Introduction to Physics of Liquids, Centrifugal Pumps Systems, and Pump Operation

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Colorado Environmental Council for Training Inc.

Delta Marriott Thornton/Northglenn Hotel

10 E. 120th Ave.

Northglenn, CO 80233

November 7, 2022

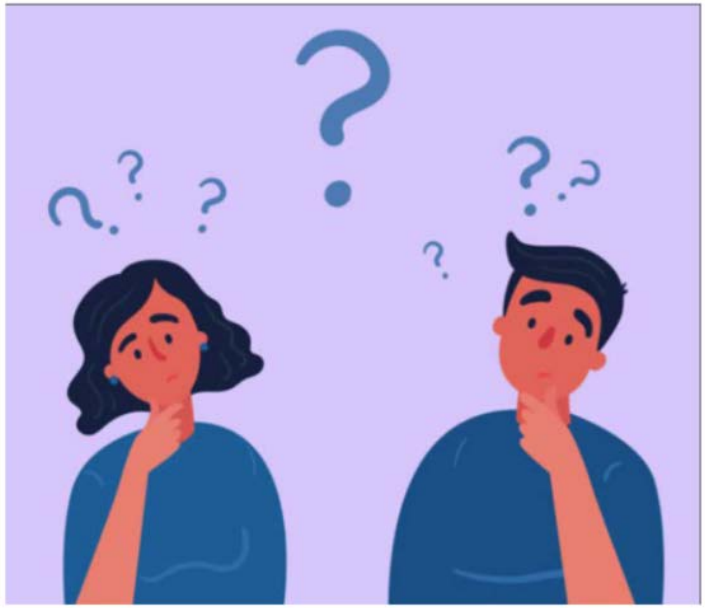
by

Arvada Pump Company

Welcome –

Why are you here today ?

(Other than “my boss said I had to” …….?)



What do you expect or want to learn about?

Do you have any specific questions yet?

DIHYDROGEN OXIDE & SELECTED SDS INFORMATION

- **Chronic Effects on Humans:**
  - No determined negative effects.
- **Other Toxic Effects on Humans:**
  - Non-corrosive for skin. Non-irritant for skin. Non-sensitizer for skin. Non-hazardous in case of ingestion. Non-corrosive to the eyes. Noncorrosive for lungs.
- **Lethal Dose 50 –** Approximately 6 liters for 75 kg (165 lb.) person (immediate)
- **Toxicity to Animals:**
  - Not available.

DIHYDROGEN OXIDE & SELECTED SDS INFORMATION - CONTINUED

- **Taste:** Varies depending on source
- **Color:** Colorless.
- **Odor Threshold:** Not available.
- **pH (1% soln./water):** 7 [Neutral.]
- **Boiling Point:** 100°C (212°F)
- **Specific Gravity:** 1 (Water = 1)
- **Vapor Pressure:** 2.3 kPa (@ 20°C)

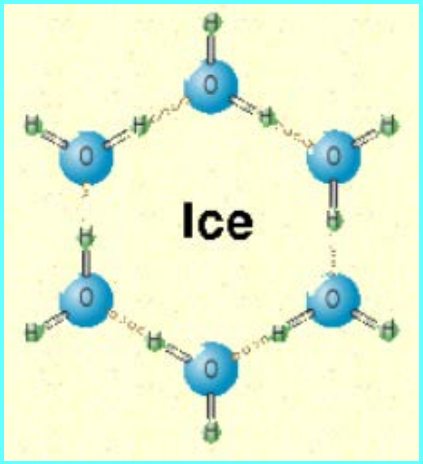
DIHYDROGEN OXIDE -

- **Solid** below 32 degrees F
- **Gas** above 212 F @ Sea Level
- **Liquid:** above 32 degrees F
- **Density:** Lower as solid than liquid
- **Crystalline Structure Solid** – 6 sided

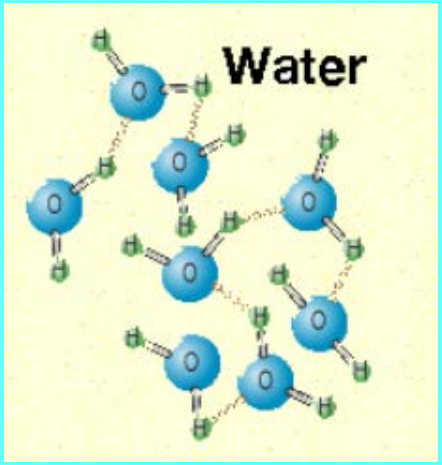
- ***WHAT IS THIS SUBSTANCE?***

What is It?

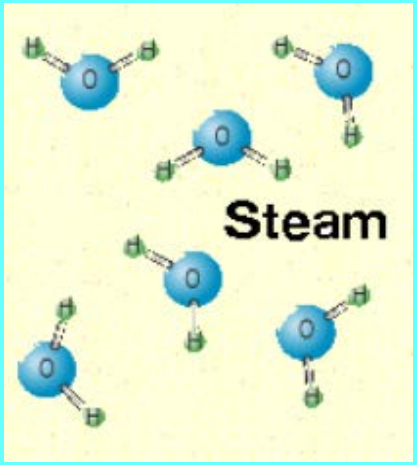
- H2O - or WATER !!
- SG = 1.0



SOLID



LIQUID



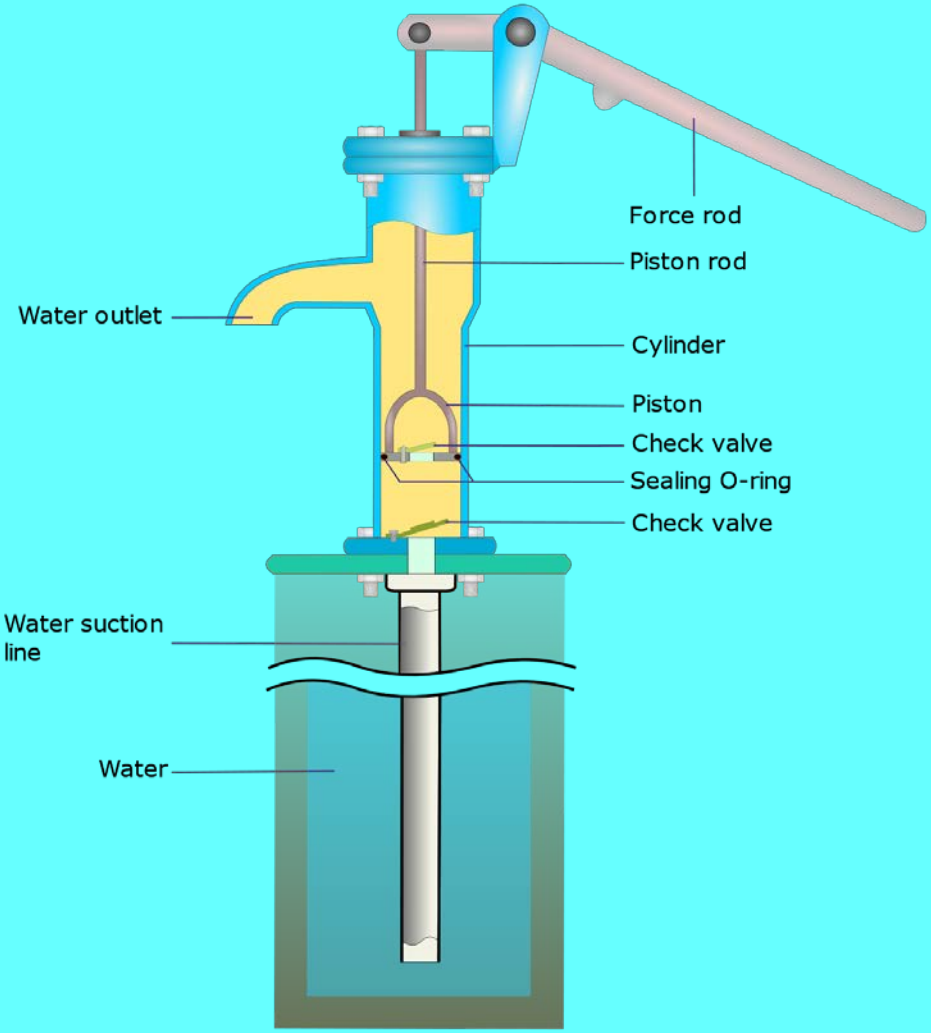
GAS

Types and Classification of Pumps

- Positive Displacement
  - Reciprocating
  - Rotary
  - Progressive Cavity
- Kinetic Pumps – Due to Velocity of Liquid
  - Centrifugal
  - Peripheral
  - Special

POSITIVE DISPLACEMENT PUMPS

Hand-Operated Well Pump



Metering Pumps – Chem Feed

Single Action Diaphragm Pump

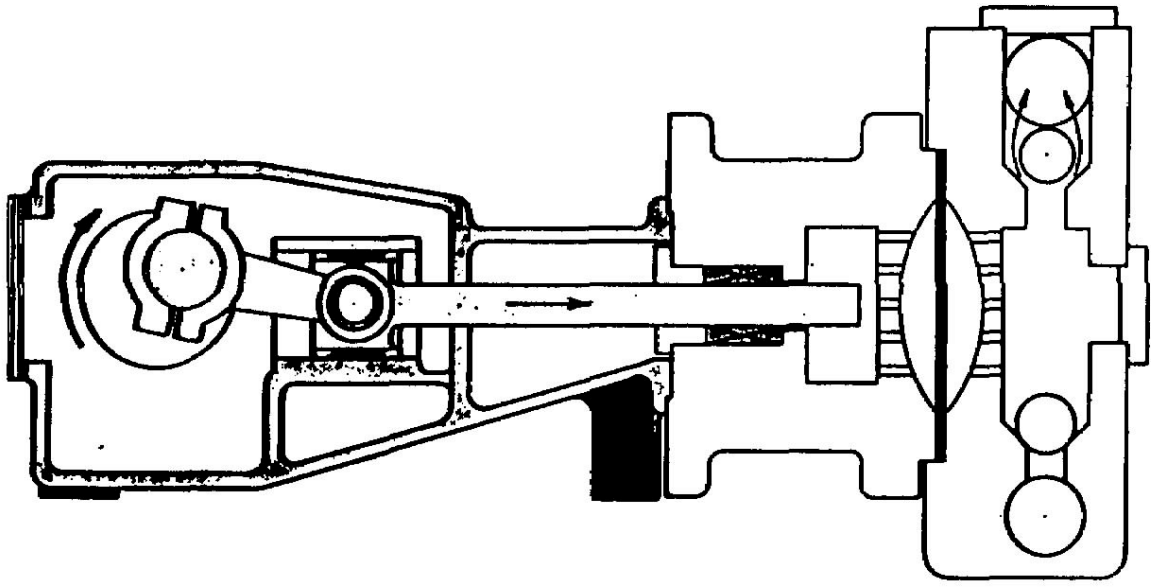


Fig. 6 HORIZONTAL SINGLE-ACTING FLAT DIAPHRAGM PUMP

Cylindrical Diaphragm Pump

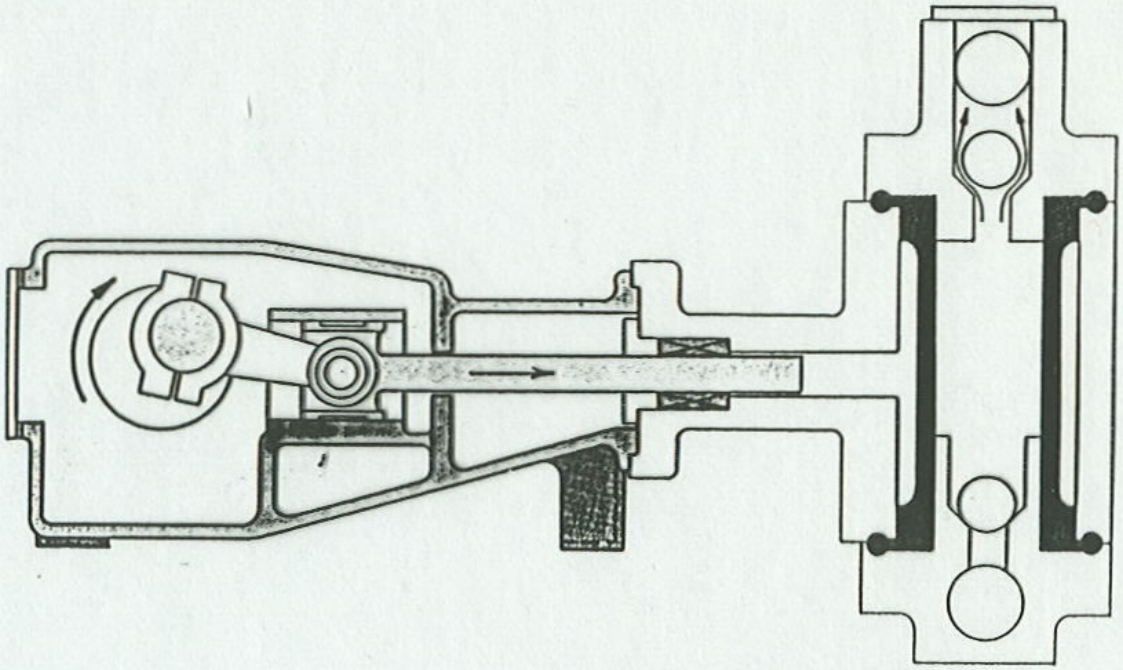
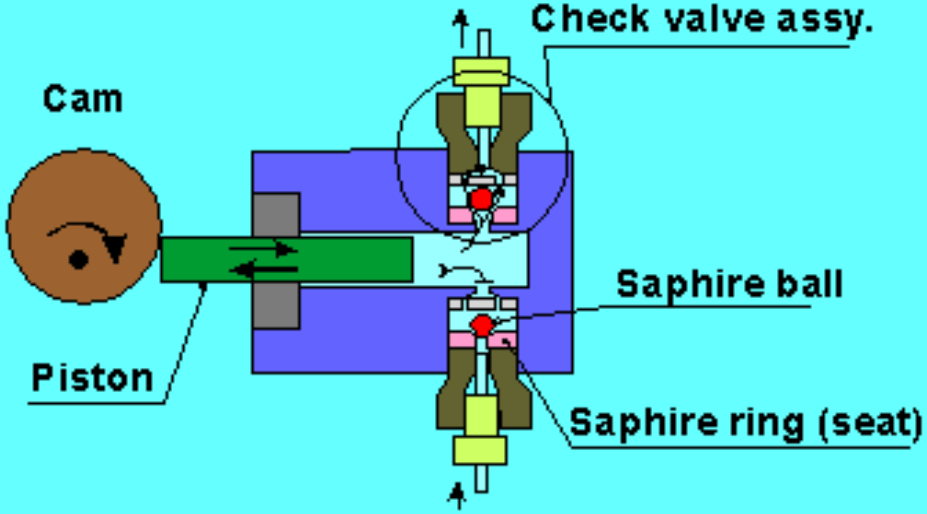
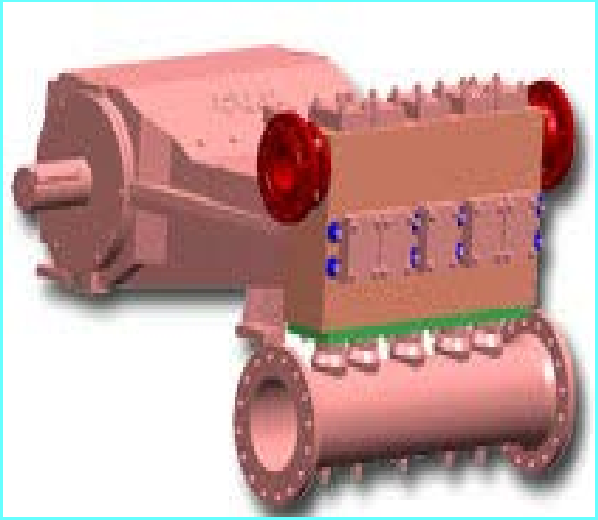


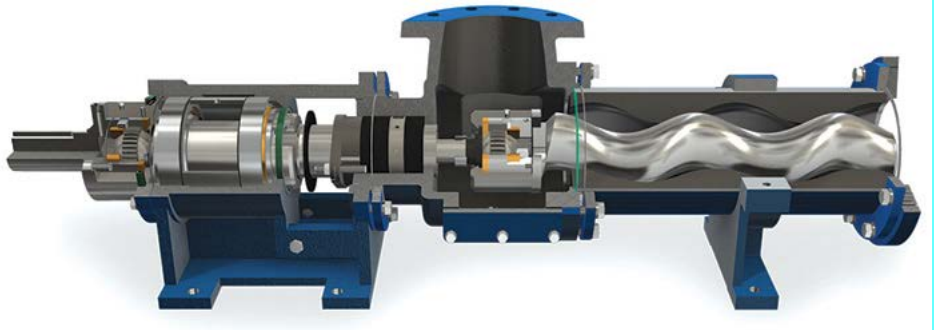
Fig. 7 HORIZONTAL SINGLE-ACTING CYLINDRICAL DIAPHRAGM PUMP

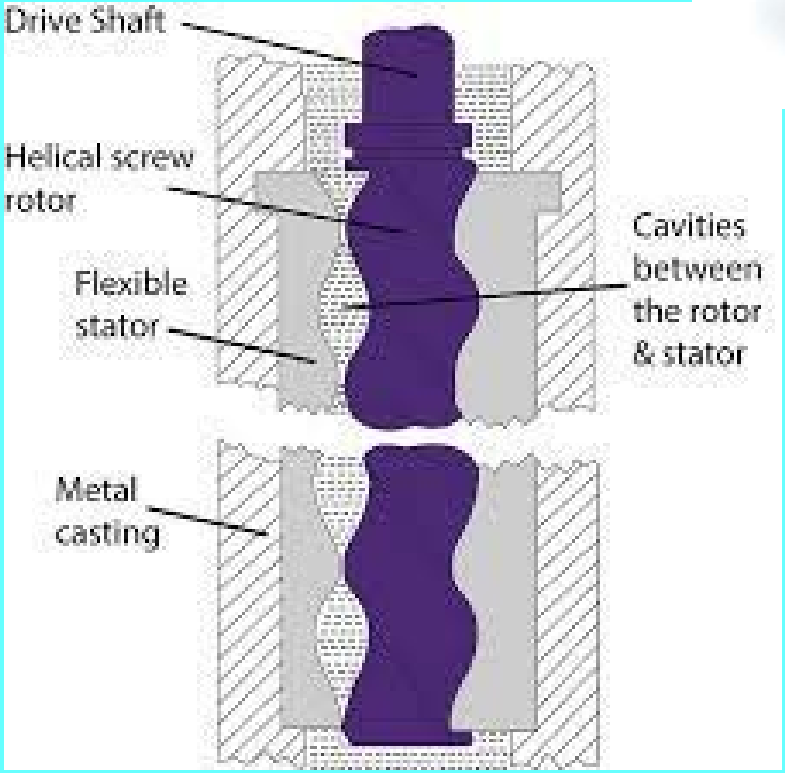
Reciprocating Plunger / Piston



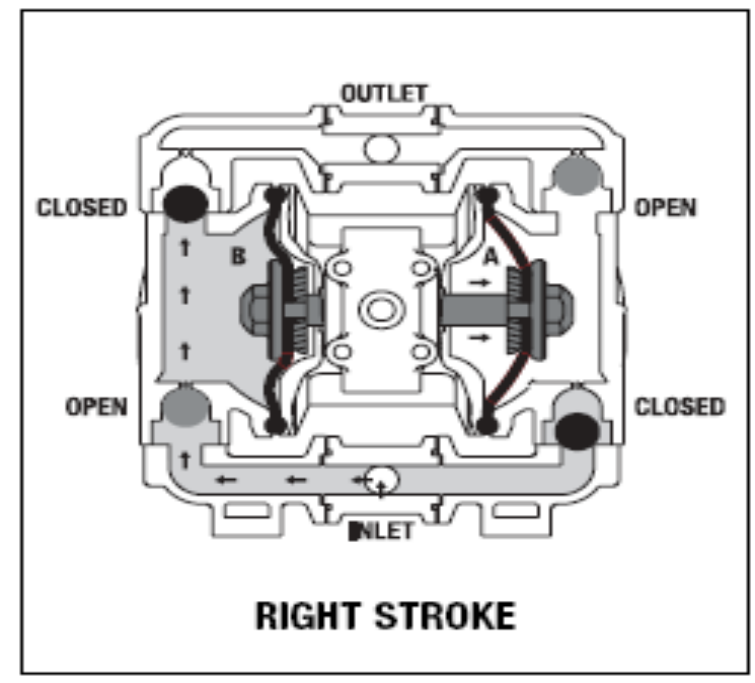


Progressive Cavity Pumps

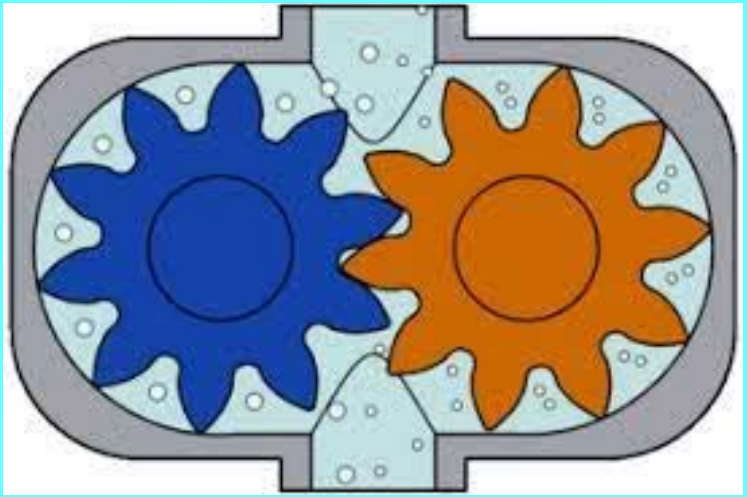




Double Air Diaphragm or AOD

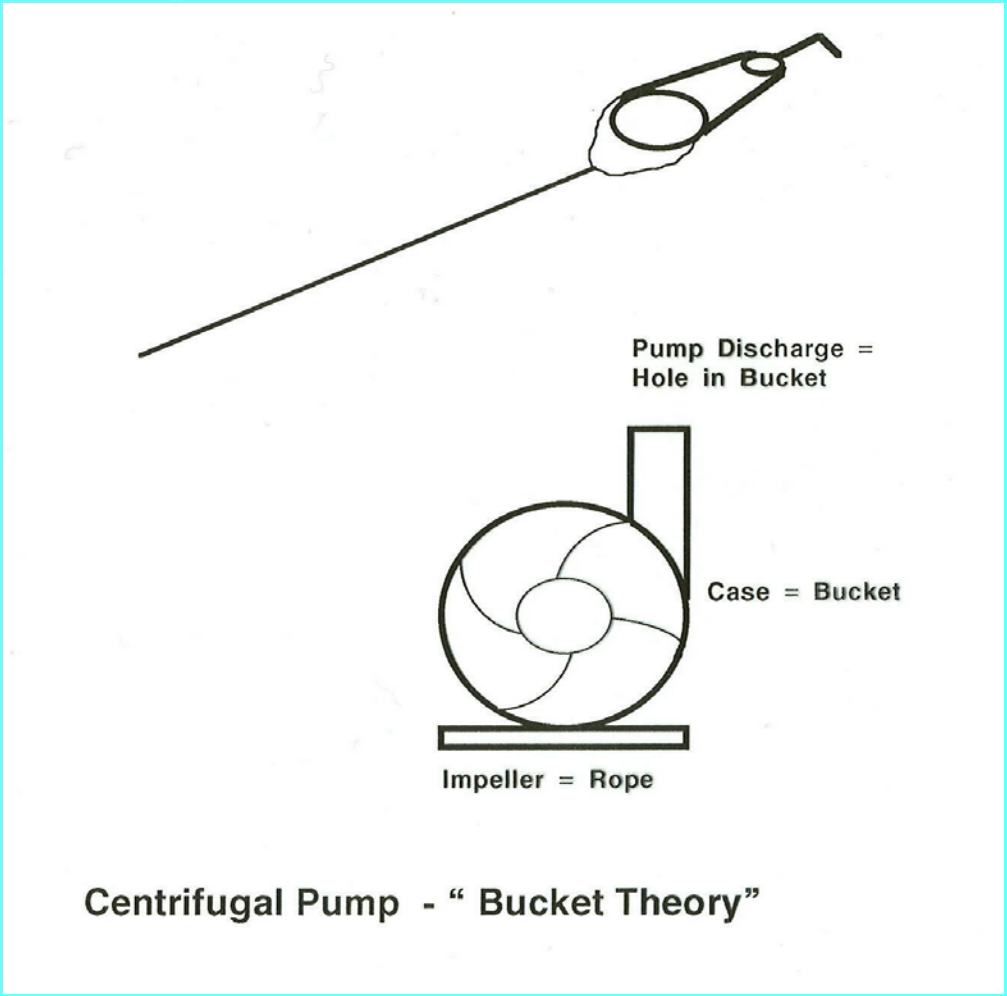


Gear Pumps

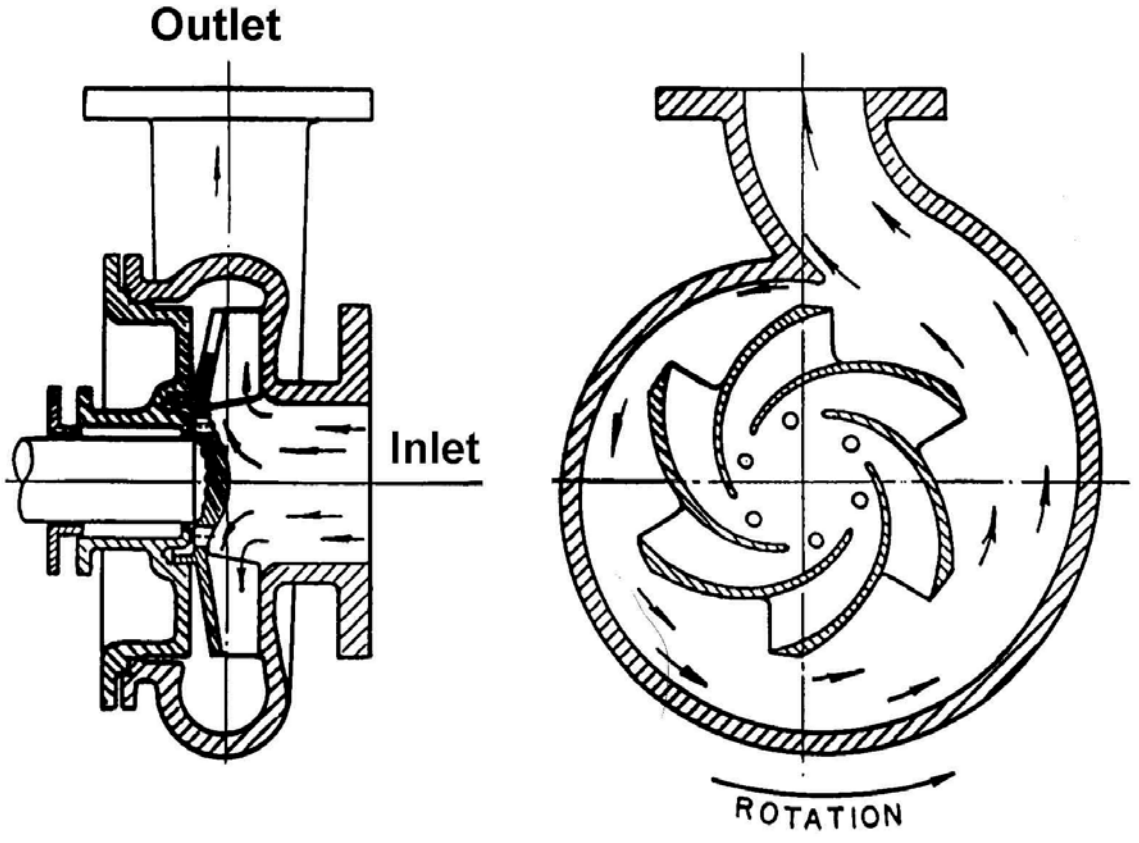


CENTRIFUGAL PUMPS

CENTRIFUGAL PUMP / BUCKET ANALOGY



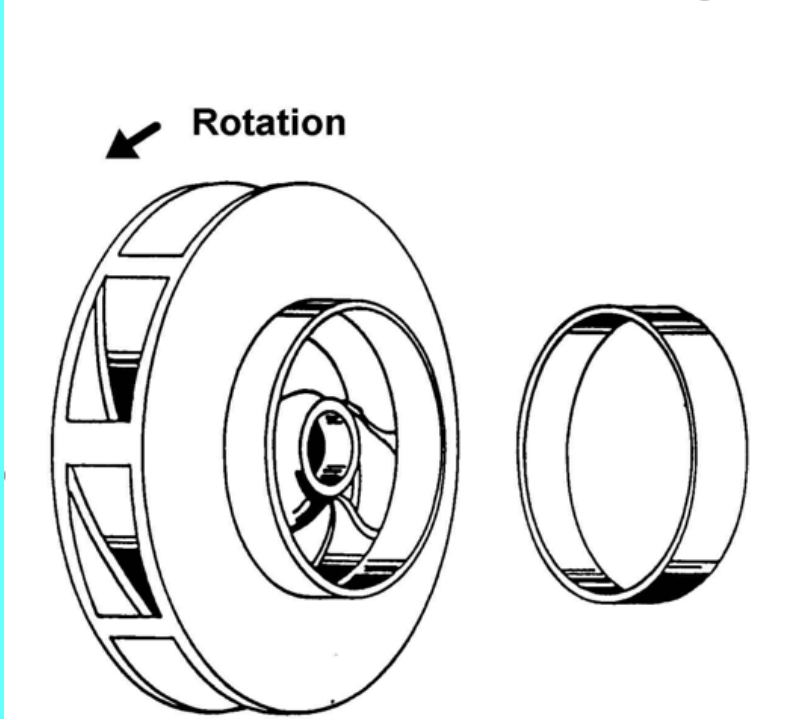
END SUCTION
VOLUTE STYLE PUMP



End Suction Centrifugal Pump

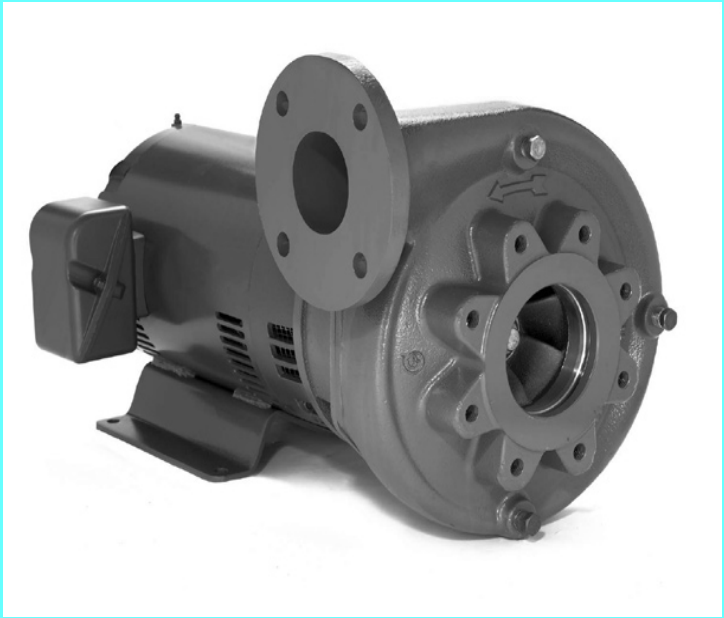
PUMP IMPELLERS – OPEN VS. CLOSED

Semi-Open Impeller

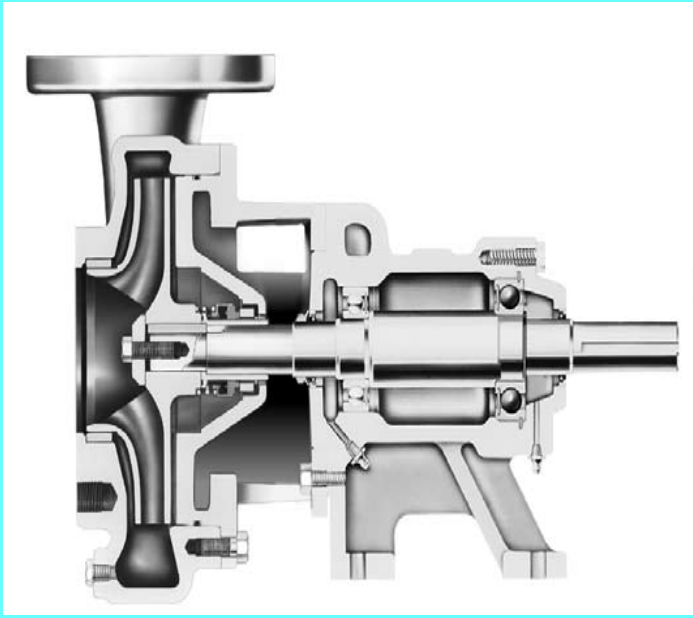


Enclosed Impeller with Case Ring
(Case Ring Stationary)

Centrifugal End Suction Pump

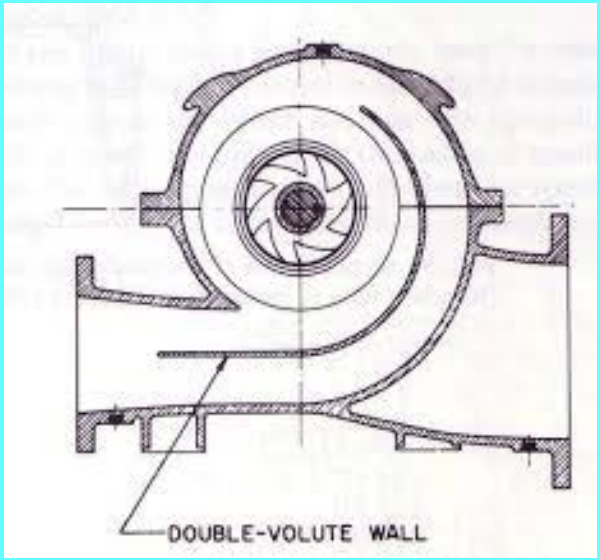


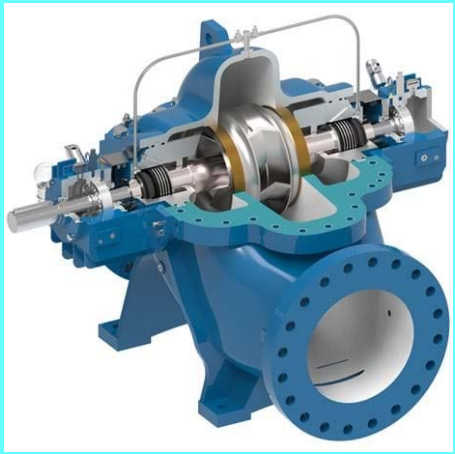
Close Coupled

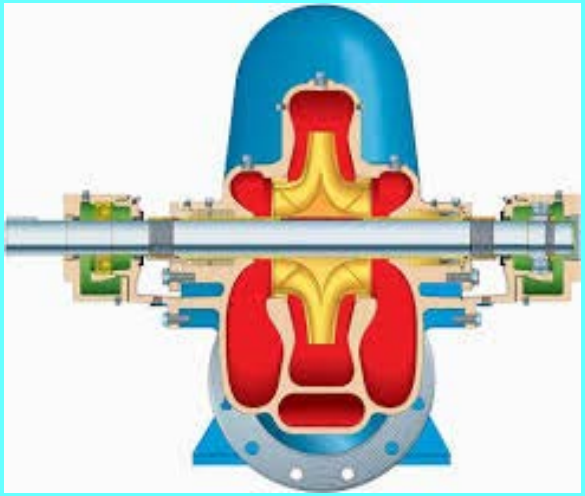


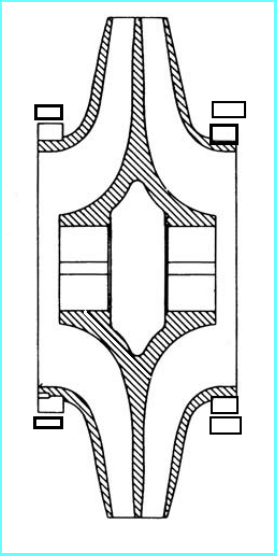
Frame Mounted

Centrifugal Double Suction Pump

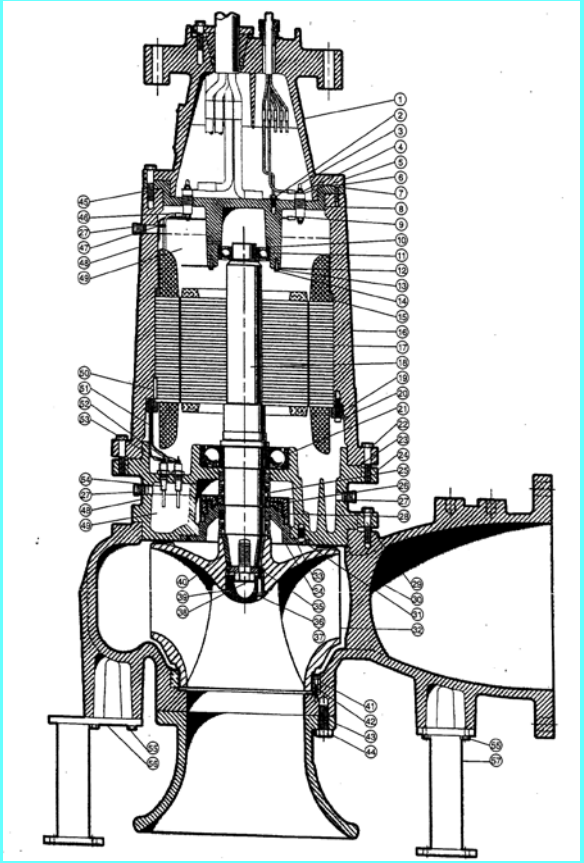




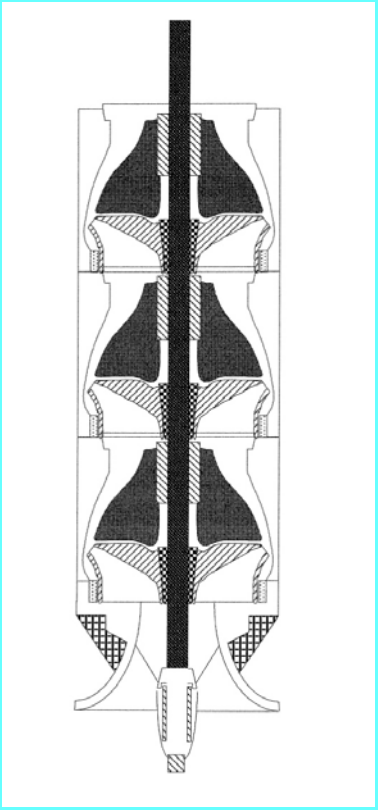




Single Suction Non-Clog Sewage



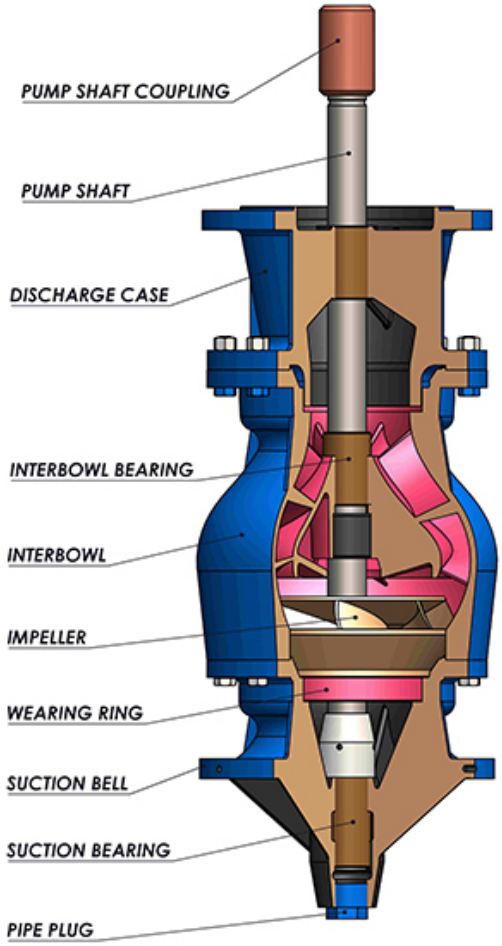
Vertical Turbine Pumps



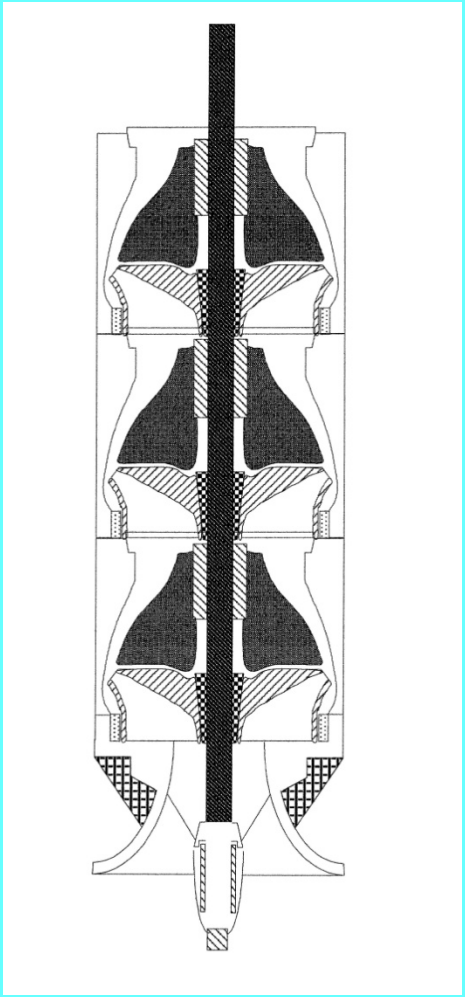
Vertical Lineshaft Turbine

Submersible Turbine

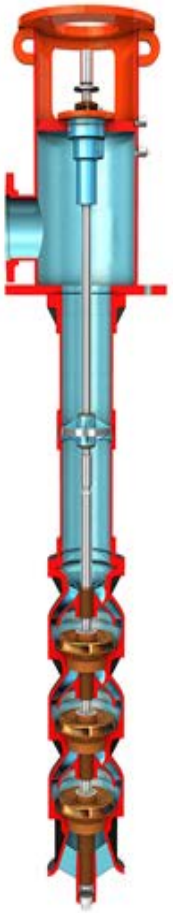
Vertical Turbine Bowl Assembly



Vertical Turbine Top Discharge



Multiple Stages



Discharge Head

Column

Bowl Assembly

Mixed Flow and Axial Flow Pumps

High Capacity / Low Head

- Axial Flow
  - 500 – 1,000,000 GPM
  - 2-80 Ft. TDH
- Mixed Flow
  - 600-250,000 GPM
  - 1.5-100 FT TDH
  -

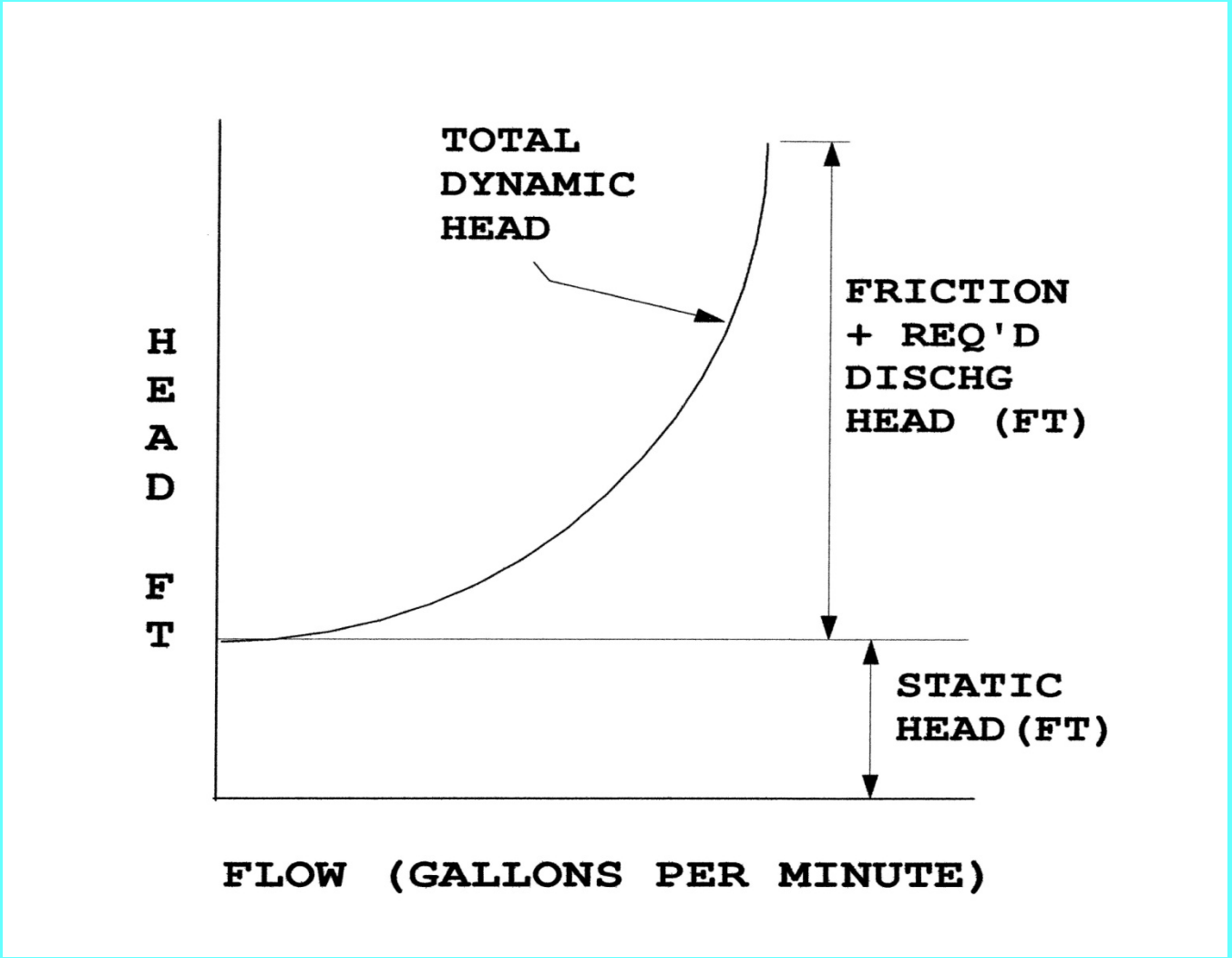
What Makes Up A System Curve?

- Elevation Change
- Friction Losses
  - Pipe, Valves, Fittings, Heads, Nozzles
- Incoming System Pressure
- Required Discharge Pressure
- Variation in Flow Requirements

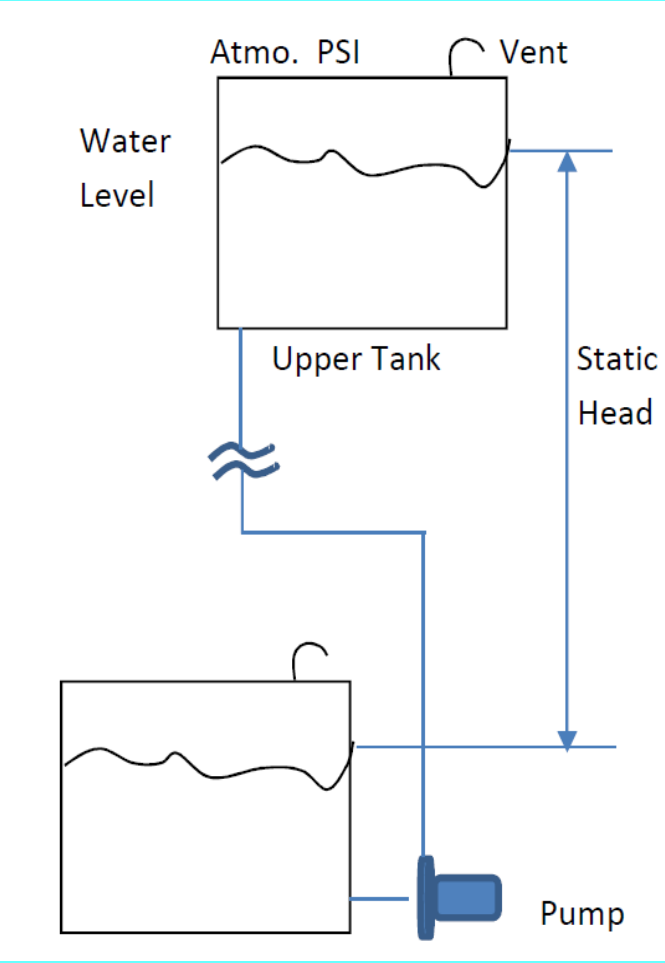
Pump Selection & Operation

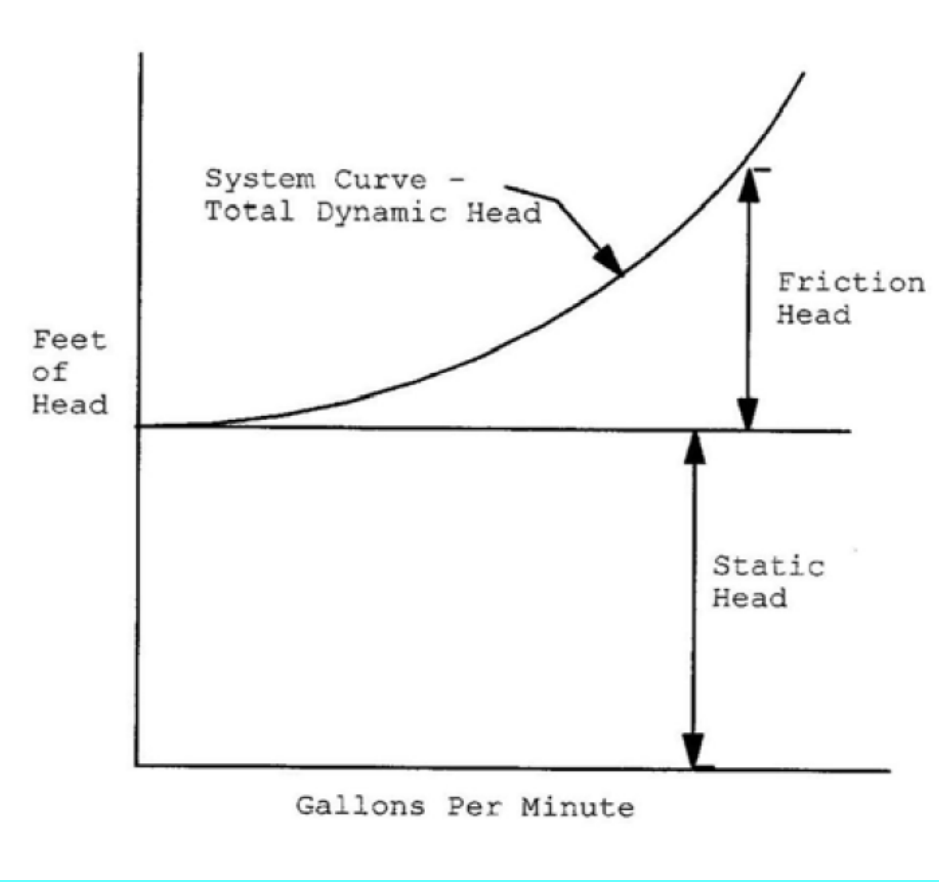
- System Curves
  &
  - Pump Curves

BASIC PUMP SYSTEM CURVE

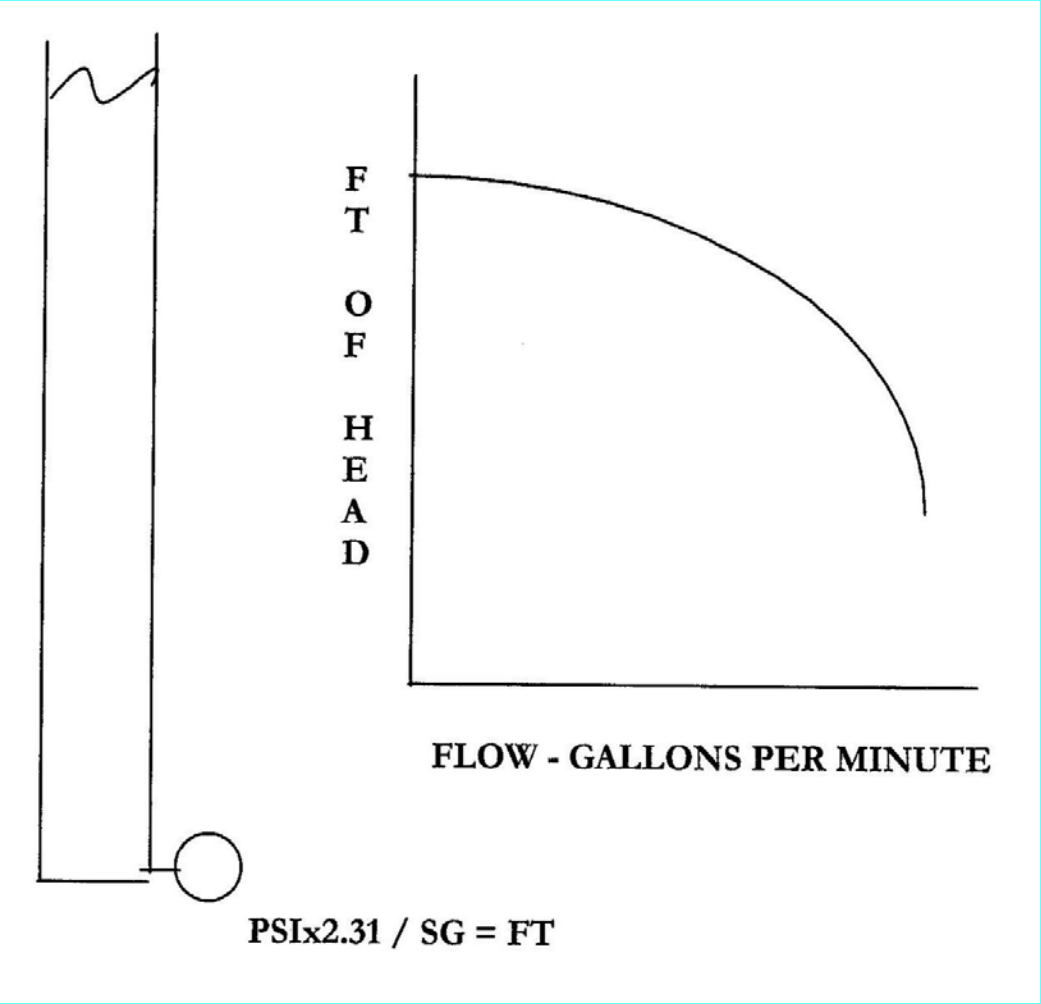


BASIC SYSTEM & SYSTEM CURVE

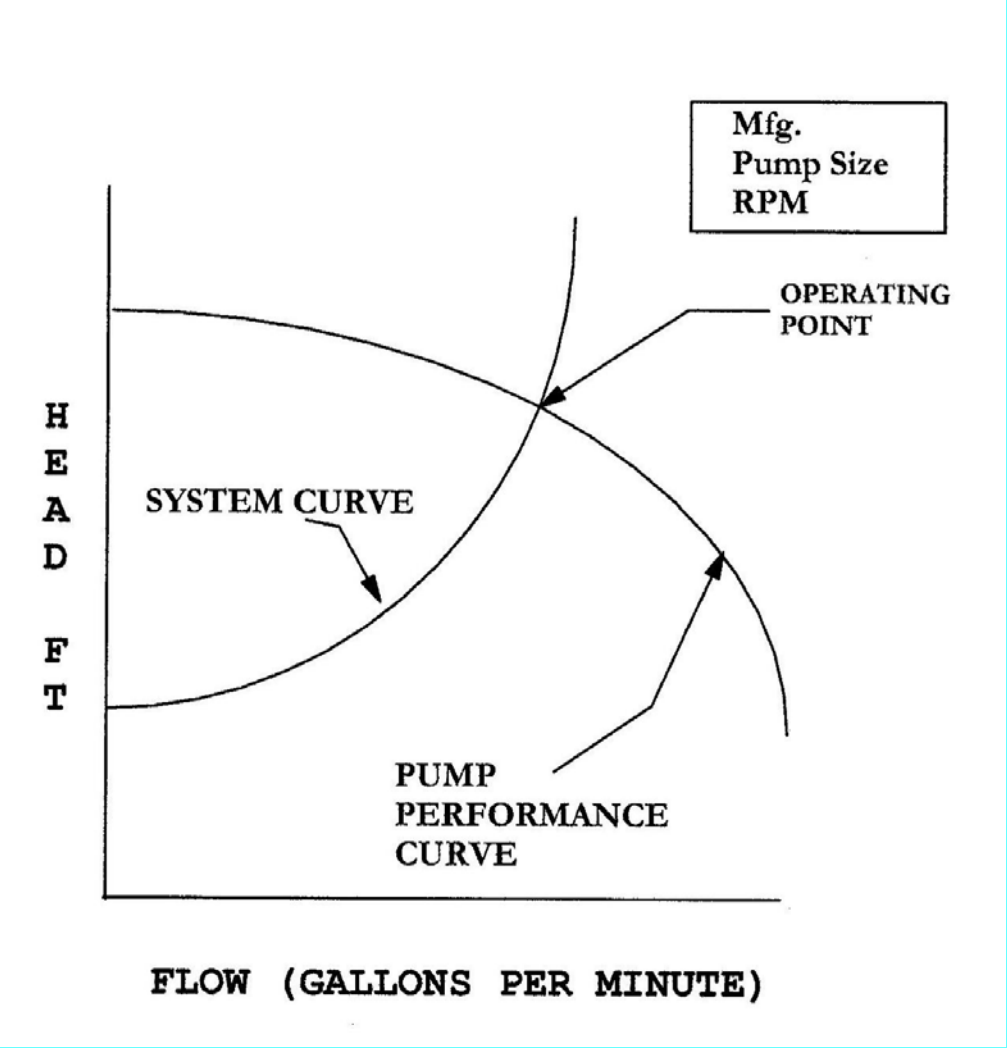




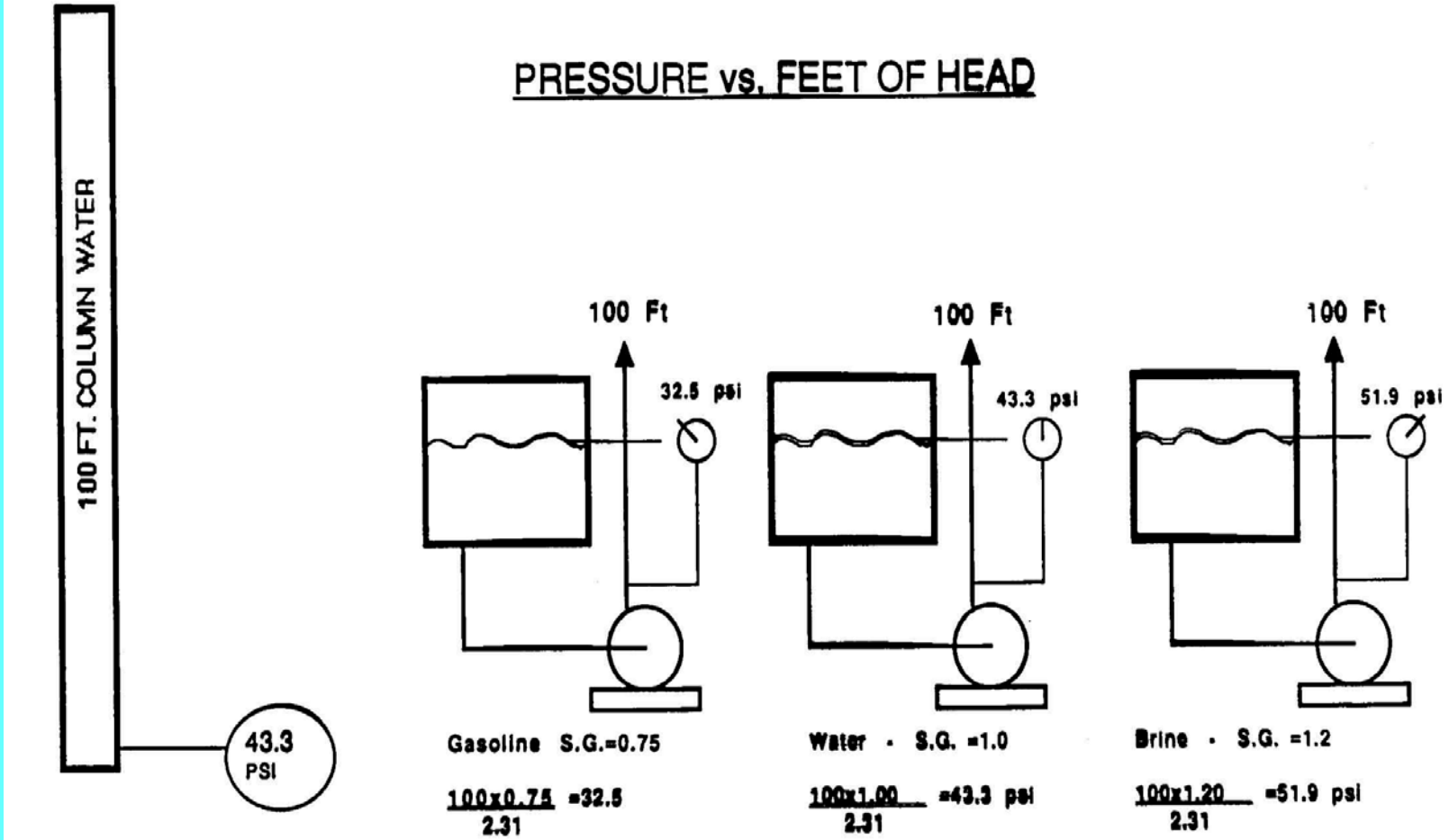
BASIC PUMP PERFORMANCE CURVE



PUMPS OPERATE WHERE SYSTEM & PUMP CURVES INTERSECT



PRESSURE (PSI) / FEET OF HEAD EFFECTS OF SPECIFIC GRAVITY

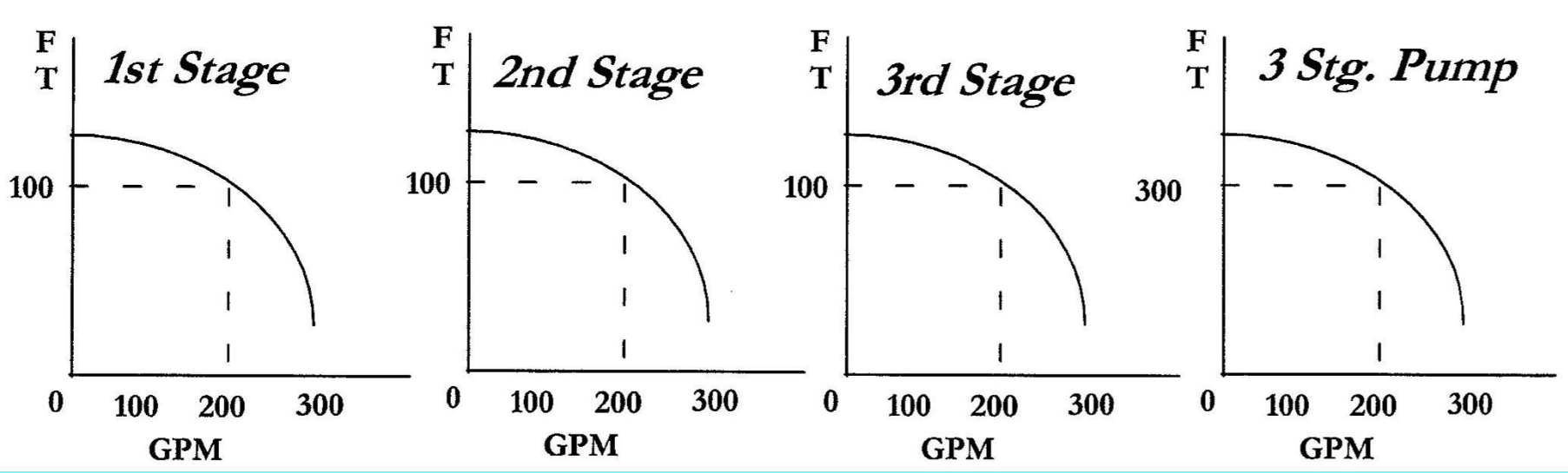


CONVERTING TO “LIKE” UNITS

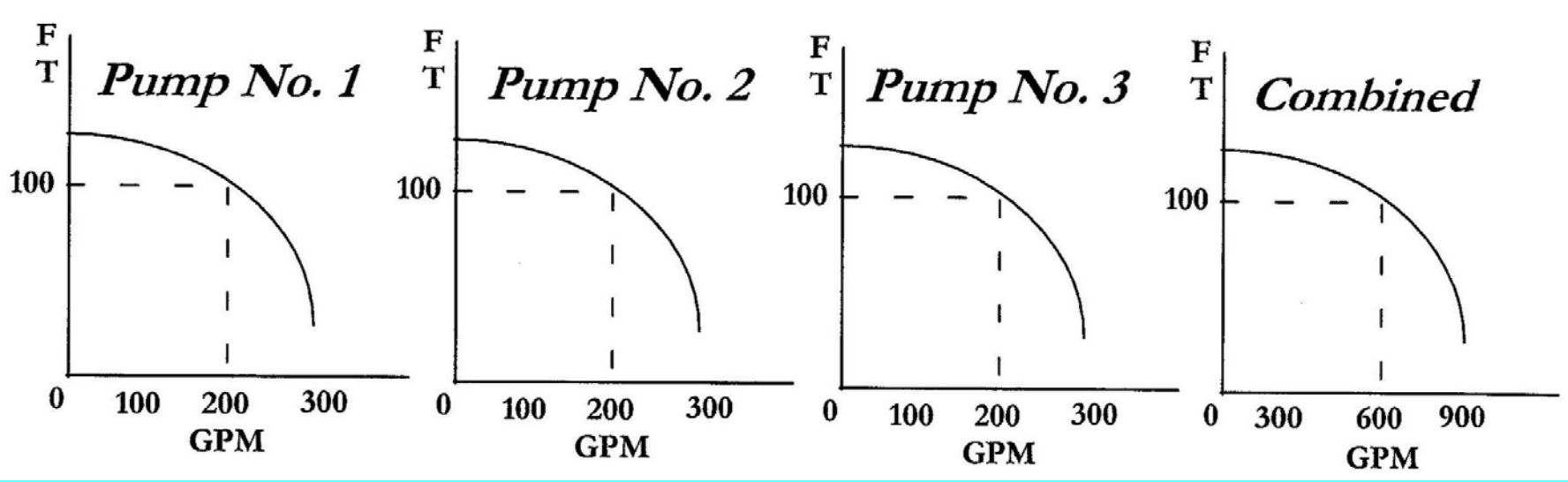
- WATER – S.G. 1.0
- STATIC HEAD (Elev. Change) = **21 FT.**
- CONVERT PSI TO FEET:
  - FRICTION LOSSES = 5.35 PSI
  - REQ’D PSI @ DISCHARGE = 80 PSI
  - (PSI X 2.31)/S.G. = FEET OF LIQUID
  - HEAD = (5.35+80)*2.31/1.0 = **197 FT.**
- TOTAL HEAD REQUIRED = **218 FT.**

Large Municipal Raw Water Irrigation Station

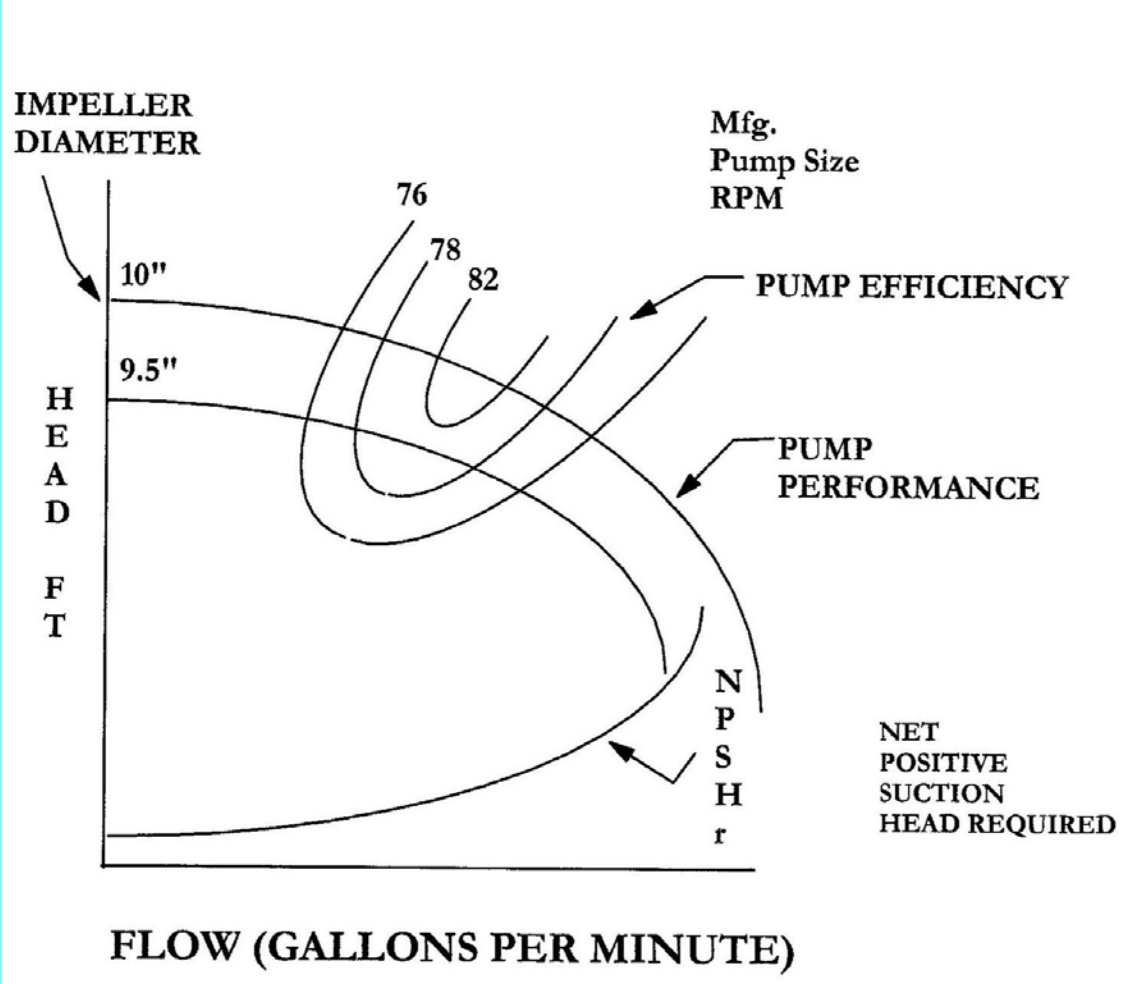
MULTIPLE STAGES INCREASE PRESSURE – FLOW CONSTANT



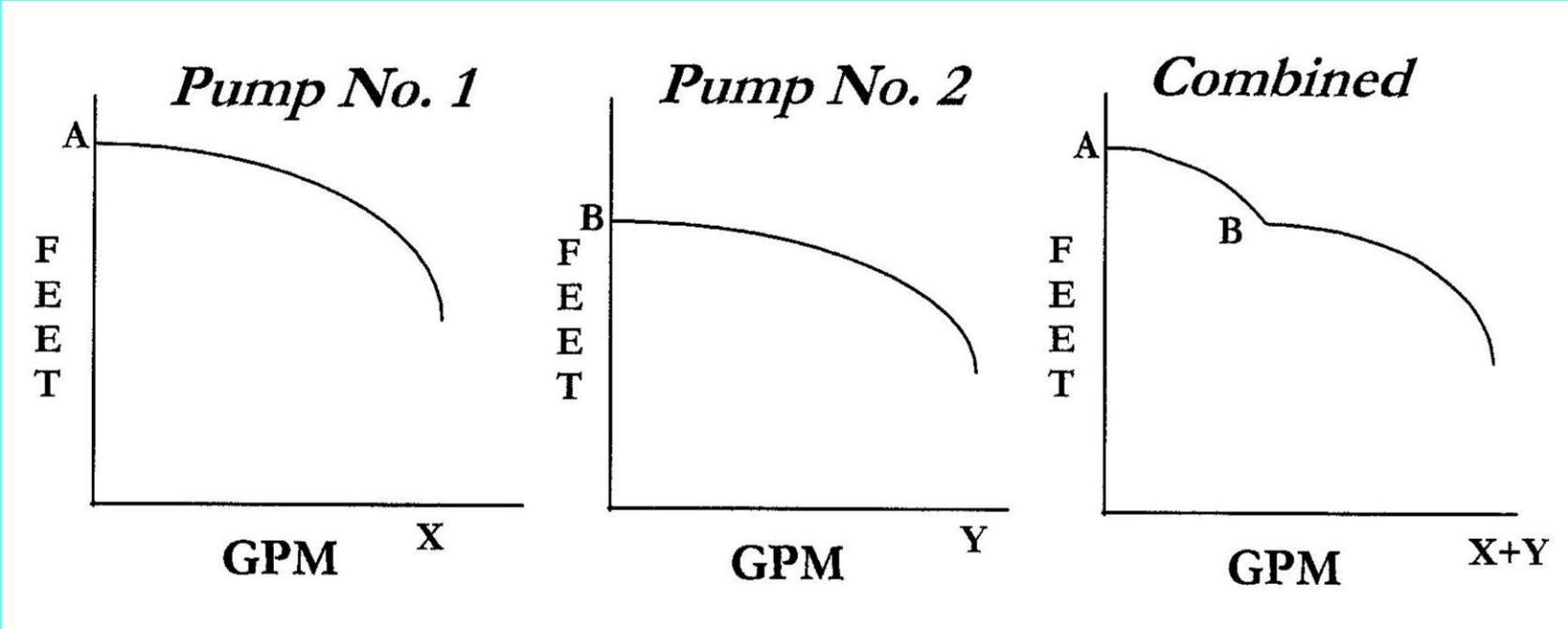
MULTIPLE IDENTICAL PUMPS – PUMPING IN PARALLEL



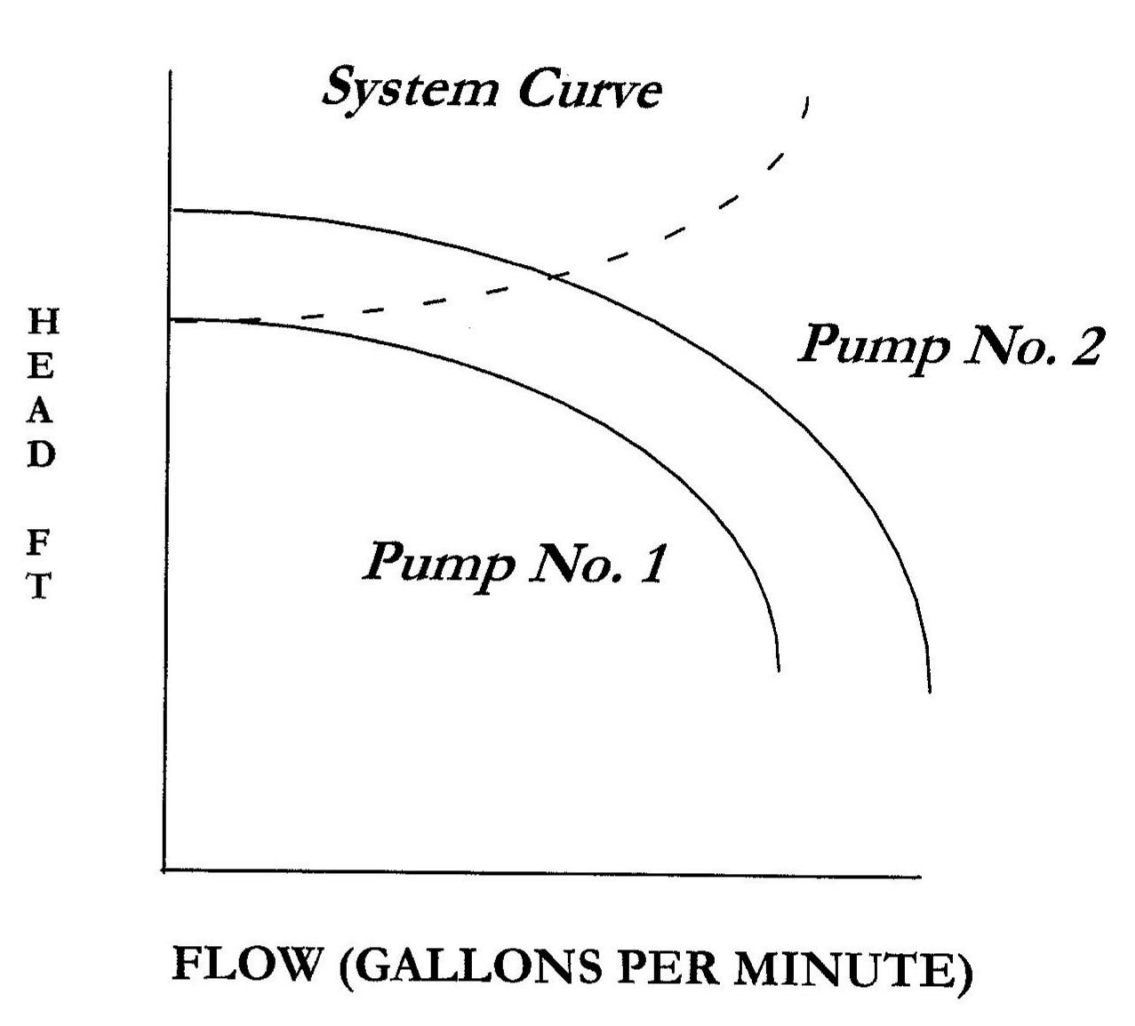
ELEMENTS OF MANUFACTURER'S PERFORMANCE CURVES



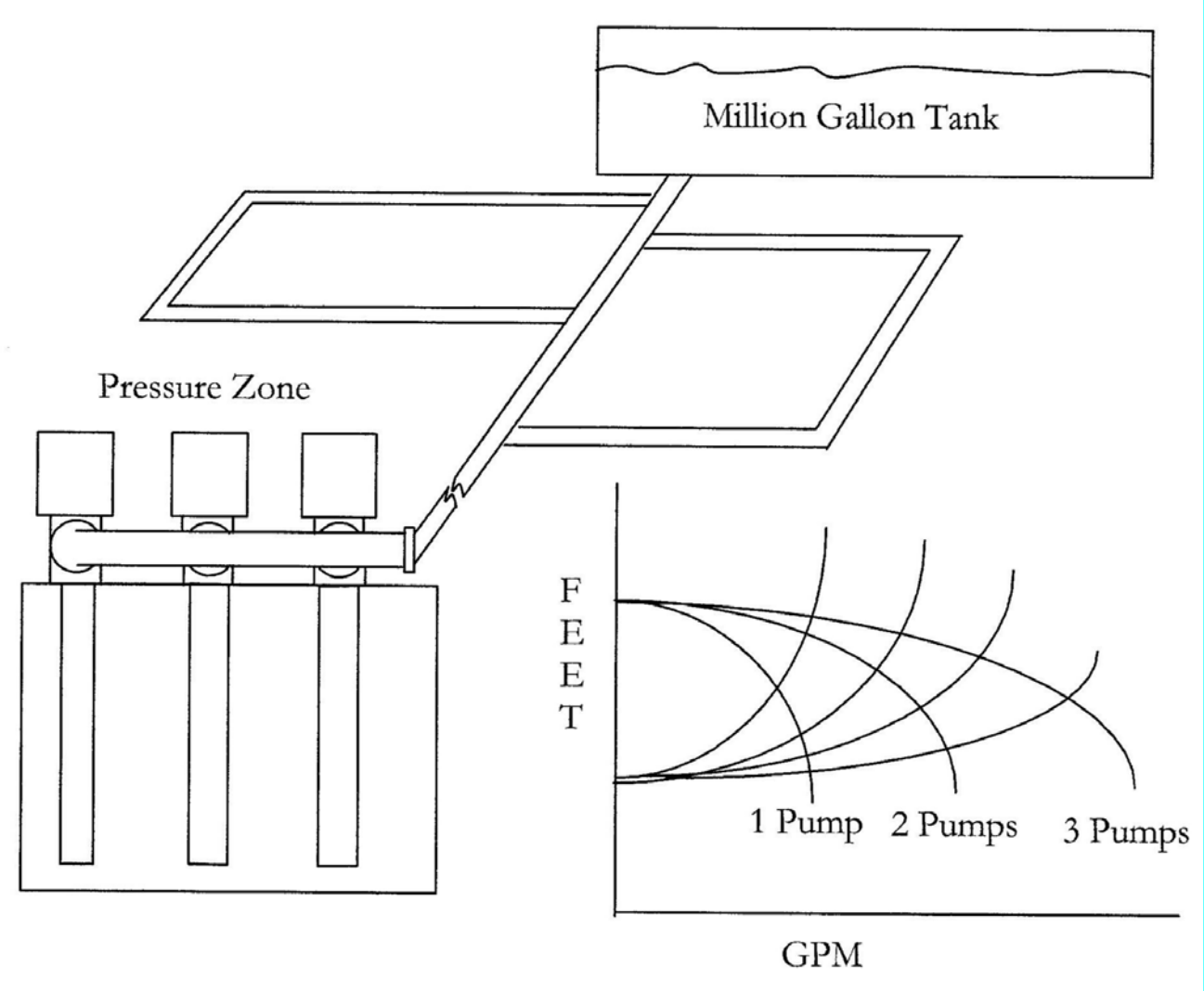
COMBINED PERFORMANCE OF TWO DISSIMILAR PUMPS



DANGER OF OPERATING DISSIMILAR PUMPS IN PARALLEL



LARGE SYSTEM SCHEMATIC +PUMP & PUMP PERFORMANCE CURVES

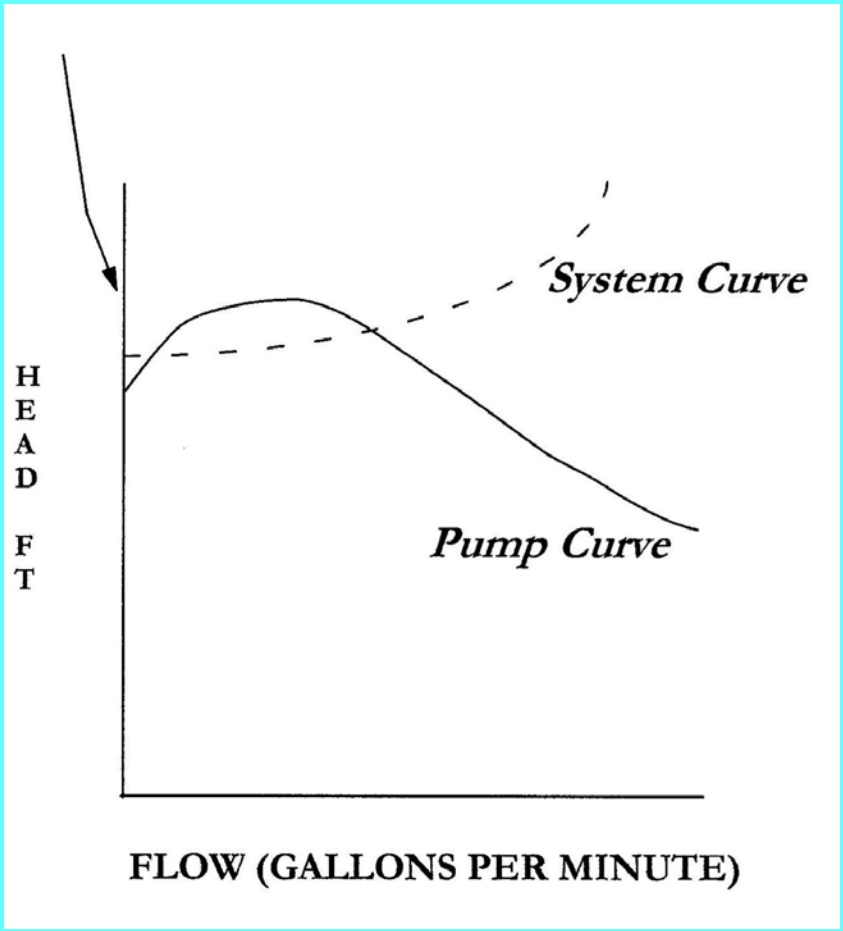


PUMP OPERATIONAL CONCERNS

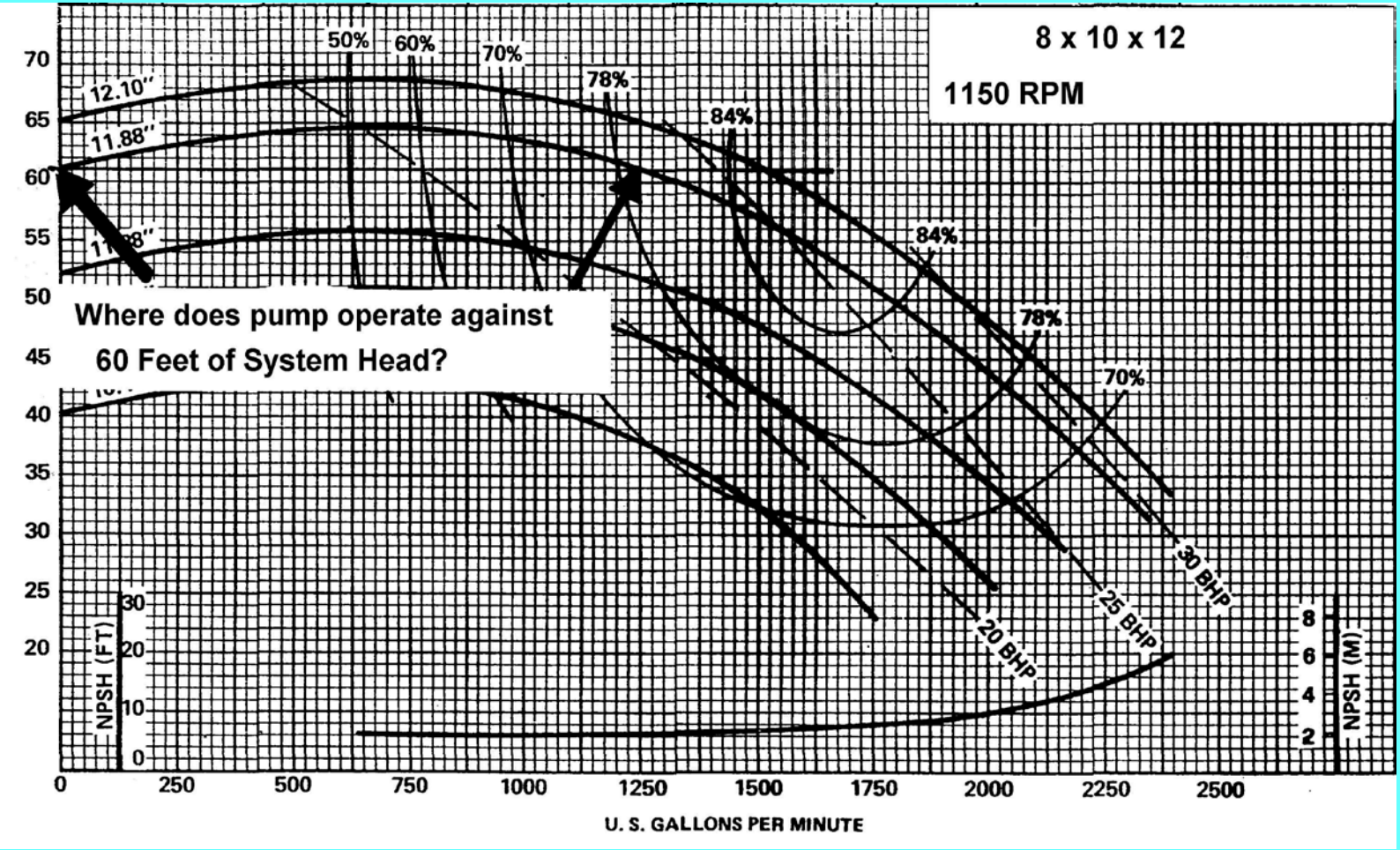
- Is the Pump Properly Selected for the Application?
- Cavitation
- Air Entrainment
- Recirculation
- Stability of Flow
- Variable Speed Operation

NON CONTINUOUSLY RISING CURVES & UNSTABLE PERFORMANCE

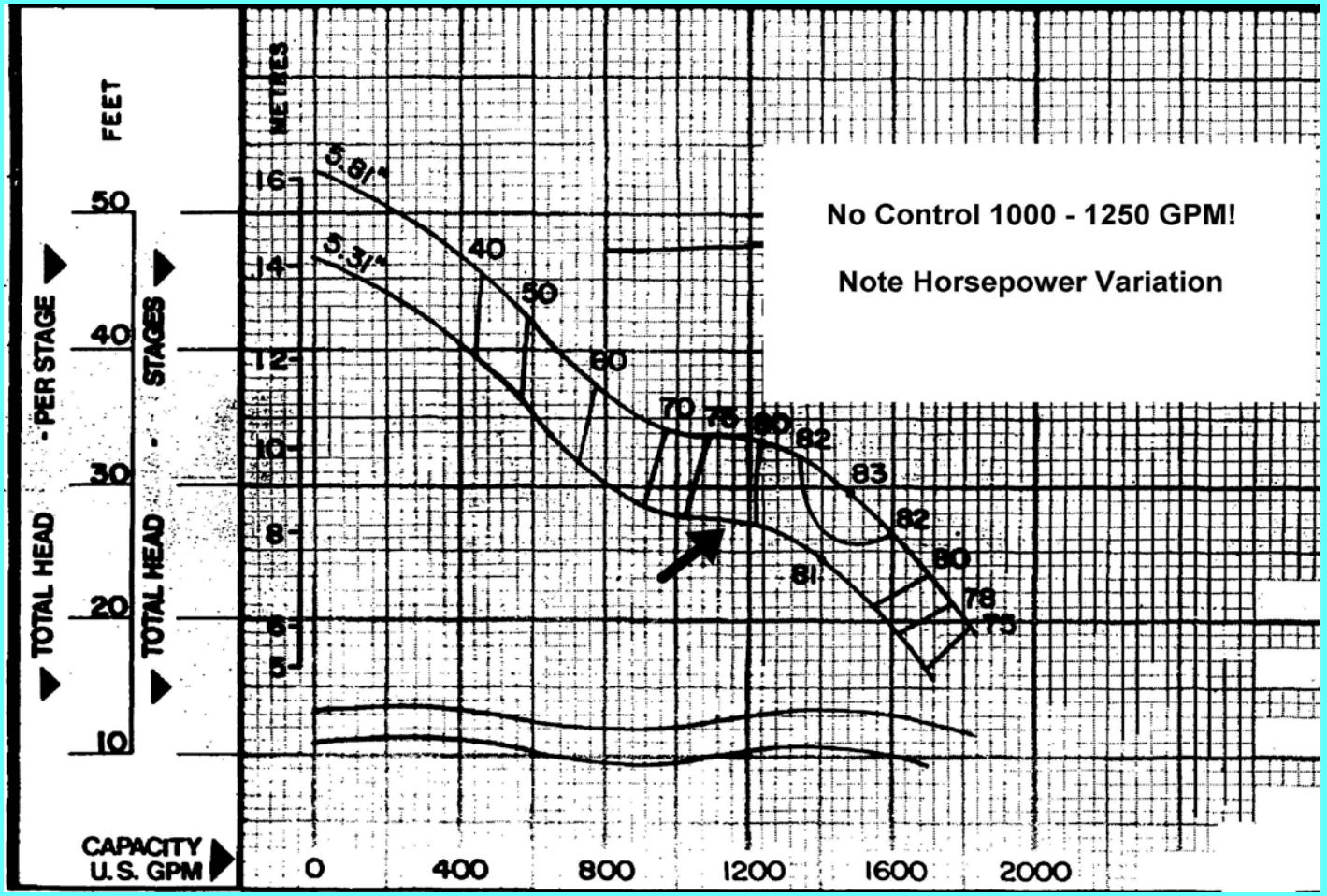
(Hint – Where Does System Curve Cross the Pump Curve?)



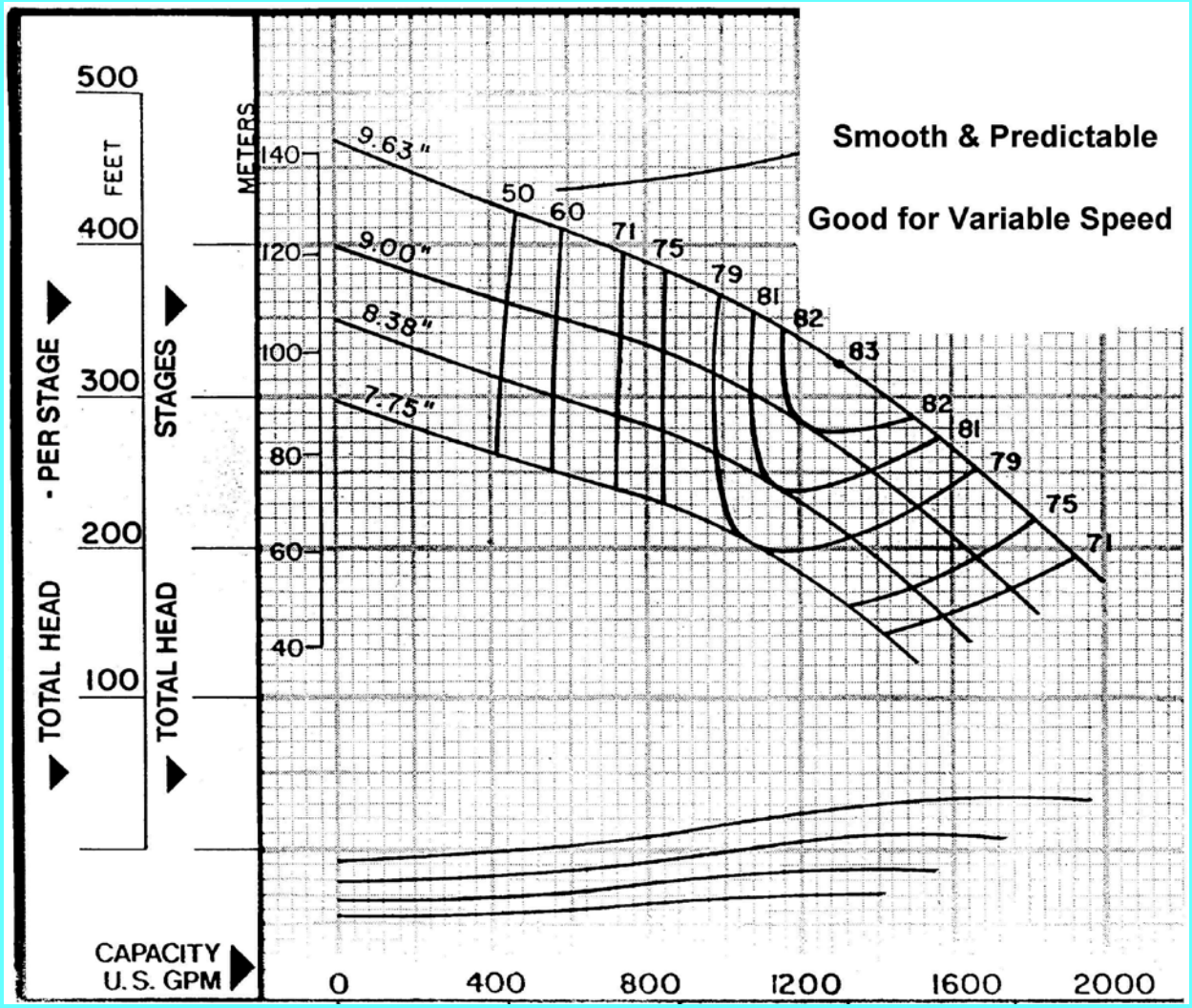
PREVENT UNPREDICTABLE PUMP PERFORMANCE - PROPER SELECTION!



Flat Unstable Performance ....

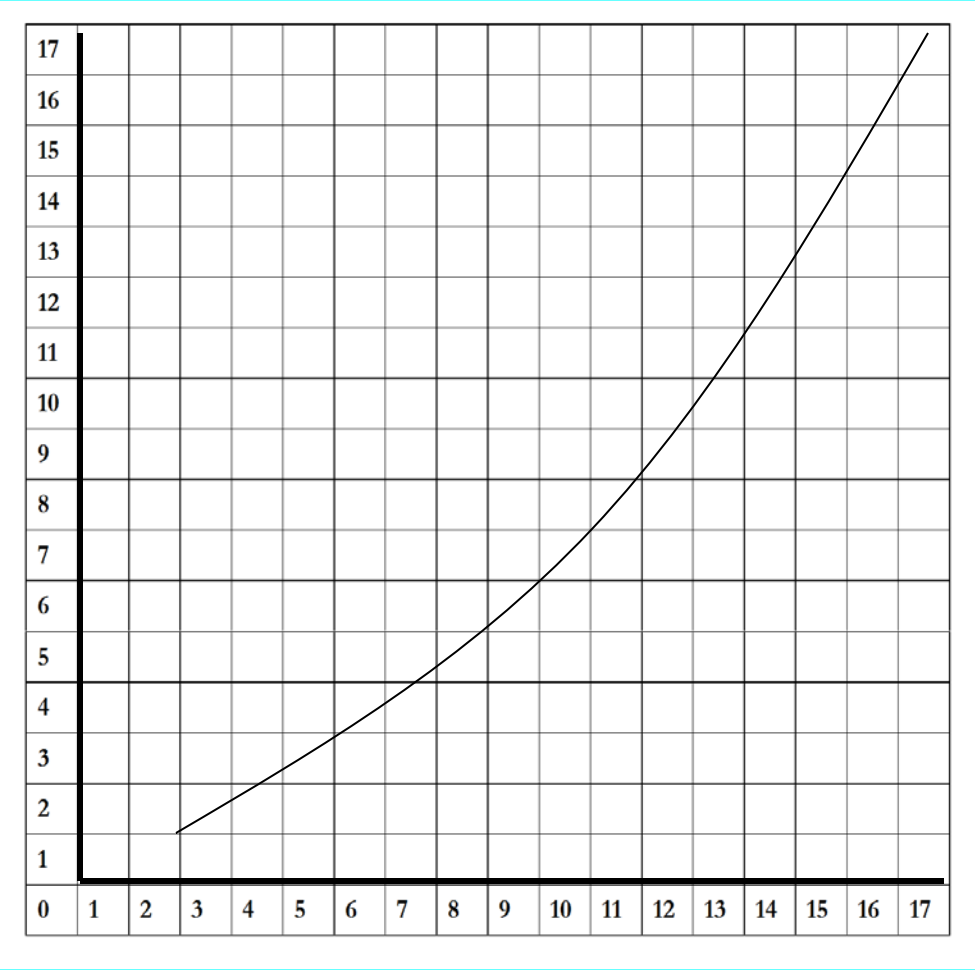


Continuously Rising /Smooth Curve – Predictable & Stability



MINIMUM SUBMERGENCE – PREVENTS VORTEX FORMATION

Submergence In Feet (Min.)

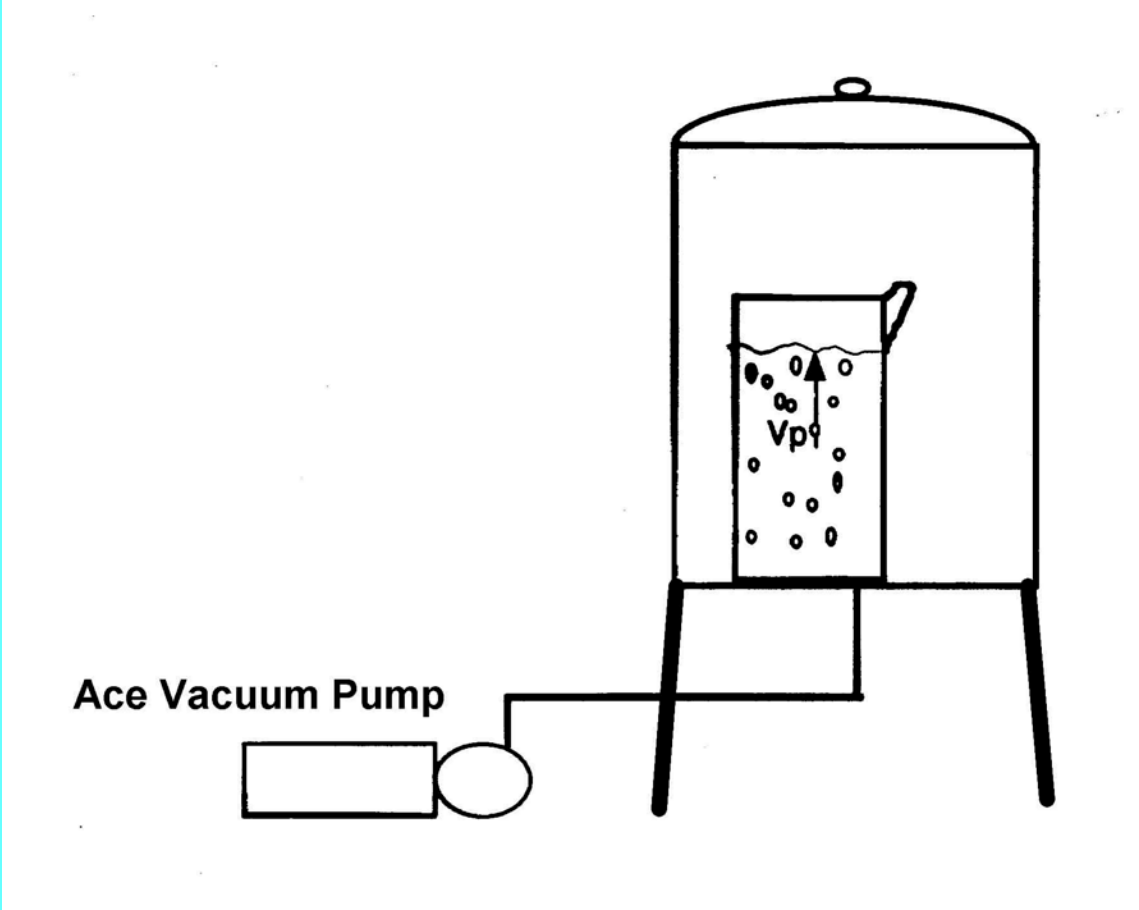


Velocity (Ft/Sec) = GPM x 0.321/Area or GPMx0.4085/$D^{2)}$

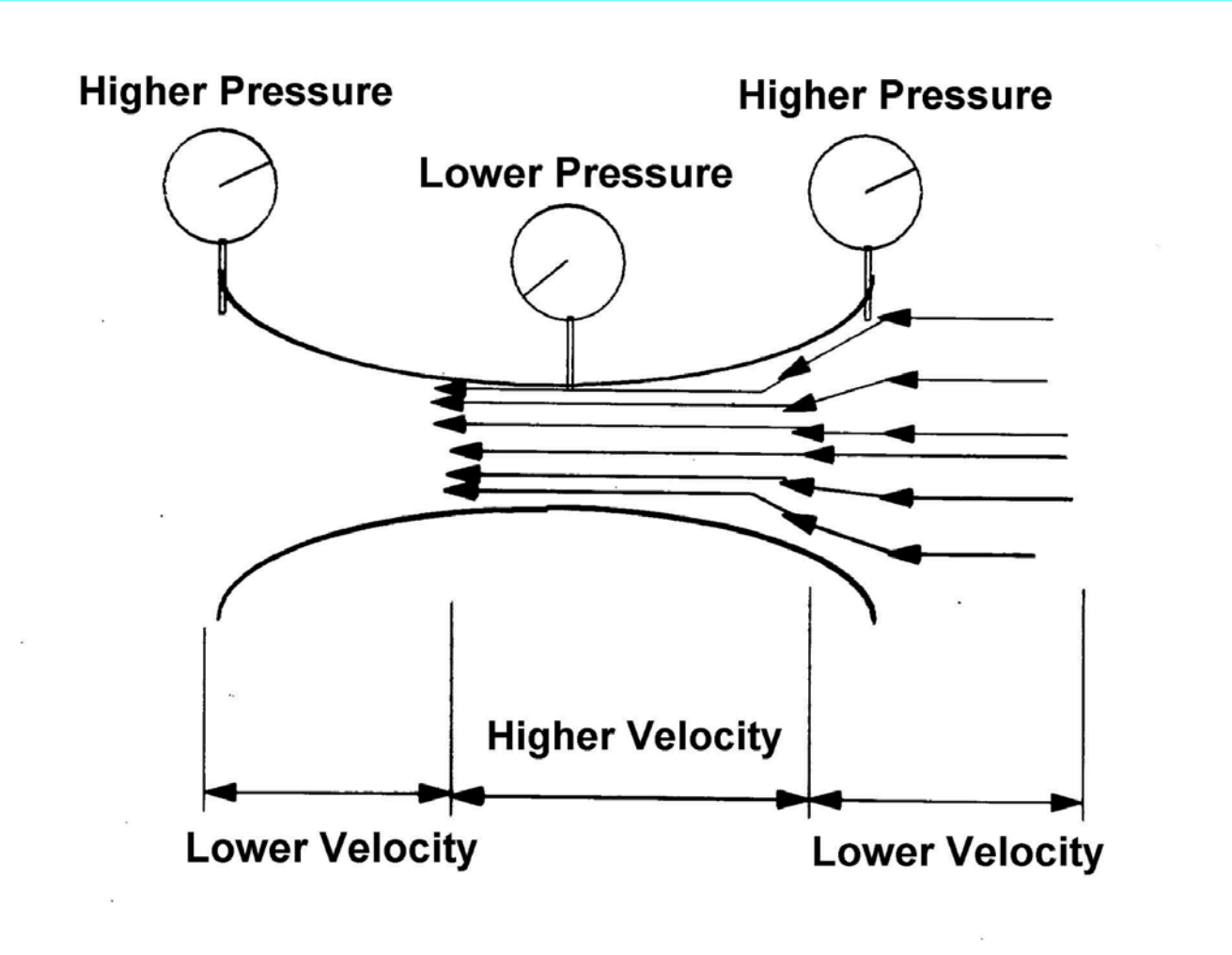
Pumping Success vs Pumping Failures

- Centrifugal Pumps only work because *liquid is not compressible* – i.e. hydraulic brake system in a car.
- What happens when water boils?
- What is Vapor Pressure?
- What's the difference in entrained air and vaporizing bubbles?

LOWER PRESSURE OR ADDED HEAT - LIQUID VAPORIZES (BOILS)!



PRESSURE VS. VELOCITY



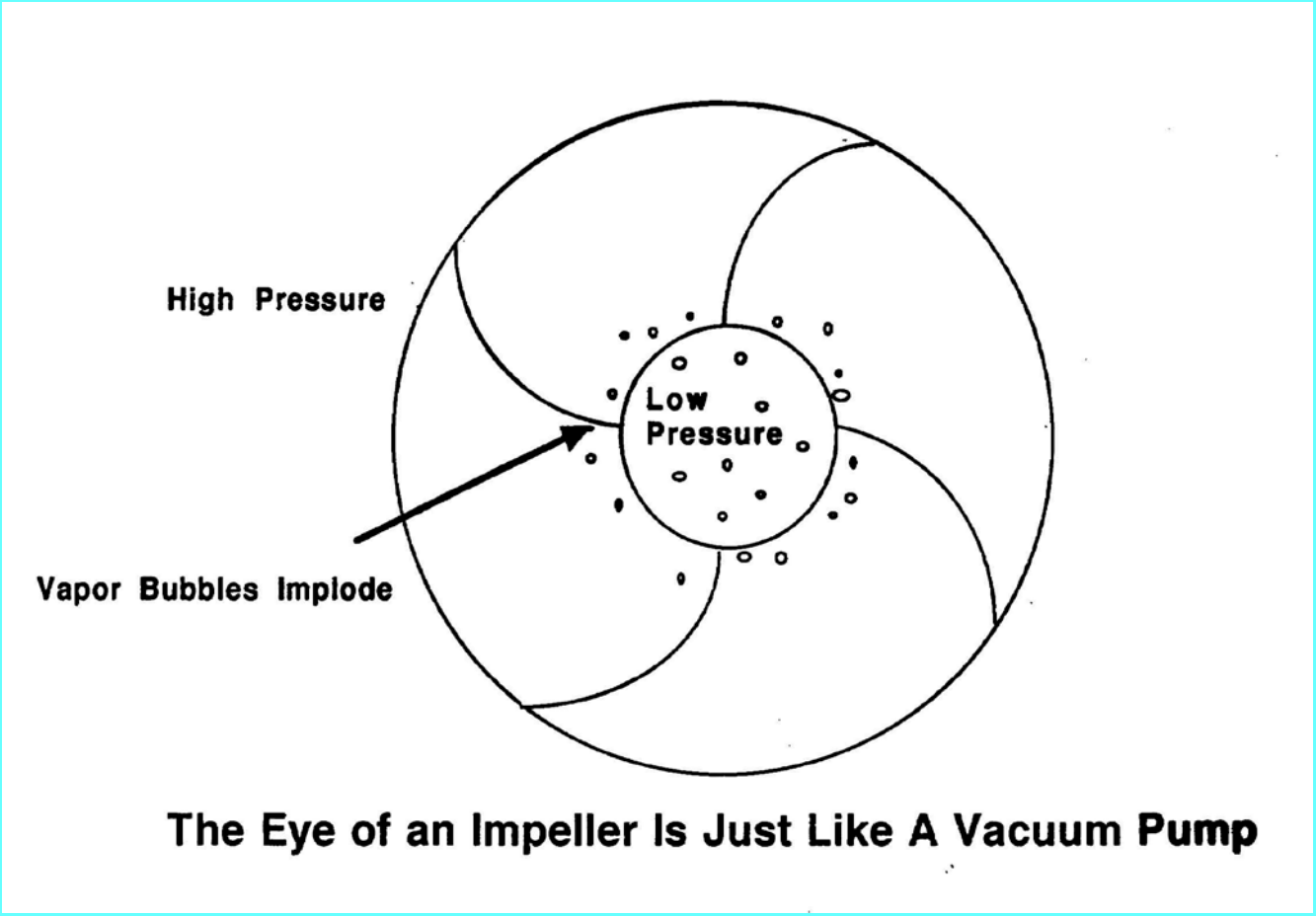
CAVITATION AND VELOCITY

- Narrowing Passage = Increased Velocity
- “Throttling” Valves Reduces Pressure
- Reduced Pressure Increased Chance for Liquid to Flash to a Vapor = Cavitation
- Therefore - ***DO NOT throttle pumps on suction side!***

WHAT IS CAVITATION ?
(SOUNDS LIKE GRAVEL)

- Absolute Pressure Drops
- Vapor Bubbles Form in Liquid
- Velocity Decreases / Pressure Increases
- Bubbles Collapse
- Energy (Heat of Vaporization) Released
- Localized Damage – Metal Surfaces Appear “Peened”) By A Hammer

CAVITATION IN PUMP IMPELLER …..



Cavitated End Suction Impellers

Cavitation

Turbine Pump Cavitation

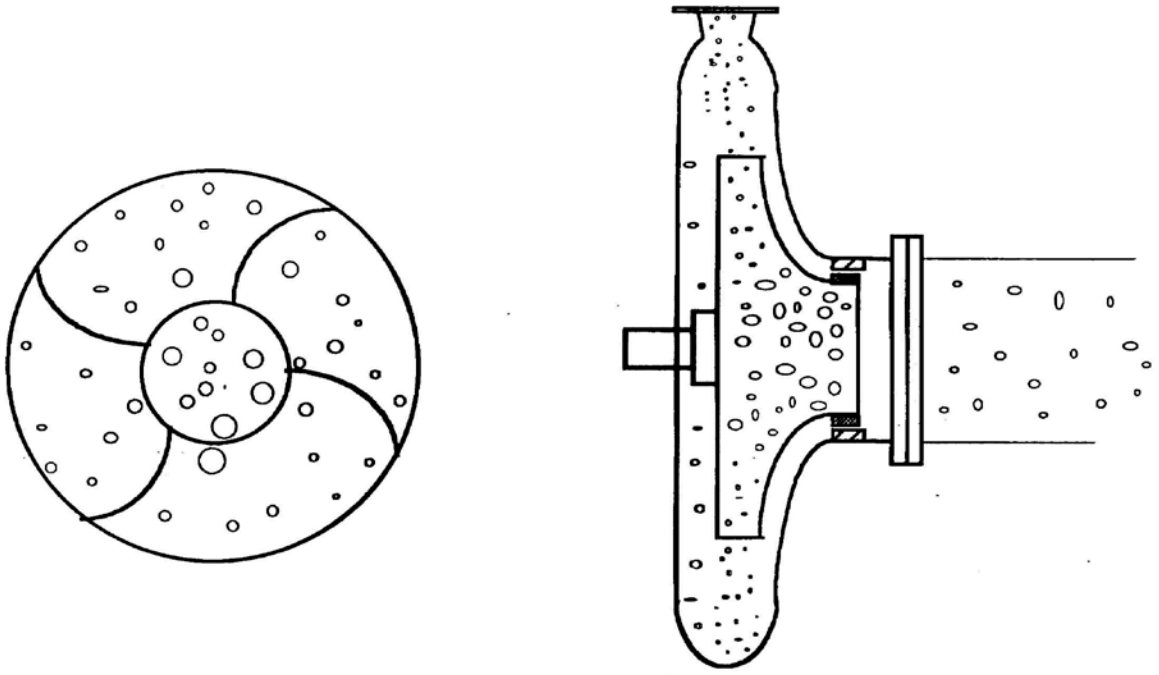
Corrosion vs Cavitation

Corrosion

Cavitation

AIR ENTRAINMENT IN PUMPS …….

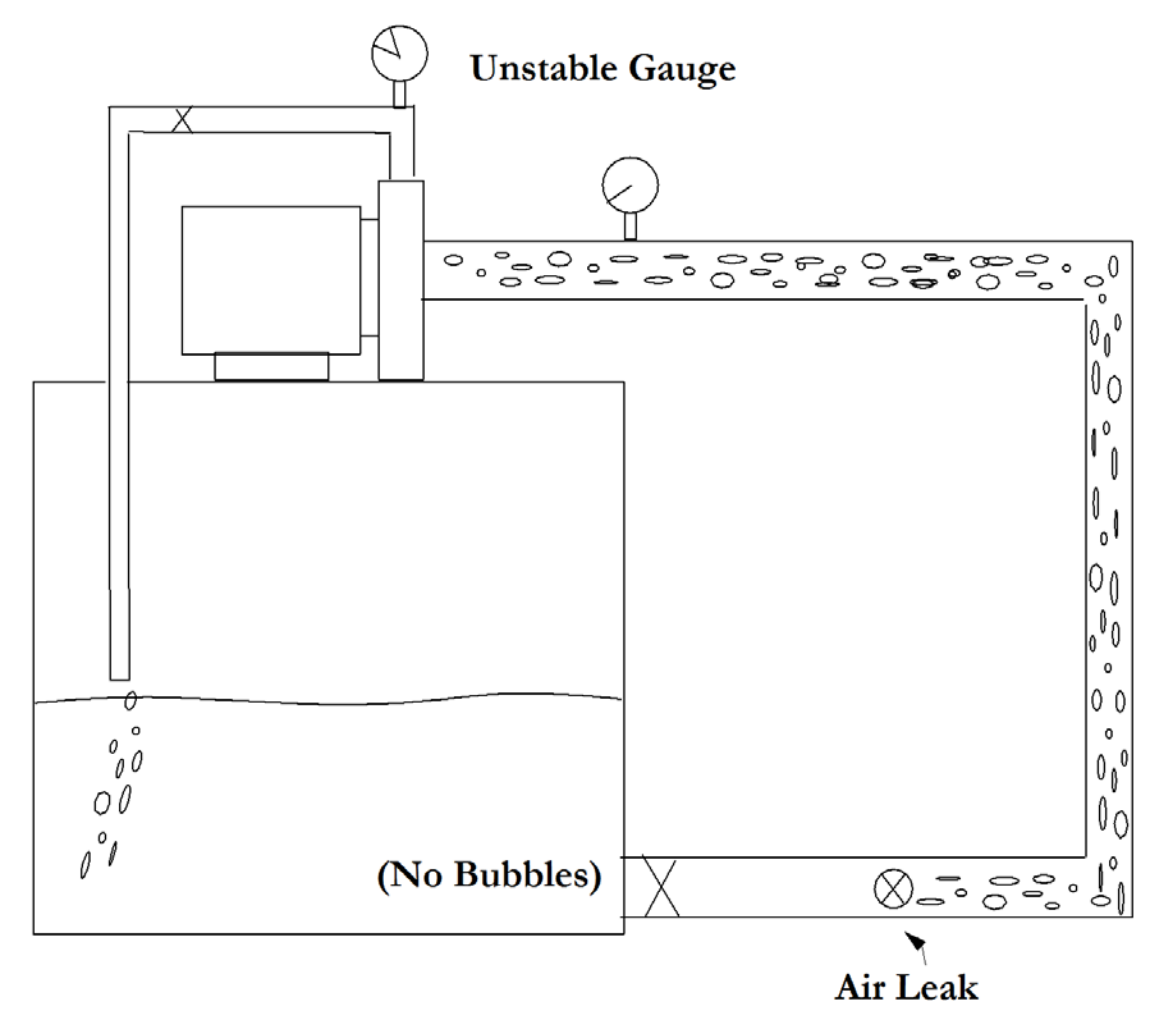
- ***Air Entrainment*** does not cause the same damage as cavitation. However, air occupies space that should be filled with fluid and air entrained liquid is compressible – i.e. reduced pump performance.



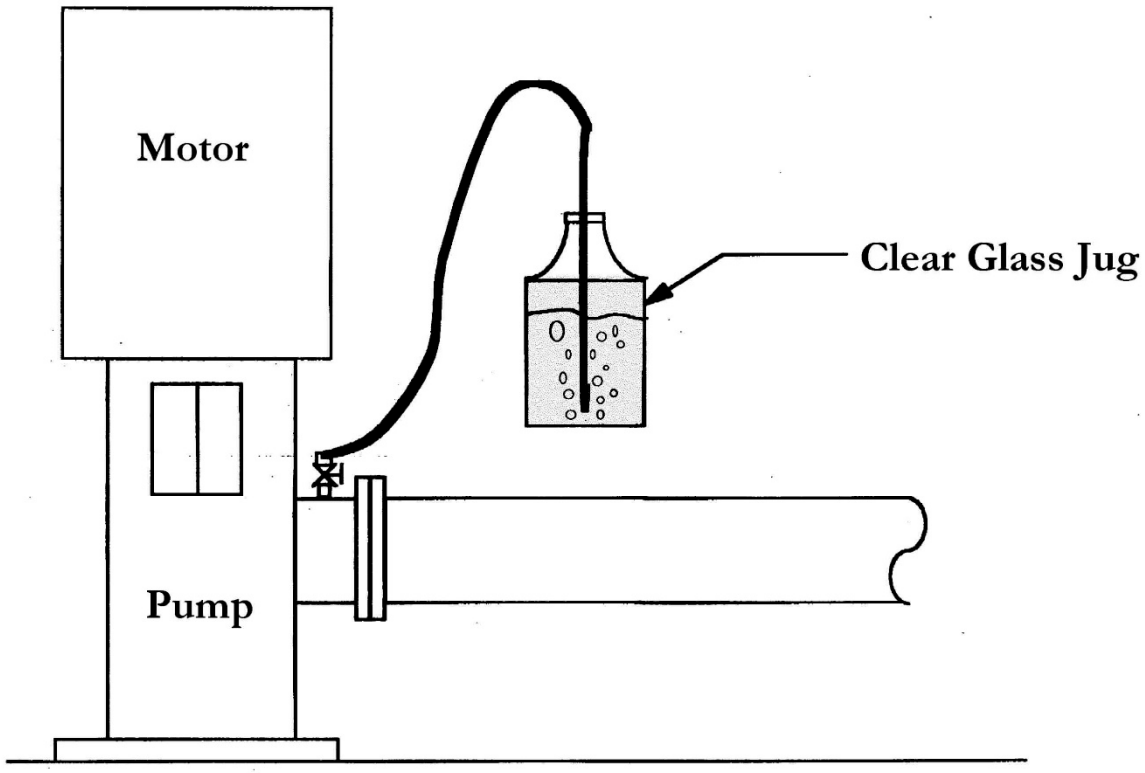
2% AIR CAN DECREASE PERFORMANCE BY 2-4%

4% AIR CAN DECREASE PERFORMANCE BY 50%

INLET AIR LEAKS DON'T NECESSARILY DRIP – JUST ALLOW AIR IN!



TESTING FOR AIR ENTRAINMENT



Shaft Sealing – Packing vs Mechanical Seals

PACKING

PROS –

- INEXPENSIVE
- WORKS GREAT ON WATER
- EASIER TO CHANGE
- CAN STILL RUN IF LEAKING
- "LOW TECH"

CONS –

- MUST LEAK TO LUBRICATE SHAFT
- CAN MAKE A MESS!
- FREEZING CONDITIONS CAUSE ICE
- NOT FOR EXPLOSIVE OR TOXIC LIQUIDS
- CAUSES WEAR ON SHAFT / SLEEVE
- NEEDS TO BE PERIODICALLY ADJUSTED

MECHANICAL SEAL(S)

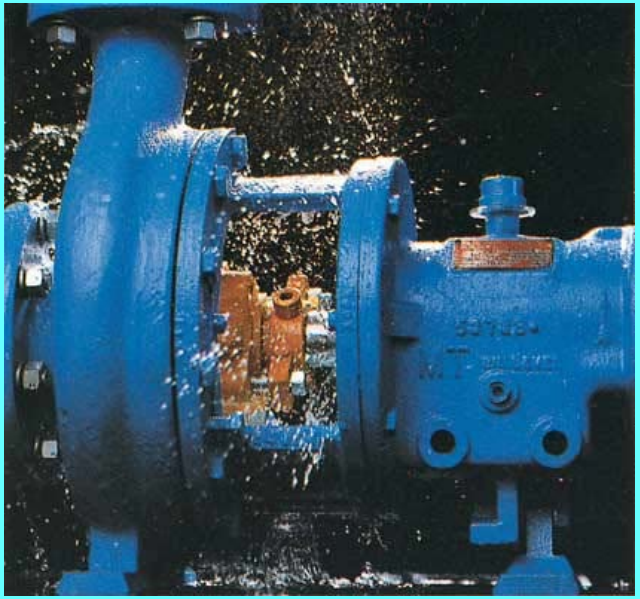
PROS –

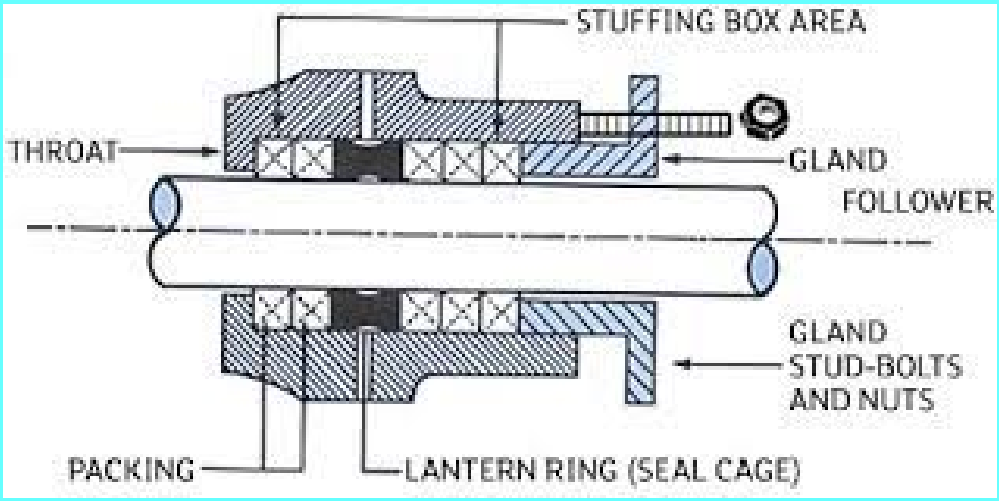
- NO LEAKAGE WHEN RUNNING
- CAN WORK WITH TOXIC FLUIDS
- CAN WORK WITH FLAMMABLES
- ENGINEERED FOR APPLICATION
- VARIETY OF MATERIALS
- NO ADJUSTMENTS REQUIRED

CONS –

- "HIGH TECH"
- EASILY BROKEN OR DAMAGED
- CAN BE EXPENSIVE
- DISASSEMBLE PUMP TO REPLACE
- CAN'T RUN IF LEAKING

Stuffing Boxes & Packing

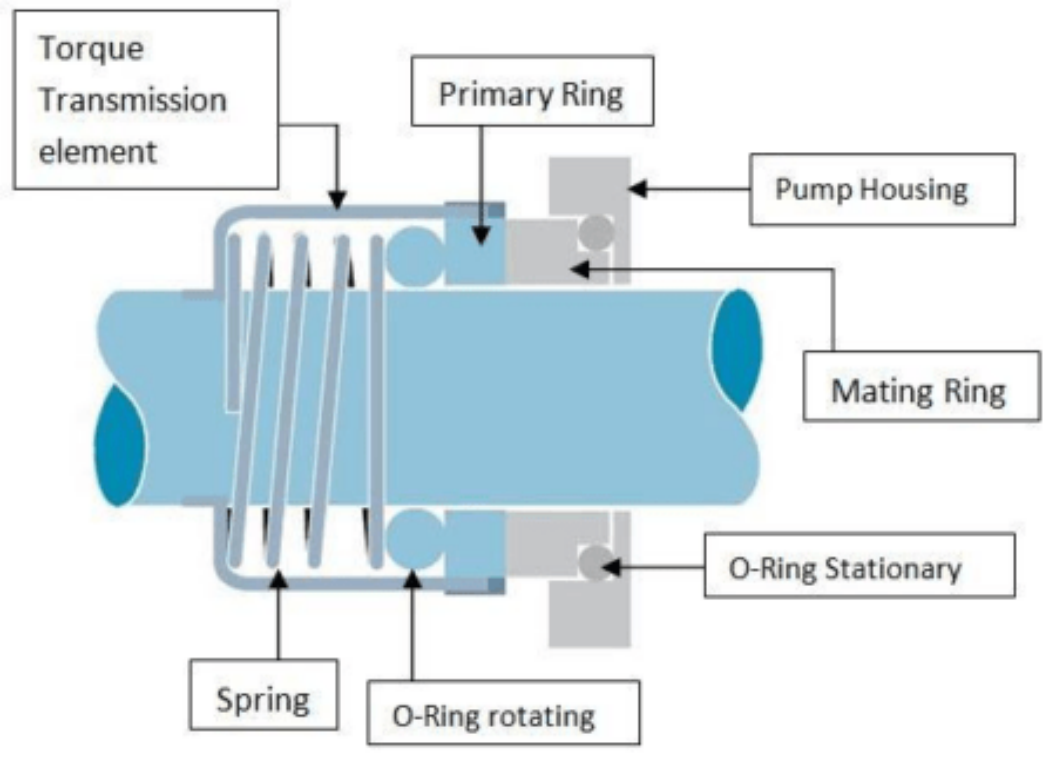




Packing MUST leak about 60 drops per minute to lubricate and cool the shaft / sleeve!

Packing, Lantern Rings & Packing Tools

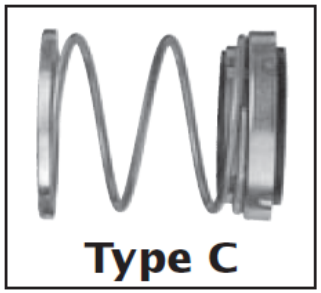
Mechanical Seals



Pumps with seals should have no visible leakage. DO NOT run seals dry!

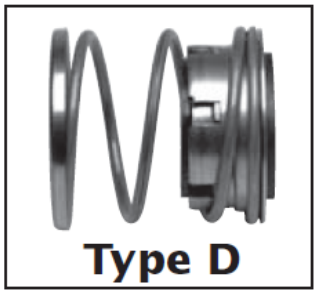
U. S. Seal – Basic Components

U.S. SEAL MFG. HEAD TYPES



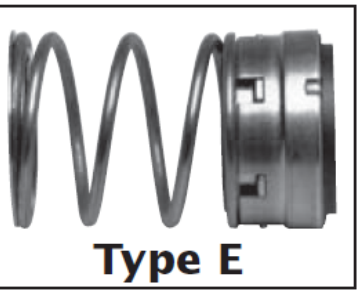
Type C

Equal to:
John Crane
Type 21



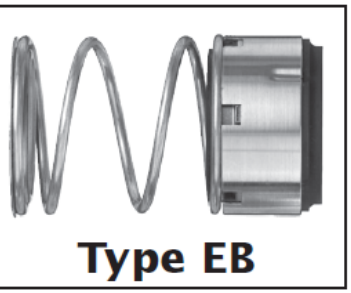
Type D

Equal to:
John Crane
Type 2



Type E

Equal to:
John Crane
Type 1



Type EB

Equal to:
John Crane Type 1
Balanced

U.S. SEAL MFG. MATING RING DESIGNS

(Available in a wide variety of materials)

Cup Mounted

1

L-Shaped

2

O-Ring

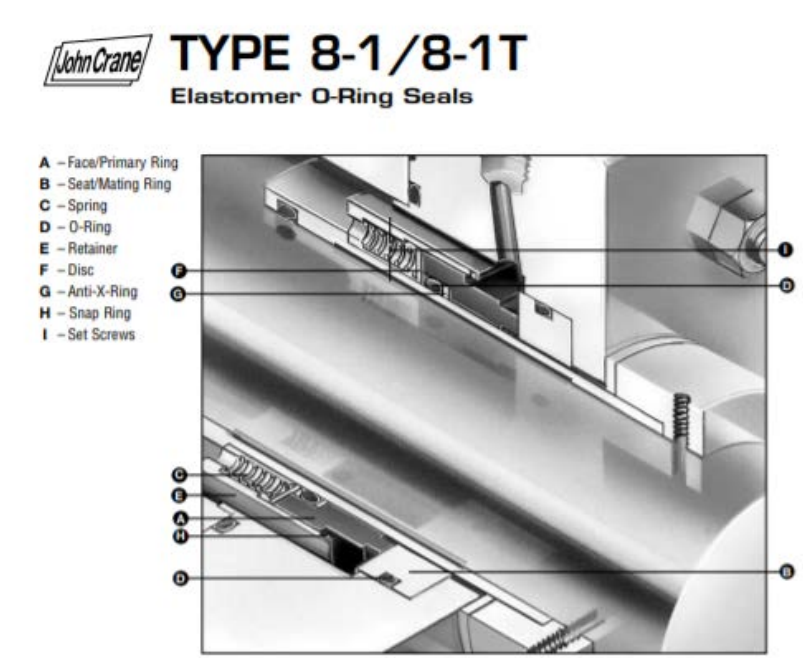
3

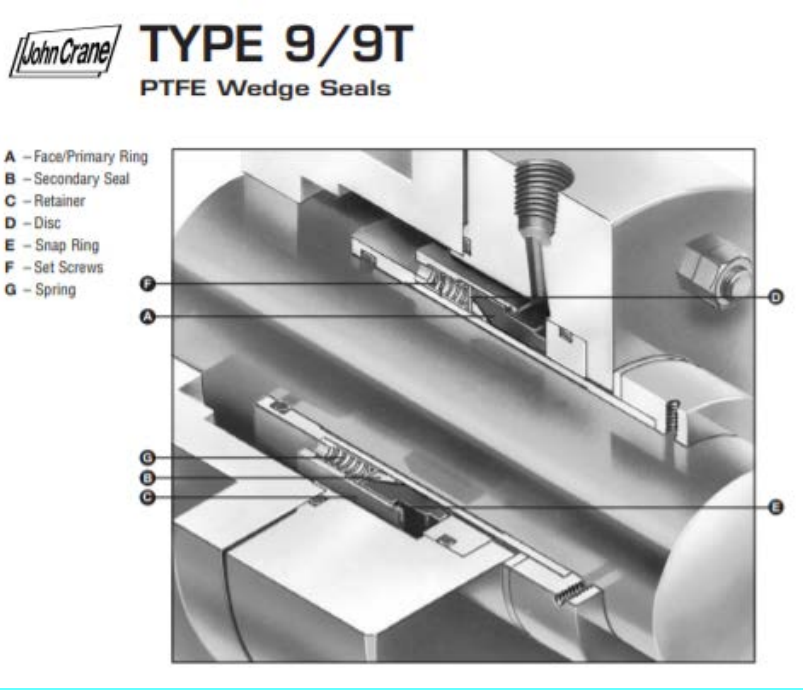
Square Cross-Section

5

AESSEAL Cartridge Mechanical Seal

John Crane Multi-spring Seals





PROVIDING FOR FLOW STABILITY

- Prevent Air Pockets Caused by Reducers and High Points in Piping
- Eliminate Elbows / Straighten Piping on Double Suction Pumps
- Eliminate Air Pockets in Discharge Piping
- Prevent Sudden Changes in Flow Rates

Maintenance Considerations

SAFETY FIRST

- ***Before Working on Equipment***
  - **Isolate ALL Energy Sources**
    - **Isolate ALL Electrical Sources**
      - **Lockout / Tagout & Test**
    - **Isolate ALL Pressure Sources**
      - **Double Block and Bleed Pressure**
        - **Lockout / Tagout & Test**
  - **DO NOT Enter Confined Space Without Proper Training, Equipment and Personnel**

Use Your 5 Senses Every Day at Work!

- **Get to KNOW Your Pump(s) System**
  - **Smell - Know What in Normal**
    - **Any Unusual Odors – Hot, Burning, Fumes,Etc?**
  - **Look –**
    - **Pressure Gauges, Unusual Leaks, Smoke, Critters?**
  - **Listen –**
    - **Does the Equipment Sound Normal or Strange**
  - **Feel It! – Is Equipment Hot or Vibrating?**
    - **(It's not Sexual Harassment, if it's not alive!)**
  - **Taste – Don't Lick the Equipment!**
    - **If you sense strange tastes – get out / get help!**

USE SOME COMMON SENSE ?

- IS THIS HOW THEY MAKE “CLEAN ENERGY?
- WHICH CAME FIRST – THE ELECTRICAL PANEL OR THE IRRIGATION SYSTEM?
- TIME FOR AN IMMEDIATE CHANGE – HEAD / PANEL RELOCATION OR XERISCAPE
- GET LOCATES FOR UNDERGROUND WIRES AND PIPING BEFORE DIGGING.

Locked Out / Tagged Out - LOTO

- o Identify All Energy Sources
- o Notify Affected Personell
- o Disconnect / Close (Valves)
- o Tag It
- o Lockout
- o TEST IT!


DANGER
ARC FLASH
AND SHOCK HAZARDS


DANGER
Arc Flash and
Shock Hazards.
Appropriate PPE
Required


shutterstock

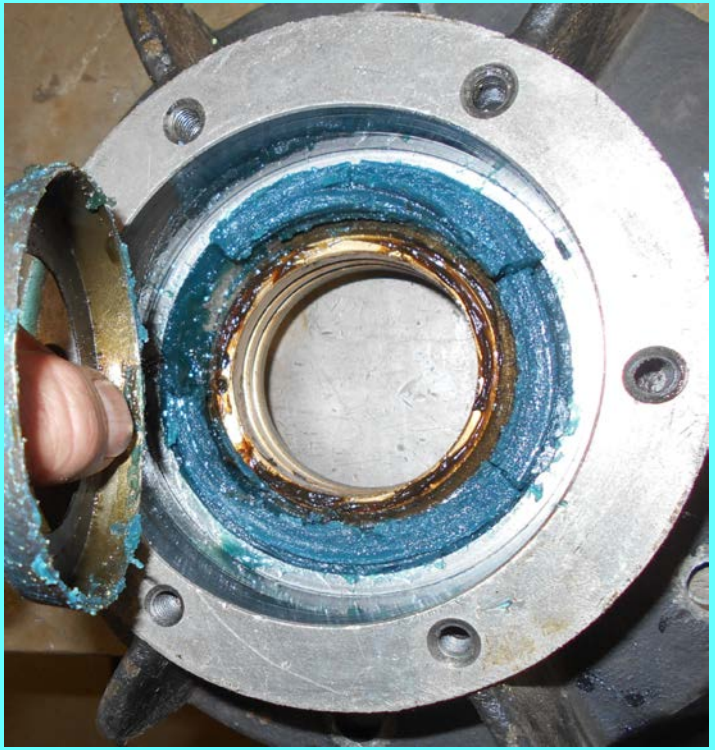
UNPOWERED MOTOR CHECKS – QUALIFIED PERSONNEL ONLY!

- **Lockout / Tagout**
- **Electric Motors**
  - **Grease Lubrication – (Non-EP)**
-

GREASE INCOMPATIBILITY CHART

	Sodium	Aluminum Complex	Barium	Calcium	Calcium Complex	Clay	Lithium	Lithium Complex	Polyurea
Sodium	C	I	I	I	I	I	I	I	I
Aluminum Complex	I	C	I	I	I	I	P	C	I
Barium	I	I	C	I	I	I	I	I	I
Calcium	I	I	I	C	I	I	P	C	I
Calcium Complex	I	I	I	I	C	I	I	I	I
Clay	I	I	I	I	I	P	I	I	I
Lithium	I	P	I	P	I	I	C	C	I
Lithium Complex	I	C	I	C	I	I	C	C	I
Polyurea	I	I	I	I	I	I	I	I	C

Grease Incompatibility



UNPOWERED MOTOR CHECKS – QUALIFIED PERSONNEL ONLY!

- **Change Oil – Drain and Refill**
  - **Check Viscosity & Oxidation Inhibitors**
- **Megger Check Motor Insulation**
- **Check for Free Rotation**
- **Open Junction Boxes / Check Splices**
- **Clean Vents & Screens**
- **Remove Dirt & Oil Buildup**

Unpowered Electrical Checks – QUALIFIED PERSONNEL ONLY!

- **Electrical Panels -**
  - **General Clean-up**
  - **Vacuum - Dirt And Carbon Tracking**
  - **Use Plastic Safe Electrical Cleaner To:**
    - **Remove Carbon Tracking**
    - **Disassemble / Clean Contactors (DO NOT File Contacts)**

Unpowered Electrical Checks – QUALIFIED PERSONNEL ONLY!

- **Electrical Panels – Continued**
  - **Lockout / Tagout**
  - **Check Overload Settings**
  - **Tighten All Connections**
  - **Phase Failure / Over-voltage Under-voltage Protection**
    - **Check Function And Settings**
  - **Lightning Protection**
    - **Check To See If Still Protected**

General Equipment Checks -

- **Motor / Pump Couplings**
  - **Check Pump / Motor Alignment**
  - **Clean , Remove Rust, Check Bolt Torque**
  - **Insure Coupling Guards Intact**
- **Seals And Packing Should Be Checked Frequently. Packed Pumps - Repack Annually**
- **Lubricate Pump Bearings**

SYSTEM CONCERNS –

- **Water / Pumpage Must Be Free of Dirt, Weeds, & Large Debris**
- **Sewage – Grease Removal**
- **Sewage Pumps – Sanitary Products, Diapers, Wipes**
- **Clean – Inlet Structures, Screens, Settling Ponds, Strainers**
- **Repairs – Start Early / Off Season Rushed Repairs May Be More Expensive!**

SYSTEM CONCERNS – Cont.

- **Gauges / Transducers**
  - **Prevent From Freezing**
  - **Check and Calibrate Annually**
- **Valves**
  - **Fully Open / Fully Close**
  - **Shutdown – Ball Valves @ 45**
- **Flush Lines / Ports Periodically**

STATION CONCERNS

- **Paint And Clean – Rusty / Dirty Equipment Is Hard To Service and Operate. Remove Corrosion And Paint During Warm Summer Months (w/o Condensation).**
- **Maintain Backup Equipment – Reduce Callouts / Emergency Repairs! Alternate Operation to Insure Backup Capability.**

Powered Electrical Testing

- Qualified Personnel
- Safe Area & Working Clearances
- JSA – Job Safety Analysis
  - Identify Hazards
  - Arc Flash Information
  - Discuss with all personnel
  - Identify Emergency Services / Phone
  - Muster Point Identified
  - Sign and Save JSA

RECOMMENDED MINIMUM TEST EQUIPMENT

- **Voltage Proximity Tester**
- **Quality Voltmeter – Rated in Excess of Highest Expected Voltage**
- **Clamp-on Amp Meter**
  - **Large Enough for All Motors in Service**
  - **If VFD's are in service, Meter must be "True RMS" for Accurate Readings**

RECOMMENDED TEST EQUIPMENT – CONTINUED

- **Electricians Quality & Tested Rubber Protective Gloves**
- **Arc Flash Gear Is Required!**
- **Safety Glasses**
- **Flashlight**
- **Infrared Temperature Gun and/or Thermal Imaging Camera**
- **Pressure Gauges & “Snubbers”**

POWERED ELECTRICAL CHECKS – QUALIFIED PERSONNEL ONLY!

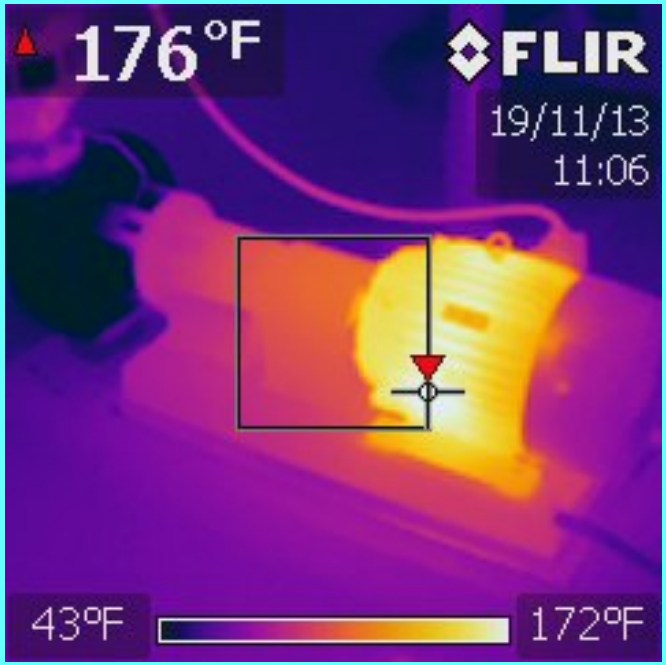
- ***DO NOT run pumps without water!***

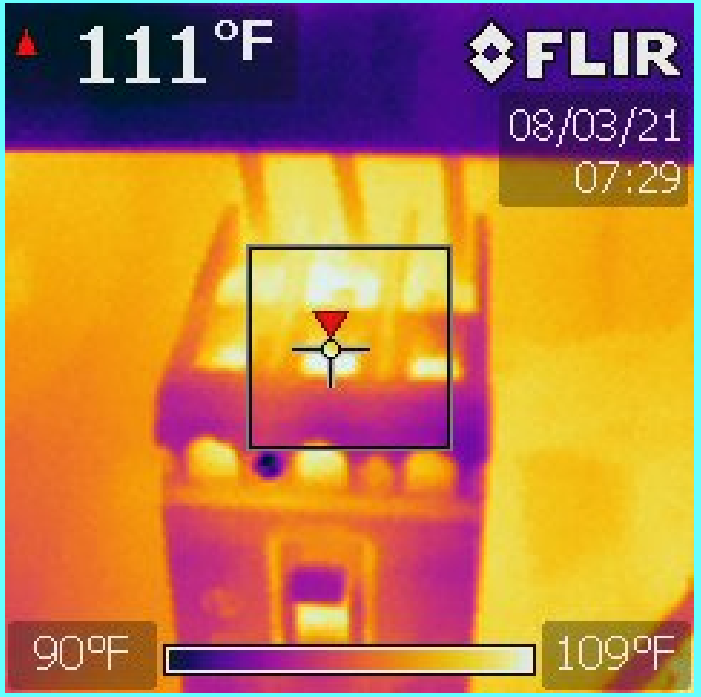
- **Voltage Checks**
  - **Each Leg to Ground**
  - **3 Phase -Leg to Leg – A/B, B/C, A/C**
    - **Check Voltage Level**
    - **Note Consistency & Balance**
  - **Check Voltage Drop Across Starter**

POWERED ELECTRICAL CHECKS – QUALIFIED PERSONNEL ONLY!

- **Check Amp Loads – Pump Pumping!**
  - **Check Each Leg vs. FLA of Motor**
  - **Check for Balance Between Legs**
- **Check for Vibration -**
  - **Anchor Bolting**
  - **Pump Vibration**
  - **Motor Vibration**
  - **Shaft Runout / Deflection**

Specialized Testing – Thermal Imaging – Panels and Equipment





Vibration Analysis

810 Vibration Tester Diagnostic Report

Device Serial Number : 1985001
Machine Setup Name : ZOO P5
Measurement Date/Time : 11/19/2013 11:34:06

Drive Train

Diagnosis

Fault description	Fault severity	Severity Score	Severity Scale
Motor Free End Bearing Wear	Moderate	28/100	

Recommendations

Recommendations	Priority	Priority Description
Monitor Motor Free End Bearing For Increased Vibration	2	Desirable

Electric Motor Winding Analysis

iTIG II

THE EASIEST TO USE TESTERS ON THE MARKET DELIVERING A NON-DESTRUCTIVE TEST SET THAT FINDS MORE FAULTS

The iTIG II motor tester and winding analyzer combines multiple testing technologies from micro-ohm resistance to high frequency surge tests and partial discharge measurements into a single light weight portable instrument. From low voltage to high voltage, 20 different tests are available.

Power Quality Analyzer

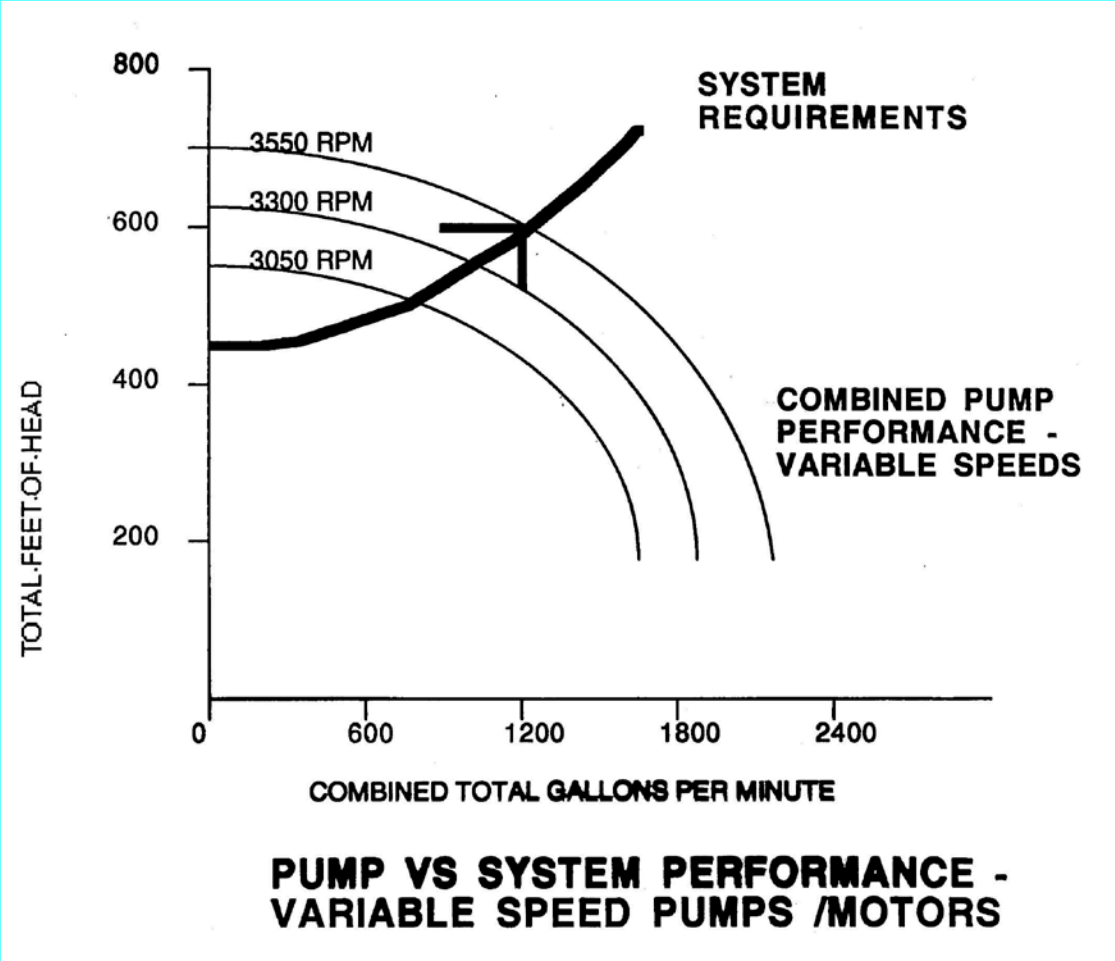
- Check and Record Incoming Power

Variable Speed Operation

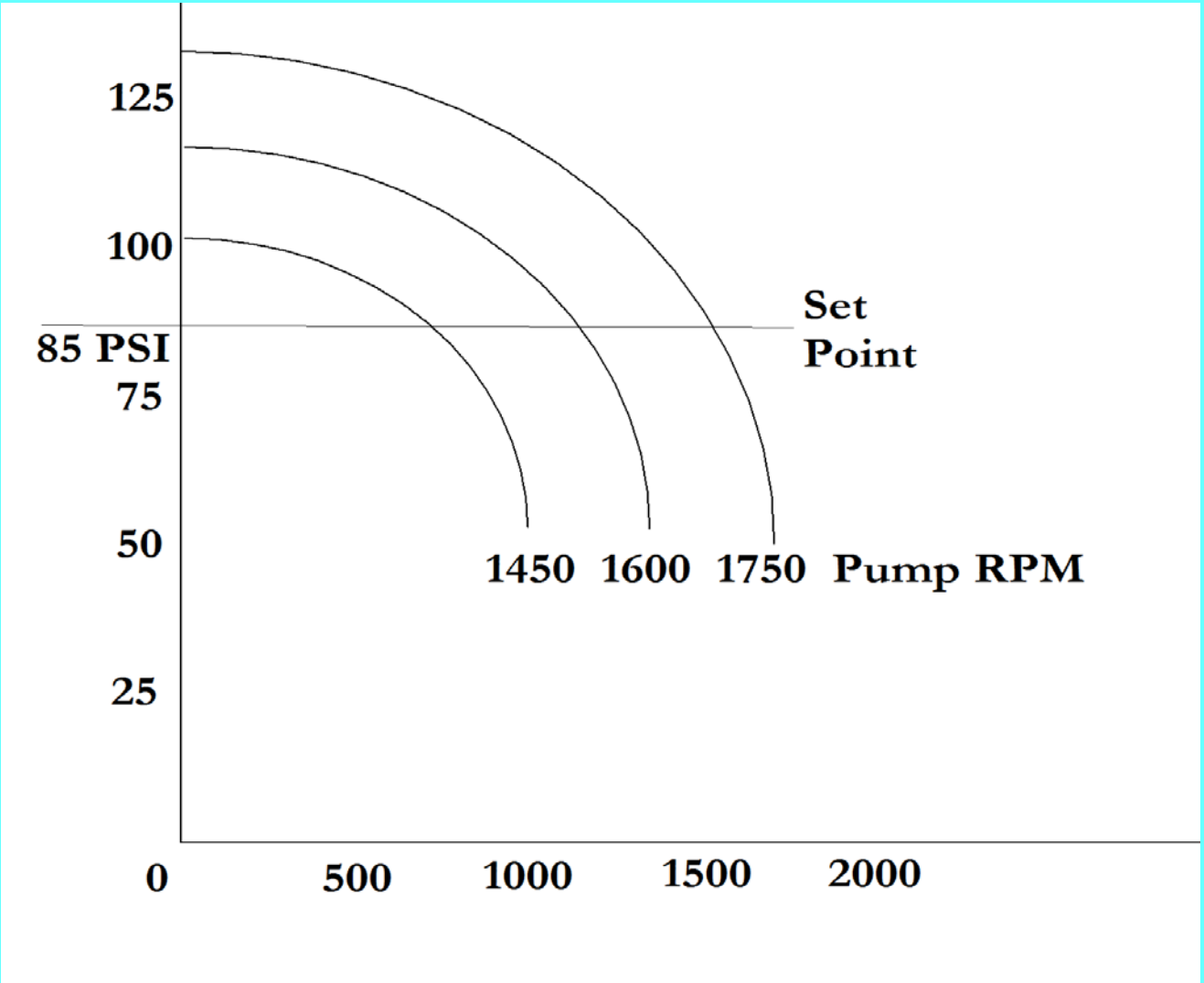
- Pump Selection
  - Does the System Have Varying Flow or Pressure Demands?
  - Steeply Rising Pump Curve?
  - What Are the Horsepower Limitations?
  - Are There NPSH Problems?

VARIABLE SPEED PERFORMANCE

- Note: The pump operates where the system curve intersects the pump curve, but with variable speed, the pump can match the system curve.



Variable Speed - Maintaining Constant Pressure / Varying Flow



Predicting Variable Speed Performance*

- Capacity – GPM $GPM1/GPM2 = RPM1/RPM2$
- Head – FT $TDH1/TDH2 = (RPM1/RPM2)^2$
- Brake HP – BHP $BHP1/BHP2 = (RPM1/RPM2)^3$

*Trimmed Impeller Performance Follows Same Relationships with DIA1 Replacing RPM 1 and DIA2 Replacing RPM 2

VARIABLE SPEED
FULL SPEED + VALVE VS. LOWER SPEED

VARIABLE SPEED PERFORMANCE

DESIRED PUMP OUTPUT **315 GPM @ 200 FT (86.5 PSI)**
LIQUID **WATER**

Original Impeller Diameter	**8**	**Inch**	**Final Impeller Diameter**	**8**	**Inch**
Performance Curve RPM	**3550**		**Reduced Operating RPM**	**3200**	
S.G.	**1.00**				

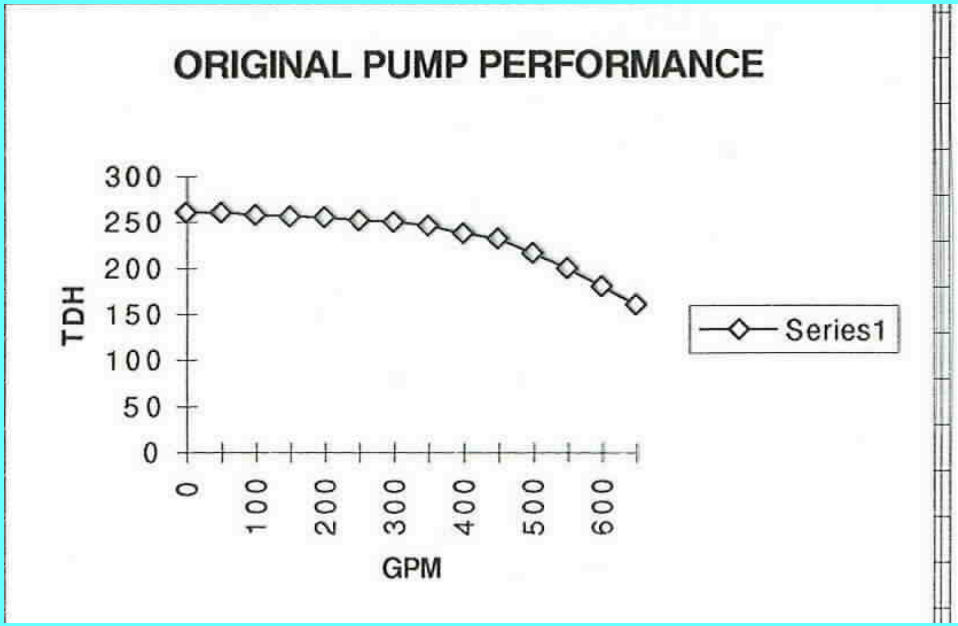
Pump Performance at 3500 RPM

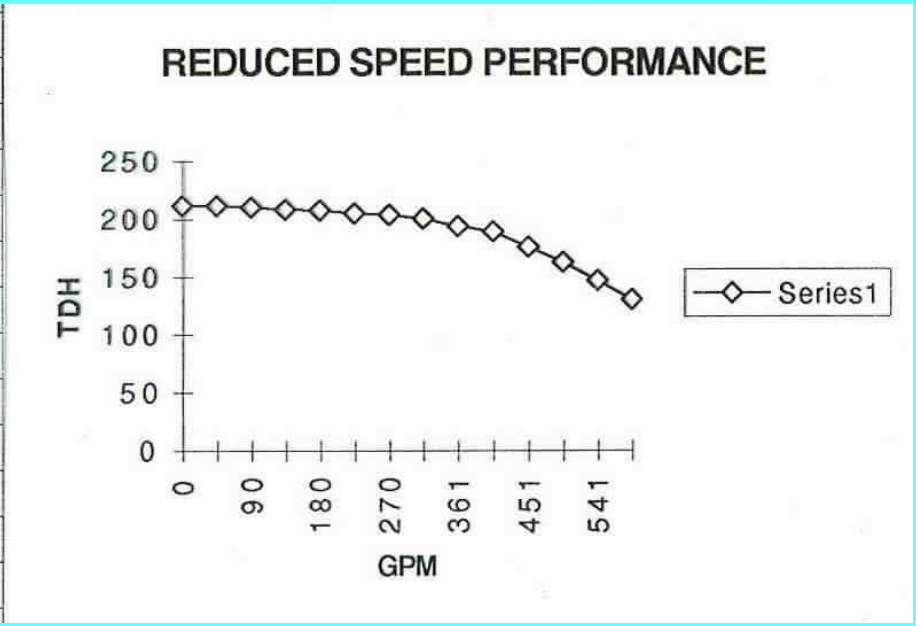
GPM	TDH	Effic	BHP
0	260	20%	0.0
50	260	35%	9.4
100	258	45%	14.5
150	256	54%	18.0
200	255	60%	21.5
250	252	64%	24.9
300	250	70%	27.1
350	**246**	74%	**29.4**
400	238	78%	31.0
450	232	80%	33.2
500	216	80%	34.2
550	200	78%	35.6
600	180	75%	36.2

Pump Performance at 3200 RPM

GPM	TDH	Effic	BHP
0	211		0.0
45	211	35%	6.9
90	210	45%	10.6
135	208	54%	13.2
180	207	60%	15.7
225	205	64%	18.2
270	203	70%	19.8
315	**200**	74%	**21.5**
361	193	78%	22.7
406	189	80%	24.3
451	176	80%	25.0
496	163	78%	26.1
541	146	75%	26.5

VARIABLE SPEED PERFORMANCE CURVES





COST ANALYSIS – VFD CONTROL VS. THROTTLING VALVE

- HP - 315 GPM @ 250 FT **27.06** BHP
- HP – 315 GPM @ 200 FT **21.50** BHP
- Savings – VFD over Valve 5.56 BHP
- **12 Hrs./Day x 135 Days/Yr. x 5.56 = 9007.20 Horsepower Hours / Year**
- 746 Watts/HP x 9007.2 = 6719.4 KWH
- At $0.0695/kwh Savings = $467.00/yr.
- **Over 20 years, savings =$9,339.25**

Keep Records / Review Changes

Inspection Services Performed:

Pump:

Manufacturer: Peerless M/N: 5AE12 S/N: 9927067941-10-A

Pump Size: 5x6x12 Impeller Trim: 10.78"

Rated Flow: 1270 Rated Head: 427

Pump Operated: x Y ___ N Pump Vibration: x Normal ___ Excessive

Anchor Bolts Tight: ___ Y ___ N x Adjusted Pump Noise: x Normal ___ Excessive

Bearing Temperatures: x OK (< 150° F) ___ Hot ___ Not Enough Operating Time to Test

x Mech. Seal Leaking: ___ Y X N Flush Line Operable: ___ Y ___ N x N/A

___ Packing ___ Adjusted ___ Changed Size: ___ # Rings: ___

Pipe Supports / Condition: x OK

Lubricant: ___ Changed x Added Type / Weight: Mobil XHP 222

Motor:

Manufacturer: Baldor/Reliance M/N: ECP84416T-4 S/N: A1309032002

Horsepower: 200 RPM: 3570

Rated Voltage: 460 Rated Amps: 213

Pump Operated: x Y ___ N Pump Vibration: x Normal ___ Excessive

Anchor Bolts Tight: ___ Y ___ N x Adjusted Pump Noise: x Normal ___ Excessive

Bearing Temperatures: x OK (< 150° F) ___ Hot ___ Not Enough Operating Time to Test

Lubricant: ___ Changed x Added Type / Weight: Polyrex EM

Voltage at Starter (Left to Right): 1: 482 2: 484 3: 480

Amperage Under Load: 1: 211 2: 213 3: 212

Winding Resistance: 1-2: 0.1 2-3: 0.1 1-3: 0.1

Megger Test Volts: 1000 Reading: >2.2 G

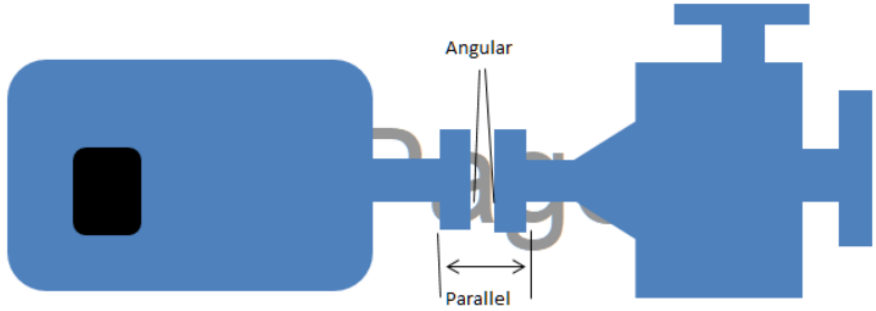
Conduit Box Opened: x Y ___ N Connections Checked: x Y ___ N

Ground Wire Tight: x Y ___ N ___ Adjusted

Motor / Pump Shaft Alignment

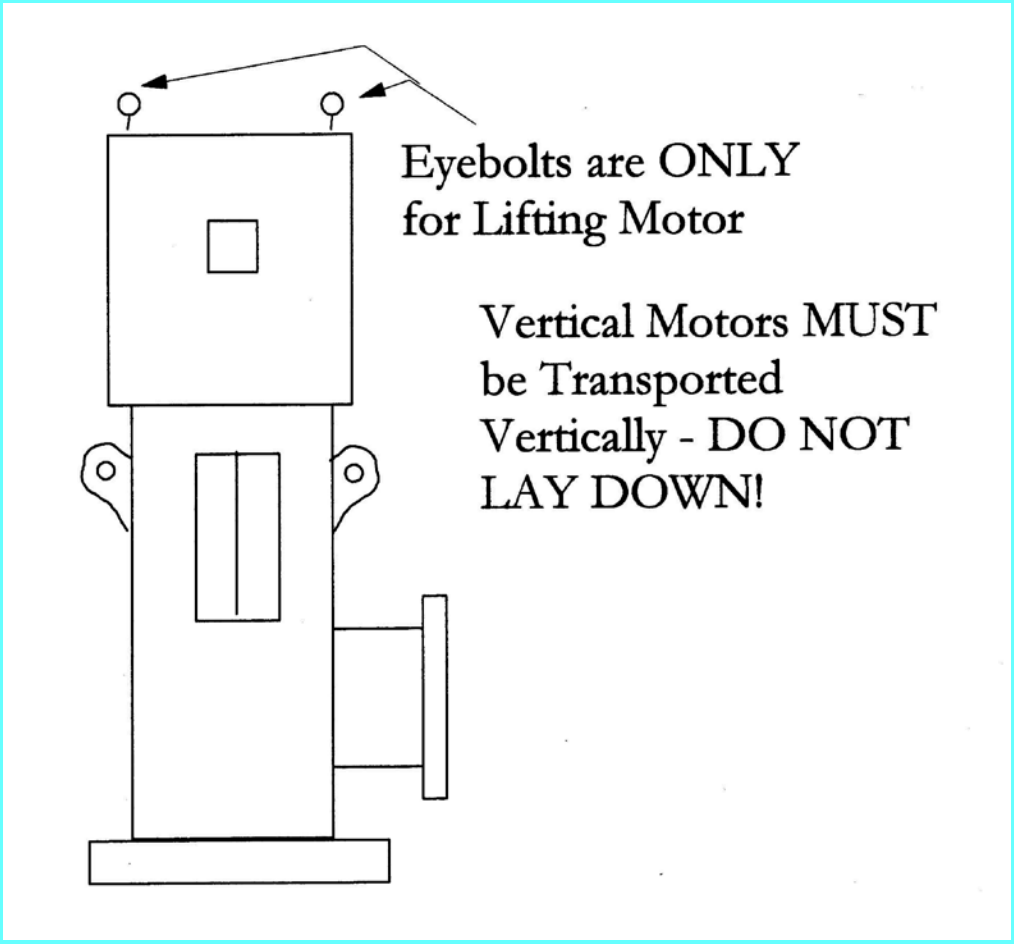
- Laser Accuracy & Printed Reports

Motor Data:
Manufacturer: Baldor M/N: EL3609T S/N: HP: RPM:
Pump Data:
Manufacturer: Aurora M/N: 344A S/N:
Coupling Data:
Manufacturer: Woods Size: 5J Parallel Spec: 0.015 Angular Spec: 0.056

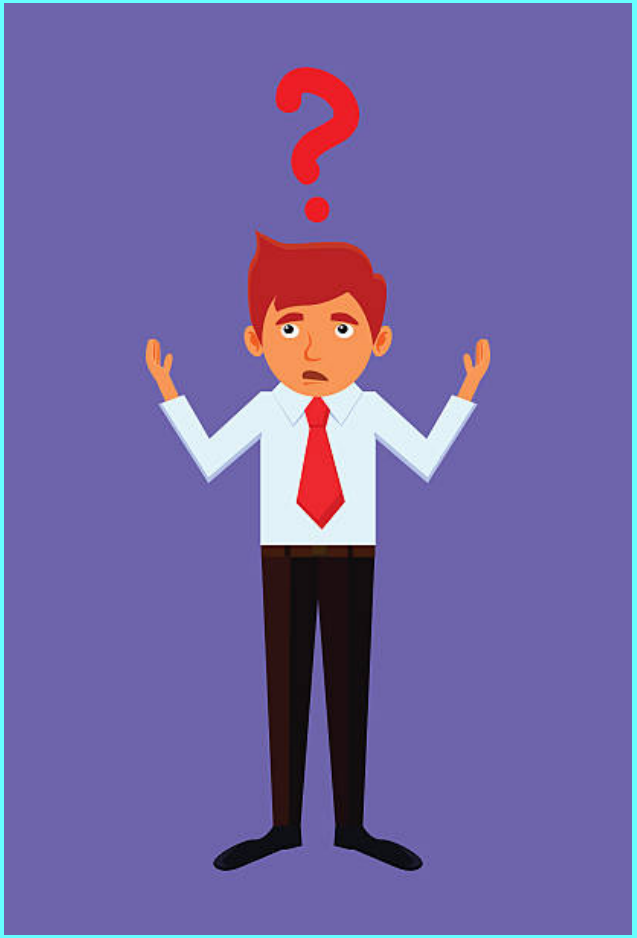


Vertical Parallel Before Adjustment:	0	Vertical Angular Before Adjustment:	15
Horizontal Parallel Before Adjustment:	7	Horizontal Angular Before Adjustment:	20
Vertical Parallel After Adjustment:		Vertical Angular After Adjustment:	
Horizontal Parallel After Adjustment:		Horizontal Angular After Adjustment:	

LIFTING & TRANSPORTING VERTICAL PUMP MOTORS



ANY QUESTIONS?



THANK YOU FOR YOUR TIME AND ATTENTION!

ARVADA PUMP COMPANY
5695 LAMAR ST.
ARVADA, COLORADO 80002

WWW.ARVADAPUMP.COM

PH: 303-424-2664
FAX: 303-424-4058