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John J. Sulck

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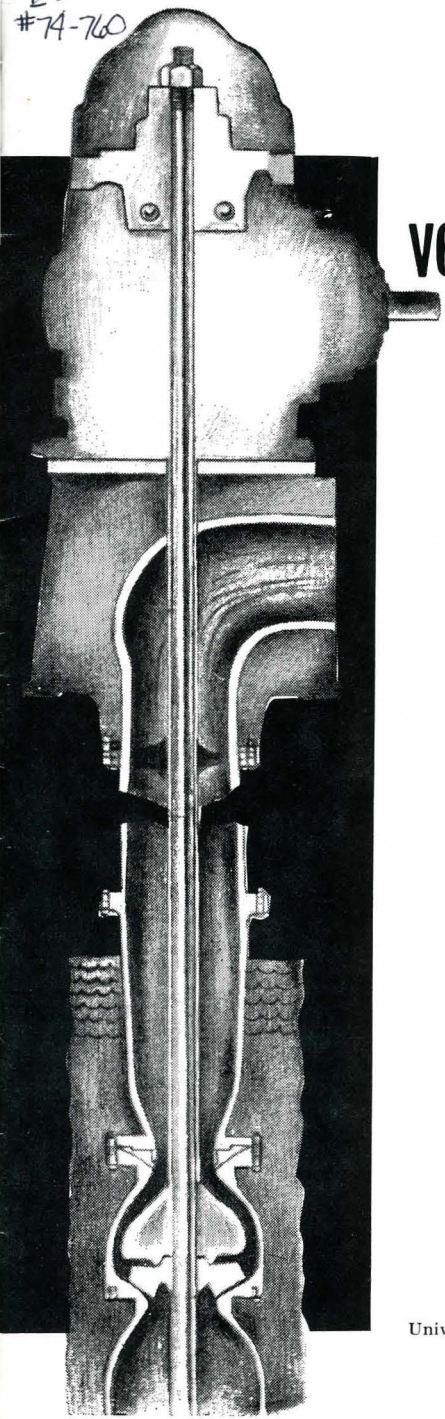
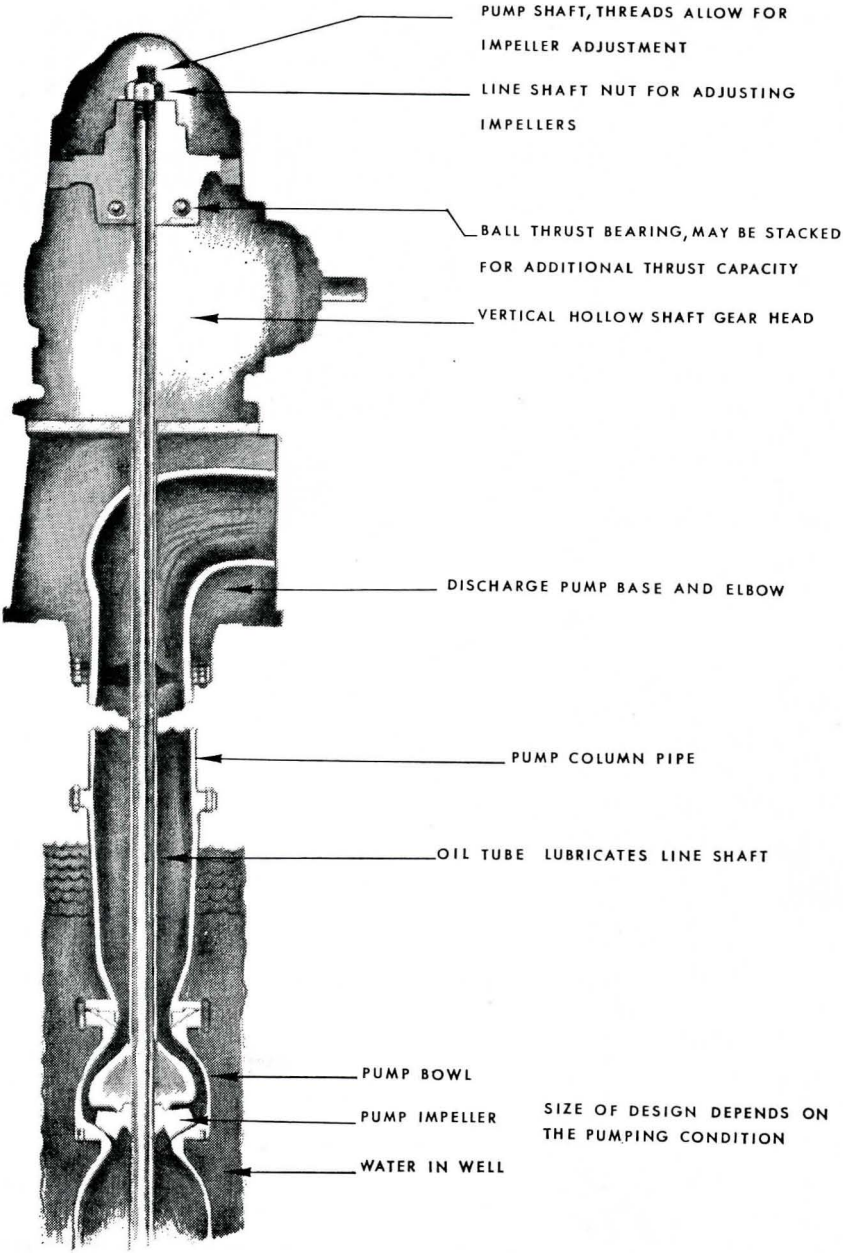


HOW TO ADJUST vertical turbine pumps FOR MAXIMUM EFFICIENCY

Extension Service
University of Nebraska College of Agriculture and Home Economics
and U. S. Department of Agriculture Cooperating
J. L. Adams, Director

VERTICAL TURBINE PUMP



SIZE OF DESIGN DEPENDS ON THE PUMPING CONDITION

How To Adjust Vertical Turbine Pumps For Maximum Efficiency

By H. Robert Mulliner
John J. Sulek[1]

REASONS FOR IMPELLER ADJUSTMENT

Fifty-eight percent of 114 irrigation wells tested by University of Nebraska College of Agriculture engineers used from 1 1/3 to 2 times the amount of fuel required.

Part of this waste was caused by the pump, either from worn impeller seals caused by pumping fine sands in the water or by improper impeller adjustment.

Faulty adjustment can reduce the efficiency of turbine pumps causing use of more fuel and producing less water. Less water lowers total productivity of the pumping unit.

Figure 1 shows how impeller adjustment affects pump capacity in gallons per minute and power requirements. Raising the impeller 1 1/2 turns beyond the optimum position reduced pump capacity by 21%.

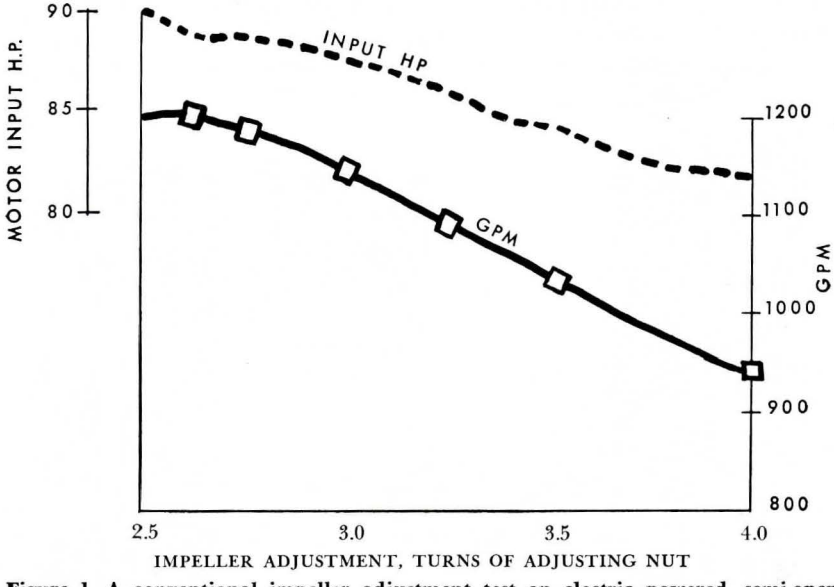


Figure 1. A conventional impeller adjustment test on electric powered, semi-open impeller turbine pump.

[1] Associate Professors, Agricultural Extension Engineering and Agricultural Engineering.

Faulty adjustment can seriously damage impellers and bowls regardless of the type. Damage will occur when the impeller rubs either the top or bottom of the bowl.

CONSTRUCTION OF TURBINE PUMPS

The turbine irrigation pump consists of one or more impellers enclosed within a bowl. When a typical impeller is rotated by the application of torque to the line shaft, water going through the impeller is accelerated to about 50 miles per hour. This velocity produces about 50 feet of lift per impeller or stage.

The line shaft extends from the bowl assembly to the top of the pump. It supplies torque to the impeller, provides support for the mechanical weight of the impeller, and supports the hydraulic downthrust acting upon the impeller.

Hydraulic downthrust is the force caused by the weight of the water being lifted and pressure against which it is pumped. The shaft and impeller weight also help to counteract upthrust.

Upthrust is a momentary upward force created in vertical turbine pumps the instant the unit is started. Upthrust is counteracted by downthrust as soon as the pump and discharge system are filled with water.

The line shaft may either be enclosed in a tube and oil lubricated or exposed and water lubricated. The nut on the head shaft provides up and down adjustment for positioning the impeller within the bowl.

Impellers are of two types: 1. The semi-open, (Figure 2); 2. The enclosed, (Figure 3).

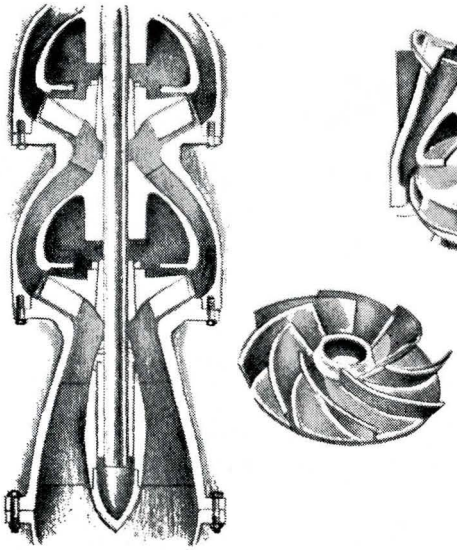


Figure 2. Semi-open impeller.

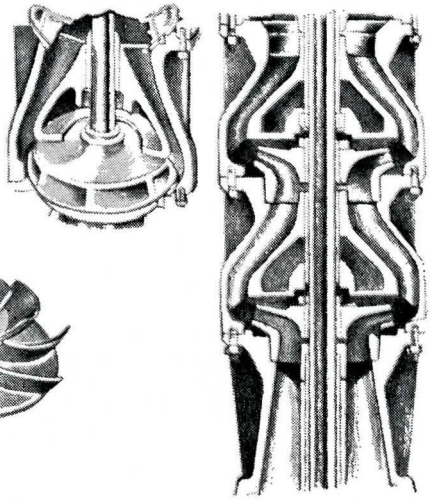


Figure 3. Enclosed impeller.

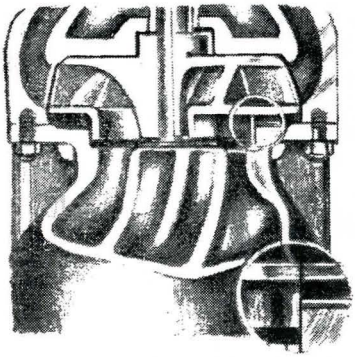


Figure 4. Side seal enclosed impeller.

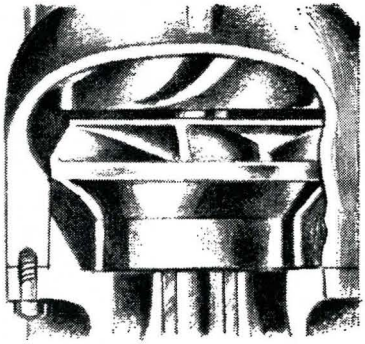


Figure 5. Bottom seal enclosed impeller.

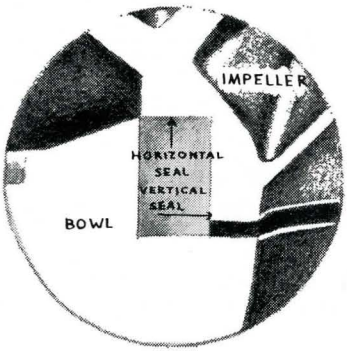


Figure 6. Side and Bottom seal enclosed impeller.

The semi-open impeller consists of vanes which are enclosed at the top only. The closer the bottom of these vanes runs to the face of the bowl without rubbing, the higher the efficiency. If vane clearance is excessive, leakage will occur. Leakage allows water to recirculate within the bowl assembly reducing efficiency, amount of water pumped, and the pump's ability to create pressure.

An enclosed impeller consists of vanes which are enclosed at top and bottom. Water enters through the bottom eye or neck of the impeller.

Efficiency of the enclosed impeller may or may not depend upon vertical adjustment, depending on the design. The seal type of the enclosed impeller differs between pump manufacturers.

The three types of seals used are: 1. Side seal only, (Figure 4); 2. Bottom seal only, (Figure 5); 3. Combination side and bottom seal, (Figure 6).

In the side seal only type, the seal is obtained by limited clearance between the neck or eye of the impeller and the vertical surface of the bowl. Vertical impeller adjustment does not affect leakage in this type.

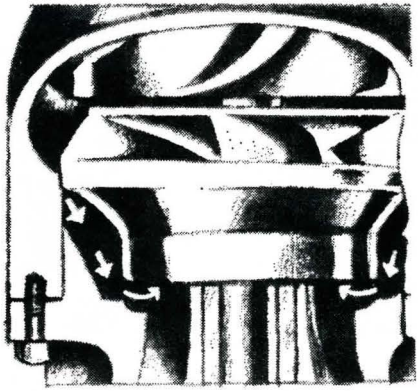


Figure 7. Leakage around impeller from poor adjustment.

With a bottom or end seal type, vertical adjustment does affect leakage. Leakage is controlled by lowering the impeller so the horizontal surfaces of the impeller eye and the bowl form a seal (Figure 7).

With an impeller with both side and bottom seal, vertical adjustment of the impeller does not affect leakage unless the side seal becomes worn by abrasive materials (sand in the water). Then vertical adjustment is important since the bottom seal will need to be used.

All types of impellers must be adjusted so that they do not drag on the top of the bowl when the pump is started, and do not drag on the bottom when operating under maximum head conditions.

Before you proceed—you must know the type of impeller and if it is to be adjusted from the top or bottom of the bowl. Refer to the serial number on pump head for your impeller type. Then see Table 3 to determine whether your pump is adjusted from the top or bottom of the bowl. Next, proceed directly to instructions in this circular for your bowl type.

IMPELLER ADJUSTMENT FROM TOP OF BOWL

Enclosed impellers with side seal only fall in this group.

1. Remove cover from the pump driver. This will expose the head shaft and adjusting nut.

2. Remove set screw or locking pin in adjusting nut. Check head shaft to determine if it has right or left hand threads. As you rotate the shaft, raise impellers by tightening the nut on top of the head shaft. Continue tightening the adjusting nut until impellers begin to drag on the top of the bowl. *Do not over tighten*—this could pull impellers from shaft.

3. After impellers begin to drag on the top of the bowl, lower by loosening the nut until the shaft will just turn free by hand. Repeat

this procedure several times to be sure of the position. Mark position of adjusting nut at this point.

4. Loosen the nut one full turn from position marked in Step 3 and replace set screw. Check operators manual for recommendations for any additional clearance recommended by the pump manufacturer.

5. Rotate impellers to make sure they are turning free before test running.

6. Operate pump. On units powered with internal combustion engines, start the pump slowly and increase speed gradually until desired speed and maximum pumping head are obtained. During this runup, listen and watch closely for unusual noises or vibrations. If they occur, shut down unit and recheck procedure for error. Observe pump operations until drawdown and discharge pressure are stabilized.

Recheck Setting of Impellers

The procedure described under adjustment from top of bowl should give maximum efficiency. However, impeller adjustment should be rechecked after about 50 hours of operation. Shaft couplings may have tightened during pumping, causing a shortening of the line shaft. In such cases, readjusting to original clearance may be required.

ADJUSTMENT FROM BOTTOM OF BOWL

Impellers which normally fall in this group are the semi-open, the enclosed with side and bottom seal, and the enclosed with bottom seal only. See Table 3 for information on pumps and impellers adjusted from the bottom.

Calculate Preliminary Impeller Adjustment

1. Impeller make and bowl number (check name plate on your pump).

2. Downthrust in pounds per feet of head (See Table 3).

3. Shaft diameter, and length (measure shaft diameter. For shaft length, see pump order sheet).

4. Total pumping head. Measure by checking:
   a. Lift (depth to water from pump head when pumping).
   b. Discharge pressure (from pressure gauge). Convert to feet of head by multiplying pounds of pressure by 2.31.
   c. Add the lift and discharge pressure to get the total pumping head.

5. Threads per inch of line shaft.

Here is an example of a preliminary adjustment.

1. Make—Peerless Bowl No. 12 MA
2. Downthrust in pounds per feet of head—10.5
3. Shaft diameter, 1 3/16″—175 feet long
4. Total pumping head
   a. Lift—159.5 ft. (depth to water when pumping)
   b. Discharge pressure—13.5 psi (read from gauge) (13.5 psi x 2.31 ft. head/psi) = 31.0 ft.
   c. Add lift (159.5 ft.) and discharge pressure (31.0 ft.) to get total pumping head—190.5 ft.
5. Threads per inch on head shaft—10 (by measurement).

Calculate Total Shaft Stretch

Hydraulic downthrust is the load which causes the line shaft to stretch. Various diameter shafts differ in the amount they will stretch under the same load. This stretch must be known before you can make proper adjustments.

Hydraulic downthrust is calculated by multiplying the total pumping head (Step 4 in example) by the downthrust in pounds per feet of head of bowl (Table 3). **Example:**

Total pumping head	190.5 ft. hd.
Downthrust	x10.5 lbs/ft. of head
Hydraulic Downthrust	2000 lbs.

Table 1 indicates that a shaft 1 3/16 inches in diameter will stretch 0.075 inches for each 100 feet in length from a hydraulic downthrust of 2000 pounds. Since the shaft in the example is 175 feet in length, then 1 3/4 times the stretch per 100 feet will give total shaft stretch. **Example:**

Line shaft is 175 ft. long	1.75 hundred ft.
Stretch per 100 ft.	x0.075 in/100 ft.
Total shaft stretch	0.131 inches

Calculate Turns of Adjusting Nut

Table 2 shows that ten threads per inch on the head shaft causes impeller to move 0.100 inches for one complete turn of nut.

Shaft stretch 0.131 inches ÷ 0.100 inches/turn = 1.3 turns on head nut.

Since the head shaft in the example has 10 threads per inch, then each turn of the nut on the top of the head shaft will raise the impeller 0.1 inches (Table 2). Then 1.3 turns will take care of line stretch in the example.

Table 1.—Shaft elongation in inches per 100 feet of shaft.[1]

Hydraulic thrust in pounds	Shaft-diameter in inches						
	3/4″	1″	1 3/16″	1 1/4″	1 7/16″	1 1/2″	1 11/16″
500	.047	.026	.019	.017	.013	.012	.009
600	.056	.032	.022	.020	.015	.014	.011
800	.075	.042	.030	.027	.020	.019	.015
1000	.094	.053	.037	.034	.025	.023	.018
1200	.112	.063	.045	.040	.031	.028	.022
1400	.131	.074	.052	.047	.036	.033	.026
1600	.150	.084	.060	.054	.041	.037	.030
1800	.169	.095	.067	.061	.046	.042	.033
2000	.187	.105	.075	.067	.051	.047	.037
2400	.225	.126	.090	.081	.061	.056	.044
2800	.262	.147	.105	.094	.071	.066	.052
3200		.169	.120	.108	.082	.075	.059
3600		.190	.134	.121	.092	.084	.067
4000		.211	.149	.135	.102	.094	.074
4400		.232	.164	.148	.112	.103	.081
4800		.253	.179	.162	.122	.112	.089
5200		.274	.194	.175	.133	.122	.096
5600			.209	.189	.143	.131	.104
6000			.224	.202	.153	.140	.111
6500			.243	.219	.166	.152	.120
7000			.261	.236	.178	.164	.129
7500				.253	.191	.176	.139
8000				.270	.204	.178	.148
9000				.303	.229	.211	.166
10000					.255	.234	.185
12000					.306	.281	.222
13000							.240
14000							.259
15000							.277

[1] Based on modules of elasticity of 30 x 10^{-6} for steel.

Table 2.—Inches impeller moves with various turns of adjusting nut on head shaft.

Threads per inch	1 Turn	1/2 Turn	1/4 Turn
8	0.125	0.063	0.032
10	0.100	0.050	0.025
12	0.083	0.042	0.021
14	0.071	0.036	0.018

Make Adjustment in Pump

1. Remove cover from the pump driver. This will expose the head shaft and adjusting nut.

2. Remove set screw of locking pin in adjusting nut. Check head shaft to determine if it has right or left hand threads. Lower impellers by loosening the adjusting nut on the top of the head shaft. Continue loosening the adjusting nut until the impeller rests on the bottom of the bowl. Shaft will not turn when impellers are resting on the bowl. (If the shaft does not lower after the nut has been loosened, it may

be necessary to hit the shaft on top. (Use wooden block to avoid damage to the threads.)

3. Raise impellers by tightening the adjusting nut until the shaft will just turn free by hand. Mark the position of adjusting nut at this point. Repeat the procedure several times to be sure of this position.

4. Tighten adjusting nut the amount calculated (in this example, 1.3 turns beyond the marked point). Check operators manual to be sure the calculated adjustments do not exceed manufacturers vertical bowl clearance. Tighten set screw. This will be the preliminary setting for the impellers.

5. Rotate impellers to make sure they are turning free before test running.

6. Operate the pump. On units powered with internal combustion engines, start the pump slowly and increase speed gradually until desired speed and maximum pumping head are obtained. During this runup, listen and watch closely for unusual noises or vibrations. If they occur, shut down unit and recheck procedure for error. Observe pump operation until drawdown and discharge pressure are stabilized.

On electrically powered units a gradual speed increase cannot be obtained, but you should listen and watch closely for unusual noises or vibrations.

Recheck Setting of Impellers

New pumping installations are usually pumped 50 to 100 hours before final impeller adjustments are made. This allows for the shaft couplings to tighten and most abrasives such as fine sands to be removed from the wells. On older installations, adjustments are made to correct for impeller and seal wear which might have decreased the efficiency of the pump.

1. Use the shaft elongation figures as determined under preliminary adjustment and make proper adjustment.

2. Unit should then be brought up to stabilized maximum head conditions and one or all of the following items observed after drawdown is stabilized.

   a. Discharge in gallons per minute for both engines and electric motors.

   b. Electrical imput if electric motor used. Use stop watch and count revolutions of electric meter; or use the clip-on ammeter for indicating the change in power requirement.

3. Stop pump and make a slight change of impeller setting by lowering 1/6 turn on adjusting nut.

4. Start pump and check for abnormal sounds or vibrations. Stop unit immediately if abnormal sounds or vibrations occur. A sound detecting device similar to the stethoscope is useful.

5. Repeat procedures described under Step 2. Maximum efficiency setting will be reached just before a sharp increase in noise level (determined by a sounding device) or a sudden increase in power requirement. This impeller setting will also give the greatest gpm and highest total head.

The imput horsepower curve in Figure 1 illustrates this sudden increase in horsepower requirements. In this case, when the semi-open impeller was set too close (dragging on the bottom) power requirements jumped with no increase in pump discharge capacity.

FREQUENCY OF ADJUSTMENT

On new pumping installations, preliminary adjustments should be made when the new pump is installed. The recheck adjustment is then made after the unit has operated from 50 to 100 hours. Annual rechecks should be made until the pump and well have been stabilized.

On older installations, adjusting may help return the pump to original efficiency. The frequency of adjustment of older pumps will depend upon the amount of abrasive material being carried in the water. Some pumps in Nebraska operating in sand-free water have retained their original efficiency after 9000 hours of pumping.

If for some reason major increases in head are planned, new adjustments must be made with pumps which have impellers adjusted from the bottom.

DIAGNOSIS OF IMPELLER DAMAGE

When the bowl assembly is removed for repairs, impellers should be inspected to see if they were damaged because of incorrect adjustment. It may be necessary to have the pump redesigned to remove the causes of the damage.

Top damage may be caused by the shaft coupling tightening during pumping, or may be due to improper original adjustment. In some cases, momentary upthrust when starting the pump may cause the failure. A special thrust bearing must be used to provide thrust protection in these pumps.

Bottom damage may be due to errors in calculating shaft elongations. Bottom damage may also be due to increases in total pumping head over what had been used in the original design and adjustments. The increase in head may be caused by using a higher pump speed; a lowering of water table in the well; or a change from the original discharge systems.

A common change is the addition of a gated pipe distribution system to a pump which was designed for open discharge.

Also, over-pumping of a well can start sand pumping which will damage both the seals and impeller vanes.

Table 3.—Hydraulic downthrust, impeller types, impeller adjustments, various impellers.

Bowl No.	Downthrust in pounds per ft. of head (peak efficiency)	Impeller type	Method of adjustment
	A & C Pump[1]		
7 HC	5.0	Enclosed	Bottom
8 HC	6.3	Enclosed	Bottom
10 HC	9.3	Enclosed	Bottom
10 HCB	12.6	Enclosed	Bottom
12 HC	12.0	Enclosed	Bottom
12 HCB	16.0	Enclosed	Bottom
14 HC	19.6	Enclosed	Bottom
	Berkeley[2]		
803,L,LL,M,H	3.64	Enclosed	Bottom
804,L,M	3.64	Enclosed	Bottom
804 H	4.93	Enclosed	Bottom
805-M,H	7.52	Enclosed	Bottom
1001 LL	2.08	Enclosed	Bottom
1001-L,M,H	4.06	Enclosed	Bottom
1002 M	6.13	Enclosed	Bottom
1003 LL	3.38	Enclosed	Bottom
1003-L,LM,MLL,M,H	9.50	Enclosed	Bottom
1004-M,H	9.92	Enclosed	Bottom
1202-L,M,H	8.98	Enclosed	Bottom
1203-L	8.98	Enclosed	Bottom
1203-M,H	13.0	Enclosed	Bottom
1203-HH	15.48	Enclosed	Bottom
1204-M	14.13	Enclosed	Bottom
1205-H	14.13	Enclosed	Bottom
1403-L	15.48	Enclosed	Bottom
1403-M,H,HH	19.10	Enclosed	Bottom
1404-H	19.10	Enclosed	Bottom
1603-L,H	27.78	Enclosed	Bottom
8 K3L	5.28	Semi-open	Bottom
8 K4M	5.36	Semi-open	Bottom
8 K4H	5.50	Semi-open	Bottom
8 K4HH	5.59	Semi-open	Bottom
8 K5M	5.65	Semi-open	Bottom
8 K5H	5.89	Semi-open	Bottom
10 K1M	9.40	Semi-open	Bottom
10 K1H	8.70	Semi-open	Bottom
10 K2M	9.08	Semi-open	Bottom
10 K2H	9.18	Semi-open	Bottom
10 K3M	9.95	Semi-open	Bottom
10 K3MH	10.4	Semi-open	Bottom
10 K3H	10.6	Semi-open	Bottom
10 K4H	10.2	Semi-open	Bottom
12 K2L,M	12.7	Semi-open	Bottom
12 K2H	13.3	Semi-open	Bottom
12 K3M	12.5	Semi-open	Bottom
12 K3H	12.2	Semi-open	Bottom
12 K4M	14.3	Semi-open	Bottom
12 K5H	14.4	Semi-open	Bottom
14 K3M	17.0	Semi-open	Bottom
14 K3H	17.9	Semi-open	Bottom
14 K3HH	18.1	Semi-open	Bottom

Table 3.—(continued)

Bowl No.	Downthrust in pounds per ft. of head (peak efficiency)	Impeller type	Method of adjustment
	Fairbanks-Morse[5]		
8 HC	6.0	Enclosed	Top
10 MC	7.0	Enclosed	Top
10 XHC	7.5	Enclosed	Top
12 MC	10.5	Enclosed	Top
12 HC	13.0	Enclosed	Top
12 XHC	12.0	Enclosed	Top
14 MC	14.0	Enclosed	Top
14 HC	18.5	Enclosed	Top
14 XHC	20.0	Enclosed	Top
16 MC	19.0	Enclosed	Top
8 XLC	5.0	Semi-open	Bottom
8 LC	6.0	Semi-open	Bottom
8 MC	6.7	Semi-open	Bottom
8 HC	7.2	Semi-open	Bottom
10 XLC	8.2	Semi-open	Bottom
10 LC	9.0	Semi-open	Bottom
10 MC	9.3	Semi-open	Bottom
10 HC	10.6	Semi-open	Bottom
12 LC	13.2	Semi-open	Bottom
12 MC	13.4	Semi-open	Bottom
12 HC	15.5	Semi-open	Bottom
14 LC	17.6	Semi-open	Bottom
14 MC	18.5	Semi-open	Bottom
14 HC	21.5	Semi-open	Bottom
	Layne Bowler (California)[4]		
8 EL	3.23	Enclosed	Bottom
8 TL	4.62	Enclosed	Bottom
8 ED	4.0	Enclosed	Bottom
8 EX	4.1	Enclosed	Bottom
8 EH	5.27	Enclosed	Bottom
8 C	7.56	Enclosed	Bottom
8 FH	7.95	Enclosed	Bottom
8 GH	8.0	Enclosed	Bottom
10 EXL	5.27	Enclosed	Bottom
10 EH	7.29	Enclosed	Bottom
10 R	8.34	Enclosed	Bottom
10 JK	12.18	Enclosed	Bottom
10 FH	14.1	Enclosed	Bottom
12 EL	6.86	Enclosed	Bottom
12 EH	9.28	Enclosed	Bottom
12 R	11.7	Enclosed	Bottom
12 KH	14.75	Enclosed	Bottom
12 FH	16.5	Enclosed	Bottom
14 TM	13.0	Enclosed	Bottom
14 KH	19.0	Enclosed	Bottom
14 R	19.0	Enclosed	Bottom
14 MS	26.2	Enclosed	Bottom
14 FH	28.9	Enclosed	Bottom
16 AX	11.35	Enclosed	Bottom
16 EH	19.0	Enclosed	Bottom
16 KH	25.8	Enclosed	Bottom
16 FH	39.4	Enclosed	Bottom

Table 3.—(continued)

Bowl No.	Downthrust in pounds per ft. of head (peak efficiency)	Impeller type	Method of adjustment
Layne Bowler (Memphis)[5]			
8 DRLC-DRHC	3.0	Enclosed	Top
8 PRHC	4.0	Enclosed	Top
8 RKLC-RKHC	4.0	Enclosed	Top
8 THC	7.0	Enclosed	Top
10 UHC	5.5	Enclosed	Top
10 RKLC-RKHC	6.0	Enclosed	Top
10 TLC	8.5	Enclosed	Top
10 THC	8.5	Enclosed	Top
12 RKAM	7.5	Enclosed	Top
12 URHC	5.0	Enclosed	Top
12 RKLC	9.0	Enclosed	Top
12 WMC	8.0	Enclosed	Top
12 TLC	13.0	Enclosed	Top
12 THC	13.0	Enclosed	Top
14 THC	19.0	Enclosed	Top
14 TLC	19.0	Enclosed	Top
14 RKLC-RKHC	16.0	Enclosed	Top
14 WMC	13.0	Enclosed	Top
14 WHC	13.0	Enclosed	Top
15 RMC	18.0	Enclosed	Top
15 RKHC	16.0	Enclosed	Top
15 DRLC-DRHC	12.0	Enclosed	Top
15 SKHC	17.0	Enclosed	Top
Peerless[6]			
8 LA	3.7	Enclosed	Bottom
8 MA	5.6	Enclosed	Bottom
8 HX	8.4	Enclosed	Bottom
10 LA	5.1	Enclosed	Bottom
10 MA	7.6	Enclosed	Bottom
10 HXB	8.3	Enclosed	Bottom
12 LA	6.9	Enclosed	Bottom
12 MA	10.5	Enclosed	Bottom
12 HXA	15.6	Enclosed	Bottom
14 LA	9.7	Enclosed	Bottom
14 MA	13.5	Enclosed	Bottom
14 HXB	17.3	Enclosed	Bottom
16 M	18.2	Enclosed	Bottom
16 MA	22.6	Enclosed	Bottom
16 HXX	24.0	Enclosed	Bottom
Western Land Roller[7]			
8 A-H	7.4	Semi-open	Bottom
8 A-M	6.0	Semi-open	Bottom
10 C-H	11.3	Semi-open	Bottom
10 C-M	7.7	Semi-open	Bottom
10 D-H	15.5	Semi-open	Bottom
10 D-M	15.5	Semi-open	Bottom
12 B-H	13.9	Semi-open	Bottom
12 C-H	12.5	Semi-open	Bottom
12 C-M	11.0	Semi-open	Bottom
12 D-H	23.0	Semi-open	Bottom

Table 3.—(continued)

Bowl No.	Downthrust in pounds per ft. of head (peak efficiency)	Impeller type	Method of adjustment
12 X-H	12.6	Semi-open	Bottom
14 C-H	18.0	Semi-open	Bottom
14 C-M	13.7	Semi-open	Bottom
14 D-H	30.2	Semi-open	Bottom
14 D-M	30.2	Semi-open	Bottom
16 O-H	33.2	Semi-open	Bottom
	Worthington[8]		
8-100 & 125	4.3	Enclosed	Bottom
8-120	4.4	Enclosed	Bottom
8-150 & 200	6.8	Enclosed	Bottom
8-225	7.2	Enclosed	Bottom
8-250,300 & 350	9.4	Enclosed	Bottom
10-50 & 80	4.6	Enclosed	Bottom
10-100	5.7	Enclosed	Bottom
10-175,225,250,300 & 302,350,352 & 400	6.9	Enclosed	Bottom
10-402	10.3	Enclosed	Bottom
10-450,500,502,550	12.0	Enclosed	Bottom
10-600	14.2	Enclosed	Bottom
10-602	15.6	Enclosed	Bottom
12-250,300, & 350	6.3	Enclosed	Bottom
12-252	5.7	Enclosed	Bottom
12-352,400 & 450	8.0	Enclosed	Bottom
12-425,500#1	7.7	Enclosed	Bottom
12-500#2	9.1	Enclosed	Bottom
12-503,503-602,602	10.5	Enclosed	Bottom
12-600 & 700	11.0	Enclosed	Bottom
12-900	17.8	Enclosed	Bottom
12-1000	19.2	Enclosed	Bottom
12-1200	21.8	Enclosed	Bottom
14-250 & 300	8.4	Enclosed	Bottom
14-400,500 & 600	8.2	Enclosed	Bottom
14-700,800,900	14.9	Enclosed	Bottom
14-850,1100	13.4	Enclosed	Bottom
14-1000,1200, & 1202	19.9	Enclosed	Bottom
14-1400 & 1600	26.4	Enclosed	Bottom
16-450,500,650 & 750	5.7	Enclosed	Bottom
16-800	12.0	Enclosed	Bottom
16-1125, & 1350	17.3	Enclosed	Bottom
16-1250 & 1500	18.5	Enclosed	Bottom
16-1750	24.8	Enclosed	Bottom
16-2250	32.8	Enclosed	Bottom

[1] From A & C Deep Well Turbine Pumps, Lubbock, Texas.

[2] Technical Data 5055, Page 7, Berkeley Pump Company, Berkeley, California.

[3] Engineering Data, Fairbanks-Morse Irrigation Pump Division, Kansas City, Kansas.

[4] Reprinted from Sec. 31, Page 2, Engineering Data, Layne-Bowler Pump Company, Los Angeles, 22 California.

[5] Reprinted from Engineering Data, Layne-Bowler Inc., Memphis, Tennessee.

[6] Sec. 110, Page 6, Peerless Pump Division, Food Machinery and Chemical Corporation, Los Angeles, California.

[7] Reprinted from Bulletin E 1-2-62, Engineering Information, Western Land Roller Company, Hastings, Nebraska.

[8] Reprinted from Engineering Data, Worthington Pump Corporation, Denver, Colorado.