PENTAIR FAIRBANKS NIJHUIS

FM-01-5001 (10-15-2022)

PROPELLER PUMPS

8000 SERIES

APPLICATION & REFERENCE DATA GUIDE

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GENERAL DATA

GENERAL

Axial and Mixed Flow Propeller pumps are designed to perform many duties requiring the movement of a high volume of water at a low discharge pressure. Because of this they have been used extensively for Municipal, Government, Industrial, and Irrigation applications. Service duties have included effluent handling, raw water intake, dewatering, reclamation, flood control and storm water removal, to name a few.

Hydraulically, the primary differences between Axial and Mixed flow impellers are N_S (specific speed) range at BEP (best efficiency point) and impeller discharge angle. Specific speed is a method of classifying impeller types and is defined as the speed in RPM at which a given impeller would operate if reduced proportionately in speed so as to deliver a capacity of 1 GPM against a total dynamic head of 1 foot. Specific speed is designated as N_S and calculated by:

$$N_S = \frac{RPM \times \sqrt{Q}}{(H^{3/4})}$$

Mixed flow pumps generally have an N_S range from 4500 to 8000. Axial flow pumps generally start at 8000 and go up.

Water enters the Mixed flow impeller parallel to the shaft and exits from the vane at a 45° to 80° angle from the shaft axis. Energy is imparted to the fluid pumped by a combination of centrifugal force and axial displacement. In the case of Axial flow units, the water enters and exits the impeller vane in a plane parallel to the shaft axis. Energy is thus imparted to the fluid by axial displacement.

A Propeller Pump consists of the following major components:

The Bowl Assembly, which includes a suction case, intermediate bowl (in the case of multi-stage units), discharge case, propellers, bowl shaft and bearings.

The Column Assembly, which includes the Pipe to direct the fluid and support the Bowl Assembly and the Lineshaft which transmits energy from the driver to the bowl shaft.

The Discharge Elbow, which provides an exit for the fluid and a connecting point for the discharge piping. Discharge Elbows can be of the above or below ground design with either a flanged or plain end (for compression type couplings) connection.

Drivers that can be used as power sources for Propeller Pumps include squirrel cage or wound rotor electric motors, hydraulic or magnetic clutch couplings, and engines or steam turbines used with right angle gears.

PUMP COMPONENT SIZE DATA CHART

The following tables cover component sizing of the Fairbanks Nijhuis™ 8211 Axial flow and 8312 Mixed flow propeller pumps.

8211

Bowl Assembly			Column		Lineshaft	Enclosing Tube		Discharge Elbows							
										Above Ground			Below Ground		
										Cast Iron	Fabricated Steel		Fabricated Steel		
Pump Size (Inches)	Number Of Stages	Pumpshaft Diameter (Inches)	Nominal Size (Inches)	Connection Type	Lineshaft Diameter (Inches)	Intermediate And Top (Inches)	Bottom (Inches)	Standard Motor B.D.	Discharge Size (Inches)	Flanged	Flanged	Plain End	Flanged	Plain End	Riser Size (Inches)
12	1	1 7/16	12	Thd.	1	1 1/2	2 1/2	16 1/2	12	Std.	Opt.	Opt.	Std.	Opt.	12
	2	1 7/16	12	Thd.	1 1/4	2	2 1/2	16 1/2	12	Std.	Opt.	Opt.	Std.	Opt.	12
20	1	1 15/16	20	Flg.	1 11/16	2 1/2	3	16 1/2	20	NA	Std.	Opt.	Std.	Opt.	16
	2	1 15/16	20	Flg.	1 15/16	3	3	20	20	NA	Std.	Opt.	Std.	Opt.	16
24	1	2 3/16	24	Flg.	1 15/16	3	3	20	24	NA	Std.	Opt.	Std.	Opt.	24
	2	2 3/16	24	Flg.	2 3/16	3	3	24 1/2	24	NA	Std.	Opt.	Std.	Opt.	24
30	1	2 7/16	30	Flg.	2 3/16	3	3 1/2	24 1/2	30	NA	Std.	Opt.	Std.	Opt.	30
	2	2 7/16	30	Flg.	2 7/16	3 1/2	3 1/2	24 1/2	30	NA	Std.	Opt.	Std.	Opt.	30
36	1	2 15/16	36	Flg.	2 7/16	3 1/2	5	24 1/2	36	NA	Std.	Opt.	Std.	Opt.	36
	2	2 15/16	36	Flg.	2 15/16	5	5	30 1/2	36	NA	Std.	Opt.	Std.	Opt.	36

8312

Bowl Assembly			Column		Lineshaft	Enclosing Tube		Discharge Elbows							
										Above Ground			Below Ground		
										Cast Iron	Fabricated Steel		Fabricated Steel		
Pump Size (Inches)	Number Of Stages	Pumpshaft Diameter (Inches)	Nominal Size (Inches)	Connection Type	Lineshaft Diameter (Inches)	Intermediate And Top (Inches)	Bottom (Inches)	Standard Motor B.D.	Discharge Size (Inches)	Flanged	Flanged	Plain End	Flanged	Plain End	Riser Size (Inches)
10	1	1 3/16	10	Thd.	1	1 1/2	2	12	10	Std.	Opt.	Opt.	Std.	Opt.	8
			12	Thd.					12	Std.	Opt.	Opt.	Std.	Opt.	12
	2	1 3/16	10	Thd.	1 1/4	2	2	16 1/2	10	Std.	Opt.	Opt.	Std.	Opt.	8
			12	Thd.					12	Std.	Opt.	Opt.	Std.	Opt.	12
12	1	1 7/16	12	Thd.	1	1 1/2	2 1/2	16 1/2	12	Std.	Opt.	Opt.	Std.	Opt.	12
			14	Thd.					14	Std.	Opt.	Opt.	Std.	Opt.	12
	2	1 7/16	12	Thd.	1 1/4	2	2 1/2	16 1/2	12	Std.	Opt.	Opt.	Std.	Opt.	12
			14	Thd.					14	Std.	Opt.	Opt.	Std.	Opt.	12
14	1	1 11/16	14	Thd.	1 1/2	2 1/2	2 1/2	16 1/2	14	Std.	Opt.	Opt.	Std.	Opt.	12
			16	Flg.					16	NA	Std.	Opt.	Std.	Opt.	16
	2	1 11/16	14	Thd.	1 11/16	2 1/2	2 1/2	16 1/2	14	Std.	Opt.	Opt.	Std.	Opt.	12
			16	Flg.					16	NA	Std.	Opt.	Std.	Opt.	16
16	1	1 11/16	16	Flg.	1 1/2	2 1/2	2 1/2	16 1/2	16	NA	Std.	Opt.	Std.	Opt.	16
			20	Flg.					20	NA	Std.	Opt.	Std.	Opt.	16
	2	1 11/16	16	Flg.	1 11/16	2 1/2	2 1/2	20	16	NA	Std.	Opt.	Std.	Opt.	16
			20	Flg.					20	NA	Std.	Opt.	Std.	Opt.	16
20	1	1 15/16	20	Flg.	1 11/16	2 1/2	3	16 1/2	20	NA	Std.	Opt.	Std.	Opt.	16
			24	Flg.					24	NA	Std.	Opt.	Std.	Opt.	24
	2	1 15/16	20	Flg.	1 15/16	3	3	24 1/2	20	NA	Std.	Opt.	Std.	Opt.	16
			24	Flg.					24	NA	Std.	Opt.	Std.	Opt.	24
24	1	2 7/16	24	Flg.	2 3/16	3	3 1/2	24 1/2	24	NA	Std.	Opt.	Std.	Opt.	24
			30	Flg.					30	NA	Std.	Opt.	Std.	Opt.	30
	2	2 7/16	24	Flg.	2 7/16	3 1/2	3 1/2	24 1/2	24	NA	Std.	Opt.	Std.	Opt.	24
			30	Flg.					30	NA	Std.	Opt.	Std.	Opt.	30
30	1	2 15/16	30	Flg.	2 7/16	3 1/2	5	30 1/2	30	NA	Std.	Opt.	Std.	Opt.	30
			36	Flg.					36	NA	Std.	Opt.	Std.	Opt.	36
	2	2 15/16	30	Flg.	2 15/16	5	5	30 1/2	30	NA	Std.	Opt.	Std.	Opt.	30
			36	Flg.					36	NA	Std.	Opt.	Std.	Opt.	36

FACTORS AFFECTING PERFORMANCE

Fairbanks Nijhuis™ propeller pump performance curves reflect total pump performance.

The performance curves shown for these pumps include the effects of the following items:

1. Hydraulic friction loss through 10 feet of column pipe.
2. Hydraulic friction loss through the standard discharge head (elbow loss).
3. Mechanical friction loss of 10 feet of lineshafting.
4. Velocity head existing at the discharge head flange. $\left(\frac{V^2}{2g}\right)$

To properly select a propeller pump, these factors must be compared to the specification requirements. If the overall column length required exceeds 10 feet, then additional column losses must be calculated and added to the head required by the specification.

Performance curves for specific sizes are based on the use of cast iron discharge heads. If the specifications require a fabricated above ground or below ground discharge elbow, additional head losses must be added to the total pump head required by the specifications. Unless the specifications state that velocity head has been included, it must be added to the total pump head required to properly select a propeller pump.

Many specified operating points require the use of two stage pumps when the conditions fall between two different impellers. When this occurs, the different impellers may be mixed to achieve the required performance.

Total pump thrust will not affect the performance of the pump but may affect the performance of the pump driver. The driver manufacturer must be informed of the thrust value. A general rule for angular contact ball bearings is that for each 1000 pounds of thrust load carried, the bearing will take .0075 HP per 100 RPM. Therefore, for 10,000 pounds of thrust at 1000 RPM, the bearing will consume .75 HP. This is internal to the driver and will reduce the output horsepower by this amount, thereby reducing the driver efficiency.

The above factor affects the head, capacity, efficiency, and horsepower shown on the performance curve. The method of properly matching requirements of specifications to Fairbanks Nijhuis performance curves will be demonstrated in the example selection section.

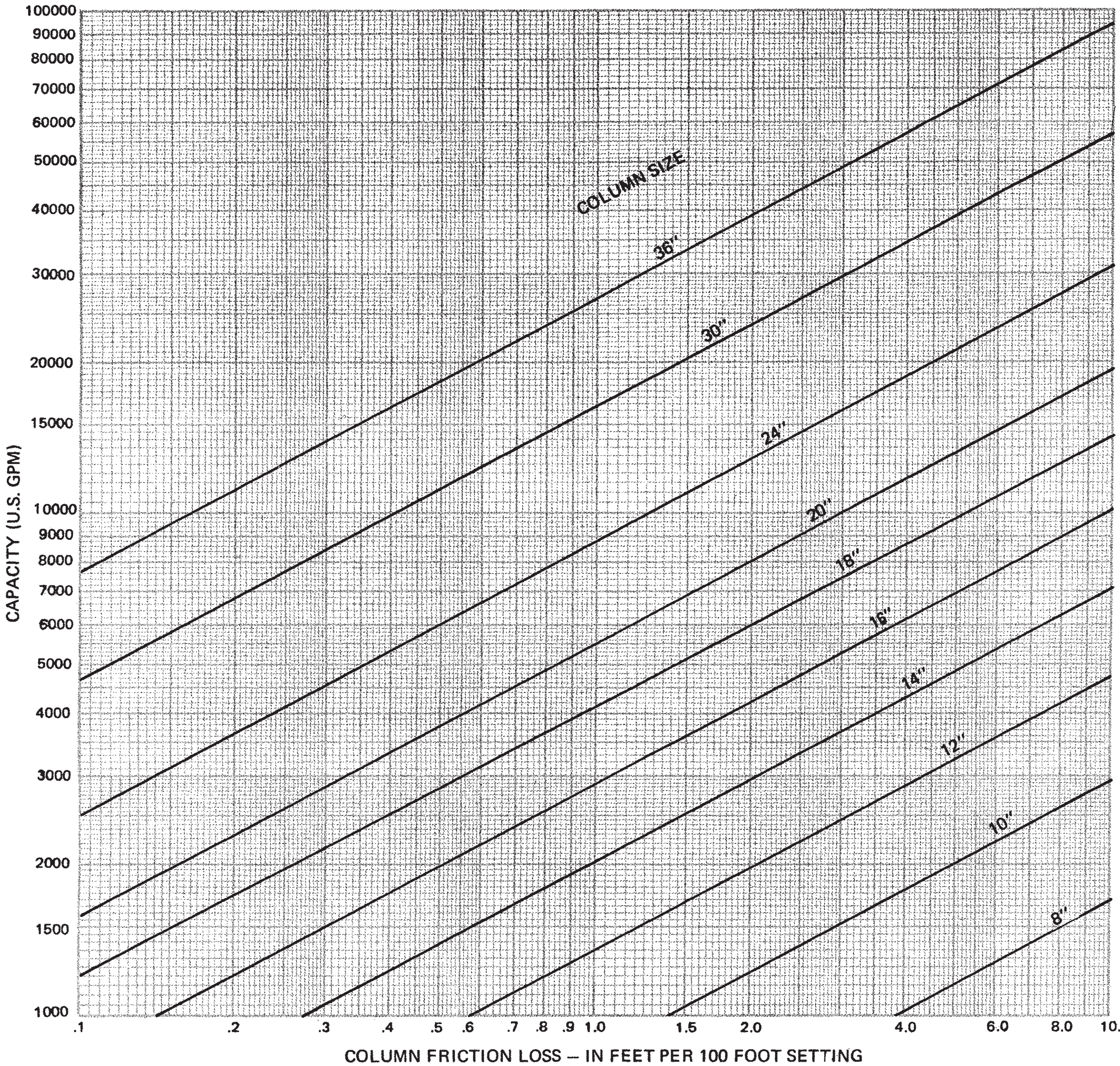
The following pump design factors must be considered if a proper application and installation is to be achieved:

Surface and below ground discharge elbows - The surface elbow and the pedestal used with the below ground elbow are designed to support the pump and driver when mounted on the pump room floor. This floor must support the base on all four sides.

Pump operation - These units are designed to operate over the capacity ranges shown on the performance curves. Operation to the left of capacities shown will result in unstable pump operation since the pump would be operating in the dog leg. Operation to the left also will drastically increase the horsepower requirements of the pump, possibly exceeding design limits.

Pump position within the sump - In order for these pumps to operate satisfactorily the intake design must be correct, and the positioning of the pump in the intake must be proper. For an intake of standard design, recommended basic positioning dimensions are shown on the dimension drawings. For non-standard designs refer to page 253 covering intake design.

COLUMN FRICTION LOSS CHART



BHP LOSS CHART

Shaft Diameter	LINESHAFT LOSS CHART HORSEPOWER LOSS PER 100 FEET OF SETTING										
	SPEED (RPM)										
	3600	2900	1800	1500	1200	1000	900	750	720	600	514
1″	1.10	.88	.55	.45	.35	.30	.27	—	—	—	—
$1\frac{1}{4}$″	1.50	1.35	.81	.68	.52	.44	.40	—	—	—	—
$1\frac{1}{2}$″	2.30	1.90	1.20	.96	.75	.60	.55	—	—	—	—
$1\frac{11}{16}$″	2.80	2.40	1.40	1.20	.94	.78	.70	.60	.55	.49	—
$1\frac{15}{16}$″	3.70	3.10	1.90	1.60	1.20	1.00	.90	.79	.72	.63	—
$2\frac{3}{16}$″	—	—	2.30	2.00	1.50	1.40	1.30	1.20	1.10	.80	—
$2\frac{7}{16}$″	—	—	2.90	2.40	1.90	1.60	1.40	1.30	1.20	.96	.88
$2\frac{11}{16}$″	—	—	3.40	2.90	2.30	1.90	1.70	1.60	1.50	1.30	1.10
$2\frac{15}{16}$″	—	—	4.10	3.50	2.70	2.30	2.00	1.80	1.70	1.40	1.10
$3\frac{3}{16}$″	—	—	5.20	4.30	3.40	2.80	2.50	2.10	2.00	1.70	1.50
$3\frac{7}{16}$″	—	—	6.00	4.80	3.90	3.30	3.00	2.40	2.30	1.90	1.70
$3\frac{11}{16}$″	—	—	7.00	5.90	4.50	3.80	3.50	2.80	2.70	2.20	1.90
4″	—	—	—	—	5.40	4.40	4.00	3.30	3.10	2.50	2.30
$4\frac{1}{2}$″	—	—	—	—	—	5.40	5.00	4.10	3.90	3.30	2.80
5″	—	—	—	—	—	—	—	5.00	4.70	4.00	3.50

HEAD LOSS TABLE

Performance curves for the following pumps are based on a cast iron surface discharge head.

12" - 8211
10" - 8312 - 10" and 12" Column
12" - 8312 - 12" and 14" Column
14" - 8312 - 14" Column Only

The cast iron surface discharge heads are limited to the capacities as shown in this table.

Discharge Size (Inches)	Maximum Capacity (GPM)
8	2200
10	3400
12	5000
14	6000

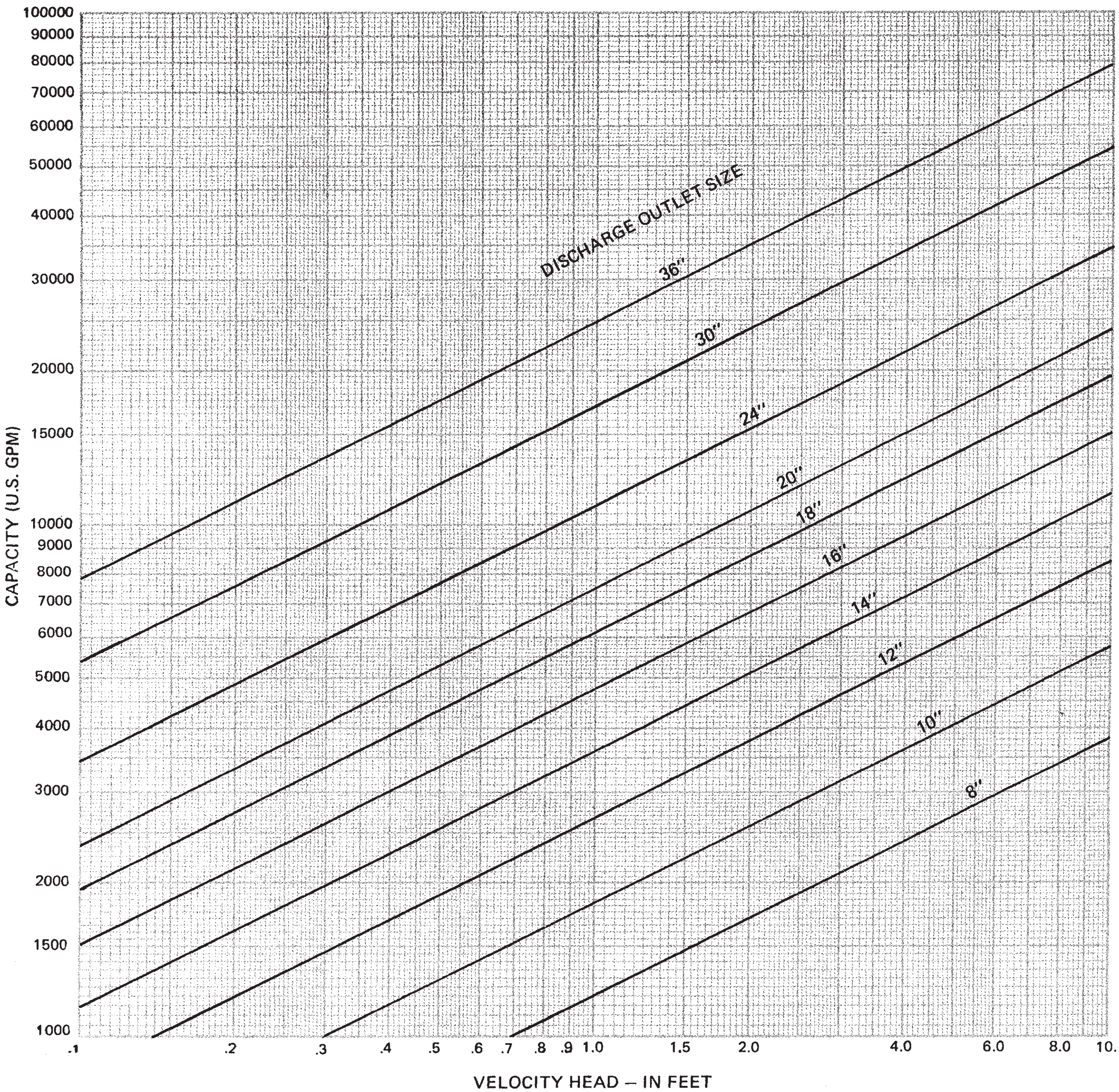
On these pumps when a fabricated steel above ground discharge head or below ground elbow is used, additional friction losses occur through the elbow. The performance curve pump total head must be reduced by the values shown in the table below. This additional head loss incurred by the use of the fabricated head will also reduce the pump efficiency by the ratio of the calculated pump total head/curve pump total head.

$$\text{Adjusted Pump Efficiency} = \frac{\text{Calculated Adjusted Pump Head}}{\text{Curve Pump Total Head}} \times \text{Curve Pump Efficiency}$$

Flow (GPM)	Column Size (1)			
	8"	10"	12"	14"
600	.056	-	-	-
800	.125	.040	-	-
1000	.190	.081	-	-
1250	.260	.135	.055	-
1500	.280	.200	.100	.050
1750	.270	.245	.145	.080
2000	.200	.255	.190	.115
2250	.050	.255	.230	.145
2500	-	.240	.250	.175
3000	-	.200	.270	.220
3500	-	.050	.265	.260
4000	-	-	.235	.275
4500	-	-	.150	.270
5000	-	-	.050	.220
5500	-	-	-	.110
6000	-	-	-	.050

1. For capacities where no head loss is shown, use head as found on the performance curve. Horsepower will not be affected.

VELOCITY HEAD CHART



TERMINOLOGY AND EQUATIONS

1. Pump Head - The pump head equals the static lift (H_{sl}) below the centerline of the discharge pipe, plus the required head (H_r) above the discharge. The head above the discharge must include any friction losses (H_l) through the discharge piping and fittings.

$$\text{Static Head} = H_{sl} + H_r$$
$$\text{Pump Head} = \text{Static Head} + H_l$$

2. Velocity Head $\left(\frac{V^2}{2g}\right)$ - The velocity head is dependent on the flow rate and the inside diameter of the discharge elbow. This value can be taken from the chart or calculated from the following equation:

$$V = \frac{\text{Flow (GPM)} \times .321}{\frac{\pi D^2}{4}}$$

$$H_v = \frac{V^2}{2 \times 32.2}$$

3. Pump Total Head (Total Dynamic Head) - The total head is the net change in energy of the fluid being pumped through the pump. This change in energy is expressed in terms of how high the fluid has been lifted and how fast the fluid is traveling at that point; and is the combination of items 1 and 2.

$$\text{Pump Total Head} = \text{Pump Head} + \text{Velocity Head}$$
$$= H_{sl} + H_r + H_l + \frac{V^2}{2g}$$

Pump Total Head is the head shown on the pump performance curves.

4. Pump Efficiency - This value is read directly from the performance curves and as the term implies is a measure of the operating efficiency of the pump.

$$\text{Efficiency} = \frac{\text{Total Head x Flow (GPM)}}{\text{3960 x Brake Horsepower}}$$

As will be shown in the example, changes to any or all of the terms defining efficiency will change the value of the pump efficiency.

5. Brake Horsepower - This is the horsepower required at the top shaft of the pump to produce the desired head and capacity.

$$\text{Brake Horsepower} = \frac{\text{Total Head x Flow (GPM)}}{\text{3960 x Pump Efficiency}}$$

Again, as in the case of efficiency, any change to any or all of the terms defining horsepower will change the value of horsepower.

6. Total Pump Thrust - This is the load that must be carried by the thrust bearing of the pump driver, electric motor, or gear drive. This thrust is composed of the weight of the rotating parts plus the hydraulic loading on these parts.

$$\text{Total Pump Thrust} = \text{Total Head} \times K_t + K_a + \text{Setting (In Feet)} \times K_s$$

Where K_t = Hydraulic thrust constant; K_a = Pump rotor weight; and K_s = Lineshaft weight per foot.

7. Overall Efficiency - This is the combined pump and motor efficiency and is sometimes called wire to water efficiency.

$$\text{Overall Efficiency} = \text{Motor Efficiency} \times \text{Pump Efficiency}$$

Note: If there is a gear drive between the motor and pump, the gear efficiency would be included in the equation.

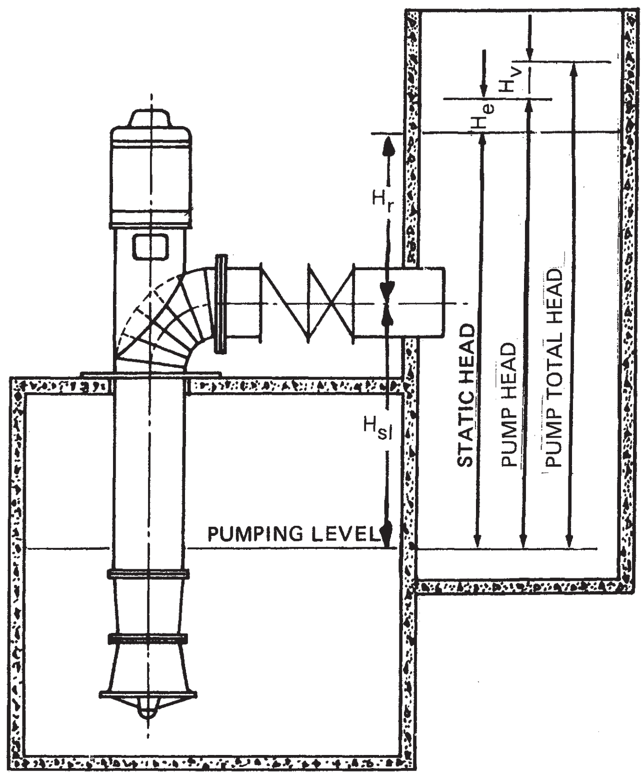
8. Input Horsepower - This is the total power used to operate the pump and motor.

$$\text{Input Horsepower} = \frac{\text{Brake Horsepower (Required at Motor Shaft)}}{\text{Motor Efficiency}}$$

9. Pump Field Efficiency - Pump efficiency shown on the performance curves is based on losses for 10 feet of column and lineshaft and the indicated elbow. Increased column and lineshaft lengths and changes in elbow type will effect the pump efficiency. The Pump Field Efficiency correction is calculated by use of the following formula:

$$\text{Pump Field Efficiency} = \frac{\text{Rated GPM x (Performance Curve Head} - \text{Additional Column Losses} - \text{Fabricated Elbow Loss)}}{\text{3960 x (Curve HP at Rated GPM} + \text{Lineshaft HP Loss)}}$$

TOTAL DYNAMIC HEAD DIAGRAM



H_e = FRICTION LOST THROUGH DISCHARGE LINE AND FITTINGS

H_v = VELOCITY HEAD AT PUMP DISCHARGE ELBOW

INTAKE DESIGN

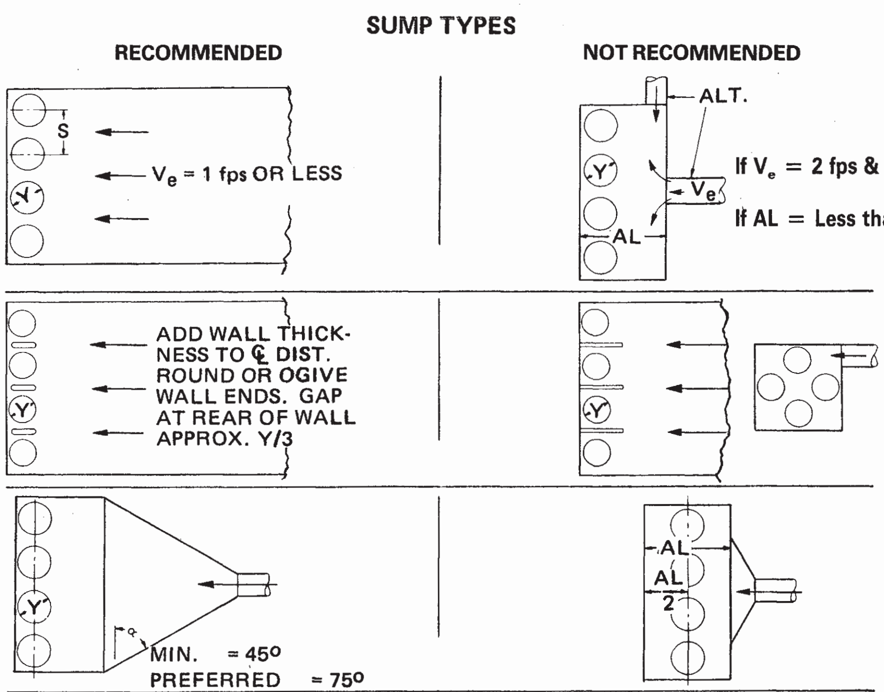
The function of the intake, whether it be an open channel or a tunnel having 100 per cent wetted perimeter, is to supply an evenly distributed flow of water to the suction bell. The geometry of the intake, combined with other factors listed in this section determine the intake flow pattern. An uneven distribution of flow, characterized by strong local currents, favors formation of vortices and with certain low values of submergence will introduce air into the pump with reduction of capacity, accompanied by noise and vibration. Uneven distribution can also increase or decrease the power comsumption with a change in total developed head. There can be vortices which do not appear on the surface, and these also may have adverse effects.

Calculated low average velocity is not always a proper basis for judging the excellence of an intake. High local velocities in currents and in swirls may be present in intakes which have very low average velocity. Indeed, the uneven distribution which they represent occurs less in a higher velocity flow with sufficient turbulence to discourage the gradual build up of a larger and larger vortex in any region. Numbers of small surface eddies may be present without causing any trouble.

The ideal approach is a straight channel coming directly to the pump. Turns and obstructions are detrimental since they may cause eddy currents and tend to initiate deep-cored vortices.

Water should not flow past one pump to reach the next if this can be avoided. If the pumps must be placed in line of flow, it may prove necessary to construct an open front cell around each pump or to put turning vanes under the pump to deflect the water upward.

All possible streamlining should be used to reduce the trail of alternating vortices in the wake of the pump or of other obstructions in the stream flow.



Numerous requests are received by Fairbanks Nijhuis™ to approve intake designs. It is the policy of Fairbanks Nijhuis to review plans submitted and give comments and/or suggestions but not to approve such plans for a specific installation. No charge will be made for such a review and we will accept no responsibility or liability for pump performance on any given pump intake structure. We recommend this type of request be referred to a consulting engineer for their analysis, lay-out and final approval.

PUMP LOCATION AND SUBMERGENCE

PUMP LOCATION

The position of the pump in the sump is a critical factor if satisfactory pump operation is to occur. The first of these position-related dimensions is the space from the sump floor to the bottom of the pump suction bell (refer to 'X' on the dimension drawings). This spacing can vary slightly, but the recommended values shown on the dimension drawings should be followed.

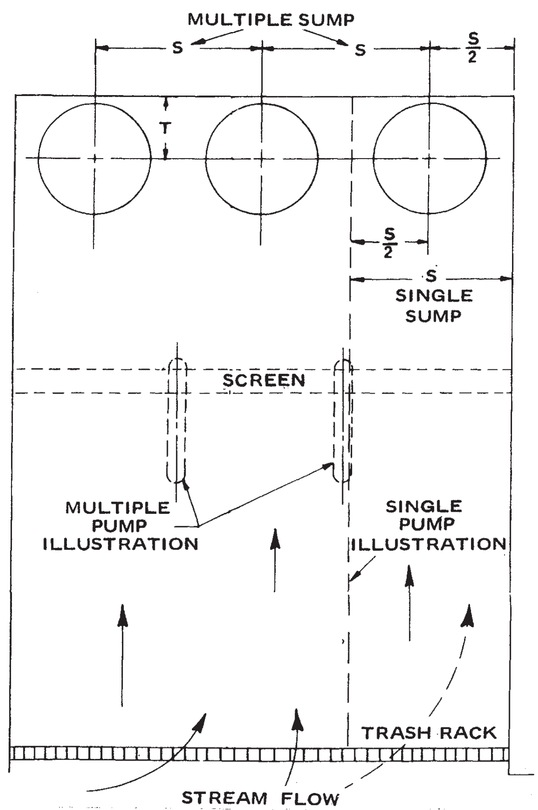
The second positioning dimension is the distance from the vertical centerline of the pump to the back wall (refer to 'T' on the dimension drawings). If the construction of the facility is such that this value must be exceeded then a false wall should be built to maintain this relationship.

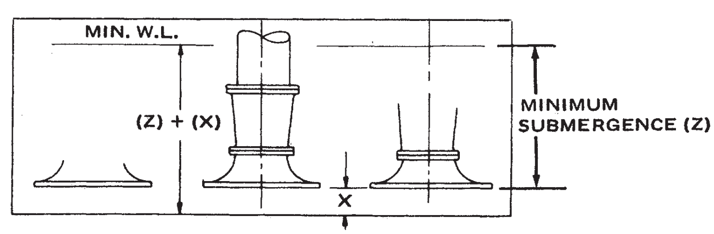
There is a third dimension to be considered, and that is the distance from the pump centerline to the side wall (refer to 'S'/2 on the dimension drawings). This dimension is a minimum dimension; however, values greatly exceeding this value may produce sump velocities so low that problems indicated under INTAKE DESIGN may occur. The dimension drawings show this value for the specific pumps. Twice this dimension (refer to 'S' on the dimension drawings) then becomes the minimum recommended sump width for a single pump sump design. Twice this basic dimension (refer to 'S') is the centerline to centerline spacing between pumps operating in the same sump.

PUMP SUBMERGENCE

Pump submergence is defined as the height of the water level above the bottom on the suction bell (refer to 'Z' on the dimension drawings). The minimum required submergence is a function of both the sump design as well as the suction characteristics of the pump. The minimum water level in the sump is the minimum required submergence ('Z' dimension) plus the spacing from the sump floor to the bottom of the pump suction bell ('X' dimension). The minimum required submergence is indicated for each pump on the dimension drawings. It should be noted that these values were determined from pumps operating in ideally designed sumps.

Any specific sump design may require additional submergence to obtain proper pump operation.





SUMP DIMENSIONS

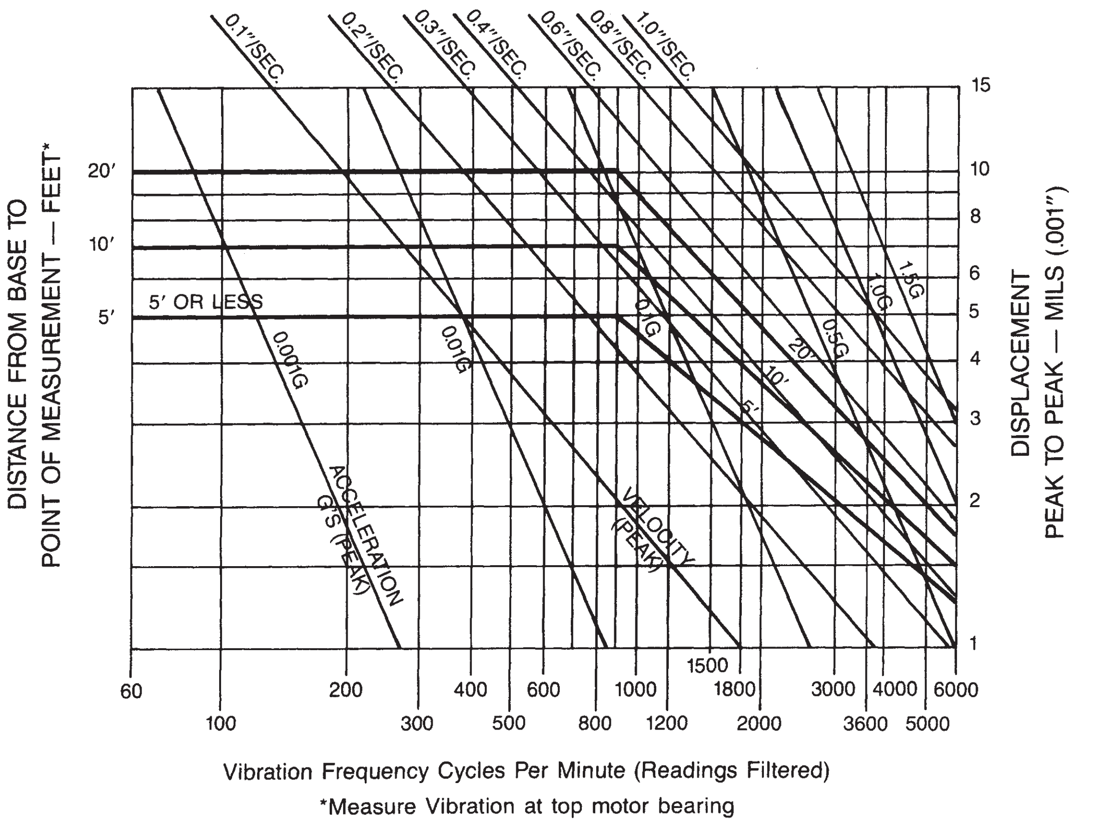
VIBRATION LIMITS

Fairbanks Nijhuis™ has adopted the vibration limits for centrifugal pumps from the Hydraulic Institute Standards. These limits are shown by the following chart. They should be used as a general guide only, and higher vibration amplitudes may be acceptable if there is no increase in vibration over a considerable period of time, and if there is no indication of other damage.

The curves apply to pumps operating at rated speed and within plus or minus 10% of the rated capacity.

Fairbanks Nijhuis accepts no responsibility for vibration problems caused by inadequate foundation or grouting, inadequate pump intake design, improperly supported piping, or by other equipment, such as drivers and flexible shafting, if it is not selected and supplied by Fairbanks Nijhuis.

Fairbanks Nijhuis is not responsible for taking vibration readings on new pumps in the field, unless this is specifically provided for in the order.



ACCEPTABLE FIELD VIBRATION LIMITS FOR VERTICAL PUMPS — Clear Liquids.

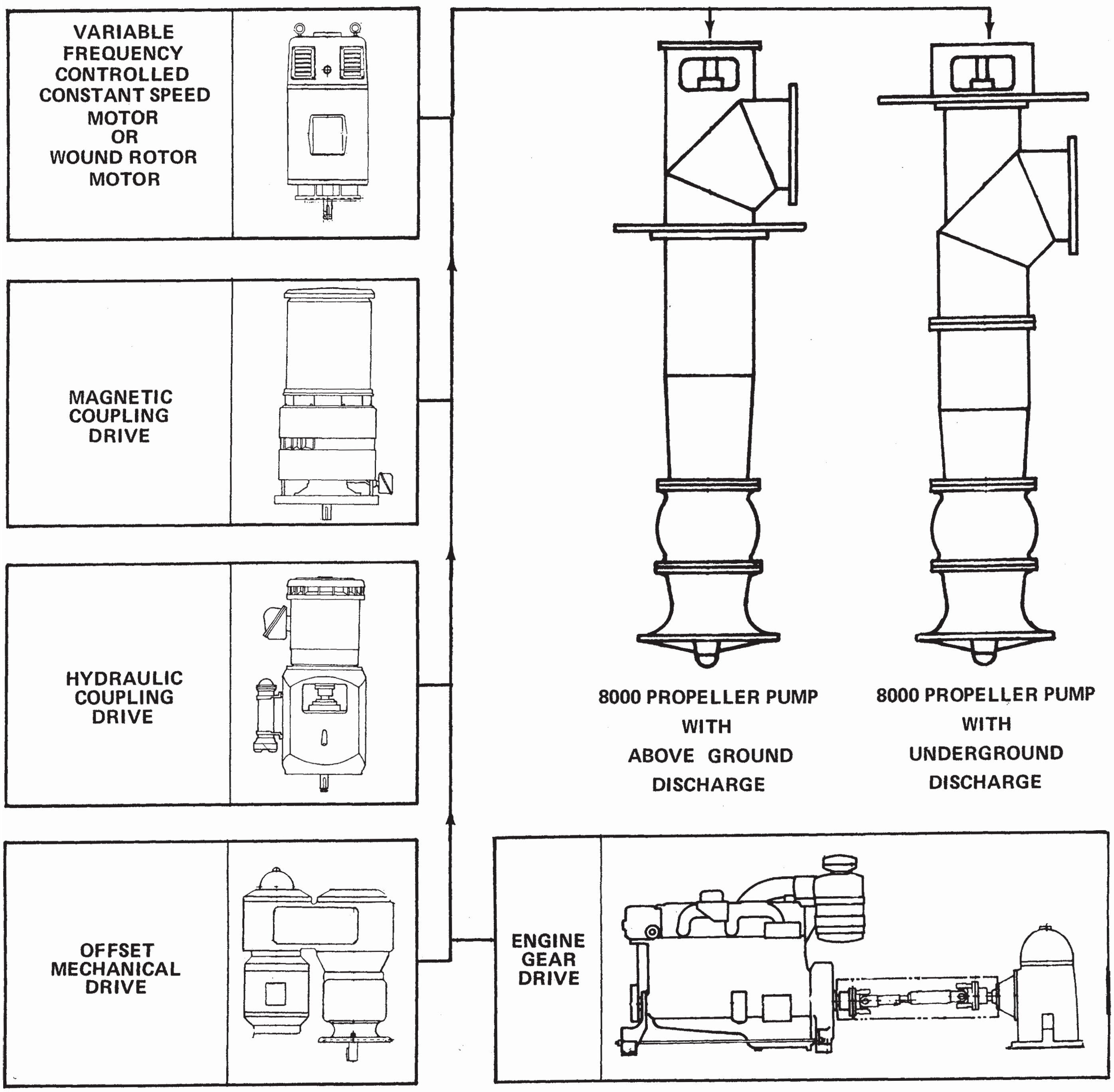
RESONANT VIBRATION

Excessive vibration due to resonance may occur when a variable speed drive is coupled to a pump. A resonant condition exists when the **operating speed** is at or near the natural frequency of the unit. When this happens, the inherent vibration of the unit is magnified and, as a result, destructive vibration may occur. **(See figure 1 for typical combinations).**

Types of variable speed drives which can cause a vibration problem include magnetic couplings, hydraulic couplings, wound rotor motors, variable voltage and frequency controlled motors, vertical mounted offset belt drives, and vertical gear and horizontal engine combination. Due to the wide operating range of a variable speed driver, the probability of operating in a resonant condition is considerably greater than with a constant speed drive.

CONSTRUCTION SKETCH

FIGURE 1



RESONANT VIBRATION

To reduce excessive vibration, it is necessary to alter the natural frequency of the unit or limit the operating range. In most cases the latter is not practical. If the natural frequency is close to the upper end of the operating speed range (Figure 2), the unit must be stiffened. This can usually be accomplished by providing lateral support at a point near the driver center of gravity or stiffening various unit components.

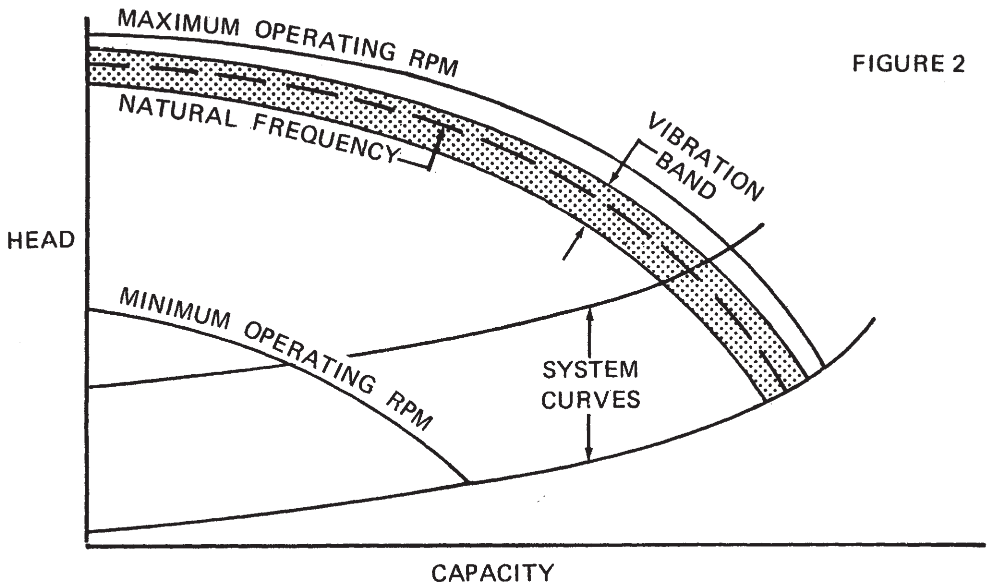


FIGURE 2

If the natural frequency is close to the lower end of the operating range (Figure 3), the unit may be made more flexible. This will lower the natural frequency below the operating range. During start-up and shut-down, the unit will pass through its natural frequency and vibration may occur. However, due to the short duration of time this vibration should not be damaging.

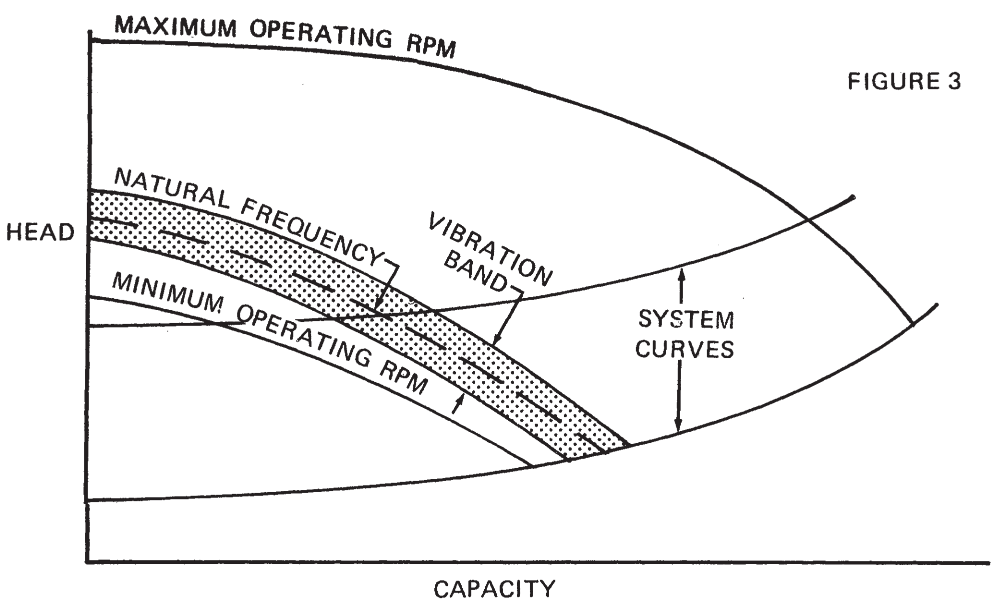


FIGURE 3

The above "fixes" are very general and are offered as guides only. As these type of units are encountered they should be evaluated based on their own individual circumstances (operating speed range and equipment configuration).

Prior to specifying or quoting variable speed units, the following information must be submitted to the Application Engineering Department in Kansas City for analysis.

REQUIRED PUMP AND MOTOR DATA

Pump Data:

Pump Size ______ , Type ______ , Stages ______

Surface Discharge ☐ (☐ Fabricated, ☐ Cast Iron)

Underground Discharge ☐

Column Size ______ Wall Thickness ______

Open Lineshaft ☐ , Enclosed Lineshaft ☐

Pump Setting ______

Minimum Water Level ______

Motor Data

Driver Type ______

Potential Manufacturer and Model Number ______

Driver HP and Speed Range ______

Driver Weight and BD ______

Distance from Base of Driver to Center of Gravity of Driver ______

Driver Deflection and/or Reed Frequency (Natural Frequency) ______

The above information must be supplied for each component or for the combination of components if the drive system includes a variable speed device directly coupled to a motor.

Application Engineering will advise charges where modification of standard Fairbanks Nijhuis™ equipment is to be required.

Should the drives be supplied by someone other than **Fairbanks Nijhuis**, the responsibility for the pumping system cannot be accepted. However, **Fairbanks Nijhuis** can supply a pumping system natural frequency check in those cases where the variable speed drive is supplied by others. Contact Application Engineering for pricing and details.

EXAMPLE SELECTION AND APPLICATION

Those factors that must be considered in the proper selection and application of a Fairbanks Nijhuis™ propeller pump are reflected in the data below.

Operation And Installation Requirements

	UNIT NUMBER 1	UNIT NUMBER 2
Rated Capacity	3700 GPM	4000 GPM
Static Head (Velocity Head is not included)	24.0 Feet	30.0 Feet
Discharge Line and Fittings Friction Loss (At Rated Capacity)	0.5 Feet	1.5 Feet
Minimum Water Level Elevation	165.0 Feet	165.0 Feet
Sump Floor Elevation	160.0 Feet	160.0 Feet
Discharge Centerline Elevation	185.92 Feet	182.40 Feet
Mounting Floor Elevation	184.40 Feet	184.40 Feet
Pump Centerline to Backwall Distance	12 Inches	20 Inches
Pump Centerline to Sidewall Distance	24 Inches	24 Inches
Floor Opening	22 Inches Square	33 Inches Square
Strainer	Required	Not Required
Discharge Size	12 Inches	12 Inches
Discharge Type	Plain End	Plain End
Shaft Lubricant	Water	Oil
Motor Size	30 HP	50 HP
Maximum Motor Speed	1770 RPM	1770 RPM
Motor Type	VHS	VHS

PRELIMINARY REQUIRED PUMP TOTAL HEAD CALCULATION

In order to make a preliminary pump selection a required pump total head must first be determined. From the data, we know that the **Velocity Head** must be determined for calculation of the required pump total head. Curves for 14 inch and smaller discharges are based on cast iron elbows, therefore a 12 inch fabricated, plain end elbow loss must be included.

	UNIT NUMBER 1	UNIT NUMBER 2
Static Head	24.0 Feet	30.0 Feet
Discharge Piping Friction Losses	0.5 Feet	1.5 Feet
Velocity Head (From Chart)		
12" Column - 3700 GPM	1.9 Feet	–
12" Column - 4000 GPM	–	2.2 Feet
Fabricated Elbow Loss (From Chart)		
12" Elbow - 3700 GPM	0.253 Feet	–
12" Elbow - 4000 GPM	–	0.235 Feet
Preliminary Required Pump Total Head	26.653 Feet	33.94 Feet

PRELIMINARY PUMP SELECTION

Using the calculated preliminary required pump total head, the best selections appear as follows:

	UNIT NUMBER 1	UNIT NUMBER 2
Pump Type	8211A	8211B
Pump Size	12"	12"
Operating Speed	1770 RPM	1770 RPM
Staging	1	2
Column and Elbow Size	12"	12"
Propeller(s)	B-1370	B-1370 & B-1369.5
Efficiency(s)	78%	78.1% & 69%
Horsepower(s)	33.5 BHP	62 BHP & 35 BHP
Lineshaft Size	1"	1$\frac{3}{16}$"
Kt	36 Lbs./Ft.	36 Lbs./Ft.
Ka	18 Lbs.	36 Lbs.
Ks	2.8 Lbs./Ft.	3.8 Lbs./Ft.
Submergence Required Above Bell ('Z' Dimension)	4' - 6"	4' - 6"
Bell to Floor Required Clearance ('X' Dimension)	1' - 3"	7"
Pump Centerline to Backwall Distance ('T' Dimension)	14"	14"
Pump Centerline to Sidewall Distance ('S'/2 Dimension)	42"/2 = 21"	42"/2 = 21"
Bowl Length	19$\frac{1}{2}$"	30$\frac{1}{4}$"

FINAL PUMP SELECTION

Based on using a 12 inch 8211 bowl to meet the specification requirements, we must consider the effects of the following factors prior to finalizing our pump selection.

A. Additional Column Losses
B. Required Pump Total Head
C. Combined Impeller Performance and Efficiency for 2 Stage Units
D. Field Operation
E. Lineshaft Horsepower Loss
F. Pump Field Efficiency
G. Pump Submergence and Positioning
H. Critical Installation Dimensions

The following installation figure can be used to illustrate and aid in the calculation of data required to evaluate these factors.

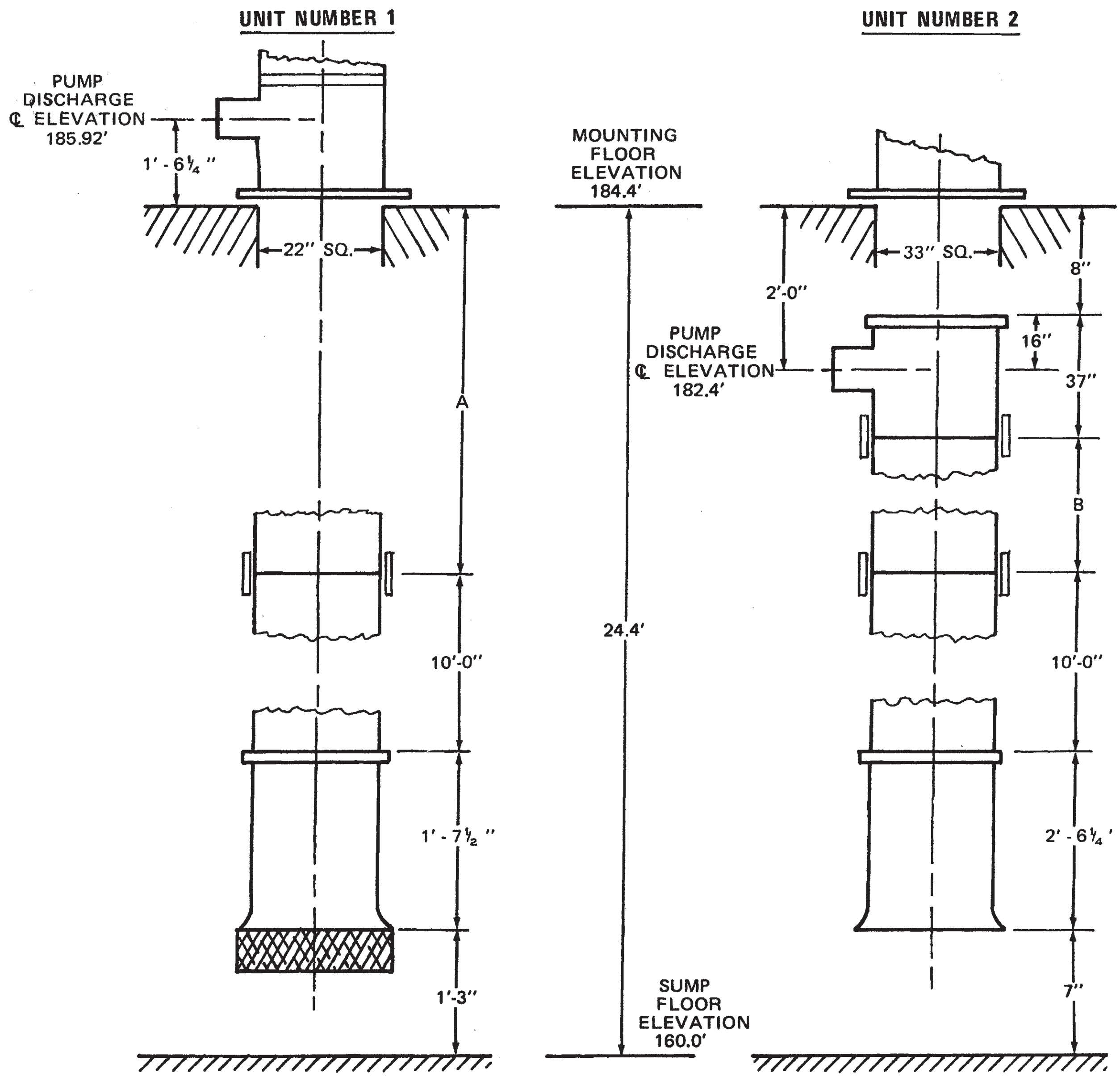


FIGURE 1

CALCULATIONS

In figure 1, the lengths for 'A' and 'B' must be calculated to determine additional column losses which must be included in the Required Pump Total Head.

A. Additional Column Losses

	UNIT NUMBER 1	UNIT NUMBER 2
Bell to Floor Length	1' - 3"	7"
Bowl Length	1' - 7½"	2' - 6¼"
Standard Column Length	10' - 0"	10' - 0"
Below Ground Elbow Length	—	3' - 1"
Riser Pipe Length	—	8"
Total Standard Pump Lengths	12' - 10½"	16' - 10¼"

Unit Number 1 A = Pit Depth (24' - 4 13/16") minus Total Standard Pump Lengths (12' - 10½") = Additional Column Length (11' - 6 5/16")

Unit Number 2 B = Pit Depth (24' - 4 13/16") minus Total Standard Pump Lengths (16' - 10¼") = Additional Column Length (7' - 6 9/16")

The Column Friction Loss Curve shows 12 inch column losses per 100 feet for 3700 GPM as 6.2 feet and 4000 GPM as 7.2 feet. Additional Column Friction Loss is calculated as follows:

UNIT NUMBER 1: $6.2 \text{ Feet} \times \frac{11.526 \text{ Feet}}{100 \text{ Feet}} = 0.715 \text{ Feet}$

UNIT NUMBER 2: $7.2 \text{ Feet} \times \frac{7.5469 \text{ Feet}}{100 \text{ Feet}} = 0.543 \text{ Feet}$

B. Required Pump Total Head

In the Preliminary Pump Selection process we accounted for all the factors required to establish Required Pump Total Head except additional column losses. Based on the values computed above, we can make a final match between the Fairbanks Morse Performance Curve and the operating and installation requirements.

	UNIT NUMBER 1	UNIT NUMBER 2
Preliminary Required Pump Total Head	26.653 Feet	33.94 Feet
Additional Column Losses	.715 Feet	.543 Feet
Required Pump Total Head	27.368 Feet	34.483 Feet

Operating conditions for Unit Number 1, 3700 GPM at 27.37 feet, fit the single stage 12 inch 8211A performance using impeller B-1370 ideally. All data recorded during the Preliminary Pump Selection is valid and may be used without modification.

C. Combined Impeller Performance And Efficiency

For Unit Number 2, an evaluation of the combined impeller performance and efficiency is required. Determination of 2 stage performance and pump efficiency is accomplished using the following data and method.

	2 Stage B-1370 Impellers @ 4000 GPM	2 Stage B-1369.5 Impellers @ 4000 GPM
Pump Total Head	47 Feet	24 Feet
Calculated Brake Horsepower	60.8 BHP	35.1 BHP
Pump Efficiency	78.1%	69%

$$\text{Pump Total Head} = \frac{47 \text{ Feet}}{2} + \frac{24 \text{ Feet}}{2} = 35.5 \text{ Feet}$$

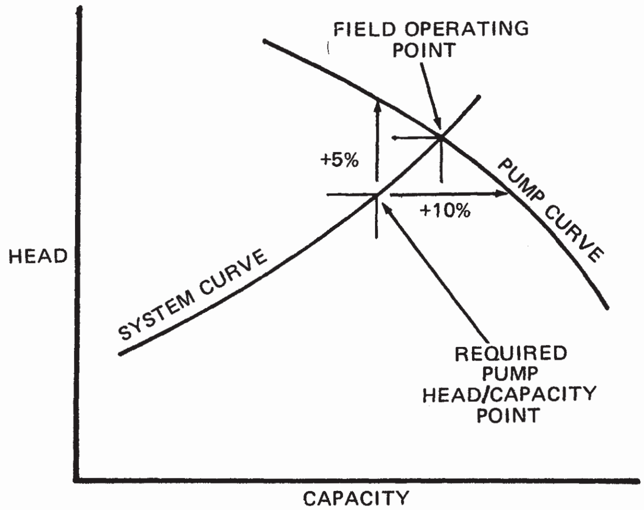
$$\text{Calculated Brake Horsepower} = \frac{60.8 \text{ BHP}}{2} + \frac{35.1 \text{ BHP}}{2} = 48 \text{ BHP}$$

$$\text{Pump Efficiency} = \frac{\text{GPM} \times \text{H}}{3960 \times \text{BHP}} = \frac{4000 \text{ GPM} \times 35.5 \text{ Feet}}{3960 \times 48 \text{ BHP}} = 74.7\%$$

The mixing of these two impellers will result in a combined performance curve producing 35.5 feet at 4000 GPM with an Efficiency of 74.7%. Pump Total Head required by Unit Number 2 to meet the operating requirements is 34.5 feet, thus at 4000 GPM this unit would be over-performing.

D. Field Operation

Both Unit Number 1 and Unit Number 2 will over perform during field operation since the Required Pump Total Head at the Rated Capacity is below the selected impeller(s). This over performance will create a different system curve intersection. As the pump attempts to increase its Capacity to intersect at the Required Pump Total Head Point, the friction losses in the discharge piping and fittings will increase.



These two factors will balance out, allowing the pump to intersect an extended system curve for field operating.

This situation is common with propeller pumps since few systems are designed to accommodate a specific pump curve. Normally, the user will accept the unit if the Capacity variation does not exceed +10% at the Required Pump Total Head point or the head variation does not exceed +5% at the Rated Capacity point.

These variations must be pointed out to the purchaser, engineer and user for their evaluation.

Drivers must be sized based on Performance Curve Head and Efficiency at the Rated Capacity Point.

E. Lineshaft Horsepower Loss

The Lineshaft Horsepower Loss Curve shows losses per 100 feet at 1770 RPM for 1 inch lineshafting at 0.55 BHP and for 1¼ inch lineshaft at 0.81 BHP. Actual lineshaft horsepower losses are for:

UNIT NUMBER 1 $0.55 \text{ BHP} \times \frac{11.526 \text{ Feet}}{100 \text{ Feet}} = 0.063 \text{ BHP}$

UNIT NUMBER 2 $0.81 \text{ BHP} \times \frac{7.5469 \text{ Feet}}{100 \text{ Feet}} = 0.061 \text{ BHP}$

This loss affects Pump Efficiency and Required Brake Horsepower.

Pump Efficiency shown on the performance curves is based on losses for 10 feet of column and lineshaft and the indicated elbow. Increased column and lineshaft lengths and changes in elbow type will effect the Pump Efficiency. The Field Efficiency correction is calculated by use of the following formula:

$$\text{Pump Field Efficiency} = \frac{\text{Rated GPM x (Performance Curve Head - Additional Column Losses - Fabricated Elbow Loss)}}{\text{3960 x (Curve HP at Rated GPM + Lineshaft HP Loss}}$$

UNIT NUMBER 1

$$\text{Pump Efficiency} = \frac{\text{3700 GPM x (28 Feet} - \text{0.715 Feet} - \text{0.253 Feet)}}{\text{3960 x (33.5 BHP} + \text{0.063 BHP)}}$$

$$= \frac{\text{3700 GPM x 27.032 Feet}}{\text{3960 x 33.563 BHP}}$$

$$= 75.3\%$$

UNIT NUMBER 2

$$\text{Pump Efficency} = \frac{\text{4000 GPM x (35.5 Feet} - \text{0.543 Feet} - \text{0.235 Feet)}}{\text{3960 x (48 BHP} + \text{0.061)}}$$

$$= \frac{\text{4000 GPM x 34.722 Feet}}{\text{3960 x 48.061 BHP}}$$

$$= 73.0\%$$

G. Pump Submergence And Positioning

As discussed under Pump Positioning, proper pump submergence and position to provide required net positive suction head and prevent vortex formation is critical. The following installation figures can be used to evaluate these factors.

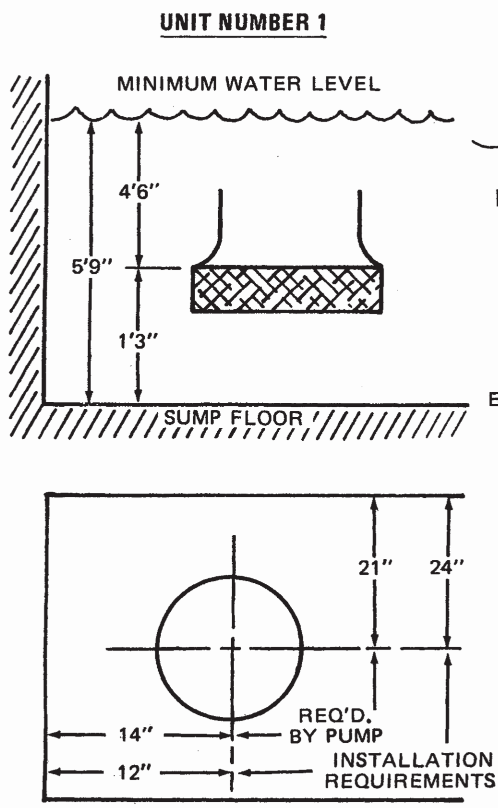


FIGURE 2

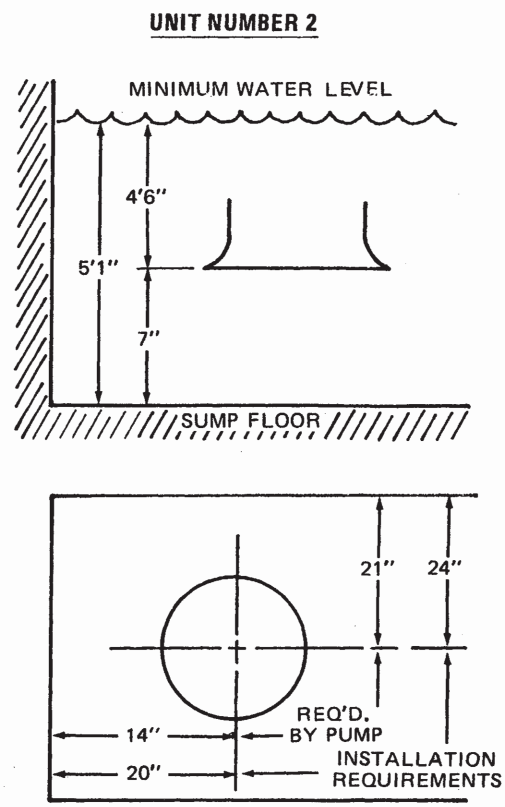


FIGURE 3

Unit Number 1

Figure 2 shows that for proper operation the minimum water level must be raised to elevation 165.75 feet. Unless this submergence is obtained the pump performance may be reduced due to air entering the eye area in a vortex formation of due to lack of adequate NPSH-A which would cause cavitation.

Backwall and Sidewall clearances from the pump centerline are adequate. The Backwall clearance required is a maximum of 14 inches with 12 inches being allowed. A minimum sidewall clearance of 21 inches is required by the pump and 24 inches is provided.

Unit Number 2

Figure 3 shows that 1 inch additional depth is required for proper submergence. Backwall clearance required by the installation (20 inches), exceeds the maximum for the pump (14 inches) by 6 inches. This must be reduced to the allowed maximum of 14 inches to avoid probable vortices which may form in the sump corners. Sidewall clearance allowed exceeds the minimum required.

H. Critical Installation Dimensions

The following installation dimensions should be checked for above ground discharge heads and below ground elbows.

Above Ground Discharge Heads

1. Mounting Floor to Discharge Elbow centerline distance (reference dimension 'C').
2. Floor opening available versus widest part below mounting floor (reference dimension 'Y', 'AY' and 'E').
3. Discharge Head Mounting Plate floor opening coverage (reference dimensions 'G' and 'H').
4. Combined Discharge Head (reference dimension 'A') and motor height versus roof or crane hook clearance.

Below Ground Elbows

1. Mounting Floor to Elbow centerline dimension for standard length elbow (reference dimension 'C' std.) or elbow and riser pipe (reference dimension 'C' min.).
2. Floor opening available versus 'Floor Opening Minimum Rectangle' taken from the dimension drawings. These dimensions provide for an opening with sufficient clearance to allow removal of any of the elbow configurations available in this book.
3. Pedestal Mounting Plate floor opening coverage (reference dimensions 'I', 'G', 'J' and 'H').
4. Combined pedestal (reference dimension 'A') and motor height versus roof or crane hook clearance.

Unit Number 1

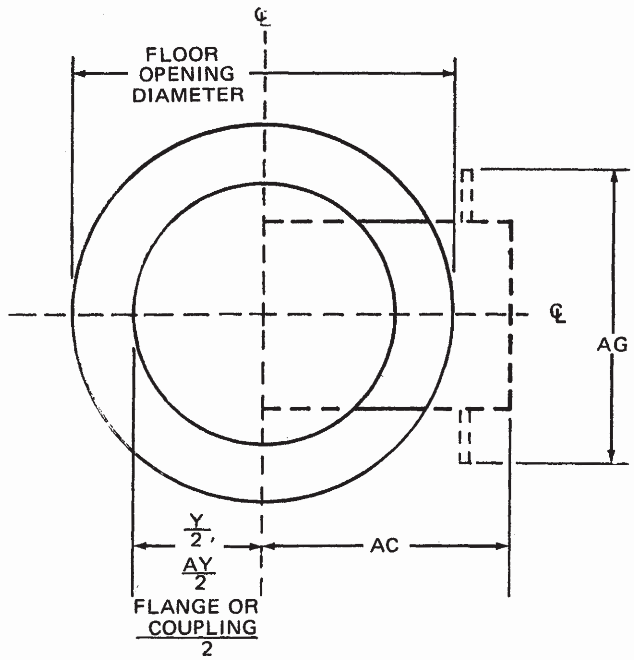
1. 'C' dimension of the fabricated, plain end above ground discharge head is 17 inches versus the installation requirements of 18¼ inches (elevation 185.92 feet - elevation 184.40 feet). Since these discharge heads are fabricated to standard lengths we would need to request that the centerline elevation be lowered or the mounting floor elevation be raised.
2. For our example selection 'Y' = 18 inches, 'AY' = 18 5/16 inches and 'E' = 17 5/8 inches. Thus the strainer width controls the floor opening dimension. The installation allows 22 inches thus no problem should be encountered.
3. The discharge head mounting plate shows base length and width (dimension 'G') as 28 inches square and anchor bolt locations (dimension 'H') as 24 inches square, thus the mounting plate has sufficient area to cover the 22 inch square floor opening.
4. To determine roof or crane hook clearance the motor height from mounting flange to eye bolt must be obtained and added to the discharge head 'A' dimension.

Unit Number 2

1. Mounting floor to elbow discharge centerline (dimension 'C') is a critical dimension for below ground discharges. In our example this dimension is 24 inches (elevation 184.4 feet - elevation 182.4 feet). Had it been 16 inches the standard elbow could have been used. To obtain the required setting, an 8 inch long riser pipe will be required. If this dimension had been greater than 16 inches but less than 20½ inches, the mounting elevation would need to be raised.

2. To determine if the floor opening available is of sufficient size to allow removal of pump vertically, it must be compared to the 'Floor Opening Minimum Rectangle' dimensions. The opening as proposed is 33" square. The 'Floor Opening Minimum Rectangle' is 21" x 33". By this comparison, it is easily determined that the pump can be removed vertically without interference with the floor opening.

   Note: This method of comparison for determining floor opening required applies only to square or rectangular openings. Circular floor openings require solution by use of the following method.



$$\sqrt{\left(\frac{AG}{2}\right)^2 + AC^2} + \frac{Y}{2}, \frac{AY}{2} \text{ or } \frac{\text{Flange or Coupling Diameter}}{2} = \text{Minimum Required Floor Opening Diameter}$$

This value must be less than the floor opening diameter.

3. The pedestal mounting plate dimensions are:

   'I' (length) = 41"
   'G' (width) = 29"
   (2) 'J' (length of bolt hole spacing) = 18½ " x 2 = 37"
   (2) 'H' (width of bolt hole spacing) = 12½ " x 2 = 25"

   In our example the pedestal mounting plate will span the 33" square floor opening but not completely cover it. Changing the floor opening to a 21" x 33" rectangle would allow for both pump removal and coverage of the floor opening.

4. To determine roof or crane hook clearance the motor height from mounting flange to eye bolt must be obtained and added to the pedestal 'A' dimension.

DRIVER SIZING

Factors which affect selection of the proper driver size are:

A. Required Pump Brake Horsepower (BHP)
B. Pump Thrust
C. Driver Thrust Bearing Loss
D. Actual Operating Speed

A. Required Pump BHP

To calculate required BHP at the rated head/capacity point use the following method:

$$BHP = \frac{\text{Rated GPM x Performance Curve Head At Rated GPM}}{\text{3960 x Pump Field Efficiency}}$$

UNIT NUMBER 1

$$BHP = \frac{3700 \text{ x } 28 \text{ Feet}}{3960 \text{ x } 75.2\%} = 34.79 \text{ BHP}$$

UNIT NUMBER 2

$$BHP = \frac{4000 \text{ x } 35.5 \text{ Feet}}{3960 \text{ x } 73\%} = 49.12 \text{ BHP}$$

B. Pump Thrust

Pump down thrust load is calculated by the following method:

Hydraulic Thrust Load = K_t x Total Head
Bowl Rotor Weight = K_a
Setting Weight = K_s x Total Lineshaft Length

UNIT NUMBER 1

Hydraulic Thrust Load (36 Lbs./Ft. x 27.362 Feet)	= 985 Lbs.
Bowl Rotor Weight	= 18 Lbs.
Setting Weight [2.8 Lbs./Ft. x (10 Feet + 12 Feet-3 9/16 Inches)]	= 62 Lbs.
Total Down Thrust	1065 Lbs.

UNIT NUMBER 2

Hydraulic Thrust Load (36 Lbs./Ft. x 34.524 Feet)	= 1243 Lbs.
Bowl Rotor Weight	= 36 Lbs.
Setting Weight [3.8 Lbs./Ft. x (10 Feet + 8 Feet-1 1/4 Inches)]	= 69 Lbs.
Total Down Thrust	1348 Lbs.

Drivers must be selected with a thrust bearing adequate for the Total Down Thrust developed by the pump.

C. Driver Thrust Bearing Loss

This thrust load will result in a reduction in available driver horsepower. Bearing manufacturers indicate the loss to be 0.0075 HP per 100 RPM per 1000 pounds thrust load for angular contact bearings. Using the following method this loss can be calculated.

$$\text{Thrust Bearing Loss} = 0.0075 \text{ HP x } \frac{\text{Motor RPM}}{\text{100 RPM}} \text{ x } \frac{\text{Pump Thrust}}{\text{1000 LB}}$$

UNIT NUMBER 1

$$\text{Thrust Bearing Loss} = 0.0075 \text{ HP x } \frac{1770 \text{ RPM}}{100 \text{ RPM}} \text{ x } \frac{1065 \text{ LB.}}{1000 \text{ LB.}} = 0.14 \text{ BHP}$$

UNIT NUMBER 2

$$\text{Thrust Bearing Loss} = 0.0075 \text{ HP x } \frac{1770 \text{ RPM}}{100 \text{ RPM}} \text{ x } \frac{1348 \text{ LB.}}{1000 \text{ LB.}} = 0.18 \text{ BHP}$$

In the example selection for Unit Number 1 and 2, this additional loss added to the required pump BHP established the maximum required pump horsepower.

	UNIT NUMBER 1	UNIT NUMBER 2
Required Pump BHP	34.79 BHP	49.12 BHP
Thrust Bearing Loss	0.14 BHP	0.18 BHP
Corrected Pump BHP	34.93 BHP	49.3 BHP

Unit Number 1 will require a 40 HP driver rather than the 30 HP specified.
Unit Number 2 will require a 50 HP driver which is in compliance with the operating requirements.

D. Actual Operating Speed

Fairbanks Nijhuis™ performance curves are based on squirrel cage induction motors common full load operating speed. Depending on type of drive, drive manufacturer and driver frame size, the full load RPM may vary. After selection of a driver, its operating RPM at its actual load should be compared to the performance curve RPM. If they vary, then the required conditions at the selected driver full load RPM should be set by the affinity laws to the performance curve RPM.

This new head/capacity point based on the performance curve RPM should then be rechecked to verify proper pump selection.

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