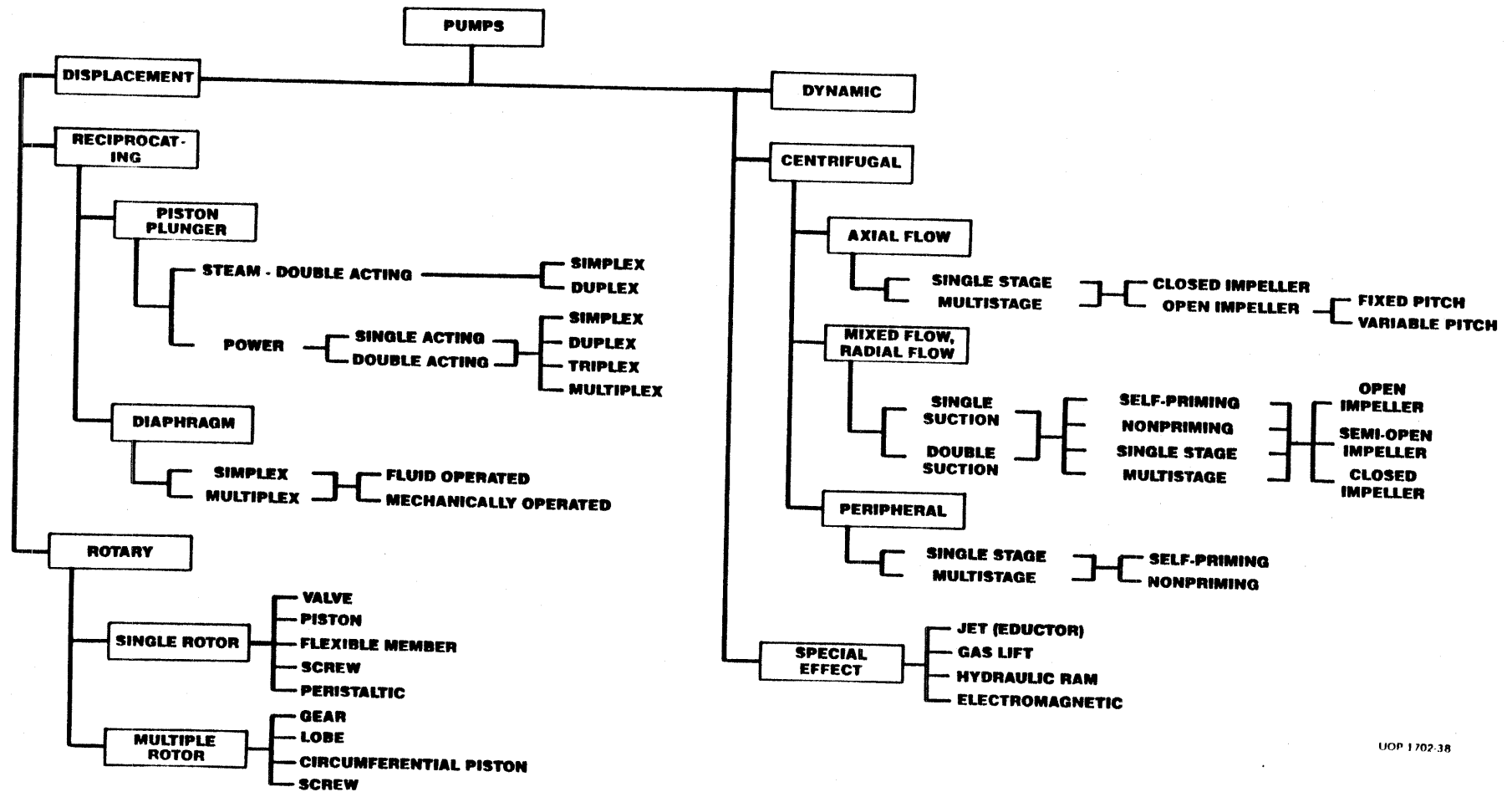
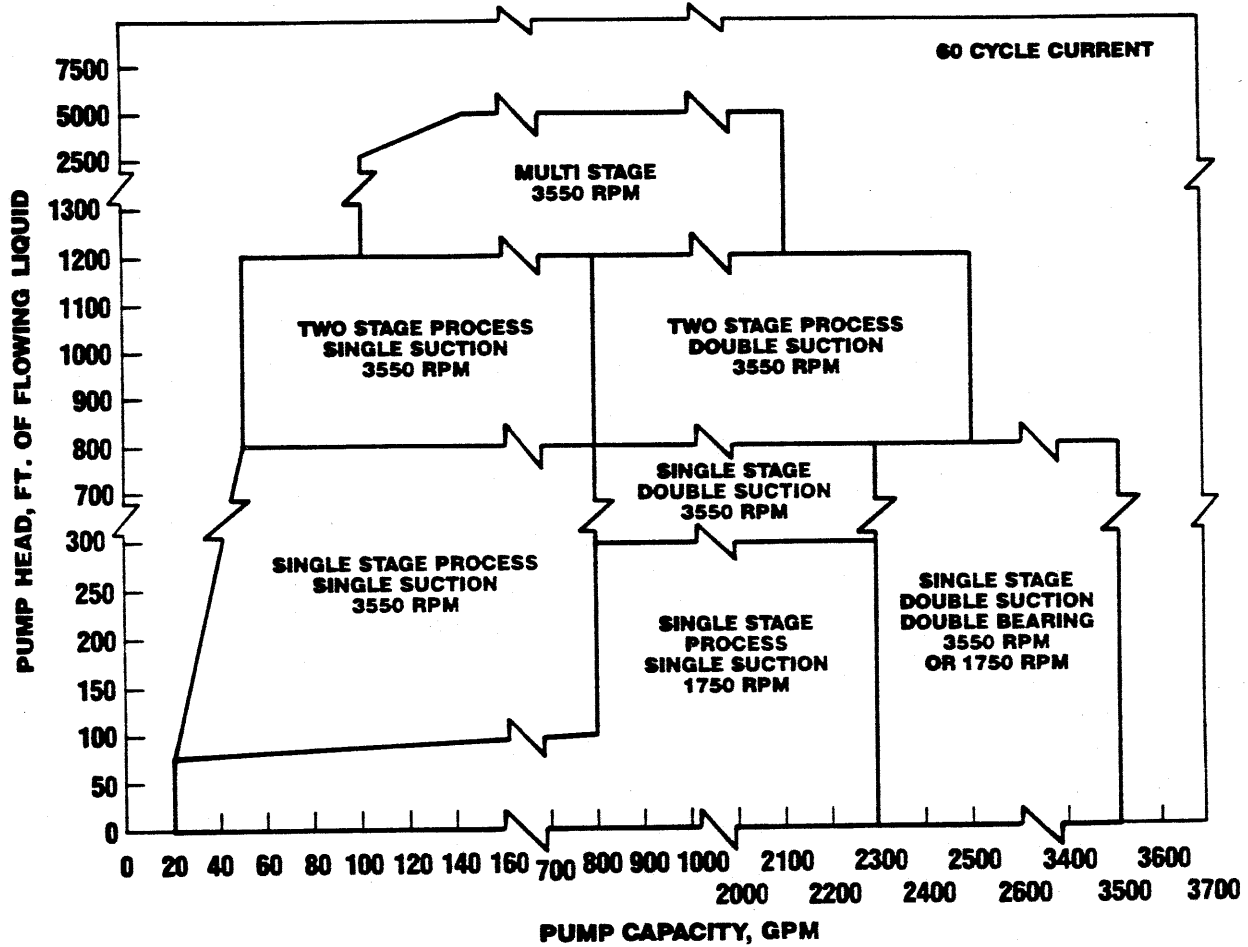

PUMPS

PUMP CLASSIFICATION



PUMP SELECTION



Determination of Pump Performance When Handling Viscous Liquids

The performance of centrifugal pumps is affected when handling viscous liquids. A marked increase in brake horsepower, a reduction in head, and some reduction in capacity occur with moderate and high viscosities.

Fig. 5 provides a means of determining the performance of a conventional centrifugal pump handling a viscous liquid when its performance on water is known. It can also be used as an aid in selecting a pump for a given application. The values shown in Fig. 5 are averaged from tests of conventional single stage pumps of 2-inch to 8-inch size, handling petroleum oils. The correction curves are, therefore, not exact for any particular pump.

When accurate information is essential, performance tests should be conducted with the particular viscous liquid to be handled.

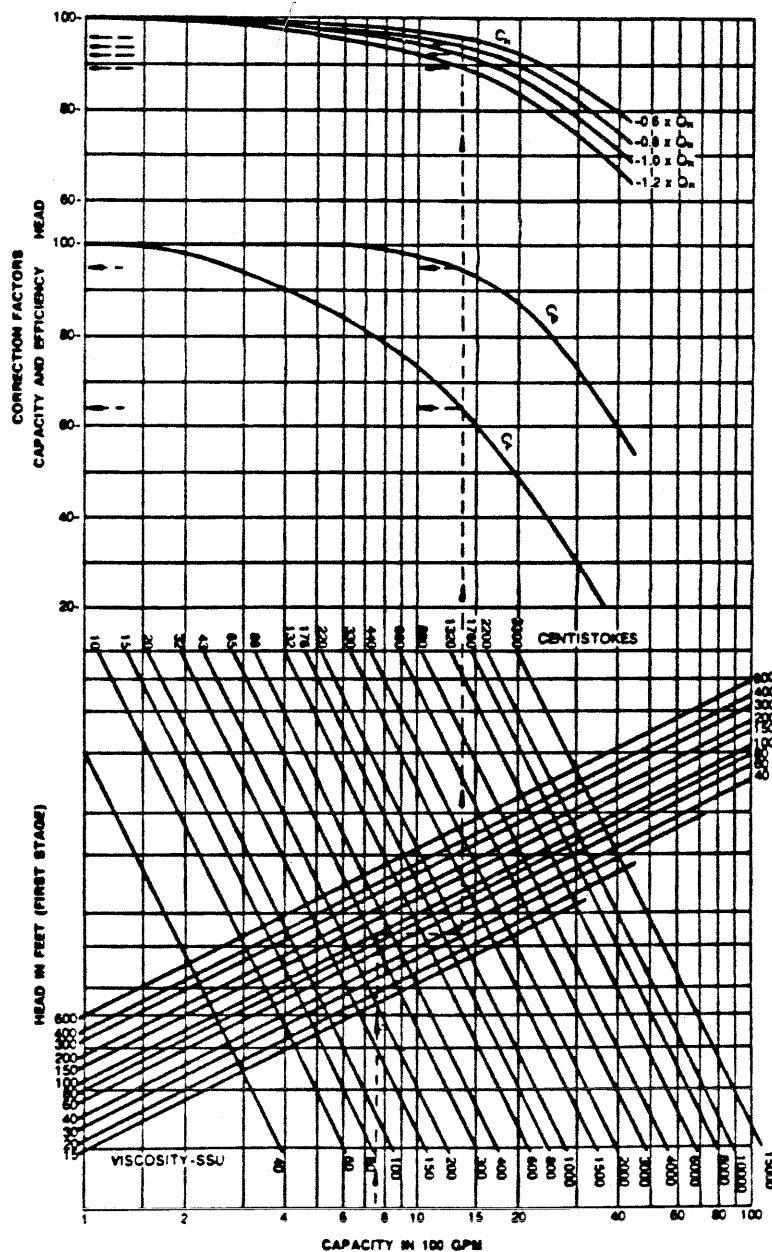
Limitations on Use of Viscous Liquid Performance Correction Chart

Reference is made to Fig. 5. This chart is to be used only within the scales shown. *Do not extrapolate.*

Use only for pumps of conventional hydraulic design, in the normal operating range, with open or closed impellers. Do not use for mixed flow or axial flow pumps or for pumps of special hydraulic design for either viscous or non-uniform liquids.

Use only where adequate NPSH is available in order to avoid the effect of cavitation.

Use only on Newtonian (uniform) liquids. Gels, slurries, paper stock and other non-uniform liquids may produce widely varying results, depending on the particular characteristics of the liquids.



**Fig. 5 Performance
Correction Chart**

MINIMUM FLOW

MINIMUM CONTINUOUS FLOW DEPENDS ON:

1) **TEMPERATURE RISE H_2O = $\frac{\text{HEAD AT MIN FLOW}}{778} \frac{1}{\text{EFF}} - 1$**

RULE OF THUMB -----> 30 GPM PER 100 BHP AT SHUTOFF

2) **NPSH**

3) **RADIAL REACTIONS ON IMPELLER**

4) **MOTOR OVERLOAD (IF SPECIFIC SPEED > 4500)**

TROUBLESHOOTING GUIDE

Trouble

Possible causes

Liquid not delivered

Pumps not primed

Air or vapor pocket in suction line

Pump not up to rated speed

Wrong rotation

Impeller or passages clogged

Failure to deliver rated capacity
and pressure

Available NPSH not sufficient

Pump not up to rated speed

Wrong rotation

Impeller or passages partially clogged

Wear rings worn or impeller damaged

Air or gases in liquid

Viscosity or specific gravity not as specified

Trouble

Possible Causes

Failure to deliver rated capacity
and pressure (continued)

Air or vapor pocket in suction line

Air leak in stuffing box

Total head greater than head for which pump
designed

Injection of low vapor pressure oil in lantern and
ring of hot pump

Pump loses prime

Air leak in suction line

Air leak in stuffing box

Air or gases in liquid

Pump overheats driver

Speed too high

Specific gravity or viscosity too high

Packing too tight

Misalignment

Total head lower than rated head

Low voltage or other electrical trouble

<u>Trouble</u>	<u>Possible Causes</u>
Pump overheats driver (continued)	Trouble with engine, turbine, gear or other allied equipment
Pump vibration	Available NPSH not sufficient
	Air or gases in liquid
	Misalignment
	Worn bearings
	Damaged rotating element
	Foundation not rigid
	Pump operating below minimum recommended capacity
	Impeller clogged
Stuffing box overheats	Packing too tight
	Packing not lubricated
	Incorrect type packing
	Gland cocked

Trouble

Bearings overheat or wear rapidly

Possible Causes

Incorrect oil level

Misalignment or piping strains

Insufficient cooling water

Bearings too tight or preloaded

Oil rings not functioning

Suction pressure appreciably different than specified

Improper lubrication

Vibration

Dirt or water in bearings

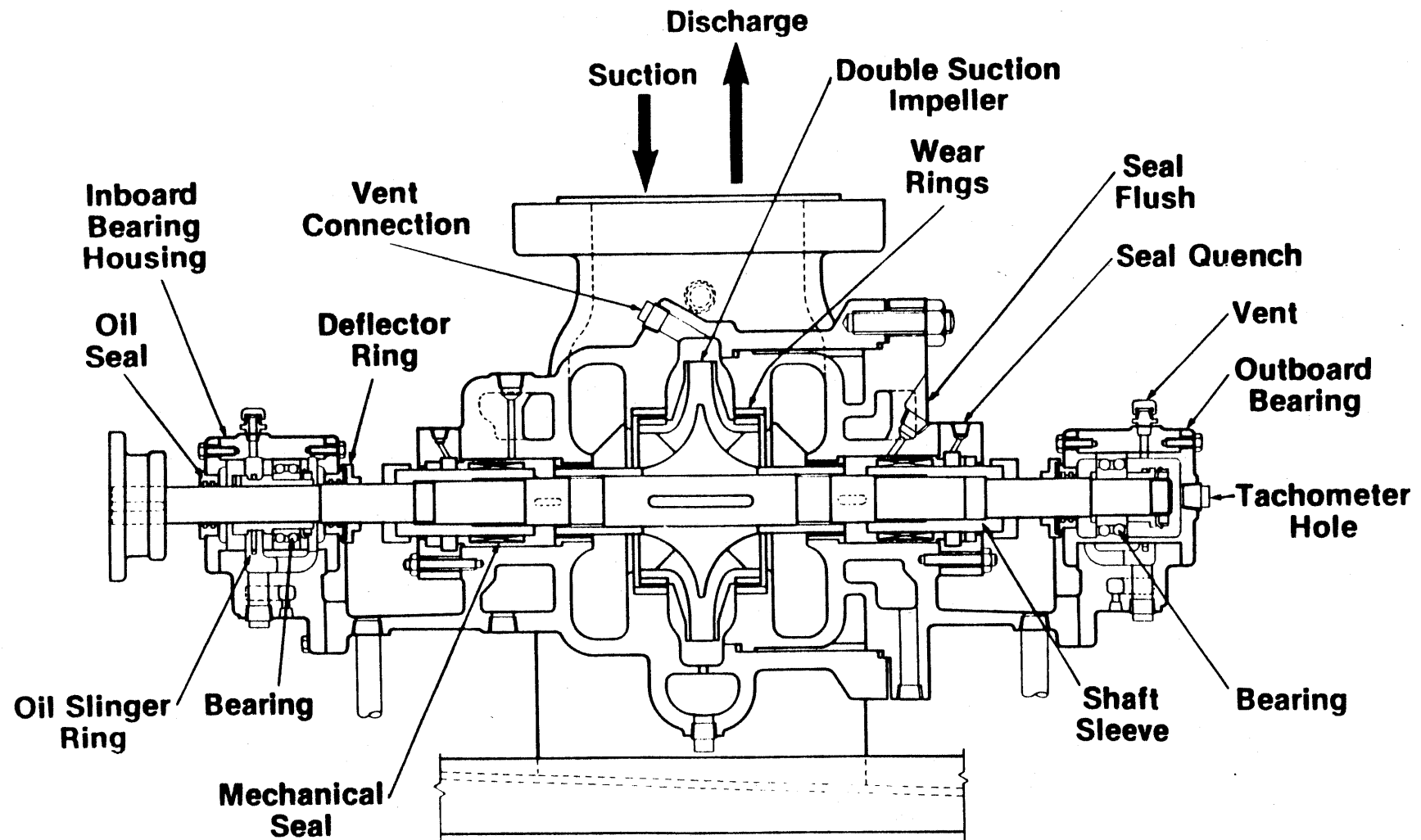
DOUBLE SUCTION MULTI-STAGE & SUNDYNE PUMPS

INTRODUCTION

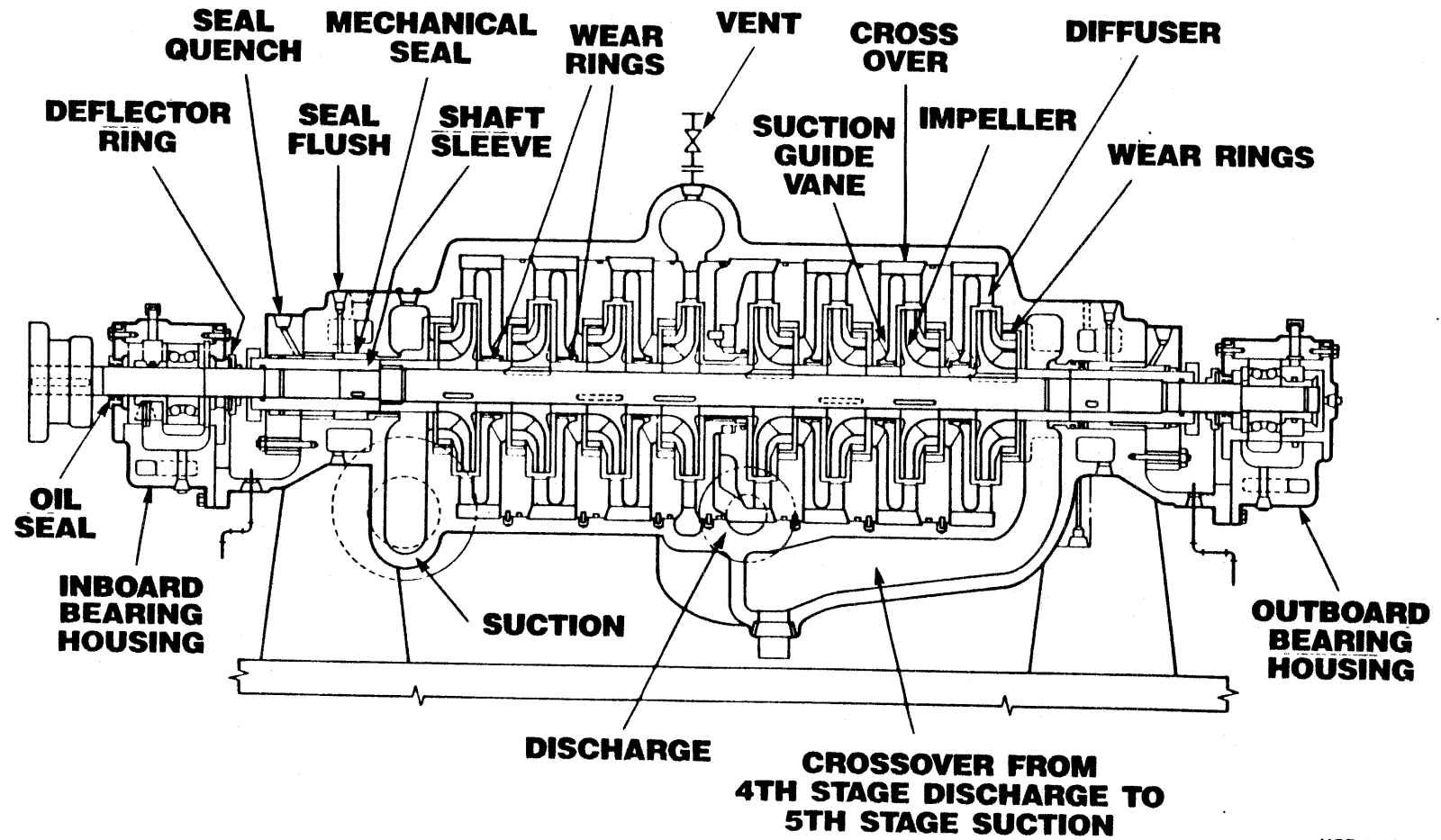
For process requirements beyond the limitation of the single-stage, single suction process pump, double suction, multi-stage and Sundyne pumps are used.

Double suction impellers allow the fluid to enter the impeller on both sides, thus higher capacities can be obtained. For higher heads, two-stage and multi-stage compressors are used. Axially split multi-stage compressors are used for temperatures of 400°F and under; for pressures under 1000 psig and specific gravities of 0.70 and above. The more expensive radially split type is used where the axially split is not applicable. Sundyne pumps are high speed and are used for low flow, high head applications where a multi-stage pump would not be appropriate. Sundyne pumps are limited to 500°F.

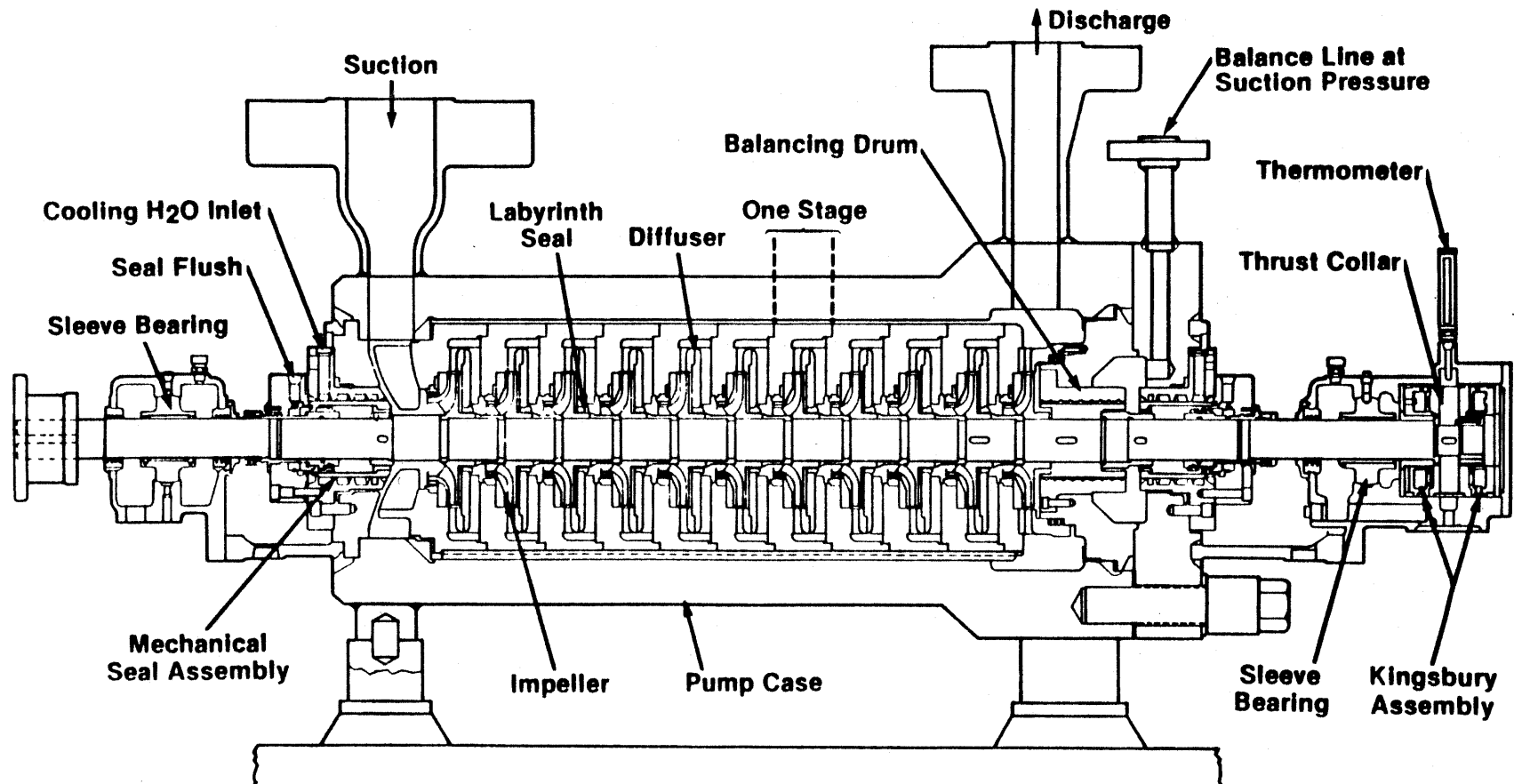
DOUBLE SUCTION SINGLE STAGE PUMP



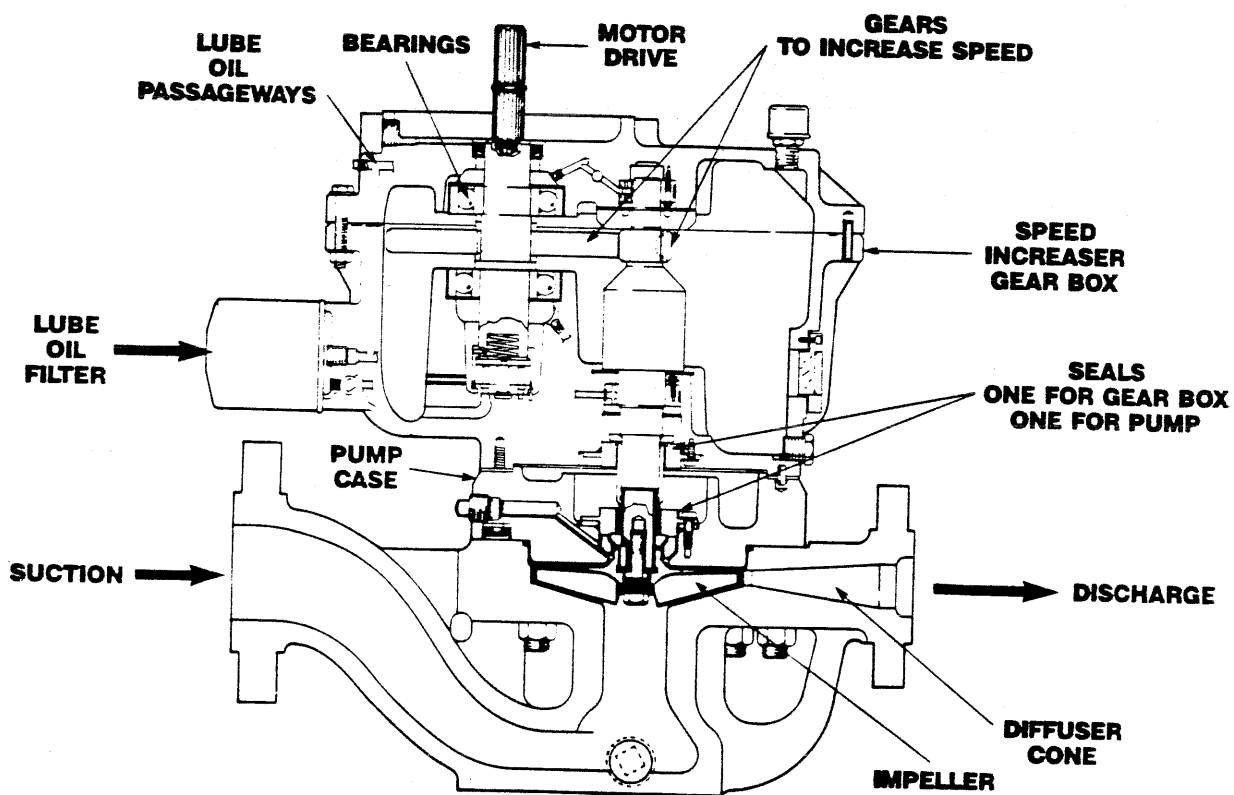
8 STAGE CENTRIFUGAL PUMP WITH OPPOSED IMPELLERS



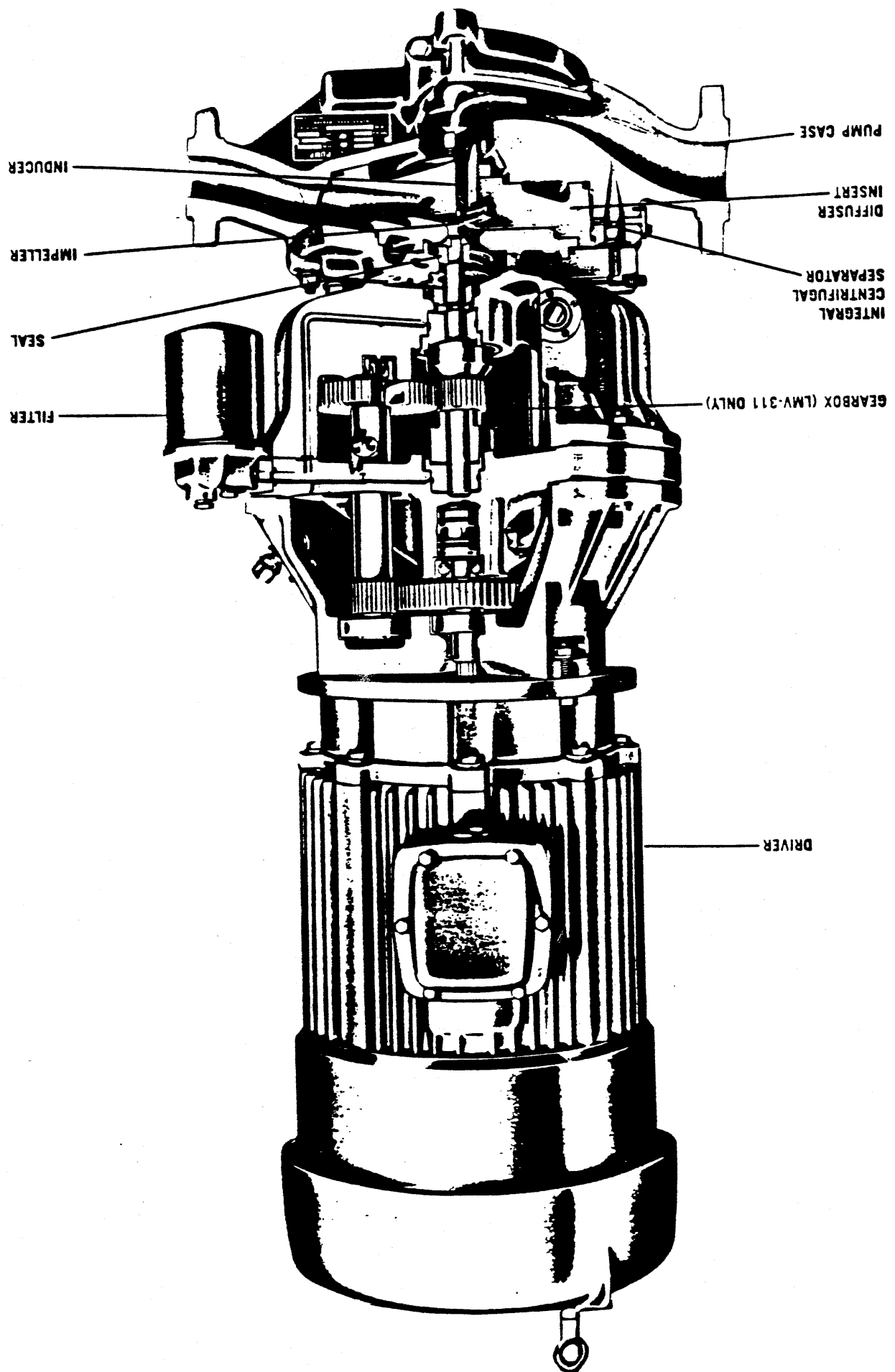
MULTI-STAGE PUMP WITH BALANCING DRUM



SUNDYNE PUMP

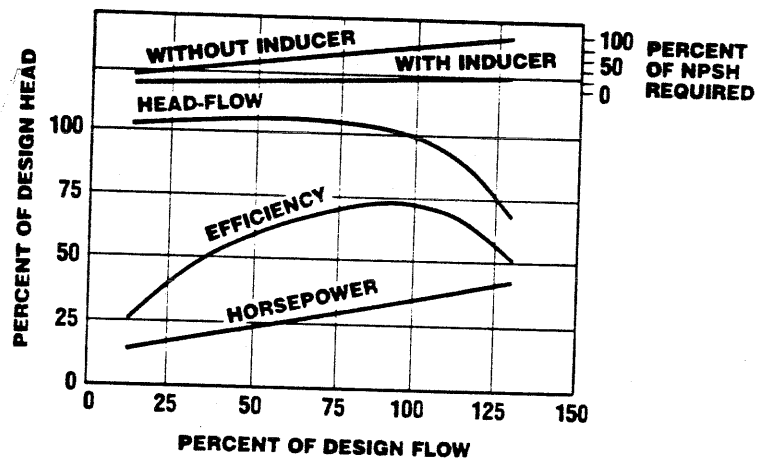
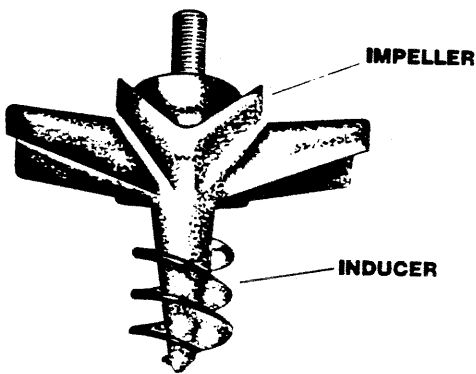


UOP 1220A-43
UOP 1702-23



SONDINE PUMP

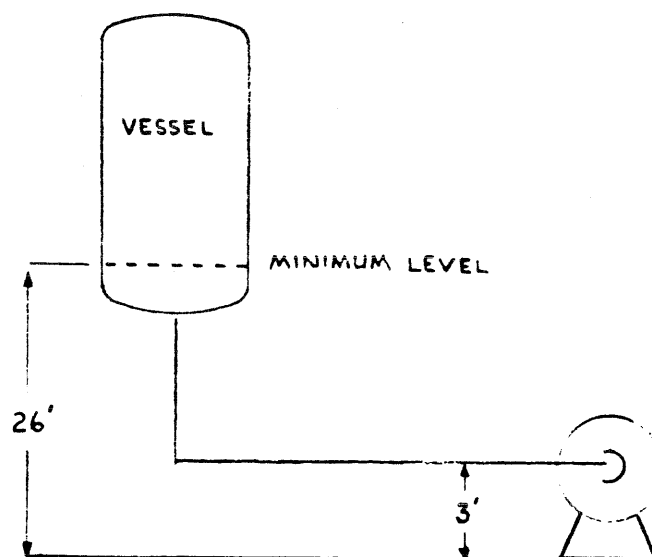
IMPELLER AND INDUCER



INDUCER . . . AN OPTIONAL HELICAL INDUCER IS AVAILABLE TO SUBSTANTIALLY REDUCE THE PUMP NPSH REQUIREMENT. IF NECESSARY, THE INDUCER MAY BE ADDED TO THE PUMP AFTER IT HAS BEEN INSTALLED AT THE SITE.

X. PROBLEMS

PROBLEM I



Liquid is at bubble point. Friction loss is 2 PSIG.

$$\text{NPSHA} = 23 - 6 = 17 \text{ Ft.}$$

Two existing pumps (operating and spare) Byron Jackson 4 x 6 x 13-1/4L (curve attached)

Present pump duty	Flow	600 GPM
	Head	500 Ft.
	NPSHR	14 Ft.
	SG	0.80
	Temp.	150°F
	60 Cycle	

Ⓐ New conditions require flow to be increased to 780 GPM.

Ⓑ Now need 18 Ft. NPSH. What can be done?

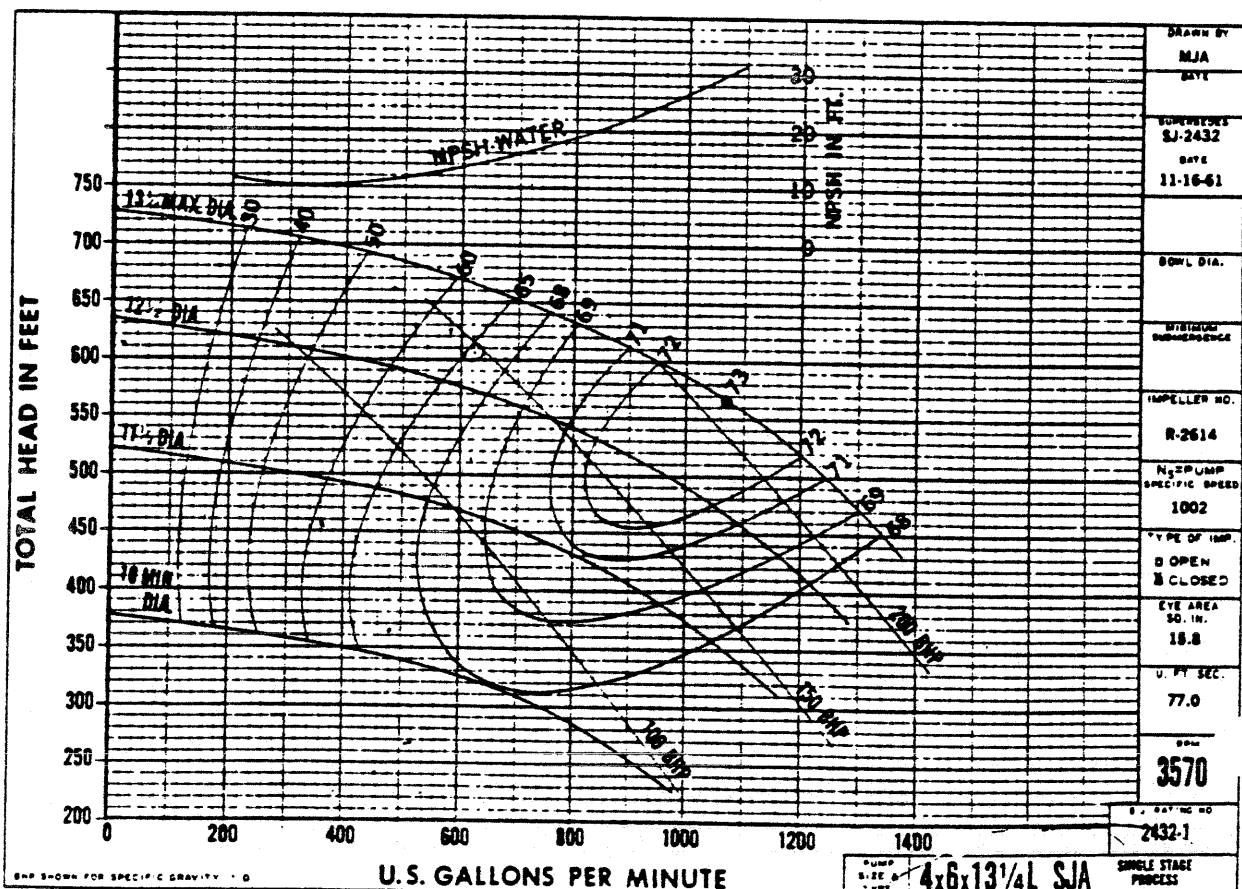
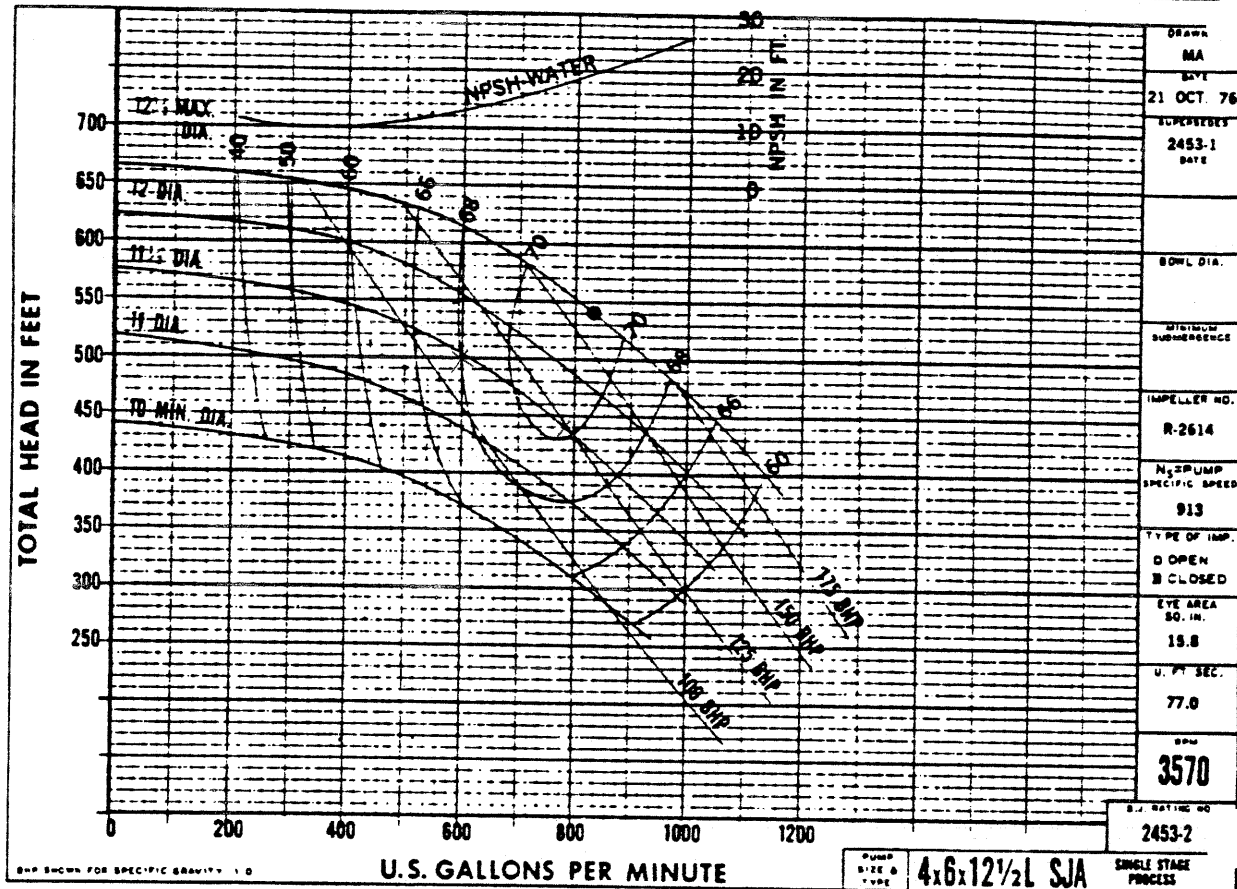
Effective OCT. 76

Byron Jackson Pump Division

BORG-WARNER CORPORATION



Section 1-250
Page 1-250-39



PROBLEM II

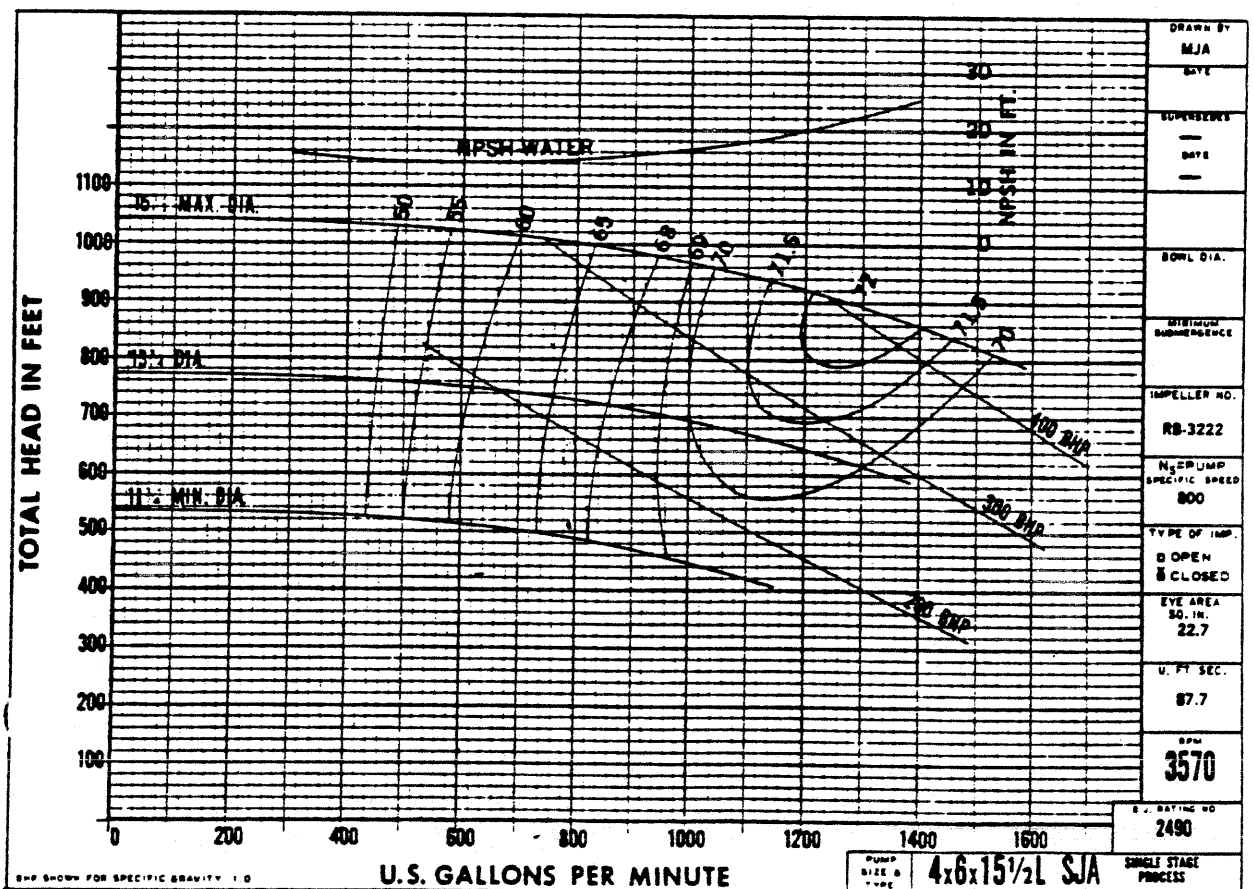
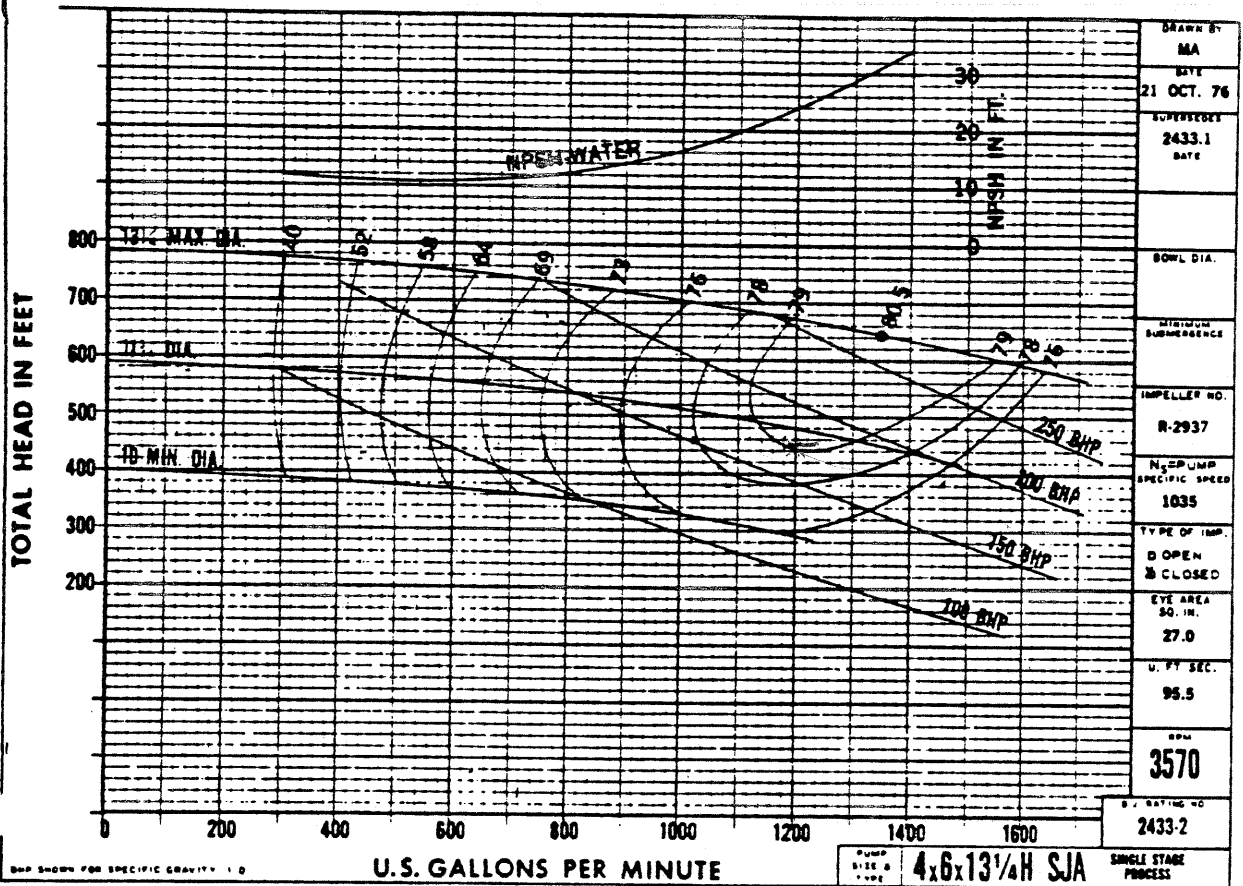
Pump is specified for 1200 GPM, 450 feet of head, 60 cycle.

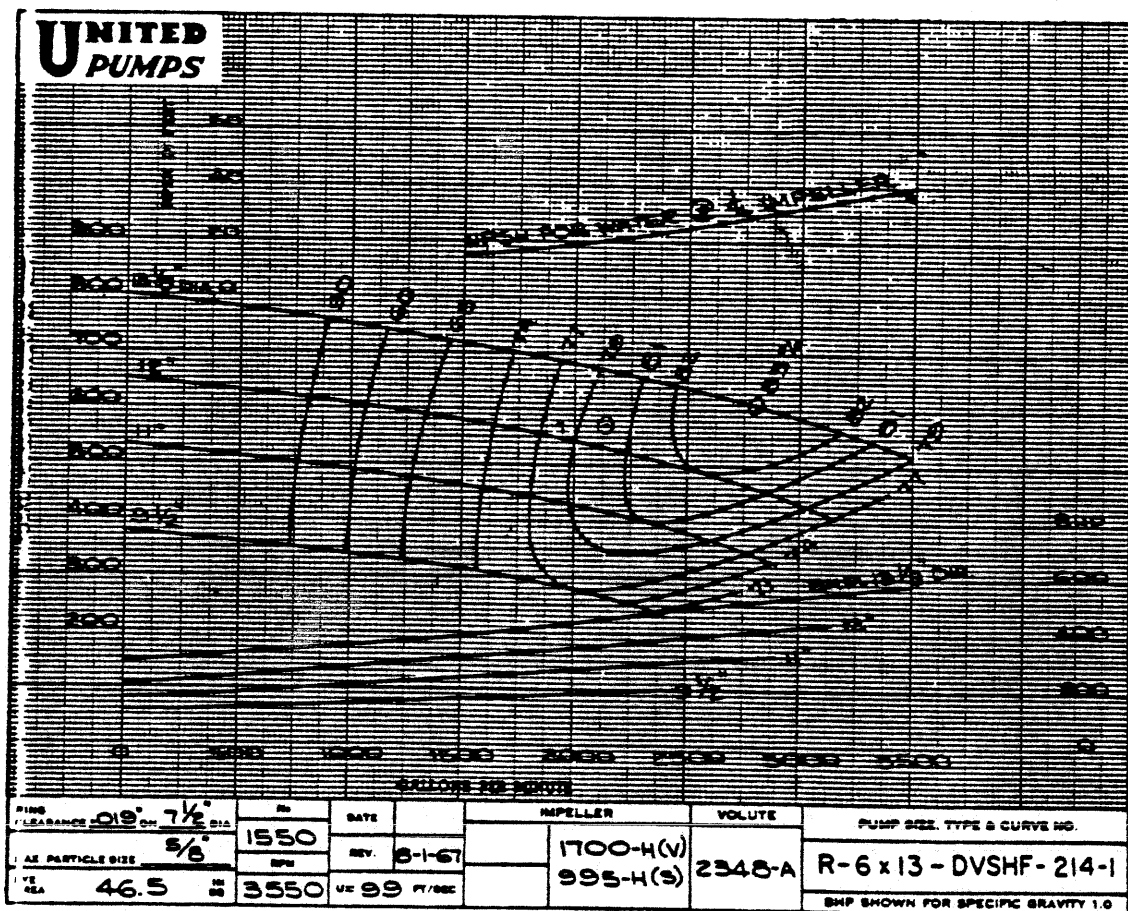
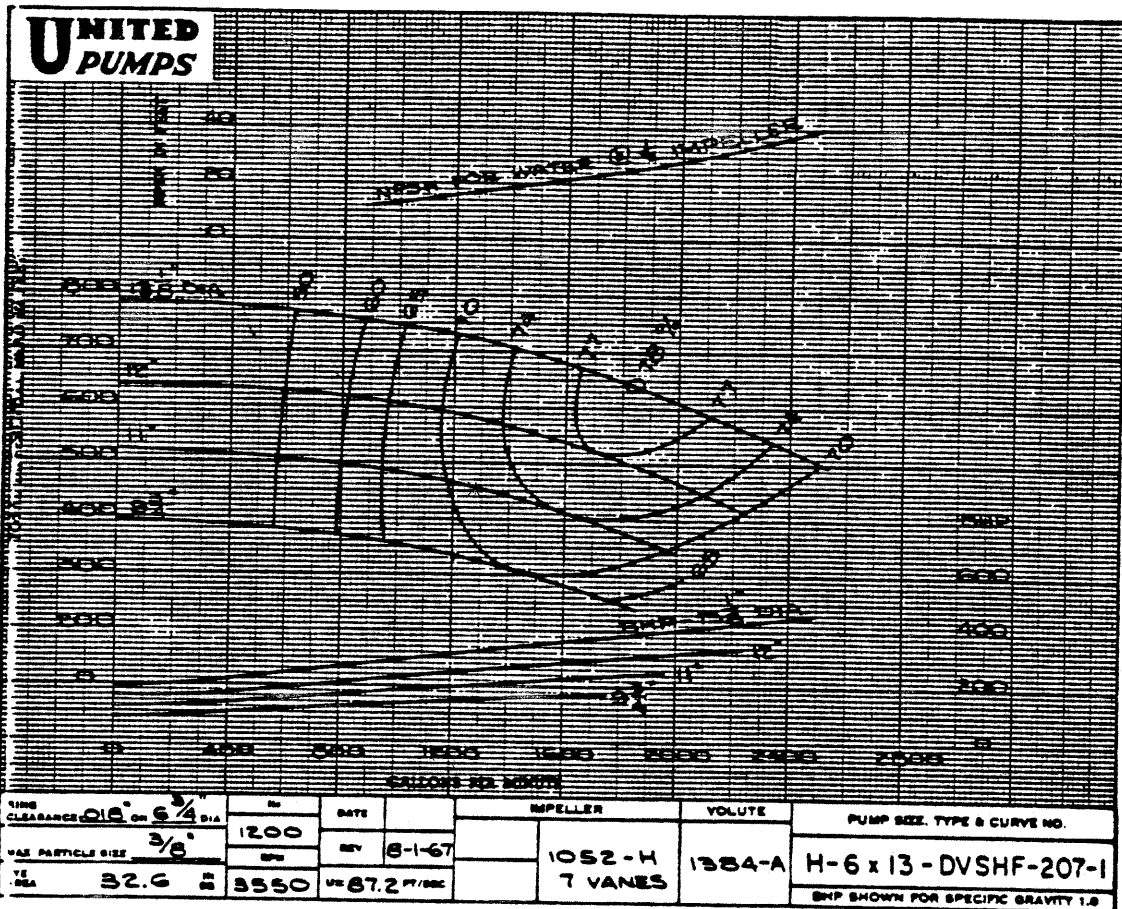
Quotations are received from three vendors as follows:

Byron Jackson	4 x 6 x 13-1/4H	Single Suction, 3550 RPM
United	H x 6 x 13	Double Suction, 3550 RPM
Pacific	8 x 23HVC	Double Suction, 1750 RPM

Pump curves are attached.

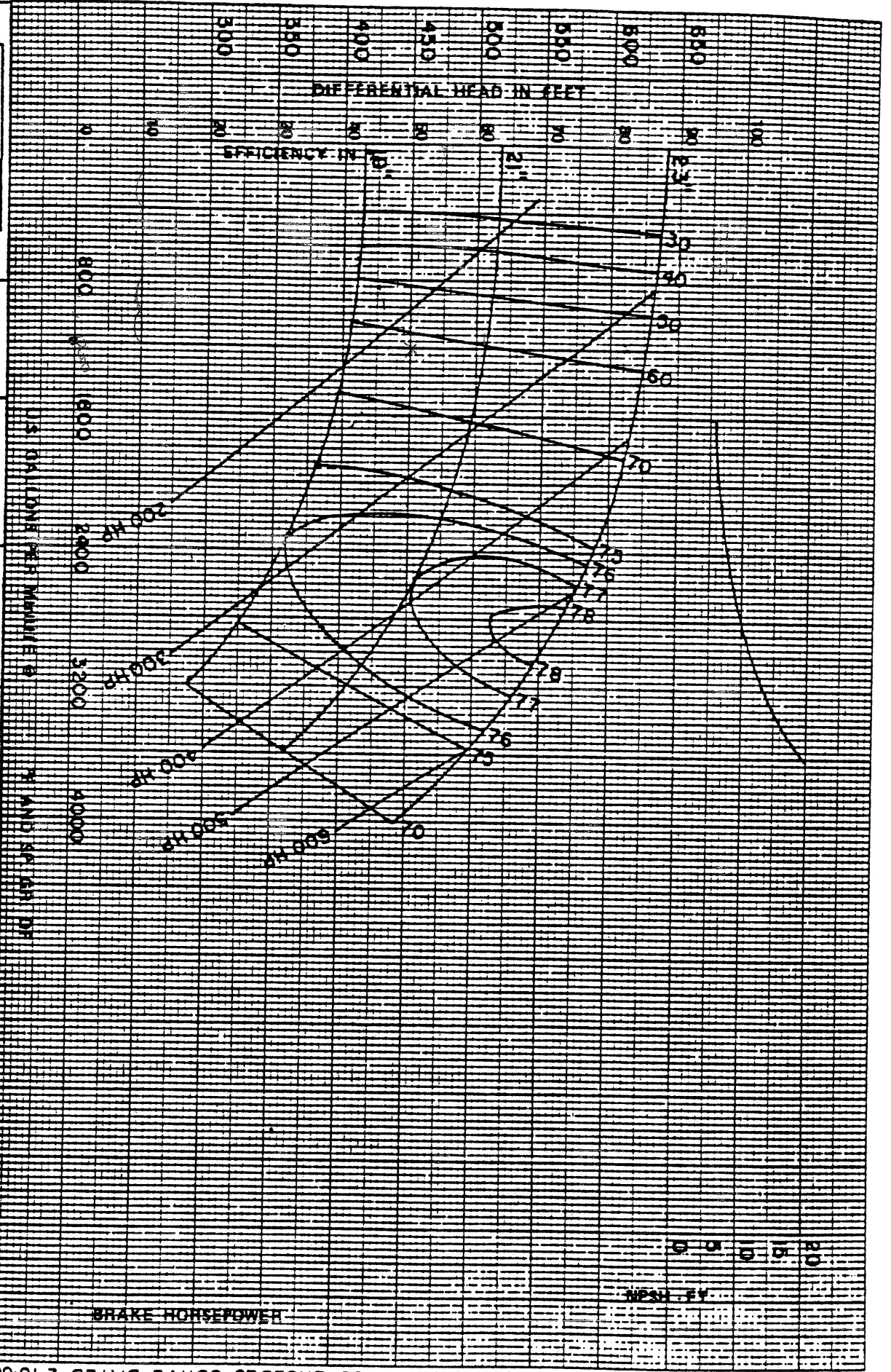
What are positive and negative qualities of each pump?





682
69
50

SUPSEDES CURVE DATED 2-18-66



PACIFIC PUMPS
PACIFIC PUMPS DIVISION
DRESSER INDUSTRIES, INC.

R.P.M.
1770

IMPELLER
PATTERN
D-2765

IMP. EYE AREA

PUMP SIZE AND TYPE

NO. STGS.

WEARING RING
CLEARANCE

MIN. INT. DIM.

HVC

1

.018

15/16

1200
450
600 gpm

DATE
3-1-78

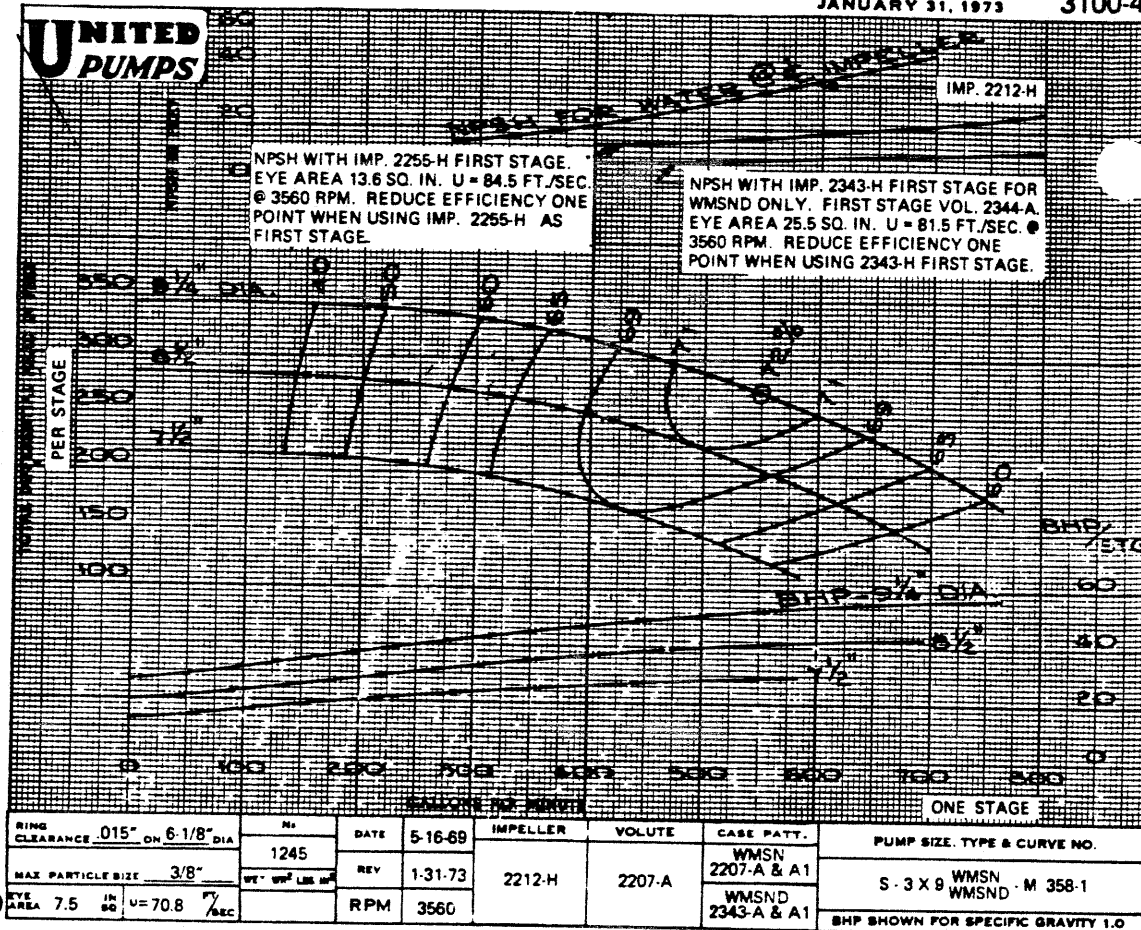
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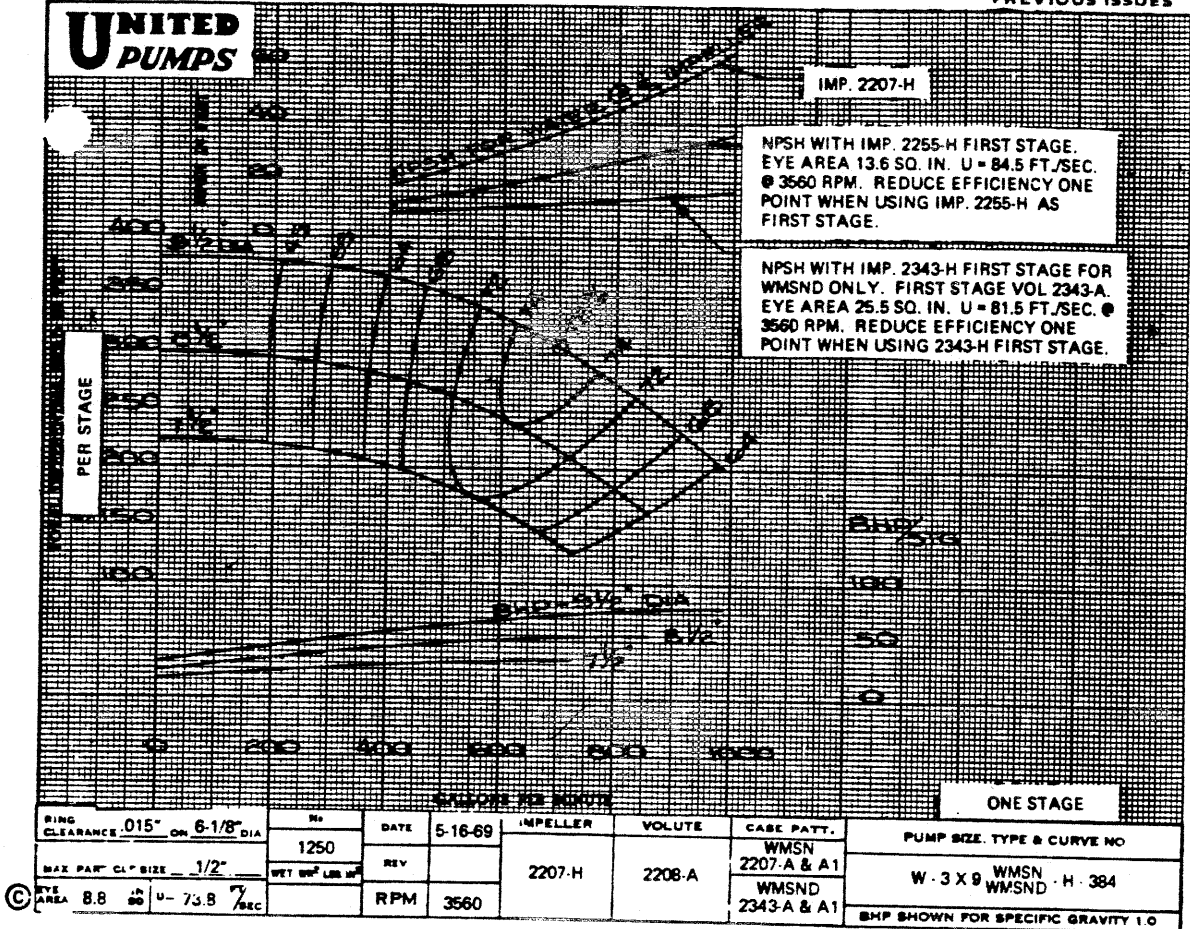
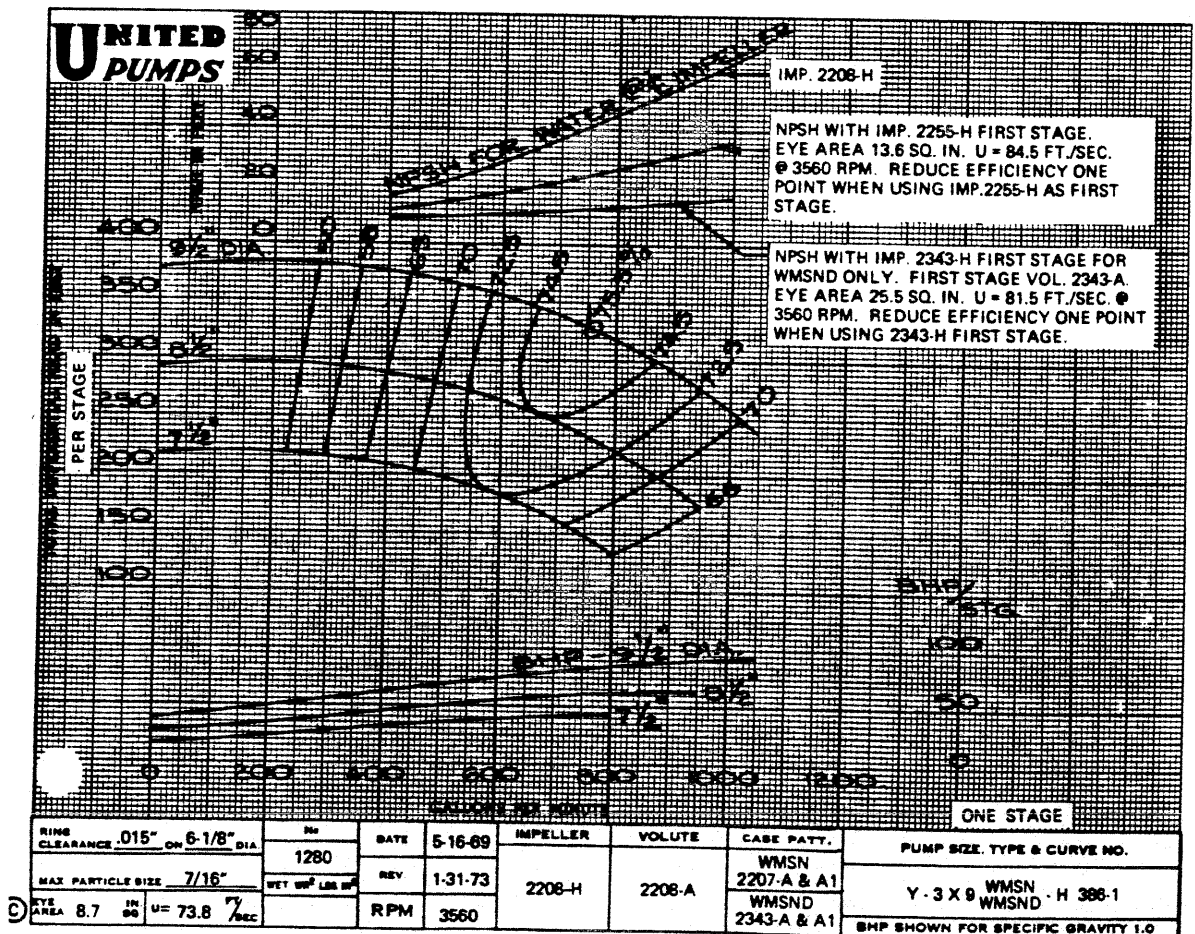
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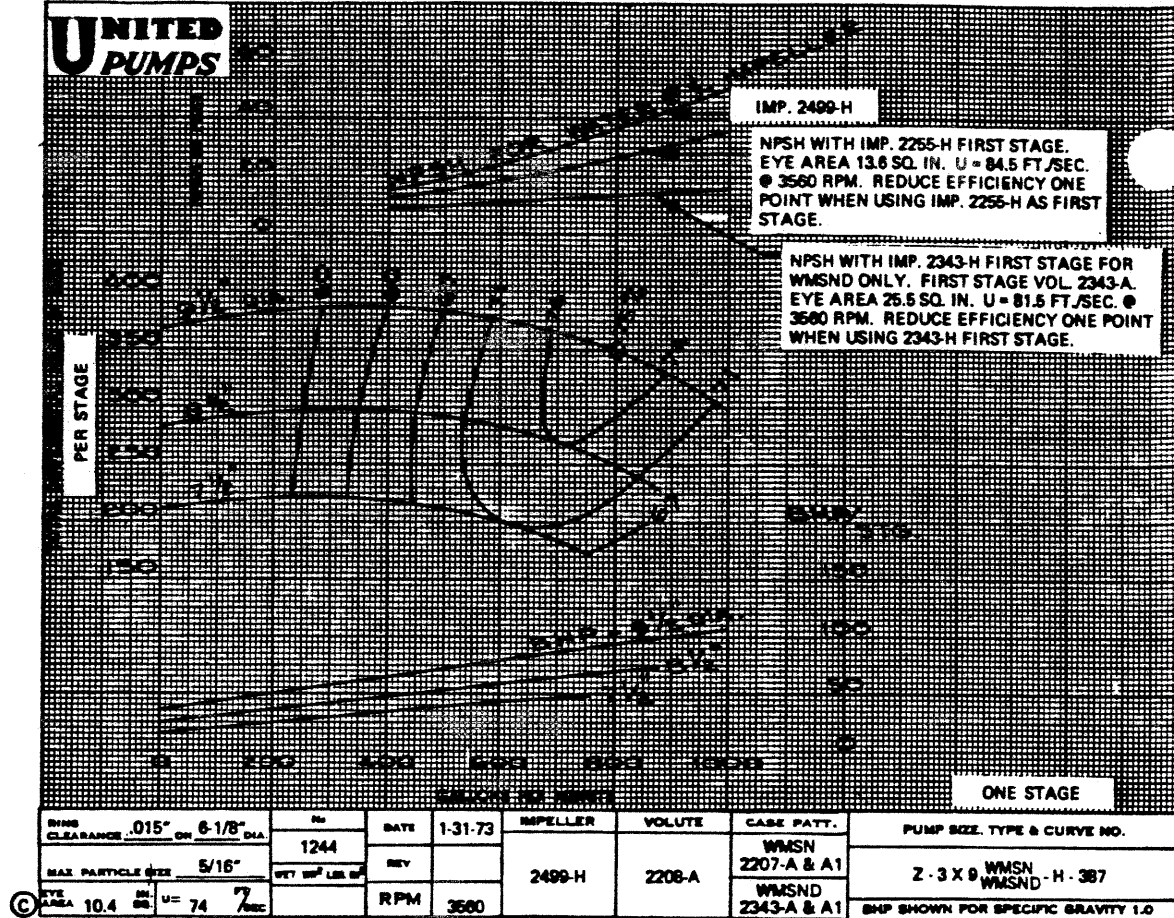
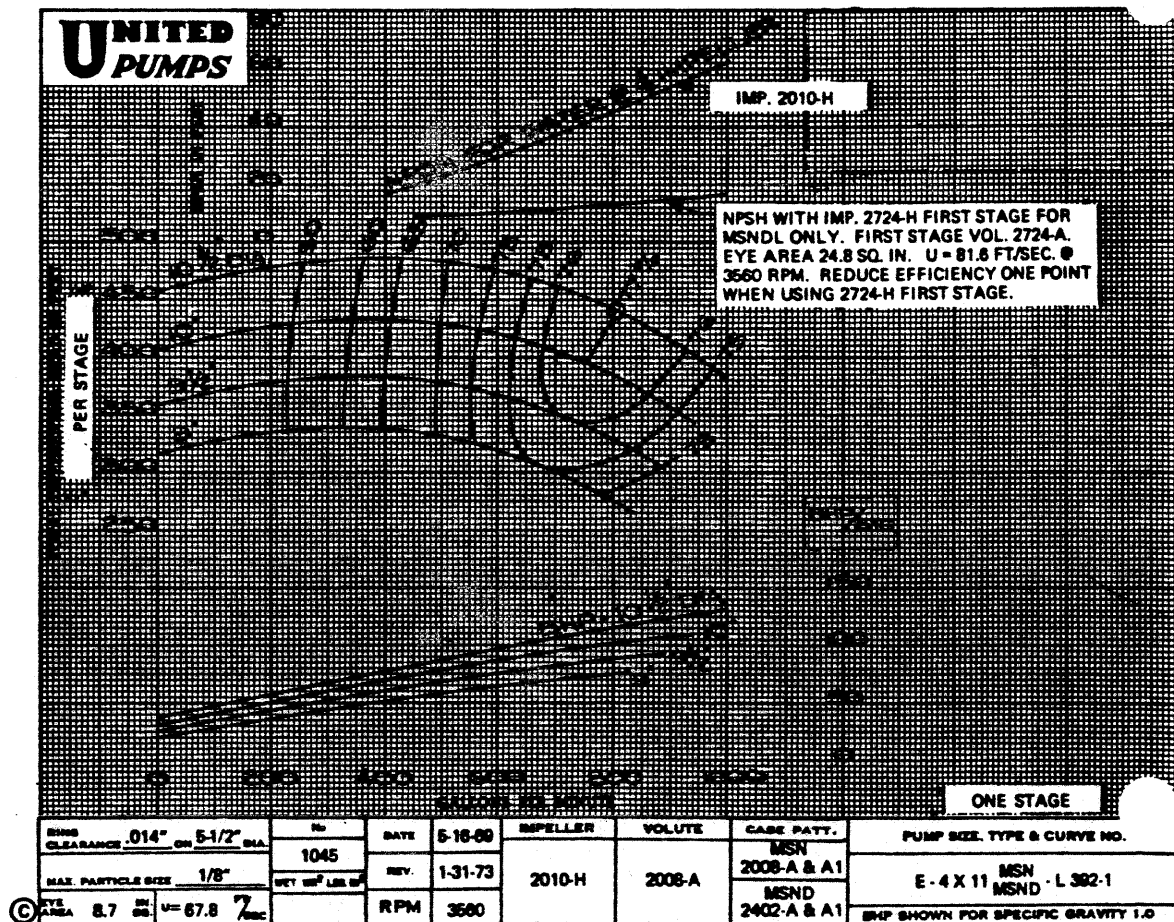
PROBLEM III

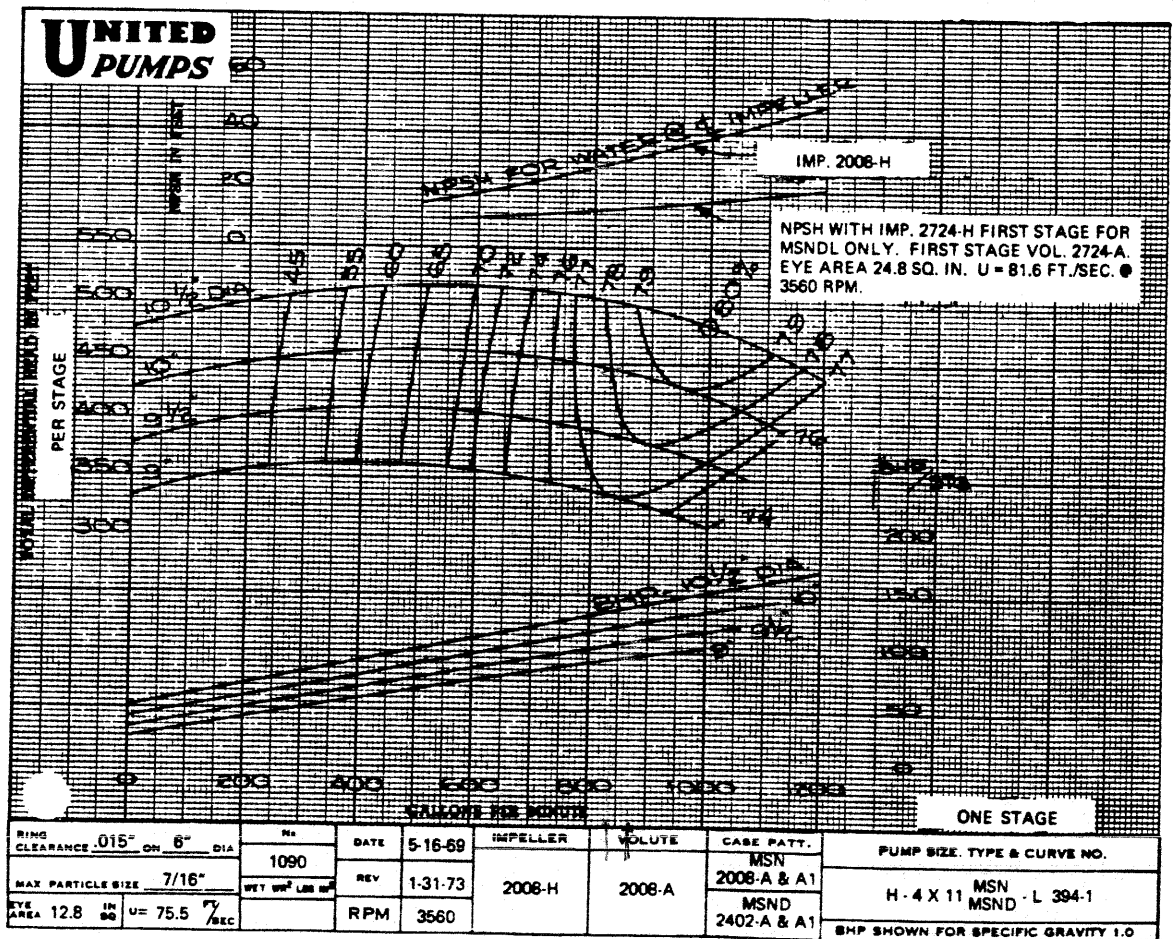
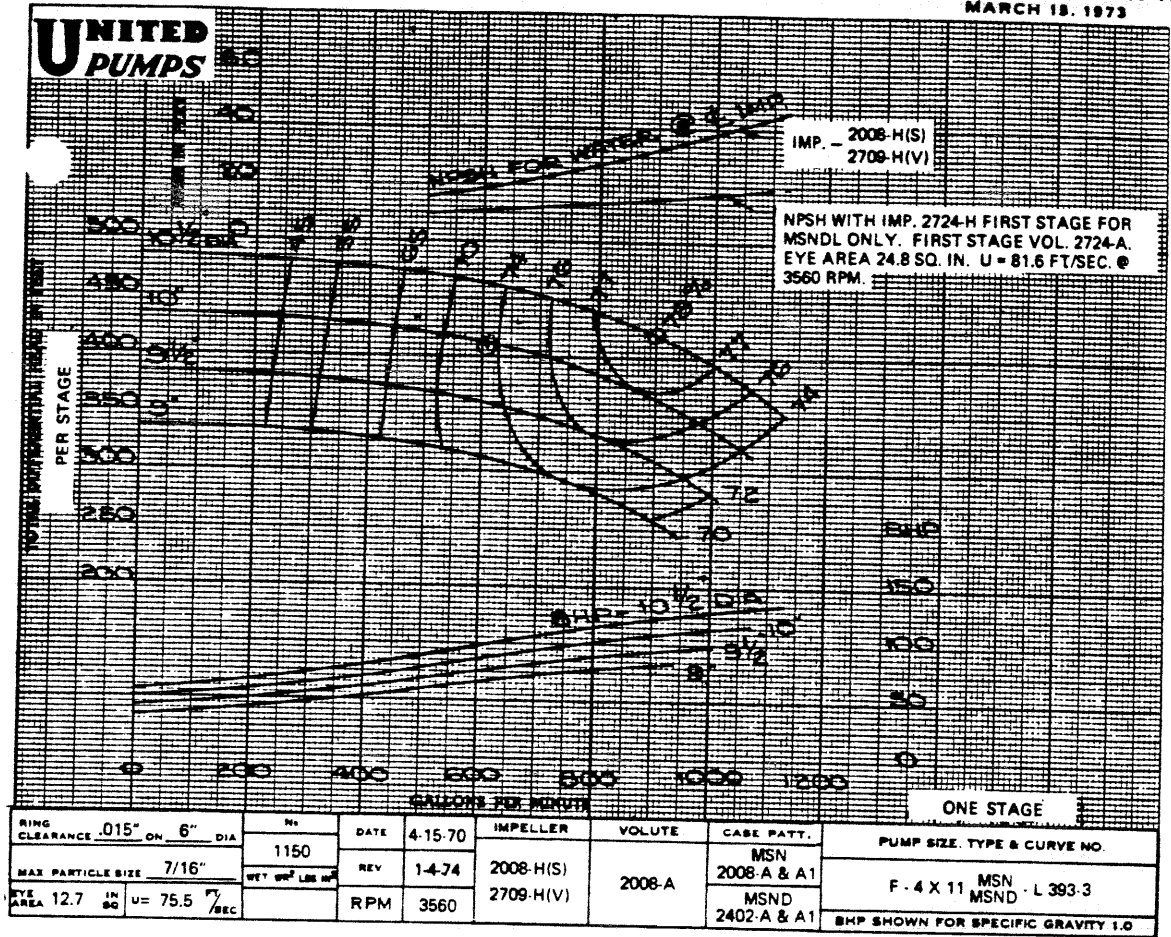
Required Pump Duty:	159 M ³ /hr	Rated Capacity
	145 M ³ /hr	Normal Capacity
	7.03 Kg/cm ² (g)	Suction Pressure
	49.22 Kg/cm ² (g)	Discharge Pressure
	0.95	Specific Gravity
	149°C	Suction Temperature
	Water	Fluid Handled
	4.0 Meters	NPSH Available
	50 Cycle	

1. Make the best pump selection from the attached curves.
2. How many stages?
3. What is the efficiency?
4. What is the horsepower (KW)?
5. What is the required NPSH?

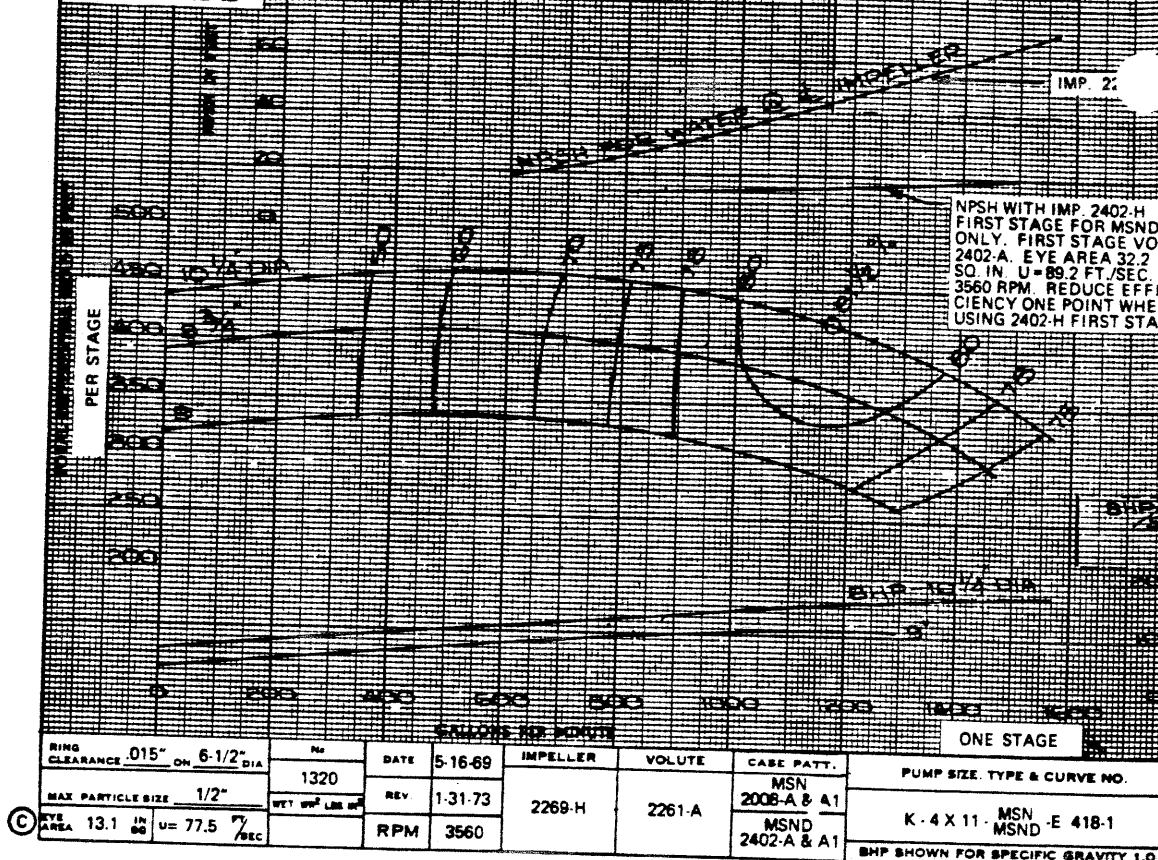
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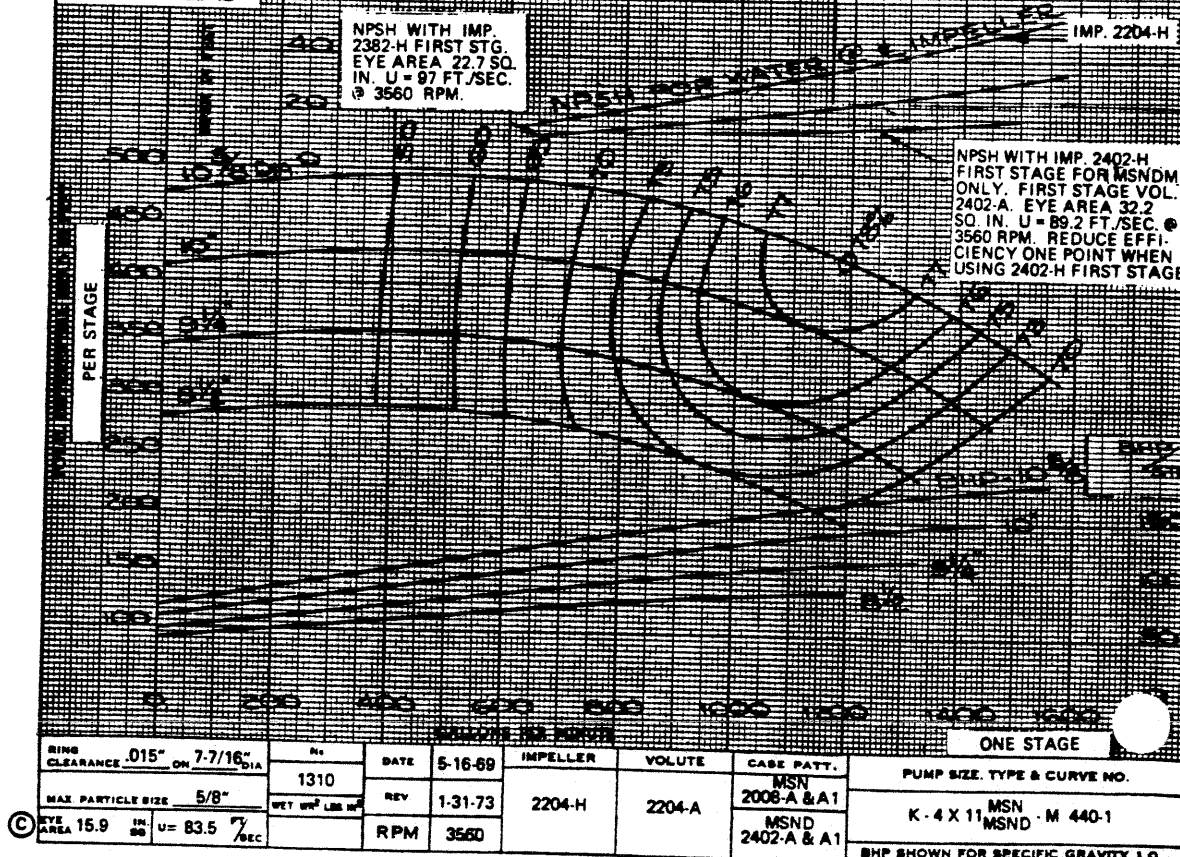
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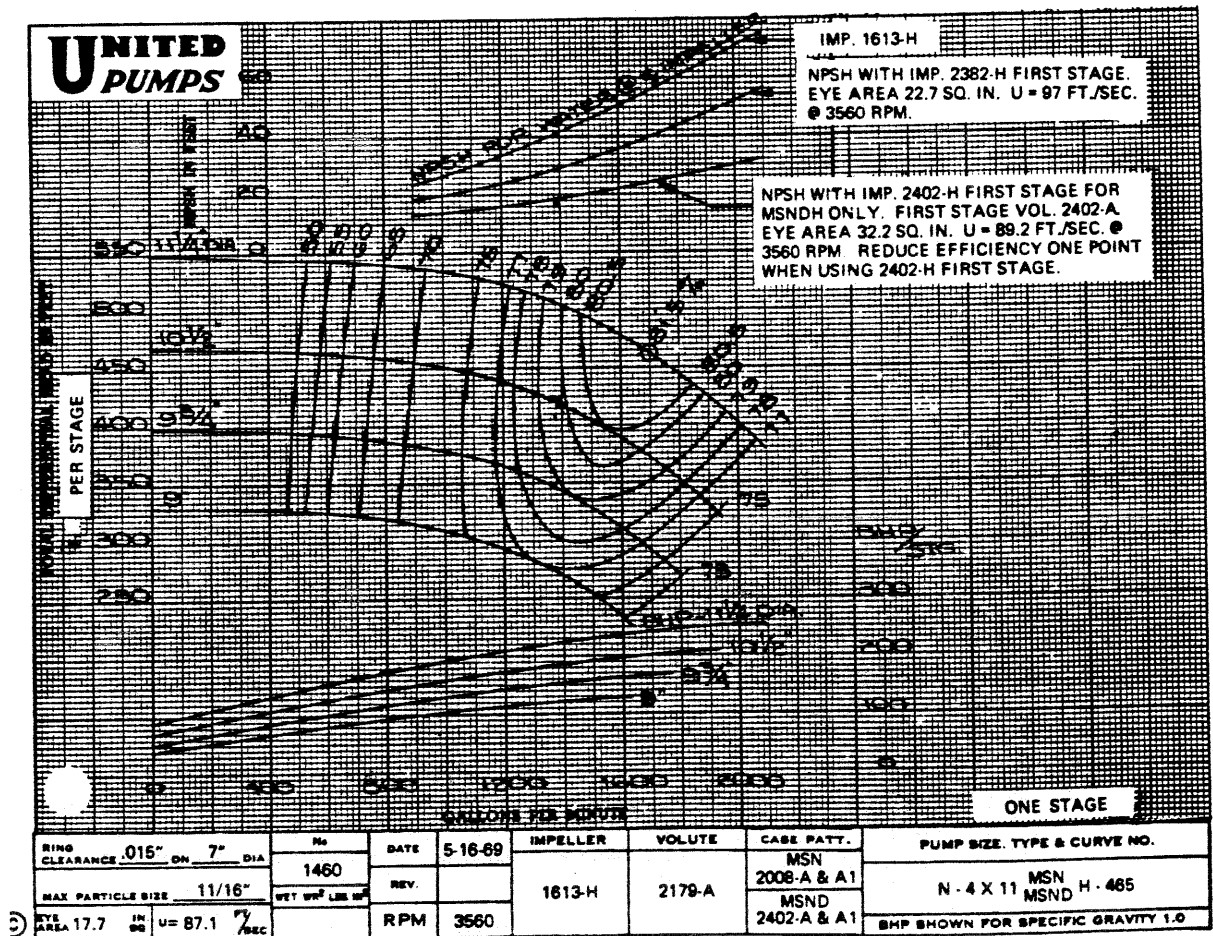
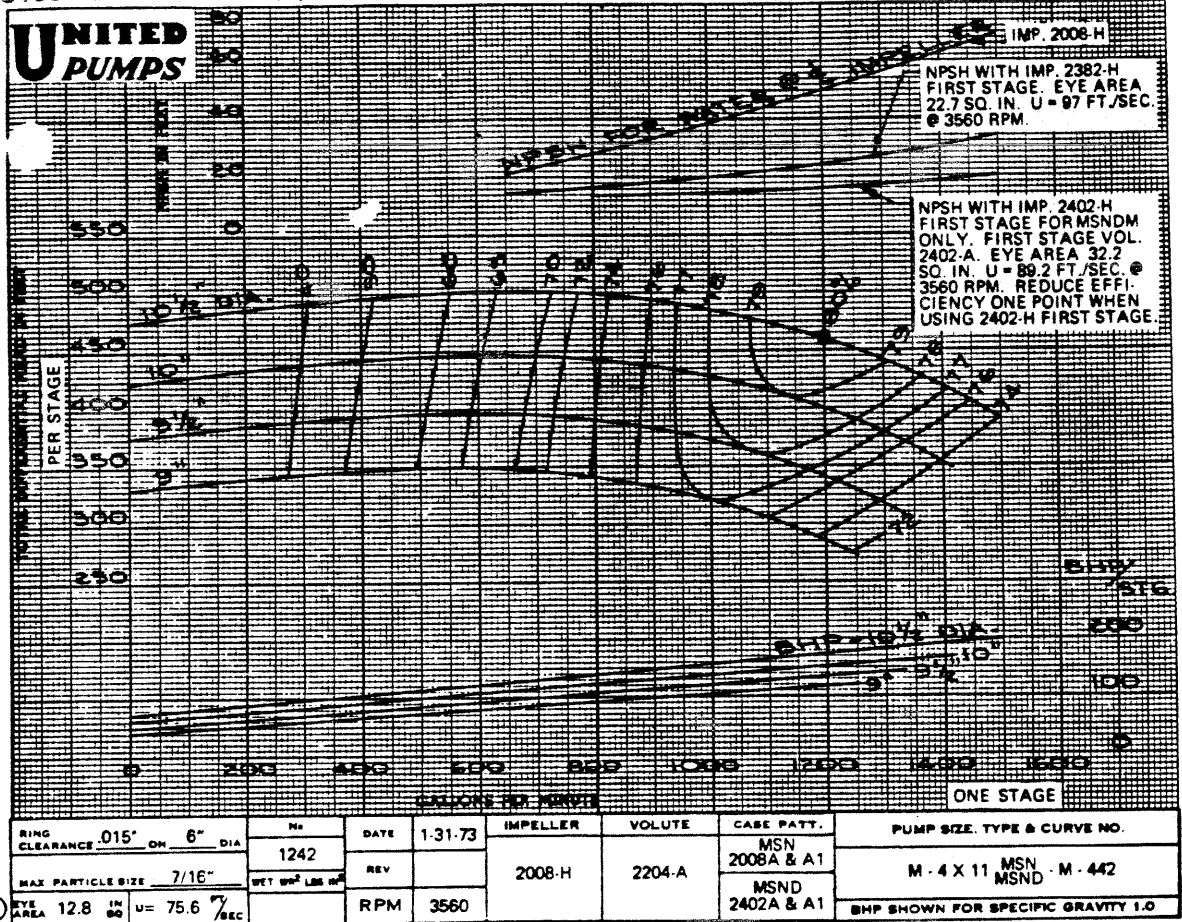


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ROTATING EQUIPMENT PUMPS

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- II. PUMP CURVES**
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 - A. Pump Components
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- IV. PUMP SELECTION AND PERFORMANCE**
- V. DOUBLE SUCTION MULTI-STAGE & SUNDYNE PUMPS**
- VI. FAN LAWS**
- VII. PUMP CONTROL**
- VIII. STANDARDS**
- IX. OTHER PUMPS**
- X. PROBLEMS**

PUMPS

INTRODUCTION

Pumps provide a means of adding energy to a fluid in order to have the capability of transporting the fluid from one level of potential and kinetic energy to another. Depending on a multitude of parameters, various means of adding the energy are employed. Some of the most prominent considerations in making a pump selection are the following:

1. Capacity
2. Differential Pressure
3. Fluid Characteristics
4. Temperature
5. Pressure
6. System Analysis

Once the specifics are defined, the basic pump type can be selected and then the specific mechanical design can be developed, including seal types, bearing selection, rotor design, materials requirements, driver selection, control and instrumentation design, etc.

Because centrifugal pumps are the most versatile type of pumps and since in our industry the "process" type pump, which basically conforms to API 610 design criteria, is used so extensively, the major impetus of this paper will be in that area.

PUMPING TERMS AND

PUMPING is the addition

RECIPROCATING PUMP

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LIQUID PISTON OR PL

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SIMPLEX reciprocating pu

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DUPLEX OR TRIPLEX re

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SINGLE-ACTING reciproc

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DOUBLE-ACTING reciproc

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SURGE CHAMBERS are

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CENTRIFUGAL PUMPS e

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PUMPS

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Because centrifugal pumps are the most versatile type of pumps and since in our industry the "process" type pump, which basically conforms to API 610 design criteria, is used so extensively, the major impetus of this paper will be in that area.

PUMPING TERMS AND DEFINITIONS

PUMPING is the addition of energy to a liquid to move it from one point to another.

RECIPROCATING PUMPS use pistons, plungers, diaphragms or other devices to displace a given volume of liquid during each stroke of the unit.

LIQUID PISTON OR PLUNGER of a reciprocating pump is the moving member that contacts the liquid and imparts energy to it.

SIMPLEX reciprocating pumps are those which are equipped with only one liquid piston or plunger.

DUPLEX OR TRIPLEX reciprocating pumps are equipped, respectively, with two or three liquid pistons or plungers.

SINGLE-ACTING reciprocating pumps produce only one suction and one discharge stroke per cycle.

DOUBLE-ACTING reciprocating pumps produce two suction and two discharge strokes per cycle.

SURGE CHAMBERS are containers built into a reciprocating pump or attached to its adjacent piping to cushion the shock of the reciprocating action and, therefore, smoothing the liquid flow.

CENTRIFUGAL PUMPS employ centrifugal force to develop a pressure rise for moving a liquid.

IMPELLER is the rotating element in a centrifugal pump through which liquid passes and by means of which energy is imparted to the liquid.

CASING of a centrifugal pump is the housing surrounding the impeller. It contains the bearings for supporting the shaft on which the impeller mounts.

SINGLE-STAGE centrifugal pump is one in which total head is developed by one impeller.

MULTI-STAGE centrifugal pump is one having two or more impellers acting in series in one casing.

CRITICAL SPEED of a centrifugal pump is that speed at which the rotating shaft corresponds to its natural frequency. At this speed, any minor imbalance of the shaft is magnified and excessive vibration will occur.

ROTARY PUMPS use gears, vanes, pistons, screws, cams, etc., in a fixed casing to produce positive displacement of a liquid.

PACKING is any material used to control leakage between a moving and stationary part in the pump.

MECHANICAL SEALS are devices mounted on the shaft of centrifugal pumps to seal the liquid in the casing. These are frequently used in preference to packing because of their longer life and minimized leakage.

CAVITATION is the phenomenon caused by vaporization of a liquid inside a pump. When the pressure at any point drops below the vapor pressure corresponding to the temperature of the liquid being pumped, vaporization of the liquid will occur. Small cavities of vapor thus formed move with the flow through the pump until a region of higher pressure is

reached. The higher pressure causes the vapor cavities to collapse with tremendous shock on the surrounding metal.

VISCOSITY is that property of a liquid that resists any force tending to produce flow.

SPECIFIC GRAVITY of a liquid is that number which denotes the ratio of the weight of the liquid to the weight of an equal volume of water.

SUCTION LIFT exists when the source of supply is below the center line of the pump.

STATIC SUCTION LIFT is the vertical distance in feet from the center line of the pump to the free level of the liquid to be pumped.

TOTAL DYNAMIC SUCTION LIFT is the vertical distance in feet from the center line of the pump to the free level of the liquid to be pumped plus all friction losses in the suction pipe and fittings.

SUCTION HEAD exists when the source of supply is above the center line of the pump.

STATIC SUCTION HEAD is the vertical distance in feet from the center line of the pump to the free level of the liquid to be pumped.

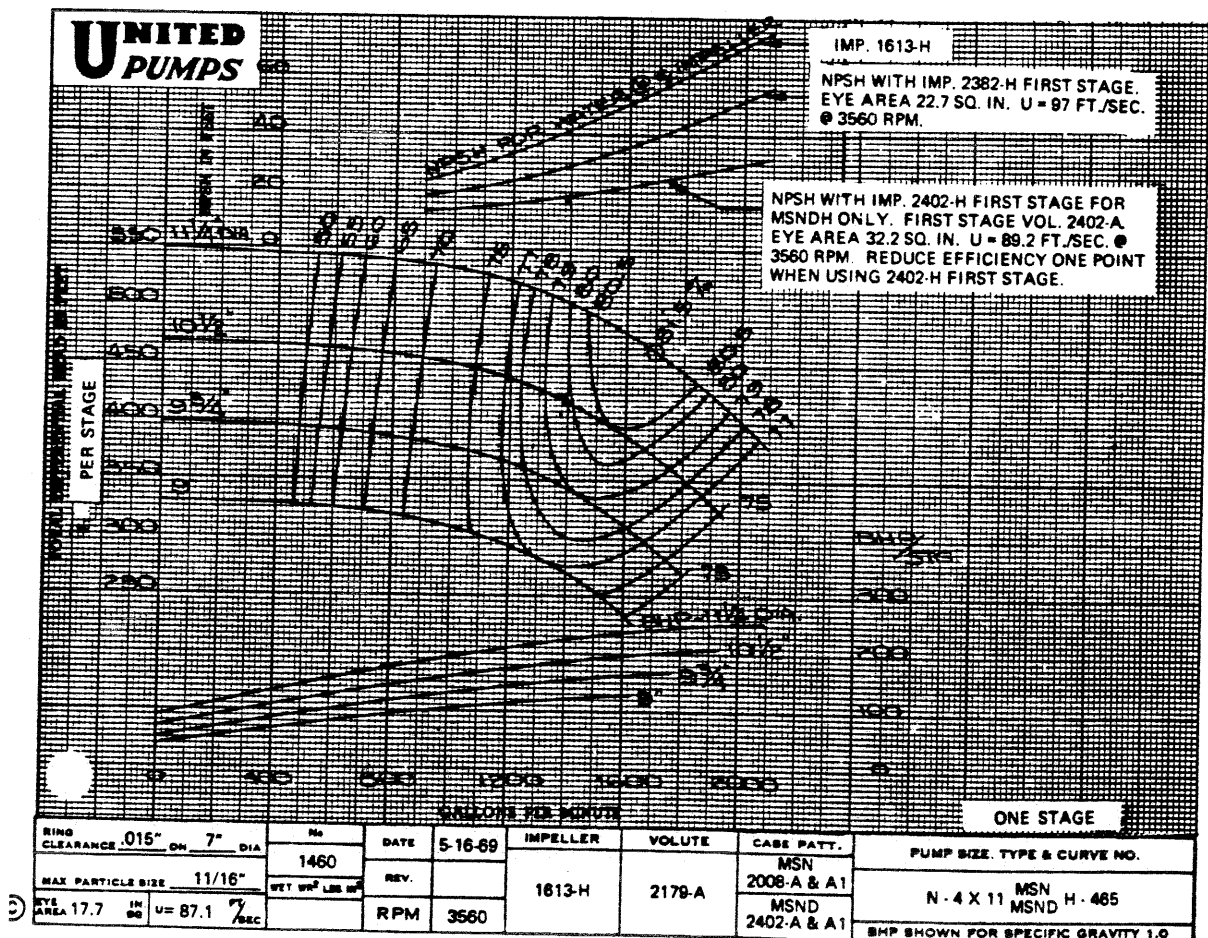
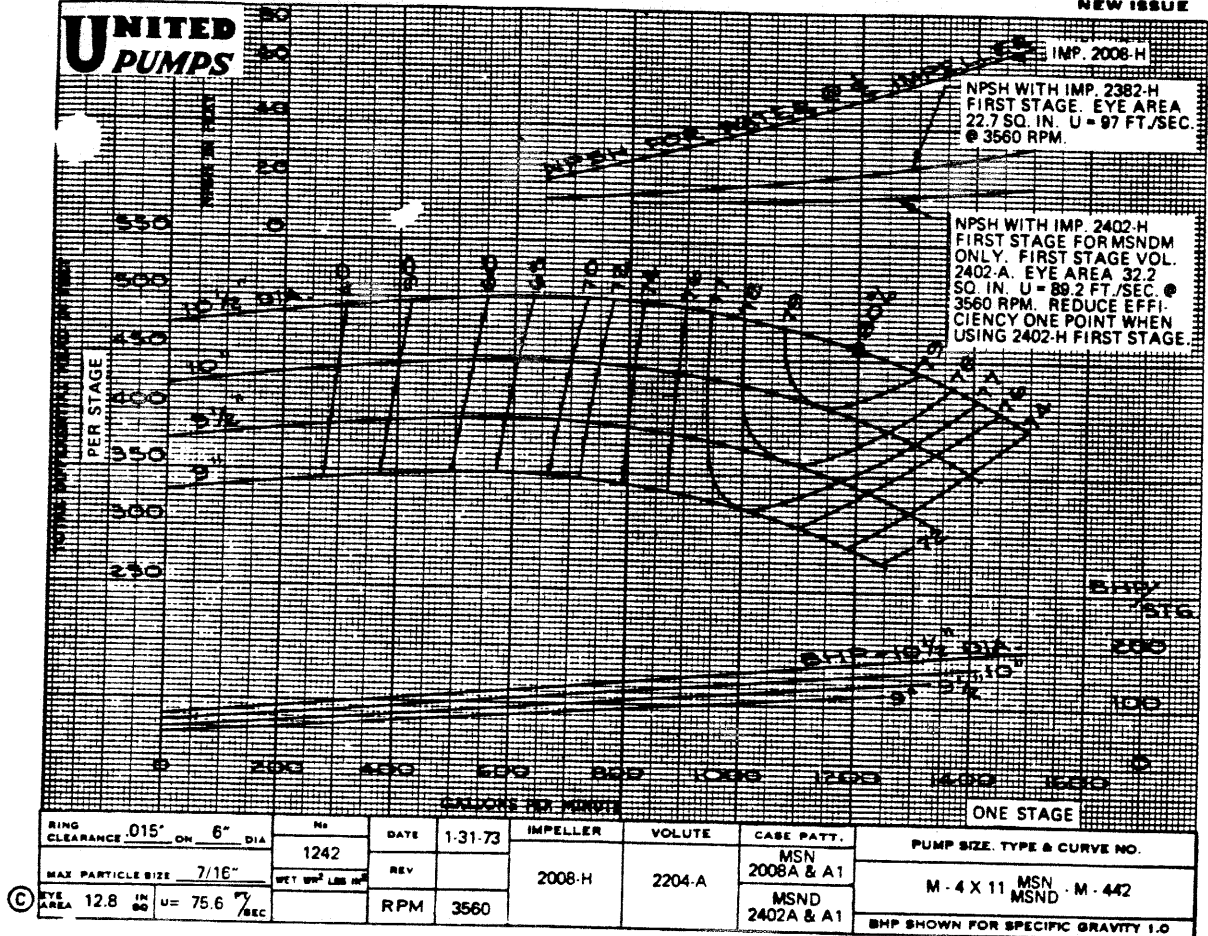
TOTAL DYNAMIC SUCTION HEAD is the vertical distance in feet from the center line of the pump to the free level of the liquid to be pumped minus all friction losses in suction pipe and fittings.

NET POSITIVE SUCTION HEAD required is the energy needed on the suction side of a pump to fill the pump to the discharge valves during operation.

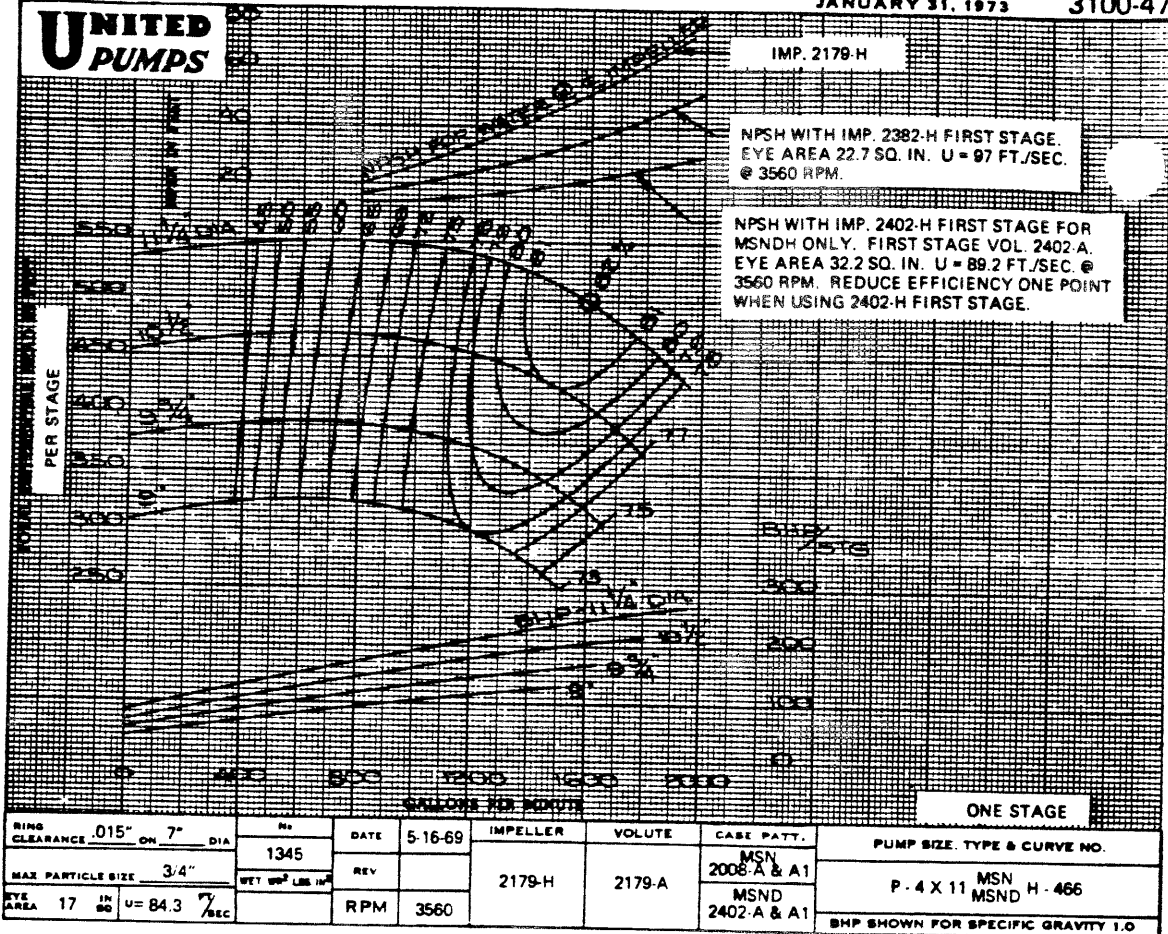
The performance of a centrifugal pump can be shown graphically on a pump characteristic curve. This is the only way that the pump manufacturer relays the pump performance to the customer. A typical curve shows head versus capacity, nps_h required, and pump efficiency.

INTRODUCTION

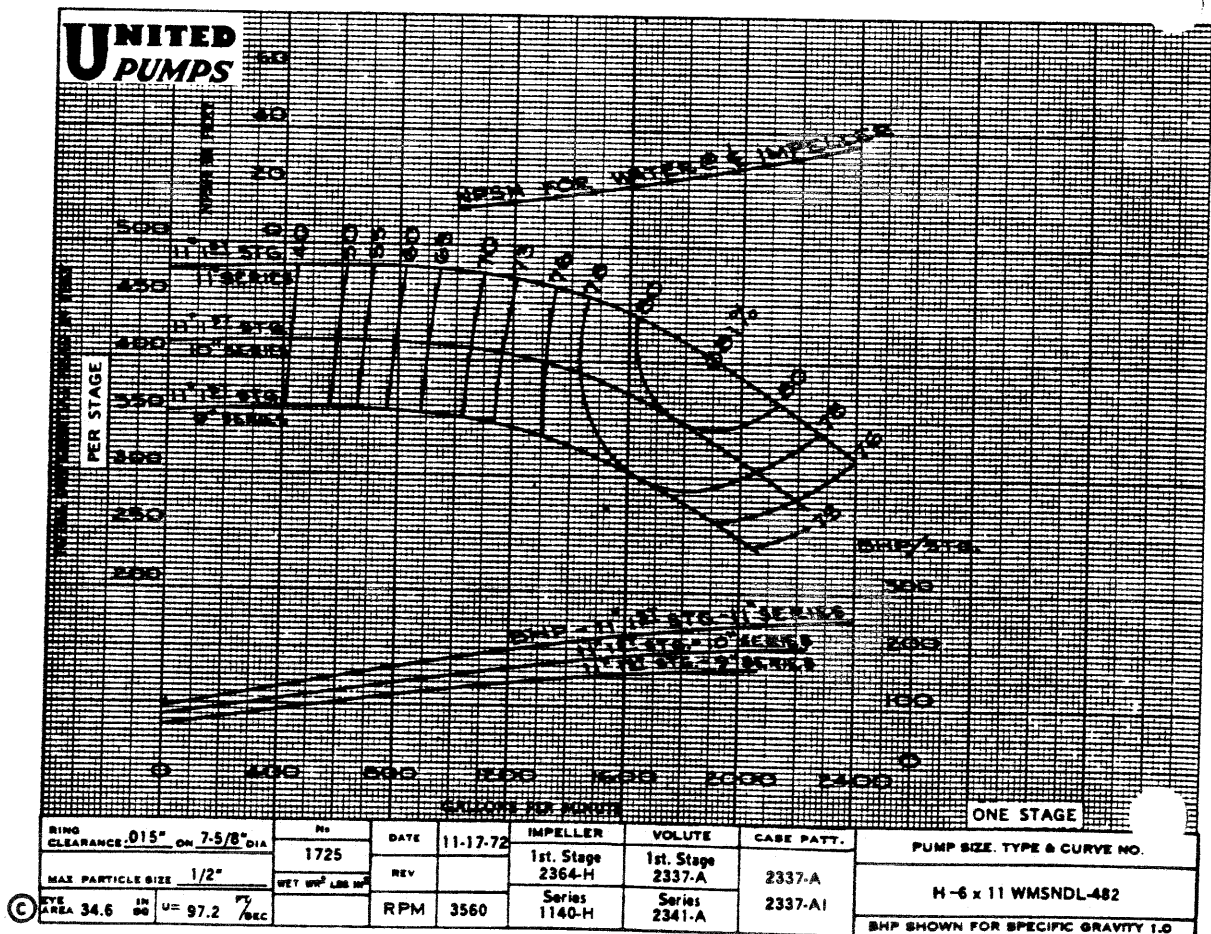
PUMP CURVES

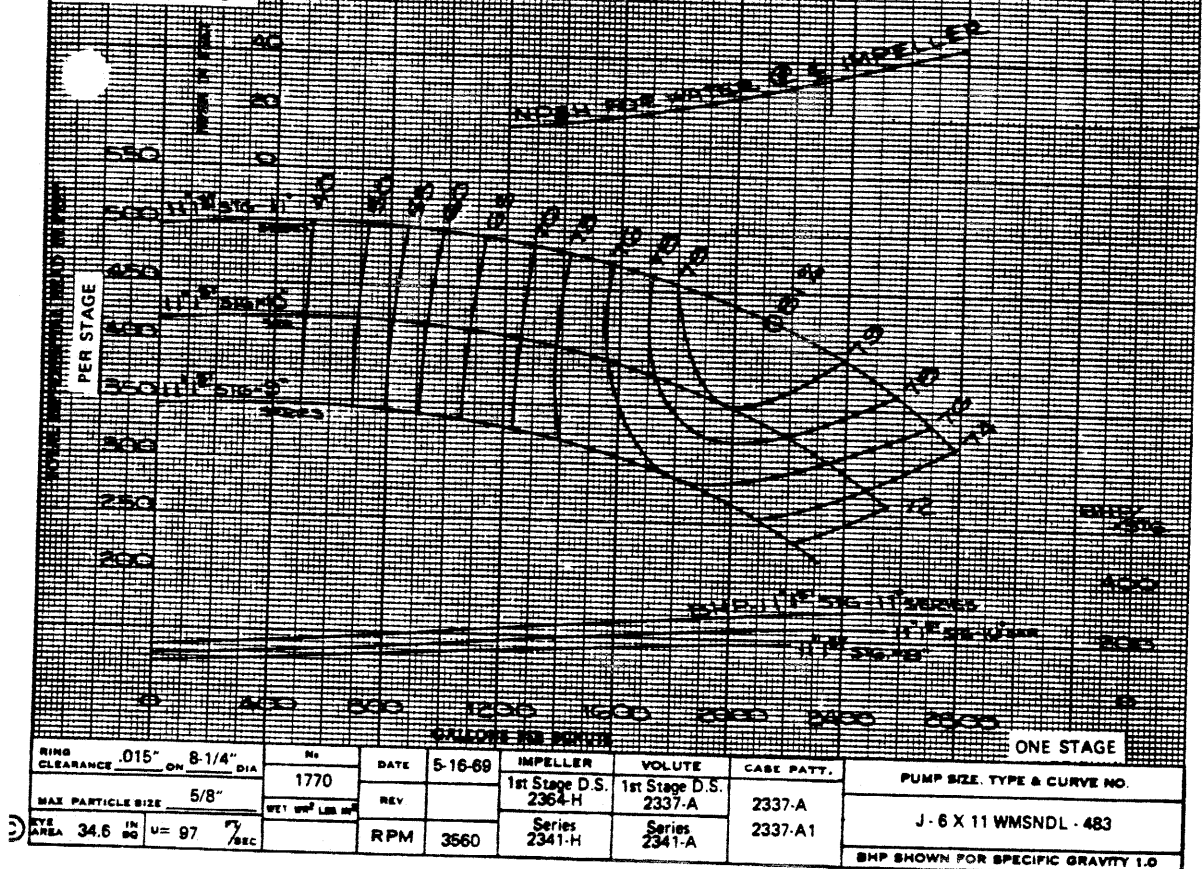
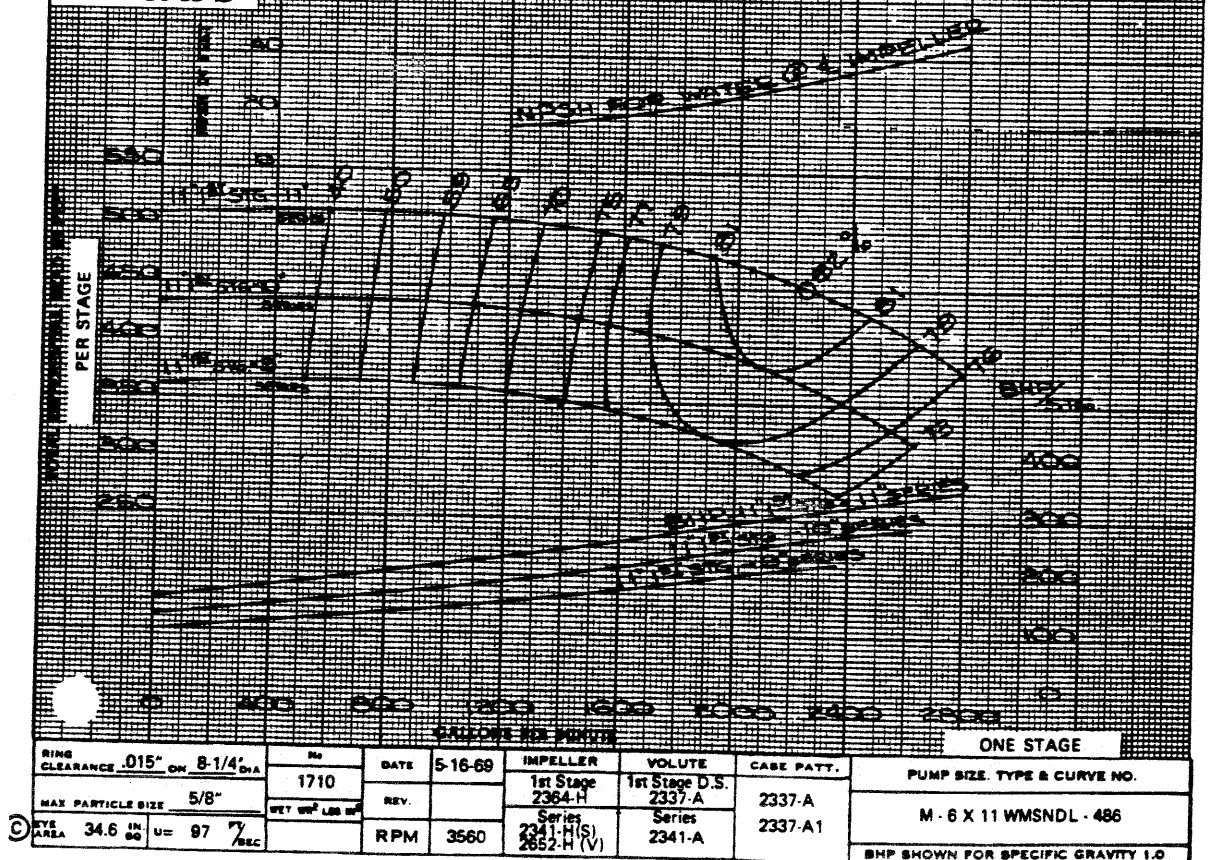


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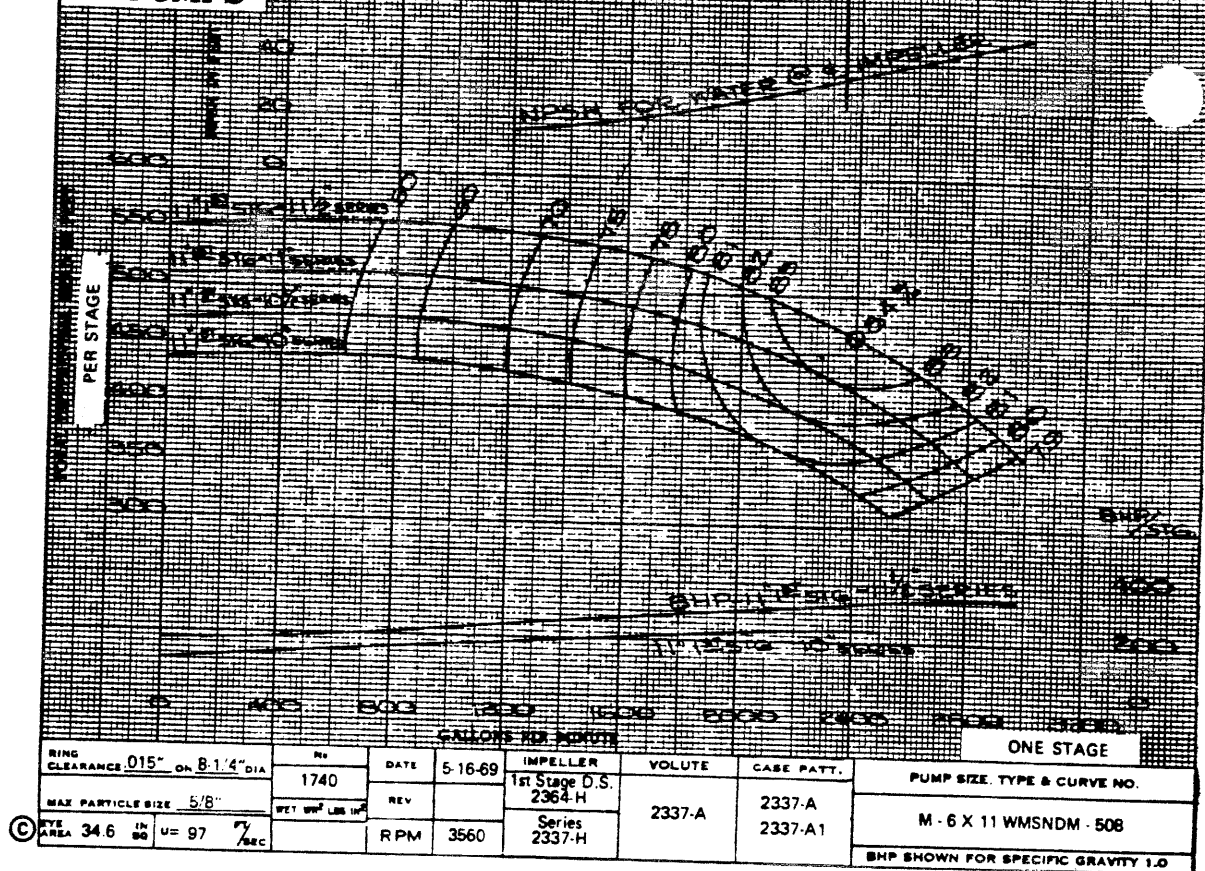


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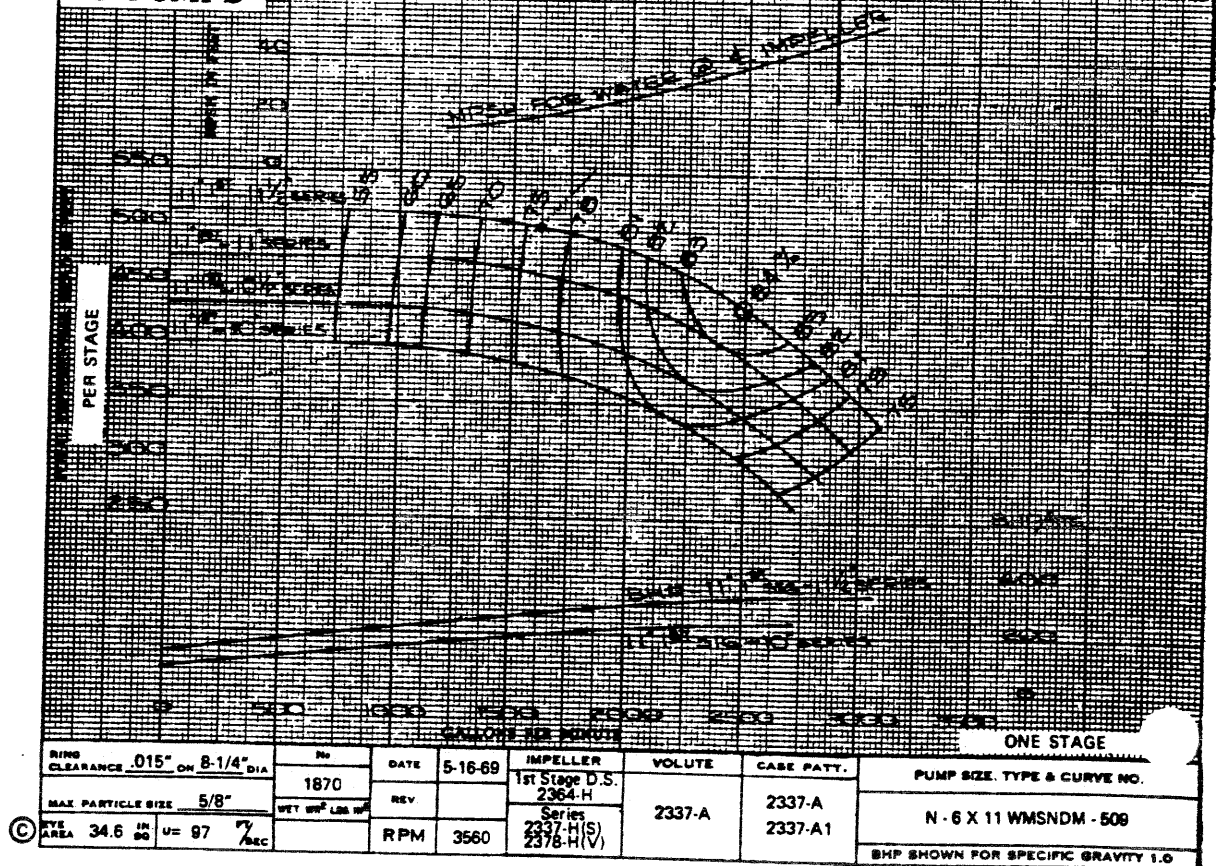


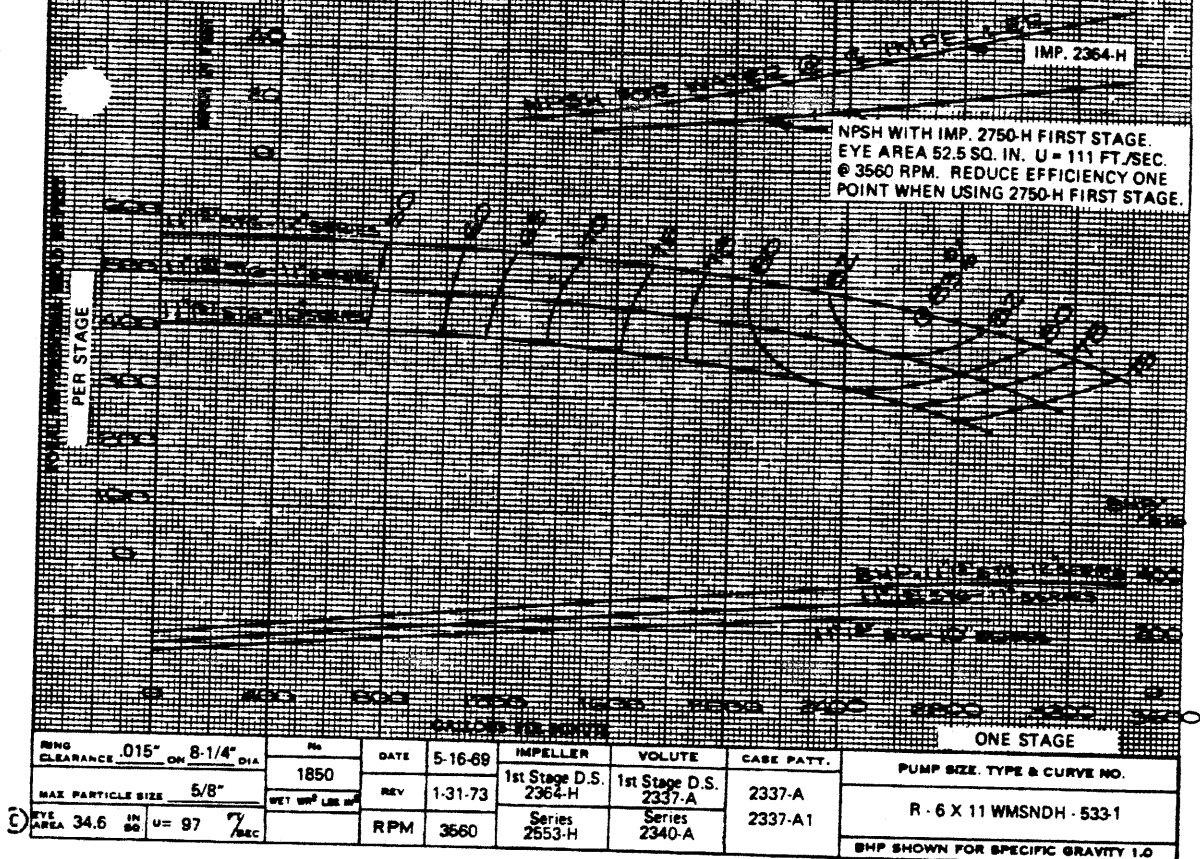
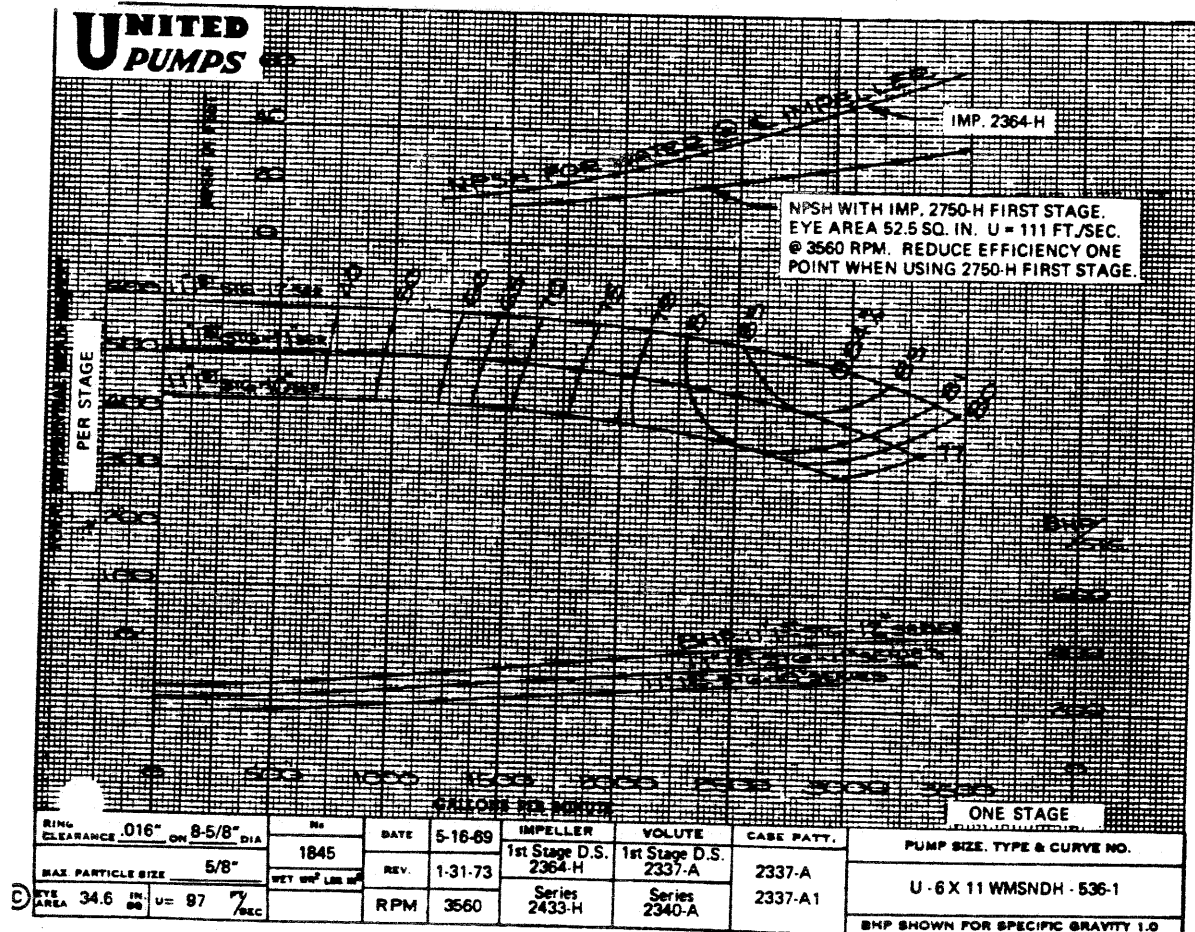
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PUMPS**

PROBLEM I ANSWER

Methods to increase available NPSH:

1. Raise minimum liquid level.
2. Modify piping to reduce friction loss.
3. Reduce pump centerline elevation.
4. Operate both pumps in parallel.
5. Purchase new pump with lower NPSH required.
6. Cool vessel liquid to reduce vapor pressure.

Note that increasing flow will increase friction loss in piping about 1 PSIG or 3 feet.

PROBLEM II ANSWER

<u>Manufacturer</u>	<u>Speed</u>	<u>Suction</u>	<u>Efficiency</u>	<u>Turndown</u>	<u>NPSH</u>
Byron Jackson	3550	Single	79%	25%	24 ft.
United	3550	Double	70%	50%	16 ft.
Pacific	1750	Double	62%	33%	6 ft.

Note that pump selections are for purposes of this problem only and are not necessarily typical of each manufacturer's offerings.

Full speed, single suction - Very good efficiency, good turndown, very high NPSH

Full speed, double suction - Good efficiency, good turndown, high NPSH

Half speed, double suction - Poor efficiency, poor turndown, very low NPSH

PROBLEM III ANSWER

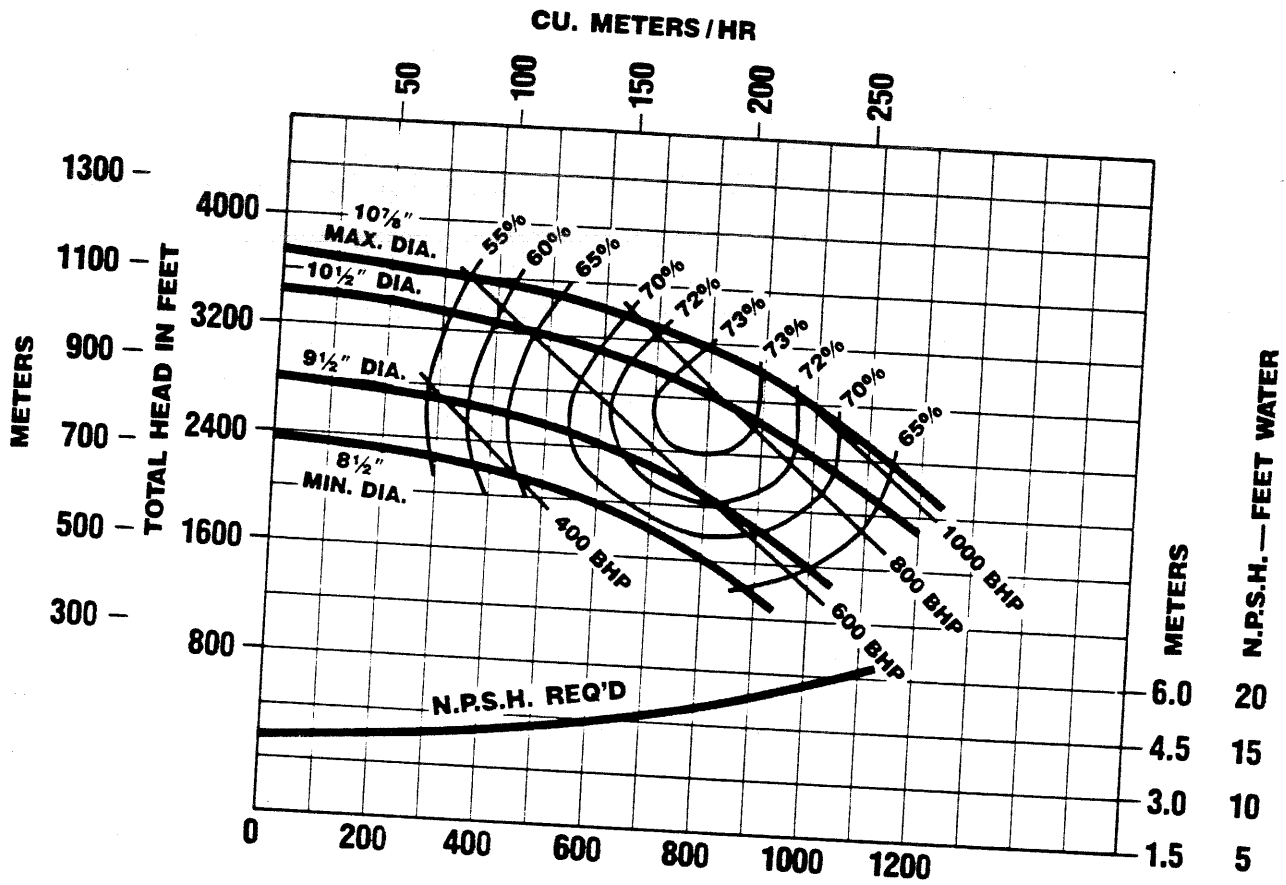
	<u>Metric</u>	<u>English (50 cycle)</u>	<u>English (60 cycle)</u>
Flow	159 m ³ /hr	700 GPM	<u>840 GPM</u>
Differential Pressure	42.19 Kg/cm ² g	600 PSIG	
Head	445 meters	1459 Ft.	<u>2101 Ft.</u>

1. Best pump selection - H4 x 11 MSND
2. Stages - 5
3. Efficiency - 78%
4. Horsepower - 314 BHP = 234 kW
5. Required NPSH - 14 ft = 4.3 meters (60 cycle) = 3.2 meters (50 cycle)

$$\frac{2101}{5} = 420.2$$

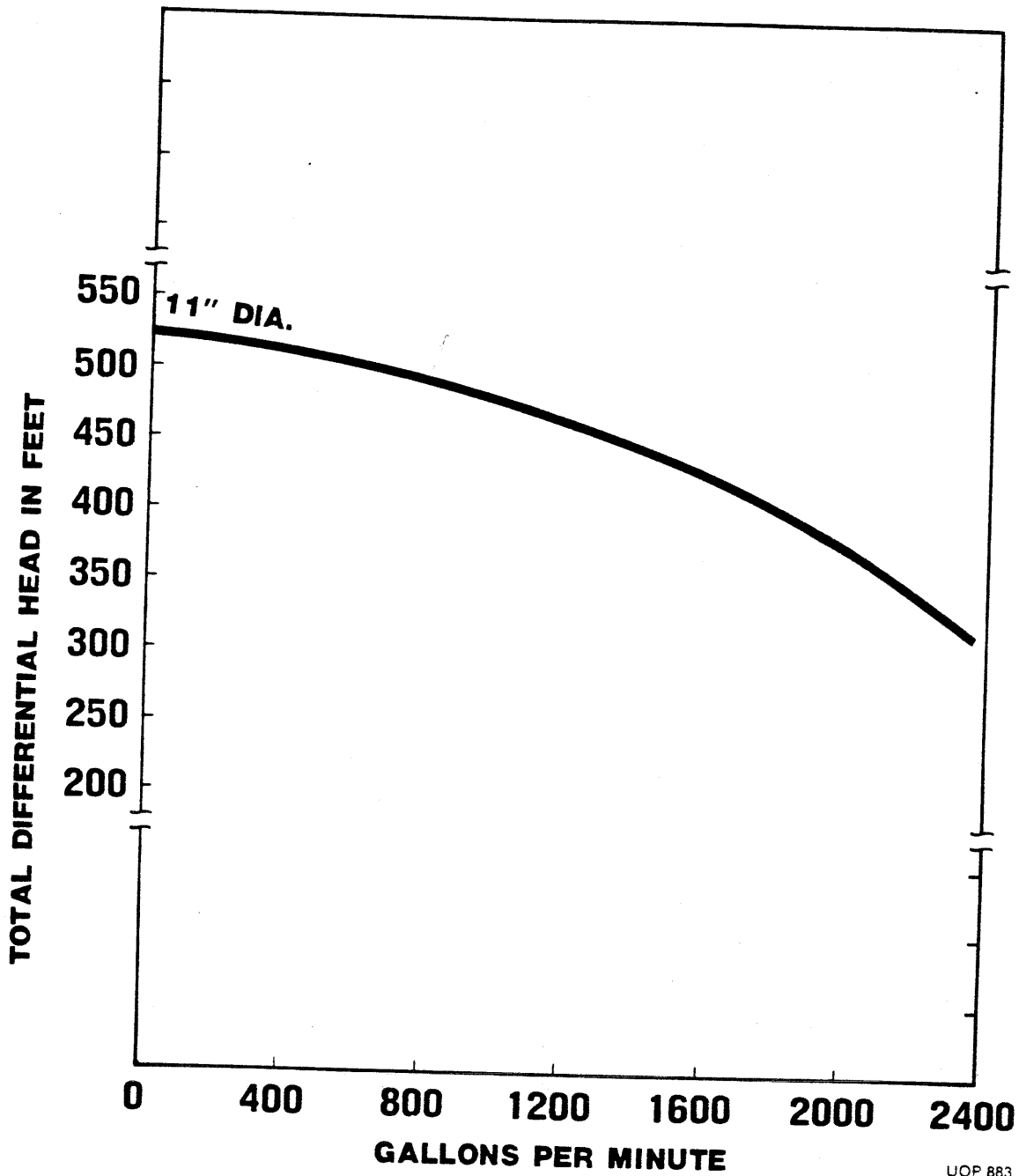
$$440 \times 5 =$$

$$\begin{array}{r} 2101 \div 6 \\ 2101 \div 5 \\ 2101 \div 4 \\ 2101 \div 3 \\ 2101 \div 2 \\ 2101 \div 1 \end{array}$$



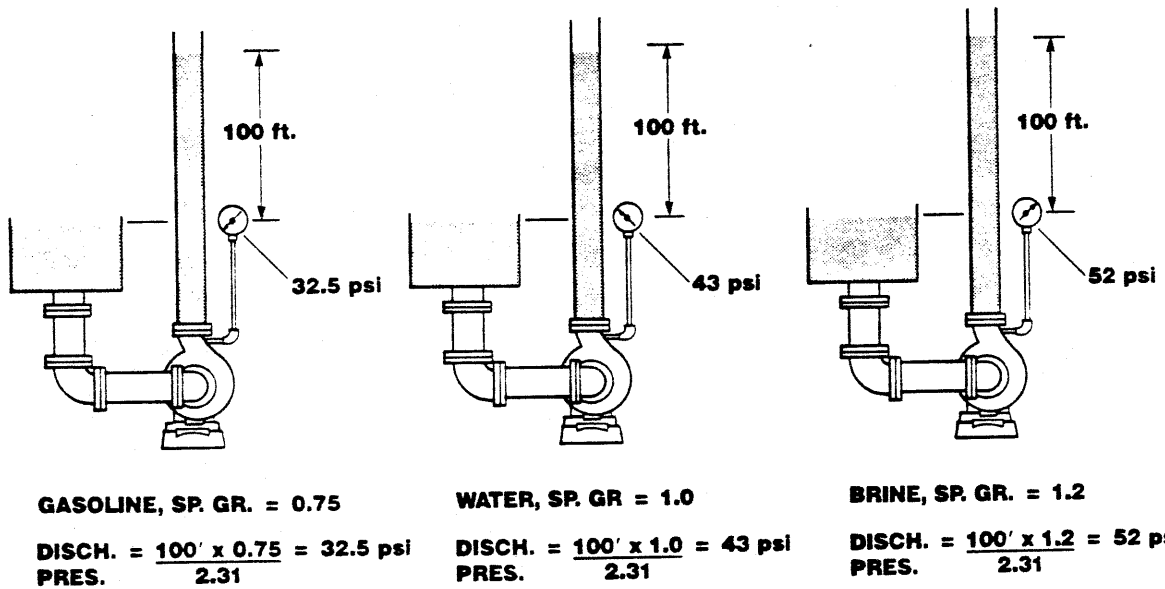
A. HEAD VERSUS CAPACITY

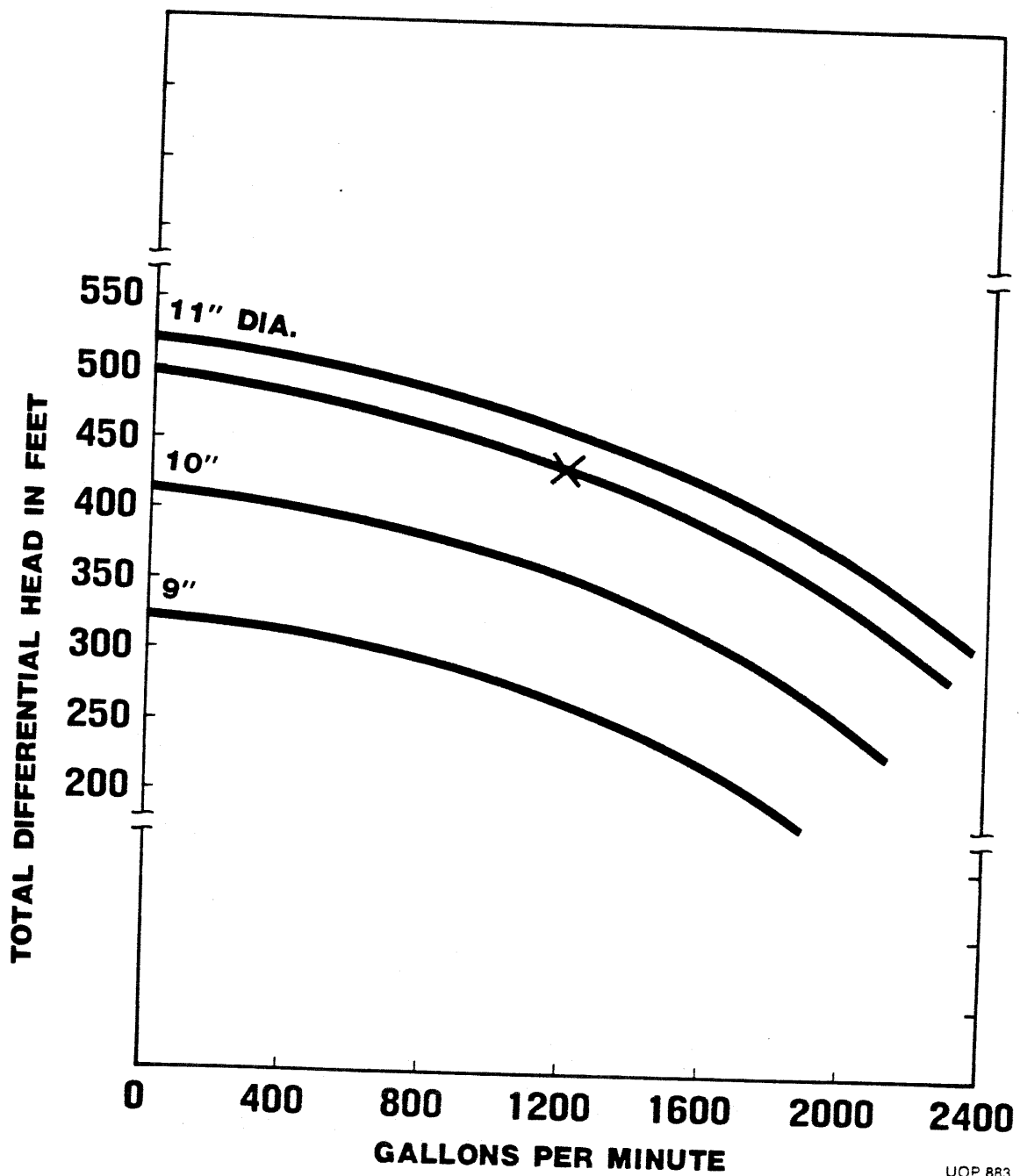
Pump performance is measured in feet of head rather than differential pressure. This is because the energy imparted to the fluid by the impeller is a function of the size and rotating speed of the impeller. It is not a function of the specific gravity of the fluid. Once this head versus capacity curve is established, it will be constant regardless of the fluid being pumped. Therefore, a given pump with a given impeller diameter and speed will raise a liquid to a certain height regardless of the weight of the fluid.



UOP 883
UOP 1702-15

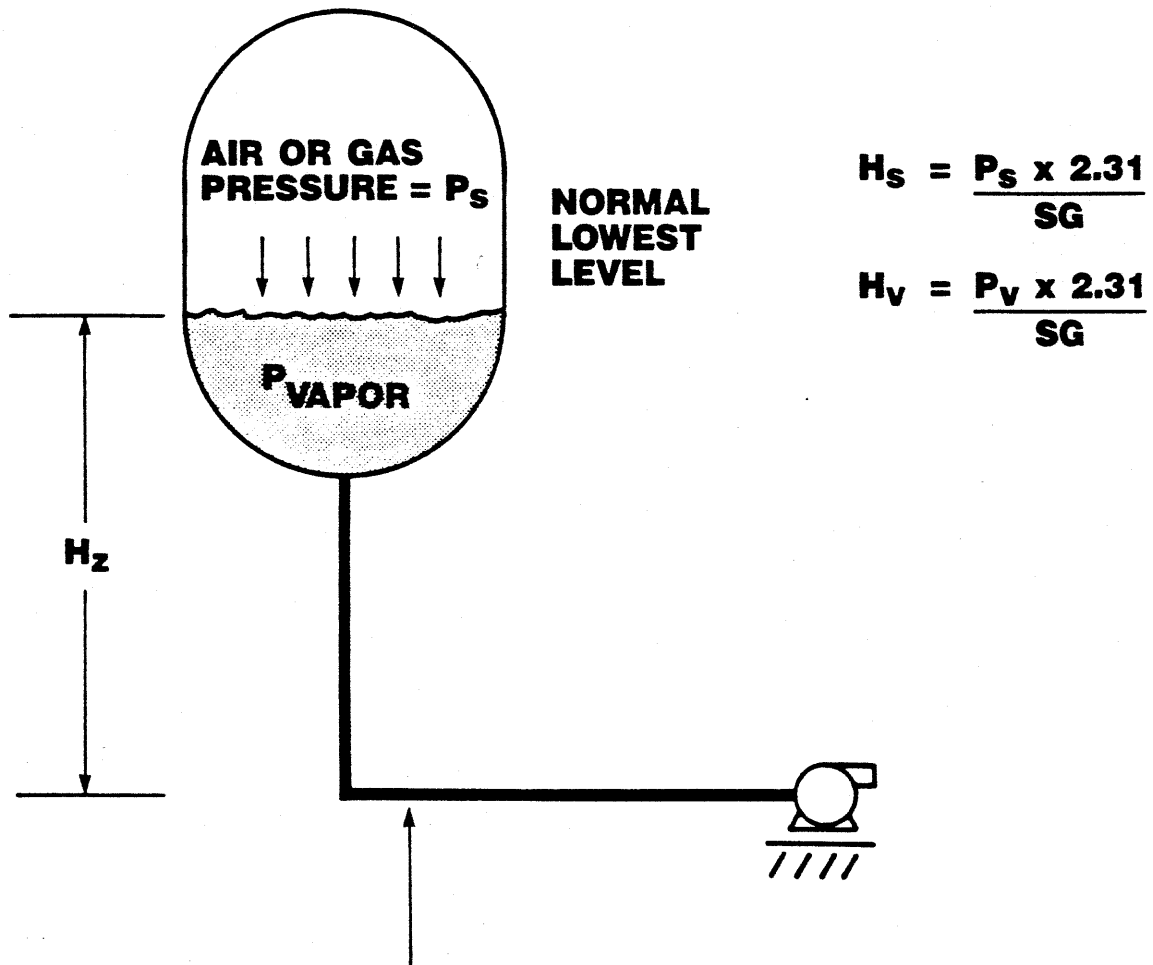
IDENTICAL PUMPS HANDLING LIQUIDS OF DIFFERENT SPECIFIC GRAVITIES





UOP 883
UOP 1702-11

NPSH



$$H_s = \frac{P_s \times 2.31}{SG}$$

$$H_v = \frac{P_v \times 2.31}{SG}$$

H_f - FRICTION LOSS, FT.

$$NPSHA = H_s \pm H_z - H_f - H_v$$

NPSHR — BY PUMP MANUFACTURER

$$NPSHR \leq NPSHA$$

B. NPSH

Pressure drop occurs between suction flange and minimum pressure point within pump impeller because of increase in velocity between suction flange and entrance of the impeller vanes and friction and turbulence losses. Pump system must have positive suction pressure sufficiently high to overcome this pressure drop. If pressure drops below vapor pressure, the liquid will vaporize. The vapor bubbles will be carried to a point of higher pressure where they will suddenly collapse. This phenomenon is called cavitation.

$$\text{NPSH} = H_p \pm H_z - H_{vp} - H_f$$

H_p = Absolute pressure at surface of liquid

H_z = Height in feet of liquid above or below centerline of pump

H_{vp} = Vapor pressure of liquid

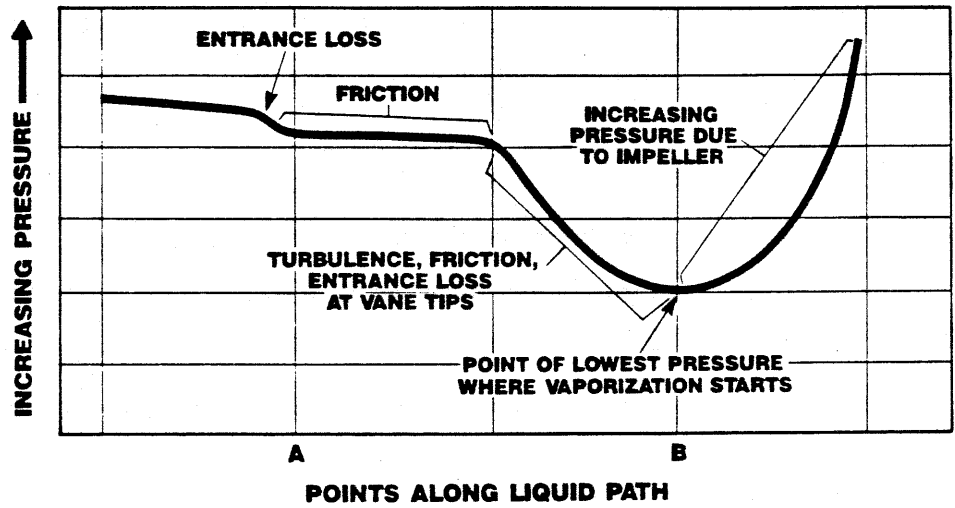
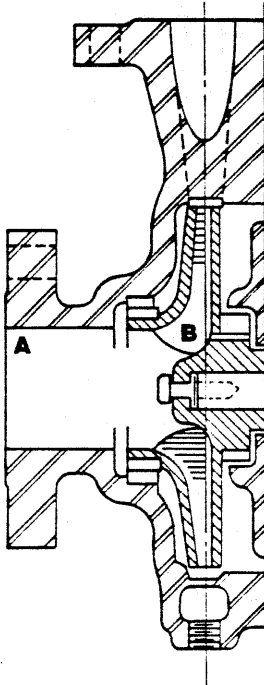
H_f = Friction loss between surface of liquid and pump suction

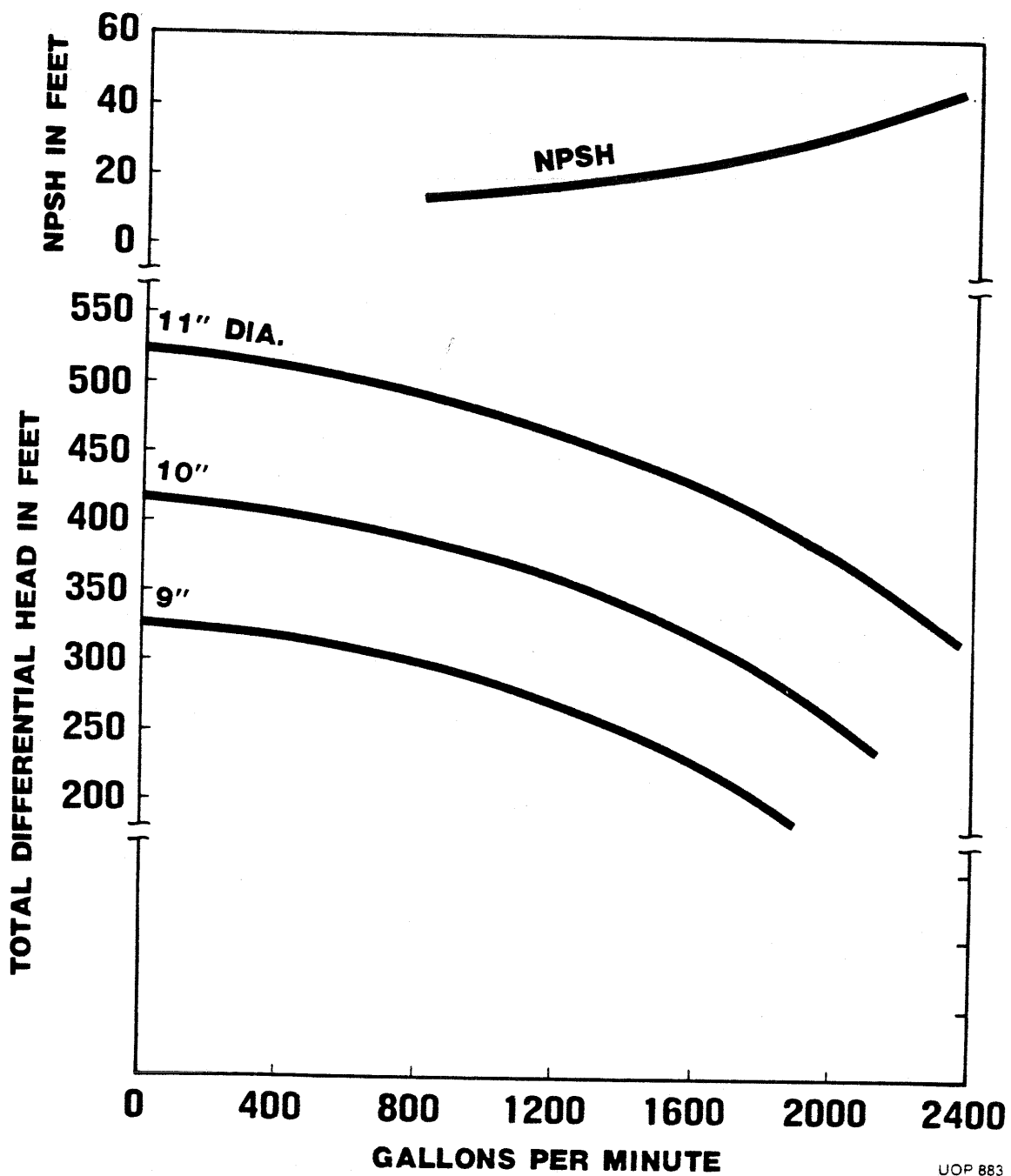
$\text{NPSHA} = \text{NPSH available - of the system}$

$\text{NPSHR} = \text{NPSH required - by pump manufacturer}$

$$\text{NPSHA} \geq \text{NPSHR}$$

NPSHR determined by suppression test. UOP requires individual suppression test if $\text{NPSHA} \leq \text{NPSHR} + 2 \text{ ft.}$

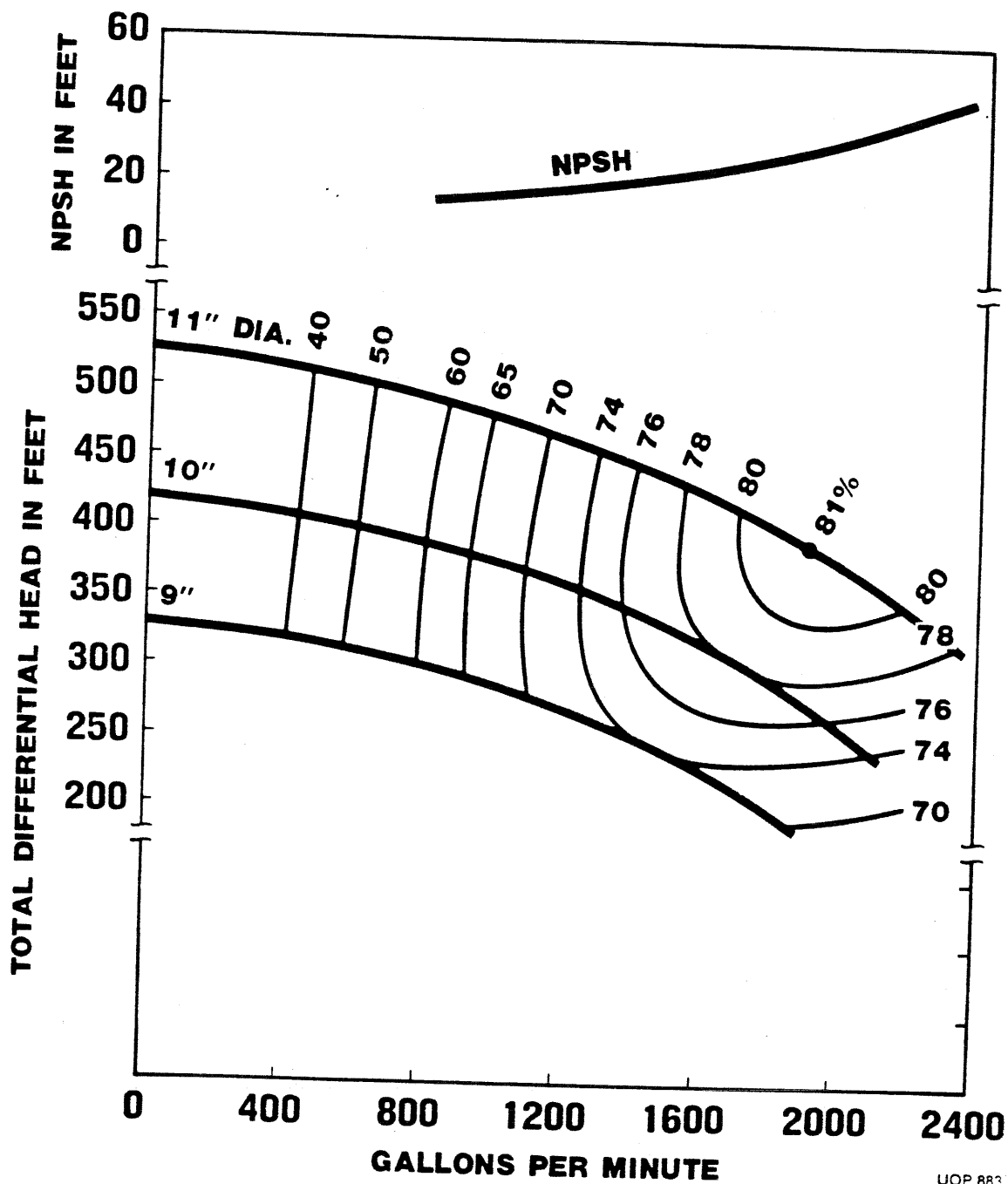


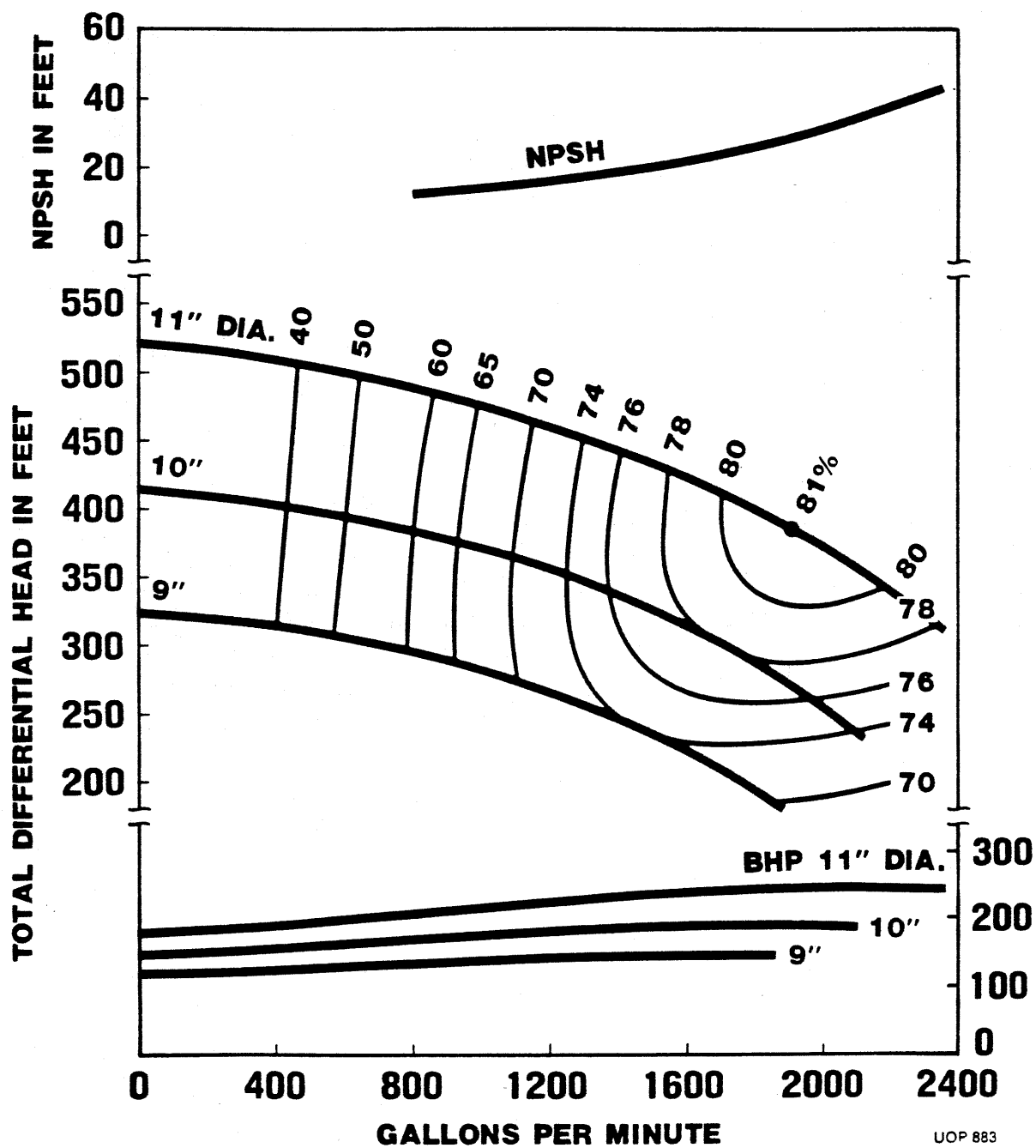


UOP 883
UOP 1702-14

C. EFFICIENCY

Pump efficiency is a ratio of hydraulic horsepower over brake horsepower. Brake horsepower is greater than the hydraulic horsepower due to the mechanical and hydraulic losses incurred in the pump. The efficiency increases with pump capacity until a certain point called best efficiency point and then starts to decrease with increasing capacity. When specifying a pump, the rated point should be at or to the left of the best efficiency point.





SINGLE-STAGE CENTRIFUGAL PUMP DESIGN

INTRODUCTION

A typical single stage, overhung process-type pump is the workhorse of the industry. All ranges of fluids are pumped at various pressures and temperatures. An average pressure and temperature rating for the standard pump is 600 psig at 800°F. These limits can usually be extended with casting revisions.

There are provisions to apply cooling water to the jacket and quench may be added to the seal. The pump can be foot or centerline mounted, with the latter required when the temperature exceeds 200°F.

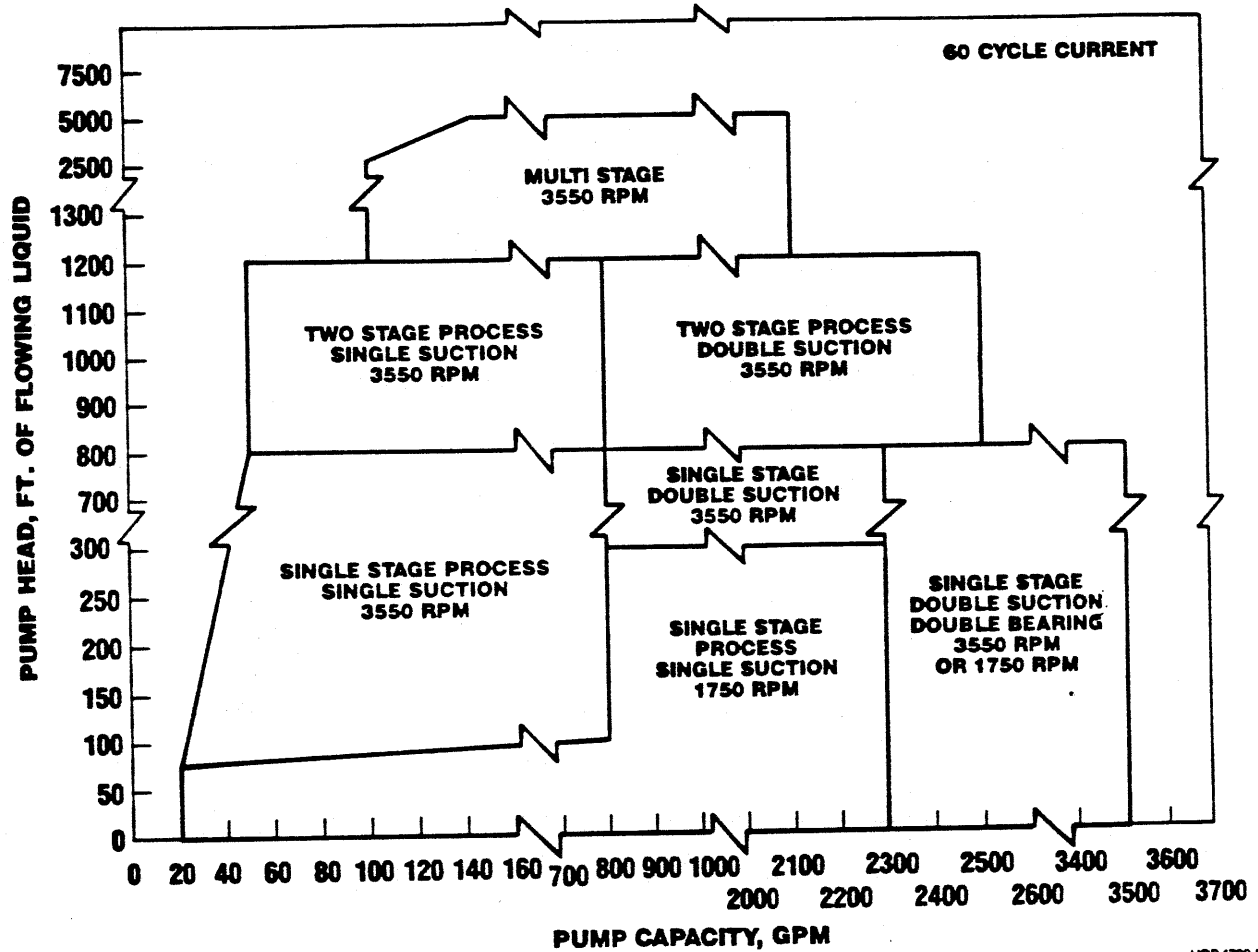
A. PUMP COMPONENTS

The basic parts are:

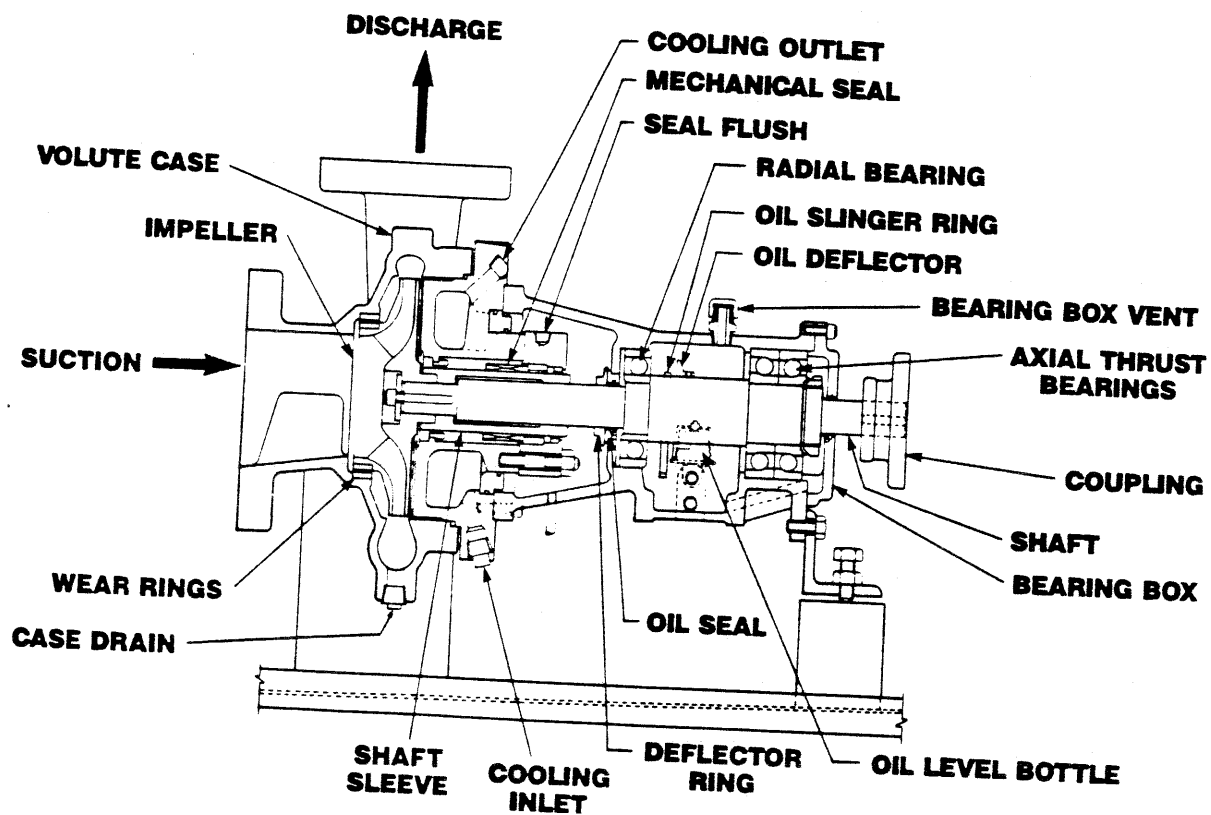
1. **Pump shaft:** a machined piece of steel, usually AISI 4340 or equal with an 11 -13% CR sleeve.
2. **Coupling with spacer:** to join shaft and driver, gear type with oil lubrication or flexible disc type (non-lubricated).
3. **Deflector ring external:** to stop contamination of lubricating oil by process liquid if there is a seal failure.
4. **Head gasket:** to stop leak between split case.
5. **Impeller key:** to locate impeller on shaft.
6. **Impeller:** to apply force to liquid - bronze, cast iron, steel, or 11-13% CR depending on fluid characteristics.
7. **Case:** to contain liquid, must be steel minimum for any hydrocarbon service, can use 5% or 11-13% CR casing to combat corrosion of sulfur in fluid. This is a temperature and weight per cent sulfur consideration. In general, at somewhere around 500°F, the corrosion rate of a sulfur/hydrocarbon stream can cause one to consider upgrading the impeller and/or casing materials. The casing corrosion allowance is 1/8" minimum.

8. **Radial ball bearing:** to balance radial thrust and hold shaft in position.
9. **Base:** for pump and driver, made of steel that is filled with cement grouting to provide vibration free foundation.
10. **Oil seal:** to prevent oil leakage along shaft.
11. **Shaft sleeve:** is replaceable and prevents wear on the shaft from the seal.
12. **Oiling ring:** oil ring carries oil to bearings from oil reservoir.
13. **Thrust ball bearing:** to balance axial thrust and hold shaft position.
14. **Deflector ring internal:** acts as a distributor ring.
15. **Bearing housing:** steel or cast iron.
16. **Wear rings:** area of high potential erosion, usually use 11 - 13% CR. Rings are replaceable. Hardness is maintained a 50 Brinell differential to minimize galling. Clearances are dependent upon materials, fluid, etc. Typically .006" and greater.
17. **Mechanical seal**

PUMP SELECTION



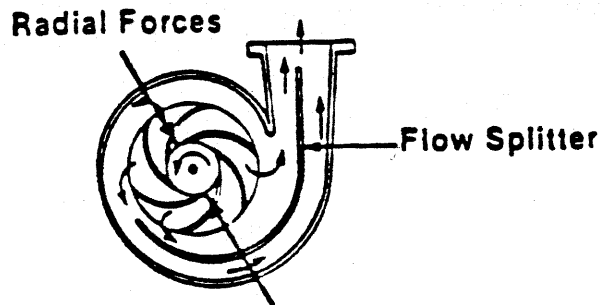
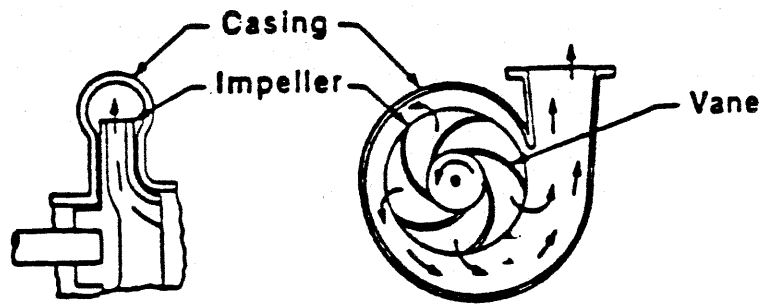
SINGLE STAGE CENTRIFUGAL PUMP



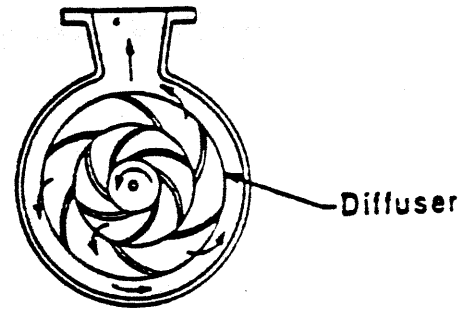
UOP 1220A-42
UOP 1702-25

IMPELLERS

CENTRIFUGAL PUMPS



DOUBLE-VOLUTE CASING
With Flow Split



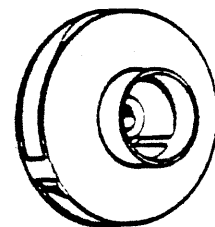
DIFFUSER
Stationary Diffuser Vane Ring
Around Impeller



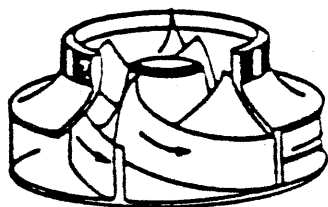
OPEN



PARTIALLY OPEN



ENCLOSED



SIDE VIEW OF
ENCLOSED IMPELLER



High



Medium



Low

PRESSURE

Developed by Different Vane Aperatures

B. IMPELLERS

There are various kinds of impellers:

1. Open impellers
2. Semi-open impellers - one side shrouded
3. Closed impellers - both sides shrouded

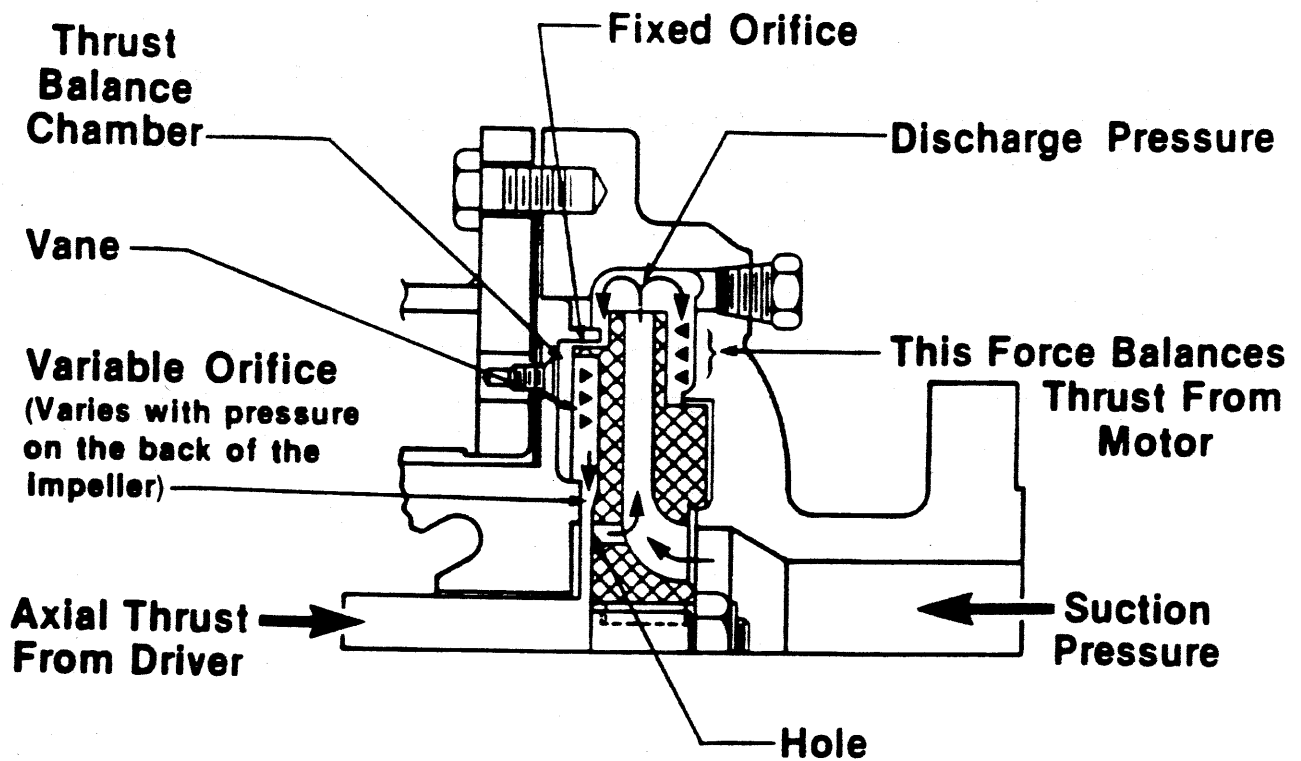
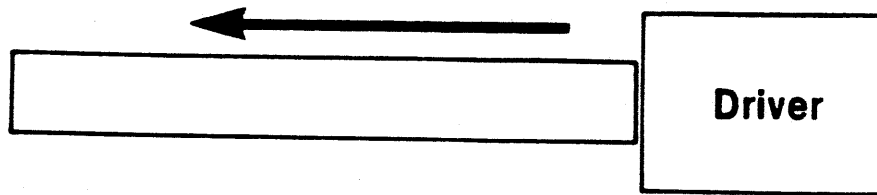
The choice will depend upon fluid characteristic and flow/pressure requirements. In general, the closed impeller, while more expensive to manufacture, is normally used in process applications due to its greater efficiency.

As the liquid produces pressure in the volute case, it also creates an unbalanced load on the shaft bearings which is known as radial thrust. To reduce this, a flow splitter is added. This is then called a double volute.

The diffuser type case is another method of overcoming radial thrust. One can see that the diffuser is a stationary vane ring around the impeller which converts the velocity to pressure all around the impeller without having any high unbalanced radial thrust at any one point.

AXIAL THRUST

Axial Thrust From Motion Of Driver



C. AXIAL THRUST

When a driver is started, axial thrust is produced along a shaft in a forward direction, by the screw motion of rotation of the shaft.

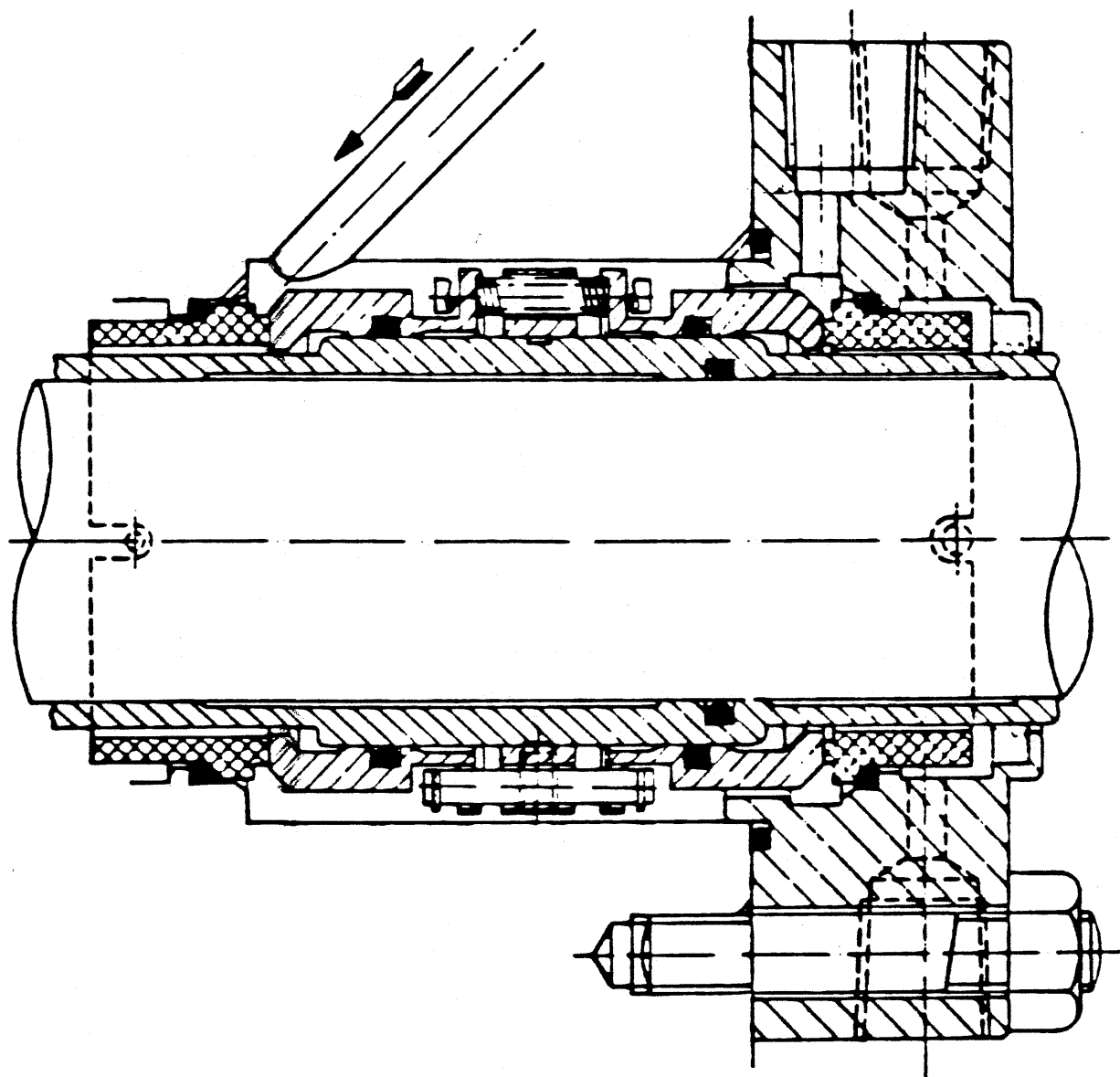
In a centrifugal pump, when normal operating conditions have been reached, the impeller is in balance axially due to the way the discharge pressure acts on the front and the backside of the impeller with any residual thrust being taken up by thrust bearings.

To reduce the imbalance caused by any high pressure acting on the back of the impeller, one of two methods is applied.

1. By fitting vanes at the back of the impeller.
2. By drilling holes in the impeller to allow the passage of liquid back to suction.

When the normal suction pressure is below atmospheric pressure, the seal is provided positive pressure and, therefore, insurance against ingressing air by eliminating balance holes or vanes and letting the thrust bearing balance the net thrust.

DOUBLE SEAL



D. SHAFT SEALING

In general, centrifugal pumps have mechanical seals. A mechanical seal has a rotating face and a stationary face. Numerous means such as bellows, wedges, and O-rings are used to seal the rotating face (seal head) against the shaft sleeve. O-rings are normally used to seal the stationary face (seat) to the casing. In some cases, larger face with the springs is held stationary and the other face rotates (rotating seat). The rotating face and the stationary face are mechanically smooth and matched so they fit together perfectly.

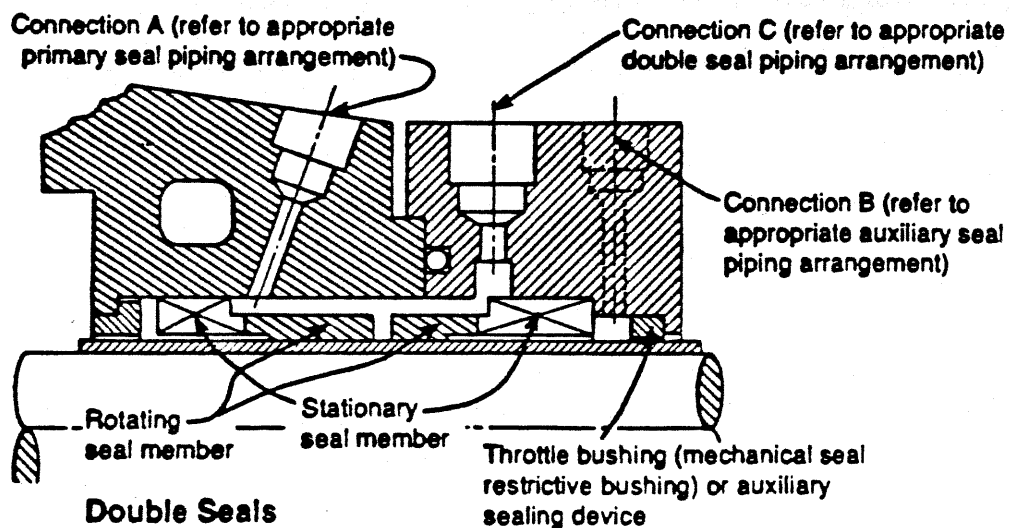
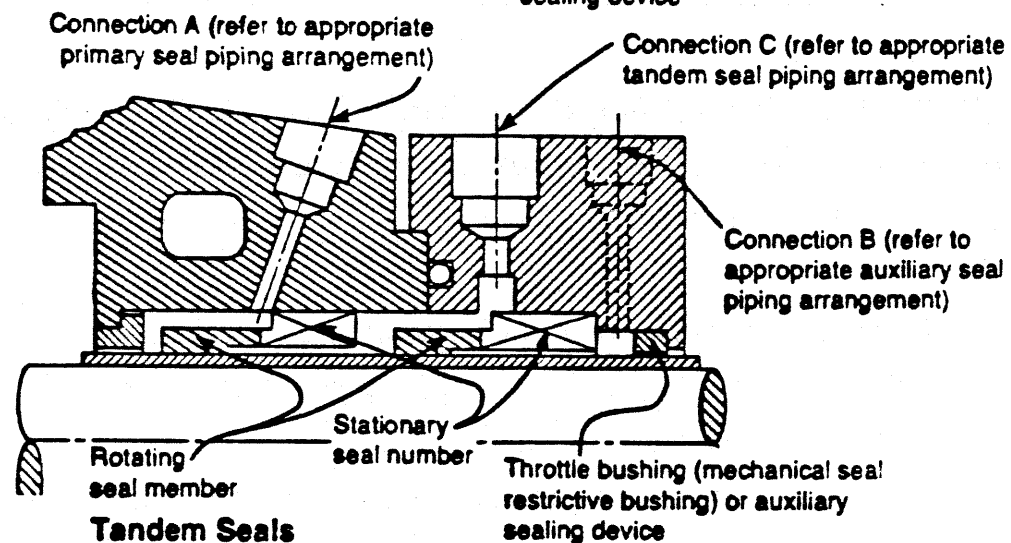
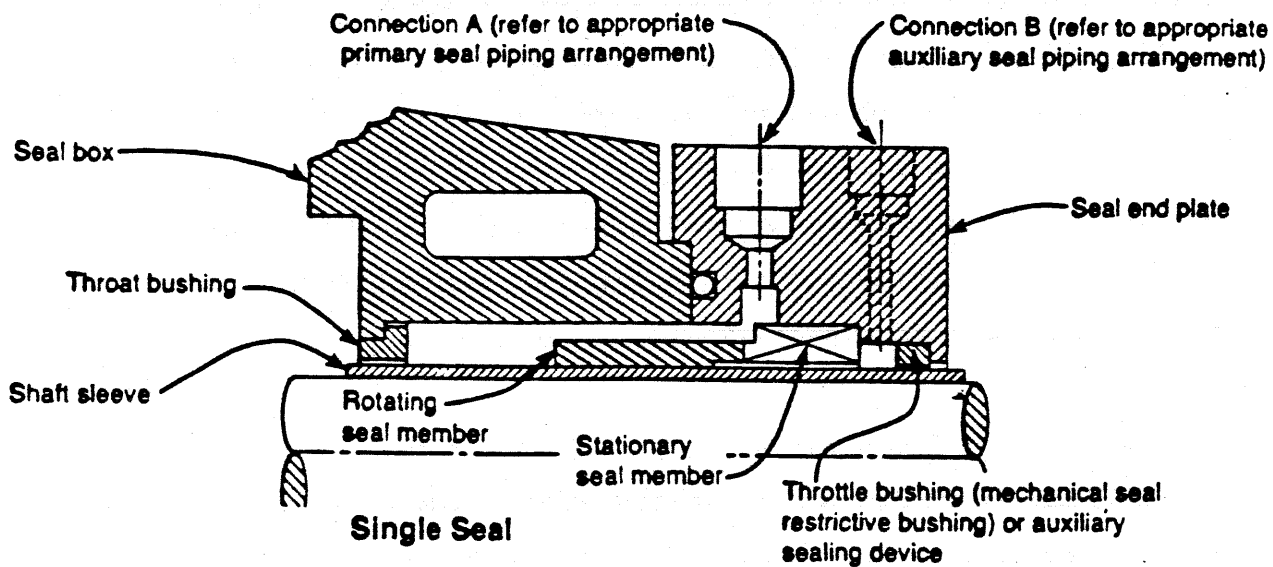
The stationary face is many times made of carbon and the rotating face of stainless steel. The seal head is driven by a spring or spring-loaded pins. It rotates with the shaft and is held against the stationary face by spring pressure.

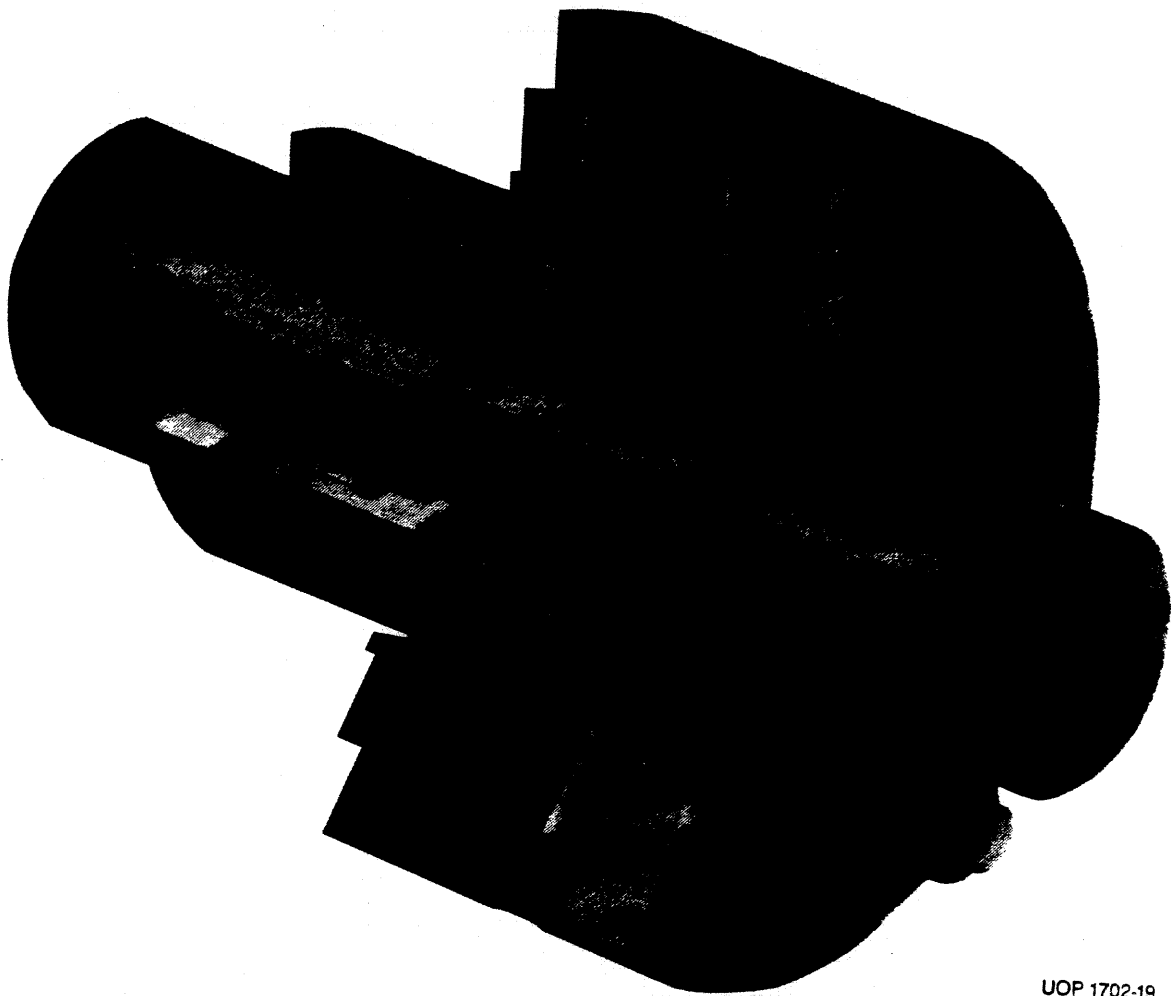
Mechanical seals are available as either internal or external, balanced or unbalanced, single, double, or tandem, to name some of the variables which must be considered. Figures show typical single mechanical seals.

Various flushing and cooling schemes are available to combat various environments that are hostile to the mechanical seal face integrity, elastomers, etc

Usage of tandem and double seals is on the increase due to more stringent environmental regulations. Currently any hydrocarbon service with a high vapor pressure or high concentration of benzene, hydrogen sulfide or aromatics require tandem seals.

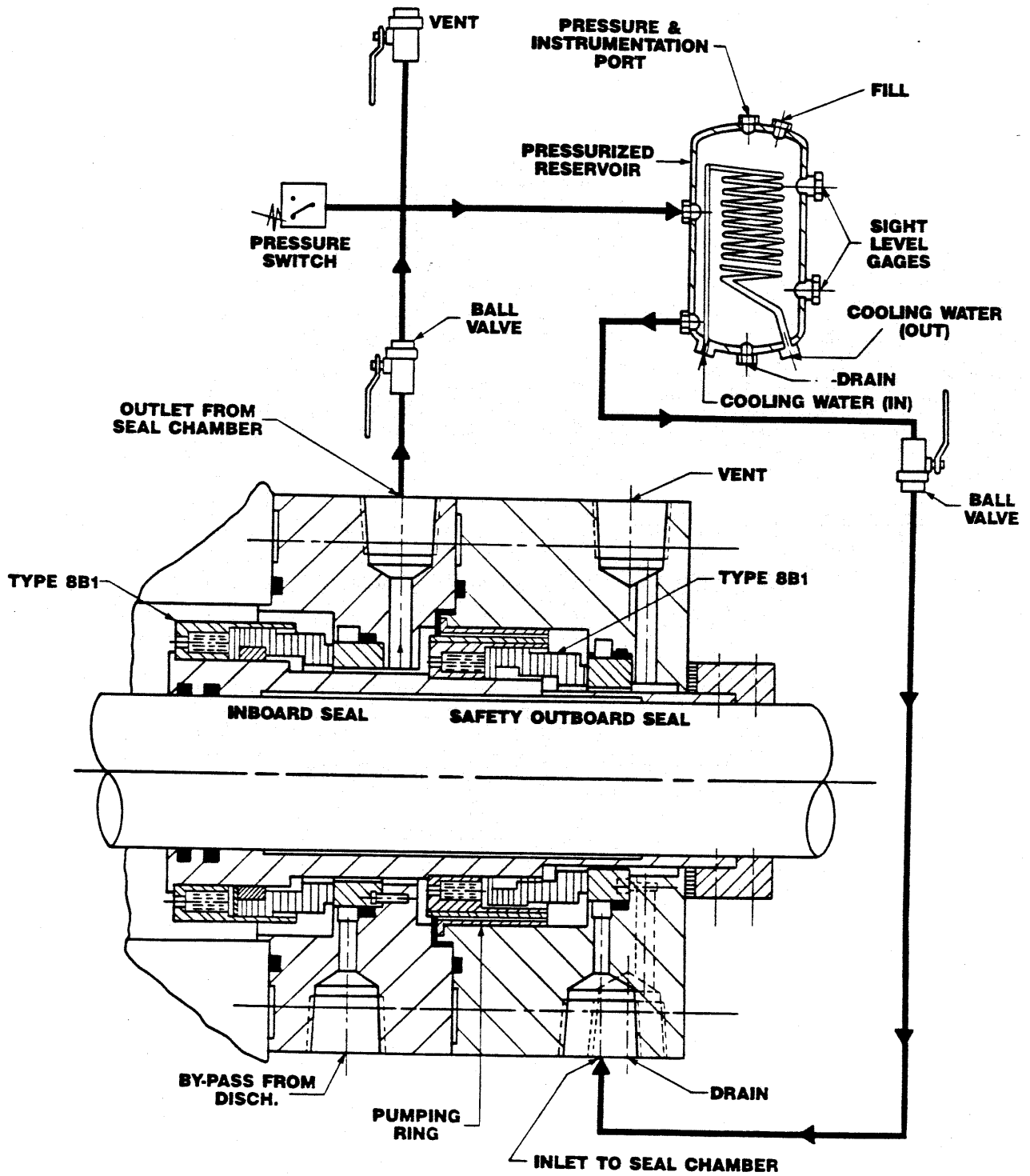
TYPICAL MECHANICAL SEAL ARRANGEMENTS





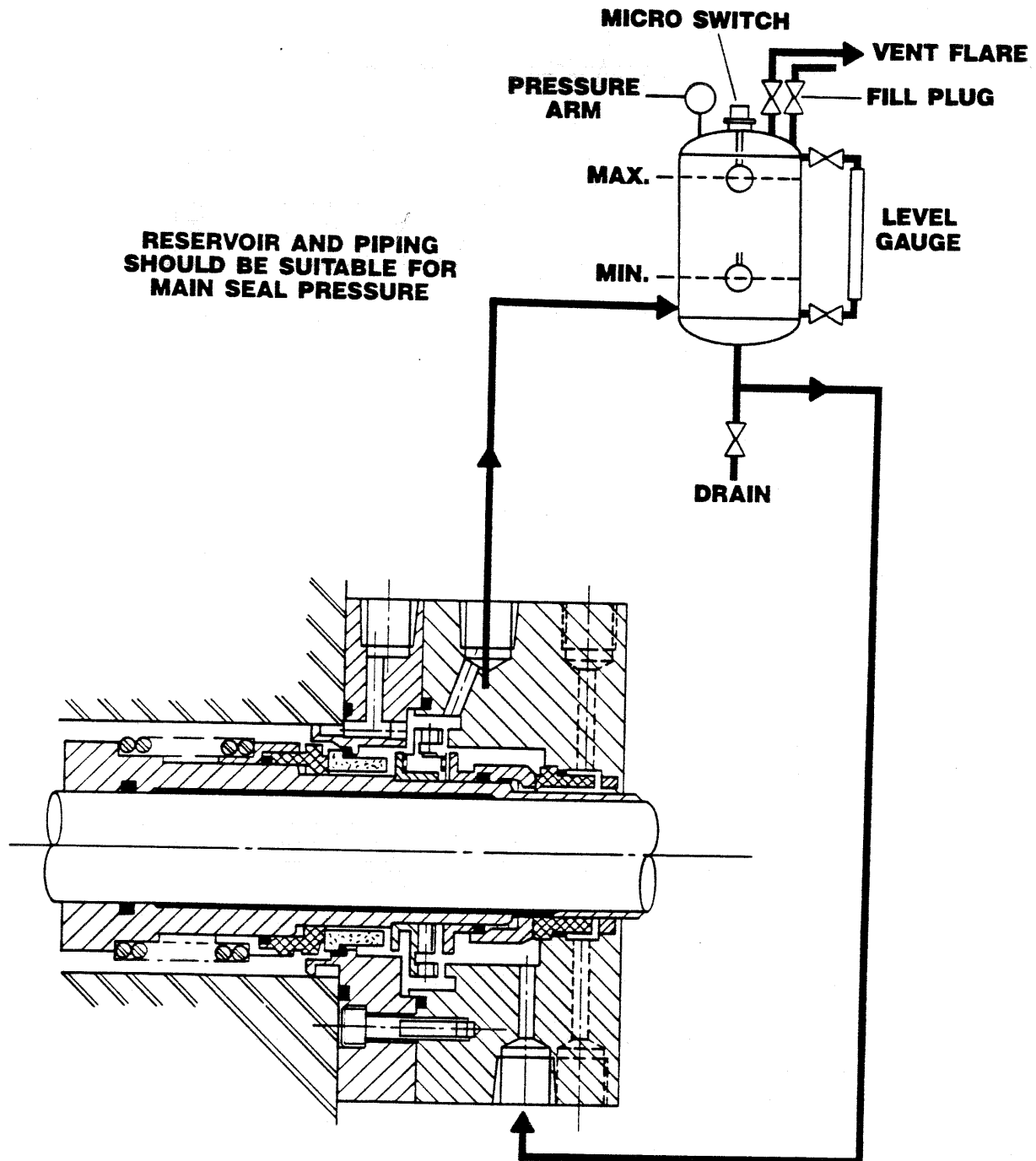
UOP 1702-19

TANDEM TYPE 8B1 SEAL USING AXIAL FLOW PUMPING RING

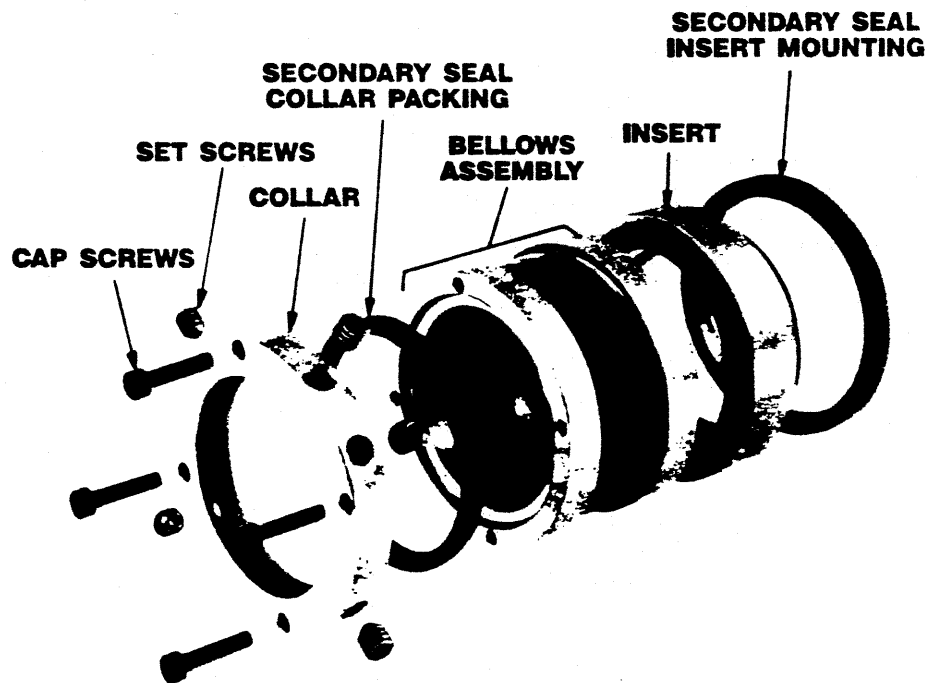
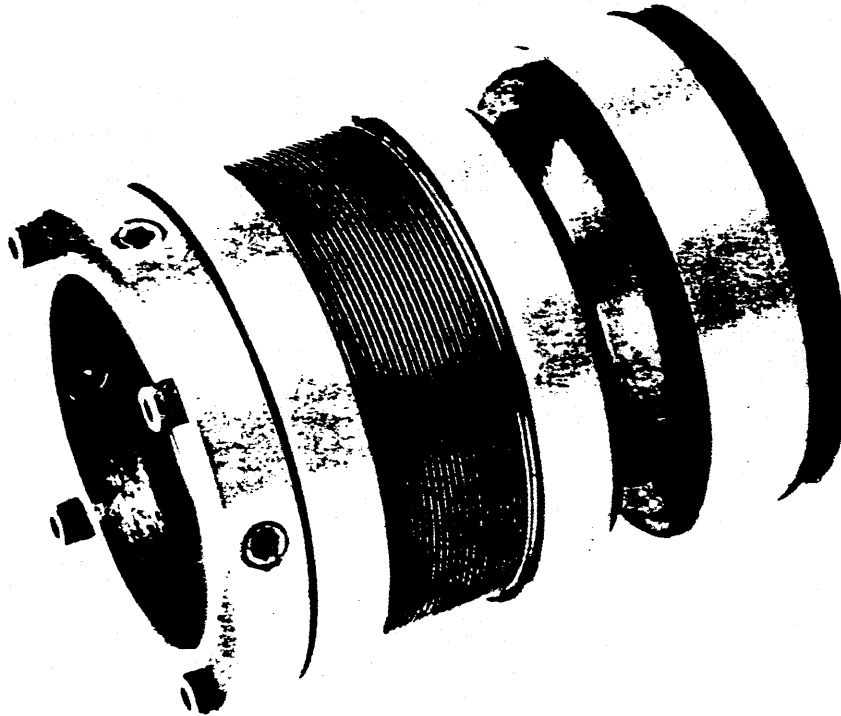


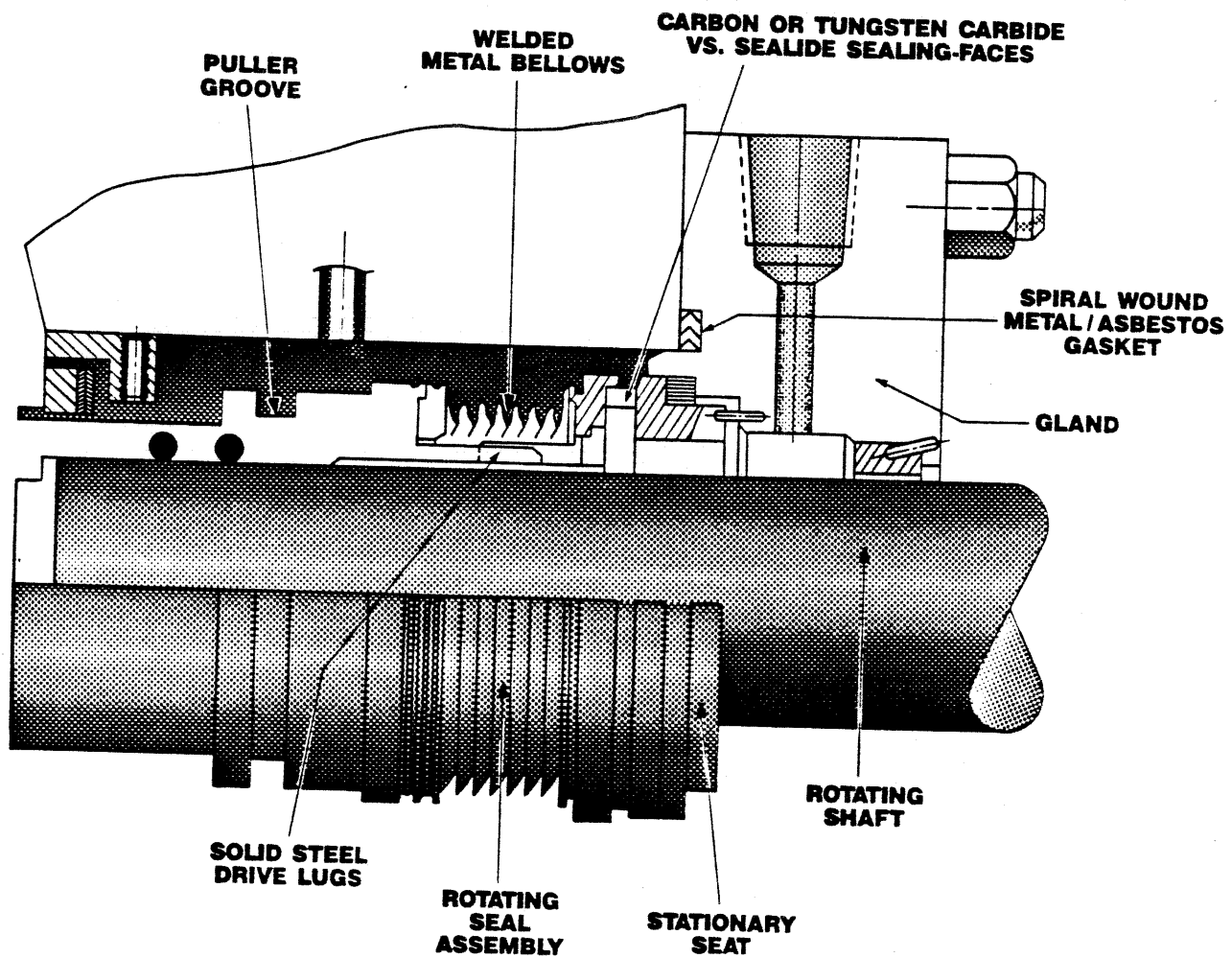
UOP 1702-10

TANDEM MECHANICAL SEALS WITH BARRIER FLUID RESERVOIR AND ANCILLARY EQUIPMENT

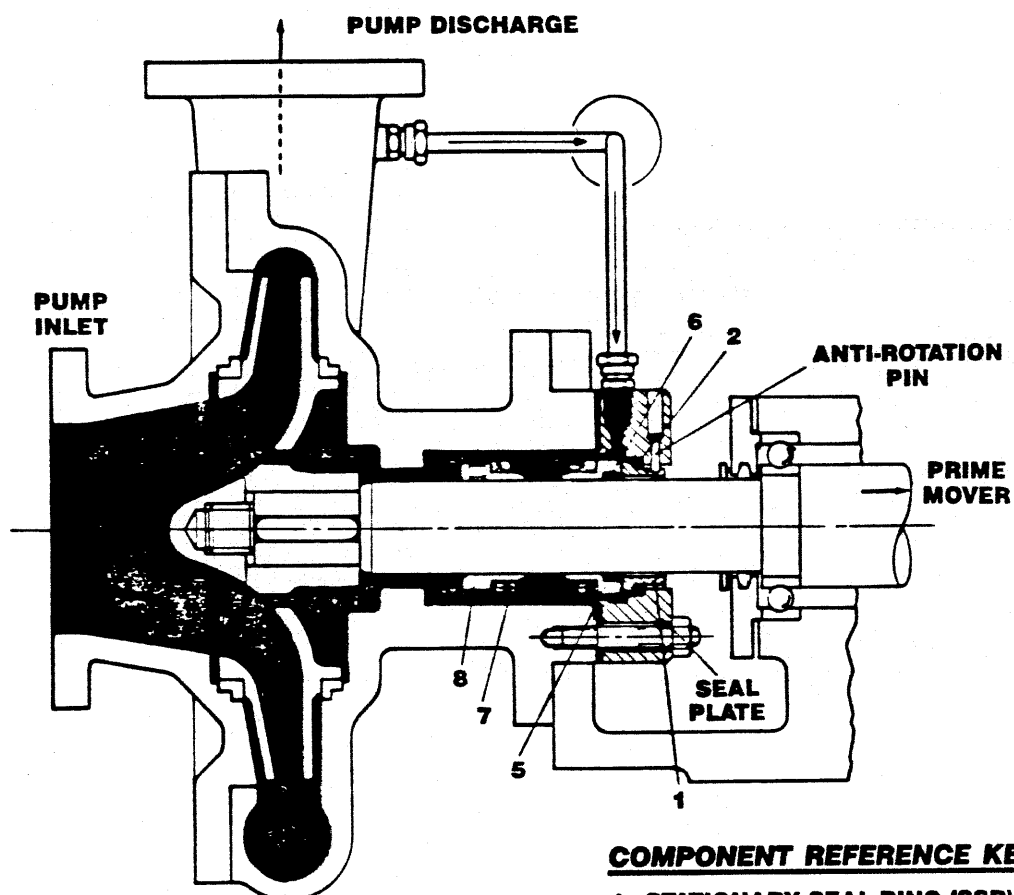


TYPE PB-D DURA SEAL[®]





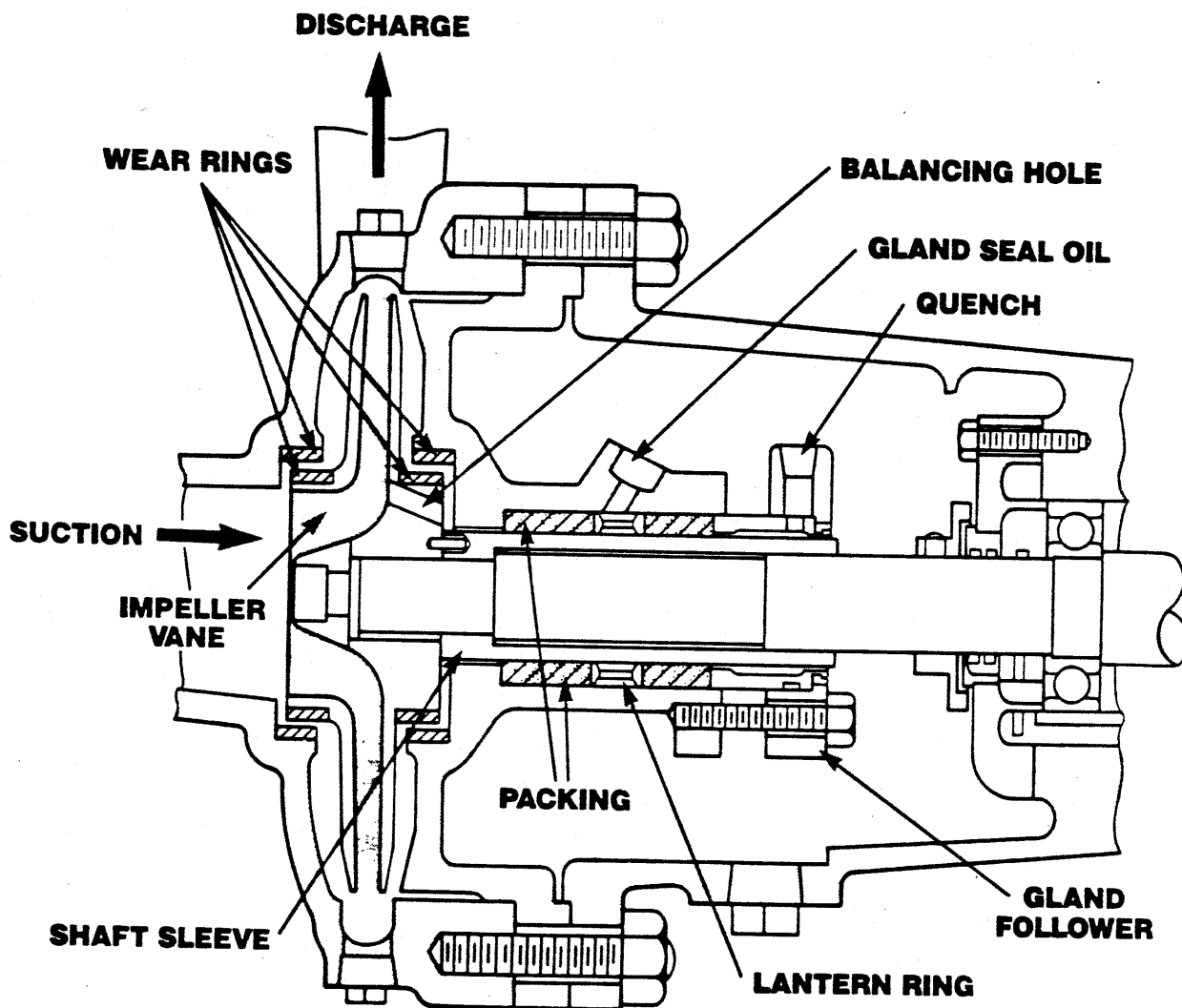
A SIMPLE FLEXIBOX SEAL (TYPE R) IN A TYPICAL PROCESS PUMP APPLICATION



COMPONENT REFERENCE KEY

- 1. STATIONARY SEAL RING (SSR)**
- 2. STATIONARY SEAL RING (SSRP)**
- PACKING**
- 5. ROTARY SEAL RING (RSR)**
- 6. ROTARY SEAL RING (RSRP)**
- PACKING**
- 7. DRIVE SPRING**
- 8. SPRING SLEEVE**

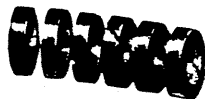
STUFFING BOX



TYPICAL PACKING



**COVERED
ASBESTOS**



**PRE-FORMED
RINGS**



**GRAPHITED
ASBESTOS**

PACKING

To stop the pumped fluid from escaping along the shaft, one method of sealing is a packed gland. Rings of packing material are fitted in a packing box. The rings of packing fit around the shaft sleeve. They may be performed rings or sections of a length of packing. The packing may consist of graphited asbestos or soft metal like ribbons of babbitt metal twisted and folded around an asbestos core.

The shaft is fitted with a sleeve which is of a harder material to provide good wearing properties and a means of replacing a normally wearing surface without having to replace the entire shaft. Many times tungsten carbide coatings are applied to the sleeve when temperature and fluid properties would cause excessive wear on softer surfaces.

In the center of the packing box, there is normally a lantern ring to evenly distribute the gland seal lubricant. The gland seal lubricant can simply be injected or can be circulated into and out of the lantern rings. The pressure must be at least 15 to 20 psi above the stuffing box pressure to assure adequate lubrication of the rings.

The lubricant must be carefully chosen as that:

1. It is compatible with the pumped fluid.
2. It is if sufficient viscosity to provide adequate lubricity.
3. The flash point is low enough to avoid flushing in stuffing box and pump.
4. It must be environmentally acceptable.

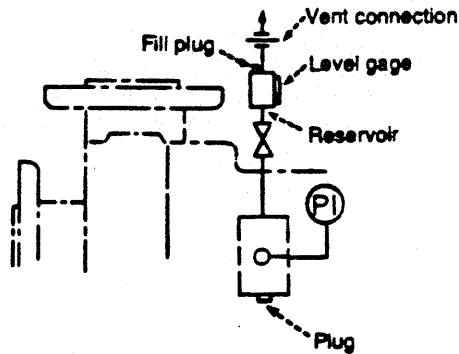
With the dramatic improvement in mechanical seal designs, packing usage is gradually being reduced. Currently only very dirty and hot (650-700°F and greater) applications require packed pumps. Packed pumps have the following disadvantages:

1. Leakage is sometimes considerable with a normal of about 1/16 gpm or more depending on the pressures, temperatures, shaft diameter, shaft rpm, packing material, etc.
2. Maintenance is much greater.
3. Auxiliary flushing requirements are normally greater and may, at times, cause problems to the process in consideration of contamination, pressure required, etc.

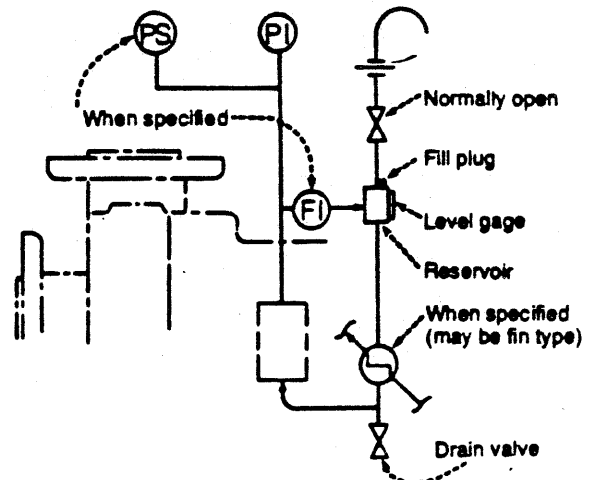
Packed pumps have the following advantages:

1. More predictable wear
2. More tolerable to shaft runout
3. More high temperature capability
4. More particulate tolerance

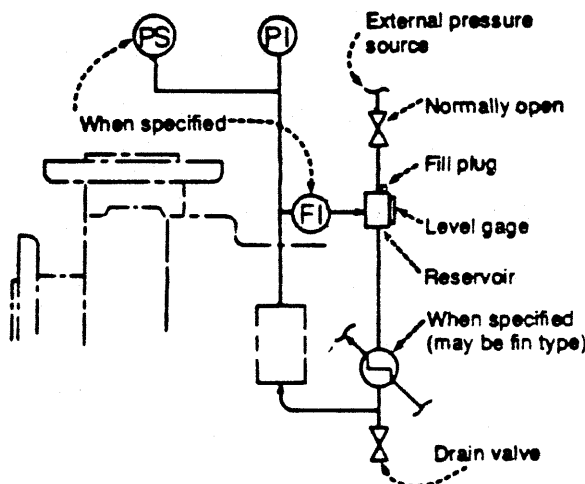
However, mechanical seals are gradually encroaching on more applications where in years past packing was the sole alternative.



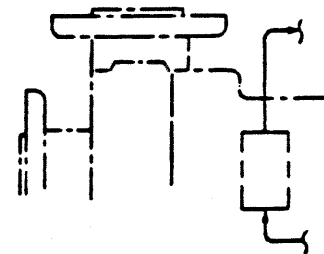
Plan 51
Dead-ended blanket (usually methanol;
see Note 2).



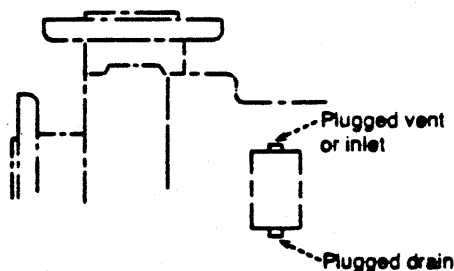
Plan 52
External fluid reservoir (see Note 2),
nonpressurized; thermosiphon or
forced circulation, as required.



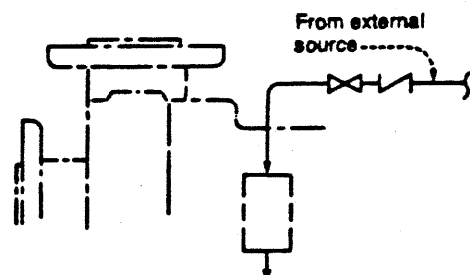
Plan 53
External fluid reservoir (see Note 2),
pressurized; thermosiphon or forced
circulation, as required.



Plan 54
Circulation of clean fluid from an
external system (see Note 2).



Plan 61
Tapped connections for purchaser's
use; Note 2 shall apply when purchaser
is to supply fluid (steam, gas, water,
etc.) to auxiliary sealing device.



Plan 62
External fluid quench (steam, gas,
water, etc., see Note 2).

NOTES

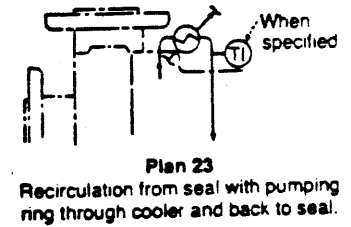
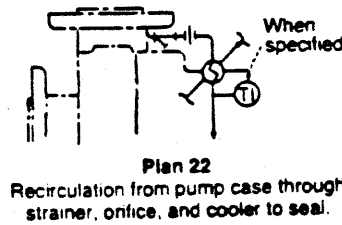
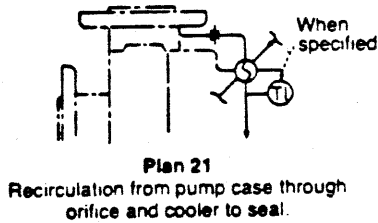
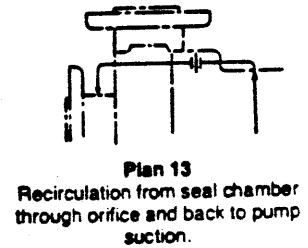
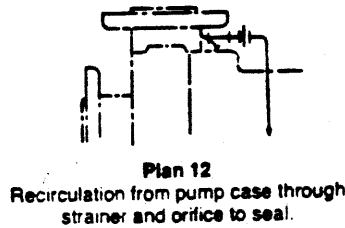
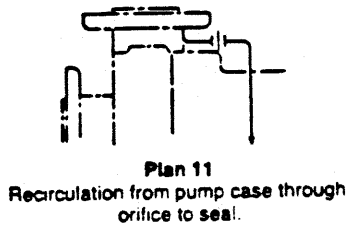
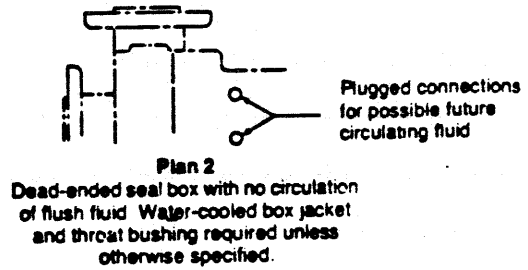
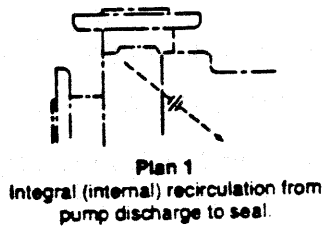
1. These plans represent commonly used systems. Other variations and systems are available and should be specified in detail by the purchaser or mutually agreed upon by the purchaser and the vendor.
2. The purchaser shall specify the fluid characteristics when supplemental seal fluid is provided. The vendor shall specify the volume (gallons per minute) and pressure (pounds per square inch gage) required, where these are factors.
3. See Figure D-2 for explanation of symbols not specified here.

Piping for Throttle Bushing, Auxiliary Seal Device, Tandem Seals, or Double Seals

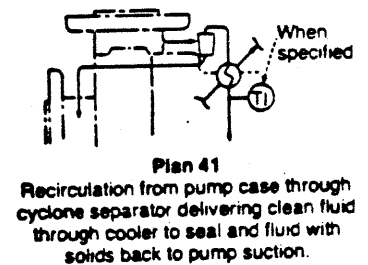
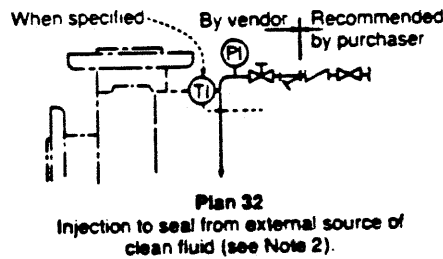
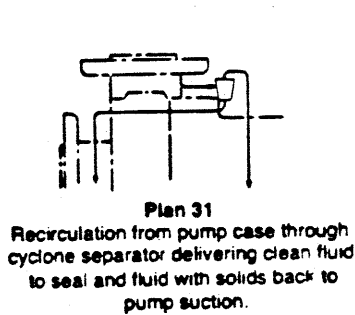
E. COOLING AND FLUSHING

Pumps with hot fluids require seal cooling and flushing to cool and clean the seal faces. API publishes cooling water and flushing plans so by calling out a letter or number on the specification, the pump vendor will know exactly what kind of cooling and/or flushing is required.

Clean Pumpage



Dirty or Special Pumpage



Legend



Cooler

(PI) Pressure gage with block valve

(TI) Dial thermometer

(PS) Pressure switch with block valve

Cyclone separator

(FI) Flow indicator

Y-type strainer

Flow-regulating valve

Block valve

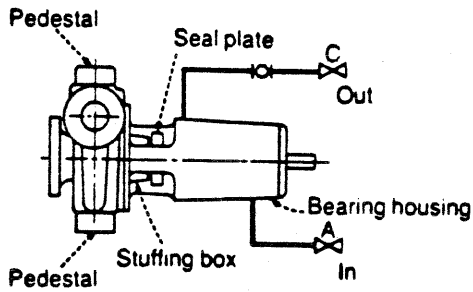
Check valve

Orifice

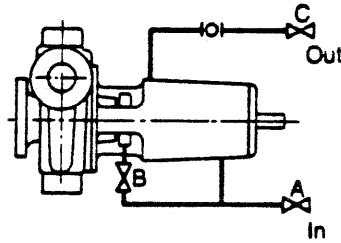
NOTES:

1. These plans represent commonly used systems. Other variations and systems are available and should be specified in detail by the purchaser or mutually agreed upon by the purchaser and the vendor.
2. For Plan 32, the purchaser shall specify the fluid characteristics, and the vendor shall specify the volume (gallons per minute) and pressure (pounds per square inch gage) required.

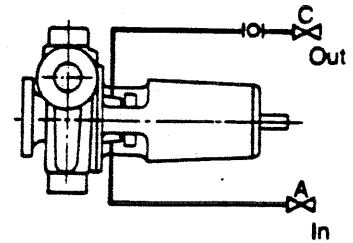
Piping for Primary Seals



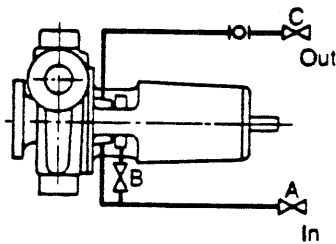
Plan A
Cooling to bearing housing.



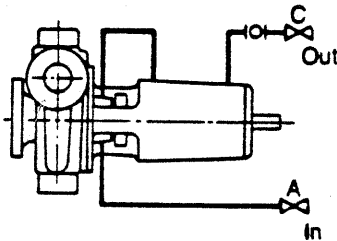
Plan B
Cooling to bearing housing with parallel flow to seal plate.



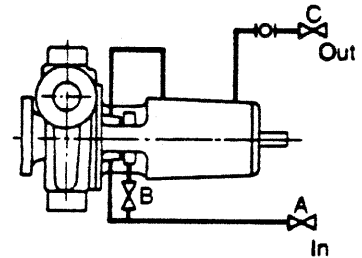
Plan C
Cooling to stuffing box jacket.



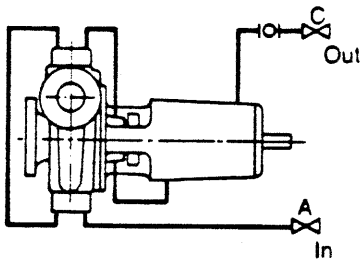
Plan D
Cooling to stuffing box jacket with parallel flow to seal plate.



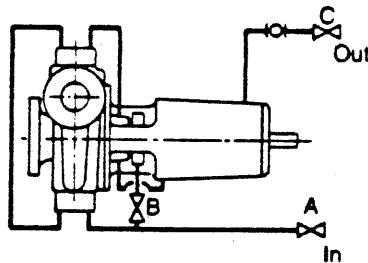
Plan E
Cooling to stuffing box jacket and bearing housing in series.



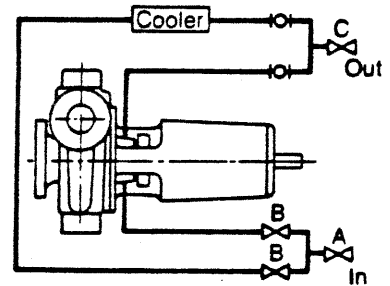
Plan F
Cooling to stuffing box jacket and bearing housing in series with parallel flow to seal plate.



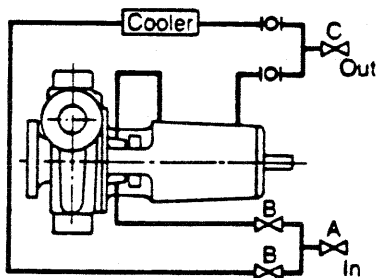
Plan G
Cooling to pedestals, stuffing box jacket, and bearing housing in series.



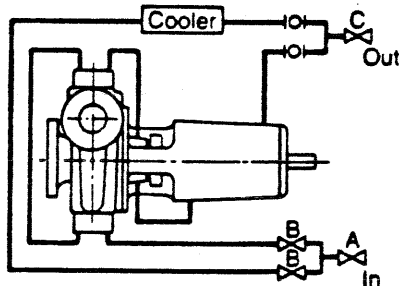
Plan H
Cooling to pedestals, stuffing box jacket, and bearing housing in series with parallel flow to seal plate.



Plan J
Cooling to stuffing box jacket with parallel flow to cooler.



Plan K
Cooling to stuffing box jacket and bearing housing in series with parallel flow to cooler.



Plan L
Cooling to pedestals, stuffing box jacket, and bearing frame in series with parallel flow to cooler.

Legend

Valve

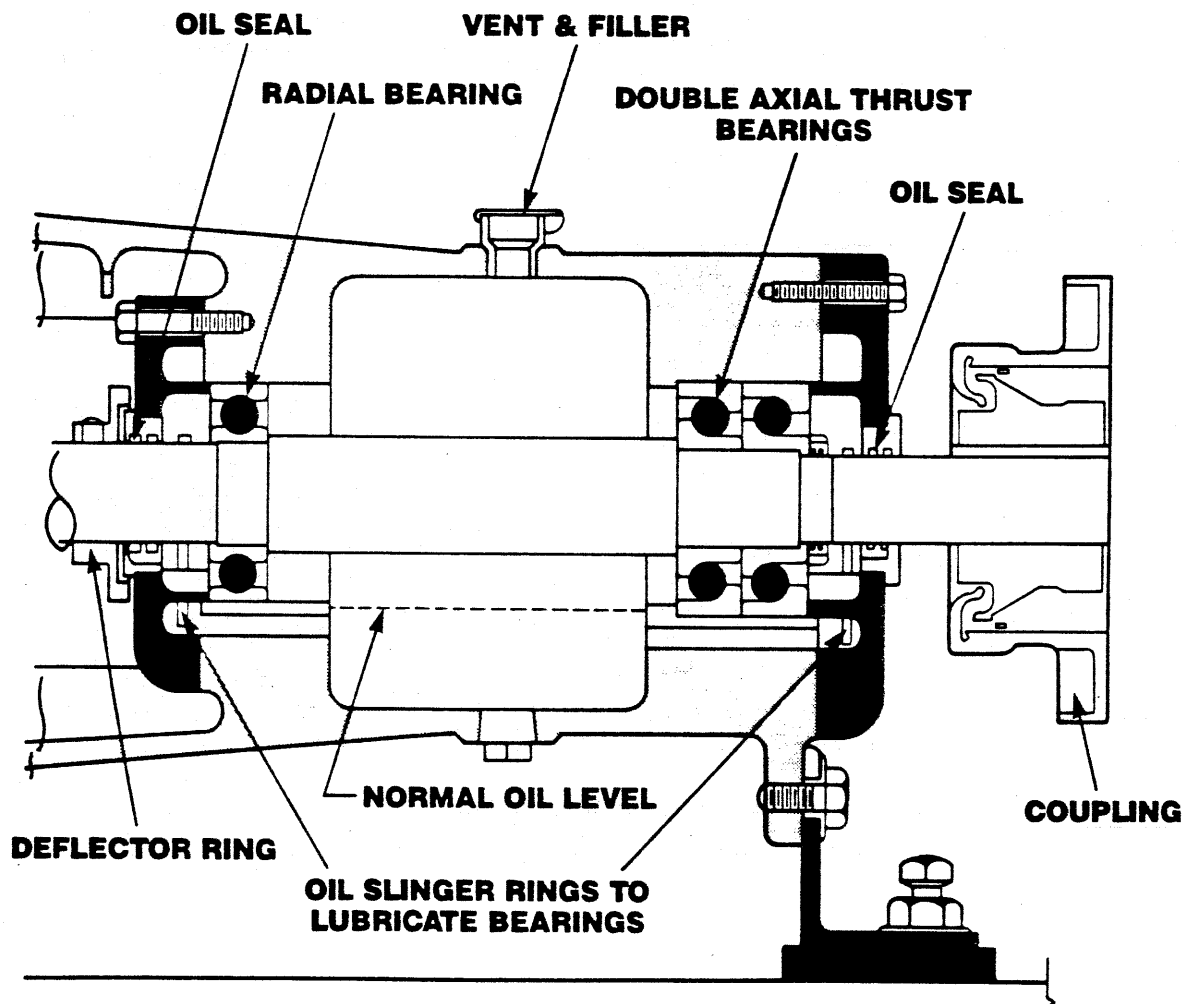
Sight flow indicator, when specified

Valve A—Inlet shutoff valve

Valve B—Branch flow control valve

Valve C—Outlet shutoff valve (optional)

BEARING BOX



UOP 1702-39
UOP 1220A-58

F. BEARINGS

To locate the shaft and allow it to rotate with minimum friction, it is located in bearings. The bearings control the axial and radial thrust.

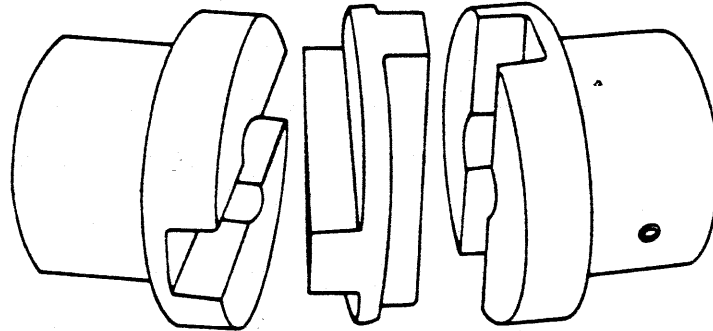
To keep bearings operating efficiently, they must be adequately lubricated - either splash, flooded, or forced - and enclosed in a bearings housing. The housing must be properly sealed against ingress of dirt and moisture and egress of oil. For a majority of light and medium duty centrifugal pumps, ball bearings with ring oil lubricators are used. In heavier duty pumps and most multi-stage pumps, sleeve type radial bearings are used. The thrust bearing requirements are dependent upon thrust loadings.

When the pumping temperature exceeds approximately 350°F (175°C), the bearing housing is cooled with water. This is usually accomplished quite simply by means of a coil located in the bottom of the reservoir. When sleeve bearings are used, the cooling water upper limit must be no greater than about 125°F since the white metal has a low melting point.

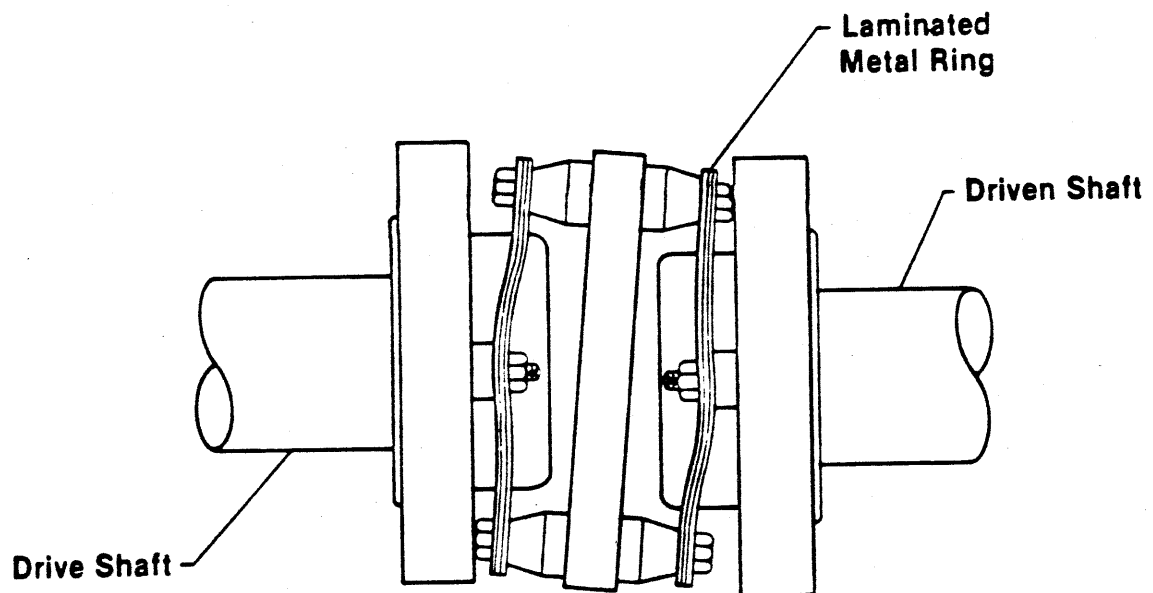
Oil mist lubrication, while considerably more expensive to implement, is many times considered due to its enhancement on bearing life, especially in dirty environments or on heavily loaded bearings. The oil mist system has cleanliness advantages and insures a continuous clean and cool lubricating spray.

Low flows, cavitations, rapid temperature rise, shaft run out, pressure surging, improper lubrication (too little or too excessive), excessive shaft overhang, incorrect initial bearing sizing, lubrication contamination, and many other reasons suggest that much care should be used when dealing with the specification and design of bearings.

CUSHIONED SINGLE-ENGAGEMENT FLEXIBLE COUPLINGS



LAMINATED METAL RING COUPLINGS



PROPORTION PUMPS

<u>CC/HR.</u>	<u>GPH</u>	<u>PSI</u>	<u>TYPE</u>
20	600	0 7500	Plunger or Diaphragm

ROTARY PUMPS

<u>GPM</u>	<u>PSI</u>	<u>TYPE</u>
10 100	0 3500	Gear or Screw

PUMP SELECTION AND PERFORMANCE

PUMP TYPE SELECTION GUIDE

This is only a general guide. There are overlapping areas between each category of pump. The separation lines should not be taken too absolute.

CENTRIFUGAL PUMPS

<u>GPM</u>		<u>HEAD</u>		<u>TYPE</u>	<u>RPM</u>
20	700	50	560	Single Stage Process	2950
40	700	560	950	Two Stage Process	2950
80	1700	850	10000	Multi-Stage	Recommend
700	1900	0	250	Single Stage Process	1450
1900	8000	0	1050	Single Stage-Double Suction-Double Bearing	1450 or 2950
700	2100	560	1100	Two Stage Process	2950
5	400	100	5800	Sundyne	Recommend

RECIPROCATING PUMPS

<u>GPM</u>		<u>PSI</u>		<u>TYPE</u>
10	100	0	4000	Multi-Plunger or Direct Acting Steam

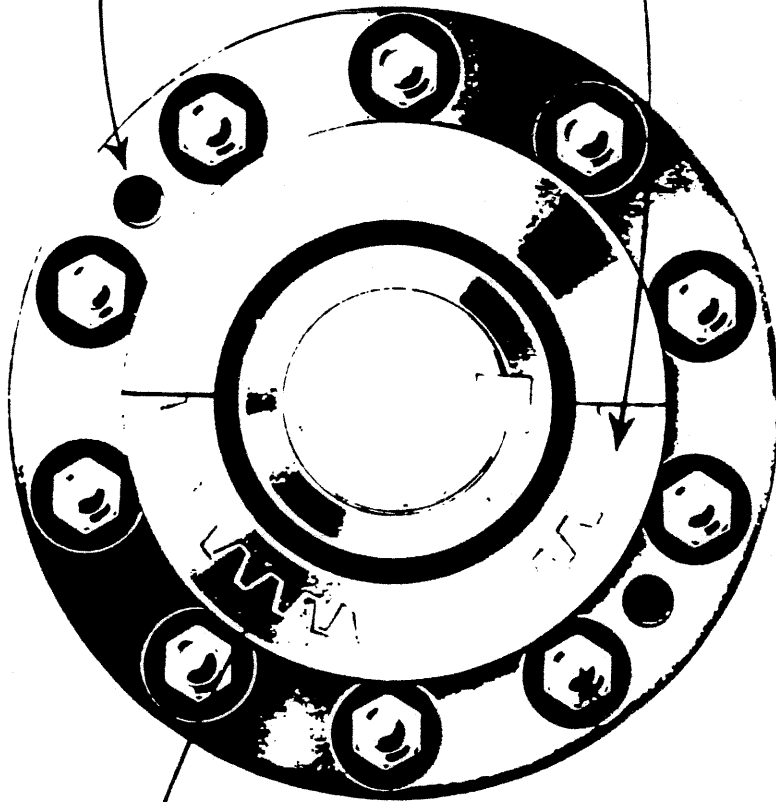
GEAR COUPLING (END VIEW)

SLEEVE JACK HOLES

Two jack holes are drilled and tapped in one sleeve to facilitate separation of center flanges.

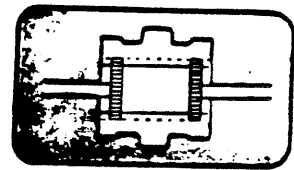
FLEXIBILITY

Each set of splines is in mesh around its entire circumference, the entire assembly revolving as one unit. Lateral and angular play is allowed between the spline faces.

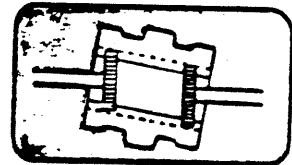


THE OIL FILM

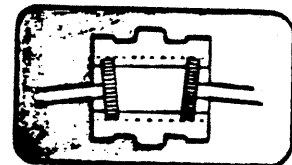
The Centrifugal-pressure oil film constantly between the splines (while running) cushions the power transmitted and actually eliminates all metal-to-metal contact. There is no metal-to-metal contact, therefore no wear.



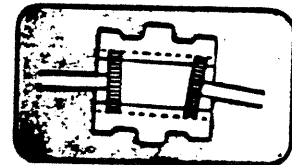
PERFECT ALIGNMENT



OFFSET MISALIGNMENT



ANGULAR MISALIGNMENT



ANGULAR AND OFFSET MISALIGNMENT

Gear-Type

The gear-type coupling is the most widely used in the oil industry today. The gear coupling consists of a gear mounted on the end of each shaft. The sleeve that covers the gears has teeth on the inside which mesh with the gears on the shafts. To make the sleeve easily removable, it is made up of two pieces. The sleeve halves are connected by bolts. This type of coupling can compensate for misalignment and end float. This type of coupling must be kept well lubricated as there is metal-to-metal contact in the gears.

G. COUPLINGS

There are two basic types of couplings which connect the pump shaft to the driver: the flexible disc or dry-type coupling and the gear-type coupling which must be lubricated with oil.

Flexible

Pumps, compressors and prime movers have very stiff shafts, and it is often impossible to keep them perfectly aligned. These machines are normally coupled with flexible couplings. Flexible couplings have at least one part that can flex or move. A simple flexible coupling is shown in the top figure. A hard rubber buffer or plastic block is placed between the two flanges. Because they cannot flex too much, they transfer torque between the two machines efficiently. Axial and radial movement are controlled by bearings in the machines. Flexible couplings can adjust for expansion and misalignment.

When a machine gets up to speed, its shaft may have a tendency to float, or move back and forth slightly as it rotates. This is called end float. Also, when a shaft heats up, it expands and when it cools off, it contracts. This expansion and contraction also causes end float. To compensate for this, instead of a solid buffer, the flexible part of the coupling consists of several thin metal plates. If end float occurs, the plates bend. This slight amount of "give" in the plates allows for end float. This is shown in the bottom figure.