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TRI-ROTOR® PUMPER

ISSUE NO 3

VISCOSITY – SPEED – GALLONAGE (VSG) RELATIONSHIP

Liquid viscosity limits the speed at which a positive displacement pump may run. The more viscous the pumpage, the slower the allowable pumping rate, for a given pump size.

Materials of construction, clearances between moving parts, port size and configuration and various other factors also help determine the maximum allowable running speed. For example, depending upon the type of metals used and the physical size of the pumping members, the pump should not be speeded beyond the allowable rubbing feet per minute of the mating parts surfaces. Generally these factors are controlled through engineering and production within the pump manufacturing plant.

Viscosity of the fluid to be pumped is an element outside the pump factory control. The pump engineer must take this liquid characteristic into consideration when fitting the pump to a given application.

A Tri-Rotor pump utilizes two reciprocating double-acting pistons in an overlapping stroke relationship, to accomplish its pumping action. One (called a "shuttle") is block-shaped and moves side to side within a U-shaped piston (Fig. 1).

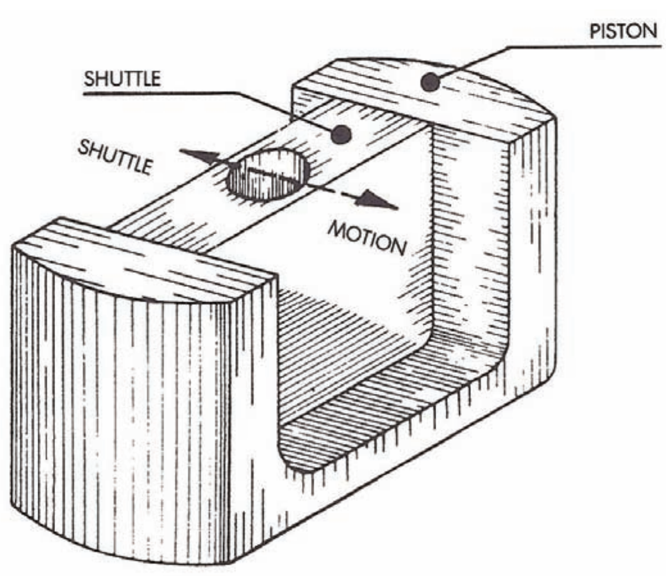


FIG 1

The U-shaped piston moves back and forth inside the slot in the rotor (Fig. 2).

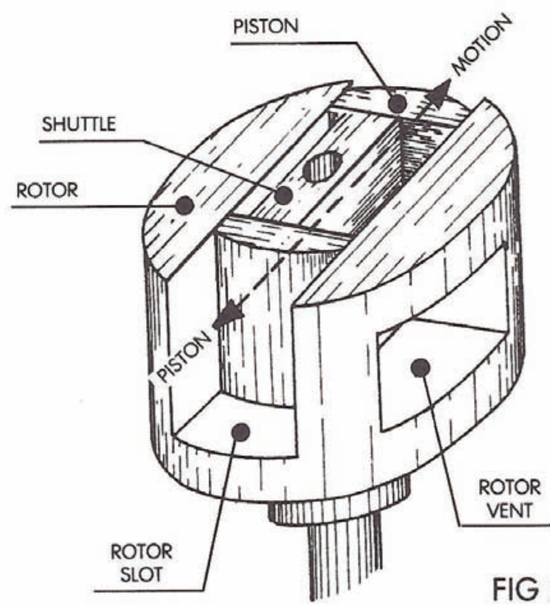
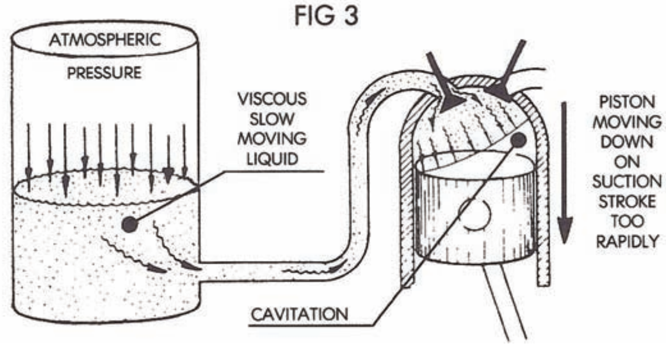


FIG 2

When a conventional piston moves down a regular cylinder on its suction stroke, the void space left above it is one of negative pressure, a "vacuum". Atmospheric (positive) pressure on the storage tank then pushes the liquid through the suction line to fill this void space.
(Fig. 3).

If the liquid is of thin water-like consistency, it will be forced into the cylinder as rapidly as the piston vacates space for it. But, if the liquid is viscous, it will resist flowing and cannot be pushed into the vacated space as rapidly. If the

FIG 3



piston is not slowed down, the viscous liquid, a slow moving blob, cannot flood over the receding piston face; and hence will leave voids (cavities) with high vacuum characteristics. Cavitation, as this condition is known, will damage the pump, reduce its efficiency and cause vibration and noise (the latter resulting from collapsing of voids). By slowing the piston down for a given viscosity fluid, cavitation is prevented – the more viscous the fluid, the slower the piston speed time must be.

Tri-Rotor pumps are designed to run fast and efficiently for handling high viscosity liquids. To attain desired capacity in a viscous pumpage application, higher speed allows use of a smaller size pump and a lower ratio power tranmission unit, thereby substantially reducing initial installation cost. Specifically, Tri-Rotor pump design achieves this as follows:

1. The pump case has "chambers" leading from the ports of the body bore (Fig. 4). The pumpage then is always in flooded contact with the rotor group, giving maximum time for a viscous liquid to flow into the pumping members.

2. By virtue of the comparatively short strokes of the shuttle and piston, a viscous pumpage can more easily fill the displaced volumes completely even though speeds are relatively high. A slow moving "blob" of liquid need not flow so far.

3. Mating parts in Tri-Rotor pumps have excellent sealing characteristics because contact areas between them are large. This low slip feature assures a high vacuum formation on the suction faces of the shuttle and piston, hastening fluid flow over them.

4. The ***Tri-Rotor V-Head*** pump provides another unique alternative for preventing cavitation without the necessity of reducing pump speed. Turning down the Manual Flow Control (MFC) shortens piston and shuttle stroke length – the more turns, the shorter. Without decreasing speed, a ***Tri-Rotor V-Head*** pump can then handle thicker and thicker fluids.

(Note that high viscosity is not the only cause of cavitation. For example, if the suction line is too long, atmospheric pressure at the storage tank will not be sufficient then to overcome pipe friction and push even a thin liquid through the suction line fast enough. Cavitation will occur, in this case, because of pump "starvation".)

The VSG Chart (page 3) shows the maximum recommended pump speeds for various viscosities from 40 SSU/4 cPs through 100,000 SSU/ 21,625 cPs for each Pump Series. Directions for determining maximum capacity (speed and delivery rate), selecting correct pump model, and establishing suction pipe sizing are explained on page 4. While most elements of the VSG chart are self-explanatory, we call attention to the following:

A. All data therein are based on non-tacky pumpages. For syrups, asphaltic, rubbery and other such type liquids, pump speeds must be less than shown. Consult factory for recommendations.

B. For liquids 10,000 SSU /2,150 cPs viscosity or heavier, the pump should be furnished with a relieved rotor group, if they are tacky in nature.

C. For liquids 10,000 SSU/2,150 cPs viscosity or heavier, specify 1-1/2" ports for Series 20 pumps and 2" ports for Series 40.

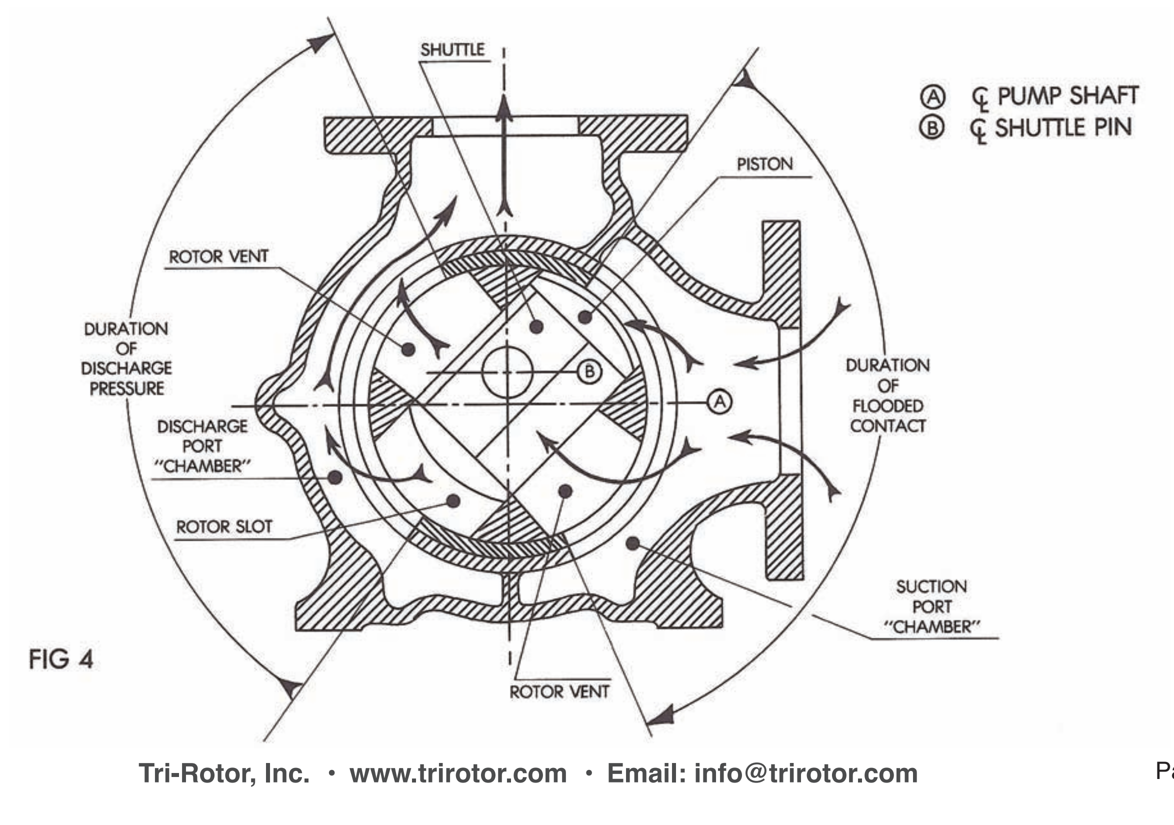


FIG 4

VSG CHART [VISCOSITY — SPEED — GALLONAGE]

SSU (Saybolt Seconds Universal) / CPS (Centipoise) — (RPM) — (GPM)

MAXIMUM RECOMMENDED PUMP SPEEDS FOR VARIOUS VISCOSITIES

	SERIES 20			SERIES 40			SERIES 80			SERIES 100			SERIES 120			SERIES 200			
Rating	20 GPM @ 1140			40 GPM @ 540 RPM			80 GPM @ 540 RPM			100 GPM @ 690 RPM			90 GPM @ 600 RPM			200 GPM @ 430 RPM			Rating
Displacement Factor	1.76 Gals/100 Revs.			6.9 Gal./100 Revs.			14.8 Gals./100 Revs.			14.8 Gals./100 Revs.			14.8 Gals./100 Revs.			46.5 Gals./100 Revs.			Displacement Factor
Port Size	1¼"x11½" THD NPT			1½"x11½" THD NPT			Four 2"x11½" THD NPT			3" Flanged			4" Flgd. Top Suction X 3" Flgd. Side Discharge			4" Flanged			Port Size
SSU / CPS	RPM	**GPM**	Suct.	RPM	**GPM**	Suct.	RPM	**GPM**	Suct.	RPM	**GPM**	Suct.	RPM	**GPM**	Suct.	RPM	**GPM**	Suct.	**SSU** / CPS
40 / 4	1800*	**30.0**	1¼	600	**42**	1½	600	**88**	2	690	**102**	3	DESIGNED SPECIALLY FOR HANDLING VISCOUS AND SEMI-SOLID PUMPAGES			520	**240**	4	**40** / 4
100 / 20	1200*	**21.0**	1¼	600	**42**	1½	600	**88**	2	690	**102**	3				520	**240**	4	**100** / 20
400 / 78	1180*	**20.6**	1¼	590	**41**	1½	590	**87**	2	690	**102**	3				445	**205**	4	**400** / 78
600 / 125	1160*	**20.4**	1¼	580	**40**	1½	588	**86**	2	685	**101**	3				435	**202**	4	**600** / 125
800 / 165	1130	**19.9**	1¼	570	**39**	1½	570	**84**	2	680	**100**	3				430	**200**	4	**800** / 165
1,000 / 200	1120	**19.7**	1¼	560	**38**	1½	560	**83**	2	670	**99**	3				425	**197**	4	**1,000** / 200
1,600 / 335	1080	**19.0**	1¼	540	**37**	1½	540	**80**	2½	650	**96**	3				410	**190**	4	**1,600** / 335
2,000 / 410	1060	**18.6**	1½	530	**36**	2	530	**79**	2½	640	**95**	3	RPM	**GPM**	Suct.	405	**188**	4	**2,000** / 410
3,000 / 620	1010	**17.7**	1½	500	**34**	2	510	**75**	2½	580	**85**	3	610	**90**	4	390	**181**	4	**3,000** / 620
5,000 / 1,060	950	**16.7**	2	480	**33**	2	470	**70**	2½	530	**78**	3	570	**84**	4	370	**172**	4	**5,000** / 1,060
8,000 / 1,700	880	**15.5**	2	440	**30**	2	440	**65**	2½	470	**70**	3	540	**80**	4	345	**160**	4	**8,000** / 1,700
9,000 / 1,900	860	**15.1**	2	420	**29**	2	420	**62**	2½	450	**67**	3	520	**77**	4	335	**156**	4	**9,000** / 1,900
CAUTION: Suction piping diameter must be separately determined, regardless of pump port size, where volatile liquids or viscous pumpage are concerned. For very viscous fluids, liquid levels should be high enough above pump centerline to assure positive pressure ("Flooded Suction") at all times.																			
Port Size	1½"x11½ THD NPT			2"x11½" THD NPT			Four 2"x11½" THD NPT			3" Flanged			4" Flgd. Top Suction X 3" Flgd. Side Discharge			4" Flanged			Port Size
10,000 / 2,150	1000	**17.6**	2	500	**34**	2½	410	**61**	3	430	**64**	3	500	**74**	4	330	**153**	4	**10,000** / 2,150
15,000 / 3,100	960	**16.9**	2½	480	**31**	3	370	**55**	3	410	**61**	3	470	**70**	4	300	**140**	4	**15,000** / 3,100
20,000 / 4,250	880	**15.5**	2½	440	**28**	3	330	**49**	3	380	**56**	4	440	**65**	4	275	**128**	4	**20,000** / 4,250
30,000 / 6,500	800	**14.1**	3	380	**25**	3	280	**41**	4	340	**50**	4	380	**56**	4	255	**118**	6	**30,000** / 6,500
40,000 / 8,610	680	**12.0**	3	320	**21**	3	230	**34**	4	300	**44**	4	330	**49**	4	210	**98**	6	**40,000** / 8,610
50,000 / 10,800	560	**9.9**	3	280	**15**	3	190	**28**	4	250	**37**	4	280	**41**	4	185	**86**	6	**50,000** / 10,800
75,000 / 16,210	400	**7.0**	3	210	**11**	3	130	**19**	4	170	**25**	4	200	**30**	4	150	**70**	6	**75,000** / 16,210
100,000 / 21,625	240	**4.2**	3	150	**8**	3	100	**15**	4	125	**19**	4	150	**22**	4	125	**58**	6	**100,000** / 21,625

Suct.-Minimum recommended diameter in inches, not longer than 10 feet and containing no more than two pipe fittings. Consult factory with all other piping arrangements.
* Use 1½" ports on Series 20 at speeds above 1140 RPM.

HOW TO USE THE VSG CHART

TO DETERMINE MAXIMUM CAPACITY OF ANY PUMP:

1. In first column of chart, find viscosity of pumpage shown in SSU (Saybolt Second Universal), and CPS (Centipoise).
2. To right of this value, under appropriate series number, find pump speed and delivery rate.
3. For intermediate values of viscosities, extrapolate.

EXAMPLE: How fast can the TRI-ROTOR ® pump Model **100CV** be run to handle 1,300 SSU viscosity castor bean oil, and what is its capacity?

ANSWER: 1,300 SSU viscosity is midway between 1,000 and 1,600 on chart. By extrapolation in Series **100** column, it will be seen that the Model **100CV** can be run 660 RPM, at which speed it will deliver 97.5 free flow.

TO SELECT CORRECT MODEL PUMP:

1. In first column of chart find viscosity of pumpage, shown in SSU (Saybolt Seconds Universal), and CPS (Centipoise).
2. Move along line to right, noting GPM delivery rate under each pump Series.
3. The correct pump size is that Series in which GPM reading is equal to or greater than the desired capacity for a given pumping installation.

EXAMPLE: What size TRI-ROTOR® pump is required for transferring 20 GPM of No. 6 Bunker C fuel oil having a viscosity of 75,000 SSU at pumping temperature.

ANSWER: Moving to right, along 75,000 SSU viscosity line on chart, note that Series **20** pump can give only 7 GPM, Series **40** only 11 GPM and Series **80** only 19 GPM, so these sizes are too small. The Series **100** can deliver 25 GPM, hence it is the correct model pump.

TO DETERMINE DISCHARGE RATE OF A PUMP FOR A GIVEN PUMP SPEED:

1. Find pump displacement factor (first column) shown in "Gallons per 100 Revolutions" of the pump shaft under the appropriate pump Series column.
2. Multiply the given displacement factor by $\frac{\text{pump RPM}}{100}$ which equals the free flow output of the pump.

EXAMPLE: A Model **200AV** pump is belt driven from a 1725 RPM motor with a 5.24:1 ratio sheave arrangement, giving an actual pump shaft speed of 329 RPM. What is its delivery rate?

ANSWER: The chart shows a displacement factor of 46.5 for this pump.
Thus, $46.5 \times \frac{329}{100} = 153$ GPM.

TO ESTABLISH CORRECT SUCTION PIPING SIZE:

1. Under applicable pump Series heading, read downward in "Suct." column.
2. Run across chart from appropriate viscosity value.
3. Correct suction pipe size is shown at intersection of 1 and 2 above.

EXAMPLE: To handle 40 GPM of colored ink 30,000 SSU viscosity at pumping temperature in a Model **80BX** pump which has 2" ports, is 2 inch suction piping satisfactory?

ANSWER: No. The chart shows that 4" piping is required.

CAUTION: Suction piping diameter and length must be separately determined, regardless of pump port size, where (1) volatile liquids or (2) viscous pumpages are concerned. The sizes shown in this chart are for suction lines not longer than 10 feet and containing no more than two pipe fittings. For very viscous fluids, liquid levels should be high enough above pump centerline to assure positive pressure ("Flood Suction") at all times.

NOTE: Relieved Rotor Group

Clearances between certain mating parts must be increased to handle some types of pumpage e.g.:

1. Sticky, tacky and stringy fluids like corn syrups, some adhesives and certain plastics materials, when viscosities are over 10,000 SSU at pumping temperature. Above 100,000 SSU additional relieving is necessary.

2. Dilatant materials and shear-sensitive chemical compounds (which thicken rapidly when agitated), and some paints -- generally only at viscosities above 10,000 SSU.

3. Hot liquids, regardless of viscosity at pumping temperatures above 180° F. in case of iron or bronze fitted pumps; 140° F. or higher, pumps of all bronze construction.

Viscosity above 10,000 SSU, in itself, does not automatically necessitate a relieved rotor group. For instance, lubricating oils, sugar syrups and most printing inks perform satisfactorily in a standard pump.

GENERAL RULE: Viscous fluids which retain their "slipperiness" or which readily thin out with slight temperature increase or agitation do not require a relieved rotor group.