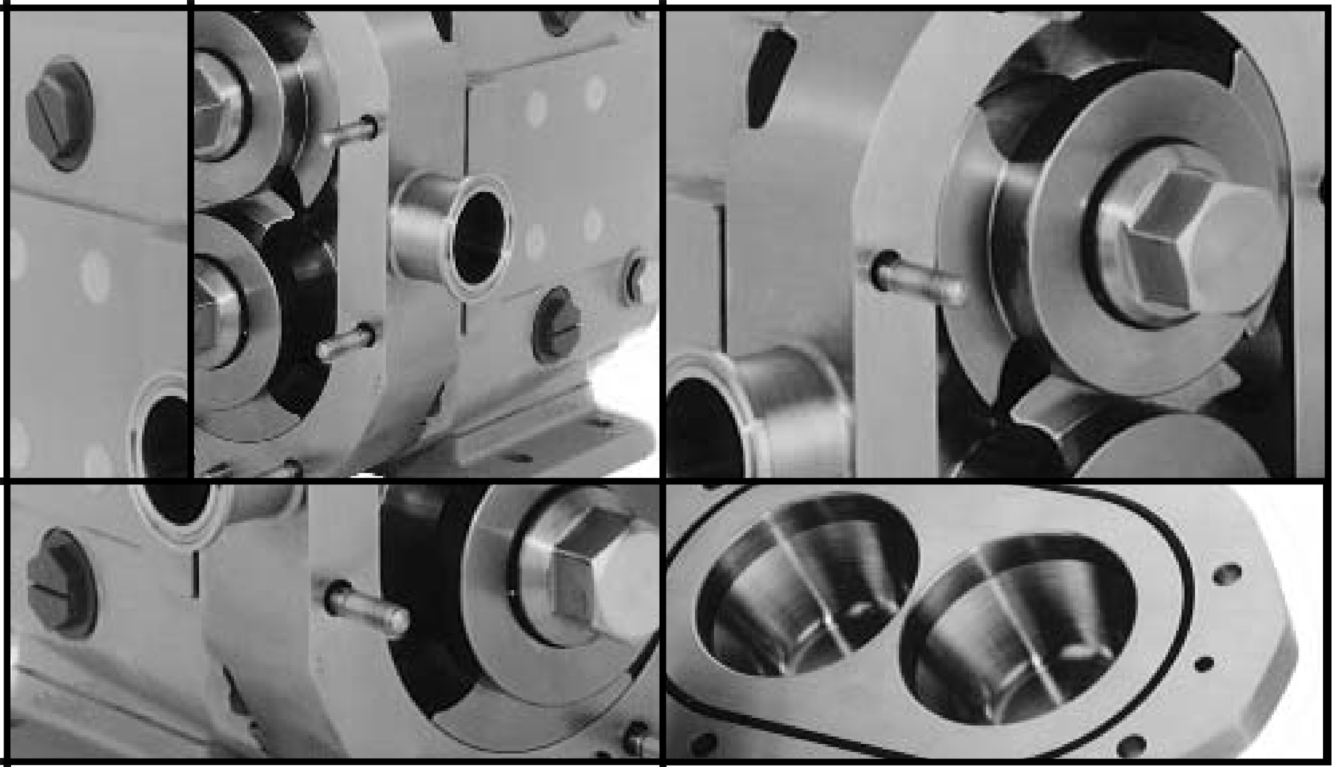
WAUKESHA CHERRY-BURRELL



WAUKESHA PUMPS

ENGINEERING MANUAL

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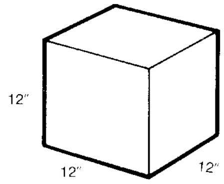
Fluid Fundamentals

Fluids include liquids, gases, and mixtures of liquids, solids, and gases. For the purposes of this manual, the terms **fluid** and **liquid** are used interchangeably to mean pure liquids, or liquids mixed with gases or solids which act essentially as a liquid in a pumping application.

DENSITY, OR SPECIFIC WEIGHT of a fluid is its weight per unit volume, often expressed in units of pounds per cubic foot, or grams per cubic centimeter.

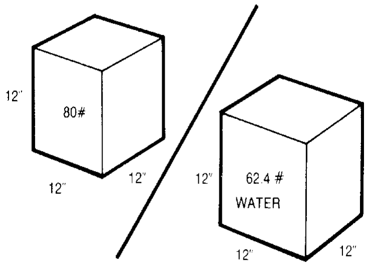
EXAMPLE: If weight is 80#; density is 80#/cu. ft.

The density of a fluid changes with temperature.



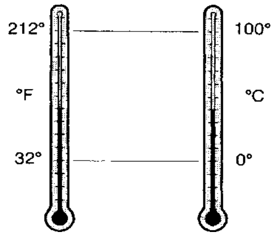
SPECIFIC GRAVITY of a fluid is the ratio of its density to the density of water. As a ratio, it has no units associated with it.

EXAMPLE: Specific gravity is $\frac{80\#}{62.4\#}$ or S.G. = 1.282

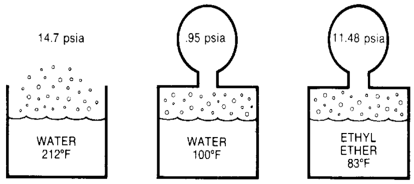


TEMPERATURE is a measure of the internal energy level in a fluid. It is usually measured in units of degrees fahrenheit (°F) or degrees centigrade (°C). The temperature of a fluid at the pump inlet is usually of greatest concern.

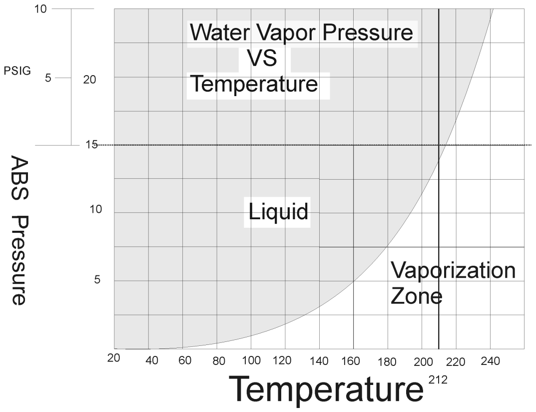
See °F – °C conversion chart on page 130.



VAPOR PRESSURE of a liquid is the absolute pressure (at a given temperature) at which a liquid will change to a vapor. Vapor pressure is best expressed in units of PSI absolute (psia). Each liquid has its own vapor pressure-temperature relationship.



For example: If 100° water is exposed to this reduced absolute pressure of 0.95 psia, it will boil at 100°F.



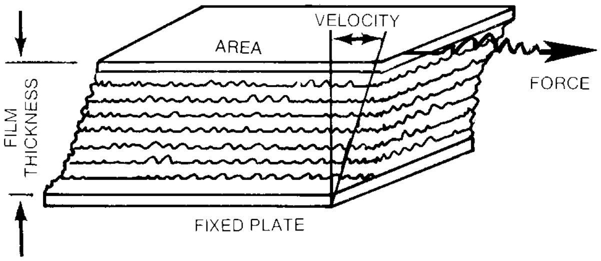
VISCOSITY – The viscosity of a fluid is a measure of its tendency to resist a shearing force. High viscosity fluids require a greater force to shear at a given rate than low viscosity fluids.

$$\text{Viscosity} = \frac{\text{Shear Stress}}{\text{Shear Rate}}$$

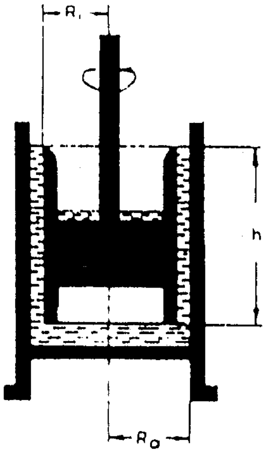
When

$$\text{Shear Stress} = \frac{\text{Force}}{\text{Area}}$$

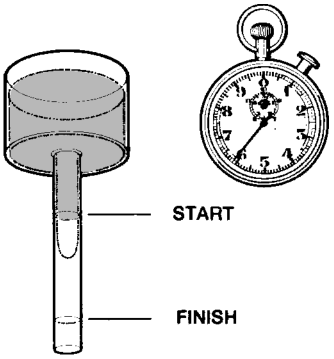
$$\text{Shear Rate} = \frac{\text{Velocity}}{\text{Film Thickness}}$$



The **CENTIPOISE** (CPS) is the most convenient unit of viscosity measurement. This measurement of **absolute** viscosity units (CPS) can be obtained from a type of instrument as shown. This type of instrument measures the force needed to rotate the spindle in the fluid (shear stress) at a known shear rate.



Other units of viscosity measurement such as the centistoke (cks) or Saybolt Second Universal (SSU) are measures of **Kinematic** viscosity where the specific gravity of the fluid influences the viscosity measured. Kinematic viscometers usually use the force of gravity to cause the fluid to flow down a calibrated tube, while timing its flow.



The **absolute viscosity**, measured in units of **cenitpoise** (1/100 of a poise) is used throughout this manual as it is a convenient and consistent unit for calculation. Other units of viscosity can easily be converted to **centipoise**.

Kinematic Viscosity x Specific Gravity = Absolute Viscosity

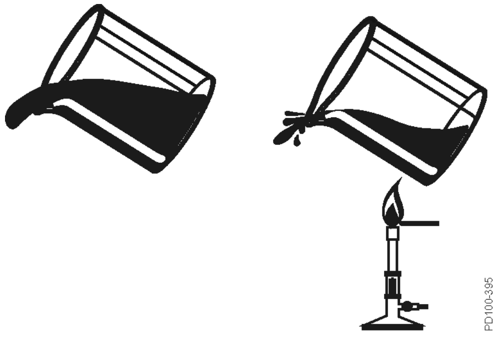
Centistokes x S.G. = Centipoise

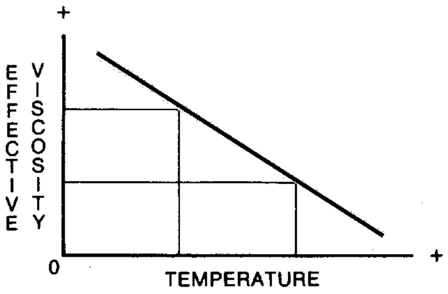
SSU x 0.2158 x S.G. = Centipoise

A conversion chart for viscosity is on 128

Viscosity unfortunately is not a constant, fixed property of a fluid, but is a property which varies with the conditions of the fluid and the system.

In a pumping system, an important factor is the normal decrease in viscosity with **temperature** increase. Another extremely important factor is **viscous fluid behavior**, discussed in the following section.





Viscous Fluid Behavior

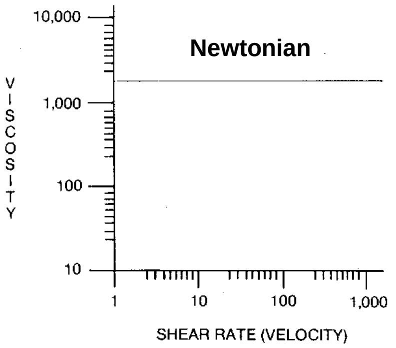
Effective Viscosity is a term describing the real effect of the viscosity of the **actual** fluid, at the **shear rates** which exist in the pump and pumping system at the design conditions.

Type: Constant Viscosity at All Shear Rates

NEWTONIAN FLUIDS Viscosity is **constant** with change in **shear rate** or agitation.

Forces to cause motion increase proportionately as speed increases.

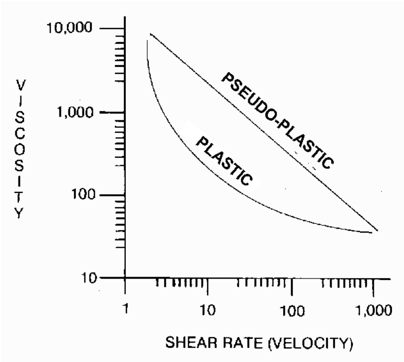
Fluids showing Newtonian behavior include water, mineral oils, syrups, hydrocarbons, resins.



Type: Decreasing Viscosity at Increasing Shear Rates

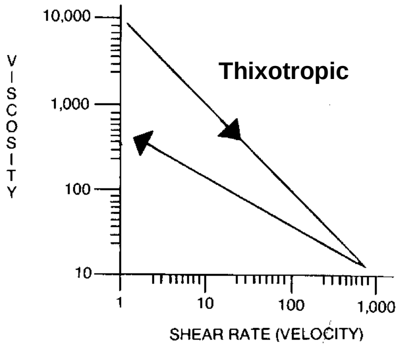
PLASTIC FLUIDS This type of fluid always requires an initial force or stress, which is called the Yield Point, before flow will start. With a Yield Point too high, flow may not start in a normal inlet system to the pump.

PSEUDO-PLASTIC FLUIDS Viscosity **decreases** as **shear rate increases.** At any constant flow rate or shear rate, viscosity stays constant and is independent of time.



THIXOTROPIC FLUIDS Along with the characteristic of the viscosity **decreasing** over a finite time as the **shear rate** is **constant**, Thixotropic flow is also characterized by: having a Yield Point; plastic or pseudoplastic behavior; a tendency to rebuild viscosity or Yield Point on standing.

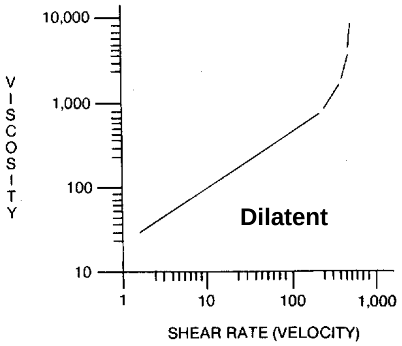
Typical fluids with the above characteristics are paints, inks, caulking compounds, gels, slurry mixes, lotions, shampoo.



Type: Increasing Viscosity at Increasing Shear Rates

DILATENT FLUIDS Viscosity **increases** as **shear rate increases.** This fluid type needs to be pumped at very conservative pump speeds since rotary pumps have areas of high shear which may cause the product to reach a sufficient viscosity to stall the drive or in extreme cases mechanically damage the pump.

Some fluids showing dilatent behavior are high solids concentrations of clays, oxides and granular or crystalline materials.

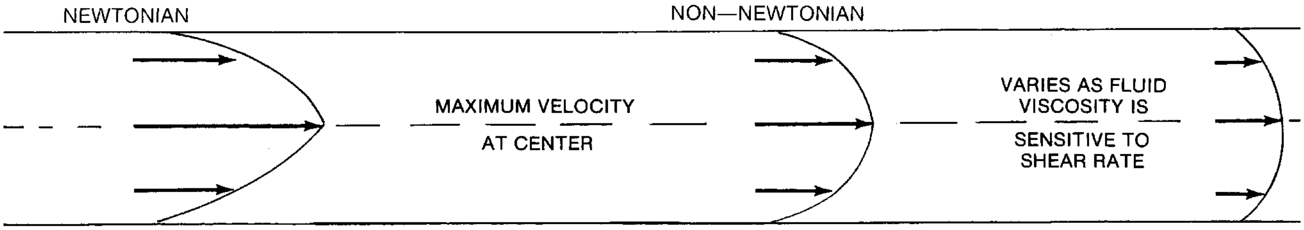


Waukesha Cherry-Burrell has the instrumentation and trained technicians to determine the product characteristics necessary to economically size a pump and assist in determining optimum line sizing for a pumping system.

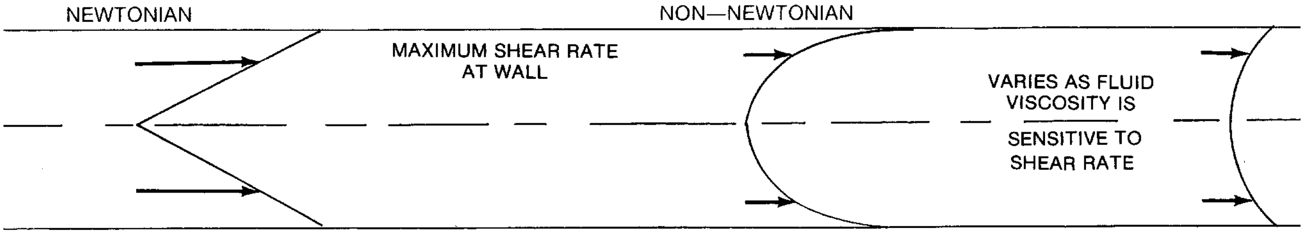
For a Newtonian fluid, the shear rate varies linerally from a maximum at the tube wall to zero at the center. In practice, a very high percentage of fluids pumped are non-Newtonian.

Plastic and pseudo-plastic types which include Thixotropic fluids have higher shear rates near the tube wall. Dilatent types have lower shear rates near tube wall.

Velocity Profile



Shear Rate Profile



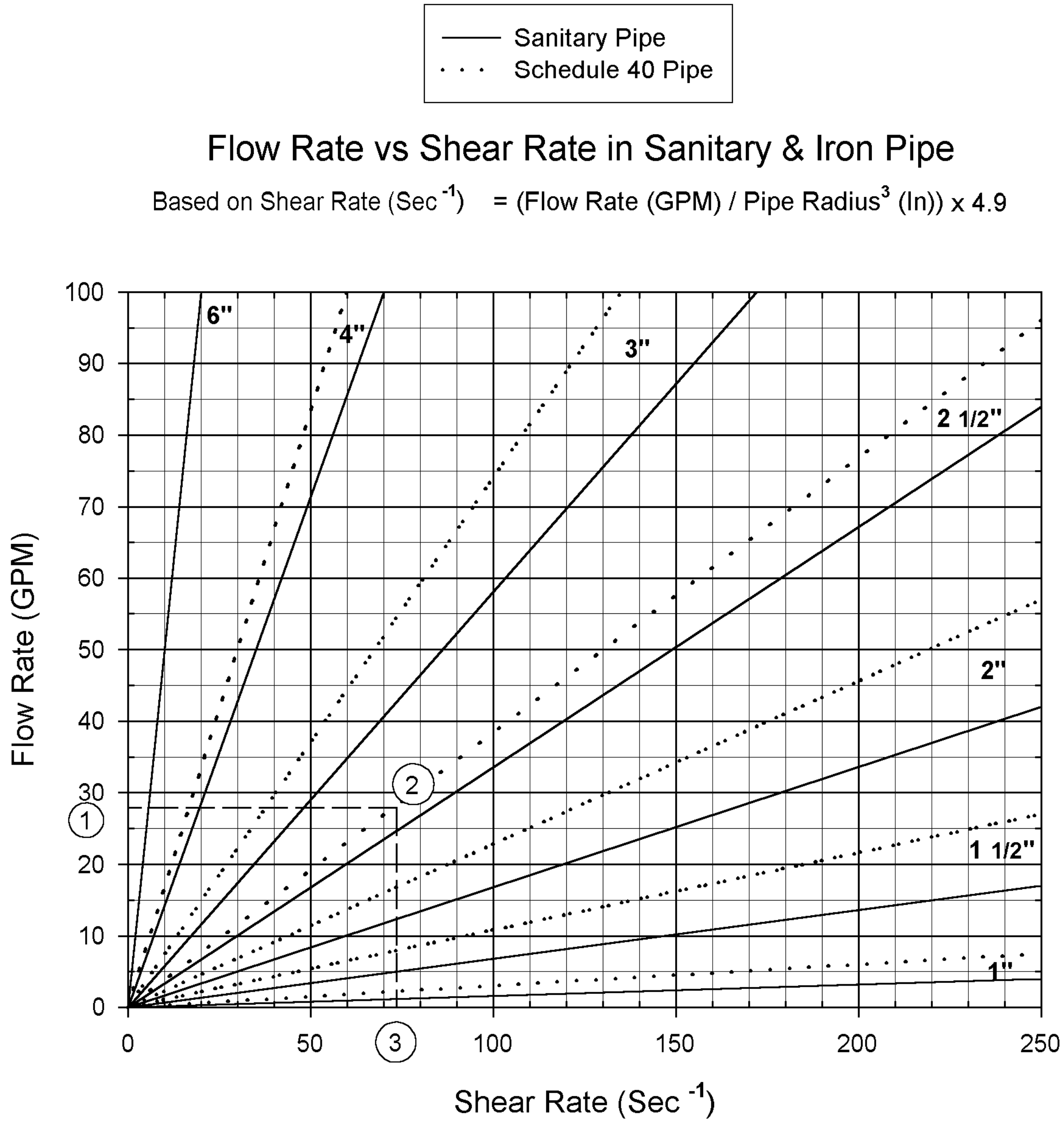
Establishing an exact shear rate on these non-Newtonian fluids is very complex and requires very specialized equipment.

The most accurate method of determining pressure drop in a pipe system and pump performance is to run the product in a pilot circuit of existing operating system, recording pressure drop through a linear length of line, pipe I.D., and flow rate. From this data, the viscosity can be determined by using the graph on 133.

When an operational test is not practical, a viscosity/shear rate relationship can be established using a properly designed viscosity instrument.

If we assume a shear rate as though it were a Newtonian fluid and use this shear rate to determine an effective viscosity, the resulting pressure drop determined in a piping system and pump power requirements will be adequate.

Flow Rate vs Shear Rate

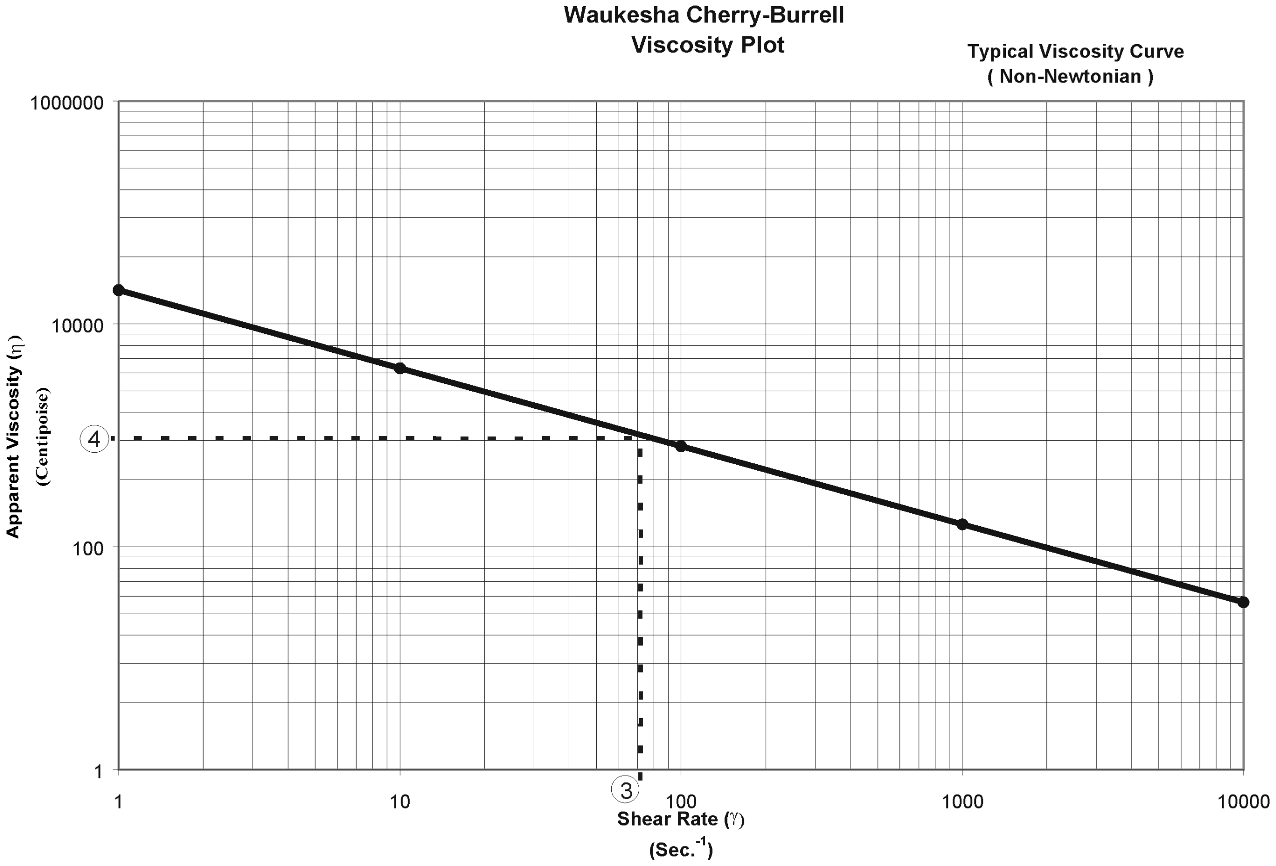


1. From a known flow rate
2. At a selected line size
3. Will establish a shear rate
4. The effective Viscosity 4 is found using this Shear Rate 3 on the Viscosity Profile Curve obtained from a viscometer (see example on page 8).

NOTE: Schedule 40 pipe will change shear rate considerably.

Viscosity Profile Curve

Typical Effective Viscosity vs Shear Rate Curve
Non-Newtonian



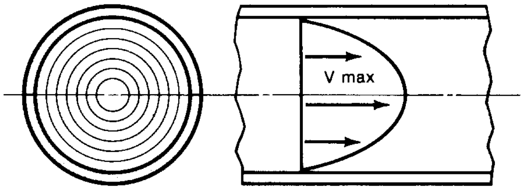
Calculating shear rate in a non-Newtonian fluid moving in a tube is complex. For a Newtonian fluid, the shear rate varies linearly from a maximum at the tube wall to zero at the center. In practice a very high percentage of fluids pumped are non-Newtonian. Plastic and pseudo-plastic types including Thixotropic fluids have higher shear rates near the wall and dilatent types have lower shear rates near the wall.

Frictional Losses

The nature of frictional losses in a pumping system can be very complex. Losses in the pump itself are determined by actual test, and are allowed for in the manufacturers' curves and data. Similarly, manufacturers of processing equipment, heat exchangers, static mixers etc. usually have data available for friction losses.

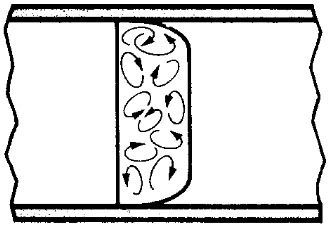
Frictional losses due to flow in pipes are commonly considered to occur in two principle modes: losses under **laminar flow** and losses under **turbulent flow**.

In **laminar** flow, sometimes called **viscous** flow, the fluid moves through the pipe in concentric layers with maximum velocity in the center of the pipe, decreasing toward the walls where the fluid particle is essentially standing still. A cross section of velocity would appear as shown at right. There is very little mixing of fluid across the pipe cross section. Friction loss is directly proportional to:



- the length of the pipe
- the flow rate
- 1/d^4 (d is pipe diameter)
- viscosity (centipoise)

In **turbulent flow**, considerable mixing takes place across the pipe cross section and the velocity is nearly the same across the section, as shown at right.



Turbulent flow is more likely to occur in **thin liquids**, and is often characterized by higher friction losses than would be expected. Friction loss is directly proportional to:

- the length of the pipe
- the flow rate squared (Q^2)
- 1/d^5 (d is pipe diameter)
- viscosity (to 1/4 to 1/10 power)

There is a range between laminar and turbulent flow, sometimes called **mixed flow**, where conditions are unpredictable and have a blend of each characteristic.

A convenient number, called the **Reynolds number**, can be used for estimating the transition between laminar and turbulent flow. The Reynolds number, a ratio of flow rate to viscosity, can be computed by the relation:

$$R = 3,160 \times \frac{Q \times S.G.}{d \times \mu}$$

where:

R = Reynolds Number

Q = Flow rate in gallons per minute

d = Internal diameter of pipe in inches

μ = Absolute (dynamic) viscosity in centipoise

S.G. = Specific Gravity of liquid relative to water at standard temperature (60°F).

For engineering purposes flow is:

Laminar — if R is less than 2,000

Turbulent — if R is greater than 4,000

Mixed — if R is between 2,000 and 4,000

In the mixed flow range, assuming turbulent flow for friction loss calculations gives a higher value which results in a margin of safety.

Computation of friction loss is very difficult using these and other relationships. Pipe friction tables have been established by the Hydraulic Institute and many other sources which can be used to compute the friction loss in a system for given flow rates, viscosities and pipe sizes.

Tables of equivalent lengths for fittings and valves are also available.

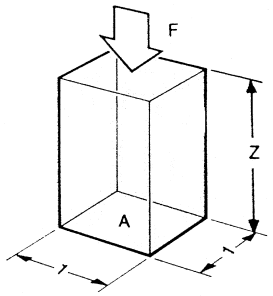
See page 131 in this manual.

Dilatent and Thixotropic fluids can materially change friction loss calculations. **The effective viscosity at actual pumping rates must be determined for accurate calculations.** Usually this can only be determined by test. Pages 126 and 127 show effective viscosities for some fluids. Consult Waukesha Cherry-Burrell for additional information or for determining the effective viscosity of your fluid.

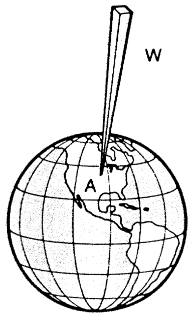
Basic Definitions and Hydraulic Fundamentals

PRESSURE – The basic definition of pressure is force per unit area. As commonly used in hydraulics and in this manual, it is expressed in pounds per square inch **(PSI)**.

$$P = \frac{F}{A}$$

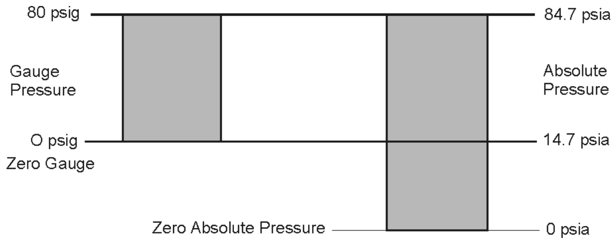


ATMOSPHERIC PRESSURE is the force exerted on a unit area by the weight of the atmosphere. At sea level, the atmospheric standard pressure is 14.7 pounds per square inch.

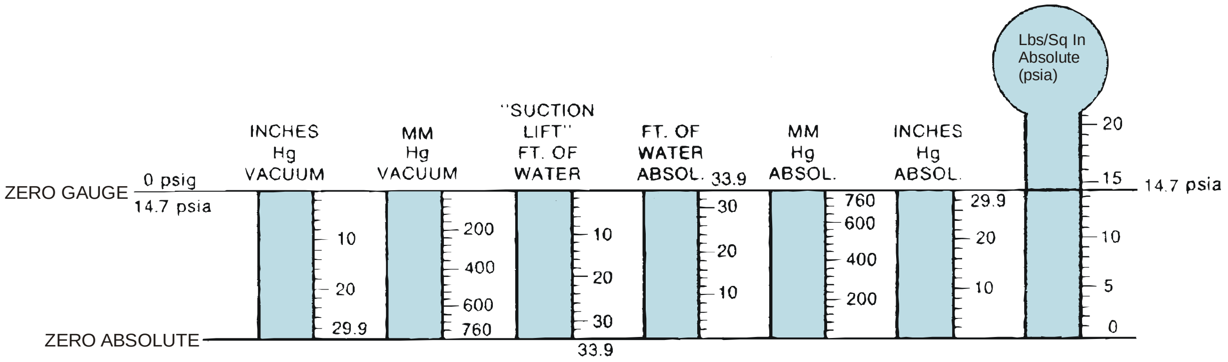


GAUGE PRESSURE – Using atmospheric pressure as a **zero reference**, gauge pressure is a measure of the force per unit area exerted by a fluid. Units are **psig**.

ABSOLUTE PRESSURE is the total force per unit area exerted by a fluid. It equals atmospheric pressure plus gauge pressure. Units are expressed in **psia**.



VACUUM OR SUCTION are terms in common usage to indicate pressures in a pumping system below normal atmospheric pressure, and are often measured as the difference between the measured pressure and atmospheric pressure in units of inches of mercury vacuum, etc. **It is more convenient to discuss these in *absolute* terms; that is from a reference of absolute zero pressure, in units of psia.**

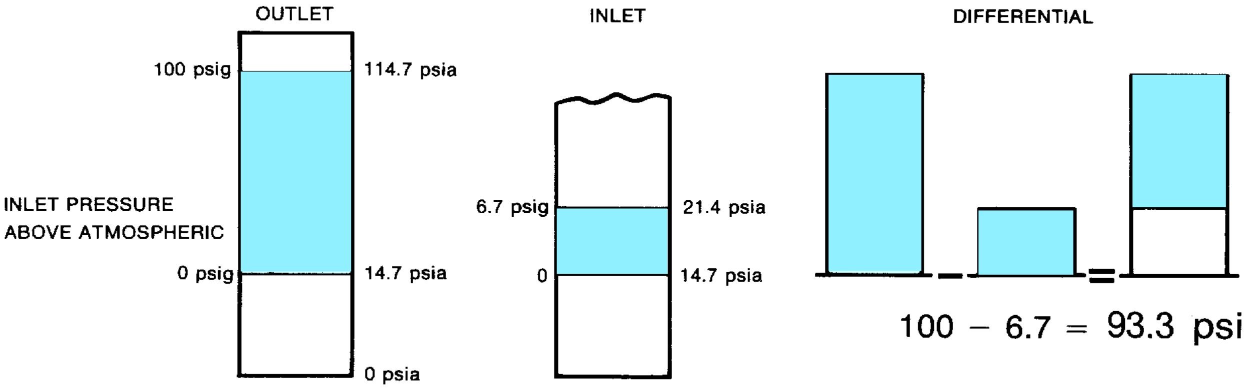


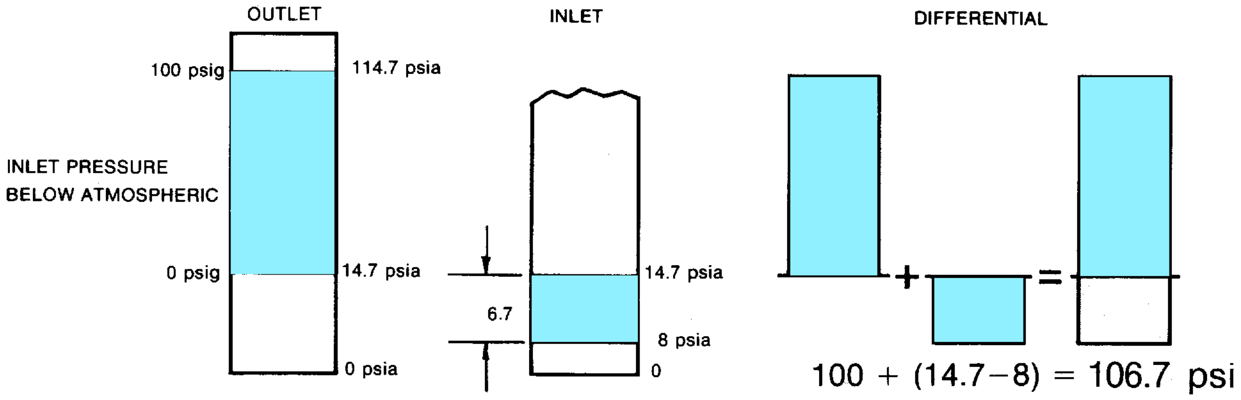
OUTLET PRESSURE or discharge pressure is the average pressure at the outlet of a pump during operation, usually expressed as gauge pressure **(psig)**.

INLET PRESSURE is the average pressure measured near the inlet port of a pump during operation. It is expressed **either** in units of absolute pressure **(psia)** preferably, or gauge pressure **(psig)**.

DIFFERENTIAL PRESSURE is the total absolute pressure difference across the pump during operation.

Examples:



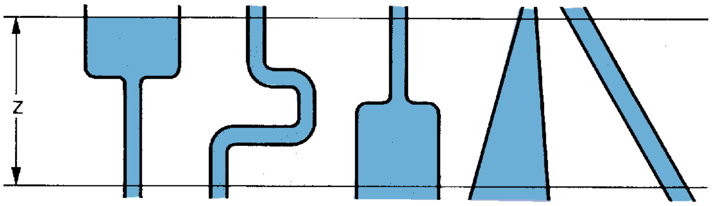


Relation of Pressure to Elevation

In a static liquid (a body of liquid at rest) the pressure difference between any two points is in direct proportion **only** to the **vertical** distance between the points.

This pressure difference is due to the weight of the liquid and can be calculated by multiplying the vertical distance by the density (or vertical distance x density of water x specific gravity of the fluid). In commonly used units:

$$\text{P static (in PSI)} = \text{Z (in feet)} \times \frac{(62.4 \text{ lbs./cu. ft.}) \times \text{S.G.}}{144 \text{ sq. in./sq. ft.}}$$

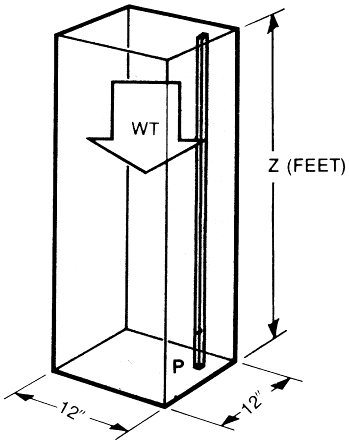


EXAMPLE: Calculate pressure difference between two points — vertical distance 18' specific gravity 1.23.

$$P = Z \times \frac{62.4}{144} \times \text{S.G.}$$

$$P = 18 \times 0.433 \times 1.23$$

$$P = 9.59 \text{ PSI}$$



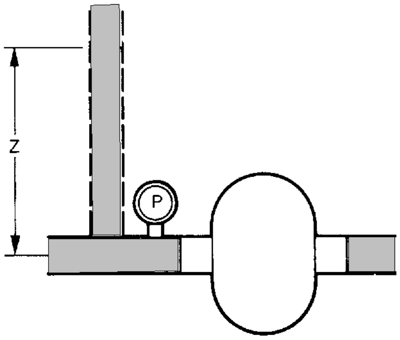
To obtain pressure in elevation units the equation is rearranged:

$$\text{Z (feet)} = \frac{\text{P static (PSI)}}{(62.4 \text{ lbs./cu. ft.}) \times \text{S.G.}} \times 144 \text{ sq. in./sq. ft.}$$

EXAMPLE: A pressure gauge reads 85 PSI. The fluid has a specific gravity of 0.95. What is the height of the equivalent column of fluid that would produce that same pressure.

$$Z = \frac{P}{62.4 \times \text{S.G.}} \times 144$$

$$Z = \frac{85 \times 144}{62.4 \times 0.95} = 206.5 \text{ ft.}$$



This relationship, the elevation equivalent of pressure, is commonly called **HEAD** and is still frequently used. Although this manual uses pressure units, it may be helpful to explain certain terms in head units: that is, pressure converted to the equivalent height of fluid that would produce that pressure.

Static Head – The hydraulic pressure at a point in a fluid when the liquid is at rest.

Friction Head – The loss in pressure or energy due to frictional losses in flow.

Velocity Head – The energy in a fluid due to its velocity, expressed as a head unit.

Pressure Head – A pressure measured in equivalent head units.

Discharge Head – The outlet pressure of a pump in operation.

Total Head – The total pressure difference between the inlet and outlet of a pump in operation.

Suction Head – The inlet pressure of a pump when above atmospheric.

Suction Lift – The inlet pressure of a pump when below atmospheric.

These terms are sometimes used to express different conditions in a pumping system, and can be given dimensions of either pressure units **(PSI)** or head units **(feet)**.

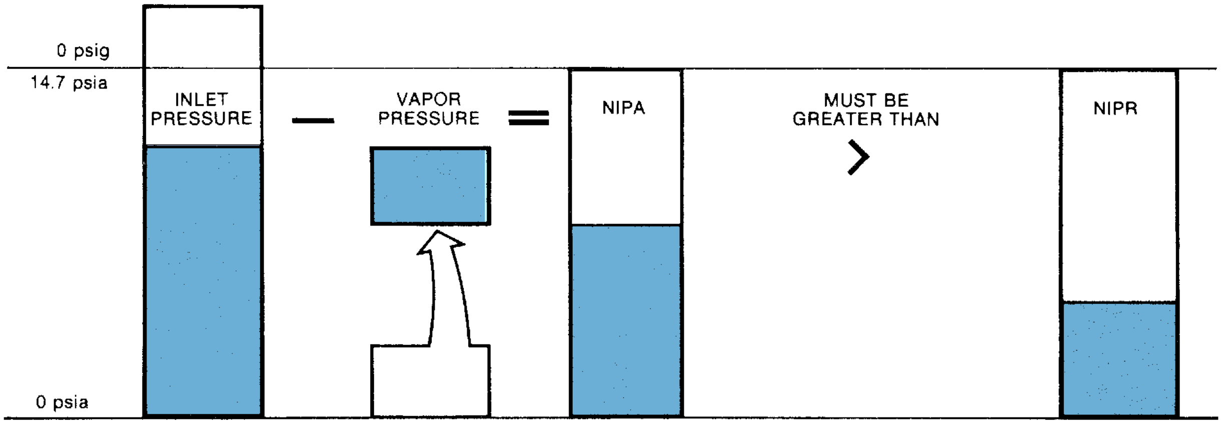
In rotary pump usage, and throughout this manual, *pressure units*, and the terms such as inlet pressure and outlet pressure, will be used, as they represent a consistent, simple way of describing pumping conditions.

Net Positive Suction Head

A common term used to describe pump inlet conditions is **Net Positive Suction Head (NPSH)**. Although still used in centrifugal pump terminology, two new terms are now used for rotary pump inlets.

Net Inlet Pressure Available (NIPA) is the average pressure (in **psia**) measured near the inlet port during operation, **minus** the vapor pressure. It indicates the amount of useful pressure energy available to fill the pump cavities.

Net Inlet Pressure Required (NIPR) is an individual pump characteristic, determined by test, of what pressure energy (in **psia**) is needed to fill the pump inlet. It is a characteristic which varies primarily with the pump speed and the viscosity of the fluid. For satisfactory operation under any set of conditions, the **NIP Available** must be **greater** than the **NIP Required**.



The terms NIPR and NIPA have been accepted and used for many years. Most PD pump users are familiar with these terms, and we will use them throughout this manual. However, it is worth noting that these terms were originally defined in the standards of the Hydraulic Institute. The Hydraulic Institute issued a significant revision to the standards in 1994. This new standard is also an ANSI standard, and is titled:

American National Standards for
Rotary Pumps
for Nomenclature, Definitions,
Application and Operation

The revised terms are as follows:

Net Positive Inlet Pressure Available (NPIPA). Net Positive Inlet Pressure Available is the algebraic sum of the inlet pressure of the liquid at the inlet temperature:

$NPIPA = p_s + p_b - p_{vb}$

Net Positive Inlet Pressure Required (NPIPR). Net Positive Inlet Pressure Required is the pressure required, above liquid vapor pressure, to fill each pumping chamber or cavity while open to the inlet chamber. It is expressed in PSI (kPa).

For purposes of this manual, the new and the old terms can be used interchangeably.

Flow of Fluid in a Pumping System

Fluids at rest, or in motion, must conform to the principle of “conservation of energy”.

In the following:

W = Weight of fluid

V = Velocity

g = Acceleration of gravity

P = Pressure

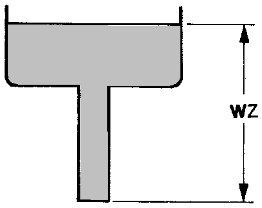
w = Weight per unit volume

Z = Height

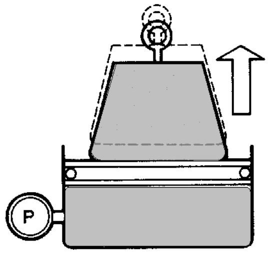
Fluid Energy

The types of fluid energy in a pumping system are:

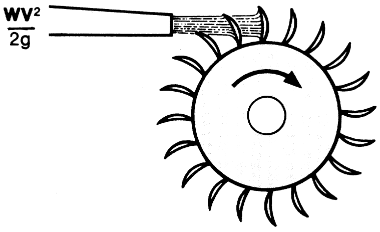
POTENTIAL ENERGY – Energy due to the elevation of the fluid above some reference level.



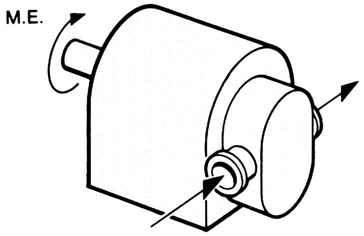
PRESSURE ENERGY – The internal energy of the fluid which could do work.



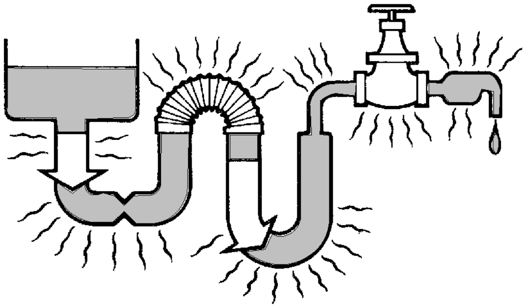
KINETIC ENERGY – Energy due to the motion of the fluid.



MECHANICAL ENERGY – Energy put into the fluid by a pump, or taken out by a motor, or other device.



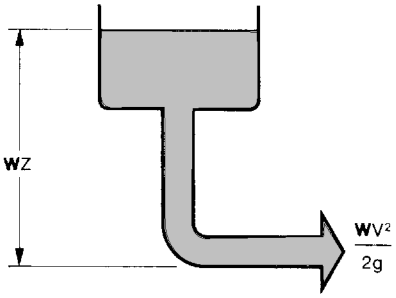
FRICTIONAL LOSSES – Represents the energy loss due to friction when a fluid flows through the parts of a system.



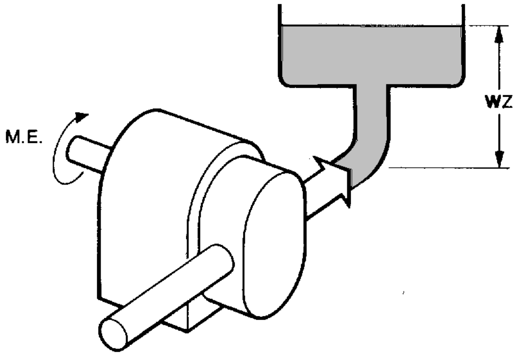
Energy Types and Losses

These forms of energy can be changed from one form to another within the system. For example:

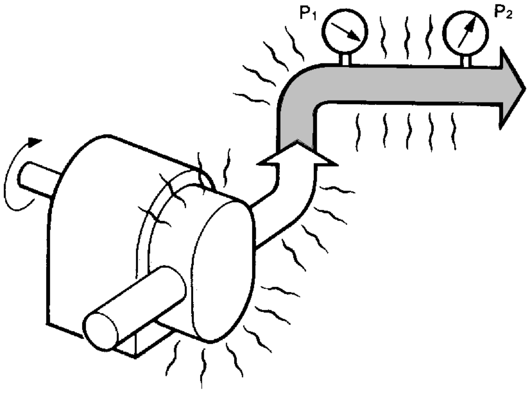
The **potential energy** of fluid in an elevated tank is changed to **kinetic energy** as it flows down through piping system.



Mechanical energy, added by a pump can be changed to **potential energy** by pumping fluid to a higher elevation.



Potential, Pressure, Mechanical, or Kinetic energy can be changed to **heat energy** through frictional losses. This energy loss is often seen as a change in pressure energy.



NOTE: The energy in a system is *conserved*, not created or destroyed but merely changed in form.

For part of a pumping system where energy is not added or removed, the total energy (E) is constant and equal to:

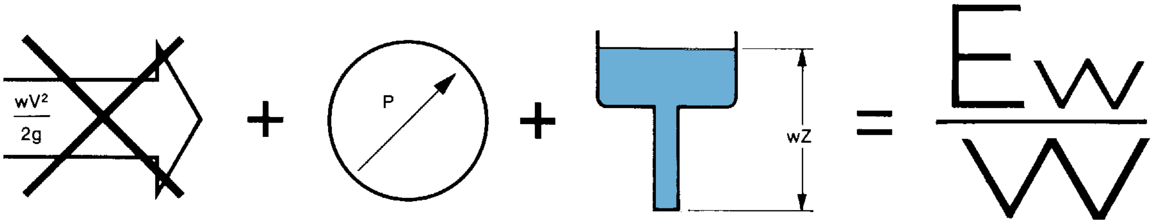
$$\frac{\mathbf{WV}^2}{2g}\begin{pmatrix}\text{Kinetic}\\ \text{Energy}\end{pmatrix} + \frac{\mathbf{WP}}{w}\begin{pmatrix}\text{Pressure}\\ \text{Energy}\end{pmatrix} + \mathbf{WZ}\begin{pmatrix}\text{Potential}\\ \text{Energy}\end{pmatrix} = E$$

If the equation is divided by W (weight) and multiplied by w (weight per unit volume) it becomes:

$$\frac{wV^2}{2g} + P + wZ = \frac{Ew}{W}\ (\text{Constant})$$

in which each term represents energy per unit volume and each has the dimension of pressure.

In a rotary pump system, the kinetic energy of the fluid is usually small in relation to other forms and is often left out.



It is then very handy to consider these energy levels in terms of **PRESSURE**, as most measurements can be easily made with pressure gauges.

For the simple steady-state system, the energy relationship is:

$$P + wZ = \frac{Ew}{W}$$

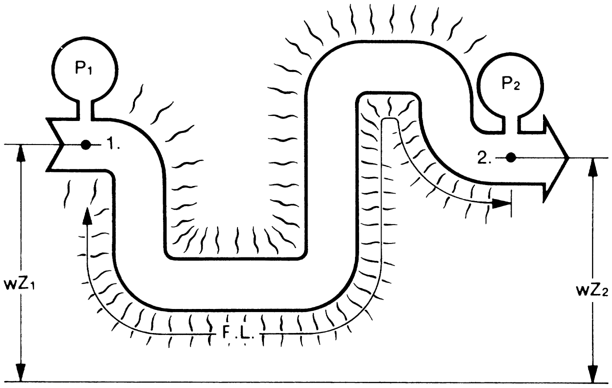
When we consider the frictional losses in flow from one point to another, the relationship takes the form:

$$\mathbf{P_1 + wZ_1 = P_2 + wZ_2 + FL}$$

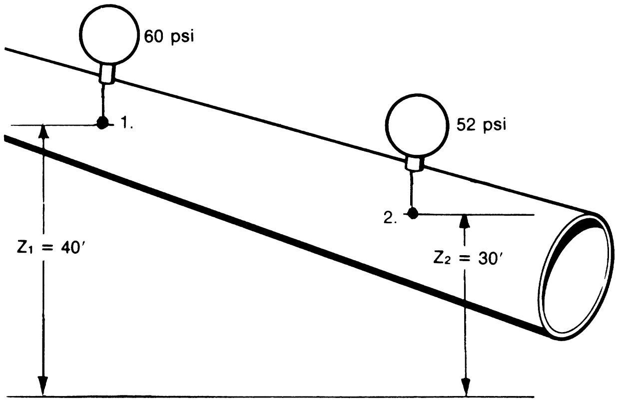
Where FL is the pressure loss due to friction of the fluid flowing from point 1 to point 2. This is the form that pressure calculations will take in this manual.

As shown before, the units are made consistent by using P in units of PSI, and by converting wZ to PSI by:

$$Z\ (\text{feet}) \times \frac{62.4}{144} \times \text{S.G. or: } Z \times 0.433 \times \text{S.G.}$$



EXAMPLE: What is the pipe friction loss or pressure loss from 1 to 2?



Specific Gravity = 1.2

P_1 = 60 psig

P_2 = 52 psig

$P_1 + wZ_1 = P_2 + wZ_2 + FL$

$60 + (0.433 \times S.G.)(Z_1) = 52 + (0.433 \times S.G.)(Z_2) + FL$

$60 + (0.433 \times 1.2)(40') = 52 + (0.433 \times 1.2)(30') + FL$

$60 + 20.78 = 52 + 15.59 + FL$

$FL = (60 + 20.78) - (52 + 15.59)$

$FL = 80.78 - 67.59$

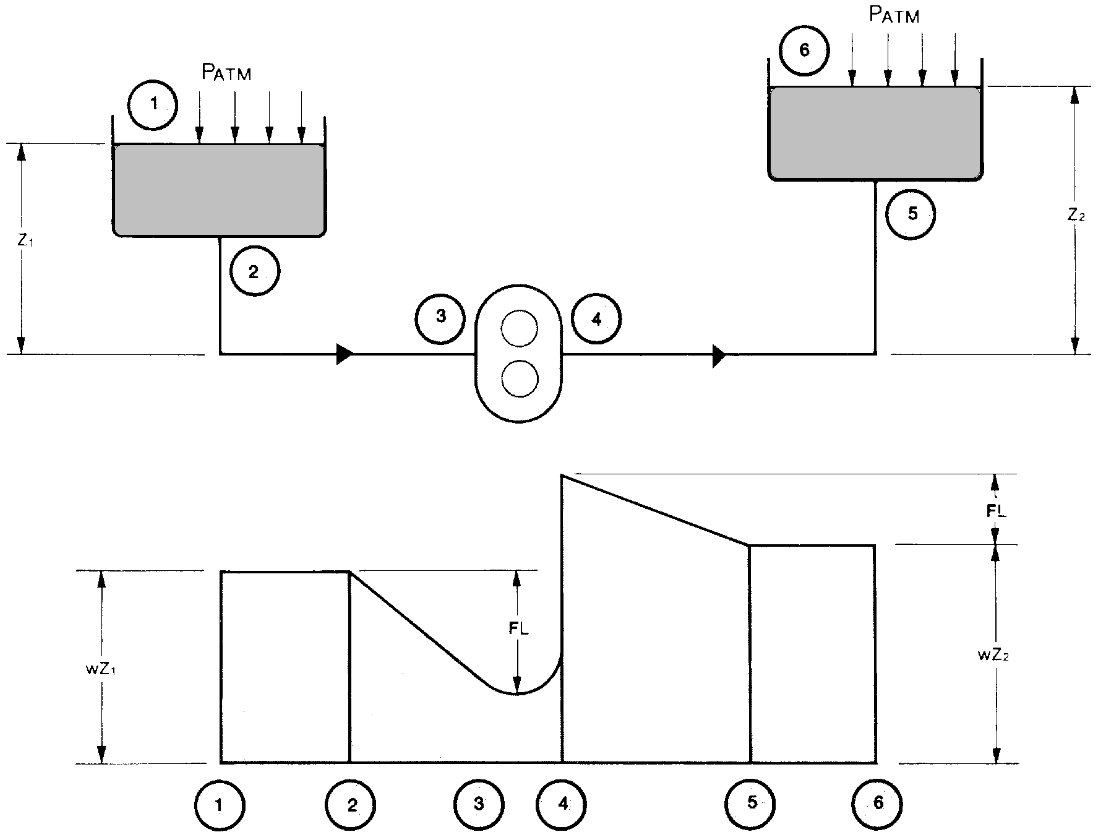
FL = 13.19 PSI

Energy Levels in a Pumping System

Using the fact that energy can change form in a system, we can look at several simple pumping systems, and at a useful type of energy level graph. The energy level graph can be used to help understand system calculations, and to help identify potential problems in a pumping system.

Open Systems

In the system below, points 1 through 6 in a system are identified. Below it the **energy gradient** line follows the fluid flow through the system.



1-2 Potential energy (wZ_1) changes to pressure energy; very small frictional loss because tank area is large.

2-3 Potential energy changing to pressure energy but with loss of pressure energy due to frictional losses (FL).

3-4 Internal pump frictional losses — then rise in pressure energy as mechanical energy is added by pump.

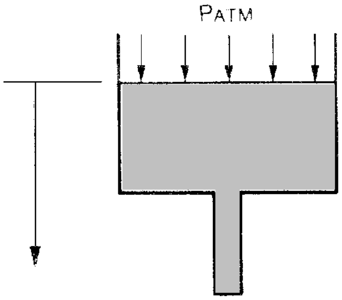
4-5 Pressure energy changing to potential energy but with loss of pressure energy due to frictional losses (FL).

5-6 Pressure energy changing to potential energy (wZ_2) — very small frictional loss.

It should be noted here that **the pump adds only enough energy to fulfill the system requirements**; that is, take the fluid at its inlet, increase its pressure sufficiently to raise it to the higher elevation and to overcome the pipe friction losses.

In this last example, the system can be called an **open system**, where at one or more points the fluid is **open** to atmospheric pressure.

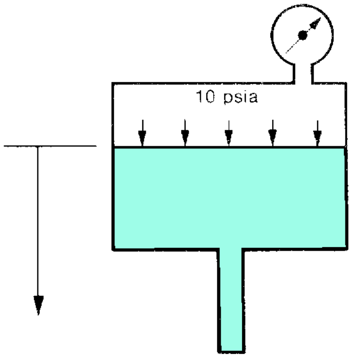
It is usually easiest to use a **free surface** (the liquid level exposed to the atmosphere) as a beginning point in calculations, because the pressure there is known and constant.



Closed Systems

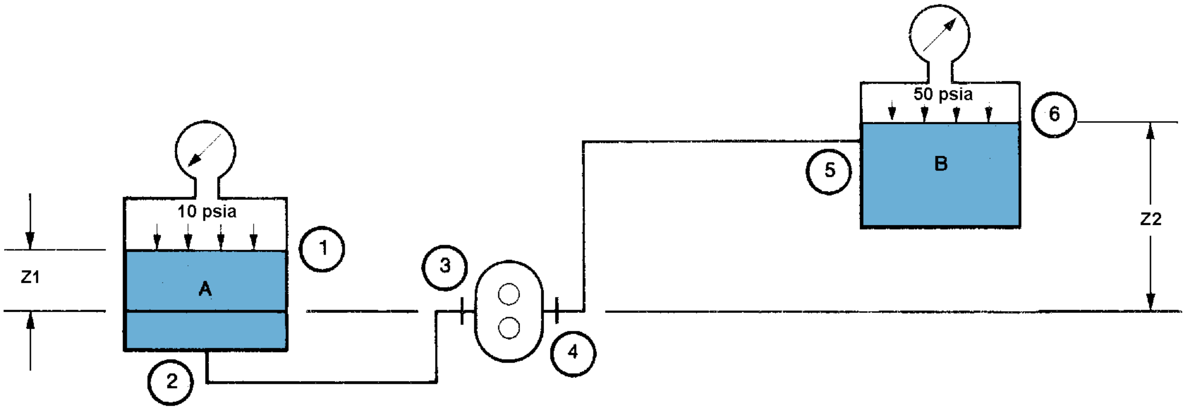
In a **closed system**, a free surface can be used as a reference, if the pressure is known.

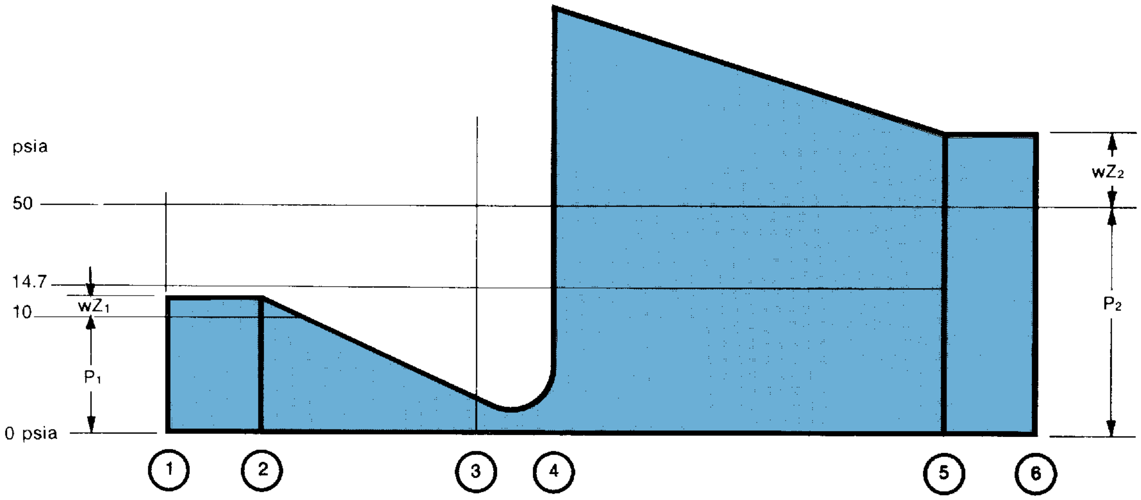
The method of analyzing energy levels in a closed system is similar.



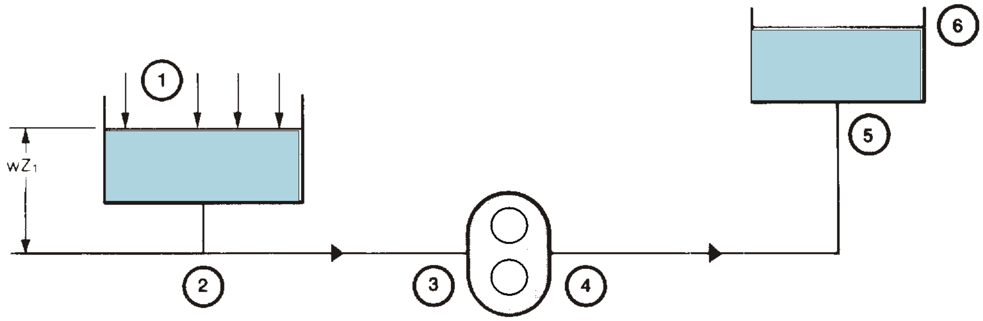
In the following example we assume that tank A has a pressure on the free surface less than atmospheric, P_1 = 10 psia, and the fluid in tank B has a free surface pressure of 50 psia. These are conditions that often can be found in processing equipment.

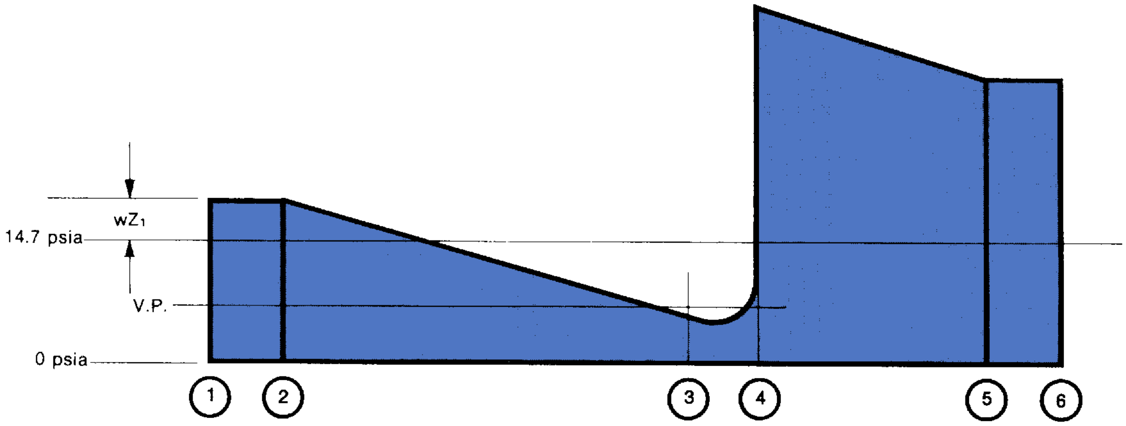
The energy gradient principles are the same, as are calculations. The inlet portion of the system is analyzed starting with the free surface pressure, the outlet portion calculated ending with the free surface pressure. The pump input must provide the difference required from its inlet to its outlet.





Below we show a pumping system with a low potential energy level (wZ_1) at the inlet. With high frictional losses to the pump inlet, the energy available to fill the pump may become **critically** low.





At point 1 or 2, the atmospheric pressure plus the potential energy due to elevation provide the only energy available to get the fluid into the pump. If the friction loss is great in the inlet line, the pressure at the inlet (3) may fall below the liquid vapor pressure. Reduced flow or no flow will occur as the liquid flashes into vapor.

The term **flooded suction** is sometimes used to describe the condition where a fluid level is above the pump inlet.

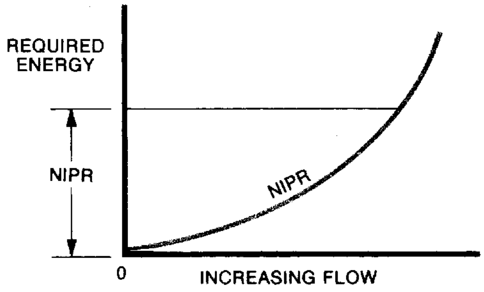
The fluid level **does not** ensure flow into the pump; the **energy available** at the inlet port must be high enough to overcome frictional losses and maintain a margin over the liquid vapor pressure.

The Inlet Side

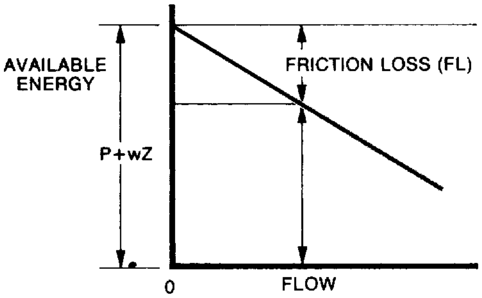
NOTE: The energy *available* to push a fluid into the pump inlet is usually very limited, often less than the 14.7 psia *atmospheric* pressure on the free surface of the fluid. This fact makes the inlet side in a pump installation the *critical* part of pump selection.

The energy **required** by a pump, called **Net Inlet Pressure Required (NIPR)**, is characteristic of the pump, and varies primarily with the pump speed and the fluid viscosity.

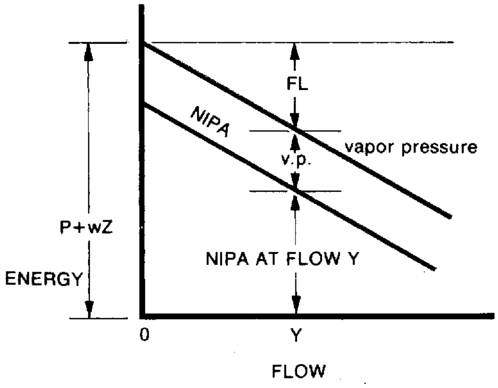
With a given fluid viscosity, the energy graph of a pump would appear as shown, with the NIPR increasing as flow increases.



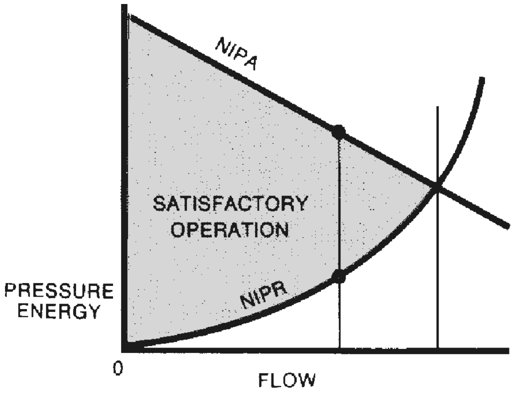
In a typical pumping system, the graph for energy **available** at the pump inlet would appear as shown. As flow increases, the friction loss increases — thus **reducing** the energy available.



From the previous energy graph, the **vapor pressure** of the fluid must be subtracted — because the vapor pressure represents the pressure energy needed to keep the fluid as a fluid — **the energy level left is NIPA**. A graph of energy available to fill the pump at any flow rate can be plotted as shown.

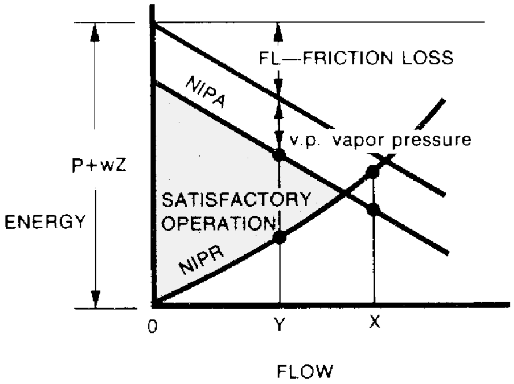


Combining the graph of NIPA and NIPR, we have the result as shown.

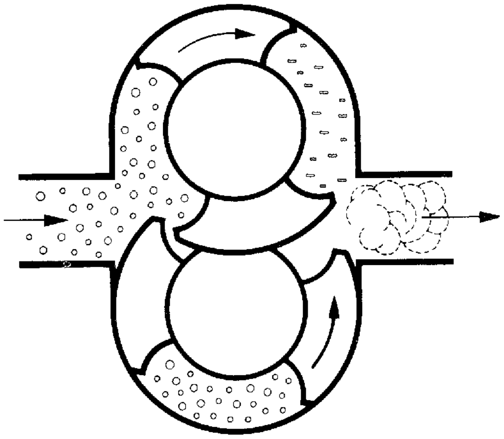


NOTE: NIPA must be greater than NIPR to enable satisfactory operation.

The total graph of system energy and losses would appear as shown, plotted against increasing flow.

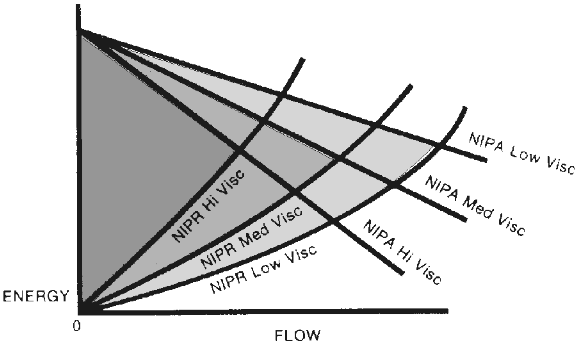


If the NIPA is too low for a specific pumping condition, as at Point X above, the pressure at a point in the pump, or near its inlet, will become lower than the vapor pressure of the fluid. The fluid will vaporize, or change to a gas, which will fill the pump cavities instead of fluid. This will reduce the pumping capacity of the pump. The collapse of this vapor in the pump or outlet line is called cavitation and is the cause of noisy, inefficient operation, often resulting in pump damage.



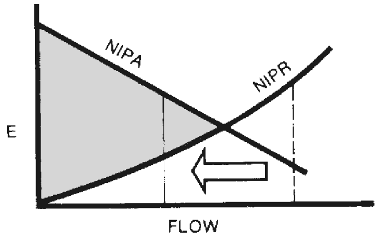
As fluid viscosity increases, the effect can be seen on both NIPA and NIPR. Friction losses increase in direct proportion to absolute viscosity, thus lowering NIPA.

The NIPR of the pump also increases, and they both act to rapidly decrease the zone of satisfactory operation. It is usually necessary to reduce pump speeds to pump viscous liquids.

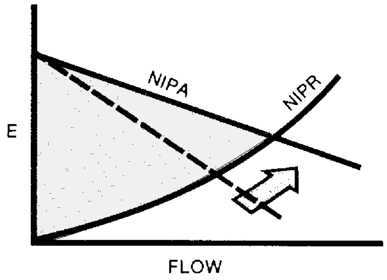


The system characteristics can be changed to assure operation in the satisfactory zone. With these physical changes, the NIPA or NIPR lines can be shifted to expand the zone of operation — to avoid cavitation or pump “starvation” and assure that NIPA is greater than NIPR.

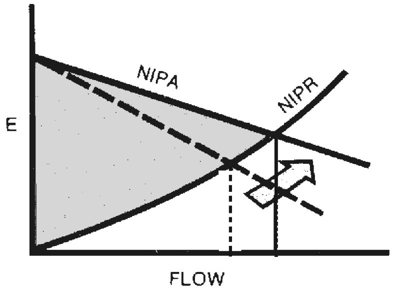
Slow Down the Speed of the Pump (Decrease Flow).



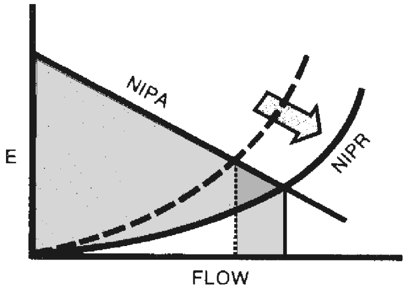
Increase Inlet Line Size.



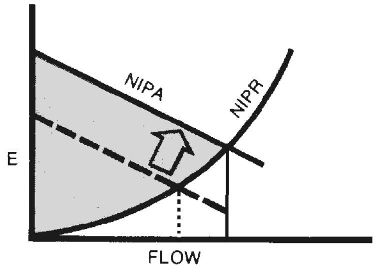
Shorten Inlet Line Length.
Minimize Direction and Size Changes.
Reduce Number of Fittings.



Increase Pump Size for Given Flow (This Lowers NIPR).



Elevate Liquid Source — OR —
Lower Pump — OR —
Pressurize Source Tank.

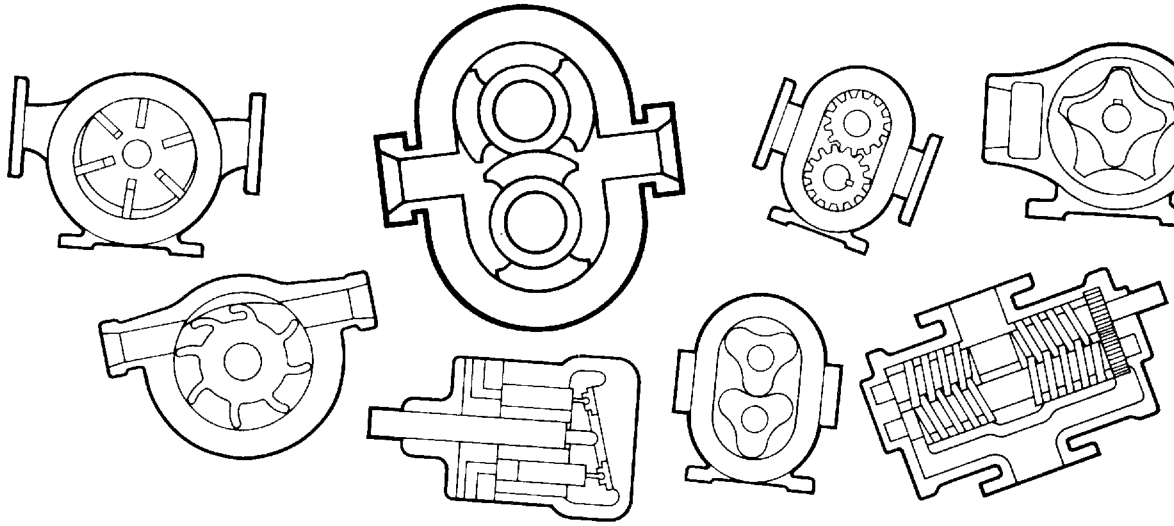


Using any of these changes, or combinations of them, the system and pump characteristics can be selected to allow operation at satisfactory flow rates and system conditions.

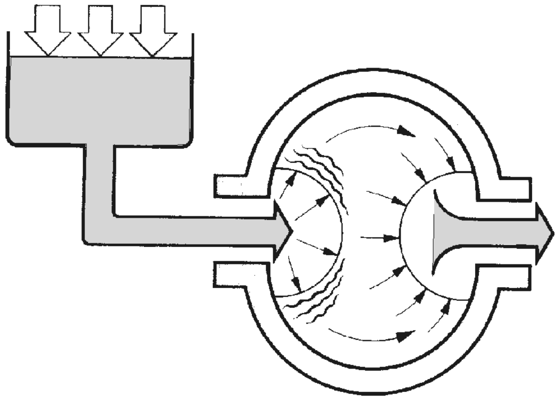
Rotary pumps, such as those made by Waukesha Cherry-Burrell, have better inlet characteristics (low NIPR) than most other types of pumps, and are often selected for their ability to operate under low net available inlet pressures, to self prime, to lift the liquid on the inlet side, or to pump fluids from vacuum equipment. They are particularly suited for pumping viscous liquids and are often the only pumps which can be used in this service.

Rotary Pump Fundamentals

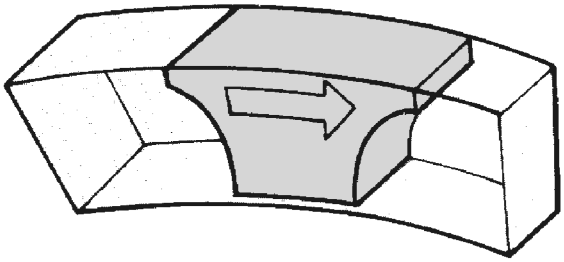
A rotary pump is a positive displacement pump which moves fluids by means of the motion of rotors, cams, pistons, screws, vanes, or similar elements in a fixed casing, usually without the need of inlet or outlet valves.



The motion of the rotary parts causes specific volumes to be **created** near the pump inlet, allowing atmospheric or external pressures to force liquid into the pump. Near the outlet these volumes are collapsed or **destroyed,** forcing the liquid out of the pump.

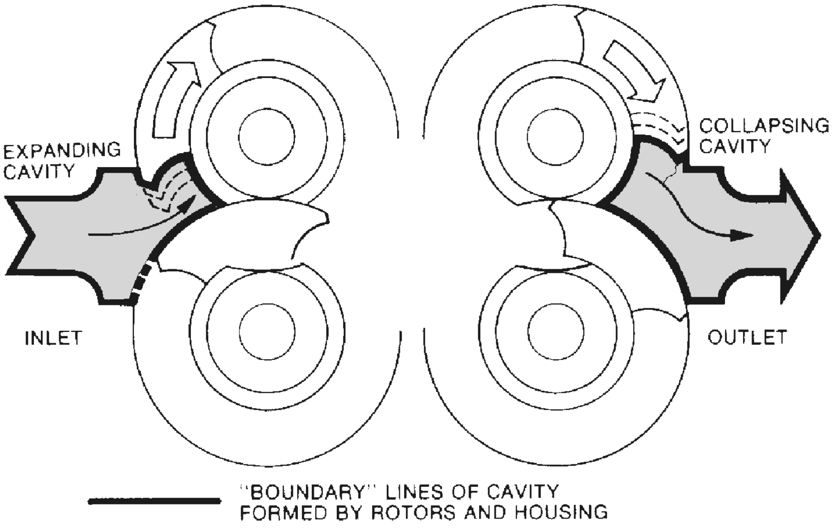


The Waukesha Cherry-Burrell rotary **external circumferential piston (ECP) pump**, has arc shaped **pistons** traveling in the annularly shaped **cylinders** as shown.

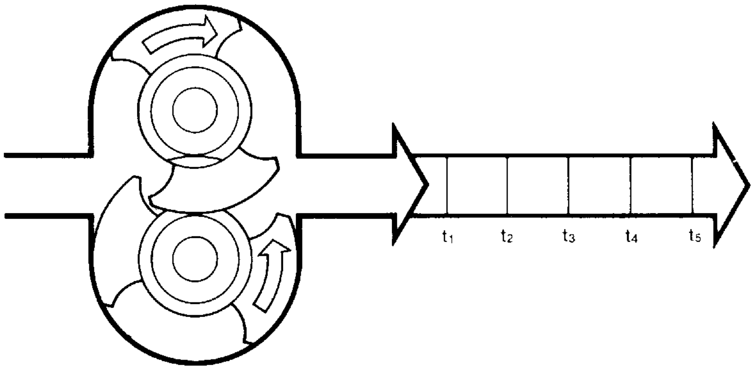


Each rotor has two **pistons**; two rotors are used in the pump — driven by external timing gears to rotate in opposite directions.

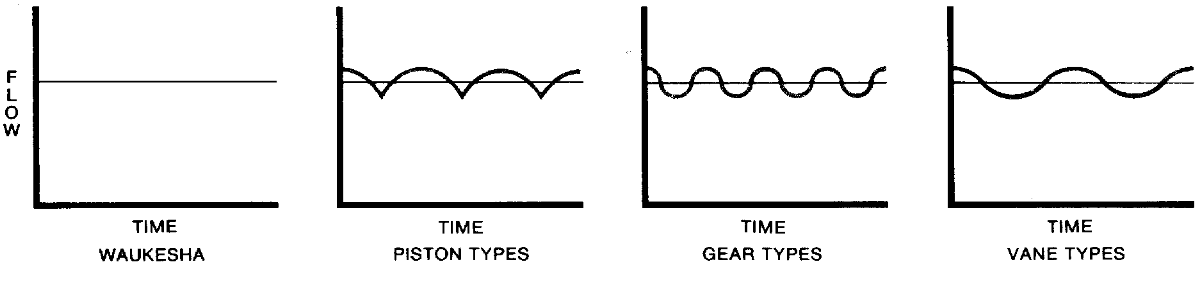
The motion of the rotors **creates** an expanding cavity on the inlet side allowing fluid to flow into the pump chamber. The rotors then carry the fluid around the cylinder to the outlet side, where it is forced out of the pump as the cavity contracts.



The rotors turn at constant velocity, and the shape of the rotors and cavities allow the Waukesha Cherry-Burrell ECP Pump to deliver a constant volume per unit of time for any rotor position.

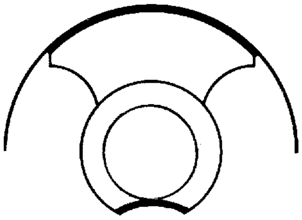


This means a Waukesha Cherry-Burrell ECP Pump delivers a smooth, non-pulsating flow. Many other pump types have a variation in flow per unit of time, resulting in pulsations.

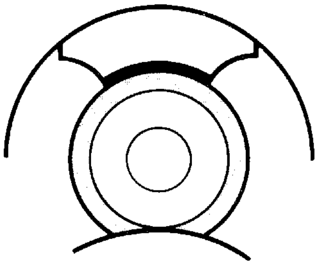


Each rotor forms a long **seal** path:

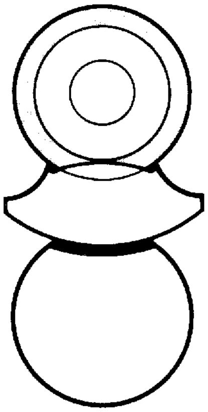
- Between its outer diameter and the housing:



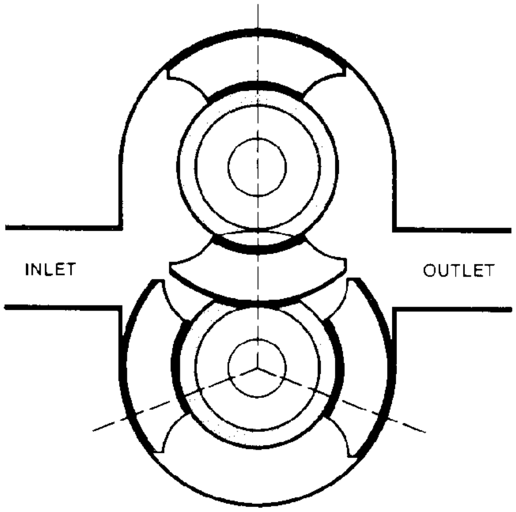
- Between its inner diameter and the Body Hub:



- Or, between the outer diameter and the **scallop** in the opposite Hub.

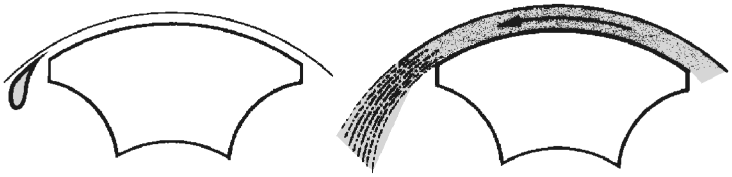


So, at any position in the rotation of the two rotors, there is a long and continuous "sealing" path between the inlet and outlet.



These long sealing paths limit the backflow or **slip** from the high pressure pump outlet to the low pressure inlet.

The clearance between rotating and stationary parts is even more important in limiting slip. Slip increases rapidly with increasing clearances (proportional to clearance to the 3rd power — C^3).



Using alloy combinations that minimize galling, Waukesha Cherry-Burrell ECP Pumps can be machined to very close clearances, making it a low slip pump.

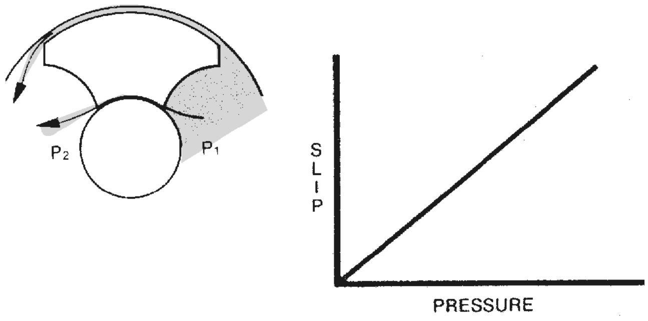
The combination of the basic style, the materials of construction, and close clearances makes the **Waukesha Cherry-Burrell ECP Pump** one of the most efficient rotary pumps available.

Slip and Efficiency

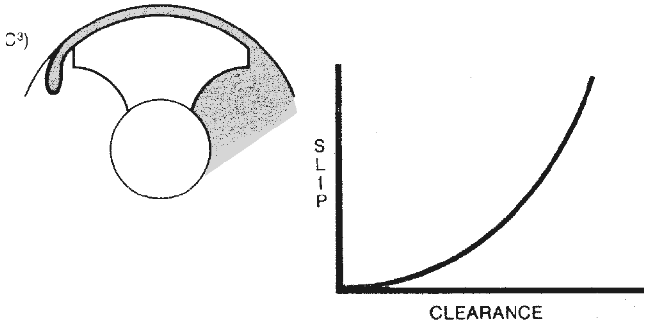
Pump performance in many cases is dependent on the slip (slip flow), which occurs in a pump.

Stated again, slip increases:

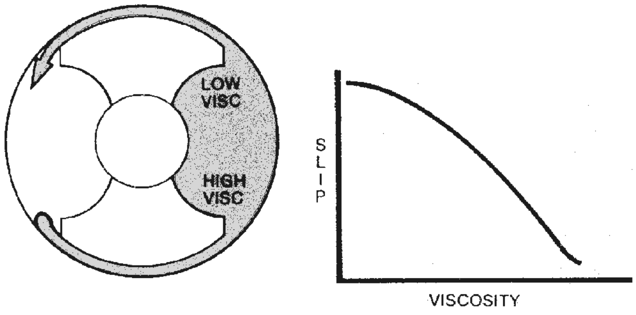
- **Directly with pressure.**



- **Directly with clearance.**



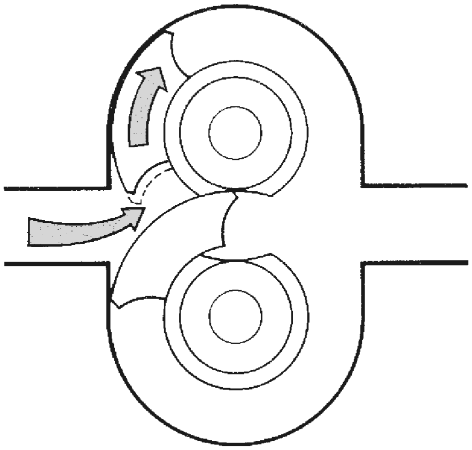
- **Inversely with viscosity.**



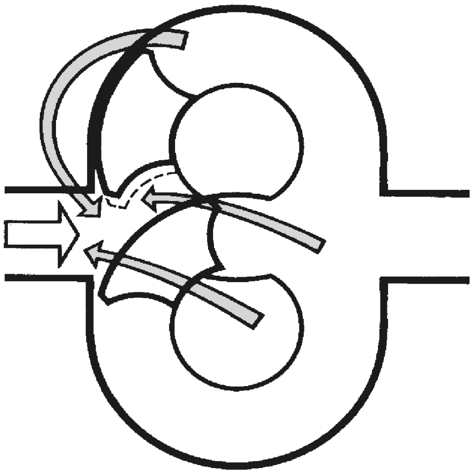
The major effect of slip on pump performance is the loss in flow capacity.

Let us illustrate it this way.

The expanding cavity on the inlet side creates a low pressure area that sucks fluid in to equlized the pressure. This cavity can be filled with fluid from the inlet line in normal performance.



However, if the slip is high, the cavity can be partly filled with fluid flowing back through the pump from the outlet side.

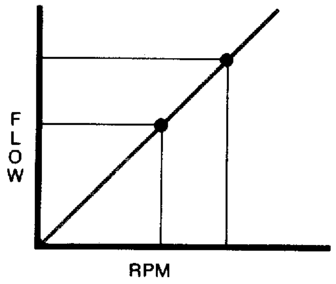


If this occurs, the pump loses the ability to deliver the volume of fluid it is theoretically capable of pumping. This phenomena is sometimes defined by the term **volumetric efficiency**, or:

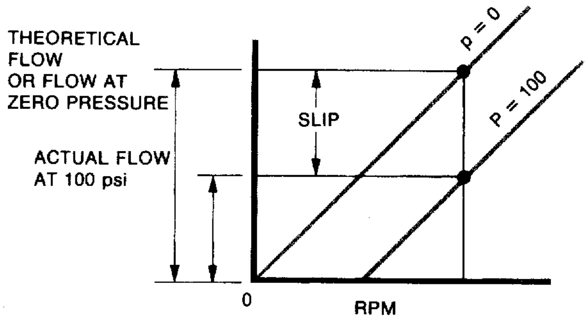
$$\text{V.E.} = \frac{\text{Actual Flow}}{\text{Theoretical Flow}}$$

Although often used by pump manufacturers, this term is less useful than really understanding slip.

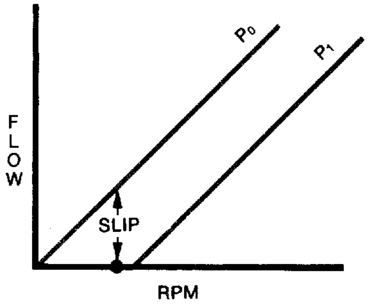
For a **given pump** and fluid, the slip is proportional to the pressure differential from outlet to inlet. If the pump had no slip, the volume pumped would be directly proportional to the speed or rpm.



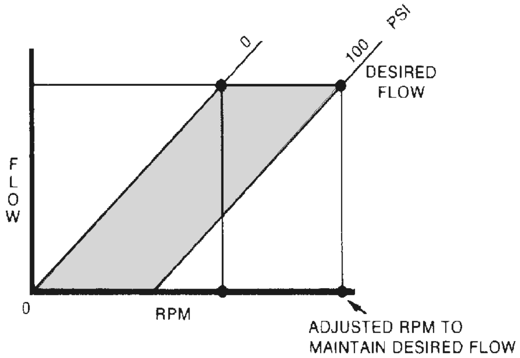
When the slip flow is superimposed on this graph for a given pressure differential, we can see the loss of flow which is due to slip.



If the slip is high enough at a certain speed, **no flow at all can occur**.

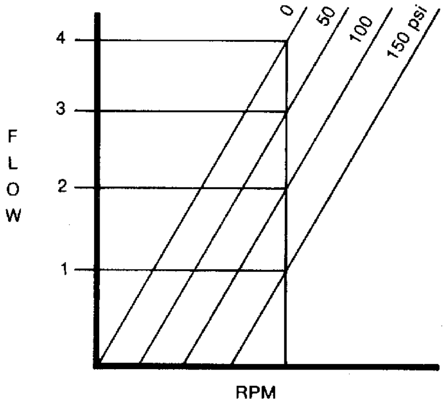


If a certain flow is needed at a given pressure, the speed must be increased.



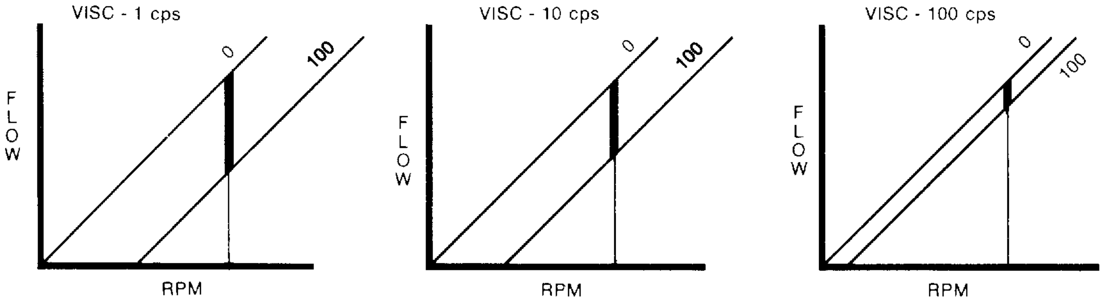
If the pressure is increased, the slip will increase, and therefore, the actual flow will decrease.

This type of chart is commonly used to show pump performance. It should be remembered that this type of chart shows the performance for only one fluid viscosity.



If the viscosity increases, the slip will decrease (for a given pressure differential and pump).

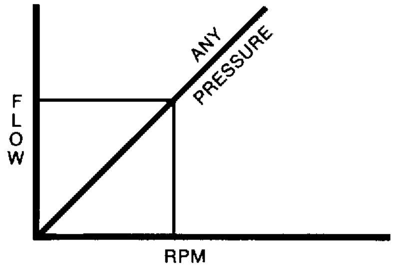
So a series of charts would actually be needed to cover a full range of viscosities.



In a standard clearance Waukesha Cherry-Burrell ECP Pump the slip is essentially zero when the viscosity is above 200 to 300 centipoise.* Therefore, the pump will deliver its theoretical displacement **at any pressure** in its working range.

The flow performance can then be shown as one line for all viscosities above 200 to 300 CPS, and the theoretical or zero pressure line can be used to find flow and rpm.

Later we will develop a type of chart which can be used for all viscosities, even between 1 and 200 - 300 CPS range.



*See individual pump curves for zero slip.

The Effect of Slip on Pump Performance

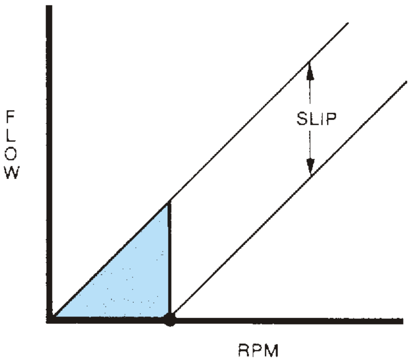
When the internal slip of a pump is low, as in the Waukesha Cherry-Burrell ECP Pump, the pump can be used effectively to:

1. Pump low viscosity fluid in low NIPA systems.
2. Pump from **vacuum** vessels.
3. Self prime. (And lift fluids from lower levels.)
4. Meter fluids.

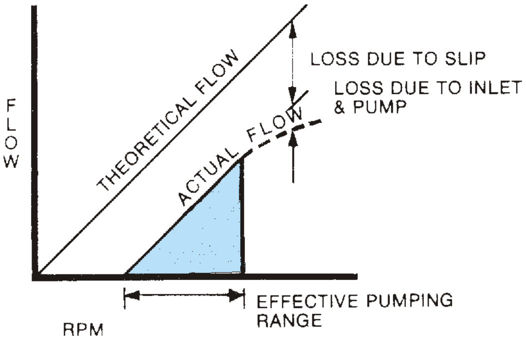
---

1. LOW NIPA SYSTEMS – When pumping low viscosity fluids in low NIPA systems, the effect of slip in reducing capacity, along with the energy requirements in entry to the pump (NIPR) must be considered. A careful balance must be made in selecting pump size and speed.

At low pump speeds, the inlet losses are low, but if the pressure differential across the pump causes excessive slip, little or no flow may result.



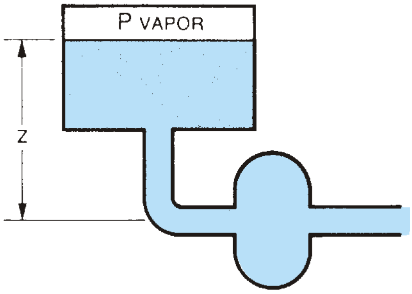
At higher speeds, the inlet and internal pump losses may be high enough to limit flow. At these higher speeds a **point of no return** can be reached where high velocities within the pump chamber create localized low pressure zones. Vapor formation can take place in these zones, and the vapor can fill the pump cavities, destroying its ability to sustain uniform flow of fluid.

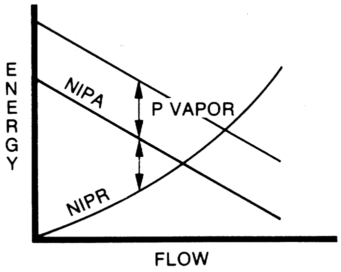


The selection of pump size to get the required flow and acceptable speeds may also be cost dependent, with smaller pumps generally less costly.

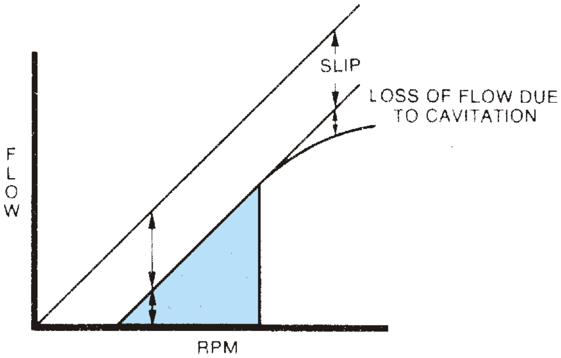
2. VACUUM VESSELS – Pumping from vacuum vessels is an extreme example of low NIPA operation which is possible with a low slip pump. Typically the vacuum chamber is used to evaporate fluids or to process at low temperatures. This causes an additional problem, in that operation is taking place at the vapor pressure of the fluid. In these cases, the maximum energy available to push fluid into the pump is that of the **liquid leg** or elevation.

If this liquid leg is low, and NIPA is barely higher than the NIPR, cavitation in the lines or pump can easily occur. In the design of these systems, it is typical to elevate the tanks, often to 30 feet or more, to obtain the leg needed.



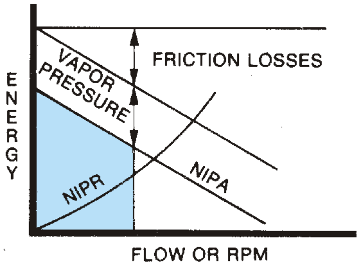


If the viscosity is low, the additional factor of slip flow must be overcome. We have again the limits on speed range — where at low speeds the slip may be a high percentage of theoretical flow, resulting in little net flow, and at higher speeds, the flow can be limited by cavitation or vaporization of fluid.

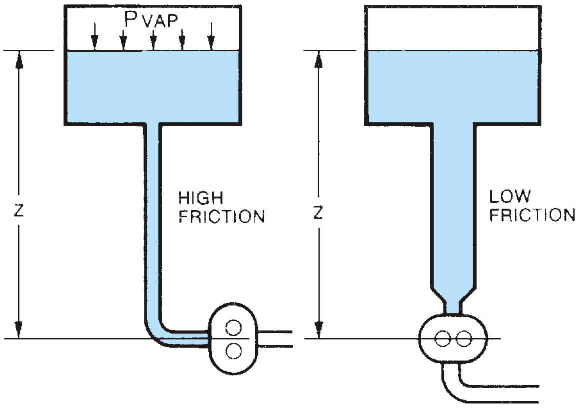


Pumping low viscosity fluids from a vacuum is nearly impossible with a high slip pump. The low slip Waukesha Cherry-Burrell ECP Pump can do this job when the system and pump conditions are carefully selected.

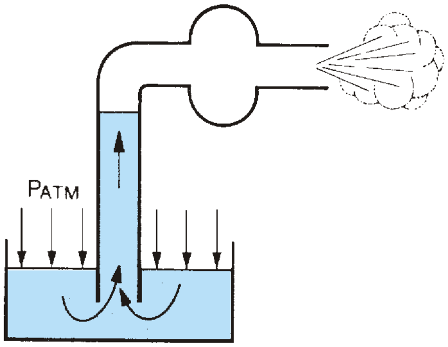
In pumping viscous fluids from vacuum vessels, slip is not a factor, and the NIPA and NIPR values determine the operating range, with both subject to the increased frictional losses due to higher viscosities.



Care in systems design must be taken, because raising the liquid level to obtain more energy to fill the pump also means that the inlet lines are longer and the increased frictional losses may offset the higher elevation. A typical solution to this problem is a large diameter standpipe, (to reduce frictional loss) tapering down to the pump port size just at the inlet, with a minimum of elbows and fittings.



3. PRIMING ABILITY – The Waukesha Cherry-Burrell ECP Pump clearances are small enough, that at higher speeds, the pump can even move air. What this means is that the pump can be use to **dry prime**, or actually evacuate the air in the inlet line, reducing the pressure and allowing the liquid to move up in line, fill the pump chamber and begin normal pumping.



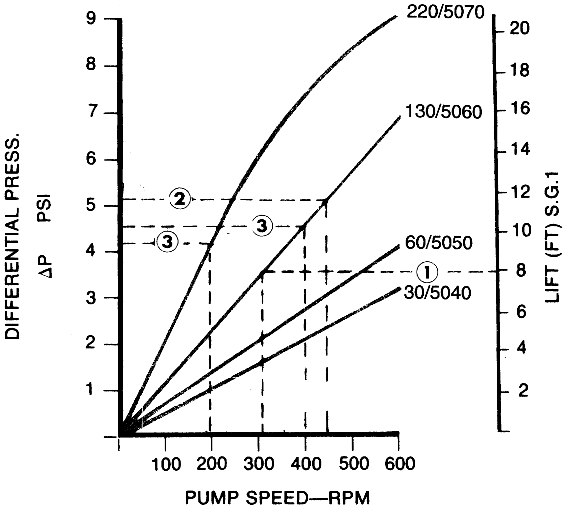
This ability can be very important and useful, as the Waukesha Cherry-Burrell ECP Pump is one of the few pumps which can be used to empty barrels, tanks, and tank cars, etc. … in this way, without priming with liquid.

When pumping low viscosity fluids this **dry priming** action happens rapidly. Higher viscosity fluids move up the inlet piping more slowly, but they **will move** and the priming **will** take place. The Waukesha Cherry-Burrell ECP Pump can run **dry** without damage, long enough for these viscous fluids to reach the pump inlet.

Chart – Shows the dry priming ability of different size pumps at various speeds. The pressure differential shown is expressed in psia, but can easily be converted to vertical lifts. The second scale shows the lift possible for water, assuming 14.7 psia atmospheric pressure and negligible line losses.

See following examples on how to use charts.

Prime Characteristics Waukesha ECP Pumps
ΔP Pumping Air vs. Pump Speed



Determining Speed for Liquid Lift

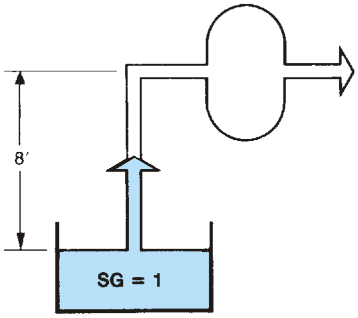
Example 1:

Given a ‘130’ size ECP pump handling water, what minimum speed must the pump run to lift water (self prime) from a tank with a liquid surface 8 feet below the pump?

The chart on page 39 shows a lift requirement of 8 feet for a liquid of S.G.= 1. The curve for the ‘130’ size pump indicates a minimum speed of 305 RPM.

$$8\text{ ft.} \times \frac{62.4\text{ lbs/ft}^3}{144\text{ in}^2\text{/ft}^2} \times \text{S.G.} = \text{PSI}$$

$$8\text{ ft.} \times 0.433 \times 1 = 3.46\text{ PSI}$$



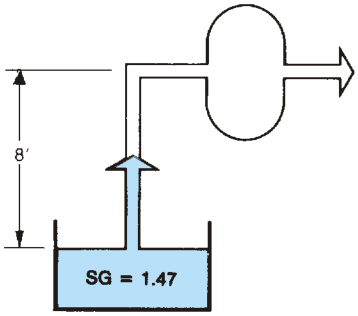
Example 2:

Effect of specific gravity on priming ability. For the pump above, a ‘130’ size, with a lift requirement of 8 feet, what speed must the pump run to lift Trichloroethylene of S.G. = 1.47?

8 ft. x 0.433 x S.G. = PSI

8 ft. x 0.433 x 1.47 = 5.09 PSI

On chart for 5.09 PSI ‘130’ size pump requires minimum speed of 445 RPM.



When a pump must be selected for its priming ability, it can be seen on the graph that a smaller pump, running faster, often must be used to develop more **dry prime** differential pressure.

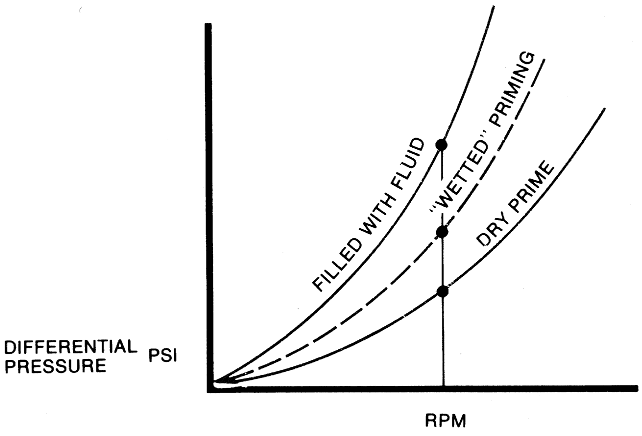
Example 3:

For a 100 GPM flow rate, a ‘220’ size ECP pump at 200 RPM could be used, or a smaller ‘130’ size ECP pump at 400 RPM. (See typical flow vs. RPM curves.)

For 100 GPM flow rate, on water (S.G. = 1):

‘220’ size pump at 200 RPM can develop 4.2 PSI differential or lift 9.7 feet.

‘130’ size pump at 400 RPM can develop 4.5 PSI differential or lift 10.4 feet.

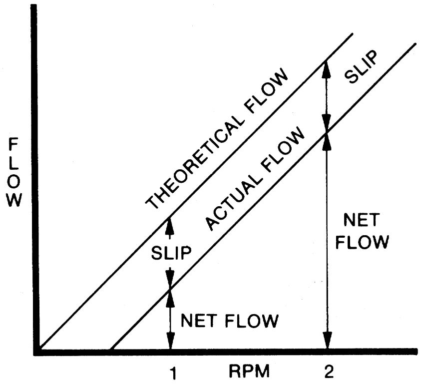


Of course, if it is possible to have some fluid in the pump, priming will be improved even more. The film of liquid in the clearances of the pump will **close up** those clearances, and allow a higher pressure differential to be created, approaching the differential which could be developed if the pump were filled with fluid. Because it will still be pumping air, it will not reach full pumping conditions until all the air is expelled and the lines and pump cavities are filled with fluid.

4. METERING FLUIDS – A low slip pump can be used effectively to meter fluids. If the slip is low, a pump will deliver nearly its theoretical displacement in each revolution. By electrically counting and controlling revolutions of the pump, or its revolutions per minute, we can get a measure of the amount of liquid displaced, or the rate (GPM) of flow.

Let's see how this can be done with a low slip pump.

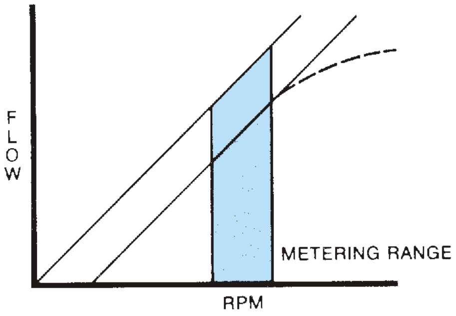
We saw before that slip is proportional to pressure. In a metering application, to reduce slip as much as possible, the pressure differential should be kept low. This can be aided with short, large diameter lines with few fittings or bends. With this low pressure differential, slip will be low and constant.



Looking then at a FLOW-RPM chart, we can see that at a low pump speed, the slip might be still a sizeable **percentage** of theoretical flow (1). If the pump speed is increased, the slip becomes a small percentage of theoretical flow (2), and by counting shaft revolutions only a small constant error exists, which can be compensated for in several ways.

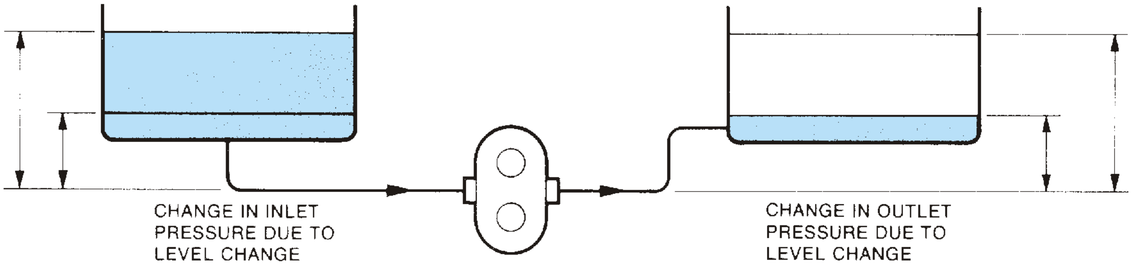
In any case, **repeatability** is usually obtained and is often what is really needed.

Then for metering **low** viscosity fluids, the pump size should be selected so it will run at high speed, but avoiding loss of flow due to cavitation.

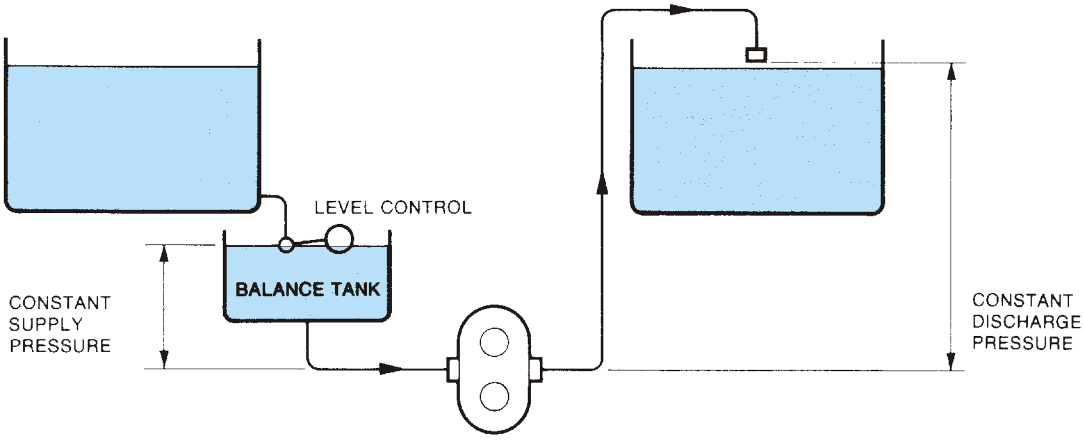


To obtain best metering performance when using a standard Waukesha Cherry-Burrell ECP Pump on low viscosity fluids, the system should be designed to operate under a constant pressure differential if possible. On the inlet side, changes in pressure due to liquid level changes in a supply tank can be minimized by using a small balance tank with a level control.

In the outlet side, pressure can often be kept constant by discharging at the top of the delivery container.



NOT OPTIMUM



PREFERRED

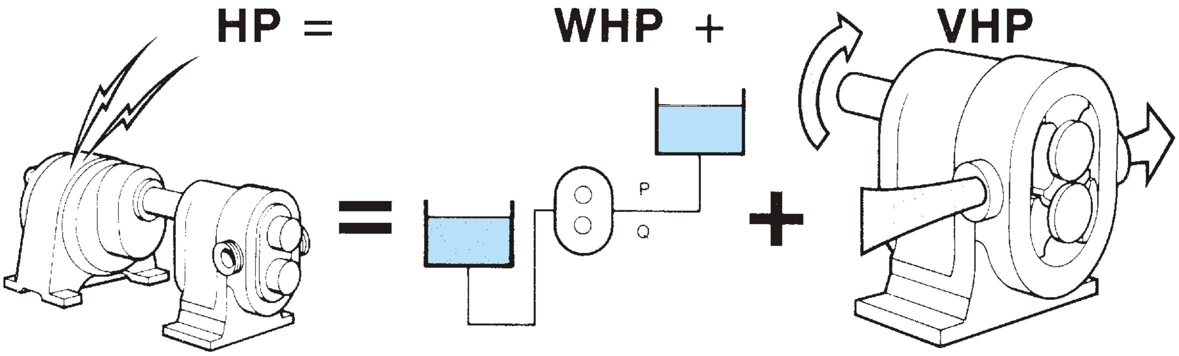
Power Requirements in a Pumping System

All the system energy requirements, and the energy losses in the pump must be supplied by the pump drive in the form of mechanical energy. The rate of energy input needed is defined as power, commonly dimensioned as horsepower, where 1 HP = 33,000 ft-lbs/minute.

In a pump and system, we find it convenient to consider separately:

- Power required due to external system conditions — WHP — sometimes called fluid horsepower, hydraulic horsepower or water horsepower.
- Power required due to internal conditions in the pump — VHP — which includes viscous power losses and mechanical friction.

Therefore, **total horsepower** needed at the pump shaft:



WHP is defined as $\frac{QP}{1714}$

where: Q = GPM (for this calculation, slip is ignored so Q = displacement x RPM)
P = Pressure in PSI
1714 is a conversion constant

VHP, viscous horsepower, is the power loss due to viscous fluid friction in the pump. We have also included the mechanical losses due to bearing, seal, and gear drag. VHP is determined by test of each pump.

Many manufacturers use the term efficiency defined as:

$$EFF = \frac{WHP}{BHP}$$

and often use it in a horsepower formula as follows:

$$HP = \frac{QP}{1714 \times EFF}$$

which is equivalent to:

$$HP = \frac{WHP}{EFF}$$

Although a useful concept, it means that a vast number of efficiency values must be determined by test for many combinations of flow, pressure and viscosity.

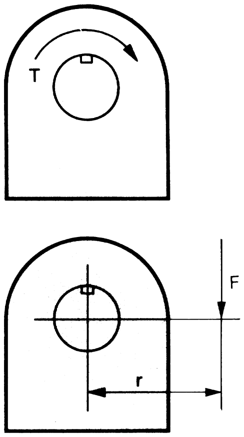
By identifying VHP and WHP separately, Waukesha Cherry-Burrell has developed a very simple and effective form of horsepower chart for calculation of all conditions of viscosity, flow and pressure. This is discussed later in the section entitled “Calculating Power Requirements.”

Torque

The power requirements for mechanical devices such as pumps and pump drives are best expressed in terms of Torque and Speed where:

Torque

- is the moment of the forces required to cause motion.
- is usually expressed in units of in-lbs or ft-lbs.
- can sometimes be identified as F x r.



In rotary motion, HP (the rate of doing work) can be expressed in terms of Torque and RPM

$$\text{HP} = \frac{\text{T (ft-lbs)} \times \text{N (rpm)}}{5250} \text{ or } \frac{\text{T (in-lbs)} \times \text{N (rpm)}}{63025}$$

Since power requirements were calculated as HP = WHP + VHP, the horsepower will generally be known, and it may be necessary to calculate torque. Rearranging the equation:

$$\text{T(ft-lbs)} = \frac{\text{HP} \times 5250}{\text{N (rpm)}}$$

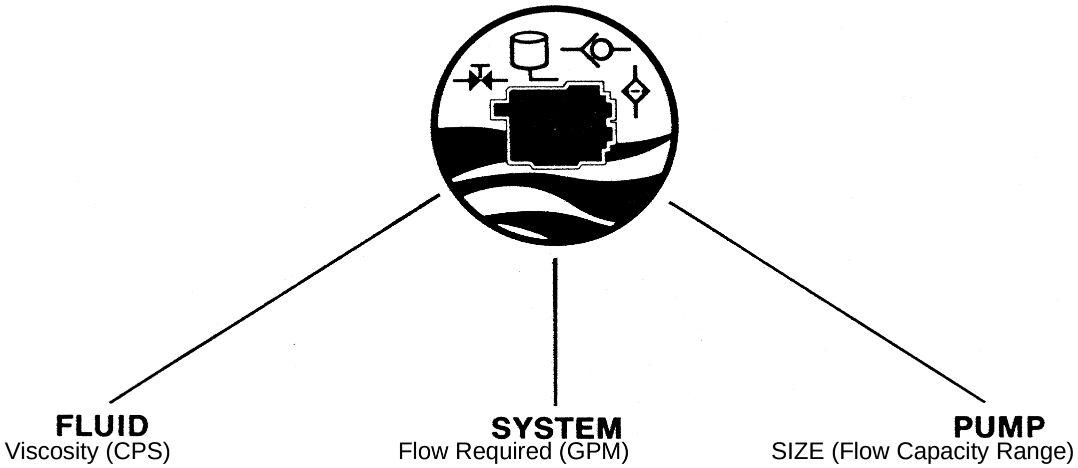
or

$$\text{T(in-lbs)} = \frac{\text{HP} \times 63025}{\text{N (rpm)}}$$

Later, in selecting drives for pumps, it can be seen that not only must a drive have sufficient horsepower to drive the pump, but in the useful range of the drive the **torque** must be adequate to drive the pump. In addition, the drive components such as V-belts, couplings, and clutches must have enough torque capacity to do the job.

How to Select a Waukesha Cherry-Burrell Pump

Starting with these characteristics:



Review the individual pump curves to find the smallest model that can achieve the required flow rate. See curves starting on page 91. Quick sizing selection can be determined from curve index on page 92.

Special considerations that might modify preliminary choice.

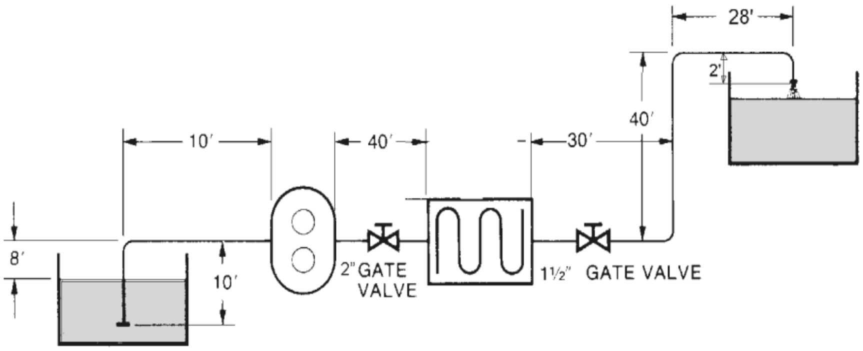
Effective Viscosity	
For Newtonian Fluids	Use Size Selection Guide
For Non-Neutonian Fluids	Utilizing **effective** viscosity, use Size Selection Guide.
See page 3, 4, 5, and 126, 127 or consult Waukesha Cherry-Burrell's Application Engineering Department.	
Unfavorable Inlet Conditions	
Low NIPA (See page 37)	Consider larger size pump to decrease NIPR.
Vacuum Services (See page 38)	
(Size Selection Guide is based on 0 psig at inlet.)	
High Vapor Pressure	
(Often associated with high temperature.)	Consider larger size pump to decrease NIPR.
Abrasive Fluids	Consider larger size pump to reduce speed and wear.
Shear Sensitive Fluids	Consider larger size pump to minimize shear.
Expected combination of **high pressure** and **high viscosity**.	Consider larger size pump to reduce speed and increase load capacity.
Minimum damage wanted to particulates	Consider larger size pump for more gentle handling and the use of single wing rotors.
Severe Duty Cycle	
Frequent Start-Stop Multi-Shift Operation High Pressure Operation High Horsepower Operation	Consider larger size pump to increase service life.

EXAMPLE: Given these requirements:

Fluid
Viscosity — 10 CPS
specific gravity — 1.47
Vapor Pressure — 1.6 psia at 80°F

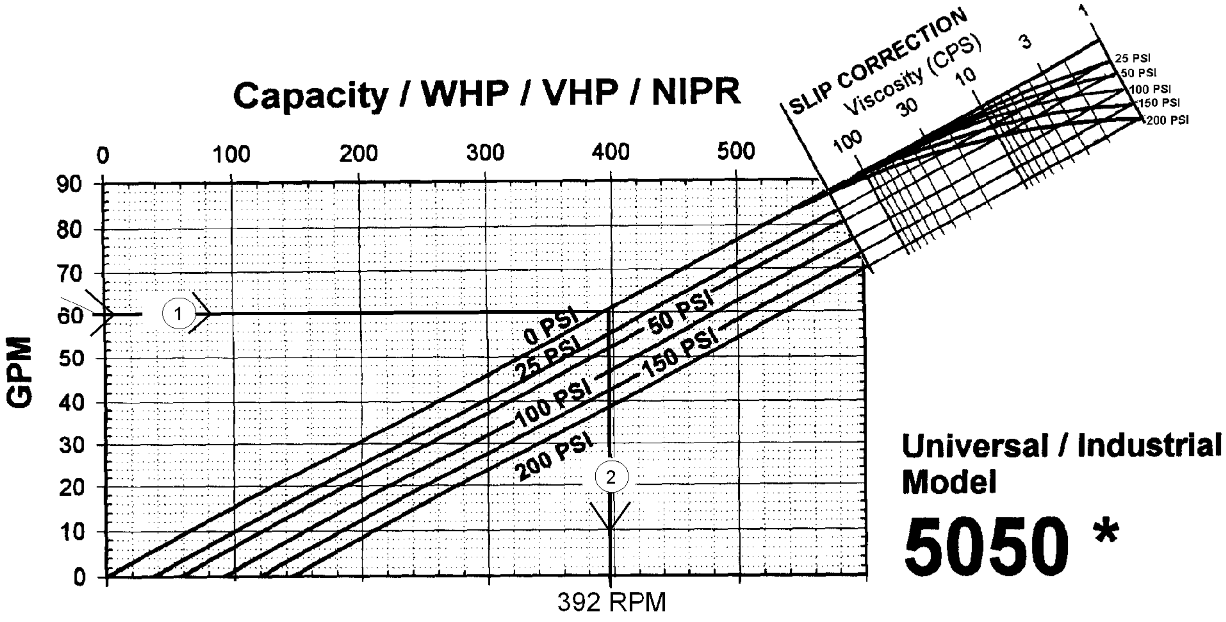
System
60 GPM required in system below.
Outlet line after heat exchanger must be 1-1/2 inch.

Pump
to be Industrial model (5000 Series).

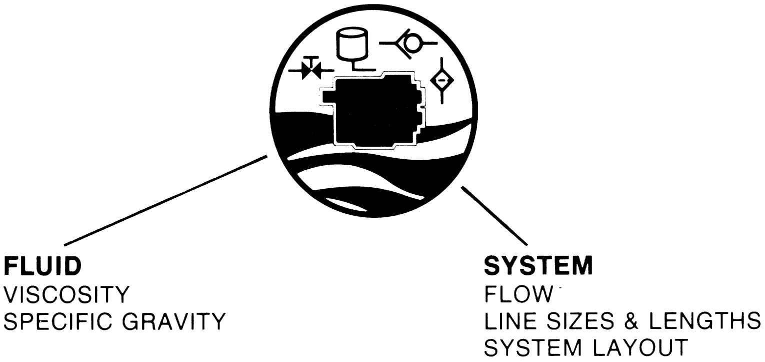


Pump
Size, speed, horsepower to be determined.

Preliminary choice of a model 5050 size pump is made.



With the preliminary size just selected, and using these factors:



Using the system layout, determine line lengths and diameters of the discharge line.

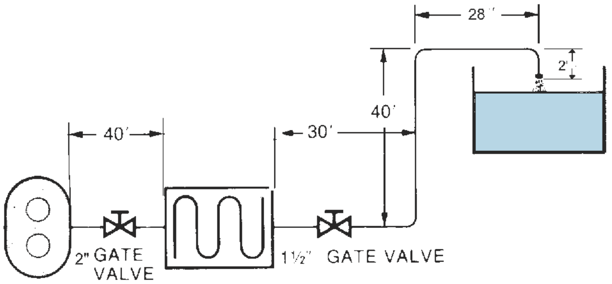
When necessary to design a system, a **suggested starting point** is to use line sizes of the same size as the pump port.

Sanitary	
Pump Size	**Line Size**
6	1" or 1-1/2"
15	1-1/2"
18	1-1/2" or 2"
30	1-1/2" or 2"
45	2"
60	2-1/2"
130	3"
180	3"
210	4"
220	4"
320	6"
420	6"
520	8"

Industrial	
Pump Size	**Line Size**
5040	1-1/2"
5050	2"
5060	3"
5070	4"
5080	6"

Determine **friction loss** in **discharge piping**.

From the system layout, determine the number and types of fittings and valves.



Tabulate these fittings as on the table below. If the piping system has more than one size of piping, group line lengths and fittings of each together.

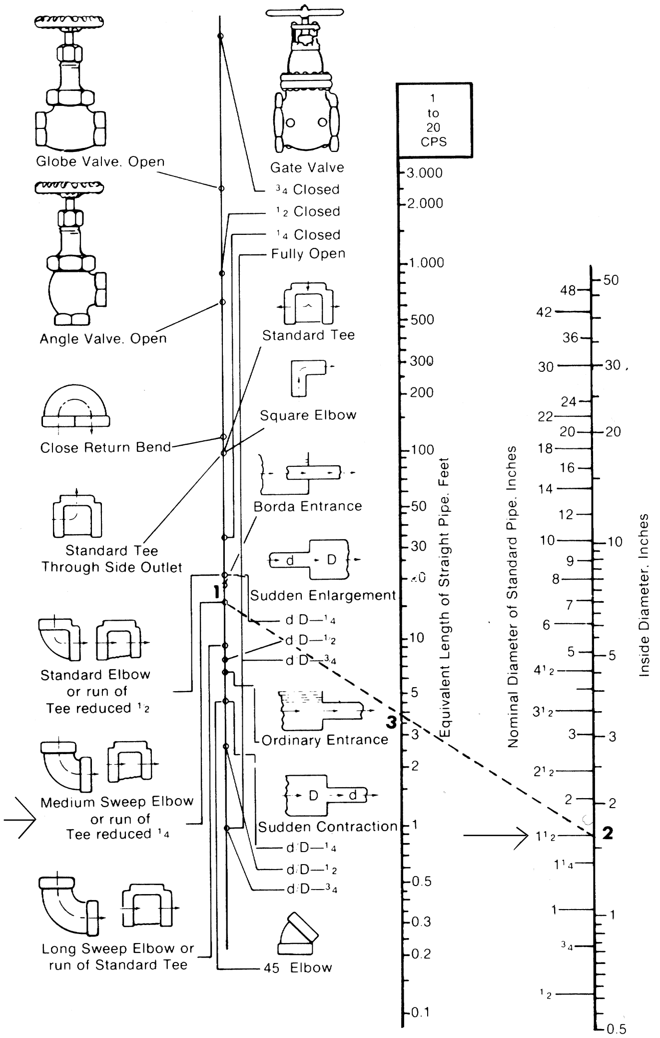
Pipe Diameter	**2"**	**1-1/2"**
Length	40 ft	100 ft
Elbows	none	3
Valves	1 Gate	1 Gate
Other Fittings	none	none

Note: Use fully open gate valves and medium sweep elbows in this example.

Determine equivalent length of each fitting using page 131. Enter valves and add line lengths and equivalent lengths together.

See equivalent length table on page 50.

Resistance of Valves and Fittings to Flow of Fluids



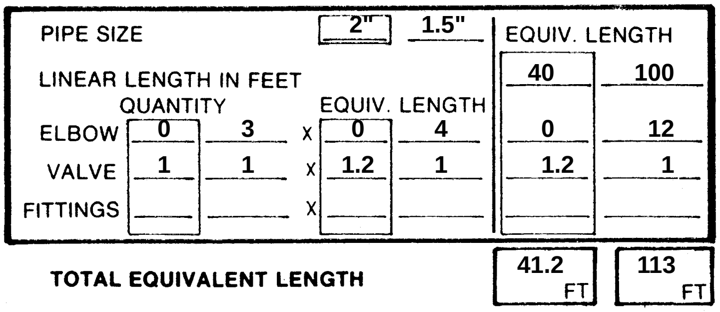
VISCOSITY CORRECTION TABLE

EQUIVALENT LENGTH OF PIPE FOR VISCOSITY RANGE (CPS) OF

20 to 100 CPS	200 to 1.000 CPS	2.000 to 10.000 CPS	20.000 to 100.000 CPS
3000	2.250	1.500	750
2000	1.500	1.000	500
1000	750	500	250
500	375	250	125
200	150	100	50
100	75	50	25
50	37.5	25	12.5
30	22.5	15	7.5
20	15	10	5
10	7.5	5	2.5
4		2	1
2	1.5	1	.5
1	.75	.5	.25
0.5	.375	.25	.125
0.3			
0.2			
0.1	.075	.05	.025

In the above example, 1-1/2" standard pipe size and medium sweep elbow.

Discharge Piping



PIPE SIZE				2"	1.5"	EQUIV. LENGTH	
LINEAR LENGTH IN FEET						40	100
	QUANTITY			EQUIV. LENGTH			
ELBOW	0	3	X	0	4	0	12
VALVE	1	1	X	1.2	1	1.2	1
FITTINGS			X				
TOTAL EQUIVALENT LENGTH						41.2 FT	113 FT

Using flow and line size, **determine** pressure drop in discharge piping due to **friction loss** using pipe frictional loss graph below.

If two or more line sizes are used, find the pressure drop in each section separately, and add together.

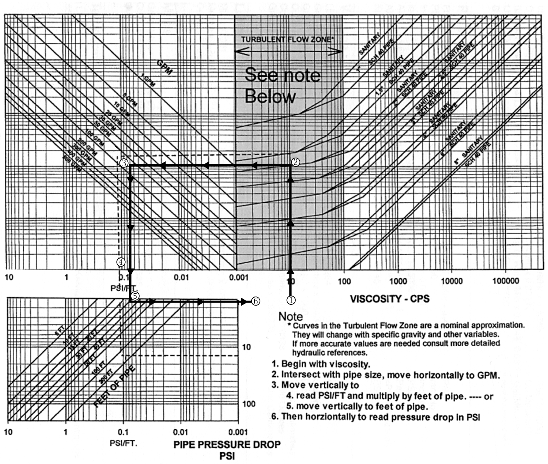
EXAMPLE: At 60 GPM, and 10 CPS

2 in.*	1-1/2 in.**
2.9 PSI	13.6 PSI

F.L. = 2.9+13.6=16.5 PSI

*Equivalent Length of 41.2 ft

** Equivalent length of 113



Note
* Curves in the Turbulent Flow Zone are a nominal approximation. They will change with specific gravity and other variables. If more accurate values are needed consult more detailed hydraulic references.

1. Begin with viscosity.
2. Intersect with pipe size, move horizontally to GPM.
3. Move vertically to
   4. read PSI/FT and multiply by feet of pipe. ---- or
   5. move vertically to feet of pipe.
6. Then horziontally to read pressure drop in PSI

NOTE: Full size graph available on page 133.

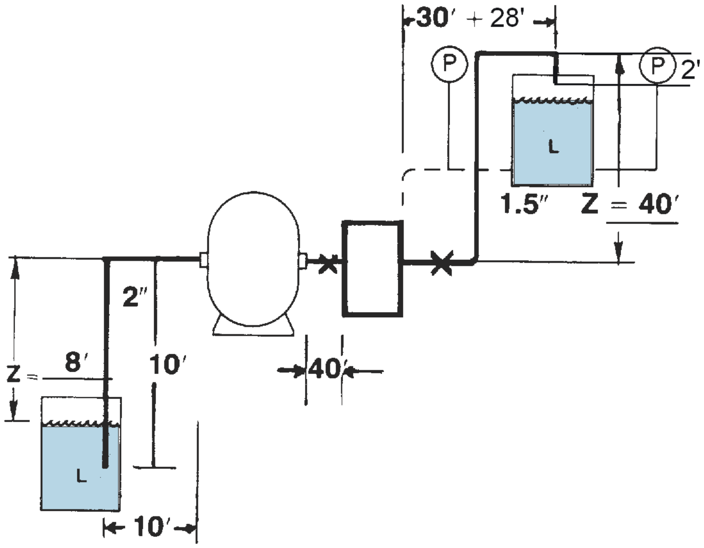
Determine static pressure requirements due to elevation change.

EXAMPLE:

$$P = 40\text{ ft.} \times \frac{62.4}{144} \times \text{S.G.}$$

$$P = 40\text{ ft.} \times 0.433 \times 1.47$$

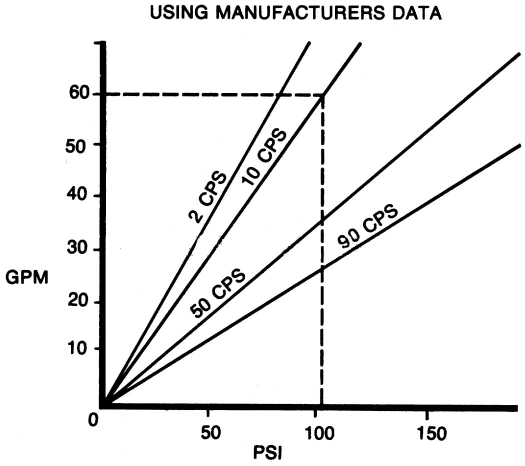
$$P = 25.5\text{ PSI}$$



Determine pressure requirements due to equipment in the system, such as filters, heat exchangers, relief valves, orifices, nozzles, pressurized tanks.

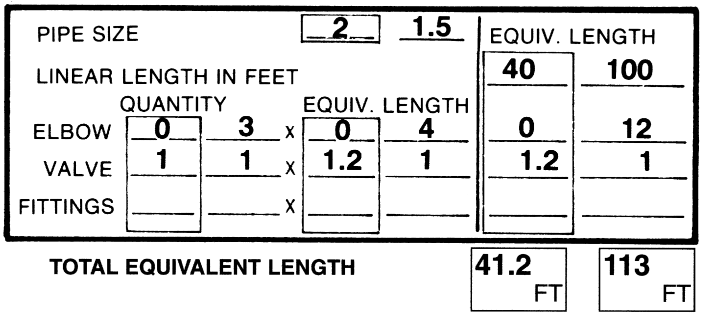
EXAMPLE:

105 PSI



Add the pressure requirements due to friction loss and elevation changes. This pressure must be less than the rated pressure of the pump.

DISCHARGE



PIPE SIZE	2	1.5				EQUIV. LENGTH	
LINEAR LENGTH IN FEET						40	100
	QUANTITY			EQUIV. LENGTH			
ELBOW	0	3	x	0	4	0	12
VALVE	1	1	x	1.2	1	1.2	1
FITTINGS			x				
TOTAL EQUIVALENT LENGTH						41.2 FT	113 FT

Friction Losses
Pg. 50, 51

2.9 PSI + 13.6 PSI = 16.5 PSI

Static Pressure Requirement
Pg. 13, 14, 51

25.5 PSI

Equipment Pressure Drop

+ 105 PSI

Total Discharge Pressure

147 PSI

This pressure can now be used for further calculations.

However, if the pressure is too high, consider one or more of these changes to reduce pressure to a workable level.

- **Reduce flow**
- **Larger diameter piping and fittings**
- **Shorter length of piping and fewer fittings**

Determining Pump Speed

FLUID
Viscosity

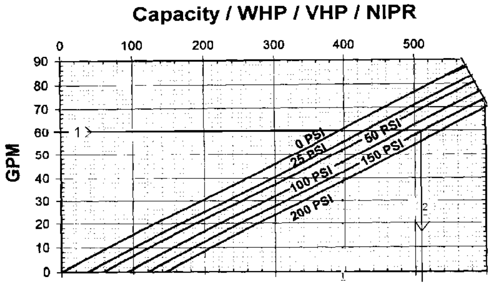
SYSTEM
Pressure

PUMP
Pump Size

A typical type of Flow-Speed Chart shown can be used to determine pump speed and compensate for slip.

EXAMPLE: Using 60 GPM and 147 PSI pressure, the curve indicates a speed of 509 RPM.

EXAMPLE: However, this type of curve is valid only for water, or fluid of the same viscosity. For fluids of viscosity of over approximately 200 CPS, the zero pressure line can be used on 5050. See individual curves for zero slip viscosity starting on page 91.



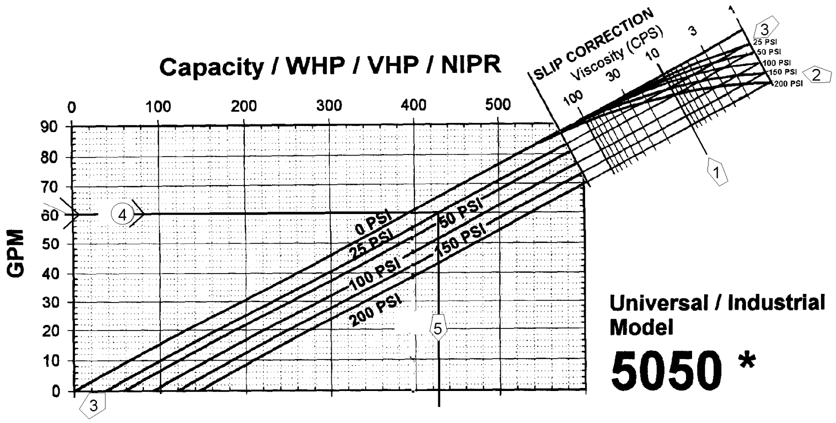
To allow speed determination for **any** viscosity, Waukesha Cherry-Burrell has developed a nomen graph on every curve.

Starting with the known viscosity, 10 CPS, on the viscosity scale, move down to the pressure previously calculated, 147 PSI.

From that point, a line (3-3) drawn parallel to the chart lines, becomes the **operating line** for that viscosity and pressure.

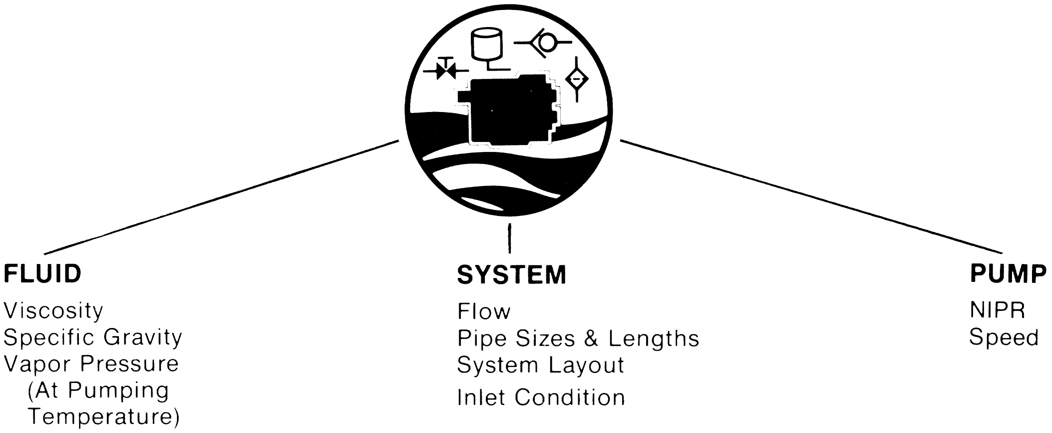
Using the desired flow, 60 GPM, move horizontally to the **operating line**, and then vertically down to the RPM scale: Read 426 RPM.

Note that for all viscosities above approximately 200 CPS, the 0 PSI line is the operating line. In other words, no slip occurs and no speed correction is needed, with standard clearance pumps.



Checking the Inlet

Using these characteristics:



FLUID

Viscosity
Specific Gravity
Vapor Pressure
(At Pumping
Temperature)

SYSTEM

Flow
Pipe Sizes & Lengths
System Layout
Inlet Condition

PUMP

NIPR
Speed

Determine static pressure available due to elevation.

See equation on page 13.

EXAMPLE:

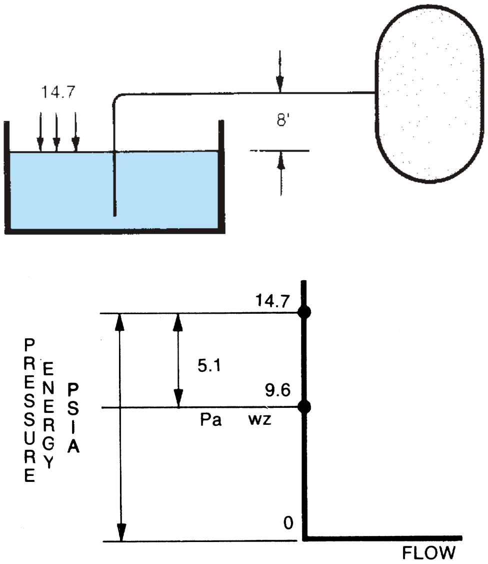
$$\text{Static Pressure Avail} = P_{ATM} + wz$$

$$P = 14.7 + \left(-8 \times \frac{62.4}{144} \times \text{S.G.}\right)$$

$$P = 14.7 + (-8 \times 0.433 \times 1.47)$$

$$P = 14.7 - 5.1$$

$$P = 9.6 \text{ psia}$$



NOTE: Atmospheric pressure is 14.7 PSIA at sea level, which we assumed in this example. Above sea level it is very important to determine atmospheric pressure at the current elevation of the equipment.

Using the system layout, determine line lengths and diameters of the inlet line.

When designing a new inlet system, a suggested starting point is to use line sizes of the same size as the pump port.

Sanitary	
Pump Size	**Line Size**
6	1" or 1-1/2"
15	1-1/2"
18	1-1/2" or 2"
30	1-1/2" or 2"
45	2"
60	2-1/2"
130	3"
180	3"
210	3"
220	4"
320	6"
420	6"
520	8"

Industrial	
Pump Size	**Line Size**
5040	1-1/2"
5050	2"
5060	3"
5070	4"
5080	6"

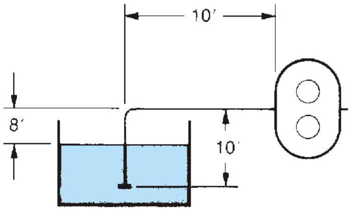
Due to the normally limited pressure energy available on the inlet side, it is good practice to keep the inlet line as short and straight as possible. It may be necessary to increase line size above those shown when:

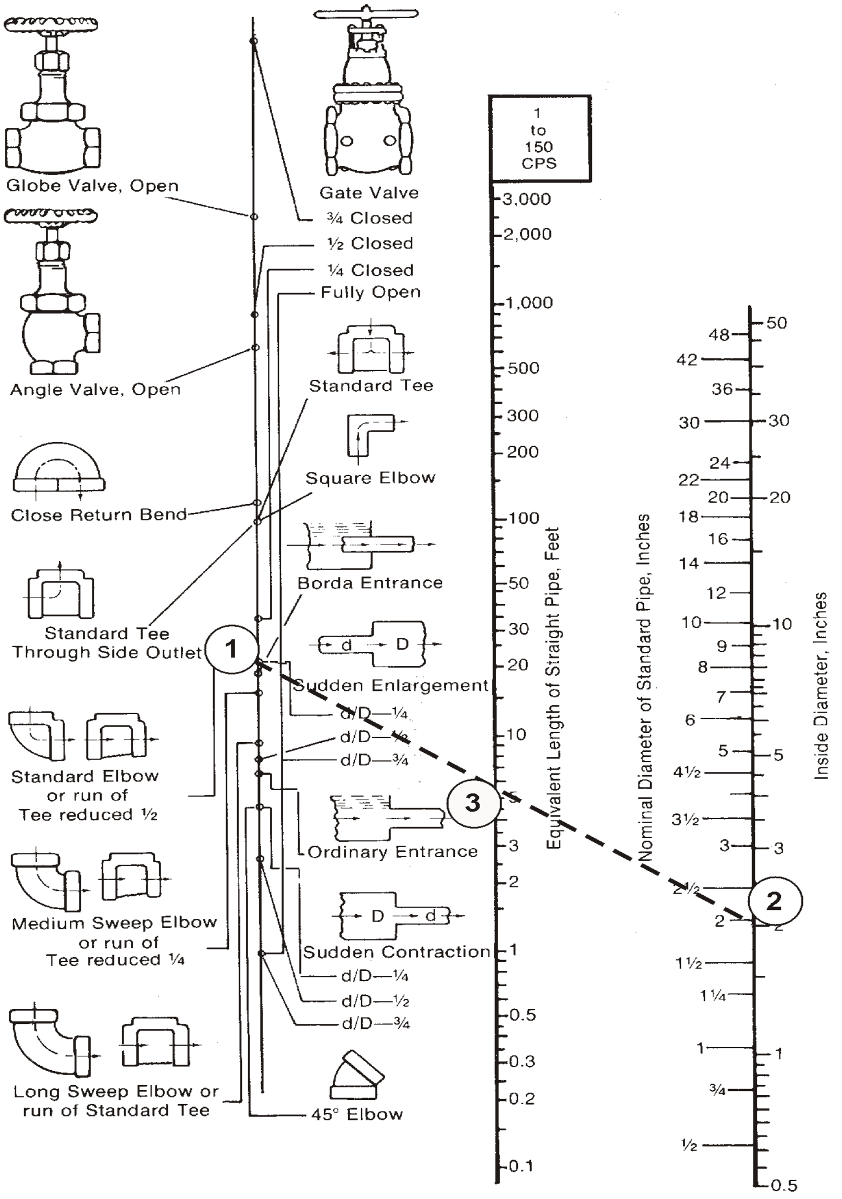
- Pumping high viscosity fluids
- Lifting fluids from lower elevations
- Pumping from vacuum vessels

See pages 21, 38 for more complete discussion of these conditions.

From the system layout determine the number and types of fittings and valves and tabulate these fittings. If the piping system has more than one size of piping, group the line lengths and fittings of each together.

Pipe Diameter	**2”**
Length	20 feet
Elbows	One
Valves	None
Other Fittings	None





VISCOSITY CORRECTION TABLE

EQUIVALENT LENGTH OF PIPE FOR VISCOSITY RANGE (CPS) OF

1 to 150 CPS	150 to 1,500 CPS	1,500 to 15,000 CPS	15,000 to 100,000 CPS
3000	2,250	1,500	750
2000	1,500	1,000	500
1000	750	500	250
500	375	250	125
200	150	100	50
100	75	50	25
50	37.5	25	12.5
30	22.5	15	7.5
20	15	10	5
10	7.5	5	2.5
4		2	1
2	1.5	1	.5
1	.75	.5	.25
0.5	.375	.25	.125
0.3			
0.2			
0.1	.075	.05	.025

NOTE: Full size graphic available on page **131**.

Determine equivalent length of each fitting using the above graph.
Enter the number valves, fittings, and add line lengths and equivalent lengths together.

INLET (Suction Piping)

Note: A standard elbow was used for this example.

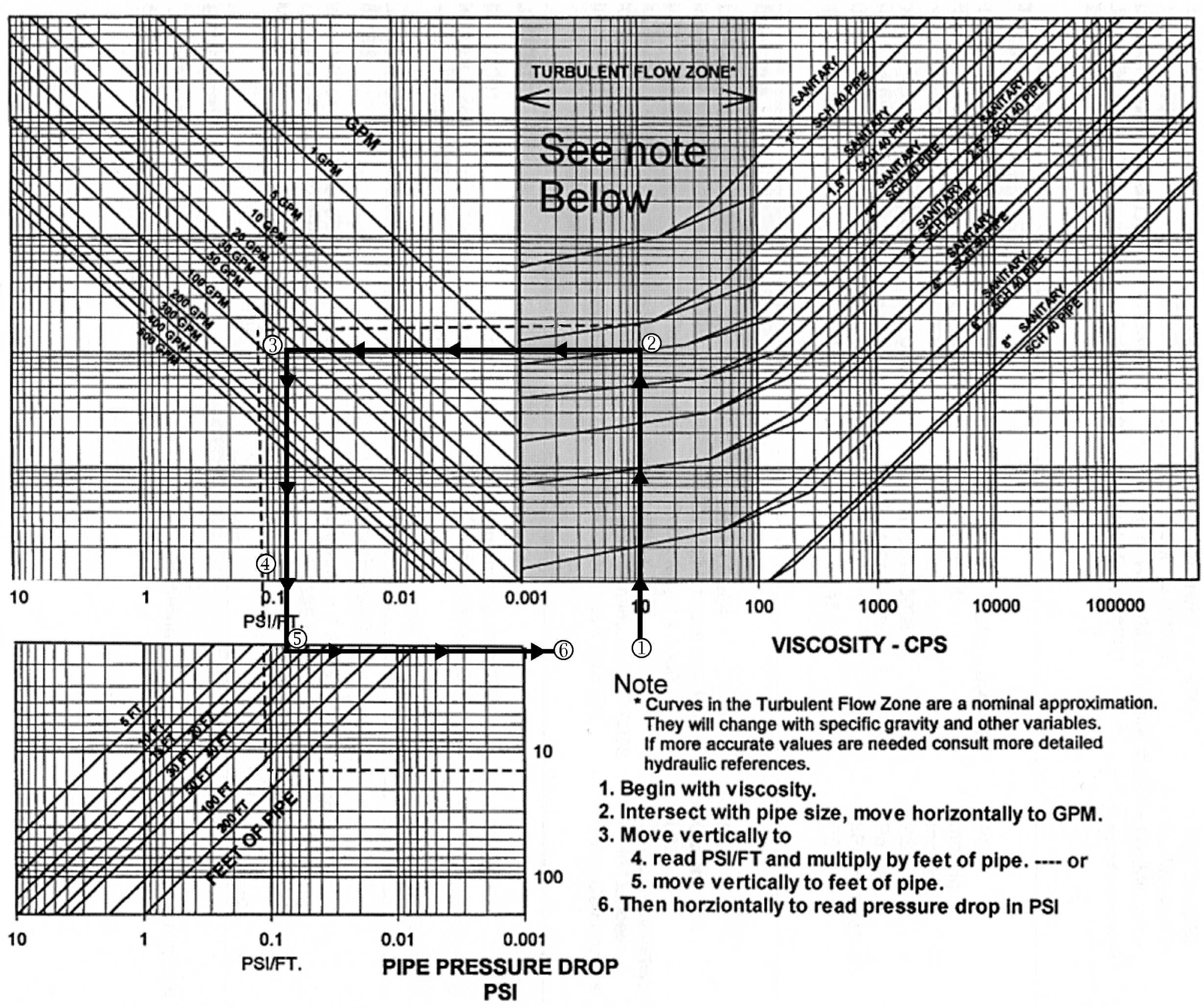
PIPE SIZE					**2**	EQUIV. LENGTH	
LINEAR LENGTH IN FEET							**20**
	QUANTITY			EQUIV. LENGTH			
ELBOW		**1**	x		**5.4**		**5.4**
VALVE		0	x		0		0
FITTINGS		0	x		0		0

TOTAL EQUIVALENT LENGTH FT | **25.4** FT

Using flow and line size, determine pressure drop in suction line due to friction loss using pipe frictional loss graph below.

If two or more line sizes are used, find the pressure drop in each section separately, and add together.

EXAMPLE: F.L. = 1.8 PSI at 60 GPM, 10 CPS, 2” pipe and 25.4 ft total equivalent length.



Note

* Curves in the Turbulent Flow Zone are a nominal approximation. They will change with specific gravity and other variables. If more accurate values are needed consult more detailed hydraulic references.

1. Begin with viscosity.
2. Intersect with pipe size, move horizontally to GPM.
3. Move vertically to
    4. read PSI/FT and multiply by feet of pipe. ---- or
    5. move vertically to feet of pipe.
6. Then horizontally to read pressure drop in PSI

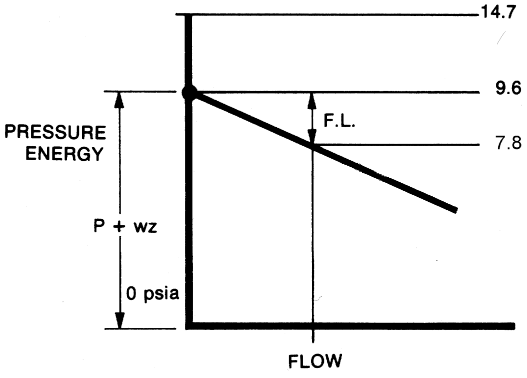
NOTE: Full size graphic available on page 133.

Subtract the pressure drop due to friction loss from the static pressure available.

EXAMPLE: Static Pressure – FL = Inlet Pressure
9.6 – 1.8 = 7.8 psia

Based on example flow of 60 GPM, 2” pipe, 10 CPS and 25.4 ft total equivalent length.

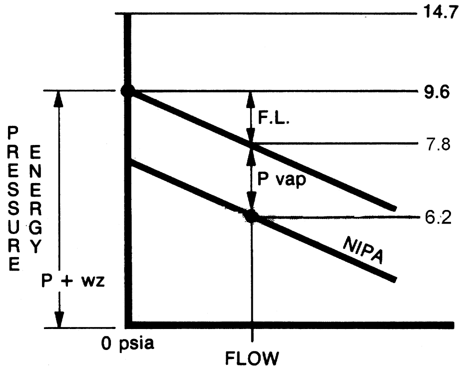
See page 54 for static pressure calculation.



Determine the vapor pressure of the fluid at pumping temperature. Refer to references for values for typical fluids. **Subtract** this vapor pressure from the inlet pressure in the system as calculated above. **This point is the Net Inlet Pressure Available (NIPA)** for these system and fluid conditions.

EXAMPLE: Given –

Vapor Pressure = 1.6 psia at 80°F
Inlet Press – VP = NIPA
7.8 – 1.6 = 6.2



This NIPA must be greater than the Net Inlet Pressure Required (NIPR) of the pump. Every pump has a set of NIPR curves which are determined by speed and fluid viscosity. These curves are shown starting on page 93 for Waukesha Pumps.

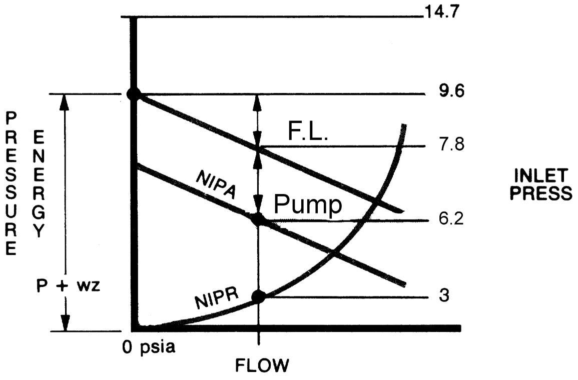
See page 121 for the 5050 curve used in this example.

Comparing NIPA with NIPR:

In this case the design is satisfactory as NIPA (6.2 psia) is greater than NIPR (2.7 psia).

If NIPA is less than NIPR, changes in system conditions are needed. Refer to page 25 for suggestion of changes to permit satisfactory operation.

NIPR based on 60 GPM at 426 RPM, in this example.



FLUID—NAME OR TYPE

SIMILAR TO:

PUMPING TEMPERATURE

80 °F NORMAL ____ °F MAX ____ °F MIN

VISCOSITY: ____ SSU 10 CPS AT 80 °F

☐ NEWTONIAN ☐ THIXOTROPIC ☐ DILATENT

SPECIFIC GRAVITY 1.47

VAPOR PRESSURE AT P.T. 1.6 PSIA

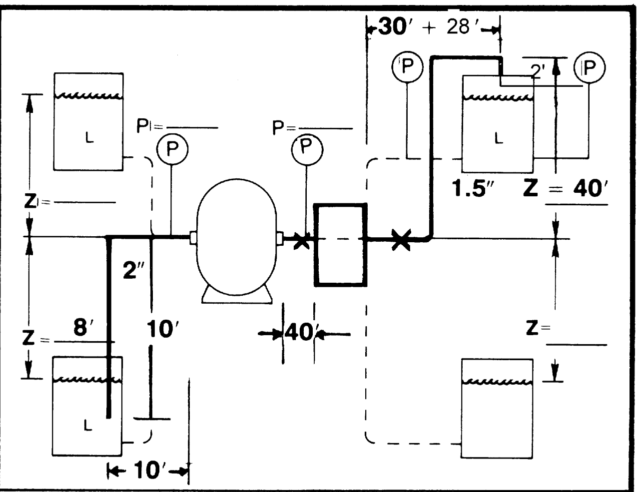
☐ INFLAMM. OR HAZARDOUS ☐ TOXIC

SOLIDS % MAX PARTICLE SIZE

☐ ABRASIVE ☐ NON ABRASIVE

CORROSION REQMT. PH

OTHER FLUID CHARACTERISTICS



OPERATING CONDITIONS

CAPACITY REQD 60 GPM ____ GPM MAX ____ GPM MIN

INLET CONDITION ____ PSIA

DISCHARGE PRESSURE ____ PSIG MIN ____ PSIG MAX

EFFECTIVE VISCOSITY REF: PG. 5 10 CPS

REQD GPM 60

PRELIMINARY PUMP SELECTION PG. 47 5050

DISCHARGE

	QUANTITY			EQUIV. LENGTH		EQUIV. LENGTH	
PIPE SIZE	2"	1.5"					
LINEAR LENGTH IN FEET						40	100
ELBOW	0	3	x	0	4	0	12
VALVE	1	1	x	1.2	1	1.2	1
FITTINGS			x				

TOTAL EQUIVALENT LENGTH PG. 47, 50 — 41.2 FT, 113 FT

INLET

	QUANTITY			EQUIV. LENGTH		EQUIV. LENGTH	
PIPE SIZE		2"					
LINEAR LENGTH IN FEET							20'
ELBOW		1	x		5.4'		5.4'
VALVE			x				
FITTINGS			x				

TOTAL EQUIVALENT LENGTH PG. 56 — ____ FT, 25.4 FT

FRICTION LOSSES PG. 51 2.9 PSI + 13.6 PSI = 16.5 PSI

FRICTION LOSSES PG. 57 ____ PSI + 1.8 PSI = 1.8 PSI

STATIC PRESSURE REQMT. PG. 13, 54 (Z. x .433 x S.G.) 25.5 PSI

EQUIPMENT PRESSURE DROP 0 PSI = 1.8 PSI

EQUIPMENT PRESSURE DROP PG. 52 + 105 PSI

STATIC PRESSURE REQMT. PG. 13, 54 (Z. x .433 x S.G.) + ±5.1 PSI

TOTAL DISCHARGE PRESSURE PG. 52 147 PSI

TOTAL INLET PRESSURE DROP 6.9 PSI

PUMP SPEED PG. 53, 93 420

DIFFERENTIAL PRESS PG. 12, 60 DISCH 147 + INLET 6.9PSI = D.P. 154

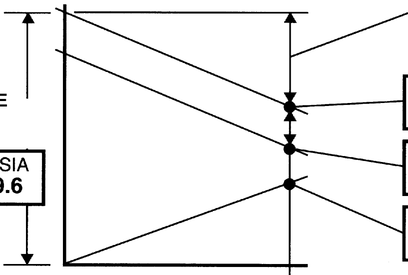
HORSEPOWER PG. 60, 93 to 124 WHP 5.9 + VHP .7 = HP 6.6

TORQUE PG. 62 1056 IN/LB

DRIVE SELECTION

USE 7.5HP GEAR MOTOR AT 426RPM

STATIC PRESSURE PG. 13, 54



PSIA 9.6

0 PSIA

V.P. PSI 1.6

NIPA-PSIA 6.2

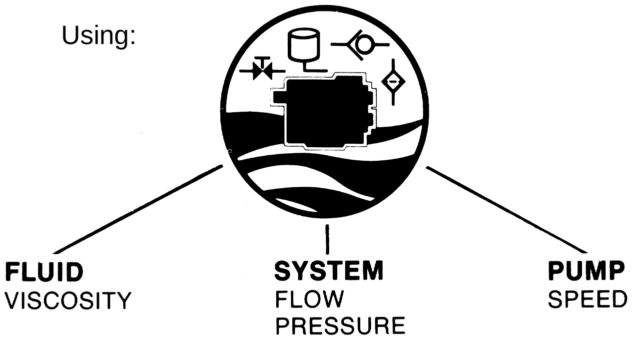
NIPR-PSIA 2.7

SPEED 426

NIPA MUST EXCEED NIPR

Calculating Power Requirements

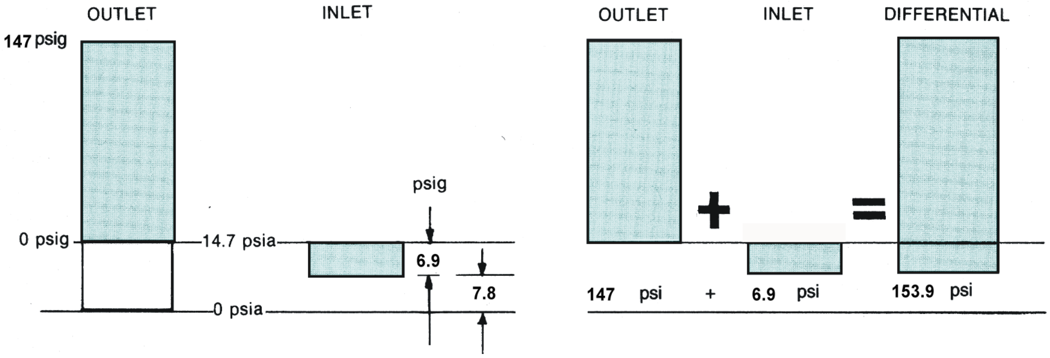
Using:



Determine **differential pressure** developed by pump:

- Using outlet pressure calculated
- Add or subtract inlet pressure (see pg. 12)
- Total = Differential pressure

Example shown is with inlet pressure below atmospheric pressure



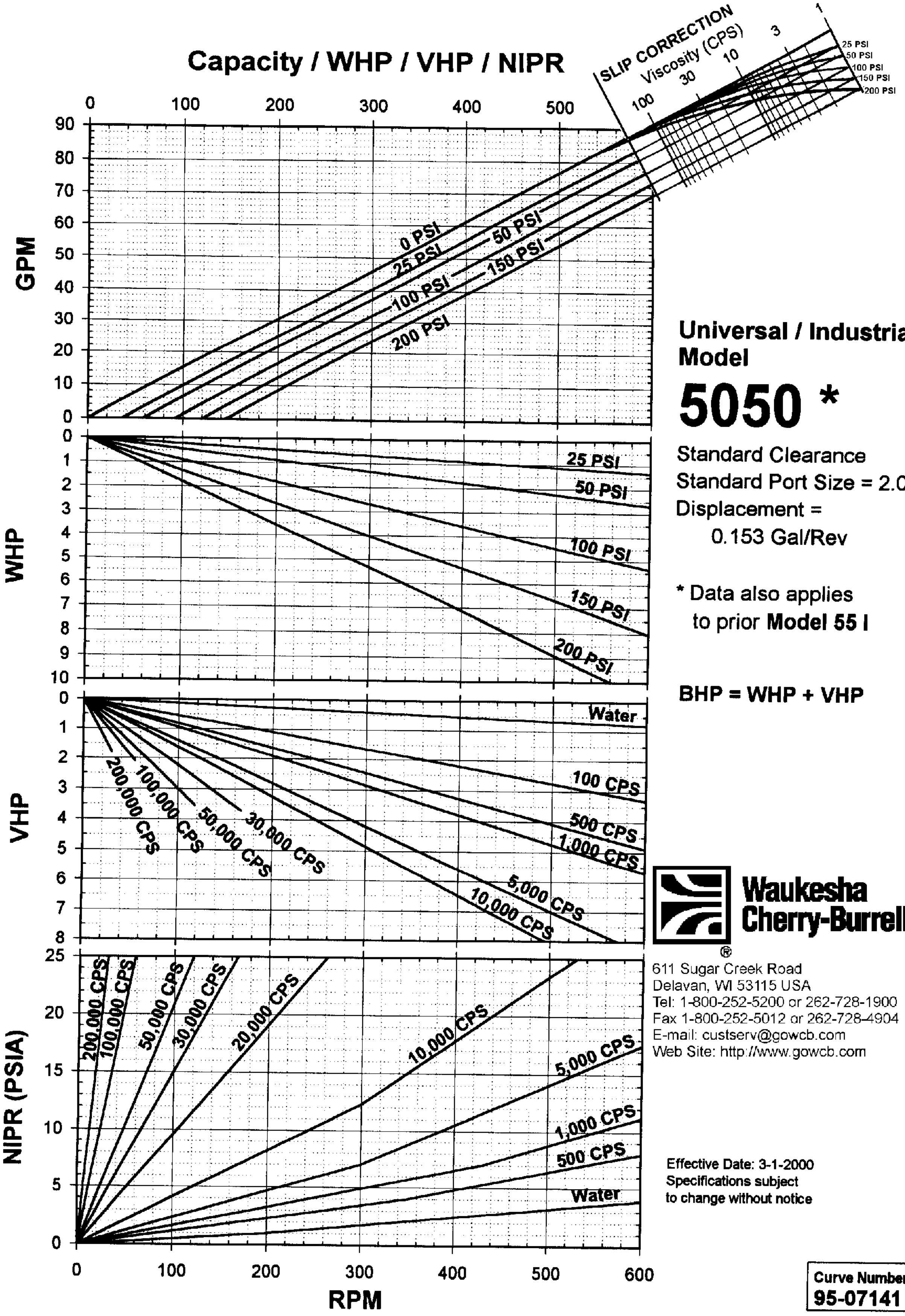
Using the differential pressure, plus the viscosity, flow rate, and pump speed determined earlier, the required HP can be easily found on the page 66. Starting at the pump speed, 420 RPM, follow vertical line down to the pressure line 154 PSI. A horizontal line to the left will give you the value for WHP, 5.9.

Then continue down on the RPM line to the viscosity line for 10 CPS and draw a horizontal line to the VHP scale, and read .7 HP.

Add WHP and VHP together for a required power of 6.6 HP. (See page 43 for discussion of HP, WHP and VHP.)

NOTE: HP, flow, and pressure will vary with gear motor speed. Constant speed gear motor may not be available for speed selected. Variable speed may be required. All values must be calculated at actual speed pump will be run at.

Capacity / WHP / VHP / NIPR



Universal / Industrial Model

5050 *

Standard Clearance
Standard Port Size = 2.0"
Displacement =
0.153 Gal/Rev

* Data also applies to prior **Model 55 I**

BHP = WHP + VHP

Waukesha Cherry-Burrell®
611 Sugar Creek Road
Delavan, WI 53115 USA
Tel: 1-800-252-5200 or 262-728-1900
Fax 1-800-252-5012 or 262-728-4904
E-mail: custserv@gowcb.com
Web Site: http://www.gowcb.com

Effective Date: 3-1-2000
Specifications subject to change without notice

Curve Number
95-07141

NOTE: This type of pump performance curve is used primarily to calculate required horsepower. If it is necessary to calculate efficiency, use:

- **output flow Q in GPM**
- **differential pressure P in PSI as calculated**
- **total input horsepower from curve (VHP + WHP)**

EXAMPLE:

$$\text{EFF} = (\text{output} \div \text{input}) \times 100$$

$$\text{EFF} = \left(\frac{QP}{1714} \div \text{WHP} + \text{VHP}\right) \times 100$$

$$\text{EFF} = \frac{60 \times 154}{1714} \div (5.9 + .7) \times 100$$

$$\text{EFF} = \frac{5.39}{6.6} \times 100 = 81.7\%$$

Torque Requirements – With the horsepower and speed just determined, the torque needed can be calculated. Using this relationship for HP:

$$\text{HP} = \frac{\text{T (ft.-lbs.)} \times \text{N (RPM)}}{5250}$$

Rearranging, we get

$$T = \frac{\text{HP} \times 5250}{N}$$

Torque is sometimes expressed in inch-lbs. or

$$\text{Torque (ft.-lbs.)} \times \frac{12"}{\text{ft.}} = \text{T (inch-lbs.)}$$

In our example

$$\text{Torque} = \frac{6.6 \times 5250}{426} = 81.3 \text{ ft.-lbs,}$$

or

$$81.3 \times 976 = 1116 \text{ inch-lbs.}$$

This **torque** should not exceed the torque limit of the pump shaft. **Torque should** be checked especially on high viscosity, low speed applications. See next page for torque limits.

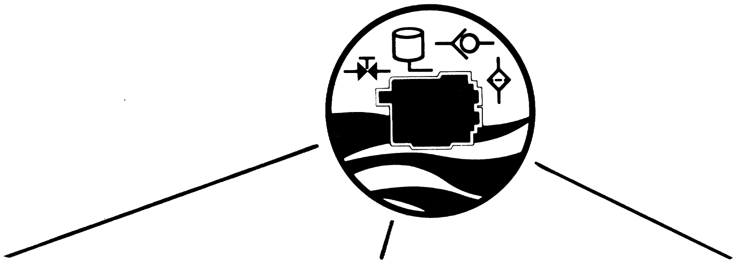
The table below shows the torque limits of various Waukesha Cherry-Burrell pumps.

Sanitary		
	Torque Limit	
Pump Size	(FT.-LBS.)	(INCH-LBS.)
6-15-18	66.6	800
30, 33	250	3,030
45, 60, 130, 133	420	5,050
180, 220, 223	790	9,500
210, 320, 323	1,320	15,800
420, 423	2,190	26,250
520, 523	2,190	26,250

Industrial		
	Torque Limit	
Pump Size	(FT.-LBS.)	(INCH-LBS.)
5040	100	1,200
5050, 5060	190	2,300
5070	790	9,500
5080	1,320	15,800

This completes the pump selection procedure for your Waukesha Cherry-Burrell pump. Following this is some general information to help you select a pump drive. Because of the great variety of available drives, we cannot include the detailed information which is found in drive manufacturers catalogs. However, Waukesha Cherry-Burrell is happy to assist in drive selection, and does maintain a stock of suitable drives in commonly used sizes.

Selecting the Pump Drive



Drive Characteristics
Constant or variable speed
Performance ratings
Service factors

Service Requirements
Power source
Duty cycle
Service life
Space requirements
Environment
Cost

Pump Requirements
Horsepower
Speed
Torque

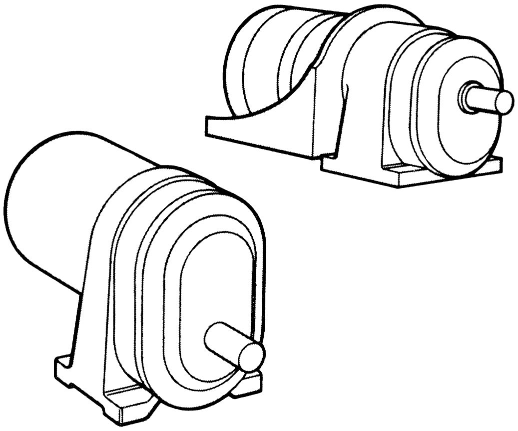
Rotary pumps are slow to medium speed pumps, and generally require a speed reduction from normal motor speeds of 1750, 1150 or 850 rpm. Using HP, speed, and torque required, a selection can be made from one of the readily available types of drives discussed below.

---

1. CONSTANT SPEED DRIVES – When exact flow is not critical with changes in system and pump conditions, a constant speed drive is a good choice.

Integral Gear Motor and Motor-Reducer Drives

These are rugged, self-contained drives generally using a 1750 rpm, 3-phase induction motor and helical gear reductions. Commercially available in a wide range of HP and speeds.

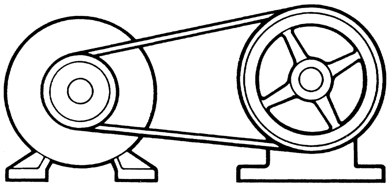


With the calculated speed and horsepower required, a conservative approach is to select the next lower stock speed, and a stock horsepower equal or above the requirement, using the manufacturers' recommended service class and ratings.

If a minimum flow must be maintained even with system changes and pump wear, the next higher speed may be needed. In this case, the system should be recalculated, as the higher speed and resulting higher flow and pressure drop will require higher horsepower. The drive selected must be able to supply this power.

The integral gear motor is generally more compact, lower in cost, and easier to install with only one coupling and guard.

The motor and separate reducer is sometimes preferred for its flexibility, especially in changing standard motors for maintenance.



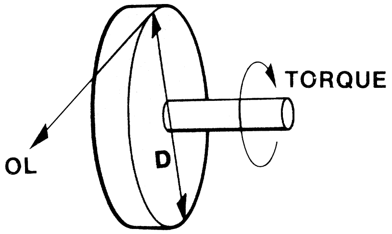
2. V-BELT DRIVES – V-belt Drives are usually the lowest initial cost constant speed drive, and offer some flexibility to change pump speed by a change in sheave size. Using readily available standard motors of 1750 and 1150 rpm, a range of medium pump speeds are possible. Due to sheave size and space limitations, the useful range of pump speeds is generally 200 to 600 rpm. Table 1 shows some practical combinations for use with Waukesha Cherry-Burrell pumps.

Table 1

Pump Speed	Motor Speed	V-Belt Section	Motor Sheave Diameter	Pump Sheave Diameter	Practical Center Distance	Approximate HP/Belt
220	1160	A	3	15.6	18.8	1.23
260	1160	A	3	13.2	15.1	1.14
290	1160	A	3	12.0	11.0	1.12
330	1160	A	3	10.6	12.4	1.12
390	1160	A	3	9.0	11.9	1.13
440	1750	A	3	12.0	13.6	1.62
495	1750	A	3	10.6	12.4	1.52
580	1750	A	3	9.0	11.9	1.54
640	1750	A	3	8.2	12.6	1.62
210	1160	B	3.4	18.4	15.9	1.49
260	1160	B	3.4	15.4	14.8	1.47
290	1160	B	3.4	13.6	16.5	1.49
360	1160	B	3.4	11.0	16.5	1.51
440	1750	B	3.4	13.6	14.0	1.88
480	1750	B	3.4	12.4	15.2	1.93
540	1750	B	3.4	11.0	16.5	1.93
630	1750	B	3.4	9.4	17.9	1.97
690	1750	B	3.4	8.6	16.8	1.97
220	1160	3V	2.65	14	12.1	1.14
270	1750	3V	3	19	16.3	2.2
305	1750	3V	3.5	19	16	2.74
370	1750	3V	3	14	15.6	2.25
430	1750	3V	2.65	10.6	12.7	1.66
490	1750	3V	3	10.6	12.5	2.22
555	1750	3V	3.35	10.6	12.2	2.73
605	1750	3V	2.8	8	11.2	1.92
650	1750	3V	3	8	11.1	2.27
700	1750	3V	2.8	6.9	10.9	1.92
340	1160	C	7	24	23.6	7.56
400	1160	C	7	20	21.8	7.83
450	1160	C	7	18	21.6	7.73
505	1160	C	7	16	20.4	7.53
510	1750	C	7	24	23.6	9.57
610	1750	C	7	20	21.8	9.57
680	1750	C	7	18	21.6	9.69
290	1160	5V	7.1	28	29.6	11.48
380	1160	5V	7.1	21.2	21.6	10.83
430	1160	5V	8	21.2	21.0	13.1
510	1160	5V	7.1	16	21.4	11.2
545	1160	5V	7.1	15	19.8	10.9
580	1750	5V	7.1	21.2	21.6	14.9
620	1750	5V	7.5	21.2	21.4	16.3

One disadvantage of a V-belt drive is the side load or overhung load it puts on both pump and motor shafts and bearings, particularly at low speeds and higher horsepowers. Table 2 shows the calculation of overhung loads and permissible load for various pumps.

Table 2
Calculation of Overhung Loads



The overhung load (OL) can be calculated using the torque calculated previously.

$$OL = K \times \frac{\text{Torque (inch-lbs.)}}{\frac{\text{Pitch diameter}}{2}}$$

or

$$K \times \frac{T}{D/2}$$

Where K = 1.0 for Chain Drives
1.25 for Timing Belt
1.5 for V-Belts

It can be seen that the overhung load can be kept to a minimum by using the largest practical pulley size.

EXAMPLE: For 7.0 HP at 428 RPM, we previously calculated a torque of 1032 in.-lbs. Assuming a driven sheave of 18.4 in. P.D. for a V-belt drive:

$$OL = K \times \frac{T}{D/2} = \frac{1.5 \times 1032}{18.4/2} = 168 \text{ lbs.}$$

Permissible Overhung Loads for Waukesha Cherry-Burrell Pumps

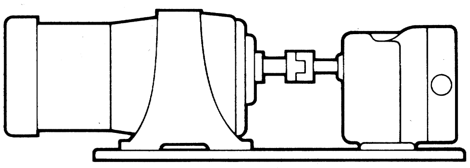
Based on location of sheave on pump shaft being as close to gear case as possible, and using a driven sheave of practical size.

Sanitary	
Pump Size	**O.H.L.-LBS.**
6, 15, 18	140
30	420
45, 60, 130	670
180, 220	750
210, 320	1,370

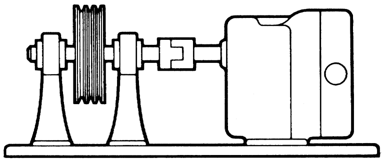
Industrial	
Pump Size	**O.H.L.-LBS.**
5040	260
5050, 5060	300

Industrial	
Pump Size	**O.H.L.-LBS.**
5070	870
5080	1,370

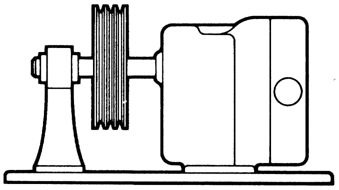
Beyond these loads, a jack shaft arrangement, or an outboard bearing arrangement can be used, or a change made to a direct drive



DIRECT DRIVE



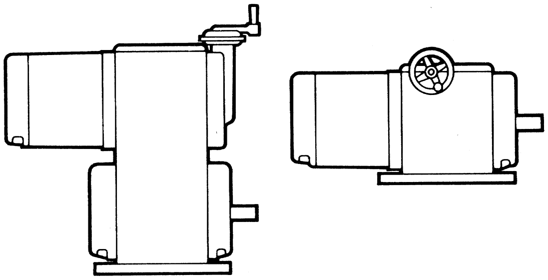
JACK SHAFT



OUTBOARD BEARING

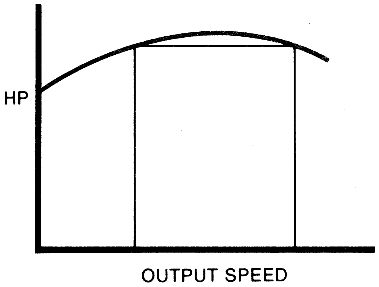
Timing Belt Drives can be used successfully on pumps. They have good high speed power capability, and will not slip at lower speeds. Refer to manufacturers' catalogs for selection and application.

3. VARIABLE SPEED DRIVES – Many excellent types of packaged variable speed drives are available which are well matched to pump requirements. They offer the ability to adjust pump speed to control flow and adjust for system conditions and eventual pump wear.

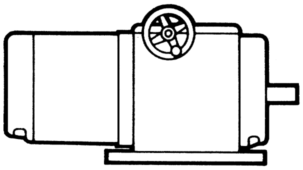


a. Belt type variable speed drives are available in a wide choice of horsepower and speed ranges. Coupled directly to a pump, they provide a compact drive at a reasonable cost.

In selecting a drive from a manufacturers' catalog, the torque capability must be checked for the range of speeds needed, and compared to the pump torque requirements. Waukesha Cherry-Burrell has preselected certain models which have good torque capabilities over a broad speed range.



b. Traction type VS drives have been used successfully on pump applications, and recent developments in lubricants have greatly improved capacity and life. Some drives are infinitely variable from zero speed, and reversible.



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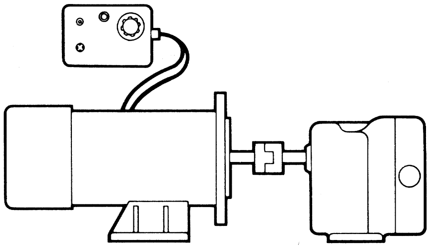
c. Electronic Variable Speed Drives. Recently many types of electronically controlled variable speed drives have become available. Using DC and AC motors, with variable voltage or frequency to vary speed, they can be applied as adjustable speed pump drives. Generally a speed reducer is needed to get the required torque at the lower pump speeds; thus permitting a smaller and more economical motor and control.



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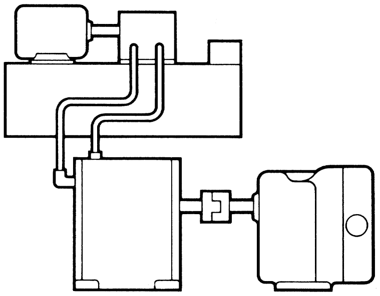
d. Hydraulic Drives. Packaged or custom designed hydraulic drives are extremely well suited for Waukesha Cherry-Burrell pump drives. They have excellent high torque capabilities over a broad speed range, with many available control options.



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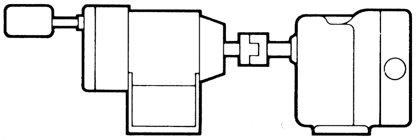
e. Air motors provide a good low cost drive with adequate torque capabilities when suitable motors are used. They have definite speed control limitations, but are useful in special situations.



Waukesha Cherry-Burrell can provide assistance in selecting a Waukesha Cherry-Burrell pump and associated drive to fit your application. The application data sheet in this manual illustrates the type of information needed to aid in the selection.

It should be noted that many local, state, and federal codes govern the use of drives and controls, in addition to other practical factors of selection. Some of these factors to consider are:

- State and OSHA Safety Codes
- Local, State and National Electrical Codes
- Local, State and National Sanitary Standards
- User, Industry and Manufacturers Standards
- Hazardous Liquid Duty
- Explosion Hazards, Inflammable Vapors
- Air Borne Dust, Lint Particles, etc.
- High Humidity Environment
- Wet Environment
- Ambient Temperature Considerations
- Adequate Mechanical and/or Electrical Overload Protection
- Duty and Service Considerations
- Lubrication and Maintenance Requirements

Selecting the Pump Type

Waukesha Cherry-Burrell builds pumps for two general areas of application: **Sanitary** service and general **Industrial** application.

The **Sanitary** type features both COP (Clean Out of Place) and CIP (Clean In Place) designs. Rotors, body, and all parts in contact with the fluid are designed and manufactured for acceptability by USDA and 3A sanitary standards.

Available in 316 stainless steel with **Waukesha 88** rotors. 316SS rotors are available as an option.

The **Industrial** type is built for general heavy duty service in a wide variety of industrial applications. Available in three basic material choices:

- 316 stainless steel with **Waukesha 88** rotors
- optional 316SS rotors
- ductile iron (ASTM #A-395)

Sanitary Pump Features and Options

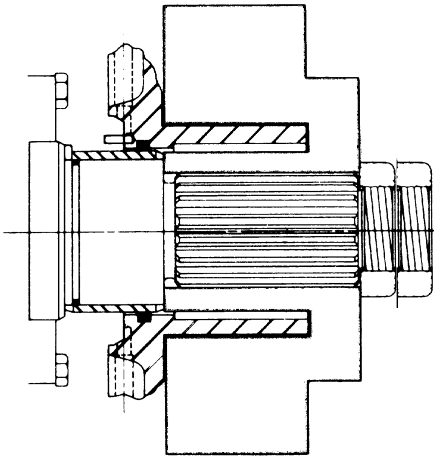
The Waukesha Cherry-Burrell Sanitary style pump features simple take-apart or CIP construction. The cover, body, rotors, and seal parts can be disassembled by removing the cover and rotor nuts. Reassembly alignment is assured by precision locating dowels.

The Waukesha Cherry-Burrell Sanitary Pump is the standard of the food industry, and is used to pump nearly every edible product. In addition, its features make it very suitable for pumping pharmaceuticals, dyes, chemicals, latex and many other products. Its easy take-down, high efficiency, corrosion resistance, seal choices, and its performance-to-cost ratio make it suitable for a number of medium duty industrial uses.

1. SEAL OPTIONS — Seal construction for a Sanitary pump differs from Industrial seal design. For sanitary service, seal parts are simple in shape and have no corners or crevices which would be hard to clean. The seals are made to be removed and cleaned daily, often by personnel unskilled in seal care.

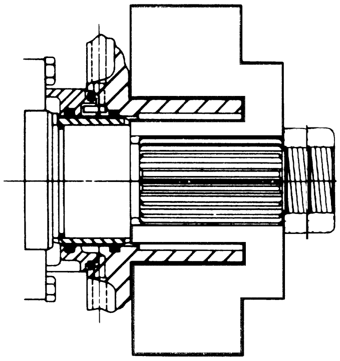
a. Universal I O-ring Seal: Stationary O-ring in body groove. Rotating, replaceable shaft sleeve.

- Easy to clean
- Easy to assemble
- Periodic seal replacement required
- Best at moderate temperatures (to 180°F)
- Choice of sleeve and O-ring styles and materials



b. Universal I Twin O-ring Seal: Two Stationary O-rings with flushing space, rotating, replaceable shaft sleeve.

- Easy to clean and service
- Liquid **seal** or barrier
- Prevents air entry
- Cools and extends life
- Flushes away particle build-up
- Choice of sleeve and O-ring styles and materials



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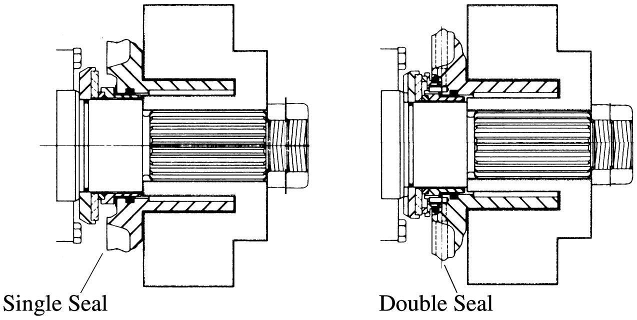
c. Universal I, Universal II, Universal Lobe Sanitary Mechanical Seal: Single or double as shown. Rotating seal seat. Floating, stationary seal assembly. (Universal I shown)

- Long life
- Wide temperature range
- High speed capability
- High pressure performance
- Choice of face and O-ring materials
- Requires greater care in handling
- Flushing arrangements available



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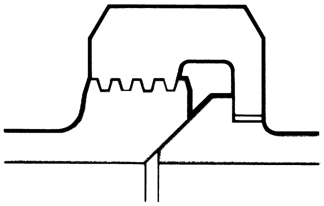
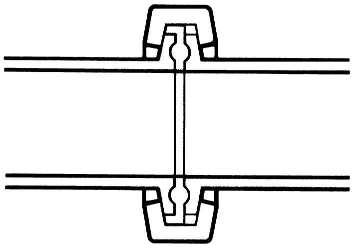
2. PORT OPTIONS – Bevel seat, IMDA thread.



Sanitary clamp type fittings (gasketed). Wide variety of styles available.

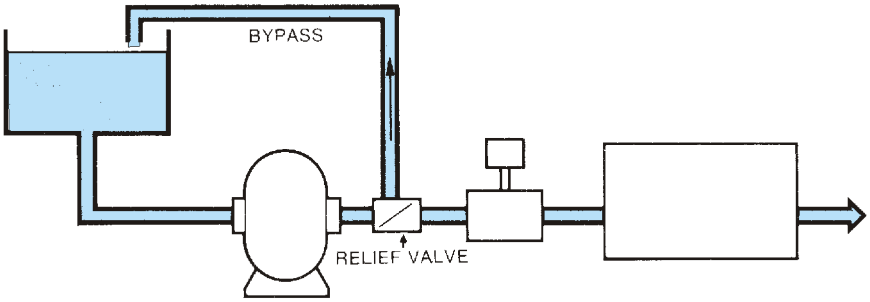
- S line (shown)
- I line
- Q line
- DIN
- SMS
- RJT



NPT or flanged connections are not considered a **sanitary** connection. NPT connections are normally used for industrial applications. Contact your Waukesha Cherry-Burrell Representative for more information.

3. RELIEF VALVE OPTIONS – As a positive displacement pump can develop very high pressures, the piping system and equipment may require protection from excessive pressure due to a restricted or closed discharge line.

An external relief valve, or by-pass, can be used:



The Waukesha **Vented Cover** is a unique integral, compact, internal by-pass valve which can be used as a pressure relief valve. It is bi-directional; that is, the pump flow or rotation can be in either direction. However, the combinations of flow, pressure, and viscosity which may be encountered may exceed the by-pass capability of the vented cover passages. Specific operating conditions should be furnished to Waukesha Cherry- Burrell Application Engineering for recommendation.

Three types of Vented Covers are available:

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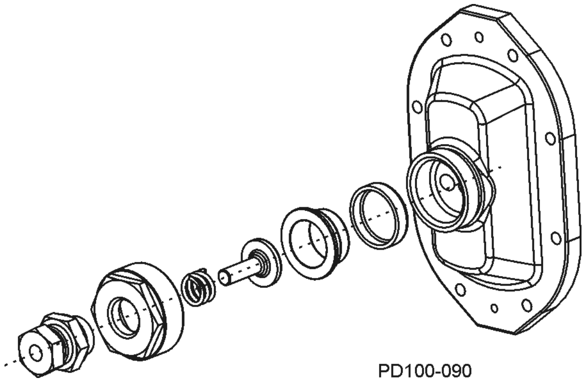
a. Manual. By-pass pressure is adjusted by a threaded adjusting screw which compresses a spring. Several spring sizes are available, each with limited operating range.



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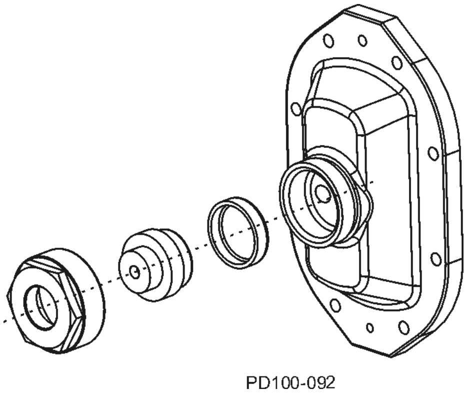
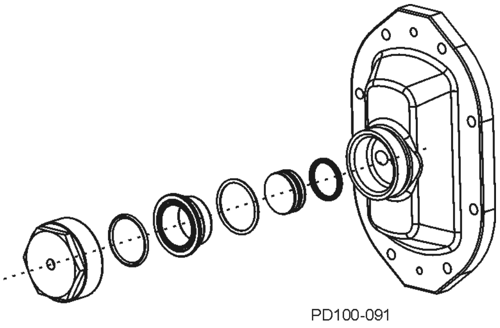
b. Pneumatic. By-pass pressure is adjusted by regulated air or gas pressure, operating on the side of a diaphragm opposite the pumped fluid. Most sensitive control of the three types.



c. Piston. By-pass pressure is adjusted by regulated air or gas pressure, operating on the side of a metal piston, opposite the pumped fluid. Extended pressure range possible.

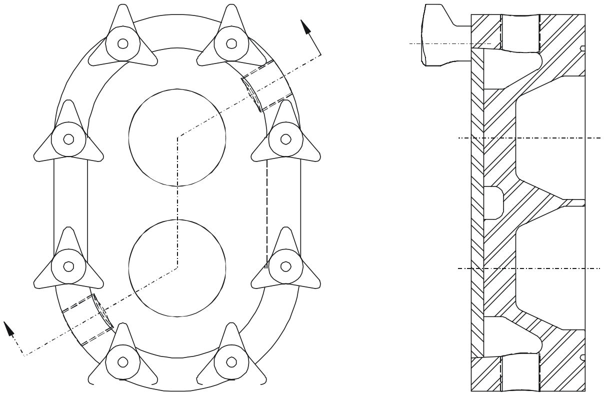


On all three types of relief valve covers, the temperature and chemical resistance of the elastomer diaphragms and O-rings determine the useful range.

Standard material — Buna N

Optional material — Silicone, Viton®, EPDM

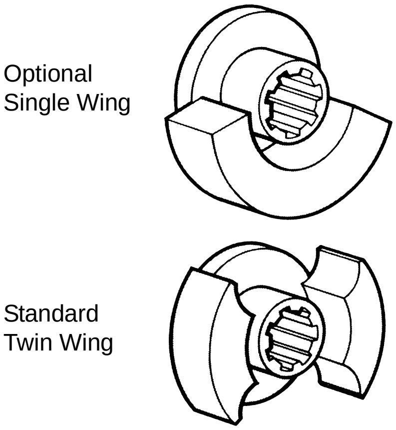
4. JACKETED COVERS – A jacketed cover is available for Waukesha Cherry-Burrell pumps. This type of cover is used to transfer heat to the pumping body prior to introducing the types of fluid that change consistency (set-up) when coming into contact with chilled or excessively warm surfaces. It is also commonly used to maintain product temperature within the pumping body during extended shut-down periods.



5. ECP ROTOR TYPES

Single Wing — Recommended for handling products containing discrete particles that should see minimum damage or breakage such as large curd cottage cheese, chilli containing beans, fruit preservatives, pie fillings, etc.

Twin Wing — This type is standard and suitable for most applications.



U1 Rotors Shown

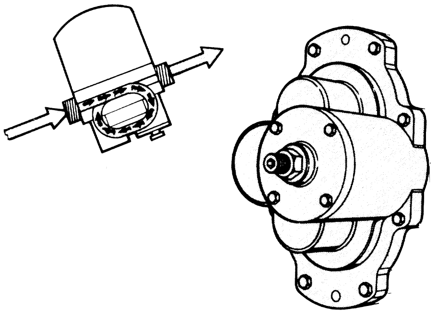
Industrial Pump Features

For general pump applications, the Waukesha Cherry-Burrell Industrial series is most suitable. Its flow, pressure and viscosity range, along with its close clearance construction, make it extremely versatile in a wide variety of pumping applications.

The industrial pump is constructed to be easy to maintain, with pumping head disassembly especially convenient. Commercially available mechanical seals or packing are available.

1. RELIEF VALVE – A unique, compact pressure relief valve that is completely integrated within the pump cover features full flow characteristics to handle any pressure within the pump's rating. By-pass pressure is set by adjustable spring tension operating on the end of a metal piston opposite the pumped fluid.

The pump cover is reversible for right or left hand flow direction. O-ring seals are furnished in material compatible with the product being pumped.

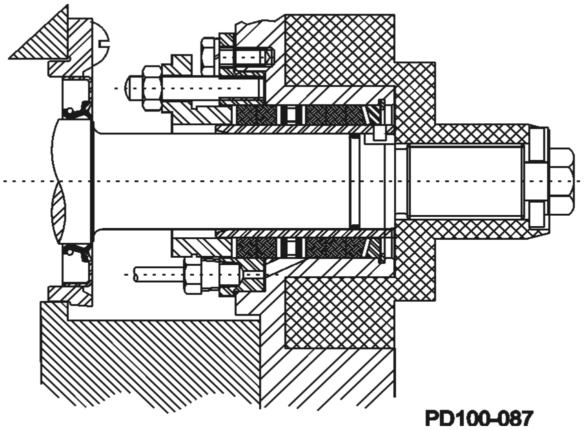


2. SEAL OPTIONS – The gland area for the seal is capable of using many arrangements of packing or mechanical seals, chosen for the specific duty.

a. Packing. A simple, low cost, and easy-to-maintain sealing arrangement. It is not sensitive to thermal changes, and external adjustment to maintain sealing is possible, until packing replacement can be conveniently made.

A small amount of liquid leakage is normal for packing lubrication.

To suit the required service, a variety of packing materials and replaceable shaft sleeves are available. Standard sleeves are 316 stainless or ceramic coated stainless.



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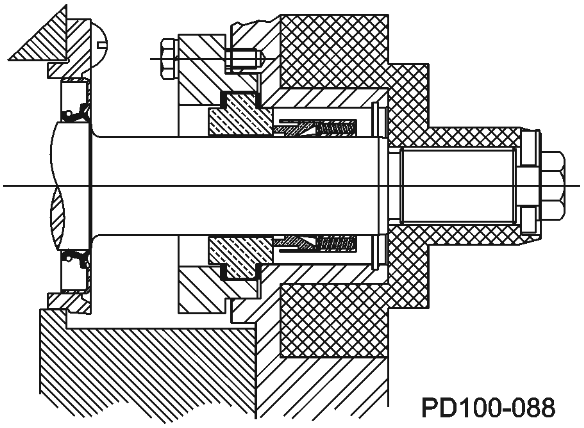
b. Mechanical Seals. There are many different makes, types, materials and arrangements that can be installed on a Waukesha Cherry-Burrell pump. Under suitable conditions, a mechanical seal arrangement provides long life and leak-free sealing. The following are the most commonly used arrangements.

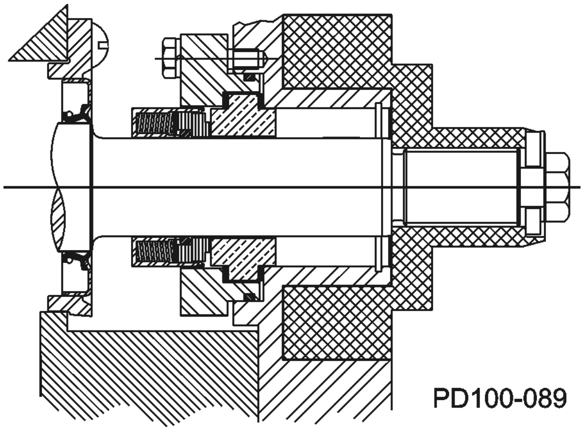
Single Inside Seal – Most commonly used for general conditions.

- Seal is enclosed and protected
- Simplest arrangement
- All parts cooled and lubricated by pumped fluid
- Natural circulation of fluid
- Seal face in compression
- Best when fluid conditions are nearly ideal



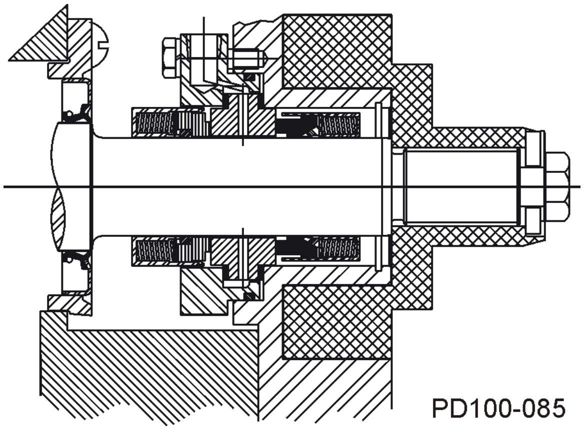
Single Outside Seal – Used when minimum exposure to the pumped liquid is wanted.

- Seal elements not in liquid
- Good for shear sensitive and high viscosity fluids



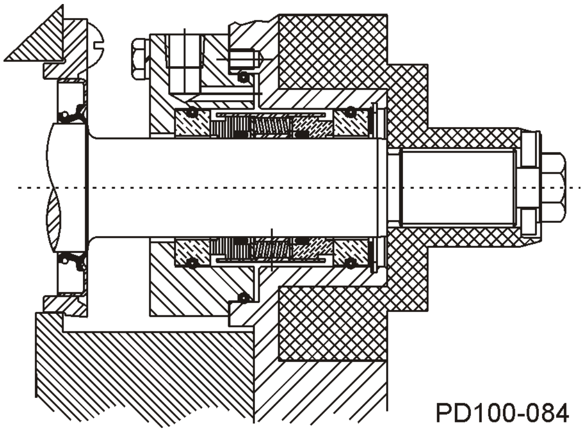
Double (Inside-Outside) Seal – Used with a flushing liquid to:

- Cool and lubricate the seal faces
- Carry away leakage past the inner seal
- Good for toxic and hazardous fluids, as well as high vapor pressure fluids
- Good for fluids which would “set-up” in contact with air



Double Inside Seal – A solution for difficult applications. All the advantages of an Inside-Outside seal plus minimum exposure to pumpage.

- All seal elements in flushing fluid
- Good lubrication and cooling
- Maintain a flushing pressure higher than the pump pressure, causing any leakage to be **into** the pump chamber — good for abrasive liquids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Rotor Clearance Options — Sanitary and Industrial

The standard clearance rotors for your Waukesha Cherry-Burrell pump are designed to operate with most fluids at temperatures up to 200°F. Expansion of the pump parts at higher temperatures requires additional clearance. We offer the hot clearance rotor option for temperatures up to 300°F.

If your application requires special clearance, or for temperatures above 300°F, please consult Waukesha Cherry-Burrell.

Some high viscosity or shear sensitive fluids (i.e., chocolate) may require extra clearance. We offer a complete line of rotors with specialized clearances.

Standard Waukesha Cherry-Burrell rotors are made with Alloy 88 metal which gives optimum pumping efficiency and wear characteristics for most fluids. We also offer optional rotors made of 316 stainless steel. **For applications that require the added chemical compatibility of this material, consult Waukesha Cherry-Burrell.**

Special Purpose Pump Types

RF MODELS

The Rectangular Flange design is a large opening pump designed for pumping highly viscous materials. Generally used for food products.

Universal I Models: 014-U1, 024-U1, 034-U1, 064-U1, 134-U1, 224-U1, 324-U1.

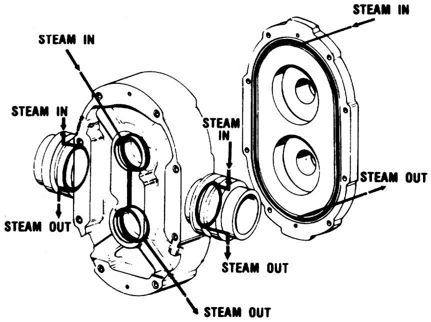
Universal II Models: 014-U2, 034-U2, 064-U2, 134-U2, 224-U2.

Universal Lobe Models: 034-UL, 054-UL, 134-UL

ASEPTIC MODELS

This pump is designed for aseptic processing in the canning, food, dairy and other industries. A special live steam or sterile solution **seal** is maintained at every possible opening into the pump.

Models 33U1, 133U1, 213U2, 233U1, 323U1, 423UHC, 523UHC



Pump Installation

The installation of your Waukesha Cherry-Burrell pump and its piping system should follow good practice to give optimum performance.

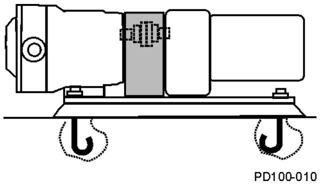
1. Installing the Pump and Drive Unit

Pumps of this type and size are generally mounted on a common base plate with the drive.

The unit can be installed in the plant location in several ways:

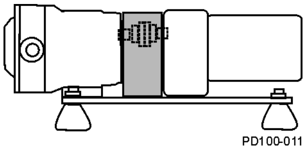
a. Permanent installation on foundation with bolts and grout.

Level unit before grouting.

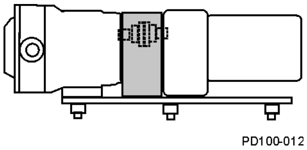


b. Leveling and/or vibration isolation pads.

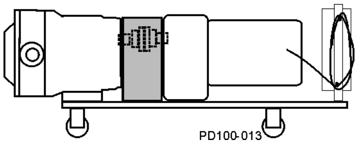
Many commercial types available.



c. Adjustable leg base, commonly used for sanitary pumps. For washdown under base. Can be easily moved or repositioned.



d. Portable bases — for movement to different locations.



2. Good Piping Practice

All piping to the pump should be supported independently, to minimize the forces exerted on the pump. Such forces can cause misalignment of pump parts and lead to excessive wear of rotors, bearings and shafts.

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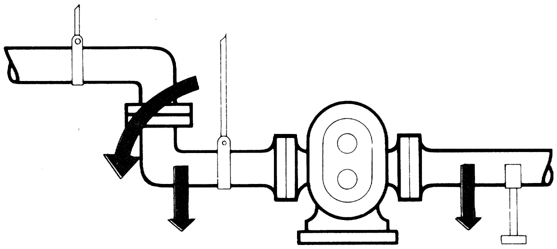
a. **Piping support:** Weight of piping and fluid — support piping independently with hangers or pedestals. On rectangular inlet flange pumps, hopper should also be supported independently.



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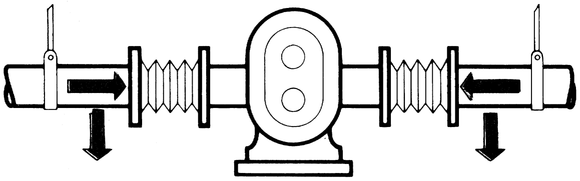
b. **Thermal expansion of piping** can cause tremendous forces. Use thermal expansion joints to minimize forces on pump.

Flexible joints can also be used to limit the transmission of mechanical vibration. Anchor free ends of any flexible hose in system.



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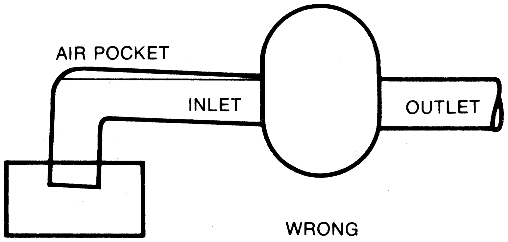
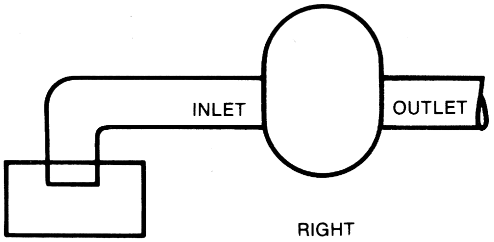
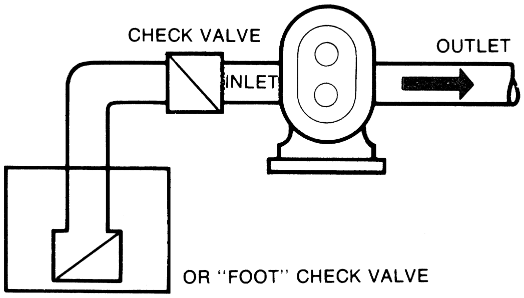
c. **Piping Layout:**

1. **Inlet side** — slope piping up to inlet to avoid air pocket.

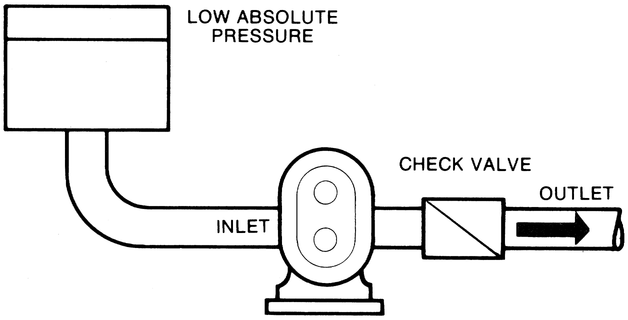




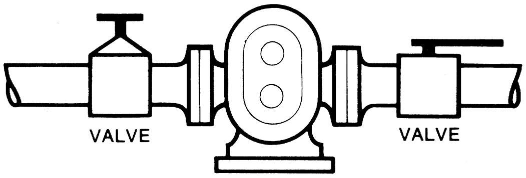
2. **Inlet Side** — use check valves to keep inlet line full, particularly with low viscosity fluids, and in start-stop operation.



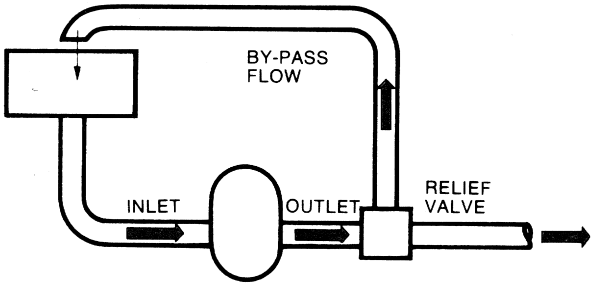
3. **Inlet Vacuum Service** — use check valve on outlet side.
   - Prevents backflow (air or fluid)
   - Facilitates initial start-up (minimizes differential pressure pump must supply to start flow)



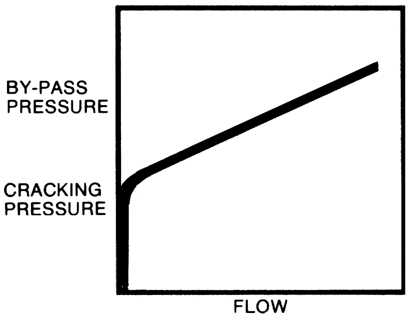
4. **Isolation Valves** — permit pump maintenance and removal safely and without emptying entire system.



5. **Relief Valve** — To protect the pump and piping system against excessive pressure, a relief valve should be installed. An integral relief valve, designed to bypass the fluid internally from the pump outlet to the inlet, should not be used on applications where the discharge must be closed for more than a few minutes. Prolonged operation of the pump with closed discharge will cause heating of the fluid circulating through the relief valve. When such operation is necessary, the relief valve, whether integral, attachable, or line-mounted, should discharge externally through piping connected to the fluid source, or if that is not practical, into the inlet piping near the source.

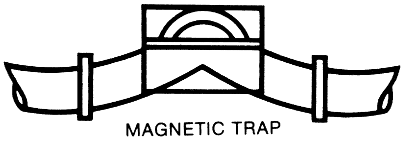


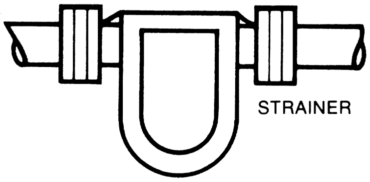
A particular relief valve design will have a characteristic curve as shown. The **cracking pressure** can usually be set by spring adjustment, or by adjustable pneumatic pressure, etc. Flow will begin to bypass when this **cracking pressure** is reached. As flow increases through the bypass, the system pressure will also increase.



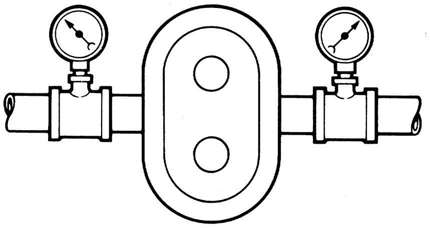
The pressure increase for a given valve design depends on the valve setting, the flow rate, and the viscosity of the fluid being pumped. If the full-flow bypass pressure exceeds the maximum allowable for the particular pump and piping system, an oversize attachable relief valve may sometimes be used to limit the full-flow bypass pressure to an acceptable value.

6. **Inlet Side: Strainers and Traps** — Inlet side strainers and traps can be used to prevent pump damage from foreign matter. Selection must be **carefully made** as clogging can easily occur, restricting the inlet, causing cavitation and flow stoppage.





7. **Pressure gauges** — Pressure and Vacuum gauges provide the easiest way to tell you something about the pump operation.
   - Normal or abnormal pressures
   - Overflow conditions
   - Indication of flow
   - Changes in pump condition
   - Changes in system conditions
   - Changes in fluid viscosity



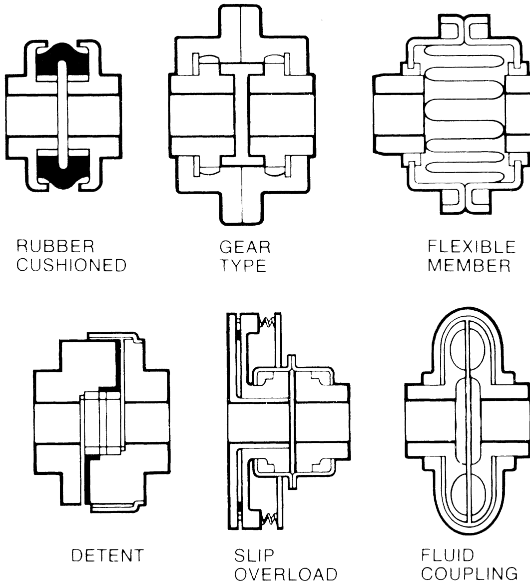
Wherever possible — install gauges!!

3. Alignment of Pump to Drive

Pumps and drives which are ordered from the factory and mounted on a common base plate are accurately aligned before shipment. The alignment should be re-checked after the complete unit has been installed and the piping completed. Periodic re-checking is advisable during the pump service life.

In-line drives. For initial pump installation, and for re-checking alignment, the following steps are advised.

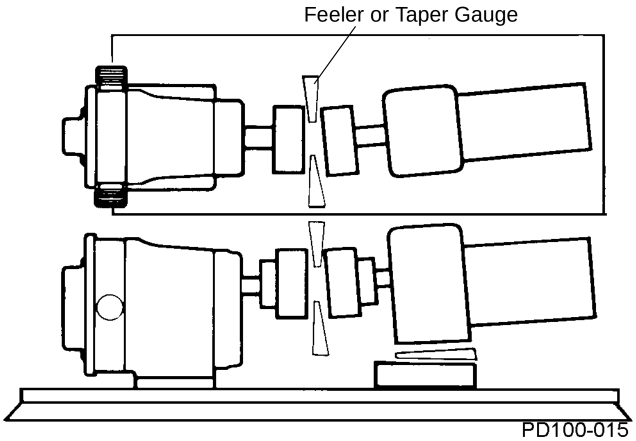
A flexible coupling should be used to connect the drive to the pump. Many different types are available, including couplings with slip or overload provision.



A flexible coupling is used to compensate for end play and **small** differences in alignment. The pump and drive shaft should be aligned as closely as possible.

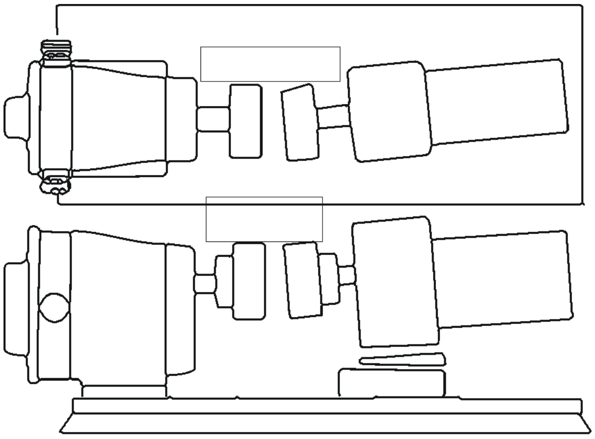
Check angular alignment using feeler or taper gauge.

Adjust to get equal dimension at all points — at the same time, set space between coupling halves to the coupling manufacturer’s recommended distance.



PD100-015

Check parallel misalignment using straight edges and shims.

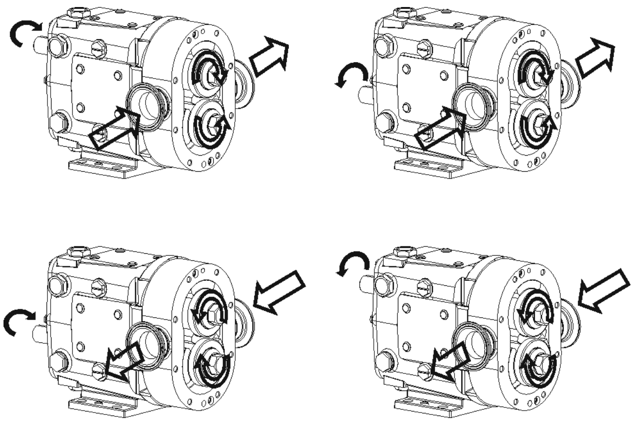


PD100-023

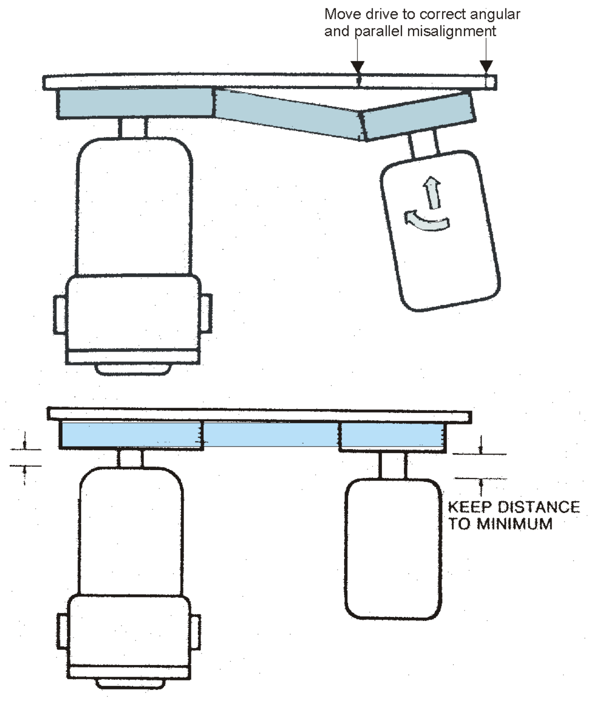
NOTE: After piping is complete, and drive and couplings are aligned, turn pump shaft manually to see that it turns freely without binding.

Check rotation direction of drive to see that pump will rotate in proper direction facing **Liquid End** of pump.

Then connect coupling halves.



Align belt and chain drives using straight-edges and visual check.



After piping is complete and before belts are installed, **turn pump shaft manually** to see that it turns freely.

Check rotation direction of pump to see that pump will rotate in proper direction. **Then install belts and tension them correctly.**

Start-Up Check List

The Waukesha Cherry-Burrell Pump is a positive displacement pump and thus can develop very high pressures. To protect lines, equipment and personnel, certain precautions must be taken.

1. Review “Pump Installation”, particularly “Relief Valves”. Install relief valves if needed in system.
2. Check that piping and pump are clean and free of foreign material, such as welding slag, gaskets, etc. **Do not use pump to flush system.**
3. See that all piping connections are tight and leak free. Where possible, check system with **non-hazardous** fluid.
4. Check to see that pump and drive are lubricated. See pump lubrication section in Maintenance Manual. Install breather plug. Check drive lubrication instruction.
5. Check that all guards are in place and secure.
6. Seals: Packing — supply flushing fluid if needed. Leave packing gland loose for normal **weepage**! Make adjustments as initial conditions stabilize, to maintain normal weepage.

   Double O-ring or double mechanical seals — Check that flush liquid is connected and turned on.
7. See that all valves are open on discharge system, and free flow path is open to destination.
8. See that all valves are open on inlet side, and that fluid can reach pump.
9. Check direction of pump and drive rotation (jogging is recommended).
10. Start pump drive. Where possible, start at slow speed, or jog.

Check to see that liquid is reaching pump within several minutes. If pumping does not begin and stabilize, check items under “No Flow” or “Insufficient Flow” in Pump Troubleshooting section.

Troubleshooting a Pumping System

Once a pump is properly selected and installed in a system, operation should be trouble free. However, in existing systems, or as pump and system conditions change, problems may develop. Following are some troubleshooting hints to help identify and solve problems.

Problem	Possible Cause	Solutions
No flow, pump not turning	Drive Motor not running	Check resets, fuses, circuit breakers
	Keys sheared or missing	Replace
	Drive belts, power transmission components slipping or broken	Replace or adjust
	Pump shaft, keys, or gears sheared	Inspect; replace parts
No flow, pump turning	Wrong direction of rotation	Reverse
No flow, pump not priming	Valve closed in inlet line	Open valve
	Inlet line clogged or restricted	Clear line, clean filters, etc.
	Air leaks due to bad seals or pipe connections	Replace seals; check lines for leakage (can be done by air pressure, or by filling with liquid and pressurizing with air)
	Pump speed too slow	Refer to “Dry Prime” chart, speed up pump. Filling inlet lines with fluid may allow initial start-up. Foot valve may solve start-up problems permanently.
	Liquid drains or siphons from system during off periods	Use foot valve or check valves
	Air lock. Fluids which **gas off** or vaporize, or allow gas to come out of solution during off periods	Manual or automatic air bleed from pump or lines near pump
	Extra clearance rotors, worn pump	Increase pump speed, use foot valve to improve priming
	Net inlet pressure available too low	Check NIPA, NIPR, recalculate system. Change inlet system as needed.

Problem	Possible Cause	Solutions
No flow, pump not priming (continued)	On **Vacuum** inlet system: on initial start-up, atmospheric **blow back** prevents pump from developing enough differential pressure to start flow.	Install check valve in discharge line
No flow	Relief valve not properly adjusted, or held off seat by foreign material (flow is being recirculated to inlet)	Adjust or clear valve
Insufficient flow	Speed too low to obtain desired flow	Check flow-speed chart
	Air leak due to bad seals or pipe connections	Replace seals, check inlet fittings
Fluid vaporization (**starved** pump inlet)	Strainers, foot valves, inlet fittings or lines clogged	Clear lines. If problem continues, inlet system may require change
	Inlet line size too small, inlet line length too long. Too many fittings or valves. Foot valves, strainers too small.	Increase inlet line size. Reduce length, minimize direction and size changes, reduce number of fittings. Refer to “The Inlet Side” section.
	NIPA too low	Raise liquid level in source tank
	NIPA too low	Increase by raising or pressurizing source tank
	NIPA too low NIPA < NIPR	Select larger pump size with smaller NIPR
	Fluid viscosity greater than expected	Reduce pump speed and accept lower flow, or change system to reduce line losses
	Fluid temperature higher than expected (vapor pressure higher)	Reduce temperature, reduce speed and accept lower flow or change system to increase NIPA
Insufficient flow, fluid being bypassed somewhere	Relief valve not adjusted or jammed	Adjust or clear
	Flow diverted in branch line, open valve, etc.	Check system and controls

Problem	Possible Cause	Solutions
Insufficient flow, high slip	Hot (HC) or extra clearance rotors on **cold** fluid, and/or low viscosity fluid	Replace with standard clearance rotors
	Worn pump	Increase pump speed (within limits). Replace rotors, recondition pump.
	High pressure	Reduce pressure by system changes
Noisy operation	**Cavitation**	
	High fluid viscosity, High vapor pressure fluids, High temperature	Slow down pump, reduce temperature, change system
	NIPA < NIPR	To increase NIPA or reduce NIPR, see Manual Sections and Pump Charts
	Air or gas in fluid	
	Leaks in pump or piping	Correct leaks
	Dissolved gas or naturally aerated products	Minimize discharge pressure. Also see “Cavitation” above.
	Mechanical noises **Rotor to body contact**	
	Improper assembly	Check clearance with shims
	Rotor to body contact	
	Distortion of pump due to improper piping installation	Reassemble pump or re-install piping to assure free running
	Pressure higher than rated	Reduce pressure if possible
	Worn bearing	Rebuild with new bearings, lubricate regularly
	Worn gears	Rebuild with new gears, lubricate regularly
	Rotor to rotor contact	
	Loose or mis-timed gears, twisted shaft, sheared keys, worn splines	Rebuild with new parts

Problem	**Possible Cause**	**Solutions**
Noisy operation (continued)	**Relief valve chattering**	Readjust, repair or replace
	Drive component noise — gear trains, chains, couplings, bearings.	Repair or replace drive train
Pump requires excessive power (overheats, stalls, high current draw, breakers trip)	**Higher Viscous losses than expected**	If within pump rating, increase drive size
	Higher pressure than expected	Reduce pump speed, increase line size
	Fluid characteristics	
	Fluid colder than expected, viscosity high	Heat fluid, insulate or heat trace lines. Use pump with more running clearances.
	Fluid sets up in line and pump during shut down	Insulate or heat trace line. Install **soft start** drive. Install recirculating bypass system. Flush with other fluid.
	Fluid builds up on pump surfaces (Example: latex, chocolate, fondants)	Use pump with more running clearance
Short pump service life	High corrosion rate	Upgrade material of pump
	Pumping abrasives	Larger pumps at slower speeds can help
	Speeds and pressures higher than rated	Reduce speeds and pressures by changes in system
	Worn bearings and gears due to lack of lubrication	Set up and follow regular lubrication schedule
	Misalignment of drive and piping. Excessive overhung load or misaligned couplings.	Check alignment of piping. Check drive alignment and loads.

Engineering Data Section

The performance curves in this manual are based on actual test data under specific conditions, and are considered representative. As variations in fluids, system conditions, and normal manufacture can occur, performance of a specific pump may vary from these curves. Waukesha Cherry-Burrell should be consulted for more precise information if needed, and for performance requirements outside of the ranges shown.

NOTE: Consult Waukesha Cherry-Burrell’s Application Engineering Department for sizing of CIPable and Aseptic models.

Waukesha PD Pump Sanitary/Industrial Model Cross Reference

Displacement Gallons / Rev	DO	Universal 1	Universal 1 RF	Universal 1 CIP	CDL	Aseptic	Universal 2	Universal 2 RF	Universal Lobe	Universal Lobe RF	Universal High Capacity	Industrial DI	Industrial SS	5000 DI	5000 SS
0.0075	3														
0.0082		006-U1					006-U2								
0.0133	10														
0.0142		015-U1	014-U1	12			015-U2	014-U2							
0.029	16	018-U1	024-U1	22			018-U2								
0.033									018-UL						
0.051						33									
0.060	25	030-U1	034-U1	32			030-U2	034-U2				25DI	25I	5040DI	5040SS
0.071					4040				030-UL	034-UL					
0.098							045-U2								
0.123									050-UL	054-UL					
0.142					4050										
0.153	55	060-U1	064-U1	62			060-U2	064-U2	060-UL			55DI	55I	5050DI	5050SS
0.205						133									
0.254	125	130-U1	134-U1	132			130-U2	134-U2	130-UL	134-UL		125DI	125I	5060DI	5060SS
0.373					4060										
0.380							180-U2								
0.440						233						200DI	200I	5070DI	5070SS
0.502						213-U2	210-U2		220-UL						
0.522		220-U1	224-U1	222			220-U2	224-U2							
0.616						323									
0.754		320-U1	324-U1				320-U2					300DI	300I		5080SS
0.878									320-UL						
1.619						423-UHC					420-UHC				
1.831															
2.375						523-UHC					520-UHC				
2.670															
NOTES	1			2	3	6						4	5		

Shaded columns are obsolete model series. See notes 1 thru 5 for replacement model series.

1. DO models obsolete; replaced by Universal 1 Series.
2. Universal CIP models obsolete; replaced by Universal 2 Series.
3. CDL models obsolete.
4. Industrial DI models obsolete; replaced by 5000 DI Series.
5. Industrial I models obsolete; replaced by 5000 SS Series.
6. Aseptic models available in Universal, Universal 2, and UHC Series.

Pump Curves

IMPORTANT

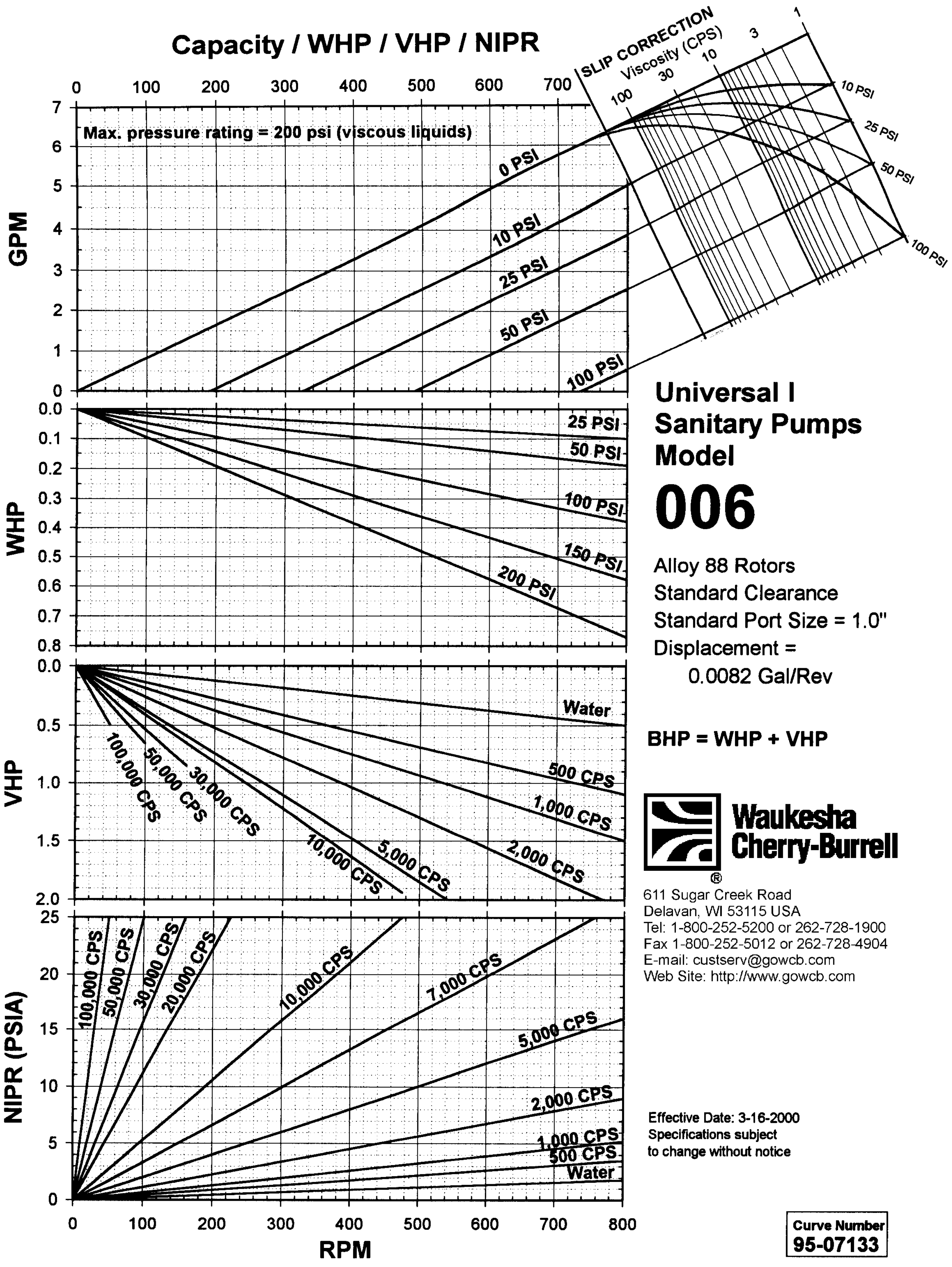
The pump curves provided in this document are for reference only and may not be current. Contact your Waukesha Cherry-Burrell representative for a copy of our most up-to-date PD Pump Curve booklet.
(Publication number 95-03062).

Curve Index

Pump Series Size	Displacement Per Revolution	Nominal Capacity To *	Inlet and Outlet	Pressure Range Up To** (See Note 1 below)	Curve Number	Page Number
Universal 1						
006	0.0082 Gal (0.031 Liter)	7 GPM (1.6 m3/hr)	1" or 1-1/2"	200 PSI (13.8 bar)	95-07133	93
015	0.0142 Gal (0.054 Liter)	10 GPM (2.3 m3/hr)	1-1/2"	200 PSI (13.8 bar)	95-07134	94
018	0.029 Gal (0.110 Liter)	17 GPM (3.9 m3/hr)	1-1/2" or 2"	200 PSI (13.8 bar)	95-07135	95
030	0.060 Gal (0.227 Liter)	36 GPM (8.2 m3/hr)	1-1/2" or 2"	200 PSI (13.8 bar)	95-07136	96
060	0.153 Gal (0.579 Liter)	90 GPM (20.4 m3/hr)	2-1/2"	200 PSI (13.8 bar)	95-07137	97
130	0.254 Gal (0.961 Liter)	150 GPM (34.1 m3/hr)	3"	200 PSI (13.8 bar)	95-07138	98
220	0.522 Gal (1.976 Liter)	310 GPM (70.4 m3/hr)	4"	200 PSI (13.8 bar)	95-07139	99
320	0.754 Gal (2.854 Liter)	450 GPM (102 m3/hr)	6"	200 PSI (13.8 bar)	95-07140	100
Universal II						
006-U2	0.0082 Gal (0.031 Liter)	8 GPM (1.8 m3/hr)	1" or 1-1/2"	300 PSI (20.7 bar)	95-07075	101
015-U2	0.0142 Gal (0.054 Liter)	11 GPM (2.5 m3/hr)	1-1/2"	250 PSI (17.2 bar)	95-07076	102
018-U2	0.029 Gal (0.110 Liter)	20 GPM (4.5 m3/hr)	1-1/2" or 2"	200 PSI (13.8 bar)	95-07077	103
030-U2	0.060 Gal (0.227 Liter)	36 GPM (8.2 m3/hr)	1-1/2" or 2"	250 PSI (17.2 bar)	95-07078	104
045-U2	0.098 Gal (0.371 Liter)	58 GPM (13.2 m3/hr)	2"	450 PSI (31.0 bar)	95-07106	105
060-U2	0.153 Gal (0.579 Liter)	90 GPM (20.4 m3/hr)	2-1/2"	300 PSI (20.7 bar)	95-07079	106
130-U2	0.253 Gal (0.958 Liter)	150 GPM (34.1 m3/hr)	3"	200 PSI (13.8 bar)	95-07080	107
180-U2	0.380 Gal (1.438 Liter)	230 GPM (52.2 m3/hr)	3"	450 PSI (31.0 bar)	95-07107	108
210-U2 213-U2	0.502 Gal (1.900 Liter)	300 GPM (68.1 m3/hr)	4"	500 PSI (34.5 bar)	95-07156	109
220-U2	0.521 Gal (1.972 Liter)	310 GPM (70.4 m3/hr)	4"	300 PSI (20.7 bar)	95-07081	110
320-U2	0.752 Gal (2.847 Liter)	450 GPM (102 m3/hr)	6"	300 PSI (20.7 bar)	95-07132	111
Universal Lobe						
018-UL	0.033 Gal (0.125 Liter)	33 GPM (7.5 m3/hr)	1-1/2" or 2"	200 PSI (13.8 bar)	95-07089	112
030-UL	0.071 Gal (0.269 Liter)	71 GPM (16.1 m3/hr)	1-1/2" or 2"	300 PSI (20.7 bar)	95-07082	113
060-UL	0.153 Gal (0.579 Liter)	120 GPM (27.3 m3/hr)	2-1/2"	300 PSI (20.7 bar)	95-07083	114
130-UL	0.253 Gal (0.958 Liter)	170 GPM (38.6 m3/hr)	3"	200 PSI (13.8 bar)	95-07084	115
220-UL	0.502 Gal (1.900 Liter)	300 GPM (68.1 m3/hr)	4"	200 PSI (13.8 bar)	95-07085	116
320-UL	0.878 Gal (3.324 Liter)	520 GPM (118.1 m3/hr)	6"	200 PSI (13.8 bar)	95-07145	117
UHC						
420-UHC 423-UHC	1.619 Gal (6.129 Liter)	640 GPM (145.4 m3/hr)	6"	200 PSI (13.8 bar)	95-07086	118
520-UHC 523-UHC	2.375 Gal (8.990 Liter)	830 GPM (188.5 m3/hr)	8"	150 PSI (10.3 bar)	95-07087	119
5000						
5040	0.060 Gal (0.227 Liter)	36 GPM (8.2 m3/hr)	1-1/2"	200 PSI (13.8 bar)	95-07092	120
5050	0.153 Gal (0.579 Liter)	90 GPM (20.4 m3/hr)	2"	200 PSI (13.8 bar)	95-07141	121
5060	0.254 Gal (0.961 Liter)	150 GPM (34.1 m3/hr)	3"	200 PSI (13.8 bar)	95-07142	122
5070	0.440 Gal (1.666 Liter)	260 GPM (59.1 m3/hr)	4"	200 PSI (13.8 bar)	95-07143	123
5080	0.754 Gal (2.854 Liter)	450 GPM (102 m3/hr)	6"	200 PSI (13.8 bar)	95-07144	124

* **Note**: Most applications are not suitable for continuous operation at maximum capacity shown.

** **Note**: Contact Application Engineering for higher pressure applications.



Universal I Sanitary Pumps Model

006

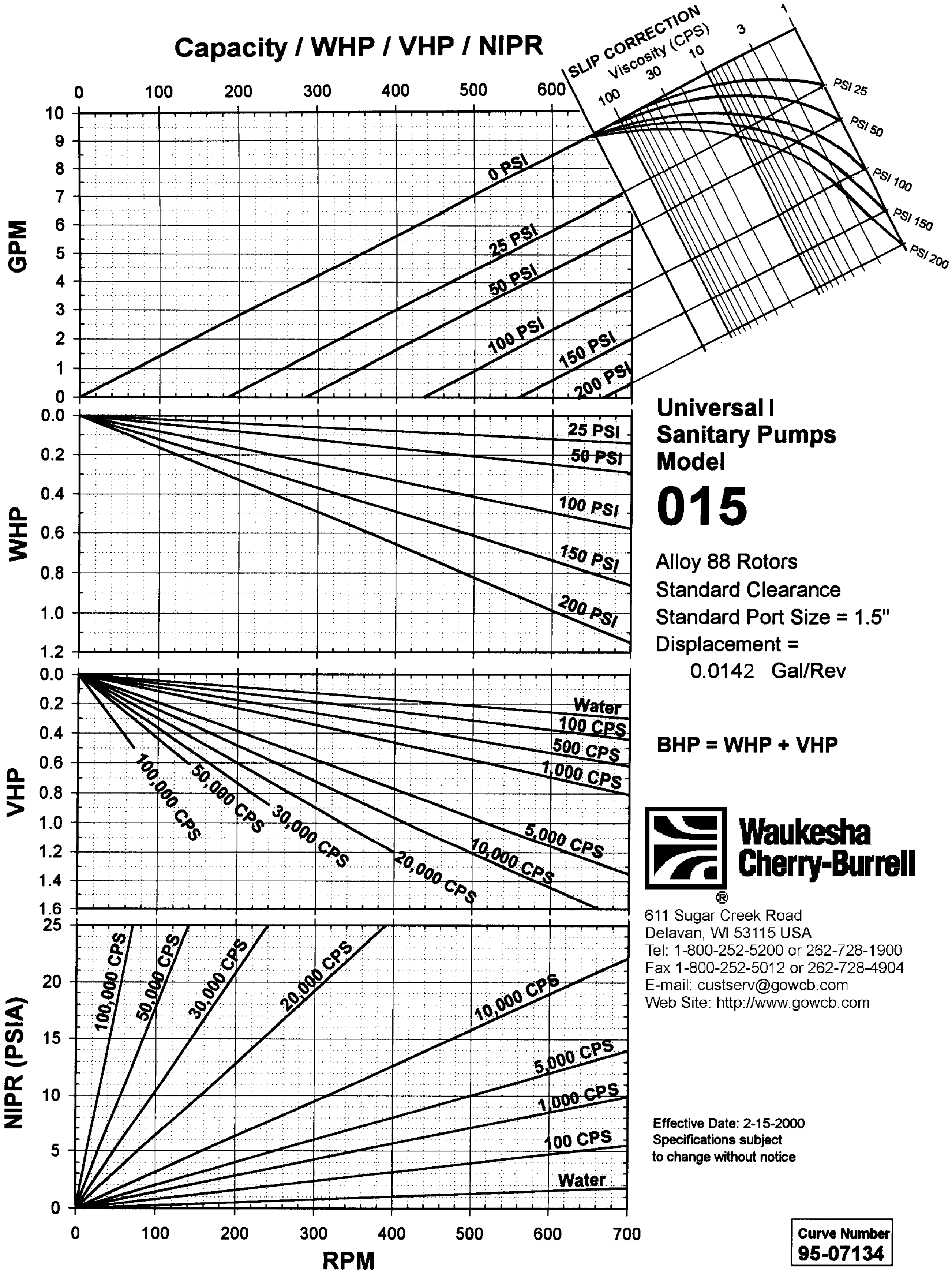
Alloy 88 Rotors
Standard Clearance
Standard Port Size = 1.0"
Displacement =
0.0082 Gal/Rev

BHP = WHP + VHP

Waukesha Cherry-Burrell®
611 Sugar Creek Road
Delavan, WI 53115 USA
Tel: 1-800-252-5200 or 262-728-1900
Fax 1-800-252-5012 or 262-728-4904
E-mail: custserv@gowcb.com
Web Site: http://www.gowcb.com

Effective Date: 3-16-2000
Specifications subject
to change without notice

Curve Number
95-07133



Universal I Sanitary Pumps Model

015

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 1.5"
Displacement =
0.0142 Gal/Rev

BHP = WHP + VHP

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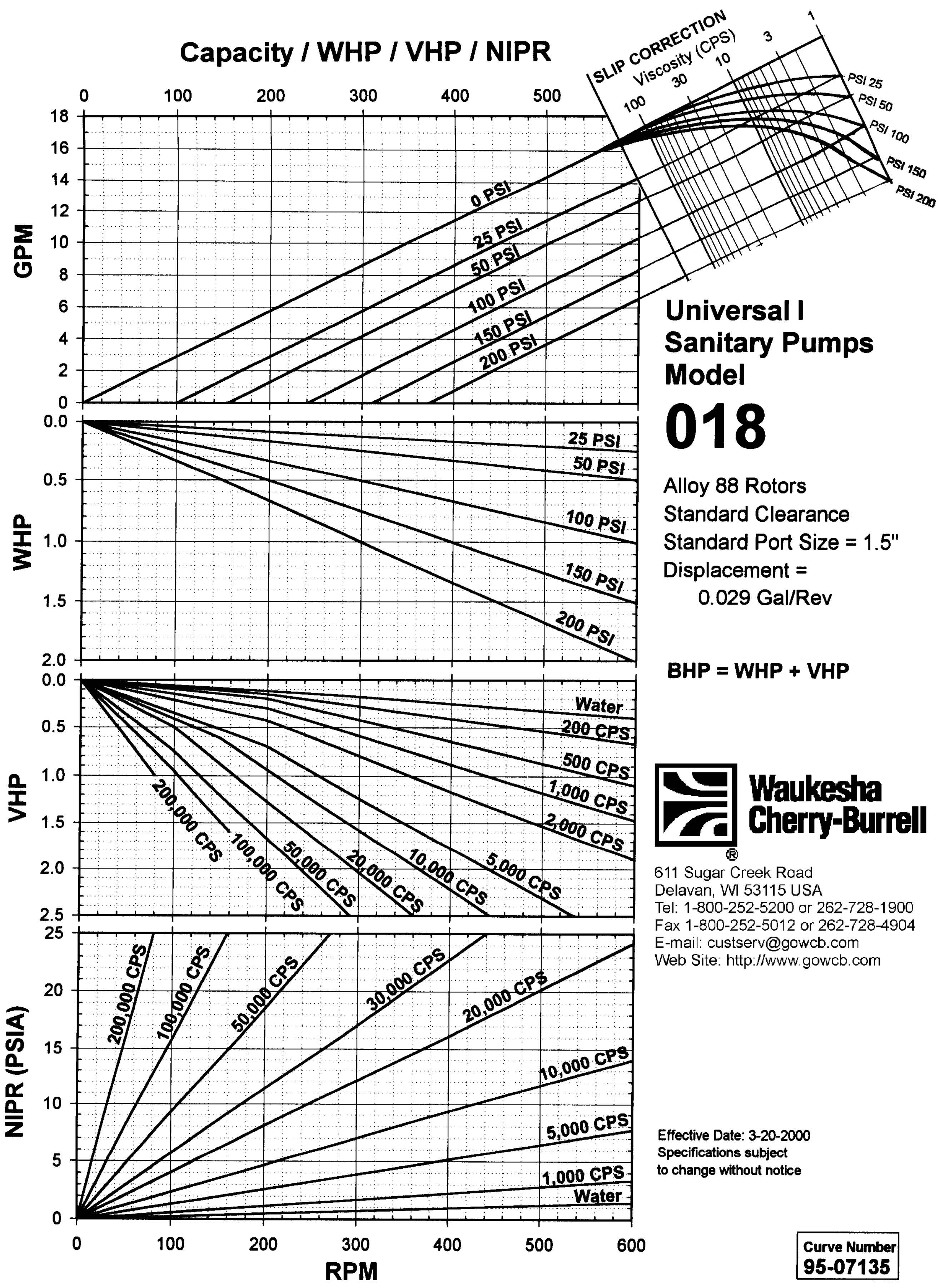
Web Site: http://www.gowcb.com

Effective Date: 2-15-2000
Specifications subject
to change without notice

Curve Number
95-07134



Universal I Sanitary Pumps Model

018

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 1.5"
Displacement =
0.029 Gal/Rev

BHP = WHP + VHP

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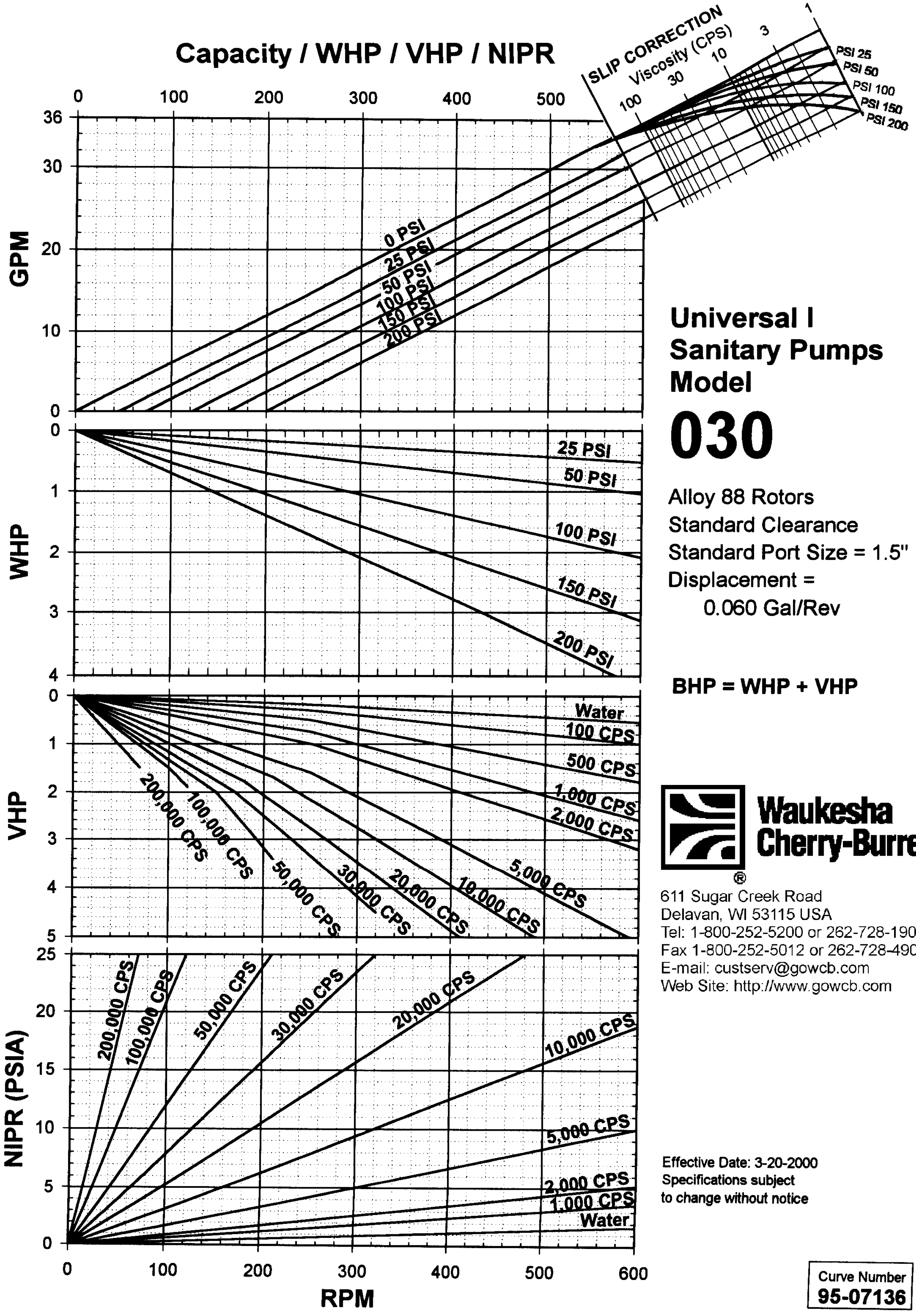
Web Site: http://www.gowcb.com

Effective Date: 3-20-2000
Specifications subject to change without notice

Curve Number
95-07135



Universal I Sanitary Pumps Model

030

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 1.5"
Displacement =
0.060 Gal/Rev

BHP = WHP + VHP

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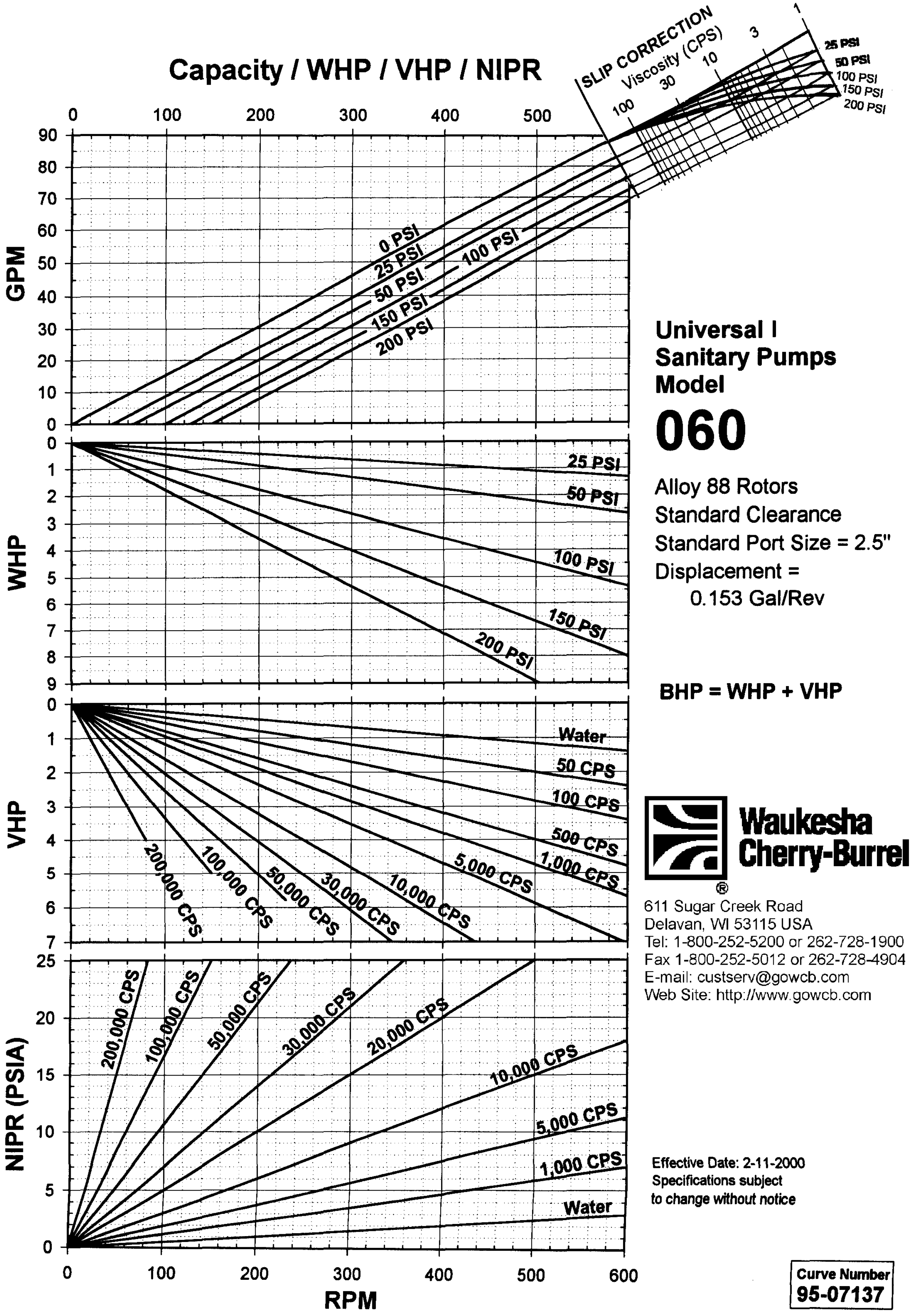
Web Site: http://www.gowcb.com

Effective Date: 3-20-2000
Specifications subject to change without notice

Curve Number
95-07136

Capacity / WHP / VHP / NIPR



Universal I Sanitary Pumps Model

060

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 2.5"
Displacement =
0.153 Gal/Rev

BHP = WHP + VHP

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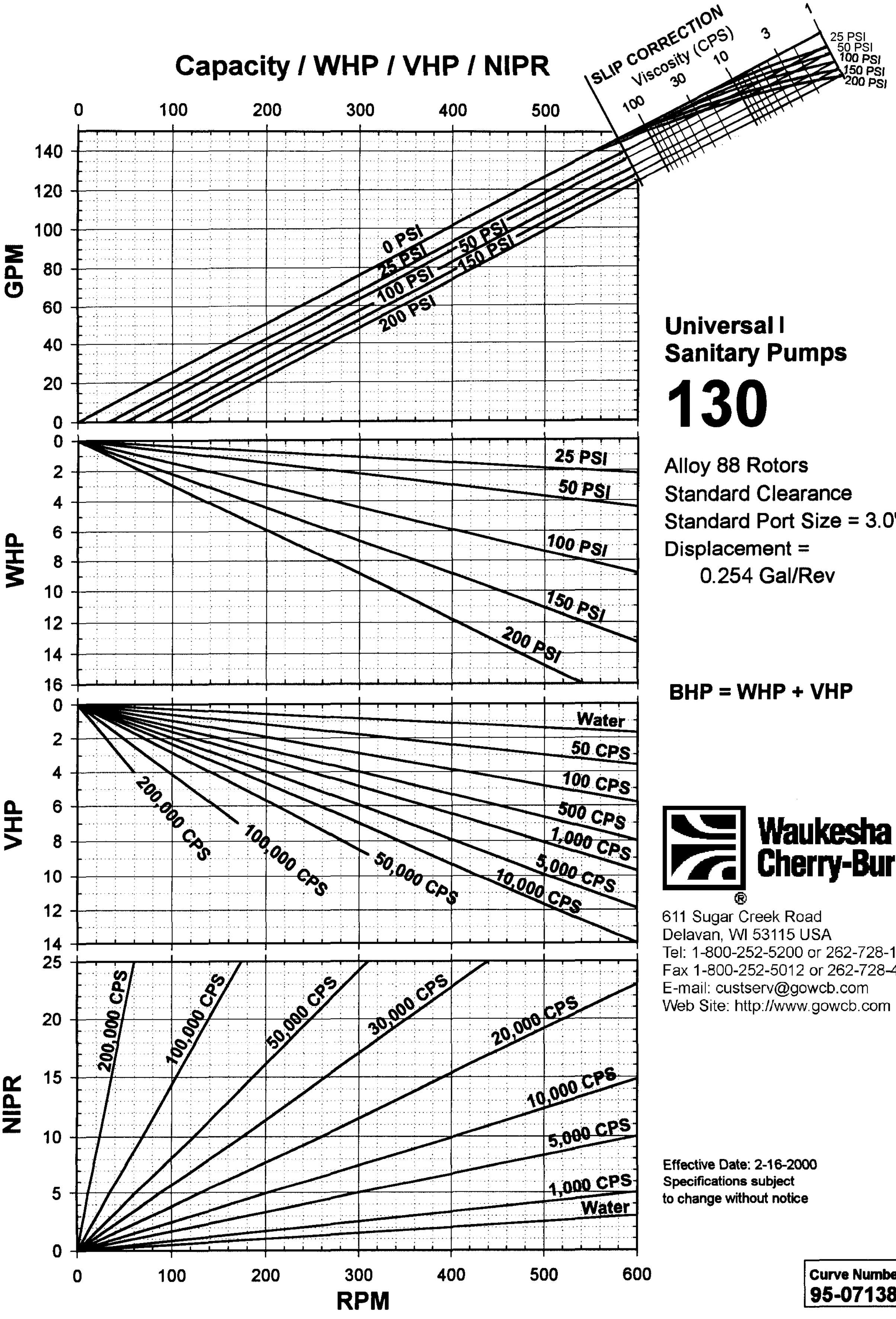
Web Site: http://www.gowcb.com

Effective Date: 2-11-2000
Specifications subject
to change without notice

Curve Number
95-07137



Universal I
Sanitary Pumps

130

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 3.0"
Displacement =
0.254 Gal/Rev

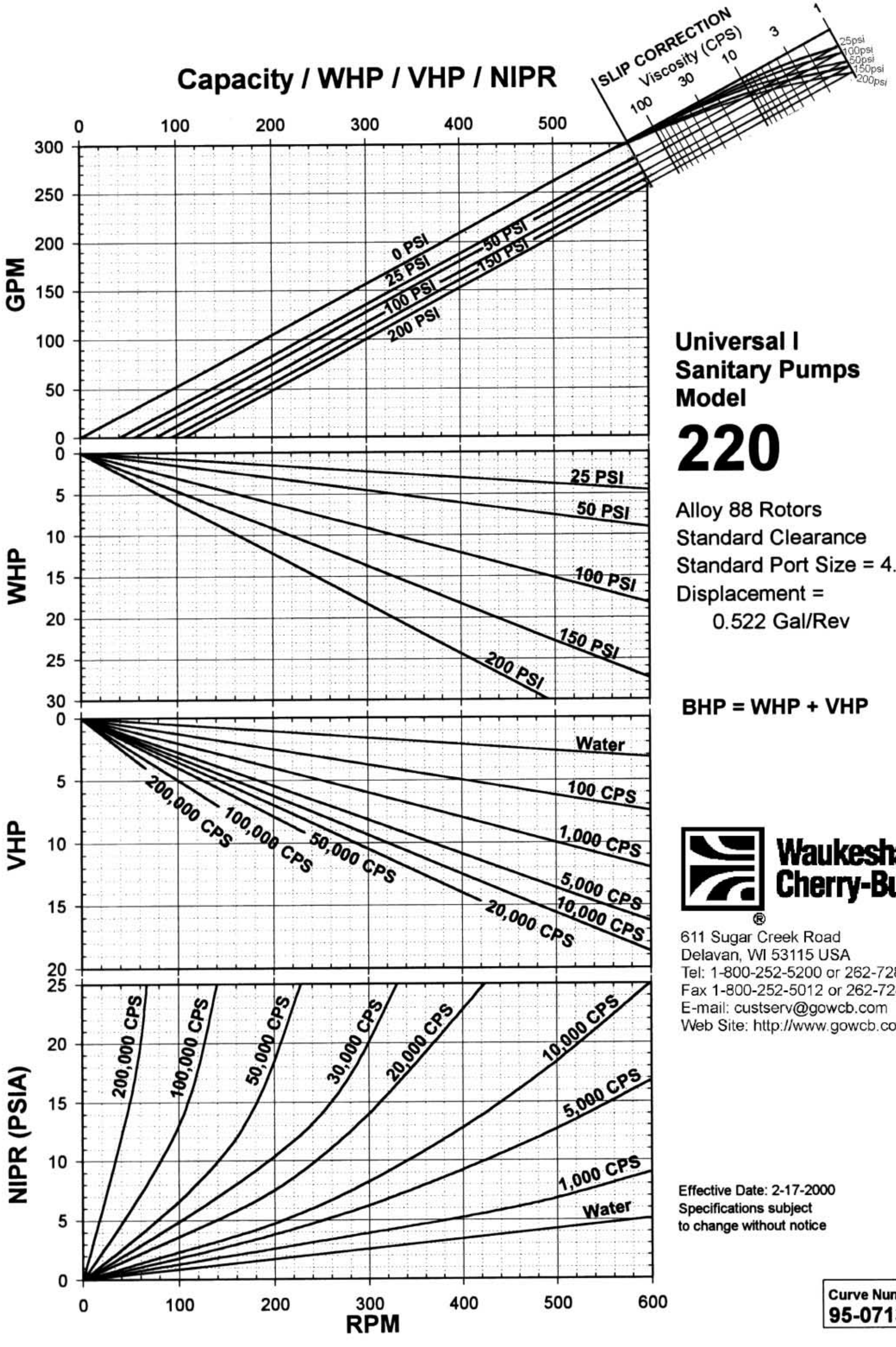
BHP = WHP + VHP

Waukesha Cherry-Burrell®

611 Sugar Creek Road
Delavan, WI 53115 USA
Tel: 1-800-252-5200 or 262-728-1900
Fax 1-800-252-5012 or 262-728-4904
E-mail: custserv@gowcb.com
Web Site: http://www.gowcb.com

Effective Date: 2-16-2000
Specifications subject
to change without notice

Curve Number
95-07138



Universal I Sanitary Pumps Model

220

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 4.0"
Displacement =
0.522 Gal/Rev

BHP = WHP + VHP

Waukesha Cherry-Burrell®

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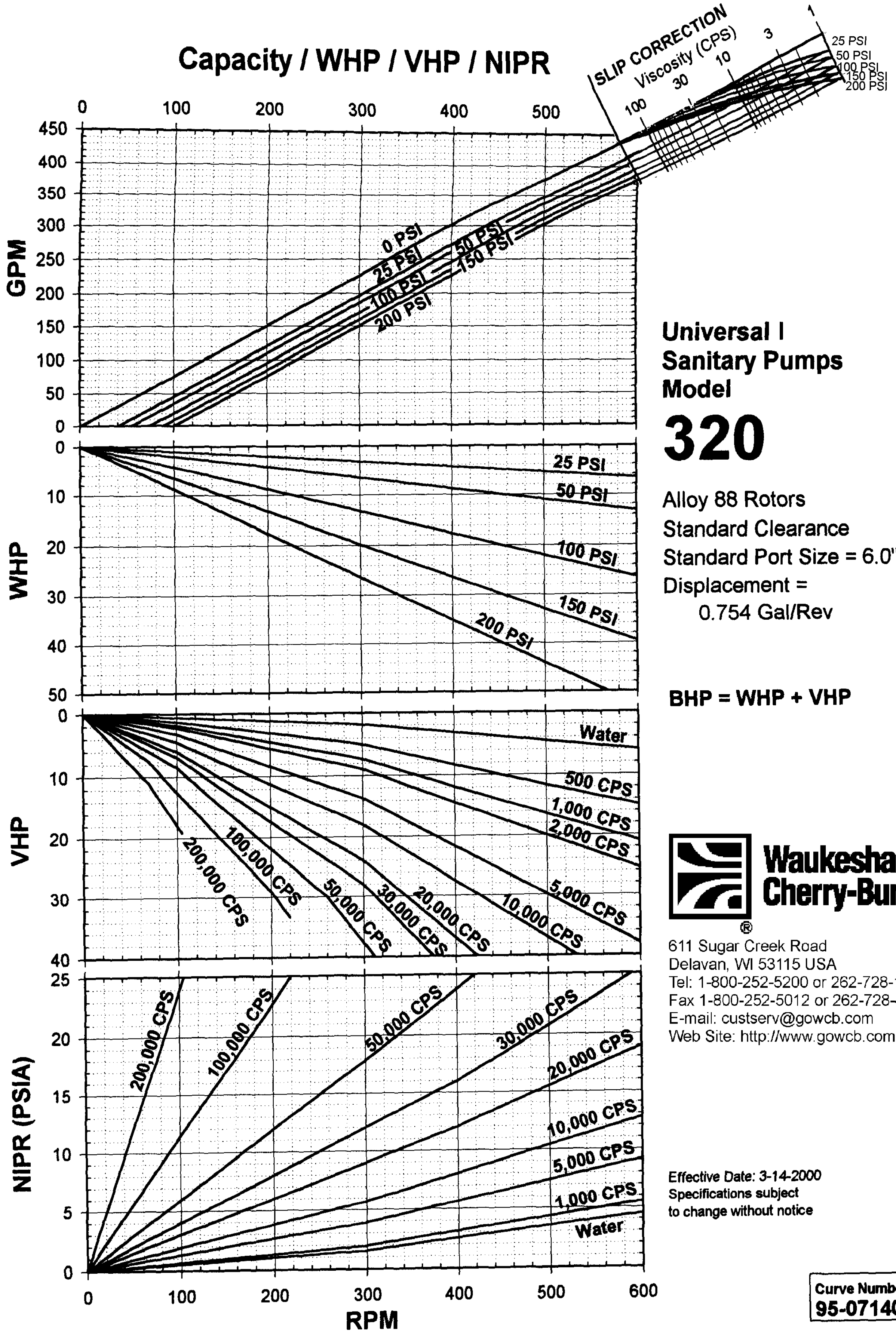
Web Site: http://www.gowcb.com

Effective Date: 2-17-2000
Specifications subject
to change without notice

Curve Number
95-07139

Capacity / WHP / VHP / NIPR



Universal I Sanitary Pumps Model

320

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 6.0"
Displacement =
0.754 Gal/Rev

BHP = WHP + VHP

Waukesha Cherry-Burrell®

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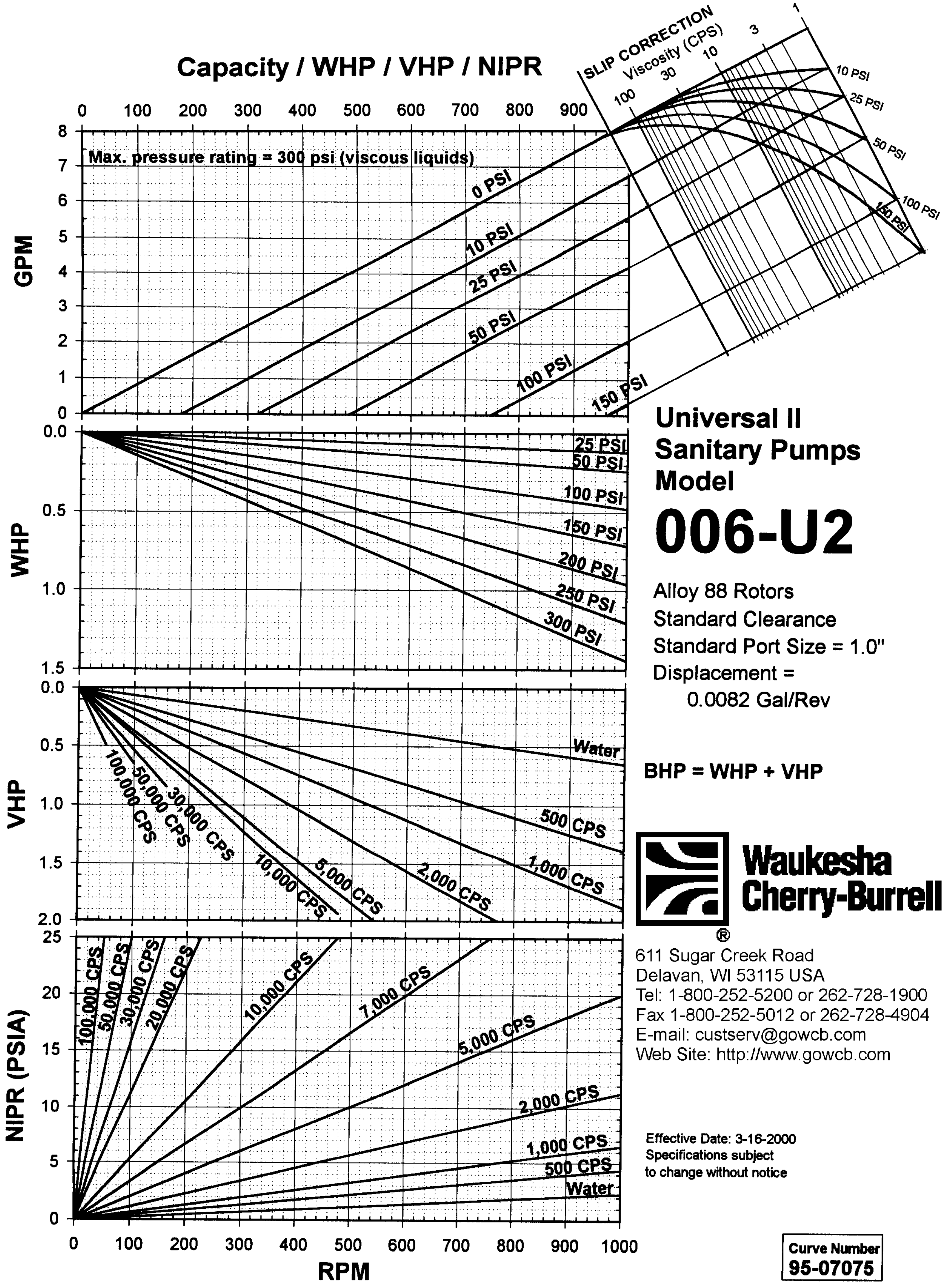
Tel: 1-800-252-5200 or 262-728-1900
Fax 1-800-252-5012 or 262-728-4904
E-mail: custserv@gowcb.com
Web Site: http://www.gowcb.com

Effective Date: 3-14-2000
Specifications subject to change without notice

Curve Number
95-07140



Universal II Sanitary Pumps Model

006-U2

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 1.0"
Displacement =
0.0082 Gal/Rev

BHP = WHP + VHP

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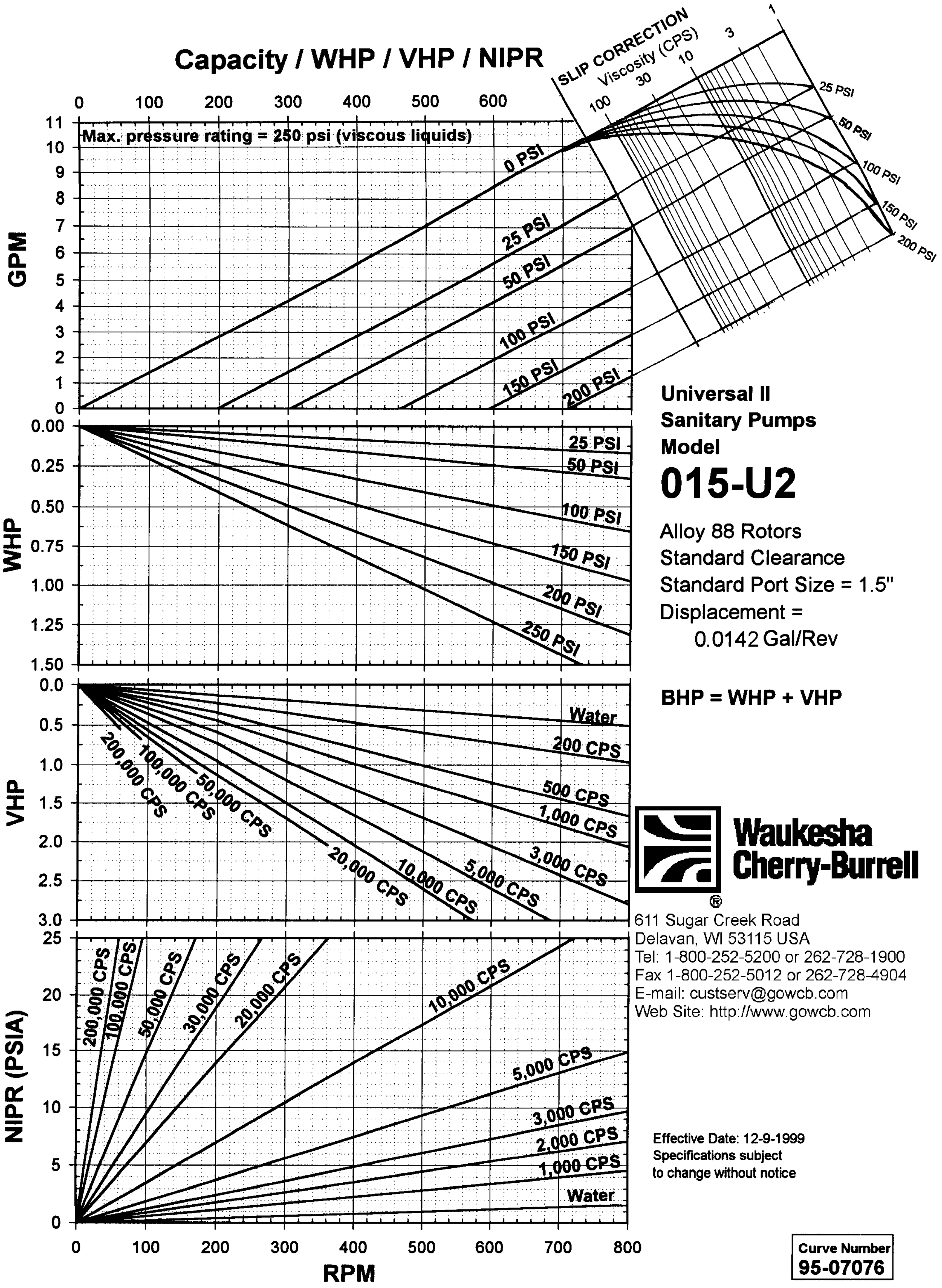
Web Site: http://www.gowcb.com

Effective Date: 3-16-2000
Specifications subject to change without notice

Curve Number
95-07075

Capacity / WHP / VHP / NIPR



Universal II
Sanitary Pumps
Model

015-U2

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 1.5"
Displacement =
0.0142 Gal/Rev

BHP = WHP + VHP

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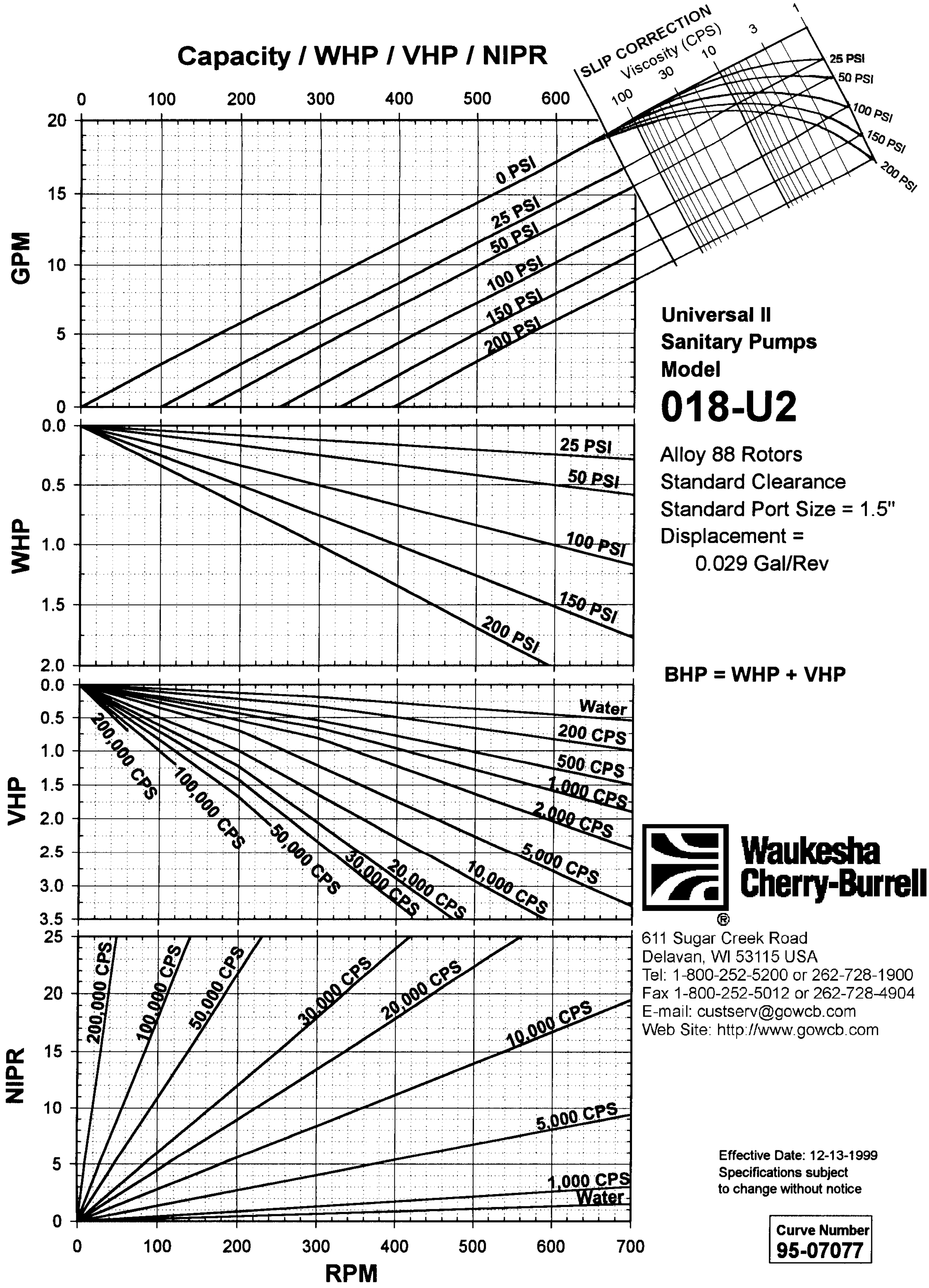
Web Site: http://www.gowcb.com

Effective Date: 12-9-1999
Specifications subject
to change without notice

Curve Number
95-07076



Universal II
Sanitary Pumps
Model
018-U2

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 1.5"
Displacement =
0.029 Gal/Rev

BHP = WHP + VHP

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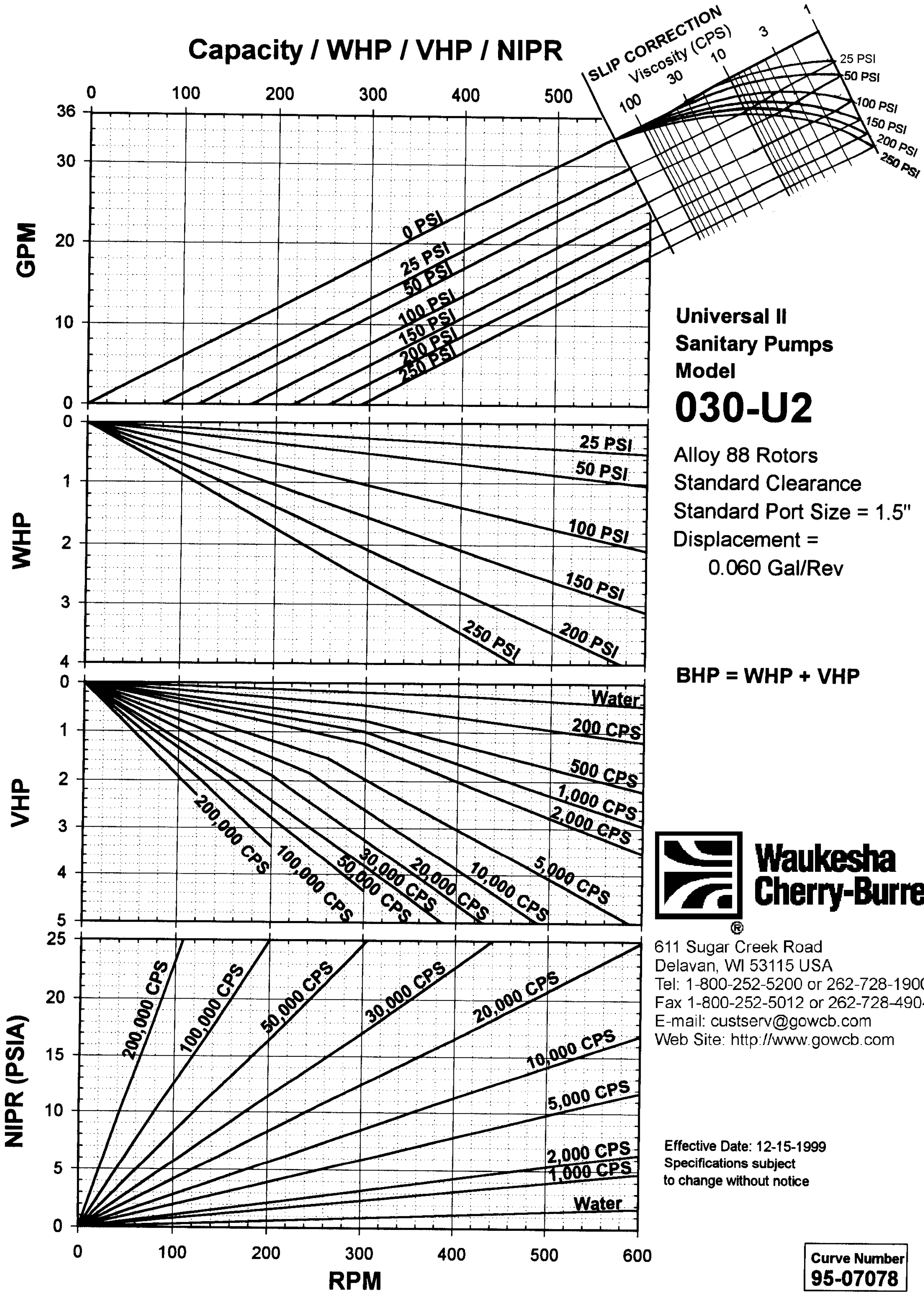
Web Site: http://www.gowcb.com

Effective Date: 12-13-1999
Specifications subject
to change without notice

Curve Number
95-07077

Capacity / WHP / VHP / NIPR



Universal II
Sanitary Pumps
Model

030-U2

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 1.5"
Displacement =
0.060 Gal/Rev

BHP = WHP + VHP

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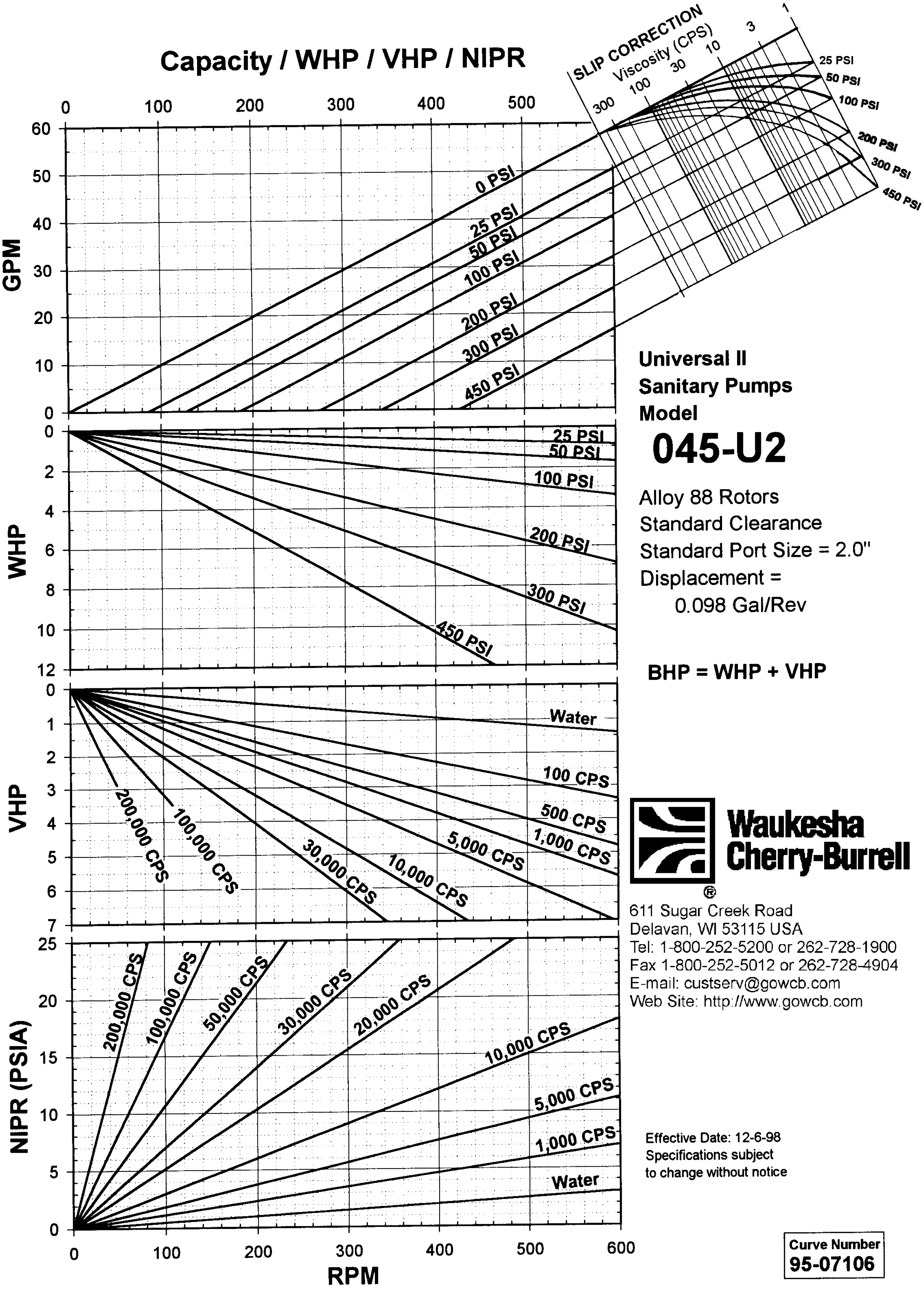
E-mail: custserv@gowcb.com
Web Site: http://www.gowcb.com

Effective Date: 12-15-1999
Specifications subject to change without notice

Curve Number
95-07078



Universal II
Sanitary Pumps
Model

045-U2

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 2.0"
Displacement =
0.098 Gal/Rev

BHP = WHP + VHP

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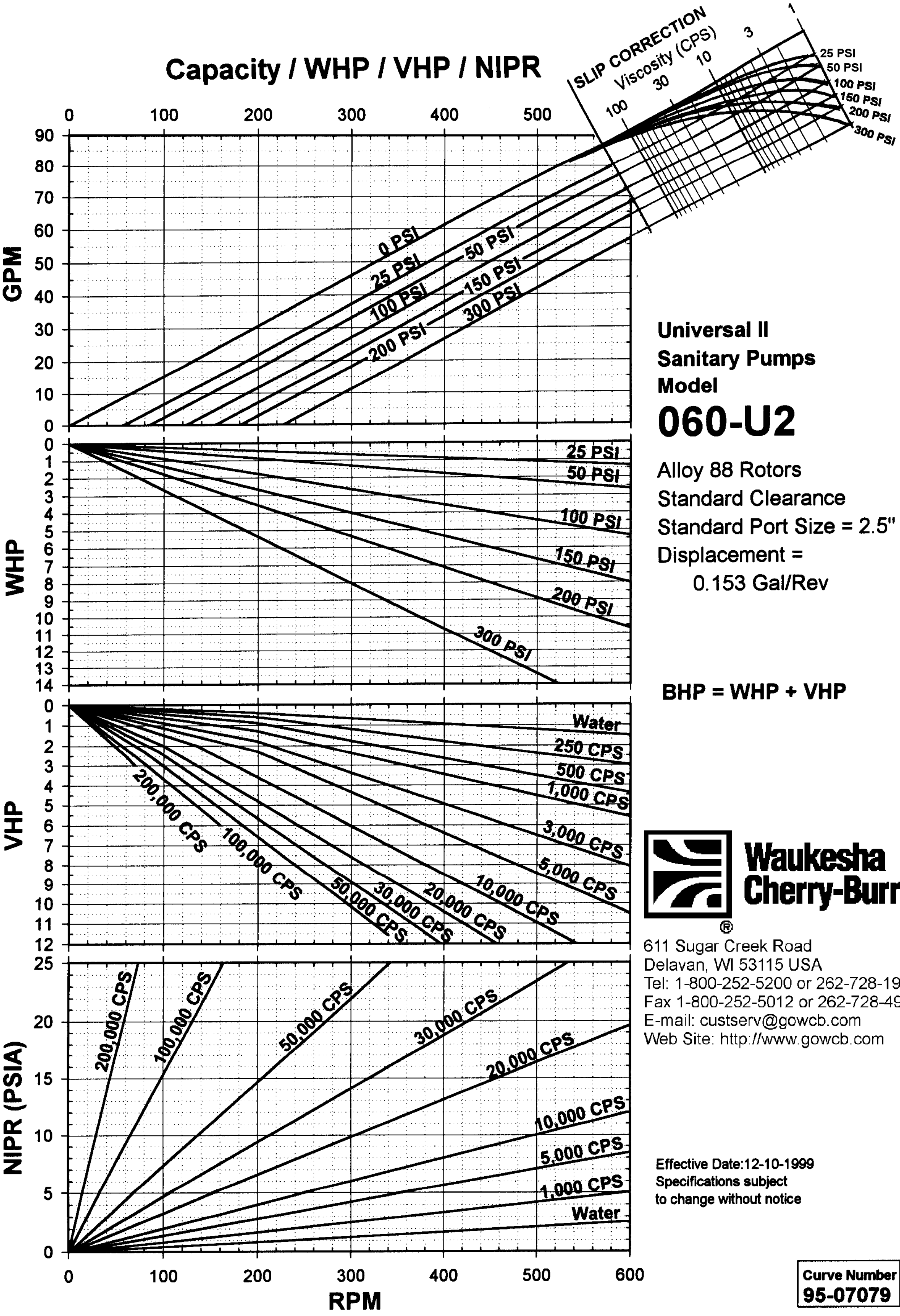
Fax 1-800-252-5012 or 262-728-4904
E-mail: custserv@gowcb.com
Web Site: http://www.gowcb.com

Effective Date: 12-6-98
Specifications subject
to change without notice

Curve Number
95-07106

Capacity / WHP / VHP / NIPR



Universal II
Sanitary Pumps
Model

060-U2

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 2.5"
Displacement =
0.153 Gal/Rev

BHP = WHP + VHP

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Delavan, WI 53115 USA
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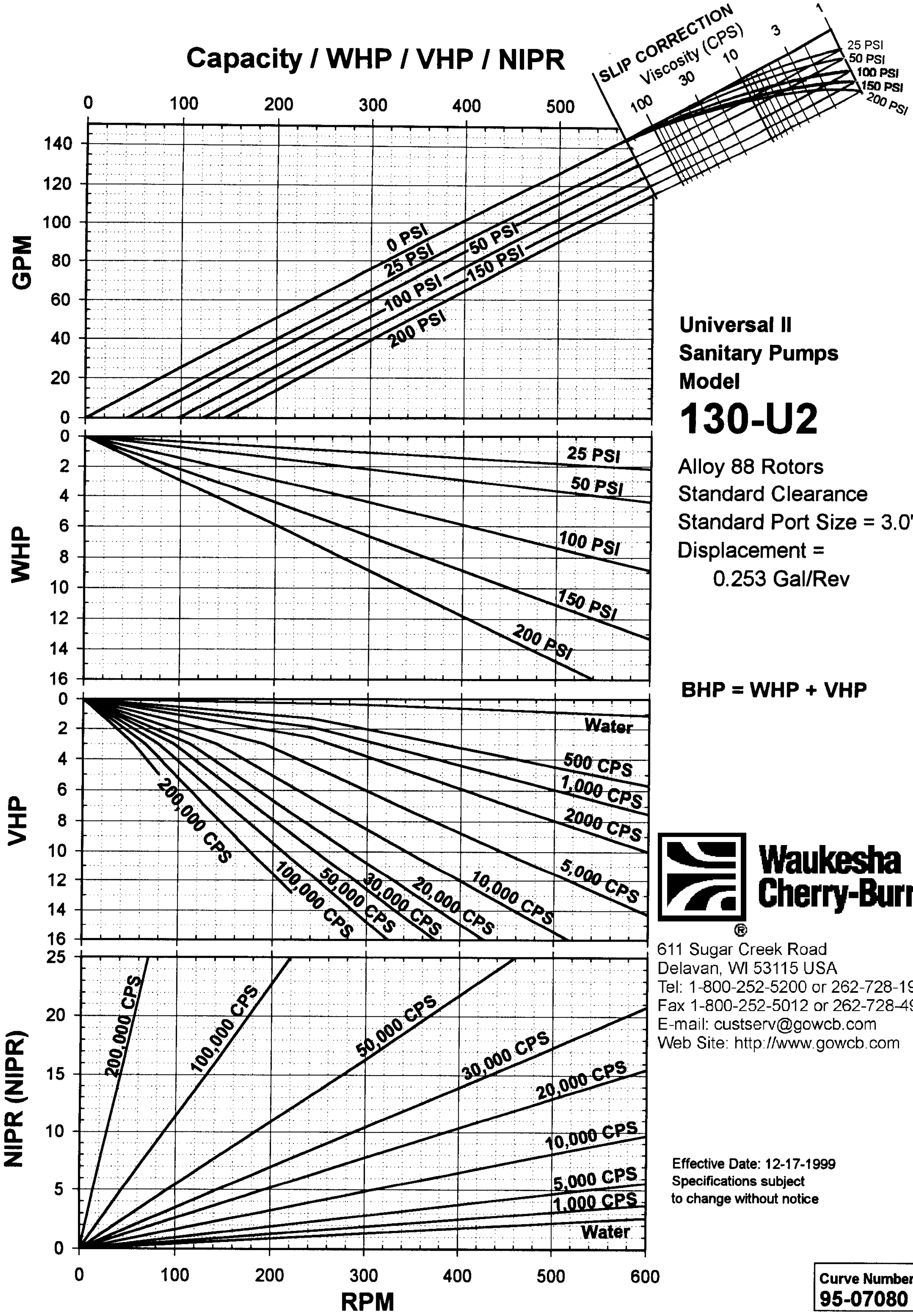
Fax 1-800-252-5012 or 262-728-4904
E-mail: custserv@gowcb.com
Web Site: http://www.gowcb.com

Effective Date:12-10-1999
Specifications subject
to change without notice

Curve Number
95-07079

Capacity / WHP / VHP / NIPR



Universal II
Sanitary Pumps
Model
130-U2

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 3.0"
Displacement =
0.253 Gal/Rev

BHP = WHP + VHP

Waukesha Cherry-Burrell®

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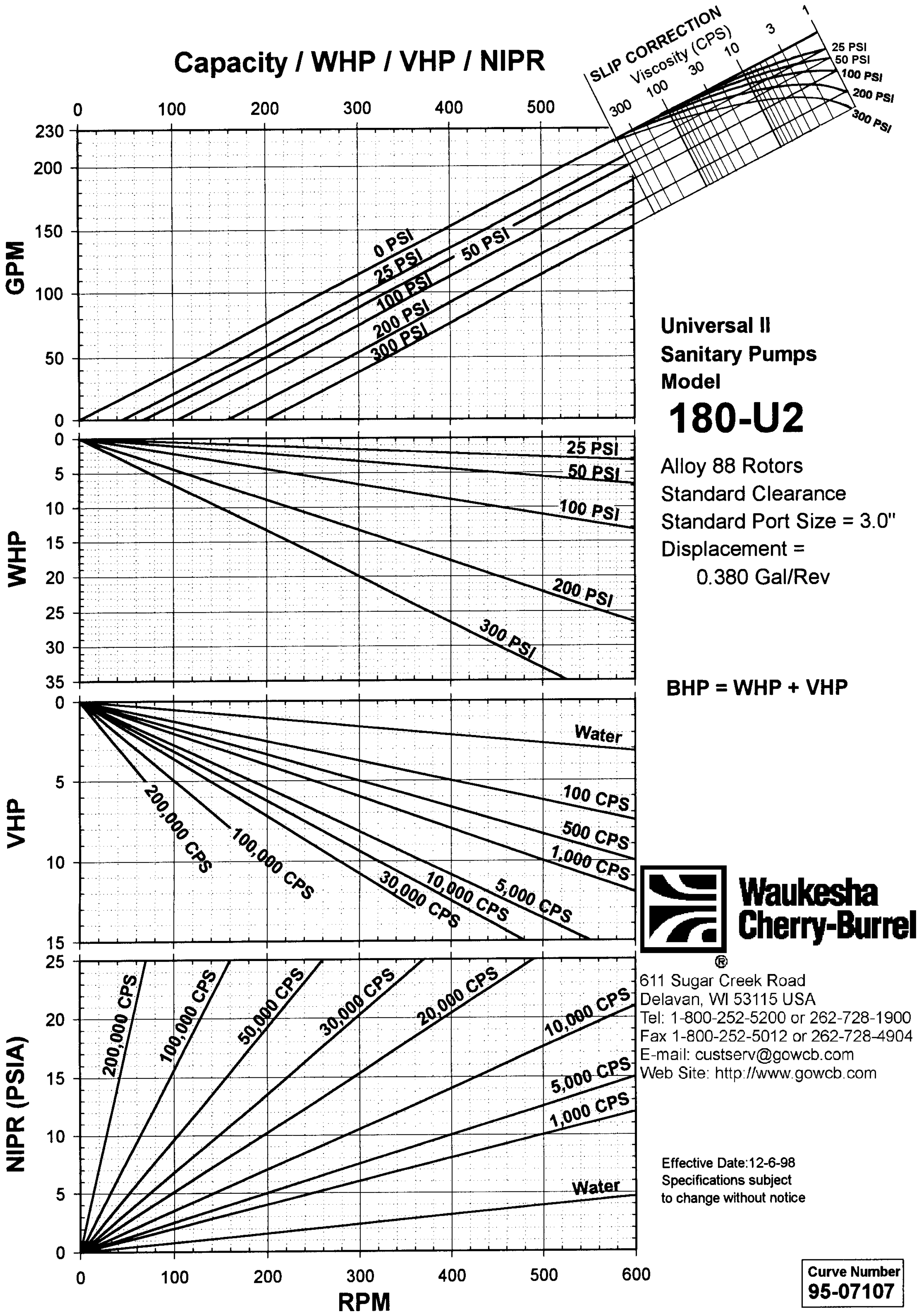
Fax 1-800-252-5012 or 262-728-4904
E-mail: custserv@gowcb.com
Web Site: http://www.gowcb.com

Effective Date: 12-17-1999
Specifications subject
to change without notice

Curve Number
95-07080

Capacity / WHP / VHP / NIPR



Universal II
Sanitary Pumps
Model

180-U2

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 3.0"
Displacement =
0.380 Gal/Rev

BHP = WHP + VHP

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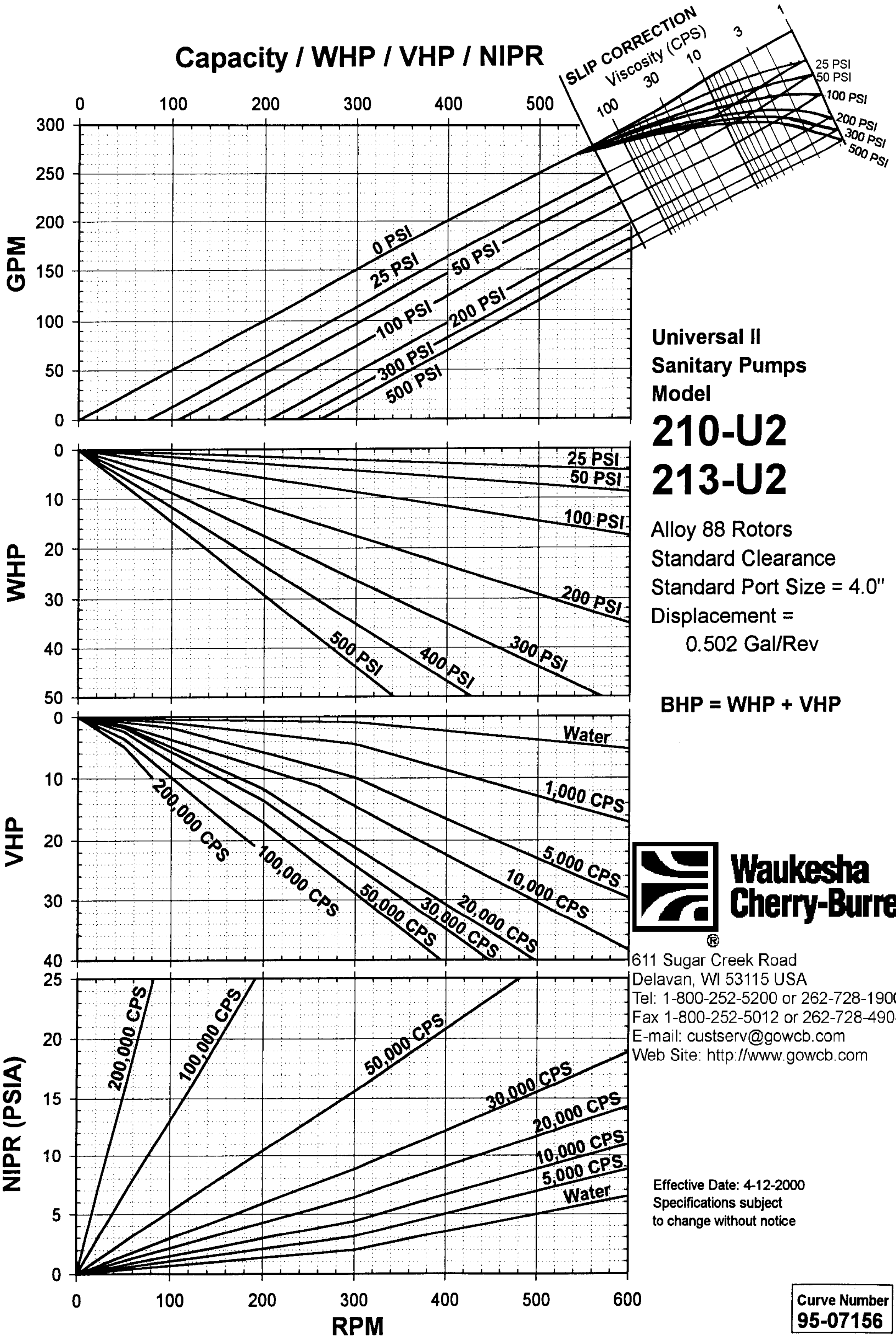
E-mail: custserv@gowcb.com
Web Site: http://www.gowcb.com

Effective Date:12-6-98
Specifications subject
to change without notice

Curve Number
95-07107



Capacity / WHP / VHP / NIPR

Universal II
Sanitary Pumps
Model

210-U2
213-U2

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 4.0"
Displacement =
0.502 Gal/Rev

BHP = WHP + VHP

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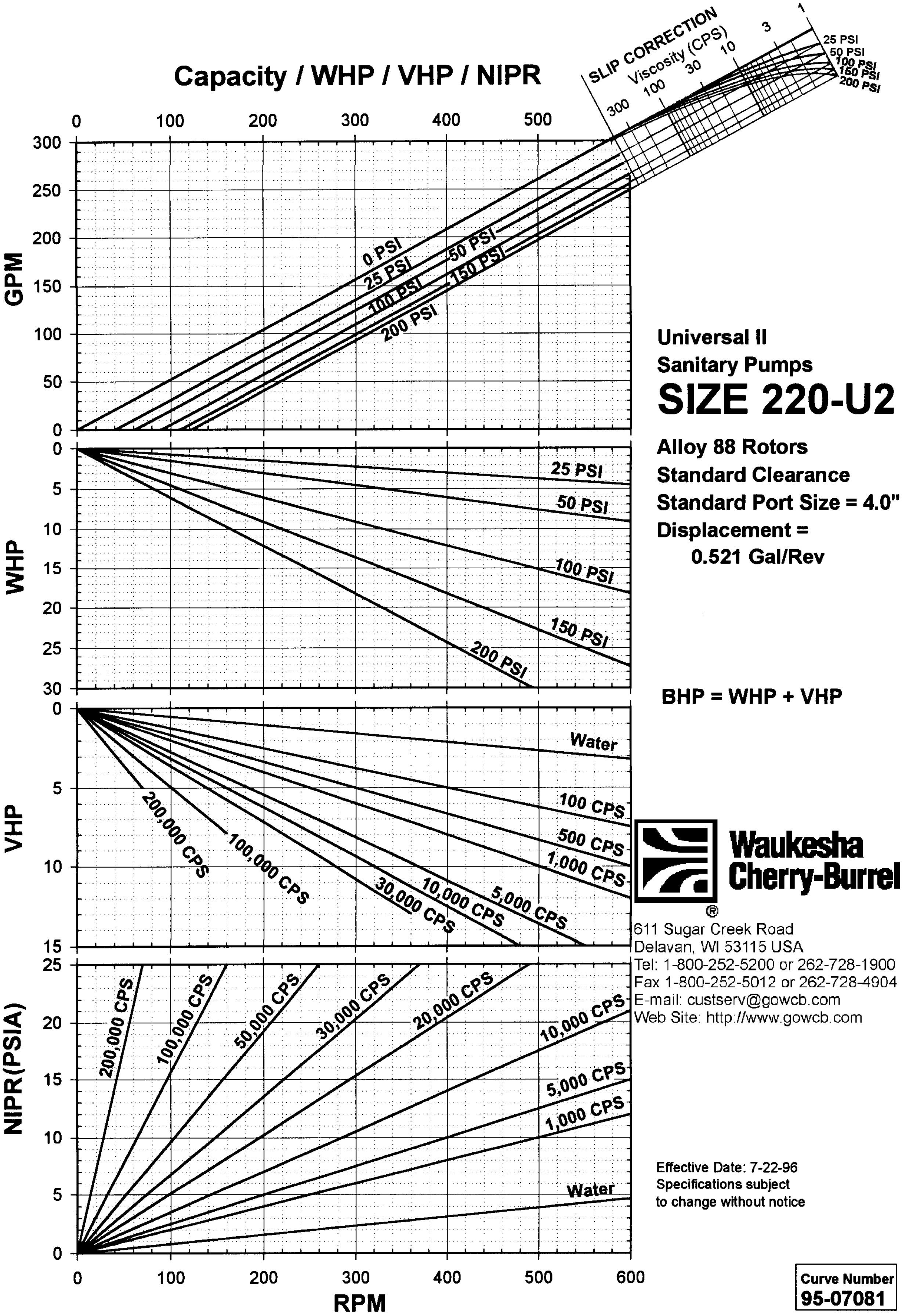
Web Site: http://www.gowcb.com

Effective Date: 4-12-2000
Specifications subject
to change without notice

Curve Number
95-07156



Universal II
Sanitary Pumps

SIZE 220-U2

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 4.0"
Displacement =
0.521 Gal/Rev

BHP = WHP + VHP

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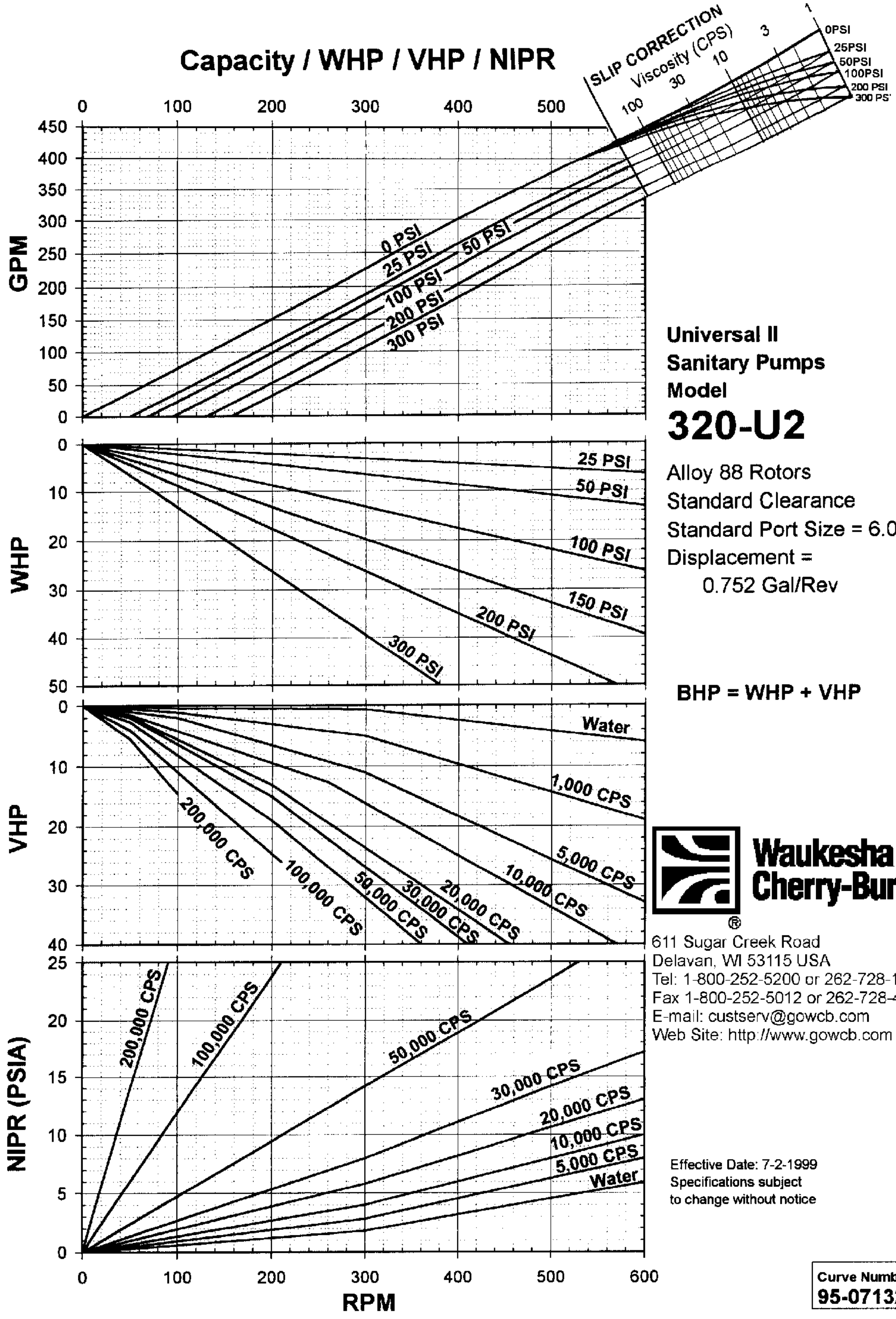
Web Site: http://www.gowcb.com

Effective Date: 7-22-96
Specifications subject
to change without notice

Curve Number
95-07081

Capacity / WHP / VHP / NIPR



Universal II
Sanitary Pumps
Model

320-U2

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 6.0"
Displacement =
0.752 Gal/Rev

BHP = WHP + VHP

Waukesha Cherry-Burrell®

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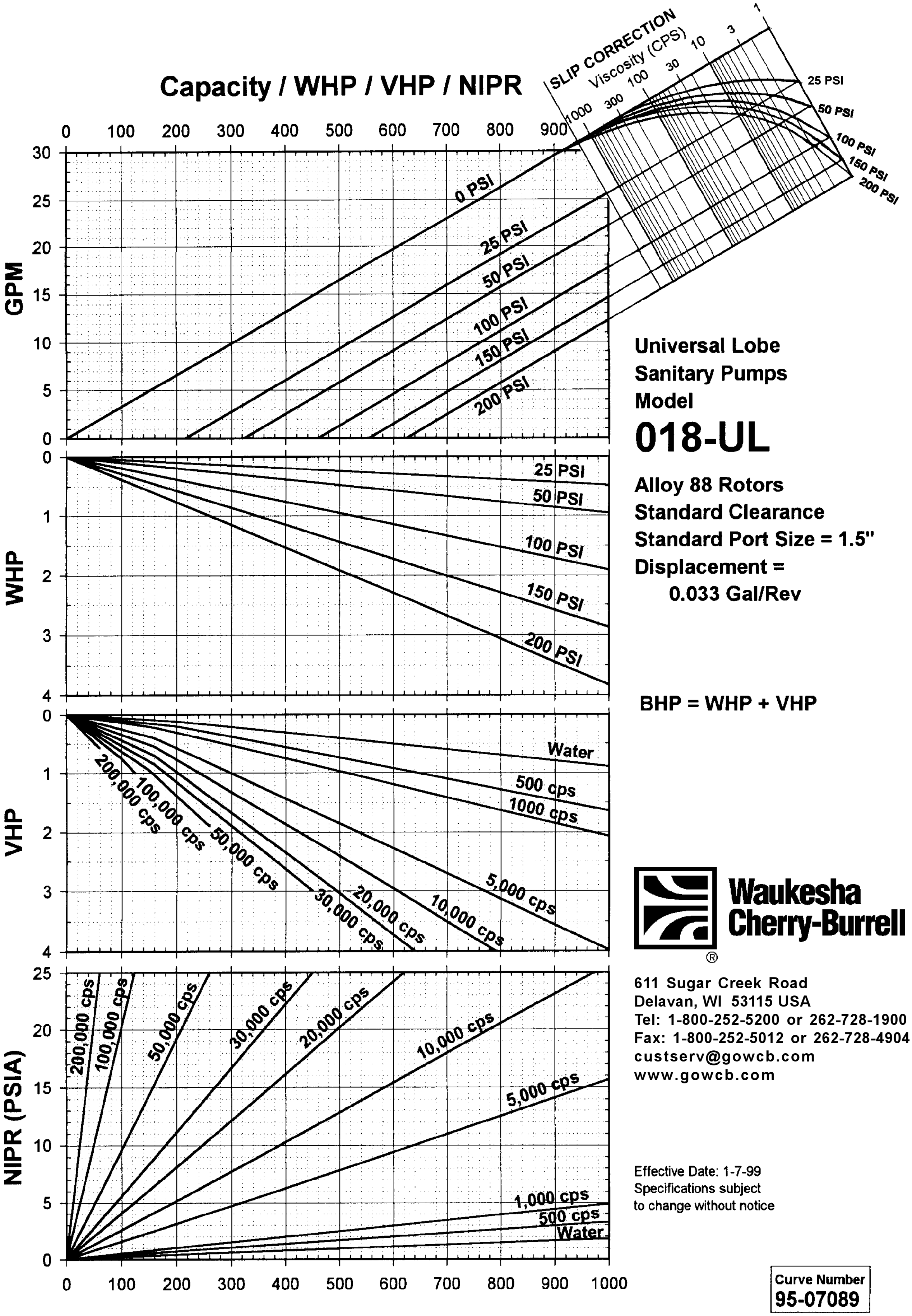
Tel: 1-800-252-5200 or 262-728-1900
Fax 1-800-252-5012 or 262-728-4904
E-mail: custserv@gowcb.com
Web Site: http://www.gowcb.com

Effective Date: 7-2-1999
Specifications subject
to change without notice

Curve Number
95-07132



Universal Lobe
Sanitary Pumps
Model

018-UL

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 1.5"
Displacement =
0.033 Gal/Rev

BHP = WHP + VHP

Waukesha Cherry-Burrell®

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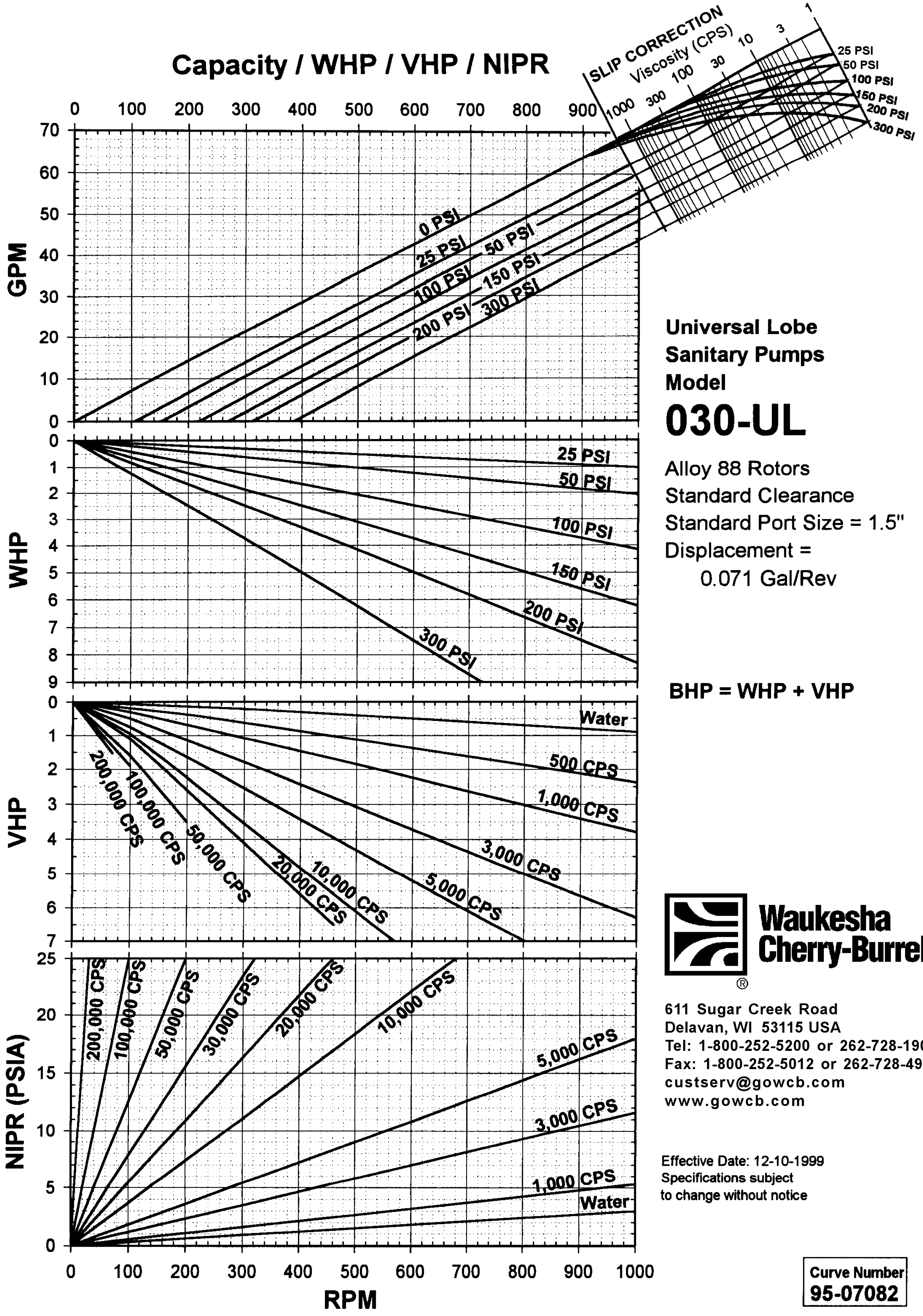
Delavan, WI 53115 USA
Tel: 1-800-252-5200 or 262-728-1900
Fax: 1-800-252-5012 or 262-728-4904
custserv@gowcb.com
www.gowcb.com

Effective Date: 1-7-99
Specifications subject
to change without notice

Curve Number
95-07089



Universal Lobe Sanitary Pumps Model

030-UL

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 1.5"
Displacement =
0.071 Gal/Rev

BHP = WHP + VHP

Waukesha Cherry-Burrell®

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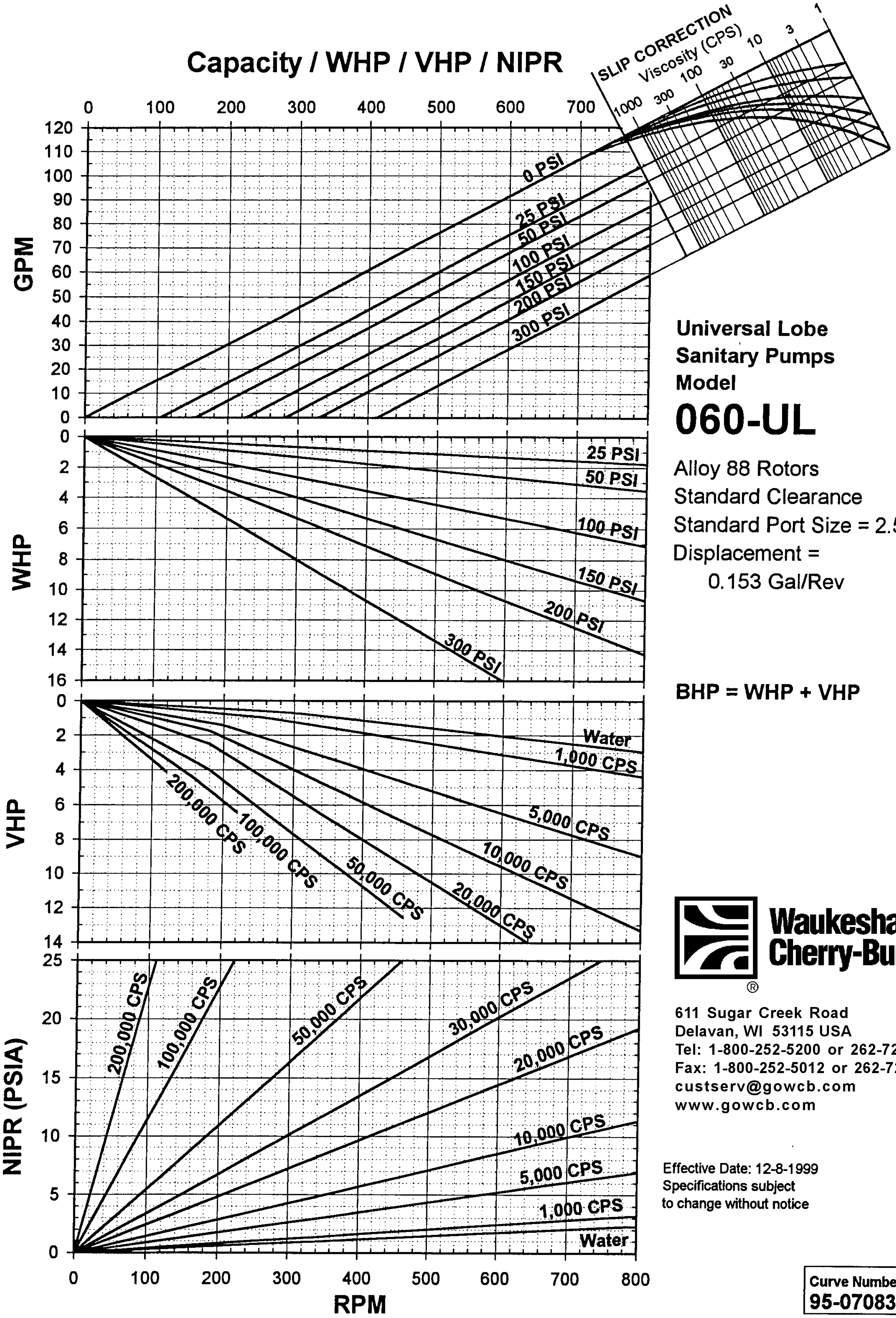
Tel: 1-800-252-5200 or 262-728-1900
Fax: 1-800-252-5012 or 262-728-4904
custserv@gowcb.com
www.gowcb.com

Effective Date: 12-10-1999
Specifications subject
to change without notice

Curve Number
95-07082



Universal Lobe
Sanitary Pumps
Model

060-UL

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 2.5"
Displacement =
0.153 Gal/Rev

BHP = WHP + VHP

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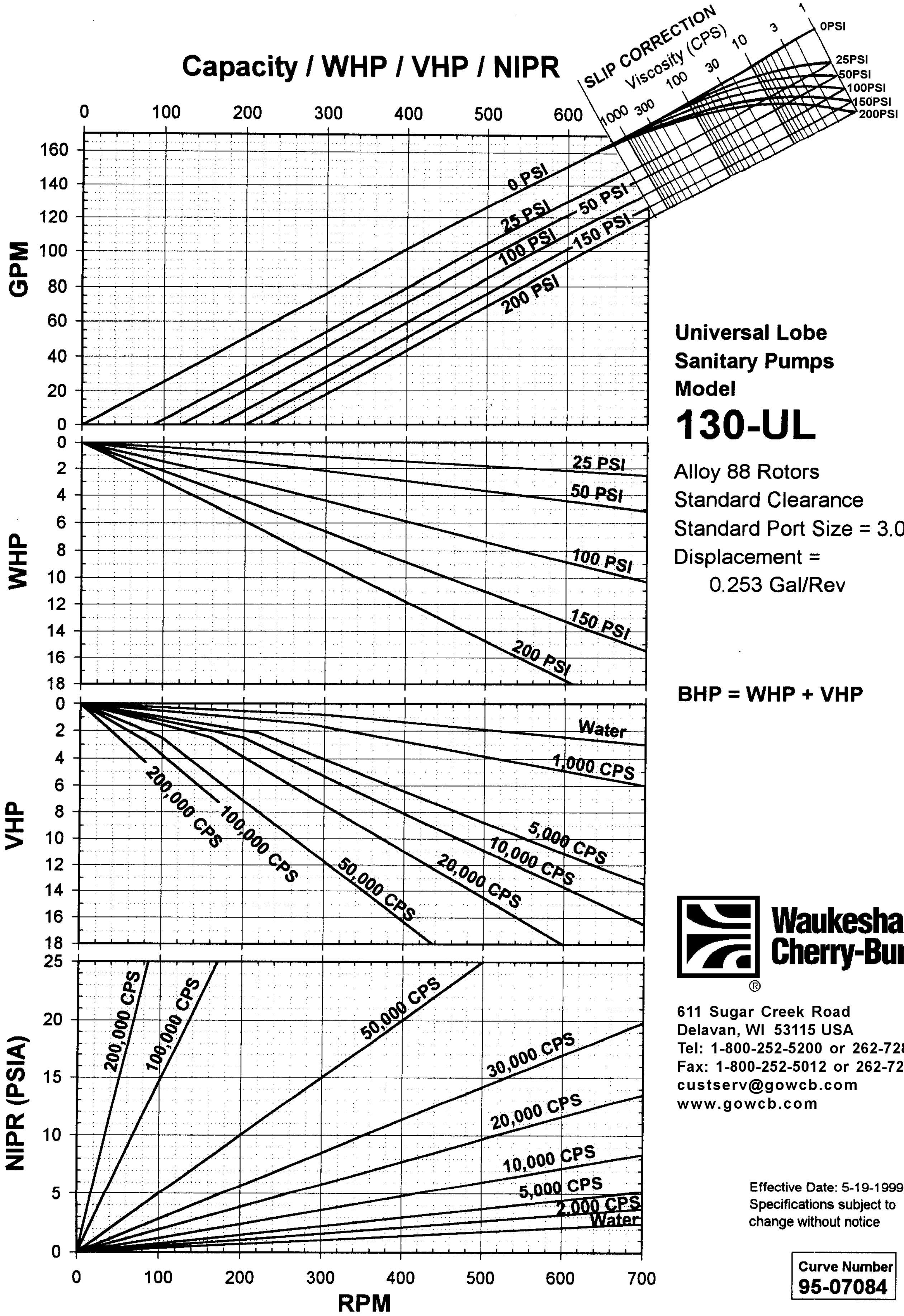
Tel: 1-800-252-5200 or 262-728-1900
Fax: 1-800-252-5012 or 262-728-4904
custserv@gowcb.com
www.gowcb.com

Effective Date: 12-8-1999
Specifications subject
to change without notice

Curve Number
95-07083



Universal Lobe Sanitary Pumps Model

130-UL

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 3.0"
Displacement =
0.253 Gal/Rev

BHP = WHP + VHP

Waukesha Cherry-Burrell®

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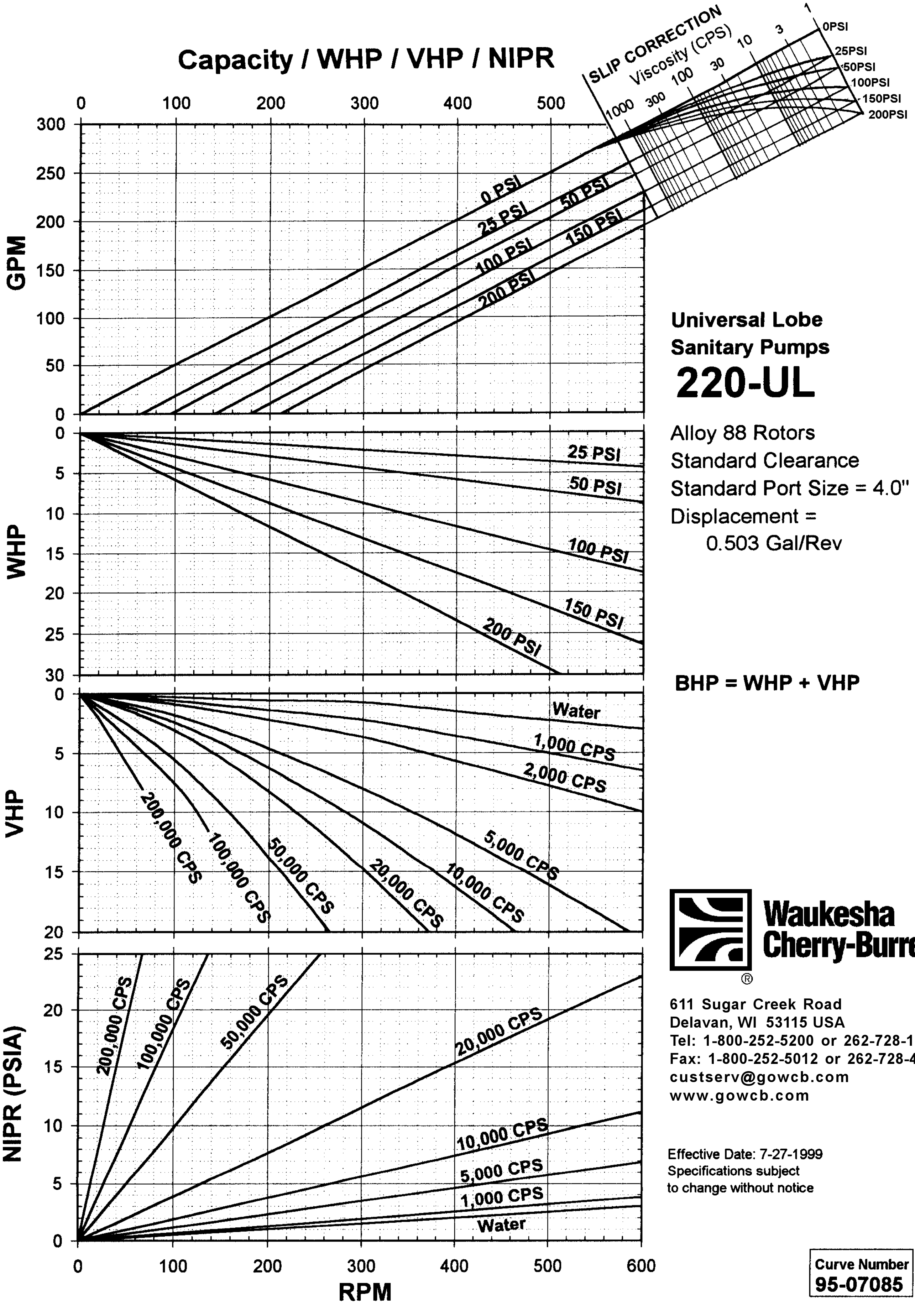
custserv@gowcb.com
www.gowcb.com

Effective Date: 5-19-1999
Specifications subject to change without notice

Curve Number
95-07084



Universal Lobe
Sanitary Pumps

220-UL

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 4.0"
Displacement =
0.503 Gal/Rev

BHP = WHP + VHP

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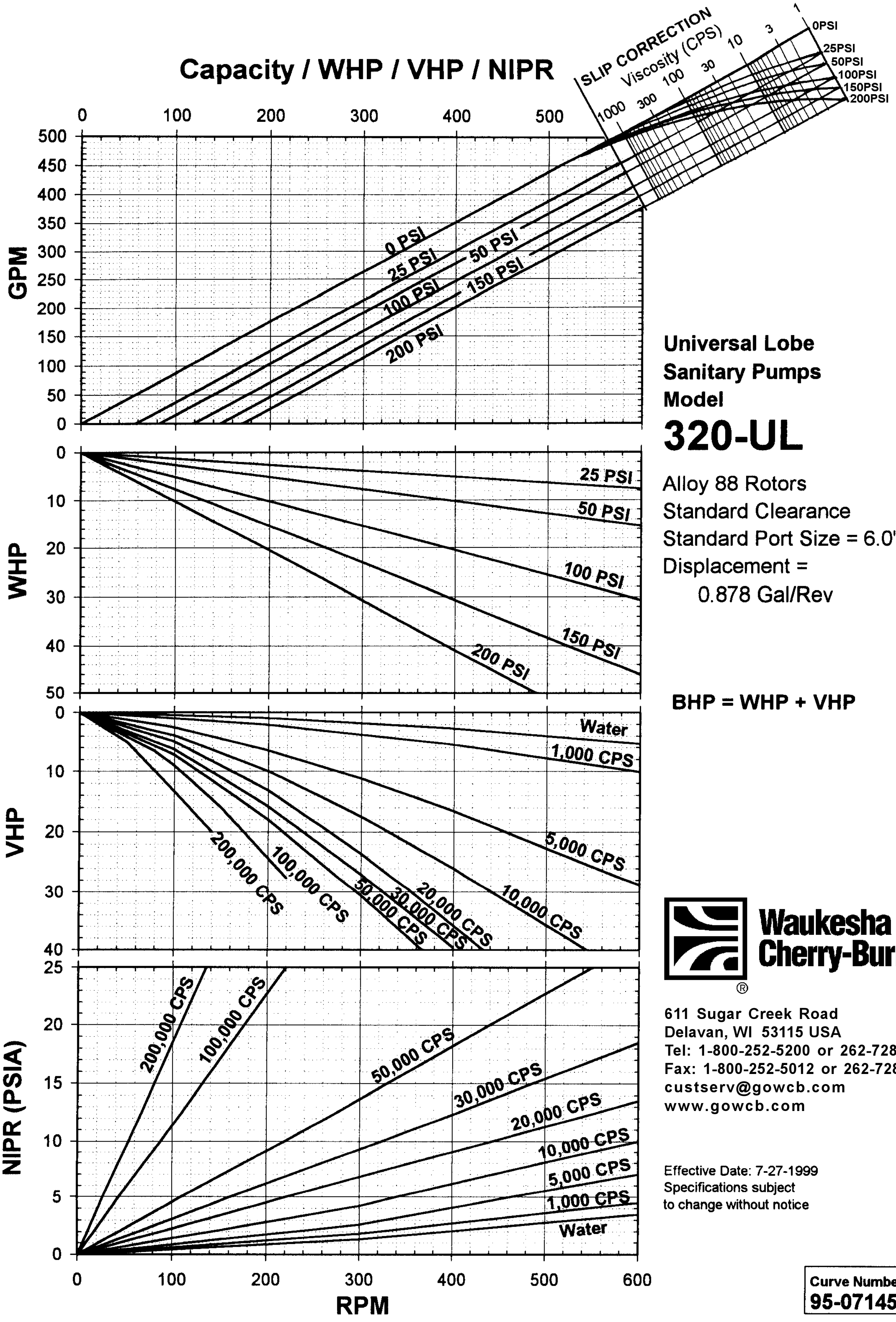
custserv@gowcb.com
www.gowcb.com

Effective Date: 7-27-1999
Specifications subject
to change without notice

Curve Number
95-07085

Capacity / WHP / VHP / NIPR



Universal Lobe
Sanitary Pumps
Model

320-UL

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 6.0"
Displacement =
0.878 Gal/Rev

BHP = WHP + VHP

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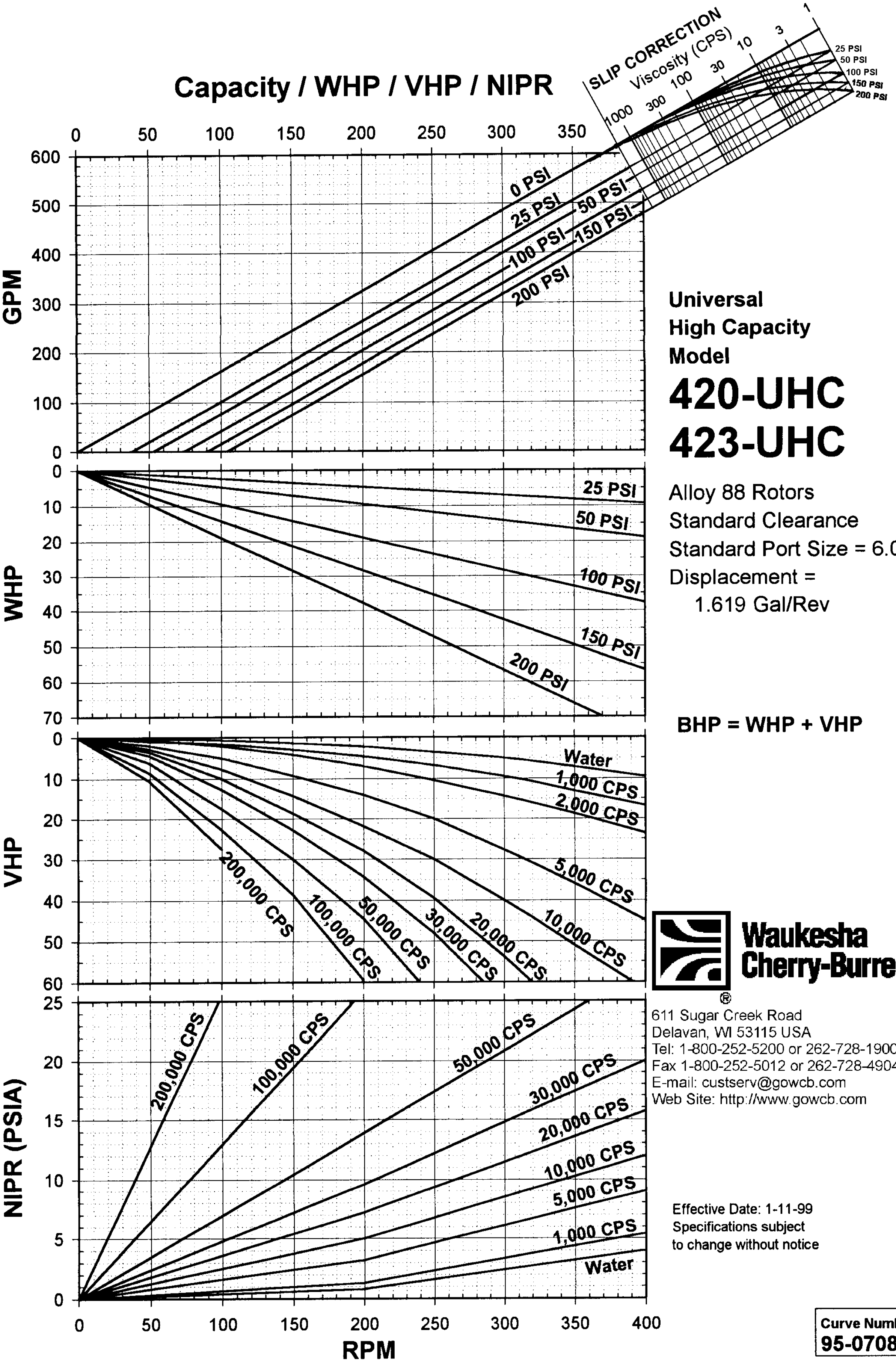
custserv@gowcb.com
www.gowcb.com

Effective Date: 7-27-1999
Specifications subject
to change without notice

Curve Number
95-07145



Universal
High Capacity
Model

420-UHC
423-UHC

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 6.0"
Displacement =
1.619 Gal/Rev

BHP = WHP + VHP

Waukesha Cherry-Burrell®

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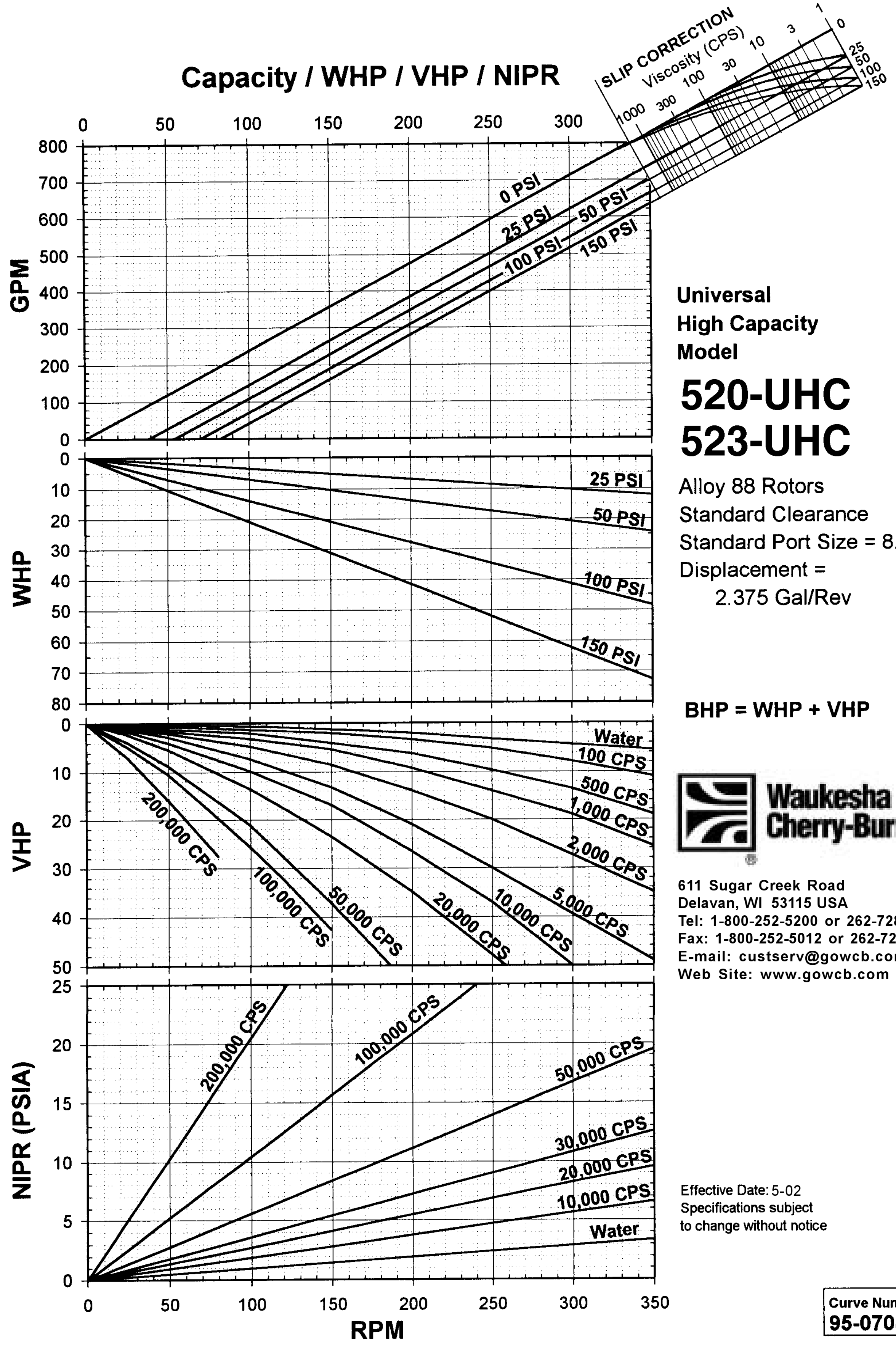
Web Site: http://www.gowcb.com

Effective Date: 1-11-99
Specifications subject
to change without notice

Curve Number
95-07086



Universal
High Capacity
Model

520-UHC
523-UHC

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 8.0"
Displacement =
2.375 Gal/Rev

BHP = WHP + VHP

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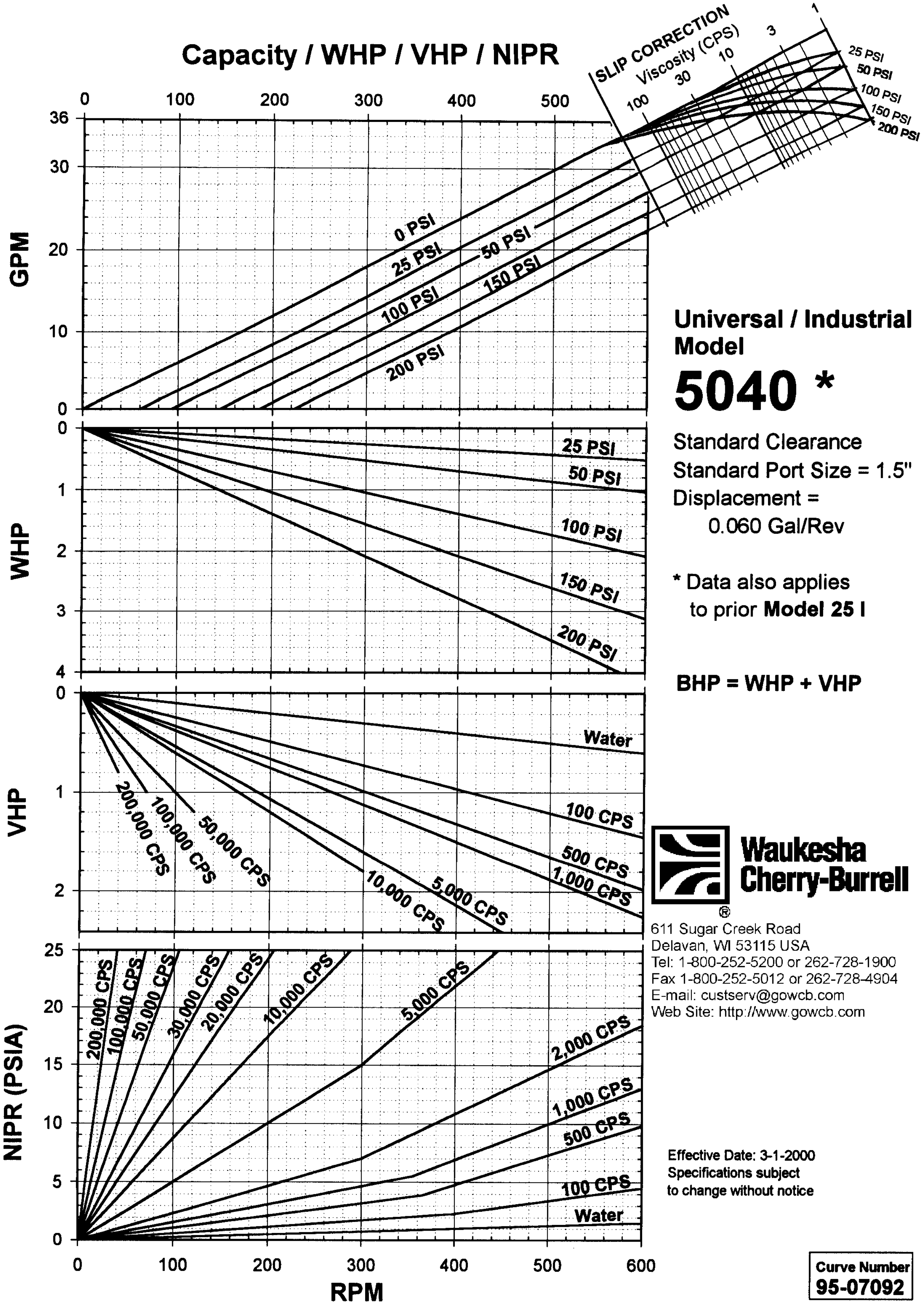
Fax: 1-800-252-5012 or 262-728-4904
E-mail: custserv@gowcb.com
Web Site: www.gowcb.com

Effective Date: 5-02
Specifications subject
to change without notice

Curve Number
95-07087



Universal / Industrial Model

5040 *

Standard Clearance
Standard Port Size = 1.5"
Displacement =
0.060 Gal/Rev

* Data also applies
to prior **Model 25 I**

BHP = WHP + VHP

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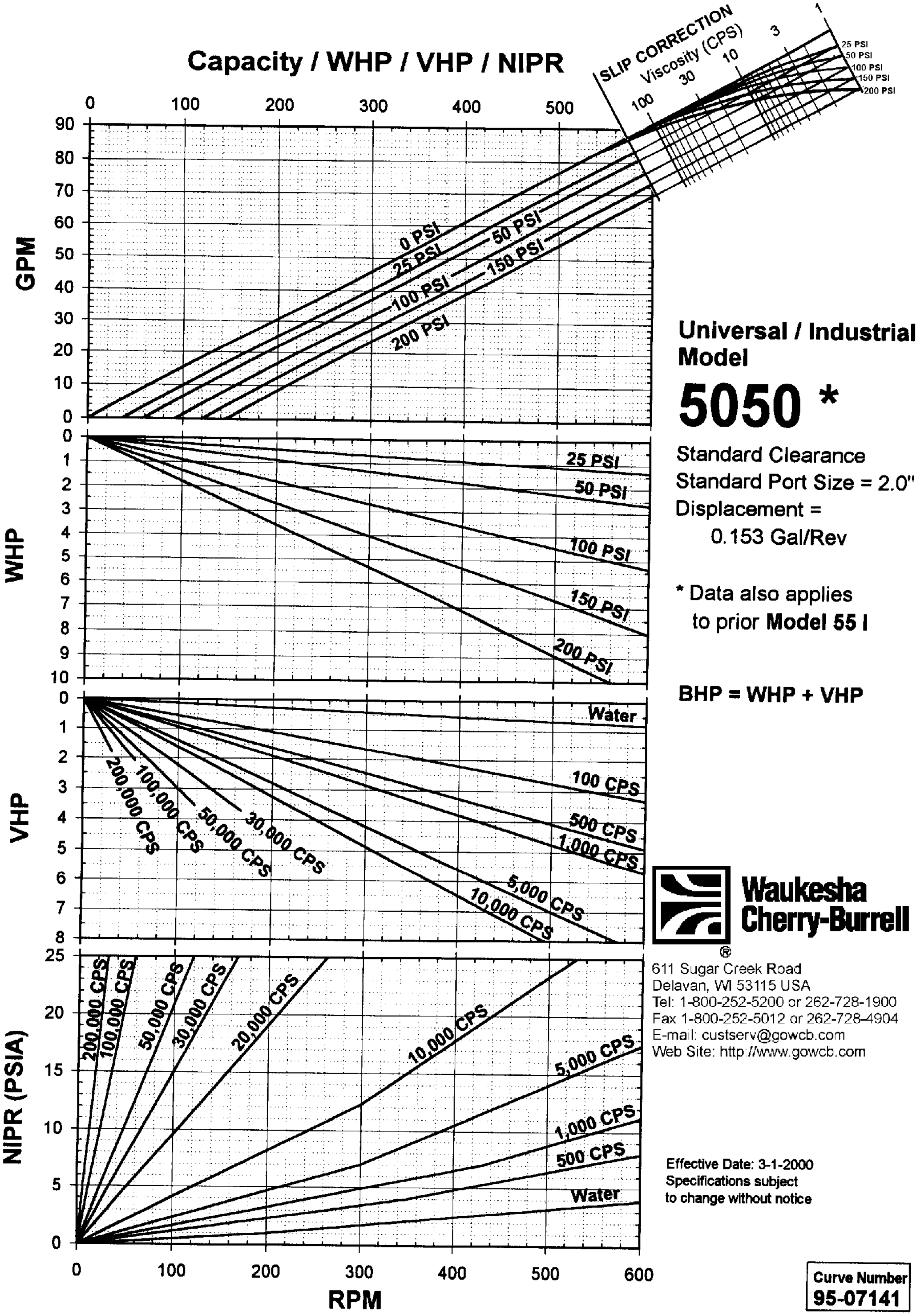
Web Site: http://www.gowcb.com

Effective Date: 3-1-2000
Specifications subject to change without notice

Curve Number
95-07092



Universal / Industrial Model

5050 *

Standard Clearance
Standard Port Size = 2.0"
Displacement =
0.153 Gal/Rev

* Data also applies to prior **Model 55 I**

BHP = WHP + VHP

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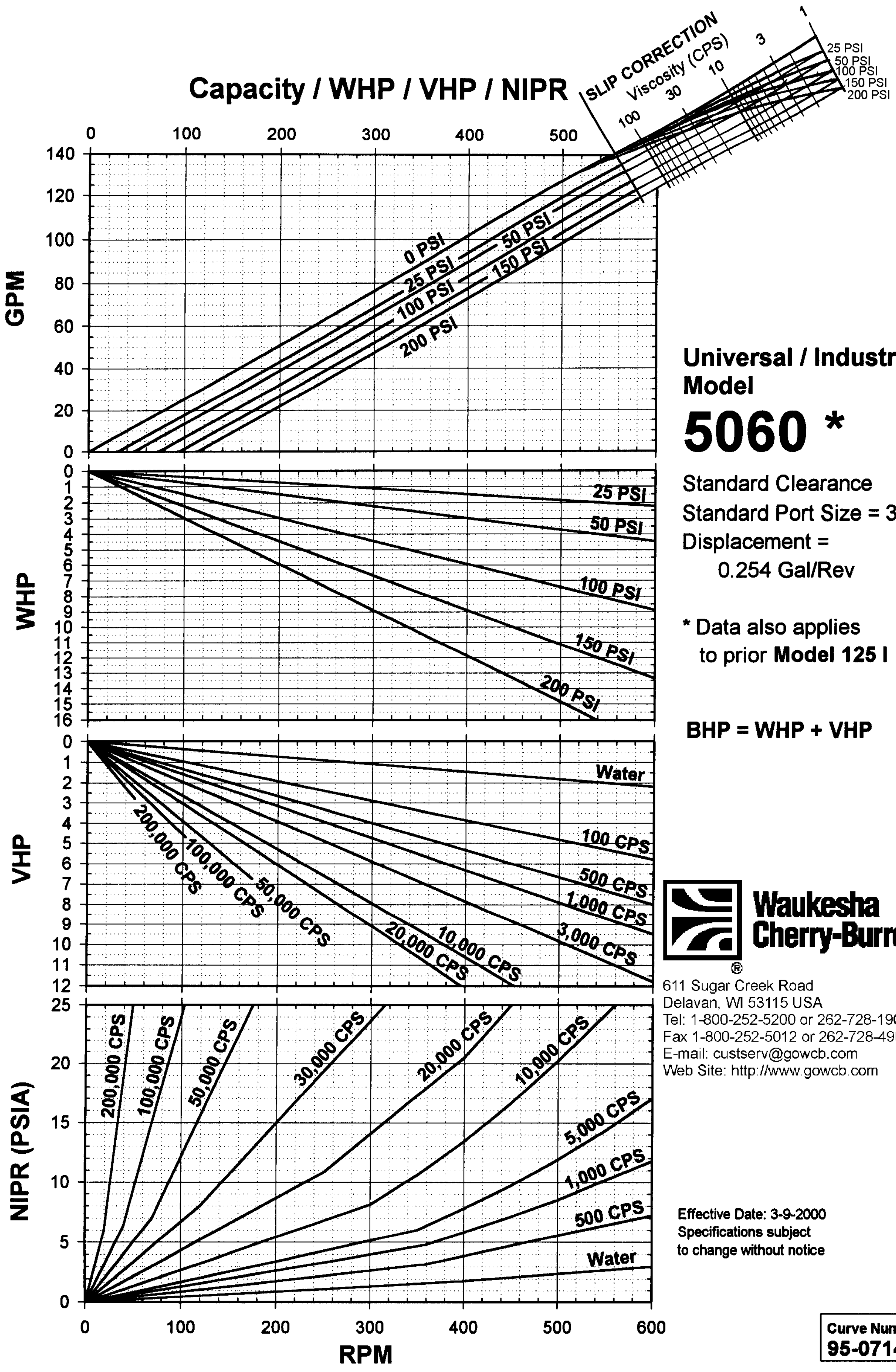
Web Site: http://www.gowcb.com

Effective Date: 3-1-2000
Specifications subject to change without notice

Curve Number
95-07141



Universal / Industrial Model

5060 *

Standard Clearance

Standard Port Size = 3.0"

Displacement =
0.254 Gal/Rev

* Data also applies
to prior **Model 125 I**

BHP = WHP + VHP

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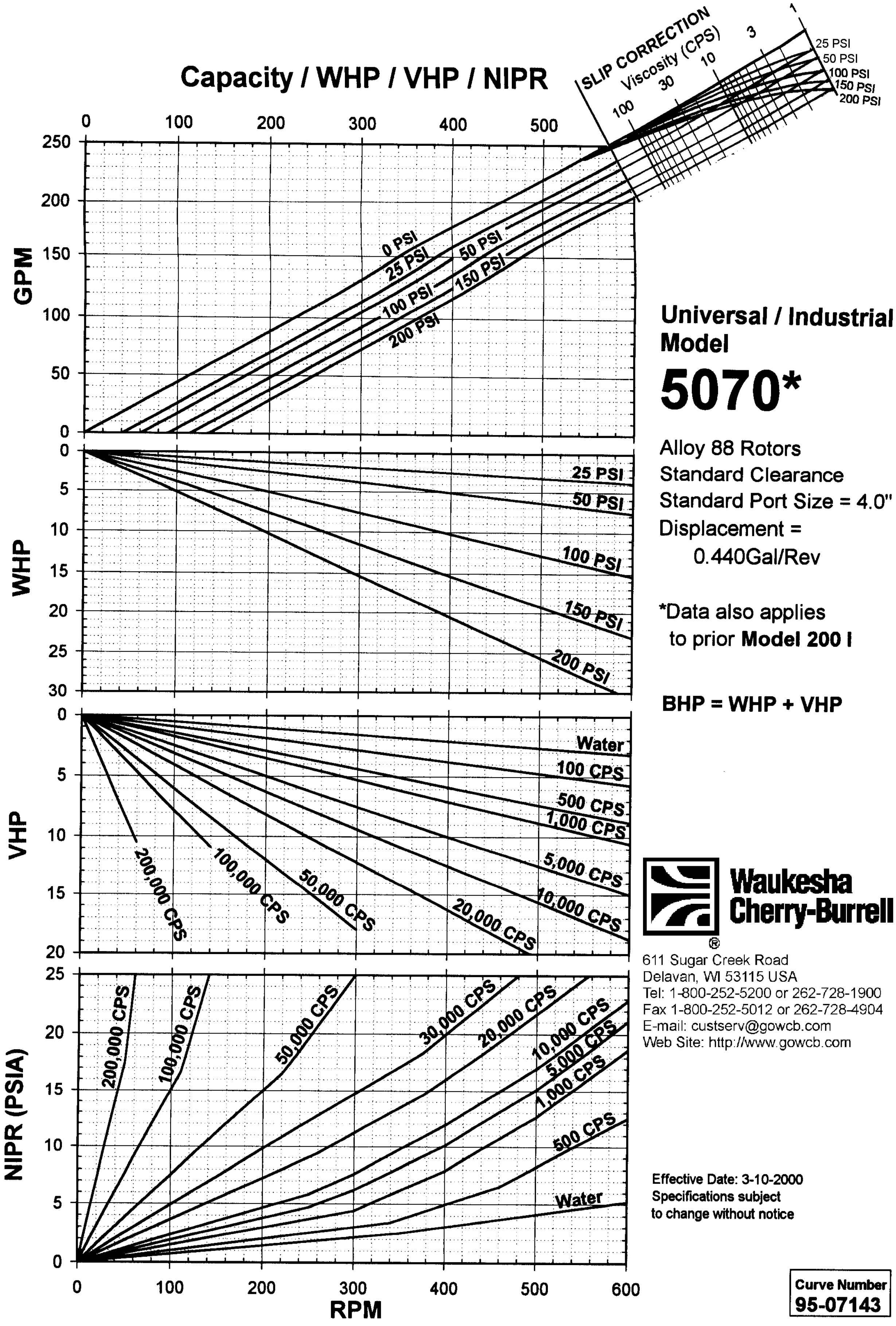
Web Site: http://www.gowcb.com

Effective Date: 3-9-2000
Specifications subject
to change without notice

Curve Number
95-07142

Capacity / WHP / VHP / NIPR



Universal / Industrial Model

5070*

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 4.0"
Displacement =
0.440Gal/Rev

*Data also applies to prior **Model 200 I**

BHP = WHP + VHP

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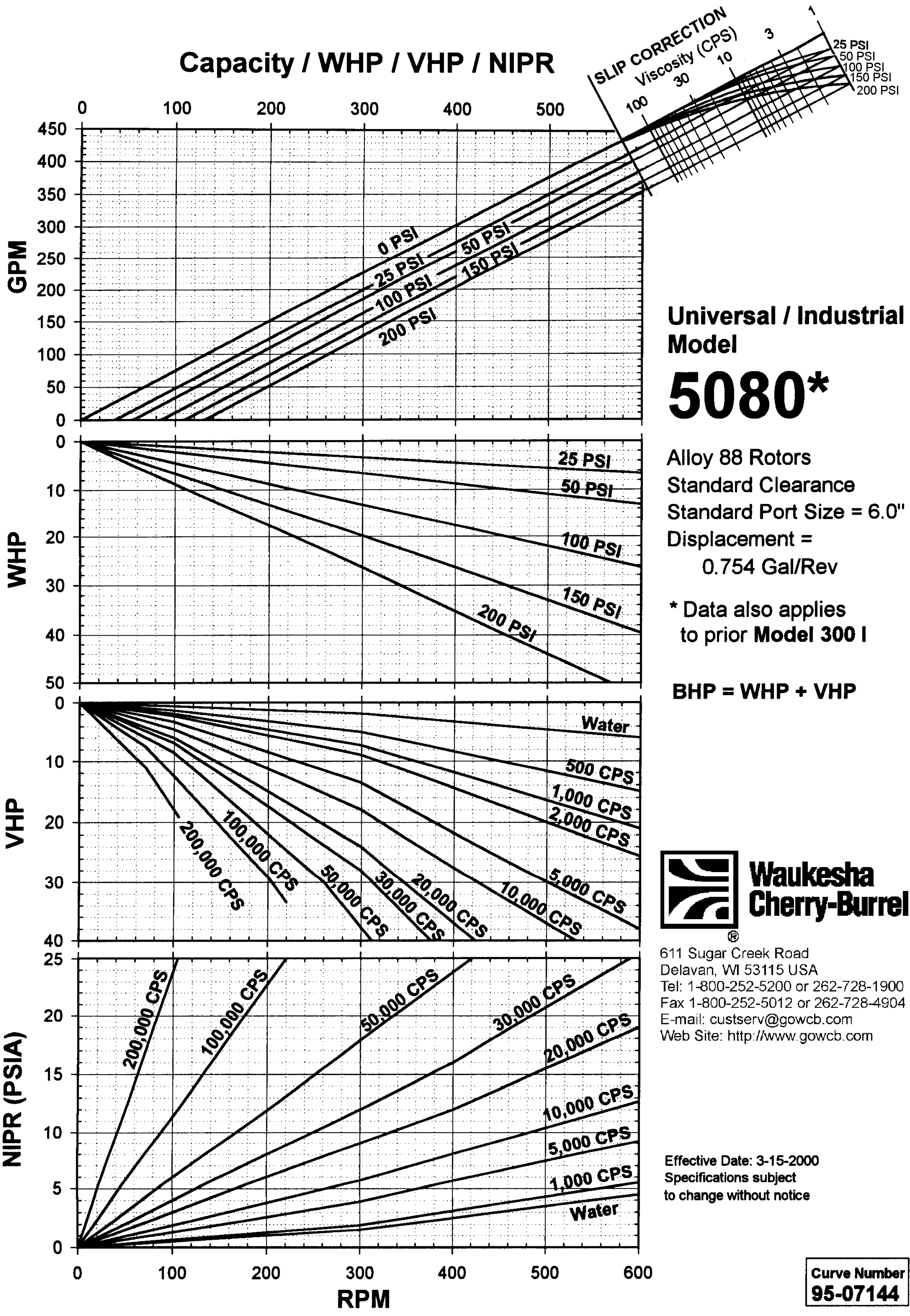
Web Site: http://www.gowcb.com

Effective Date: 3-10-2000
Specifications subject to change without notice

Curve Number
95-07143

Capacity / WHP / VHP / NIPR



Universal / Industrial Model

5080*

Alloy 88 Rotors
Standard Clearance
Standard Port Size = 6.0"
Displacement =
0.754 Gal/Rev

* Data also applies to prior **Model 300 I**

BHP = WHP + VHP

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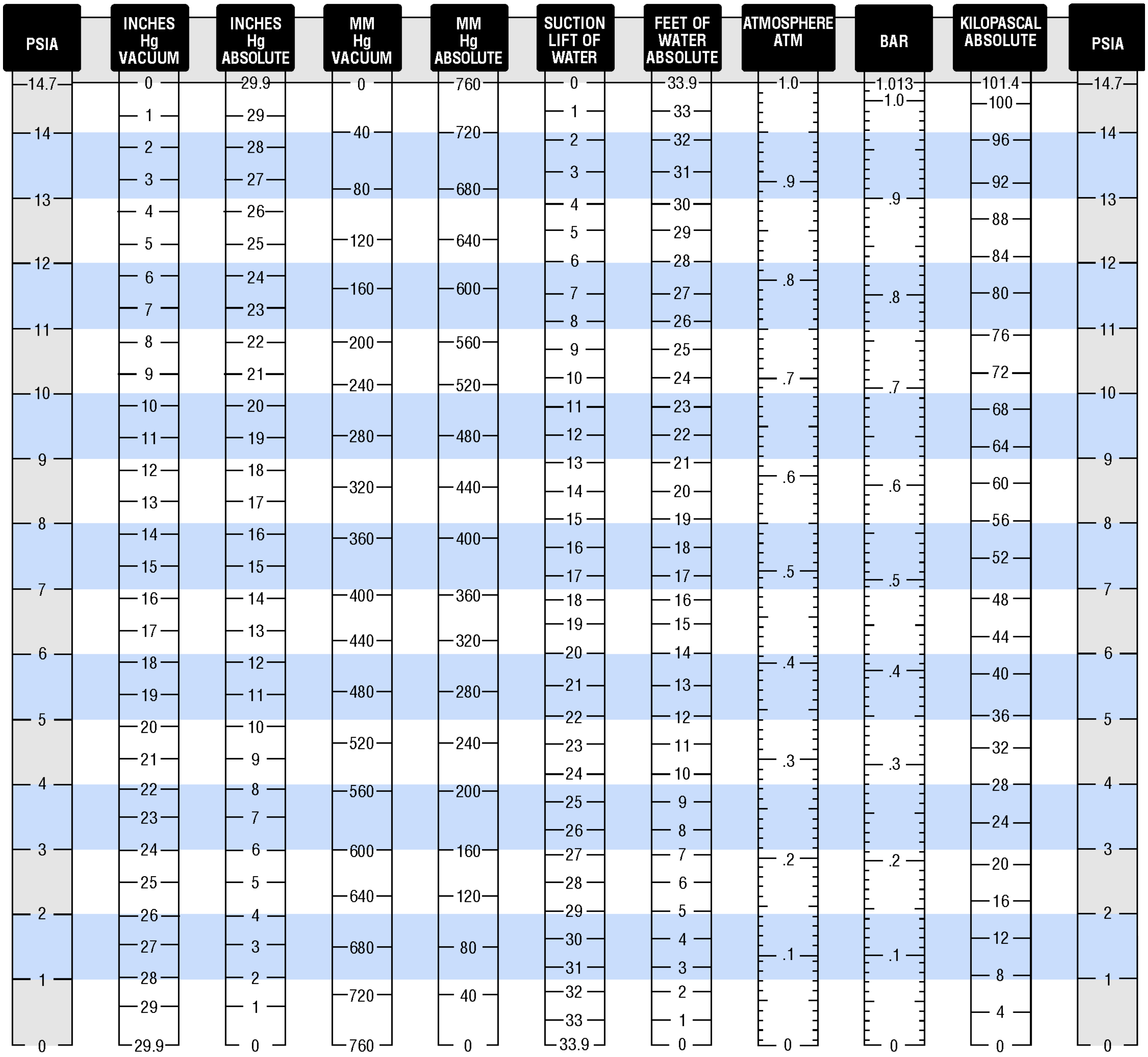
Web Site: http://www.gowcb.com

Effective Date: 3-15-2000
Specifications subject to change without notice

Curve Number
95-07144

Absolute Pressure Conversion

The scales below show different ways of expressing pressures below atmospheric pressure (0 psig, 14.7 PSI). The preferred scale is **PSIA** (lbs/in^2 absolute) which is used throughout this manual. Other scales can be converted to PSIA easily by use of this chart.



PD100-172

Fluid Viscosity

Typical fluid viscosities are listed below. Values for many common organic and inorganic fluids can be found in other references. The values given for thixotropic fluids are effective viscosities at normal pumping shear rates. Effective viscosity can vary greatly with changes in solids content, concentration, etc. Waukesha will test your fluid if necessary to determine effective viscosity.

Viscous Behavior Type: N — Newtonian T — Thixotropic D — Dilatent

Fluid	Specific Gravity	Viscosity CPS	Viscous Type
Reference — Water	1.0	1.0	N
ADHESIVES			
“Box” Adhesives	1 ±	3,000	T
PVA	1.3	100	T
Rubber & Solvents	1.0	15,000	N
BAKERY			
Batter	1.	2,200	T
Butter, Melted	0.98	18 @ 140°F	N
Egg, Whole	0.5	60 @ 50°F	N
Emulsifier		20	T
Frosting	1.	10,000	T
Lecithin		3,250 @ 125°F	T
77% Sweetened Condensed Milk	1.3	10,000 @ 77°F	N
Yeast Slurry 15%	1.	180	T
BEER, WINE			
Beer	1.0	1.1 @ 40°F	N
Brewers Concentrated Yeast — 80% Solids		16,000 @ 40°F	T
Wort			
Wine	1.0		
CONFECTIONERY			
Caramel	1.2	400 @ 140°F	
Chocolate	1.1	17,000 –120°F	T
Fudge, Hot	1.1	36,000	T
Toffee	1.2	87,000	T
COSMETICS, SOAPS			
Face Cream		10,000	T
Gel, Hair	1.4	5,000	T
Shampoo		5,000	T
Toothpaste		20,000	T
Hand Cleaner		2,000	T
DAIRY			
Cottage Cheese	1.08	225	T
Cream	1.02	20 @ 40°F	N
Milk	1.03	1.2 @ 60°F	N
Cheese, Process		30,000 @ 160°F	T
Yogurt		1,100	T
DETERGENTS			
Detergent Concentrate		10	N

Fluid	Specific Gravity	Viscosity CPS	Viscous Type
DYES AND INKS			
Ink, Printers	1 to 1.38	10,000	T
Dye	1.1	10	N
Gum		5,000	T
FATS AND OILS			
Corn Oil	0.92	30	N
Lard	0.96	60 @ 100°F	N
Linseed Oil	0.93	30 @ 100°F	N
Peanut Oil	0.92	42 @ 100°F	N
Soybean Oil	0.95	36 @ 100°F	N
Vegetable Oil	0.92	3 @ 300°F	N
FOODS, MISC			
Black Bean Paste		10,000	T
Cream Style Corn		130 @ 190°F	T
Catsup	1.11	560 @ 145°F	T
Pablum		4,500	T
Pear Pulp		4,000 @ 160°F	T
Potato — Mashed	1.0	20,000	T
Potato Skins & Caustic		20,000 @ 100°F	T
Prune Juice	1.0	60 @ 120°F	T
Orange Juice Conc.	1.1	5,000 @ 38°F	T
Tapioca Pudding	0.7	1,000 @ 235°F	T
Mayonnaise	1.0	5,000 @ 75°F	T
Tomato Paste — 33%	1.14	7,000	T
Honey	1.5	1,500 @ 100°F	
MEAT PRODUCTS			
Animal Fat, Melted	0.9	43 – 100°F	N
Ground Beef Fat	0.9	11,000 – 60°F	T
Meat Emulsion	1.0	22,000 – 40°F	T
Pet Food	1.0	11,000 – 40°F	T
Pork Fat Slurry	1.0	650 – 40°F	T
MISC CHEMICALS			
Glycols	1.1	35 @ Range	
PAINT			
Auto Paint, Metallic		220	T
Solvents	0.8–0.9	0.5 to 10	N
Titanium Dioxide Slurry		10,000	T
Varnish	1.06	140 @ 100°F	
Turpentine	0.86	2 @ 60°F	

Fluid	Specific Gravity	Viscosity CPS	Viscous Type
PAPER & TEXTILE			
Black Liquor Tar		2,000 @ 300°F	
Paper Coating 35%		400	
Sulfide 6%		1,600	
Black Liquor	1.3	1,100 @ 122°F	
Black Liquor Soap		7,000 @ 122°F	
PETROLEUM AND PETROLEUM PRODUCTS			
Asphalt — Unblended	1.3	500 to 2,500	
Gasoline	0.7	0.8 @ 60°F	N
Kerosene	0.8	3. @ 68°F	N
Fuel Oil #6	0.9	660 @ 122°F	N
Auto Lube Oil SAE 40	0.9	200 @ 100°F	N
Auto Trans Oil SAE 90	0.9	320 @ 100°F	N
Propane	0.46	0.2 @ 100°F	N
Tars	1.2	Wide Range	
PHARMACEUTICALS			
Castor Oil	0.96	350	N
Cough Syrup	1.0	190	N
“Stomach” Remedy Slurries		1,500	T
Pill Pastes		5,000 ±	T
PLASTICS, RESINS			
Butadiene	0.94	0.17 @ 40°F	
Polyester Resin (Typ)	1.4	3,000	T
PVA Resin (Typ)	1.3	65,000	
(Wide variety of plastics can be pumped, viscosity varies greatly)			
STARCHES, GUMS			
Corn Starch Sol 22°B	1.18	32	T
Corn Starch Sol 25°B	1.21	300	T
SUGAR, SYRUPS, MOLASSES			
Corn Syrup 41 Be	1.39	15,000 @ 60°F	N
Corn Syrup 45 Be	1.45	12,000 @ 130°F	N
Glucose	1.42	10,000 @ 100°F	
Molasses — A	1.42	280 to 5,000 @ 100°F	
B	1.43 to 1.48	1,400 to 13,000 @ 100°F	
C	1.46 to 1.49	2,600 to 5,000 @ 100°F	
Sugar Syrups			
60 Brix	1.29	75 @ 60°F	N
68 Brix	1.34	360 @ 60°F	N
76 Brix	1.39	4,000 @ 60°F	N
WATER & WASTE TREATMENT			
Clarified Sewage Sludge	1.1	2,000 Range	

Viscous Behavior Type:

N — Newtonian

T — Thixotropic

D — Dilatent

Viscosity Conversion Chart

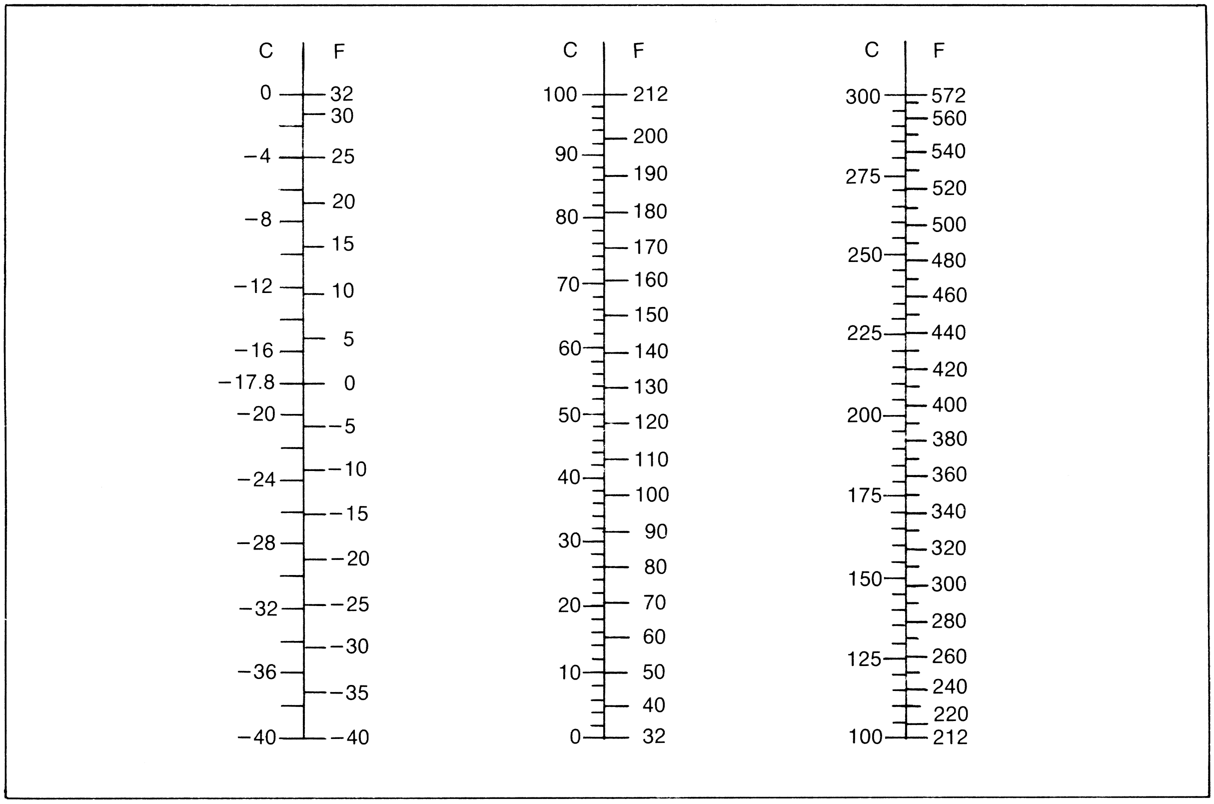
When Specific Gravity is 1		When Specific Gravity is Other than 1											
Read Directly Across		Find CKS Then Multiply CKS x S.G. = CPS	Find Stokes Then Multiply Stoke x S.G. = Poise										
CPS	**Poise**	**CKS**	**STOKE**	**Saybolt Universal (SSU)**	**Seconds Engler**	**Degrees Engler**	**Dupont Parlin #7**	**Dupont Parlin #10**	**Dupont Parlin #15**	**Dupont Parlin #20**	**Krebs Units**	**Mac-Michael**	**Pratt & Lambert F**
1	.01	1	.01	31	54	1.0	20		4.2				
2	.02	2	.02	34	57	1.1	23		4.3				
4	.04	4	.04	38	61	1.3	24		4.4				
7	.07	7	.07	47	75	1.6	26		4.6				
10	.10	10	.10	60	94	1.9	28	11	4.7				
15	.15	15	.15	80	125	2.5	30	12	4.9				
20	.20	20	.20	100	170	3.0	32	13	5.0			125	
25	.24	25	.24	130	190	4.1	37	14	5.1			139	
30	.30	30	.30	160	210	4.9	43	15	5.4			151	
40	.40	40	.40	210	300	6.0	50	16	5.7			177	
50	.50	50	.50	260	350	7.5	57	17	6.0		30	201	
60	.60	60	.60	320	450	9.1	63	18	6.3	3.1	33	230	
70	.70	70	.70	370	525	10.5	68	20	6.8	3.2	35	260	
80	.80	80	.80	430	600	12.4	73	22	7.5	3.3	37	290	7.3
90	.90	90	.90	480	875	14.0	78	23	7.7	3.4	38	315	7.8
100	1.0	100	1.0	530	750	15.3	81	25	8.0	3.5	40	335	8.3
120	1.2	120	1.2	580	900	16.1	90	30	8.3	3.6	43	380	8.9
140	1.4	140	1.4	690	1,050	20.0	106	32	8.9	3.9	46	415	9.8
160	1.6	160	1.6	790	1,200	23.0	120	37	9.7	4.1	48	465	10.8
180	1.8	180	1.8	900	1,350	26.3	135	41	10.7	4.3	50	520	11.9
200	2.0	200	2.0	1,000	1,500	29.2	149	43	11.5	4.5	52	570	12.5
220	2.2	220	2.2	1,100	1,650	32.2		45	12.2	4.8	54	610	13.0
240	2.4	240	2.4	1,200	1,800	35.0		49	13.0	5.0	56	660	14.2
260	2.6	260	2.6	1,280	1,950	37.7		53	13.7	5.3	58	700	15.1
280	2.8	280	2.8	1,380	2,100	40.5		58	14.4	5.6	59	750	15.6
300	3.0	300	3.0	1,475	2,250	43.0		64	15.0	5.9	60	800	16.7
320	3.2	320	3.2	1,530	2,400	44.7		66	15.5	6.1		825	17.3
340	3.4	340	3.4	1,630	2,550	47.5		70	16.4	6.4		875	18.5
360	3.6	360	3.6	1,730	2,700	50.3		74	17.3	6.7	62	925	19.6
380	3.8	380	3.8	1,850	2,850	54.0		79	18.2	7.0		980	21.0
400	4.0	400	4.0	1,950	3,000	57.0		84	19.1	7.3	64	1,035	22.1
420	4.2	420	4.2	2,050	3,150	59.9		88	20.0	7.6		1,070	23.2
440	4.4	440	4.4	2,160	3,300	63.6		93	21.0	8.0		1,125	24.x
460	4.6	460	4.6	2,270	3,450	67.0		100	22.0	8.5	65	1,180	26.x
480	4.8	480	4.8	2,380	3,600	69.5		104	23.0	8.9	67	1,240	27.x
500	5.0	500	5.0	2,480	3,750	73.1		107	23.9	9.2	68	1,290	28.1
550	5.5	550	5.5	2,660	4,125	78.0		115	26.3	9.7	69	1,385	30.1
600	6.0	600	6.0	2,900	4,500	85.0		126	28.5	10.6	71	1,510	32.8
700	7.0	700	7.0	3,380	5,250	95.0		145	31.9	12.1	74	1,760	38.2
800	8.0	800	8.0	3,880	6,000	110		168	36.4	13.9	77	2,020	44.4
900	9.0	900	9.0	4,300	8,750	125		185	40.0	15.5	81	2,240	48.6
1,000	10.0	1,000	10.0	4,600	7,500	135		198	43.0	16.8	85	2,395	52.0
1,100	11	1,100	11	5,200	8,250	151		224	48.0	18.7	88	2,710	58.1
1,200	12	1,200	12	5,620	9,000	164		242	53.2	20.2	92	2,930	63.6
1,300	13	1,300	13	6,100	9,750	177		262	58.0	22.0	95	3,180	69.0
1,400	14	1,400	14	6,480	10,350	188		280	61.6	23.2	96	3,370	73.4
1,500	15	1,500	15	7,000	11,100	203		300	69.0	25.0	98	3,650	79.3
1,600	16	1,600	16	7,500	11,850	217		322	72.0	26.7	100	3,900	85.0
1,700	17	1,700	17	8,000	12,600	233		344	76.0	28.5	101	4,180	90.5
1,800	18	1,800	18	8,500	13,300	248		366	81.0	30.0		4,420	96.2
1,900	19	1,900	19	9,000	13,900	263		387	86.0	31.8		4,830	102.0
2,000	20	2,000	20	9,400	14,600	275		405	90.0	33.0	103	4,900	106.2
2,100	21	2,100	21	9,850	15,300	287		433	94.5	34.7		5,120	111.3
2,200	22	2,200	22	10,300	16,100	300		453	99.0	36.0		5,360	116.6
2,300	23	2,300	23	10,750	16,800	314		473	105.7	38.0	105	5,600	124
2,400	24	2,400	24	11,200	17,500	325		493	110.3	39.5	109	5,840	127
2,500	25	2,500	25	11,600	18,250	339		510	114	40.8	114	6,040	131
3,000	30	3,000	30	14,500	21,800	425		638	142	51.0	121	7,550	165
3,500	35	3,500	35	16,500	25,200	485		725	164	57.0	129	8,600	187
4,000	40	4,000	40	18,500	28,800	540		814	186	64.5	133	9,640	210
4,500	45	4,500	45	21,000	32,400	615		924	214	73.5	136	10,920	238
5,000	50	5,000	50	23,500	36,000	690			239	82.0		12,220	267
5,500	55	5,500	55	26,000	39,600	765			265	90.6		13,510	295
6,000	60	6,000	60	28,000	43,100	820			285	97.5		14,570	318
6,500	65	6,500	65	30,000	46,000	885			306	104		15,610	340
7,000	70	7,000	70	32,500	49,600	960			331	113		16,900	369
7,500	75	7,500	75	35,000	53,200	1,035			356	122		18,200	397
8,000	80	8,000	80	37,000	56,800	1,095			377	129		19,250	420
8,500	85	8,500	85	39,500	60,300	1,175			402	138		20,600	449
9,000	90	9,000	90	41,080	63,900	1,220			417	143		21,350	465
9,500	95	9,500	95	43,000	67,400	1,280			433	150		22,400	488
10,000	100	10,000	100	46,500		1,385			464	162		24,200	527
15,000	150	15,000	150	69,400	106,000					242			
20,000	200	20,000	200	92,500	140,000					322			
30,000	300	30,000	300	138,500	210,000					483			
40,000	400	40,000	400	185,000	276,000					645			
50,000	500	50,000	500	231,000	345,000					805			
60,000	600	60,000	600	277,500	414,000					957			
70,000	700	70,000	700	323,500	484,000					1,127			
80,000	800	80,000	800	370,000	550,000					1,290			
90,000	900	90,000	900	415,500	620,000					1,445			
100,000	1,000	100,000	1,000	462,000	689,000					1,810			
125,000	1,250	125,000	1,250	578,000	850,000					2,010			
150,000	1,500	150,000	1,500	694,000						2,420			
175,000	1,750	175,000	1,750	810,000						2,820			
200,000	2,000	200,000	2,000	925,000						3,220			

Viscosity Conversion Chart

When Specific Gravity is 1		When Specific Gravity is Other than 1												
Read Directly Across		Find CKS Then Multiply CKS x S.G. = CPS	Find Stokes Then Multiply Stoke x S.G. = Poise											
CPS	**Poise**	**CKS**	**STOKE**	**Redwood Standard #1**	**Redwood Admiralty #2**	**Saybolt Furol**	**Stormer 100 KG Load**	**Ford #3**	**Ford #4**	**Zahn #1**	**Zahn #2**	**Zahn #3**	**Zahn #4**	**Zahn #5**
1	.01	1	.01	29										
2	.02	2	.02	32										
4	.04	4	.04	36	4.9									
7	.07	7	.07	44	5.9		2.5	8						
10	.10	10	.10	52	6.8		3.6	9	5	30	16			
15	.15	15	.15	63	8.4	13	5.8	10	8	34	17			
20	.20	20	.20	86	10.1	15	7.3	12	10	37	18			
25	.24	25	.24	112	12.5	17	9.6	15	12	41	19			
30	.30	30	.30	138	14.8	19	11.9	19	14	44	20			
40	.40	40	.40	181	19.5	24	15.6	25	18	52	22			
50	.50	50	.50	225	24.2	29	19.5	29	22	60	24			
60	.60	60	.60	270	28.8	34	24.0	33	25	68	27			
70	.70	70	.70	314	33.3	39	28.1	36	28	72	30			
80	.80	80	.80	364	38.0	42	32.5	41	31	81	34			
90	.90	90	.90	405	42.5	49	36.5	45	32	88	37	10		
100	1.0	100	1.0	445	47.0	54	40.7	50	34		41	12	10	
120	1.2	120	1.2	492	56.0	59	44.5	58	41		49	14	11	
140	1.4	140	1.4	585	65.1	70	53	66	45		58	16	13	
160	1.6	160	1.6	670	74.0	79	61	72	50		66	18	14	
180	1.8	180	1.8	762	83.0	91	70	81	54		74	20	16	
200	2.0	200	2.0	817	91.5	100	77	90	58		82	23	17	10
220	2.2	220	2.2	933	99.5	110	85	98	62		88	25	18	11
240	2.4	240	2.4	1,020	108	120	92	106	65			27	20	12
260	2.6	260	2.6	1,085	115	128	98	115	68			30	21	13
280	2.8	280	2.8	1,170	124	138	106	122	70			32	22	14
300	3.0	300	3.0	1,250	133	148	114	130	74			34	24	15
320	3.2	320	3.2	1,295	141	153	118	136	89			36	25	16
340	3.4	340	3.4	1,380	150	163	125	142	95			39	26	17
360	3.6	360	3.6	1,465	159	173	133	150	100			41	27	18
380	3.8	380	3.8	1,570	170	185	143	160	106			43	29	19
400	4.0	400	4.0	1,650	179	195	150	170	112			46	30	20
420	4.2	420	4.2	1,740	188	205	158	180	118			48	32	21
440	4.4	440	4.4	1,830	199	216	166	188	124			50	33	22
460	4.6	460	4.6	1,925	209	227	175	200	130			52	34	23
480	4.8	480	4.8	2,020	219	238	183	210	137			54	36	24
500	5.0	500	5.0	2,100	228	248	191	218	143			58	38	25
550	5.5	550	5.5	2,255	245	266	204	230	153			64	40	27
600	6.0	600	6.0	2,460	267	290	221	250	170			68	45	30
700	7.0	700	7.0	2,860	311	338	260	295	194			76	51	35
800	8.0	800	8.0	3,290	357	388	298	340	223				57	40
900	9.0	900	9.0	3,640	396	430	331	365	247				63	45
1,000	10.0	1,000	10.0	3,900	424	460	354	390	264				69	49
1,100	11	1,100	11	4,410	479	520	400	445	299				77	55
1,200	12	1,200	12	4,680	509	562	433	480	323					59
1,300	13	1,300	13	5,160	560	610	470	520	350					64
1,400	14	1,400	14	5,490	596	648	498	550	372					70
1,500	15	1,500	15	5,940	645	700	539	595	400					75
1,600	16	1,600	16	6,350	690	750	577	635	430					80
1,700	17	1,700	17	6,780	735	800	615	680	460					85
1,800	18	1,800	18	7,200	780	850	654	720	490					91
1,900	19	1,900	19	7,620	829	900	695	760	520					96
2,000	20	2,000	20	7,950	865	940	723	800	540					
2,100	21	2,100	21	8,350	906	985	757	835	565					
2,200	22	2,200	22	8,730	950	1,030	793	875	592					
2,300	23	2,300	23	9,110		1,075	827	910	617					
2,400	24	2,400	24	9,500		1,120	861	950	645					
2,500	25	2,500	25	9,830		1,160	893	985	676					
3,000	30	3,000	30	12,300		1,450	1,115	1,230	833					
3,500	35	3,500	35	14,000		1,650	1,223	1,400	950					
4,000	40	4,000	40	15,650		1,850	1,420	1,570	1,060					
4,500	45	4,500	45	17,800		2,100	1,610		1,175					
5,000	50	5,000	50	19,900		2,350	1,810		1,350					
5,500	55	5,500	55			2,600	2,000		1,495					
6,000	60	6,000	60			2,800	2,150		1,605					
6,500	65	6,500	65			3,000	2,310		1,720					
7,000	70	7,000	70			3,250	2,500		1,870					
7,500	75	7,500	75			3,500	2,690		2,010					
8,000	80	8,000	80			3,700	2,850		2,120					
8,500	85	8,500	85			3,950	3,040		2,270					
9,000	90	9,000	90			4,100	3,150		2,350					
9,500	95	9,500	95			4,350	3,310		2,470					
10,000	100	10,000	100			4,650	3,580		2,670					
15,000	150	15,000	150			6,940								
20,000	200	20,000	200			9,250								
30,000	300	30,000	300			13,860								
40,000	400	40,000	400			18,500								
50,000	500	50,000	500			23,100								
60,000	600	60,000	600			27,750								
70,000	700	70,000	700			32,350								
80,000	800	80,000	800			37,000								
90,000	900	90,000	900			41,550								
100,000	1,000	100,000	1,000			46,200								
125,000	1,250	125,000	1,250			57,800								
150,000	1,500	150,000	1,500			69,400								
175,000	1,750	175,000	1,750			81,000								
200,000	2,000	200,000	2,000			92,500								

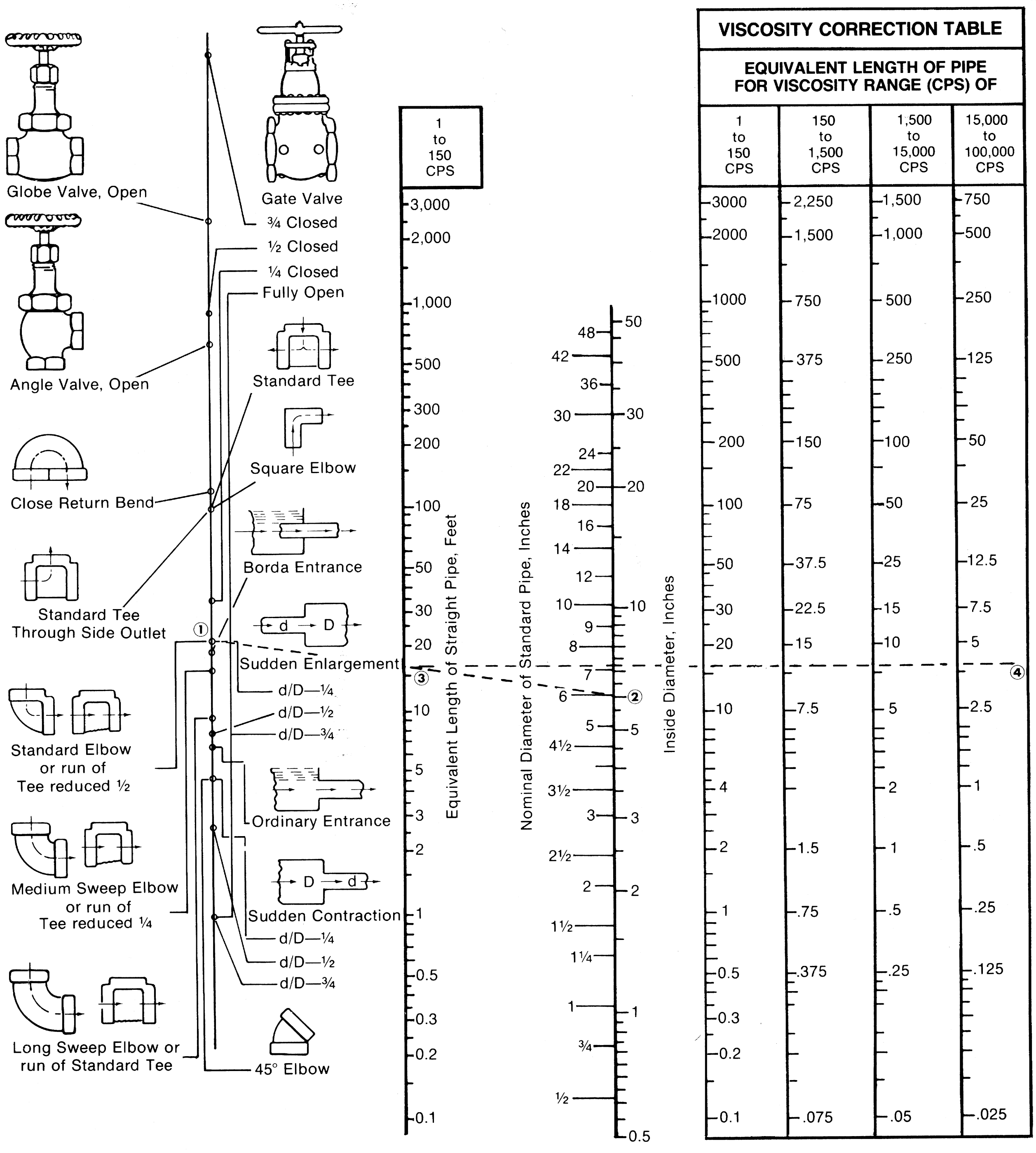
Temperature Conversion

0.555 (°F - 32) = °C (1.8 x °C) + 32 = °F

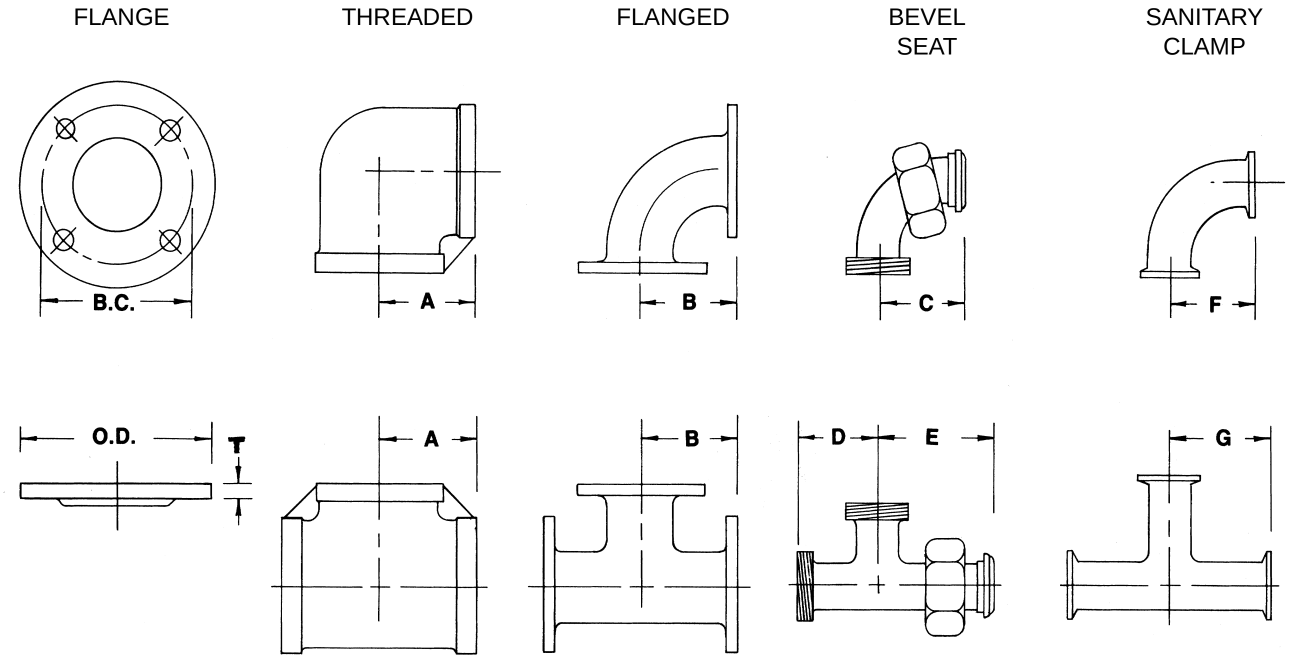


Friction Loss in Valves and Fittings

Find fitting reference point 1 line size point 2, read equivalent length at point 3. For high viscosity move straight across from 3 and read point 4 in proper viscosity column.

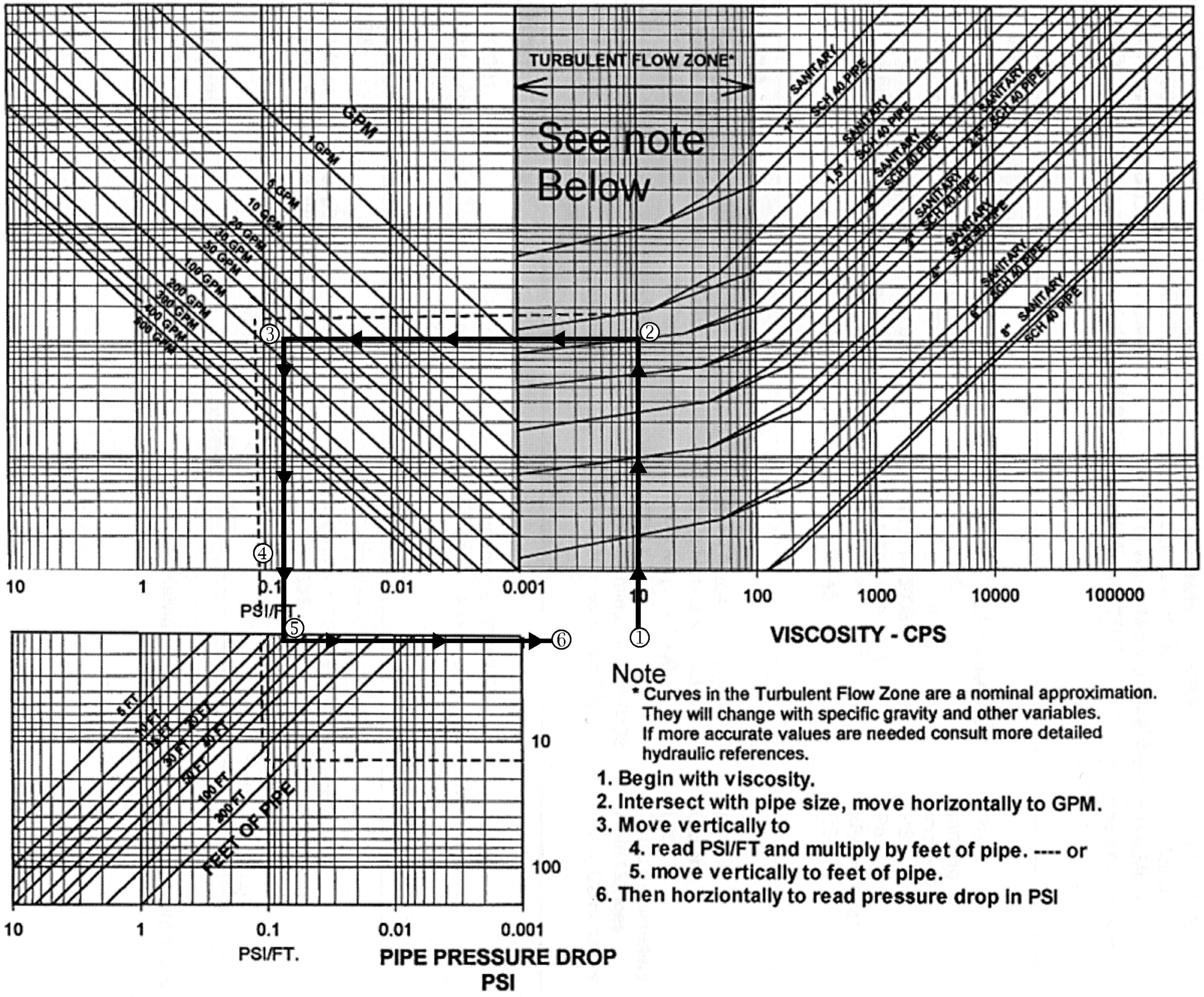


Piping Fitting Dimensions



Pipe					150# MSS Flange				Fittings						
	Sanitary		SCH. 40												
Nom. Size	I.D.	O.D.	I.D.	O.D.	O.D.	T	B.C.	Holes No—Dia.	A	B	C	D	E	F	G
1	.870	1.000	1.049	1.315	4-1/4	3/8	3-1/8	4—5/8	1-1/2	—	2	1-13/16	2-11/16	2	2-3/8
1-1/4	—	—	1.380	1.660	4-5/8	13/32	3-1/2	4—5/8	1-3/4	—	—	—	—	—	—
1-1/2	1.370	1.500	1.610	1.900	5	7/16	3-7/8	4—5/8	1-15/16	—	2-7/8	2-3/8	3-13/32	2-3/4	2-3/4
2	1.870	2.000	2.067	2.375	6	1/2	4-3/4	4—3/4	2-1/4	4-1/2	3-23/32	2-25/32	3-13/16	3-1/2	3-1/2
2-1/2	2.370	2.500	2.469	2.875	7	9/16	5-1/2	4—3/4	2-11/16	5	4-27/32	3-3/16	4-1/4	4-1/4	3-1/2
3	2.834	3.000	3.068	3.500	7-1/2	5/8	6	4—3/4	3-1/16	5-1/2	5-29/32	3-1/2	4-5/8	5	3-3/4
4	3.834	4.000	4.026	4.500	9	11/16	7-1/2	8—3/4	3-13/16	6-1/2	8-1/16	4-21/32	6-1/8	6-5/8	4-1/2
6	5.782	6.000	6.065	6.625	11	13/16	9-1/2	8—7/8	—	8	—	—	—	10-1/2	6-1/2
8	7.782	8.000	7.981	8.625	13-1/2	15/16	11-3/4	8—7/8	—	9	—	—	—	13-1/2	7-1/2

Pipe Frictional Loss Graph



Note

* Curves in the Turbulent Flow Zone are a nominal approximation. They will change with specific gravity and other variables. If more accurate values are needed consult more detailed hydraulic references.

1. Begin with viscosity.
2. Intersect with pipe size, move horizontally to GPM.
3. Move vertically to
    4. read PSI/FT and multiply by feet of pipe. ---- or
    5. move vertically to feet of pipe.
6. Then horziontally to read pressure drop in PSI

Miscellaneous Engineering Constants

Flow

Lbs of Water/Hr x 0.002@68°F = Gal/Min
Gal/Min x 500 = Lbs of Water/Hr@68°F
(Lbs of Fluid/Hr ÷ S.G.) x 0.002 = Gal/Min
Liters/Min x 0.264 = Gal/Min (US)
GPM x 3.785 = Liters/Min

Cu Meters/Hr x 4.4 = Gal/Min (US)
Gal/Min x 0.227 = Cu Meters/Hr
Kg of Water/Min x 0.264@68°F = Gal/Min (US)
Gal/Min x 3.8 = Kg of Water/Min@68°F

Pressure

Ft of Water x 0.433@68°F = PSI
PSI x 2.31@68°F = Ft of Water
Inches Hg x 0.491 = PSI
Inches Hg x 1.135@68°F = Ft of Water
ATM x 14.7 = PSI
ATM x 33.9 = Ft of Water@68°F
Kg/Sq cm x 14.22 = PSI

Meters of Water x 1.42 = PSI
ATM x 760 = mm Hg
mm HG x 0.039 = Inches Hg
Bar x 14.5 = PSI
Newton/Meter^2 x 1 = Pascal
PSI x 6.9 = kPa (Kilopascal)
kPa x 0.145 = PSI

Volume

Lbs Water x 0.119@68°F = Gal
Gal (Brit) x 1.2 = Gal (US)
Gal x 128 = Fluid Ounces
Cubic Ft x 7.48 = Gal
Cubic In. x 0.00433 = Gal
Gal x 3.785 = Liters

Liter x 0.264 = Gal
Cubic Meters x 264.2 = Gallons
Cubic Meter x 1000 = Liter
Liters x 1000 = Cubic Centimeters
Cubic Centimeters x 0.0338 = Fluid Ounces
Fluid Ounces x 29.57 = Cubic Centimeters

Length

Mils x 0.001 = Inches
Meters x 3.281 = Feet
Centimeters x 0.394 = Inches

Millimeters x .0394 = Inches
Microns x .0000394 = Inches

Mass

Gal of Water x 8.336@68°F = Lbs
Cubic Ft of Water x 62.4@68°F = Lbs
Ounces x 0.0625 = Lbs

Kilograms x 2.2046 = Lbs
Lbs x 0.4536 = Kilograms
Metric Ton x 2204.623 = Lbs

Temperature

(1.8 x °C) + 32 =°F
.555 (°F - 32) =°C
Degrees Kelvin - 273.2 =Degrees Centigrade

Power

$$HP = \frac{T\ (\text{ft-lb}) \times RPM}{5250} = \frac{T\ (\text{in-lb}) \times RPM}{63025}$$

$$HP = \frac{\text{Disp (Gals)} \times RPM \times PSI}{1714 \times EFF}$$

$$T\ (\text{in-lbs}) = \frac{HP \times 63025}{RPM} \times 12$$

$$T\ (\text{ft-lbs}) = \frac{HP\ X\ 5250}{RPM} x12$$

Horsepower x 0.746 = Kilowatts
Horsepower x 42.43 = BTU/Min
Metric Horsepower x 0.9863 = Horsepower

Miscellaneous

Average Absolute Atmospheric Pressure
Altitude above Sea Level

Feet	PSIA	IN Hg
0	14.7	29.9
500	14.4	29.4
1,000	14.2	28.9
1,500	13.9	28.3
2,000	13.7	27.8
3,000	13.2	26.8
4,000	12.7	25.9
5,000	12.2	24.9
6,000	11.7	24.0
7,000	11.3	23.1

Heat of Fusion of Water = 144 BTU/Lb
Heat of Vaporization of Water = 970 BTU/Lb

Metric Prefixes

Mega = 1,000,000
Kilo = 1,000
Hecto = 100
Deca = 10

Deci = 0.1
Centi = 0.01
Milli = 0.001
Micro = 0.000,001

Viscosity Conversion (approximate)

$$\frac{\text{Absolute Viscosity (Centipoise)}}{\text{Specific Gravity}} = \begin{array}{c}\text{Kinematic Viscosity}\\ \text{(Centistokes)}\end{array}$$

SSU@ 100 F x 0.2158 =
Saybolt Furol x 2.123 =
Redwood Std x 0.255 =
Redwood Admirality x 2.3392 = Centistokes
Engler-Degrees x 7.4389 =
Ford Cup # 4 x 3.53 =
MacMichael x 0.415 =
Stormer x 2.802 =

Chemical Compatibility of Pump Materials

The following table is a **partial list** of common fluids which can be handled by Waukesha pumps of the materials indicated.

The list is based primarily on acceptable corrosion rates. Rates of 0 to 0.010 inches per year (ipy) are considered acceptable for even low viscosity fluids, as pump clearances, and thus pump performance will not change greatly in normal service.

Corrosion rates of 0.010 to 0.020 ipy can often be tolerated with higher viscosity liquid (above 1,000 CPS).

Corrosion rates are greatly influenced by concentration, temperature, and fluid viscosity. Mixtures of liquids, aerated liquids, or liquids with certain ions present (i.e., chloride) may have considerably different corrosion rates, and should be investigated in references, or by actual test.

Unless otherwise indicated, the temperature for the fluid is 70°F, concentration 0 to 100%.

Many other liquids can be handled at a variety of conditions. Corrosion tables, such as the Corrosion Data Survey of The National Association of Corrosion Engineers can be consulted for an indication of material acceptability, and Waukesha Cherry-Burrell will be happy to furnish recommendations for your fluid. This table is intended as a guide only and Waukesha Cherry-Burrell reserves the right of approval of all applications.

A — Acceptable, C — Conditionally Acceptable, X — Not Recommended

Fluids	Stainless Steel Pumps	Ductile Iron Pumps
Acetone Anhydride	A	X
Acetone	A	A
Acetylene	A	A
Acid		
Acetic below 50%	A	X
Boric below 30%	A	X
Carbolic above 80%	A	A
Citric	A	X
Fatty Acids	A	A
Fruit	A	X
Lactic below 10%	A	X
Nitric	A	X
Oxalic	X	X
Palmitic	A	X
Phosphoric below 85%	A	X
Pyroligneous below 10%	A	X
Sulphuric below 25%	A	X
Tannic	A	A
Adhesives	A	A
Alcohol		
Butyl	A	A
Ethyl	C	C
Methyl	A	C
Propyl	A	A
Aluminum Sulphate	A	X
Anhydrous Ammonia	A	A

Fluids	Stainless Steel Pumps	Ductile Iron Pumps
Ammonium		
Chloride below 20%	A	X
Hydroxide below 50%	A	X
Nitrate	A	X
Meta-Phosphate	A	X
Analine Dyes	A	X
Animal Fats	A	A
Asphalt	A	A
Beet Juice & Pulps	A	A
Beer	A	X
Beer Wort	A	A
Benzene	A	X
Black Liquor	A	A
Blood	A	X
Butadiene	A	A
Brines	A	X
Butter	A	X
Carbon Disulfide	A	A
Carbon Tetrachloride	A	X
Carbonated Beverages	A	X
Calcium Carbonate	A	X
Cane Sugar & Liquor	A	A
Chocolate Syrup	A	A
Chlorine (Dry)	A	X
Clay Slurries & Coatings	A	A

Fluids	Stainless Steel Pumps	Ductile Iron Pumps
Castor Oil	A	X
Catsup	A	X
Cellulose Acetate	A	X
Cheese	A	X
Chloroform below 80%	C	X
Coffee Extracts	A	X
Corn Syrup	A	A
Cottonseed Oil	A	A
Creosote	A	A
Detergents	A	X
Dextrose	A	A
Dyes	A	X
Eggs	A	X
Ether	A	X
Ferric Sulfate below 20%	A	X
Formaldehyde	A	X
Fruit Juice	A	X
Freon	A	A
Furfural (below 20%)	A	X
Gasoline	A	A
Gelatin	A	X
Glucose	A	A
Glue	A	A
Glycerin	A	A
Glycols — Ethylene	A	C
Hydrazine	A	X
Herbicides	A	A
Hydrogen Peroxide		
below 10%, above 90%	A	X
Insecticides	A	A
Ink	A	A
Ketones	A	X
Lactose	A	X
Lacquers	A	A
Latex	A	C
Linseed Oil	A	A
Lubricating Oils	A	A
Lye—Caustic below 25%	A	X
Magnesium Sulfate	A	A
Margarine	A	X
Mayonnaise	A	X
Meats—Ground	A	X
Meats—Fats	A	A

Fluids	Stainless Steel Pumps	Ductile Iron Pumps
Methane	A	A
Methyl Ethyl Ketone	A	A
Milk	A	X
Molasses	A	A
Naptha	A	A
Oil		
Most Types of Mineral & Vegetable	A	A
Paint	A	A
Plasticizers	A	A
Polyvinyl Acetate	A	X
Polyvinyl Chloride	A	X
Potassium Chloride	A	X
Propane	A	A
Rosin	A	A
Sewage	A	A
Soap Liquors & Solutions	A	A
Sodium Acetate	X	A
Carbonate	A	A
Sodium Cyanide	A	A
Hydroxide below 0.25%	A	X
Bisulfide	A	X
Sulfate	A	X
Peroxide	X	A
Phosphate (Neutral)	X	X
Silicate	A	A
Nitrate	A	A
Starch	A	X
Styrene	A	A
Sucrose	A	A
Sugar Solutions	A	C
Tallow	A	A
Tomato—Juices, Concentrate, Catsup	A	X
Trichoroethylene	A	X
Toluene	A	A
Turpentine	A	A
Waxes & Emulsions	A	A
Wine	A	X
Xylene	A	X
Yeast	A	X
Zinc Sulfate below 25%	A	X

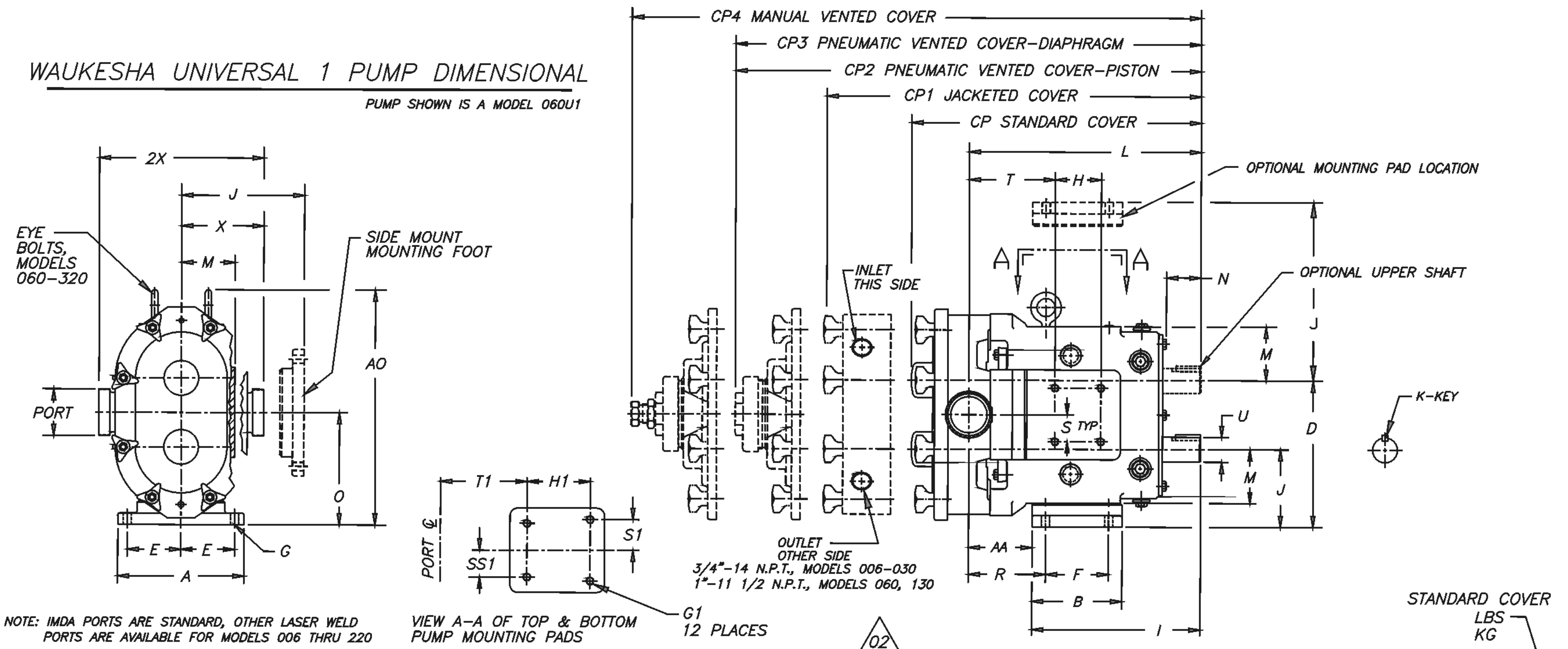
Pump Dimensions

IMPORTANT

The pump dimensions provided in this document are for reference only and may not be current. Contact your Waukesha Cherry-Burrell representative for a copy of our most up-to-date information.

WAUKESHA UNIVERSAL 1 PUMP DIMENSIONAL

PUMP SHOWN IS A MODEL 060U1

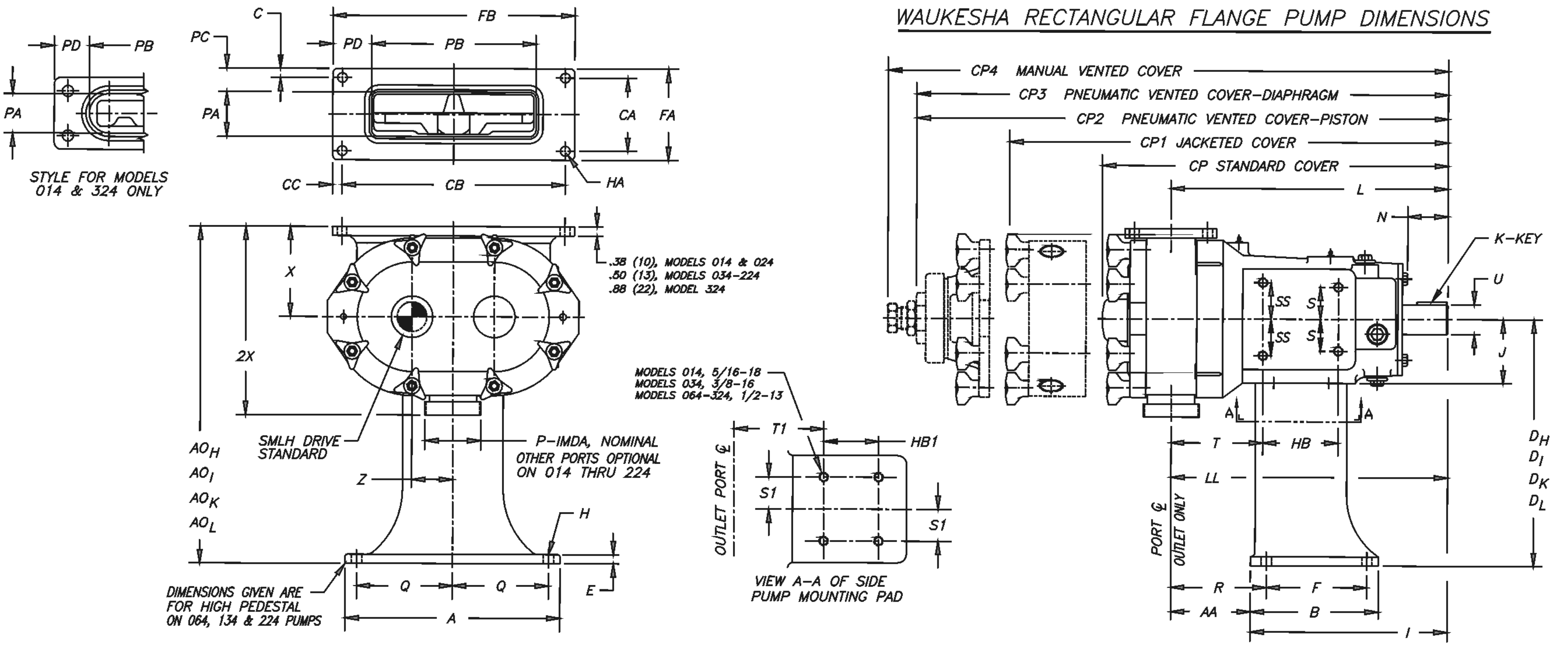


NOTE: IMDA PORTS ARE STANDARD, OTHER LASER WELD PORTS ARE AVAILABLE FOR MODELS 006 THRU 220

STANDARD COVER LBS KG

SIZE PUMP		A	AA	AO	B	CP	CP1	CP2	CP3	CP4	D	E	F	G	G1	H	H1	I	J	K +.002 -.000	L	M	N	O	PORT	R	S	S1	SS1	T	T1	U +.000 -.001	X	2X	WT.
006 015	IN	4.75	1.95	8.30	3.75	12.04	13.47	13.53	13.62	15.25	5.50	1.94	2.31	.41, SLOT	5/16-18x.62	2.50	2.50	7.66	2.93	.1875	9.61	2.12	2.00	4.21	1 1/2" IMDA	2.79	1.00	1.00	1.00	2.51	2.51	.875	3.49	6.97	52
	MM	121	50	211	95	306	342	344	346	387	140	49	59	10, SLOT	–	64	64	194	74	4.763	244	54	51	107	–	71	25	25	25	64	64	22.23	89	177	24
018	IN	4.75	2.18	8.30	3.75	12.46	13.90	13.95	14.04	15.67	5.50	1.94	2.31	.41, SLOT	5/16-18x.62	2.50	2.50	7.66	2.93	.1875	9.84	2.12	2.00	4.21	1 1/2" IMDA	3.02	1.00	1.00	1.00	2.74	2.74	.875	3.55	7.09	54
	MM	121	55	211	95	316	353	354	357	398	140	49	59	10, SLOT	–	64	64	194	74	4.763	250	54	51	107	–	77	25	25	25	70	70	22.23	90	180	24
030	IN	6.25	2.78	10.29	4.25	14.58	16.42	15.98	16.07	17.67	6.86	2.31	2.56	.41, SLOT	3/8-16x.62	1.81	2.75	8.83	3.56	.25	11.61	2.62	2.32	5.21	1 1/2" IMDA	3.84	1.12	1.12	1.12	4.00	3.59	1.250	4.25	8.50	100
	MM	159	71	261	108	370	417	406	408	449	174	59	65	10, SLOT	–	46	70	224	90	6.35	295	67	59	132	–	98	28	28	28	102	91	31.75	108	216	45
060	IN	8.25	4.14	15.31	5.87	18.91	20.69	20.47	20.76	22.07	9.56	3.50	4.12	.53	1/2-13x.88	3.00	4.13	10.99	5.06	.375	16.14	3.50	2.25	7.31	2 1/2" IMDA	5.01	1.75	2.00	1.75	5.62	5.01	1.625	5.37	10.75	255
	MM	210	105	389	149	480	526	520	527	561	243	89	105	13	–	76	105	279	129	9.525	385	89	57	186	–	127	44	51	44	143	127	41.28	136	273	116
130	IN	8.25	4.78	15.31	5.87	19.85	21.63	21.42	21.70	23.01	9.56	3.50	4.12	.53	1/2-13x.88	3.00	4.13	10.99	5.06	.375	16.77	3.50	2.25	7.31	3" IMDA	5.65	1.75	2.00	1.75	6.25	5.66	1.625	5.37	10.75	260
	MM	210	121	389	149	504	549	544	551	584	243	89	105	13	–	76	105	279	129	9.525	401	89	57	186	–	144	44	51	44	159	144	41.28	136	273	118
220	IN	8.50	3.69	19.13	9.00	23.37	–	26.07	–	27.87	12.38	3.75	7.25	.53, SLOT	1/2-13x1.00	5.38	5.38	14.80	6.38	.50	18.49	4.50	2.75	9.38	4" IMDA	4.44	2.69	2.69	2.69	6.00	6.00	2.000	6.63	13.25	450
	MM	216	94	486	229	594	–	662	–	708	314	95	184	13, SLOT	–	137	137	376	162	12.7	470	114	70	2.38	–	113	68	68	68	152	152	50.80	168	337	204
320	IN	12.00	4.12	22.38	11.63	30.17	–	–	–	–	13.88	5.25	8.00	.66	1/2-13x1.00	5.38	5.38	17.80	6.88	.625	21.92	5.06	4.06	10.38	6" 150# FLANGE	5.37	2.69	2.69	2.69	8.37	8.37	2.375	8.00	16.00	795
	MM	305	105	568	295	766	–	–	–	–	353	133	203	17	–	137	137	452	175	15.875	557	129	103	264	–	136	68	68	68	213	213	60.45	203	406	361

WAUKESHA RECTANGULAR FLANGE PUMP DIMENSIONS



D6

SIZE PUMP		A	AA	AO_H	AO_I	AO_K	AO_L	B	C	CA	CB	CC	CP	CP1	CP2	CP3	CP4	D_H	D_I	D_K	D_L	E	F	FA	FB	H
014	IN	6.75	1.95	–	–	–	12.50	4.13	.50	1.62	6.50	.50	12.04	13.47	13.53	13.62	15.25	–	–	–	8.88	.38	2.31	2.63	7.50	.41
	MM	171	50	–	–	–	318	105	13	41	165	13	306	342	344	346	387	–	–	–	226	10	59	67	191	10
024	IN	6.75	2.18	–	–	–	12.50	4.13	.50	2.00	7.00	.50	12.46	13.90	13.95	14.04	15.67	–	–	–	8.88	.38	2.31	3.00	8.00	.41
	MM	171	55	–	–	–	318	105	13	51	178	13	316	353	354	357	398	–	–	–	226	10	59	76	203	10
034	IN	8.00	2.88	14.25	13.75	13.25	12.75	4.25	.62	1.88	10.75	.62	14.58	16.42	15.98	16.07	17.67	10.38	9.88	9.38	8.88	.38	3.00	3.12	12.00	.44
	MM	203	73	362	349	337	324	108	16	48	273	16	370	417	406	408	449	264	251	238	226	10	76	79	305	11
064	IN	11.75	4.35	19.18	–	–	18.44	7.00	.50	4.00	12.20	.52	18.91	20.69	20.47	20.76	22.07	14.25	–	–	13.50	.50	5.50	5.00	13.23	.56
	MM	298	110	487	–	–	468	178	13	102	310	13	480	526	520	527	561	362	–	–	343	13	140	127	336	14
134	IN	11.75	5.00	19.18	–	–	18.44	7.00	.78	3.00	14.00	.63	19.85	21.63	21.42	21.70	23.01	14.25	–	–	13.50	.50	5.50	4.55	15.25	.56
	MM	298	127	487	–	–	468	178	20	76	356	16	504	549	544	551	584	362	–	–	343	13	140	116	387	14
224	IN	15.00	4.75	23.75	–	–	19.75	9.50	.63	4.37	16.75	.63	23.37	–	26.07	–	27.87	17.50	–	–	13.50	.63	8.25	5.62	18.00	.56
	MM	381	121	603	–	–	502	241	16	111	425	16	594	–	662	–	708	445	–	–	343	16	210	143	457	14
324	IN	18.00	6.56	–	–	–	36.00	12.00	.63	8.25	18.50	.69	30.17	–	–	–	–	–	–	–	27.13	.75	9.50	9.50	19.88	.69
	MM	457	167	–	–	–	914	305	16	210	470	18	766	–	–	–	–	–	–	–	689	19	241	241	505	18

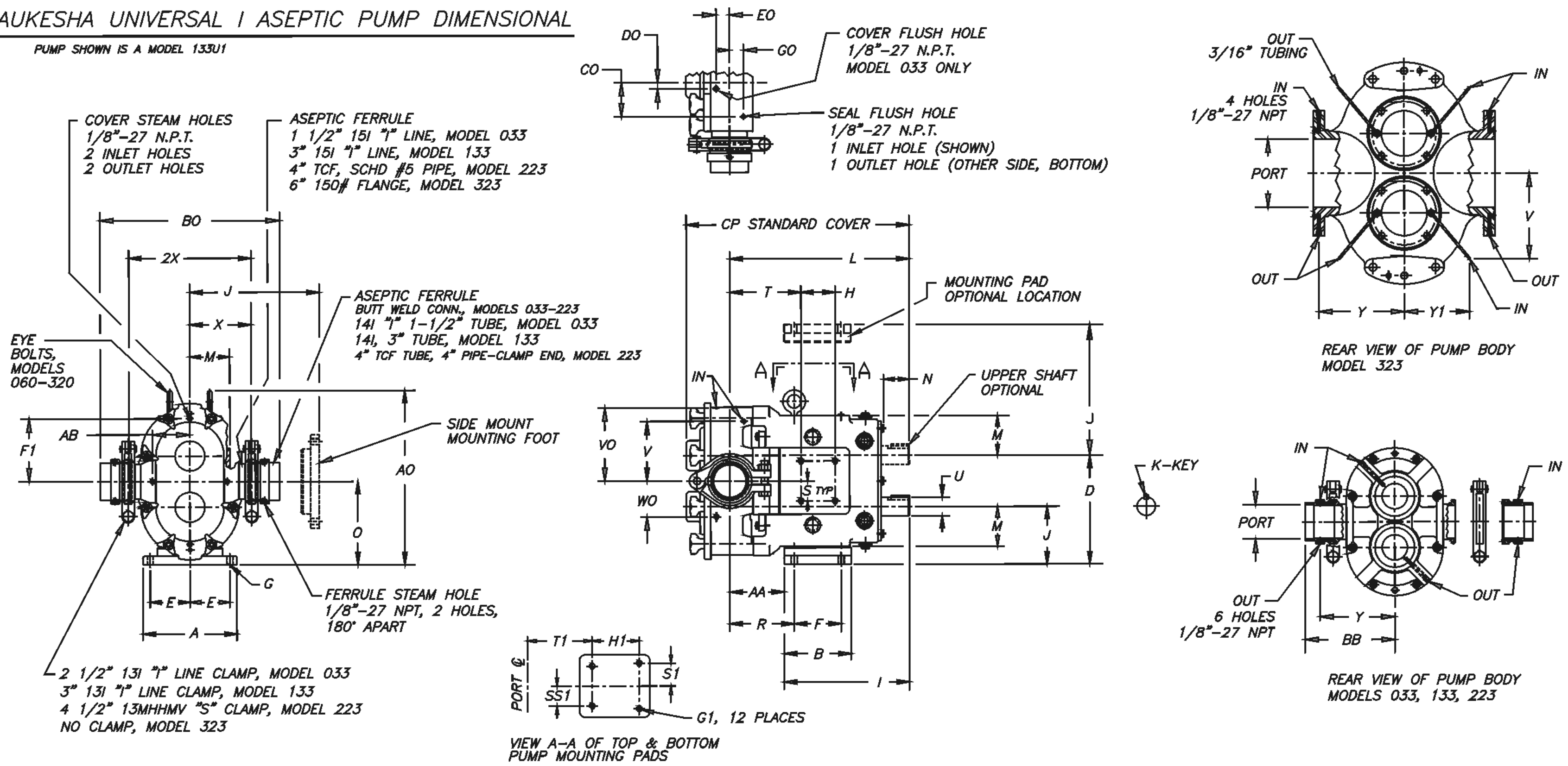
SIZE PUMP		HA	HB	HB1	I	J	K +.002 −.000	L	LL	N	P	PA	PB	PC	PD	Q	R	S	S1	SS	T	T1	U +.000 −.001	X	2X	Z	WT
014	IN	.41	2.50	2.50	7.66	2.12	.1875	9.61	9.61	2.00	1.5	1.44	4.94	.59	1.28	2.81	2.79	1.00	1.00	1.00	2.51	2.51	.875	3.63	7.11	1.28	47
	MM	10	64	64	195	54	4.763	244	244	51	–	37	125	15	33	71	71	25	25	25	64	64	22.23	92	181	33	21
024	IN	.41	2.50	2.50	7.66	2.12	.1875	9.84	9.84	2.00	1.5	1.75	5.13	.63	1.44	2.81	3.02	1.00	1.00	1.00	2.74	2.74	.875	3.63	7.11	1.28	49
	MM	10	64	64	195	54	4.763	250	250	51	–	44	130	16	37	71	77	25	25	25	70	70	22.23	92	181	33	22
034	IN	.53	2.75	1.81	8.49	2.62	.25	11.36	11.37	2.32	2.0	1.81	6.84	.66	2.58	3.38	3.51	1.12	1.12	1.12	3.35	3.76	1.250	3.88	8.12	1.65	100
	MM	13	70	46	216	67	6.35	289	289	59	–	46	174	17	66	86	89	28	28	28	85	96	31.75	99	206	42	45
064	IN	.53	4.13	3.00	10.77	3.50	.375	15.16	15.12	2.25	2.5	2.44	9.00	1.28	2.11	5.25	5.23	2.00	1.75	1.75	5.01	5.60	1.625	4.94	10.31	2.25	255
	MM	13	105	76	274	89	9.525	385	384	57	–	62	229	33	54	133	133	51	44	44	127	142	41.28	125	262	57	116
134	IN	.53	4.13	3.00	10.77	3.50	.375	15.78	15.76	2.25	3.0	3.19	9.38	.68	2.94	5.25	5.87	2.00	1.75	1.75	5.65	6.25	1.625	4.94	10.31	2.25	280
	MM	13	105	76	274	89	9.525	401	400	57	–	81	238	17	75	133	149	51	44	44	144	159	41.28	125	262	57	127
224	IN	.53	5.38	5.38	13.74	4.50	.50	18.49	18.49	2.75	4.0	4.06	11.25	.78	3.38	6.88	5.37	2.69	2.69	2.69	6.00	6.00	2.000	6.25	12.87	3.00	505
	MM	13	137	137	349	114	12.70	470	470	70	–	103	286	20	86	175	136	68	68	68	152	152	50.80	159	327	76	229
324	IN	.66	5.38	5.38	16.86	5.06	.625	23.42	23.42	4.06	6.0	5.00	17.38	2.25	1.25	7.75	7.81	2.69	2.69	2.69	9.87	9.87	2.375	8.87	17.88	3.50	775
	MM	17	137	137	428	129	15.875	595	595	103	–	127	441	57	32	197	198	68	68	68	251	251	60.33	225	454	89	352

STANDARD COVER W/ STD. UNIVERSAL FOOT
LBS
KG

NOTE: MODEL 324 HAS 8 BOLT HOLES IN RECTANGULAR FLANGE, & OUTLET PORT IS A ROUND FLANGE.

WAUKESHA UNIVERSAL I ASEPTIC PUMP DIMENSIONAL

PUMP SHOWN IS A MODEL 133U1



03 WAUKESHA TYPE ASEPTIC UNION SHOWN, MODELS 033, 133 & 223

LBS KG

SIZE PUMP		A	AA	AB	AO	B	BB	BO	CO	CP	D	DO	E	EO	F	F1	G	G1	GO	H	H1	I	J	K +.002 -.000	L	M	N	O	PORT	R	S	S1	SS1	T	T1	U +.000 -.001	V	VO	WO	X	2X	Y	Y1	WT.
033	IN	6.25	2.78	–	10.29	4.25	5.56	11.13	2.11	14.58	6.86	.54	2.31	.37	2.56	–	.41, SLOT	3/8-16x.62	.75	1.81	2.75	8.83	3.56	.25	11.61	2.62	2.32	5.21	1-1/2"	3.84	1.12	1.12	1.12	4.00	3.59	1.250	3.95	4.73	4.14	4.31	8.63	4.88	9.76	105
	MM	159	71	–	261	108	141	283	54	370	174	14	59	9	65	–	10, SLOT	–	19	46	70	224	90	6.35	295	67	59	132	–	98	28	28	28	102	91	31.75	100	120	105	109	219	124	248	48
133	IN	8.25	4.78	3.28	15.31	5.87	7.89	15.77	3.01	19.59	9.56	–	3.50	–	4.12	5.53	.53	1/2-13x.88	1.23	3.00	4.13	10.99	5.06	.375	15.77	3.50	2.25	7.31	3"	5.65	1.75	2.00	1.75	6.25	5.66	1.625	5.26	–	–	5.31	10.62	6.57	–	265
	MM	210	121	83	389	149	200	401	76	498	243	–	89	–	105	140	13	–	31	76	105	279	129	9.525	401	89	57	186	–	144	44	51	44	159	144	41.28	134	–	–	135	270	167	–	120
223	IN	8.50	3.69	4.34	19.13	9.00	8.97	17.94	3.08	23.37	12.38	–	3.75	–	7.25	7.34	.53, SLOT	1/2-13x1.00	.88	5.38	5.38	14.80	6.38	.50	18.49	4.50	2.75	9.38	4"	4.44	2.69	2.69	2.69	6.00	6.00	2.000	7.40	–	–	6.56	13.13	7.84	–	455
	MM	216	94	110	486	229	228	456	78	594	314	–	95	–	184	186	13, SLOT	–	22	137	137	376	162	12.7	470	114	70	2.38	–	113	68	68	68	152	152	50.80	188	–	–	167	334	199	–	206
323	IN	12.00	4.12	4.84	22.38	11.63	–	–	–	30.17	13.88	–	5.25	–	8.00	8.34	.66	1/2-13x1.00	–	5.38	5.38	17.80	6.88	.625	21.92	5.06	4.06	10.38	6" 150# FLANGE	5.37	2.69	2.69	2.69	8.37	8.37	2.375	7.52	–	–	8.00	16.00	7.50	5.75	795
	MM	305	105	123	568	295	–	–	–	766	353	–	133	–	203	212	17	–	–	137	137	452	175	15.875	557	129	103	264	–	136	68	68	68	213	213	60.45	191	–	–	203	406	191	146	361

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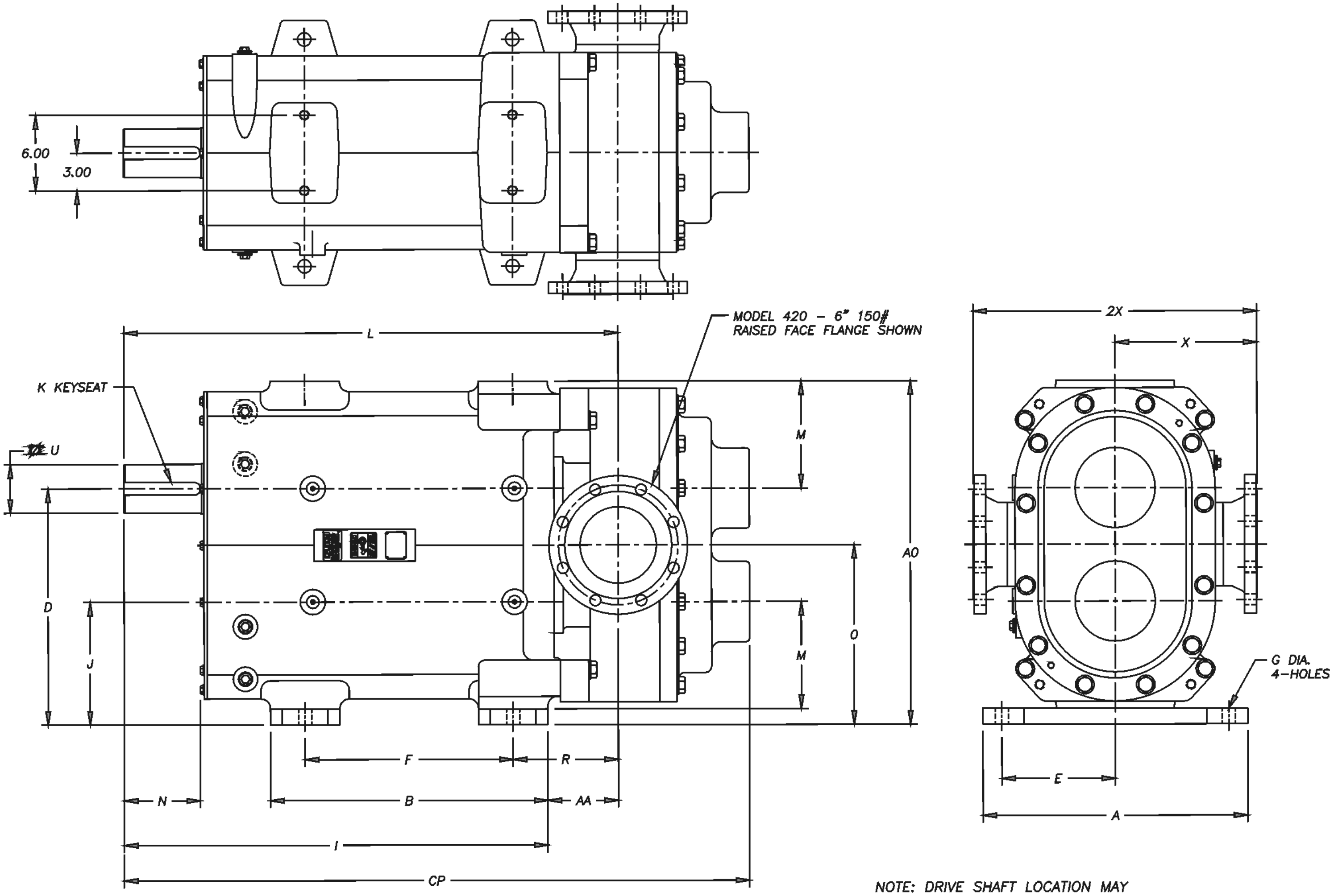
UNIVERSAL UHC PUMP DIMENSIONAL

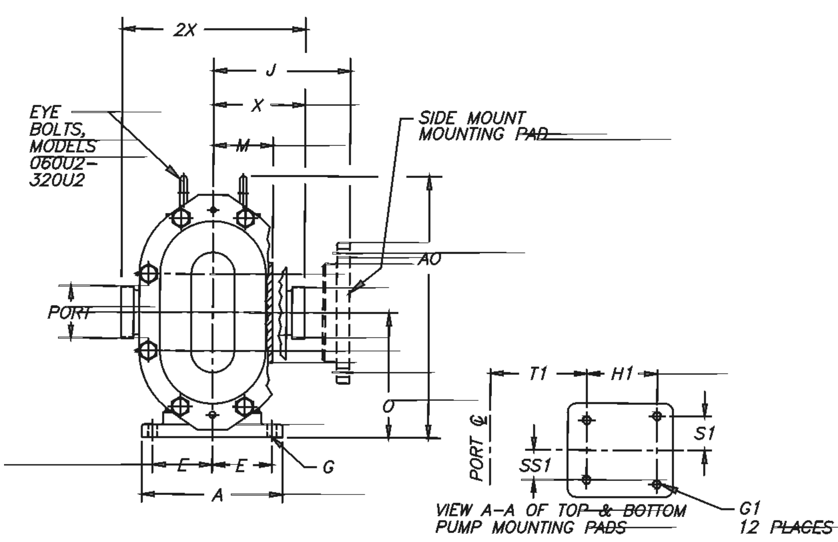
PUMP SHOWN IS A MODEL 420UHC

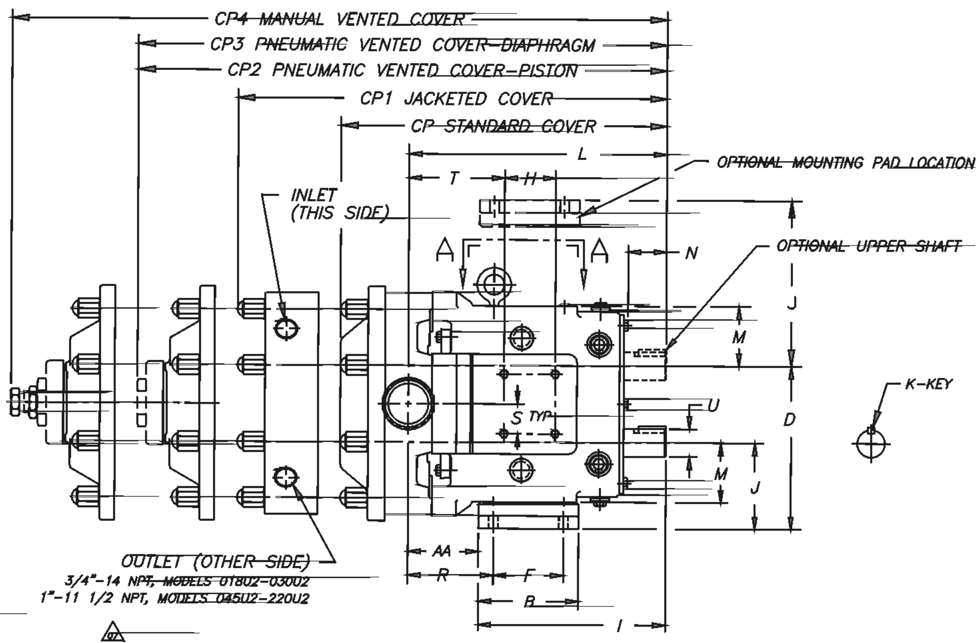


NOTE: DRIVE SHAFT LOCATION MAY BE ON EITHER CENTER LINE

Model	Dim	A	AA	AO	B	CP	D	E	F	G	I	J	K $^{+.002}_{-.000}$	L	M	N	O	R	U $^{+.000}_{-.005}$	X	2X	FLANGE SIZE
420UHC 423UHC	Inch	21.00	5.60	27.25	22.00	49.60	18.75	9.00	16.50	1.06	33.60	9.75	1.00	39.22	8.50	6.04	14.25	8.35	3.875	11.25	22.50	ANSI 6"
	mm	533.4	142.2	692.2	558.8	1259.8	476.2	229	419.1	26.92	853.4	247.6	25.4	995.4	215.9	153.4	362	212.1	98.42	285.7	571.5	
520UHC 523UHC	Inch	21.00	5.95	27.25	22.00	51.47	18.75	9.00	16.50	1.06	33.60	9.75	1.00	39.55	8.50	6.04	14.25	8.70	3.875	11.25	22.50	ANSI 8"
	mm	533.4	151.2	692.2	558.8	1307.3	476.2	229	419.1	26.92	853.4	247.6	25.4	1004.5	215.9	153.4	362	221.0	98.42	285.7	571.5	

WAUKESHA UNIVERSAL 2 PUMP DIMENSIONS

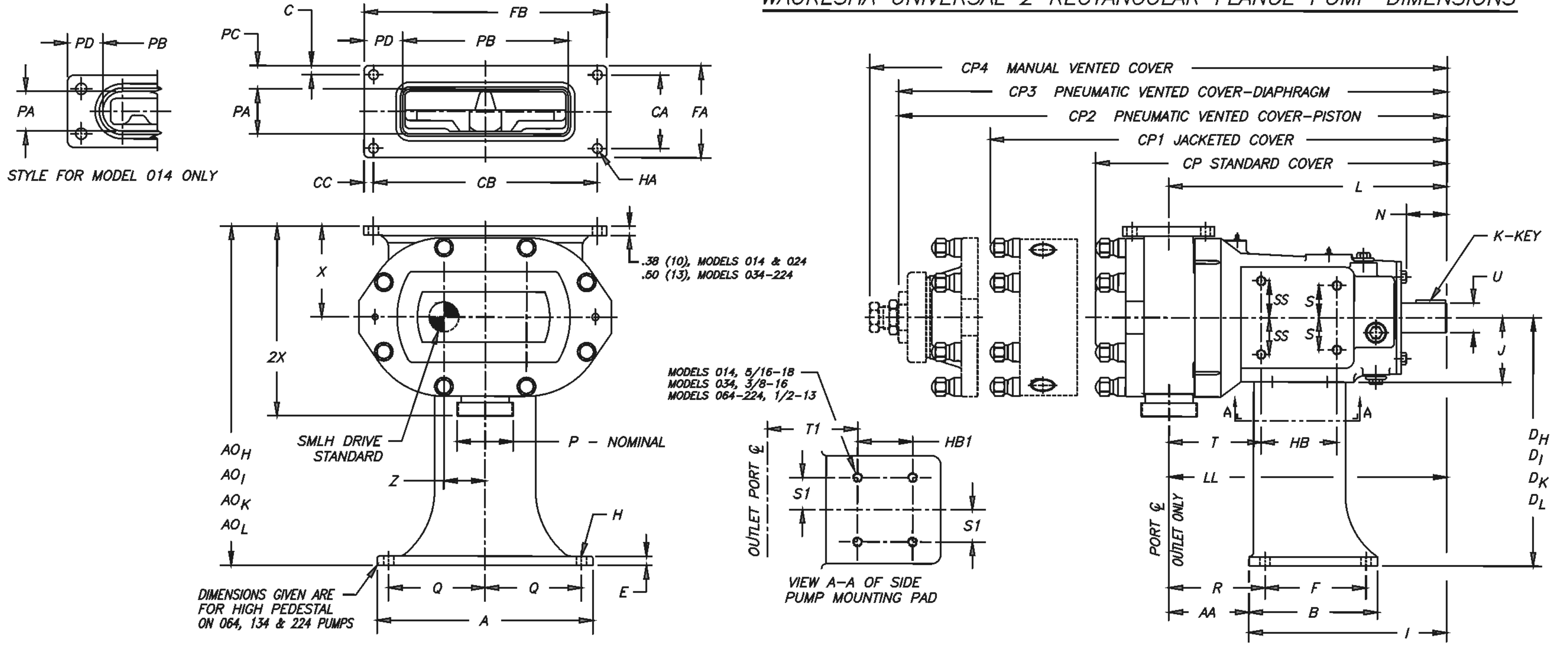




PUMP MODEL		A	AA	AO	B	CP	CP1	CP2	CP3	CP4	D	E	F	G	G1	H	H1	I	J	K +.002 −.000	L	M	N	O	PORT SIZE	R	S	S1	SS1	T	T1	U +.000 −.001	X	2X
006U2	IN	4.75	1.95	8.30	3.75	11.71	13.92	13.20	13.29	14.92	5.50	1.94	2.31	.41, SLOT	5/16–18x.62	2.50	2.50	7.66	2.93	.1875	9.61	2.12	2.00	4.21	1"	2.79	1.00	1.00	1.00	2.51	2.51	.875	3.49	6.97
	MM	121	50	211	95	297	354	335	338	379	140	49	59	10, SLOT	–	64	64	194	74	4.763	244	54	51	107	–	71	25	25	25	64	64	22.23	89	177
015U2	IN	4.75	1.95	8.30	3.75	11.71	13.92	13.20	13.29	14.92	5.50	1.94	2.31	.41, SLOT	5/16–18x.62	2.50	2.50	7.66	2.93	.1875	9.61	2.12	2.00	4.21	1 1/2"	2.79	1.00	1.00	1.00	2.51	2.51	.875	3.49	6.97
	MM	121	50	211	95	297	354	335	338	379	140	49	59	10, SLOT	–	64	64	194	74	4.763	244	54	51	107	–	71	25	25	25	64	64	22.23	89	177
018U2	IN	4.75	2.18	8.30	3.75	12.37	14.59	13.86	13.95	15.58	5.50	1.94	2.31	.41, SLOT	5/16–18x.62	2.50	2.50	7.66	2.93	.1875	10.48	2.12	2.00	4.21	1 1/2"	3.02	1.00	1.00	1.00	2.74	2.51	.875	3.49	6.97
	MM	121	55	211	95	314	371	352	354	396	140	49	59	10, SLOT	–	64	64	194	74	4.763	266	54	51	107	–	77	25	25	25	70	64	22.23	89	177
030U2	IN	6.25	2.78	10.29	4.25	14.49	16.49	15.89	15.98	17.58	6.86	2.31	2.56	.41, SLOT	3/8–16x.62	1.81	2.75	8.83	3.56	.25	11.61	2.62	2.32	5.21	1 1/2"	3.84	1.12	1.12	1.12	4.00	3.59	1.250	4.25	8.50
	MM	159	71	261	108	368	419	404	406	447	174	59	65	10, SLOT	–	46	70	224	90	6.35	295	67	59	132	–	98	28	28	28	102	91	31.75	108	216
045U2	IN	8.25	3.86	15.31	5.87	18.59	20.70	20.68	20.97	22.28	9.56	3.50	4.12	.53	1/2–13x.88	3.00	4.13	10.99	5.06	.375	14.86	3.50	2.25	7.31	2"	4.73	1.75	2.00	1.75	5.34	5.01	1.625	5.37	10.75
	MM	210	98	389	149	472	526	525	533	566	243	89	105	13	–	76	105	279	129	9.525	377	89	57	186	–	120	44	51	44	136	127	41.28	136	273
060U2	IN	8.25	4.14	15.31	5.87	19.14	21.25	21.23	21.52	22.83	9.56	3.50	4.12	.53	1/2–13x.88	3.00	4.13	10.99	5.06	.375	15.14	3.50	2.25	7.31	2 1/2"	5.01	1.75	2.00	1.75	5.62	5.01	1.625	5.37	10.75
	MM	210	105	389	149	486	540	539	547	580	243	89	105	13	–	76	105	279	129	9.525	385	89	57	186	–	127	44	51	44	143	127	41.28	136	273
130U2	IN	8.25	4.78	15.31	5.87	20.15	22.27	22.25	22.53	23.84	9.56	3.50	4.12	.53	1/2–13x.88	3.00	4.13	10.99	5.06	.375	15.77	3.50	2.25	7.31	3"	5.65	1.75	2.00	1.75	6.25	5.66	1.625	5.37	10.75
	MM	210	121	389	149	512	566	565	572	606	243	89	105	13	–	76	105	279	129	9.525	401	89	57	186	–	144	44	51	44	159	144	41.28	136	273
180U2	IN	8.50	3.45	19.13	9.00	23.26	25.32	26.71	N/A	28.51	12.38	3.75	7.25	.53, SLOT	1/2–13x1.00	5.38	5.38	14.80	6.38	.50	18.25	4.50	2.75	9.38	3"	4.20	2.69	2.69	2.69	5.76	6.00	2.000	6.53	13.06
	MM	216	88	486	229	591	643	678	–	724	314	95	184	13, SLOT	–	137	137	376	162	12.7	464	114	70	238	–	107	68	68	68	146	152	50.80	168	332
210U2	IN	12.00	3.45	22.38	11.63	27.08	–	–	–	–	13.88	5.25	8.00	.66	1/2–13x1.00	5.38	5.38	17.80	6.88	.625	21.24	5.06	4.06	10.38	4"	4.70	2.69	2.69	2.69	7.70	7.98	2.375	7.37	14.73
	MM	305	88	568	295	688	–	–	–	–	353	133	203	17	–	137	137	452	175	15.88	539	129	103	264	–	119	68	68	68	196	203	60.45	187	374
213U2	IN	12.00	3.45	22.38	11.63	27.08	–	–	–	–	13.88	5.25	8.00	.66	1/2–13x1.00	5.38	5.38	17.80	6.88	.625	21.24	5.06	4.06	10.38	4" 300# FLANGE	4.70	2.69	2.69	2.69	7.70	7.98	2.375	8.62	17.25
	MM	305	88	568	295	688	–	–	–	–	353	133	203	17	–	137	137	452	175	15.88	539	129	103	264	–	119	68	68	68	196	203	60.45	219	438
220U2	IN	8.50	3.69	19.13	9.00	24.00	26.06	27.45	N/A	29.25	12.38	3.75	7.25	.53, SLOT	1/2–13x1.00	5.38	5.38	14.80	6.38	.50	18.49	4.50	2.75	9.38	4"	4.44	2.69	2.69	2.69	6.00	6.00	2.000	6.63	13.25
	MM	216	94	486	229	610	662	697	–	743	314	95	184	13, SLOT	–	137	137	376	162	12.7	470	114	70	238	–	113	68	68	68	152	152	50.80	168	337
320U2	IN	12.00	3.84	22.38	11.63	27.66	–	–	–	–	13.88	5.25	8.00	.66	1/2–13x1.00	5.38	5.38	17.80	6.88	.625	21.63	5.06	4.06	10.38	6" 150# FLANGE	5.09	2.69	2.69	2.69	8.09	8.37	2.375	8.00	16.00
	MM	305	97	568	295	703	–	–	–	–	353	133	203	17	–	137	137	452	175	15.88	549	129	103	264	–	129	68	68	68	205	213	60.45	203	406

NOTE: DIMENSIONS 'X' AND '2X' APPLY FOR BEVEL SEAT, 'S' CLAMP, 'Q' CLAMP, 15I AND 14I FITTINGS (EXCEPT 213U2 & 320U2).

WAUKESHA UNIVERSAL 2 RECTANGULAR FLANGE PUMP DIMENSIONS



△05

SIZE PUMP		A	AA	AO_H	AO_I	AO_K	AO_L	B	C	CA	CB	CC	CP	CP1	CP2	CP3	CP4	D_H
014U2	IN	6.75	1.95	–	–	–	12.50	4.13	.50	1.62	6.50	.50	11.71	13.92	13.20	13.29	14.92	–
	MM	171	50	–	–	–	318	105	13	41	165	13	297	354	335	338	379	–
034U2	IN	8.00	2.88	14.25	13.75	13.25	12.75	4.25	.62	1.88	10.75	.62	14.49	16.49	15.89	15.98	17.58	10.38
	MM	203	73	362	349	337	324	108	16	48	273	16	368	419	404	406	447	264
064U2	IN	11.75	4.35	19.18	–	–	18.44	7.00	.50	4.00	12.20	.52	19.14	21.26	21.23	21.52	22.83	14.26
	MM	298	110	487	–	–	468	178	13	102	310	13	486	540	539	547	580	362
134U2	IN	11.75	5.00	19.18	–	–	18.44	7.00	.78	3.00	14.00	.63	20.16	22.27	22.26	22.53	23.84	14.26
	MM	298	127	487	–	–	468	178	20	76	356	16	512	566	565	572	606	362
224U2	IN	15.00	4.75	23.75	–	–	19.75	9.50	.63	4.37	16.75	.63	24.00	26.06	27.45	–	29.26	17.50
	MM	381	121	603	–	–	502	241	16	111	425	16	610	662	697	–	743	445

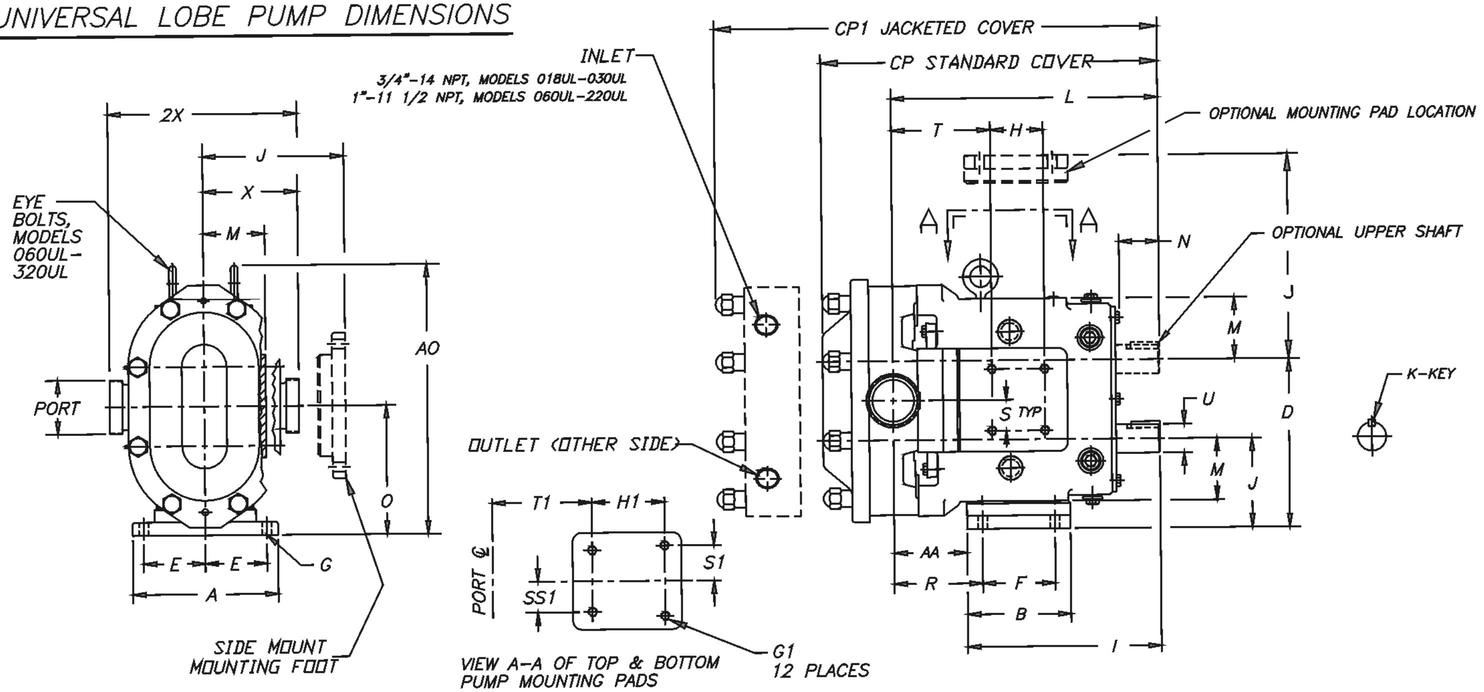
SIZE PUMP		D_I	D_K	D_L	E	F	FA	FB	H	HA	HB	HB1	I	J	K +.002 -.000	L	LL	N	P
014U2	IN	–	–	8.88	.38	2.31	2.63	7.50	.41	.41	2.50	2.50	7.66	2.12	.1875	9.61	9.61	2.00	1.5
	MM	–	–	226	10	59	67	191	10	10	64	64	195	54	4.763	244	244	51	–
034U2	IN	9.88	9.38	8.88	.38	3.00	3.12	12.00	.44	.53	2.75	1.81	8.49	2.62	.25	11.36	11.37	2.32	2.0
	MM	251	238	226	10	76	79	305	11	13	70	46	216	67	6.35	289	289	59	–
064U2	IN	–	–	13.50	.50	5.50	5.00	13.23	.56	.53	4.13	3.00	10.77	3.50	.375	15.16	15.12	2.25	2.5
	MM	–	–	343	13	140	127	336	14	13	105	76	274	89	9.525	385	384	57	–
134U2	IN	–	–	13.50	.50	5.50	4.56	15.26	.56	.53	4.13	3.00	10.77	3.50	.375	15.78	15.76	2.25	3.0
	MM	–	–	343	13	140	116	387	14	13	105	76	274	89	9.525	401	400	57	–
224U2	IN	–	–	13.50	.63	8.25	5.62	18.00	.56	.53	5.38	5.38	13.74	4.50	.50	18.49	18.49	2.75	4.0
	MM	–	–	343	16	210	143	457	14	13	137	137	349	114	12.70	470	470	70	–

SIZE PUMP		PA	PB	PC	PD	Q	R	S	S1	SS	T	T1	U +.000 -.001	X	2X	Z	WT
014U2	IN	1.44	4.94	.59	1.28	2.81	2.79	1.00	1.00	1.00	2.51	2.51	.875	3.63	7.11	1.28	47
	MM	37	125	15	33	71	71	25	25	25	64	64	22.23	92	181	33	21
034U2	IN	1.81	6.84	.66	2.58	3.38	3.51	1.12	1.12	1.12	3.35	3.76	1.250	3.88	8.12	1.65	100
	MM	46	174	17	66	86	89	28	28	28	85	96	31.75	99	206	42	45
064U2	IN	2.44	9.00	1.28	2.11	5.25	5.23	2.00	1.75	1.75	5.01	5.60	1.625	4.94	10.31	2.25	255
	MM	62	229	33	54	133	133	51	44	44	127	142	41.28	125	262	57	116
134U2	IN	3.19	9.38	.68	2.94	5.25	5.87	2.00	1.75	1.75	5.65	6.25	1.625	4.94	10.31	2.25	280
	MM	81	238	17	75	133	149	51	44	44	144	159	41.28	125	262	57	127
224U2	IN	4.06	11.26	.78	3.38	6.88	5.37	2.69	2.69	2.69	6.00	6.00	2.000	6.25	12.87	3.00	505
	MM	103	286	20	86	175	136	68	68	68	152	152	50.80	159	327	76	229

WT: STANDARD COVER W/ STD. UNIVERSAL FOOT
LBS
KG

__NOTE:__ DIMENSION '2X' APPLIES FOR BEVEL SEAT, 'S' CLAMP, 'Q' CLAMP, 15I AND 14I FITTINGS.

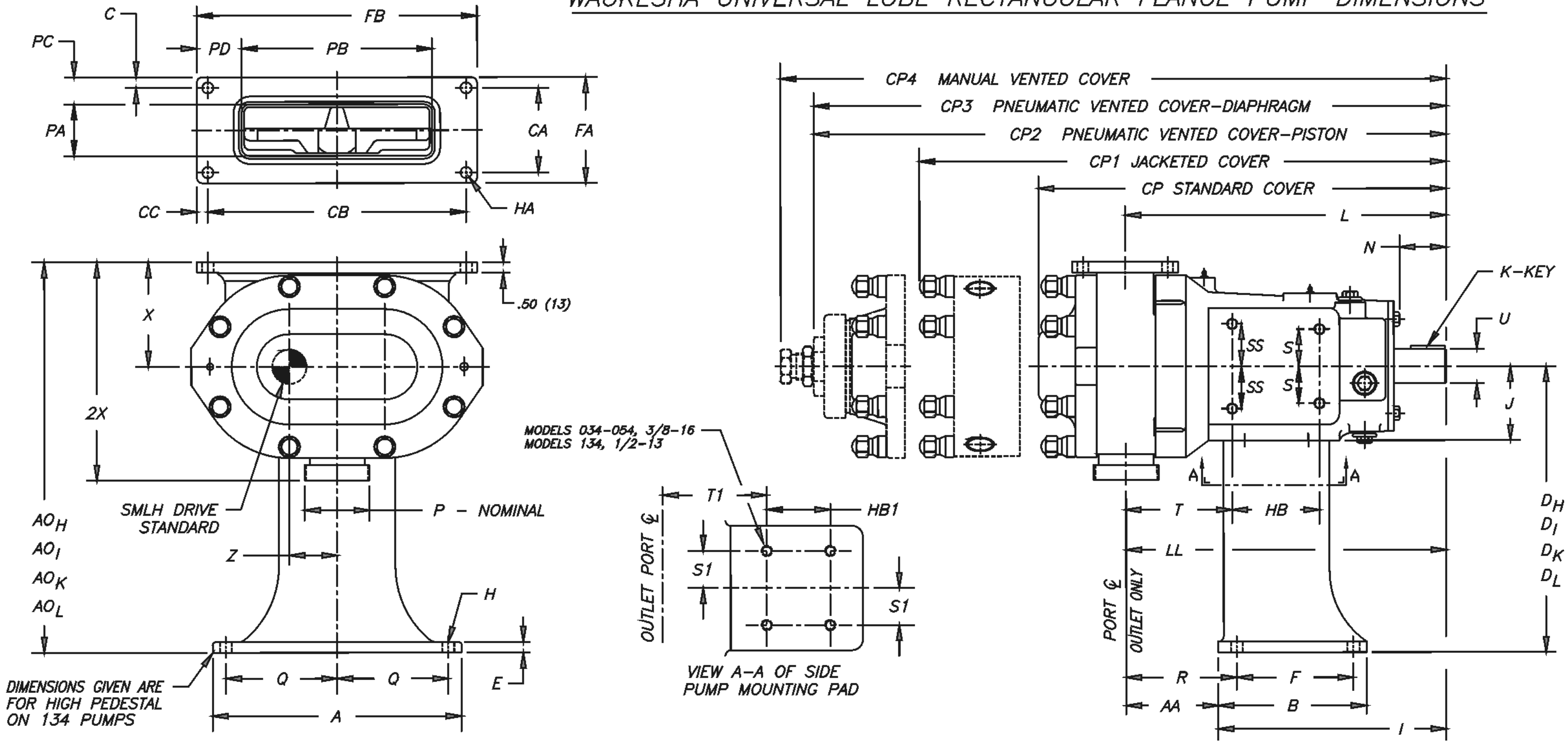
WAUKESHA UNIVERSAL LOBE PUMP DIMENSIONS



PUMP MODEL		A	AA	AO	B	CP	CP1	D	E	F	G	G1	H	H1	I	J	K +.002 -.000	L	M	N	O	PORT SIZE	R	S	S1	SS1	T	T1	U +.000 -.001	X	2X
018UL	IN	4.75	2.82	8.30	3.75	12.37	14.53	5.50	1.94	2.31	.41, SLOT	5/16-18x.62	2.50	2.50	7.66	2.93	.1875	10.48	2.12	2.00	4.21	1 1/2"	3.66	1.00	1.00	1.00	3.38	2.51	.875	3.49	6.97
	MM	121	72	211	95	314	369	140	49	59	10, SLOT	–	64	64	194	74	4.763	266	54	51	107	–	93	25	25	25	86	64	22.23	89	177
030UL	IN	6.25	2.78	10.29	4.25	14.49	16.43	6.86	2.31	2.56	.41, SLOT	3/8-16x.62	1.81	2.75	8.83	3.56	.25	11.61	2.62	2.32	5.21	1 1/2"	3.84	1.12	1.12	1.12	4.00	3.59	1.250	4.25	8.50
	MM	159	71	261	108	368	417	174	59	65	10, SLOT	–	46	70	224	90	6.35	295	67	59	132	–	98	28	28	28	102	91	31.75	108	216
050UL	IN	6.25	3.11	10.29	4.25	15.50	17.44	6.86	2.31	2.56	.41, SLOT	3/8-16x.62	1.81	2.75	8.83	3.56	.25	11.94	2.62	2.32	5.21	2 1/2"	4.17	1.12	1.12	1.12	4.33	3.92	1.250	4.31	8.62
	MM	159	79	261	108	394	443	174	59	65	10, SLOT	–	46	70	224	90	6.35	303	67	59	132	–	106	28	28	28	110	100	31.75	109	219
060UL	IN	8.25	4.14	15.31	5.87	18.26	21.00	9.56	3.50	4.12	.53	1/2-13x.88	3.00	4.13	10.99	5.06	.375	15.14	3.50	2.25	7.31	2 1/2"	5.01	1.75	2.00	1.75	5.62	5.01	1.625	5.37	10.75
	MM	210	105	389	149	464	533	243	89	105	13	–	76	105	279	129	9.525	385	89	57	186	–	127	44	51	44	143	127	41.28	136	273
130UL	IN	8.25	4.78	15.31	5.87	19.28	22.02	9.56	3.50	4.12	.53	1/2-13x.88	3.00	4.13	10.99	5.06	.375	15.77	3.50	2.25	7.31	3"	5.65	1.75	2.00	1.75	6.25	5.66	1.625	5.37	10.75
	MM	210	121	389	149	490	559	243	89	105	13	–	76	105	279	129	9.525	401	89	57	186	–	144	44	51	44	159	144	41.28	136	273
220UL	IN	8.50	3.69	19.13	9.00	23.07	25.81	12.38	3.75	7.25	.53, SLOT	1/2-13x1.00	5.38	5.38	14.80	6.38	.50	18.49	4.50	2.75	9.38	4"	4.44	2.69	2.69	2.69	6.00	6.00	2.000	6.63	13.25
	MM	216	94	486	229	586	655	314	95	184	13, SLOT	–	137	137	376	162	12.7	470	114	70	2.38	–	113	68	68	68	152	152	50.80	168	337
320UL	IN	12.00	3.84	22.38	11.63	26.66	—	13.88	5.25	8.00	.66	1/2-13x1.00	5.38	5.38	17.80	6.88	.625	21.63	5.06	4.06	10.38	6" 150# FLANGE	5.09	2.69	2.69	2.69	8.09	8.37	2.375	8.00	16.00
	MM	305	97	568	295	677	—	353	133	203	17	–	137	137	452	175	15.88	549	129	103	2.64	–	129	68	68	68	205	213	60.45	203	406

NOTE: DIMENSIONS 'X' AND '2X' APPLY FOR BEVEL SEAT, 'S' CLAMP, 'Q' CLAMP, 15I AND 14I FITTINGS (EXCEPT 320UL).

WAUKESHA UNIVERSAL LOBE RECTANGULAR FLANGE PUMP DIMENSIONS



SIZE PUMP		A	AA	AO_H	AO_I	AO_K	AO_L	B	C	CA	CB	CC	CP	CP1	CP2	CP3	CP4
034UL	IN	8.00	2.88	14.25	13.75	13.25	12.75	4.25	.62	1.88	10.75	.62	14.49	16.49	15.89	15.98	17.58
	MM	203	73	362	349	337	324	108	16	48	273	16	368	419	404	406	447
054UL	IN	8.00	3.35	14.25	13.75	13.25	12.75	4.25	.62	2.88	10.50	.62	15.50	17.50	16.90	16.99	18.59
	MM	203	85	362	349	337	324	108	16	73	267	16	394	445	429	432	472
134UL	IN	11.75	5.00	19.18	–	–	18.44	7.00	.78	3.00	14.00	.63	20.15	22.27	22.25	22.53	23.84
	MM	298	127	487	–	–	468	178	20	76	356	16	512	566	565	572	606

SIZE PUMP		D_H	D_I	D_K	D_L	E	F	FA	FB	H	HA	HB	HB1	I	J	K +.002 -.000	L	LL	N
034UL	IN	10.38	9.88	9.38	8.88	.38	3.00	3.12	12.00	.44	.53	2.75	1.81	8.49	2.62	.25	11.36	11.37	2.32
	MM	264	251	238	226	10	76	79	305	11	13	70	46	216	67	6.35	289	289	59
054UL	IN	10.38	9.88	9.38	8.88	.38	3.00	4.12	11.75	.44	.53	2.75	1.81	8.49	2.62	.25	11.86	11.84	2.32
	MM	264	251	238	226	10	76	105	298	11	13	70	46	216	67	6.35	301	301	59
134UL	IN	14.25	–	–	13.50	.50	5.50	4.55	15.25	.56	.53	4.13	3.00	10.77	3.50	.375	15.78	15.76	2.25
	MM	362	–	–	343	13	140	116	387	14	13	105	76	274	89	9.525	401	400	57

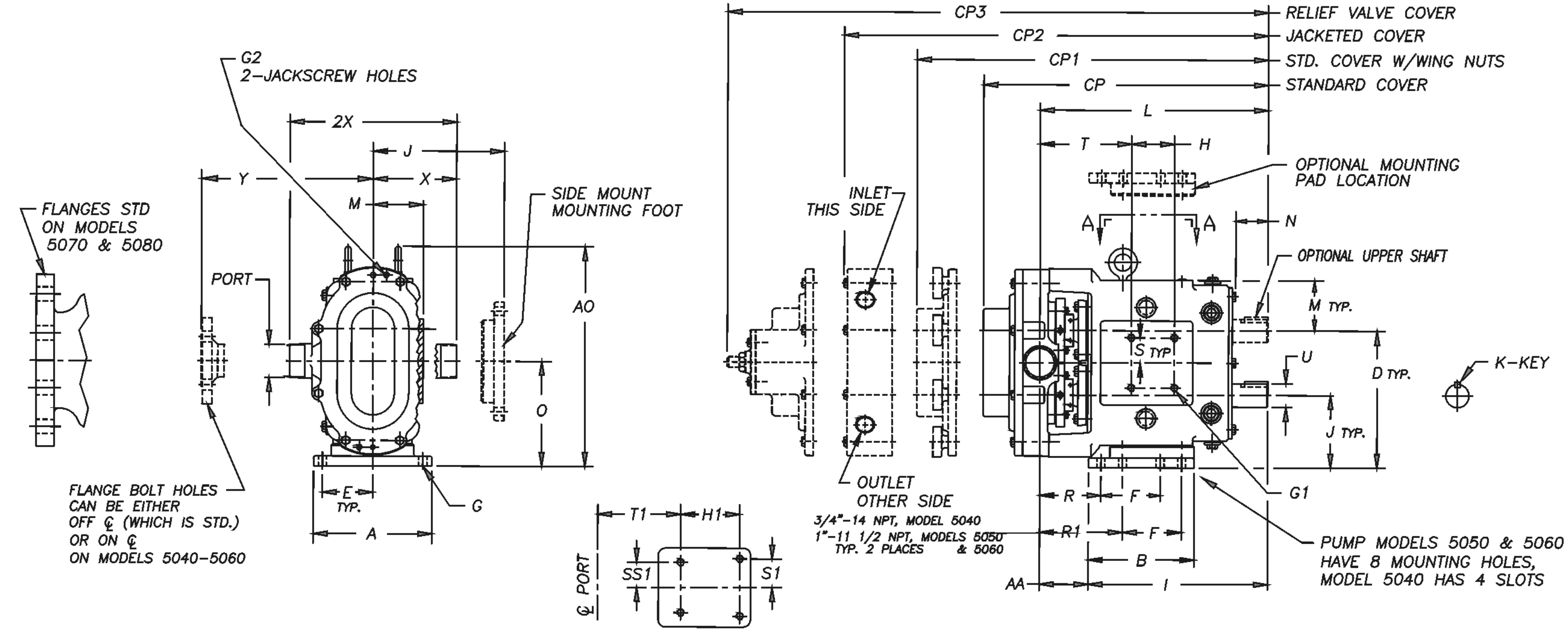
SIZE PUMP		P	PA	PB	PC	PD	Q	R	S	S1	SS	T	T1	U +.000 -.001	X	2X	Z
034UL	IN	2.0	1.81	6.84	.66	2.58	3.38	3.51	1.12	1.12	1.12	3.35	3.76	1.250	3.88	8.12	1.65
	MM	–	46	174	17	66	86	89	28	28	28	85	96	31.75	99	206	42
054UL	IN	2.5	2.37	6.87	.88	2.44	3.38	3.98	1.12	1.12	1.12	3.82	4.23	1.250	3.88	8.18	1.65
	MM	–	60	175	22	62	86	101	28	28	28	97	107	31.75	99	208	42
134UL	IN	3.0	3.19	9.38	.68	2.94	5.25	5.87	2.00	1.75	1.75	5.65	6.25	1.625	4.94	10.31	2.25
	MM	–	81	238	17	75	133	149	51	44	44	144	159	41.28	125	262	57

NOTE: DIMENSION '2X' APPLIES FOR BEVEL SEAT, 'S' CLAMP, 'Q' CLAMP, 15I AND 14I FITTINGS.

UNIVERSAL-INDUSTRIAL 5000 SERIES PUMP DIMENSIONAL

STAINLESS STEEL BODIES

PUMP SHOWN IS A MODEL 5050UI



VIEW A-A OF TOP & BOTTOM
PUMP MOUNTING PADS

NOTES: 1) TO HOLD PORT TO MOUNTING THE SAME AS OLD "I" PUMPS, USE HOLES DIMENSIONED FROM PORT BY "R"

2) TO HOLD SHAFT TO MOUNTING THE SAME AS OLD "I" PUMPS, USE HOLES DIMENSIONED FROM PORT BY "R1"

03

FOR MODELS 5040,5050 & 5060 FLANGE OPTIONS ARE THE SAME SIZE, 150# FLANGES.

150# FLANGE LASER 5040-5060

NPT

STD COVER

SIZE PUMP		A	AA	AO	B	CP	CP1	CP2	CP3	D	E	F	G	G1	G2	H	H1	I	J	K +.002 -.000	L	M	N	O	PORT	R	R1	S	S1	SS1	T	T1	U +.000 -.001	X	2X	Y	2Y	WT.
5040	IN	6.25	4.06	10.04	4.25	16.52	16.52	16.91	18.64	6.86	2.31	2.56	.41 WIDE SLOT	3/8-16 x 5/8	5/16-18	1.81	2.75	8.83	3.56	.25	12.89	2.62	2.32	5.21	1 1/2"-11 1/2 NPT	4.87	–	1.12	1.12	1.12	5.28	4.87	1.250	4.69	9.37	5.96	11.91	100
	MM	159	103	255	108	419	419	430	473	174	59	65	10 WIDE SLOT	–	–	46	70	224	90	6.35	327	67	59	132	–	124	–	28	28	28	134	124	31.75	119	238	151	303	45
5050	IN	8.25	3.40	15.31	7.38	19.83	19.83	20.44	23.08	9.56	3.50	4.13	.56	1/2-13 x 7/8	3/8-16	3.00	4.13	12.49	5.06	.375	15.89	3.50	2.25	7.31	2"-11 1/2 NPT	4.28	5.78	1.75	2.00	1.75	6.37	5.78	1.625	5.81	11.62	6.63	13.25	240
	MM	210	86	389	187	504	504	519	586	243	89	105	14	–	–	76	105	317	129	9.525	404	89	57	186	–	109	147	44	51	44	162	147	41.28	148	295	168	337	109
5060	IN	8.25	4.10	15.31	7.38	20.78	20.78	21.39	24.03	9.56	3.50	4.13	.56	1/2-13 x 7/8	3/8-16	3.00	4.13	12.49	5.06	.375	16.59	3.50	2.25	7.31	2 1/2"-8 NPT	4.97	6.47	1.75	2.00	1.75	7.07	6.47	1.625	5.81	11.63	6.75	13.50	245
	MM	210	104	389	187	528	528	543	610	243	89	105	14	–	–	76	105	317	129	9.525	421	89	57	186	–	126	164	44	51	44	180	164	41.28	148	295	171	343	111
5070	IN	11.00	4.27	19.13	9.50	26.31	26.31	–	28.50	12.38	4.75	7.50	.66	1/2-13 x 1.00	1/2-13	5.38	5.38	15.29	6.38	.50	19.56	4.50	2.75	9.38	4"-150# FLANGE	5.27	–	2.69	2.69	2.69	7.07	7.07	2.000	–	–	7.37	14.75	475
	MM	279	108	486	241	668	668	–	724	314	121	191	17	–	–	137	137	388	162	12.7	497	114	70	238	–	134	–	68	68	68	180	180	50.80	–	–	187	375	215
5080	IN	12.00	4.12	22.38	11.63	30.17	30.17	–	34.05	13.88	5.25	8.00	.66	1/2-13 x 1.00	5/8-11	5.38	5.38	17.80	6.88	.625	21.92	5.06	4.06	10.38	6"-150# FLANGE	5.37	–	2.69	2.69	2.69	8.37	8.37	2.375	–	–	8.00	16.00	810
	MM	305	105	568	295	766	766	–	865	353	133	203	17	–	–	137	137	452	175	15.875	557	129	103	264	–	136	–	68	68	68	213	213	60.33	–	–	203	406	367

FLUID—NAME OR TYPE

SIMILAR TO:

PUMPING TEMPERATURE

___________°F NORMAL _________°F MAX ___________°F MIN

VISCOSITY: __________ SSU ________ CPS AT __________°F

☐ NEWTONIAN ☐ THIXOTROPIC ☐ DILATENT

SPECIFIC GRAVITY

VAPOR PRESSURE AT P.T. PSIA

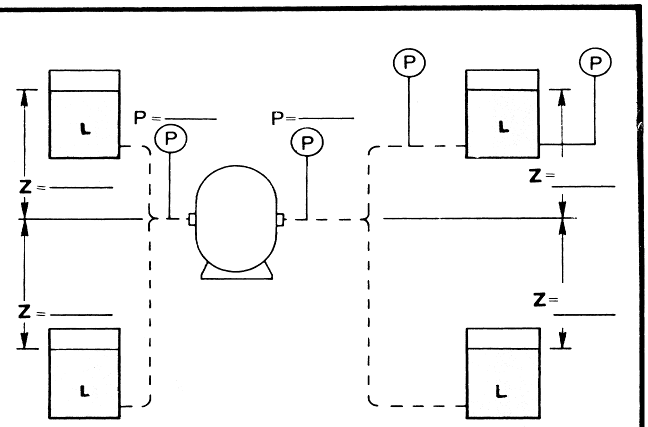
☐ INFLAMM. OR HAZARDOUS ☐ TOXIC

SOLIDS % MAX PARTICLE SIZE

☐ ABRASIVE ☐ NON ABRASIVE

CORROSION REQMT. PH

OTHER FLUID CHARACTERISTICS



OPERATING CONDITIONS

CAPACITY REQD

______ GPM ______ GPM MAX _______ GPM MIN

INLET CONDITION

________________ PSIA

DISCHARGE PRESSURE

_____________ PSIG MIN _________ PSIG MAX

EFFECTIVE VISCOSITY
REF: PGS 5, 131, 132

REQD
GPM

PRELIMINARY PUMP
SELECTION PG 47

DISCHARGE

PIPE SIZE _____ EQUIV. LENGTH

LINEAR LENGTH IN FEET

	QUANTITY		EQUIV. LENGTH	
ELBOW		X		
VALVE		X		
FITTINGS		X		

TOTAL EQUIVALENT LENGTH FT FT

INLET

PIPE SIZE _____ EQUIV. LENGTH

LINEAR LENGTH IN FEET

	QUANTITY		EQUIV. LENGTH	
ELBOW		X		
VALVE		X		
FITTINGS		X		

TOTAL EQUIVALENT LENGTH FT FT

FRICTION LOSSES
PG 51 PSI + PSI = PSI

STATIC PRESSURE REQMT.
PG 13, 14, 51 (Z x 0.433 x S.G.) PSI

EQUIPMENT PRESSURE DROP + PSI

TOTAL DISCHARGE PRESSURE PSI

FRICTION LOSSES
PG 57 PSI + PSI = PSI

EQUIPMENT PRESSURE DROP + PSI = PSI

STATIC PRESSURE REQMT.
PG 13, 14, 57 (Z x .433 x S.G.) + PSI

TOTAL INLET PRESS. DROP PSI

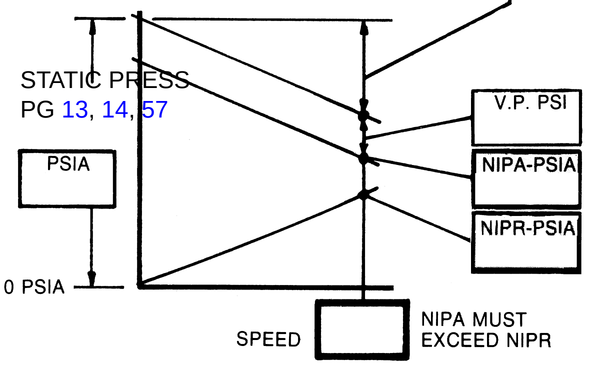
PUMP SPEED

DIFFERENTIAL PRESS
PG 13, 60 DISCH PSI + INLET PSI = D.P.

HORSEPOWER WHP + VHP = H.P.

TORQUE

DRIVE SELECTION
PG 64



For assistance from Waukesha Cherry-Burrell's Application Engineering Department in selecting a drive, please send us your requirements on application data sheet.

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MM 604 Effective Date 11/02