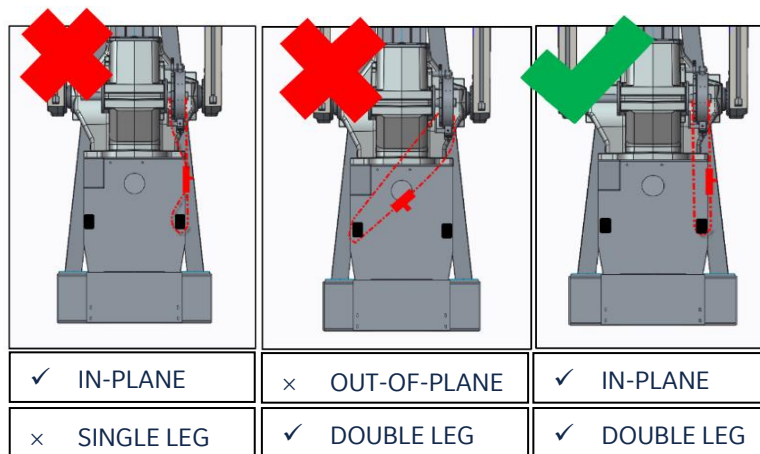


Figure 4: Brake drum chaining

While using this configuration, it is also important to make sure the location on the brake drum is chosen such that the chain will tighten if the unit were to begin moving in the direction of operation. The ideal chain point on the brake drum will result in the chain being at a right angle (90°) to the high speed pinion. The brake drum slot used for chaining should be within the 25° zone above or below the 90° position. This will provide the most strength. Figure 5 shows a theoretical tie-off point in the bottom left and the ideal regions to loop the chain through the brake drum slot for clockwise and counter clockwise operation. It may be necessary to make adjustments to the crank position in order to have a crank drum slot in the correct location.

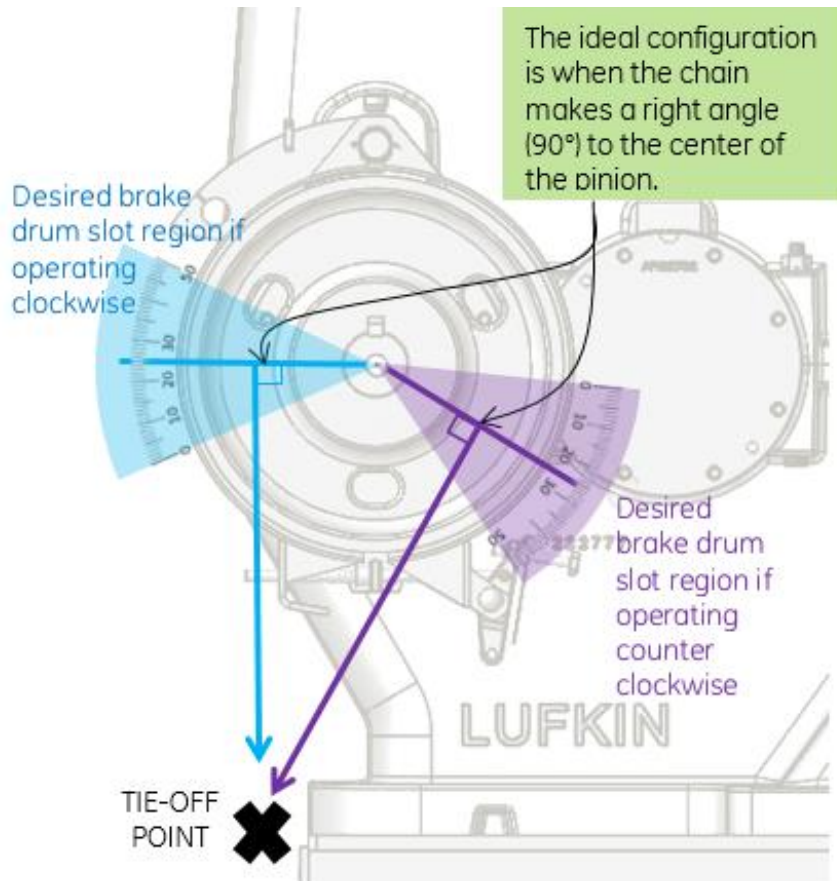


Figure 5: Ideal zone to chain on brake drum for chain Configuration 1

Configuration 2: The second option is a chain and hook from the brake drum to the trunnion. In Figure 6, the chain and hook method is being used to secure the unit against counterclockwise rotation.

Thread the chain through the slots in the brake drum. Select the slot based on the direction of operation and the anchor point (high-prime or trunnion). Chaining should always result in an immediate tightening of the chain if the unit were to begin moving.

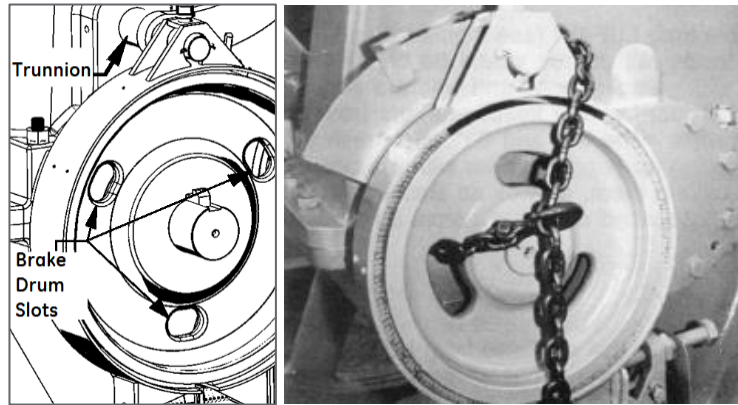


Figure 6: Brake drum chaining for Configuration 2

2.4 Personnel Safety During Lifting Operations



Large objects in motion can cause death. Proper safety protocols should be established and maintained to minimize worker risk.

Personal safety around suspended loads is paramount and strict attention is necessary in observing the restricted Red Zone (area where dropped materials would strike) below and surrounding any lifted object. The Red Zone is a dynamic changing area especially when moving suspended loads. The planned lifted height, size, weight, and configuration of the object being moved must be assessed for reducing potential workplace incidents. In some cases, it may be necessary based on the planned lift assessment to expand the Red Zone.

Consideration to the environmental conditions including weather, wind speed, and temperature should be made to ensure the safety of all team members. Wind and variable conditions pose additional risk during lifts.

The Recommended Practice:

The area below and surrounding the lifted object is cleared of all non-essential personnel. No one is permitted directly below a lifted load. Essential personnel should be positioned no greater than 45 degrees from the outermost point of the lifted object.

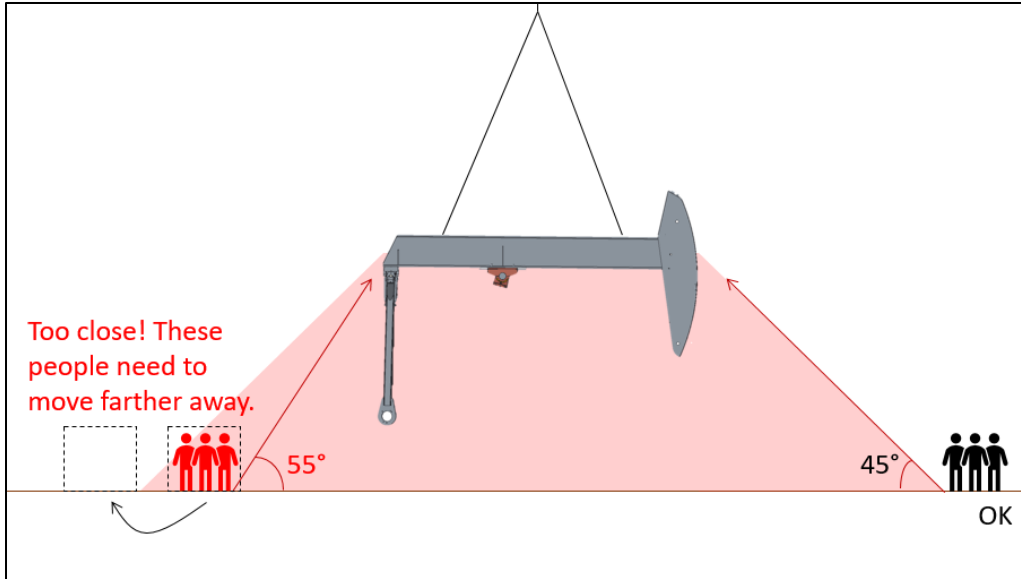


Figure 7: Recommended Safe Distance

As always, ensure that all federal, local, company, and site-specific requirements are met.

2.5 Guarding of Units



Contact with large moving parts will cause severe injury or death. Do not operate pumping units without proper guards in place.

Guards provide a safety barrier between the moving parts of the pumping unit and people who are familiar with the operation of pumping units. They also provide a barrier between the moving parts and animals. When pumping units are operated where they are accessible to the general public, it may be necessary to place the pumping unit with guards in an enclosed area with a locked entrance. The enclosure must prevent entry of unauthorized persons. Federal, State and local regulations may require specific types of guarding, dependent upon the location of your unit; therefore, the type of guarding needed is known only by the user who must choose the proper guarding. It is essential that the user of the pumping unit comply with all applicable safety requirements. For additional information on guarding of pumping units, refer to the latest revision of API RP11ER.

2.5.1 Crank Guards

Under normal operating circumstances, the open 3-rail guards would be considered minimum guarding. This type guard keeps workers from accidentally walking or falling into the crank sweeps. The wire mesh guards would normally be considered adequate for animals that might be able to move through the guards described above.

During maintenance, the crank guards should be removed and placed outside of the work area to facilitate escape during any unexpected event.

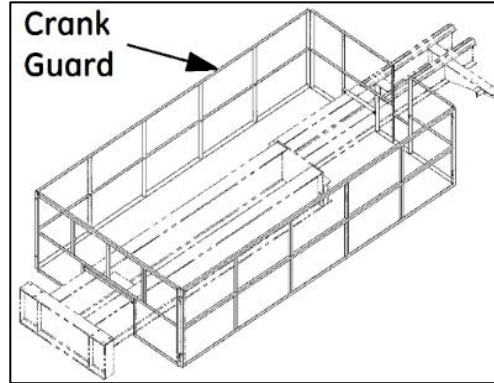


Figure 8: Typical crank guard

2.5.2 Horsehead Guards

This type guard is recommended by API RP11ER for units where the horsehead or carrier bar descends to 7 ft. or less from grade or work platform. This guard is designed to keep people from walking into the area below the horsehead and carrier bar.



Figure 9: Typical horsehead guard

2.5.3 Belt Guards



Not using or incorrect use of belt guards and leaving belts exposed could result in serious injury or death for persons and animals around the well site.

Belt guards are designed to cover exposed sheaves and belts and to provide a barrier between rotating belts and sheaves and people, animals, and objects.

2.5.4 Prime Mover Guards



Not using or incorrect use of prime mover guards and leaving prime movers exposed could result in serious injury or death for persons and animals around the well site.

Exposed flywheels of prime movers must be guarded. These guards provide a barrier between rotating belts and sheaves and people, animals, and objects.

2.6 Ladders

API RP11ER compliant ladders are available upon request. Ladders may be necessary for servicing and inspection if bucket trucks are not in use or available.

2.7 Fall Arrest Requirements



Personnel working above 4 ft. may be required to have their safety harness tied off to a secure point on the pumping unit. Failure to comply could cause severe injury or death.

OSHA requirements and/or local requirements should be adhered to. If personnel are not using a bucket truck or similar method to work at elevated locations, it will be necessary to identify and use adequate tie-off locations and fall protection equipment. Ensure that the selected fall protection equipment meets the load requirements established by OSHA and/or local regulatory agencies.

2.8 Proper Clothing and Tools (PPE)

Ensure that all local, regional, and federal PPE requirements are met prior to entering a well site. Furthermore, ensure that all additional requirements mandated by the well operator are also met. This can include hard hats, safety glasses, gloves, fire retardant clothing (FRC), safety shoes, and H2S monitors. Snug fitting clothing is recommended. Remove jewelry. Wear hard hats, side-shield safety glasses, impact gloves, and safety shoes. Fire retardant clothing is a typical requirement for well-site work. An H2S monitor may be needed, depending on site requirements.

Use proper tools for the job. Tools are designed for specific purposes and must be used properly. Always keep tools clean and in good condition. Check for damage and follow all necessary certifications and procedures to ensure lifting equipment remains safe to use. Refer to your company's safety regulations or site-specific regulations.

2.9 Vehicle Placement at Well sites

It is recommended to park non-essential vehicles at least 40 feet away from pumping unit and approach the pumping unit from the rear when possible. If windy conditions exist, it is recommended to park upwind of pumping unit with the driver side facing downwind so as the entry and exit of the vehicle is not impacted. Refer to your company's safety regulations or site-specific regulations.

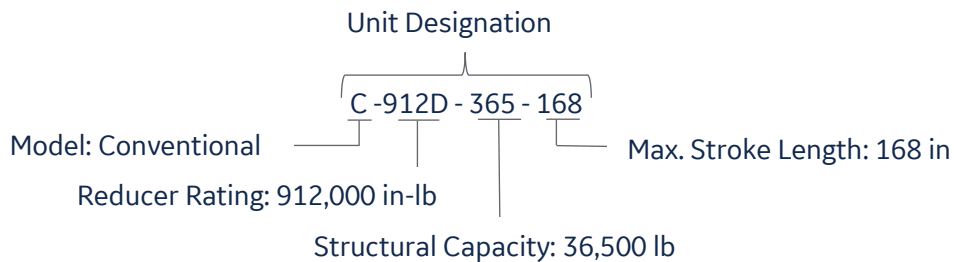
2.10 Training

It is essential that only properly trained personnel, under competent supervision, be allowed to work with this equipment. Training programs are an important part of safe and correct operation. Training also provides the knowledge necessary to maximize the performance of your equipment. LUFKIN INDUSTRIES LLC., recognizes the importance of training and conducts training schools to help familiarize your personnel with safe operating and maintenance procedures. Pumping Unit Operation and Maintenance Schools are offered throughout the year. The dates for each school can be found on the BHGE website and are available upon request by contacting your nearest BHGE sales office. Refer to your company's safety regulations or site-specific regulations.

3 Installation Equipment Sizing Charts

The following charts are a general guide to assist in selecting the proper equipment for installing your LUFKIN pumping unit. If there are further concerns or questions about the weight of a part, contact BHGE. An example for using the charts would be as follows:

What is needed to set a C-912D-365-168 pumping unit?



- a. To determine the estimated height that will be required while lifting, go to the 168" stroke in Table 1. In this case, the height needed during the walking beam assembly installation is greater than the horsehead installation and the maximum estimated hook height is 54 feet. Also, account for any additional height needed due to the bottom of the pumping unit base setting above ground level.
- b. To determine the estimated weight capacity that will be required during installation, go to 912D in Table 2. This table shows that the reducer with cranks will weight approximately 28,600 pounds. The reducer with cranks is the heaviest lift during installation. If the unit is a 228D or smaller, the reducer and cranks are shipped mounted to the unit base. This will increase the weight for the maximum lift. The weight of the reducer and cranks mounted to the base will not be greater than 2 times the reducer and cranks weight.

NOTICE

Install counterweights after the gear reducer has been set in place. Do not lift gear reducer with counterweights installed.

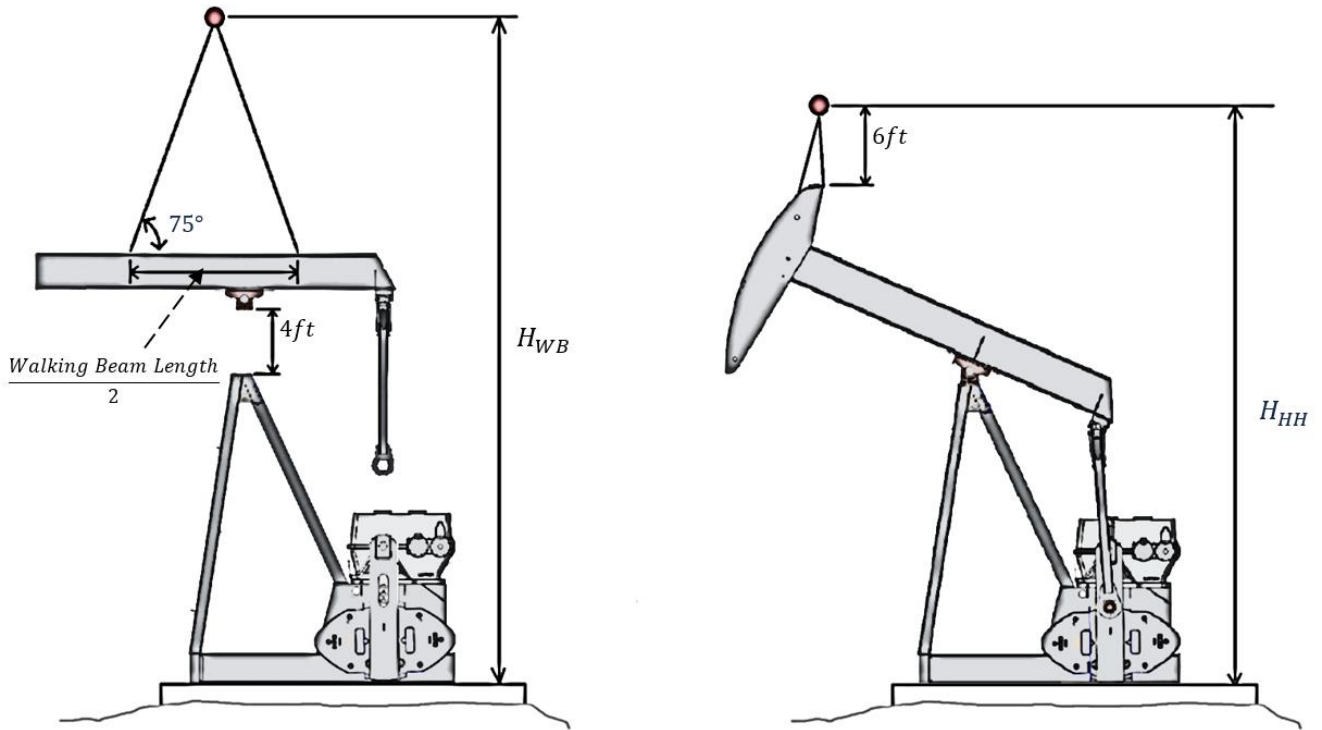


Figure 10: Schematic for Estimated Lifting Heights.
 Lifting Walking Beam, Equalizer and Pitman assembly on left. Lifting Horse head on right.

Stroke Length [in]	H_{WB} [ft] Maximum Estimated Hook Height for Walking Beam, Equalizer and Pitman lift. Measured from top of foundation.	H_{HH} [ft] Maximum Estimated Hook Height for Horsehead Lift. Measured from top of foundation.
240	62	51
216	58	46
192	56	45
168	54	41
144	52	39
120	50	38
100	44	34
86	43	32
74	37	29
64	33	25
54	27	21
48	24	24

Table 1: Estimated lifting heights for unit installation.

Reducer Size	Maximum Weight of Reducer with Cranks [lb]
1824D	33,900
1280D	32,300
912D	28,600
640D	25,900
456D	18,440
320D	16,510
228D	11,820
160D	8,630
114D	7,350

Table 2: Estimated weights for the reducer and cranks.

Master Counter Weight	Weight [lb]
00LH	7450
00H	5910
0H	5360
00ROL	4820
0AH	4300
00RO	3810
1H	3360
0RO	3340
2H	2820
0ARO	2650
3CH	2390
1RO	2070
2RO	1670
3CRO	1320
5ARO	910
5CRO	650
6RO	500
7RO	300

Auxiliary Counter Weight	Weight [lb]
0D	2260
00D	2160
00SL	1350
00S	1080
0S	1040
0AS	850
1S	660
2S	570
3BS	570
5A	370
5CS	320
6S	190
7S	150

Table 3: Counterweight weights.

Note: These weights are provided for convenience. The counterweights should not be installed during the lifting operation of the reducer and cranks.

4 Lubricant Specifications

4.1 Reducer Oil

The reducer lubricant should be selected based on the expected ambient temperatures in which the gearbox will be operating. The lubricant selected should be an Anti-Scuff lubricant as defined by AGMA 9005-F16. Anti-scuff lubricants were formerly known as Extreme Pressure, or EP. Other considerations include compatibility with materials in the gearbox, rust and oxidation inhibitors, anti-foaming agents, and pour point.

Synthetic gear lubricant may be required when units are operated intermittently or shut down for periods of time while subjected to low ambient temperatures. Minimal heat is generated inside the gearbox during standard operation. Synthetic oils are less sensitive to temperature changes which allow for broader operating zones. Like their conventional counterparts, these should also be anti-scuff lubricants that contain additives to reduce corrosion and foaming. The higher cost associated with synthetics should be evaluated relative to the operator's need for these characteristics.

A list of approved lubricants is provided below. Not all approved lubricants are available from BHGE. Please contact your BHGE sales or service representative if there is a need for a lubricant that is not listed.

When changing lubricants, compatibility should first be verified since cross-contamination of lubricants can degrade the incoming lubricant's properties. For additional information on Gearbox Maintenance, see Section 13.1.1, "Reducer."

Lubricant	Allowable Ambient Temperature during Operation, °F																								
	-30	-25	-20	-15	-10	-5	0	5	10	15	20	25	30	35	40	45	50	95	100	105	110	115	120	125	
Mobil, SHC 629 (ISO 150) ^s	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
Schaeffer, #167 Moly Full Synthetic ISO 150 ^s		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Mobil, SHC 630 (ISO 220) ^s			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Chevron, Meropa ISO 150					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
Schaeffer, #267 Supreme Lube ISO 150					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Mobil, 600 XP ISO 150							✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Mobil, 600 XP ISO 220							✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Finke Mineralolwerk GMBH, Aviaticon OEL EP 150								✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Chevron, Meropa ISO 220								✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Finke Mineralolwerk GMBH, Aviaticon OEL EP 220								✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Shell, Omala S2 G ISO 220									✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

^sSynthetic Lubricant

Table 4: Approved Lubricants for BPU Gear Reducers

4.2 Reducer Oil Capacity

The following table presents the oil capacity for the Conventional and Reverse Mark gearboxes. Please note that the Gen2 Conventional and Reverse Mark gearboxes have slightly less oil capacity. Refer to the Gen2 manual or contact your Sales representative for assistance.

Model	Capacity [gallons]
1824D	165
1280D	120
912D	107
640D	70
456D	55
320D	50
228D	34
160D	22
114D	17
80D	17
57D	13
40D	7

Table 5: Reducer oil capacity for Legacy Conventional and Reverse Mark gearboxes

4.3 Structural Bearing Grease



Do not use soda soap grease.

For ambient temperatures down to 0°F, use premium NLGI No. 1 lithium complex, soap base grease with an extreme pressure additive and a base oil viscosity equivalent to AGMA No. 7 (414-506 cSt. at 40°C.) For ambient temperatures down to -30°F, use a premium NLGI No. 1 lithium complex, soap base grease with an extreme pressure additive and a base oil equivalent to AGMA No. 5 (198-242 cSt. at 40°C.)

When changing greases, even within the same manufacturer, compatibility testing between the greases is recommended.

4.4 Wireline



Do not use crude oil or lubricants that may damage the wireline. Do not use solvent.

Clean the wire rope by wire brushing; do not use solvent. Apply a good wire rope lubricant that will penetrate and adhere to the rope. The recommended lubricant to use for GE/Lufkin wirelines is, in order of preference, WRL or WLD made by Jet-Lube. It is recommended that the user apply this lubricant via spray onto the entire surface area of the wire rope, including the area making contact with the horsehead.

5 Fasteners

Bolting is a vital part of an oil field pumping unit and bolt failures are among the most common issues. Application of the recommended torque will prevent loosening and extend the life of the pumping unit.

5.1 Metal-to-Metal Joints



Proper eye protection must be worn; flying metal could cause damage to the eyes.

The surfaces under the bolt head, nut, and the contacting surfaces must be flat, clean and free of burrs so the bolted members join in “metal-to-metal” contact. Bolts, which are properly tightened during unit installation and retightened about a week later, will retain their grip under normal operating conditions. Improperly tightened bolts will break in fatigue and may cause equipment damage or injury to personnel. Table 6 gives required tightening torques for dry and lubricated bolts.

It is recommended to use a pneumatic or electric torque wrench to ensure that torque requirements are met. Please refer to your torque wrench operator manual for proper use.

Match mark nut to surface (Figure 11) after final torqueing. Inspect for movement at each scheduled maintenance interval and perform corrective actions if needed.

	Grade 2 Low or Medium Carbon Steel		Grade 5 Medium Carbon Steel Quenched and Tempered	
	Preload Torque [ft.-lbs.]		Preload Torque [ft.-lbs.]	
Bolt Size	Dry	Lubricated	Dry	Lubricated
$\frac{3}{8}$ " - 16 UNC	19 - 21	17 - 19	30 - 32	26 - 29
$\frac{1}{2}$ " - 13 UNC	46 - 51	42 - 46	71 - 79	64 - 71
$\frac{5}{8}$ " - 11 UNC	92 - 102	83 - 92	143 - 157	128 - 142
$\frac{3}{4}$ " - 10 UNC	164 - 181	147 - 163	253 - 279	228 - 252
$\frac{7}{8}$ " - 9 UNC	159 - 176	142 - 157	409 - 451	367 - 406
1" - 8 UNC	238 - 262	214 - 236	612 - 676	550 - 608
1 $\frac{1}{8}$ " - 7 UNC	336 - 372	303 - 335	755 - 834	679 - 751
1 $\frac{1}{4}$ " - 7 UNC	475 - 525	427 - 472	1064 - 1176	958 - 1059
1 $\frac{3}{8}$ " - 6 UNC	622 - 688	560 - 619	1395 - 1542	1256 - 1388
1 $\frac{1}{2}$ " - 6 UNC	826 - 912	743 - 822	1849 - 2049	1667 - 1843

Table 6: Metal-to-metal bolt torque requirements



Figure 11: Match mark nut to surface

5.2 Non-Standard Bolting Applications

There are other bolting applications which do not require the standard bolt torques as defined in Section 5.1. An example is a bolting application in which the two mating parts are not in direct contact in the immediate vicinity of the bolt are considered elastic grip.

For base hold-down clamp bolts, torque 1 ¼” bolts to 192 – 208 ft.-lbs and 1 ½” bolts to 230 – 250 ft.-lbs.

NOTICE

The base hold-down clamp bolt torques are identified in pumping unit mounting plans that are shipped with every unit. Do not use the standard torque values in Table 6.

Another application would be for an adjusting screw in which the position of a component or tensioning of a belt is the goal. As such, adjustment bolts do not have a prescribed torque.

For heel clamps and wireline retainer, torque to two-thirds of the values given in Table 6.

5.3 Bolt Kits

Pumping unit bolts are shipped in kits that facilitate their grouping and identify where they should be used and the torque range that should be applied.

5.4 Fastening Components

While a bolt, nut and spring washer make up a general arrangement, there are several joints around the unit that contain other components as part of the assembly. These include flat washers and spherical washers.

Flat washers are used in joints that require increased bearing area.

Spherical washers (Figure 12) can be utilized in joints where bolt head and nut interfacing surfaces are not parallel. Some center bearing foot to Samson post connections utilize spherical washers. Please ensure that the cone is located on top of the cup during installation.

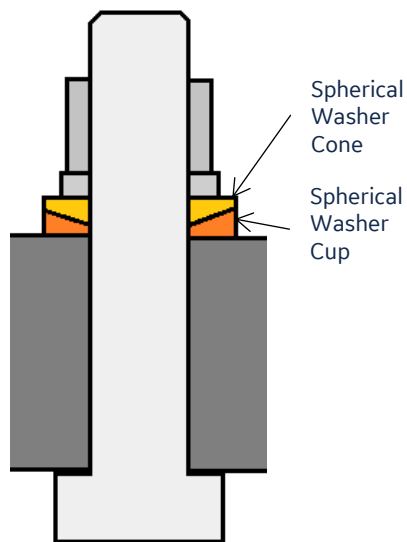


Figure 12: Spherical washer cup and cone diagram

6 Site Preparation and Foundation Requirements



Poor preparation of the site and/or foundation can cause pumping unit equipment damage and potentially void the warranty.

Pumping units, by their nature, transmit very large forces to the supporting earth. Foundations provide a means of distributing these forces over a broad area allowing the soil and subgrade to generate sufficient strength and stiffness to withstand them while yielding only very small deflections. The stability and rigidity provided by the foundation and the site preparations necessary to constrain movement are essential in maintaining proper alignment and providing the beam pumping unit with long operational life. Many times, structural failures involving pumping units can be traced back to an insufficient foundation or poorly prepared site.

The means by which pumping unit foundations transmit their loads into the earth take several forms ranging from simple bearing surface contact with the underlying soil to driven or helical piles sunk deeply into the ground. In each case, the foundation must possess sufficient strength and stiffness to allow localized forces applied by the pumping unit to be adequately absorbed by the foundation and distributed over an area of soil contact or to a series of piers (piles) so that the local load bearing capacities of these elements are not exceeded.

Refer to the mounting plan for additional requirements including size of foundation and minimum distance between the front of the unit base and the edge of the foundation.

6.1 Foundation Support and Flatness

The top (pumping unit mounting) surface of the foundation should be as flat (planar) and rigid as possible under all operational loading conditions. The flatness tolerance of the unloaded structural slab should at maximum be 1/8 in. over any 10 ft. span when checked with a straight edge. Such deviations can typically be corrected by shimming and/or grouting between the foundation and pumping unit base to prevent undue initial stress on the structure.

Static loading associated with the stationary assembled pumping unit connected to the polished rod (mean well load) should produce flatness distortions no greater than 0.025 inches measured over any 10 ft. span relative to the foundation's unloaded state. The allowable deflection under dynamic loading varies somewhat by pumping unit model but in general, additional flatness distortions resulting from live loads should be limited to less than 0.030 inches per 10 ft. span throughout the operating cycle.

The pumping unit base structure is typically clamped to the top surface of the foundation and excessive deflection, either static or dynamic, can result in damage to the structural components or the pumping unit mechanism.

Pumping unit alignment relative to the well head depends substantially on the position and orientation of the foundation. Misalignment can lead to accelerated wear in wirelines and structural bearings and will induce undue

stress on structural components. Gross settlement of the foundation should be limited according to the following criteria:

- Maximum deviation from level: 1/16 inch over 48 inch span.
- Maximum horizontal shift: ½ inch in any direction.
- Maximum vertical settlement: 1 inch relative to surrounding terrain.

6.2 Foundations Mounted on Grade

Foundations of this type typically derive their support through a distributed area of contact with the earth. This includes poured in place reinforced concrete slabs, pre-cast concrete slabs, board mats, and certain other integrated portable pumping unit base structures that are specifically designed for similar distributed load bearing capability. These foundations often do not require any other form of anchorage to fix their location relative to the earth. They are, however, highly reliant on proper site preparation to provide the necessary stability and strength to resist pumping unit forces over time.

6.2.1 Site Preparation - General

Contact a local geotechnical engineer to conduct soil testing and evaluate the soil and installation site.

Soil tests should, at a minimum, report the following:

- Soil bearing strength
- Soil density
- Modulus of sub-grade reaction
- Shear wave velocity

Based on this evaluation, the geotechnical engineer should provide a detailed plan for installation site preparations.

6.2.2 Pumping Unit Loading

The loads applied by the pumping unit to the foundation are derived in part from the weight of its various components. When in motion however, heavy crank arms, counterweights, and articulating structural components produce inertial forces that add or subtract from these vertically oriented weights. Depending on their mass, position and speed, these moving components also produce horizontally oriented forces that must be resisted else the pumping unit will slide. The well (polished rod) load is typically cantilevered forward (toward the well) of the unit base periphery tending to concentrate the reaction loading near the forward extremity of the base during peak up-stroke loading. The foundation and sub-grade must therefore provide adequate support in the forward area of the base. Additionally, support reactions at the forward and aft ends of the pumping unit sub-base pedestal are needed to resist flexural loading induced by the gear reducer torque. The base reaction maximum load range is provided in the pumping unit mounting plan drawing supplied with your pumping unit.

6.2.3 Excavation

Initial site preparations involve the removal of loose materials (scoria, etc.) surface vegetation, roots, and other organic materials from the soil that will underlie the pumping unit foundation. Excavation should be accomplished according to the geotechnical engineer's site plan to a depth sufficient to reach undisturbed soil. Normally, this will require a depth of 3 ft. or greater. The excavated pit should be at least 1 ft. wider and longer than the foundation. Compact the bottom of the pit with appropriate compaction equipment. Carry excavations deeper in areas that "pump" or "rut" during the compaction process. Excavate to firm natural soil and compact to 95% maximum dry density as approved by the geotechnical engineer.

6.2.4 Fill and Compaction

Select fill material shall be sandy clay with a liquid limit of 28 or more and a plasticity index between 10 and 20. Site soils shall not be used as fill unless approved by the geotechnical engineer. Place select fill in 6 in. loose lifts. Compact each lift at the optimum moisture content (+2%) to 95% maximum dry density as determined by the standard proctor compaction test and approved by a geotechnical engineer. On top of the select fill, place 1 ft. minimum of compacted crushed stone base.

Compacted crushed base shall contain crushed gravel with a minimum of 60% of the particles retained on a No. 4 sieve with two (2) or more crushed faces (the user may reference Texas Department of Transportation Test Procedure Tex-460-A, Part 1 as an adequate example of a determinant of this requirement). Blending of two (2) or more sources is allowed. For examples of state specific Department of Transportation requirements that meet the standards defined above, the user may reference Texas Department of Transportation Item 247, Type A, Grade 1 and/or North Dakota Department of Transportation requirements for Type 5 aggregate. The contractor shall submit supplier certifications stating that their crushed base meets the requirement of AASHTO T2, T27, and T11. Crushed base shall be compacted as approved by the geotechnical engineer.

6.2.5 Site Drainage

The foundation site should be elevated slightly relative to the surrounding area such that water will tend to drain away from the foundation. The site shall be graded at 1:6 minimum to drain water away from the slab on grade. Water should not be permitted to pool adjacent to or drain across the site. Poor drainage can yield uneven settling of the foundation. Uneven foundations cause undue stresses in the unit base and can result in failure.

6.2.6 Soil Load Bearing Capacity

The soil load bearing capacity should normally exceed 1,500 psf and is recommended to be as large a value as is feasible. If the building official determines that the in-place soils presented at the build site have a soil load bearing capacity of less than 1,500 psf, the allowable soil bearing capacity shall be determined using the appropriate soil investigation method, and shall be properly documented and reported to all parties involved with the construction and assembly of the beam pumping unit. For reference regarding the appropriate techniques and methods of testing and investigating soil load bearing capacity, please refer to the most recent revision of the International Building Code. Select foundation design with sufficient soil contact area to distribute pumping unit loads appropriately. If necessary, amend the soil with materials designed to increase the bearing capacity beneath the foundation as recommended by the geotechnical

engineer. Soil pressure should not exceed that of the bearing strength in any location. Nose pads are required if soil bearing strength is less than 3,000 psf.

6.2.7 Soil Stiffness

The required soil stiffness depends on the magnitude of the applied loads from the pumping unit, the ground contact area of the foundation, and the allowable vertical deflection of the foundation under load (see above). Pumping unit base loading information is typically available from the pumping unit manufacturer to use in selecting an appropriate foundation design. The compacted fill and crushed base material is expected to have a modified sub-grade reaction modulus of 400 pci or greater. The geotechnical engineer shall verify the subgrade reaction modulus by performing a plate load test or other methods as described in ACI 360R specifications.

6.3 Foundation Mounted on Piles

Foundations of this type derive their support from discreet piles (piers) that have been sunk into the earth to sufficient depth to achieve the required load bearing capacity. The piles are typically spaced at intervals beneath the foundation so as to concentrate their numbers in areas where the highest applied loads are predicted to occur. This form of foundation support is popular in cold climate locations with substantial frost heaving or in locations where normal surface preparations may be impractical (marshes, etc). Pile supported foundations are often elevated above grade such that they rest completely on the piles and make no direct contact with the soil. This is common in cold climates where frost heaving might otherwise lift the foundation off the piles. Foundations used in this type of mounting are typically precast concrete pads - with embedded steel pads or plates to fix them to the top of the piles - or steel fabricated mats. The design of the foundation must be sufficient to distribute the local pumping unit loads over a series of piles with the cumulative capacity to withstand them. The foundation stiffness should be sufficient to perform this function while limiting deflections to within the allowable limits for the pumping unit structure. Lateral support for the foundation is typically provided via diagonal bracing of the exposed piles or by supplemental attachment of the foundation to piles driven at an angle relative to vertical. The design of the pile-support network should consider the primary support reaction locations indicated in the mounting plan.

6.4 Foundation Bolt Anchorage Systems

While there are many bolt anchorage designs, some are more robust than others. It is imperative that the type selected for a given foundation withstand the static bolt preload and the operational loads transmitted from the pumping unit. The pumping unit's mounting plan specifies the required bolt torque which can be used to calculate the preload. Figure 13 depicts three common designs found in concrete foundations: thick-wall pipe, rectangular tubing, and anchor nuts as shown from left to right. See mounting plans for details.

Note that inadequate anchorages can yield or fracture and consequently damage the concrete foundation. This leads to insufficient clamping force that can allow the pumping unit to shift during operation. Cases have been documented where a pumping unit has moved several feet away from its proper position on the foundation after an anchorage failure has occurred.

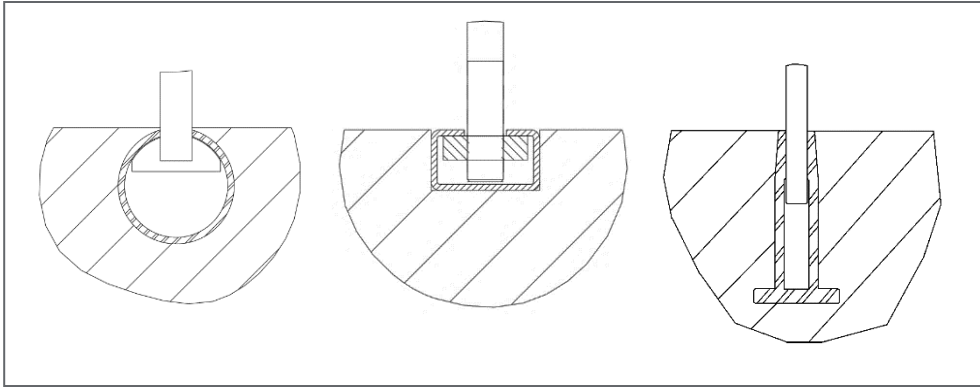


Figure 13: Typical foundation anchors

6.5 Grade Height and Well Clearance

Carrier bar clearance from the bottom of the steel base is shown on the mounting plan. This should be considered when the grade height of the foundation is established. Also consider additional height for rod clamps, a load cell, rod rotators, and maintain a minimum clearance of 6 inches between the stuffing box and the bottom of the carrier bar.

The polished rod should be vertical to minimize wireline wear, stuffing box wear, and to aid in the alignment of the unit.

6.6 Alignment Marks

Mark a center line from the front to the rear of the foundation which extends from the center of the well through the center of the foundation. Place a cross mark perpendicular to the center line the distance shown on the foundation drawing from the center of the well to the front cross member of the unit base. This distance is normally referred to as the set-back dimension. The steel base has center marks on the edges of the bottom flanges of the front and rear cross members. The initial alignment involves matching the center lines on the base and foundation and placing the base the proper distance from the polished rod.

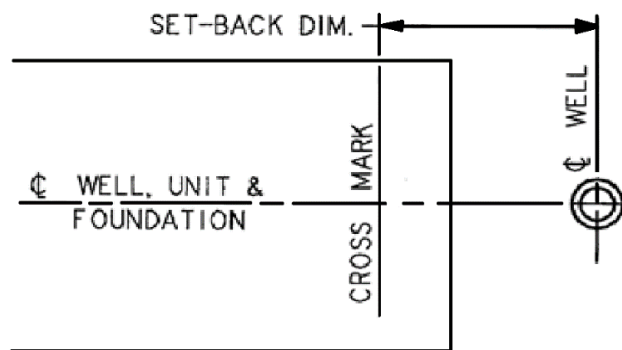


Figure 14: Critical alignment marks for Pumping Unit Installation

7 Unit Installation



Before proceeding with the installation of a pumping unit, you and your crew should fully discuss the job to be done. Make sure everyone is aware of the hazards involved. Review Section 2, "Important Safety Instructions," of this manual.

During installation, clean all bolted joint interfaces of foreign materials to insure good contact between the parts.

The following sections include the general installation sequence, precautions, and alignment checks.

7.1 Base Installation



Do not stand under suspended loads.

Lift the base in a level orientation and place on the foundation. Verify that the underside of the base is free of debris. Align the center line marks on the bottom flanges of the front and rear cross-members with the cross mark on the foundation. See Figure 14. Position the front cross-member of the base to within $\frac{1}{4}$ inch of the setback provided on the mounting plan. The setback is the distance from the centerline of the polish rod to the front cross member of the pumping unit.

Verify that the front cross-member is centered to the well head by measuring from the center of the forward-most Samson Post bolt hole to the centerline of the polish rod on both sides. The distance from the centerline of the polish rod to the left-most Samson Post bolt hole and the distance to the right-most Samson Post bolt hole should be within $\frac{1}{4}$ inch of one another.

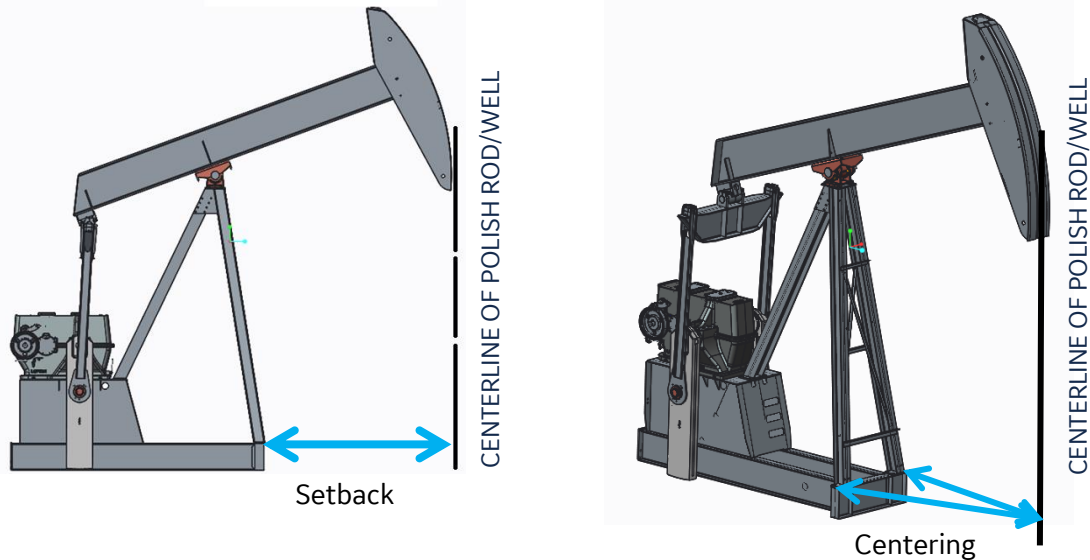


Figure 15: Setback dimension on left, centering dimensions on right.

Check the level of the base across side beams. They should be level within 1/16" over 36 inches or less than 1/10th degree. Consult the pumping unit mounting plan for specific details regarding mounting and shimming requirements. Mounting plans identify regions between the foundation and the pumping unit's base that require metal to concrete contact after tie downs are installed.

If you have a two piece base (unit base and prime mover base), the prime mover base will be positioned next. See Section 16, "Base Types" for an illustration of the different types of unit and prime mover bases. Remove the bolts from the joint plates. Join the bases together, tightening the bolts per Table 6.

Locate and install foundation hold-down clamps and bolts. Snug tighten. Final tightening of the foundation bolts will be done after unit alignment. Do NOT tighten base to foundation bolts per Table 6.

After base is placed and secured, final verification of setback and centering should be performed.

NOTICE

Ensure that the base is installed directly onto the foundation. Refer to the mounting plan for locations where metal-to-concrete contact is required.

Do not place wood or pvc boards between base and foundation.

7.2 Crank Pin Installation



Improper cleaning of the crank pin and crank pin hole, as well as improper tightening of the crank pin, can cause damage to the pumping unit.



Do not install the crank pin without properly applying an oil film onto the bores and pin taper outer diameter.



Proper eye protection must be worn; flying metal could cause damage to the eyes.

Some of the larger reducers are shipped without the crank pins mounted in the cranks. With a medium or fine grit emery cloth, remove any paint and foreign material from the crank pin, crank pin sleeve (both sides if equipped), crank pin hole, and the mating surfaces between the crank and the crank pin nut. Clean these same areas with an approved solvent (per your company's quality policy.)

With a 1 inch brush, apply three very light stripes (approximately 0.0005 – 0.001 in. thickness) of non-drying machinist blue, equally spaced down the length of the pin.



Figure 16: Application of machinist blue to check fit between pin and crank.

Remove any excess with a clean, lint-free cloth; a thick stripe will give a false indication of good contact. Insert the crank pin bearing assembly in the crank pin hole without smearing the machinist blue. Thread the crank pin nut onto the crank pin and use a hammer wrench to tighten the nut until it will no longer rotate. To ensure proper contact between the crank pin and crank pin hole or sleeve, use a sledge hammer to turn the wrench one additional cotter pin notch beyond hand tightening.

Remove the crank pin bearing assembly and inspect the crank pin hole or sleeve. Machinist blue should be present along at least 85% of each zone of the bore or sleeve's length. In addition, contact should be made along the 2 inches from "large end" and along 1.5 inches from "small end" (Figure 17). If the contact does not meet these criteria, contact your nearest BHGE Service organization.

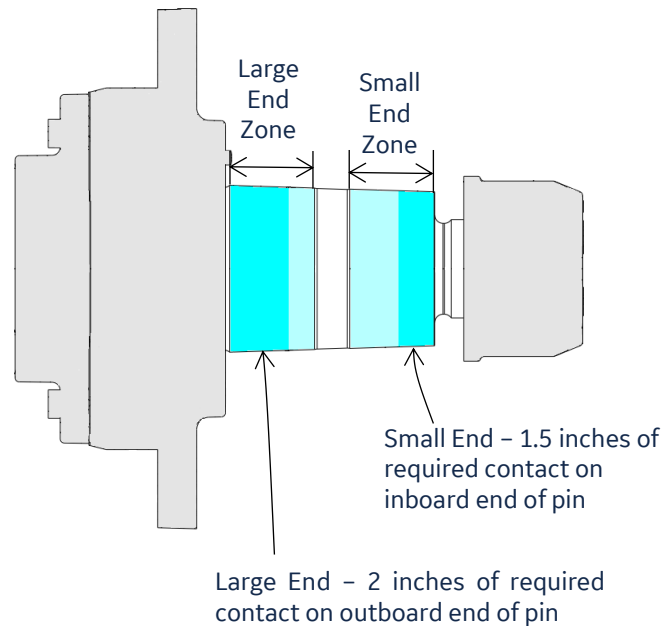


Figure 17: Required contact for crank pins

Clean the crank pin as described above and apply a light coat of clean oil to the crank pin hole. Wipe away any excess with a clean hand. Line up the crank pin bearing assembly with the crank pin sleeve. With a single motion, insert the assembly into the crank and thread the crank pin nut onto the crank pin.

For crank pin tightening, use a hammer wrench and your body weight and tighten the crank pin until it will no longer rotate. Mark the position of the hole in the crank pin on the crank pin nut and then use a pneumatic or hydraulic torque wrench and torque to the appropriate value in the table below. After torque is achieved, turn the nut until there is alignment with the pin hole and verify that the cotter pin has turned at least three notches.

Crank Pin Size	Nut Size	Maximum Torque (ft-lbs)	Minimum Torque (ft-lbs)
4S	2 ½ - 6 UN	2790	1830
3S	2 ½ - 6 UN	3030	1830
2S	3 - 6 UN	3330	2150
1S	3 - 6 UN	3920	2420
0S	3 - 6 UN	5110	3390

Table 7: Crank pin torque

If a pneumatic torque wrench is not available, utilize a hammer wrench and at least a 16 lb-sledge hammer per the following instructions: Using a hammer wrench and your body weight, tighten the crank pin nut until it will no longer rotate. Mark the location of the hole in the crank pin on the crank pin nut. Use at least a 16-lb sledge hammer to turn the nut at least 3 additional cotter pin notches. Watching carefully, hammer the wrench until the hole in the crank pin lines up with the third cotter pin notch. Continue to tighten only if the nut can be turned to the next notch. In summary, the crank pin nut should be tightened to at least 3 cotter pin notches beyond initial make-up.

Install the cotter pin. Never back the nut off to insert the cotter pin. If you have turned the nut too far, remove the crank pin and repeat all of the installation procedure.

7.3 Reducer Installation



The reducer with cranks is an assembly made up of heavy rotating parts. Be certain the cranks are locked against rotation. (Refer to Securing the Cranks) Do not stand under the load while installing; exercise extreme care.

Reducers are shipped from the factory with the brake linings engaged against the brake drum by a shipping screw.

Clean the top of the sub-base. Support the reducer in a safe manner to clean the reducer's mounting surface.

Attach slings to the reducer and both cranks to stabilize the load (Figure 18). Position sling around housing wing. Do not allow the sling to bear against the slow speed shaft oil seal or breakage will result. It is recommended that the sling arrangement have a minimum hook height of 20 feet above the reducer crankshaft.

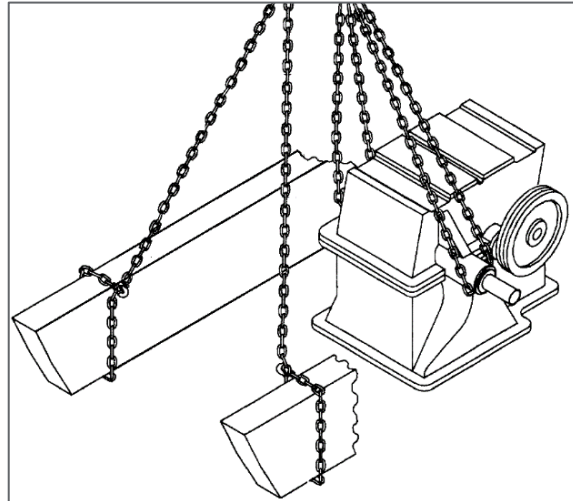


Figure 18: Reducer lifting

Use the centerline marks on the front and rear of the reducer for initial alignment. Place the reducer on the sub-base and install the bolts from the bottom, leaving them loose so the reducer can be shifted for alignment. Shift the reducer on the sub-base until the distance from the crankshaft to the front Samson post bolt holes on the base are within 1/8" of each other on each side of the unit (Figure 19).

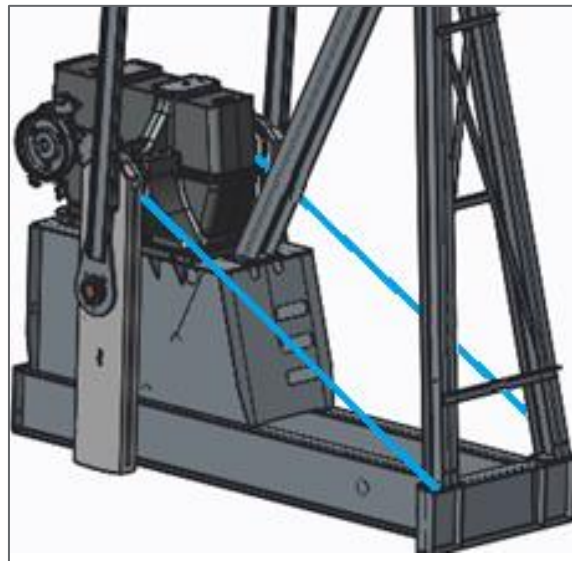


Figure 19: Centering of reducer relative to base

While the reducer to the sub-base bolts are loose, measure the gap under the bolt heads using a feeler gauge. If the gap under the bolt head is greater than 0.03 inches, use a steel horseshoe shaped shim to remove gap (Figure 20). No more than two adjacent bolt locations should be shimmed nor more than three locations overall. Contact your BHGE sales representative if the joint requires shims in more than three bolt locations.



Figure 20: On left, verification of gap between reducer and sub-base. On right, installing steel horseshoe-shaped shim.

Tighten the bolts that attach the reducer to the sub-base per Table 6: Metal-to-metal bolt torque requirements. After completing the initial bolt tightening for the entire joint, re-check bolt torque to adjust for any loosening that might have occurred as successive bolts were initially tightened.

7.4 Crank Rotation



This machinery is made up of heavy parts that will be rotating during this operation. Personnel must exercise extreme care when working around the sweep of the cranks. Clear all personnel and objects from the crank sweep area before proceeding.

To rotate the cranks to a safe position, remove the chains from the reducer but not the cranks. Disengage the positive-stop pawl, if engaged, and lock into the disengaged position, using the locking bolt and nut where provided. Clear the crank sweep area. Slowly loosen the installation and shipping screw. Use the crane to allow the cranks to slowly rotate to bottom, the 6 o'clock position. Remove the chains from the cranks. While the cranks are in 6 o'clock position, it is safe to connect the brake system.

NOTICE

Anytime it becomes necessary to rotate the cranks to another position, attach chains to both cranks. Use a long sling to minimize excessive stress on the sling and cranks. After the cranks are in the desired position, set the brake, engage the positive-stop pawl and chain the drum. Refer to Section 2.3, "Securing the Cranks."

7.5 Brake System Installation and Adjustment



Due to friction linings and variable force, the brake is not intended as a safety stop but is intended for operational use only. When maintenance is to be conducted on or around the pumping unit, the cranks and counterweights must be securely fixed in a stationary position. Refer to Section 2.3, “Securing the Cranks.”

Most units are shipped with the type "B" brake. Some units have a fabricated trunnion located horizontally from the low speed pinion carrier, while others have the trunnion mounted in the housing and located vertically from the high speed pinion. Features of the type "B" brake are: 1) an installation and shipping screw used for locking the brake for shipping purposes; 2) two adjusting nuts provided to adjust each lining independently.

57D and smaller units are shipped with the Type “A” brake. This is shoe type brake also equipped with two adjusting nuts for independent lining adjustments.

7.5.1 Type "B" Brake Installation

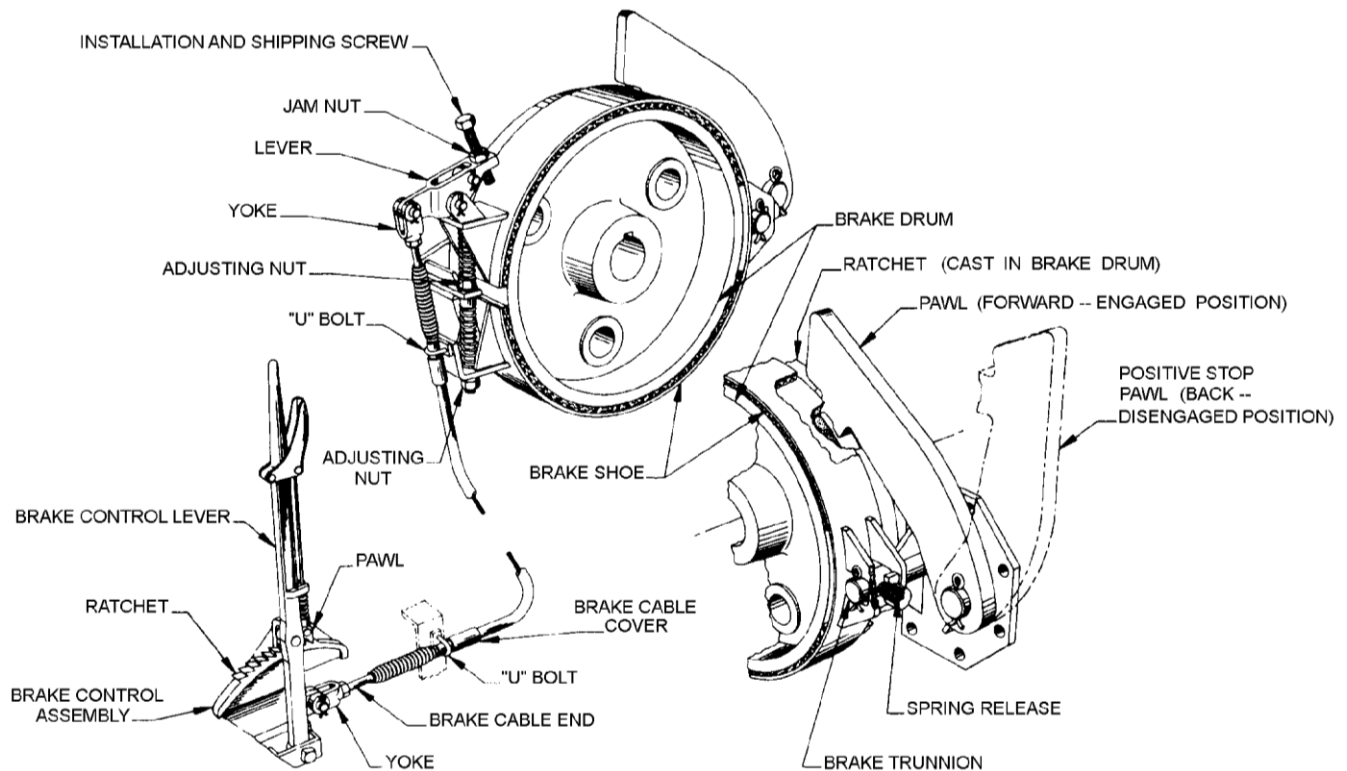


Figure 21: Type "B" Brake Assembly

- 1) Units are shipped from the factory with the brake linings engaged against the drum via the shipping screw.
- 2) Make sure the brake drum key is tight.
- 3) Attach the brake control assembly to the prime mover base.
- 4) Attach the brake cable to the base or hi-prime bracket, using the U bolt provided.
- 5) Move the brake control lever forward to locate the pin hole on the lever between the yoke on the end of the brake cable. Install the pin and cotter pins.
- 6) The adjustment of the brake is set at the factory but may require final adjustment once the brake control lever is installed.

With the installation and shipping screw backed out flush with the lever, adjust the position of both linings with the adjusting nuts until they just clear the drum. The spring release on the trunnion should pull the lining away from the drum near the trunnion.

- 7) Using the brake control lever, engage the brake. Full engagement should occur with several notches of the ratchet on the brake assembly still remaining to compensate for subsequent lining wear and cable stretch. Further adjustment to meet this condition may be made by repositioning the cable yoke on the brake control lever end. When adjusting the yoke, care should be taken not to cause the brake cable to over travel internally in the cable cover. Should this occur, move both yokes the same amount in opposite directions.
- 8) Check the brake lining clearance after all adjustments are complete and readjust if needed.
- 9) Set the brake before continuing with unit installation.

7.5.2 Type "A" Brake Installation

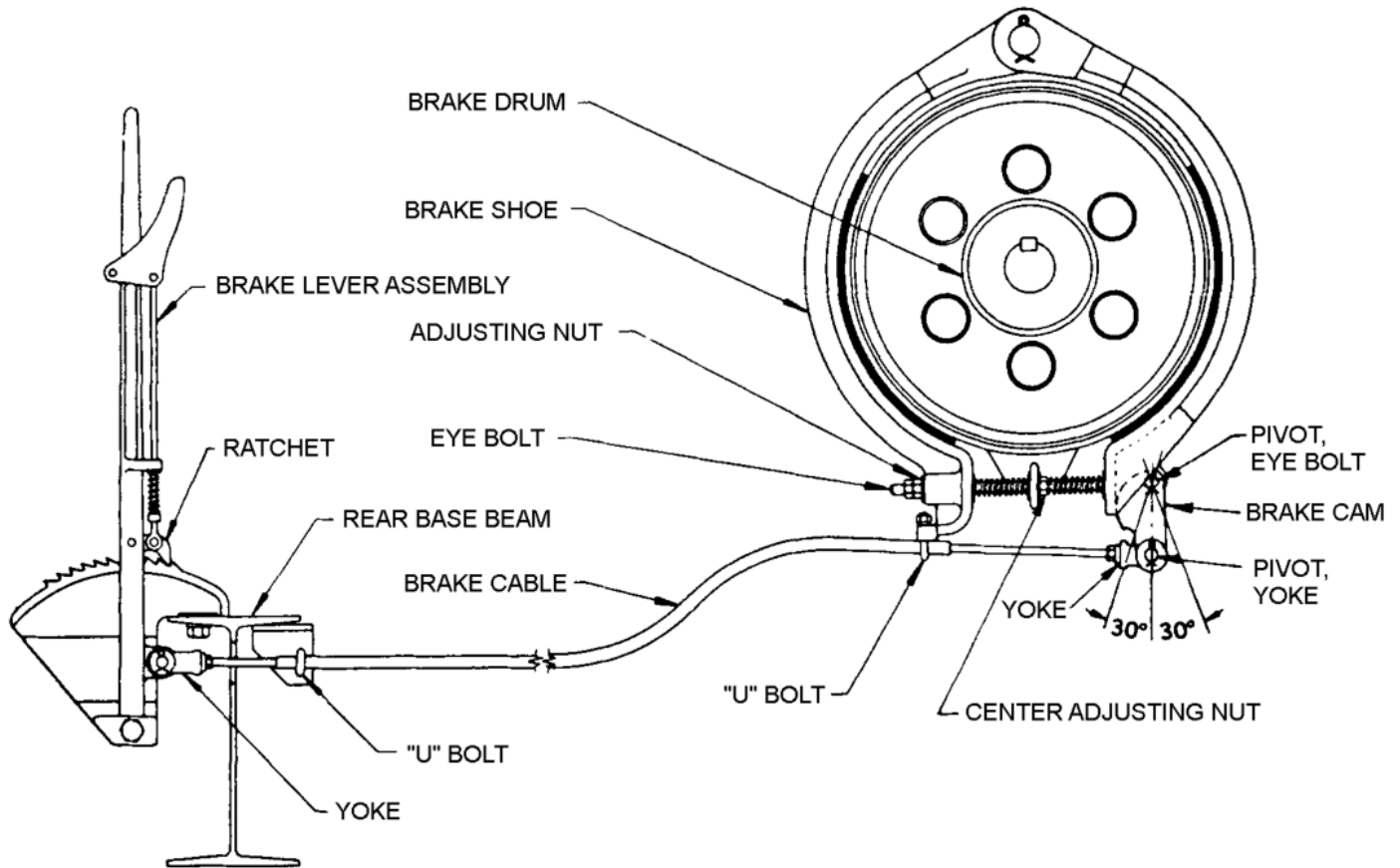


Figure 22: Type "A" Brake Assembly

- 1) Adjust the position of both brake shoes by moving both adjusting nuts until both linings just clear the drum.
- 2) Attach the brake control assembly to the base.
- 3) Attach the brake cable to the base or hi-prime bracket using the U-bolt provided.
- 4) Move the brake control lever forward to locate the pin hole on the lever between the yoke on the end of the brake cable. Install the pin and cotter pins.
- 5) When the brake is disengaged, the pivot yoke of the cam should be at about a 30 degree angle to the right. Simultaneously, the brake lever would be "full off" to the right of vertical.
- 6) When the brake is fully engaged, the lower end of the cam would be vertical or up to a 30 degree angle to the left. Simultaneously, the brake lever has the ratchet engaged and several notches still available for engagement.
- 7) To achieve the proper engaged and disengaged positions of the cam and brake lever, either or both yokes can be adjusted in or out on the ends of the brake cable.
- 8) Be certain the rod end does not bottom out on the cable cover when engaging or disengaging the brake. When the yoke positions are established, tighten the jam nuts against the yokes.
- 9) Make sure the brake drum key is tight.
- 10) Set the brake before continuing with unit installation.

7.6 Master Counterweight Installation

⚠ WARNING

This machinery is made up of heavy parts that can rotate unexpectedly. Extreme care must be exercised when working around the sweep of the cranks.

⚠ WARNING

Stay clear during lifting of counterweights (Refer to Section 2.4, “Personnel Safety During Lifting Operations.”) A slipping or falling counterweight can cause serious injury or death. Placing hands between weights and crank can cause serious injury. To avoid injury, hold the bolts with large channel lock pliers or other suitable tool.

⚠ WARNING

Ensure all counterweight bolts are torqued to specification prior to removing lifting straps.

It is recommended that when using less than 4 master counterweights and/or auxiliary counterweights, operators should keep weight balanced between the leading and the lagging sides of the cranks. Failure to do so will induce a phase angle that could cause the gearbox to be overloaded.

⚠ CAUTION



⚠ CAUTION

Ensure the crank T slot is free of ice. Failure to do so may result in loosening of joint upon thaw.

Orient the cranks straight down. Set the brake, engage the pawl and chain the drum (refer to Section 2.3, “Securing the Cranks”). Clean the mounting surfaces of the counterweights and cranks of any foreign materials. Units are usually shipped with the counterweight bolts located on the topside of the cranks. Half of these will need to be removed and placed on the opposite side of the cranks. Slide the counterweight bolts into the T slot (bolt tracks) of the crank through the opening near the crankshaft. Using the auxiliary weight bolt holes, lift the counterweight with a sling. Some weights have a hole positioned at the center of gravity of the counterweight. A single chain may be used to lift from that hole.

Using the auxiliary weight bolt holes, lift the counterweight with a sling or if provided, use the single chaining hole positioned at the center of gravity of the counterweight.

On cranks equipped with adjustment teeth, install symmetrical weights such that the recess for the adjusting pinion is located toward the long end of the crank (Figure 23).

On asymmetrical weights, the curved side must be located toward the long end of the crank (Figure 23).

Line the counterweight bolts up with the holes in the weights and slowly swing the weight into position against the face of the crank. Lift or lower the weights to the desired position and tighten the counterweight bolts per Table 6: Metal-to-metal bolt torque requirements. Install the second nut as a jam nut and also tighten per Table 6: Metal-to-metal bolt torque requirements. Match mark the counterweight to crank surface to enable future identification of movement. Remove lifting straps after all bolts are fully torqued.

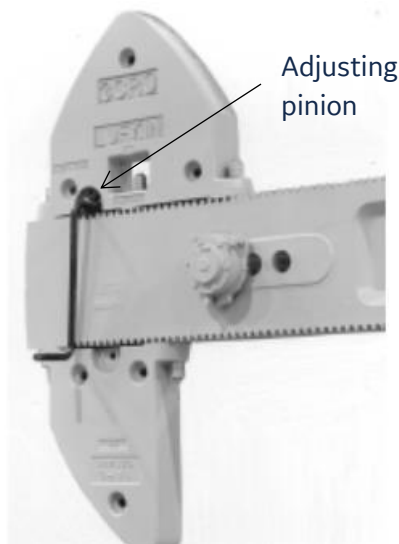


Figure 23: Master counterweights

7.7 Auxiliary Weight Installation



Stay clear during lifting of counterweights. (Refer to Section 2.4, “Personnel Safety During Lifting Operations.”) A slipping or falling counterweight can cause serious injury or death.

Install the auxiliary weights with the cranks down. Support the weight by passing a chain through one of the mounting holes. Lower the weight in between the reducer and the crank until a bolt hole lines up with the corresponding hole in the master counterweight. Insert a bolt so that the threads point away from the reducer (Figure 24). Continue to lower the weight until the remaining holes line up. Insert another bolt as described above. Remove the chain and install the remaining bolt(s). Tighten all bolts per Table 6.



Figure 24: Auxiliary counterweight installation

7.8 Samson Post Installation



Do not stand under any suspended loads. Use tag lines to assist in directional control of large suspended objects.

7.8.1 Setting the Samson Post

Clean the surfaces between the front and rear leg connection plates and the unit base and foot plates of the Samson post.

Full metal to metal contact should be established along span of surface between rear leg and connection plates before fasteners are installed. If shims between the connection plates and rear leg are necessary, they typically will have been installed at the factory. If a replacement front or rear leg is being installed, verify that the total gap, the sum of the gap on both sides of the rear leg flanges, is no greater than 0.075 inches. If the total gap is greater than 0.075 inches, shims will be necessary (Figure 25).

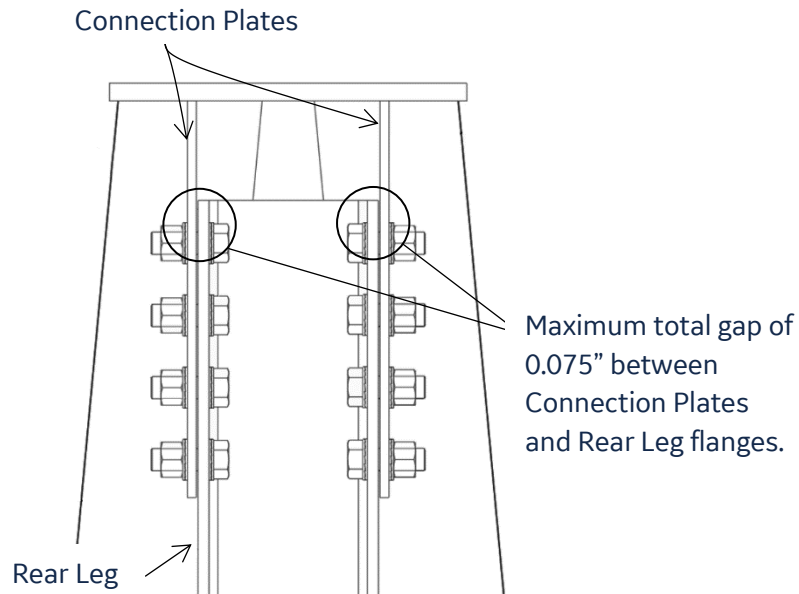


Figure 25: Rear Leg Installation

The post and rear leg assembly is shipped with pivot bolts in the connection plate holes (Figure 26). The rest of the fasteners are in bolt kits in a loose parts crate.

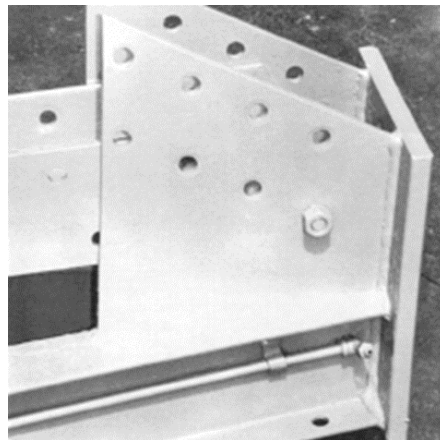


Figure 26: Samson Post assembly with pivot bolts installed

Align the holes in the rear leg with the holes in the connection plates and install these bolts. Install the bolts so the nuts are on the outside and hand tighten. Bolts will be tightened to specification after the center bearing plate is leveled.

Lift the post assembly with a sling attached near the top of the assembly. This will hang the post in a near level position for easy attachment to the base, as shown in Figure 27.



Figure 27: Samson Post assembly during installation

Attach the front and rear post members to the base by installing the bolts from the bottom so the nuts will be on the top side. Hand tighten bolts on all legs.

Final tightening of the foot plate bolts will be done after the center bearing plate is leveled in Section 7.8.3, “Leveling Samson Post Top Plate.”

7.8.2 Ladder Installation



Do not stand under any suspended loads. Use tag lines to assist in directional control of large suspended objects.



Never use the ladder while the unit is in operation

The ladder attaches directly to the Samson Post or to brackets attached to the post leg as shown in Figure 28. Install the bolts and tighten per Table 6: Metal-to-metal bolt torque requirements.

On smaller units, a clamp-on type loop may be furnished with ladders to provide support for a person when working in the area of the center bearing (Figure 28). The loop must be located in a position that insures maximum safety to personnel and does not create a pinch point between the loop and the walking beam.



Figure 28: On left, ladder prior to attachment to Samson Post. On right, ladder with support loop installed in area of Center Bearing.

7.8.3 Leveling Samson Post Top Plate

Check the level of the Samson post top plate from left to right as shown in Figure 29. If out of level more than 1/16 inch, place shims under the post legs to achieve a level Samson Post top plate.



Figure 29: Checking levelness of Samson Post top plate in transverse direction

7.8.4 Tightening Samson Post Bolts



Proper eye protection must be worn. Flying metal could cause damage to the eyes.

After leveling at the center bearing plate is achieved, use a feeler gauge to check for gaps between the foot plates and the base under the bolt locations as shown in Figure 30. If the gap is greater than 0.06 inches, contact your BHGE sales representative.

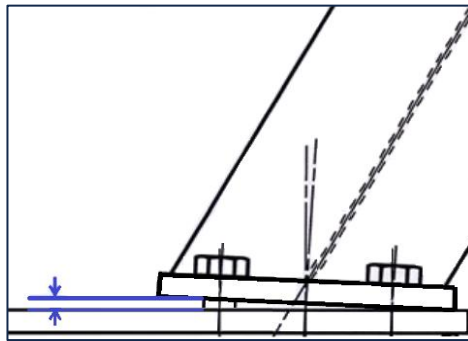


Figure 30: Check for gap under Rear Leg during installation

Tighten the bolts at the rear leg foot plate followed by the front leg foot plates. Next, tighten the upper joint between the front and rear Samson Post legs. Tighten all bolts per Table 6: Metal-to-metal bolt torque requirements.

7.9 Prime Mover Installation



Do not stand under any part of the load while installing the prime mover. Do not place fingers and hands between the prime mover and the slide rails.

Place the slide rail bolts in the T-slots near the reducer end so the belts can be easily installed after positioning the prime mover. Guide the slide rails onto the bolts. Space the slide rails to match the mounting holes of the prime mover. Install and space the mounting bolts in the T-slots on the slide rails to match the mounting holes of the prime mover. Slowly lower the prime mover onto the mounting bolts. To prevent injury to fingers and hands, use pliers or other tools to position the bolts. Install the nuts but do not tighten until the belt alignment is completed.

Some bases are tailor made for a particular engine. These do not use slide rails, instead the engine feet mount directly to the T slots on the base.

7.10 V-Belts Installation and Alignment

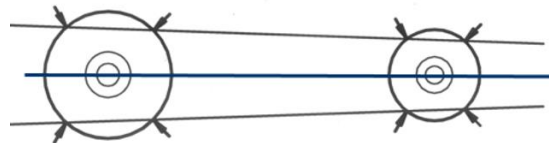


Ensure that the prime mover is properly de-energized and all LOTO is complete.

Install a matched set of belts. Use the inside grooves if either sheave has an excess number of grooves. Use a string to line up the inside faces of the sheaves as shown in Figure 31. Shift the prime mover as required and then tighten the bolts that attach the prime mover to the slide rails.



Check alignment with string near centers



Check alignment with string at $\frac{1}{4}$ radius, top and bottom

Figure 31: Sheave to motor alignment

Tighten the belts by using the adjustment screws to move the prime mover until the belt tension is uniform across the width of the belts. The tension of the belts may be checked with a belt tensiometer per the belt manufacturer's recommended value. A tensiometer is in use in Figure 32.

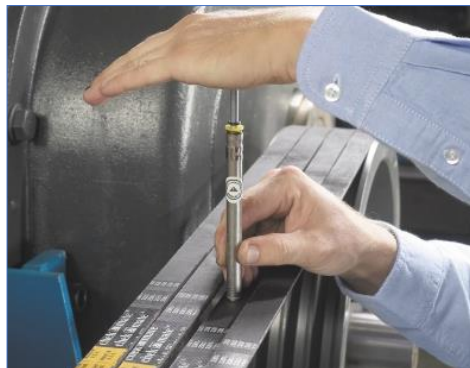


Figure 32: Belt Tensiometer

The belts should contact the sides of the groove rather than the bottom as shown in Figure 33. If the belts are sitting in the groove, they may be the incorrect belts or worn.

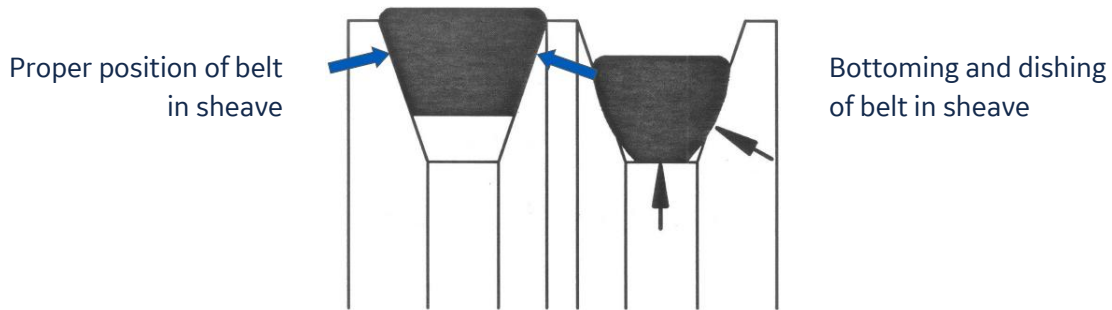


Figure 33: Belt seating in sheave

Tighten the bolts attaching the slide rails to the T slots, following the requirements in Table 6: Metal-to-metal bolt torque requirements.

7.11 Belt Cover Installation



Ensure that the prime mover is properly de-energized and all LOTO is complete.

Remove the bottom pan from the belt cover and install the cover (Figure 34). The front support fits over two slow speed shaft studs on the reducer and is retained by the jam nuts that are located on the reducer studs. The rear belt cover support fits on the prime mover base. Check inside the cover to be sure the sheaves and belts have adequate clearance. The cover can be shifted sideways to adjust clearance but do not over shift and allow the sheaves to rub against the belt cover. Replace the bottom pan. Some belt covers are equipped with a center support or a wind brace, which should be attached at this time. Tighten all bolts following the requirements in Table 6: Metal-to-metal bolt torque requirements.

NOTICE

It is essential that the user of the pumping unit comply with all applicable safety requirements concerning the guarding of belts and sheaves. For additional information concerning belt guards, see API RP11ER.



Figure 34: Belt cover installation

7.12 Center Bearing and Tail Bearing to Walking Beam Assembly



Do not stand under any suspended loads.



Proper eye protection must be worn. Flying metal could cause damage to the eyes.

7.12.1 Lifting of Walking Beam



Walking beams lifted using a choking configuration can be susceptible to slipping along the beam.

The following walking beam lifting methods are listed in the preferred order:

- Lifting lugs (if available)
- Beam clamps
- Chains in a choking configuration

For the choking configuration, it is recommended to design the lifting plan such that horizontal movement of the sling is not possible. This is in preventing unwanted movement of the rigging along the beam.

7.12.2 Connection of Walking Beam and Center Bearing

Clean the surfaces between the center bearing and walking beam. Position the beam over the center bearing assembly. Align the bolt holes. Install the bolts and snug tighten. Final tightening of these bolts is performed in Section 7.12.3, "Connection of Equalizer Bearing to Walking Beam."



Figure 35: Lifting walking beam for installation to center bearing

7.12.3 Connection of Equalizer Bearing to Walking Beam

Your new pumping unit is shipped with the equalizer hinge pin mounted in the walking beam lugs. To remove the pin for cleaning, loosen the pinch bolts on the walking beam lugs and end cap from the equalizer hinge pin stud.

Clean the equalizer hinge pin and all of its contacting surfaces, including the bearing housing, of any rust preventive material, burrs or foreign material with a file and a safe solvent (per your company's safety regulations) prior to assembling. After cleaning the surfaces, recoat them with a light oil to ease the assembly process. Position the walking beam over the equalizer and equalizer bearing assembly and slowly lower the beam until the assembly fits between the two lugs welded to the rear end of the walking beam, as shown in Figure 36.



Figure 36: Connecting the Walking Beam to the Equalizer

Install the hinge pin from the front end of the beam, passing it through the front lug first, then the equalizer bearing box and finally the rear lug on the walking beam. On some of the smaller pumping units, the hinge pin is installed from the rear toward the front. Next, slide the end cap onto the hinge pin stud and install the elastic stop nut. Snug tighten

the hinge pin nut and the pinch bolts. Final tightening will be done after rotation of the unit, Section 8.2, “First Crank Revolution.”

7.12.4 Equalizer Bearing Hinge Pin Lubrication

Using grease that meets requirements in Section 4.3, “Structural Bearing Grease,” lubricate the Hinge Pin shown in Figure 37.



Figure 37: Greasing the Hinge Pin

7.12.5 Center Bearing and Equalizer Bearing Alignment



Engagement of the adjustment bolts to the saddle casting during operation can lead to an extraneous load path on the walking beam. Over time this can cause damage to the walking beam. Ensure a minimum of ¼” between end of bolt and saddle.



Improper tightening of the center bearing to walking beam bolts can result in severe damage to the pumping unit.

After assembling the center bearing assembly and the equalizer bearing assembly to the walking beam, carefully measure the distance between the end of the center bearing shaft and the end of the equalizer bearing shaft on both sides. For proper alignment, these distances should be the same. If necessary, loosen the center bearing saddle bolts so the center bearing assembly can be rotated until the shaft centers are the same on both sides. The adjustment bolts may be used to make minor positional changes.



Figure 38: Verifying Center Bearing to Equalizer Bearing distance is equal on right and left side

After obtaining the alignment, tighten the bolts between the center bearing saddle and the walking beam, per Table 6: Metal-to-metal bolt torque requirements.

Prior to unit start up, adjustment bolts must be backed off to a minimum of $\frac{1}{4}$ inch clearance relative to the saddle casting after adjustments are complete as shown in Figure 39.

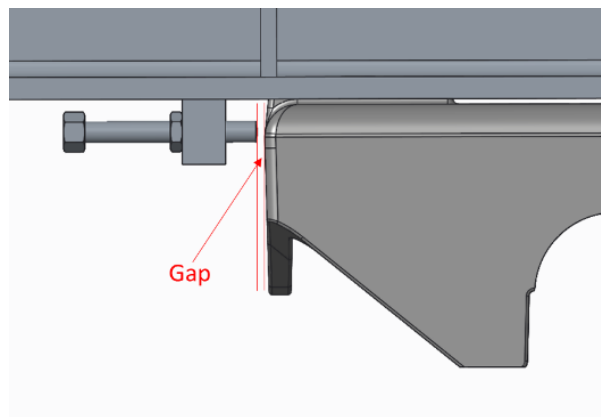


Figure 39: A gap of $\frac{1}{4}$ " minimum between the adjustment bolt and saddle is necessary post adjustment.

7.13 Pitman to Equalizer Assembly



Figure 40: Connection the Pitmans to the Equalizer

On top of the equalizer beam is a lubrication hose clip located only on one side of the bearing. The pitman with the lubrication line attached to it must be located on the same side.

The lubrication line grommet must be located under one of the mounting bolts of this pitman. Clean the surfaces between the pitman upper connections and the equalizer. Bolt the upper end of the pitmans to the equalizer. Snug tighten. Final tightening will be done after unit alignment (Section 7.23, "Unit Alignment").

7.14 Equalizer Bearing Lubrication and Hose Installation

Attach the lubrication hose to the lubrication line on the pitman and fill with grease as specified in Section 4.3. Attach the hose to the equalizer bearing housing (Figure 41). Only one line is needed for equalizer bearing lubrication. Check the equalizer bearing lubrication per Section 7.25.



Figure 41: Equalizer Pin Lubrication

7.15 Pitman Box Lubrication

Using grease recommended Section 4.3, lubricate the upper pitman boxes as shown in Figure 42.



Figure 42: Lubricating the Pitman Box

7.16 Walking Beam Installation



Do not stand under any part of the load while cleaning the center bearing base.

Lift walking beam, center bearing, equalizer and pitman assembly to a horizontal position. Refer to Section 7.12.1, "Lifting of Walking Beam," for preferred lifting methods. Lift the beam high enough to clean the bottom of the center bearing base. Remove any debris from the bottom of the center bearing base.

7.16.1 Pitman Parallelism

Continue lifting the assembly until the pitmans are off the ground. View the walking beam/pitman assembly from the side and sight from one pitman arm to the other to make sure they are parallel (Figure 43). In the event the pitman arms do not line up, contact your nearest BHGE representative.



Figure 43: Verifying initial pitman alignment

7.16.2 Center Bearing to Post Installation



Do not stand under any part of the load while installing the center bearing. Use tag lines on the pitmans to keep personnel a safe distance from load while maneuvering the assembly. Refer to Section 2.4, “Personnel Safety During Lifting Operations.”

Clean the top plate of the Samson post of any foreign materials. Lift the walking beam/pitman assembly in a level configuration and position the center bearing over the top of the Samson post. The center bearing has a male boss which fits into the hole in the top plate of the Samson post to aid in rough alignment of the center bearing to the Samson post. Install the Center Bearing to Samson Post bolts and snug tighten. These bolts will be thoroughly tightened later, after pitman alignment is checked.

7.16.3 Pitman/Crank Pin Connection



Do not hammer the pitman lower connection onto the crank pin bearing box. This could result in damage to the crank pin bearings.

With the crane, slowly lower the rear of the walking beam until the pitman's lower connections are aligned with the crank pins. Use ropes to guide the pitman connections to prevent contact with the crank pin or other parts of the unit. Clean the contact surfaces between the pitman lower connection and the crank pin bearing box. The pitman ends should fit easily on the crank pin bearing boxes.

If the pitman does not fit the crank pin squarely, the upper pitman bolts may need to be loosened to get the proper alignment. Align the cap screw holes and install the cap screws, tightening them per Table 6: Metal-to-metal bolt torque requirements.



Figure 44: Tightening cap screws joining the Pitman and the Crank Pin Housing

7.16.4 Pitman Alignment



Failure to properly align the pitman to the crankshaft causes undue stresses on the structural components, which will lead to a shortened life of the pumping unit.



Proper eye protection must be worn; flying metal could cause damage to the eyes.

Using a tape, carefully measure the distance between the end of the crankshaft and the nearest part of the pitman on both sides of the gearbox, as shown in Figure 45. The two distances should be within 1/8 of an inch of each other.



Figure 45: Measuring the distance between the pitman and the crankshaft

In the event the pitman to crankshaft distances are not within these limits, rotate the walking beam by turning the center bearing on the post until the alignment between the pitman and the crankshaft end is satisfactory.

Tighten the center bearing to Samson post bolts per Table 6: Metal-to-metal bolt torque requirements. Remove the lifting equipment from the walking beam.

7.17 Center Bearing Lubrication and Hose Installation

Attach the lubrication hoses to the lubrication lines, which are located on both front legs of the Samson post, and fill the hose/line assemblies with grease recommended in Section 4.3, "Structural Bearing Grease." Attach the hose to the center bearing (both sides). The bearing lubrication will be performed in Section 7.25, "Bearing Assembly Lubrication."

7.18 Preparation for Horsehead Installation



The cranks will be rotated during this operation. Exercise extreme care when working around the sweep of the cranks.

Attach chains to both cranks (see Notice in Section 7.4, “Crank Rotation”). Clear all personnel and objects from the crank sweep area. Remove the slack in the chains by using the crane. Be sure the load is equalized. Release the brake. Slowly raise the cranks until the walking beam is in a horizontal position. Reset the brake, engage the pawl and chain the drum (see Section 2.3, “Securing the Cranks”).

7.19 Wireline Installation

The procedure illustrated in Figure 46 involves looping the wireline around the wireline seat, which is located at the top of the horsehead. Loosely bolt the wireline retainer in place over the seat and the wireline. Stretch out the wireline by pulling on the carrier bar until the carrier bar is parallel with the bottom of the horsehead and the wireline is against the seat. Tighten the bolt holding the wireline retainer in place per Section 5.2, “Non-Standard Bolting Applications.”



Figure 46: Installing Wireline on Horsehead

7.20 Wireline Bail Installation

A wireline bail is furnished on 120" stroke and larger Conventional pumping units and on all Reverse Mark pumping units. The bail prevents the wireline from sliding off the side of the horsehead in the event slack occurs in the wireline. To install the wireline bail, insert the pins on the bail into the pipe sockets on the side of the horsehead.



Figure 47: Wireline Bail installation for 120" stroke or greater

7.21 Horsehead Installation



Do not stand under any part of the load while positioning the horsehead. Do not place hands or fingers inside the horsehead during installation.

7.21.1 Standard Horsehead Installation



The safety bar, hinge pin and/or the latch bolt must be installed and tightened at all times except during horsehead removal.

Before lifting the horsehead, make sure the adjusting screws are flush with the inside of the side plates (Figure 48).



Figure 48: Turning Adjustment Screws until flush with the side plates prior to Horsehead lift

Clean the wireline track of any foreign material. Place the horsehead on the beam, making sure the rocker plate inside the upper portion of the horsehead fits firmly against the top flange of the beam and is between the seat bar and the angle spacer (Figure 49). Some of the smaller units are shipped with a hinge pin, which needs to be installed at this time.

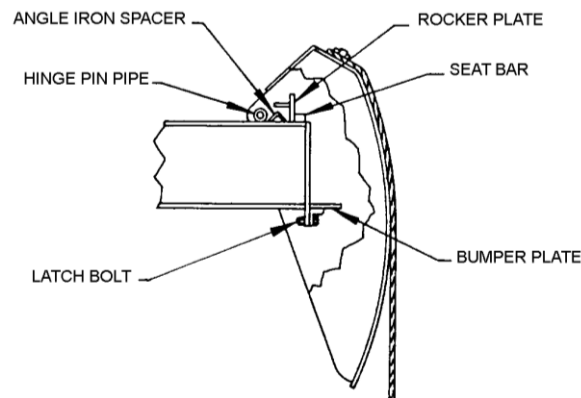


Figure 49: Horsehead components

Insert the pin through the side plate and the hinge pipe that is located on top of the walking beam. Add the washers and the cotter pins to hold the hinge pin in place. Allow the horsehead to swing down so the bumper plate inside the horsehead contacts the front plate of the walking beam.

Most of the larger stroke length units are equipped with a horsehead safety bar (see Figure 50). Install the bar through the slot in the side of the head and through the angle welded to the front plate of the beam. To keep the bar from sliding out, the roll pin, which is part of the bar, must go through the slot on the side plate and then rotate 90° to bear against the inside of the side plate. Visually check that the safety bar is through the angle and not above or below it.

Units with shorter stroke lengths are equipped with a latch bolt (throat bolt). See Figure 49. These units are normally shipped from the factory with the horsehead mounted to the walking beam. At this time, be sure the latch bolt is installed. The latch bolt will need to be loosened during adjustments in Section 7.22, "Horsehead Alignment."

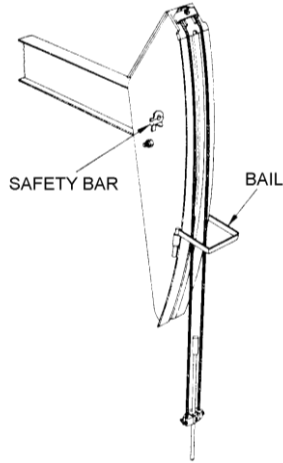


Figure 50: Safety Bar and Bail location

7.21.2 For Pivoting Horsehead

The lever on the bottom of the walking beam attaches to a latch pin. Pull the lever back towards the ladder with approximately 10kg of force. When the lever is as far back as you can comfortably pull it then tie the chain on the lever to the hook so the lever does not slide back to its original position (Figure 51).

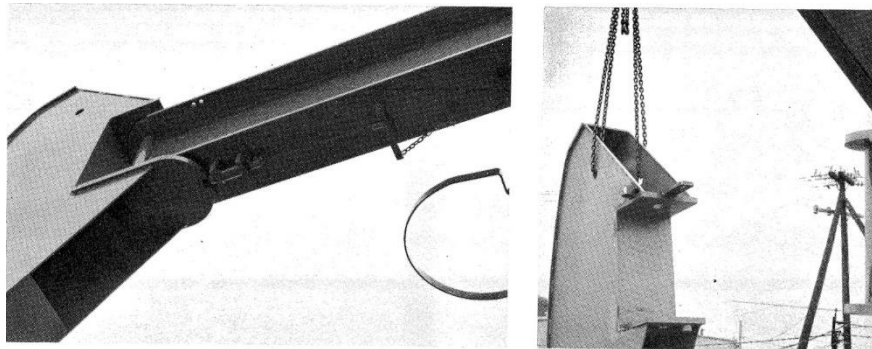


Figure 51: Pivoting Horsehead installation

Attach chains through the lifting holes in the side plates of the horsehead (Figure 51). Lift the horsehead and clean the wireline track of any foreign material. If necessary, adjust the chains until the head hangs perpendicular to the walking beam.

Install the horsehead on the beam, aligning the holes in the head with the pipe at the front end of the walking beam. Place two Teflon washers between the hole in the top section of the walking beam and the hole in the horsehead where the pin fits. Align the hole in the horsehead with the hole in the washers and the walking beam and insert the large pin until the pin shoulders out on the top plate of the head (Figure 52). Tighten the long bolt and hex nut at the lower end of the large pin to ensure that it remains in place.

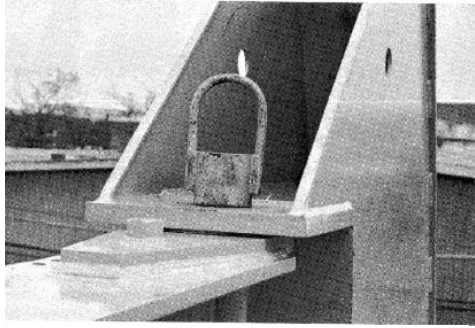


Figure 52: Pin on Pivoting Horsehead

7.22 Horsehead Alignment

7.22.1 For Standard Horsehead

With the walking beam in a horizontal position, use a level or a plumb bob, as shown in Figure 53, to check the vertical alignment of the horsehead. The horsehead may be vertically aligned by adjusting the appropriate screw followed by tightening the other screw until it touches the walking beam flange. Once positioned properly, jam nuts should be tightened to lock adjusting bolts in place.



Figure 53: Checking alignment of Horsehead

Tighten the latch bolt on units so equipped per Table 6: Metal-to-metal bolt torque requirements.

NOTICE

It is essential that the user of the pumping unit comply with all applicable safety requirements concerning the guarding of horseheads. Refer to API RP111ER. Guards are available from LUFKIN.

7.22.2 For Pivoting Horsehead

With the walking beam in a horizontal position, use a level or a plumb bob to check the vertical alignment of the horsehead. If the alignment is off vertical more than 1/16" per 12" (5mm per meter), shim under one side of the center bearing saddle until the misalignment is equal to or less than the 1/16" per 12".

To shim, loosen the four bolts on the saddle half of the center bearing. Using a chisel in the relieved portion of the saddle, wedge open a space between the saddle and the walking beam and insert shims (Figure 54). Retighten the center bearing bolts per Table 6: Metal-to-metal bolt torque requirements and recheck alignment.

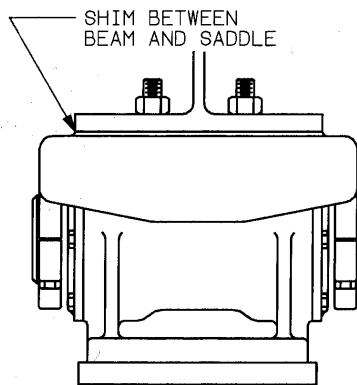


Figure 54: Correcting Pivoting Horsehead alignment with shims

NOTICE

It is essential that the user of the pumping unit comply with all applicable safety requirements concerning the guarding of horseheads. Refer to API RP111ER. Guards are available from BHGE.

7.23 Unit Alignment

Using a rope, hold the carrier bar away from the polished rod. Do not stand under the horsehead. Lower a plumb bob from the center of the top of the horsehead down beside the polished rod. Alignment is achieved when the distance from the string to the center of the polished rod is the same as the distance between the string and where the center of the wireline will travel when connected to the well load. An alternate method can be used after complete unit assembly and before starting the unit. After applying the well load to the unit, use a level to check the vertical alignment of the polished rod in various stroke positions. Move the entire pumping unit on its foundation if adjustment is required.

After establishing the final alignment of the unit to the well:

1. Attach chains to both cranks (see Notice in Section 7.4, "Crank Rotation"). Remove the slack to support both cranks equally. Unchain the drum and disengage the pawl. (Refer to Section 2 of this manual for safety

precautions.) After making sure the crank sweep area is clear, release the brake. Use the crane to slowly lower the cranks to the bottom at the 6 o'clock position. Reset the brake.

2. Be sure all foundation hold down clamps are installed with spacers over the base beam webs and tighten the foundation bolts.
3. Tighten the bolts connecting the upper pitman boxes to the equalizer. Do not tighten the hinge pin bolt nor the pinch bolts at the equalizer until after rotation of the unit in Section 8.2, "First Crank Revolution."
4. Check all other bolts to be sure they are tight. Refer to Section 5.1, "Metal-to-Metal Joints" for bolt tightening requirements.

7.24 Reducer Lubrication



Damage will occur to the reducer if it operated with the improper amount or type of lubricant.

Check the oil level with the dip stick located at the front of the reducer. If the oil level is low, remove the inspection cover and add oil to the proper level. See Section 4.1, "Reducer Oil," for the lubrication type and the quantity required.



Figure 55: Dip Stick to check reducer oil level

7.25 Bearing Assembly Lubrication



Damage will occur to the crank pin bearing, equalizer bearing or center bearing if the unit is operated with the improper amount or type of lubricant in the assemblies.



Excessive grease flow rate may cause damage to seals. Exercise caution when utilizing pneumatic greasing systems.

Crank pin, equalizer and center bearing assemblies are lubricated at the factory; however, it is a good practice to check the assemblies. The grease fitting for the crank pin bearing is located on the crank pin housing. The grease fitting for the equalizer bearing is located on one of the pitman arms. The grease fittings for the center bearing are located on the front Samson post legs. Using grease as specified in Section 4.3, "Structural Bearing Grease," pump grease into the bearing assembly until it overflows through the relief fitting. Lubrication lines are pre-lubricated; therefore, only a small amount of grease should be required for this check. Pump the grease in slowly to avoid damage to the seals.

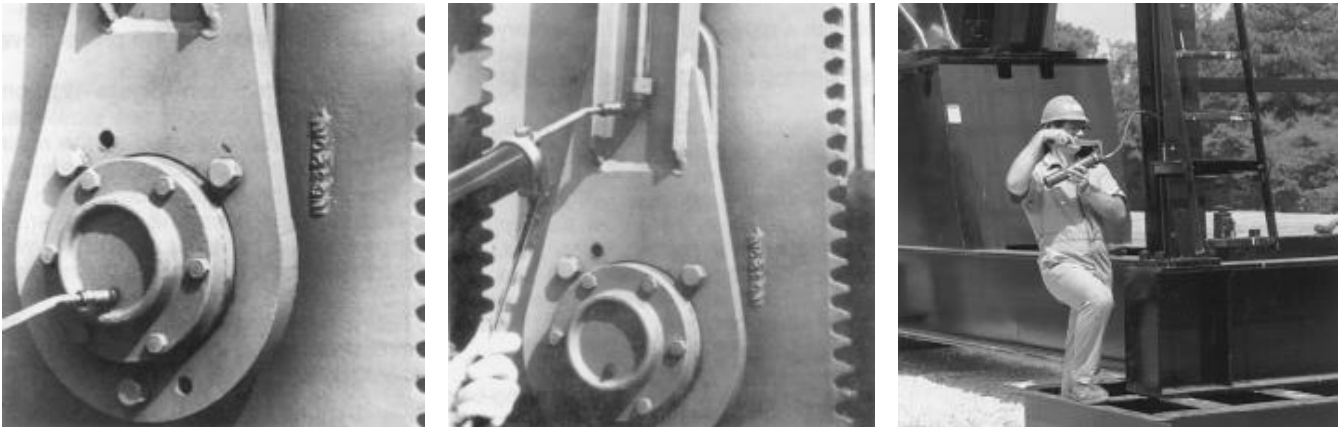


Figure 56: From left to right – direct lubrication of crank pin bearing, remote lubrication of equalizer bearing, remote lubrication of center bearing.

If the unit is not furnished with a remote lubrication system for the equalizer bearing and center bearing, grease ports for the are located directly on the bearing assemblies.

7.26 Crank Guard Installation



Stay clear of crank swing area while installing guards. (Refer to Section 2.4, “Personnel Safety During Lifting Operations.”)

Never operate pumping units without guards in place.

When crank guards are purchased from BHGE, a crank guard installation schematic is shipped with the unit. This shows the panel part numbers and their location relative to each other and to the well head. The front panel, located between the Samson post legs, connects to the base beam flanges where possible. The side panel is attached to the front and rear panels with hinges consisting of stationary hooks on the side panels and vertical piper receptacles on the front and rear panels. Whenever you choose to furnish your own guards in lieu of guards available from BHGE, insure they meet all Federal, State and local laws.

7.27 Attaching the Well Load



When connecting a crane hoist line to the polish rod, ensure that no component catches the lower end of the horsehead during lifting operations. The horsehead may become detached from the walking beam and fall. It is recommended that the main hoist hook be above the horsehead during lifting operations.



Keep hands from between the polished rod clamp and the stuffing box in the event the polished rod clamp slips or the unit moves.

Hold the carrier bar away from the polished rod with a rope or chain. If necessary, attach a polished rod extension to the polished rod so it will rise above the horsehead. Verify that the rod string is free to move the full length of the pumping unit stroke by slowly lifting the polished rod with a crane.

NOTICE

Ensure that the length of downhole pump stroke exceeds the stroke length of the pumping unit. Failure to do so may result in rod string separation or possible damage to the pumping unit.

Remove the gate from the carrier bar and position the slot in the carrier bar around the polished rod. Replace the gate and secure the gate latch in the notch provided. Install the rod clamp at the carrier bar and tighten the bolts according to the clamp manufacturer's torque recommendations. Verify with the rod clamp manufacturer that the clamp's load capacity exceeds the pumping unit structure rating. Release the brake and slowly let the load down with the crane until the well load is on the unit and slack occurs in the lifting chains. Reset the brake. Remove the rod clamp that was at the well stuffing box.

8 Pre-Operation



Before operating any unit, review the safety section (Section 2) of this manual. Exercise extreme caution to remain clear of the crank sweep and other moving parts while performing any of the following tasks.

8.1 Direction of Rotation



Electrical contact can cause serious injury or death. Electrical power must be locked out prior to performing any work on the electric motor. All electrical work must be performed by a qualified electrician.

The LUFKIN Reverse Mark pumping unit must rotate clockwise only. This is determined by looking at the unit from the side with the horsehead located to your right.

The LUFKIN Conventional pumping unit can operate equally well with the rotation in either direction. Whenever evidence of excessive wear or pitting of the gear teeth is noticed, the direction of rotation can be reversed. Reversing the rotation causes different contact surfaces of the gear teeth to be exposed to the load, which extends the life of the gear elements. If your prime mover is a three-phase electric motor, this can easily be done by reversing the leads on the motor.

8.2 First Crank Revolution



Contact with heavy rotating parts will cause serious injury or death. Stay clear of the crank swing and horsehead areas.



Failure to remove the end play between the equalizer bearing housing and the beam lugs will cause damage to the equipment.



To avoid damage to the unit, all bolts must be retightened after one week of operation.

Clear the crank swing area of all obstructions left on the unit and foundation. The first revolution of the crank should be as slow as possible. Check for proper clearance between the cranks and the belt cover, crank guards and pitman side members. Bottom-hole-pump spacing should also be checked during the first revolution.

After slowly rotating the unit through several revolutions, stop the unit with the horsehead at the top of the upstroke. Set the brake. LOTO all energy sources. Install a polished rod clamp at the stuffing box. Tighten the hinge pin to remove the end play between the equalizer bearing housing and the beam lugs. The hinge pin pinch bolts should be tightened to the value stated in Table 6: Metal-to-metal bolt torque requirements. Recheck all bolt connections for tightness.

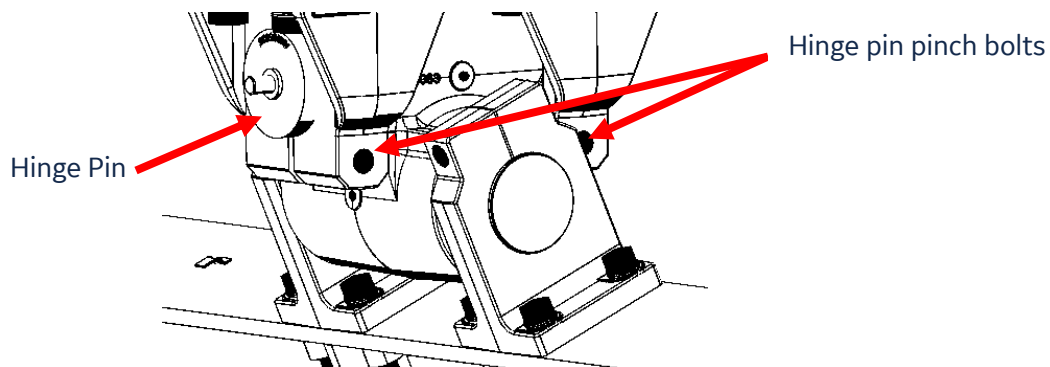


Figure 57: Equalizer Hinge Pin and Pinch Bolts

Remove the polished rod clamp at the stuffing box. Reverse the LOTO of all energy sources and release the brake. Operate the unit for 30 minutes and retighten the V-belts.

9 Counterbalance Adjustment

9.1 Determining the Required Counterbalance



Do not enter the crank swing area or stand under the horsehead while performing any of the following tasks.

Efficient operation, minimum torque loading and maximum life of a pumping unit are all a result of proper counterbalance. Counterbalance requirements can be determined very accurately or estimated by several methods.

1) Polished rod dynamometer

A dynamometer card analysis may be used to determine loading and counterbalance. However, its accuracy depends on the input data for the pumping unit and counter balance. This process involves using a dynamometer to record the well load through a stroke cycle and then using torque factors to determine the reducer torque and counterbalance required for balanced conditions.

2) Ammeter

A clip-on ammeter may be used to compare the upstroke and down stroke current on electrically powered units. When the counterbalance is adjusted so the current peaks are equal, the unit will be approximately in balance. Some motor control panels and variable speed drives are equipped with on-board ammeters.

3) Vacuum gauge

A vacuum gauge may be used to compare torque peaks on engine driven units much like the ammeter is used on electrically driven units. Vacuum pressure decreases as engine output increases.

9.2 Counterweight Adjustment



Stay clear of the crank swing area and do not stand under the load while adjusting counterweights. (Refer to Section 2.4, “Personnel Safety During Lifting Operations.”)



Improperly tightened counterweight bolts can allow the counterweights to move on the crank. Impact movement of the counterweights could break through the stop on the crank end and damage the unit or cause serious injury or death to personnel.

9.2.1 Cranks with Tooth Rack

Rotate the unit and apply the brake so that the crank is slightly downhill in the direction that the weights are to be moved. Set the brake, LOTO all energy sources, engage the pawl and chain the brake drum. Refer to Section 2.3, “Securing the Cranks.” Loosen the counterweight bolts just enough to allow the weights to be moved. Use the pinion adjusting tool on units equipped with cranks which have teeth, as shown in Figure 58, to move the weights to the desired position. Some of the larger weights may have to be moved with the aid of a crane or a pry bar. The weight on the bottom of the crank may be moved in a like manner. After positioning the weights in the desired location, tighten the counterweight bolts and install a second jam nut. Torque bolts per Table 6: Metal-to-metal bolt torque requirements.



Figure 58: Crank with Tooth Rack

9.2.2 Cranks without Tooth Rack

Stop the unit with the cranks at the bottom, the 6 o'clock position. Set the brake, LOTO all energy sources engage the pawl and chain the brake drum. Refer to Section 2.3, "Securing the Cranks." Attach chains as shown in Figure 59. Take up the slack in the chains with a crane. Loosen the counterweight bolts just enough to move the weights. Lift or lower the weights to the desired position and tighten the counterweight bolts per Table 6: Metal-to-metal bolt torque requirements. Install the second nut as a jam nut and also tighten per Table 6: Metal-to-metal bolt torque requirements.



Figure 59: Standard Crank

10 Stroke Change



Extreme caution must be exercised during the following procedure to prevent serious personal injury. Before performing a stroke change, review Section 2, “Important Safety Instructions” of this manual.

The following description of a stroke change is given while viewing the pumping unit from the side with the well head located to the right.

10.1 Stroke Change Preparation



Do not place hands between the polished rod clamp and carrier bar in the event the polished rod clamp slips or the unit moves.



Stay clear of the crank swing area.



Abrupt braking may damage the gear teeth in the reducer. A slow, even pull on the brake lever is recommended.

Locate the cranks at about the 2 o'clock position and set the brake.

Place a polished rod clamp at the stuffing box and tighten according to the clamp manufacturer's torque recommendations.

Remove the crank guards. Attach chains to the cranks (see Notice in Section 7.4, “Crank Rotation”). Using the crane, remove the slack from the chains. Release the brake. Using the crane, raise the cranks up enough to remove the well load from the carrier bar and set the brake.

Disconnect the carrier bar from the polished rod.

Put a long rope or chain through the carrier bar and put the gate back into the carrier bar. Be sure the rope or chain is long enough so the carrier bar can be held without lifting a person off the ground. Hold the end of the rope or chain and pull the carrier bar away from the polished rod while easing off the brake and slowly letting the cranks down to the 4 o'clock position (Figure 60). Set the brake.

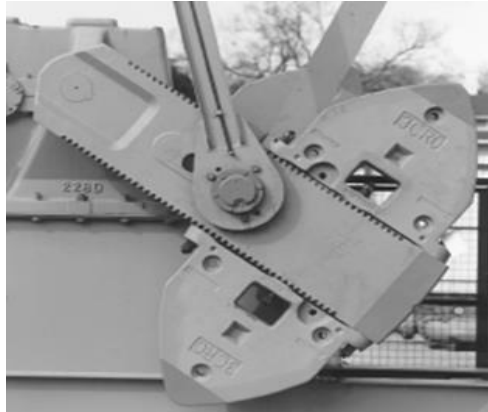


Figure 60: Cranks stopped at the 4 o'clock position

Disconnect or LOTO all energy sources. Engage the pawl and chain the drum. Refer to Section 2.3, "Securing the Cranks."

Place a safe come-a-long or ratchet-boomer (1.5 ton minimum) between the carrier bar and the front cross-member of the base. Place another between the equalizer and the holes on the front of the sub-base. Snug both come-a-longs or ratchet-boomers to restrain possible movement or tilting of the walking beam which would occur once the crank pins are removed from the cranks.

10.2 Crank Pin Removal



Proper eye protection must be worn; flying metal may cause damage to the eyes.

Using a drive nut (furnished as an optional item) is the recommended way to drive out the crank pin. First, remove the cotter pin. Remove the crank pin nut using a box-end hammer-wrench (furnished with a set of wrenches as an option) and at least a 14-pound sledge hammer with a full length handle. Then thread the drive nut onto the pin until it bottoms out. Hammer against the head of the drive nut until the pin is loose. When the pin is loose, do not remove it from the hole. Remove the drive nut and install the original nut 3 or 4 threads deep. Follow the same procedure on the opposite crank pin.

Check the crank pin clearance in the hole and adjust come along accordingly so when the pins are removed they will not fall nor pull up in a sudden motion. Remove the nuts and pull the crank pins out of the holes. The pitman side member will support the crank pin bearing assembly until the pin is installed into another hole. Remove the crank pin

sleeve for reinstallation. Inspect the crank pin and hole surfaces for rust and wear. These conditions may indicate that the pin was loose. Apply rust preventive to the crank pin bore after the pin is removed.

10.3 Crank Pin Installation



Improper cleaning of the crank pin and crank pin hole, as well as improper tightening of the crank pin, can cause damage to the pumping unit.

With an emery cloth, remove any paint and foreign material from the crank pin, crank pin sleeve (if present), crank pin hole and the mating surfaces between the crank and crank pin nut. Clean these same areas with an approved solvent per your company's quality policy.

Adjust come-a-longs or ratchet-boomers simultaneously to line up the crank pins with the proper holes for the stroke length desired. Refer to Section 10.1, "Stroke Change Preparation," for information on securing.

Perform contact check and installation as outlined in Section 7.2, "Crank Pin Installation."

10.4 Putting the Unit into Operation



Always work the crane from above the horsehead. Catching the bottom of the horsehead with the crane could cause the horsehead to fall off the beam.



Keep hands from between the carrier bar, accessory items and polished rod clamp in the event the polished rod clamp slips or the unit moves.

With the brake engaged, remove the come-a-longs or ratchet-boomers. Keeping the brake engaged, unchain the drum and disengage the pawl.

Hold the carrier bar away from the polished rod with the rope or chain and slowly release the brake to let the cranks go to 6 o'clock position. Set the brake. If necessary, attach a polished rod extension to the polished rod so it will rise

above the horsehead. From above the horsehead, slowly lift the polished rod with the crane until the carrier bar can be reattached below the upper polished rod clamp.

Remove the rope or chain from the carrier bar and attach the carrier bar to the polished rod. Slowly let the polished rod down until the well load is on the unit and not on the crane. Remove the polished rod clamp which was used at the stuffing box to clamp off the well load.

Reinstall the crank guards. After a stroke length change, check the bottom hole pump spacing. Also, the counterbalance should be checked and the weights repositioned as required for proper balancing. See Section 9, "Counterbalance Adjustment."

11 Well Servicing



Before performing any task around a pumping unit, refer to Section 2, "Important Safety Instructions". All mechanical sucker rod pumping units, of necessity, have rotating parts. Even a temporarily stationary pumping unit has components which can start moving from the effect of gravity. It is essential to prevent rotation of the cranks stopped in any position for the purpose of service or maintenance.

11.1 Well Servicing Preparation



Always work the crane from above the horsehead. Catching the bottom of the horsehead with the crane could cause the horsehead to fall off the beam.



Do not attempt to service the well without first removing the horsehead.



Keep hands from between the polished rod clamp, accessory items and the stuffing box in the event the polished rod clamp slips or the unit moves.



Abrupt braking may damage the gear teeth in the reducer. A slow, even pull on the brake lever is recommended.

To clamp off the well load, place a polished rod clamp at the stuffing box and tighten according to the clamp manufacturer's torque recommendations.

Remove the crank guards.

Attach chains to the cranks. See Notice in Section 7.4, "Crank Rotation." Using the crane, remove the slack from the chains. Remove the pawl and release the brake. Slowly lift the cranks until the walking beam is in a near level position. Reset the brake, engage the pawl, and chain the drum. Refer to Section 2.3, "Securing the Cranks" for proper procedures.

Disconnect the carrier bar from the polished rod.

Attach a long rope or chain through the carrier bar and install the gate back into the carrier bar. Be sure the rope or chain is long enough so that personnel can hold the carrier bar in a safe manner during horsehead removal.

11.2 Horsehead Removal

11.2.1 Standard Horsehead Removal



Under no circumstances should well servicing be attempted without first removing the horsehead. Be certain to remove the latch bolt, safety bar and/or the hinge pin before attempting to remove the horsehead. Do not stand under any part of the load while lifting.

Attach the chain to the horsehead. Back off the adjusting screw on either side of the horsehead until they are flush with the side plates. Remove the latch bolt, safety bar and/or hinge pin. While holding the carrier bar away from the polished rod, slowly lift the horsehead from the beam. Place the horsehead on the ground a safe distance from the work area and ensure the wireline is not beneath any part of the horsehead to avoid damage.

Keeping the brake engaged, remove the other safety precautions for securing the unit against rotation. Slowly release the brake to lower the cranks to the 6 o'clock position. Reinstall safety precautions to secure the unit against rotation before well servicing. Refer to Section 2.3, "Securing the Cranks."

11.2.2 Pivoting Horsehead Removal



Do not attempt well servicing or to lift the rod string without first securing the horsehead out of the way.



All personnel should be clear from the unit and the crank arm swing area while pivoting the horsehead.

Pull the lever beneath the walking beam to disengage the latch which connects to the horsehead. Secure the latch in the open position by attaching the chain on the lever to the hook on the underside of the beam.

Use the rope on the carrier bar to keep the carrier bar away from the polished rod. Unchain the drum and disengage the pawl. Slowly release the brake until the walking beam is lifted approximately 10-15 degrees above the horizontal position. Apply the brake again, engage the safety pawl, chain the drum, and LOTO the prime mover. Using the rope and carrier bar, rotate the horsehead to one side or the other from the ground and tie it back to the Samson post legs (Figure 61).

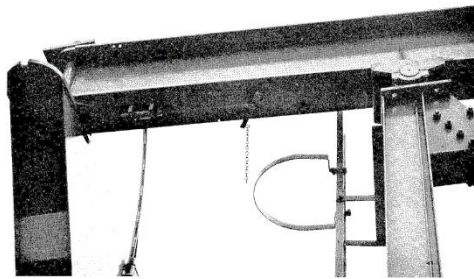


Figure 61: Pivoting Horsehead

11.3 Horsehead Installation

After well servicing is completed.

11.3.1 Standard Horsehead Installation



The safety bar, hinge pin and/or the latch bolt must be installed and tightened at all times except during horsehead removal.

After well servicing is completed, reattach the chains to the cranks as previously described. Unchain the drum, disengage the pawl and release the brake. Slowly lift the cranks until the beam is in a near horizontal position as before. Set the brake, engage the pawl and chain the drum. Remove the chain from the cranks and re-attach to the horsehead. Reinstall and check the alignment of the horsehead as described in Section 7.21.1, "Standard Horsehead Installation."

11.3.2 Pivoting Horsehead Installation

After well servicing is completed, untie the rope from the Samson post, unchain the drum, disengage the pawl, release the brake, and reverse lockout/tagout of the prime mover. Slowly lower the front of the walking beam using the prime

mover. The head should naturally swing back to its working position. After applying the brake, engaging the pawl and chaining the drum, release the lever beneath the beam so that the latch will secure the horsehead position.

11.4 Putting the Unit into Operation



Keep hands from between the carrier bar, accessory items and polished rod clamp in the event the polished rod clamp slips or the unit moves.

Remove the rope or chain from the carrier bar and attach the carrier bar to the polished rod.

With the brake engaged, unchain the drum and disengage the pawl. Slowly release the brake to transfer the well load back to the carrier bar. Be sure the load is not on the polished rod clamp at the stuffing box. Reset the brake.

Remove the polished rod clamp which was used at the stuffing box to clamp off the well load.

Reinstall all guards before attempting to operate the pumping unit. Check the bottom hole pump spacing.

12 Operational Inspections



Never approach a pumping unit assuming that everything is normal. With time, some components could work loose and present a potentially dangerous situation. Approach operating units from the rear if possible.



Do not perform any task on the unit until you review Section 2, “Important Safety Instructions.” The cranks and counterweights must be secured against rotation.

Operational inspections are essential to prolong the life of the unit and to prevent expensive failures. Many items can be checked by visual inspection and by listening for unusual noises.

The following visual inspections are recommended before approaching the unit:

- 1) Look at the brake from the side to see if there is still adequate thickness of lining and if key is present. If engaging the brake, check that the brake handle pawl is not engaged in the last available tooth. If so, the brake will need adjustment. Refer to Section 7.5, “Brake System Installation and Adjustment.”
- 2) Look at both crank pins to see if they may have worked loose.
- 3) From a distance, observe motion of the pumping unit horsehead and equalizer, making sure that both are tracking along a straight line.
- 4) On units driven by slow speed engines, look to see if the flywheel is loose.
- 5) Look at the counterweights to be sure they have not moved from the desired position.
- 6) Look at the center bearing to be sure it has not worked loose or is leaning to one side.
- 7) Look for any relative movement of the Pumping Unit Base and the Foundation. To do so, inspect the vertical alignment of the unit with the well and see if the polished rod is working to one side of the stuffing box. Check to see that the wireline is tracking properly on the horsehead. Wireline tracks should be an equal distance from the edges of the horsehead wrapper sheet within ½” tolerance. Wireline tracks form on the horsehead wrapper face after a relatively short period of operational service. They can be helpful as indicators of the contact path between the wire rope and horsehead wrapper face.
 - a. Look for uniform tracking marks along the horsehead’s wrapper sheet. Uniform “single path” tracking can be utilized as a visual indication of proper tracking.
 - b. If multiple track marks or wide wear regions are witnessed on the wrapper sheet of the horsehead, then overall unit alignment should be checked. Mechanical (sliding) wear of the wireline could be occurring. Multiple track marks could indicate a change in position of the unit. A change in alignment can be caused if the base shifts on the foundation due to loose hold

down bolts. Misalignment can also result from a foundation that has settled to an unlevelled position.



Uniform tracking marks on Horsehead.



Horsehead with wireline removed. Wide tracking marks observed.



Multiple tracking marks on wrapper sheet

Figure 62: Indications of Unit Alignment by Wireline Tracks

- 8) Look for obvious broken strands of wire fraying from the wireline.
- 9) Visually compare the distance between the pitman side members and the cranks on each side of the unit.
- 10) Look for any obviously loose or missing bolts. Loose bolts will eventually fail in fatigue. This is the major cause of most pumping unit failures. Loose bolts can usually be located by looking for rust at the bolted joint and by checking for movement of match marks.
- 11) Inspect the condition of ladders, platforms, fall protection anchorages, and associated components.
- 12) Look for areas of rusting. Rusting could indicate the presence of structural cracks and/or loose joints.
- 13) Listen for any abnormal noises and vibrations coming from the pumping unit. Noises such as popping occurring at intervals may indicate an assembly issue.
- 14) Look for any lubricant releases.
- 15) Look for rod float. If present, adjustments need to be made to eliminate it. System damage may occur if it is not corrected.
- 16) Under the hold down clamps, look for gaps between the base beams and the foundation.

If any of the above conditions exist, the unit must be shut down immediately and the problem corrected.

13 Preventative Maintenance



The cranks and counterweights must be secured against rotation prior to performing any maintenance or while working around the pumping unit. Do not perform any task on the unit until you review Section 2, “Important Safety Instructions.”

The following sections outline the required maintenance schedules and actions by component to ensure that proper operation and longevity of the pumping unit is achieved.

13.1 Monthly Maintenance

13.1.1 Reducer

Check the reducer oil level. Remove the dipstick located at the front of the reducer. The oil level should be within the “full” range on the dipstick. Loss of oil from the reducer is usually caused by seal leakage at the shafts or leakage at the parting line. If the oil level is low, remove the inspection cover and add oil to the proper level. (Refer to Section 4.1, “Reducer Oil”)

If oil appears milky, contaminated, or to have water, refer to Section 13.3.1, “Reducer Lubrication Inspections.”

13.1.2 Structural Bearing Assemblies

Visually check the crank pin bearings, equalizer bearing, and center bearing for seal leaks. Do not confuse grease discharge from the bearing housing vents with seal leakage.

13.2 Quarterly Maintenance

13.2.1 Belts and Sheaves

Belt alignment and tension should be checked and adjusted to prolong belt life. Under normal use belts will stretch and wear. Belts need replacing once they have exceeded their allowable stretch. Belt manufacturers suggest running new belts 30 minutes and then retightening. Consult your belt supplier. Refer to Section 7.10, "V-Belts Installation and Alignment."

Check the sheaves for wear, chips and cracks. Worn belts will sit lower in the sheave as shown on the right hand side of Figure 63. Replace them if any of these conditions exist. Keeping sheaves in good condition will prolong belt life.

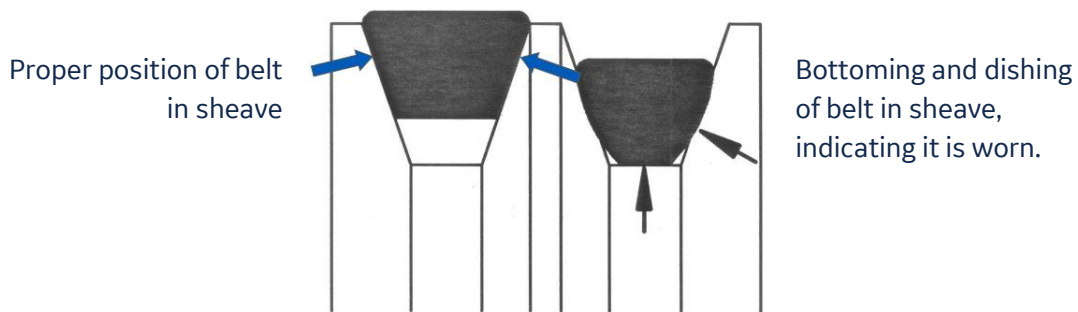


Figure 63: Properly fitting belt on left, worn belt on right.

13.2.2 Brake

Inspect the brake lining for wear and clearance adjustment. When the brake control lever is fully engaged, there should be several notches left on the ratchet. If adjustment is required, follow the instructions that pertain to the type brake existing on the unit.

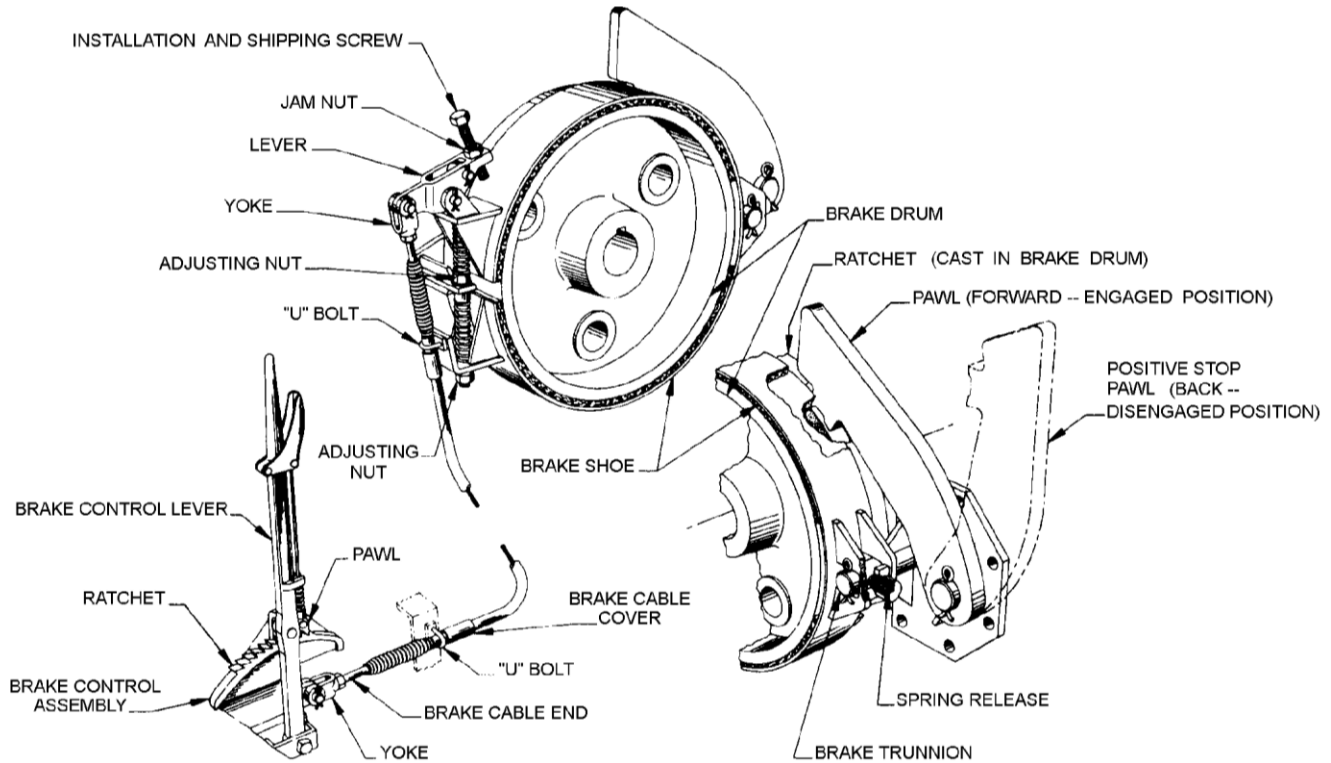


Figure 64: Type "B" Brake Assembly

Some units in the field have the type "B" brake as seen in Figure 64. Before adjusting the brake, refer to Section 2, "Important Safety Instructions."

- 1) Stop the unit with the long end of the crank in the 6 o'clock position. Lockout/tagout all energy sources. Clamp the polished rod at the stuffing box. Engage the positive stop pawl. Chain the equalizer down to the sub-base.
- 2) Position the brake lever in its forward (or disengaged) position.
- 3) Adjust the position of both linings with the adjusting nuts until they just clear the drum. The spring release on the trunnion should pull the lining away from the drum near the trunnion.
- 4) Using the brake control lever, engage the brake. Full engagement should occur with several notches of the ratchet on the brake assembly still remaining to compensate for subsequent lining wear and cable stretch. Further adjustment to meet this condition may be made by repositioning the cable yoke on the brake control lever end. When adjusting the yoke, care should be taken not to cause the brake cable to over travel internally in the cable cover. Should this occur, move both yokes the same amount in opposite directions.
- 5) Check the brake lining clearance after all adjustments are complete and readjust if needed.
- 6) Make sure the brake drum key is tight.
- 7) Unchain the equalizer, disengage the positive stop pawl, and remove the polished rod clamp at the stuffing box before attempting to restart the unit.

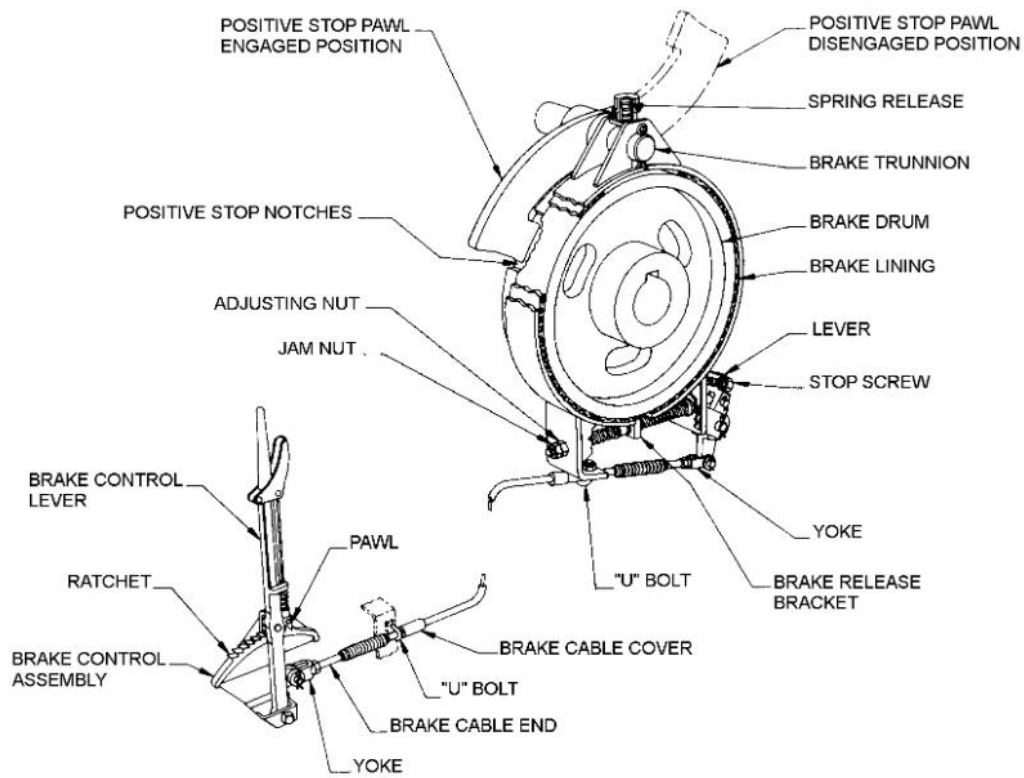


Figure 65: Type "C" Brake Assembly, Top Mounted

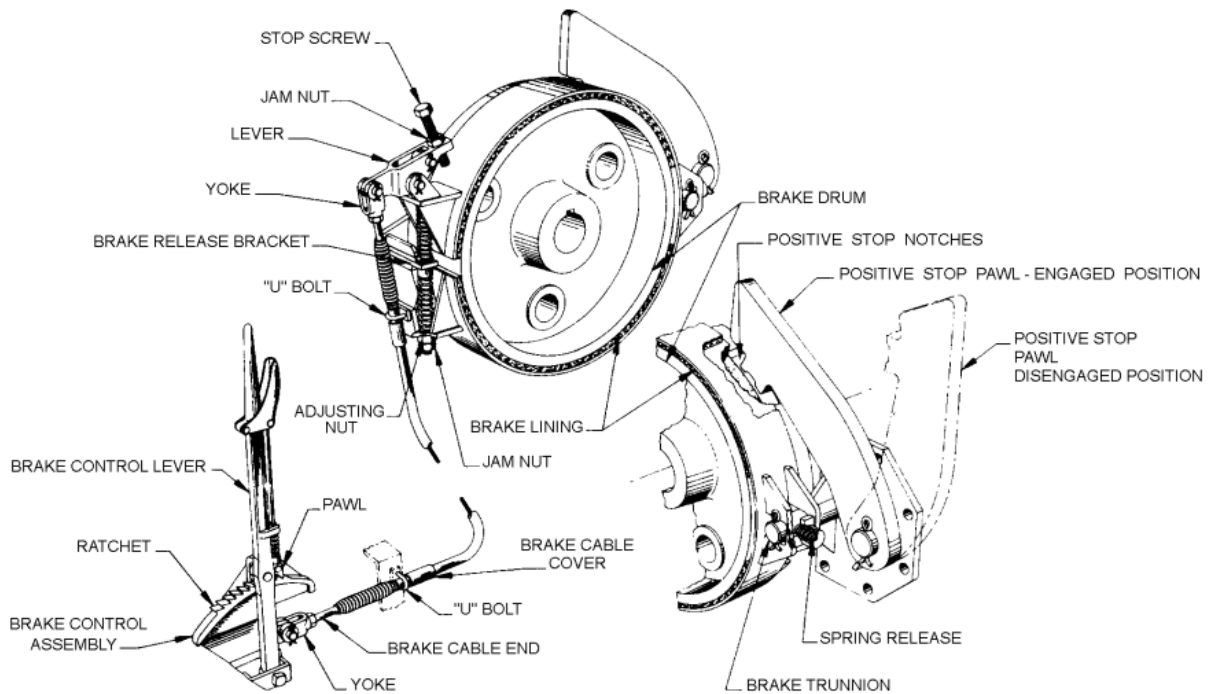


Figure 66: Type "C" Brake Assembly, Side Mounted

Some units in the field have the Type “C” brake. This type of brake will have the trunnion mounted to the top as in Figure 65 or the side as in Figure 66. It has a single adjusting nut that simultaneously adjusts both brake linings. Before adjusting the brake, refer to Section 2, “Important Safety Instructions.”

- 1) Stop the unit with the long end of the crank in the 6 o'clock position. Lockout/tagout all energy sources. Clamp the polished rod at the stuffing box. Engage the positive-stop pawl. Chain the equalizer down to the sub-base.
- 2) Position the brake lever control in its forward (disengaged) position.
- 3) Adjust the position of both brake linings by loosening the jam nut and moving the adjusting nut until both linings just clear the drum. Retighten the jam nut.
- 4) Using the brake control lever, engage the brake. Full engagement should occur with several notches of the ratchet on the brake assembly still remaining to compensate for subsequent lining wear and cable stretch. Further adjustment to meet this condition may be made by repositioning the cable yoke on the brake control lever end. When adjusting the yoke, care should be taken to not cause the brake cable to over travel internally in the cable cover. Should this occur, move both yokes the same amount in opposite directions.
- 5) Make sure the brake drum key is tight.
- 6) Unchain the equalizer, disengage the positive stop pawl and remove the polished rod clamp at the stuffing box before attempting to restart the unit.

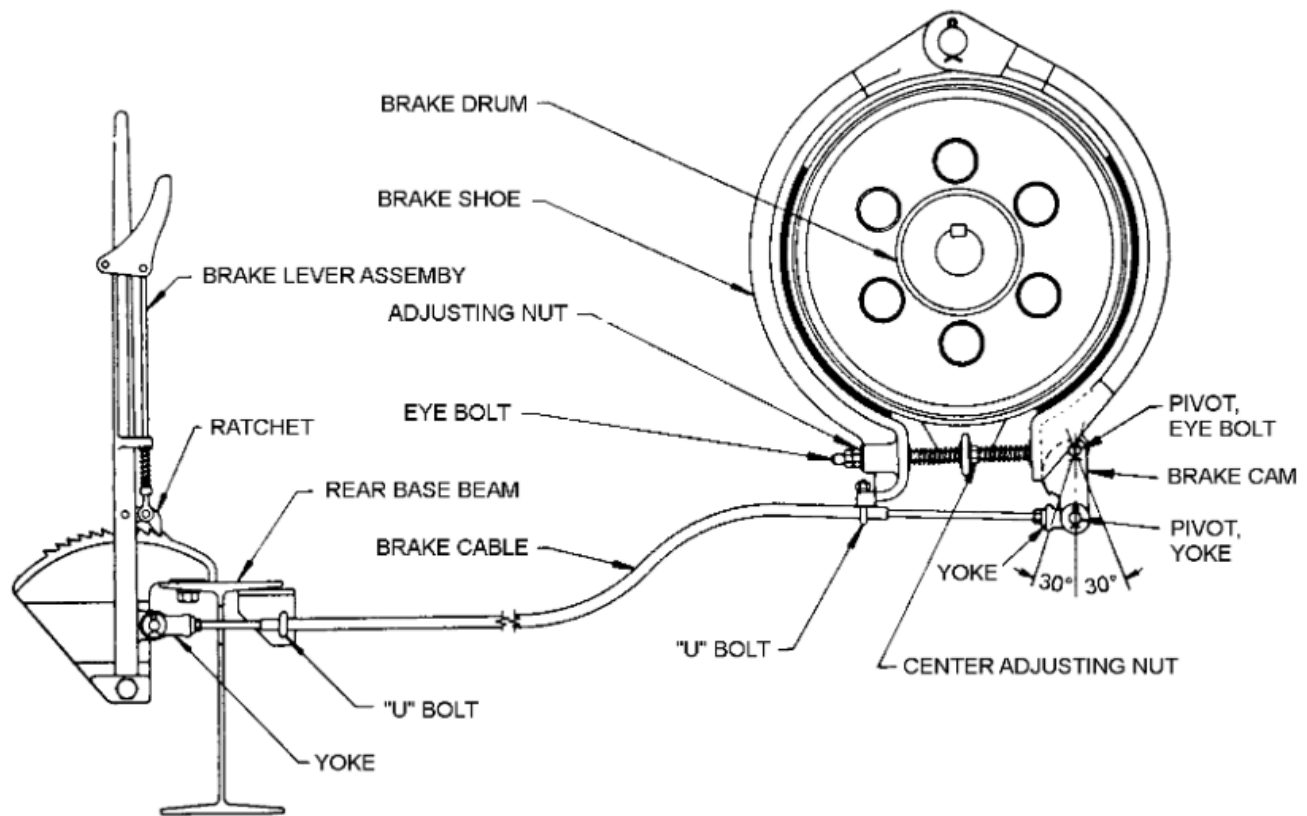


Figure 67: Shoe Type Brake

Some smaller and older units in the field may have the shoe type brake as seen in Figure 67. Before adjusting the brake, refer to Section 2, "Important Safety Instructions."

- 1) Stop the unit with the long end of the crank in the 6 o'clock position. Lockout/tagout all energy sources. Clamp the polished rod at the stuffing box. Chain the equalizer down to the sub-base.
- 2) Position the brake lever in its forward (disengaged) position.
- 3) Adjust the position of both brake shoes by moving both adjusting nuts until both linings just clear the drum.
- 4) When the brake is disengaged, the pivot yoke of the cam should be at a 30 degree angle to the right. Refer to Figure 67. Simultaneously, the brake lever would be "full off," to the right of vertical.
- 5) When the brake is fully engaged, the lower end of the cam would be vertical or up to a 30 degree angle to the left. Refer to Figure 67. Simultaneously, the brake lever has the ratchet engaged and several notches still "available" for engagement.
- 6) To achieve the proper engaged and disengaged positions of the cam and the brake lever, either or both yokes can be adjusted in or out on the ends of the brake cable.
- 7) Be certain the rod end does not bottom out on the cable cover when engaging or disengaging the brake. When the yoke positions are established, tighten the jam nuts against the yokes.
- 8) Make sure the brake drum key is tight.
- 9) Unchain the equalizer and remove the polished rod clamp at the stuffing box before attempting to restart the unit.

13.2.3 Brake Drum

Inspect the brake drum for cracks around the hub and key area. Also, look at the brake pawl notches to see if any of them have been chipped, cracked or broken out. Replace the drum if any of these conditions exist.

13.2.4 Brake Cable

Inspect the condition of the brake cable. If the rubber coverings at the ends of the cable are cracked, moisture will get into the cable and possibly freeze up its movement. Make sure the brake rods are not bent. Replace the cable if any of these conditions exist.

13.2.5 Crank Phase Marks

On the end of the crankshaft, there is a match mark placed partially on the shaft and partially on the crank. These should remain lined up. If for any reason they are not lined up, you should contact your BHGE representative.

13.3 Semi-Annual

13.3.1 Reducer Gear Inspections

Check the gear tooth condition for abnormal wear. There are many modes of gear tooth failures. Only the most common are included in this section. The following is paraphrased from ANSI/AGMA 110.04, Nomenclature of Gear Tooth Failure Modes.

Score marks on the teeth are an indication that the film thickness of the oil is insufficient for the loads imposed. Score marks are vertical marks on the teeth from the top of the teeth to the root (Figure 68).

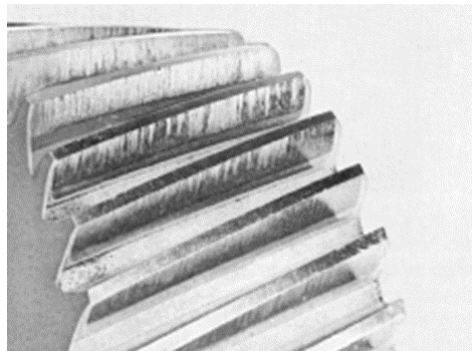


Figure 68: Score marks typically from insufficient film thickness

Pitting is a type of surface fatigue which occurs when the endurance limit of the material is exceeded. It shows up as small cavities along the surface of the teeth. The type of pitting shown in Figure 69 is usually caused by torque overload. Continued overload may result in gear tooth failures.

For more detailed descriptions, illustrations, causes, and remedies, see ANSI/AGMA Standard 110.04. Figure 68 and Figure 69 were extracted from "AGMA Standard Nomenclature of Gear Tooth Failure Modes" (AGMA 110.04), with the permission of the publisher, The American Gear Manufacturer's Association, Suite 1000, 1901 North Fort Myer Drive, Arlington, Virginia 22209.

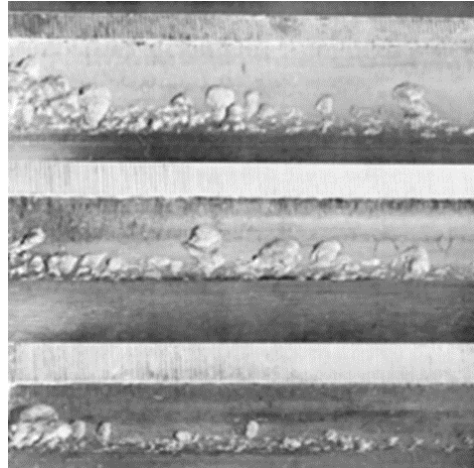


Figure 69: Pitting typically caused by torque overload

13.3.2 Reducer Lubrication Inspections

To ensure the health of the gear train, the gear oil should be filtered or replaced every 18 months or there should be a continuous monitoring program in place. When replacing oil, refer to Section 4.1, "Reducer Oil" for requirements. If filtering the oil, refer to Section 13.4, "Continuous Oil Monitoring Programs." If there is no monitoring program in place, remove the inspection covers and visually inspect the lubricant. Look for foam, sludge, milkiness and metal particulates in the oil. A burnt smell can also indicate there is an issue with the lubricant. If any of those conditions are present, a filtration or oil replacement is required. If the oil has been in use for over 18 months, replace or filter the oil. Check the oil level and drain any water that has collected at the bottom of the gearbox. In some cases, a portion of the water content and solids can settle via gravity if the oil is left undisturbed for a long period of time.

If a continuous monitoring program is in place, take an oil sample. Oil samples should be taken at the mid-sump level with a clean, dust-free bottle. The process should be repeatable and defined by the operating company. The recommended interval for monitoring programs is three to six months. Refer to Section 13.4, "Continuous Oil Monitoring Programs" for additional guidance and oil condemning limits.

13.3.3 Structural Bearings

Lubricate the structural bearings with grease as recommended in Section 4.3, "Structural Bearing Grease." Grease fittings are located at ground level. Pump grease in slowly to avoid pushing out the oil seals. Discharge from the vents located on each bearing housing indicates that the housing is full.

In cold weather, voids may form in the grease during filling. A good practice in these conditions is to operate the unit after initial filling and then grease again to top off.

13.3.4 Upper Pitman Pins

Lubricate the upper pitman pins with grease as recommended in Section 4.3, “Structural Bearing Grease.” The grease fittings are located on top of the upper pitman boxes at the equalizer. The purpose of these pins is to allow the pitmans to swing away from the equalizer during unit assembly, unit disassembly and during stroke changes.

13.3.5 Wireline

Wirelines should be examined and lubricated per Section 4.4, “Wireline.” every three to six months. The wirelines should be checked for:

- 1) Broken Strands (fraying or necking down of the wire)
- 2) Wear (abrasion)
- 3) Rust or other corrosion
- 4) Kinking, crushing, bird-caging or other damage to the rope structure
- 5) End attachments that are cracked, deformed, or worn to an extent that strength could be affected

If there is a need to clean the wireline of foreign contaminants, use a wire brush only. Do not use solvents.

For discard criteria, contact BHGE with your specific wireline and unit type.

13.3.6 Bolts

Check all bolts. Confirm torques. Check match marking if present. If rust or staining is present, the joint may be loose. Retighten as recommended in Section 5, “Fasteners.”

Check the ground for bolts. Identify source of bolt and take corrective actions.

13.3.7 Safety Signs and Tags

In the event any of the signs or decals are destroyed, damaged or become unreadable for any reason, refer to Section 15, “Safety Sign Replacement,” for replacement part numbers and their location on the unit.

13.4 Continuous Oil Monitoring Programs

A robust oil monitoring program may enable detection of problems in the gearbox prior to expensive failures. The following are recommendations for sampling intervals, testing requirements, condemning limits, and visual checks to help assess the health of your oil.

When designing an oil maintenance program, due diligence should be performed to identify the frequency between oil changes and how to remove contaminants in the system. If laboratory testing is not practical, the oil should be replaced every 18 months.

If laboratory testing of oil samples is used to determine if the oil needs to be replaced, the primary question is whether the contents of the oil has exceeded the condemning limits. If laboratory testing of oil samples is used to avoid downtime due to failures, the operator should consider collecting and analyzing oil samples every six months or less. Observation of trends and spikes in levels will be the most useful indication that something has changed in the gear

train and it is difficult to assess without multiple data points. Regardless of intent, it is critical that the oil sample be taken from the correct location and in a clean and repeatable manner.

To ensure the sample is representative of the lubricant passing through the rolling elements, take a mid-level sample directly below either inspection cover after the gearbox has been operating for at least 10 minutes and is stationary for less than 30 minutes between unit shut down and the time the sample is retrieved. The method of retrieval may be a hand pump with a tube. Ensure that for each sample taken, the tube and pump are clean, free of debris or water that may contaminate the sample. Taking one to two samples for discard prior to the sample for laboratory testing will enable a flushing of the system. A clean, dust-free bottle should be used for each sample and are typically available upon request from laboratories. A typical laboratory testing regime will require at least 4 ounces (about 120 ml). Taking an oil sample from the drain location or the wing will yield unsatisfactory results because oil and debris tends to collect in these less turbulent regions of the gearbox.

It may be useful to have a sample bottle with the new lubricant in it for comparison. After taking the sample, it will help answer the following questions:

- Is the oil clear? A milk-like color can indicate water contamination and a crackle test may be performed.
- Can you see metal particles in the oil? If so, look for any potential gear wear.
- Is there sludge, grit or foam present in the gearbox?

If sampling is solely to determine if the oil requires replacement, these visual checks may be useful in immediate identification of oil that is beyond its useable state.

While collecting the sample, it would also be a good opportunity to again check the oil level and drain any water that has collected at the bottom of the gearbox. In some cases, a portion of the water content and solids can settle via gravity if the oil is left undisturbed for a long period of time.

With each sample, maintenance of the following information may be useful for future reference and in development of a preventative maintenance program:

- Well site/Location
- Gearbox Serial Number
- Oil Name (Product and ISO Grade)
- Date of Sampling
- Date of last oil change or filtration
- Number of total operating hours
- Number of operating hours since last oil change

Standard laboratory testing of gearbox lubricant includes:

- Viscosity at 40C
- Viscosity at 100C and/or Viscosity Index
- Total Acid Number (TAN)
- Water content
- Particle Count or FDRS/FDRL

- Additive, Contaminants and Wear Metal Contents including but not limited to:
 - Silicon
 - Iron
 - Copper
 - Lead
 - Sulfur
 - Phosphorous
 - Molybdenum

TAN, water, silicon, iron, copper and lead concentrations are all criteria for condemning lubricants per API RP 11G. Excess in any of these should result in action to improve lubrication conditions. Sulfur, Phosphorous and Molybdenum are common additives for Anti-Scuff (formerly Extreme Pressure) lubricants. Monitoring these levels may be useful in that depletion of the additives could result in lower performance. Particle counts or FDRS/FDRL may be useful if periodic samples are being taken and recorded. These results are most useful to identify trends and do not typically have value as a single data point. Regarding the ASTM standards for testing, multiple test methods may be used and vary based on the equipment the laboratory is using. The laboratory should be able to provide the test standards which they will be performing the tests to. Ensure that the testing method will yield results in parts per million (ppm).

Condemning Limits for water and solid contaminants are presented in *Table 8* (“Condemning Limits”). If the oil sample results are higher than the limits in *Table 8*, the oil should be replaced or filtered.

Criteria	Allowable/Condemning Limit
Water, ppm	1000
Iron (Fe), ppm	300
Lead (Pb), ppm	75
Copper (Cu), ppm	275
Silicon (Si), ppm	60
TAN	4 x New Oil

Table 8: Contaminant Condemning Limits

Metal contaminants may be higher than expected during the first six months due to the break in period. After the break in period, if contaminants are higher than the condemning limits, the oil should be replaced or filtered. After completion, the wear levels should stabilize.

Bear in mind that being under the Condemning Limits does not mean the operating condition are perfect; the cleaner the oil, the better. If the trend shows a consistent increase in a particular metal contaminant but it is still under the Condemning Limit, the operator should consider looking for the source of the wear and understand that oil replacement may not alleviate the problem.

If filtration of lubricants is being pursued, filter to a cleanliness level of 19/17/14 per ISO 4406. A filter with a $\beta_{19(c)} = 200$ has been shown to achieve the cleanliness level. However, contact the lubricant manufacturer to verify this filter size is appropriate for the oil in use. The Beta ratio is the efficiency of a filter to remove particles larger than a specific

size. If the beta ratio is too small, additives may be removed from the oil. If the beta ratio is too large, it may be inadequate in separating out contaminants. See Section A.7 of AGMA 9005-F16 for more information on Filterability.

When changing out the oil, it is important to clean the gearbox which may be done with flushing oil. This process is intended to remove the debris in the gearbox. Ensure that the flushing oil chosen is compatible with the operating lubricant, primer, and components in the gearbox such as yellow metals as well as the lubricant in use. Contact your local representative if more information on compatible cleaning agents is required.

When handling oils outside the gearbox, it is equally important to avoid contamination. AGMA 9005-F16 states that “care must be exercised not to mix lubricants with different additive chemistry.” This mixture may result in undesirable impacts to the performance during operation. If transporting oil, introduction of undesirable conditions can come from a simple handling error such as use of the same container for different lubricants during transportation.

14 BHGE Service

14.1 Personnel

BHGE has capable sales and service personnel throughout the oil producing areas of the world. These people are competent and experienced, not only in the proper sizing of surface pumping units, but also in any service that may be needed. Contact the BHGE Sales Office nearest you to inquire about the availability of BHGE service.

14.2 Repair and Replacement Parts

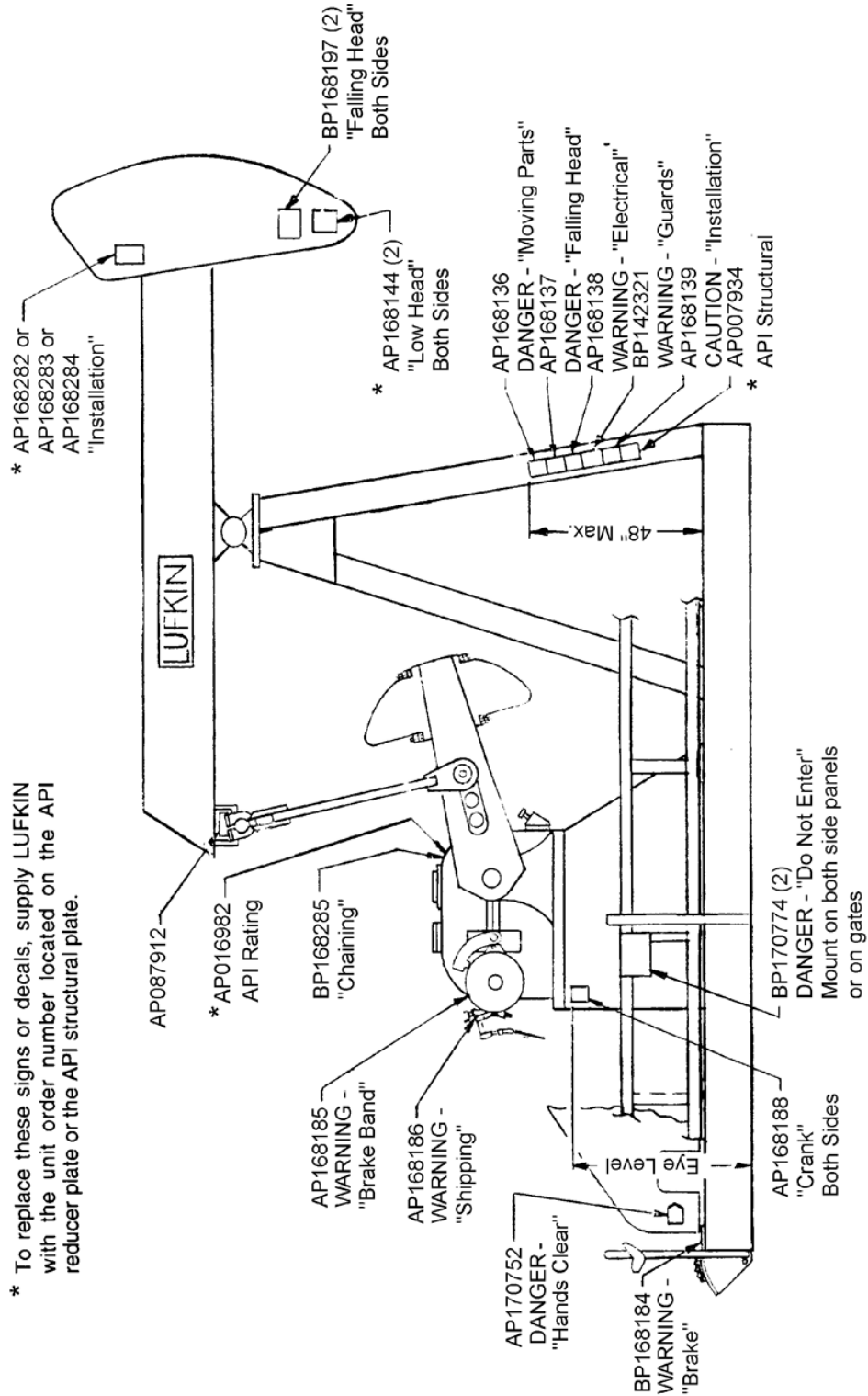


For repair or modification to a LUFKIN pumping unit, use only original LUFKIN parts that meet specifications. (Consult your nearest BHGE sales office.)

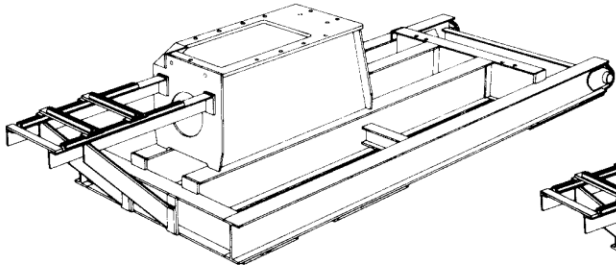
A complete line of repair and replacement parts is available from several warehouse locations as well as our manufacturing plant in Lufkin, Texas. A parts list is available for most pumping unit assemblies. When parts are needed for a particular unit, furnish the complete unit designation, serial number and BHGE's shipping order number.

15 Safety Sign Replacement

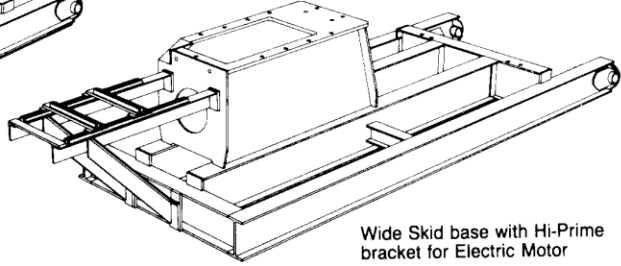
Refer to the following figure to identify part numbers for Safety Sign replacement orders.



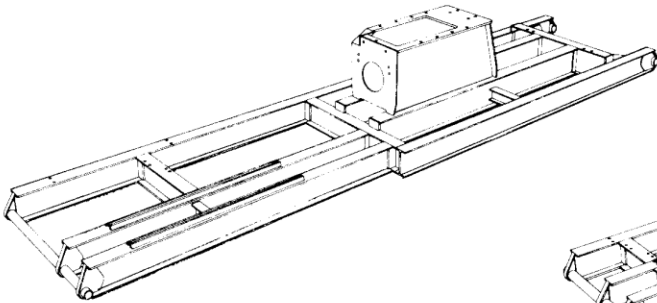
16 Base Types



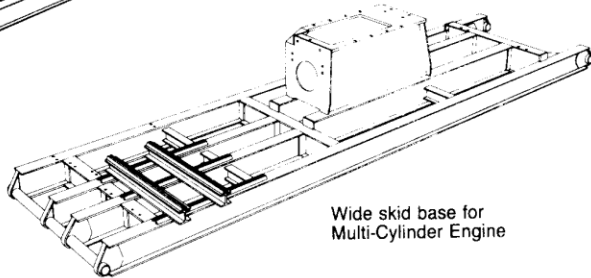
Wide Skid-UNISET base with Hi-Prime bracket for Electric Motor



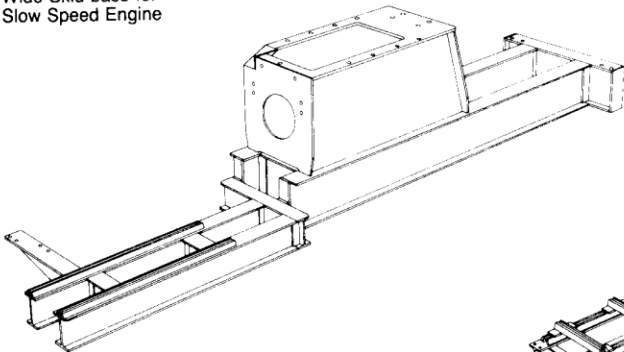
Wide Skid base with Hi-Prime bracket for Electric Motor



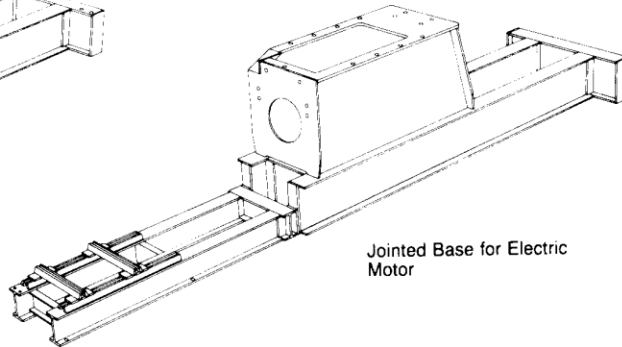
Wide Skid base for Slow Speed Engine



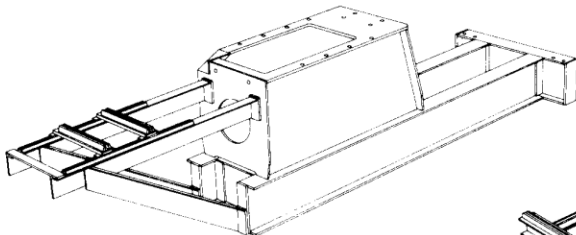
Wide skid base for Multi-Cylinder Engine



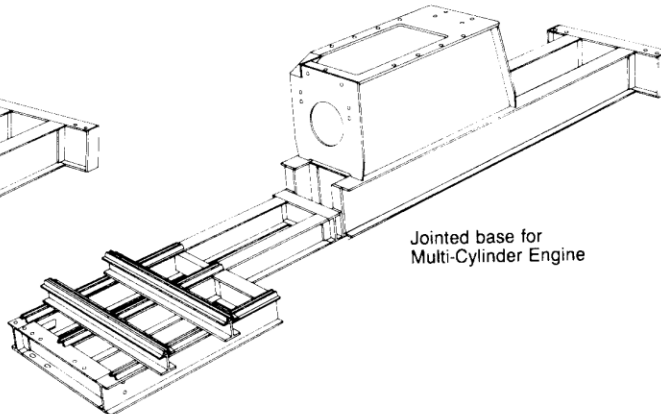
Jointed base for Slow Speed Engine



Jointed Base for Electric Motor



Stub Base with Hi-Prime Bracket for Electric Motor



Jointed base for Multi-Cylinder Engine

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