Series or Parallel Operation?

The two–stage, series–parallel fire apparatus pump, long the standard of the fire service, provides for a wide range of capacities over a range of pressure roughly twice as wide as is possible with a single stage pump. A 1000 gpm series–parallel pump will deliver 500 gpm at 300 psi net pump pressure at essentially the same speed and power demand required for 1000 gpm at 150 psi. A typical 1000 gpm single stage pump must be driven at a speed 30% – 35% higher to deliver 500 gpm at 300 psi than for 1000 gpm at 150 psi, and will require 80% – 85% more power. More important, in many cases, is the ability to develop net pressures up to 400 or 500 psi when it is necessary or desirable to do so, while the single stage pump is usually limited to a net pressure of about 300 psi or less. In order to use a series–parallel pump to best advantage, however; the operator must know when to use each mode – series (pressure) or parallel (volume).

The ”best” mode (transfer valve position) for any particular pumping condition will depend on the characteristics of the particular pump–engine combination used, and also whether the pump is drafting, taking water from a hydrant, or in relay; a discussion of the effect of each of these factors is beyond the scope of this paper except that it may be stated that, if positive suction pressure can be maintained (hydrant or relay operation), the pump can usually handle up to 75% of its rated capacity when it has been placed into the series mode without serious loss of efficiency , but if drafting there is danger of cavitation if it is called on for appreciably more than 50% of rated capacity. Some general rules may be set forth; however, which, if followed, will provide for satisfactory operation.

General Rules

Capacity	Net Pressure (PSI)	T.V. Position
Less than 50% rated	All	Series (pressure)
More than 50% rated	Less than 200 PSI	Parallel (volume)
More than 50% rated	More than 200 PSI	See below

If it is necessary to pump more than 50% rated capacity at pressures over 200 psi, the operator should first try to pump in *parallel*, if *drafting,* or in *series, if off a hydrant or in relay.* If power is insufficient to reach the desired performance, the other mode should be tried, and the best mode for the conditions then chosen.

How does the operator determine the capacity? While it is quite possible to calculate the approximate capacity if the lengths of the lines, nozzle sizes, and line pressures are known, it isn’t often practical to do so under fire ground conditions. It is usually sufficient to estimate the capacity on the basis of the number and size of the outlets in use, and the pump or line pressure. (Of course flow meters will permit fast determination of the capacity but very few pumpers in use are equipped with these.) In the final analysis the operator must learn to recognize the conditions which dictate the best mode of operation, and learning comes from experience.

Changing Transfer Valve Position While Pumping

Usually, the transfer valve can be changed from parallel to series or vice versa *without* materially affecting the capacity or net pressure. Of course, if drafting relatively high capacity, the pump cannot be changed from parallel to series without causing cavitation, but if cavitation can be avoided there will seldom be any serious effect. The important principle involved, if the relief valve (or pressure sensitive engine governor) is not acting to limit the pressure, is that the pump pressure is determined by the friction loss in the hose lines and by the nozzles in use, and that, therefore, *the pump pressure cannot increase unless the capacity increases*, nor the pump pressure decrease unless the capacity decreases.

The effect of changing the transfer valve position can be determined easily by simple tests. In tests run by the Waterous Company, using a Waterous Model CM pump, driven by a Detroit 6V71N diesel engine, the following results were obtained (no change in throttle position):

Initial Condition			Final Condition		
T.V. Position	**GPM**	**PSI**	**T.V. Position**	**GPM**	**PSI**
Parallel	1000	150	Series	820	105
Parallel	750	200	Series	735	195
Parallel	200	150	Series	250	245
Parallel	100	150	Series	130	265
Parallel	500	200	Series	540	245
Series	740	200	Parallel	755	205
Series	500	200	Parallel	440	160
Series	300	200	Parallel	250	150
Series	700	250	Parallel	680	230
Series	300	250	Parallel	235	160

It can be seen from the above that in most cases the pressure dropped, regardless of which way the transfer valve was moved. There was a slight increase when the pump was changed from series to parallel when pumping more than 700 gpm at 200 psi, but a pronounced increase only when it was changed from parallel to series while being used to pump low capacity at high pressure. These tests were made with some static pressure on both suction and discharge. As the discharge pressure depends to some extend on the suction pressure, and is the sum of the static discharge pressure and the friction loss (including nozzle pressure) in the discharge system, the results of tests similar to these but made with other suction conditions and/or more or less static discharge pressure will be somewhat different. Certainly, though, the results of these are indicative of what will happen if the transfer valve position is changed without changing the throttle setting or the discharge system.

Power actuators often will move the transfer valve when the pump pressure is relatively high, but manual operation is usually very difficult unless the pump pressure is below 100 psi. Normally, the pump will not be damaged by changing the transfer valve position, regardless of the pressure; however, the operator should always follow established rules of procedure as developed by his fire department to suit its particular needs, with safety considerations being paramount.