PUMP BASICS

TYPES OF PUMPS

- CENTRIFUGAL
  - Low pressure
  - High flow
  - flow changes when pressure changes

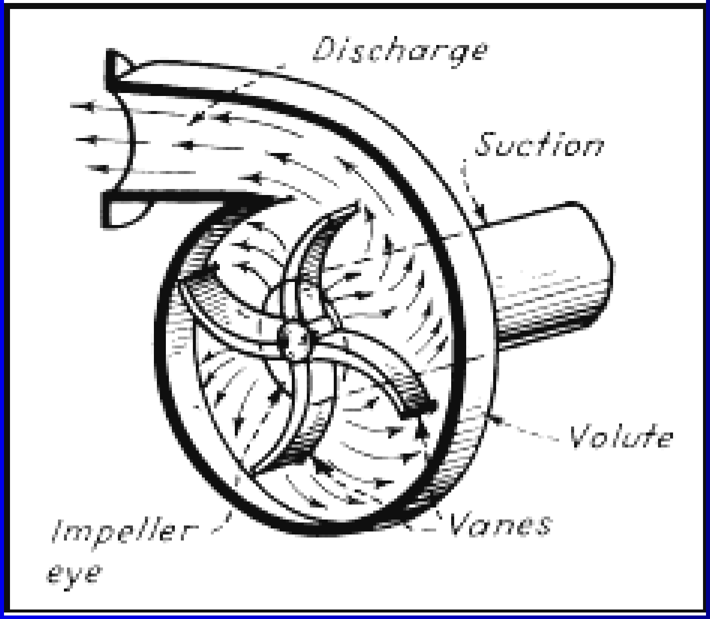
- POSITIVE DISPLACEMENT
  - High pressure
  - Low flow
  - Flow does not change when pressure changes

TERMINOLOGY

- CENTRIFUGAL
  - MOVING AWAY FROM CENTER
- CENTRIFUGAL FORCE
  - INERTIA OF A BODY REVOLVING AROUND A CENTER POINT

CENTRIFUGAL FORCES

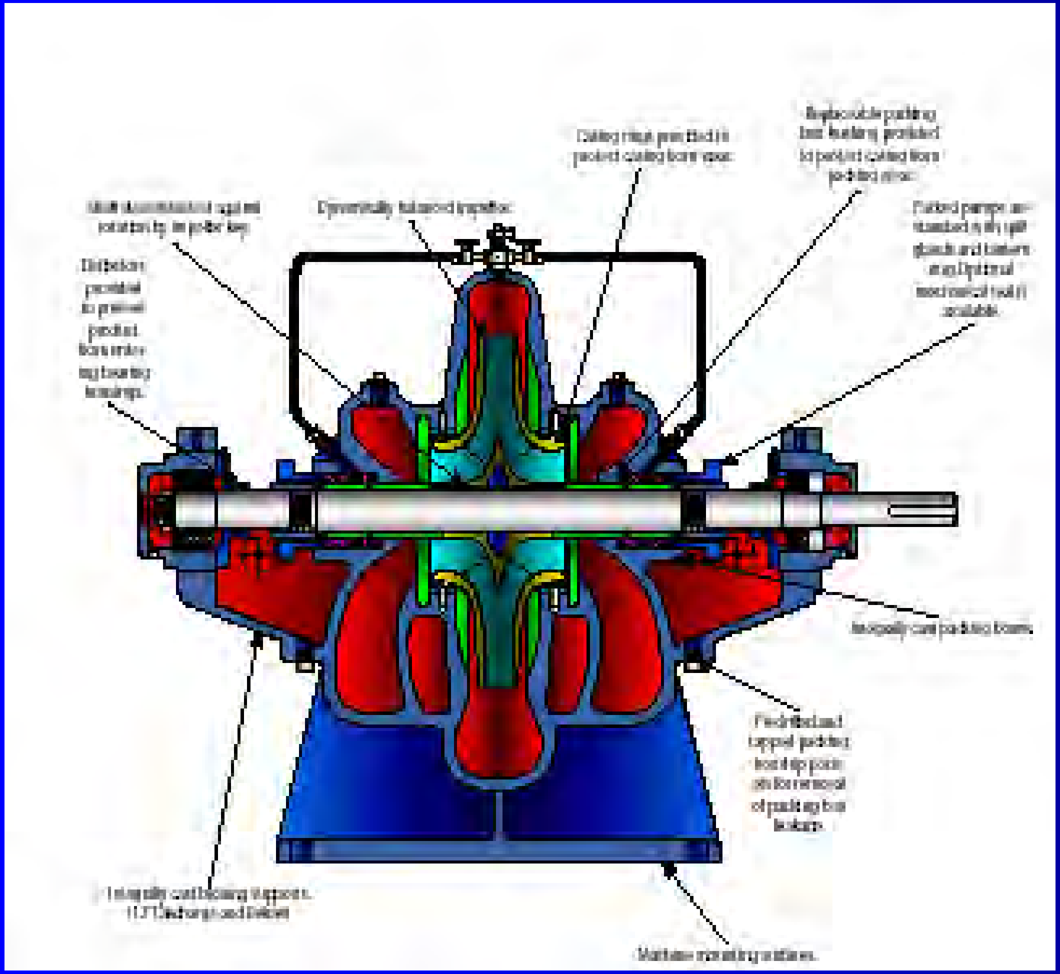
IMPELLER ROTATION



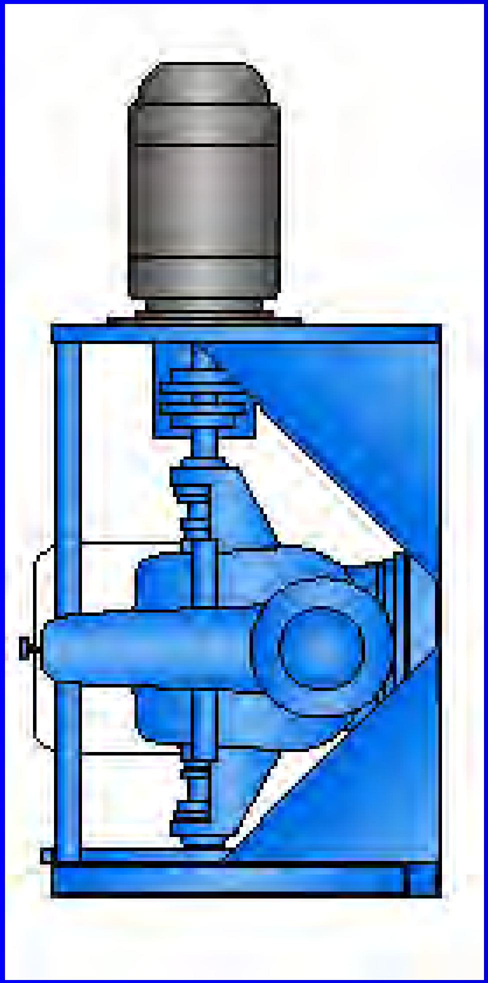
CENTRIFUGAL PUMP DESIGN

- SPLIT CASE
  - Initial design
  - Horizontal shaft
  - Top & bottom halves of casing for maintenance
  - Large amount of floor space
- END SUCTION
  - Less floor space
  - Suction and discharge at right angles

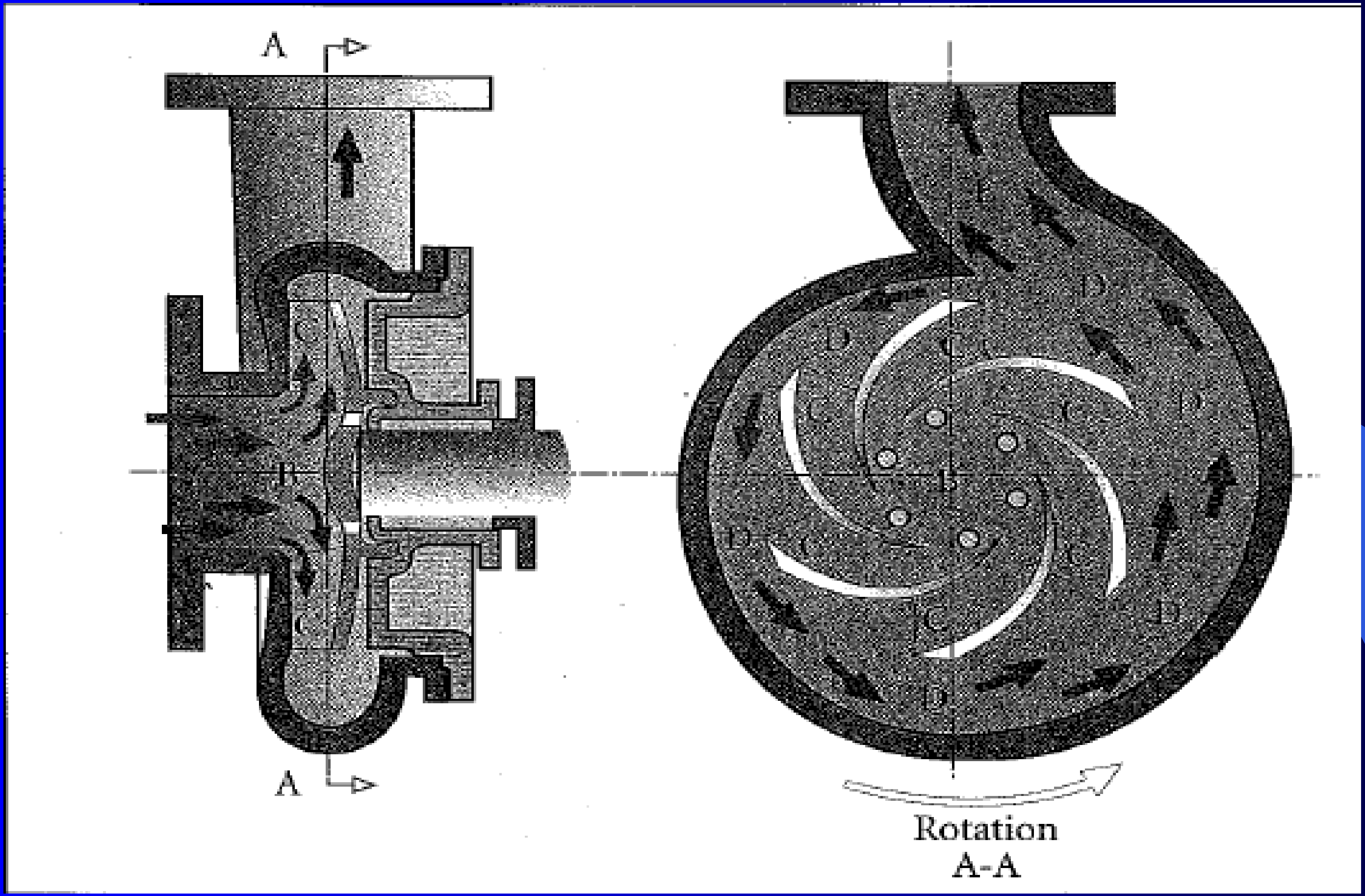
SPLIT CASE HORIZONTAL



VERTICAL SPLIT CASE



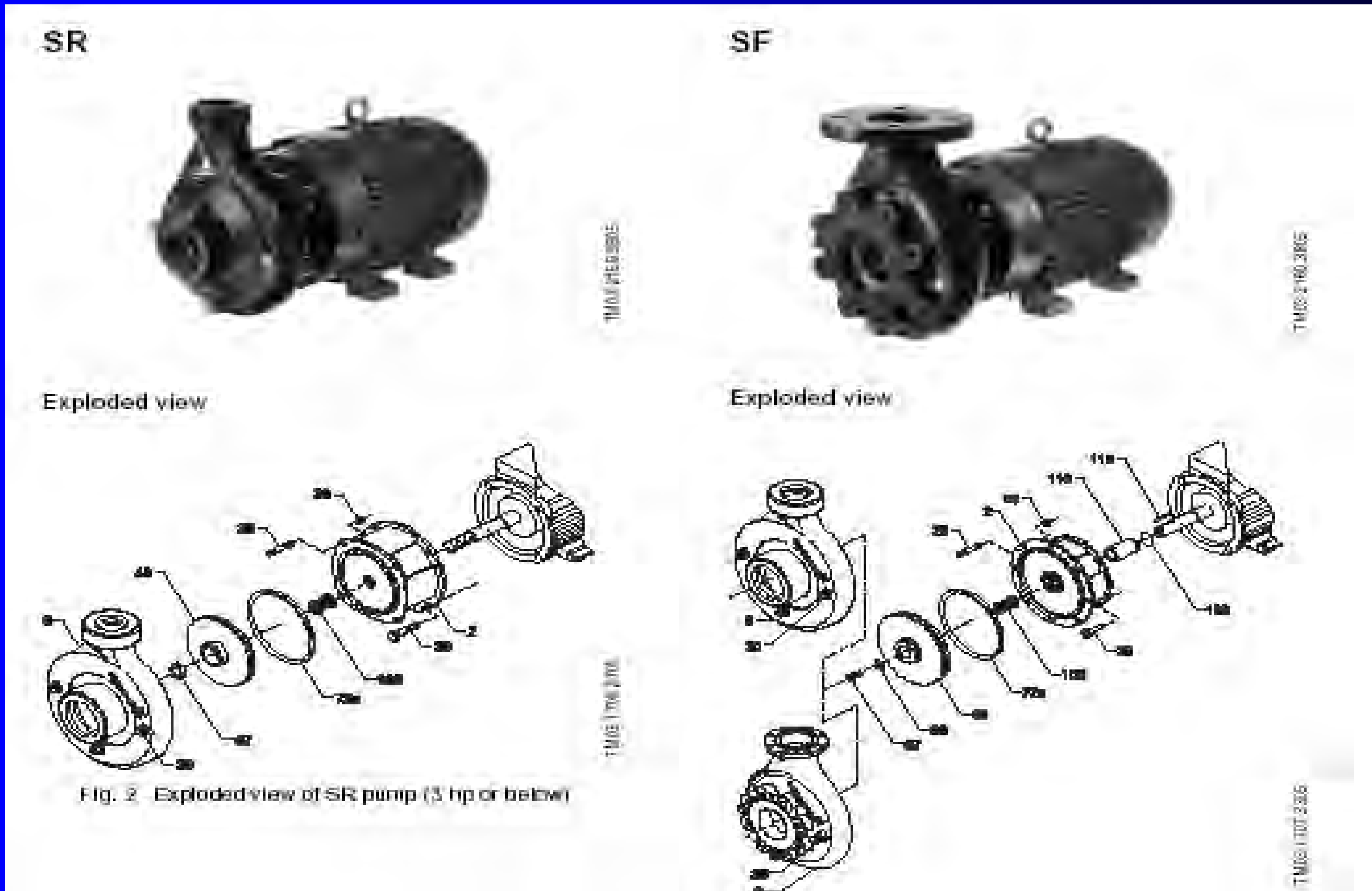
END SUCTION UNITS



END SUCTION

- CLOSE COUPLED UNITS
  PUMP IS ASSEMBLED ON MOTOR SHAFT
- FRAME MOUNTED UNITS
  ASSEMBLY INCLUDES PUMP, MOTOR, BASE, COUPLING & OSHA COUPLING GUARD

END SUCTION CLOSE-COUPLED



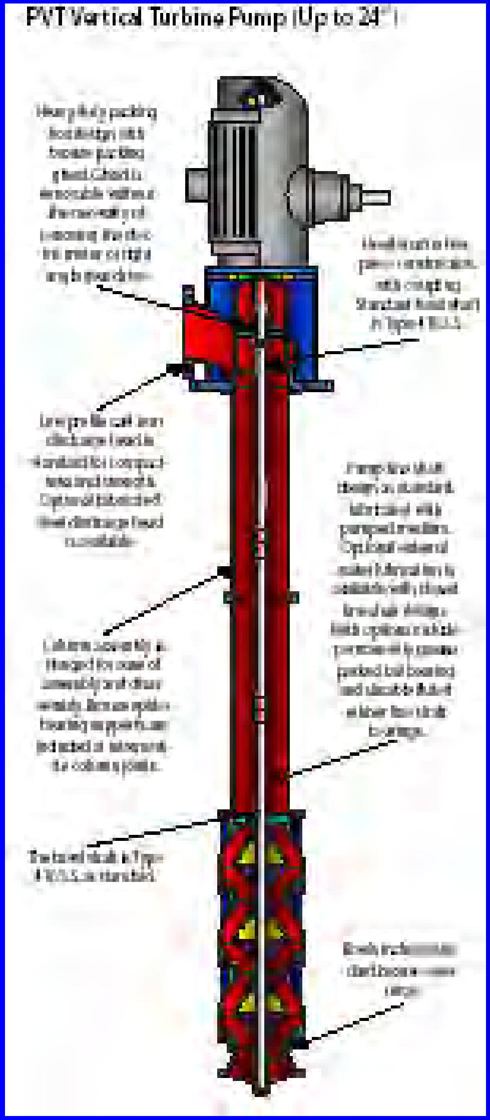
END SUCTION

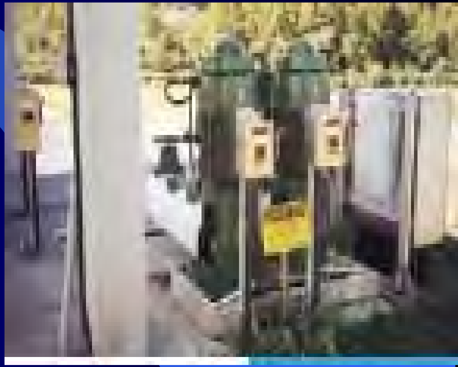

Copyright 2001 Flo-Pak, Inc.

MULTI-STAGE PUMPS

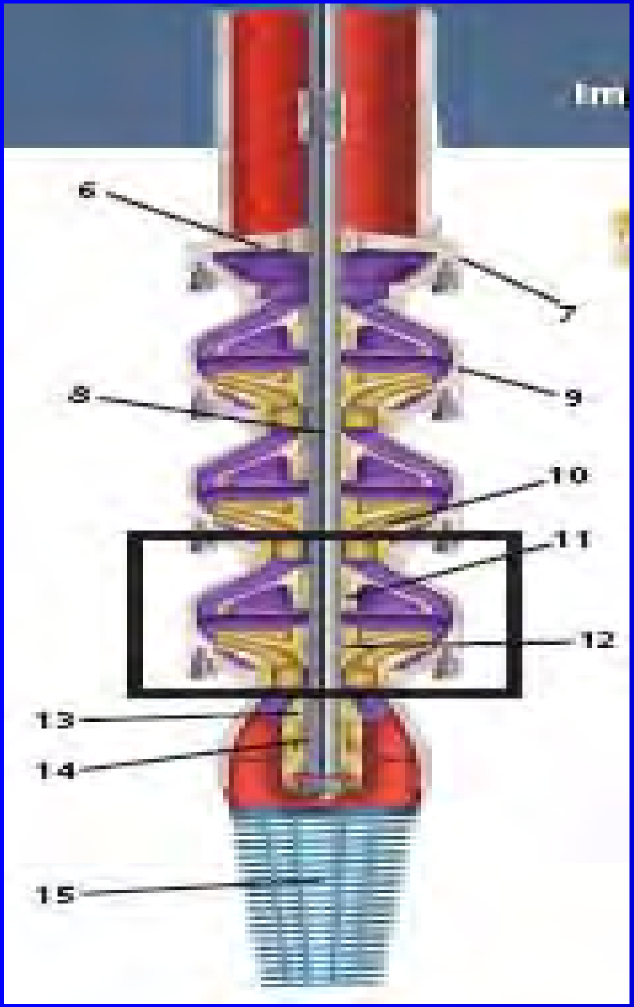
- MULTIPLE IMPELLLERS ON SINGLE SHAFT
- AXIAL FLOW, NOT RIGHT ANGLE
- VERY HIGH DISCHARGE PRESSURE
  - LIKE PUTTING SINGLE-IMPELLER PUMPS IN SERIES
    - FLOW DOES NOT CHANGE
  - PUMPS IN PARALLEL CHANGES FLOW NOT PRESSURE
- EXAMPLES:
  - LINE SHAFT TURBINES
  - SUBMERSIBLE TURBINES

VERTICAL TURBINE





VERTICAL TURBINE IMPELLER ASSEMBLY



6 Discharge Bowl Bearing
Bronze.

7 Discharge Bowl
Close grained cast iron.

8 Pump Shaft
Oversized high strength polished stainless steel.

9 Intermediate Bowls
Close grained cast iron. Waterways glass lined for maximum efficiency.

10 Impellers
Silicon bronze, designed for maximum efficiency. Precision balanced for smooth operation.

11 Intermediate Bowl Bearings
Bronze or rubber for long pump life under any well conditions.

12 Lock Collets
Steel construction secures impeller to pump shaft.

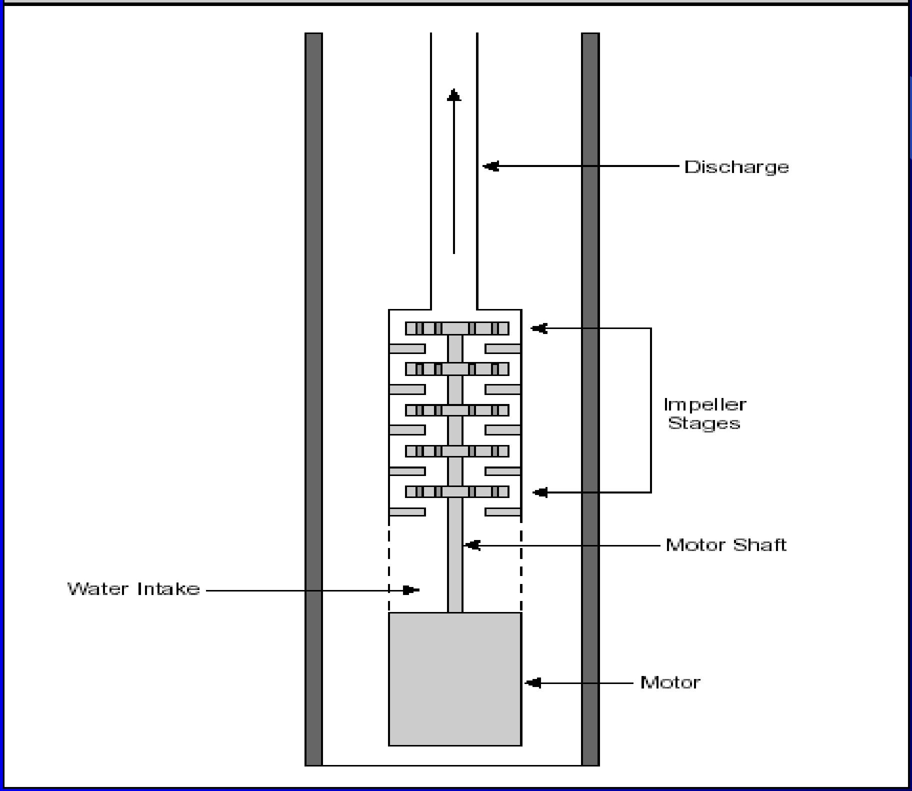
13 Sand Collar
Accurately located at suction bowl bearing to eliminate possible sand buildup.

14 Suction Bowl Bearing
Bronze. Grease packed for long trouble-free life.

15 Tail Pipe or Strainer — Optional
Optional tail pipe cut to desired length for best suction conditions. Strainer provides protection from large solids.

SUBMERSIBLE PUMP-MOTOR ASSEMBLY

Figure 2-3: Submersible Pump Elementary Overview Diagram



CENTRIFUGAL PUMP COMPONENTS

SHAFT ASSEMBLY

- Connects pump to motor
- Can be direct-coupled
  - Same shaft for pump and motor
- frame-mounted
  - Motor shaft and pump shaft mechanically coupled
  - alignment must be maintained
- shaft sleeve
  - fits over shaft
  - protects shaft where shaft passes thru pump casing
- bearings
  - supports & holds spinning shaft in place
  - radial bearings prevent side-to-side movement
  - thrust bearings prevent up & down movement from water pressure against impeller

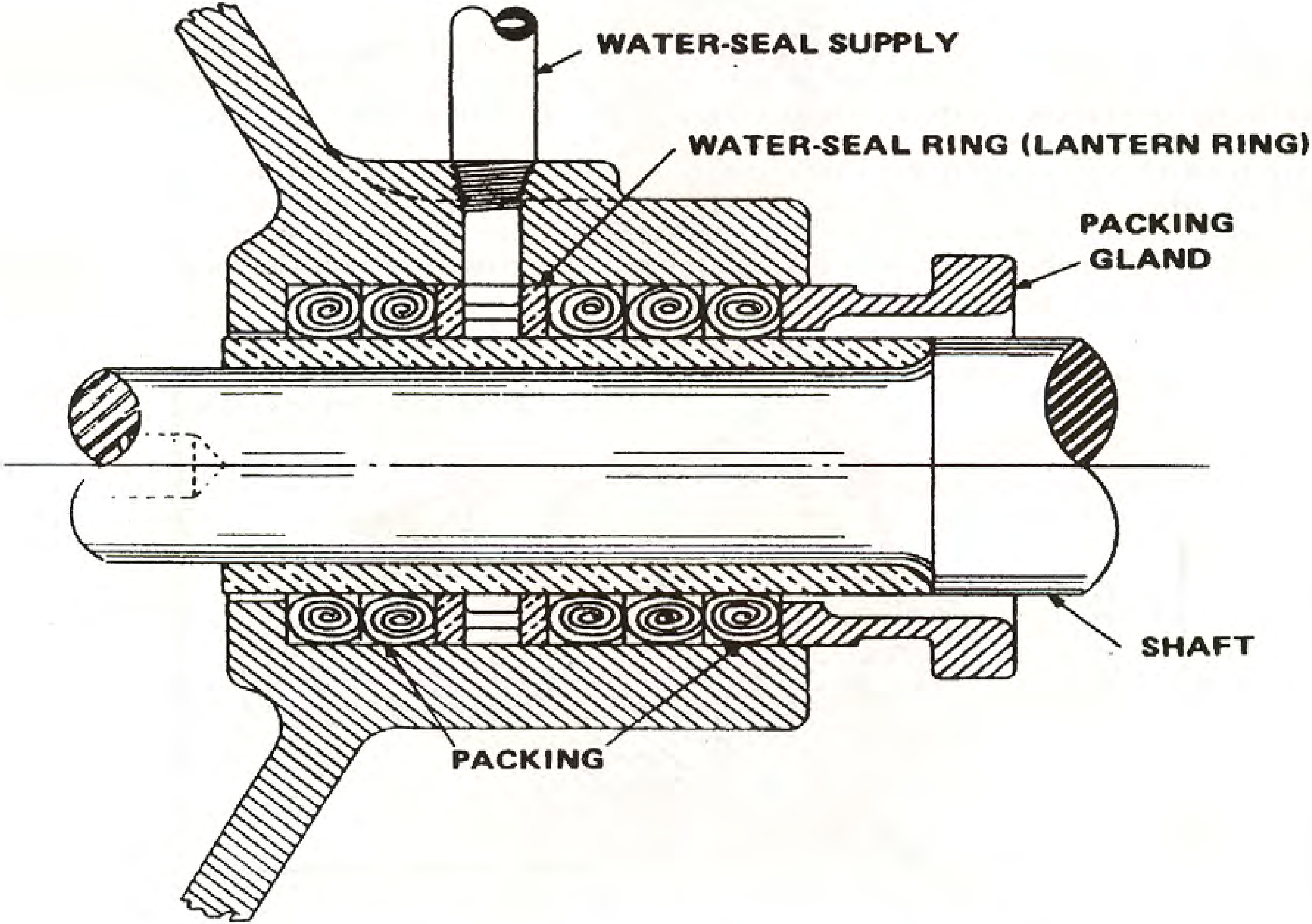
PUMP ASSEMBLY

- Volute
  - Portion of casing that directs water as it enters and leaves the impeller
  - X-sectional area increases, velocity decreases, pressure increases
- piping
  - Diameter suction side > diameter discharge side
  - 4 fps suction side velocity
  - 7 fps discharge side velocity
- Prevent air pockets in suction side piping
  - Slope horizontal runs up towards pump
  - Use eccentric reducers with flat side on top
- NEVER use pump to support piping
- Wear rings
  - prevent water from recirculating back thru pump from discharge to suction side of impeller
  - close tolerance between pump & impeller to as little as 0.010”
  - Become worn from friction & are replaceable


Wear Ring

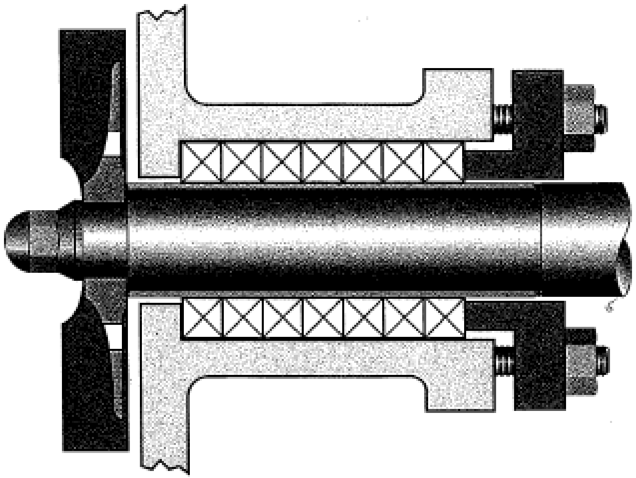
SEALS

- Plugs hole where shaft enters pump body
- Keeps water in & air out of pump
- Stuffing box
  - Part of pump casing where shaft passes through
  - Contains several rings of packing
  - Want rings staggered to allow distribution of lubricating/cooling water
- Packing gland
  - Metal ring on top of stuffing box
  - Used to put pressure on packing to <u>minimize</u> water leakage
- Seal water
  - Used to cool & lubricate the rings of packing
  - Can come from low pressure side (suction) of pump if sufficient pressure
  - Otherwise pipe from discharge side (high pressure) of pump
  - Need air gap if mixing potable & nonpotable water
- Lantern ring
  - Used to direct water from seal water piping to the inside of the stuffing box where the rings of packing are located around the shaft sleeve
  - Metal ring with holes
  - Water circulates around the outside of ring & passes thru the holes to get to the packing

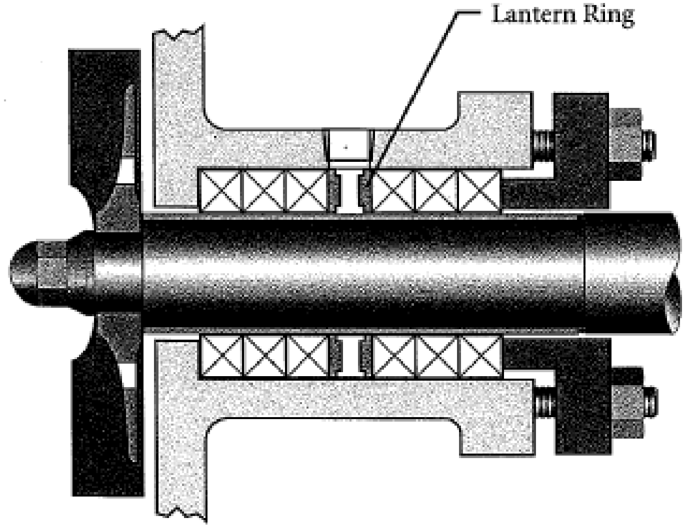


STUFFING BOX WITH LANTERN RING

Packing & Glands

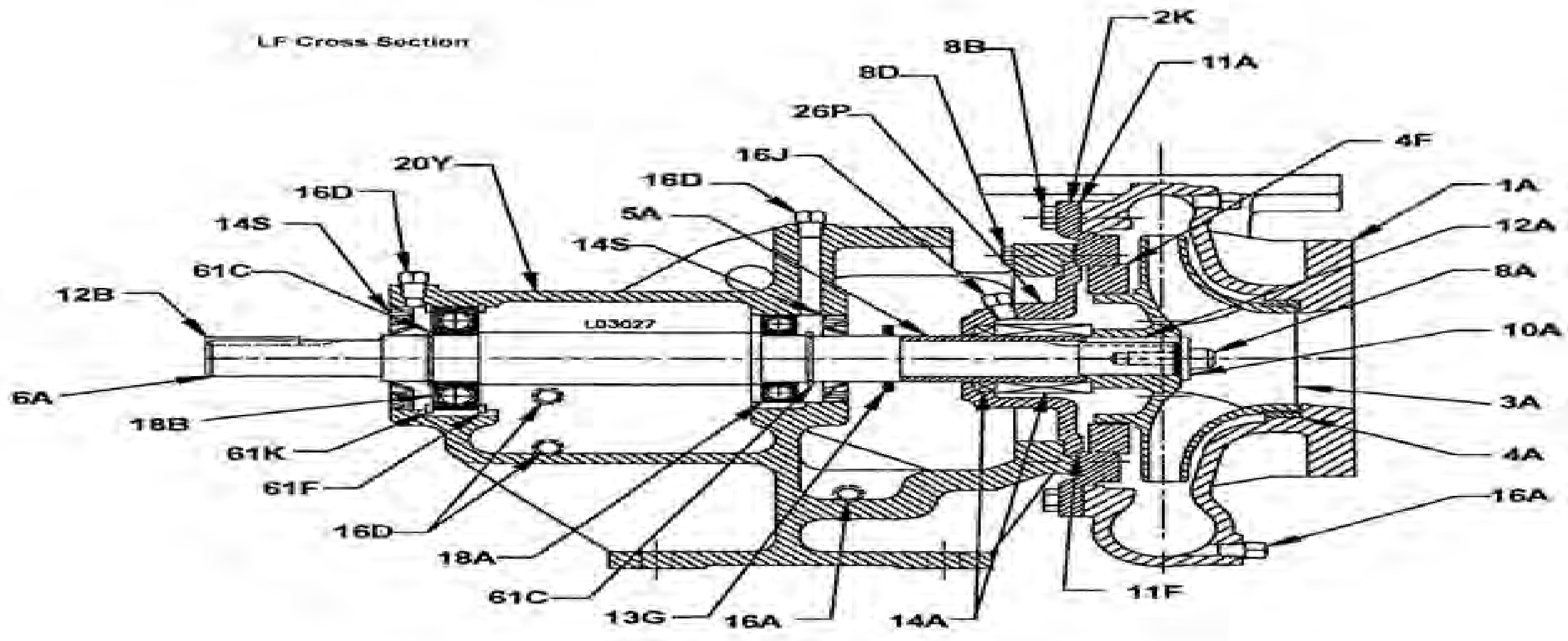


Packing Solid



Packing with
Lantern Ring

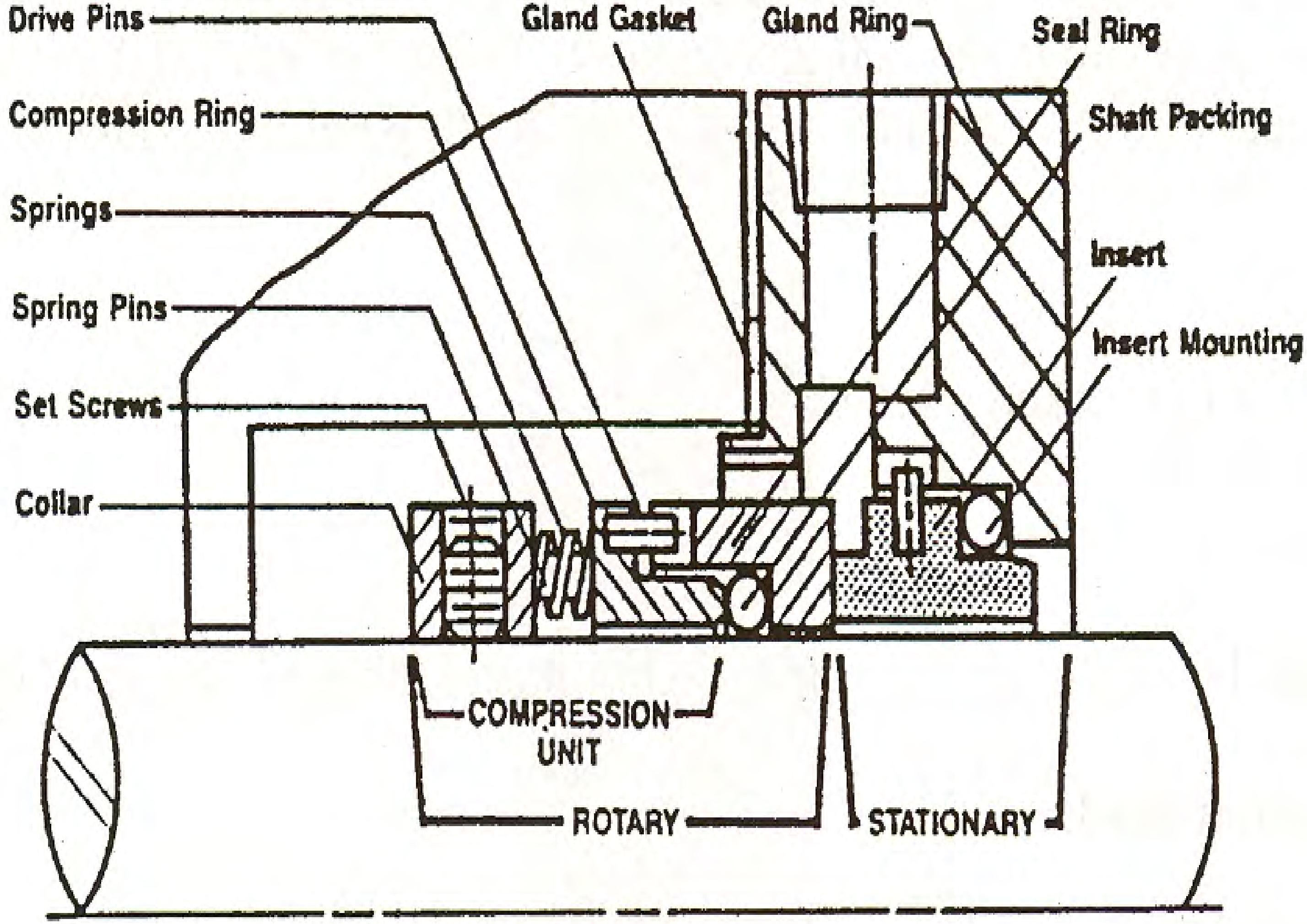
END SUCTION FRAME MOUNTED PUMP ANATOMY



ITEM NO	PART NAME	ITEM NO	PART NAME	ITEM NO	PART NAME
1A	Casing	*10A	Washer, Packing	16L	Plug, Seal Chamber
2K	Backplate	10A	Washer, Impeller	18A	Bearing, Inboard
3A	Enclosed Impeller	11A	Gasket, Casing	18B	Bearing, Outboard
4A	Case Wear Ring	11F	Gasket, Backplate	20Y	Bearing Frame
**4F	Balance Ring	12A	Key, Impeller	*22A	Stud, Packing Gland
5A	Shaft Sleeve	12B	Key, Coupling	26P	Seal Housing
*5L	Lantern Ring	*13A	Packing	*26U	Packing Box
6A	Shaft	13G	Slinger	*35F	Nut, Packing Gland
*7A	Packing Gland	14A	Shaft Seal	61C	Snap Ring
8A	Cap Screw, Impeller	14S	Lip Seal	*61J	Snap Ring
8B	Cap Screw, Casing	16A	Plug, Drain	*Packed Pumps Only	
8D	Cap Screw, Brg. Frame	16D	Plug, Grease/Oil Filter	**If Applicable	

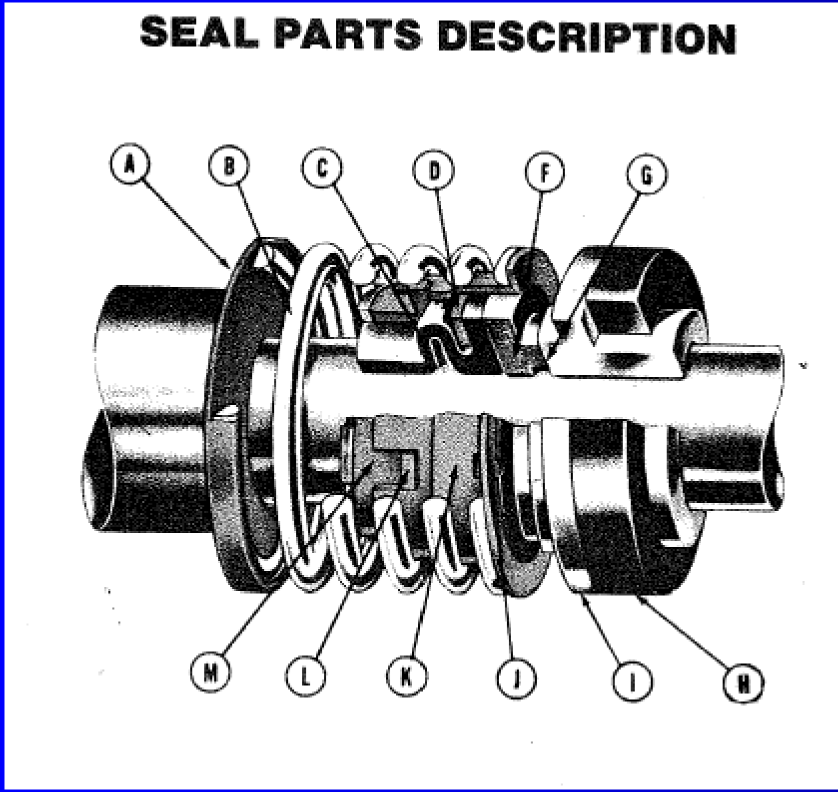
MECHANICAL SEALS

- Replaces packing rings inside the stuffing box
- Includes 2 highly polished seal faces
- One face is inserted in a gland ring
  - Gland ring replaces the packing gland
- Other seal face is attached to the rotating shaft
  - Held in place on shaft with a locking collar
  - Collar includes a spring-loaded assembly that pushes the 2 seal faces together when pump not running
- Seal water (same criteria as for packing seals)
  - When pump running seal water forces 2 seal faces apart
  - This closes gap & keeps water in & air out
  - Insufficient seal water pressure or no pressure will result in seal faces rubbing against each other & seal failure



MECHANICAL SEAL COMPONENTS

MECHANICAL SEAL



A Spring Holder

B Spring

C Synthetic Rubber Bellows

D Disc

F Sealing Washer

G Lapped Sealing Faces

H Seat Ring

I Stationary Floating Seat

J Washer Driving Notch

K Retainer

L Driving Band

PUMP HYDRAULICS

TERMINOLOGY

- FLOW RATE
- HEAD
- NPSH (NET POSITIVE SUCTION HEAD)
- PUMP EFFICIENCY
- MOTOR RPM
- HP (HORSEPOWER)
- ELECTRICAL PHASES

FLOW RATE

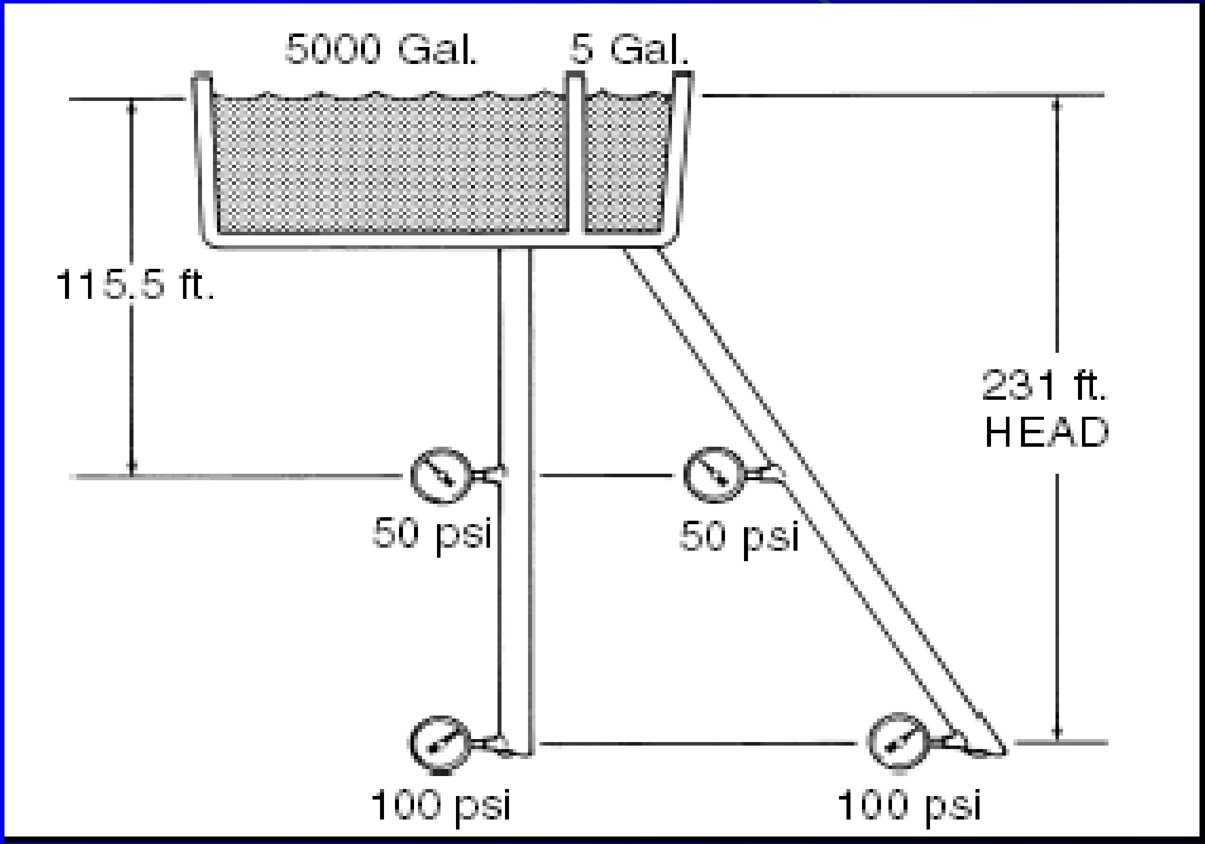
THE VOLUME PER TIME OF WATER TYPICALLY MEASURED AS:

- GPM (GALLONS PER MINUTE)
- GPH (GALLONS PER HOUR)
- GPD (GALLONS PER DAY)

Pressure & Head

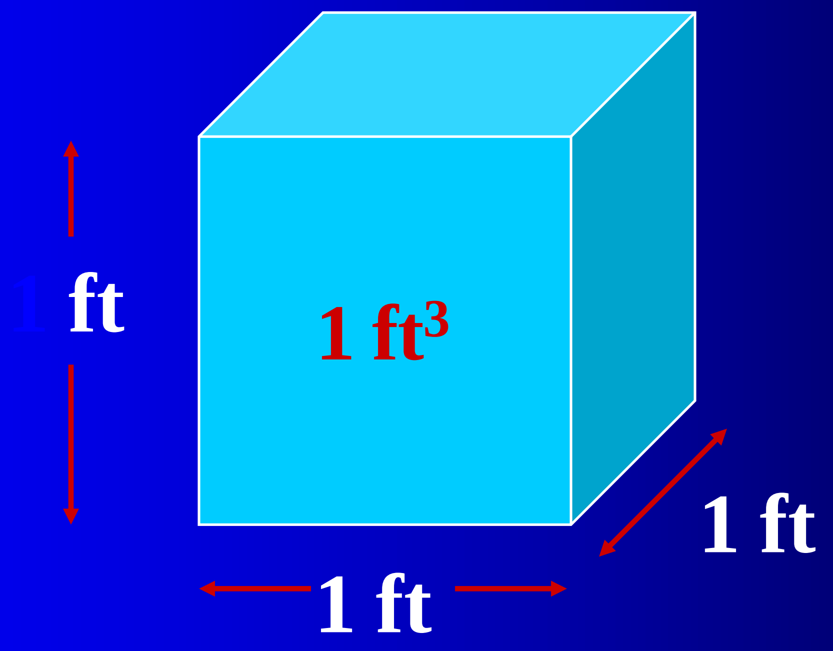
- Pressure is a force based on weight per unit area
- Measured in pounds per square inch, lbs/in^2 (psi), or pounds per square foot, lbs/ft^2
- Pressure is exerted on the bottom of a container and is not related to the volume of the container or the size of the base
- Pressure is only dependant on the height of the fluid in the container
- The height of the fluid in a container is referred to as head, which is a direct measurement in feet & is what exerts the pressure

PRESSURE VS FEET OF HEAD



Relationship between Pressure & Head

- **Weight of water is 62.4 pounds per ft^3**
- **7.48 gal/ft^3 x 8.34 lbs/gal = 62.4 lbs/ft^3**



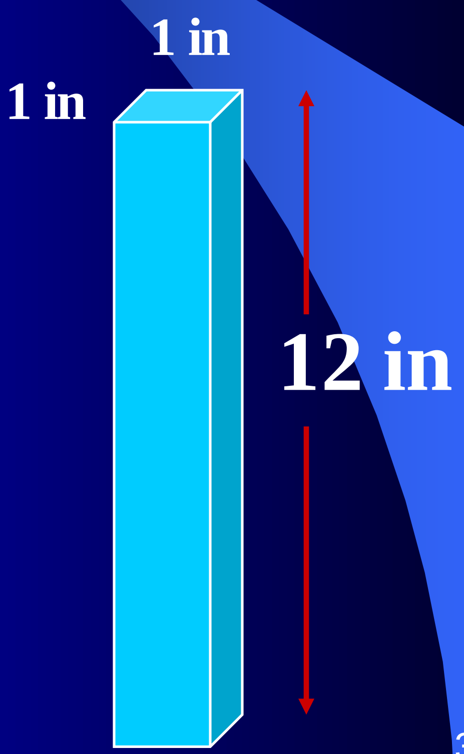
Pressure & Head

Imagine a cube of water 1ft x 1ft x 1ft. Then, the surface area of any one side of the cube will contain 144 in^2 (12in x 12in = 144 in^2). The cube will also contain 144 columns of water one foot tall & one inch square.

Weight = 62.4lbs/144in^2
= 0.433lbs/in^2 or
= 0.433 psi

Therefore, 1 foot of head
= 1ft   0.433psi
= 2.31 ft/psi

So, 1ft = 0.433 psi, and
1psi = 2.31 feet



Remember these conversion factors

- PSI x 2.31 = FEET

Example:

43.3 PSI x 2.31 FT/PSI = 100 FT

- FEET x 0.433 PSI/FT = PSI

Example:

100 FT x 0.433 PSI/FT = 43.3 PSI

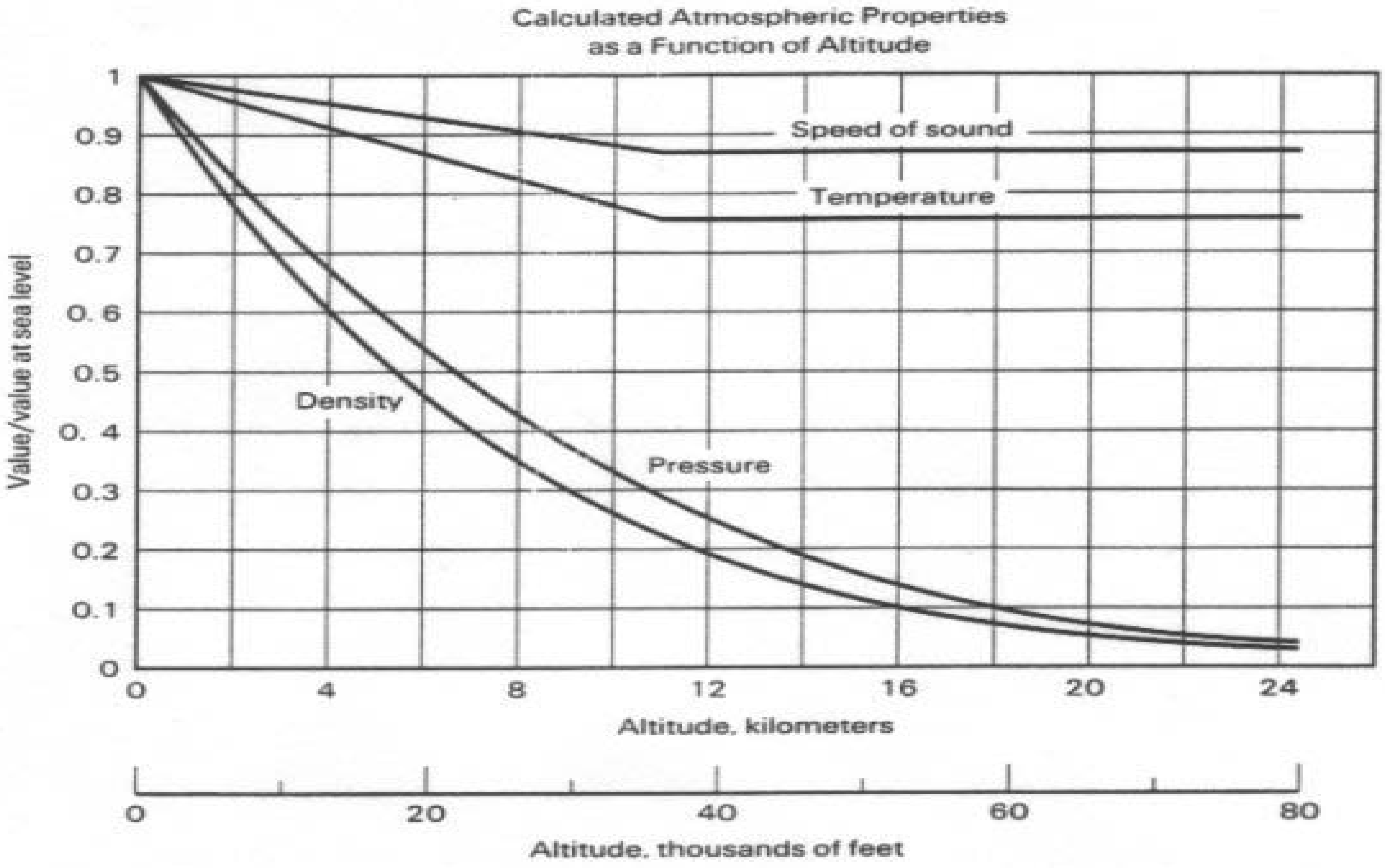
PRESSURE GAUGES

- PSI = POUNDS PER SQUARE INCH
- PSIG = PSI GAUGE
- PSIA = PSI ABSOLUTE

Gage vs Absolute Pressure

- PSIG common type of pressure within plant environment
  - Does not include effects of atmospheric pressure
    - P_{atm} = 14.7 psi = 33.9 ft = 34 ft (at sea level)
    - maximum practical lift of a pump at sea level
  - PSIG = 0 means system is at atmospheric pressure
  - PSIG < 0 considered a vacuum *for the system* (still some value below atmospheric pressure)
    - until PSIG < -14.7 psi pressure due to atmosphere
- PSIA pounds per square inch absolute
  - Usually used to describe a vacuum
  - Includes atmospheric pressure
  - PSIA = 0 means no pressure in system
  - PSIA < 0 absolute vacuum
- PSIA = PSIG + P_{atm}

CHANGES IN ATMOSPHERIC PRESSURE WITH HEIGHT



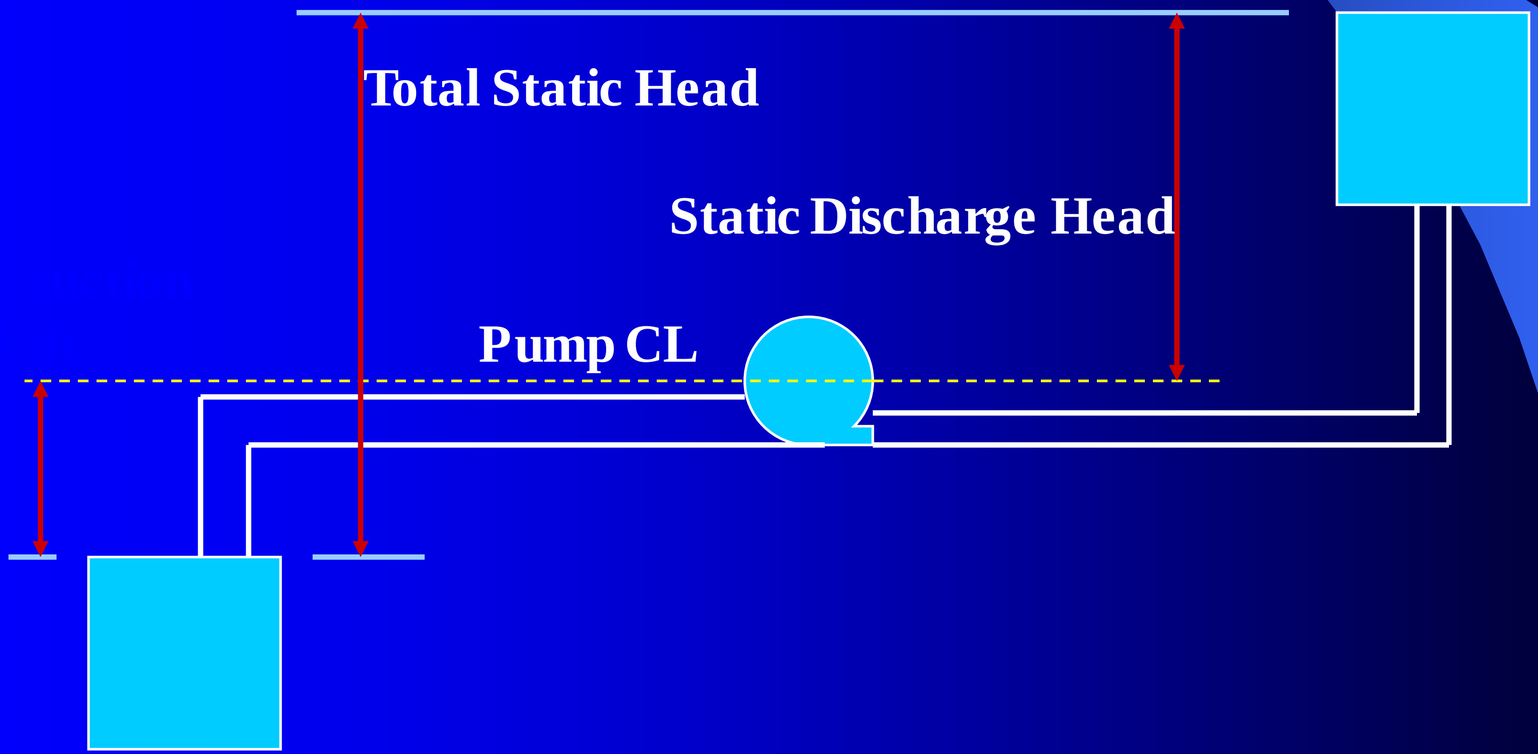
Energy and Head

Energy in water has 4 forms:

- **elevation head, E_H**
  - **measured in feet as height above datum**
- **pressure, P in psi**
  - **pressure head, P_H in ft = P x 2.31 ft/psi**
- **velocity, V in fps**
  - **velocity head, V_H in feet = $V^2/2g$**
  - **g = gravitational acceleration = 32.2 ft/s^2**
- **head loss, H_L measured in feet**
  - **caused by turbulence, friction**
  - **creates heat energy which is lost from system**
  - **increases with smaller pipe diameter, higher flow, rougher pipe walls**

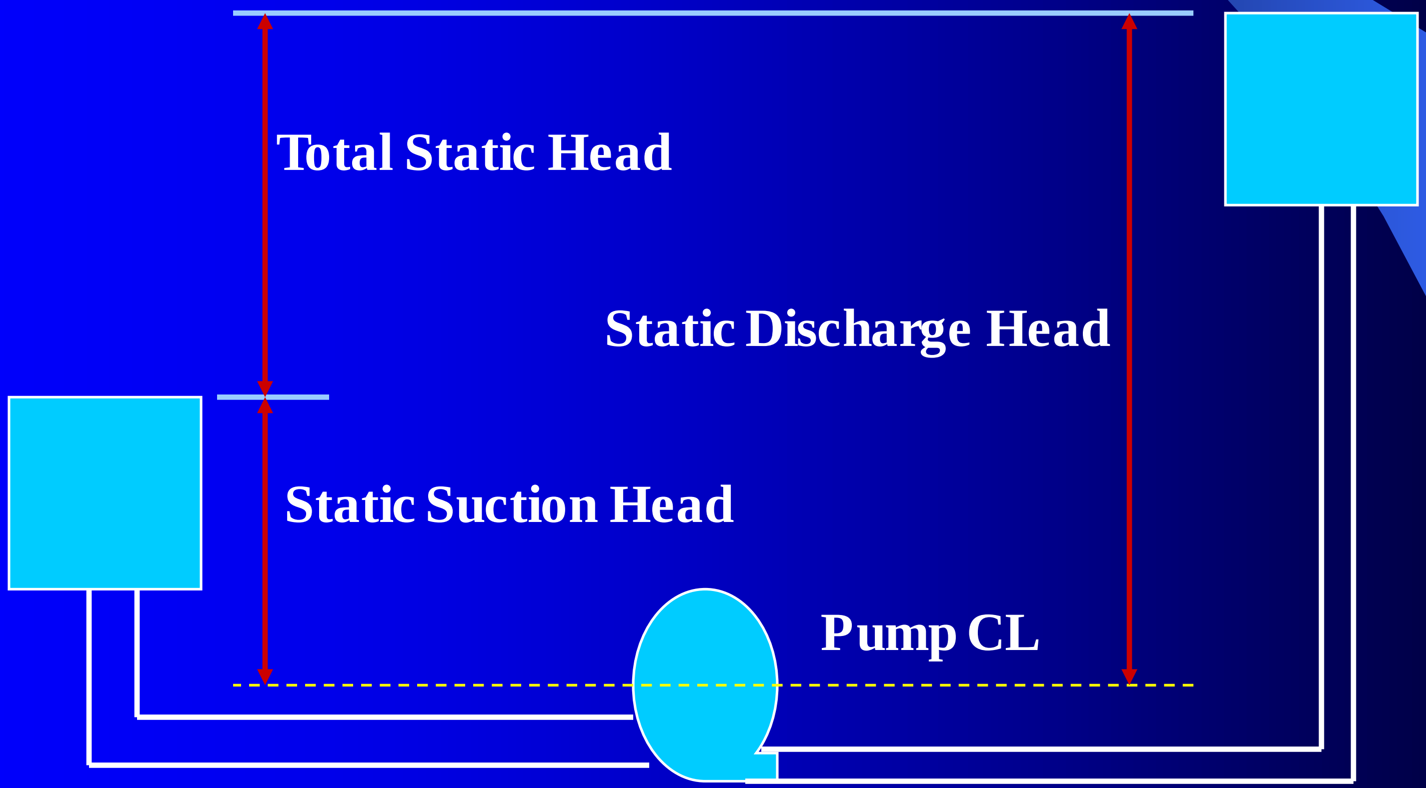
Static Suction Lift TDH

- Fluid level suction side below eye of pump impeller
- TDSL = static suction lift + V_{Hs} + H_{Ls}
- TDDH = static discharge head + V_{Hd} + H_{Ld}
- TDH = SSL + V_{Hs} + H_{Ls} + SDH + V_{Hd} + H_{Ld}



Static Suction Head TDH

- Fluid level suction side above eye of pump impeller
- TDSH = static suction head + $P_{atm} - V_H - H_L$
- TDDH = static discharge head + $V_{Hd} + H_{Ld}$
- TDH = SDH - SSH + $V_{Hs} + H_{Ls} + V_{Hd} + H_{Ld}$



NET POSITIVE SUCTION HEAD, NPSH

- NPSH is the total energy available to move water into the volute and the eye of the impeller
- At sea level NPSH = 1 atm = 14.7 psi = 34 ft
- However, this energy is reduced by:
  - static suction lift (biggest factor)
  - velocity head, V_H to get water moving
  - head loss, H_L
  - Vapor pressure (based on temperature)
    - Portion of water evaporates when placed under a vacuum (at the eye of impeller)
- NPSHR = net positive suction head required
- NPSHA = net positive suction head available

Net Positive Suction Head, NPSH

- **For suction lift condition**

  $$NPSH = P_{atm} - P_v - \text{static suction lift} - H_L$$

- **For suction head condition**

  $$NPSH = \text{static suction head} + P_{atm} - P_v - H_L$$

Vapor Pressure vs Temperature

Temperature, ^{o}F	Vapor Pressure, feet
32	0.204
59	0.565
68	0.774
100	2.17
150	8.56
200	26.45

Table 2-15: Altitude vs. Barometric Pressure and Boiling Point of Water

Altitude		Barometer Reading		Atm. Pressure		Boiling Point
Feet (ft.)	Meters (m)	in.-Hg	mm-Hg	psia	ft. Water	°F
0	0.0	29.9	760	14.7	33.9	212.0
+ 500	+ 152.4	29.4	747	14.4	33.3	211.1
1000	304.8	28.9	734	14.2	32.8	210.2
4000	1219.2	25.8	655	12.7	29.2	204.7
4500	1371.6	25.4	645	12.4	28.8	203.8
5000	1524.0	24.9	633	12.2	28.2	202.9
5500	1676.4	24.4	620	12.0	27.6	201.9
6000	1828.8	24.0	610	11.8	27.2	201.0
6500	1981.2	23.5	597	11.5	26.7	200.1
7000	2133.6	23.1	587	11.3	26.2	199.2
7500	2286.0	22.7	577	11.1	25.7	198.3
8000	2438.4	22.2	564	10.9	25.2	197.4
8500	2590.8	21.8	554	10.7	24.7	196.5
9000	2743.2	21.4	544	10.5	24.3	195.5
9500	2895.6	21.0	533	10.3	23.8	194.6
10000	3048.0	20.6	523	10.1	23.4	193.7
15000	4572.0	16.9	429	8.3	19.2	184.0

Total Dynamic Head, TDH

- Total energy in feet required to move water from fluid level suction side to fluid level discharge side
  - combination of E_H, V_H and H_L of suction and discharge lines
  - V_H discharge side > V_H suction side due to reduced diameter of discharge piping
- Total dynamic suction lift, TDSL
  - fluid level suction side below eye of impeller
  - TDSL = static suction lift + V_H + H_L
  - Compare to net positive suction head, NPSH – energy reqd to move water into volute or impeller eye
    - available NPSH = P_{atm} – P_v – static suction lift – H_L
    - Check pump curve to compare available vs required NPSH
- Total dynamic suction head, TDSH
  - fluid level suction side above eye of impeller
  - NPSH = static suction head + P_{atm} – P_v – H_L
  - pump choice ok if static suction head ≥ NPSH required
  - TDSH = static suction head + P_{atm} – V_H – H_L

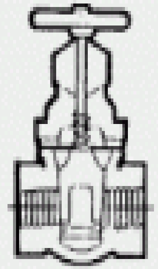
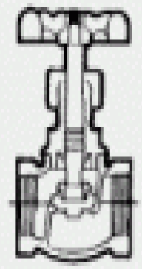
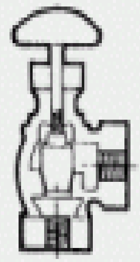
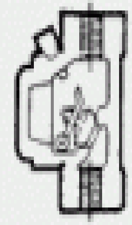
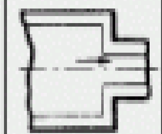
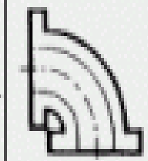
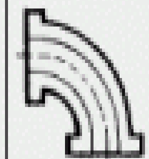
VELOCITY CHART & FRICTION OF WATER

(new steel pipe) at 60° F

1 INCH

FLOW U.S. GPM	STANDARD WEIGHT STEEL - SCH. 40, 1.049" Inside Diameter: VELOCITY (Ft./Sec.)	VELOCITY (Head Ft.)	HEAD LOSS (Ft./100 Ft.)	EXTRA STRONG STEEL - SCH. 80, .957" InsideDiameter: VELOCITY (Ft./Sec.)	VELOCITY (Head Ft.)	HEAD LOSS (Ft./100 Ft.)
2	0.74	.009	**.385**	.89	.01	**.599**
3	1.11	.019	**.787**	1.34	.03	**1.19**
4	1.48	.034	**1.270**	1.79	.05	**1.99**
5	1.86	.054	**1.90**	2.23	.08	**2.99**
6	2.23	.077	**2.65**	2.68	.11	**4.17**
8	2.97	.137	**4.50**	3.57	.20	**7.11**
10	3.71	.214	**6.81**	4.46	.31	**10.80**
12	4.45	.308	**9.58**	5.36	.45	**15.20**
14	5.20	.420	**12.80**	6.25	.61	**20.40**
16	5.94	.548	**16.50**	7.14	.79	**26.30**
18	6.68	.694	**20.60**	8.03	1.00	**32.90**
20	7.42	.857	**25.20**	8.92	1.24	**40.30**
22	8.17	1.036	**30.30**	9.82	1.50	**48.40**
24	8.91	1.23	**35.80**	10.70	1.80	**57.20**
26	9.65	1.45	**41.70**	11.60	2.10	**66.80**
28	10.39	1.68	**48.10**	12.50	2.40	**77.10**
30	11.10	1.93	**55.00**	13.40	2.80	**88.20**
35	13.00	2.62	**74.10**	15.60	3.80	**119.00**
40	14.80	3.43	**96.10**	17.90	5.00	**154.00**
45	16.70	4.33	**121.00**	20.10	6.30	**194.00**

FRICTION LOSSES THROUGH PIPE FITTINGS & VALVES

SIZE OF PIPE (Inches)	GATEVALVE  WIDE OPEN	GATEVALVE 1/4 CLOSED	GATEVALVE 1/2 CLOSED	GATEVALVE 3/4 CLOSED	 GLOBE VALVE-WIDE OPEN	 ANGLE VALVE-WIDE OPEN	 CHECK VALVE-WIDE OPEN	 ORDINARY ENTRANCE TO PIPE LINES	 STD. 90° ELBOW	 MEDIUM SWEEP 90° ELBOW	 LONG SWEEP 90° ELBOW
STRAIGHT PIPE IN FEET (EQUIVALENT LENGTH)											
1/8"	.14	.85	5.00	19.00	9.00	5.00	2.00	.46	.74	.65	.50
1/4"	.21	1.25	7.00	26.00	12.00	6.00	3.00	.60	1.00	.86	.70
3/8"	.27	1.80	9.00	36.00	16.00	8.00	4.00	.75	1.40	1.15	.90
1/2"	.41	2.10	12.00	44.00	17.60	7.78	5.18	.90	1.60	1.55	1.10
3/4"	.55	2.90	14.00	59.00	23.30	10.30	6.86	1.40	2.30	2.06	1.50
1"	.70	3.40	18.00	70.00	29.70	13.10	8.74	1.60	2.70	2.62	2.00
1-1/4"	.92	4.80	24.00	96.00	39.10	17.80	11.50	2.50	3.60	3.45	2.50
1-1/2"	1.07	5.60	28.00	116.00	45.60	20.10	13.40	3.00	4.50	4.03	2.90
2"	1.38	7.00	36.00	146.00	58.60	25.80	17.20	3.50	5.40	5.17	3.60
2-1/2"	1.65	8.40	41.00	172.00	70.00	30.90	20.60	4.00	6.50	6.17	4.40
3"	2.04	10.00	52.00	213.00	86.90	38.40	25.50	5.00	8.50	7.67	5.50
3-1/2"	2.10	12.50	60.00	246.00	100.00	52.00	24.00	5.50	10.0	8.50	6.30
4"	2.40	14.00	70.00	285.00	116.00	57.00	27.00	6.50	12.0	9.50	7.20

MECHANICAL POWER

- EXPRESSED AS HORSE POWER

- THE AMOUNT OF WORK REQUIRED TO LIFT ONE POUND TO THE HEIGHT OF ONE FOOT IS DEFINED AS 1 FT-LB

- ONE HORSE POWER IS THE THEORETICAL POWER REQUIRED TO LIFT 33,000 POUNDS TO A HEIGHT OF ONE FOOT IN ONE MINUTE

- 1 HP = 33,000 FT-LB/MINUTE
- 1 HP = 550 FT-LB/SECOND

ELECTRICAL POWER

- MEASURED IN HP, WATTS (W) OR KILOWATTS (KW)

- 1,000 W = 1 KW = 1.34 HP or

- 1 HP = 746 W = 0.746 KW

ELECTRICAL POWER

- SINGLE PHASE: 115 OR 230 VOLT AC CONSIST OF THREE LEGS (HOT, NEUTRAL & GROUND. NORMALLY REQUIRES A STARTING CIRCUIT (RELAYS AND CAPACITORS)

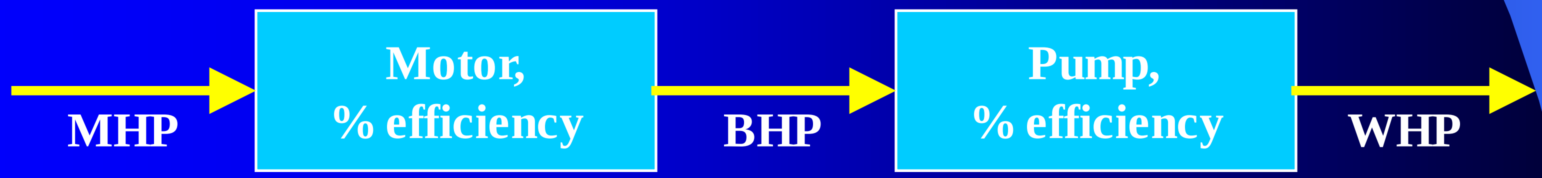
- THREE PHASE: 208/230/460 VOLT AC CONSIST OF THREE HOT LEGS & A GROUND. POSSIBLE TO REVERSE ROTATION BY CHANGING ANY TWO LEADS. BALANCING PHASE IS IMPORTANT TO LIFE.

Pump and Motor Efficiencies

- motor or wire HP, MHP = electrical energy in HP supplied to motor; motor efficiency determines brake HP

- brake HP, BHP = mechanical energy in HP supplied to pump shaft from motor; pump efficiency determines water HP

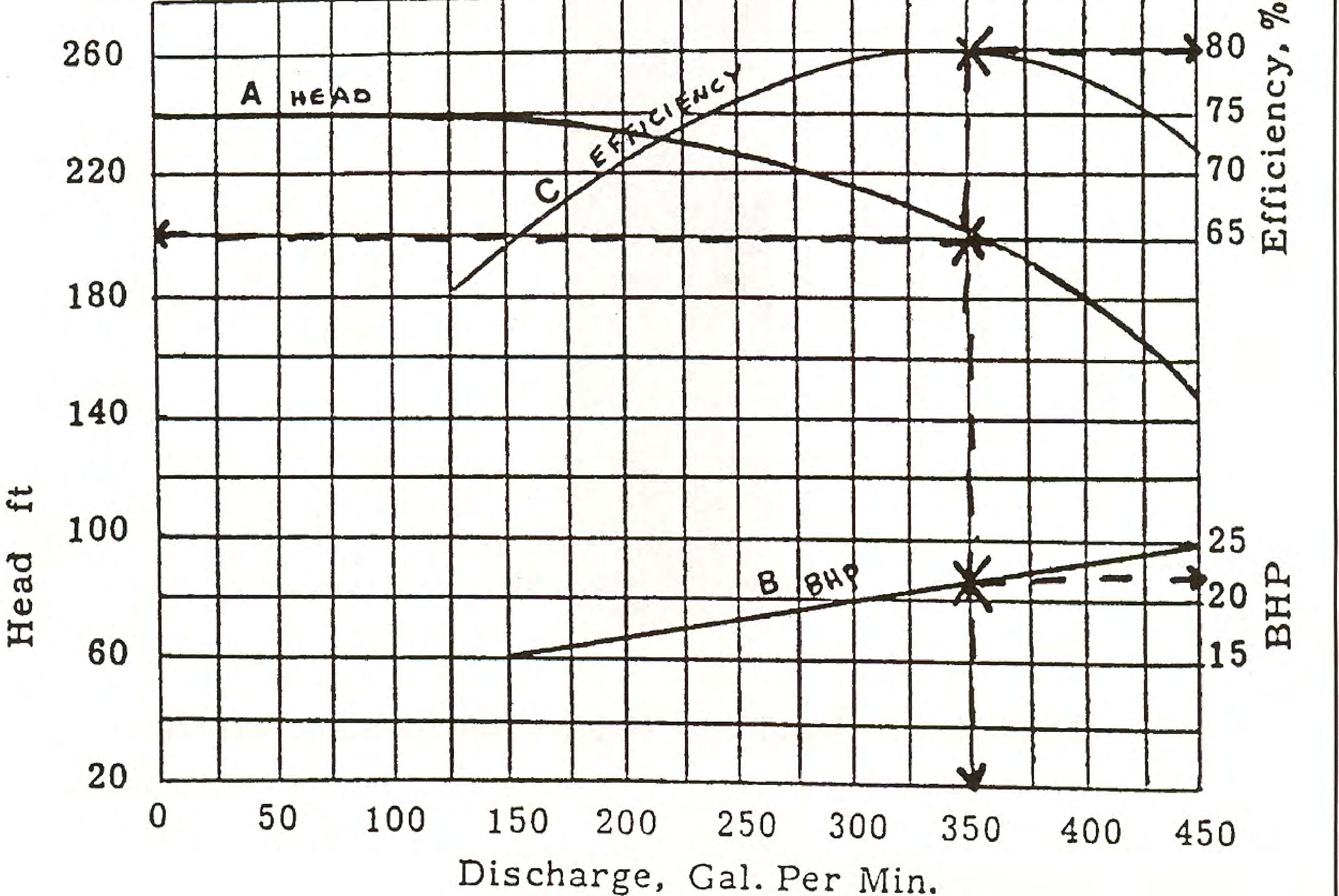
- water HP, WHP = mechanical energy in HP transferred to water by pump



Horsepower Requirements

- **Water HP – energy transferred to water by pump**
  - **HP = (Q, gpm x 8.34 #/gal x TDH, ft)/33,000 ft-#/min**
  - **WHP = (Q x TDH)/3960**
- **Brake HP – energy transferred to shaft of pump from shaft of motor**
  - **Brake HP = WHP/Eff_{pump}**
- **Motor or Wire HP – energy required in electrical input to the motor**
  - **Motor or Wire HP = BHP/Eff_{motor}**
  - **used to calculate cost of pump operation**

PUMP CURVES

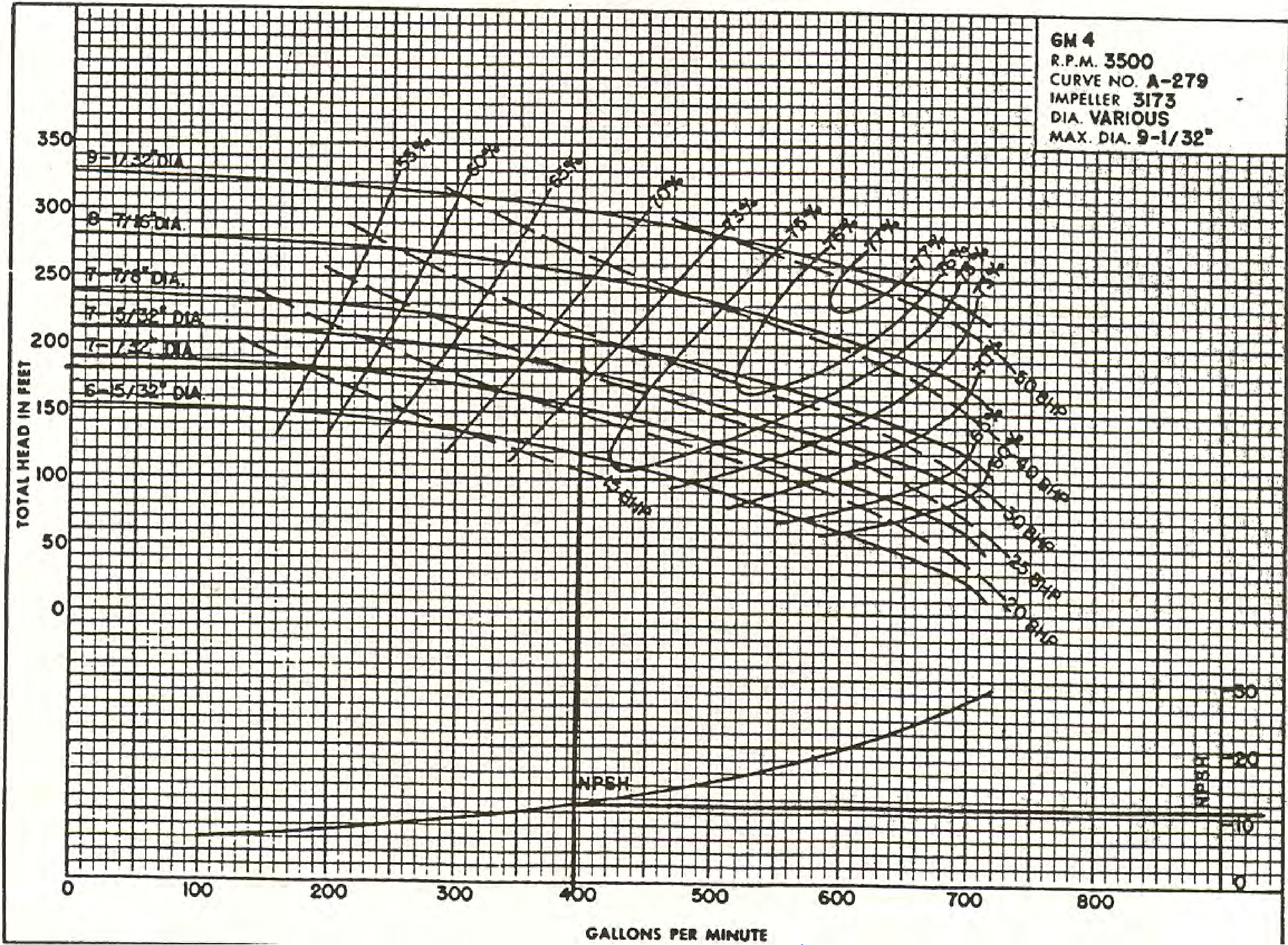


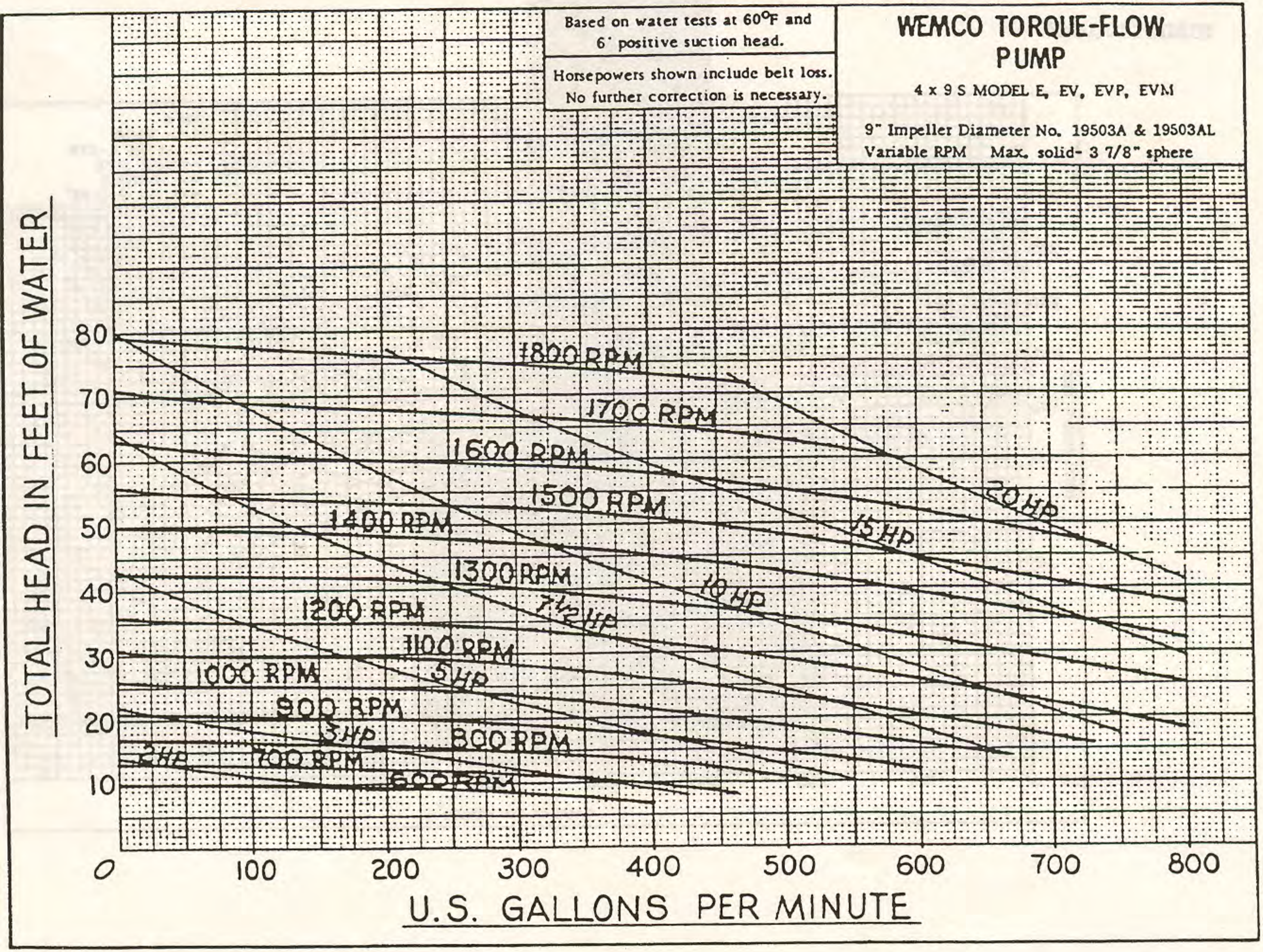
260
220
180
140
100
60
20
Head ft
A HEAD
C EFFICIENCY
B BHP
80
75
70
65
Efficiency, %
25
20
15
BHP
0
50
100
150
200
250
300
350
400
450
Discharge, Gal. Per Min.

PUMP CURVE

Pump curve characteristics

- Head Capacity curve – curve A
  - Shows relationship between head in feet and capacity, or flow in gpm
- Brake horsepower curve – curve B
  - Indicates power in horsepower required for pump to meet head and flow conditions from curve A
- Efficiency curve – curve C
  - Provides efficiency of the pump


GM 4
R.P.M. 3500
CURVE NO. A-279
IMPELLER 3173
DIA. VARIOUS
MAX. DIA. 9-1/32"
9-1/32" DIA.
8-7/16" DIA.
7-7/8" DIA.
7-5/32" DIA.
7-1/32" DIA.
6-15/32" DIA.
55%
60%
65%
70%
73%
75%
76%
77%
50 BHP
40 BHP
30 BHP
25 BHP
20 BHP
15 BHP
NPSH
TOTAL HEAD IN FEET
GALLONS PER MINUTE
0
50
100
150
200
250
300
350
100
400
500
600
700
800
10
20
30



WEMCO TORQUE-FLOW PUMP
TYPICAL PERFORMANCE CURVE
New Issue
SHEET
DATE: Feb. 15, 1967
D62

Affinity Laws

- Impeller diameter and pump speed (rpm) for pump curve must match impeller diameter and speed of pump
- Can use affinity laws to compensate for changes in diameter
  - $Q_2 = Q_1 \times D_2/D_1$
  - $H_2 = H_1 \times (D_2/D_1)^2$
  - $HP_2 = HP_1 \times (D_2/D_1)^3$
- For changes in speed
  - $Q_2 = Q_1 \times RPM_2/RPM_1$
  - $H_2 = H_1 \times (RPM_2/RPM_1)^2$
  - $HP_2 = HP_1 \times (RPM_2/RPM_1)^3$

Shut-Off Head

- The maximum amount of head or pressure a pump can develop
- Flow drops to 0 when a pump reaches shut-off head
- Pump curve NOT valid if pump can not generate rated shut-off head
  - Could be due to worn impeller or worn wear rings
  - Could also be due to pump running at lower rpm than rating

MECHANICAL SYSTEMS OPERATION & MAINTENANCE (O&M)

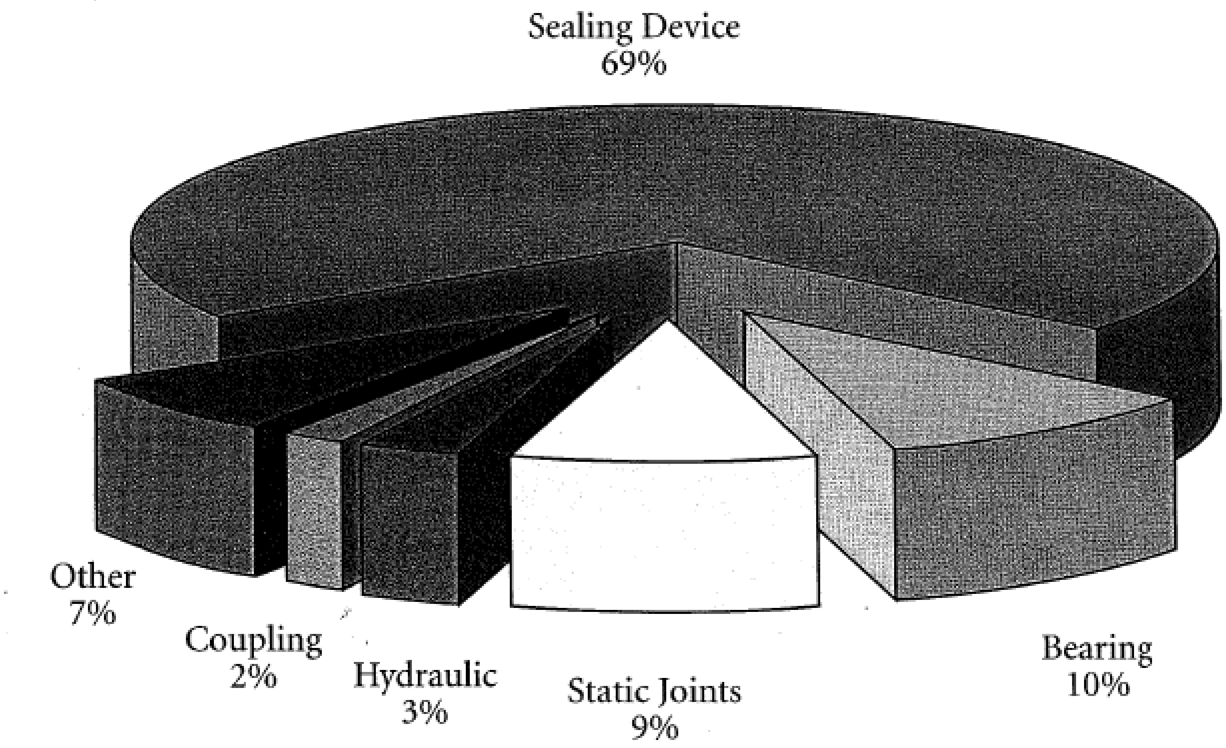
MAINTENANCE & TROUBLESHOOTING

MOST OF THE TIME THE PART THAT FAILED IS SELDOM THE ROOT CAUSE OF THE FAILURE. UNTIL YOU CORRECT THE ROOT CAUSE, REPEAT FAILURES WILL OCCUR.

MAINTENANCE & TROUBLESHOOTING

- PACKING & GLANDS
- MECHANICAL SEALS
- BEARINGS
- SHAFTS
- SUBMERSIBLE WELL SYSTEMS

Causes of Rotating Equipment Failure



Packing Problems

Troubleshooting Failure of Compression Packings

Problem	Probable cause	Remedial action
Pump fails to deliver any fluid	Loss of prime resulting from a loose or defective packing that allows air to enter pump housing	Tighten or replace packing. Prime pump as in normal startup.
Pump delivers only a small quantity of fluid	Air entering stuffing box to cause partial loss of prime Adjustment of packing needed	Check for leakage through stuffing box with pump operating (outflow of fluid). If leakage is not observed after gland adjustment, three possibilities exist: 1. Lantern ring clogged or displaced to block sealing liquid line 2. Sealing liquid line is blocked 3. Worn shaft or shaft sleeve under packing that allows air passage into pump chamber.
	Air entering stuffing box to cause partial loss of prime Defective packing	Replace packing after inspection of surface condition of shaft or shaft sleeve.
Pump pressure is less than normal	Defective packing	Replace packing after checking shaft.
Pump operates normally initially followed by a drop in discharge volume	Air entering stuffing box Loose or defective packing	Make gland adjustment and observe leakage and pump delivery. If no change, replace packing.
Pump requires excess power	Excessive packing tightness	Reduce gland pressure and retighten normally with leakage. If no leakage is visible, check packing and shaft.
Stuffing box leaks excessively	Defective packing	Replace packing.
	Improper type of packing Improperly installed packing	Replace packing material after checking compatibility with pumped fluid.
	Shaft deterioration through damage or wear	Remachine and refinish or replace shaft.
Stuffing box overheats	Excess packing tightness	Reduce gland pressure.
	Insufficient packing lubrication	Reduce gland pressure; remove packing for inspection, replacement, or both.
	Improper type of packing	Recheck material selection and install new packing of suitable type.
	Insufficient flow of cooling water to stuffing box jackets	Check water supply lines for closed valves or blocked lines.
	Improperly packed stuffing box	Replace packing following recommended procedure.
Packing wear rate is excessive	Shaft or shaft sleeve wear or surface finish deterioration	Remachine and refinish or replace shaft.
	Insufficient packing lubrication Marginal or no lubrication	Repack with packing looseness that allows some leakage.
	Improperly installed packing	Remove old packing, clean stuffing box, and replace packing following recommended procedure.
	Improper type of packing	Recheck material selection and install new packing of suitable type.
	Movement of packing to prevent its seating-in caused by pressure pulsation in external seal liquid line	Eliminate source of pulsation.

Source: Harold Woodhouse, Dean Hill

MECHANICAL SEAL COMMON FAILURES

- RUN-DRY
- DEAD HEADING
- TEMPERATURE
- ALIGNMENT
- VIBRATION
- PARTICULATE / ABRASIVES
- CHEMICAL INCOMPATIBILITY

GUIDLINES FOR THE PROPER INSTALLATION OF MECHANICAL SEALS

PREPARATION OF THE PUMP

(a) It is important that the seal chamber or stuffing box is clean and free of all foreign matter.

(b) The shaft or shaft sleeve on which the seal is installed must be to exact size, straight, smooth, and free of sharp corners, nicks, scratches or burrs.

(c) The Face of the Stuffing boxes must be clean, smooth and square with the axis of the shaft.

(d) Make sure all holes are plugged in the stuffing box that are not to be used in the appliance operation.

(e) End fit up of Horizontal split case pumps must match perfectly. The gasket between the halves that extend must be flush with the surface on which the mechanical seal gland and gasket is to seal. Make sure there are no burrs or sharp corners.

(f) The maximum permitted shaft end play is .005".

(g) Check the shaft for alignment with a dial indicator. Excessive misalignment may mean a bent shaft or faulty bearings.

(h) If a shaft sleeve is used, make certain the sleeve is properly gasketed to the shaft to prevent any leakage under the sleeve.

(i) Check pump impeller and wear rings for proper clearance. SHAFT MUST TURN FREELY. Vibrations caused by rubbing and improper clearances can cause seal failure.

INSTALLATION OF SEAL

(a) Cleanliness in seal installation is imperative to keep any foreign matter out of the seal chamber. Always handle mechanical seals with extreme care. Be sure no foreign matter is on either seal face.

(b) Make sure the new seal goes on exactly the same way the old seal came off. Be sure to identify all parts as they are removed and reinstalled.

(c) Where set screws are used as a drive between seal and shaft, the shaft should be counter sunk to receive the cup point. Make sure all set screws are tight.

(d) Use four (4) equal spaced gland bolts when possible. TIGHTEN BOLTS EVENLY. When possible, follow API-ASME Code for unfired vessels in selecting gland bolt size. Check clearances between shaft and gland with feeler guages. The gland must be accurately centered.

(e) Test seals statically under pressure before starting pump. Make adjustments if required to stop any leakage through gland gasket if noticed.

(f) NEVER OPERATE MECHANICAL SEALS DRY. Be sure suction and discharge of pump is open and a positive head of fluid is present before starting pump. This applies even when just checking for proper rotation and adjustment of electrical connections.

SEAL PROBLEM SOLVING

	PROBLEM	POTENTIAL CAUSE	SOLUTION
A.*	CRACKED, CHIPPED, BROKEN CERAMIC OR SILICON SEAT	SEAL RAN DRY. VERY HOT SEAL FACE CAME IN CONTACT WITH COOLER LIQUID.	CHECK TO INSURE SEAL CHAMBER IS FULL OF LIQUID BEFORE STARTING UP APPLIANCE. AT HIGH TEMPERATURE, INSURE FLUSHING AT SEAL FACES.
B.*	CARBON OR METAL SEAL FACE IS SCORED AND/OR GROOVED	ABRASIVE PARTICLES ARE IN THE SYSTEM, CAUSING ABRASION TO SEAL FACES.	HAVE SYSTEM CLEANED AND FLUSHED, INSTALL ABRASIVE SEPARATOR OR GO TO S.C. OR T.C. HARD FACE.
C.*	CARBON OR METAL SEAL FACE WEARS UNEVENLY.	SEAL NOT PROPERLY INSTALLED OR SHAFT MISALIGNMENT.	MAKE SURE OF PROPER INSTALLATION AND CHECK SHAFT ALIGNMENT.
D.*	FLEXIBLE BELLOWS TORN	COUPLING MISALIGNMENT	REALIGN APPLIANCE AND MOTOR.

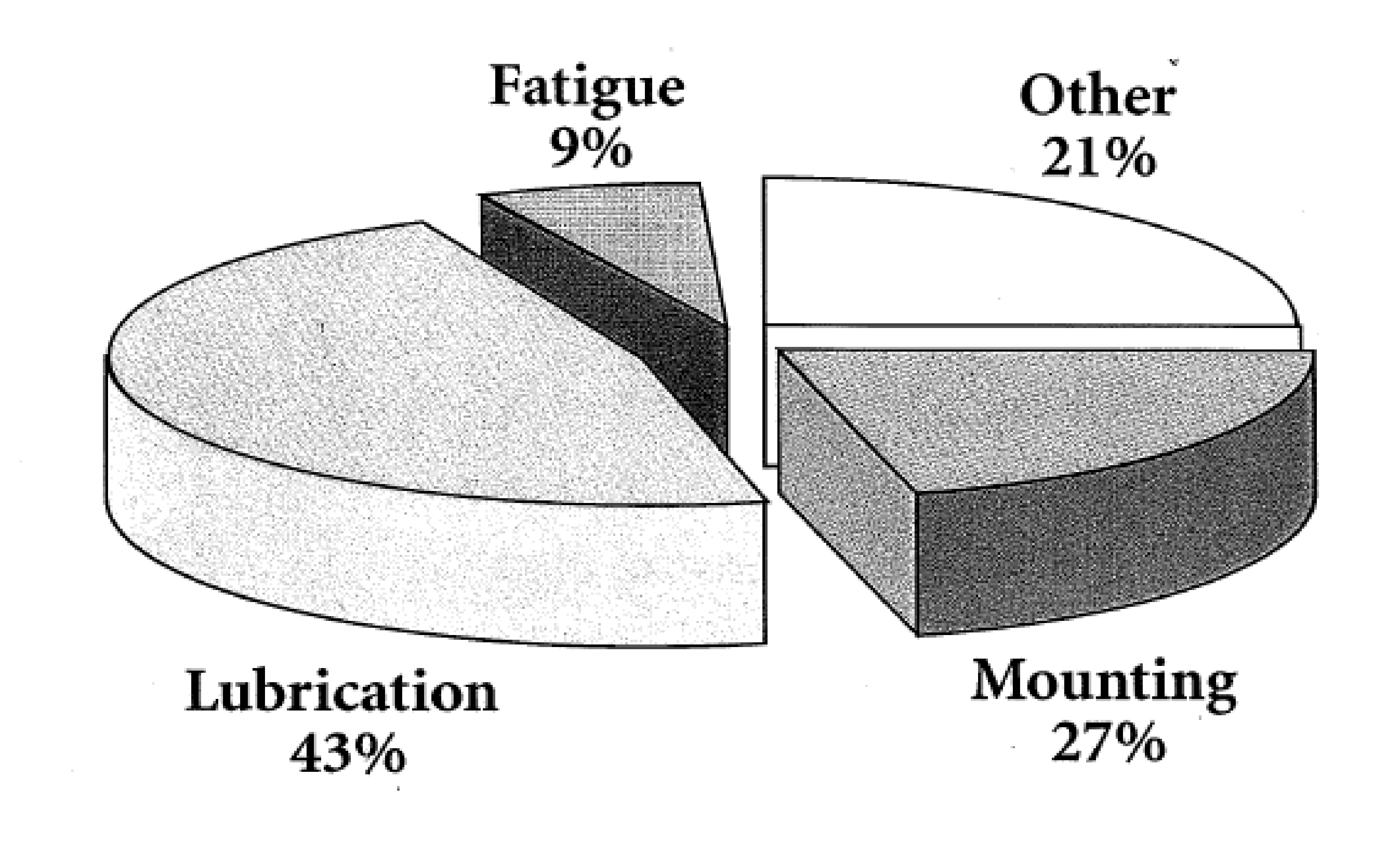
note: *
In A,B,C,D, above, always make sure that the seal when fully compressed is not longer than the length of of the stuffing box or seal enclosure in which it is installed. Over compression is a major cause of seal failure.

E.	RETAINER DRIVE TABS WORN OR BROKEN.	CAVITATION, VIBRATION, LOSS OF FLUID AT SEAL FACES OR COUPLING MISALIGNMENT.	INSURE PROPER LUBRICATION AT SEAL FACES, OR REALIGN PUMP & MOTOR.
F.	BELLOWS HARD OR BRITTLE. EXCESSIVE CARBON WEAR.	TEMPERATURE TOO HIGH ? CHECK FOR PUMP CAVITATION	USE VITON OR TEFLON MEMBERS, HIGH TEMPERATURE CARBON, METAL OR TUNGSTEN CARBIDE SEAT.
G.	SHORT SEAL LIFE IN TREATED SYSTEMS	TEMPERATURE HIGHER THAN EXPECTED OR DESIGNED FOR.	CONSULT WITH ENGINEERING WITH TEMPERATURE AND PPM FOR PROPER SEAL RECOMMENDATION.
H.	SEAL FRETS OR WEARS OUT SHAFT.	CHECK BEARINGS FOR SHAFT WHIP, AXIAL MOVEMENT. BE SURE TO CHECK STRAIGHTNESS.	REPLACE BEARINGS OR SHAFT.
I.	BELLOWS SOFT AND STICKY, PERHAPS DISSOLVING.	BELLOWS NOT COMPATIBLE WITH MATERIAL BEING PUMPED.	CONSULT ENGINEERING FOR ALTERNATE RECOMMENDATION.

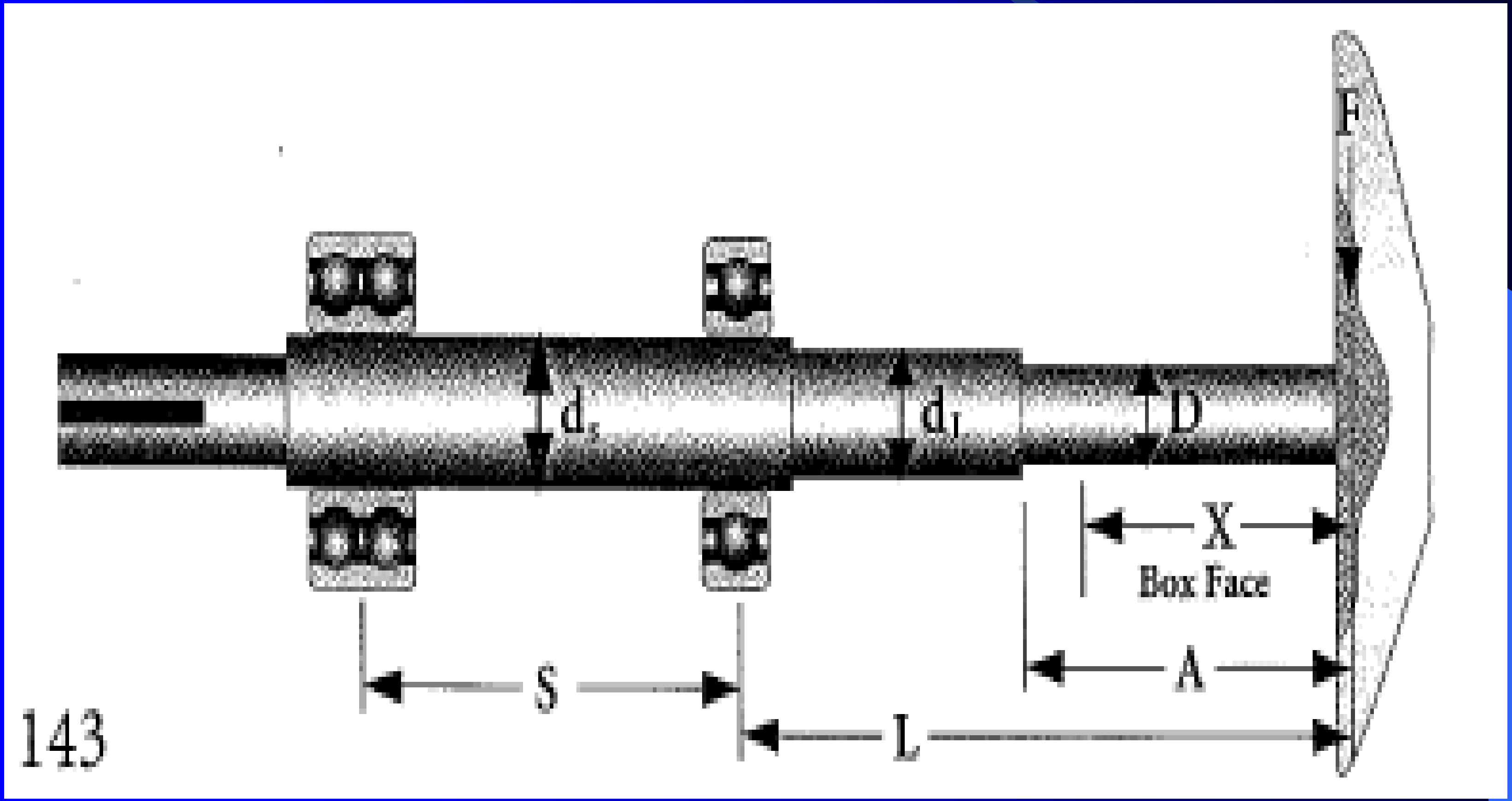
ELASTOMERS AND MEMBERS

Quantum uses BUNA-N (NITRILE) as the standard elastomer. Buna-N has a service range -50 to +212 F.
Quantum uses VITON (Dupont) as an alternative standard material for temperatures in excess of +212 F to +400 F.

BEARINGS



RADIAL, AXIAL, & THRUST LOADS



BEARING MAINTENANCE

- LUBRICATE PER MANUFACTURERS RECOMMENDATIONS
- SEALED OR SHIELDED BEARINGS ARE FACTORY LUBRICATED AND RATED FOR 10,000 HOURS & UP
- OVER GREASING IS NOT RECOMMENDED.
- BE AWARE WHEN PLACING ON SHAFT OF CREATING FLATS SPOTS

COMMON FAILURES

- LACK OF LUBRICATION / TEMPERATURE
- DIRT
- IMPROPER INSTALLATIONS (FLAT SPOTS)
- FATIGUE
- VIBRATION

STATIC JOINTS COMMON FAILURES

- NO PIPE SUPPORT
- OVER-TORQUEING BOLTS
- IMPROPER ALIGNMENT (BASES & SUPPORTS)

HYDRAULIC COMMON FAILURES

- CAVATION WEAR
- SYSTEM DESIGN
- PARTICULATE MATTER
- SYSTEM ADD-ONS

COUPLINGS
COMMON FAILURES

- MISALIGNMENT
- IMPROPER SIZING (HP VS. RPM)
- FATIGUE

GENERAL START UP OF PUMPS

- **Start-up of a Centrifugal Pump:** The suction valve should be open and generally operators understand this, but the positioning of the discharge valve is somewhat of a mystery. When given the choice of placing the valve in the fully open, fully closed or partially open position, there seems to be very little consensus among operators when procedure does not dictate one of the three. The most appropriate position to place a discharge valve in during pump start-up is approximately 25% open.

- **Pump Throttling:** There is a widespread misunderstanding within operations that a pump can be throttled through pinching off of the suction valve. While you may recognize this to be inappropriate, a survey of the operators in your plant would uncover a significant percentage that do not know this.

SUBMERSIBLE PUMP TROUBLESHOOTING

Motor Does Not Start

Possible Cause	Checking Procedures	Corrective Action
A. No power or incorrect voltage.	Check voltage at line terminals The voltage must be ± 10% of rated voltage.	Contact power company if voltage is incorrect.
B. Fuses blown or circuit breakers tripped.	Check fuses for recommended size and check for loose, dirty or corroded connections in fuse receptacle. Check for tripped circuit breakers.	Replace with proper fuse or reset circuit breakers.
C. Defective pressure switch.	Check voltage at contact points. Improper contact of switch points can cause voltage less than line voltage.	Replace pressure switch or clean points.
D. Control box malfunction.	For detailed procedure, see pages 44-45.	Repair or replace.
E. Defective wiring	Check for loose or corroded connections or defective wiring.	Correct faulty wiring or connections.
F. Bound pump.	Check for misalignment between pump and motor or a sand bound pump. Amp readings will be 3 to 6 times higher than normal until the overload trips.	Pull pump and correct problem. Run new installation until the water clears.
G. Defective cable or motor.	For detailed procedure, see pages 42-44.	Repair or replace.

Motor Starts Too Often

A. Pressure switch.	Check setting on pressure switch and examine for defects.	Reset limit or replace switch.
B. Check valve - stuck open.	Damaged or defective check valve will not hold pressure.	Replace if defective.
C. Waterlogged tank.	Check air charge.	Repair or replace.
D. Leak in system.	Check system for leaks.	Replace damaged pipes or repair leaks.

Motor Runs Continuously

Possible Cause	Checking Procedures	Corrective Action
A. Pressure switch.	Check switch for welded contacts. Check switch adjustments.	Clean contacts, replace switch, or adjust setting.
B. Low water level in well.	Pump may exceed well capacity. Shut off pump, wait for well to recover. Check static and drawdown level from well head.	Throttle pump output or reset pump to lower level. Do not lower if sand may clog pump.
C. Leak in system.	Check system for leaks.	Replace damaged pipes or repair leaks.
D. Worn pump.	Symptoms of worn pump are similar to those of drop pipe leak or low water level in well. Reduce pressure switch setting, if pump shuts off worn parts may be the fault.	Pull pump and replace worn parts.
E. Loose coupling or broken motor shaft.	Check for loose coupling or damaged shaft.	Replace worn or damaged parts.
F. Pump screen blocked.	Check for clogged intake screen.	Clean screen and reset pump depth.
G. Check valve stuck closed.	Check operation of check valve.	Replace if defective.
H. Control box malfunction.	See pages 44-45 for single phase.	Repair or replace.

Motor Runs But Overload Protector Trips

A. Incorrect voltage.	Using voltmeter, check the line terminals. Voltage must be within ± 10% of rated voltage.	Contact power company if voltage is incorrect.
B. Overheated protectors.	Direct sunlight or other heat source can raise control box temperature causing protectors to trip. The box must not be hot to touch.	Shade box, provide ventilation or move box away from source.
C. Defective control box.	For detailed procedures, see pages 44-45.	Repair or replace.
D. Defective motor or cable.	For detailed procedures, see pages 42-44.	Repair or replace.
E. Worn pump or motor.	Check running current, See pages 13 & 22-26.	Replace pump and/or motor.

QUESTIONS?