Fristam PUMPS®

Engineered For Lasting Performance™

Positive Displacement Pump Technical Manual

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3-A®

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ANAB ACCREDITED

Fristam PUMPS®

Engineered For Lasting Performance™

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FKL Series Specifications

Temperature Differential:
Δ140°F (standard rotor), Δ210°F (high temp. rotor)
Pump Housing Material:
316L stainless steel
Rotor Material:
808 non-galling stainless steel
optional: 316L stainless steel
Rotor Cap and Bolt Material:
316L stainless steel
Pump Cover Material:
316L stainless steel
Pump Shaft Material:
316L stainless steel
Product Contact Surface Finish:
32 Ra
optional: 25 Ra, 20 Ra, 15 Ra & electropolish (except 808 alloy rotors)
Fittings (Suction/Discharge):
1.5”–6”
optional: rectangular inlet available on FKL 50 - FKL 400
Fitting Style:
Sanitary clamp (FKL 15 – FKL 250)
300# flange (FKL 400 – FKL 600)
optional: many others available
Seal Type:
Single mechanical, double mechanical, aseptic double mechanical
Single O-ring and double O-ring (available on FKL 15–FKL 250 only)
Seal Flush Requirements:
Double seals only, 3–12 gallons per hour at 1–2 psi (60 psi maximum)
Mechanical Seal Face Materials (Stationary/Rotating):
Carbon / Chrome oxide coated stainless steel
optional: Silicon carbide / Silicon carbide
optional: Chrome Oxide / Silicon carbide
Elastomer Materials:
Cover Gasket–Buna; Seal O-rings–Viton
optional: many others available
Gearbox Material:
Cast iron / zinc plated / painted (Epoxy)
Gearbox Lubrication:
SAE 15W40 oil
Base Plate:
304 Stainless Steel with adjustable legs

FKL Model Specifications

Model		15	20	25	50	75
Displacement	gal/rev	0.0155	0.032	0.056	0.096	0.156
(at max rpm)	gpm	15.5	25.6	33.6	57.6	93.6
	l/m	58.7	96.9	127.2	218	354
	m^3/hr	3.5	5.8	7.6	13.1	21.3
Speed (max)	rpm	1000	800	600	600	600
Pressure (max)	psi	200	200	300	500	500
	bar	14	14	21	35	35
Fittings						
Housing		1.5" clamp	1.5" clamp	1.5" clamp	2.5" clamp	2.5" clamp
Seal Flush Thread		1/16" NPT	1/16" NPT	1/16" NPT	1/16" NPT	1/16" NPT
Weight	lbs	75	75	104	135	360
(complete pump)	kg	34	34	47	61	163
Special Options						
Rectangular Inlet		N/A	N/A	N/A	Yes	Yes
O-Ring Seal		Yes	Yes	Yes	Yes	Yes

Model		150	205	250	400	580	600
Displacement	gal/rev	0.259	0.45	0.54	0.74	1.82	2.24
(at max rpm)	gpm	155	270	324	444	728	896
	l/m	588	1022	1226	1681	2756	3392
	m^3/hr	35.3	61.3	73	100	165	203
Speed (max)	rpm	600	600	600	600	400	400
Pressure (max)	psi	500	500	500	500	300	300
	bar	35	35	35	35	21	21
Fittings							
Housing		3" clamp	4" clamp	4" clamp	6" flange	6" flange	6" flange
Seal Flush Thread		1/16" NPT	1/16" NPT	1/16" NPT	1/16" NPT	1/8" NPT	M10 x 1.5
Weight	lbs	451	680	744	950	1580	1680
(complete pump)	kg	205	308	338	431	717	762
Special Options							
Rectangular Inlet		Yes	Yes	Yes	Yes	N/A	N/A
O-Ring Seal		Yes	Yes	Yes	N/A	N/A	N/A

FL II Series Specifications

Temperature Differential:
Δ240°F (standard rotor), Δ390°F (high temp. rotor)
Pump Housing Material:
316L stainless steel
Rotor Material:
316L stainless steel
Rotor Cap and Bolt Material:
316L stainless steel
Pump Cover Material:
316L stainless steel
Pump Shaft Material:
316L stainless steel
Product Contact Surface Finish:
32 Ra
optional: 25 Ra, 20 Ra, 15 Ra & electropolish
Fittings (Suction/Discharge):
3/4"–4"
optional: rectangular inlet available on FL II 75, 100, 130 models
Fitting Style:
Sanitary clamp
optional: many others available
Seal Type:
Single mechanical, double mechanical, aseptic double mechanical
Seal Flush Requirements:
Double seals only, 3–12 gallons per hour at 1–2 psi (60 psi maximum)
Mechanical Seal Face Materials (Stationary/Rotating):
Carbon / Chrome oxide coated stainless steel
optional: Silicon carbide / Chrome oxide
optional: Silicon carbide / Silicon carbide
optional: Chrome Oxide / Silicon carbide
Elastomer Materials:
Viton
optional: many others available
Gearbox Material:
Cast iron / painted (Epoxy)
Gearbox Lubrication:
Bearings–permanently greased
Timing Gears–EP 220 Compound (oil)
Base Plate:
304 Stainless Steel with adjustable legs

FL II Model Specifications

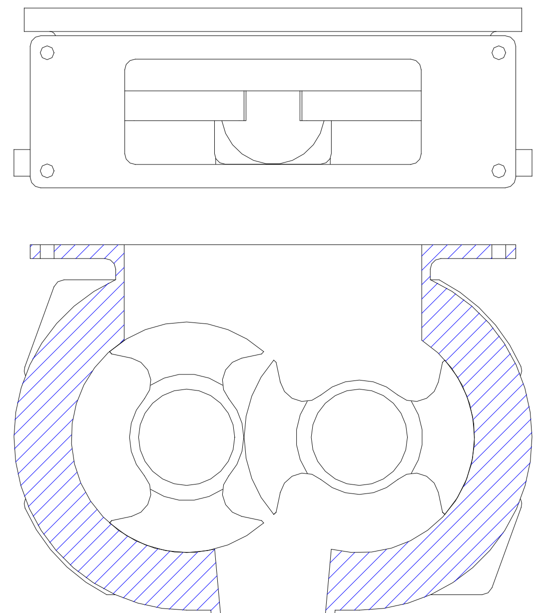
Model		15	58S	58L	75S	75L
Displacement	gal/rev	0.0056	0.0267	0.039	0.072	0.098
(at max rpm)	gpm	10.1	26.7	39	57	78
	l/m	38	101	147	218	297
	m^3/hr	2.3	6.1	8.9	13.1	17.8
Speed (max)	rpm	1800	1000	1000	800	800
Pressure (max)	psi	130	120	100	170	120
	bar	9	8	7	12	8
Fittings						
Housing		.75" clamp	1" clamp	1.5" clamp	1.5" clamp	2" clamp
Seal Flush Thread		M8	M8	M8	M8	M8
Weight	lbs	30	35	40	55	65
(complete pump)	kg	14	16	18	25	30
Special Options						
Rectangular Inlet		N/A	N/A	N/A	Yes	Yes

Model		100S	100L	130S	130L
Displacement	gal/rev	0.176	0.274	0.465	0.645
(at max rpm)	gpm	105	164	279	387
	l/m	400	622	1056	1465
	m^3/hr	24	37.3	63.4	87.9
Speed (max)	rpm	600	600	600	600
Pressure (max)	psi	170	120	170	120
	bar	12	8	12	8
Fittings					
Housing		2.5" clamp	3" clamp	3" clamp	4" clamp
Seal Flush Thread		M8	M8	M8	M8
Weight	lbs	125	145	265	300
(complete pump)	kg	61	66	120	136
Special Options					
Rectangular Inlet		Yes	Yes	Yes	Yes

FKL/FL II Special Pump Options

Rectangular Inlet

On many models (FKL 50–400, FL II 75–100), a rectangular inlet is offered to enhance the pump's ability to handle very viscous products. The large dimensional opening minimizes buildup of product at the inlet which promotes flow into the pump. Performance is maintained even when pumping very viscous materials because inlet restrictions are greatly reduced, thereby maintaining high volumetric efficiencies. Rectangular inlets match industry standards.



Rectangular Inlet Design

High Temperature Rotors

Positive pump efficiency depends upon maintaining close internal clearances between the rotors and the pump housing. These clearances are not a problem until higher temperatures cause the shaft and rotors to expand inside the pump housing. If the proper measures are not taken, this expansion can result in rotor to cover or even rotor to housing damage.

To counteract this effect, Fristam Pumps offers a high temperature rotor. This rotor leaves greater clearances throughout the pumping cavity.

High temperature rotors are specified for pumps that are cleaned or steamed at elevated temperatures, although process conditions may be cooler.

"Chocolate" Rotors

Specially machined rotors are available to produce the larger gaps required to pump chocolate and certain other viscous and abrasive products. Usage of these rotors should be discussed with the Fristam factory, in order to assure their proper application.

Clip Tip Rotors

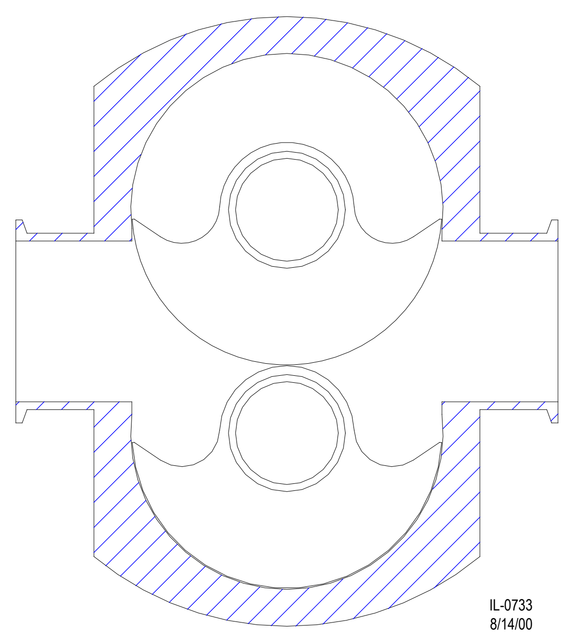
Specially designed rotor which allows larger hard particulates to be pumped without damaging the rotor.

Single Lobe Rotors

The single lobe option is offered for products containing large solids. At low speeds, a single lobe rotor can handle the large particles more gently.

Thermal Siphon

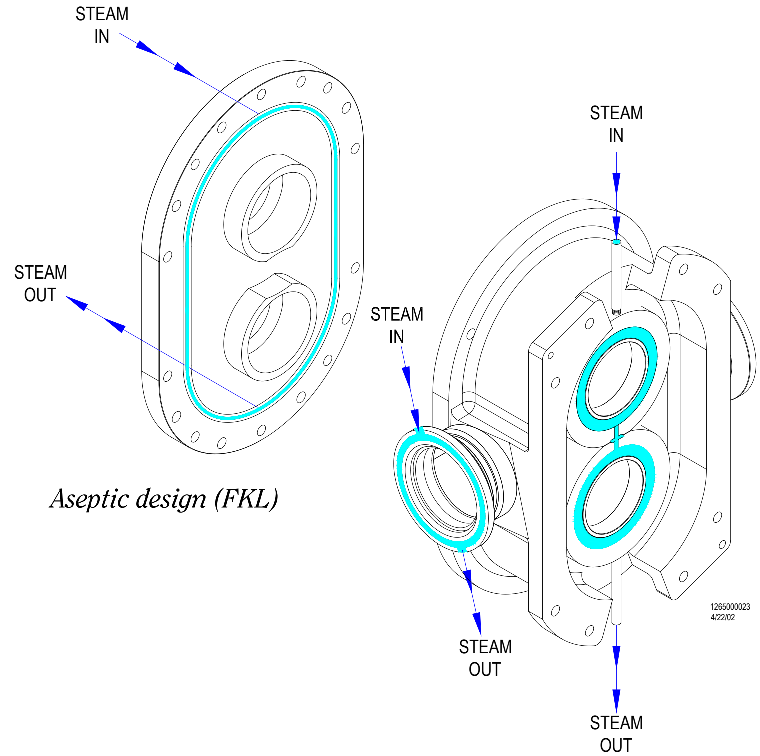
Self contained seal flushing system for applications where water can not be used as a flushing liquid.



Single Lobe Rotor Design (FL II)

Aseptic Design (FKL only)

Aseptic designs are available for most of the FKL models. All of the dynamic and static sealing surfaces are steam traced to ensure product sterility.



Aseptic design (FKL)

Electropolish

Electropolish, an electrochemical process, provides additional smoothing, cleaning and passivation of pump surfaces. It is generally used in conjunction with high polish to produce extremely smooth product surfaces. Like high polish, the electropolish process removes some material and can produce a slight reduction in pump performance when pumping low viscous products.

Note: FKL 808 (standard) rotors cannot be electropolished. The chemical process adversely affects the non-galling alloy of which they are constructed.

High Grit Polish

25 Ra (180 grit), 20 Ra (240 grit), and 15Ra (320 grit) internal surface finishes are options offered for those applications requiring extremely smooth product surfaces. To accomplish this, additional material is removed from standard internal surfaces using finer grit abrasives. The removal of material will open the gaps between components slightly and increase slip. Some reduction of performance will result when pumping low viscosity fluids.

Tungsten Carbide Coating

Coating sprayed on to pump interior which will allow the pump to have a greater life when pumping abrasive products.

Kolsterizing

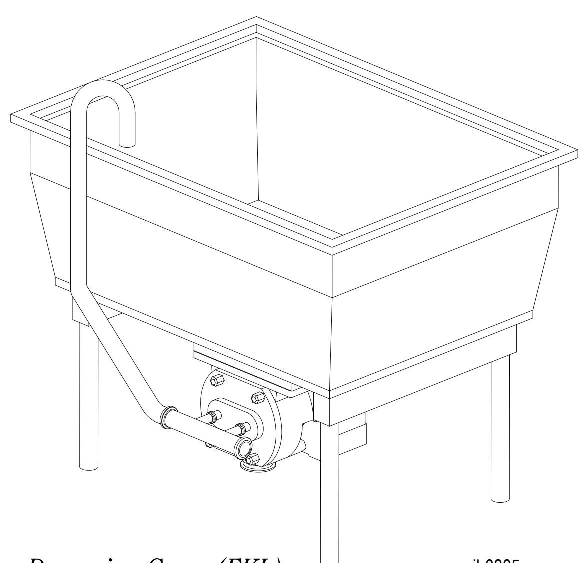
A hardening process for SS components which greatly increases the metal's resistance to wear from abrasive products.

Pressure Relief Cover

Fristam offers a spring loaded Teflon diaphragm pressure relief cover for customers that require a safety valve.

Degassing Cover (FKL only)

Exclusively for the baking industry, Fristam offers an optional degassing cover to vent the natural gases that are produced in dough. When used with Fristam's heavy-duty FKL Series positive displacement pump this feature gives the dough a finer texture and greater uniformity. Applications include transferring from a dough trough to a bun or bread divider or continuous conveyor belt.



Degassing Cover (FKL)

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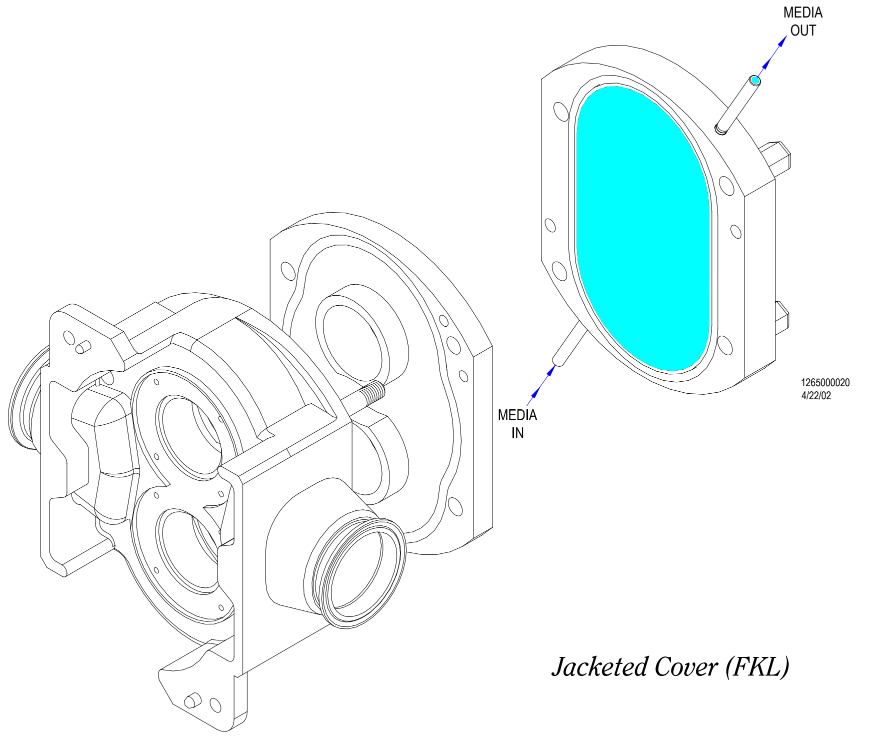
Jacketed Cover (FKL)

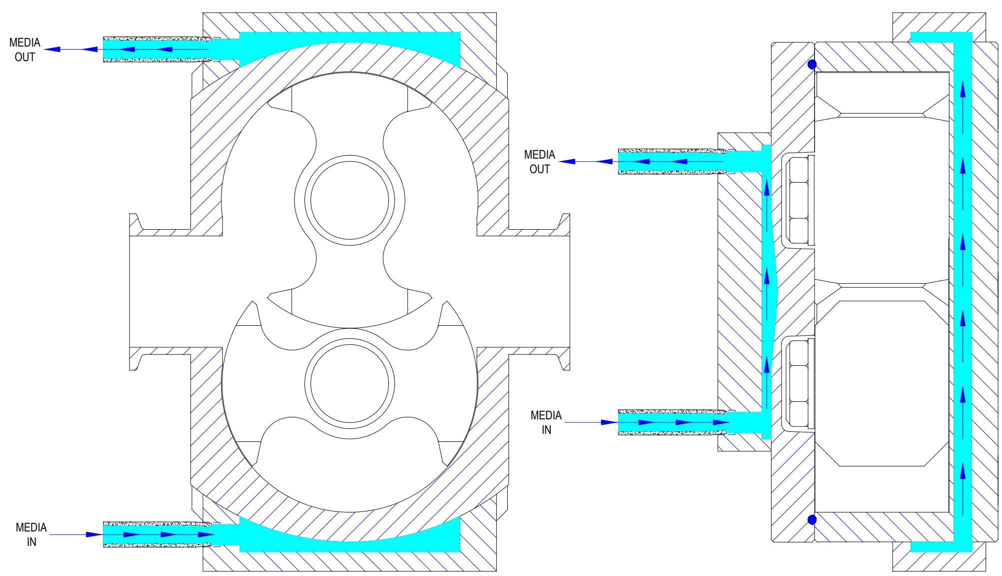
For applications that require either a heating or cooling jacket to maintain the products state, Fristam Pumps can provide a jacketed cover. This jacketed cover is applied directly over the existing cover simply by using longer housing studs. The jacketed cover is constructed of 304 Stainless Steel.

Jacketed Housing and Cover

For applications that require either a heating or cooling jacket to maintain the products state, Fristam Pumps can provide a jacketed housing and/or cover. On the FL II pumps, the jacket is integral to the housing and/or cover. The jacketed cover is constructed of 304 Stainless Steel.



Jacketed Cover (FKL)



Jacketed Housing and Cover (FL II)

PD Pump Seal Option Guide

Mechanical Seal or O-ring Seal?

O-ring seals are recommended for applications where the pump will be regularly disassembled for cleaning.

Single or Double Seal?

Double seals are recommended for applications involving abrasive and/or sticky products and/or vacuum conditions of more than 12” Hg.

Material Options

Carbon vs. Chrome oxide-coated 316L SS: recommended for simple transfer applications

Chrome oxide-coated 316L SS vs. Silicon carbide: recommended for more difficult applications with pressure spikes, high viscosity (over 1,000 cps), or sticky (sugar-based) products

Silicon Carbide vs. Silicon carbide: recommended for the pharmaceutical industry and applications with high sodium concentrations

Positive Displacement Pump Basics

A. Definitions and Terms

Density

Density is the mass of a substance per unit volume. Generally, we express density in units of pounds per cubic inch.

Specific Gravity

Specific gravity is used to compare the density of a product to the density of water. The specific gravity of a product is expressed as its density divided by the density of water. This number will have no units, because it is simply a ratio.

Brix

Also called degrees Brix (°Brix), it is a hydrometer scale for sugar solutions. It is expressed as grams of soluble solids per 100g of liquid and is temperature corrected. Sugar content is approximately proportional to the °Brix value, with sugars contributing 55 to 75% of the °Brix.

Viscosity

Viscosity is a measurement of a product's resistance to flow. Low viscosity products (e.g. water) have little resistance to flow, while higher viscosity products have a greater resistance to flow. It is key to positive pump sizing and operation because it affects slip within the pump as well as the pressure required to overcome frictional loss in the lines. The product's resistance to flow produces system backpressure and heat. It will be explained later that the increased resistance to flow can be seen in the relationship between the frictional pressure loss (psi / foot tubing), flow rate (gpm), and product viscosity (cps) in the Friction Loss curves. It will also be explained that this same resistance to flow, by higher viscosity products, can be seen in reduced product slip inside the pump.

Newtonian vs. Non-Newtonian Fluids

A Newtonian fluid will have the same viscosity whether or not it is in motion. Examples of this type of fluid would be water and high fructose corn syrup (HFCS). A non-Newtonian fluid will have a different viscosity depending on the velocity of its flow. The majority of fluids are of this type, some examples would be ketchup, orange juice concentrate and shampoo.

Thixotropic Fluids

A thixotropic fluid is a type of non-Newtonian fluid that will become less viscous as the shear rate increases. This is also known as shear thinning, ketchup is a good example of this type of fluid. While the product is static, or standing still, the viscosity can be very high. As the fluid begins to flow it becomes less viscous and starts to run like water. After it sits again, it becomes very viscous. This thinning is due to shear in the fluid. As the fluid begins to move, the molecules will slide over each other and require less force to stay in motion. This force causes a shear stress in the fluid.

Apparent Viscosity

As previously explained, non-Newtonian fluids have less viscosity in motion, than at rest. The viscosity of a product in motion is known as its apparent viscosity. When a non-Newtonian fluid is in motion the apparent viscosity should be used for calculating the pressure drop. The apparent viscosity can be measured using a viscometer and plotting the results as a "Viscosity vs. Shear Rate" curve. This curve can be used with a shear rate curve for the tubing that is used in the system, to determine the apparent viscosity.

1. Find the product's flow rate (75 gpm) on the "Flow Rate vs. Shear Rate" curve for tubing.

2. Draw a line to the right until it intersects the 3" tubing diameter.

3. Follow the line down to find the shear rate. Shear rate=125

4. Find the shear rate on the "Viscosity vs. Shear Rate" curve for the product.

5. Move up until you intersect the line.

6. Move left to find the apparent viscosity. Apparent viscosity = 1500 cps.

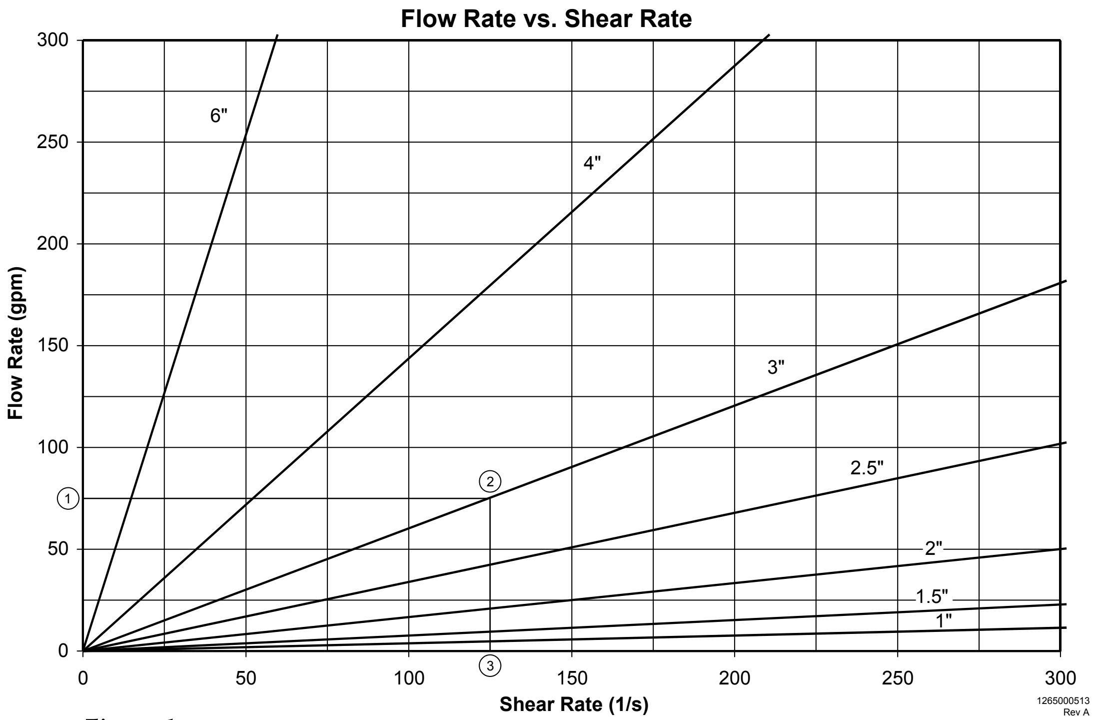


Figure 1

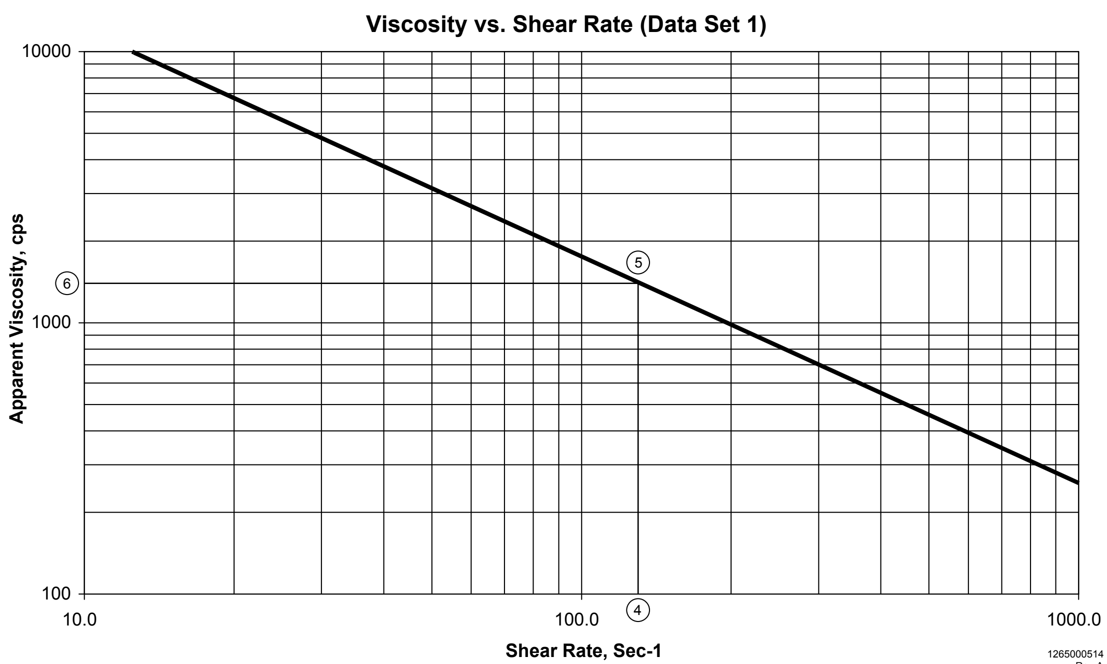


Figure 2

Atmospheric Pressure

Atmospheric pressure is the force exerted by the weight of the atmosphere. At sea level, the average atmospheric pressure is 14.7 pounds per square inch (psia). Refer to Table 2 for the average atmospheric pressure at different elevations.

Gauge Pressure

Gauge pressure is the pressure read on a gauge installed in a system. At sea level the average atmospheric pressure is 14.7 psia, this would be equal to 0 psi gauge pressure. This is measured in units of pounds per square inch gauge or psig.

Figure 3

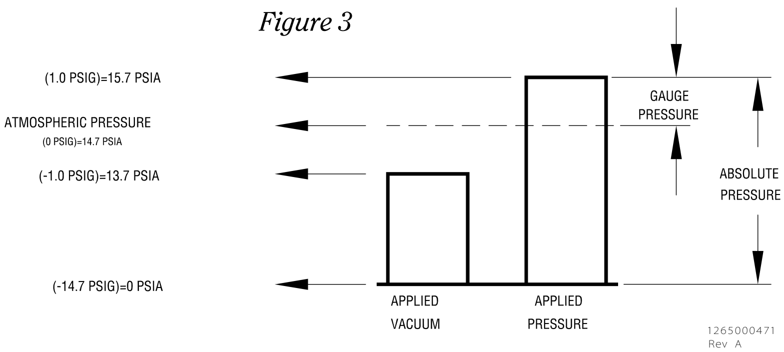


Table 2: Average Absolute Atmospheric Head

Altitude Above Sea Level (feet)	Atmospheric Pressure	Inches of 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

Absolute Pressure

Absolute pressure is calculated by adding the atmospheric pressure to the gauge pressure. This is measured in units of pounds per square inch absolute or psia.

Static Pressure (Head)

Static pressure is the pressure exerted by a column of liquid above the centerline point of measurement.

$p_z = (Z / 2.31) \times sg$

p_z = static pressure (psia)

Z = liquid level (ft)

sg = specific gravity (product)

2.31 = conversion factor (dimensionless)

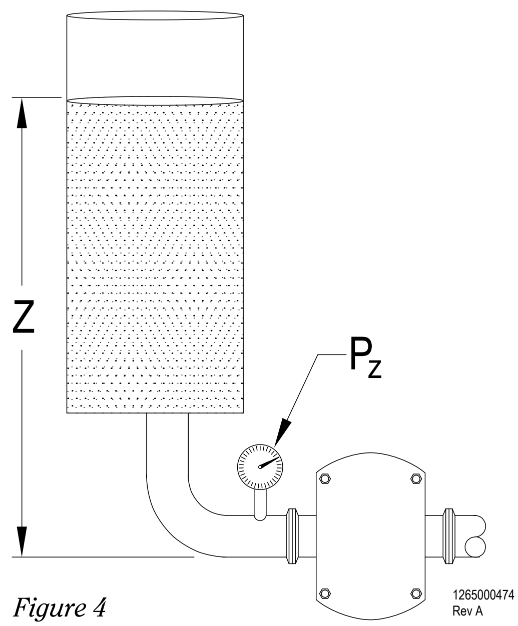


Figure 4

Vacuum

Vacuum refers to a pressure that is below the normal atmospheric pressure. If the tank feeding the inlet of a pump is at an absolute pressure less than atmospheric, the tank is said to be under vacuum. Vacuum is typically measured in units of inches of mercury (inches Hg). This number must be converted to psia, for NIPA calculations. For the conversion, see Table 6.

Vapor Pressure

The vapor pressure of a fluid is the pressure required at a given temperature to keep the fluid from turning to vapor. Water at 210°F has a vapor pressure of 14.123 psia. See Table 1 for the water vapor pressure.

NIPR – Net Inlet Pressure Required

NIPR is the pressure required by a pump to perform smoothly without cavitating. NIPR is measured in psia.

NIPA – Net Inlet Pressure Available

NIPA is the absolute pressure available at the inlet of the pump. NIPA is measured in psia.

Table 6: Pressure Conversions

Pressure			
Feet of Water	x	0.433	= PSI
Inches of Mercury	x	0.491	= PSI
Atmospheres	x	14.7	= PSI
Meters of Water	x	1.42	= PSI
Bar	x	14.7	= PSI
Kilo Pascals	x	0.145	= PSI
Atmospheres	x	33.9	= Feet of Water
PSI	x	2.31	= Feet of Water
Inches of Mercury	x	1.13	= Feet of Water
Meters of Water	x	3.28	= Feet of Water

Table 1: Vapor Pressure

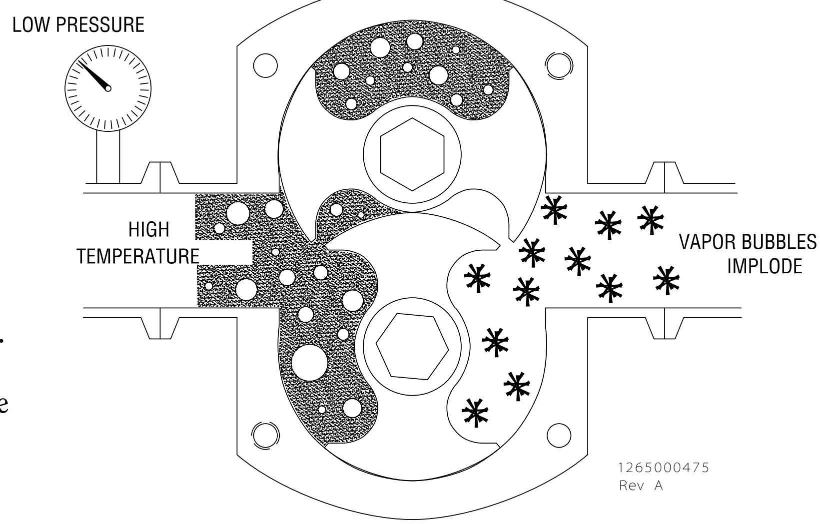
Water Temperature (°F)	Vapor Pressure (psia)
35	0.09
40	0.121
45	0.147
50	0.177
55	0.213
60	0.256
65	0.316
70	0.362
75	0.429
80	0.506
85	0.595
90	0.698
95	0.815
100	0.949
110	1.275
120	1.692
130	2.223
140	2.889
150	3.718
160	4.741
170	5.992
180	7.511
190	9.340
200	11.526
210	14.123
212	14.696

Cavitation

Cavitation is the formation of vapor bubbles due to insufficient pressure at the inlet of the pump. High product temperature and/or low pressure on the inlet side of the pump can lead to insufficient pressure. Over time, cavitation can seriously damage a pump. Additional pressure energy would be required to supply the pump with the energy it requires to keep from cavitating. Four ways to increase NIPA are raise the level of the product in the tank, pressurize the tank, lower the pump or decrease the product temperature.

If the NIPR of the pump is greater than the NIPA in the system, the pump will cavitate. If the NIPR is less than the NIPA, the pump will not cavitate.

Figure 5

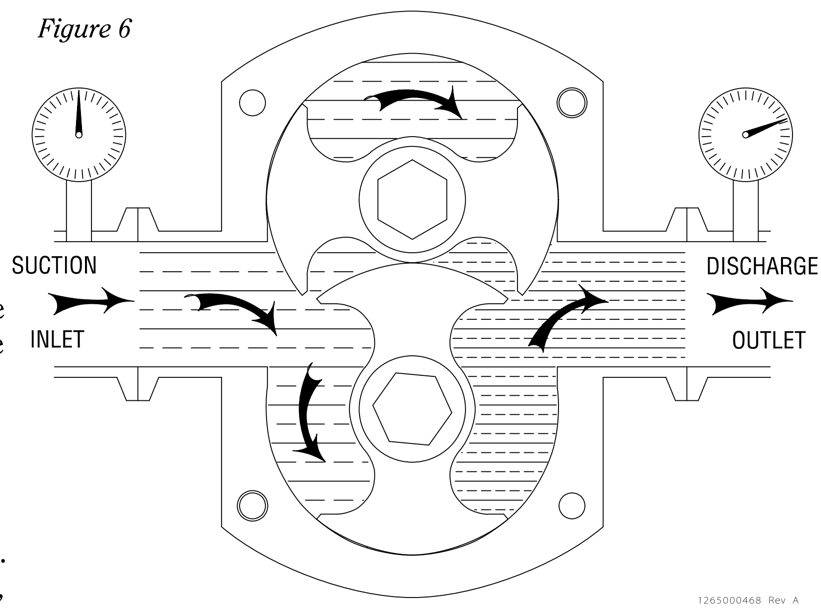


B. How a Positive Pump Operates

Positive Displacement Pump Operation (assuming sufficient NIPR)

Positive displacement pumps use two opposing, rotating elements (rotors) to displace product from the suction side of the pump to the discharge side of the pump. As the rotors rotate, the chamber formed between the rotors, housing and cover collects the product on the inlet side of the pump and carries the product to the discharge side of the pump.

Figure 6



Slip and Efficiency -

Positive pumps sometimes do not pump the full displacement for which they are rated because of a phenomenon called slip. To allow a positive pump's rotors to rotate, small clearances must be maintained between the rotors and housing. At lower viscosities these clearances allow some product to slip from the discharge side to the inlet side as the pump operates. The product that slips by will partially fill the inlet cavity. This amount of product must be "repumped" preventing the pump from reaching its full rated capacity and decreasing its volumetric efficiency.

- Internal clearances – The tighter the clearances, the less slip occurs.
- Viscosity – The amount of slip varies inversely with viscosity. The thicker the product, the less slip will occur. This reduction in slip eventually reaches a point called "zero slip".
- Zero slip – Zero slip is the point at which the product is thick enough that it will no longer flow past the rotors. This point varies depending upon the internal clearances of the pump. The FKL reaches zero slip at 200 cps and the FL II achieves it at 500 cps. At these points the amount of differential pressure no longer becomes a factor.

Volumetric Efficiency = Actual Flow/Flow at Zero Slip

Full volumetric efficiency is achieved on all products with viscosities above the zero slip point.

Actual flow for products between one and the zero slip point will depend on the interaction of product viscosity and the differential pressure. At a constant product viscosity below zero slip, increasing the discharge pressure increases the product slip. At a constant discharge pressure, decreasing the product viscosity increases the product slip.

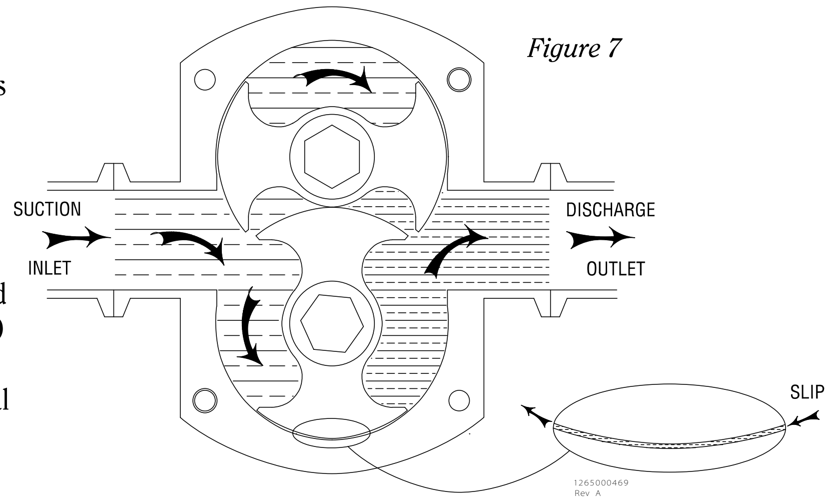


Figure 7

For products with a viscosity between 1 and 200 cps for the FKL and between 1 and 500 cps for the FL II the flow rate is dependent on the product viscosity and the differential pressure. At a constant product viscosity below zero slip, increasing the discharge pressure increases the product slip. At a constant discharge pressure, decreasing the product viscosity increases product slip. As the slip increases, the volumetric efficiency of the pump decreases because the full volume of the suction chamber is not available for new product.

Slip = (Flow @ 0 psi) – (Flow @ 10 psi)

Slip = 100 gpm - 70 gpm

Slip = 30 gpm

VE = 70%

Figure 8 shows the effect that increasing the discharge pressure has on slip and volumetric efficiency. At 0 psi, the volumetric efficiency is 100%. As the pressure increases, product slips from the discharge side of the pump to the suction

$$\text{Volumetric Efficiency} = \frac{\text{Flow @ 10 psi}}{\text{Flow @ 0 psi}}$$

$$VE = \frac{70\ \text{GPM}}{100\ \text{GPM}} \times 100$$

Figure 8

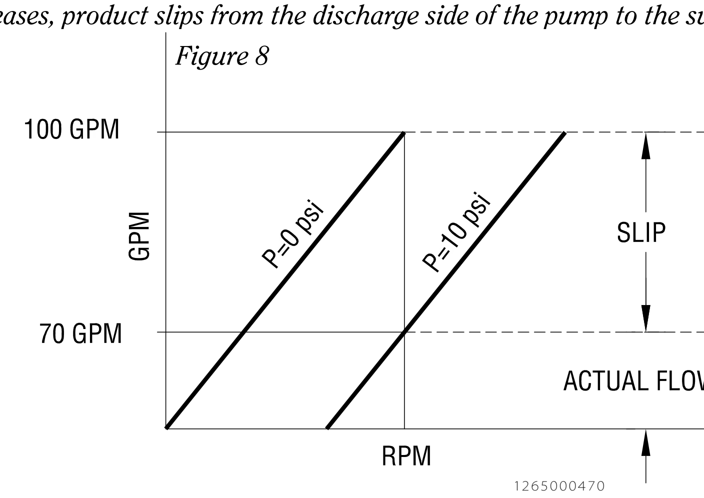
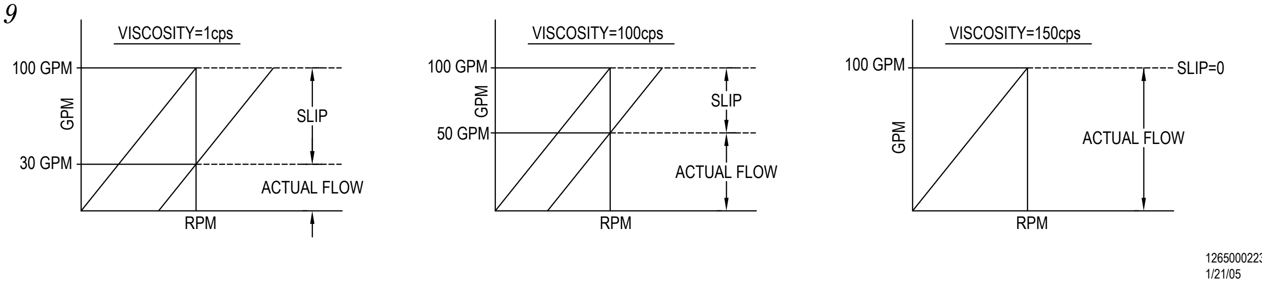


Figure 9



side.

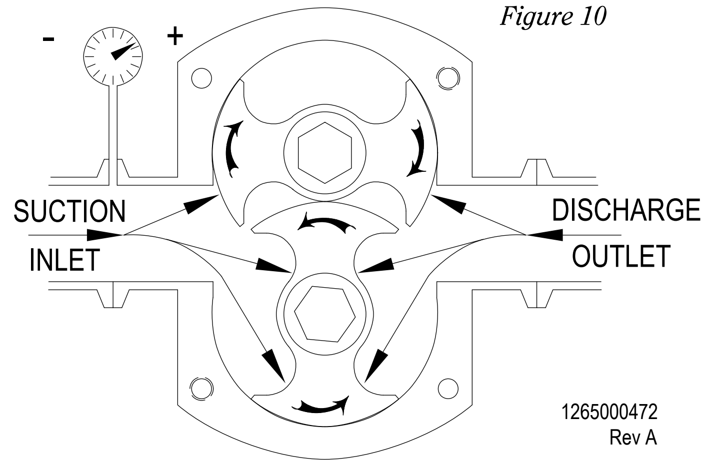
Figure 9 shows that as product viscosity increases, slip decreases. As product slip decreases, volumetric efficiencies increase. At 200 cps the slip is zero and volumetric efficiency is 100%, assuming that the net inlet pressure of the pump is satisfied. At 200 cps, the zero psi pressure line is used for sizing the FKL.

Differential Pressure

The differential pressure that the pump must generate is key to sizing. Differential pressure is the total pressure against which a pump must work. Generally the suction pressure is negligible and the discharge pressure makes up nearly all of the differential pressure. If the suction gauge pressure is positive, the differential pressure across the pump is the discharge pressure minus the suction gauge pressure.

Differential Pressure (psi) = Discharge Pressure (psi) – Suction Pressure (psi)

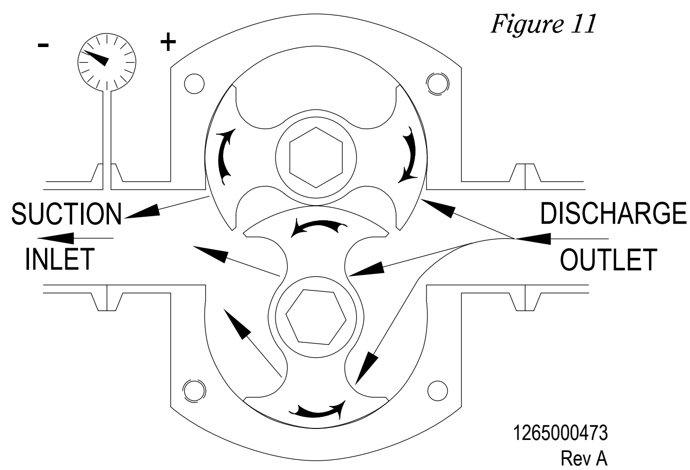
Figure 10



The pressure gradient inside the pump shows that the positive pressure on the suction side (Figure 10) of the pump assists the rotor movement and reduces the product slip inside the pump. Pressurized tanks and product levels above the pump on the suction side contribute to positive suction pressures.

The pressure gradient inside the pump shows that the negative pressure on the suction side (Figure 11) of the pump pulls against the movement of the rotors and increases product slip inside the pump. A vacuum drawn on a tank and frictional losses in inlet piping contribute to negative suction pressures.

Figure 11

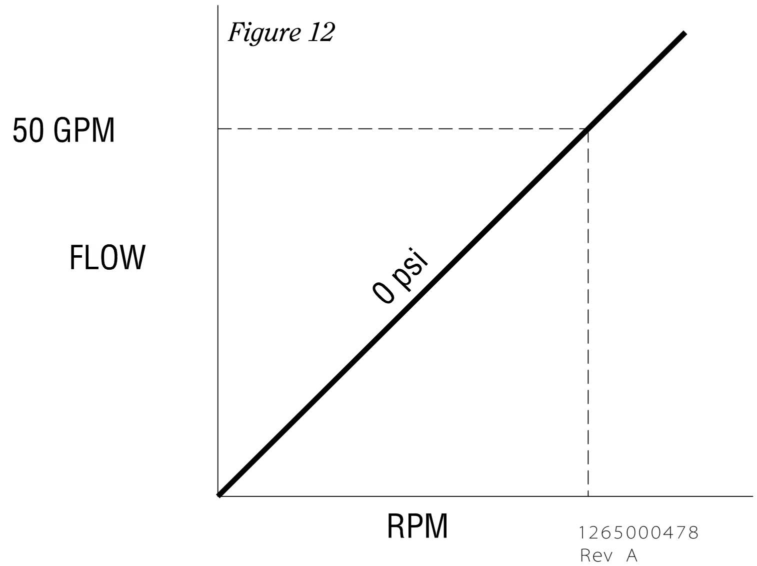


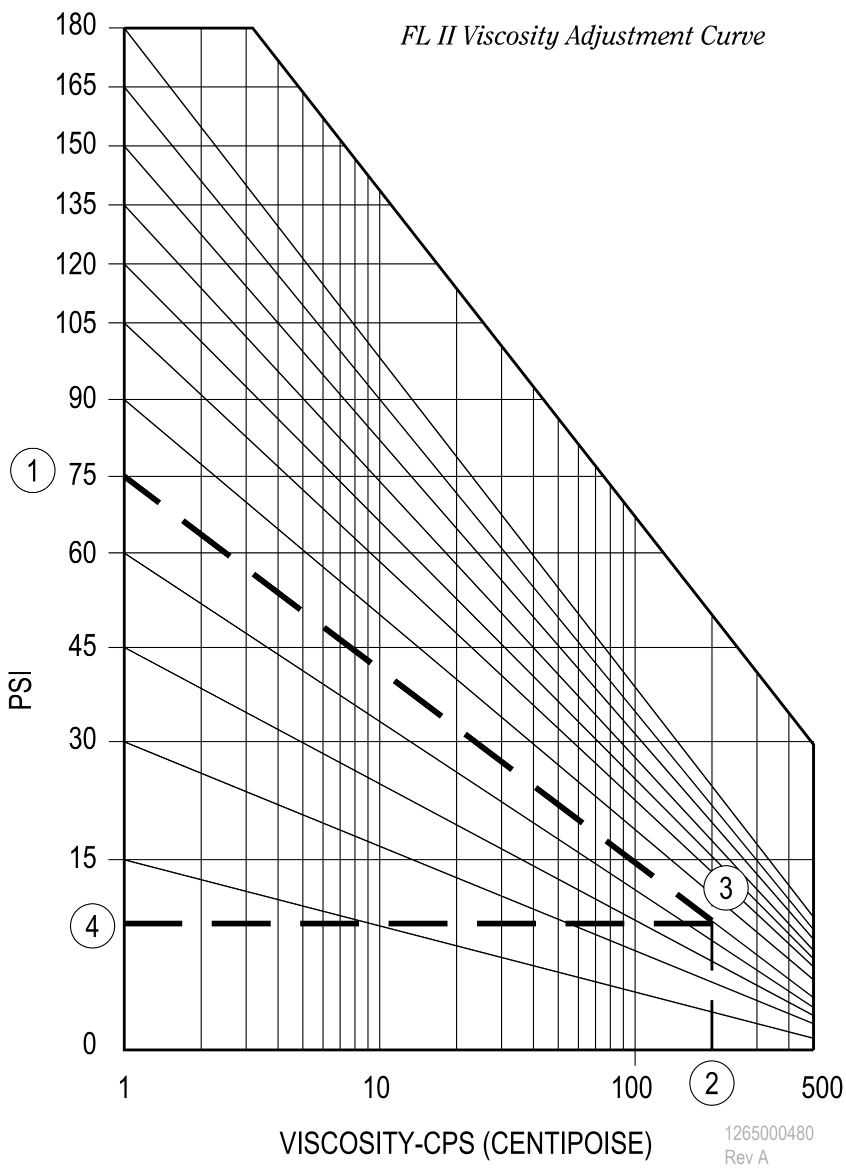
Pump Speed

Pump speed is affected by product viscosity and the differential pressure. At zero slip, the pump speed will be directly related to the flow rate and displacement. The zero psi line on the pump curves may be used to determine the pump speed. In the FKL pump the slip stops at a product viscosity of about 200 cps and in the FL II pump it stops at about 500 cps.

For water like products with a viscosity of one cps, calculate the differential pressure. Select the curve labeled with that differential pressure to determine the pump speed required.

If the product viscosity falls in between 1 cps and zero slip, you need to use the viscosity correction to determine the pump speed.



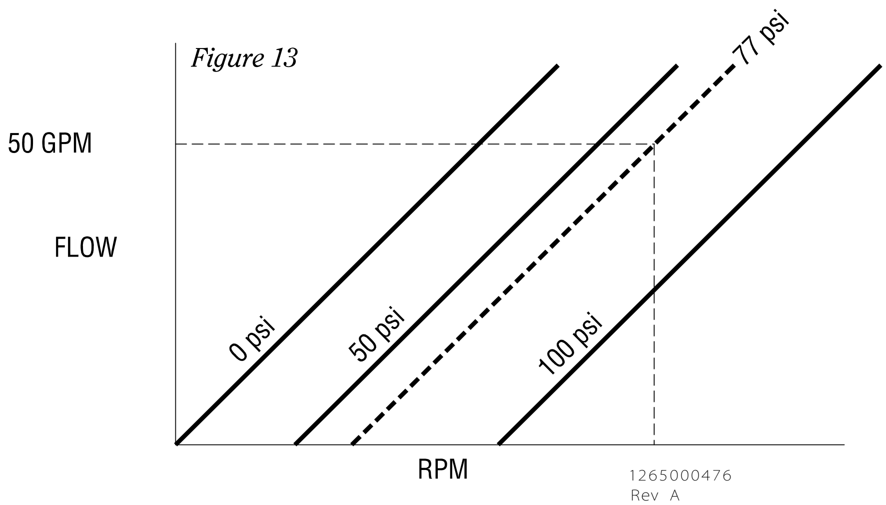


Work Horsepower (WHp)

The power required to pump the product through a system. This is based on the pump speed and the pressure against which it is working.

Viscosity Horsepower (VHp)

The power required to move product through the pump. This is based on the pump speed and the viscosity of the product as it passes through the pump. The measurement is take with zero backpressure on the pump.



C. Frictional Losses through Sanitary Tubing

Friction loss is the loss of pressure energy through the interaction between the product and the tubing. The higher the product viscosity, the more pressure energy is lost through friction. This manual contains six graphs in Section III that can be used to calculate the system pressure drop through 1 ½”, 2”, 2 ½”, 3”, 4” and 6” tubing. Use the product’s apparent viscosity and required flow rate to determine the frictional pressure drop through 1 foot of tubing, then multiply by the length of tubing in your system to obtain the total tubing frictional loss.

Examples 1, 2 and 3 show the effect of product viscosity and tubing size on frictional loss.

Example 1 – Determine the pressure loss resulting from 50 gpm of water at 1 cps flowing through 100 ft. of 1 ½” tubing. (see figure 14)

Directions:

1) Locate the product viscosity on the horizontal axis.

2) Move up vertically until you intersect the system flow rate.

3) Move horizontally and record the pressure loss in psi / foot tubing.

Given:

p_f = tubing frictional loss (psi) = f × L

f = frictional pressure loss (psi/ft tubing)

L = tubing length (ft)

Refer to figure 14:

f = 0.1 psi/ft

L = 100 ft

p_f = 0.1 psi/ft × 100 ft

p_f = 10 psi

Example 2 – Now determine the pressure loss resulting from a flow rate of 50 gpm of 300 cps product flowing through 100 ft. of 1 ½” tubing.

f = 1.1 psi/ft

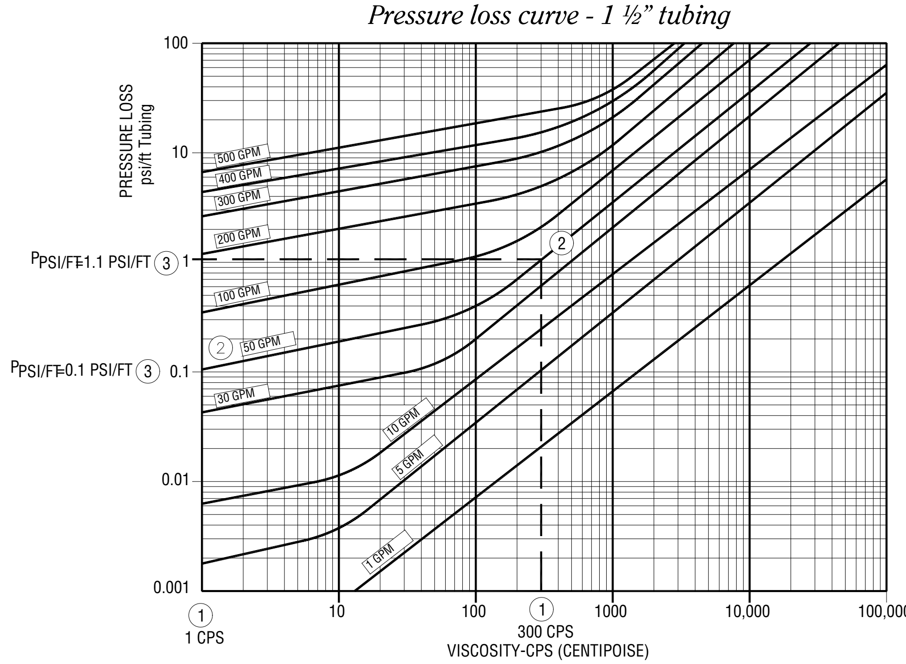
L = 100 ft

p_f = 1.1 psi/ft × 100 ft

p_f = 110 psi

Increasing the product viscosity from 1 cps to 300 cps increases the frictional pressure losses from 0.1 psi/ft to 1.1 psi/ft.

Figure 14 - Example 1 & 2 - Pressure loss curve - 1 ½” tubing



Example 3 – (see figure 15) Increasing the tube size will reduce pressure loss through the piping system. A 300 cps viscosity product flowing at 50 gpm through 1 ½" tubing will develop 110 psi of system backpressure. Now repeat the example using 2" tubing and compare the result.

f = 0.32 psi/ft

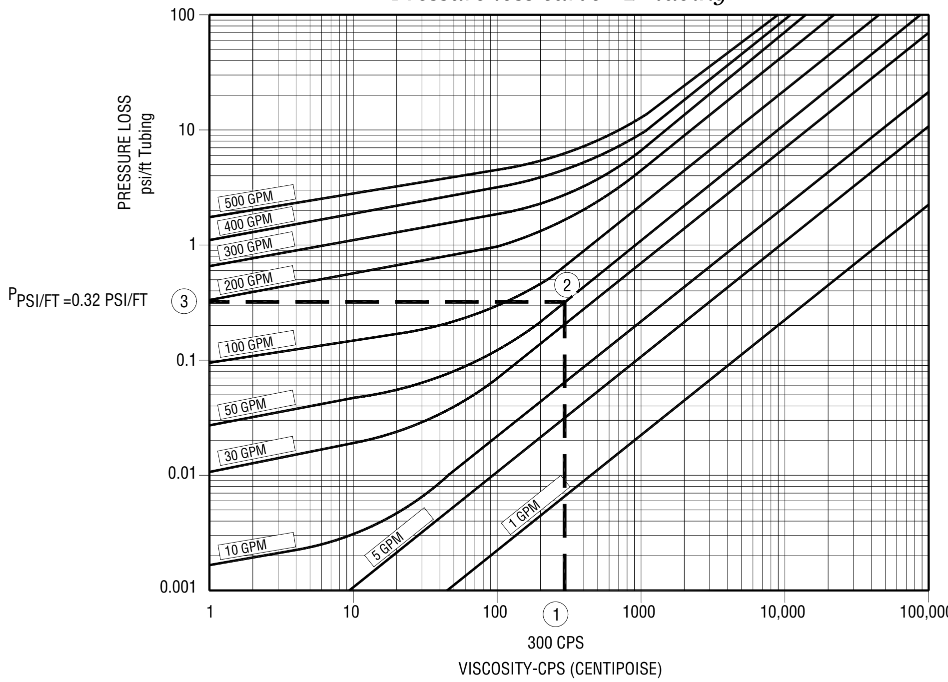
L = 100 ft

p_f = 0.32 psi/ft × 100 ft

p_f = 32 psi

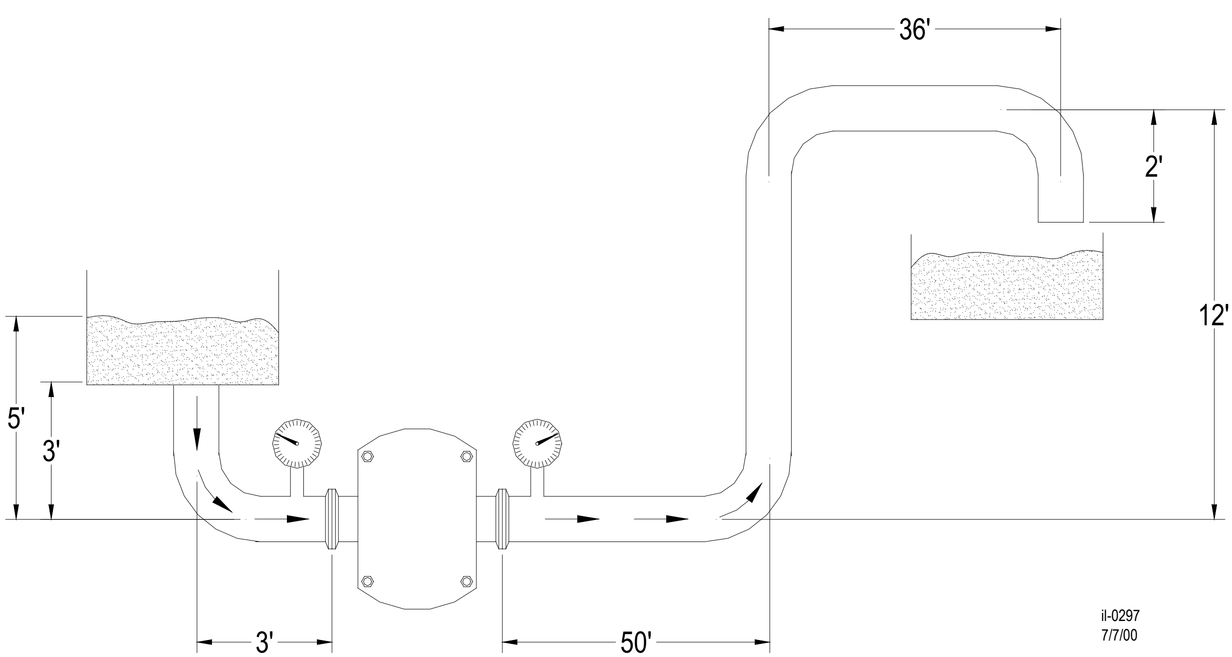
Increasing the tubing diameter from 1 ½" to 2" decreases the pressure loss by 0.78 psi / foot of tubing.

Figure 15 - Example 3 - Pressure loss curve - 2" tubing



D. Calculating System Pressure

Refer to the pump inquiry sheet and use the system components specified to calculate the discharge and suction pressures of the system.



Application Data Sheet

Product Section I

Product ____________________

Flow ____________________

Discharge Pressure ____________________

Inlet Pressure ____________________

Viscosity ____________________

Thixotropic ____________________

% Solids ____________________

Dilatent ____________________

Particulate Size ____________________

Newtonian ____________________

Specific Gravity ____________________

Temperature ____________________

CIP Temperature ____________________

SIP Temperature ____________________

Abrasive ____________________

Non-Abrasive ____________________

System Component Section II

For applications where the duty point is not specified a complete description of the process system is required. Fill in the suction and discharge piping components below.

Suction Tubing	Discharge Tubing	
Tubing Size ____________	Tubing Size ____________	Tubing Size ____________
Tubing Length ____________	Tubing Length ____________	Tubing Length ____________
Elbows ____________	Elbows ____________	Elbows ____________
Tees ____________	Tees ____________	Tees ____________
Valves ____________	Valves ____________	Valves ____________
Vertical ____________ (from liquid level)	Vertical ____________	Vertical ____________
Misc. ____________	Misc. ____________	Misc. ____________

Comments: ____

____

____

____

Application Data Sheet

Product Section I

Product X

Flow 50 GPM

Discharge Pressure to be calculated

Inlet Pressure to be calculated

Viscosity 200 cps

Thixotropic --

% Solids none

Dilatent --

Particulate Size none

Newtonian x

Specific Gravity 1.35

Temperature 150°F

CIP Temperature 150°F

SIP Temperature --

Abrasive --

Non-Abrasive x

System Component Section II

For applications where the duty point is not specified a complete description of the process system is required. Fill in the suction and discharge piping components below.

Suction Tubing	Discharge Tubing	
Tubing Size 2”	Tubing Size 1 1/2”	Tubing Size
Tubing Length 6’	Tubing Length 100’	Tubing Length
Elbows 1	Elbows 3	Elbows
Tees	Tees 0	Tees
Valves	Valves 0	Valves
Vertical 5’ (from liquid level)	Vertical 10’	Vertical
Misc.	Misc.	Misc.

Comments: *Sizing Example* - plant is located at an elevation of 4000’

1. Total Discharge Pressure Losses

Several factors will go into calculating the total discharge pressure of the system. In our example, we must calculate the frictional losses resulting from 200 cps product flowing through 100’ of 1 ½” tubing and three elbows at 50 gallons per minute. The elevation change of ten feet must also be included in the discharge pressure calculation.

Static Pressure

Determine the static pressure resulting from the elevation change from the centerline of the pump to the discharge of the system

p_z = static pressure (psi)

Z = liquid level (ft) = 12’ – 2’

sg = specific gravity = 1.35

$p_z = (Z / 2.31) \times sg$

$p_z = (10 / 2.31) \times 1.35$

$p_z = 5.84$ psi

Frictional Loss – Tubing

Determine the frictional loss through 1 ½” discharge tubing.

Refer to the Friction Loss curves to determine the friction loss resulting from 50 gpm of 200 cps product through 100’ of 1 ½” tubing.

1) Locate 200 cps on the horizontal axis of the chart.

2) Move vertically until you intersect the 50 gpm flow rate line.

3) Move horizontally and record the pressure loss in psi / foot of tubing.

p_f = tubing frictional loss (psi)

f = friction factor = 0.7 psi / ft

L = total length of tubing (ft) = 100 ft

$p_f = f \times L$

$p_f = 0.7 \times 100$

$p_f = 70$ psi

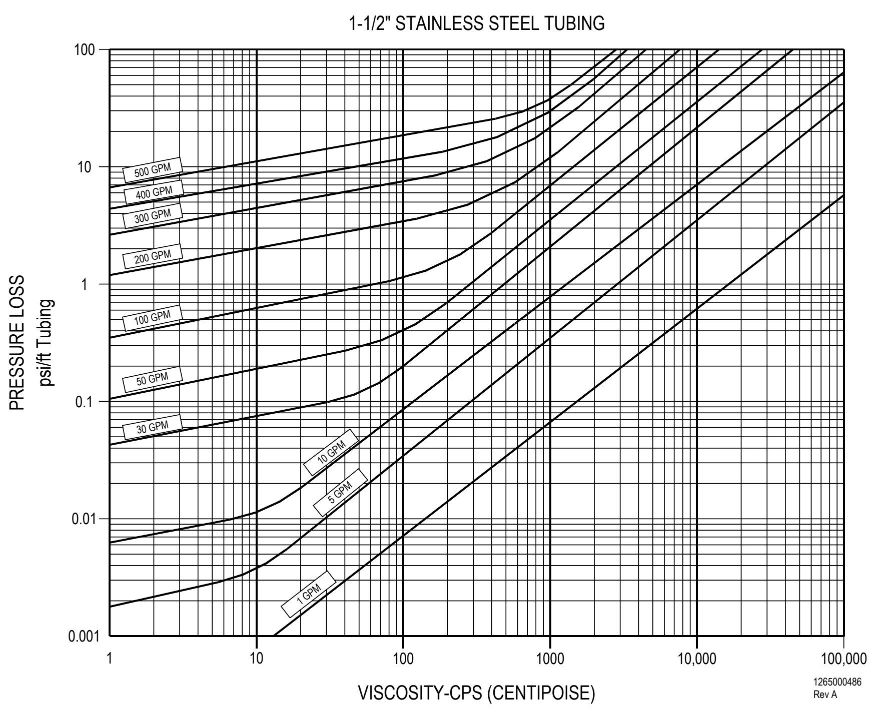


Figure 17 - Pressure loss curve - 1 ½” tubing

Frictional Loss – Elbows and Tees

To calculate the frictional loss for the fittings, we will first convert the fittings into an equivalent length of tubing. Refer to Table 3 to determine the equivalent length of the three elbows in the discharge tubing. Note that as the viscosity increases, the loss goes down for any one tubing size. This happens because the higher viscosity product flows through the fitting with less turbulence.

Next, we will calculate the pressure loss over that length of tubing.

p_{fe} = frictional loss in fittings (psi) = $L_e \times n \times f$

L_e = equivalent length / elbow (ft/elbow) = 2 ft/elbow

n = number of elbows = 3

f = frictional pressure loss (psi/ft) = 0.7 psi/ft

$p_{fe} = L_e \times n \times f$

$p_{fe} = 2 \times 3 \times 0.7$

$p_{fe} = 4.2$ psi

Table 3: Elbow Length Equivalent (feet)

B 200 cps

A. 1 1/2 tubing

Size	1 to 150 cps	150 to 1,500 cps	1,500 to 15,000 cps	15,000 to 100,000 cps
1 ½	2.5	2	1.4	0.7
2	3.5	2.3	1.8	0.8
2 ½	4	2.5	2	1
3	5	3.5	2.5	2
4	6	4.5	3	2
6	9	6.5	4	2.25

Figure 18 - Calculating the equivalent length/elbows (Le). In the previous step, we learned the discharge tubing is 1 ½" and the product is 200 cps.

Total Frictional Pressure Loss

Combine the tubing frictional loss and the frictional loss in fittings to find the total frictional pressure loss.

p_t = total frictional loss (psi) = $p_f + p_{fe}$

p_f = tubing frictional loss (psi) = 70 psi

p_{fe} = frictional loss in fittings (psi) = 4.2 psi

$p_t = p_f + p_{fe}$

$p_t = 70 + 4.2$

$p_t = 74.2$ psi

Total Discharge Pressure Losses

Combine the total frictional pressure loss and the static pressure to find the total discharge pressure loss.

p_d = total discharge pressure (psi) = $p_t + p_z$

p_t = total frictional loss (psi) = 74.2 psi

p_z = static pressure (psi) = 5.84 psi

$p_d = p_t + p_z$

$p_d = 74.2$ psi + 5.84

$p_d = 80.04$ psi

2. Pump Suction – Calculating NIPA

The NIPA (net inlet pressure available) should be calculated to determine the pressure energy available to the pump. The NIPA of the system should be compared to the NIPR (net inlet pressure required) of the pump model being considered to execute the specific duty. If the NIPA of the system is less than the NIPR for the pump, the system should be modified to increase the NIPA or a pump model requiring less NIPA should be considered.

Atmospheric Pressure

Refer to Table 2 to determine the average atmospheric pressure.

The altitude above sea level is 4,000 ft.

p_a = 12.7 psia

Table 2: Atmospheric Pressure

Altitude Above Sea Level (feet)	Atmospheric Pressure	Inches of 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

Figure 19 - Finding the Atmospheric Pressure.

Static Pressure

The total height above the centerline of the pump inlet is 5 feet (Figure 20).

p_z = static pressure (psi)

Z = total height (ft) = 5 ft

sg = specific gravity = 1.35

$p_z = (Z / 2.31) \times sg$

$p_z = (5 / 2.31) \times 1.35$

p_z = 2.92 psi

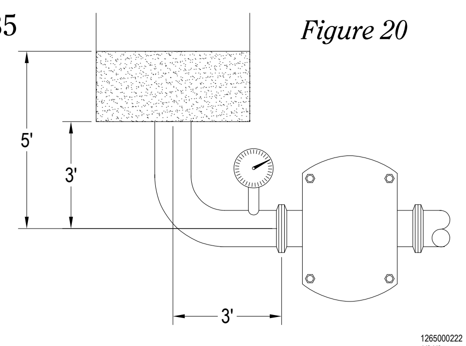


Figure 20

Vapor Pressure

Determine the vapor pressure for water by looking at Table 1.

Since our product does not have a vapor pressure table, most do not, we will use the table for water. The table for water is similar to what a table for another fluid would be like (Figure 21).

The product temperature is 150°F.

vp = 3.718 psia

Table 6: Vapor Pressure

Water Temperature (°F)	Vapor Pressure (psia)
100	0.949
110	1.275
120	1.692
130	2.223
140	2.889
150	3.718
160	4.741
170	5.992
180	7.511
190	9.340
200	11.526
210	14.123
212	14.696

Figure 21 - Finding the vapor pressure using the temperature.

Frictional Loss – Tubing

Refer to the pressure loss curves in Section III to determine the frictional loss in psi / foot of tubing for a 200 cps product traveling at 50 gpm through 6 feet of 2" tubing.

p_f = tubing frictional loss (psi)

f = frictional pressure loss (psi/ft tubing) = 0.21 psi/ft (Figure 22)

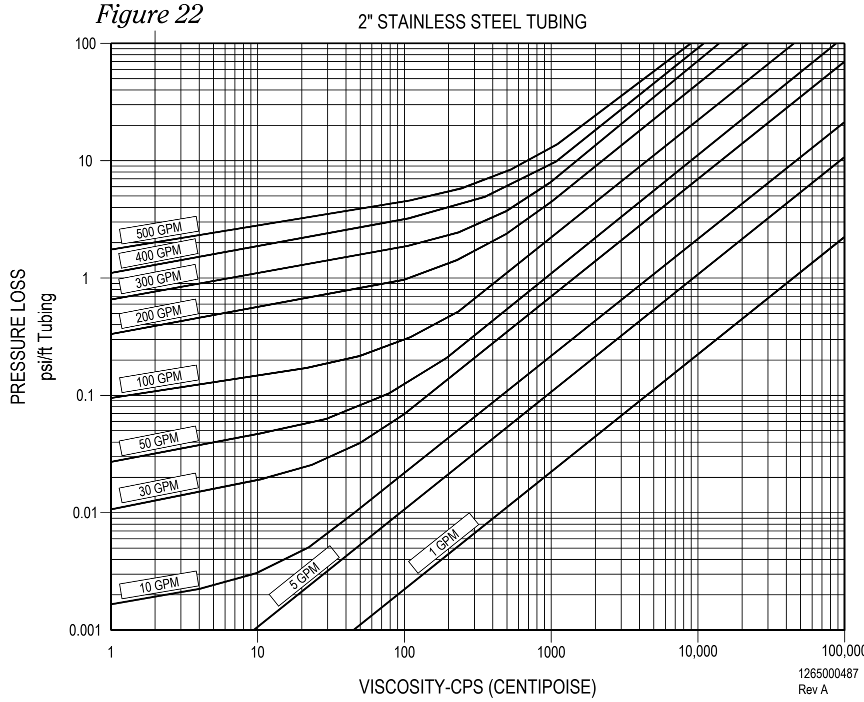
L = tubing length (ft) = 6 ft

$p_f = f \times L$

$p_f = 0.21 \text{ x } 6$

$p_f = 1.26$ psi

Figure 22



Frictional Loss - Elbows and Tees

Refer to Table 3 for the equivalent length of tubing for 200 cps product flowing through one 2" elbow.

p_{fe} = frictional loss in fittings (psi)

L_e = equivalent length / elbow (ft/elbow) = 2.3 ft (Figure 23)

n = number of elbows = 1

f = frictional pressure loss (psi/ft) = 0.21 psi/ft

$p_{fe} = L_e \times n \times f$

$p_{fe} = 2.3 \times 1 \times 0.21$

$p_{fe} = 0.48$ psi

B. 200 cps

A. 2" tubing

Size	1 to 150 cps	150 to 1,500 cps
1 ½	2.5	2
2	3.5	2.3
2 ½	4	2.5
3	5	3.5
4	6	4.5
6	9	6.5

Figure 23- Calculating the equivalent length by the tubing size and cps.

Total Frictional Losses

Combine the tubing frictional loss and the frictional loss in fittings, to find the total frictional loss.

p_t = total frictional loss (psi)

p_f = tubing frictional loss (psi) = 1.26 psi

p_{fe} = frictional loss in fittings (psi) = 0.48 psi

$p_t = p_f + p_{fe}$

$p_t = 1.26 + 0.48$

$p_t = 1.74$ psi

NIPA

Net Inlet Pressure Available

p_a = atmospheric pressure (psia)

p_z = static pressure (psi)

vp = vapor pressure (psi)

p_t = total frictional loss (psi)

NIPA* = $p_a + p_z - vp - p_t$

NIPA = 12.7 + 2.92 – 3.718 – 1.74

NIPA = 10.162 psia

* NIPA is calculated in absolute pressure (psia)

3. Differential Pressure

For proper pump selection, the differential pressure should be calculated. When calculating the differential pressure, use the gauge pressure at the inlet and not the NIPA.

The values used in these examples were calculated above.

Gauge Pressure at Inlet

p_s = gauge pressure at inlet (psi)

p_z = static pressure (psi) = 2.92 psi

p_t = total frictional loss (psi) = 1.74 psi

$p_s = p_z - p_t$

p_s = 2.92 – 1.74

p_s = 1.18 psi

Differential Pressure

P = differential pressure

p_d = total discharge pressure (psi) = 80.04 psi

p_s = gauge pressure at inlet (psi) = 1.18 psi

$P = p_d - p_s$

P = 80.04 – 1.18

P = 78.86 psi

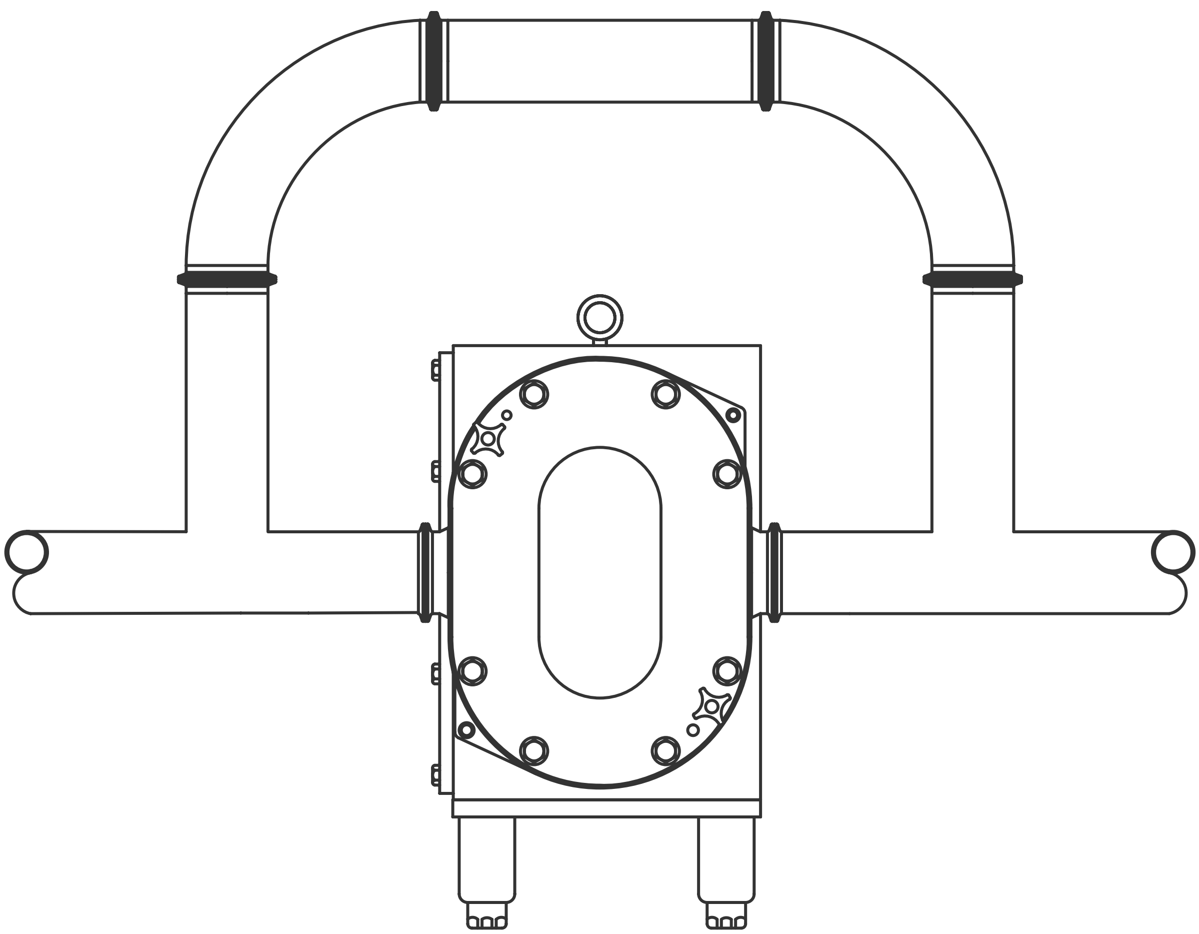
E. Positive Displacement Pump Cleaning Recommendations

Some recommendations for cleaning PD pumps are as follows:

When you are running products or cleaning solutions with different temperatures, you need to allow enough time for all of the wetted components inside the pump to reach a steady-state temperature before you start the pump. If your process does not allow you to stop the pump during this transition, you need to install rotors that provide larger clearances. Note: that the clearances inside the FKL pump are extremely small.

If the process lines are to be cleaned with the pump, use a by-pass loop around the pump during the CIP mode to maintain pipe velocity. Once the wetted components are at a steady temperature, the pump can be started and run around 100 RPM with a backpressure of at least 10 PSI. As the product viscosity increases, the required backpressure may need to be increased as well.

Contact Fristam if you have any questions.



Selecting a Positive Displacement Pump Using Performance Curves

Choosing a Pump Series

A. Gather all application information including product nature, viscosity, temperature, NIPA, flow rate and pressure loss.

B. Decide what series pump to use, FL II or FKL. For simple applications the more economical FL II pump will work, when the duty exceeds the capabilities of this pump the FKL should be applied.

The FKL and FL II Product Lines – Better Choices for Better Performance

To best match the broad range of positive displacement pump applications Fristam provides two product lines, the FKL and the FL II. While sharing many similarities the pumps are fundamentally different in design.

The FKL is a circumferential piston pump, meaning that its rotors run in a channel described by the pump housing and built-in internal hubs. The purpose of this design is to achieve high performance by maintaining tighter clearances and restricting product slip within the pump. The design produces higher pressures, the ability to self-prime and the capability of handling more difficult products and applications.

The FL II is a rotary lobe pump. Rotary lobes use the movement of two lobes in a pumping chamber to accomplish the pumping action. This style of pump is designed for standard duty applications.

Choosing Between the FKL or FL II

The FKL can be selected for any application within the capabilities of it or the FL II. Within its range, the FL II will often be a more attractive selection because of its economy and simplicity. The FL II should be considered for applications within the following parameters.

- Pressures to 170 psi
- Viscosities to 50,000 cps
- Flooded suction with at least 7 psia available
- Mechanical seals required
- 316L stainless steel rotors required
- Product is low to moderately shear sensitive

Selecting a Pump Size

Use the composite curves to make your initial pump selection.

1. Locate the product viscosity on the horizontal axis (1).
2. Locate the required flow rate on the vertical axis (2).
3. Determine the intersection between the flow rate and product viscosity (3).
4. Select a pump model above the intersection (3).

When selecting, keep in mind that it is best to run a positive displacement pump at no more than 400 to 500 rpm. The lower speeds reduce seal wear, extend pump life, reduce suction pressure requirements and produce quieter operation. The composite curves are based on the maximum speed of the pumps; therefore, the model selected will usually be one or two above the duty point.

For example: For a flow rate of 50 gpm and a product with a viscosity of 200 cps, the model directly above the duty point is an FL II 75L.

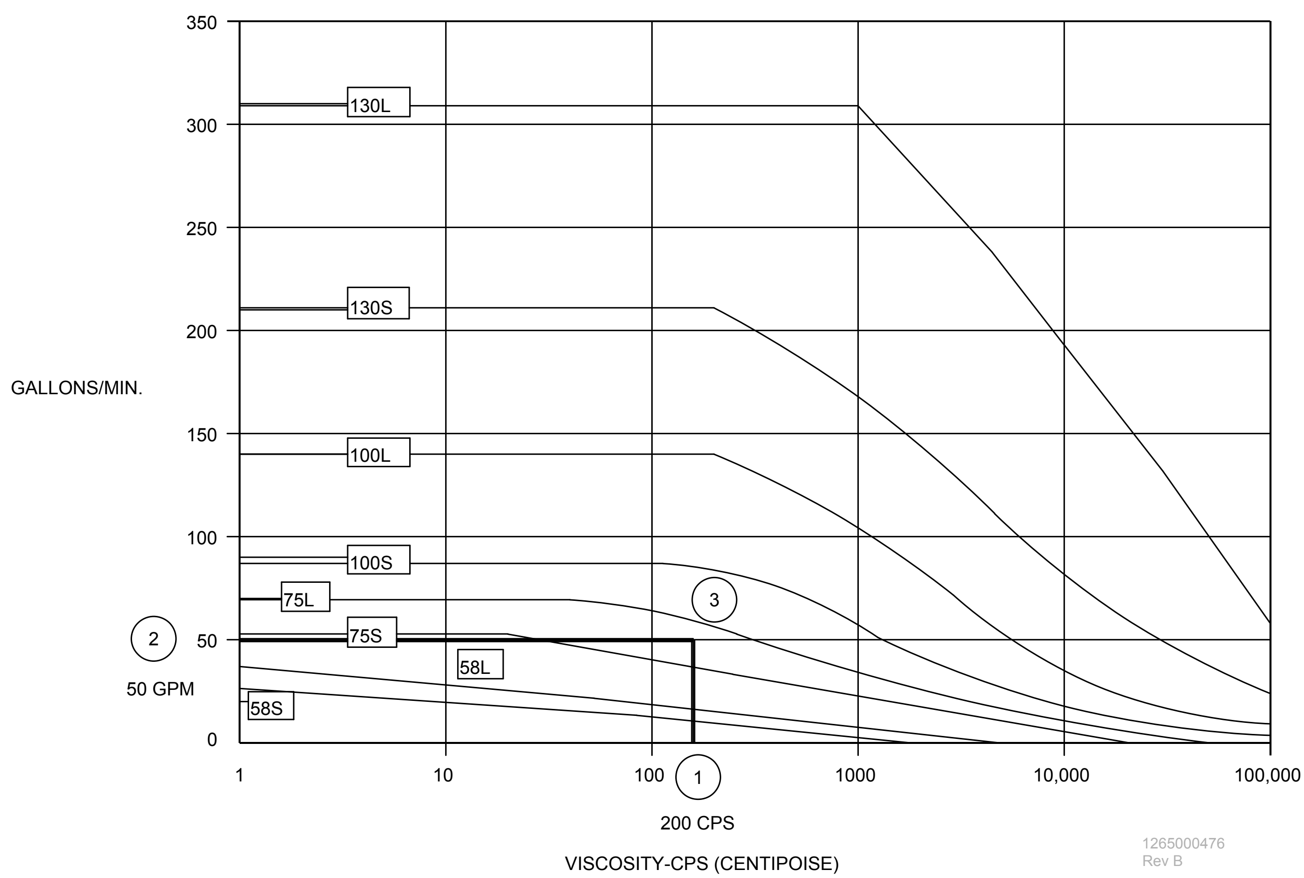


Figure 24

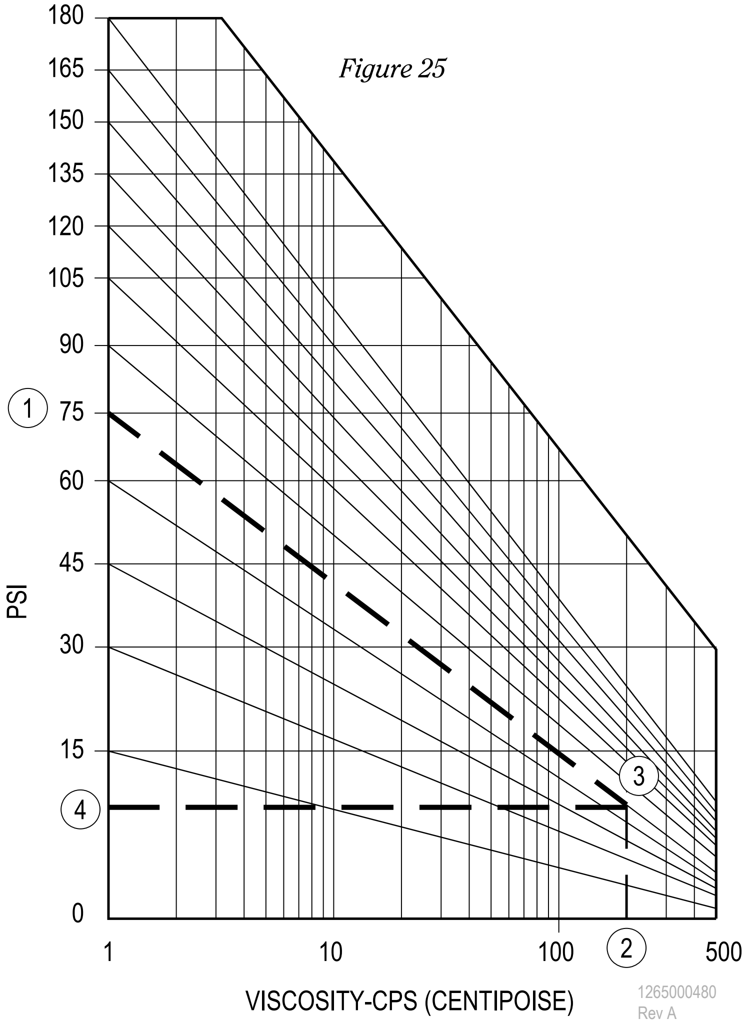
However, if we look at the individual curve for this pump we will see that it would have to run above the desired speed range. Therefore, to maintain the desired speed range, we will select the next larger model, an FL II 100S.

Viscosity Adjustment

Viscosity adjustment is not necessary for products with a viscosity above the pumps zero-slip point. Also viscosity adjustment is not necessary for products at 1 cps, since the curves are calculated at 1 cps. The zero slip point is 500 cps for the FL II and 200 cps for the FKL. Speed must be increased for products with a viscosity below the zero slip point in order to deliver the required flow rate. This is the most confusing part of PD selection. It is necessary because pump performance will vary for viscosities below the zero slip point. The adjustment converts the slip factor for different viscosity products into an equivalent based on water.

1. Locate the calculated differential pressure on the vertical axis (1).
2. Follow the pressure line, down and to the right, until it intersects (3) the product viscosity (2).
3. Record the adjusted pressure value on the vertical axis (4). This value is the pressure that will be used on the slip curve.

FL II Viscosity Adjustment Curve



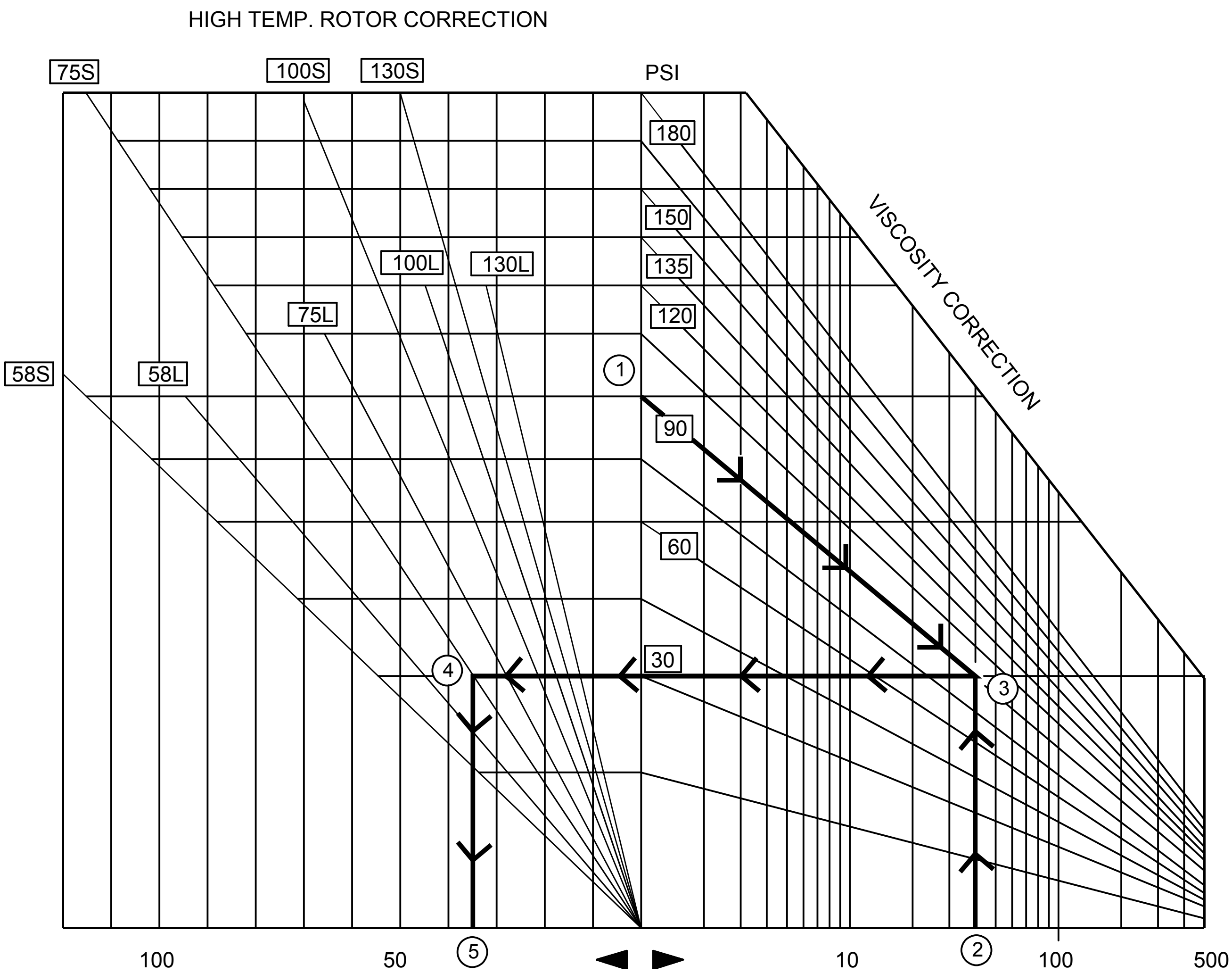
High Temperature Rotor Adjustment

For applications that fall below the zero slip point and require high temperature rotors, another speed adjustment is necessary. The increased clearances produced by these rotors require this adjustment, to compensate for the additional slip they produce.

For any of the FL II pumps, use the curve below.

1. Locate the calculated differential pressure on the vertical axis (1).
2. Follow the pressure line, down and to the right, until it intersects (3) the product viscosity (2).
3. Read all the way to the left until you find the line representing the model that was selected (4).
4. Record the additional speed at the horizontal axis (5). This number will be added to the speed calculated for the pump.

Figure 26 - FL II High Temperature Rotor Correction Curve



Determining Pump Speed

To determine the pump speed:

1. Locate the required flow rate on the pump curve (1).
2. Move horizontally until you intersect the correct pressure (2). This will depend on the viscosity of the product. For products with a viscosity of 1 cps, the correct pressure line will be the differential pressure. For viscosities between 1 and 500 cps for the FL II pump, the correct line will be the viscosity-adjusted pressure. For viscosities above 500 cps for the FL II, the correct line will be 0 psi.
3. Move straight down until you intersect the horizontal axis (3).

Determining Horsepower Requirements

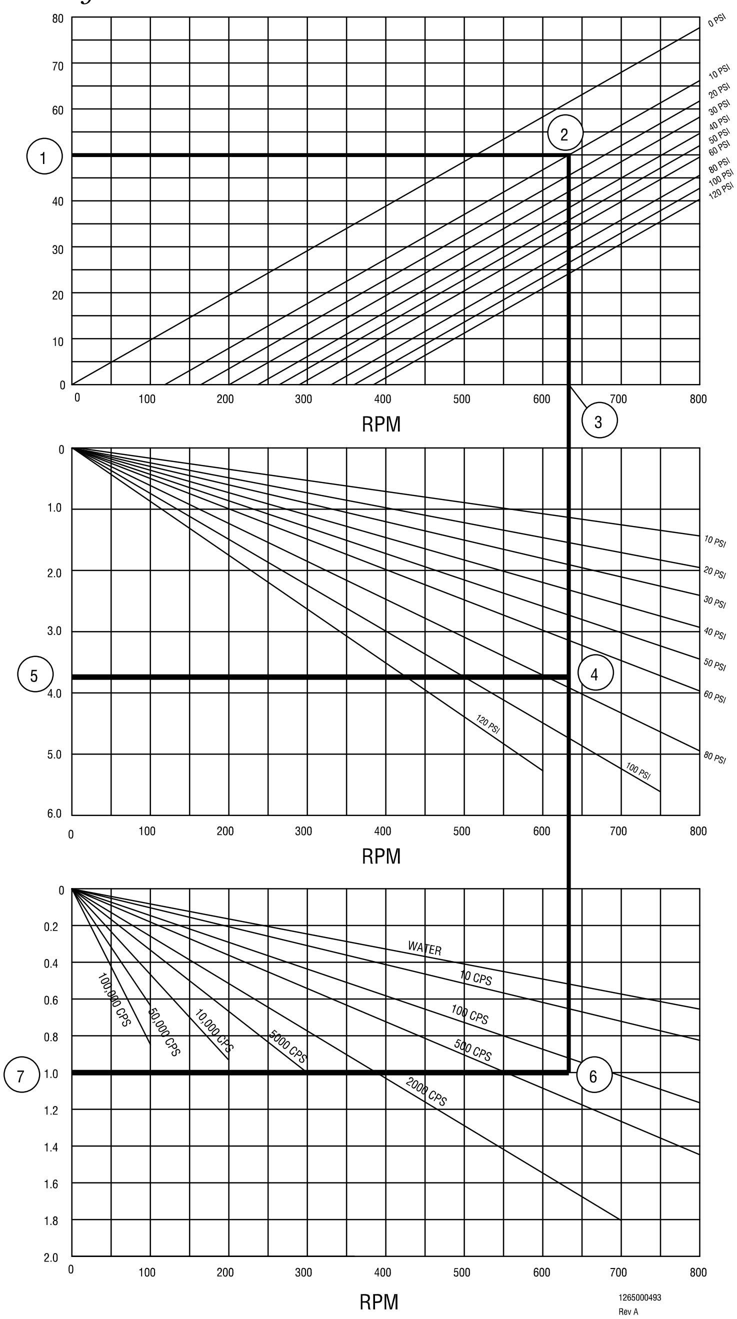
1. Determine the Work Horsepower (WHp). Continue to move down until you intersect the differential pressure (4), not the adjusted pressure. Read the power off the vertical axis directly to the left (5).

2. Determine the viscosity horsepower (VHp). Continue to move down (from the differential pressure point) until you intersect the product viscosity (6). Read the power off the vertical axis directly to the left (7).

3. Add these two numbers together to calculate the overall brake horsepower.

BHp = WHp + VHp

Figure 27



Net Inlet Pressure Required (NIPR)

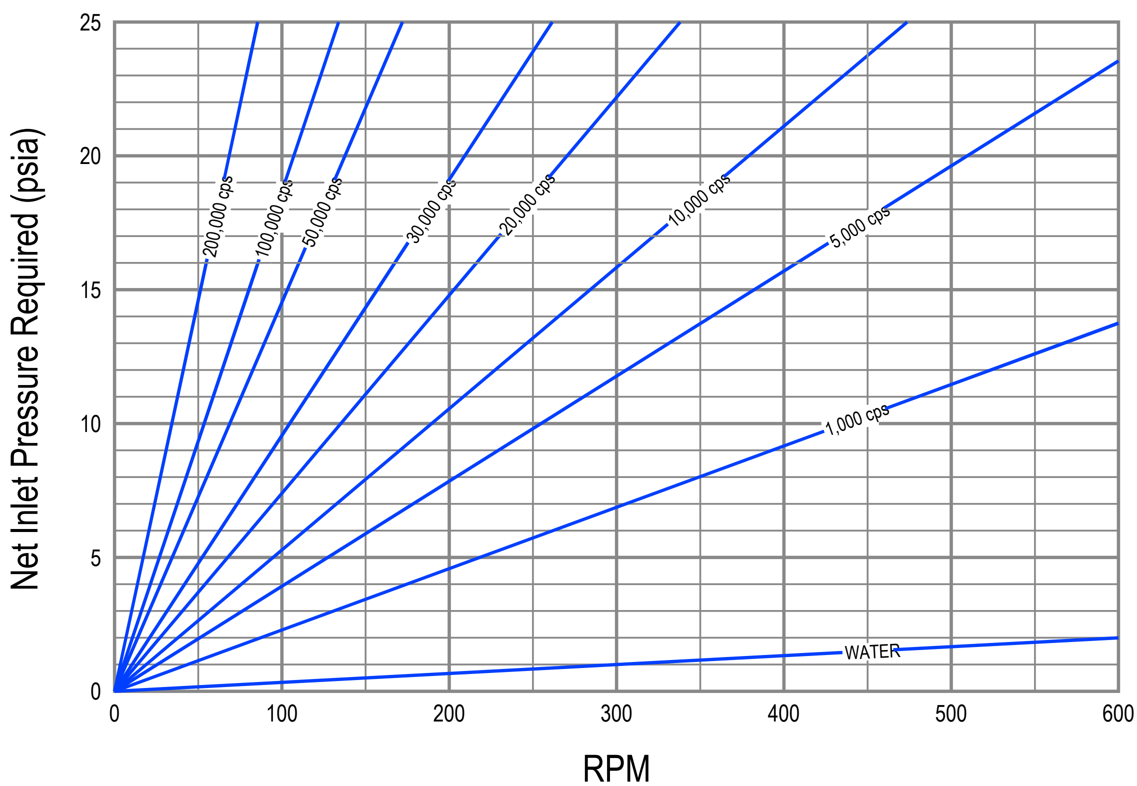
Check the Net Inlet Pressure Required (NIPR) for the selected pump. For the FL II pumps, be sure that the NIPR is at least 7 psia. For the FKL, each pump has its own curve.

Determining Drive Torque Requirements

Calculate the application torque. The application torque will be used to help size the pump drive and the coupling used to connect the drive to the pump. Each of these components will have a maximum allowable torque and the application torque cannot exceed this.

T = (63,025 x BHp) / speed

Figure 28: FKL 25 NIPR curve



Pump Selection Examples

Example 1

Water at 1 cps, 1.0 SG and 68°F

The duty will be 20 gpm @ 200 psi and the NIPA will be 4 psia

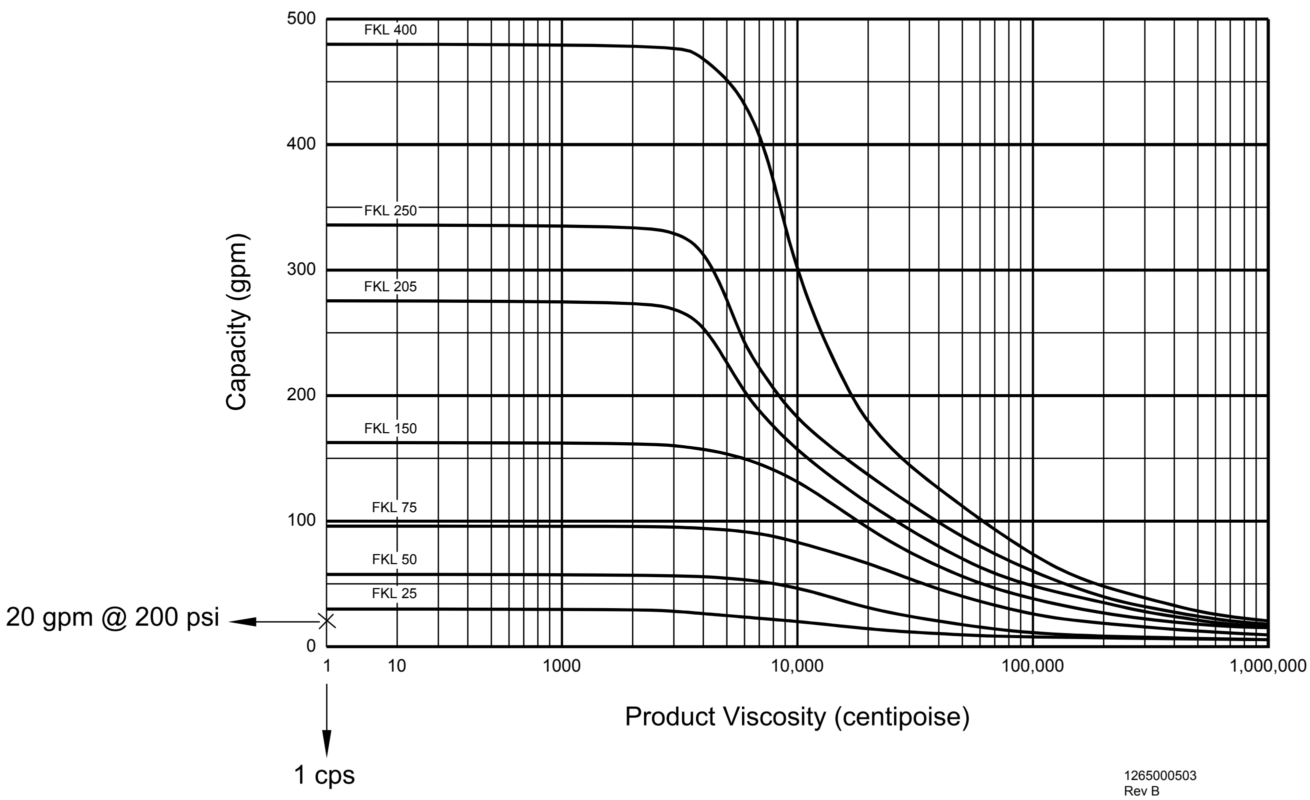
The pressure of this duty point exceeds the maximum of any of our FL II pumps and the NIPA is relatively low, therefore we will select a FKL pump for this application.

Look at the composite curve and select a model (as explained earlier).

The model that will work best is the FKL 50.

This duty will not require a viscosity or temperature adjustment since the product is at 1 cps. The actual slip line can be read off the curve.

Figure 29



Calculate the pump speed, horsepower and application torque.

For example 1, the FKL 50 requires 494 rpm to deliver 1 cps product at 20 gpm against 200 psi.

BHp = WHp + VHp

BHp = 6.1 + 0.4

BHp = 6.5

T = Torque (in/lbs.)

T = (BHp x 63,025) / speed

T = (6.5 x 63,025) / 494

T = 829 in-lbs

Check the NIPR of the pump using Figure 30.

The NIPR is 2.7 psia, therefore the NIPA of 4 psia is more than enough. The final selection would be a FKL 50, running at 494 rpm with a 7.5 hp drive and having a torque of 829 in-lbs.

Figure 30

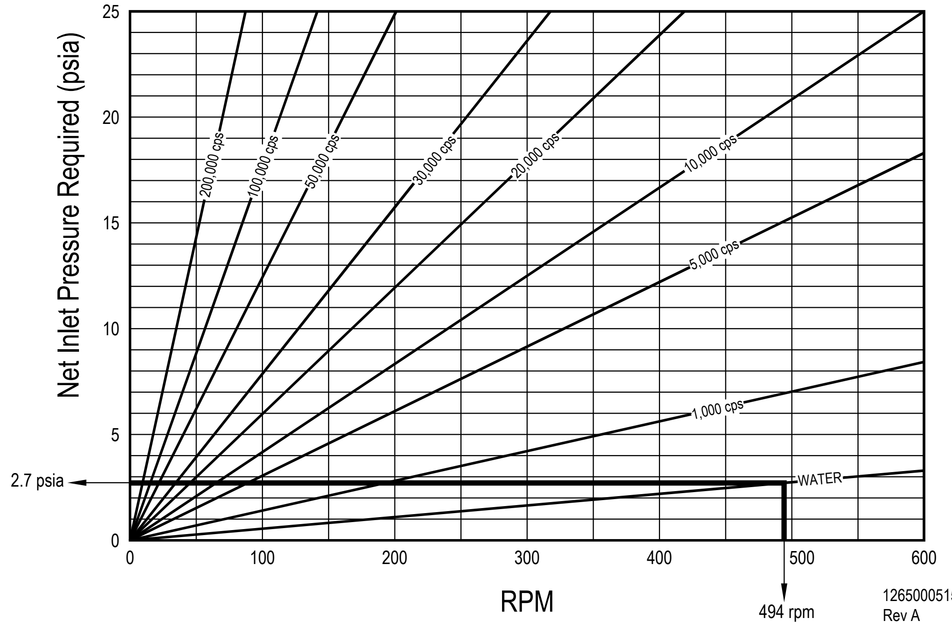
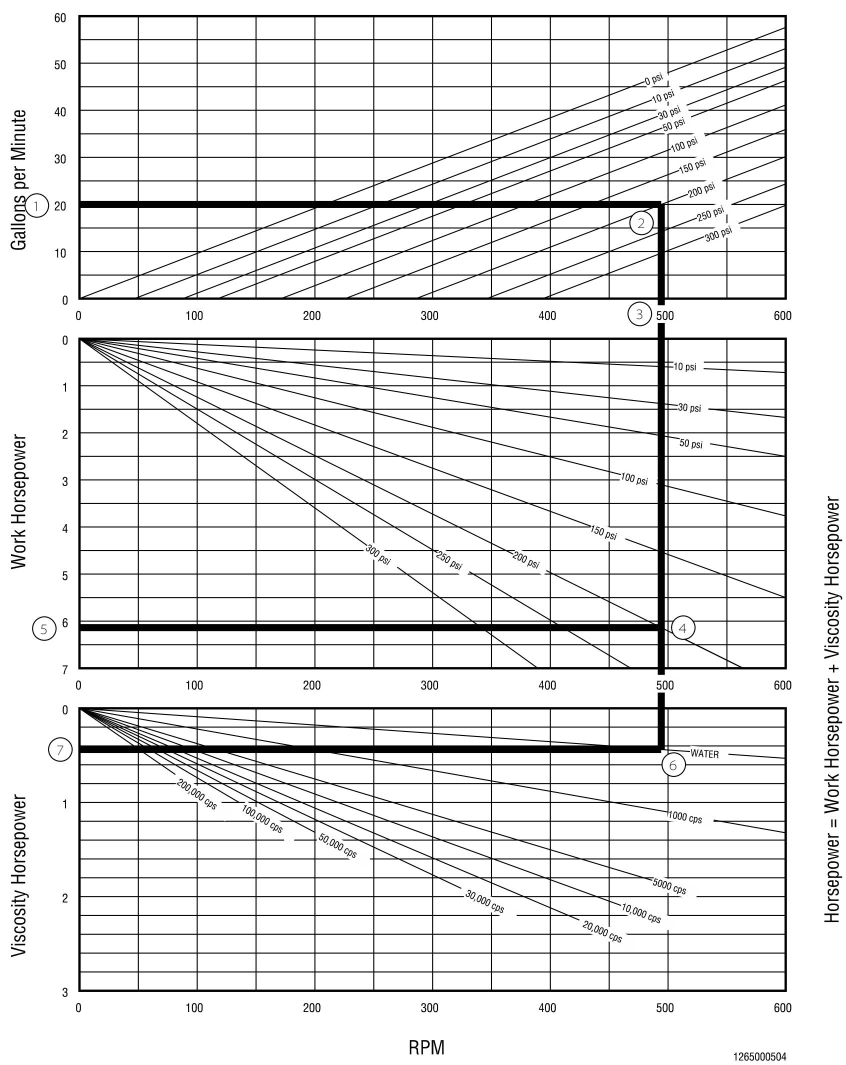


Figure 31



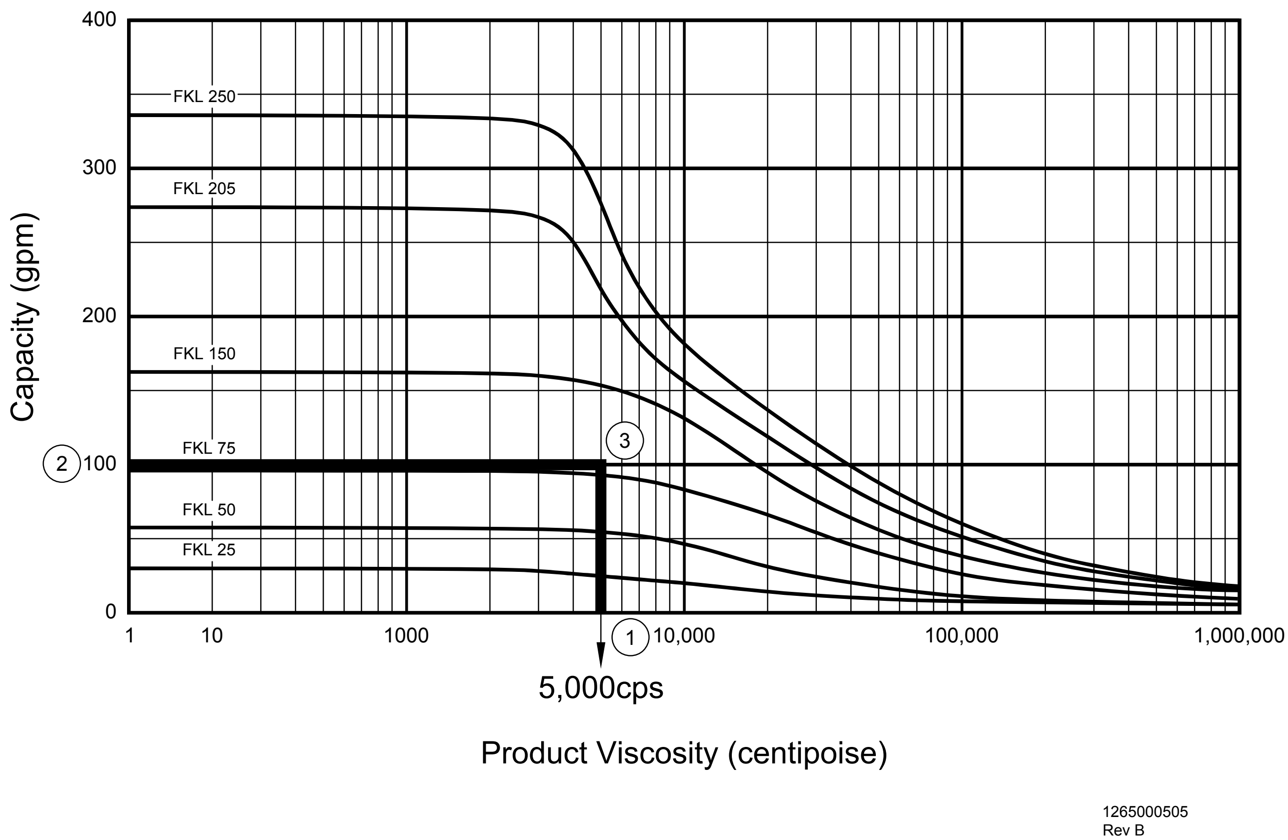
Example 2

High Fructose Corn Syrup at 5,000 cps, 1.32 SG and 38°F

The duty will be 100 gpm @ 250 psi and the NIPA will be 10 psia

The pressure of this duty point exceeds the maximum of any of our FL II pumps; therefore, we will select a FKL pump for this application. Look at the composite curve (Figure 32) and select a model (as explained earlier).

Figure 32

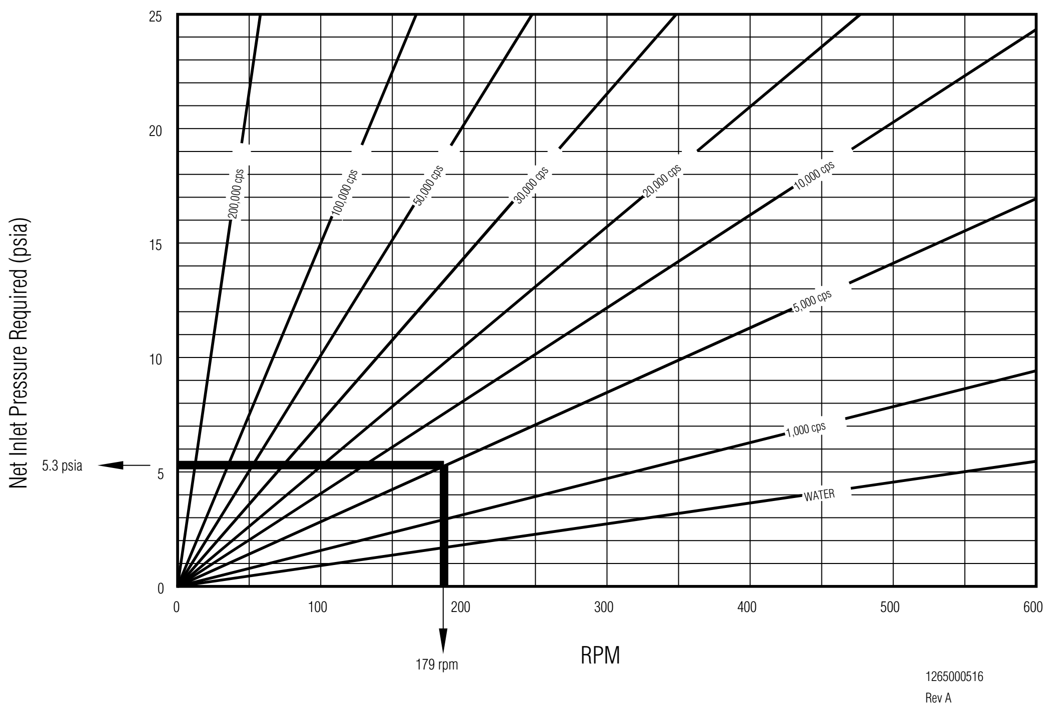


The model that will work best is the FKL 250. The FKL 150 is above the duty point, but the speed required is too high.

This duty will not require a viscosity or temperature adjustment.

Calculate the pump speed, horsepower and application torque. The speed can be calculated by dividing the flow rate by the displacement, or it can be found by reading the zero slip line on the slip chart.

Figure 33



For example 2, the FKL 250 requires 179 rpm to deliver 5,000 cps product at 100 gpm against 250 psi.

BHp = WHp + VHp

BHp = 17.5 + 5.0

BHp = 22.5

T = (BHp x 63,025) / speed

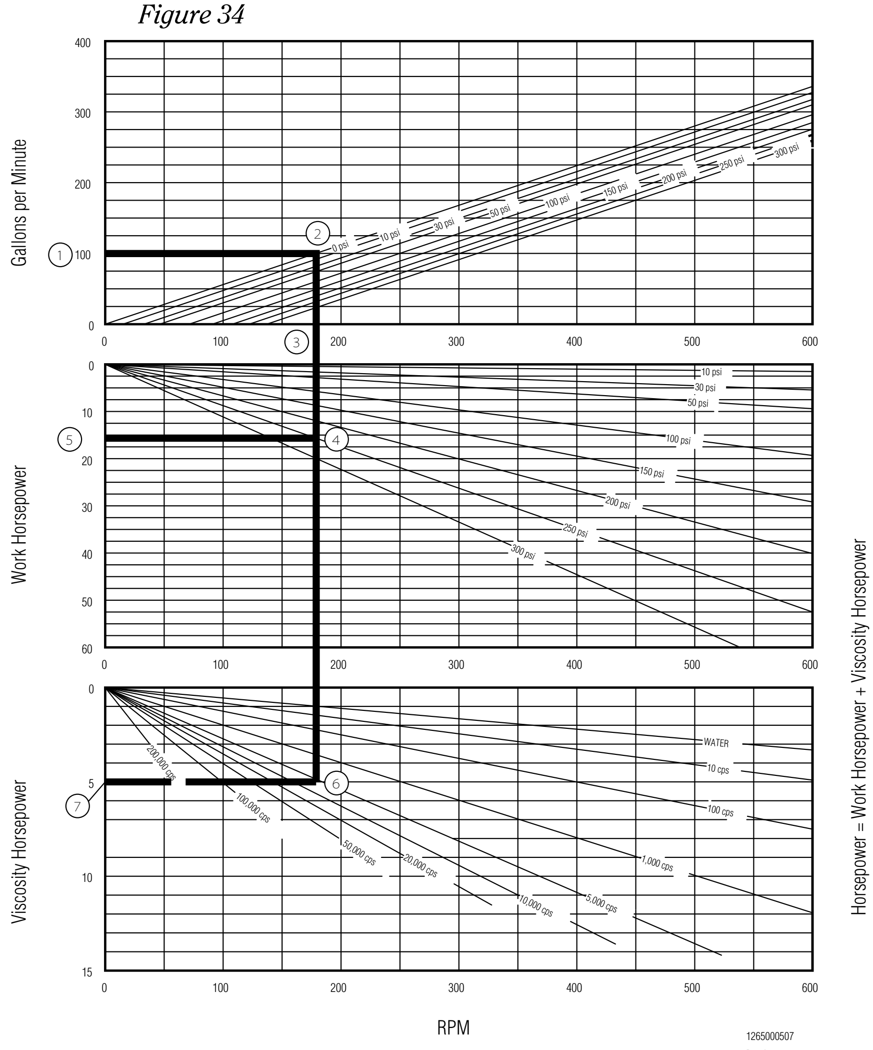
T = (22.5 x 63,025) / 179

T = 7,922 in-lbs

Check the NIPR of the pump using the NIPR curve Figure 33.

The NIPA of 10 psi will be more than the 5.3 psi required for the FKL 250. The final selection would be a FKL 250, running at 179 rpm with a 25 hp drive and having a torque of 7,922 in-lbs.

Figure 34



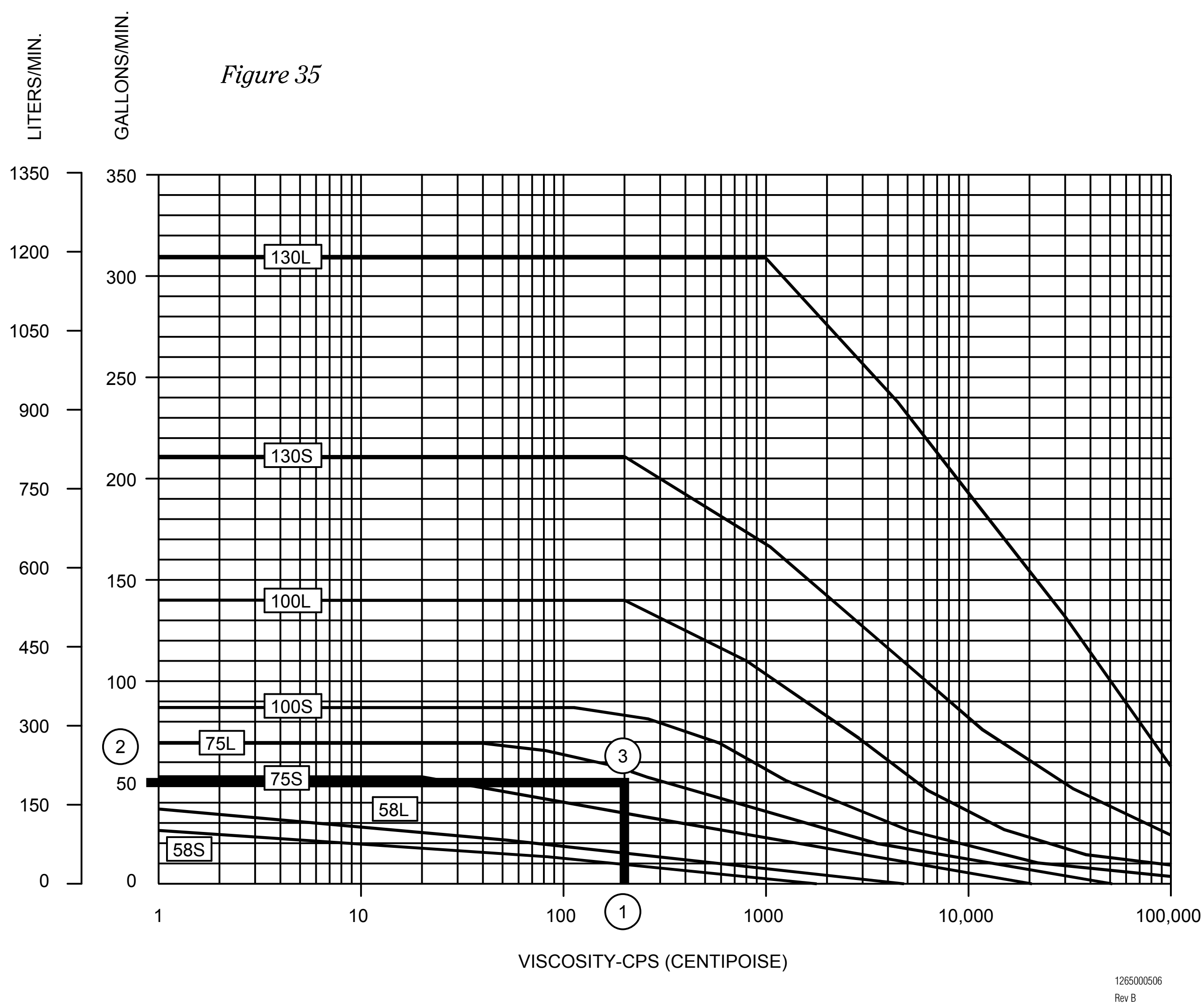
Example 3

Pie filling at 200 cps, 1.2 SG and 90°F

The duty will be 50 gpm @ 75 psi and the NIPA will be 10 psia

This is a simple application with a low duty point pressure and plenty of NIPA; therefore, we will select a FL II pump. Look at the composite curve (Figure 35) and select a model (as explained earlier).

Figure 35



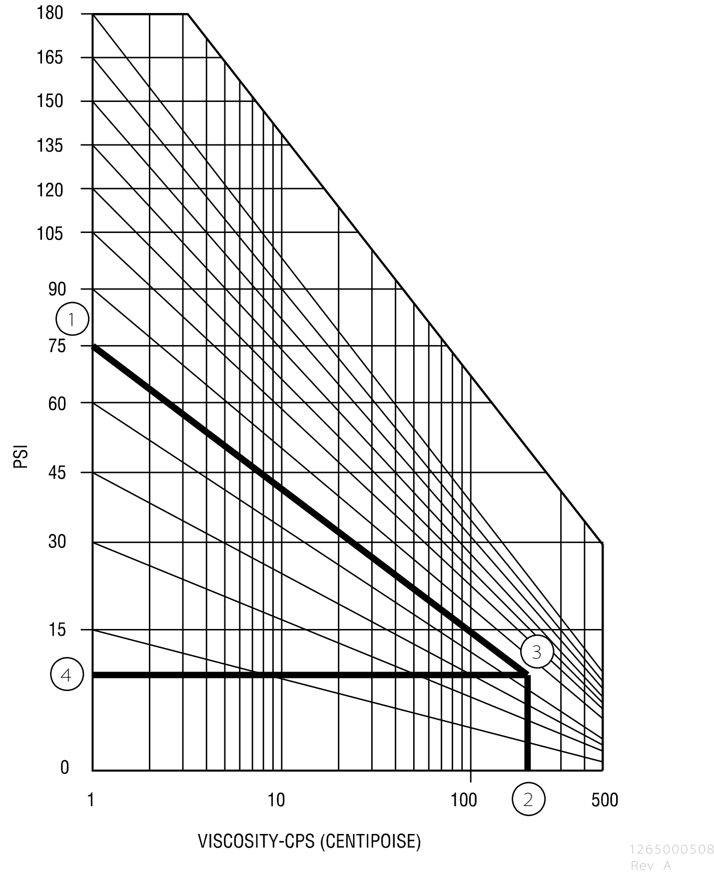
The FL II 100S is above the duty point. We will not select the FL II 75L for this application, because we are trying to keep the pump speed below the 400 – 500 rpm range.

This duty will require a viscosity adjustment, but will not require a high temperature adjustment.

Following the viscosity adjustment procedure for the FL II pump, we determine the slip curve will be read on the 10 psi line.

The NIPA for the application is 10 psia, which is more than adequate for the FL II 100S.

Figure 36



Calculate the pump speed, horsepower and application torque.

For example 3, the FL II 100S requires 390 rpm to deliver 200 cps product at 50 gpm against 75 psi.

BHp = WHp = VHp

BHp = 4.2 + 1.2

BHp = 5.4

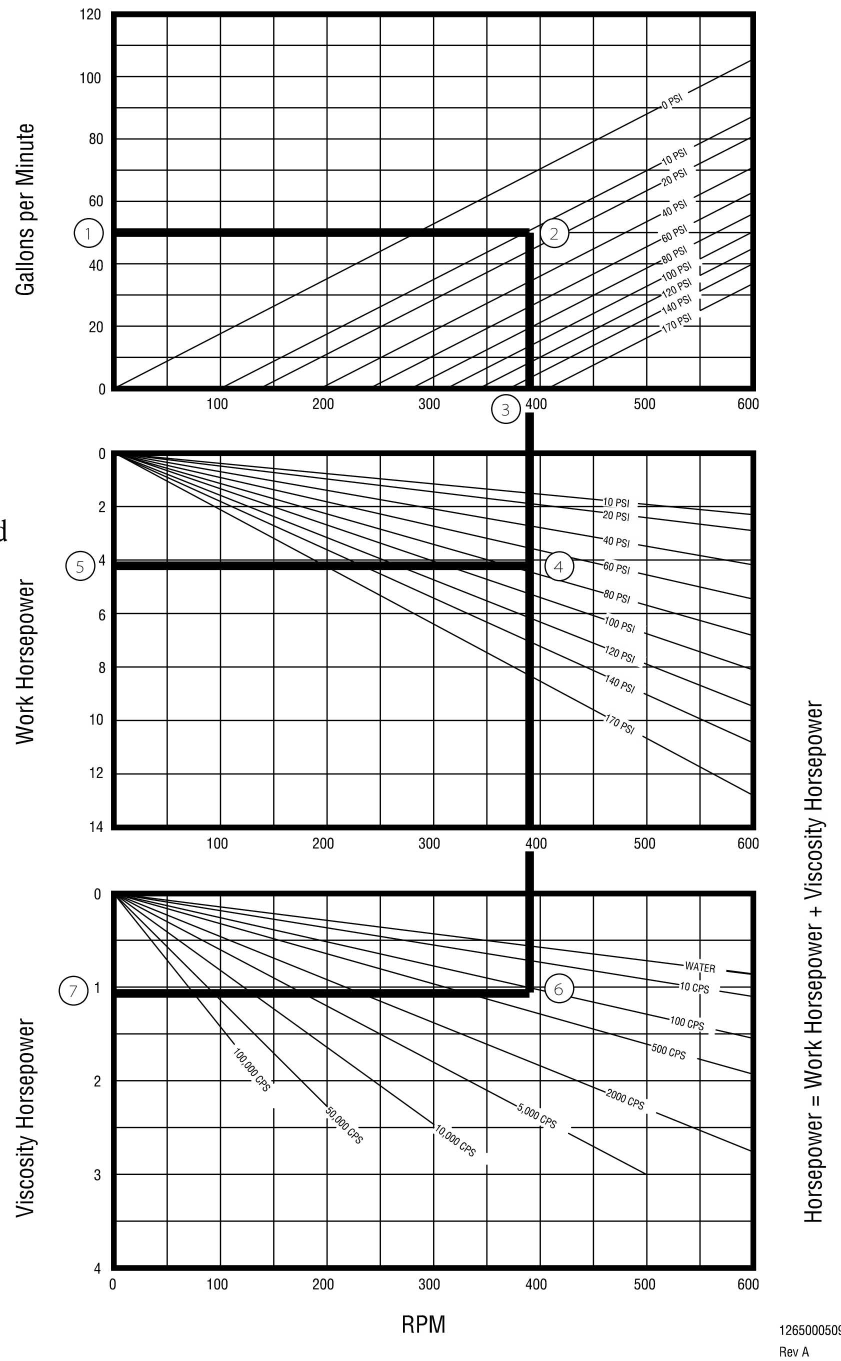
T = (BHp x 63,025) / speed

T = (5.4 x 63,025) / 390

T = 873 in-lbs

The final selection would be a FL II 100S, running at 390 rpm with a 7.5 Hp drive and having a torque of 873 in-lbs.

Figure 37



Example 4

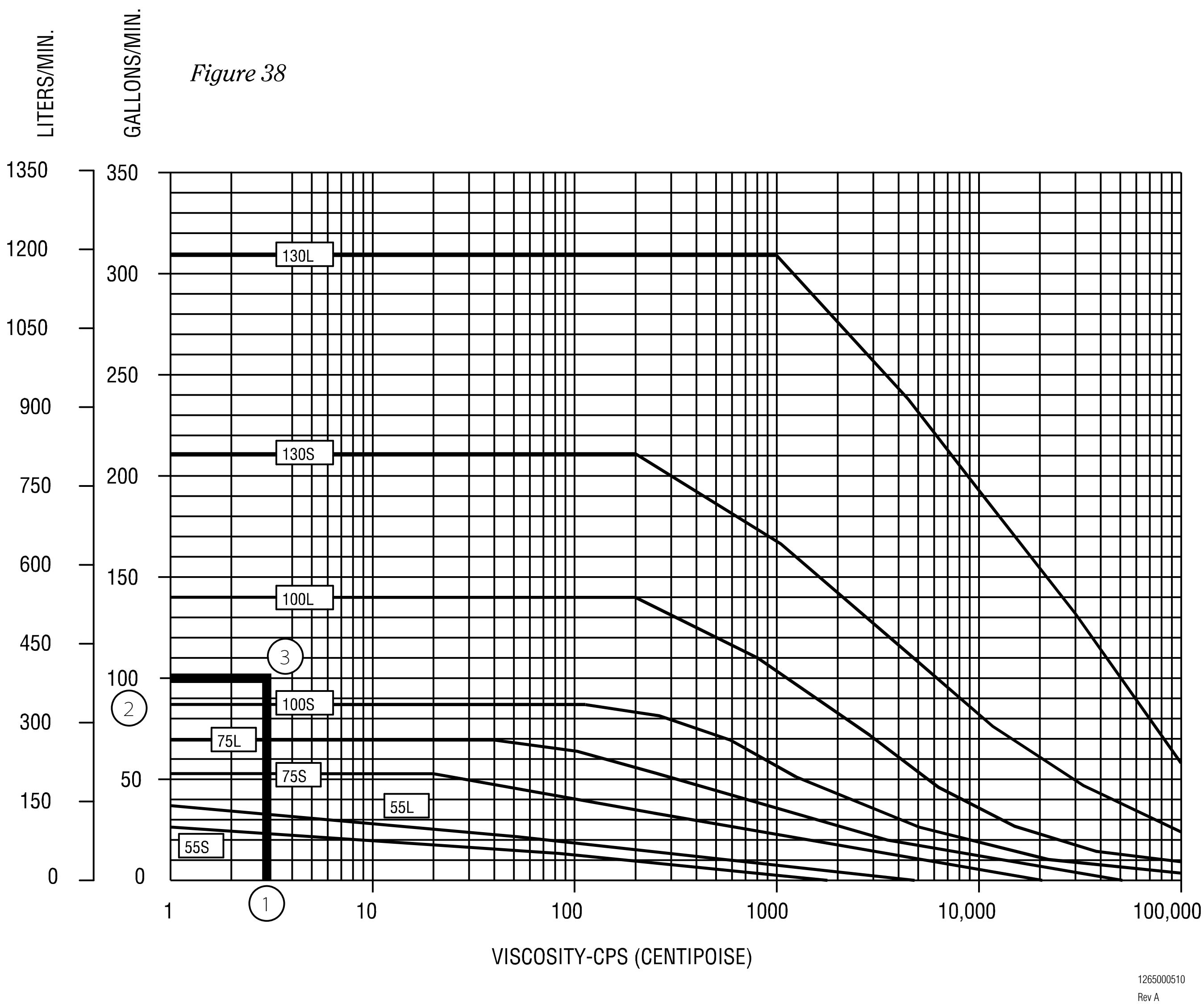
Vegetable Oil at 3 cps, 0.98 SG and 275°F

The duty will be 100 gpm @ 80 psi and the NIPA will be 10 psia

This is a simple application with a low duty point pressure and plenty of NIPA; therefore, we will select a FL II pump. Look at the composite curve (Figure 38) and select a model (as explained earlier).

The FL II 130S falls above the duty point and will fall within the preferred speed range.

Figure 38

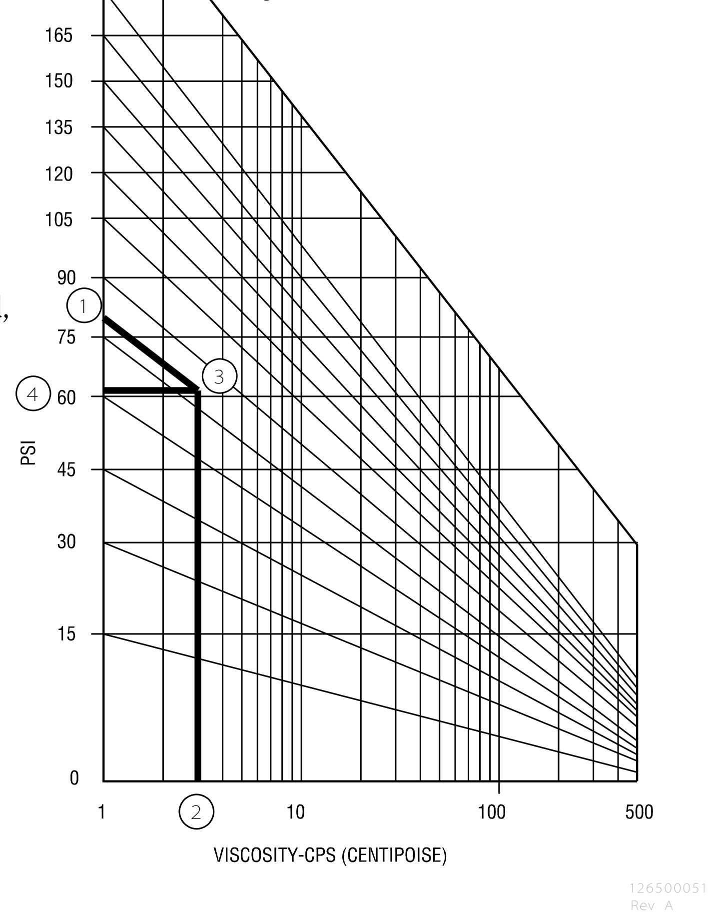


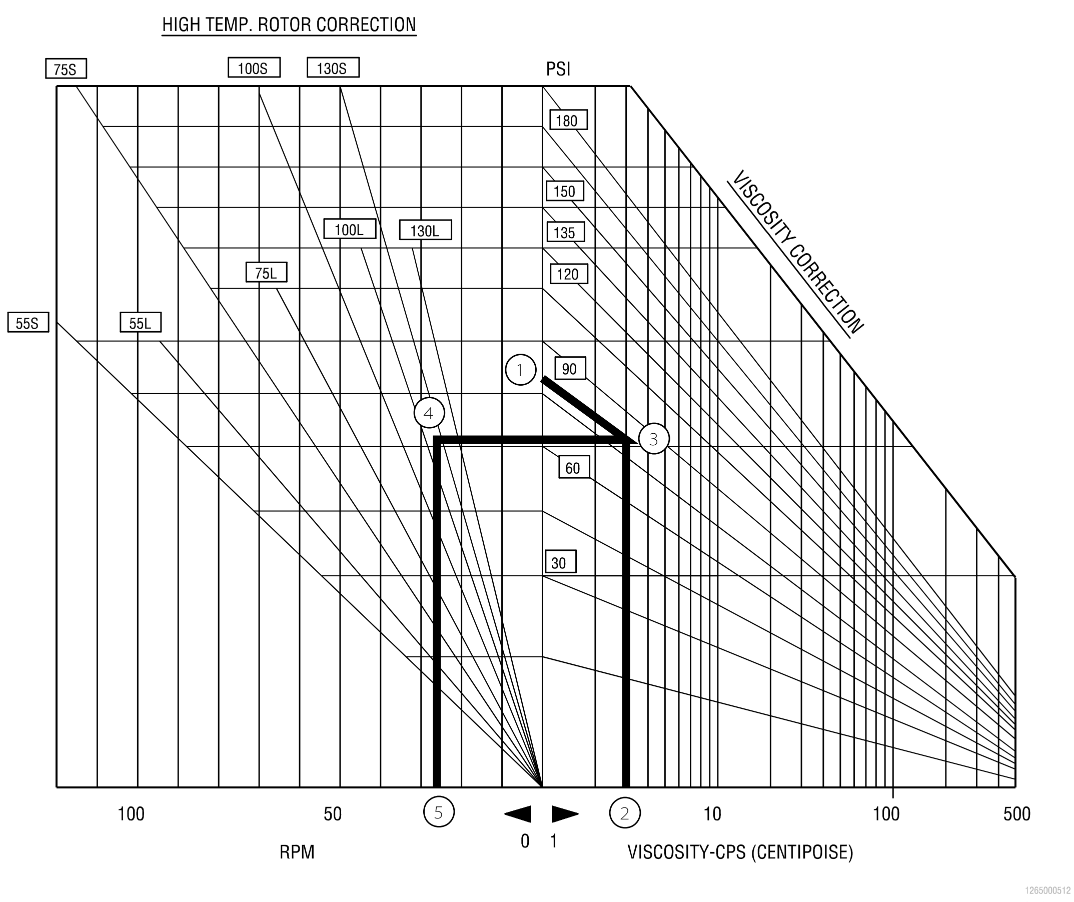
This duty will require a small viscosity adjustment and a high temperature adjustment.

Following the viscosity adjustment procedure for the FL II pump, we determine the slip curve will be read on the 62 psi line.

Use the High Temperature Rotor Correction curve (Figure 40) to determine the speed adjustment. We will add 27 rpm to the speed, to compensate for the high temperature rotors.

Figure 39





The NIPA for the application is 10 psia, which is more than adequate for the FL II 130S.

Calculate the pump speed, horsepower and application torque.

For example 4, the FL II 130S requires 360 rpm to deliver 3 cps product at 100 gpm against 80 psi. We then need to add 27 rpm to the 360 rpm.

BHp = WHp + VHp

BHp = 10.0 + 1.5

BHp = 11.5

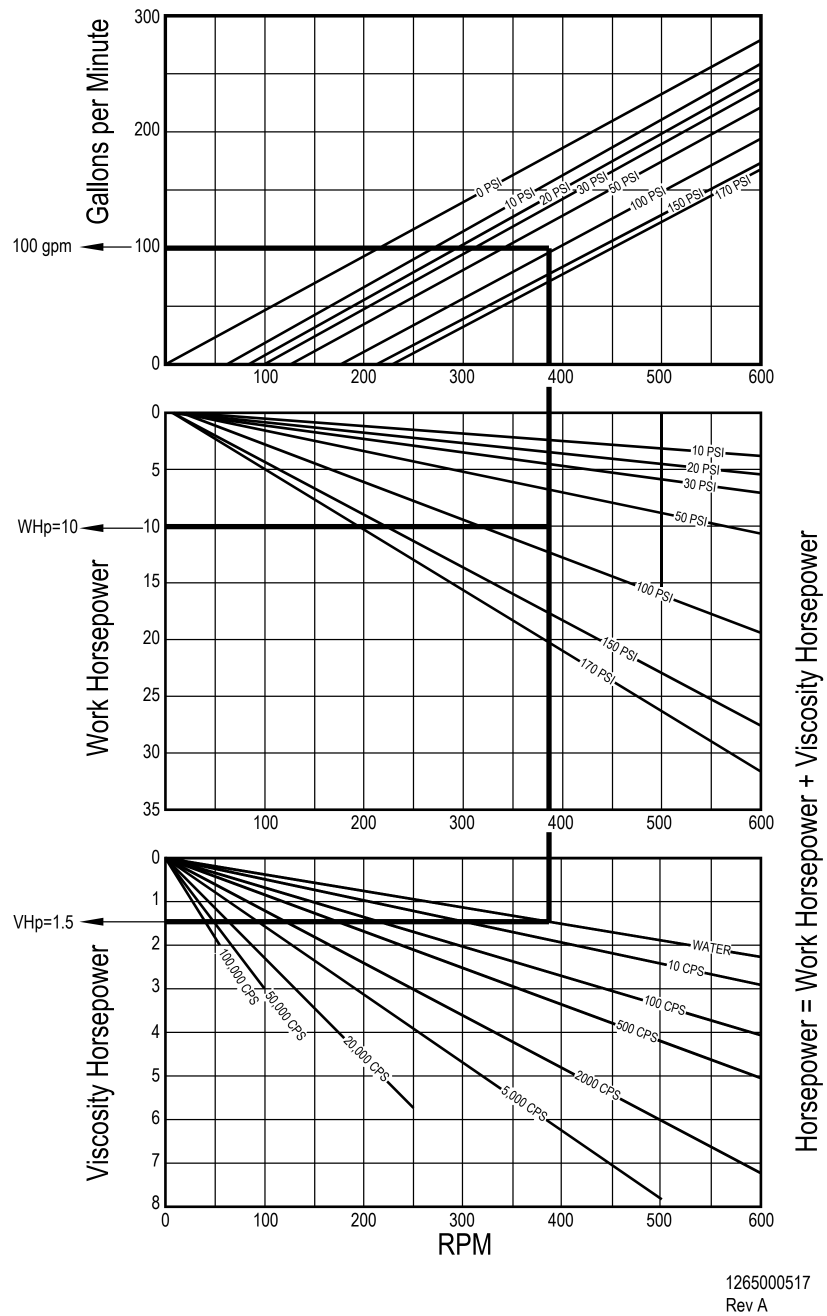
T = (BHp x 63,025) / speed

T = (11.5 x 63,025) / 387

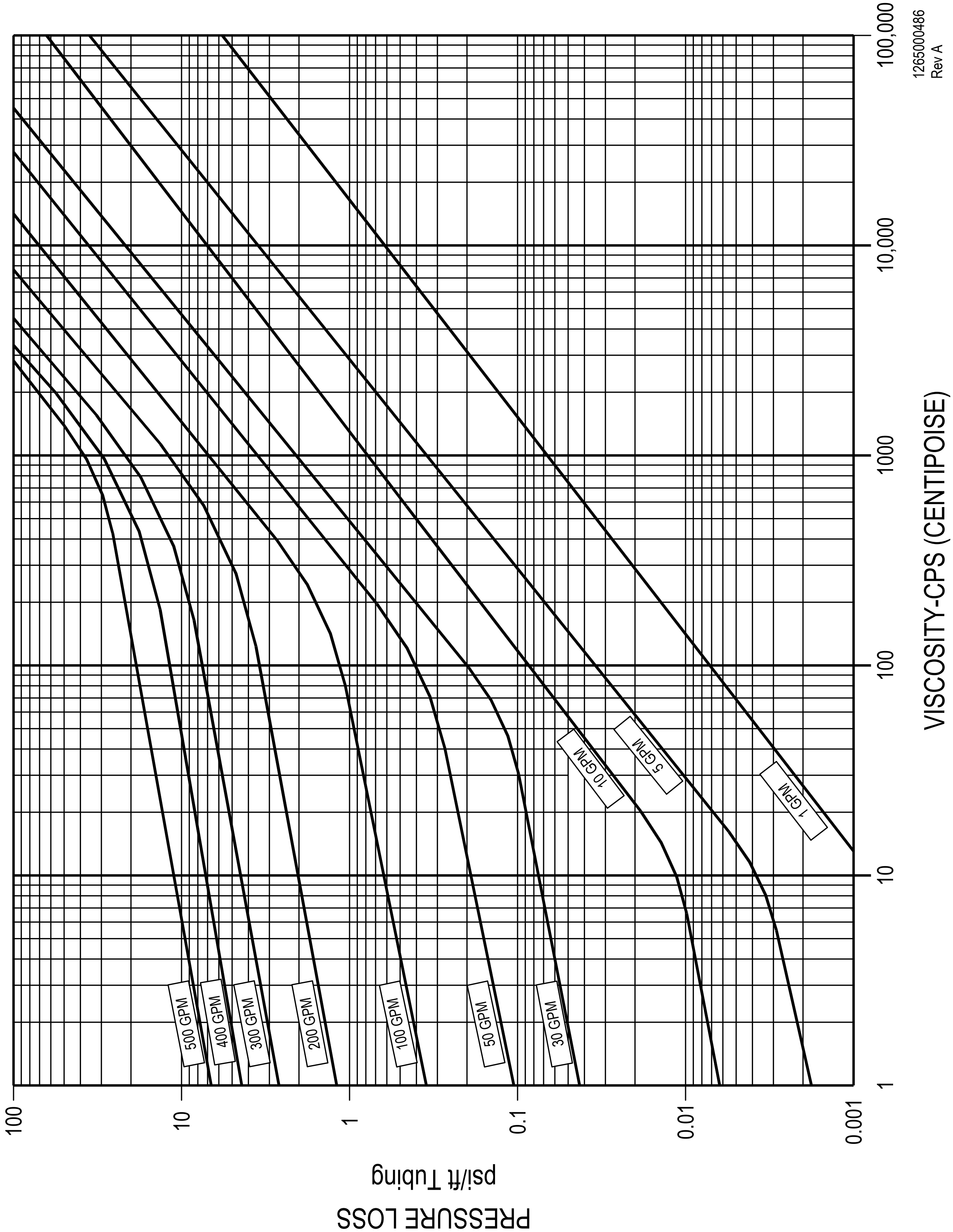
T = 2,085 in-lbs

The final selection would be a FL II 130S, running at 387 rpm with a 15 Hp drive and having a torque of 2,085 in-lbs.

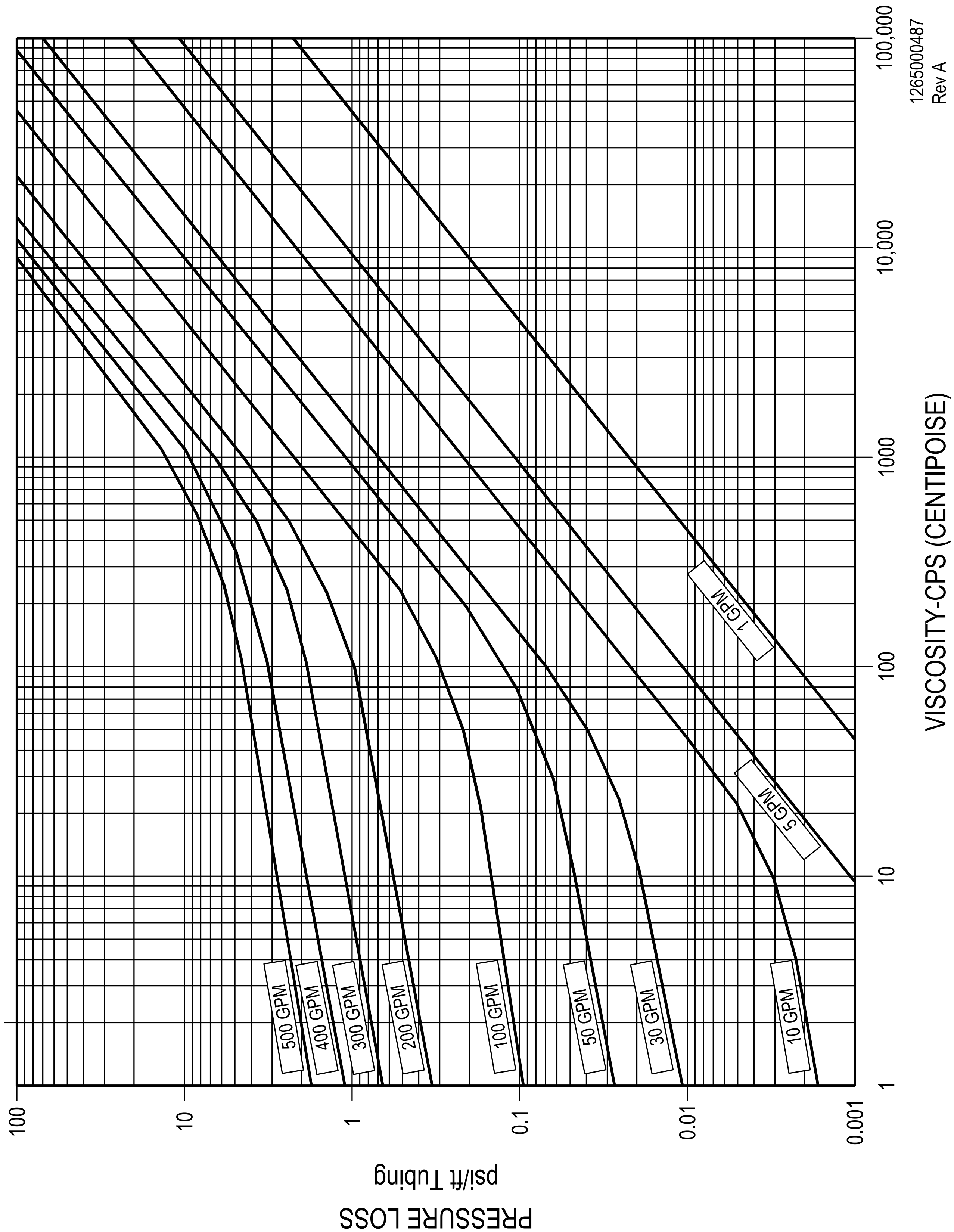
Figure 41



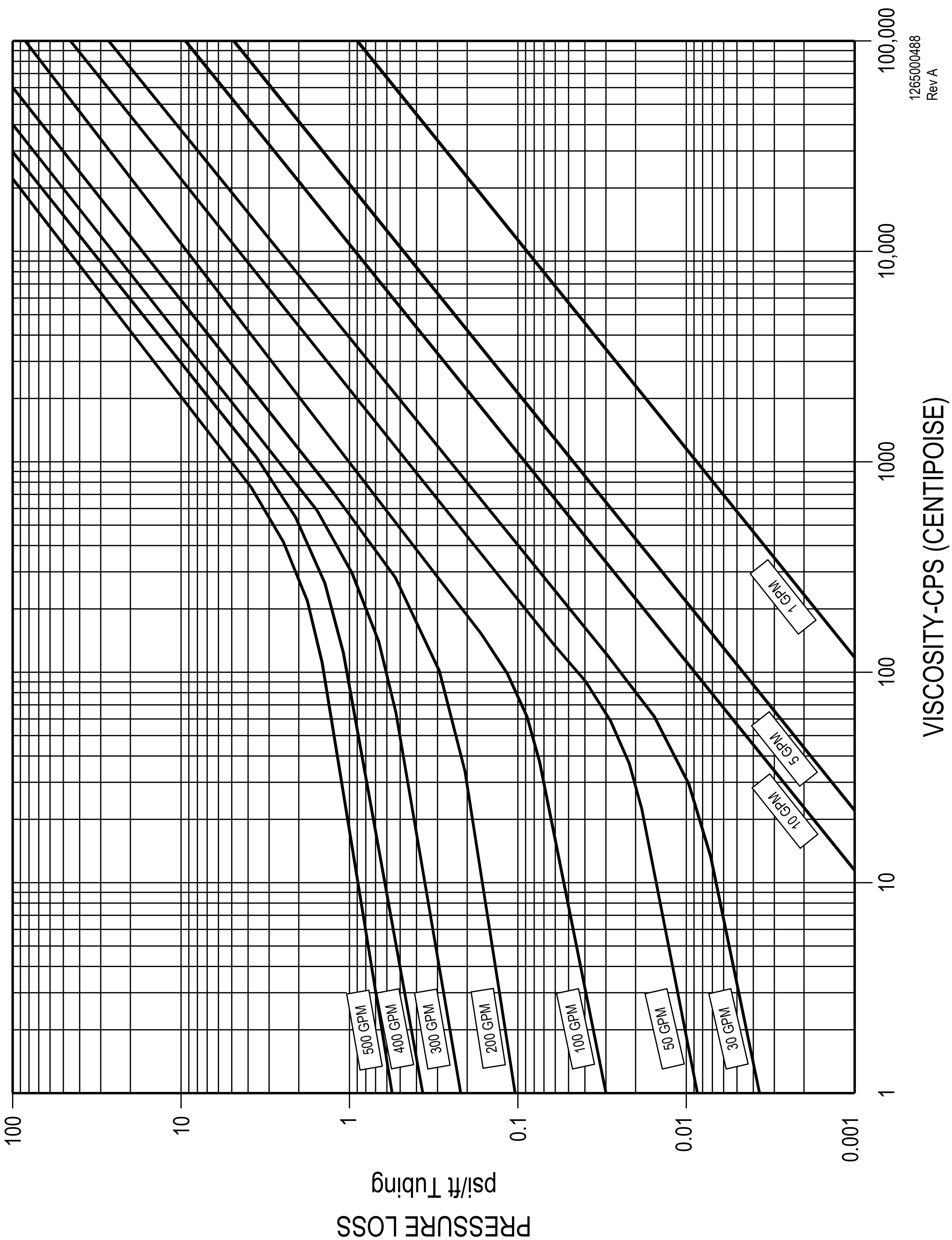
Friction Loss Curve—1.5" Stainless Steel Tubing



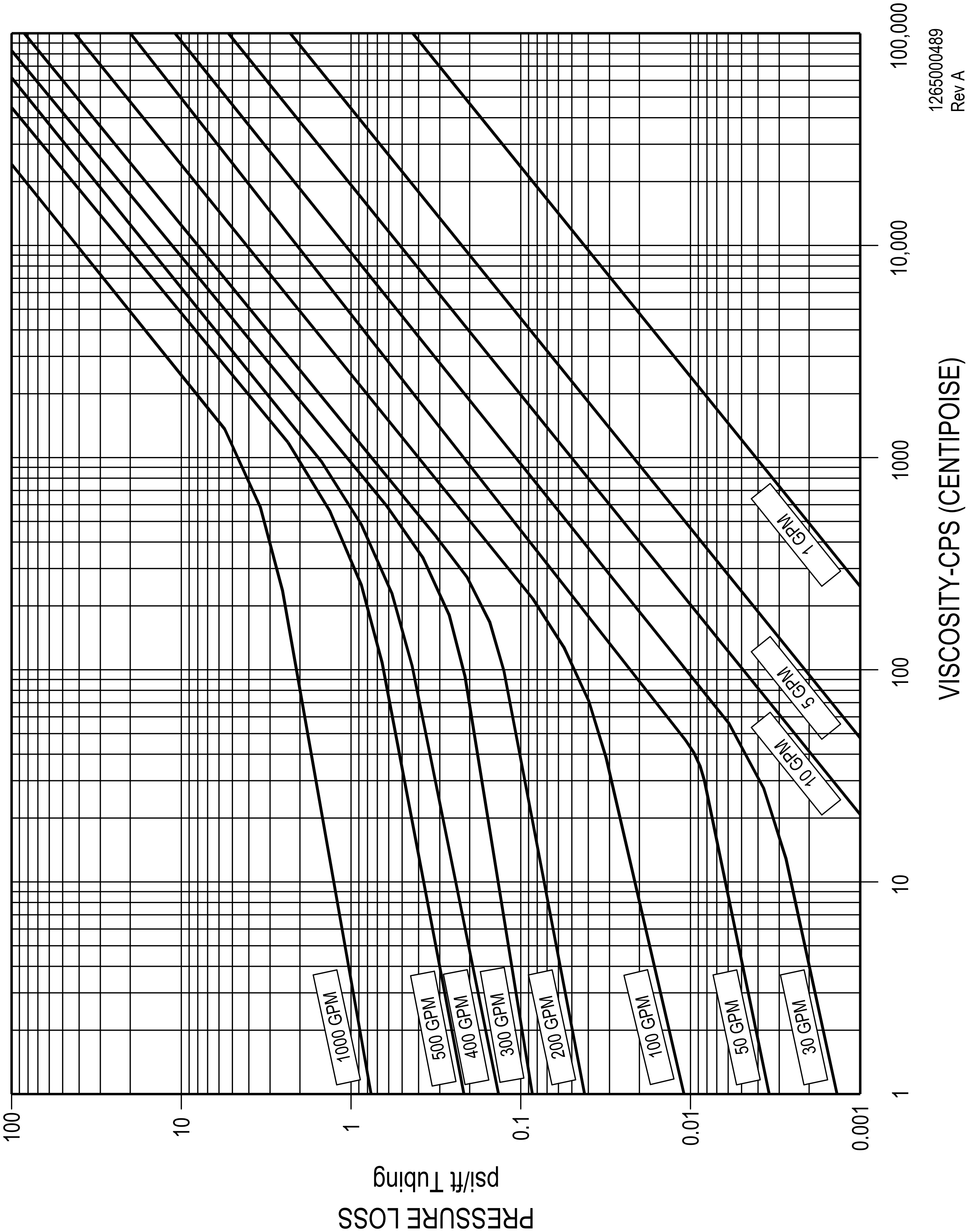
Friction Loss Curve—2” Stainless Steel Tubing

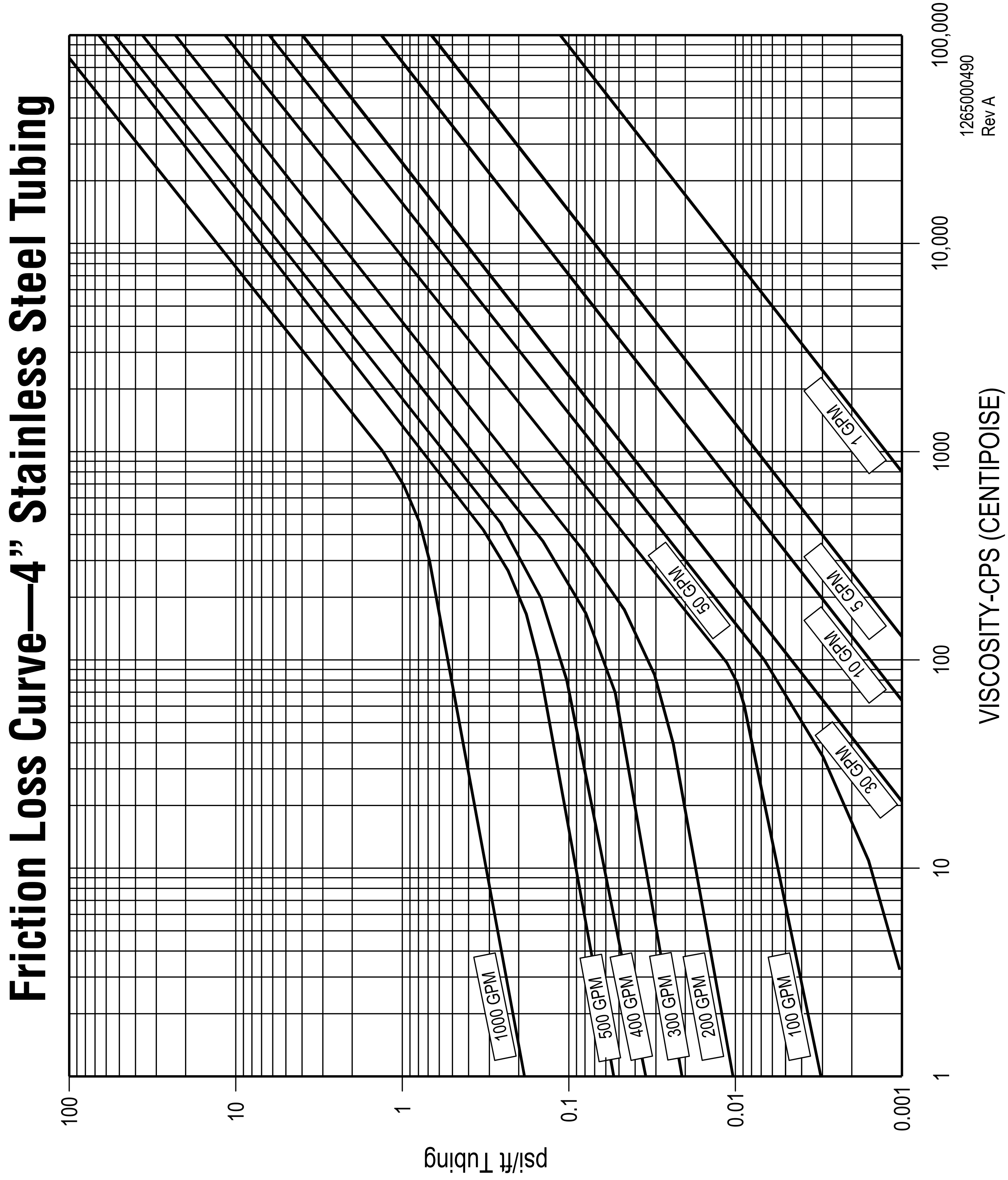


Friction Loss Curve—2.5” Stainless Steel Tubing

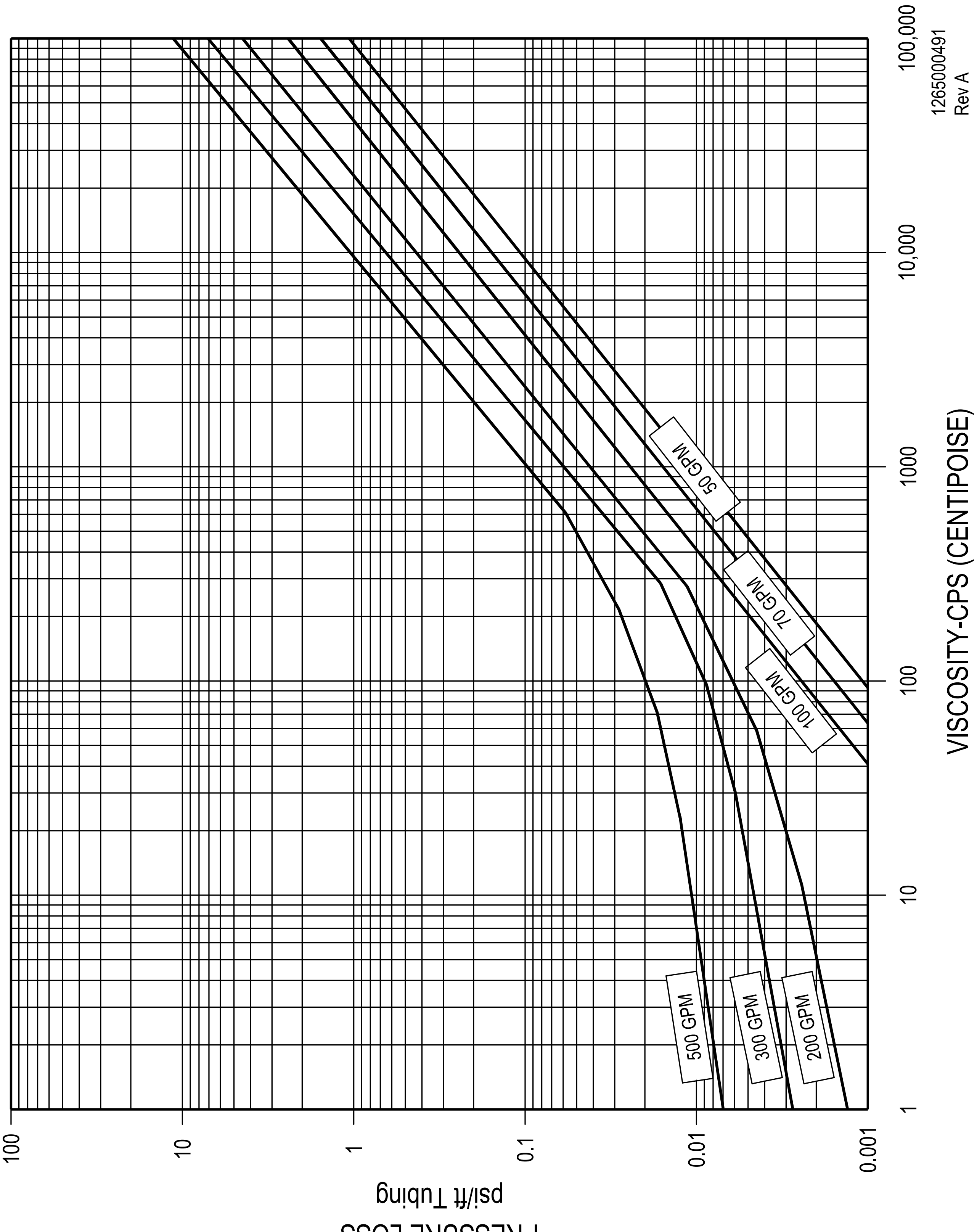


Friction Loss Curve—3” Stainless Steel Tubing

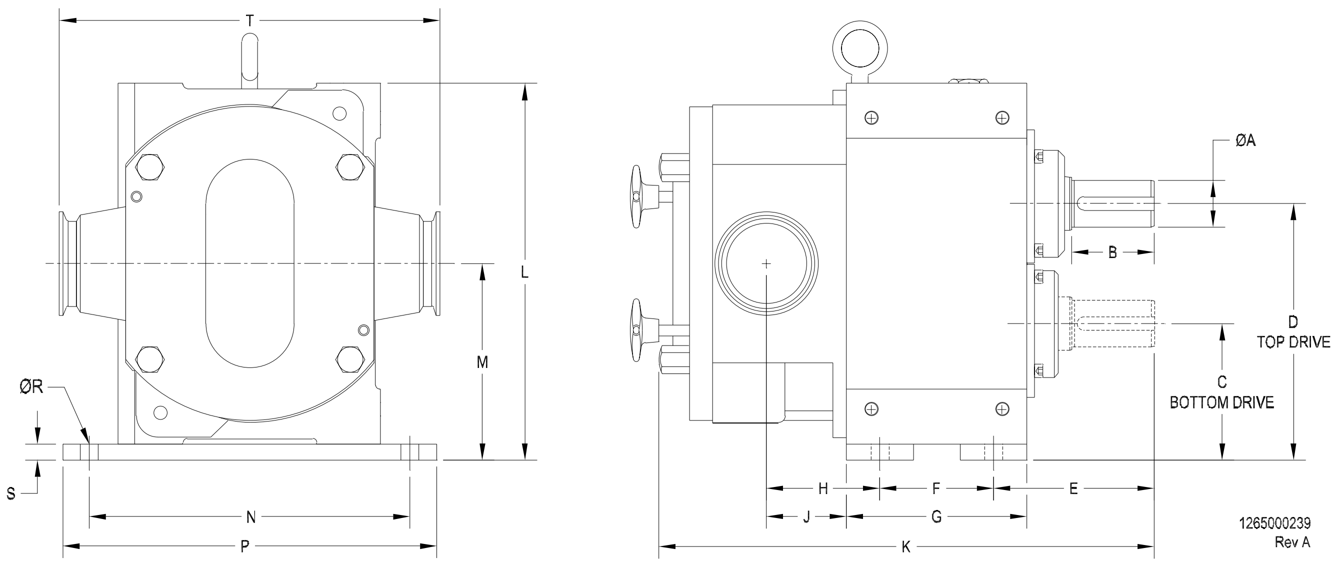



Friction Loss Curve—4” Stainless Steel Tubing
PRESSURE LOSS
psi/ft Tubing
100
10
1
0.1
0.01
0.001
1
10
100
1000
10,000
100,000
VISCOSITY-CPS (CENTIPOISE)
1000 GPM
500 GPM
400 GPM
300 GPM
200 GPM
100 GPM
50 GPM
30 GPM
10 GPM
5 GPM
1 GPM
1265000490
Rev A

Friction Loss Curve—6” Stainless Steel Tubing



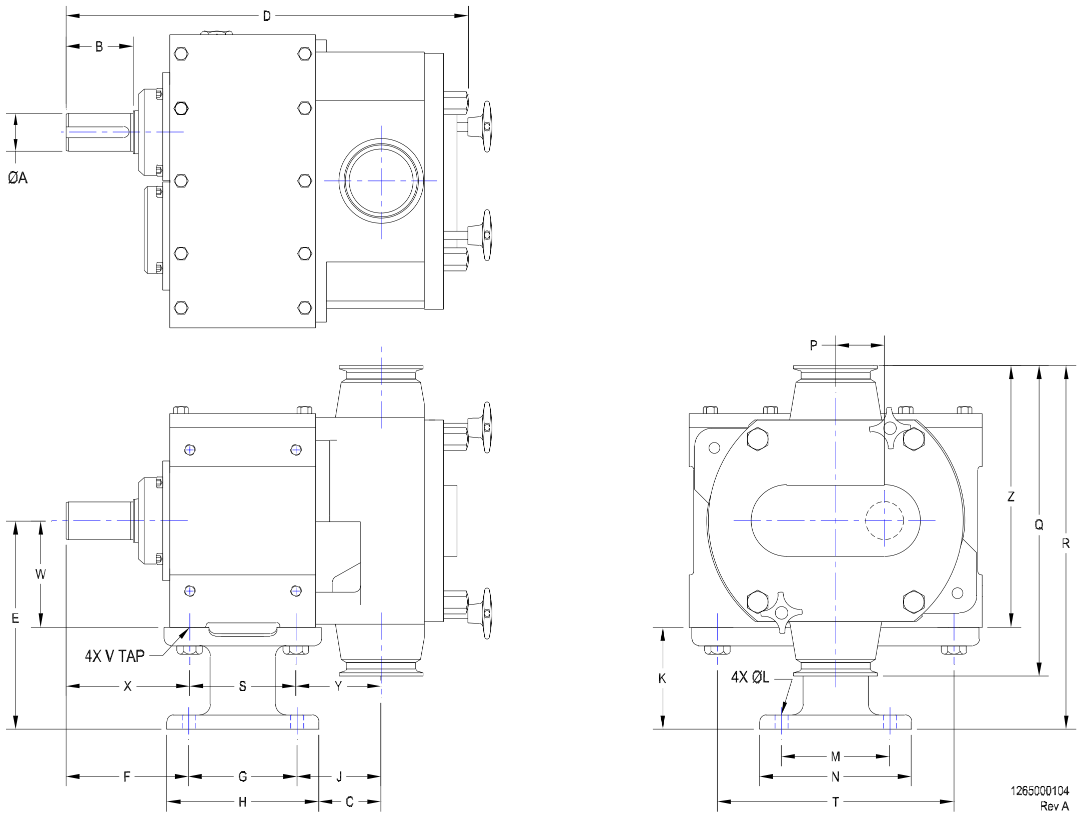
FKL Horizontal Mount Dimensional Drawing
Models 15—600



PUMP MODEL	INLET/OUTLET	DIMENSIONS IN MILLIMETERS (INCHES)																			WEIGHT
		ØA	B	C	D	E	F	G	H	J	K	L	M	N	P	ØR	S	T	U	V	
FKL 15	1-1/2" CLAMP	3/4"	63 (2.48")	71.5 (2.81")	137.5 (5.41")	82 (3.23")	82 (3.23")	107.5 (4.23")	39 (1.54")	26 (1.02")	242.5 (9.55")	196.5 (7.74")	104.5 (4.11")	150 (5.91")	170 (6.69")	10.5 (0.41")	9.5 (0.37")	175.2 (6.90")	50 (1.97")	4.76 (0.19")	19 kg (42 lbs)
FKL 20	1-1/2" CLAMP	3/4"	63 (2.48")	71.5 (2.81")	137.5 (5.41")	82 (3.23")	82 (3.23")	107.5 (4.23")	41 (1.61")	28 (1.10")	245.5 (9.67")	196.5 (7.74")	104.5 (4.11")	150 (5.91")	170 (6.69")	10.5 (0.41")	9.5 (0.37")	175.2 (6.90")	50 (1.97")	4.76 (0.19")	20 kg (44 lbs)
FKL 25	1-1/2" CLAMP	1-1/4"	41 (1.61")	93.5 (3.68")	173.5 (6.83")	76 (2.99")	117 (4.61")	155 (6.10")	84 (3.31")	65 (2.56")	328.5 (12.93")	254.5 (10.02")	133.5 (5.26")	219 (8.62")	241 (9.49")	11 (0.43")	12.5 (0.50")	195 (7.68")	33 (1.30")	6.4 (0.25")	49 kg (108 lbs)
FKL 50	2-1/2" CLAMP	1-3/8"	62 (2.44")	102.5 (4.04")	192.5 (7.58")	120.5 (4.74")	85 (3.35")	135 (5.32")	85 (3.35")	60 (2.36")	371 (14.61")	282.5 (11.12")	147.5 (5.81")	240 (9.45")	280 (11.02")	13.5 (0.53")	12.5 (0.50")	285 (11.22")	55 (2.17")	7.9 (0.31")	64 kg (141 lbs)
FKL 75	2-1/2" CLAMP	1-5/8"	73 (2.87")	157 (6.18")	271 (10.67")	118 (4.65")	150 (5.91")	200 (7.87")	103.5 (4.07")	78.5 (3.09")	453 (17.83")	409 (16.10")	214 (8.43")	343 (13.50")	393 (15.47")	17.5 (0.69")	19 (0.75")	306 (12.05")	55 (2.17")	9.5 (0.38")	169 kg (372 lbs)
FKL 150	3" CLAMP	1-3/4"	67 (2.64")	171 (6.73")	291 (11.46")	114 (4.49")	177.5 (6.99")	227.5 (8.96")	111.5 (4.39")	86.5 (3.40")	494 (19.45")	443 (17.44")	231 (9.09")	364 (14.33")	414 (16.30")	17.5 (0.69")	19 (0.75")	326 (12.83")	61 (2.40")	9.5 (0.38")	210 kg (463 lbs)
FKL 205	4" CLAMP	2-1/4"	106 (4.17")	174.5 (6.87")	323 (12.72")	143 (5.63")	182 (7.17")	233 (9.17")	113 (4.45")	87.5 (3.44")	548 (21.57")	478.5 (18.84")	249 (9.80")	381 (15.00")	419 (16.50")	17.5 (0.69")	19 (0.75")	342 (13.46")	75 (2.95")	12.7 (0.50")	287 kg (632 lbs)
FKL 250	4" CLAMP	2-1/2"	79 (3.11")	196.5 (7.74")	359 (14.13")	129.5 (5.10")	215 (8.46")	265 (10.43")	123 (4.84")	98 (3.86")	578.5 (22.78")	532.5 (20.96")	275.8 (10.86")	381 (15.00")	419 (16.50")	17.5 (0.69")	19 (0.75")	377 (14.84")	65 (2.56")	15.9 (0.63")	343 kg (756 lbs)
FKL 400	6" CLAMP	2-7/8"	95 (3.74")	209.5 (8.25")	385.5 (15.18")	152.5 (6.00")	234 (9.21")	285 (11.22")	106 (4.17")	80.5 (3.17")	637.5 (25.10")	569.5 (22.42")	297.5 (11.71")	432 (17.01")	482 (18.98")	22 (0.88")	25.5 (1.00")	499.5 (19.66")	80 (3.15")	19 (0.75")	440kg (970 lbs)
FKL 580	6" CLAMP	100 (3.94")	141 (5.55")	210 (8.27")	430 (16.93")	208 (8.19")	204 (8.03")	254 (10.00")	197 (7.75")	172 (6.77")	774 (30.47")	680.5 (26.79")	345 (13.60")	500 (19.69")	540 (21.25")	22 (0.88")	25.5 (1.00")	704 (27.72")	130 (5.12")	28 (1.10")	708kg (1560 lbs)
FKL 600	6" 300# FLANGE	100 (3.94")	141 (5.55")	210 (8.27")	430 (16.93")	208 (8.19")	204 (8.03")	254 (10.00")	197 (7.75")	172 (6.77")	774 (30.47")	680.5 (26.79")	345 (13.60")	500 (19.69")	540 (21.25")	22 (0.88")	25.5 (1.00")	707 (27.83")	130 (5.12")	28 (1.10")	750kg (1660 lbs)

1265000240 Rev G

FKL Vertical Mount Dimensional Drawing Models 15—600

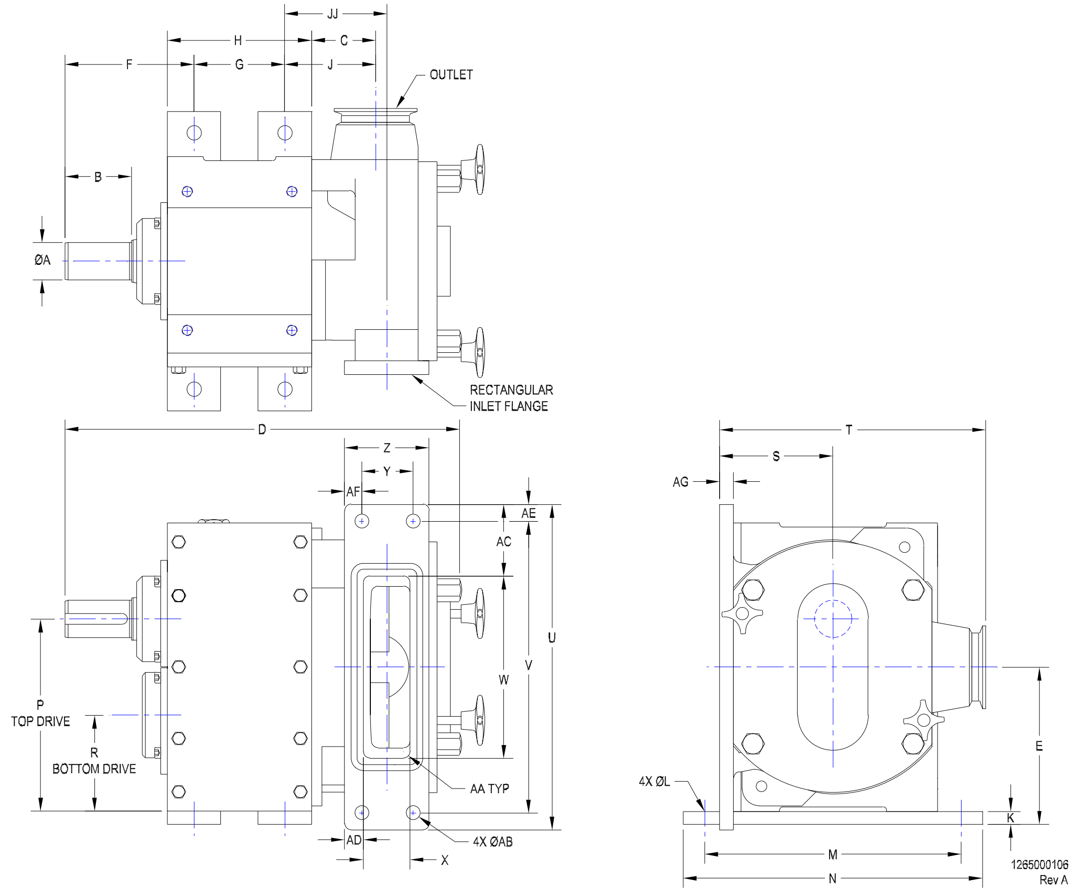


PUMP MODEL	INLET / OUTLET	DIMENSIONS IN MILLIMETERS (INCHES)									
		ØA	B	C	D	E	F	G	H	J	K	ØL
FKL 15	1-1/2" CLAMP	3/4"	63 (2.48")	30 (1.18")	242.5 (9.55")	141 (5.55")	82 (3.23")	82 (3.23")	100 (3.94")	39 (1.54")	78 (3.07")	9 (0.35")
FKL 20	1-1/2" CLAMP	3/4"	63 (2.48")	32 (1.26")	245.5 (9.67")	141 (5.55")	82 (3.23")	82 (3.23")	100 (3.94")	41 (1.61")	78 (3.07")	9 (0.35")
FKL 25	1-1/2" CLAMP	1-1/4"	41 (1.61")	66 (2.60")	328.5 (12.93")	174 (6.85")	76 (2.99")	117 (4.61")	153 (6.02")	84 (3.31")	88 (3.46")	11 (0.43")
FKL 50	2-1/2" CLAMP	1-3/8"	62 (2.44")	57.5 (2.26")	371 (14.61")	192 (7.56")	113 (4.45")	100 (3.94")	140 (5.51")	77.5 (3.05")	94 (3.70")	12 (0.47")
FKL 75	2-1/2" CLAMP	1-5/8"	73 (2.87")	78.5 (3.09")	454 (17.87")	271 (10.67")	118 (4.65")	150 (5.91")	200 (7.87")	103.5 (4.07")	136 (5.35")	17.5 (0.69")
FKL 150	3" CLAMP	1-3/4"	67 (2.64")	87.5 (3.44")	494 (19.45")	291 (11.46")	113 (4.45")	175 (6.90")	225 (8.86")	115 (4.53")	141 (5.55")	17.5 (0.69")
FKL 205	4" CLAMP	2-1/4"	106 (4.17")	88 (3.46")	548 (21.57")	323 (12.72")	143 (5.63")	182 (7.17")	232 (9.13")	113 (4.45")	163 (6.42")	17.5 (0.69")
FKL 250	4" CLAMP	2-1/2"	79 (3.11")	99.5 (3.92")	578.5 (22.78")	357.5 (14.07")	129.5 (5.10")	215 (8.46")	262 (10.32")	123 (4.84")	195 (7.68")	17.5 (0.69")
FKL 400	6" CLAMP	2-7/8"	95 (3.74")	-	637.5 (25.10")	385 (15.16")	-	-	-	-	-	-

PUMP MODEL	M	N	P	Q	R	S	T	V TAP	W	X	Y	Z	WEIGHT
FKL 15	88 (3.46")	105 (4.13")	33 (1.30")	175.2 (6.90")	228.6 (9.00")	82 (3.23")	88 (3.46")	M8X1.25	63 (2.48")	82 (3.23")	39 (1.54")	105.6 (4.16")	21 kg 45.5 lbs
FKL 20	88 (3.46")	105 (4.13")	33 (1.30")	175.2 (6.90")	228.6 (9.00")	82 (3.23")	88 (3.46")	M8X1.25	63 (2.48")	82 (3.23")	41 (1.61")	105.6 (4.16")	22 kg 48.5 lbs
FKL 25	122 (4.80")	158 (6.22")	40 (1.57")	195 (7.68")	271.5 (10.69")	117 (4.61")	122 (4.80")	M10X1.5	86 (3.39")	71 (2.80")	84 (3.31")	183.5 (7.22")	53 kg 117 lbs
FKL 50	100 (3.94")	140 (5.51")	45 (1.77")	285 (11.22")	334.5 (13.17")	98 (3.86")	218 (8.58")	M10X1.5	98 (3.86")	112 (4.41")	76.5 (3.01")	290 (11.42")	68 kg 150 lbs
FKL 75	100 (3.94")	150 (5.91")	57 (2.24")	306 (12.05")	424 (16.69")	150 (5.91")	215 (8.46")	M16X2	135 (5.31")	118 (4.65")	103.5 (4.07")	288 (11.34")	175 kg 387 lbs
FKL 150	130 (5.12")	180 (7.09")	60 (2.36")	326 (12.83")	454 (17.87")	177.5 (6.99")	240 (9.45")	M16X2	150 (5.91")	114 (4.49")	111.5 (4.39")	313 (12.32")	220 kg 486 lbs
FKL 205	212 (8.35")	262 (10.32")	74 (2.91")	342 (13.46")	493 (19.41")	182 (7.17")	262 (10.31")	M16X2	160 (6.30")	143 (5.63")	113 (4.45")	330 (13.00")	287 kg 632 lbs
FKL 250	215 (8.46")	262 (10.32")	81 (3.19")	377 (14.84")	546 (21.50")	215 (8.46")	262 (10.31")	M16X2	162.5 (6.40")	129.5 (5.10")	123 (4.84")	350.5 (13.80")	369 kg 813 lbs
FKL 400	-	-	88 (3.46")	499.5 (19.67")	635 (25.00")	234 (9.21")	300 (11.81")	M20X2.5	188 (7.40")	152.5 (6.00")	106 (4.17")	438 (17.24")	455 kg 1004 lbs

1265000260 Rev C

FKL Horizontal Mount Dimensional Drawing Models 50—400, Rectangular Inlet

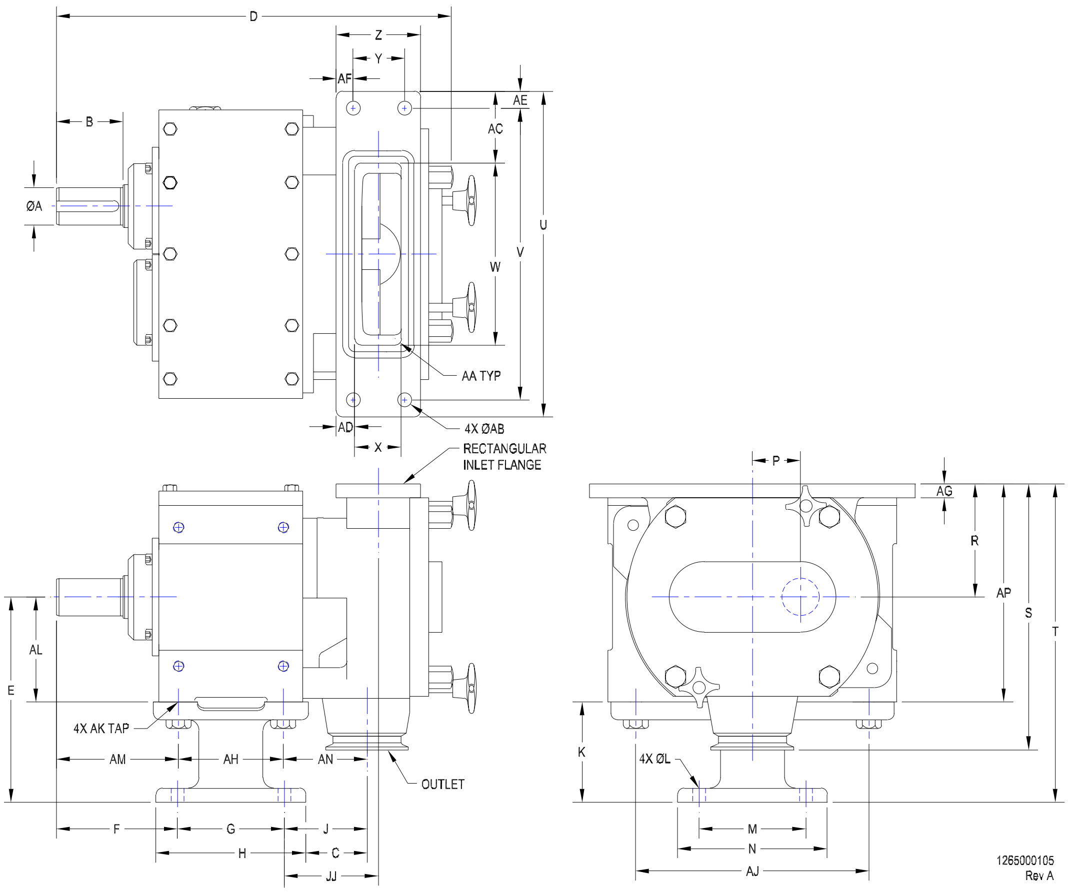


PUMP MODEL	OUTLET	DIMENSIONS IN MILLIMETERS (INCHES) ØA	B	C	D	E	F	G	H	J	JJ	K	ØL	M	N	P	R
FKL 50	2-1/2" CLAMP	1-3/8"	62 (2.44")	60 (2.36")	371 (14.61")	147.5 (5.81")	120.5 (4.74")	85 (3.35")	135 (5.32")	85 (3.35")	95 (3.74")	12.5 (0.50")	13.5 (0.53")	240 (9.45")	280 (11.02")	192.5 (7.58")	102.5 (4.04")
FKL 75	2-1/2" CLAMP	1-5/8"	73 (2.87")	78.5 (3.09")	454 (17.87")	214 (8.43")	118 (4.65")	150 (5.91")	200 (7.87")	103.5 (4.07")	105 (4.13")	19 (0.75")	17.5 (0.69")	343 (13.50")	393 (15.47")	271 (10.67")	157 (6.18")
FKL 150	3" CLAMP	1-3/4"	67 (2.64")	86.5 (3.40")	494 (19.45")	231 (9.09")	114 (4.49")	177.5 (6.99")	227.5 (8.96")	111.5 (4.39")	106 (4.17")	19 (0.75")	17.5 (0.69")	364 (14.33")	414 (16.30")	291 (11.46")	171 (6.73")
FKL 205	4" CLAMP	2-1/4"	106 (4.17")	87.5 (3.44")	548 (21.57")	249 (9.80")	143 (5.63")	182 (7.17")	233 (9.17")	113 (4.45")	113 (4.45")	19 (0.75")	17.5 (0.69")	381 (15.00")	419 (16.50")	323 (12.72")	174.5 (6.87")
FKL 250	4" CLAMP	2-1/2"	79 (3.11")	98 (3.86")	578.5 (22.78")	275.8 (10.86")	129.5 (5.10")	215 (8.46")	265 (10.43")	123 (4.84")	122.5 (4.82")	19 (0.75")	17.5 (0.69")	381 (15.00")	419 (16.50")	357 (14.06")	194.5 (7.66")
FKL 400	6" CLAMP	2-7/8"	95 (3.74")	80.5 (3.17")	637.5 (25.10")	297.5 (11.71")	152.5 (6.00")	234 (9.21")	285 (11.22")	106 (4.17")	113 (4.45")	25.5 (1.00")	22 (0.88")	432 (17.01")	482 (18.98")	385.5 (15.18")	209.5 (8.25")

PUMP MODEL	S	T	U	V	W	X	Y	Z	AA	ØAB	AC	AD	AE	AF	AG	WEIGHT
FKL 50	106 (4.17")	249 (9.80")	305 (12.01")	273 (10.75")	171 (6.73")	44 (1.73")	48 (1.89")	79 (3.11")	R6 (0.24"R)	13.5 (0.53")	67 (2.64")	17.5 (0.69")	16 (0.63")	15.5 (0.61")	13 (0.51")	68 kg 150 lbs
FKL 75	145 (5.71")	298 (11.73")	336 (13.23")	310 (12.20")	224 (8.82")	57 (2.24")	102 (4.02")	127 (5.00")	R10 (0.39"R)	13.5 (0.53")	56 (2.20")	35 (1.38")	13 (0.51")	13 (0.51")	15 (0.59")	177 kg 391 lbs
FKL 150	157 (6.18")	320 (12.60")	387 (15.24")	355 (13.98")	235 (9.25")	75 (2.95")	84 (3.31")	118 (4.65")	R10 (0.39"R)	13.5 (0.53")	76 (2.99")	21.5 (0.85")	16 (0.63")	17 (0.67")	13 (0.51")	220 kg 486 lbs
FKL 205	163 (6.42")	335 (13.19")	457 (17.99")	425 (16.73")	279 (10.98")	99 (3.90")	111 (4.37")	147 (5.79")	R10 (0.39"R)	13.5 (0.53")	89 (3.50")	22 (0.87")	16 (0.63")	16 (0.63")	13 (0.51")	289 kg 637 lbs
FKL 250	181 (7.13")	369 (14.53")	457 (17.99")	425 (16.73")	279 (10.98")	99 (3.90")	111 (4.37")	143 (5.63")	R10 (0.39"R)	13.5 (0.53")	89 (3.50")	22 (0.87")	16 (0.63")	16 (0.63")	13 (0.51")	366 kg 807 lbs
FKL 400	243 (9.57")	493 (19.41")	505 (19.88")	470 (18.50")	441 (17.36")	127 (5.00")	209.5 (8.25")	241 (9.49")	R13 (0.51"R)	17 (0.66")	32 (1.26")	57 (2.24")	17.5 (0.69")	15.5 (0.61")	22 (0.87")	513 kg 1131 lbs

1265000261 Rev C

FKL Vertical Mount Dimensional Drawing
Models 50—400, Rectangular Inlet



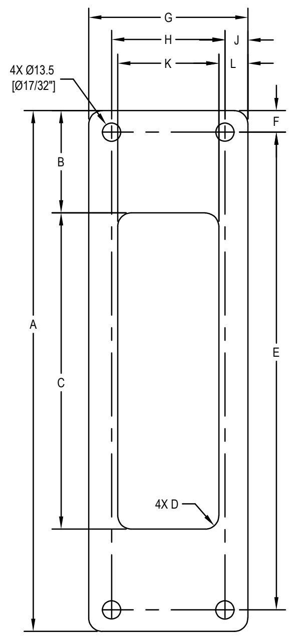
PUMP MODEL	OUTLET	DIMENSIONS IN MILLIMETERS (INCHES)																		
		ØA	B	C	D	E	F	G	H	J	JJ	K	ØL	M	N	P	R	S	T
FKL 50	2-1/2" CLAMP	1-3/8"	62 (2.44")	57.5 (2.26")	371 (14.61")	192 (7.56")	113 (4.45")	100 (3.94")	140 (5.51")	77.5 (3.05")	87.5 (3.44")	94 (3.70")	12 (0.47")	100 (3.94")	140 (5.51")	45 (1.77")	106 (4.17")	249 (9.80")	298 (11.73")
FKL 75	2-1/2" CLAMP	1-5/8"	73 (2.87")	78.5 (3.09")	454 (17.87")	271 (10.67")	118 (4.65")	150 (5.91")	200 (7.87")	103.5 (4.07")	105 (4.13")	136 (5.35")	17.5 (0.69")	100 (3.94")	150 (5.91")	57 (2.24")	145 (5.71")	298 (11.73")	416 (16.38")
FKL 150	3" CLAMP	1-3/4"	67 (2.64")	87.5 (3.44")	494 (19.45")	291 (11.46")	113 (4.45")	175 (6.89")	225 (8.86")	115 (4.53")	109.5 (4.31")	141 (5.55")	18 (0.71")	130 (5.12")	180 (7.09")	60 (2.36")	157 (6.18")	320 (12.60")	448 (17.64")
FKL 205	4" CLAMP	2-1/4"	106 (4.17")	88 (3.46")	548 (21.57")	323 (12.72")	143 (5.63")	182 (7.17")	232 (9.13")	113 (4.45")	113 (4.45")	163 (6.42")	17.5 (0.69")	212 (8.35")	262 (10.32")	74 (2.91")	163 (6.42")	335 (13.19")	486 (19.13")
FKL 250	4" CLAMP	2-1/2"	79 (3.11")	99.5 (3.92")	578.5 (22.78")	357.5 (14.07")	129.5 (5.10")	215 (8.46")	262 (10.32")	123 (4.84")	122.5 (4.82")	195 (7.68")	18 (0.71")	215 (8.46")	262 (10.32")	81 (3.19")	181 (7.13")	369 (14.53")	538.5 (21.20")
FKL 400	6" CLAMP	2-7/8"	95 (3.74")	-	637.5 (25.10")	-	-	-	-	-	-	-	-	-	-	88 (3.46")	243 (9.57")	493 (19.41")	-

PUMP MODEL	U	V	W	X	Y	Z	AA	ØAB	AC	AD	AE	AF	AG	AH	AJ	AK TAP	AL	AM	AN	AP	WEIGHT
FKL 50	305 (12.01")	273 (10.75")	171 (6.73")	44 (1.73")	48 (1.89")	79 (3.11")	R6 (0.24"R)	13.5 (0.53")	67 (2.64")	17.5 (0.69")	16 (0.63")	15.5 (0.61")	13 (0.51")	98 (3.86")	218 (8.58")	M10X1.5	98 (3.86")	112 (4.41")	76.5 (3.01")	204 (8.03")	68 kg 150 lbs
FKL 75	336 (13.23")	310 (12.20")	224 (8.82")	57 (2.24")	102 (4.02")	127 (5.00")	R10 (0.39"R)	13.5 (0.53")	56 (2.20")	35 (1.38")	13 (0.51")	13 (0.51")	13 (0.51")	150 (5.91")	215 (8.46")	M16X2	135 (5.31")	118 (4.65")	103.5 (4.07")	280 (11.02")	177 kg 391 lbs
FKL 150	387 (15.24")	355 (13.98")	235 (9.25")	75 (2.95")	84 (3.31")	118 (4.65")	R10 (0.39"R)	13.5 (0.53")	76 (2.99")	21.5 (0.85")	16 (0.63")	17 (0.67")	13 (0.51")	177.5 (6.99")	240 (9.45")	M16X2	150 (5.91")	114 (4.49")	111.5 (4.39")	307 (12.09")	220 kg 486 lbs
FKL 205	457 (17.99")	425 (16.73")	279 (10.98")	99 (3.90")	111 (4.37")	143 (5.63")	R10 (0.39"R)	13.5 (0.53")	89 (3.50")	22 (0.87")	16 (0.63")	16 (0.63")	13 (0.51")	182 (7.17")	262 (10.31")	M16X2	160 (6.30")	143 (5.63")	113 (4.45")	323 (12.72")	289 kg 637 lbs
FKL 250	457 (17.99")	425 (16.73")	279 (10.98")	99 (3.90")	111 (4.37")	147 (5.79")	R10 (0.39"R)	13.5 (0.53")	89 (3.50")	26 (1.02")	16 (0.63")	20 (0.79")	13 (0.51")	215 (8.46")	262 (10.31")	M16X2	162.5 (6.40")	129.5 (5.10")	123 (4.84")	343.5 (13.52")	366 kg 807 lbs
FKL 400	505 (19.88")	470 (18.50")	441 (17.36")	127 (5.00")	209.5 (8.25")	241 (9.49")	R13 (0.51"R)	17 (0.66")	32 (1.26")	57 (2.24")	17.5 (0.69")	16 (0.63")	22 (0.87")	234 (9.21")	300 (11.81")	M20X2.5	188 (7.40")	152.5 (6.00")	106 (4.17")	431 (16.97")	481 kg 1060 lbs

1265000262 Rev B

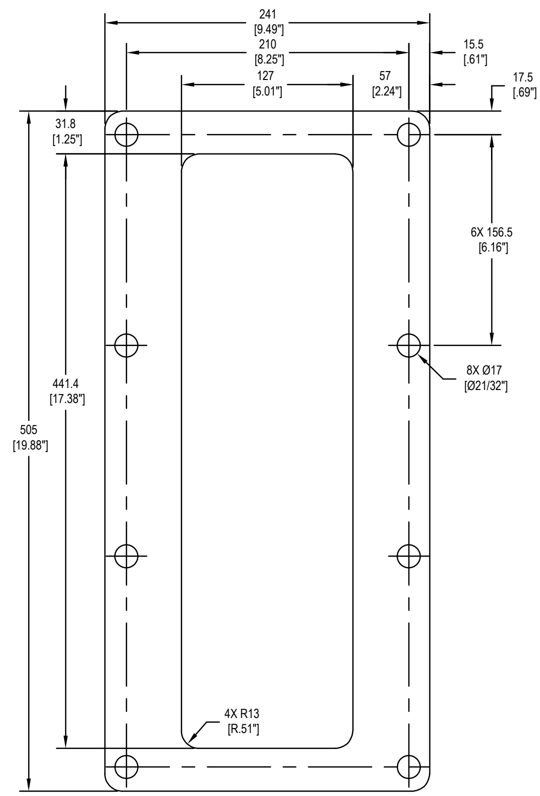
FKL Rectangular Inlet Dimensional Drawing Models 50—400

Models 50—250



	DIMENSIONS IN MILLIMETERS (INCHES)										
PUMP MODEL	A	B	C	D	E	F	G	H	J	K	L
FKL 50	305 (12.01")	67 (2.64")	171 (6.73")	R6 (0.24"R)	273 (10.75")	16 (0.63")	79 (3.11")	48 (1.89")	15.5 (0.61")	44 (1.73")	17.5 (0.69")
FKL 75	336 (13.23")	56 (2.20")	224 (8.82")	R10 (0.39"R)	310 (12.20")	13 (0.51")	127 (5.00")	102 (4.02")	13 (0.51")	57 (2.24")	35 (1.38")
FKL 150	387 (15.24")	76 (2.99")	235 (9.25")	R10 (0.39"R)	355 (13.98")	16 (0.63")	118 (4.65")	84 (3.31")	17 (0.67")	75 (2.95")	21.5 (0.85")
FKL 205 & 250	457 (17.99")	89 (3.50")	279 (10.98")	R10 (0.39"R)	425 (16.73")	16 (0.63")	147 (5.79")	111 (4.37")	16 (0.63")	99 (3.90")	22 (0.87")

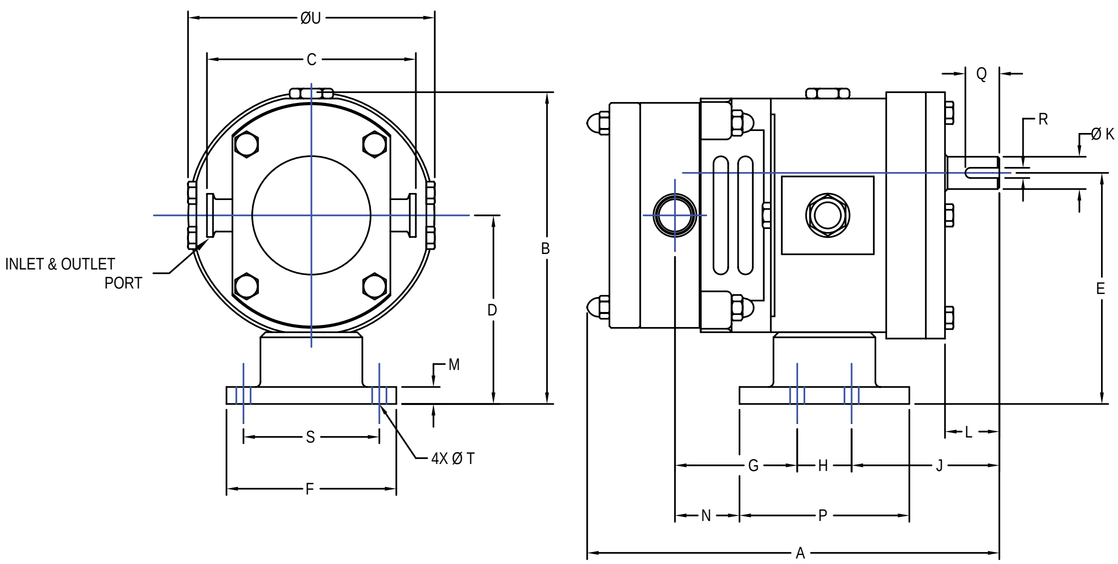
Model 400



FKL 400

1265000524
Rev B

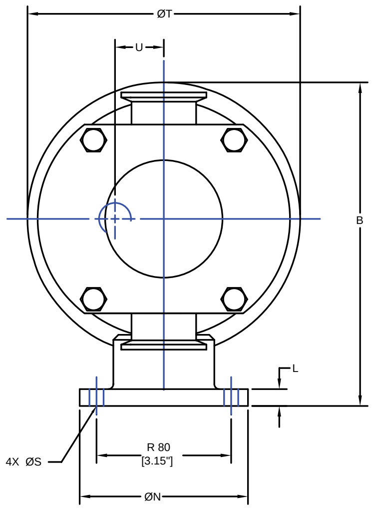
FL II Horizontal Dimensional Drawing Models 15—58

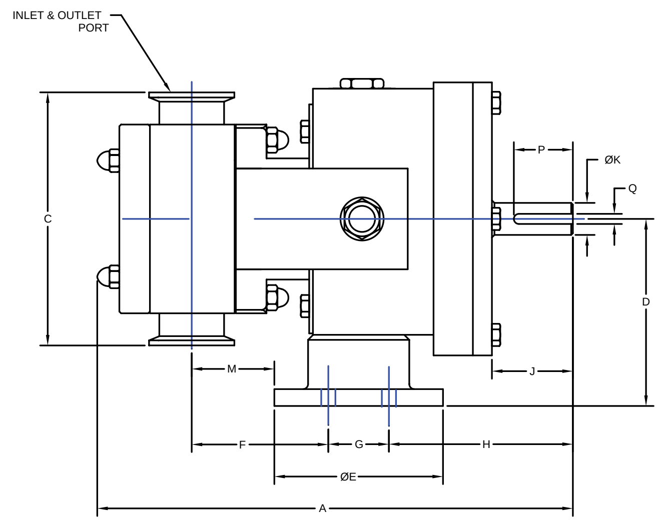


PUMP MODEL	INLET & OUTLET	DIMENSIONS IN MILLIMETERS (INCHES)																		
		A	B	C	D	E	F	G	H	J	ØK	L	M	N	P	Q	R	S	ØT	ØU
15	.75"	243 (9.05")	184 (7.24")	123 (4.84")	111 (4.37")	136 (5.35")	100 (3.94")	72 (2.83")	32 (1.26")	87 (3.42")	19j6	32 (1.26")	10 (.39")	38 (1.50")	100 (3.94")	20 (.79")	6 (.24")	80 (3.15")	Ø8.4 (Ø.33")	145 (5.71")
58S	1"	282 (11.10")	192 (7.56")	150 (5.90")	111 (4.37")	140 (5.51")	100 (3.94")	81 (3.19")	36 (1.42")	109 (4.29")	19j6	48 (1.89")	10 (.39")	49 (1.93")	100 (3.94")	35 (1.38")	6 (.24")	80 (3.15")	Ø8.4 (Ø.33")	162 (4.41")
58L	1.5"	294 (11.57")	192 (7.56")	150 (5.90")	111 (4.37")	140 (5.51")	100 (3.94")	86.5 (3.41")	36 (1.42")	109 (4.29")	19j6	48 (1.89")	10 (.39")	54.5 (2.15")	100 (3.94")	35 (1.38")	6 (.24")	80 (3.15")	Ø8.4 (Ø.33")	162 (4.41")

1265000225
Rev -

FL II Vertical Dimensional Drawing Models 15—58

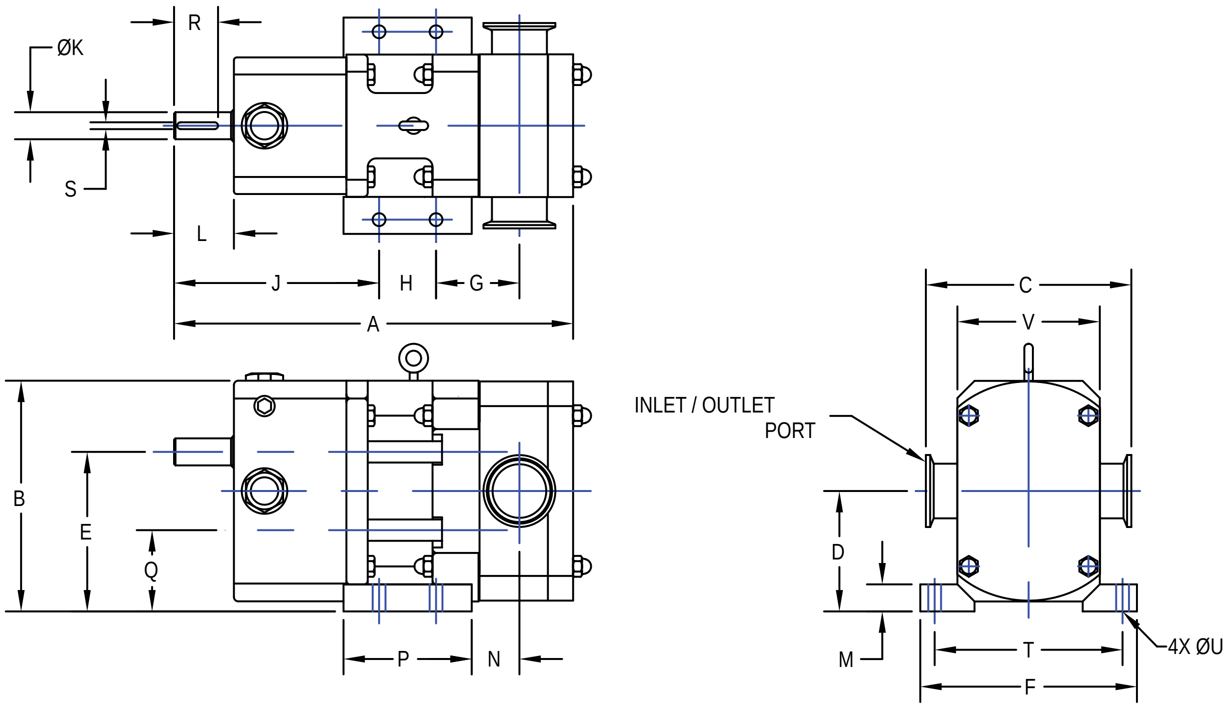




PUMP MODEL	INLET & OUTLET	DIMENSIONS IN MILLIMETERS (INCHES)																	
		A	B	C	D	ØE	F	G	H	J	ØK	L	M	ØN	P	Q	R	S	T	ØU
15	.75"	230 (9.05")	184 (7.24")	123 (4.84")	111 (4.37")	100 (3.94")	72 (2.83")	32 (1.26")	87 (3.42")	32 (1.26")	19j6	10 (.39")	38 (1.50")	100 (3.94")	20 (.79")	6 (.24")	80 (3.15")	Ø8.4 (Ø.33")	25 (.98")	145 (5.71")
58S	1"	282 (11.10")	192 (7.56")	150 (5.90")	111 (4.37")	100 (3.94")	81 (3.19")	36 (1.42")	109 (4.29")	48 (1.89")	19j6	10 (.39")	49 (1.93")	100 (3.94")	35 (1.38")	6 (.24")	80 (3.15")	Ø8.4 (Ø.33")	29 (1.14")	162 (4.41")
58L	1.5"	294 (11.57")	192 (7.56")	150 (5.90")	111 (4.37")	100 (3.94")	86.5 (3.41")	36 (1.42")	109 (4.29")	48 (1.89")	19j6	10 (.39")	54.5 (2.15")	100 (3.94")	35 (1.38")	6 (.24")	80 (3.15")	Ø8.4 (Ø.33")	19 (1.14")	162 (4.41")

1265000226 Rev -

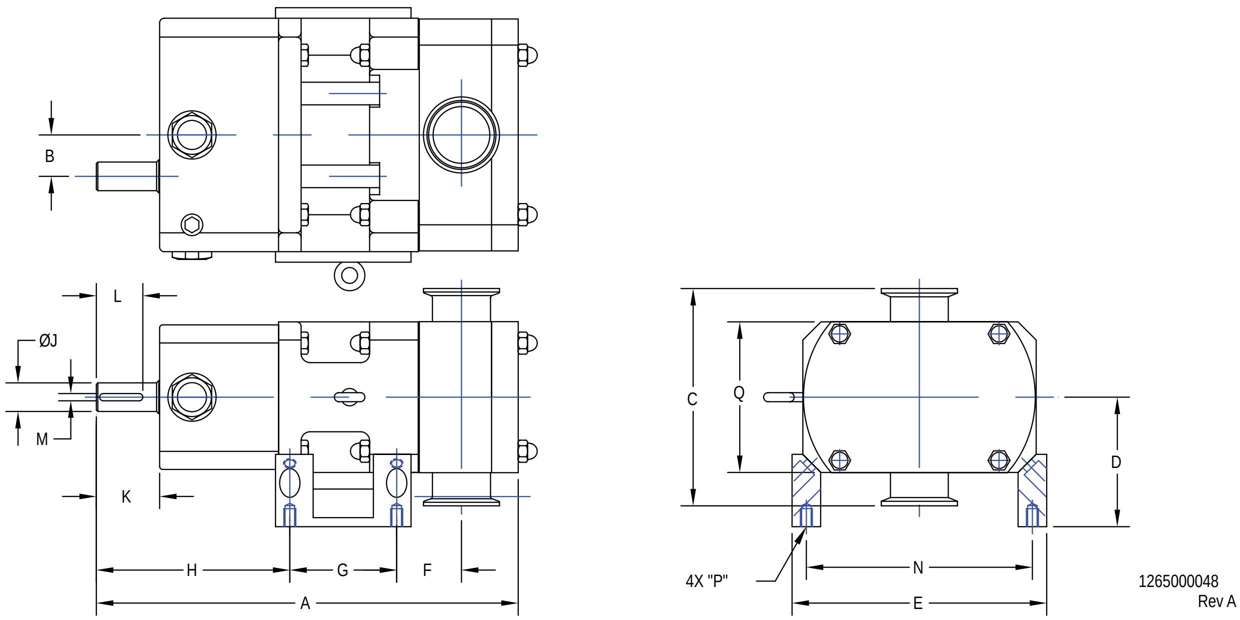
FL II Horizontal Dimensional Drawing
Models 75—100



1265000047
Rev A

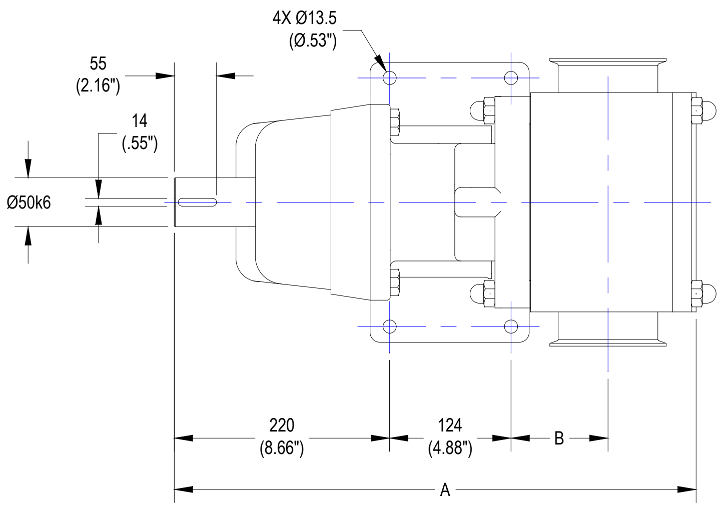
PUMP MODEL	INLET & OUTLET	DIMENSIONS IN MILLIMETERS (INCHES)																			
		A	B	C	D	E	F	G	H	J	ØK	L	M	N	P	Q	R	S	T	ØU	V
75S	1.5"	326 (12.84")	210.5 (8.29")	174 (6.85")	108.5 (4.27")	146 (5.75")	180 (7.09")	62.5 (2.46")	55 (2.17")	161 (6.34")	28j6	53 (2.08")	19 (.75")	32.5 (1.28")	115 (4.53")	71 (2.79")	45 (1.77")	8 (.32")	160 (6.30")	Ø9 (Ø.35")	129 (5.08")
75L	2"	341 (13.43")	210.5 (8.29")	180 (7.09")	108.5 (4.27")	146 (5.75")	180 (7.09")	70 (2.76")	55 (2.17")	161 (6.34")	28j6	53 (2.08")	19 (.75")	40 (1.57")	115 (4.53")	71 (2.79")	45 (1.77")	8 (.32")	160 (6.30")	Ø9 (Ø.35")	129 (5.08")
100S	2.5"	413.5 (16.28")	275 (10.82")	223 (8.78")	140 (5.51")	190 (7.48")	225.5 (8.88")	61 (2.40")	70 (2.76")	224 (8.82")	40k6	80 (3.15")	32 (1.25")	42 (1.65")	108 (4.25")	90 (3.54")	65 (2.56")	12 (.47")	200 (7.86")	Ø10.8 (Ø.43")	170 (6.69")
100L	3"	443.5 (17.46")	275 (10.82")	243 (9.57")	140 (5.51")	190 (7.48")	225.5 (8.88")	80 (3.15")	70 (2.76")	224 (8.82")	40k6	80 (3.15")	32 (1.25")	61 (2.40")	108 (4.25")	90 (3.54")	74 (2.91")	12 (.47")	200 (7.86")	Ø10.8 (Ø.43")	170 (6.69")

FL II Vertical Dimensional Drawing
Models 75—100

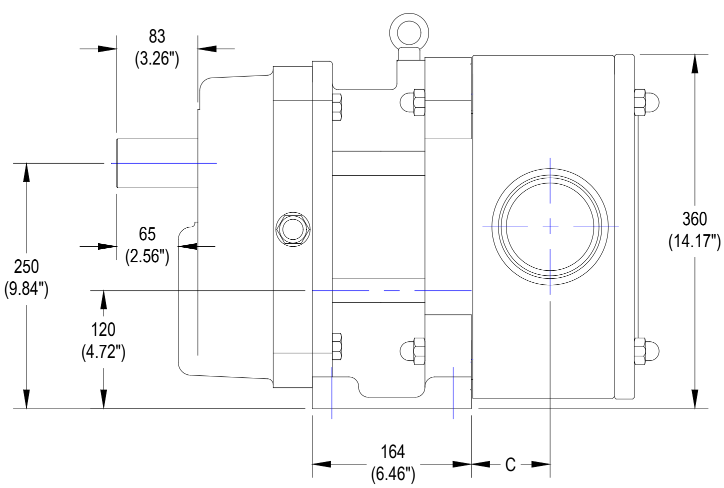


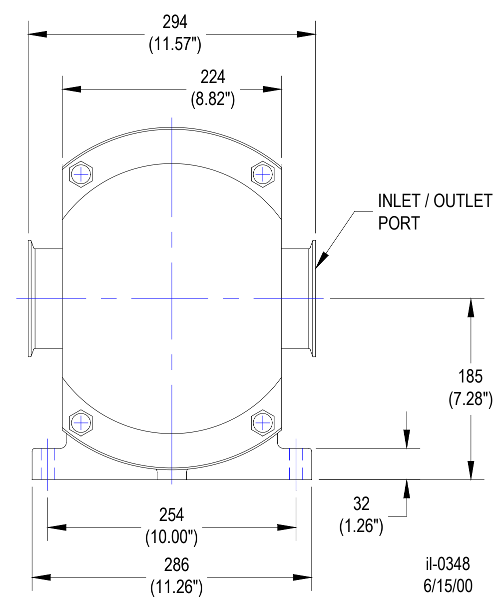
PUMP MODEL	INLET & OUTLET	DIMENSIONS IN MILLIMETERS(INCHES)														
		A	B	C	D	E	F	G	H	ØJ	K	L	M	N	P	Q
75S	1.5"	326 (12.84")	37.5 (1.48")	174 (6.85")	102 (4.02")	217 (8.54")	46.5 (1.83")	87 (3.42")	145 (5.71")	28j6	53 (2.08")	45 (1.77")	8 (.32")	198 (7.79")	5/16"-18 TAP	129 (5.08")
75L	2"	341 (13.44")	37.5 (1.48")	180 (7.09")	102 (4.02")	217 (8.54")	54 (2.13")	87 (3.42")	145 (5.71")	28j6	53 (2.08")	45 (1.77")	8 (.32")	198 (7.79")	5/16"-18 TAP	129 (5.08")
100S	2.5"	413.5 (16.28")	50 (1.97")	223 (8.78")	180 (7.10")	274 (10.80")	60.5 (2.38")	70 (2.76")	225 (8.85")	40k6	80 (3.15")	65 (2.56")	12 (.47")	249 (9.80")	3/8"-16 TAP	170 (6.69")
100L	3"	443.5 (17.46")	50 (1.97")	243 (9.57")	180 (7.10")	274 (10.80")	79 (3.11")	70 (2.76")	225 (8.85")	40k6	80 (3.15")	65 (2.56")	12 (.47")	249 (9.80")	3/8"-16 TAP	170 (6.69")

FL II Horizontal Dimensional Drawing
Model 130



PUMP MODEL	INLET & OUTLET	DIMENSIONS IN MILLIMETERS (INCHES)		
		A	B	C
130S	3"	498 (19.60")	75 (2.95")	55 (2.16")
130L	4"	533 (20.98")	99 (3.90")	79 (3.11")





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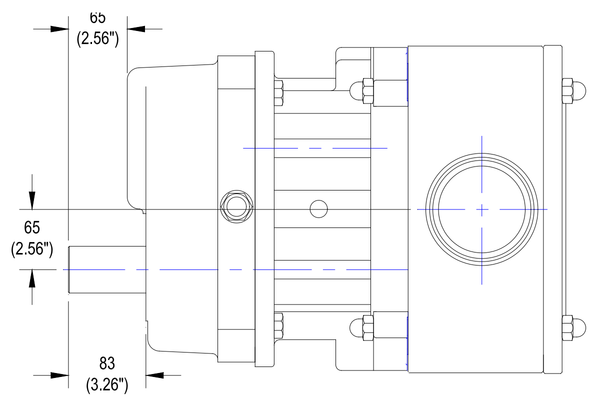
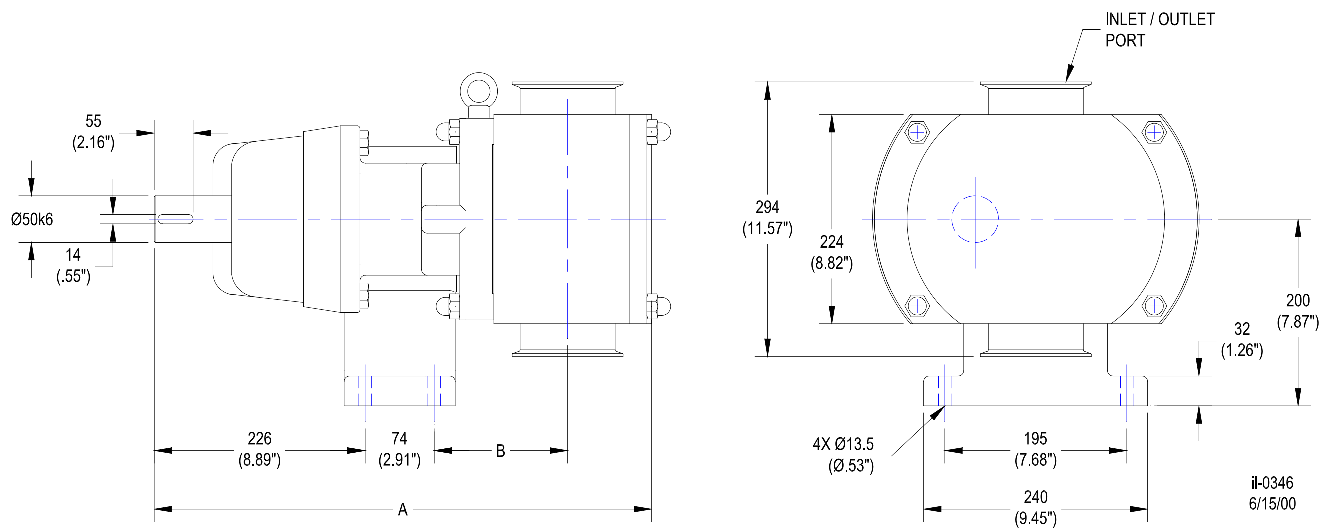
6/15/00

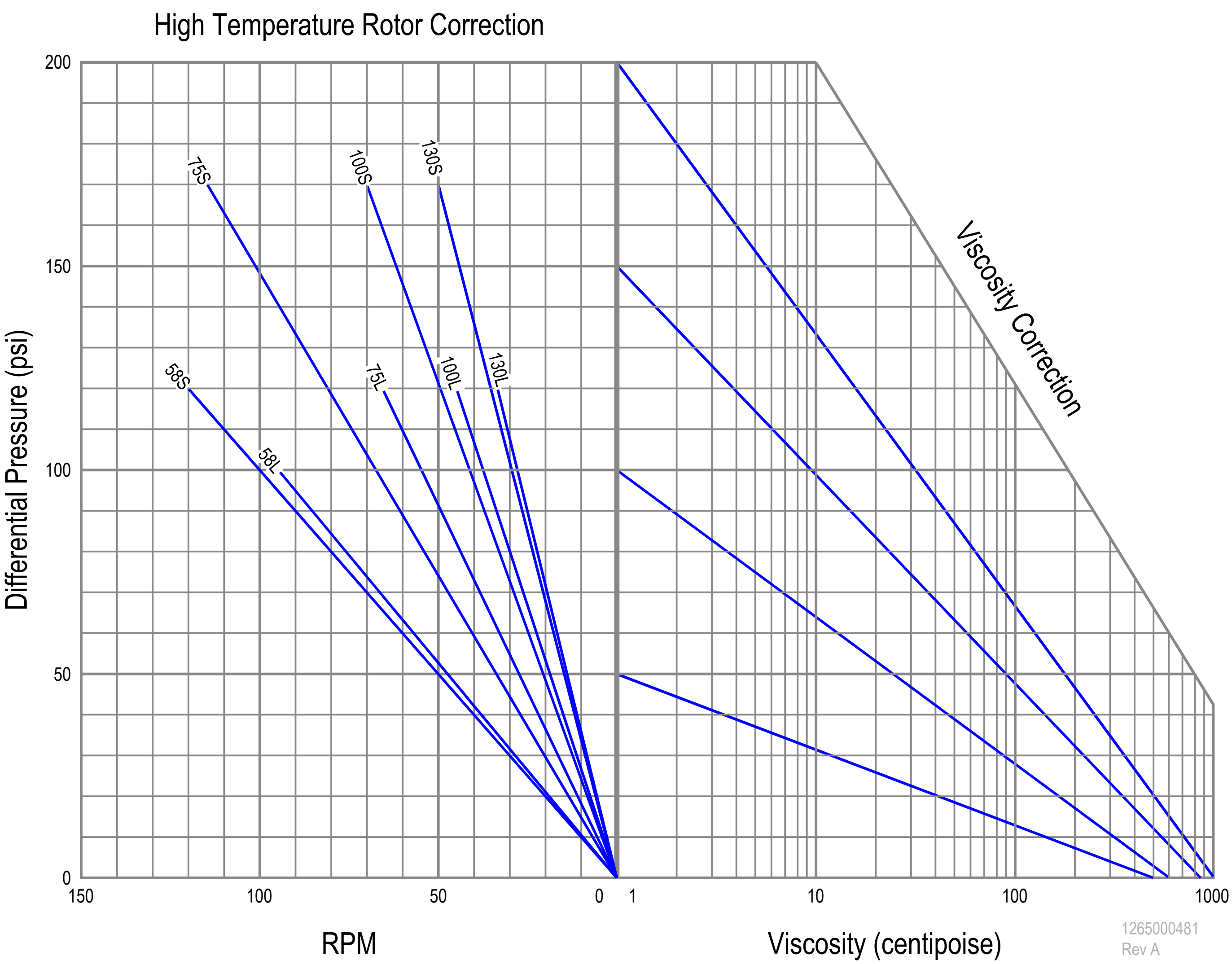
FL II Vertical Dimensional Drawing Model 130



PUMP MODEL	INLET & OUTLET	DIMENSIONS IN MILLIMETERS (INCHES) A	B
130S	3"	498 (19.60")	119 (4.68")
130L	4"	533 (20.98")	143 (5.63")

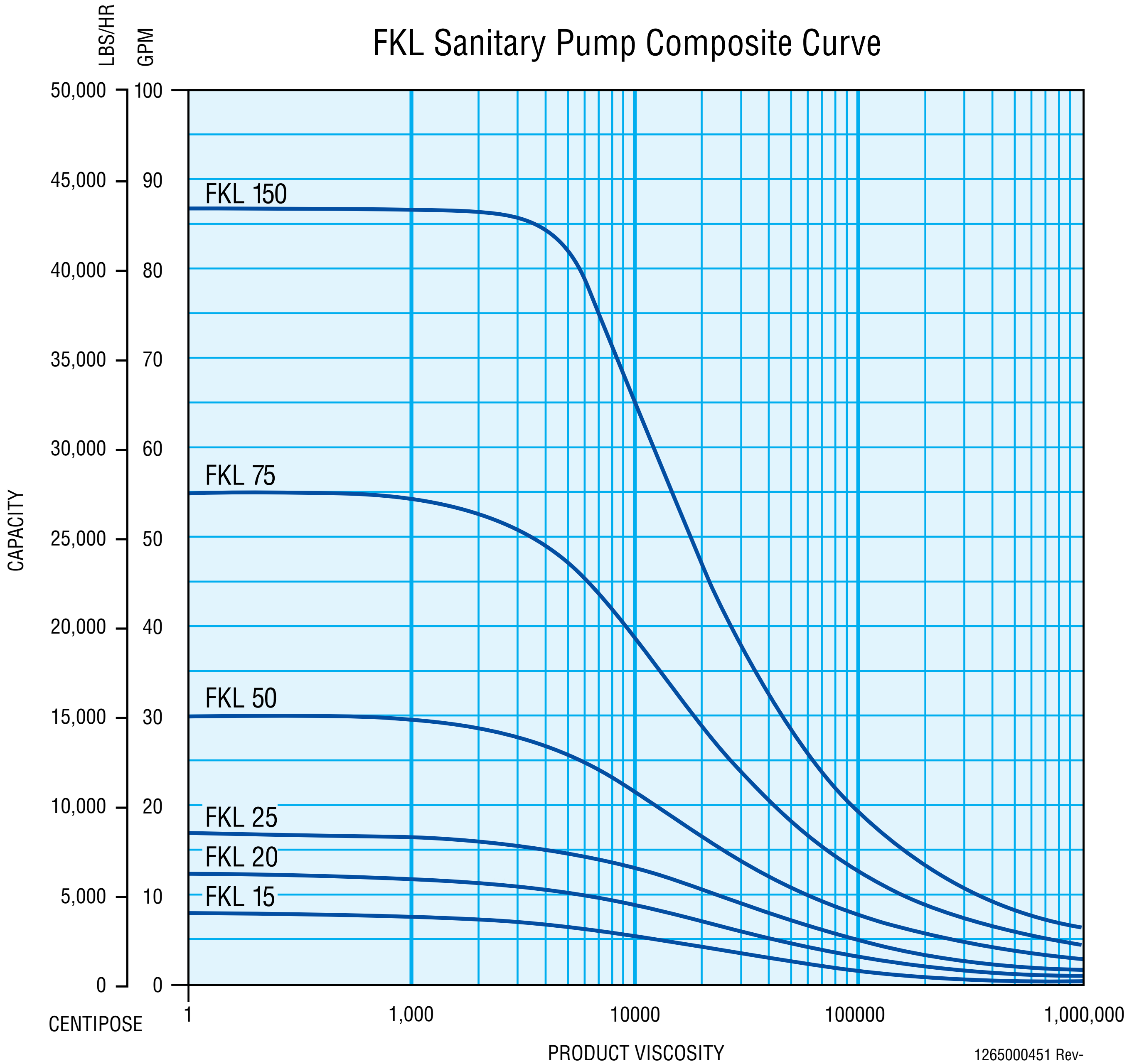


FL II High Temperature Rotor/Viscosity Adjustment Curve



Fristam PUMPS® Engineered For Lasting Performance™

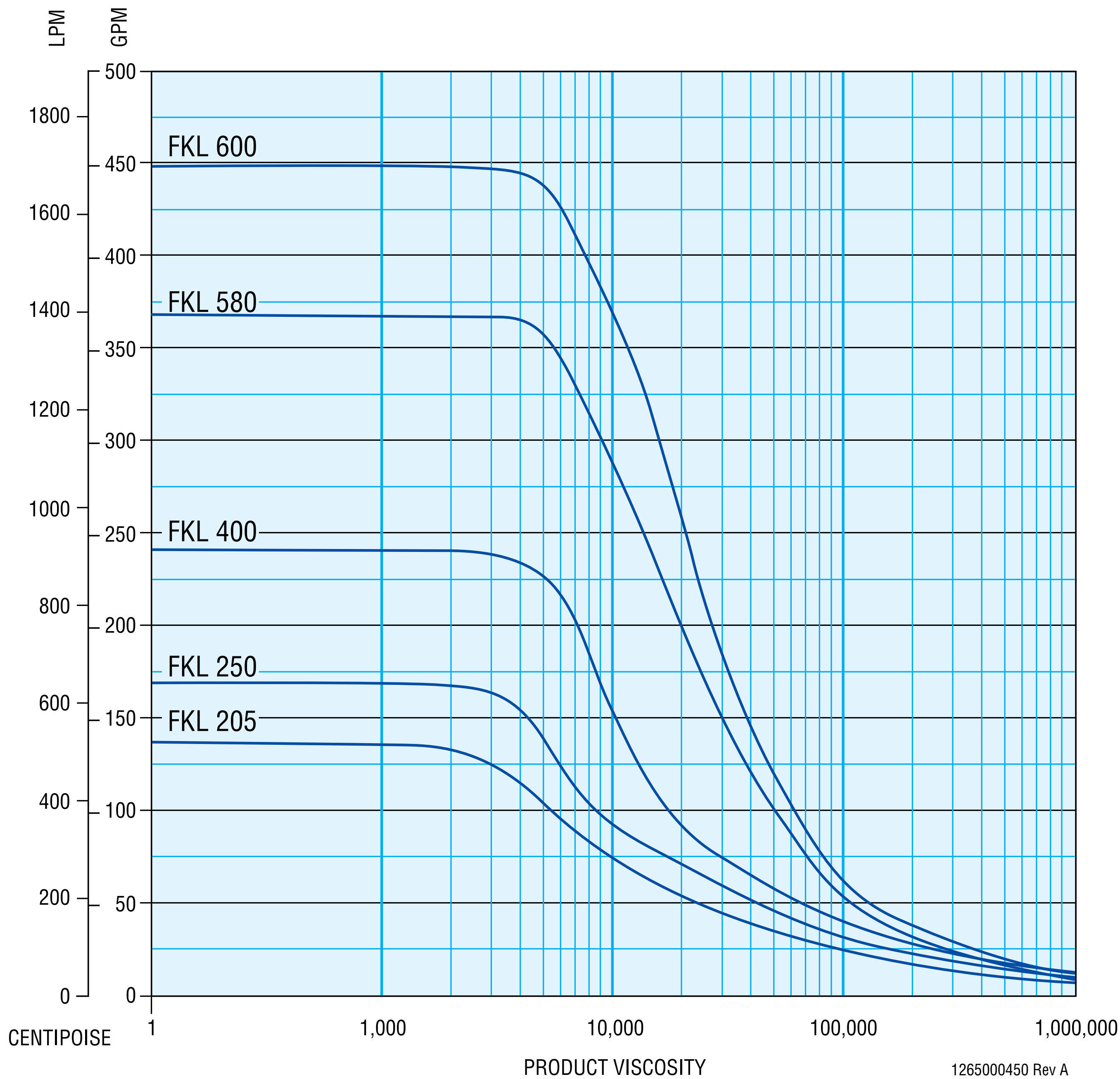
FKL Composite Performance Curve Models: 15—150



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

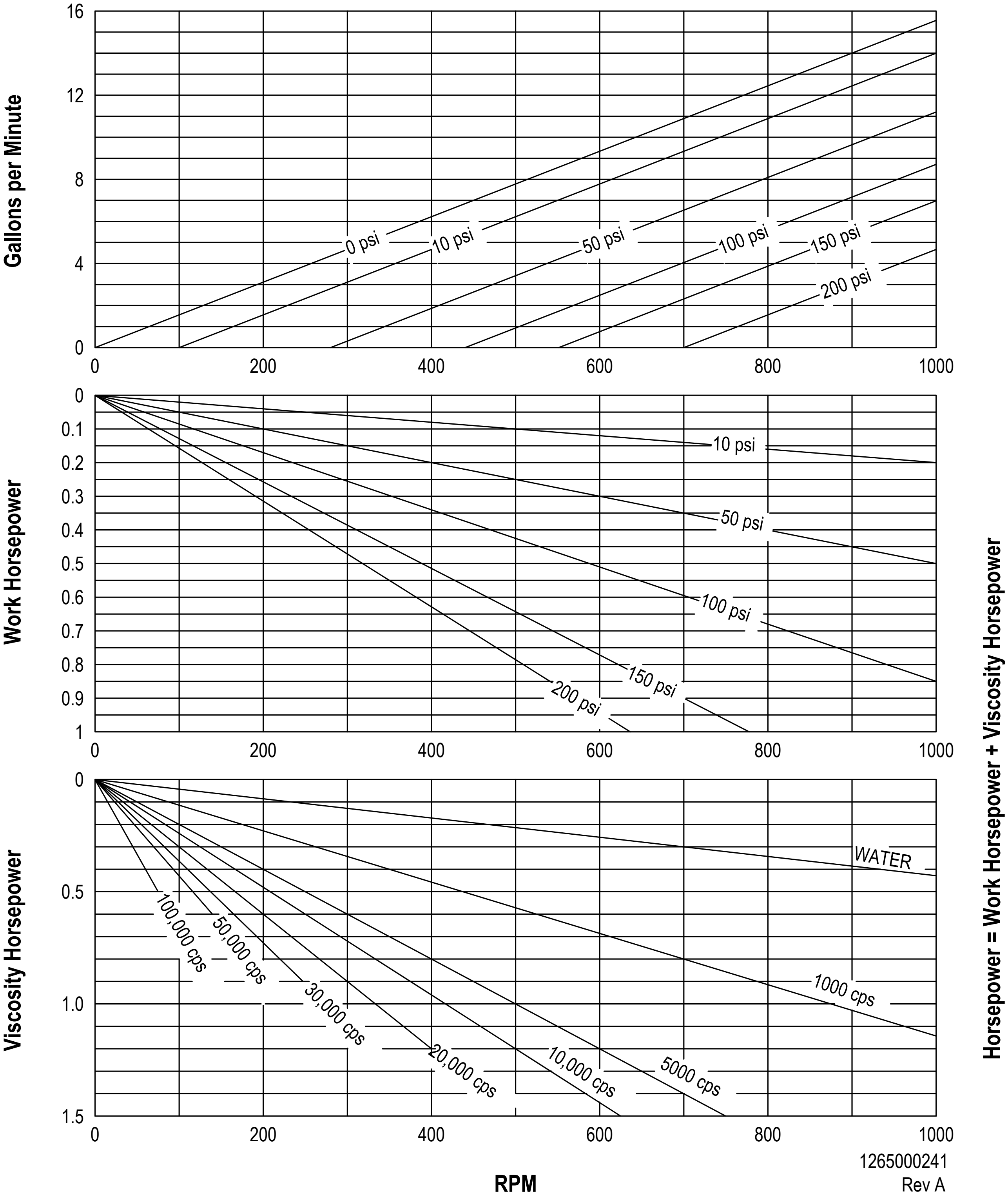
Fristam PUMPS®
Engineered For Lasting Performance™

FKL Composite Performance Curve Models: 205—600



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

FKL Performance Curves Model: 15



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

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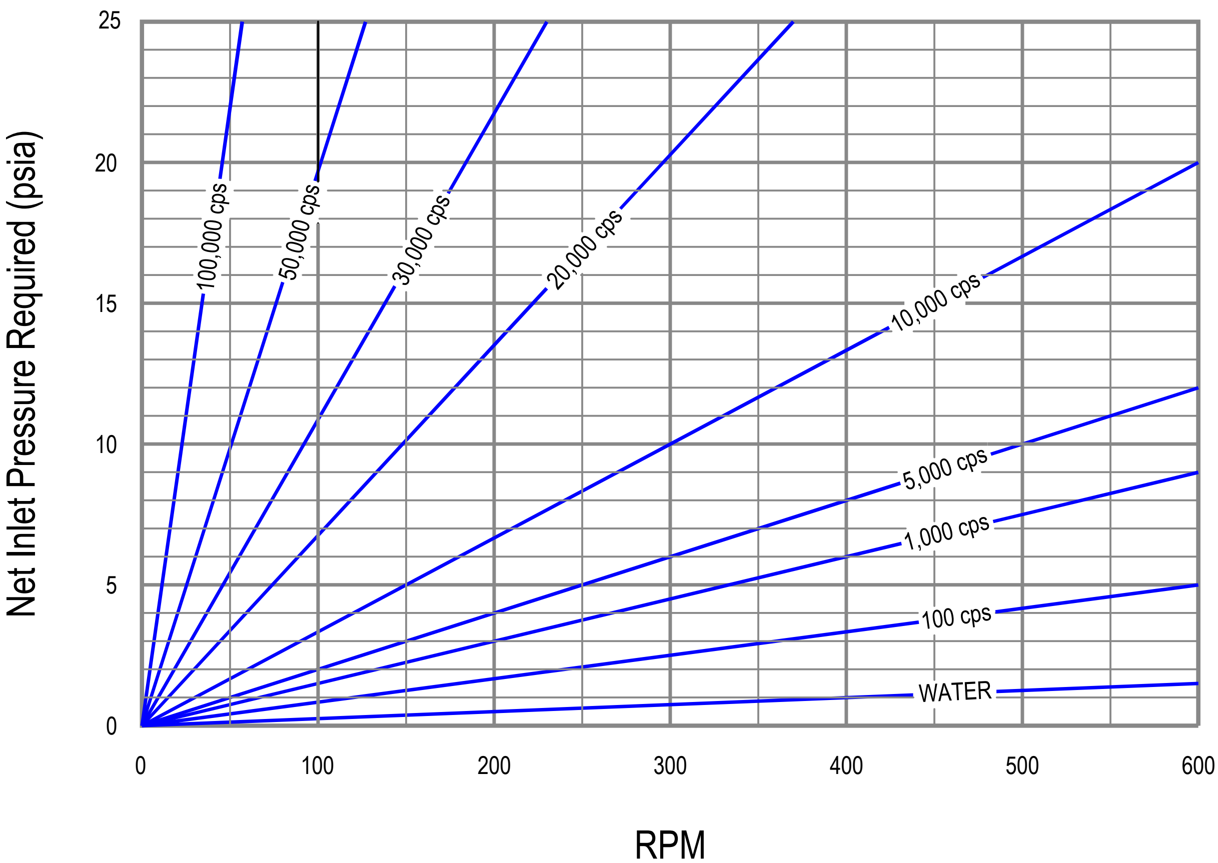
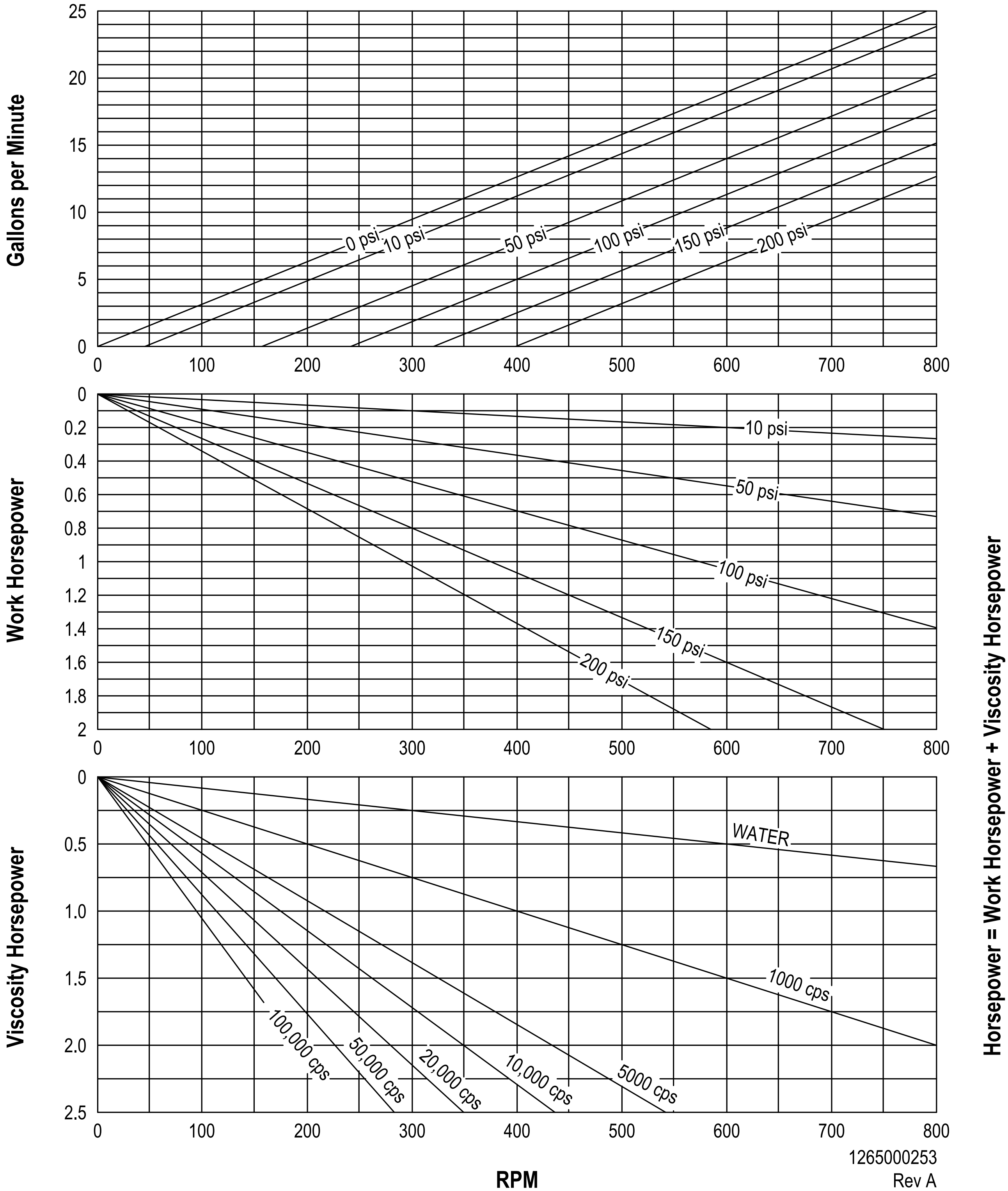
FKL Performance Curves
Model: 15



1265000466
Rev -

Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

FKL Performance Curves
Model: 20



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

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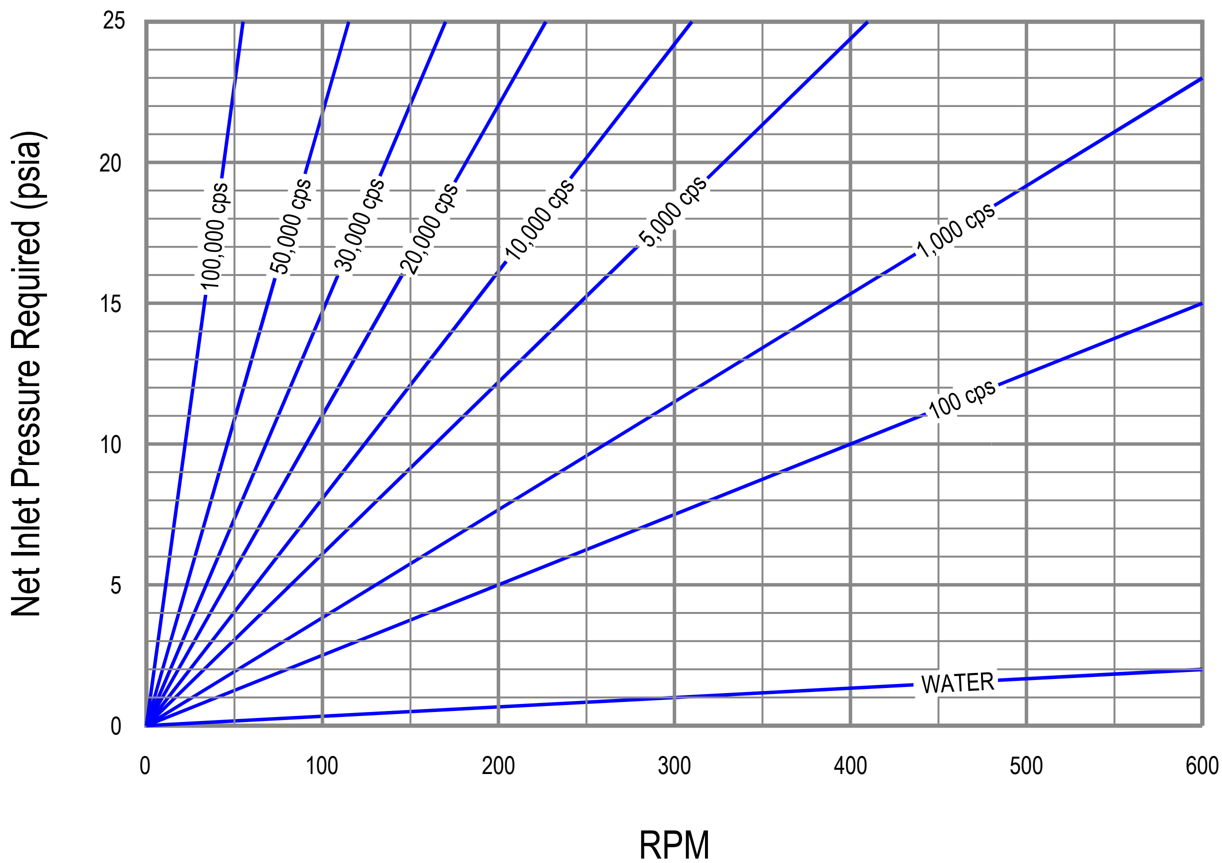
FKL Performance Curves Model: 20



1265000467
Rev -

Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

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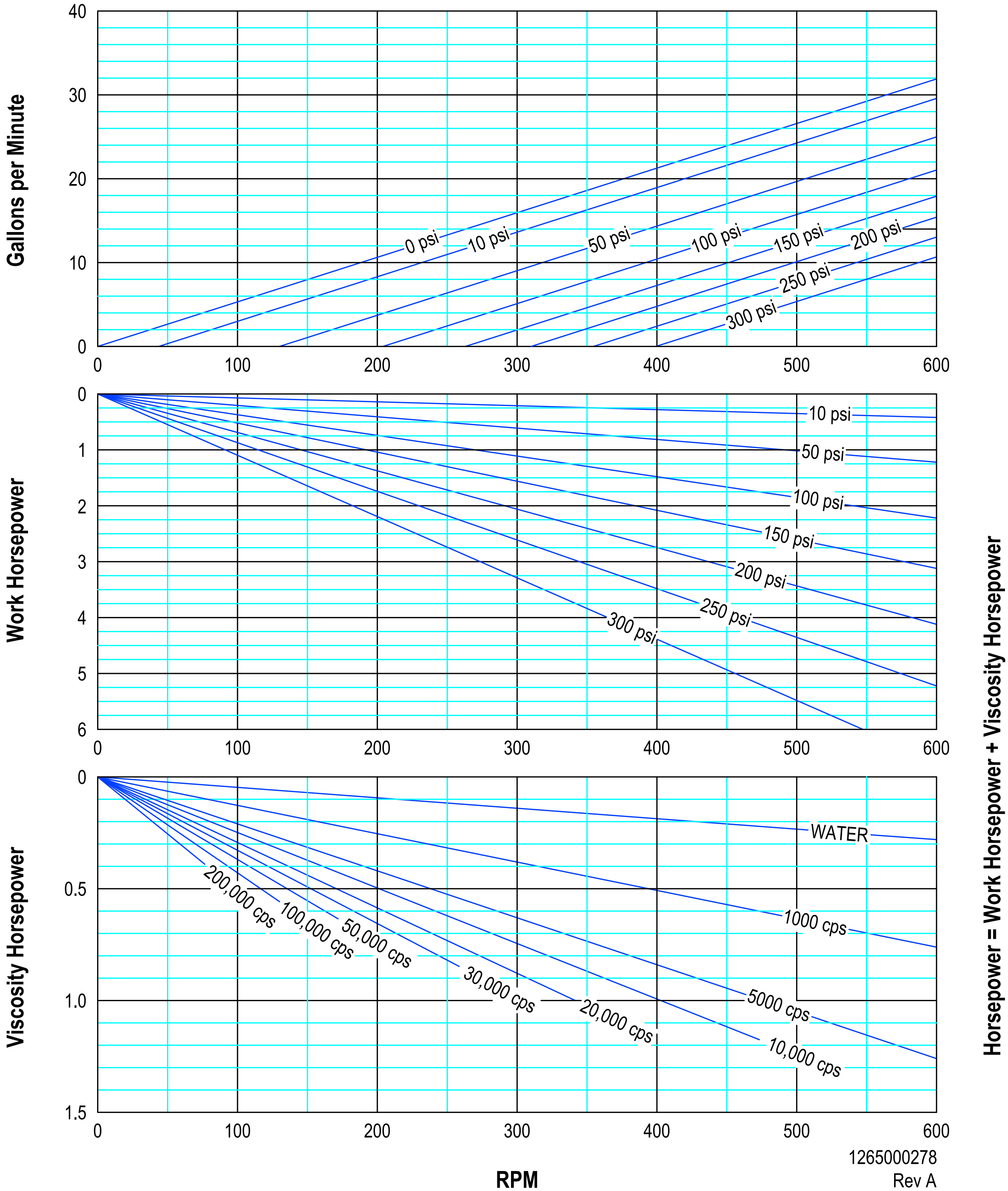
FKL Performance Curves Model: 25



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

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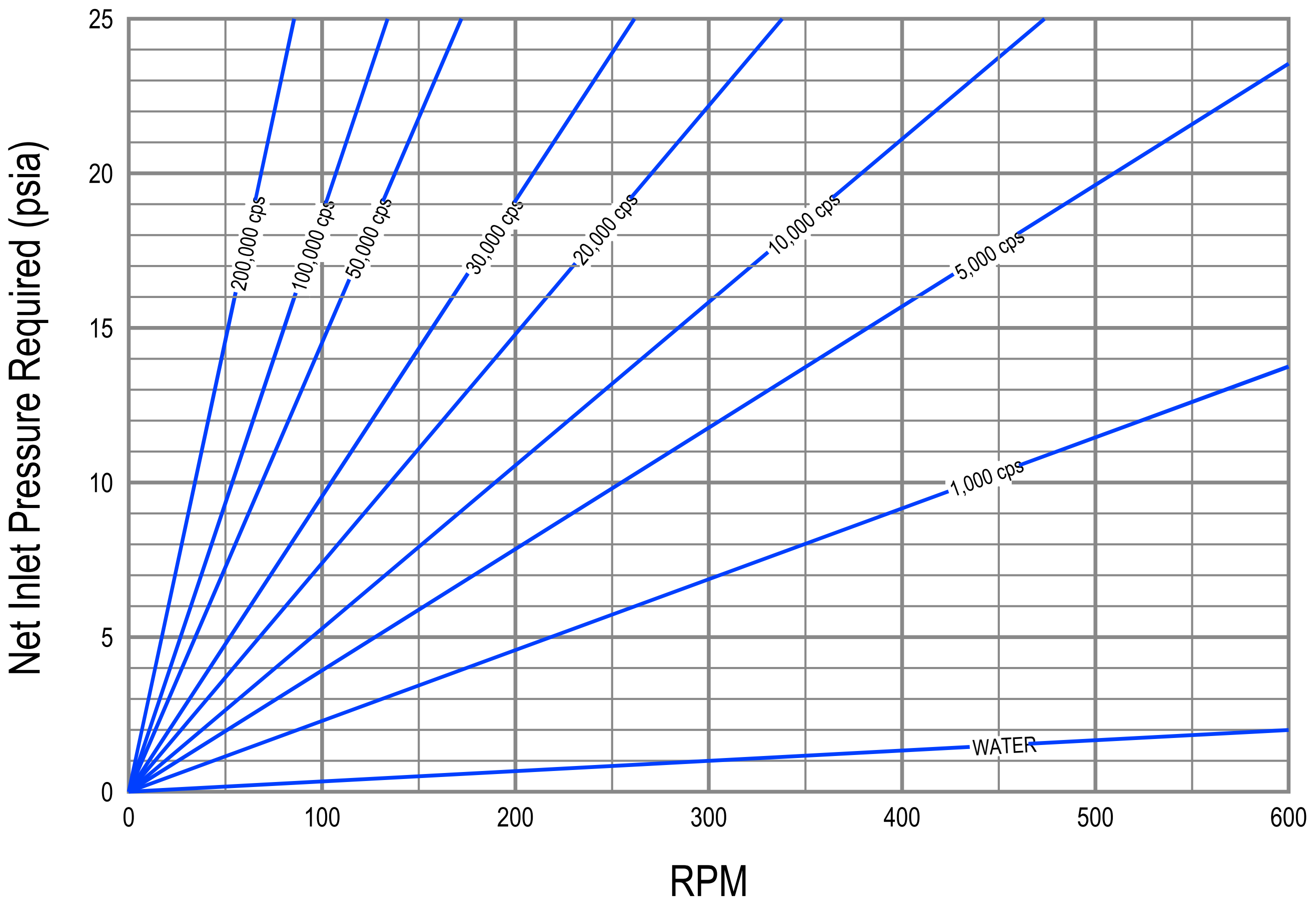
FKL Performance Curves Model: 25

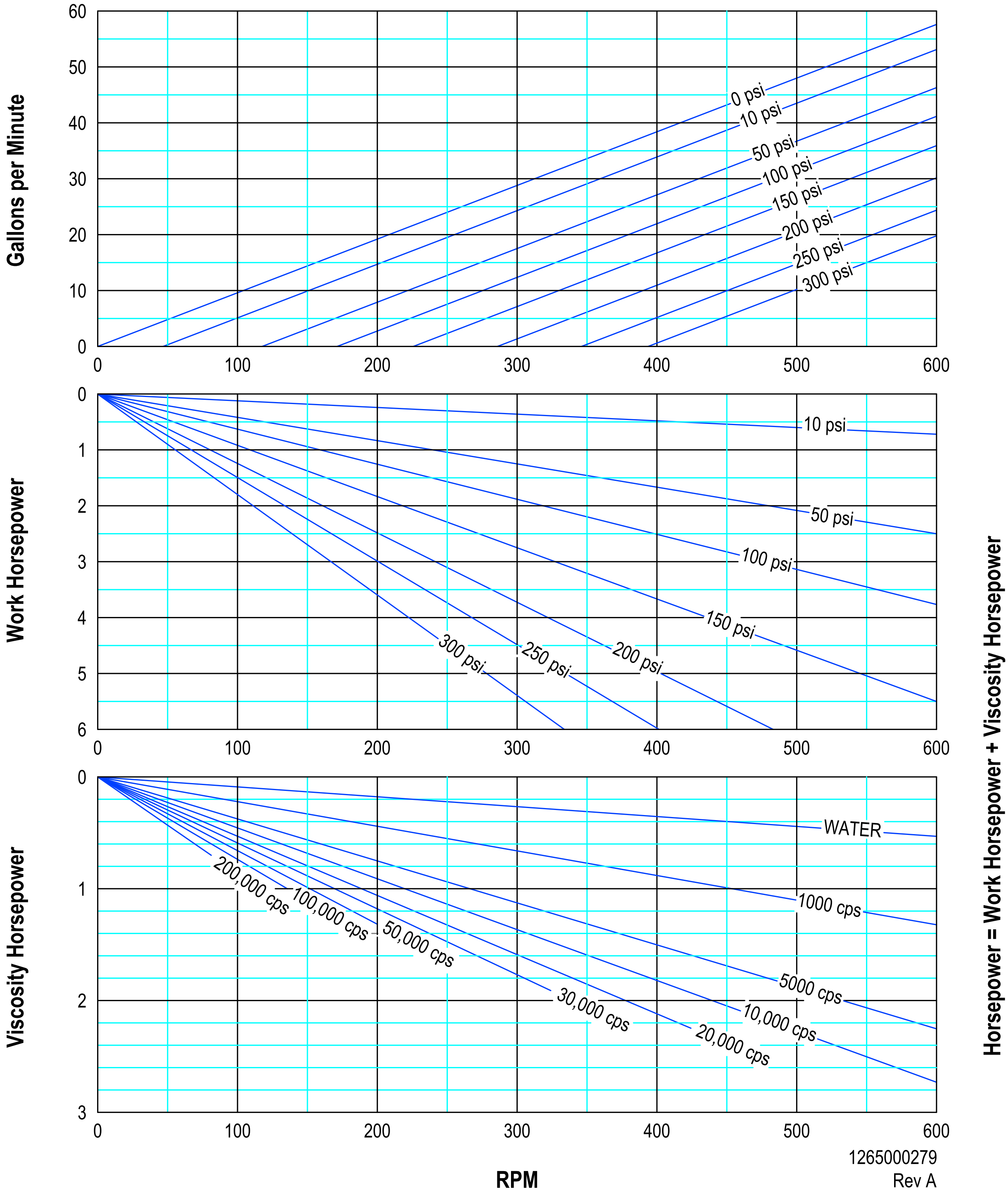


1265000496
Rev A

Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

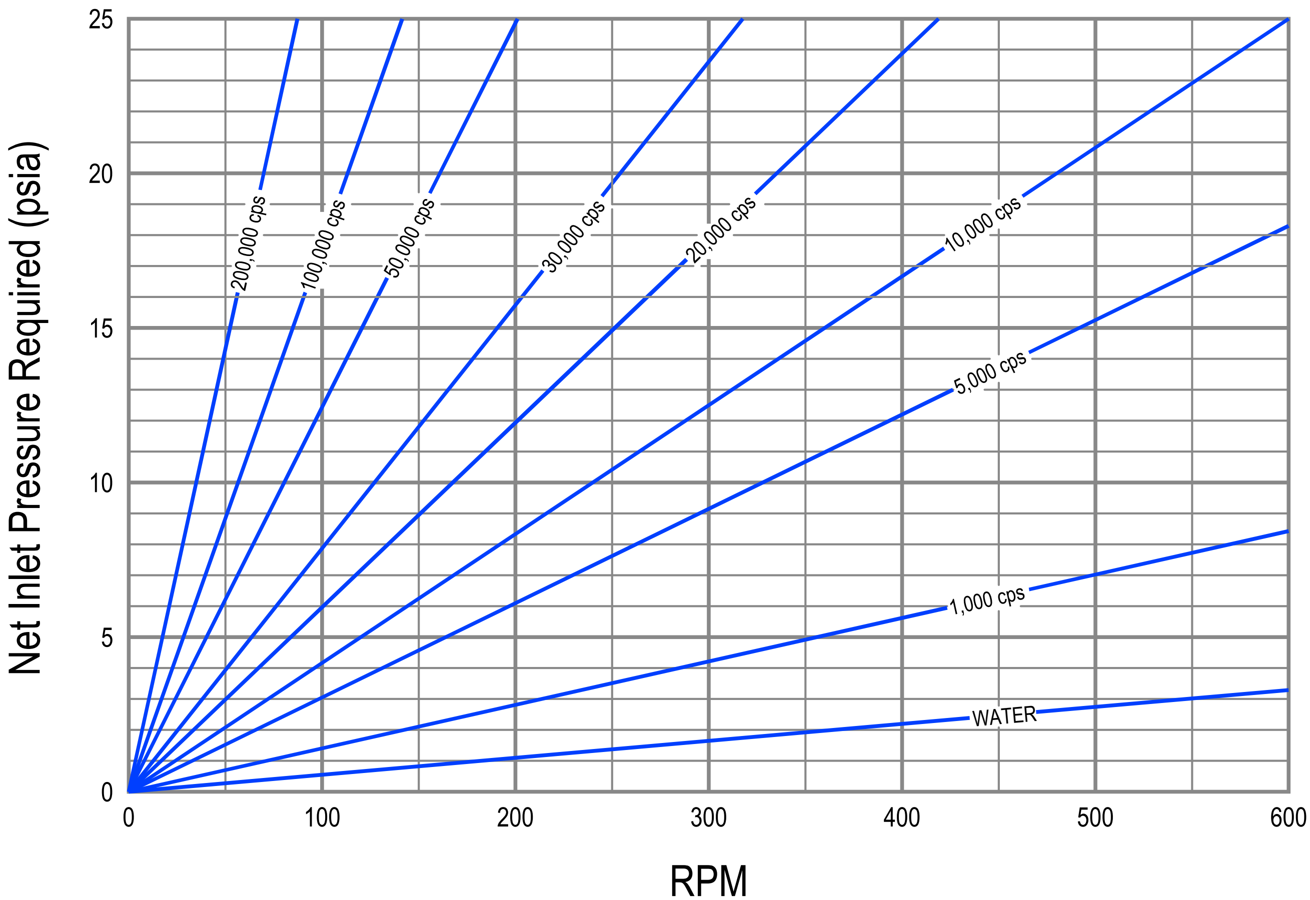
Fristam PUMPS® Engineered For Lasting Performance™

FKL Performance Curves Model: 50



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

FKL Performance Curves
Model: 50



1265000497
Rev A

Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

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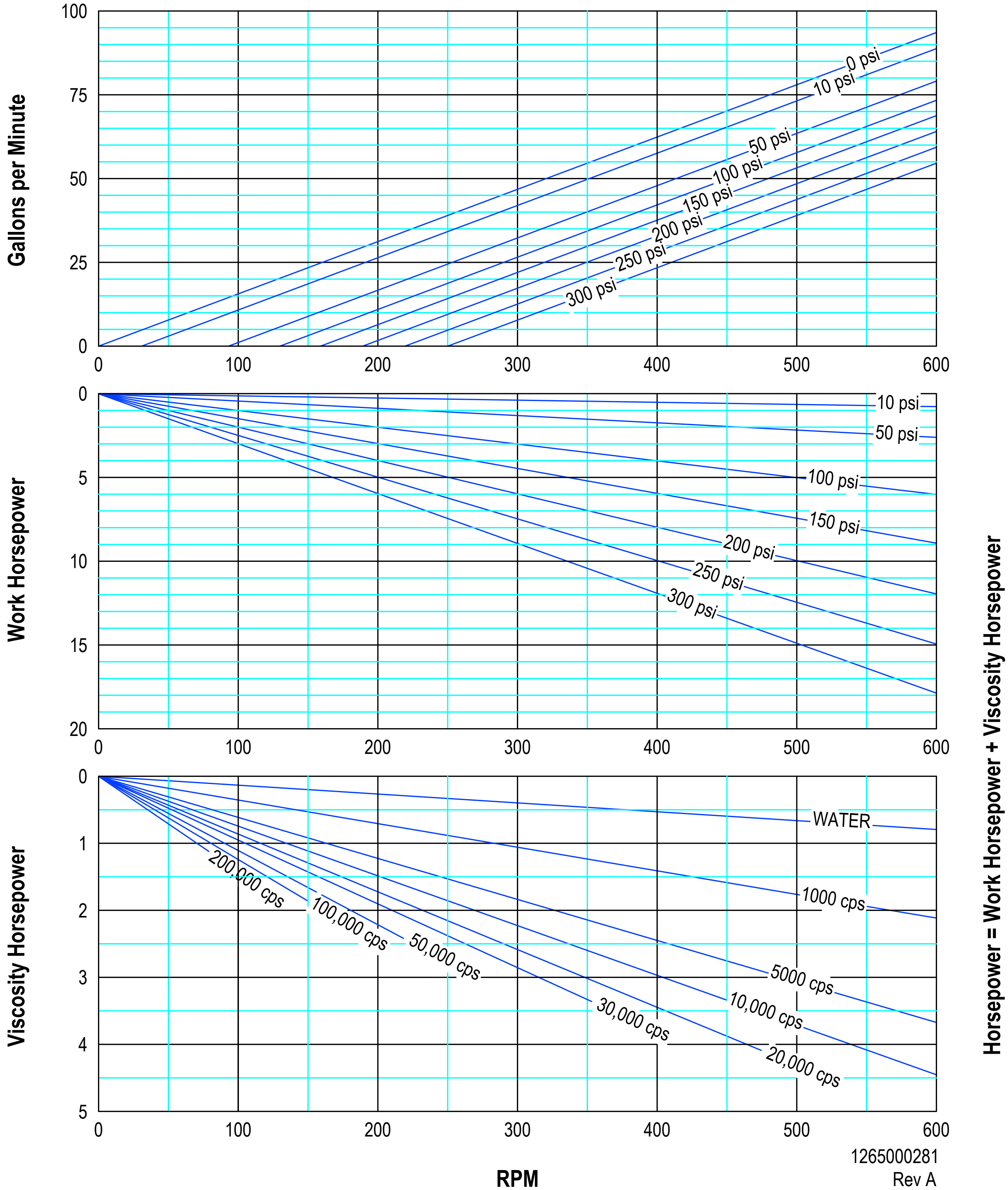
FKL Performance Curves Model: 75



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

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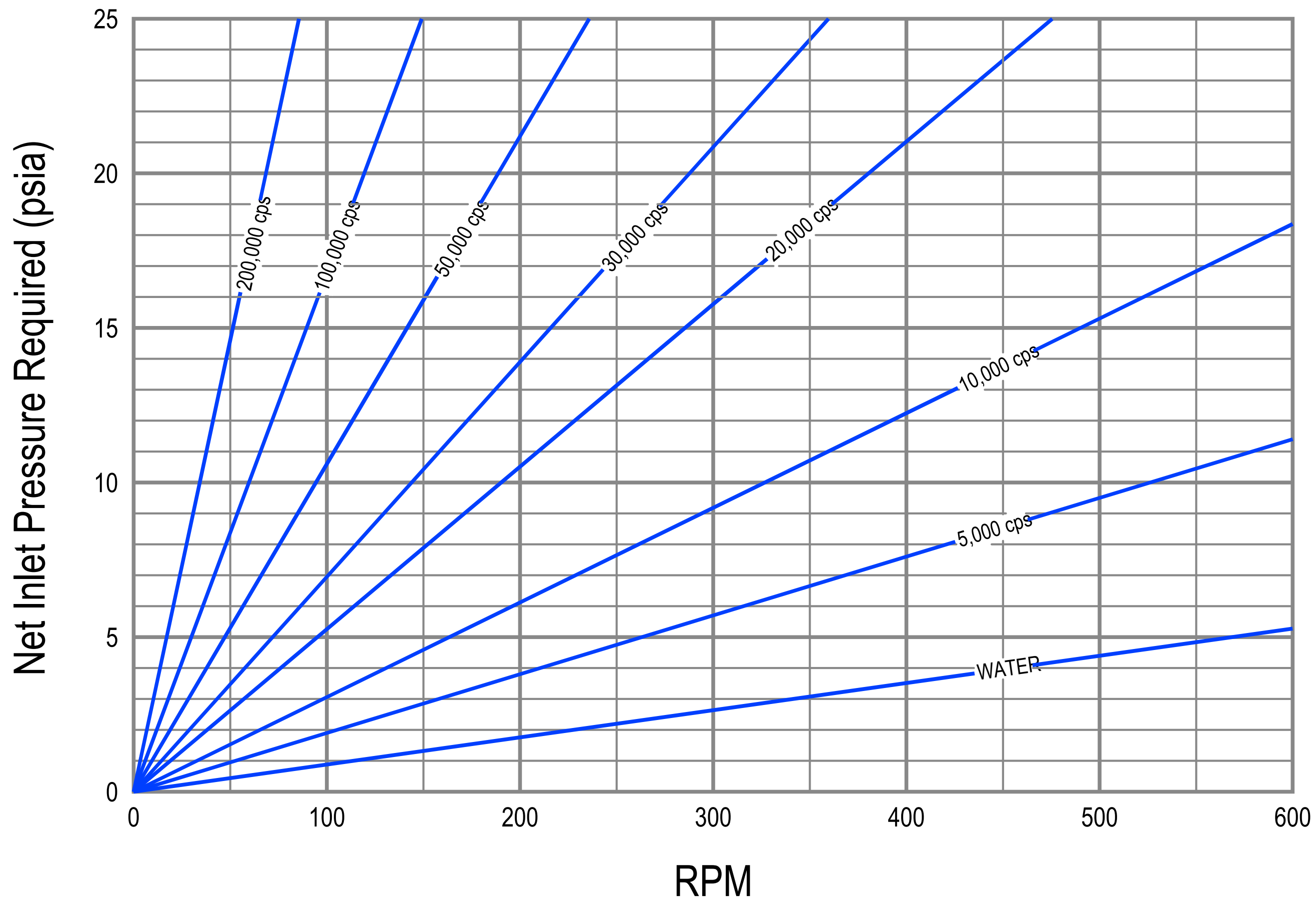
FKL Performance Curves Model: 75



1265000498
Rev A

Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

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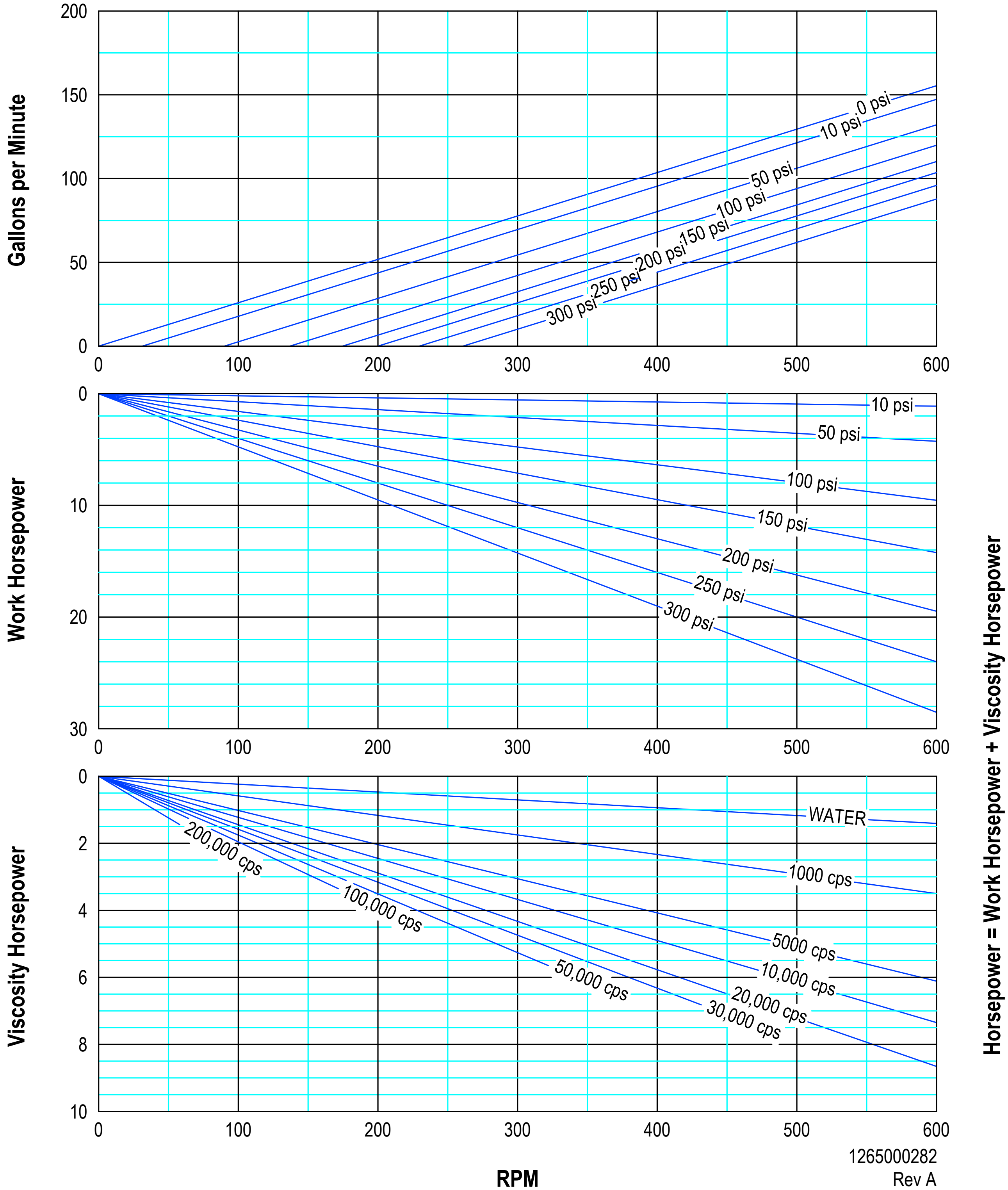
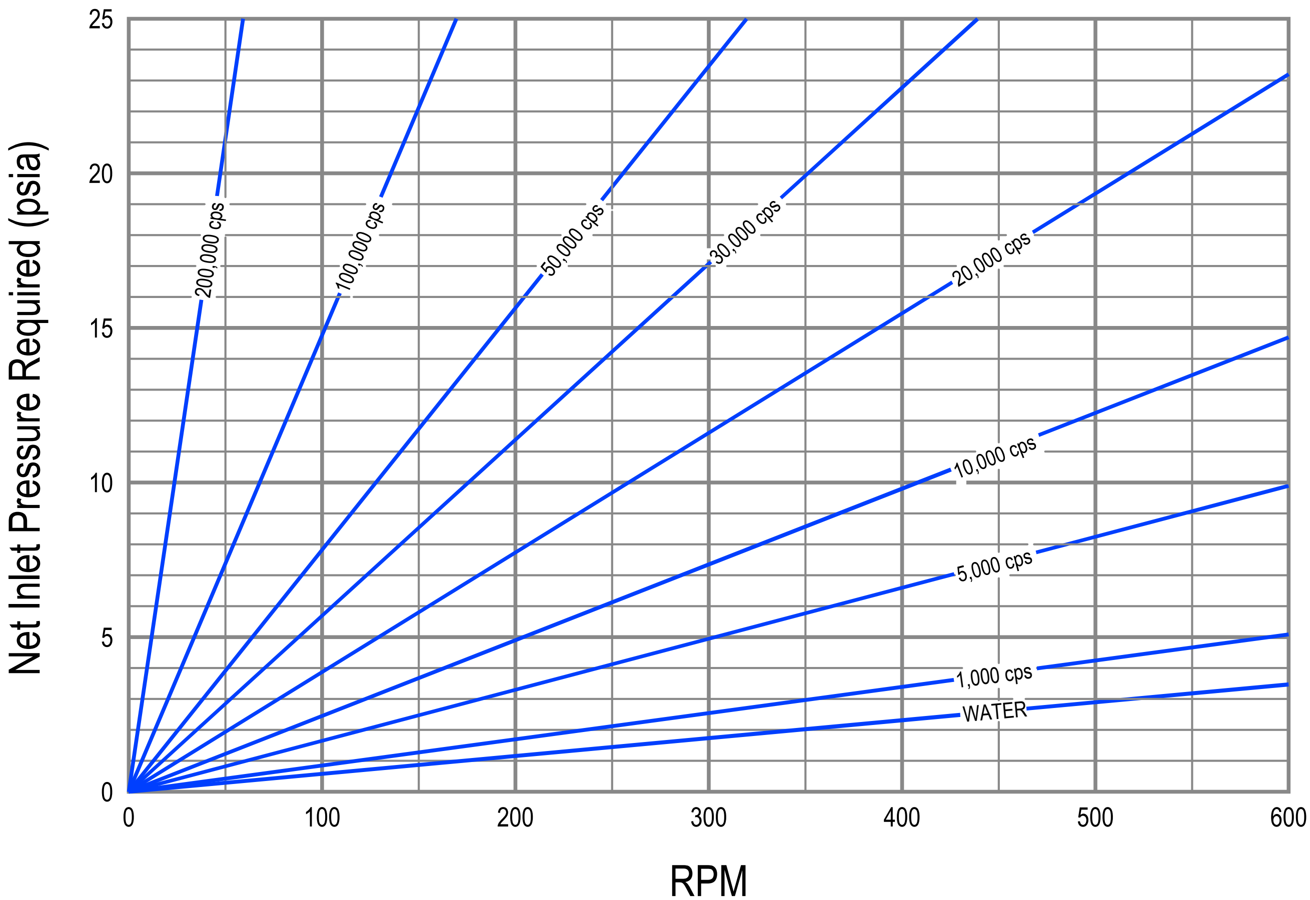
FKL Performance Curves Model: 150



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

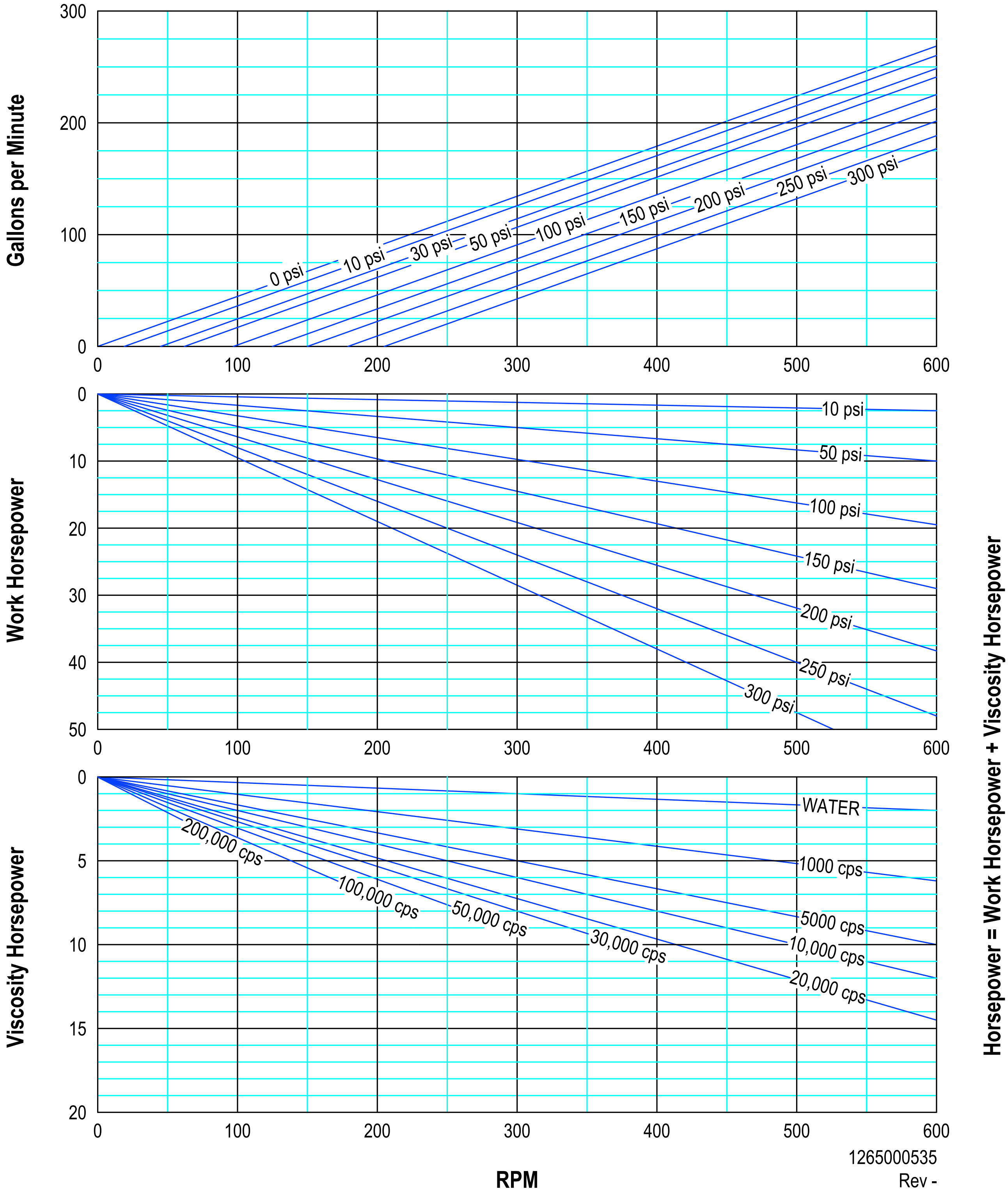
FKL Performance Curves
Model: 150



1265000499
Rev A

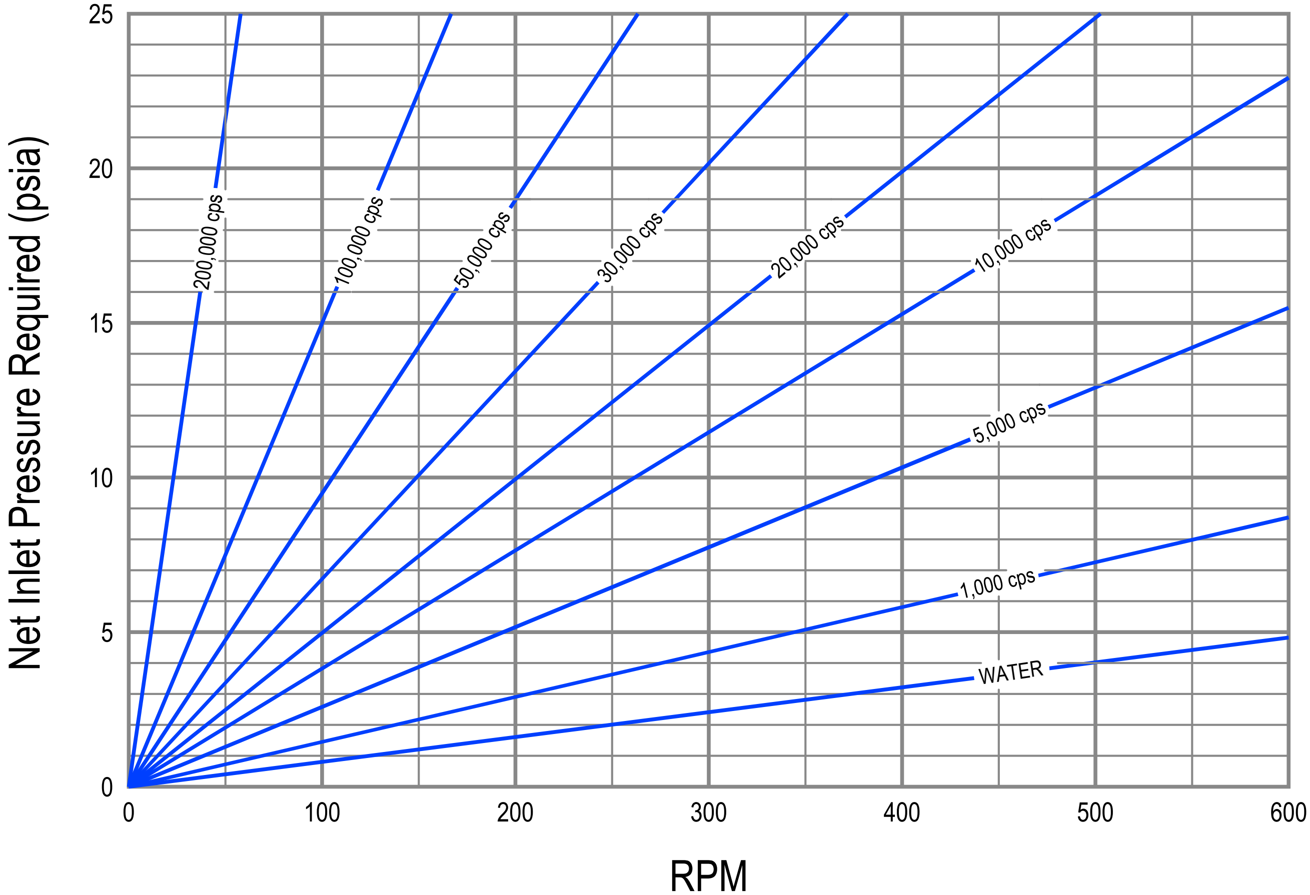
Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

FKL Performance Curves Model: 205



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

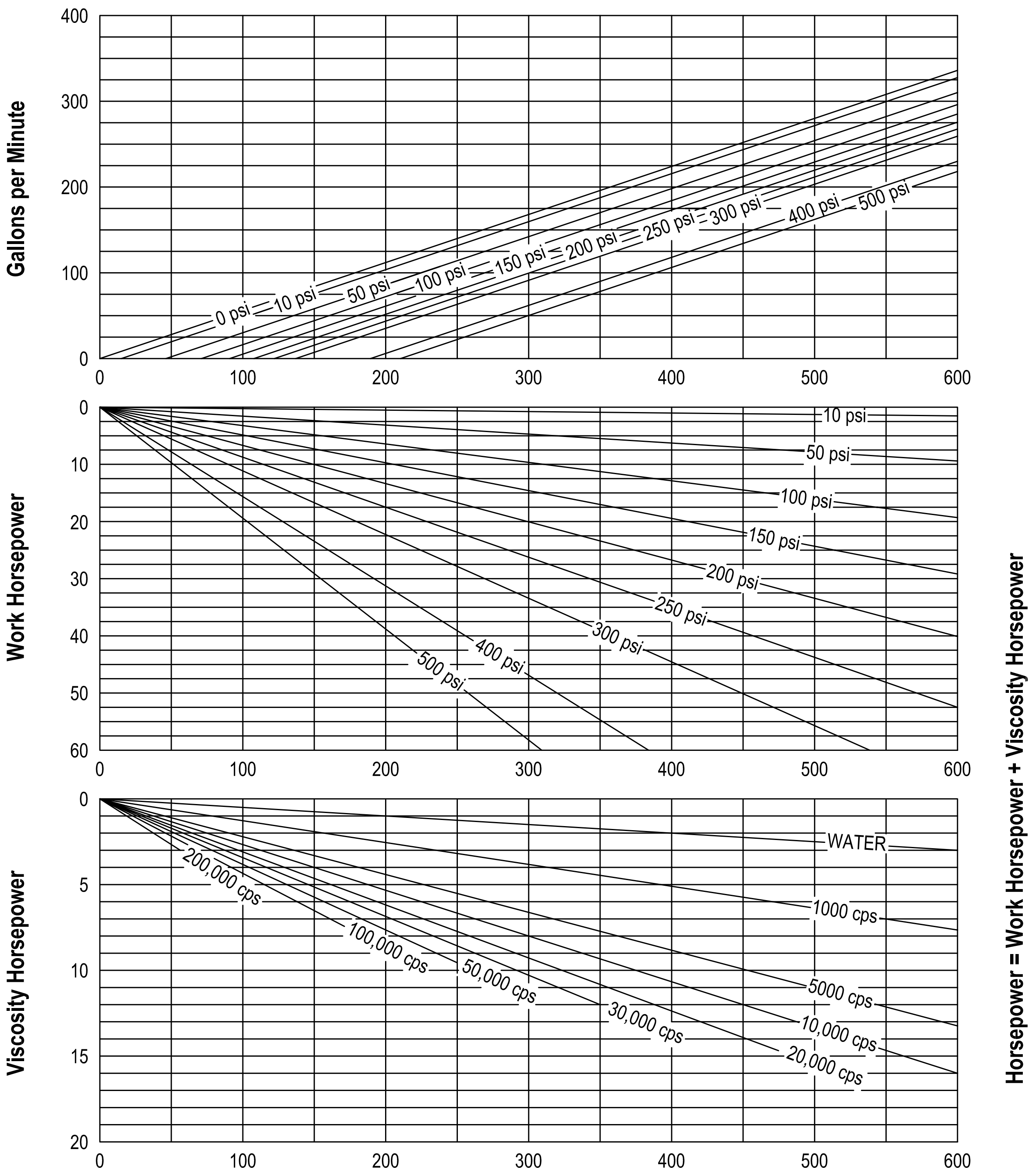
FKL Performance Curves
Model: 205



1265000568
Rev -

Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

FKL Performance Curves
Model: 250



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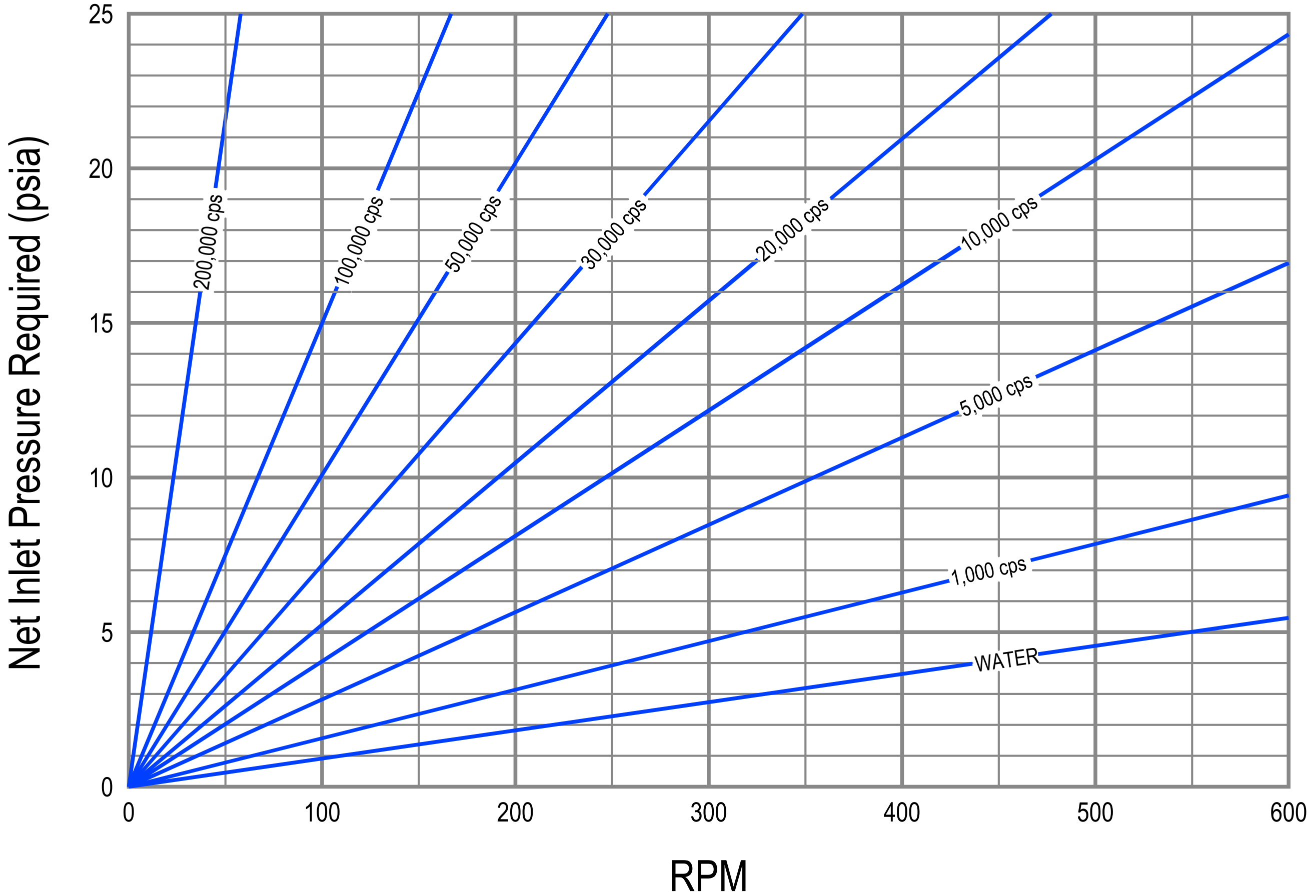
FKL Performance Curves
Model: 250



1265000500
Rev A

Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

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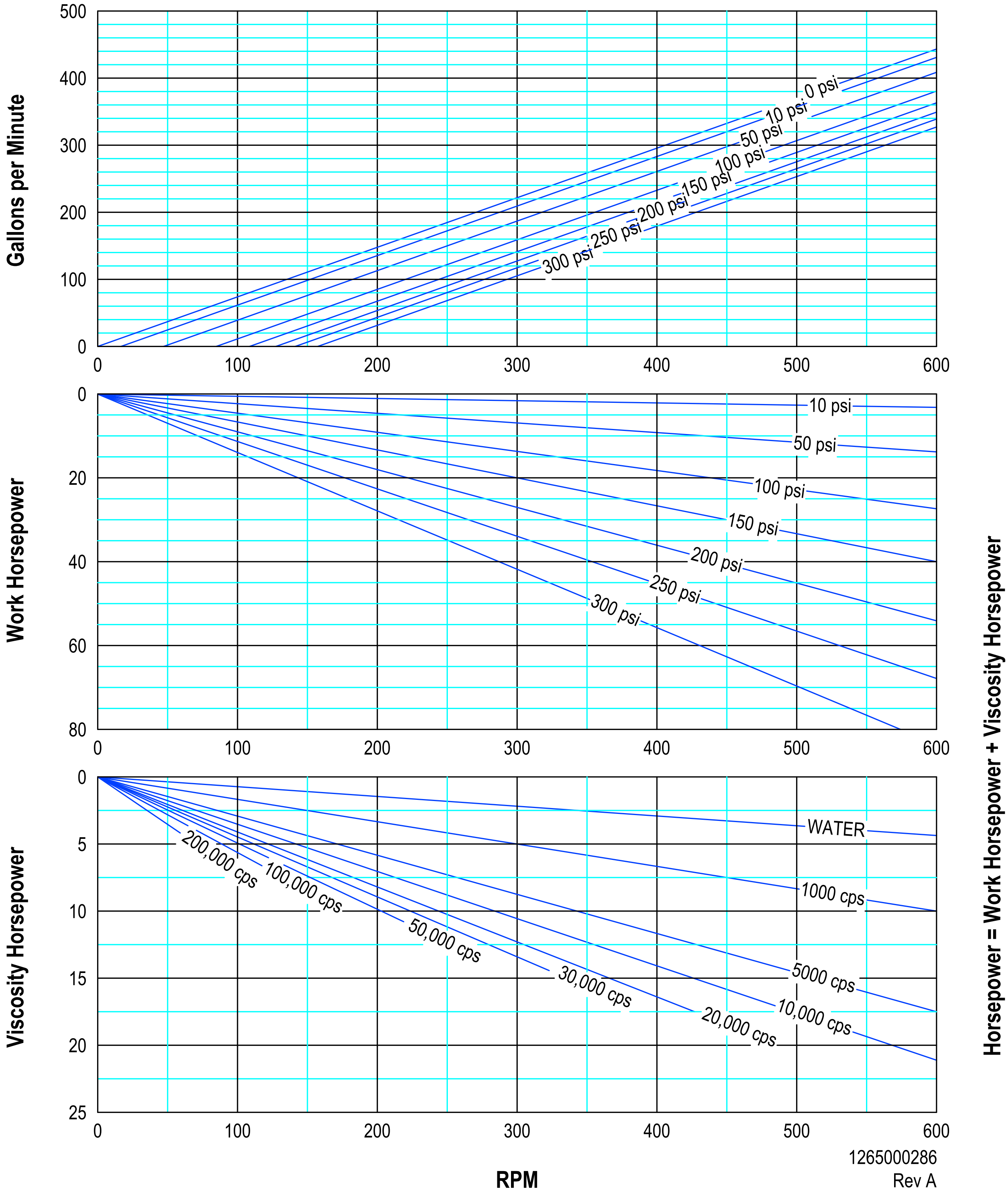
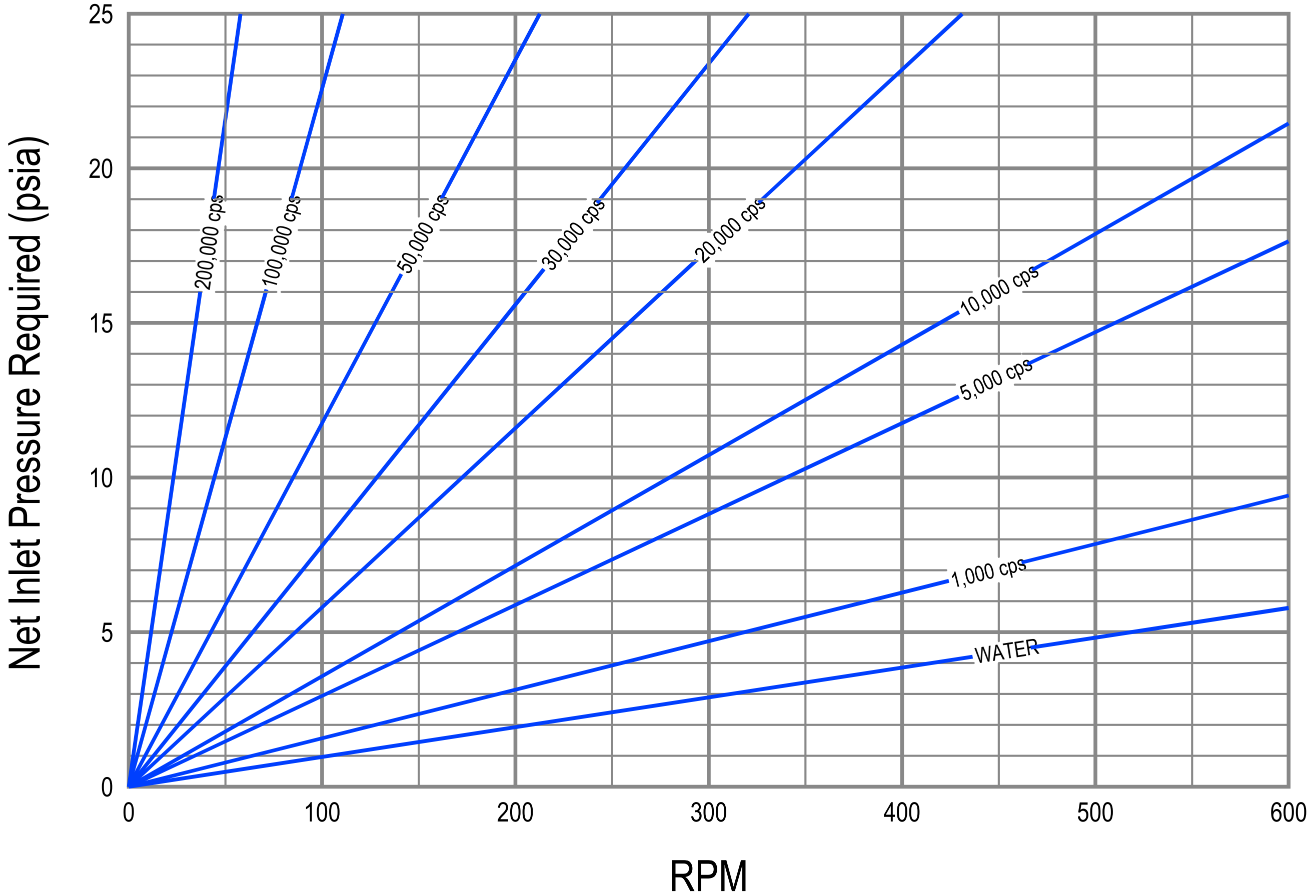
FKL Performance Curves Model: 400



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

FKL Performance Curves
Model: 400



1265000501
Rev A

Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

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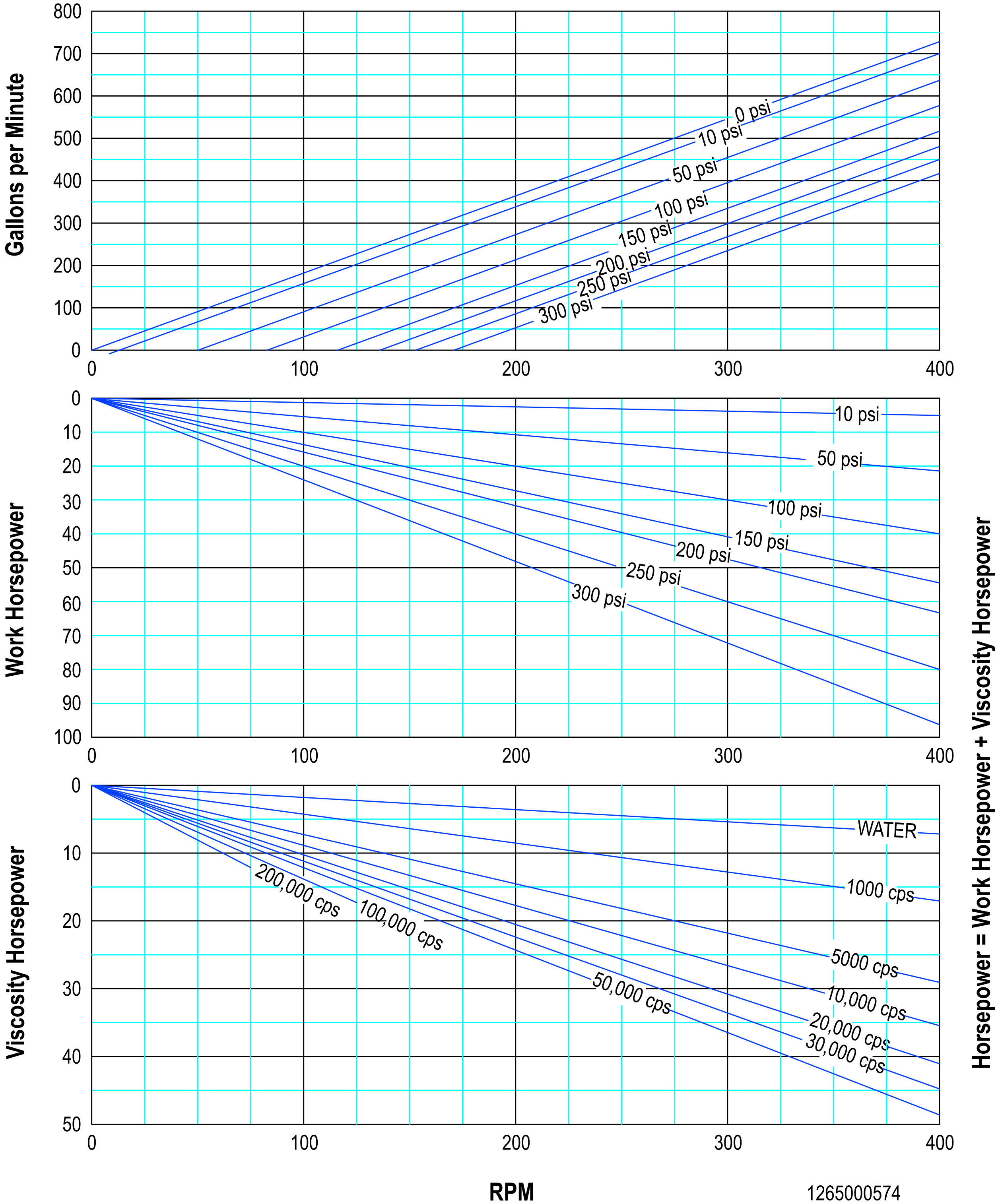
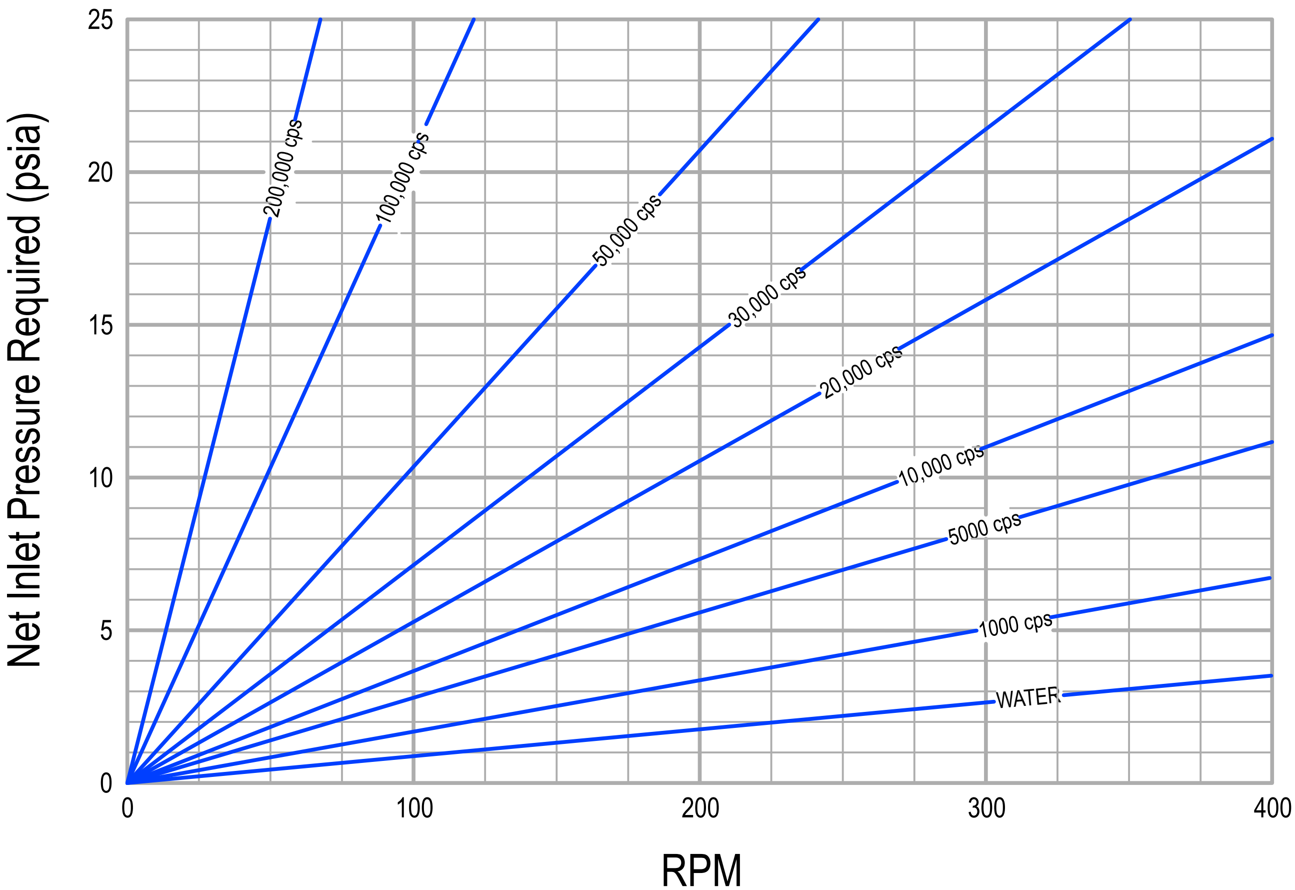
FKL Performance Curves
Model: 580



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

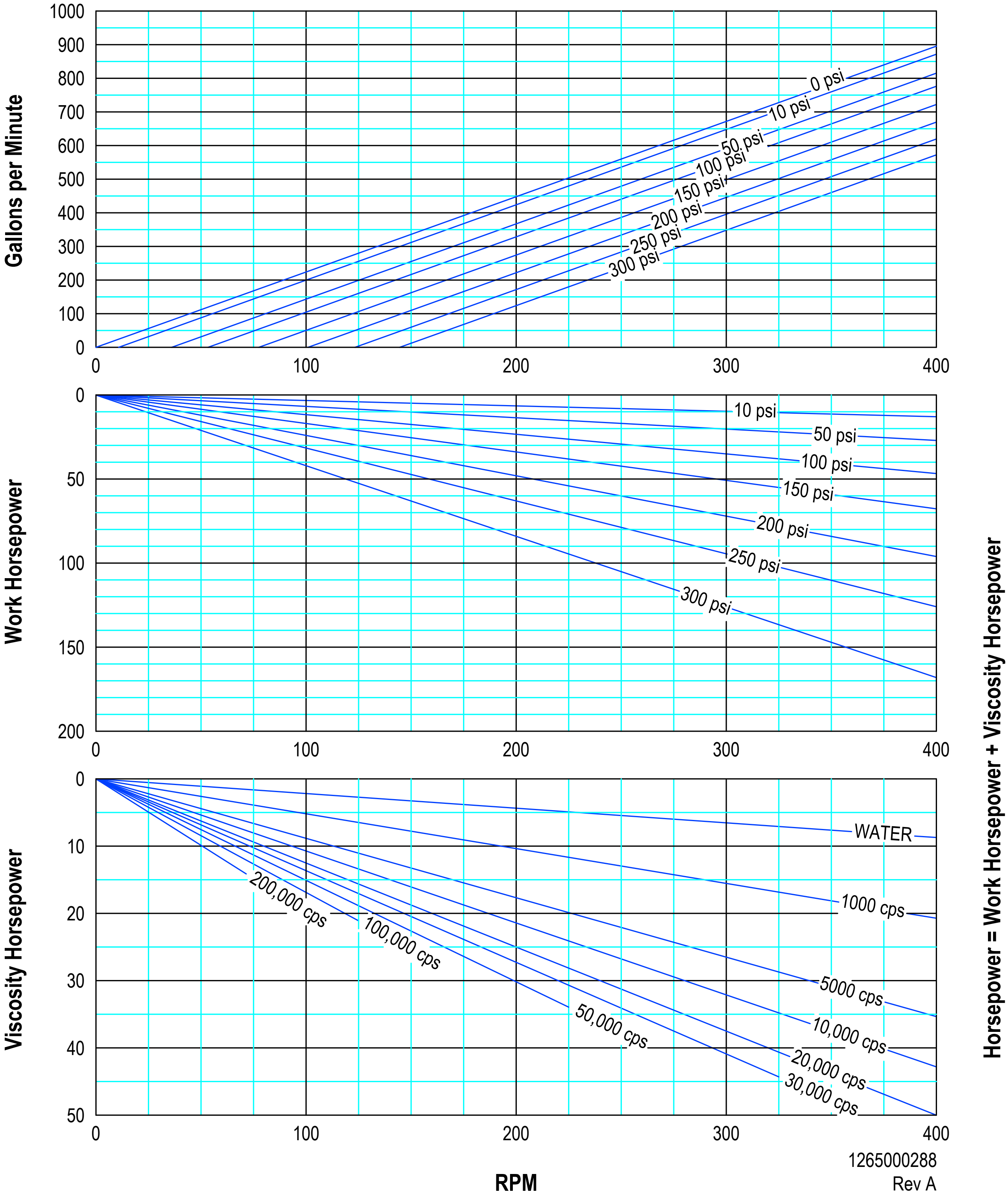
FKL Performance Curves
Model: 580



1265000575

Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

FKL Performance Curves
Model: 600



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

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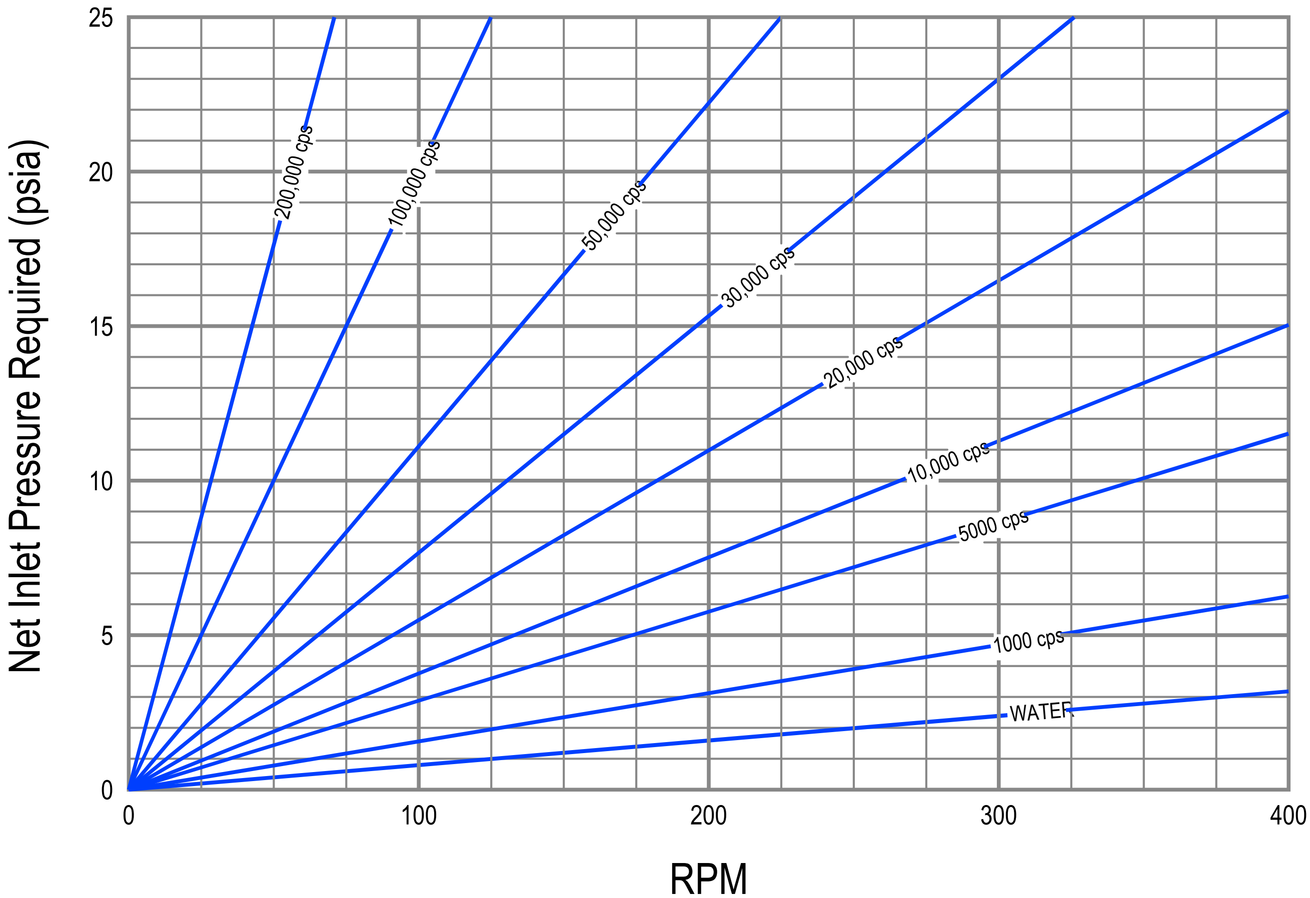
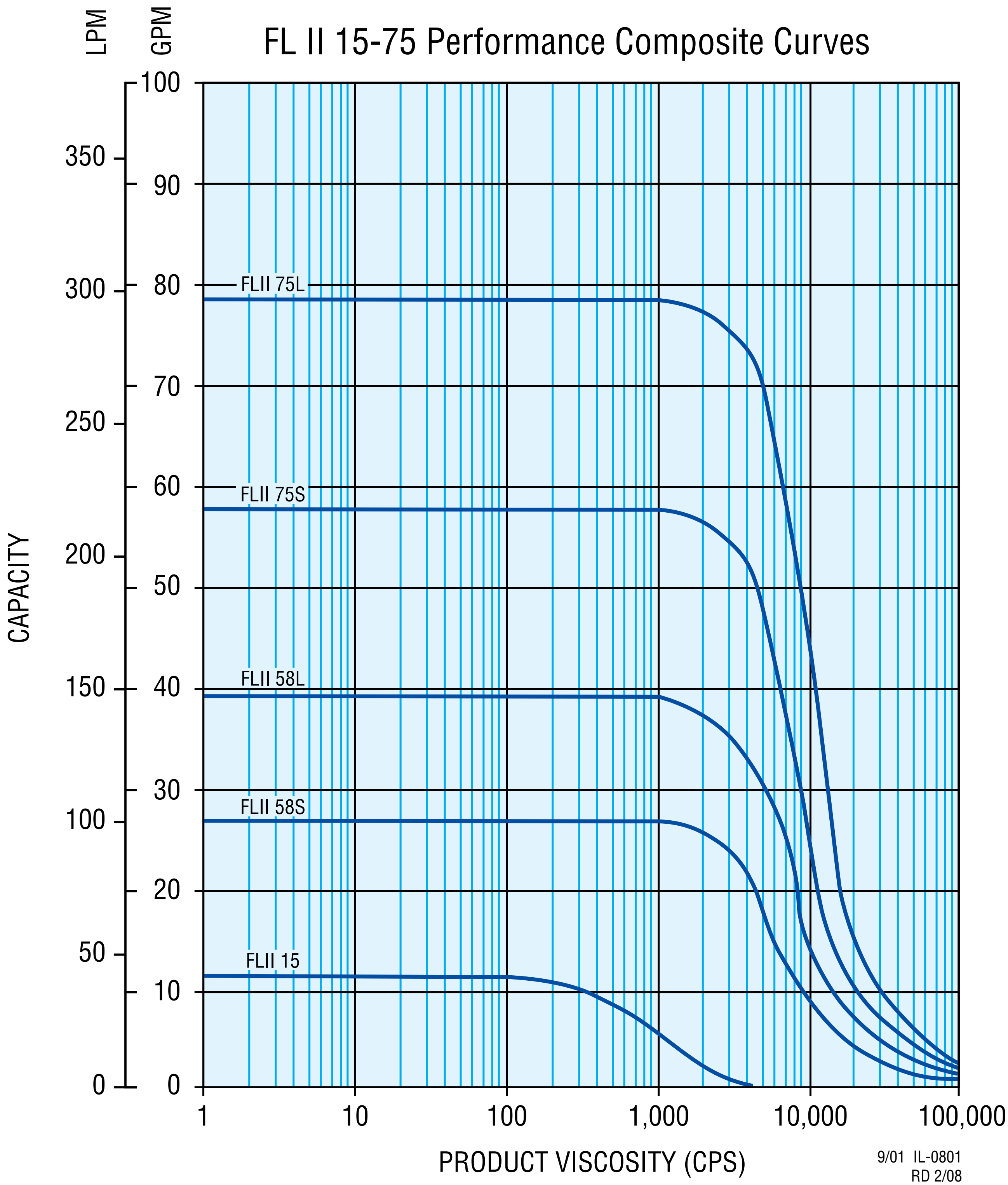
FKL Performance Curves
Model: 600



1265000502
Rev A

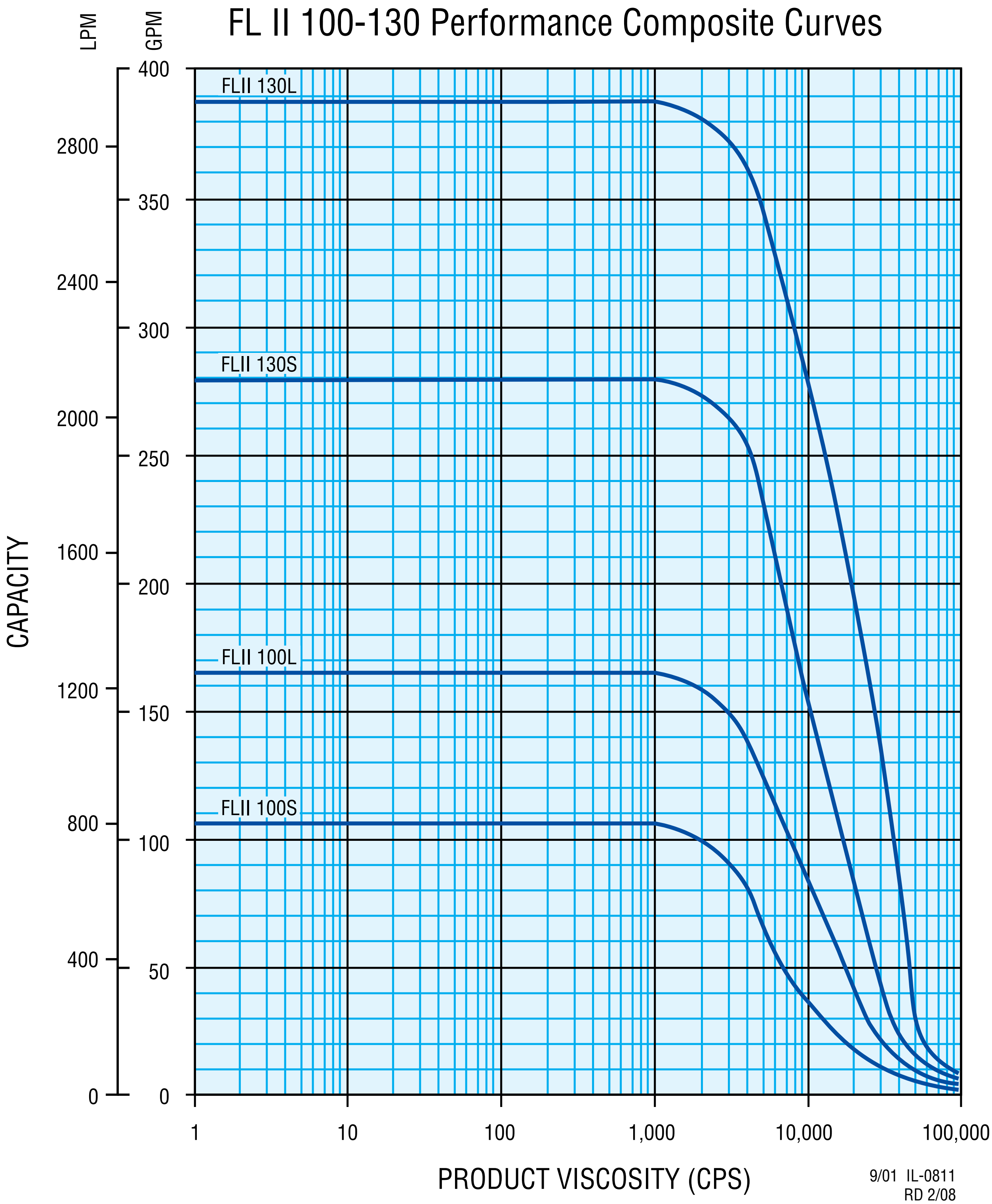
Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

FL II Composite Performance Curve Models: 15—75



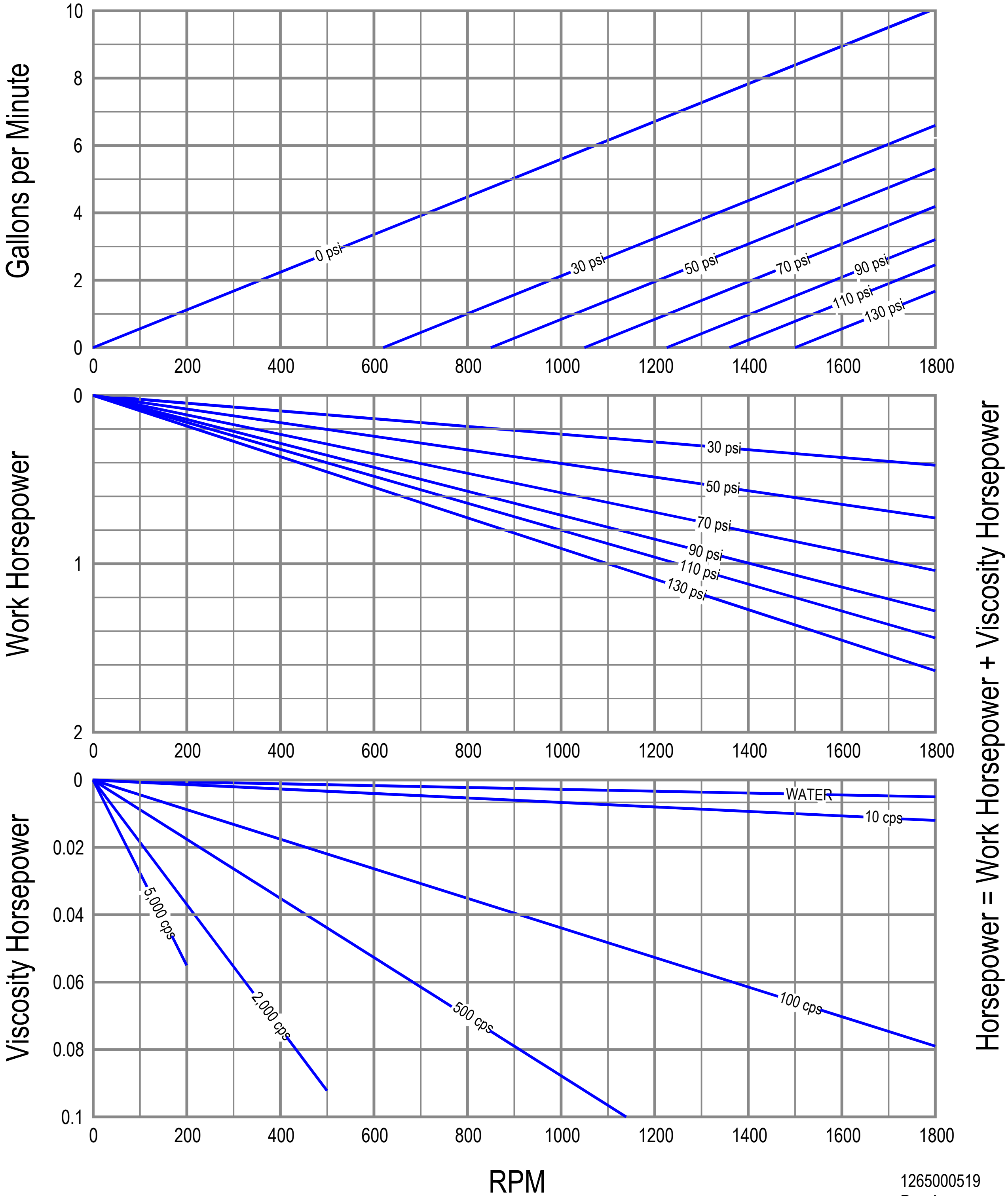
Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

FL II Composite Performance Curve Models: 100—130



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

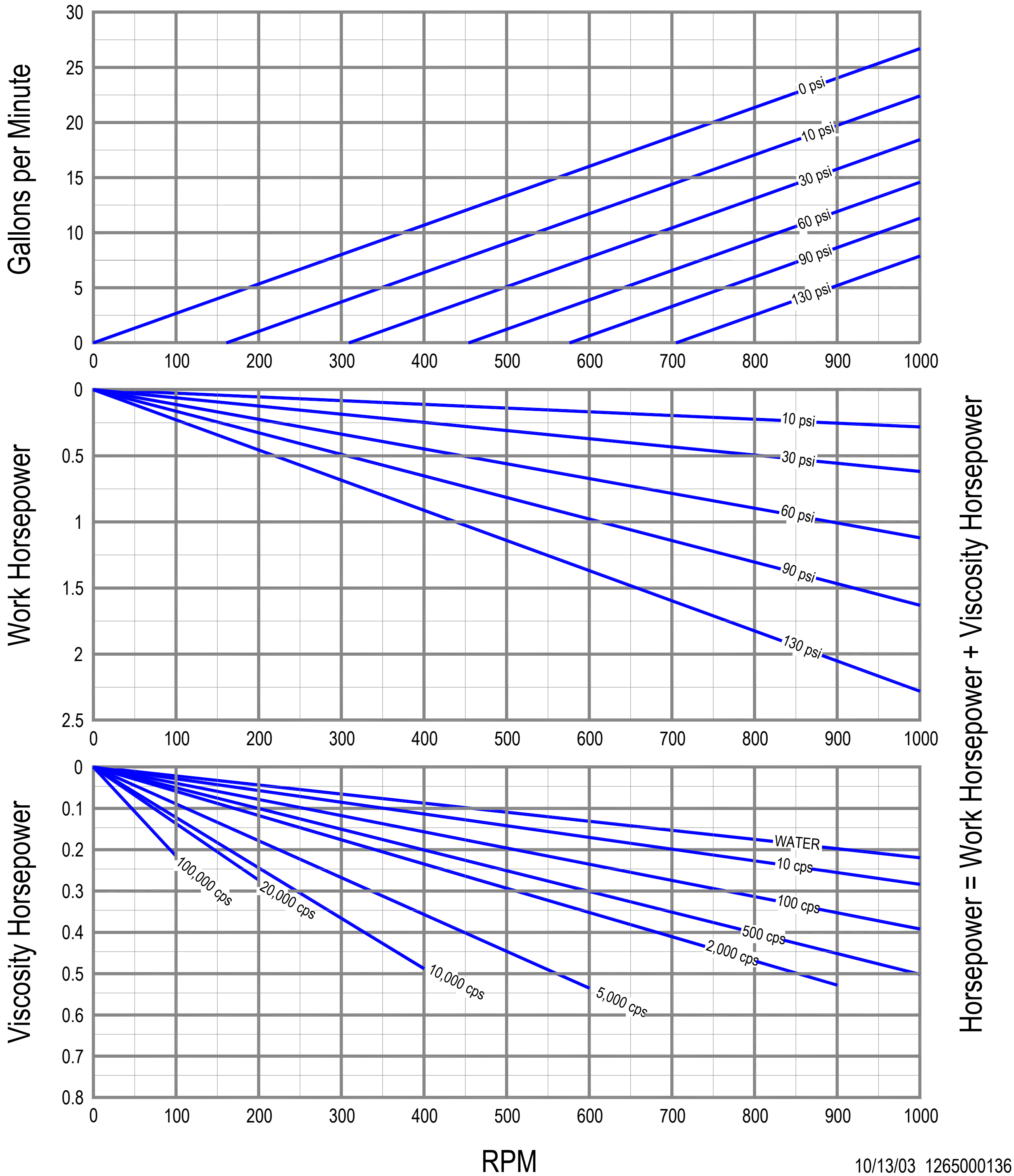
FL II Performance Curves
Model: 15



1265000519
Rev A

Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

FL II Performance Curves
Model: 58S



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

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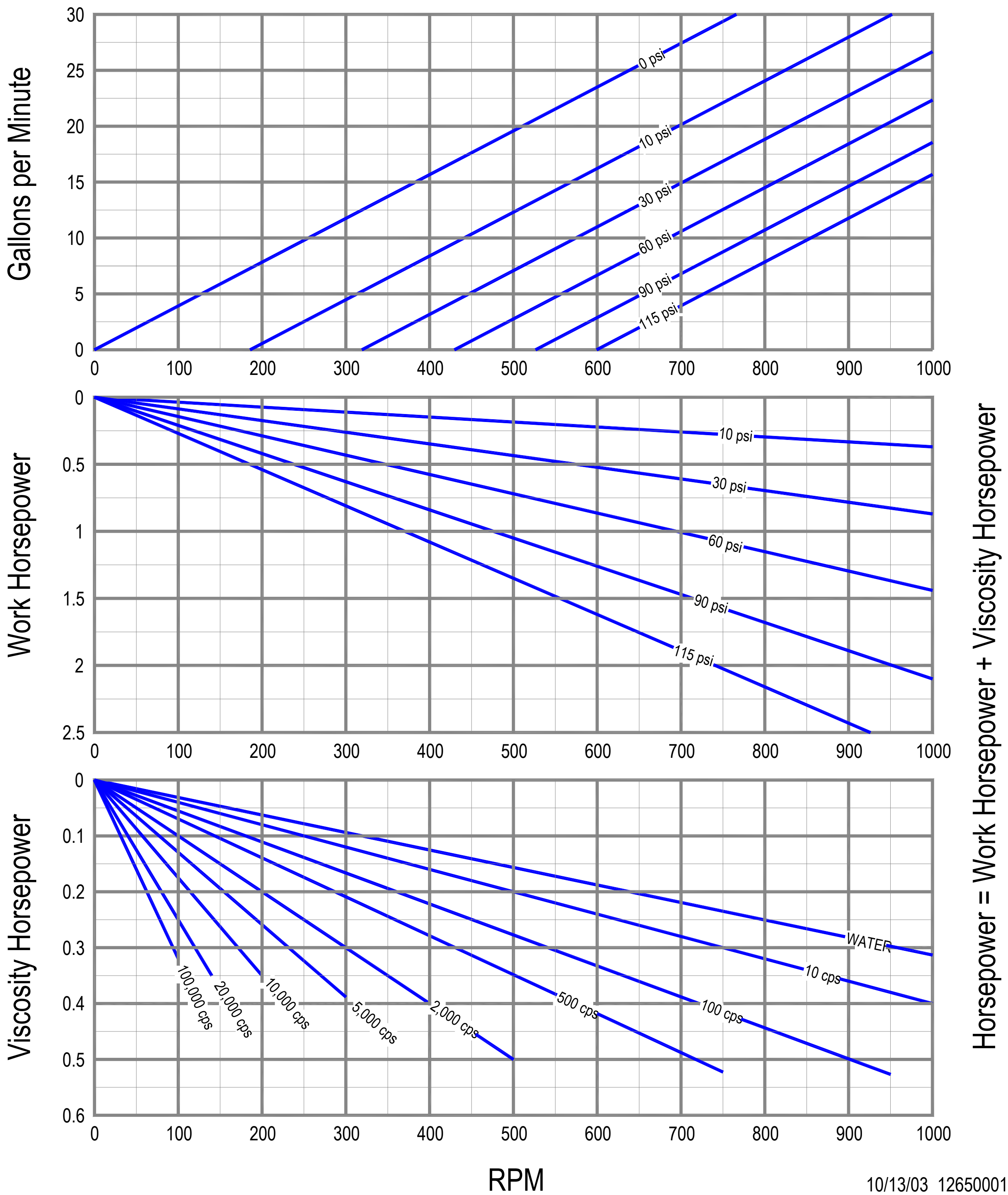
FL II Performance Curves
Model: 58L



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

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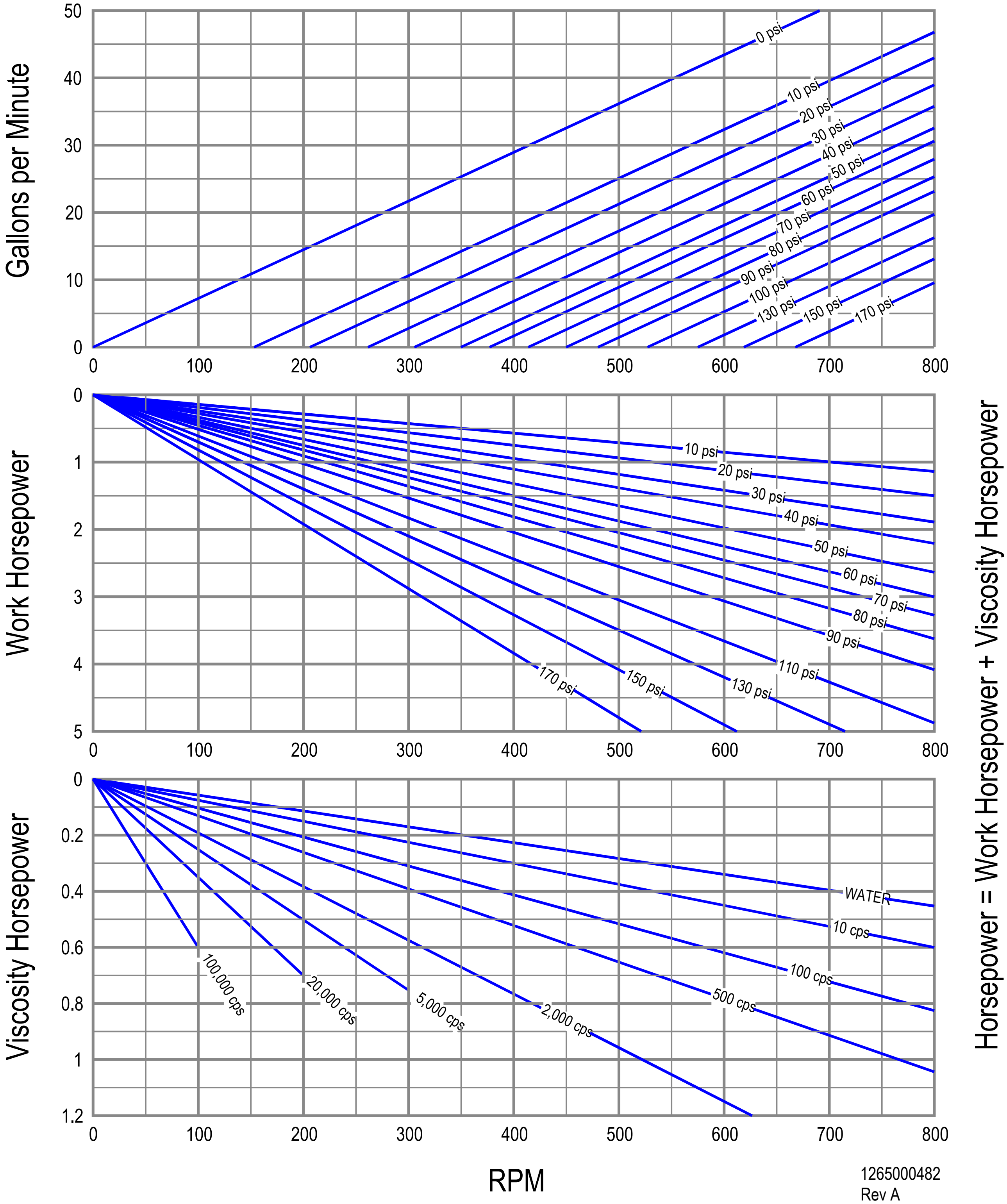
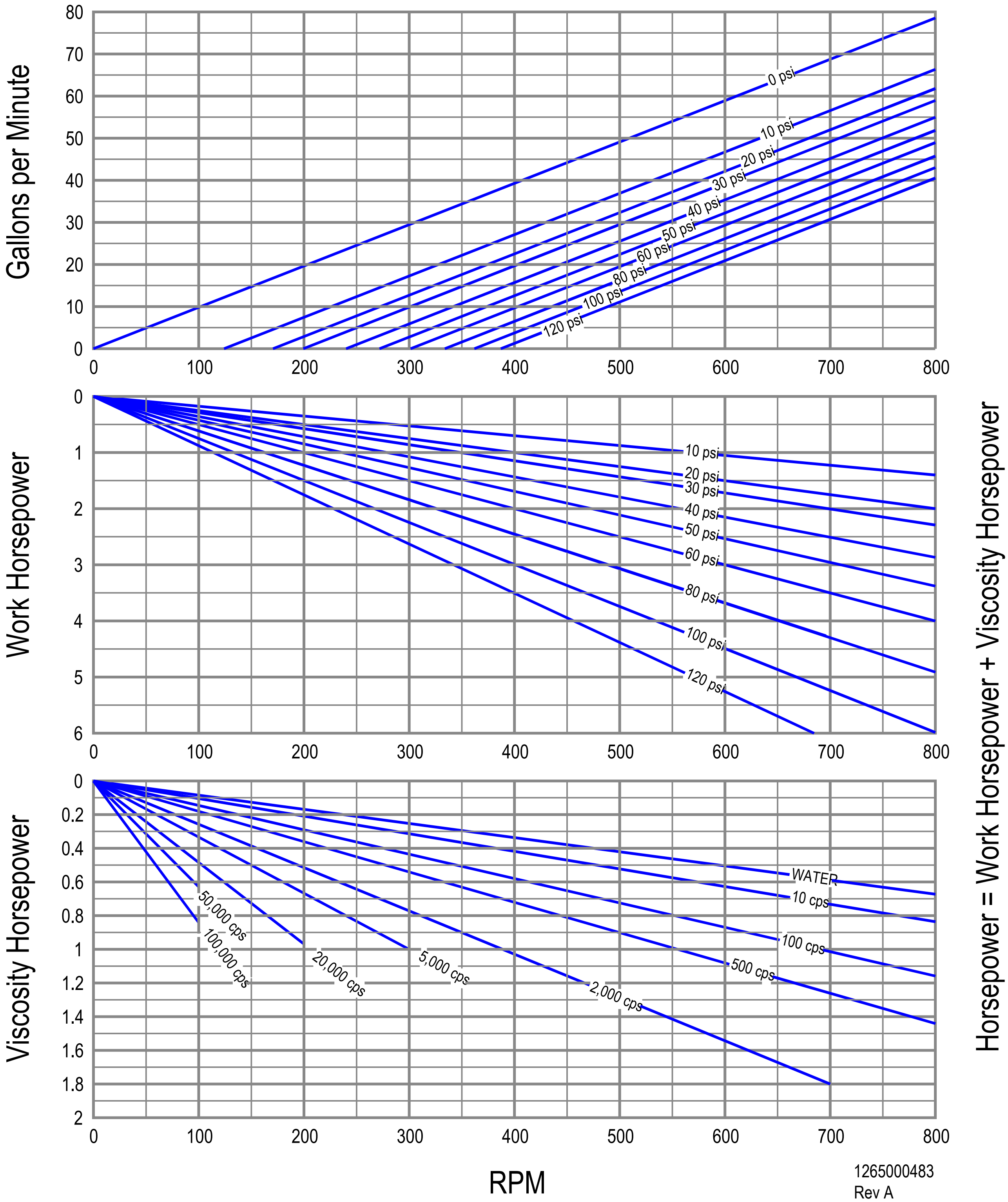
FL II Performance Curves
Model: 75S



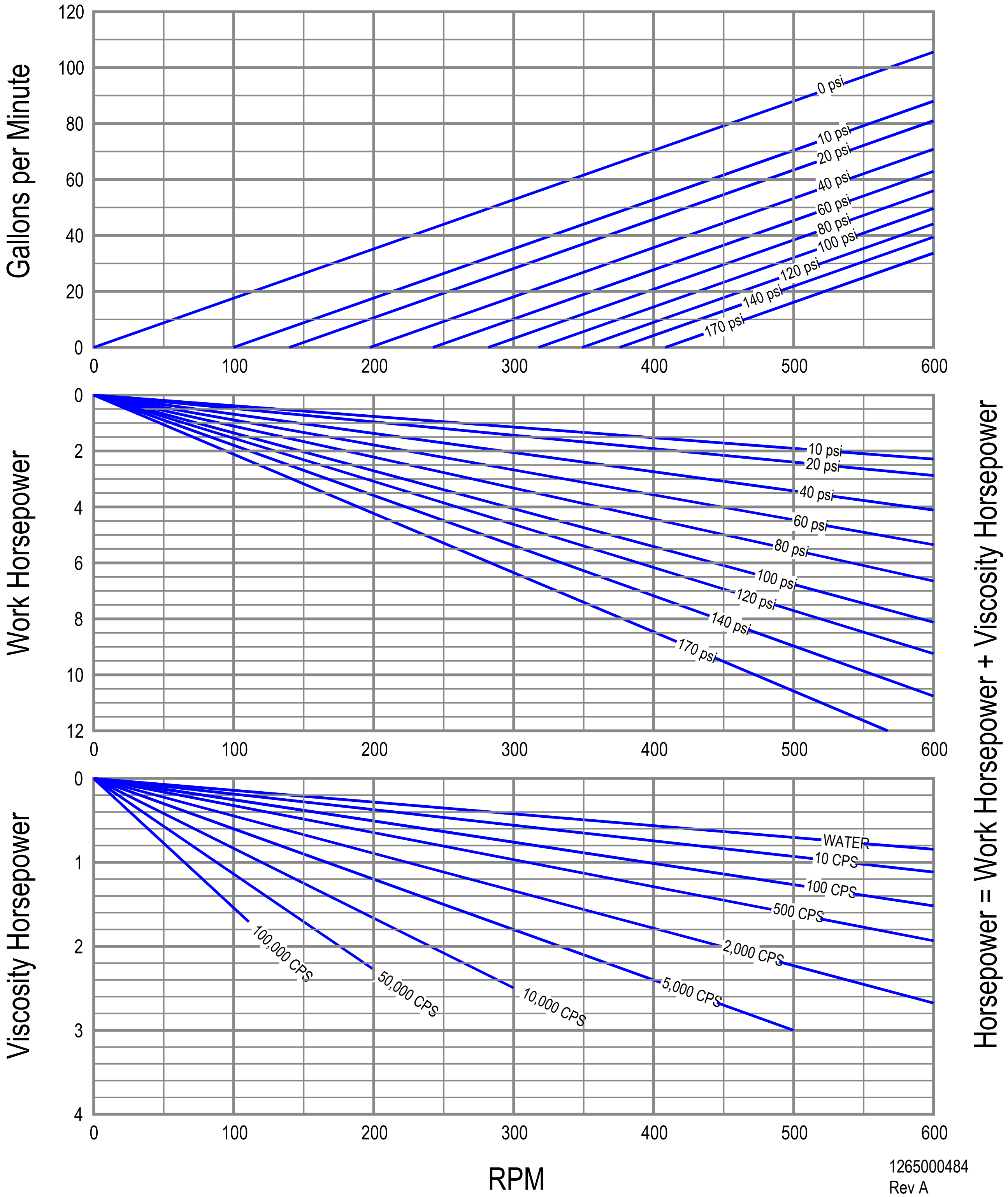
Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

FL II Performance Curves Model: 75L



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

FL II Performance Curves
Model: 100S



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

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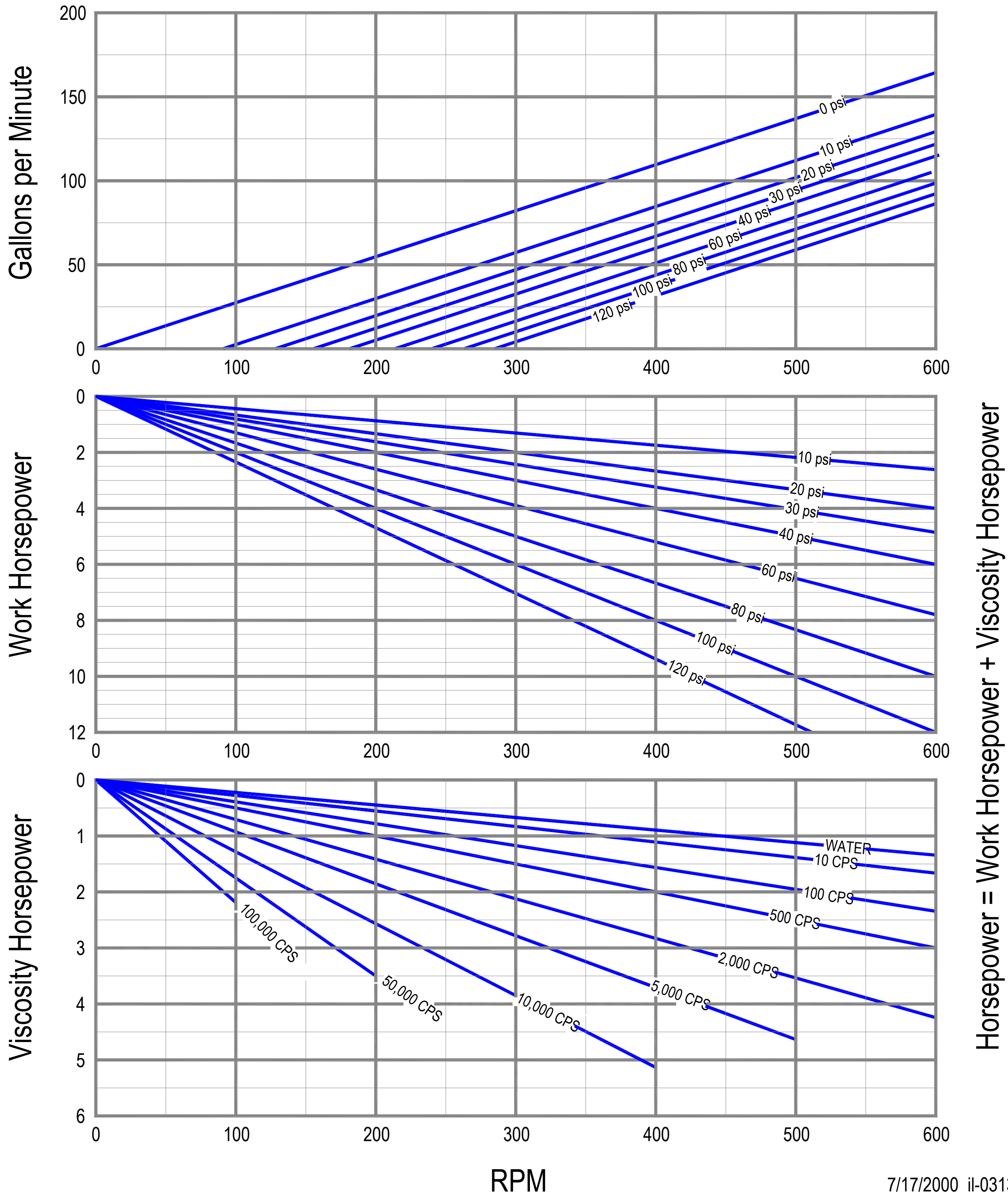
FL II Performance Curves Model: 100L



7/17/2000 il-0313

Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

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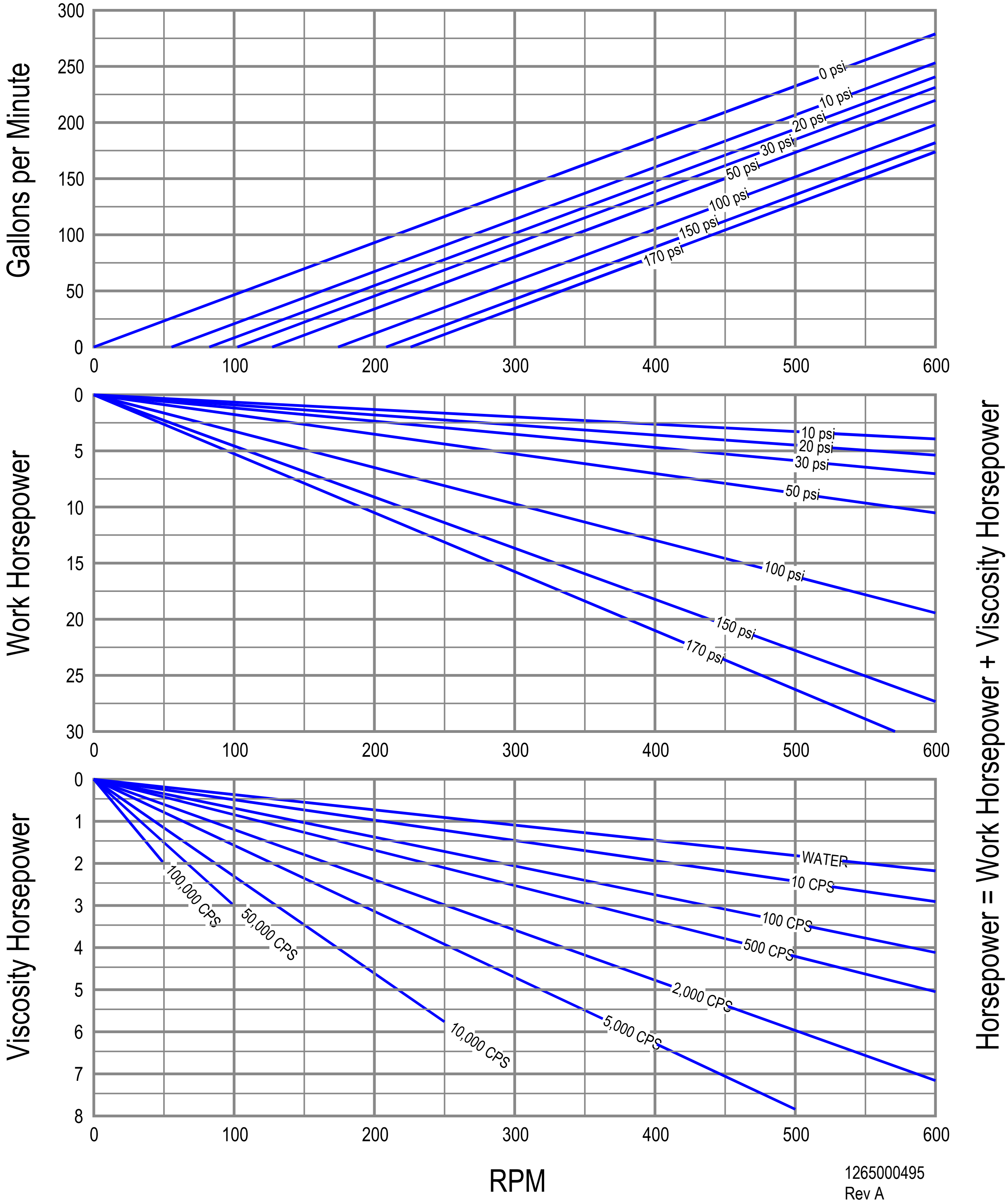
FL II Performance Curves Model: 130S



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

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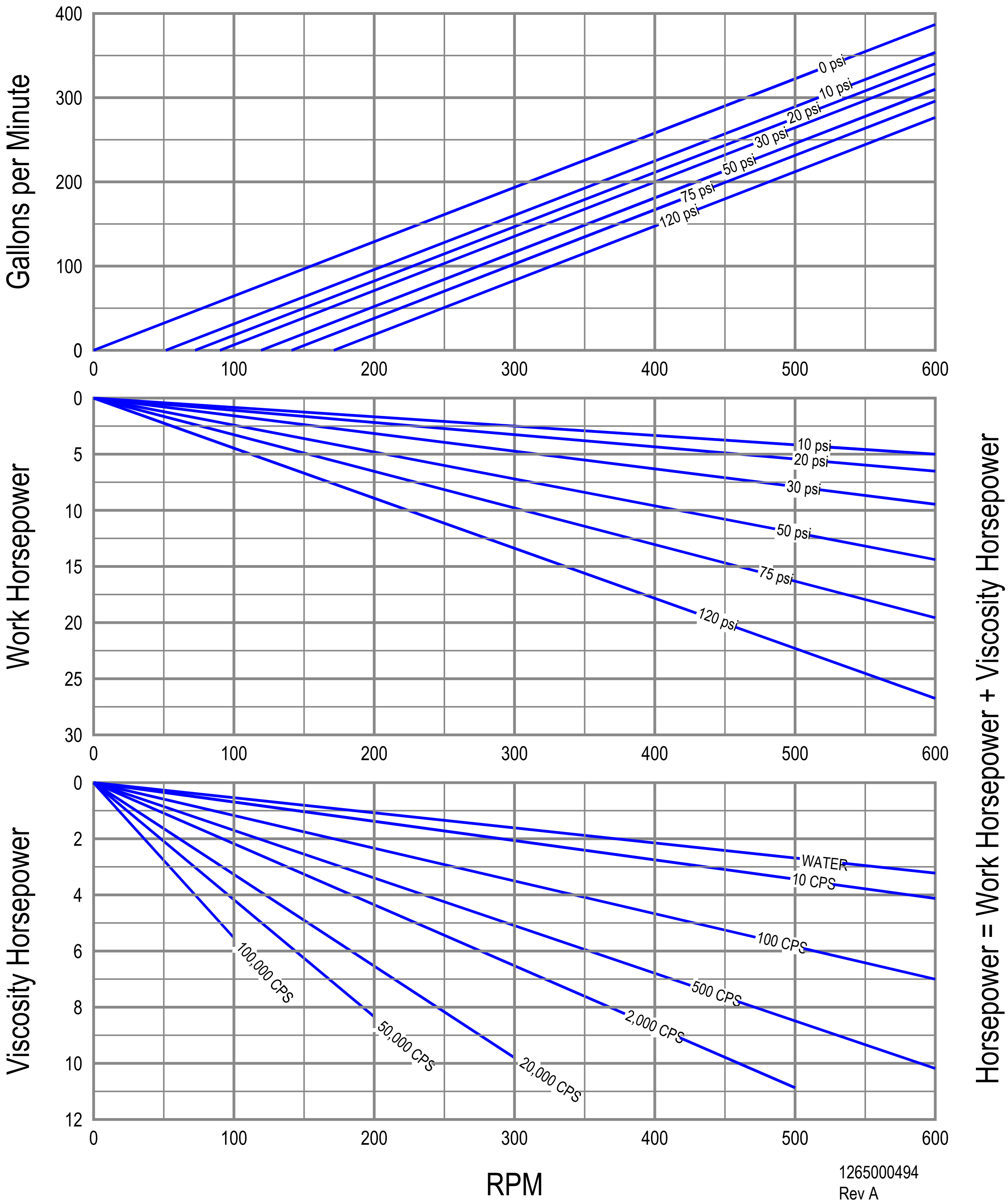
FL II Performance Curves
Model: 130L



Performance curve based on tests using 70°F water and 0 psig inlet pressure. A tolerance of ± 5% applies to all figures. Actual performance may vary by application product. Please contact Fristam for different conditions.

Supporting Tables and Conversions

Table 1: Vapor Pressure

Water Temperature (°F)	Vapor Pressure (psia)
35	0.09
40	0.121
45	0.147
50	0.177
55	0.213
60	0.256
65	0.316
70	0.362
75	0.429
80	0.506
85	0.595
90	0.698
95	0.815
100	0.949
110	1.275
120	1.692
130	2.223
140	2.889
150	3.718
160	4.741
170	5.992
180	7.511
190	9.340
200	11.526
210	14.123
212	14.696

Table 2: Average Absolute Atmospheric Head

Altitude Above Sea Level (feet)	Atmospheric Pressure	Inches of 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

Table 3: Elbow Equivalent Length (feet)

Size	1 to 150 cps	150 to 1,500 cps	1,500 to 15,000 cps	15,000 to 100,000 cps
1 ½	2.5	2	1.4	0.7
2	3.5	2.3	1.8	0.8
2 ½	4	2.5	2	1
3	5	3.5	2.5	2
4	6	4.5	3	2
6	9	6.5	4	2.25

Table 4: Tee Equivalent Length (feet)

Size	1 to 150 cps	150 to 1,500 cps	1,500 to 15,000 cps	15,000 to 100,000 cps
1 ½	9	6.5	4	2.25
2	12	8.5	6	2.7
2 ½	15	11	7.5	3.75
3	18	13	8	4
4	20	15	10	5
6	35	25	18	10

Table 5: Valve Equivalent Length (feet)

Size	1 to 150 cps	150 to 1,500 cps	1,500 to 15,000 cps	15,000 to 100,000 cps
1 ½	11	8	5.5	2
2	18	13	8	4
2 ½	20	15	10	5
3	27	20	14	7
4	33	25	17	10

Source: Tables 3 - 5 were created from Crane Co. Technical Paper No. 409. Data based on the chart are satisfactory for most applications.

Table 6: Conversion Factors and Helpful Formulas

Length

Meters	x	3.281	= Feet
Centimeters	x	0.394	= Inches
Millimeters	x	0.0394	= Inches
Inches	x	25.4	= Millimeters

Mass

Kilograms	x	2.2	= Pounds
Gallons of Water	x	8.34	= Pounds
Cubic Feet of Water	x	62.4	= Pounds
Pounds	x	0.454	= Kilograms

Volume

Liter	x	0.264	= Gallon
Cubic Feet	x	7.48	= Gallon
Pounds of Water	x	0.119	= Gallon
Imperial Gallon	x	1.2	= Gallon
Gallon	x	3.785	= Liter

Pressure

Feet of Water	x	0.433	= PSI
Inches of Mercury	x	0.491	= PSI
Atmospheres	x	14.7	= PSI
Meters of Water	x	1.42	= PSI
Bar	x	14.7	= PSI
Kilo Pascals	x	0.145	= PSI
Atmospheres	x	33.9	= Feet of Water
PSI	x	2.31	= Feet of Water
Inches of Mercury	x	1.13	= Feet of Water
Meters of Water	x	3.28	= Feet of Water

Temperature

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

Flow

Pounds of Water / Hour	x	0.002	= GPM
Pounds of Fluid / Hour	x	0.002 / SG	= GPM
Cubic Meters / Hour	x	4.4	= GPM
Liters / Minute	x	0.264	= GPM

Viscosity

Centipoise	x	1 / SG	= Centistokes
SSU	x	0.216	= Centistokes
Saybolt Furol	x	2.16	= Centistokes
Redwood Standard	x	0.237	= Centistokes
Redwood Admiralty	x	2.34	= Centistokes
Engler-Degrees	x	7.45	= Centistokes
Ford Cup #4	x	3.76	= Centistokes
MacMichael	x	0.415	= Centistokes
Stormer	x	2.81	= Centistokes

Power

T (in - lbs.) x RPM	/	63,025	= Horsepower
Kilowatts	x	1.341	= Horsepower
Metric Horsepower	x	0.9863	= Horsepower
Horsepower	x	0.746	= Kilowatts
Horsepower	x	42.44	= BTU / Minute

$$\frac{\text{GMP x Head (ft. of water) x SG}}{3960} = \text{Liquid Hp}$$

Efficiency

$$\frac{\text{Liquid HP}}{\text{Brake HP}} = \text{Efficiency}$$

*Brake HP is read off the pump curve

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