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TECHNICAL INFORMATION

Bulletin

NUMBER 102

PEERLESS PUMP HYDROCONSTANT VARIABLE SPEED FLUID DRIVES

INTRODUCTION

Hydroconstant fluid drive system is the name given by Peerless Pump to a pumping system which consists of an electric motor, stepless variable speed drive, centrifugal pump, and appropriate control apparatus. The system provides constant pressure through smooth speed variation, to a variable capacity demand application. The Hydroconstant fluid drive system is "tankless" since, unlike a hydro-pneumatic tank.

There are several manufacturers of tankless systems; almost as many as there are types of stepless variable speed drives and pressure reducing mechanisms. However, there are only two general types of tankless systems; variable speed type, and pressure reducing valve type.

Stepless variable speed drives can be bought from many manufacturers in every conceivable engineering principle. For example, mechanical variable speed devices can take the form of friction cones, variable pitch pulleys and planetary gears. Mechanical power transmission devices have an efficiency of about 90% and have generally increasing torques as the output speed decreases.

Electric motors are widely used as infinitely variable speed machines. Direct current (DC)

motors are excellent variable speed drives; many makes of Alternating current (AC) motors use various ingenious means of speed variation. In general, AC variable speed control follows these broad categories: wound rotor motor, SCR (Silicon-controlled rectifier), and variable frequency control.

Another common form of electrical variable speed drive is the magnetic field or eddy current coupling. Variable speed drives in the hydraulic field are made up of fluid couplings which operate through the medium of oil, water, or silicone compounds. Hydro-kinetic fluid couplings operate on the kinetic energy transfer principle while the silicone fluid coupling operates on the principle of shear. Hydro-kinetic couplings are applied to drives with ratings up to thousands of horsepower and generally use oil as the energy transfer fluid. The silicone fluid coupling is predominantly a lower power (5 HP at present) coupling primarily used in the automotive field as a fan drive for radiator cooling.

The data that follows provides general characteristics of the most commonly used variable speed single pump and multiple pump combinations presently used in "constant pressure" pump applications using the Peerless Pump Hydroconstant fluid drive.

PEERLESS PUMP HYDROCONSTANT VARIABLE SPEED FLUID DRIVE

The Hydroconstant fluid drive (Figure 1) has been used extensively in variable speed pump service applications. The fluid drive-coupling belongs to the general class of hydraulic power transmitting machinery known as hydrokinetic drives. The machines in this class depend for their operation on the utilization of the kinetic energy contained in a moving mass of liquid. Basically a fluid drive-coupling consists of two hollow rotating members: an impeller (pump) which transforms the rotational energy supplied by a driver into kinetic energy contained in a moving mass of liquid, and a runner (turbine) which converts the kinetic energy back to rotational energy (Figure 2).

Output torque, and speed range from zero to maximum RPM can be achieved by controlling the amount of oil in the rotating members of the fluid drive-coupling.

The oil volume inside the rotating members is controlled by a movable splitter which, depending on system pressure demand, directs an amount of oil into the rotating members. An oil jet, (150 SSU at 100° F. oil) is fed to the movable splitter by a constant oil feed pump located inside the Hydroconstant fluid coupling housing. The oil feed pump is chain driven at a constant speed by the Hydroconstant drive input shaft. The housing forms a sump for the feed-oil.

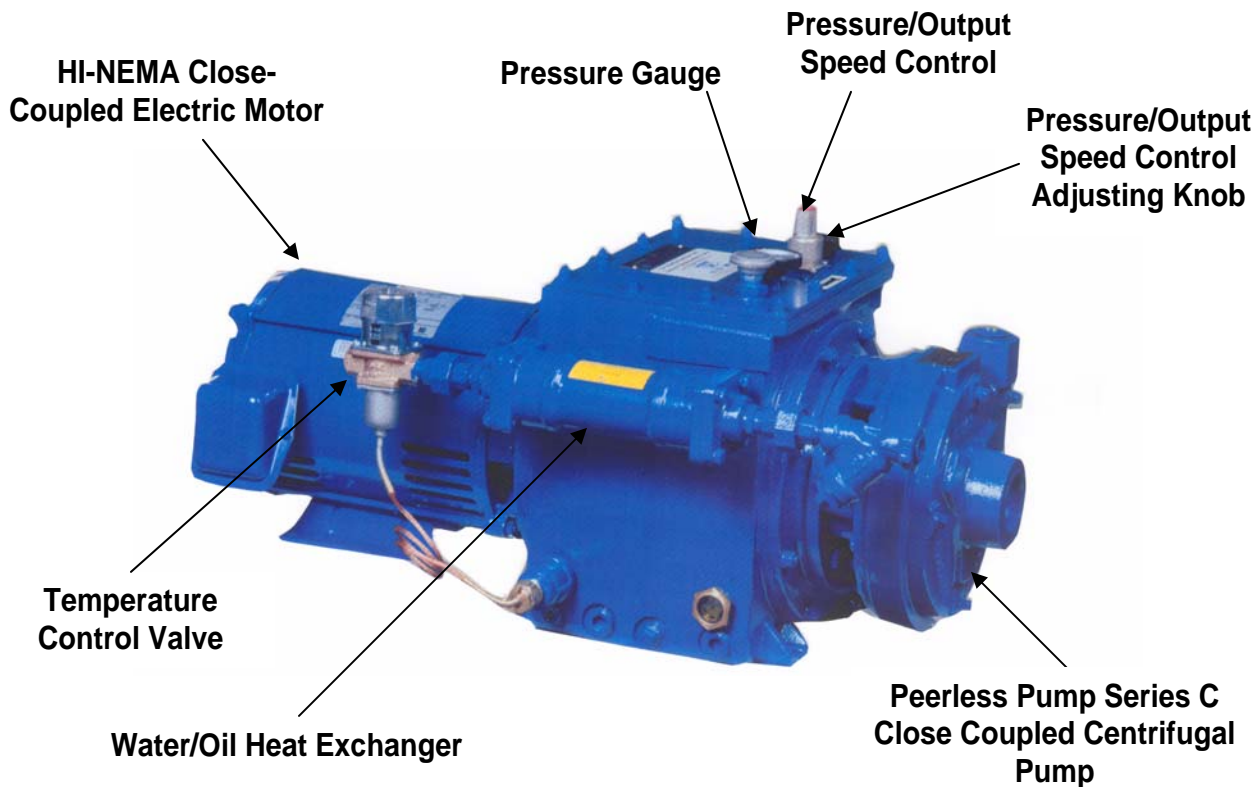


FIGURE 1
Type MP Size 6B or 8B
Hydroconstant Variable Speed Fluid Drive

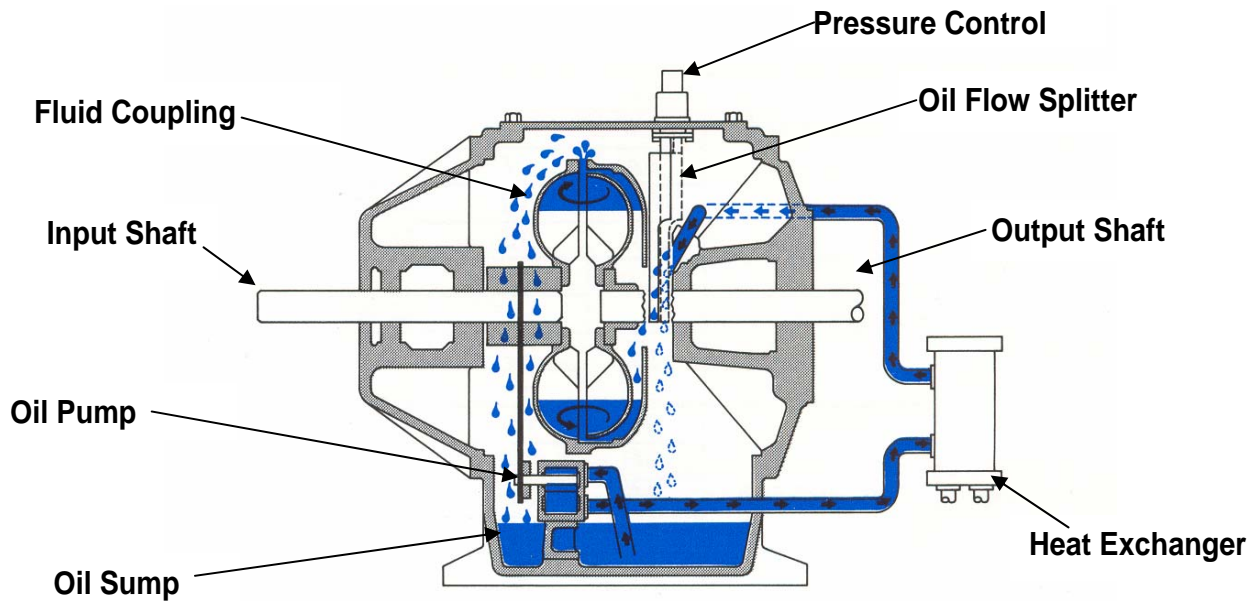


FIGURE 2. Oil Circuit

The splitter is connected to an arm located inside the Hydroconstant fluid Drive housing. By moving this arm, the splitter is move into or out of the path of the oil jet. If all of the oil jet flow is directed into the rotating members, the output shaft rotates continuously at full speed. Oil from the rotating members is constantly being discharged to the sump at an equilibrium capacity through orifices located on the periphery of a rotating member. Therefore, constant pressure equilibrium in a hydraulic system is maintained by oil supply to the rotating members being equal to the oil discharge through the orifices. The volume of oil inside the rotating members seeks a value which maintains an equilibrium of input-to-discharge oil related to the requirements of the hydraulic system pressure and, thus indirectly related to output shaft RPM.

(Pump head changes as the square of RPM)

$$\text{RPM} = \frac{\text{HP} \times \text{C}}{\text{TORQUE}}$$

Hydroconstant fluid drive output torque is always equal to input torque. Operating output speed is always lower than the input speed.

The intelligence that controls the equilibrium of Hydroconstant fluid drive oil flow and hydraulic system pressure is performed by a change of oil mass pressure. Pressure from the hydraulic system to be controlled is piped to a spring loaded piston in the hydraulic pressure control. When the pressure in the hydraulic system increases, the piston moves forward, re-establishing the equilibrium between the spring force and the piston force. The piston is connected to the arm of the splitter. From this description it is apparent how the pressure control functions. Used with the Hydroconstant fluid drive and a pump the assembly becomes part of Peerless Pump Hydroconstant pumping system.

For example, if the pump is at zero RPM and the system pressure change requires full pump RPM to satisfy the pressure setting, the time required for this speed change is about 15 seconds. The deceleration time from full RPM to zero RPM is about 20 seconds. However, for small increment speed changes the time lapse is

negligible (Figures 4 and 5). The acceleration and deceleration rate of the Hydroconstant drive limits the maximum demand flow change that the Hydroconstant fluid drive system is capable of satisfying while maintaining a constant system pressure.

MAXIMUM ACCELERATION CAPABILITY

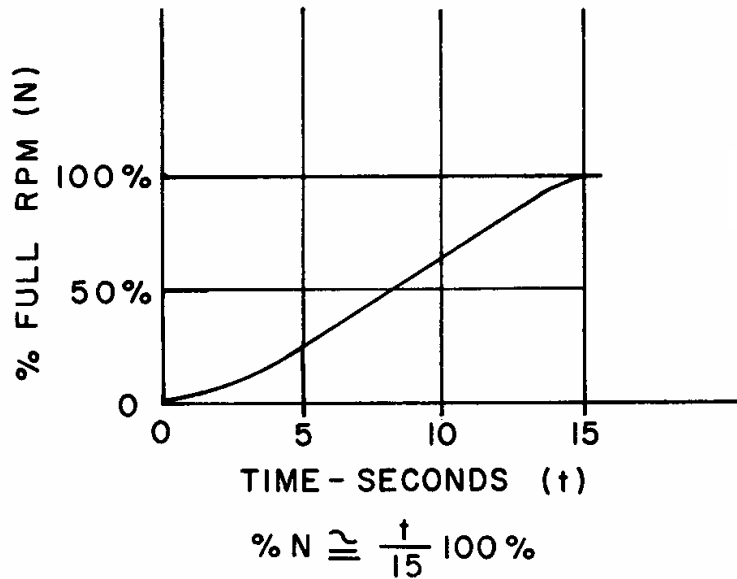


Figure 4

MAXIMUM DECELERATION CAPABILITY

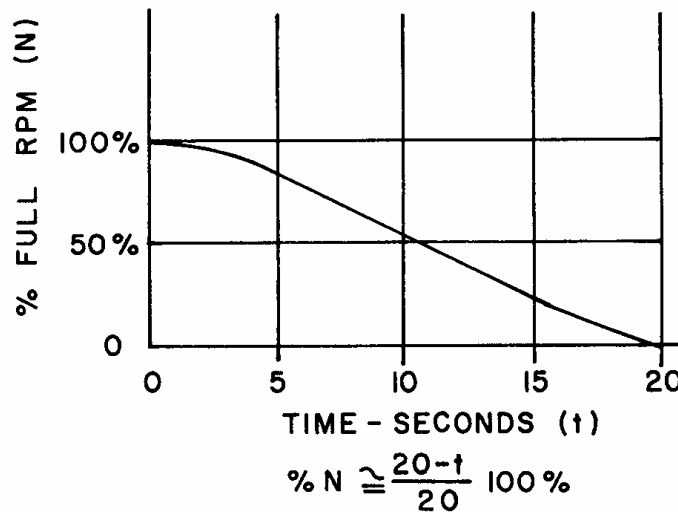


Figure 5

The two graphs (Figures 6 and 7) show the approximate "maximum demand change" of which a Hydroconstant drive pumping system is capable, while maintaining constant pressure during acceleration and deceleration.

Note: It requires about one-third of a minute to satisfy the maximum design capacity starting from zero RPM, or to reduce from maximum RPM to zero RPM (while keeping system pressure constant). The flow is changing directly as the RPM of the pump.

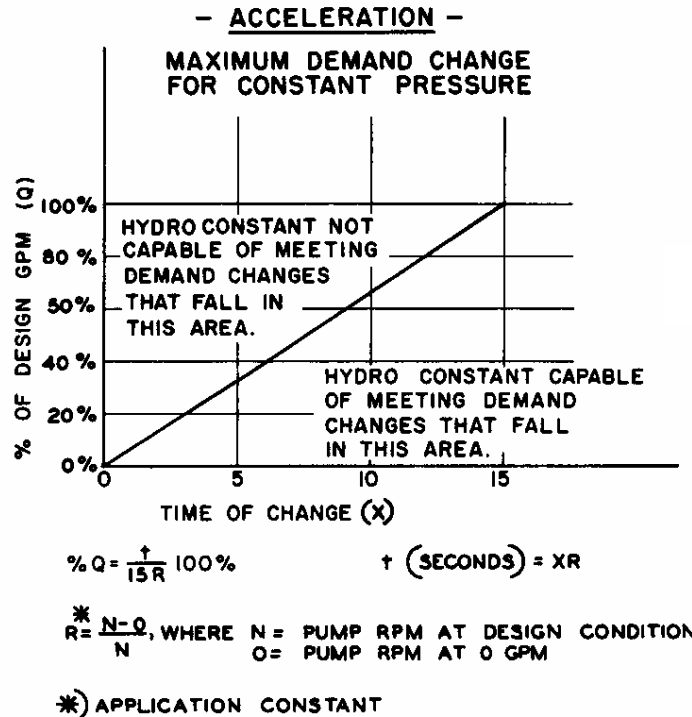


Figure 6

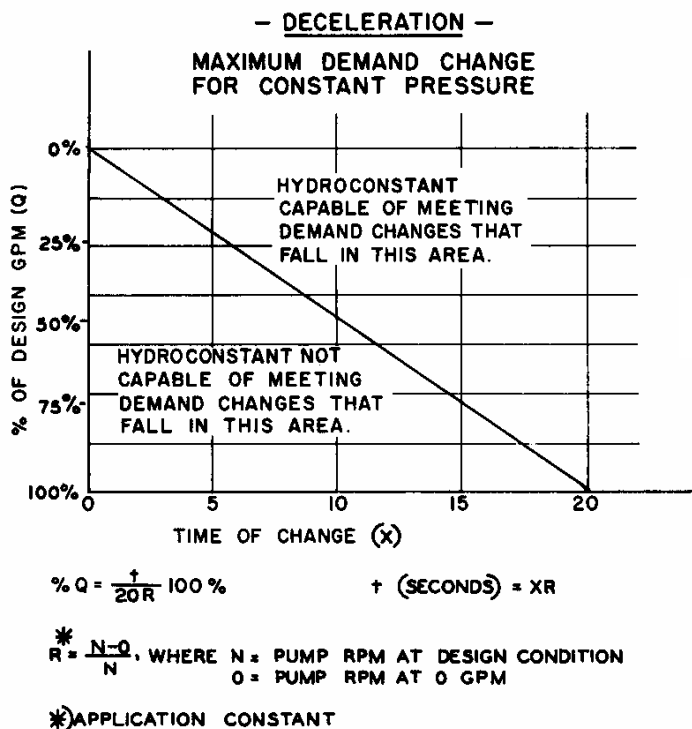


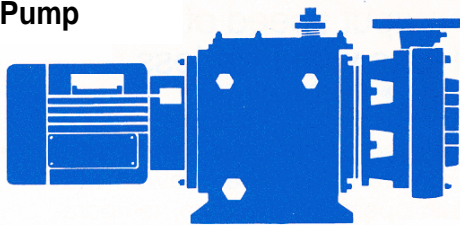
Figure 7

It is important that in the application of a Hydroconstant fluid drive consideration be given to the expected flow rate changes in the system and the capabilities of the drive as indicated by these curves (Figures 4 through 7). The head capacity characteristics of the pump should be chosen to complement the system demand requirements and the response speed of the Hydroconstant fluid drive. Refer to section on pump selection.

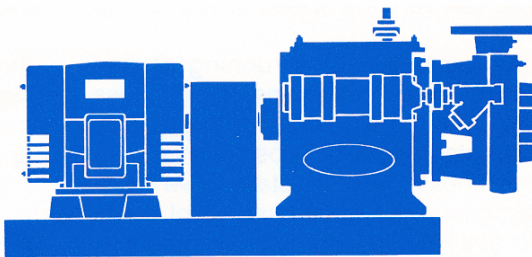
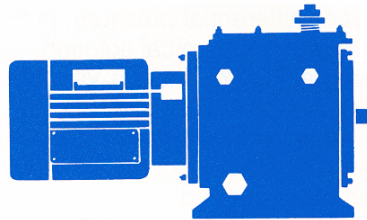
COMPONENTS OF HYDROCONSTANT FLUID DRIVE

1. Cast Iron Housing.
2. Aluminum fluid drive rotating element.
3. Oil lubricated bearings.
4. Internal oil circulating pump.
5. Non-corrosive control parts.
6. Oil level sight glass.
7. Integrated pressure control assembly which includes:
 - a. Automatic spring-loaded piston and diaphragm for sensing pneumatic or hydraulic (water) signals.
 - b. Manually adjustable pressure control.
 - c. Discharge pressure gauge.
8. When required:
 - a. Heat exchanger 125 psi maximum working pressure.
 - b. Automatic cooling water temperature control valve with Monel seals and stainless steel spring set.
 - c. Brass cooling water strainer.

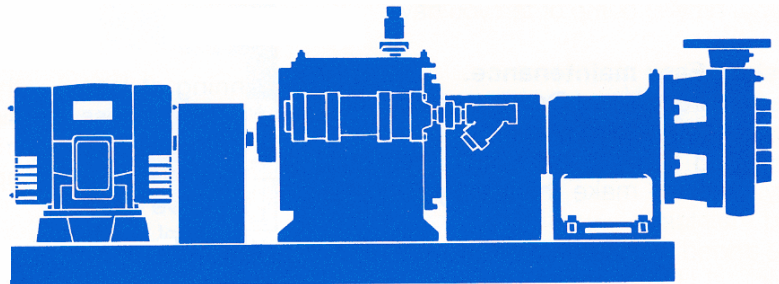
Type MP Closed Coupled Motor and Series C Close Coupled Pump



Type M Closed Coupled Motor and Output Shaft for Flexible Coupled Pump



Type MX Flexible Coupled Motor and Close Coupled Series C Pump



Type MO Flexible Coupled Motor and Output Shaft for Flexible Coupled Pump

HYDROCONSTANT FLUID DRIVE OPERATING DATA 60 HERTZ

NOMINAL RPM	TYPE	FLUID COUPLING SIZE	BHP IN		% SLIP		CIRCULATION LOSS HP	% EFFICIENCY		BHP OUT		RPM	OUT
			FULL LOAD	115% LOAD	FULL LOAD	115% LOAD		FULL LOAD	115% LOAD	FULL LOAD	115% LOAD		
1750	M,MP,MO,MX	8C	3.00	3.45	5.00	5.50	0.45	80.0	81.2	2.4	2.8	1640	1615
1750	M,MP,MO,MX	8C	5.00	5.75	6.70	7.60	0.45	84.0	85.2	4.2	4.9	1610	1580
1750	M,MP,MO,MX	8C	7.50	8.62	9.30	11.00	0.45	85.3	84.7	6.4	7.3	1565	1520
1750	M,MP,MO,MX	9B	7.50	8.62	4.20	4.65	0.50	89.1	89.5	6.7	7.7	1675	1665
1750	M,MP,MO,MX	9B	10.00	11.50	5.10	5.60	0.50	89.9	90.1	9.0	10.4	1650	1640
3500	M,MP,MO,MX	6A	3.00	3.45	3.00	4.10	0.55	76.7	81.2	2.3	2.8	3320	3285
3500	M,MP,MO,MX	6A	5.00	5.75	5.00	5.50	0.55	84.0	85.2	4.2	4.9	3275	3235
3500	M,MP,MO,MX	8C	7.50	8.62	2.20	2.50	0.70	88.0	89.3	6.6	7.7	3375	3340
3500	M,MP,MO,MX	8C	10.00	11.50	2.80	3.10	0.70	90.0	91.3	9.0	10.5	3355	3320
3500	M,MP,MO,MX	8C	15.00	17.25	3.80	4.20	0.75	91.3	91.6	13.7	15.8	3320	3280
3500	MO,MX	8C	20.00	-	4.60	-	0.90	91.0	-	18.2	-	3340	-
3500	MO,MX	8C	-	23.00	-	5.10	1.10	-	90.4	-	20.8	-	3300
3500	MO,MX	8C	25.00	-	5.20	-	1.35	89.6	-	22.4	-	3320	-
3500	MO,MX	8C	-	28.75	-	5.80	2.25	-	83.5	-	24.0	-	3275
1750	M,MP,MO,MX	9B	7.50	8.62	4.20	4.65	0.50	89.1	89.5	6.7	7.7	1675	1665
1750	M,MP,MO,MX	9B	10.00	11.50	5.10	5.60	0.50	89.9	90.1	9.0	10.4	1650	1640
1750	M,MP,MO,MX	11B	10.00	11.50	1.86	2.10	0.75	90.8	91.5	9.1	10.5	1708	1700
1750	M,MP,MO,MX	9B	15.00	17.25	6.65	7.30	0.50	90.0	89.8	13.5	15.5	1630	1620
1750	M,MP,MO,MX	11B	15.00	17.25	2.45	2.65	0.75	92.6	93.0	13.0	16.0	1705	1700
1750	M,MP,MO,MX	11B	20.00	23.00	2.90	3.10	0.75	93.2	93.6	18.6	21.5	1700	1695
1750	M,MP,MO,MX	11B	25.00	28.75	3.20	3.50	0.75	93.8	93.9	23.5	27.0	1690	1685
1750	M,MP,MO,MX	11B	30.00	34.50	3.60	3.95	0.75	93.4	93.9	28.0	32.4	1685	1680
1750	M,MP,MO,MX	11B	40.00	46.00	4.40	5.00	0.75	93.7	93.4	37.5	43.0	1670	1660
1750	M,MP,MO,MX	11B	50.00	57.50	5.45	6.40	0.75	93.1	92.3	46.8	53.1	1655	1635
3500	M,MP,MO,MX	9B	15.00	17.25	1.90	2.05	1.60	87.4	88.7	13.1	15.3	3430	3425
3500	M,MP,MO,MX	9B	20.00	23.00	2.25	2.40	1.60	89.8	90.6	18.0	20.8	3420	3415
3500	M,MP,MO,MX	9B	25.00	28.75	2.55	2.75	1.60	91.1	91.7	22.8	26.4	3410	3400
3500	M,MP,MO,MX	9B	30.00	34.50	2.80	3.00	1.60	91.9	92.4	27.6	31.9	3400	3395
3500	M,MP,MO,MX	9B	40.00	46.00	3.30	3.55	1.60	92.7	93.0	37.1	42.8	3385	3375
3500	M,MP,MO,MX	9B	50.00	57.50	3.60	4.00	1.60	93.2	93.2	46.6	53.6	3375	3360
3500	MO	9B	60.00	69.00	4.10	4.45	1.60	93.2	93.2	55.9	64.3	3355	3345
3500	MO	9B	75.00	86.25	4.70	5.15	1.60	93.2	93.0	69.9	80.2	3335	3320
3500	MO	9B	100.00	115.00	5.70	6.40	1.60	92.7	92.2	92.7	106.0	3300	3275

DESCRIPTION OF PUMPING SYSTEMS

SINGLE PUMP SYSTEM

A single pump system consists of one variable speed pump sized to satisfy 100% of the system demand. The pressure control will vary the pump speed to satisfy system demand. A standard motor starter is the only electrical control a single pump Hydroconstant system needs.

There are applications where it is desirable that the Hydroconstant system have other auxiliary controls. For example, a city ordinance may not allow a pump on stream if the water main pressure is less than a specified value. This is taken care of by the addition of the optional automatic low suction pressure cut-off control. There are any number of such optional controls that Peerless Pump will design to meet specific customer needs. All optional controls are actuated through 115 volt control circuits.

Single pump Hydroconstant systems are often applied in pairs; only one unit operates at a time while the other unit is used as a standby. Transfer of the units from standby duty to operational duty is done either manually or automatically. The pumps are sized so that each satisfies 100% of the system demand.

Pumps used on single pump Hydroconstant systems are sized for maximum GPM demand of a given application. Therefore, where the demand is very small for prolonged periods of time, it may be desirable that a single pump system use a small constant speed pump as an auxiliary supply pump. This small pump is usually called a pressure maintenance pump and is sized to satisfy about 10-20 GPM demand without the variable speed pump on stream. Of course, when the required system demand exceeds the pressure maintaining capabilities of the jockey pump the Hydroconstant drive pumping

unit will automatically come on stream. At this point it is optional whether the pressure maintenance pump is kept on stream or taken off.

MULTIPLE PUMP SYSTEMS:

Two-Pump, Variable Speed, Additive

A two pump additive system consists of two single pump variable speed units on stream so one unit complements the capacity of the other as the system demand exceeds the capabilities of lead pump. Each pump is sized to satisfy about 55% of the maximum system demand. Therefore, when the system demand is 55% or less of maximum the lead pump is on stream. When the system demand increases above 55% of maximum the second or additive pump is automatically put on stream and the lead pump is "locked-in" at full speed.

Two-Pump; One Constant Speed; One Variable Speed Additive

A two-pump additive system consists of one constant speed pump and one variable speed pump, each sized to satisfy about 55% of the system demand. The two units operate as an additive system with the variable speed pump always in the lead. The constant speed pump is automatically added on stream when the system demand exceeds 55% of maximum demand; the variable speed pump will speed-up or slow down in order to keep the system pressure constant. When the system demand decreases below 55 of maximum demand the constant speed pump is taken off stream and the variable speed pump will keep the system pressure constant.

Pressure Maintenance Pump

Either the variable speed or constant speed/variable speed two-pump additive systems can be used with a pressure maintenance pump. This pump is sized to satisfy about 10-20 GPM demand can be coordinated with the other two pumps to meet the system requirements.

PUMP SELECTION

Selection of the correct pump to be used in a Hydroconstant fluid drive unit is one of the most important factors in obtaining proper operation of the system. It is not enough to merely select a pump which will produce the specified head at the rated capacity. Careful consideration must be given to the overall head-capacity performance characteristics of the pump for each individual application. At the time of pump selection give consideration to the expected maximum demand changes and the speed of response by the Hydroconstant fluid drive coupling as described previously.

The Hydroconstant fluid drive coupling is capable of meeting a total demand change of design GPM per second:

$$5 \times \frac{(\text{Maximum RPM})}{(\text{Max. RPM}) - (\text{Min. RPM})} (\%)$$

There are three general head-capacity characteristics to be considered when applying horizontal centrifugal pumps to variable speed, constant pressure systems. (The characteristics describe the fixed speed performance graph as the capacity is decreasing):

Constantly rising
Flat
Drooping

Constantly Rising Head-Capacity Characteristics

A typical performance curve for a pump with a constantly rising head-capacity characteristic is shown in Figure 9. When applied to a variable speed drive to produce a constant discharge pressure, the speed-capacity curve is essentially a mirror image of the head-capacity curve, (assuming constant suction pressure). When a pump is expected to operate from shut-off to design capacity, and when the splitter arm position is used as the triggering mechanism for other control equipment, a pump with a constantly rising characteristic is advantageous.

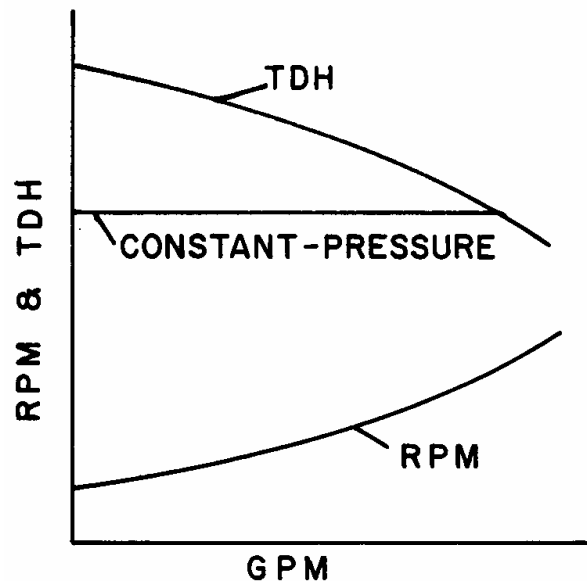


FIGURE 9. Constantly Rising Head-Capacity

Flat Head-Capacity Characteristics

A typical performance curve for a pump with a flat head-capacity characteristic is shown in Figure 10. This performance does not need much alteration by speed variation, unless the suction pressure changes widely. Again, the speed-capacity curve is a mirror image of the head-capacity curve, (assuming constant suction pressure). This pump characteristic offers practically no change in speed from shut-off to design capacity, and it becomes impractical to use splitter arm position as a triggering device for other controls. A pump with this characteristic curve can be very successfully applied to a system where large and frequent changes in capacity and suction pressure are expected.

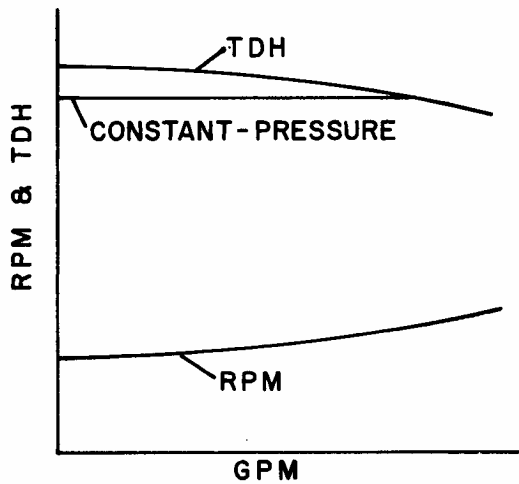


FIGURE 10. Flat Head-Capacity

Drooping Head-Capacity Characteristics

A typical performance curve for a pump with a drooping head-capacity characteristic is shown in Figure 11. An appreciable speed change may occur from design capacity to minimum speed; however, the minimum speed does not occur at shut-off. From the minimum speed point to shut-off, the pump must actually increase speed to maintain constant pressure. Where control functions must be performed with splitter arm position as the triggering mechanism, a pump with this characteristic is not desirable.

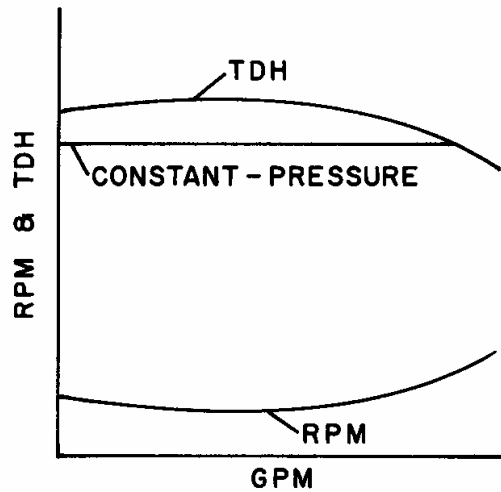


FIGURE 11. Drooping Head Capacity

This undesirable feature can be overcome, however, by the addition of a small pressure maintenance pump, which itself can have variable speed, such as utilizing a Hydroconstant fluid drive size 6 or 8. This pump will increase the pressure near shut-off if properly selected and will force the main variable speed pump to slow down so that the minimum speed does occur at the shut-off. See Figure 12 which shows the effect of adding a jockey pump.

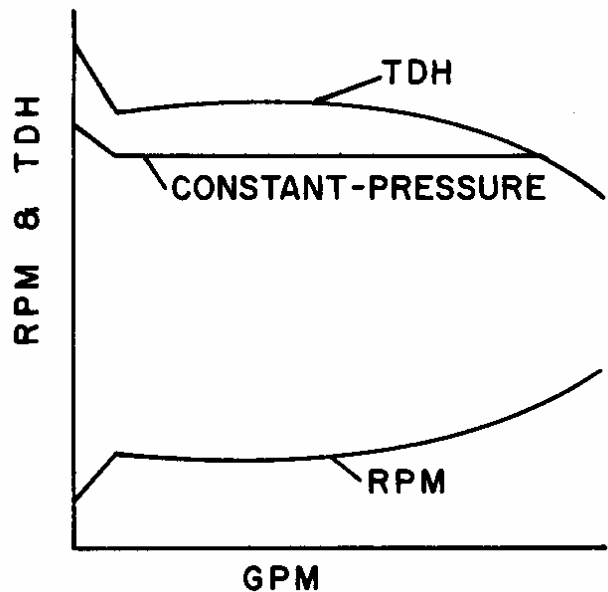


FIGURE 12. Effect of Adding a Pressure Maintenance Pump