OPERATOR'S MANUAL

HERCULES

PUMPING UNITS

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OPERATOR'S MANUAL
Hercules Energy Corp.
CONVENTIONAL PUMPING UNIT

I. INTRODUCTION

Our Conventional Pumping Units represent the result of a long lasting experience in oilfield exploitation, designing and manufacturing.

H E C Crank Balanced Pumping Units incorporate a high standard engineering, materials of quality and trained & specialized workmanship.

Through adequate care and field maintenance **Hercules Energy Corp.** enable long term service.

The **Hercules Energy Corp.** are authorized to use the API monogram. Each Pumping Unit Structure and Reducer name plate is marked with API monogram.

The H E C Pumping Unit Geometry is so designed as to keep the acceleration force peak and torque factor at lowest level and all bearings to be uniformly loaded.

Pumping Unit Structure is built up of heavy steel beams that achieve ruggedness conditions required by oil well service.

Structural bearings, provided with self-aligning roller bearings, are lubricated by the factory but, anyway, they require periodic relubrication.

The Double Reduction Gear Reducer incorporates herringbone, symetrically positioned gears. Reducer main shaft is provided with bronze bearings while inlet and intermediate shaft, with roller bearings.

H E C Gear Boxes use an oil bath lubrication system. Special grooves and wipers assure a positive lubrication of each bearing.

Desired counterbalance is obtained with sliding counterweights which can be shifted along cranks by means of a pinion and crank rack. To increase effective counterbalance auxiliary counterweights may be mounted on the inside of master counterweights.

Hercules Energy Corp. also provided with safety accessories such as: belt covers, access ladders, guards.

CAUTION

Conventional Pumping Units are equipped with heavy rotating parts which may be dangerous to operators during mounting, maintenance and service.

Thus, it is important that all operating staff be trained regarding Pumping Unit Components and the distance to be observed towards the moving parts.

Failure of this may cause serious bodily injury or even death.

STAY CLEAR OF ROTATING CRANKS, COUNTERWEIGHTS, Vee BELTS, SHEAVES OR ANY OTHER MOVING PARTS OF THE PUMPING UNIT

Special caution shall be paid to temporarily stationary Pumping Unit as the heavy rotating parts can start moving due to their own gravity. In such case the brake should be secured and kept under observation.

II. PRELIMINARY CONDITIONS AT MOUNTING

We advise the end-users to consider the following preliminary conditions before establishing the location of the Pumping Unit.

Foundation:

— subject to the wellhead height, the above soil level of the foundation will be decided so that the space between the carrier bar and wellhead with polish rod at bottom stroke allows attaching a dynamometer.

— to reduce stuffing box wear and tear, one should check the polish rod verticality.

FOUNDATION-GENERALS

The Foundation should be installed in keeping with technical features mentioned in Suppliers' Foundation Plan which is to be delivered together with each Pumping Unit.

The drawing indicates the location of hold down bolts in relation to the wellhead, number and sizes of bolts and anchor nuts, shape and dimensions of the concrete foundation, complete instructions for its lay down.

The foundation plan also includes the directions and values of forces transmitted to the foundation by the components of the Pumping Unit.

The foundation has been calculated in accordance with soil conditions given in supplier's foundation plan.

The installer shall undertake full responsability at laying down the foundation, subject to his informations on soil bearing conditions or any other characteristics existing at the well site.

A troubleless mounting and operation of Pumping Unit will be granted by a correctly carried out foundation.

An improper foundation brings about misalignment, premature wear or even breakage of the different parts of the Pumping Unit.

POURED CONCRETE FOUNDATION

This type of foundation is laid down according to the suppliers' foundation plan. As a main condition one must observe the necessary time required for complete strengthening of the concrete.

PRECAST CONCRETE FOUNDATION

If the end-user prefers a precast concrete foundation, the correct preparation of subsoil, selection and setting of precast foundation are subject to knowledge and experience with local soil conditions.

For any kind of foundation, the top of foundation should be properly flattened and leveled, checking horizontality.

III. ERECTION OF THE VULCAN PUMPING UNIT

a) MOUNTING OF THE PUMPING UNIT BASE ON THE FOUNDATION

A continuous line will be marked with a piece of chalk, from wellhead to the center of rear of the foundation; then, a cross line which will indicate the distance between the well and the front end of the base (*Fig. 1*).

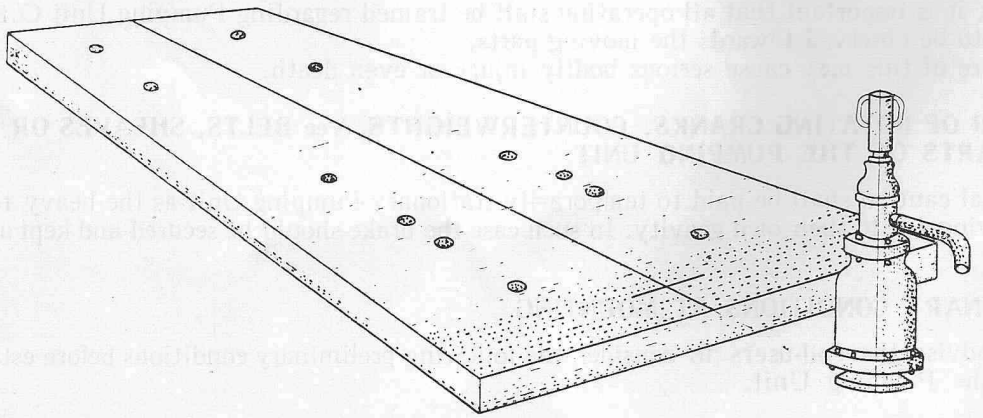


Figure 1

The base of the units has its centerline marked with white paint on the lower flanges of the rear and front cross-members.

The base is set on the foundation, aligned, centerlined and matching the two direction-lines(*Fig. 2 and 3*).

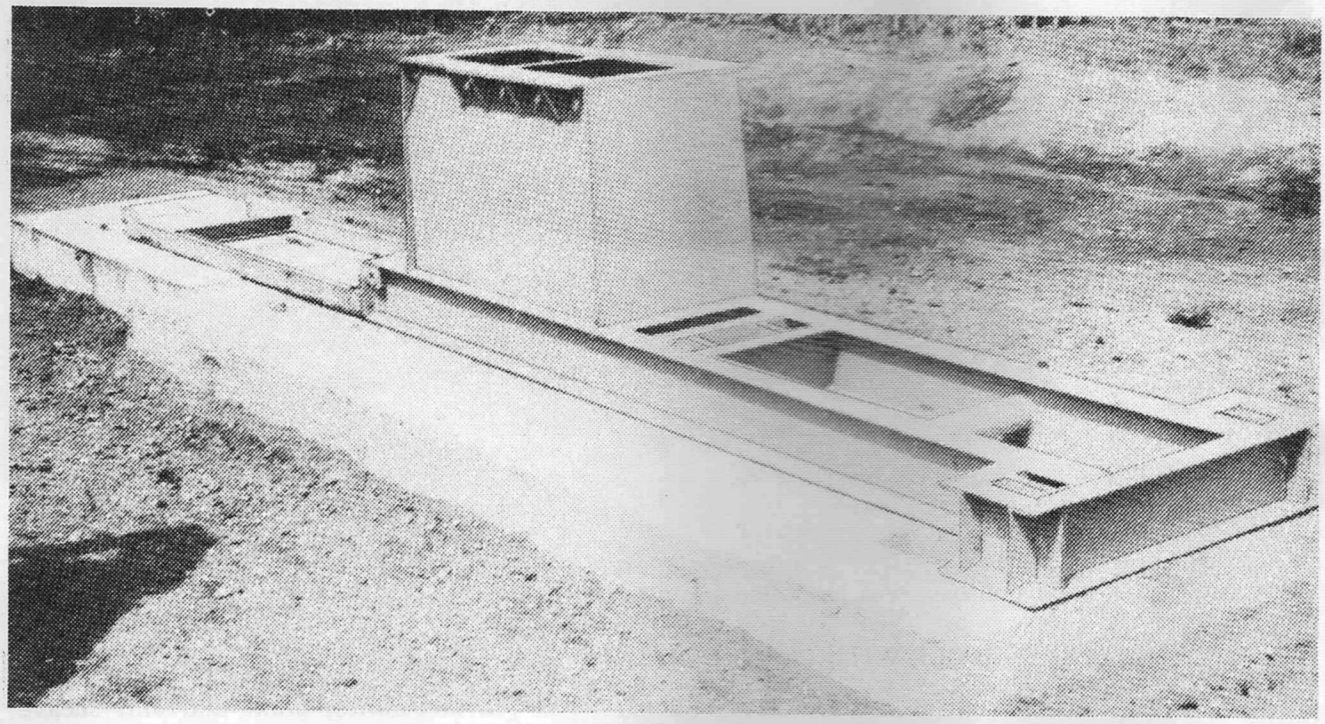


Figure 2

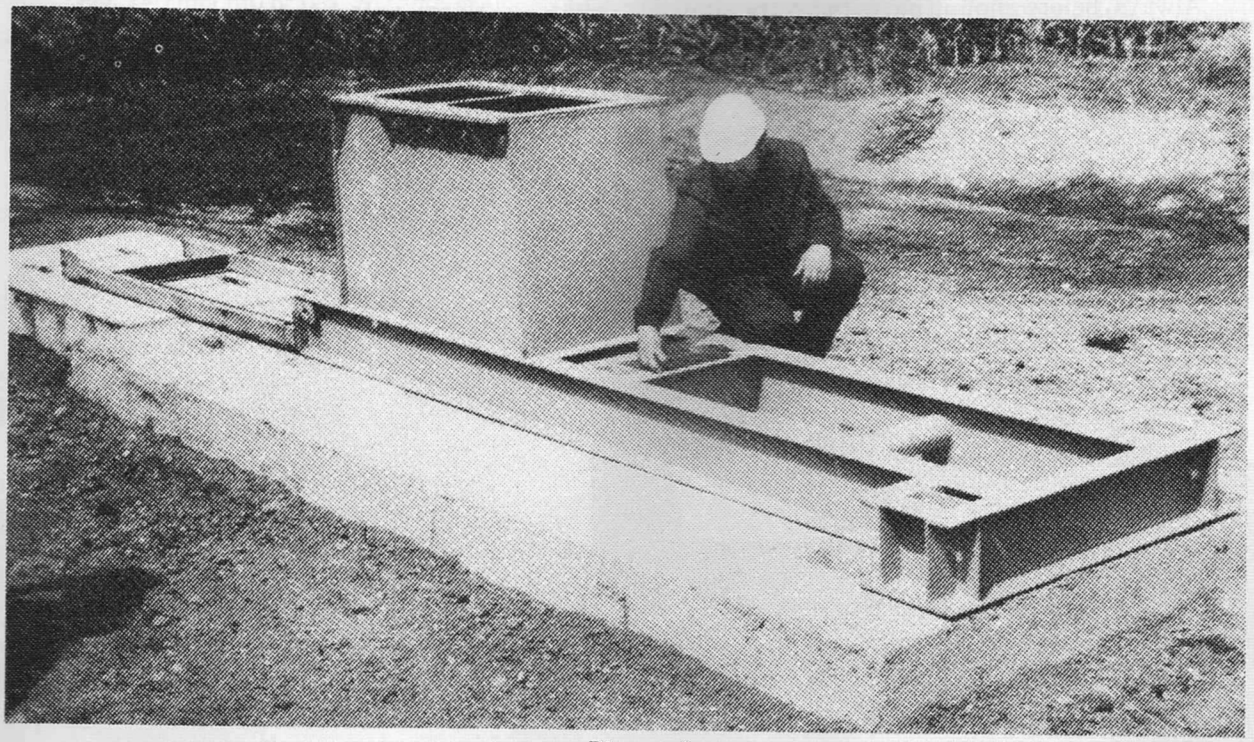


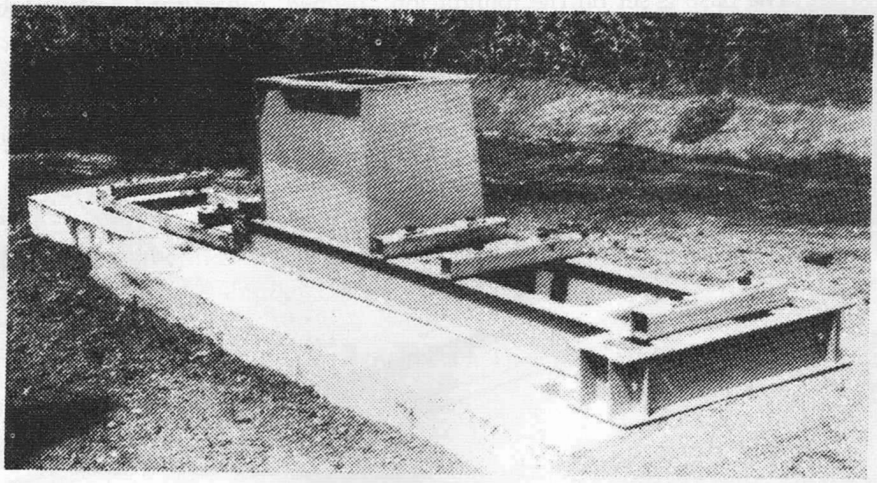
Figure 3

The horizontality must be checked, length and across, and when needed, will be adjusted by introducing spacers under base and filling in the remaining seats between base and concrete foundation with cement grout which must make complete setting to the foundation.

By following these instructions, one will accomplish both the centerlining of the unit base on the foundation and the setting of the base at the correct distance from the polished rod.

When the necessary resistance of the concrete foundation has been obtained, cross beams anchors, bolts and nuts will be used to assure base gripping to the foundation. Nuts are tighten a key and hammer tighten when pumping unit is completely aligned (Fig. 4).

Figure 4



Small, unexpected errors at the alignment may be corrected through an accurate ali justing position of reducer on the support, adjusting position of walking beam by means o zontally pushing screws of the central bearing, a.s.o.).

The extension base for electric motor or engine would be set up at the same time wit The end of extension base will be bolted to unit base and foundation bolts tightened.

b) MOUNTING REDUCER WITH CRANKS ON THE REDUCER SUPPORT

Hercules Energy Corp. deliver reducer with cranks, crank pin assemblies, brake and unit sheave already mounted.

Nuts of crank pin assemblies and unit sheave must be checked for uniform tightening.

Always before mounting reducer on support, contact surfaces will be well cleaned.

Reducer is hoisted with crane and placed on support; bolts and nuts are hammer tightened (*Fig. 5 and 6*).

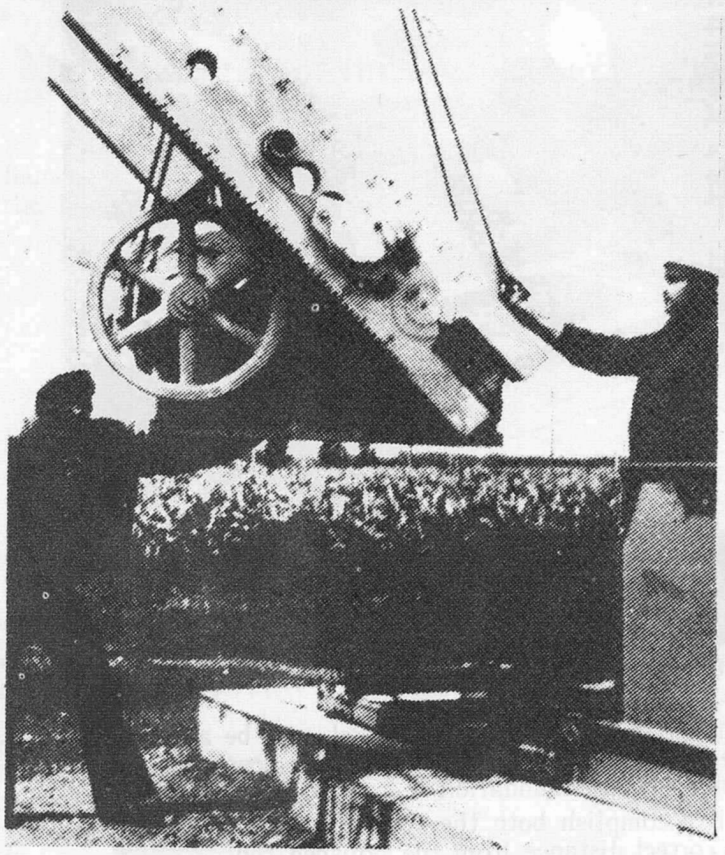


Figure 5

Figure 6

c) **BRAKE**

For setting up brake system, brake handle and rods are placed on base, connecting the vertical rod to brake lever.

To check brake service, brake handle will be pulled and, if necessary, vertical rod adjusted (*Fig. 7*)

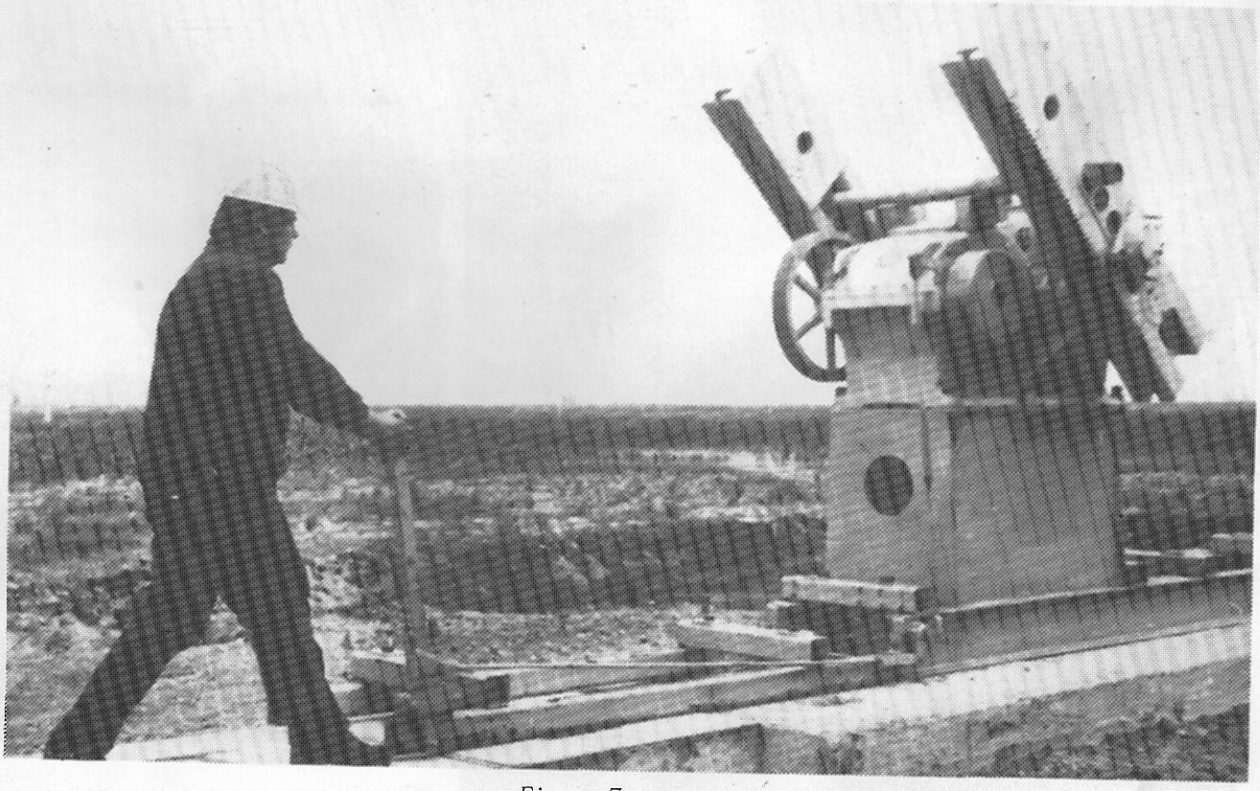


Figure 7

d) INSTALLATION OF MASTER COUNTER-WEIGHTS ON CRANKS

Cranks are hoisted at one end with crane and supporting pipe is taken off; then, cranks are easily lowered down till positioned vertically (*Fig. 8 and 9*). All the while, for safety, brake is being kept under observation.

Figure 8

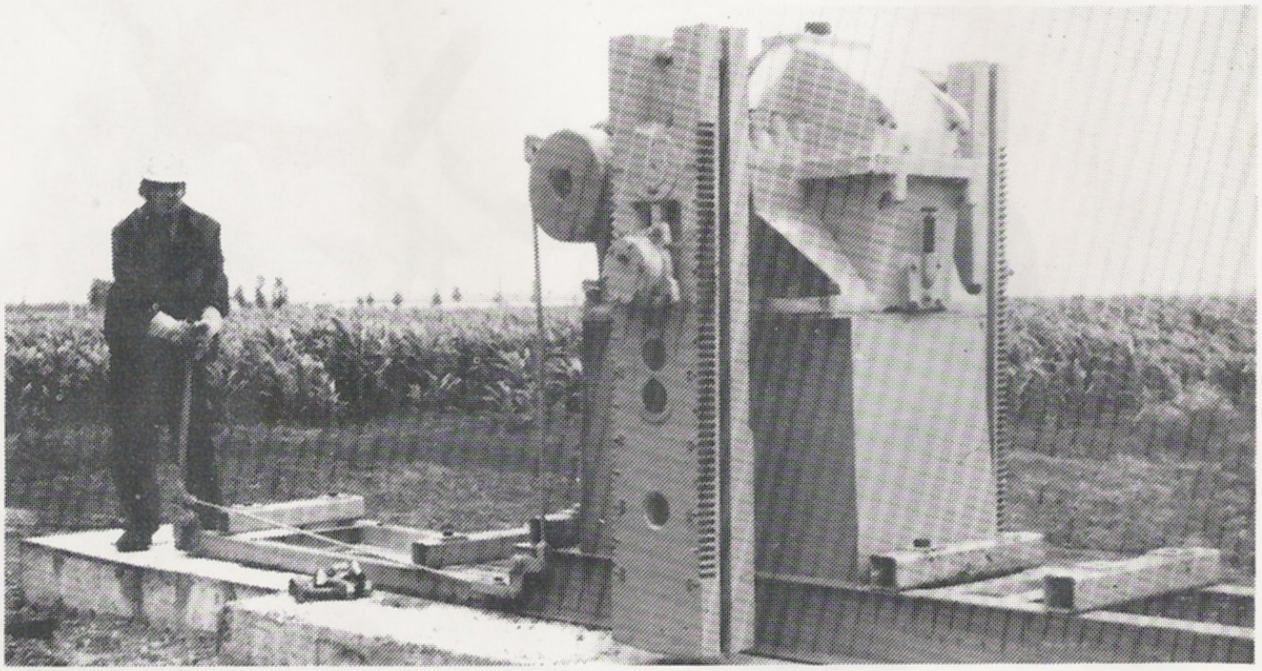


Figure 9

Weights are hoisted with crane (*Fig. 10 and 11*). For accurate mounting position, pay attention to the way chain is attached to counterweights. Bolts are placed in crank grooves and counterweights are assembled on the cranks by hammer tightening the nuts.

Figure 10

Figure 11

CAUTION: Counterweights may move on the crank if bolts are improperly tightened. Under this circumstances, counterweights may cause breaking down of crank-end stop, serious damages and even injury of operating staff.

e) INSTALLATION OF AUXILIARY WEIGHTS

Auxiliary weight is sustained by a cable, brought in position to be attached with a bolt to the master counterweight and then rotated till all holes are penetrated by bolts (*Fig. 12*). Bolts are hammer tightened.

Figure 12

f) INSTALLATION OF SAMSON POST

The rear leg of Samson Post is assembled leaving bolts loose so that post can shift to line holes n unit base (*Fig. 13*).

Figure 13

A cable or chain is tied around post top end and then post is lifted by crane and installed on base; bolts are loosely tightened (*Fig. 14*).

Figure 14

Samson Post flatness is determined by using an air bubble level and verticality by a plumb bob string check (*Fig. 15*).

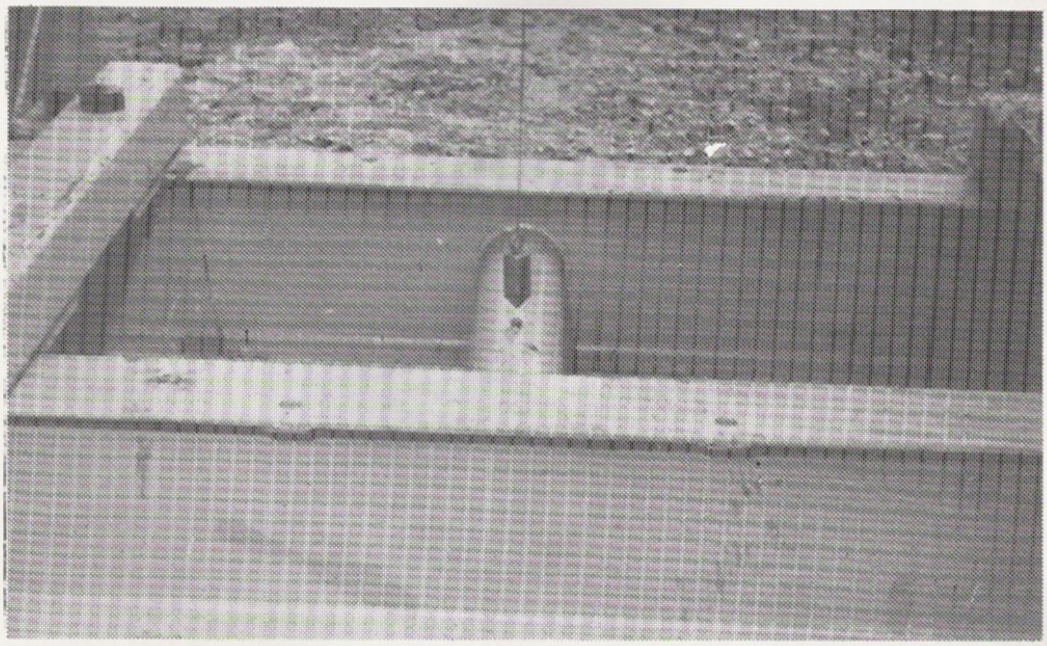


Figure 15

Verticality is secured when plumb bob string-end matches marking on base pipe- beam (marking consists of a sharp-end surrounded by a white cercle line).

If needed, spacers will be set under one of the post-legs.

Usually this adjustment is not necessary.

All attaching bolts of Samson Post base are hammer tightened.

Bolts at top of post are also tightened (*Fig. 16*).

Ladders are attached to top Samson Post and base (*Fig. 16*).

Figure 16

g) MOUNTING CENTER BEARING ON WALKING BEAM

A centering pin is inserted by hammering on center bearing plate which will be connected on walking beam (*Fig. 17*).

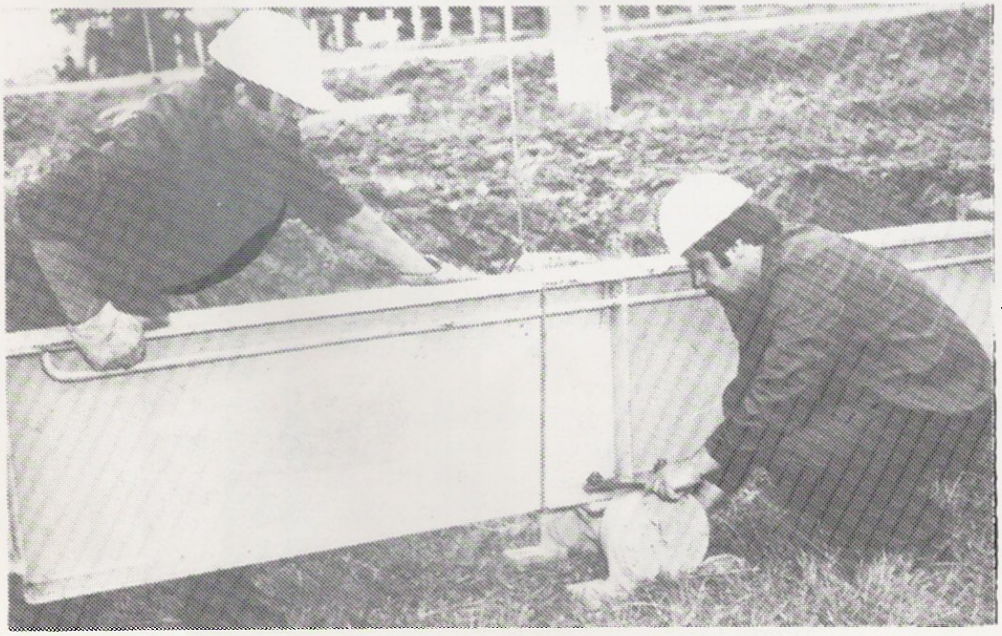


Figure 17

Center bearing and walking beam contact surfaces must be well cleaned.

Walking beam is lifted by crane and then center bearing is placed by means of centering pin which should be inserted into the hole on lower flange of walking beam.

Holes of walking beam and center bearing are aligned and assembling bolts are being inserted and tightly screwed.

Manufacturer's lubrication must be checked.

h) MOUNTING EQUALIZER BEARING AND EQUALIZER BEAM ON WALKING BEAM

Hercules Energy Corp. deliver equalizer bearing already mounted on equalizer beam (*Fig. 18*).

A centering pin is inserted by hammering on equalizer bearing plate which will be connected on walking beam.

The mounting phases to follow are similar to those described for center bearing mounting on walking beam.

Manufacturer's lubrication will be checked.

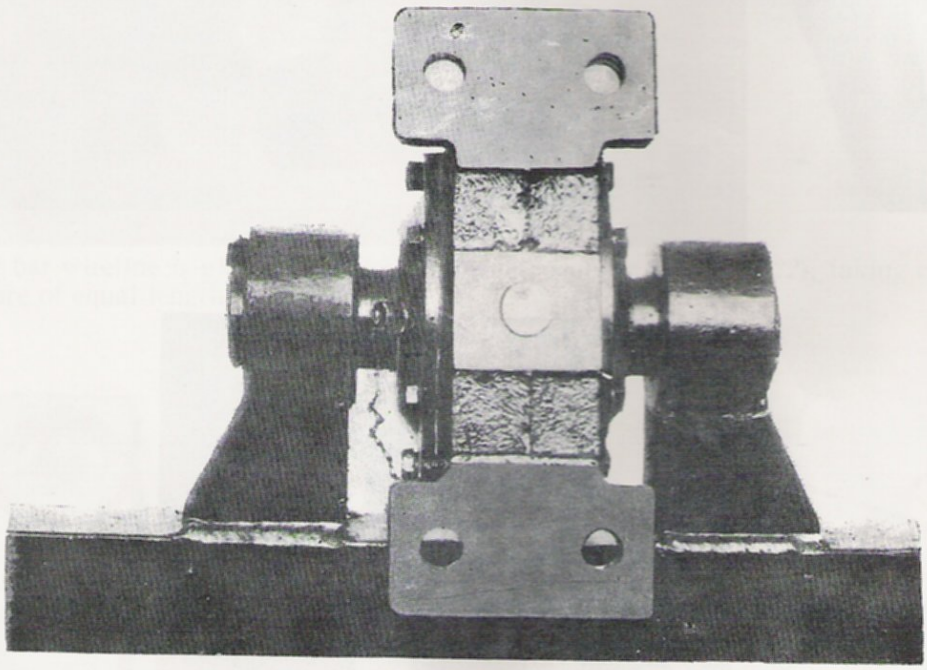


Figure 18

i) MOUNTING HORSEHEAD ON WALKING BEAM

Walking beam is placed on two wooden supports (or any other available props).

By crane, horsehead is hoisted to walking beam level and aligned to proper position (*Fig. 19*).

Horsehead is assembled to walking beam with swivelling shaft; a split pin is inserted for preventing shaft's disconnection.

Horsehead of **H E C** Pumping Unit may swivel to right-hand side of walking beam.

A worm gear device is placed at upper end of horsehead and walking beam for assuring an easy swivelling of horsehead (*Fig. 20*).

Spacers may be used for centerlining worm gear device.

Horsehead position setting: the blocking screw must be adjusted; a nut will secure against unscrewing.

Thus, horsehead is blocked at one side with a blocking screw and on the other by self-braking of gear device.

It is advisable that after mounting horsehead and worm gear device, horsehead spinning be tested; then horsehead is spun back into initial position (*Fig. 23*).

Figure 19

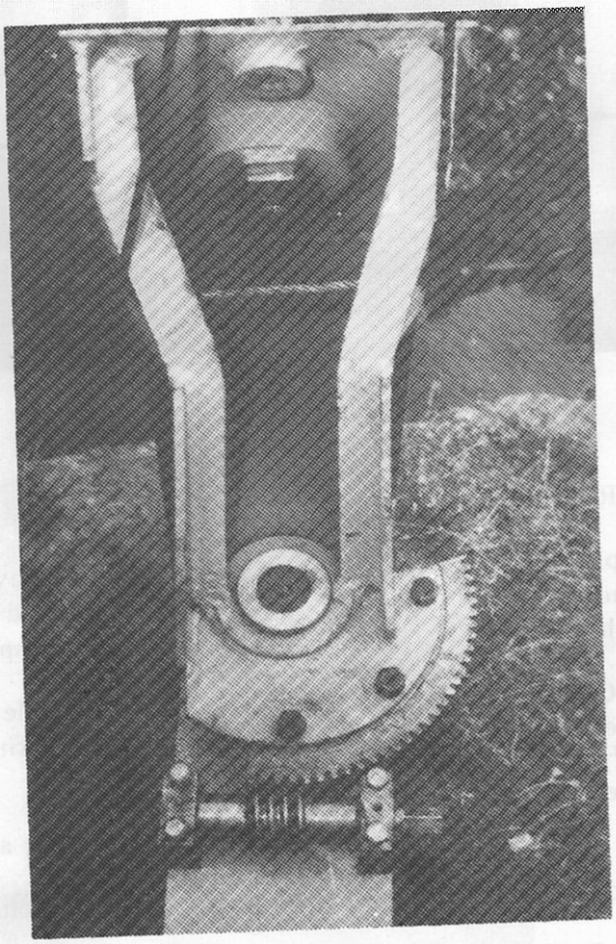


Figure 20

j) ASSEMBLING PITMAN TO EQUALIZER

When assembling pitman arms, consider manufacturer's marking on the outside of low pitmans arm ends.

Pitmans upper-ends will be fixed with bolts and secured against unscrewing with plates & screws (*Fig. 21*).

Pitman bolts must be greased when assembled.

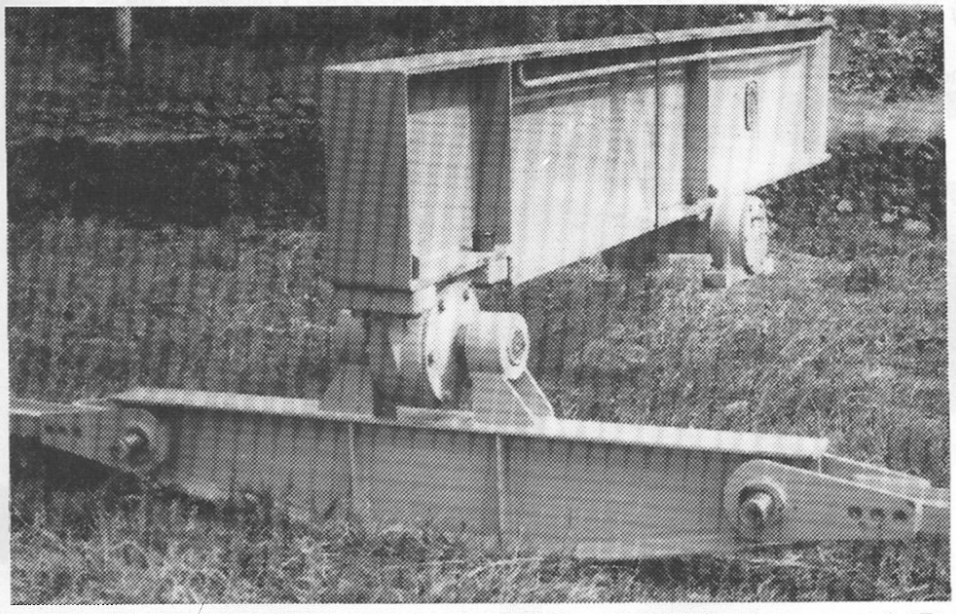


Figure 21

Carrier bar wireline is placed on roller at horsehead upper end (*Fig. 22*), taking care that its two parallel arms are of equal length.

Figure 22

Figure 23

l) SETTING WALKING BEAM ON SAMSON POST

Walking beam with equalizer bearing, equalizer, pitmans, center bearing, horsehead assembled is lifted by crane and placed on Samson Post at center bearing location (*Fig. 24 and 25*). Bolts are loosely tightened.

Wireline hanging on horsehead must be checked.

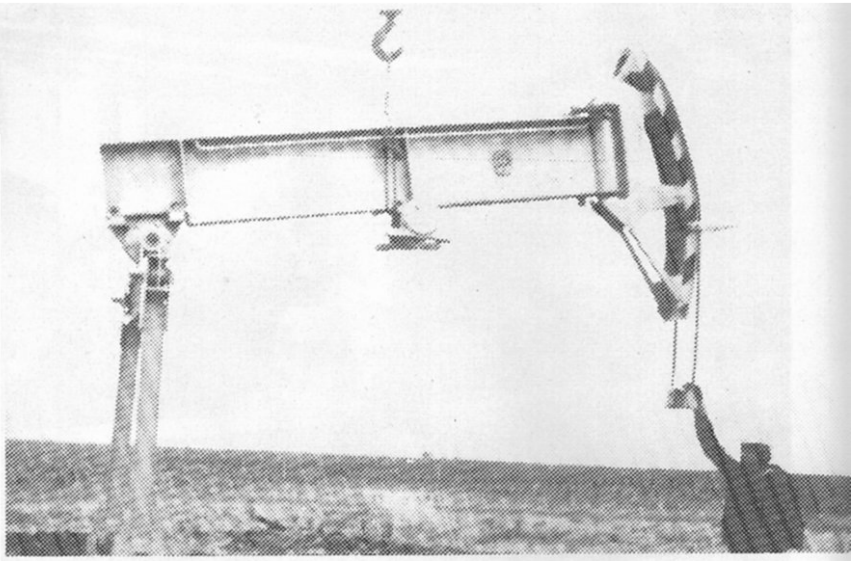


Figure 24

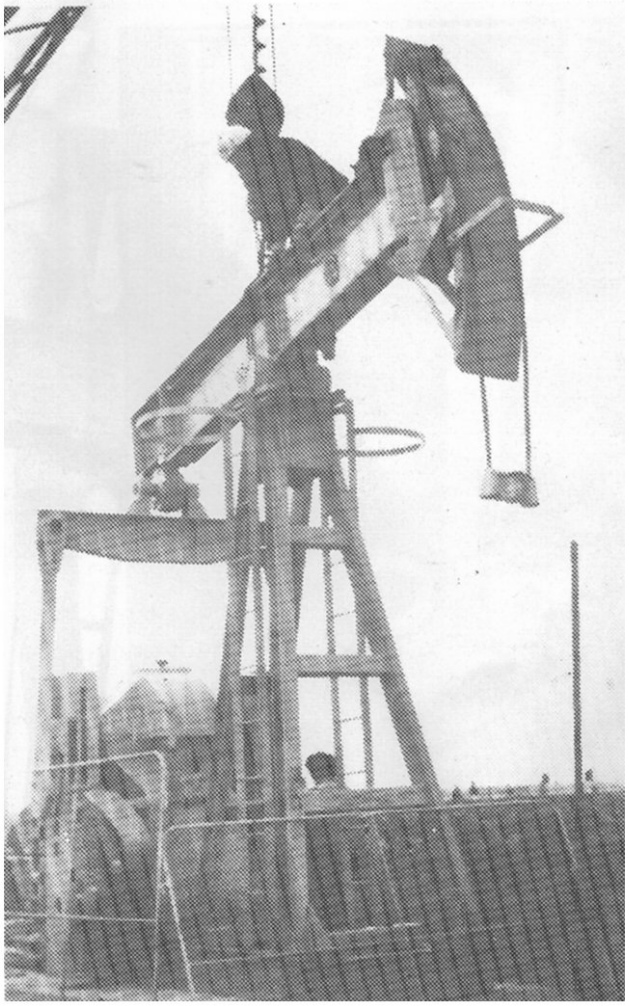


Figure 25

m) ASSEMBLING PITMAN ARMS TO CRANK PIN BEARINGS

All contact surfaces must be cleaned. Carefully, pitman bottom-ends are assembled to crank pin bearings (*Fig. 26*).

Using a long handle wrench, connecting bolts will be tightened without hammering.

Spacers between reducer main shaft-ends and pitmans must be checked.

For any necessary corrections turn around center bearing on Samson Post by means of adjusting screws which are placed on post top plate.

Figure 26

n) FINAL ALIGNMENT AND CENTERLINING OF PUMPING UNIT

Horsehead verticality is checked with a plumb bob string falling from top of horsehead along one of the two sides.

Very seldom but, it might be necessary to correct horsehead verticality by inserting spacers between Samson Post top plate and central bearing.

Position of Pumping Unit against polished rod is controlled with a plumb bob string dropped from top of horsehead.

Using post top plate adjusting screws, walking beam and horsehead may be moved forwards and backwards for proper position against wellhead.

Then all connection bolts between Samson Post and center bearing are hammer tightened.

If this procedure will not accomplish complete alignment, shift Pumping Unit base on foundation.

When required position has been obtained, foundation bolt will be hammer tightened.

o) MOUNTING OF ENGINE *(Fig. 27)*

Cross rails on extension base that sustain engine are drawn near to reducer so that belts may, without difficulty, be mounted on the two sheaves.

Distance between rails and position of "T" bolts will be adjusted to match holes in engine frame.

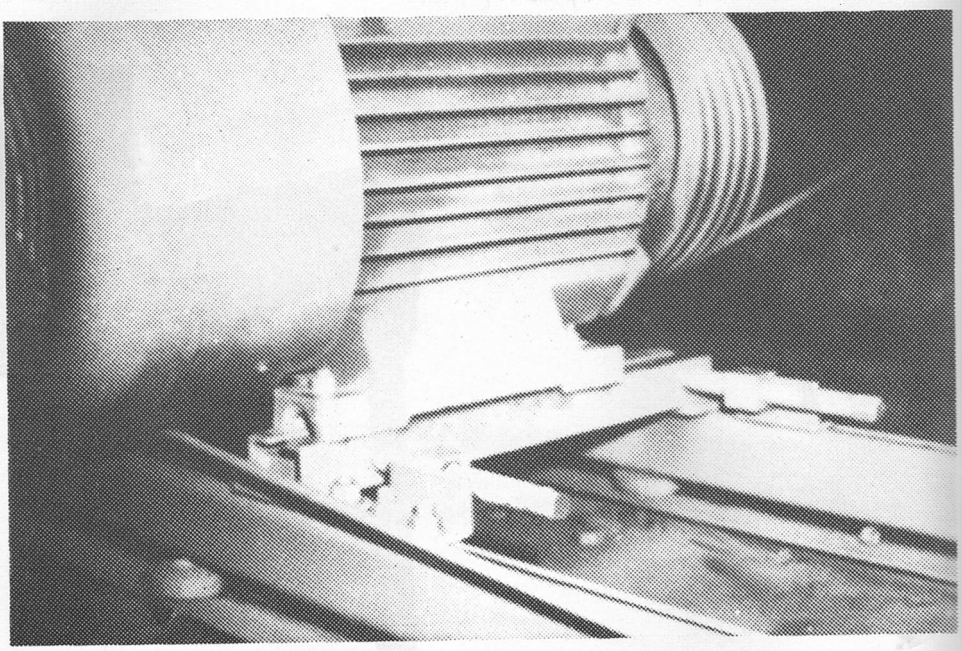


Figure 27

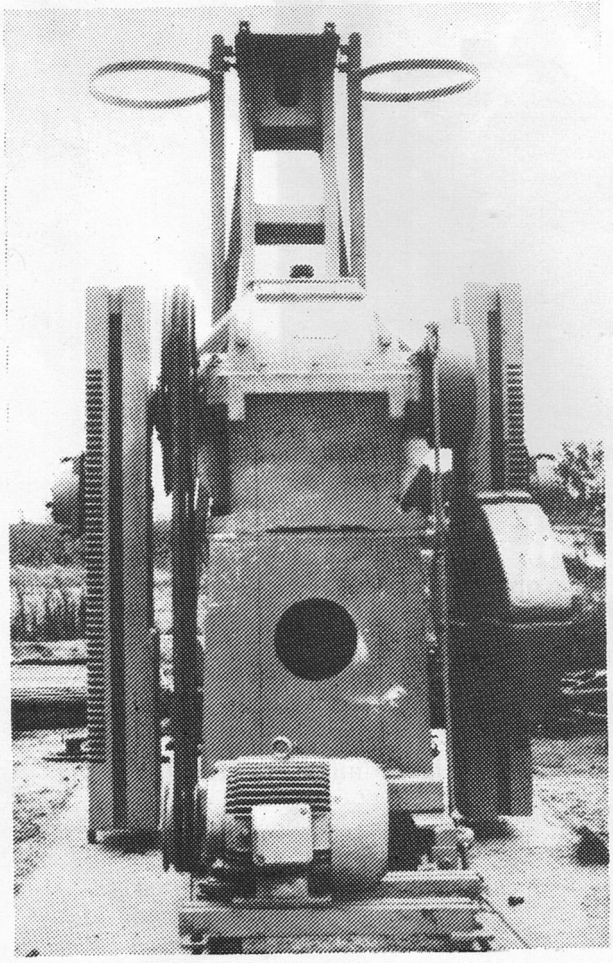


Figure 28

Engine is placed down on rails and while still sustained by crane, reducer and engine sheaves faces will be aligned with help of a string.

Then "T" head bolt nuts are tightened up.

p) MOUNTING "V" BELTS (*Fig. 28*)

The appropriate set of belts is installed on reducer and engine sheaves.

For loads lower than the rated ones, grooves next to bearing will be used.

Pushing screws on extension base are used to stretch belts.

By finger pressure belts tightness is checked; half-way between the two sheaves, one to two inches deflection should be allowed on belts. The whole set of "V" Belts, should have the same deflection.

Rail bolts to base are hammer tightened.

r) MOUNTING BELT COVER (*Fig. 29*)

The one piece belt cover is installed, one end on reducer support and the other on extension base, seeing to that inside cover is not interfering with sheaves and belts.

s) OIL TO REDUCER BOX

The end-user will fix oil level indicator complete with dip stick at rear of reducer in place of the threaded plug which assures protection of thread in oil level indicator lid.

Oil is poured in reducer box.

Type and quality of oil are indicated on reducer manufacturer's plate and in this manual.

Check oil level with a dip stick.

Attention: before putting into operation, check oil level.

Figure 29

t) MOUNTING CARRIER BAR ON POLISHED ROD

Carrier bar is attached to polished rod.

Safety latch is untightened and carrier bar placed on polished rod and then replaced and blocked; clamp for fixing polished rod is placed and tightened.

u) CHANGING COUNTERBALANCE

Unit is braked thus cranks get slightly leant on desired moving direction of counterweights.

While carrying out this operation brake should be continuously kept under observation. For safety it is recommended to place timbers beneath cranks.

Nuts fixing counterweights on cranks will be loosened and then by means of pinion crank (included in standard delivery assembly), counterweights are moved to adequate position.
Then bolt nuts will be hammer tightened.

v) SETTING UP CRANK GUARD (FENCE) — *Fig. 29*

According to foundation drawing, lay down guard supporting pipes.
Guards poles are inserted in supporting pipes and then panels hooked on poles.
CAUTION: Pumping Unit is not put into operation if crank guard (fence) is not erected yet

ATTENTION: Both by mounting operation and maintenance, bolts tightening must entirely comply to instructions given in part XII, table 7.

IV. CRANK PIN INSTALLATION AND REMOVAL

Crank pin bearings are delivered already mounted on cranks.
When the Pumping Unit has been mounted crank pin bearings bolts shall be checked and, if necessary, retightened; nuts must be secured with split pins.
If polished rod stroke length need be modified, another hole for crank pin bearing location on cranks should be selected.
The following steps should be considered when removing or installing crank pins in a new hole as well as when worn out bushings and pins have to be replaced.
Pumping Unit is stopped and braked with cranks in horizontal position.
Polished rod is blocked by a clamp fixed above the wellhead level and then brake is released till polished rod with clamp due to rods string weight, is lowered and leans against wellhead.
Cranks are moved a few degrees in the same direction either by engine or crane, hooking the rear end of walking beam and lifting it about 1 inch till carrier bar wireline slackens.
Pumping Unit is braked in this position. During this intervention brake shall be continuously kept under control by an operator.
One must consider walking beam rotation tendency due to pumping unit structural unbalance and which is taken over by crane.
In this position with carrier bar wireline slackened, crank pin bearing may be removed by taking off the split pin and nut.
Both crank pins should be removed by easy hammering, and old pin holes be covered with a thin coat of anti-corrosive paint.
Crank bore, crank pin and bushing must be thoroughly cleaned, lubricated and wiped with a cotton cloth.
If burrs occur on crank pin end they will be removed through light filing and petrol washing.
Crank Pin is installed in a new crank bore selected subject to the necessary stroke length, hand spinning the nut.
A special wrench supplied in the common set of tools is used to tighten up the nut.
It is forbidden to loosen nut for inserting a split pin.
The same steps will be followed for installing both crank pin bearings.
Brake is smoothly released till wireline hanger straightens.
Clamp fixed on polished rod is undone and all areas around Pumping Unit moving parts (cranks, walking beam, "V" belts) are cleared.
Before Pumping Unit is put back into operation, the proper counterbalance must be calculated for the new stroke length.

V. DELIVERY, SHIPPING AND STORAGE

For transport purposes Pumping Unit components are shipped pre-assembled, which fact will allow to save effort and time by erection and mounting operations.
During loading, unloading and other transport handling operations it is advisable to prevent any shocks or blows which would damage the packing or the contents.
The same attention should be paid after unpacking, by erection, warehousing or crane hoisting of the Pumping Unit parts.

Reducer is handled by hooking a cable through the eyelets of the lower case.

Pumping Unit parts and components shall be unloaded and stored in adequate places which will provide prevention from shocks, blows or rough handling.

It is advisable that Pumping Unit components are unpacked only after transportation to the oil well location.

In case of longer storage, Pumping Unit parts will be periodically inspected and, if necessary, preservation renewed.

The same indications for Pumping Unit spare parts storage should be observed.

VI. PUMPING UNIT SET FUNCTIONING

1. Before setting into function, all assembling bolts and nuts by the main parts, such as: Equalizer Bearing to Equalizer and Walking Beam, Crank Pin Bearing to Cranks and Pitman Arms, Cranks to Gear Reducer Shaft, Counterweights to Cranks, Reducer on Support, Base on Foundation a.s.o. should be checked and ensured for full tightening.

2. Operation staff access ways and protection devices shall be checked if duly mounted.

3. Moving parts access ways be inspected if ensured.

4. All lubricated points should be checked if provided with grease.

5. According to counterbalance calculations at pumping unit field location, position of counterweights on cranks will be properly established (see Annexure No. 1).

6. Before Pumping Unit's putting into operation, brake should be released.

7. For 48 hours after putting into operation, the Pumping Unit must be carefully supervised; in the meantime bearings and reducer oil temperatures shall be checked so that the latter would not exceed 60°C.

All the while the Pumping Unit should prove a smooth, noise-and vibrations-free functioning.

Atferwards, the Pumping Unit is stopped and all assembling connections are being rechecked, loose bolts tightened back and then the Pumping Unit may be put into normal operation.

8. One week after Pumping Unit's putting into operation, all bolts and nuts are rechecked for proper tightening, as well as bearings and reducer against abnormal leakages, oil level in reducer and "V" belts proper tightness.

VII. MAINTENANCE DURING OPERATION

1. H E C Pumping Unit will assure a long-term operation and give full satisfaction only if during normal operation and maintenance the present mounting, maintenance and operation instructions are being observed.

Consequently the operating staff should get acquainted, in beforehand, to these instructions.

2. From the moment the Pumping Unit has been put into operation an oil well-log must record all data and changes incurred durring Pumping Unit operation such as: technical data of crude oil, pumping depth, tubing, pump, rods, string, number of double strokes per minute, strokes length, balance, output, stops and their causes, starts, kind of intervention or repairs.

3. All warranties granted by the manufacturing plant are lost if, during tests or operation, the Pumping Unit is overloaded.

4. If any anbormal phenomena such as: misalignment, noises, blows, overheating, rust occur during Pumping Unit (or reducer) functioning, the Pumping Unit is immediately stopped and the nature, cause and location of the defect duly checked; afterwards all necessary measures meant to ammend such disfunction will be taken.

Hercules Energy Corp. recommended maintenance schedule

a) After 48 hours and one week operation — proceed as indicated in part VI.

b) Monthly maintenance:

1. Pmping Unit normal operation must be checked monthly and all possible disorders as listed in Part VII/4 will be treated accordingly.

2. Reducer oil level will be checked with a dip stick, oil level having to be situated between its high and low marks. Reducer must be discontinued.

3. Center, equalizer and crank pin bearings should be inspected for unforseen leakages.

4. The temperature by structural and reducer bearings must be checked for not exceeding 60°C.

c) Every six months:

1. The same procedures as for the monthly maintenance.

2. Grease must be added to all structural bearings.

3. Reducer oil quality must be checked by collecting a sample of the same and inspecting it either visually or by laboratory means. If any kind of dirt, water emulsion etc. are found, oil must be replaced.

VIII. LUBRICATION

The present lubrication instructions refer to normal service conditions and in case of special local conditions it is necessary to contact a specialist who will consider these circumstances and API — Recommended Practice, for Installation and Lubrication of Pumping Units (API-RP II G).

a) Viscosity recommendations for gear reducers

Table No. 1

Application	SAE Gear OIL	AGMA OIL
0°F to 140°F	90 EP	5 EP (ISO VG 220)
—30°F to 110°F	80 EP	4 EP (ISO VG 150)

For temperatures down to 0°F a SAE 90 gear oil — pour point 5°F is recommended and for temperature down to — 30°F, a SAE gear oil — pour point —15°F.

The lubricant must be premium mineral oil with anti-rust, anti-oxidation and anti-foam qualities.

b) Reducer Oil Capacity

Table No. 2

Reducer type	R 40	R 57	R 80	R 114	R 160	R 228	R 320	R 456	R 640	R 912
Capacity (US Gal)	7	12	17	19	30	43	60	70	80	100

Wrongly selected lubricants or extreme service conditions may lead to the disorders listed in Table 3.

c) Pumping Unit Bearings

H E C Pumping Units carry roller type bearings, grease lubricated and by delivery, the manufacturer provides the bearings already greased.

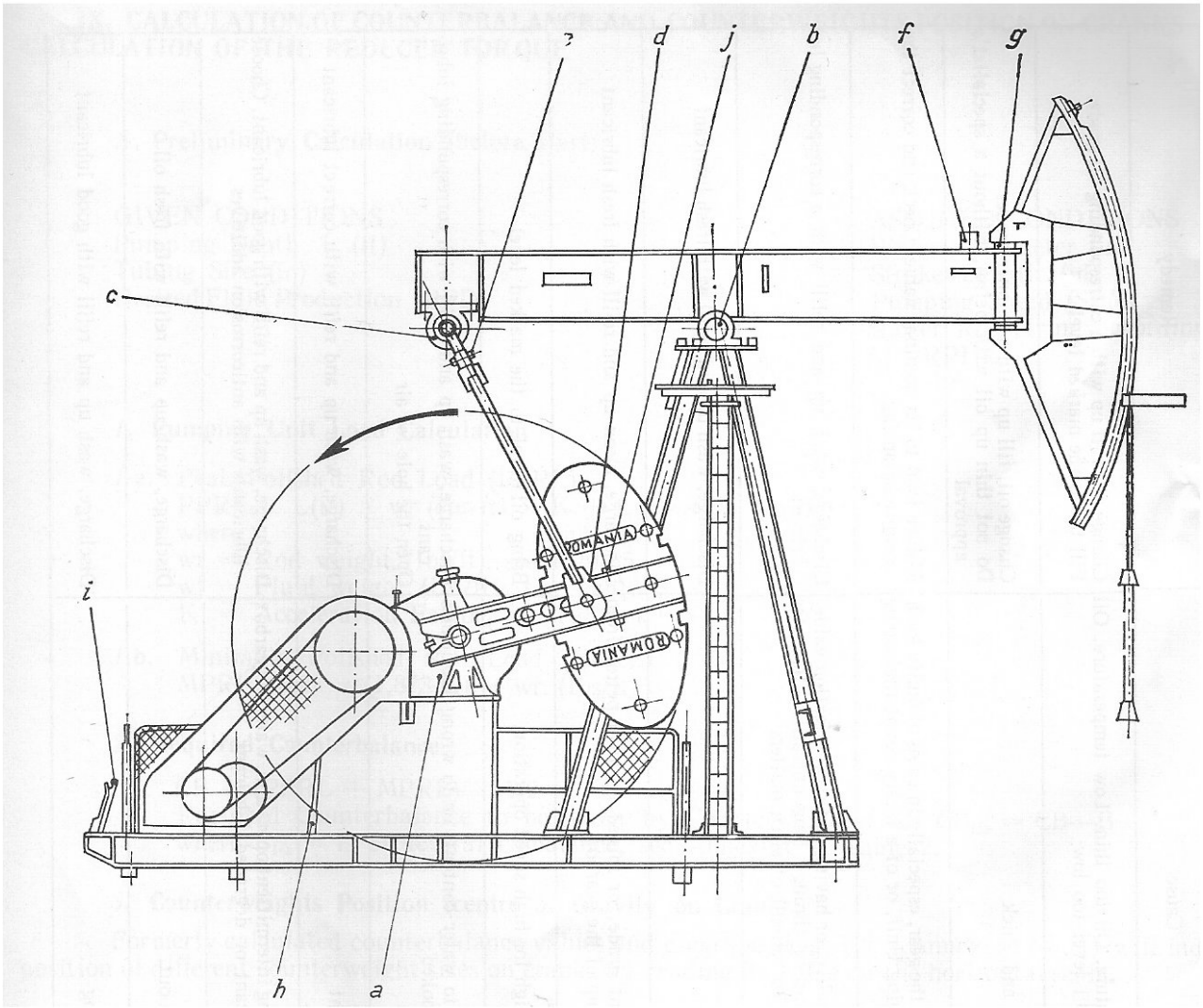
For warmer climates, a No. 1 lithium soap grease with extreme pressures additive will be employed.

For cooler climates, a No. O lithium soap grease with extreme pressures additive will be used.

It is forbidden to use a soda soap grease.

d) Lubrication of Horsehead Wire

Horsehead wire will be maintained by periodically brushing and coating with a high quality acid-or base-free lubricant.



LUBRICATING SCHEDULE

Item	Lubricating place	Lubricant
a	Gear reducer	oil
b	Center bearing	Grease
c	Equalizer bearing	
d	Crank pin bearing	
e	Equalizer shaft	
f	Worm-gear device	
g	Horsehead shaft	
h	Brake transmission joint	
i	Brake lever transmission joint	
j	Tool place	

Table No. 3

LUBRICATION DISORDERS AND THEIR REMEDY

	Disorders	Cause	Remedy
a	The gears carry over only a small quantity of oil. The lubrication grooves are empty	High temperature. Oil too thin. Low temperature. Oil too thick. Oil level too low	Change oil. Fill up with a corresponding oil grade. Fill up to the marked level
b	Difficult start at low temperature	Oil too heavy and thick	Change oil, fill up with a thinner grade. Do not thin up oil with petrol, without a specialist's approval
c	Pitting, or wear produced by heavy, continuous friction of the gears, even if lubricant available in sufficient quantities. (Not the initial running-in pitting, which is normal and disappears after a while)	Overloading of the gear, especially in cases of faulty loads on the Pumping Unit, or of a faulty counterbalancing	Reduce load to its nominal value. Check and correct the counterbalancing
		Oil of wrong quality, or having lost its lubrication value, due, to degrading through long operation, to water emulsion, or to content of alien matters	Discharge, wash up and refill with a corresponding lubricant
d	Gears or bearings wearing off rapidly, or presenting abrasions (other than by pitting)	Oil is dirty	Discharge, wash up and refill with fresh lubricant
e	Foam rising in the gearbox or leaking through the shaft seals	Wrong lubricant grade, or mixed up with petrol from the washing up of the gearbox	Discharge, clean up and refill with fresh lubricant
		Oil level too high for high speed operation	Bring oil level to the marked level
f	Oil milky instead of shining	Emulsion due to water contents or to wrong lubricants Air filter is choked	Discharge, wash up and refill with corresponding lubricant Open the hole for air
g	Heavy, soapy mud in gearbox	Wrong lubricant	Discharge, wash up and refill with correct lubricant
h	Heavy rust and corrosion of gears and bearings	Humidity during intermittent operation, water in gearbox wrong lubricant or degraded lubricant	Discharge, wash up and refill with good lubricant. Choose lubricants with anticorrosion additives
i	Sticky, insoluble deposits on gears and bearings	Oil aged, worn-out	Discharge, wash up and refill with fresh oil
		Lubricant wrong	Discharge, wash up and refill with good lubricant

IX. CALCULATION OF COUNTERBALANCE AND COUNTERWEIGHTS POSITION ON CRANKS CALCULATION OF THE REDUCER TORQUE

A. Preliminary Calculation (before start)

GIVEN CONDITIONS
Pumping Depth, L (ft)
Tubing Size (in)
Desired Fluid Production (BPD)

ASSUMED CONDITIONS
Plunger Diameter (in)
Stroke Length (in)
Pumping Speed (SPM)
Sucker Rod string according to API-RPIIL

1. Pumping Unit Load Calculation

1.a. Peak Polished Rod Load (PPRL)
PPRL = L(ft) × wr (lbs/ft) × K + L(ft) × wf (lbs/ft)
where:
wr = Rod weight (lbs/ft), see Table 5
wf = Fluid weight (lbs/ft), see Table 6
K = Acceleration Factor, see Table 4

1.b. Minimum Polished Rod Load (MPRL)
MPRL (lbs) = (1,873-K) × wr (lbs/ft)

2. Required Counterbalance

CB = (PPRL + MPRL) × 1/2
Required Counterbalance to be given by Counterweights: CB CB_{lbs} = CB—B
where B_{lbs} = is Structural Unbalance, see Annexure 1, Table 2.

3. Counterweights Position (centre of Gravity on Cranks)

Formerly calculated counterbalance values and diagrams (Fig. 1,2 ...Annexure No. 1) will indicate position of different counterweight sizes on cranks by reading its value on the horizontal scale.

4. Peak Torque

$$PT \text{ (in. lbs)} = (PPRL\text{-}CB) \times \frac{\text{Max} \cdot \overline{TF}}{-0.93}$$

(a mechanical efficiency of 95% is assumed)

Max. $\overline{TF}$ = see Annexure No. 1, Table 2

REMARK: Polished Rod Loads, Peak Torque, Counterbalance and other elements may be also calculated according to API RPIIL

B. Counterbalance by Dynamometer

An efficient operation of H E C Conventional Crank Balanced Pumping Unit is enabled by an accurate counterbalance.

The basic element in determing the right counterbalance is to find out the load at polished rod, by a dynamometer, during a pumping cycle. The reducer torque and required counterbalance will be determined as indicated by API Std. 11E instructions, Appendix B, using torque factor and polished rod position which are given in H E C Operator's Manual, Annexure No. 1.

C. Counterbalance by Ammeter

This method is used when the Pumping Unit is equipped with an electric motor.

An ammeter is clamped on one of electric motor wires. The two current peak values, if equal, will prove an approximately equal reducer torque peaks.

Table No. 4

ACCELERATION FACTOR

Length of Polished Rod Stroke-Inches

SPM	16	24	30	36	42	48	54	64	74	86	100	120	144	168
1	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.001	1.001	1.001	1.001	1.002	1.002	1.002
2	1.001	1.001	1.002	1.002	1.002	1.003	1.003	1.004	1.004	1.005	1.006	1.007	1.008	1.010
3	1.003	1.003	1.004	1.005	1.005	1.006	1.007	1.008	1.008	1.011	1.018	1.016	1.018	1.021
4	1.004	1.005	1.007	1.008	1.010	1.011	1.012	1.015	1.017	1.020	1.023	1.027	1.033	1.038
5	1.006	1.009	1.011	1.013	1.015	1.017	1.019	1.023	1.026	1.031	1.035	1.043	1.051	1.060
6	1.008	1.012	1.015	1.018	1.021	1.025	1.028	1.033	1.038	1.044	1.051	1.061	1.074	1.086
7	1.011	1.017	1.021	1.025	1.029	1.033	1.038	1.044	1.051	1.060	1.070	1.083	1.100	1.117
8	1.015	1.022	1.027	1.033	1.038	1.044	1.049	1.058	1.067	1.078	1.091	1.109	1.131	1.153
9	1.018	1.028	1.035	1.041	1.048	1.055	1.062	1.074	1.085	1.099	1.115	1.138	1.165	1.193
10	1.023	1.034	1.043	1.051	1.060	1.068	1.077	1.091	1.105	1.122	1.142	1.170	1.204	1.238
11	1.028	1.041	1.052	1.062	1.072	1.082	1.093	1.110	1.127	1.148	1.172	1.206	1.247	1.288
12	1.033	1.049	1.061	1.074	1.086	1.098	1.110	1.131	1.151	1.176	1.204	1.245	1.294	1.343
13	1.038	1.058	1.072	1.086	1.101	1.115	1.129	1.153	1.177	1.206	1.240	1.288	1.345	1.403
14	1.045	1.067	1.083	1.100	1.117	1.134	1.151	1.179	1.207	1.239	1.278	1.335	1.402	1.469
15	1.051	1.077	1.096	1.115	1.134	1.154	1.173	1.205	1.237	1.275	1.319	1.385	1.462	
16	1.058	1.087	1.109	1.131	1.153	1.174	1.196	1.233	1.269	1.312	1.363	1.436		
17	1.066	1.098	1.123	1.148	1.172	1.197	1.221	1.262	1.303	1.353	1.410	1.492		
18	1.074	1.110	1.138	1.165	1.193	1.221	1.248	1.294	1.340	1.395	1.460			
19	1.082	1.123	1.154	1.184	1.215	1.246	1.277	1.328	1.379	1.440	1.512			
20	1.091	1.136	1.170	1.204	1.239	1.272	1.306	1.363	1.420	1.488				
21	1.100	1.150	1.188	1.225	1.263	1.300	1.338	1.400	1.463					
22	1.110	1.165	1.206	1.247	1.288	1.330	1.371	1.440	1.508					
23	1.120	1.180	1.225	1.270	1.315	1.360	1.405	1.480						
24	1.131	1.196	1.245	1.294	1.343	1.392	1.441	1.523						
25	1.142	1.213	1.266	1.319	1.372	1.425	1.479							
26	1.153	1.230	1.288	1.345	1.403	1.460	1.518							
27	1.165	1.248	1.310	1.372	1.434	1.496								
28	1.178	1.267	1.334	1.400	1.467									
29	1.191	1.286	1.358	1.429	1.501									
30	1.204	1.306	1.383	1.460										

$$\text{Acceleration Factor} = 1 + \frac{S \times SPM^2}{70{,}500}$$

S = Length of Polished Rod Stroke in Inches

SPM = Strokes per min.

Table No. 5

ROD WEIGHT — lbs/ft

API RP 11 L Rod No.	Rod Area sq. in	Diameter of Plunger and Average Weight of Rods per Foot								
		1 1/16"	1 1/4"	1 1/2"	1 3/4"	2"	2 1/4"	2 1/2 "	2 3/4"	3 3/4"
44 (1/2")	0.196	0.726	0.726	0.726	0.726	0.726	—	—	—	—
55 (5/8")	0.307	1.135	1.135	1.135	1.135	1.135	1.135	1.135	1.135	—
65 (3/4"—5/8")		1.291	1.306	1.330	1.359	1.392	1.429	1.471	1.517	—
66 (3/4")	0.442	1.634	1.634	1.634	1.634	1.634	1.634	1.634	1.634	—
76 (7/8"—3/4")		1.787	1.798	1.816	1.836	1.861	1.888	1.919	1.953	2.121
77 (7/8")	0.601	2.224	2.224	2.224	2.224	2.224	2.224	2.224	2.224	2.224
86 (1"—7/8"—3/4")		2.008	2.035	2.079	2.130	2.190	2.257	2.334	2.415	—
87 (1"—7/8")		2.375	2.384	2.397	2.414	2.432	2.453	2.503	2.632	2.800
88 (1")	0.785	2.904	2.904	2.904	2.904	2.904	2.904	2.904	2.904	2.904
96 (1 1/8"—1"—7/8"—3/4")		2.601	2.622	2.653	2.696	2.742	2.795	2.853	2.918	3.239
99 (1 1/8")	0.994	3.676	3.676	3.676	3.676	3.676	3.676	3.676	3.676	3.676

Table No. 6

FLUID WEIGHT — lbs/ft
Based On Net Plunger Area

APIRP 11 L Rod No.	Diameter of Plunger and Fluid Load in lbs /ft (Specific Gravity = 1)								
	1 1/16"	1 1/4"	1 1/2"	1 3/4"	2"	2 1/4"	2 1/2"	2 3/4"	3 3/4"
44 (1/2")	0.299	0.447	0.681	0.957	1.278	—	—	—	—
55 (5/8")	0.251	0.399	0.633	0.910	1.230	1.590	1.994	2.441	—
65 (3/4"—5/8")	0.233	0.378	0.612	0.883	1.198	1.555	1.955	2.396	—
66 (3/4")	0.192	0.340	0.574	0.850	1.170	1.531	1.936	2.382	—
76 (7/8" — 3/4")	0.175	0 321	0.553	0.827	1.143	1.502	1.902	2.345	4.538
77 (7/8")	0.124	0.271	0.505	0.782	1.101	1.462	1.867	2.314	4.526
86 (1"—7/8"—3/4")	0.149	0.293	0.522	0.793	1.105	1.459	1.854	2.291	—
87 (1"—7/8")	1.106	0.253	0.485	0.760	1.077	1.436	1.837	2.281	4.478
88 (1")	0.044	0.191	0.425	0.702	1.021	1.383	1.787	2.234	4.446
96 (1/8"—1"—7/8"—3/4")	0.119	0.261	0.486	0.753	1.060	1.408	1.798	—	—
99 (1 1/8")	---	0.101	0.335	0.611	0.931	1.292	1.696	2.143	4.356

D. **Counterbalance by Vacuum Gage**

This method can be used in the situation the Pumping Unit is equipped with a multi-cylinder engine.

The two lowest values indicated by vacuum gage must be equal, and comply with the two reducer torque peaks.

E. **Counterbalance by Engine Sound**

According to the two torque peaks, a slow-down of engine speed and increased sound will be noticed at the engine (or electric motor).

F. **Counterbalance by Belts Tightness**

When reducer torque peaks are reached belts get over tightened on their load side, and present a deflection on the oposite side.

If deflection is equal at the two torque peaks then the latter are approximately equal.

X. DIRECTION OF ROTATION

HEC Pumping Unit can operate in both clockwise and counterclockwise direction of rotation.

The Manufacturer recommends that for longer service life of reducer gears and more satisfactory results in operation, direction of rotation of the Pumping Unit be changed periodically.

If an electric motor equips the Pumping Unit, the direction of rotation is changed by reversing connections to electric motor terminals.

If a cylinder engine is mounted on the Pumping Unit, direction of rotation is that which is marked on reducer and it complies to a clockwise direction when the Pumping Unit is viewed with horsehead to the left-hand side.

XI. H E C SERVICE

Hercules Energy Corp. perform technical assistance, on request, with its highly trained specialists who would advise the end-users on correctly selecting the Pumping Unit and engine size as well as all necessary production equipment (sucker rods, subsurface pumps, etc.) subject to oil well conditions.

Hercules Energy Corp. can ensure service at mounting, operation, maintenance or repairing of Pumping Units.

Spare parts may be supplied from **HEC** Service warehouse or from **H E C** directly.

When spare parts are ordered, it is necessary to mention Pumping Unit size, series, year of manufacture and name of the part, as they have been listed on the technical specification of the pumping unit.

XII. SCREWS TIGHTENING

An important part for a profitable operation of a Pumping Unit is played by the correct tightening of assemblying bolts. In case of a metal to metal grip, bolts are hammer tightened, excepting small size screws which are fastened by a box end wrench with long handle.

The proper tightening torques are given in the table below:

Tightening Torques for Nuts and Bolts at Metal to Metal Grip

Table No. *7*

Bolt Metric Size	Torque Range (ft. lbs)		Wrench size for the respective bolt
	M_{min}	M_{max}	
M 10	12	17	17
M 12	22	30	19
M 16	55	74	24
M 20	112	152	30
M 22	153	207	32
M 24	190	257	36
M 27	279	378	41
M 30	316	428	46
M 36	647	876	55

XIII. ERECTION EQUIPMENT DATA

Hercules Energy Corp. instructions in this prospectus are simply informative and are meant to help selecting the adequate lifting equipment for the given Pumping Unit.

Table No. *8*

Reducer Type	Total weight for reducer + cranks and crank pin bearings (lbs)
R 912	26,450
R 640	22,042
R 456	18,735
R 320	15,430
R 228	13,225
R 160	10,580
R 114	8,375
R 80	6,172
R 57	4,410
R 40	3,310

Pumping Unit components weights at mounting.

G — weight of walking beam, horsehead, center bearing, equalizer bearing, equalizer and pitman arms.

g — horsehead shaft weight

Table No. *9*

Stroke length (in)	G (lbs)	g (lbs)	Minimum hook height (ft)
168	11,572	194	32
144	9,147	165	29
120	8,045	132	28
100	6,282	121	25
86	4,518	105	23
74	3,967	99	22
64	3,636	88	18
54	3,306	79	15
48	2,755	66	14
42	2,645	57	12
36	2,204	48	11

XIV DISORDERS REMEDY

A. PUMPING UNIT

	Disorder	Description	Cause	Remedy
1	Instability, lack of rigidity after erection	Base frame moves Unit oscillates Noises at drive	a. Foundation faulty b. Base frame not well fixed to foundation c. Assemblies loose d. Pumping Unit badly centered e. Incorrect counterbalance f. Number of double strokes per minute, or load at polished rod too high	a. Check foundation. If faulty, make a new foundation as per lay-out and instructions b. Tighten anchoring bolts c. Check weak points, tighten connecting screws and bolts d. Center again e. Calculate again and correct counterbalance f. Ammend parameters to comply with nominal data
2	Crank pin twisting and turning	Regular metallic noises	a. Crank pin loose	a. Tighten nuts
3	Crank loose on the crank-shaft	Crank glides on crank-shaft, noises at key	Tightening loose	Tighten special nut
4	Counterweights assembling Screws loose	Noises during operation Counterweights shake on crank	Tightening fault	a. Tighten again nuts and double nuts b. Counterweight position to comply with calculation data. Tighten nuts
5	Pitmans hit cranks or counterweights	Shocks	Faulty assembling	Realign the Unit and tighten bolts
6	Center bearing assembling screws loose	Shocks, displacement of the beam, whole Unit disaligns	Assembling screws and nuts loose	Center Unit and align again whole Unit and proceed to a correct tightening
7	Equalizer bearing screws loose	Shocks	Faulty assembling of screws and nuts	Center again equalizer bearing and proceed to a correct tightening
8	Pin jammed at upper end of Pitman	Upper Pitman end noisy	Faulty assembling	Correct bore of the Pitman end and change the pin
9	Axial play of upper Pitman end	Shocks	Equalizer distorted or wear due to sand	Introduce a washer
10	Radial play of upper Pitman end	Shocks	Wear due to lack of lubrication	Machine a new bore and change pin; consulting also Vulcan service team
11	Faulty operation of the bearings	Bearings exceed 60°C temperature Noises during operation	a. Faulty lubrication b. Covers loose c. Roller bearings worn-out or broken	a. Follow lubrication instructions b. Tighten cover screws c. Dismount and wash bearing, check causes, change the defective bearing
12	Pitman broken	Shoks at joint of upper Pitman end, or all over the Unit	Pins of upper Pitman joints are jammed	Grease upper bolts of the Pitman Change broken Pitman

	Disorder	Description	Cause	Remedy
13	Uncontrolled sudden braking, or brake does not respond to controls		a. Stroke of brake shoe not set b. Brake shoe ferrodo worn-out c. Lubricant or grease on working surface of the drum	a. Set the brake shoe stroke b. Change the ferrodo c. Wash and clean operating surface of drum
14	Unequal loading of wireline hanger cable	One arm of wireline hanger is slack	Cable stuck between roller and horsehead	Introduce a washer to keep roller away from horsehead
15	Wireline worn	Wire strands broken		Center Unit again and change broken cable
16	V-belts glide in their grooves	Belts slack, belts are twisted in their grooves, number of strokes decreasing	a. Drive motor rails screws on extension base loose b. Belts stretched to different lengths during operation c. Equal stretch of all belts	a. Bring motor in position which ensures correct tightness of belts. Tighten screws b. Sort out belts of same lengths c. Tighten belts and motor rails screws
17	Motor vibrating		Motor loose on, rails or these are loose on extension base	Tighten again loose screws
			B. GEAR REDUCER	
1	Gear reducer hot	Oil temperature exceeds 60°C	a. Oil level low b. Oil in excess in gearbox	a. Fill up til reaching oil level mark b. Discharge excess through discharge plug
2	Oil leakage	Gear reducer, stand, base frame, foundation, are oily	a. Too much oil in gearbox b. Housings and/or covers are not tight c. Roller worn-out or broken	a. Discharge oil excess b. Tighten assembling screws c. Check the fault. Dismount and wash bearings. Change roller
3	Abnormal operation of bearings	Roller bearings exceeding temperatures of 60°C	a. Faulty lubrication b. Housings of gear reducer are not tight c. Roller worn-out or broken	a. Apply lubrication instructions b. Tighten cover screws c. Check the fault. Dismount and wash bearings. Change the roller
		Bushing bearings hot	a. Oil collectors sticky b. Occlusion of oil lubrication grooves	a. Check. Clean up and ensure oil flow b. Clean up. Ensure oil flow to bushing. If bearings jammed, or worn out, change them
4	Gear plays too large	Periodical noises in gearbox. (If shocks occur at each revolution of the crank, low speed stage is faulty; if shocks are frequent high speed stage is faulty).	a. Gears worn-out, as a result of wrong operation b. Gears loose on their shafts as a consequence of overload or blockage of Unit due to well accidents c. Counterbalancing faulty	a. Check state of gears. In case of advanced wear, change gears, or whole gear reducer b. Check load, which must comply with nominal conditions c. Check and correct balancing
5	Axial play of shafts	Inlet shaft or crankshaft displaced	a. Gears loose on shafts, or rims loose on hubs b. Gear teeth badly worn or broken	Stop Unit immediately and change Gear reducer