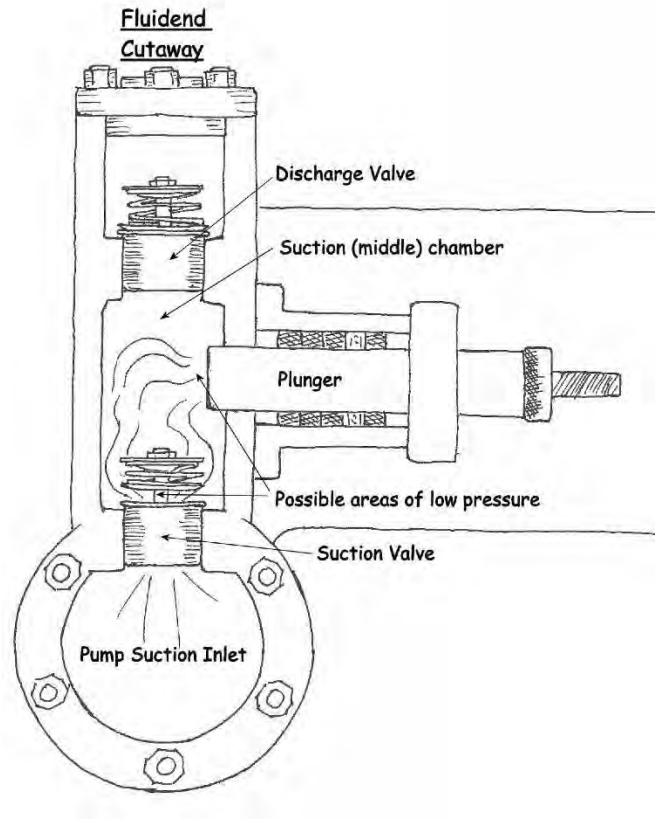
Valves that Match the Mechanical Efficiency of Reciprocating Plunger Pumps

Overview

Reciprocating plunger pumps are a type of positive displacement pump that drives liquid at high pressures in a variety of industrial applications. They operate by creating changes in pressure using a moving component known as a plunger, which on its outward motion draws fluid into the chamber through the suction valve; then on its inward motion, opens up the discharge valve and pushes the fluid out a delivery pipe at a rapid velocity (*see figure 1*).



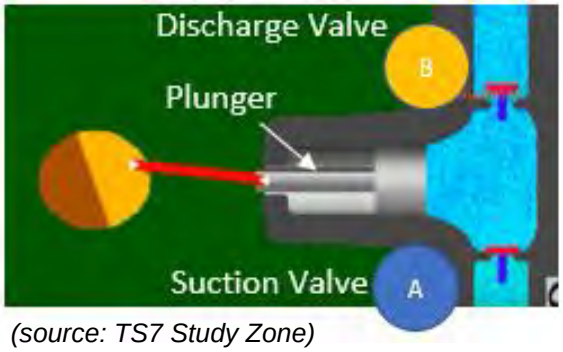
This whitepaper is going to focus specifically on plunger pump **valves**, how they work, some effects of lag time and slip, and certain types of valves that are engineered to match the mechanical efficiency of a pump. Moreover, we will compare some of the best plunger pump valves available to the market.

Plunger Pump Valves - How They Work

In a perfectly operating reciprocal pump, suction and discharge valves should gently open and close as the plunger reaches its full stroke extension into the fluid end or full point of retreat back toward the power end. For suction and discharge valves to function properly, they must work in unison. A suction valve cannot open until a discharge valve is closed, and a discharge valve cannot open until the suction valve is closed. Valves open when enough pressure is exerted to overcome the weight of the valve member and the spring force pushing back against the valve member. Valves close mainly due to spring force. When the valves do not work in unison, it creates 'lag time', which allows fluid to slip back between chambers. Practical experience tells us there is always some lag time in opening with the majority of pump valve models, but the more lag time that exists, the greater the likelihood that the pump may begin to exhibit problems.

Potential Effects of Lag time and Slip

If the pump valves are not working in unison with the plunger pump, less fluid is moved out of that pump; therefore lag time and slip negatively affect the pump efficiency, output, and ultimately, the bottom line. Other things can happen also; for example, the disc can slam shut. The lag time followed by the sudden opening of the valve or almost violent closing creates a force akin to water hammer, but within the pump's fluid end. Moreover, there is potential for vibration and cavitation to occur.

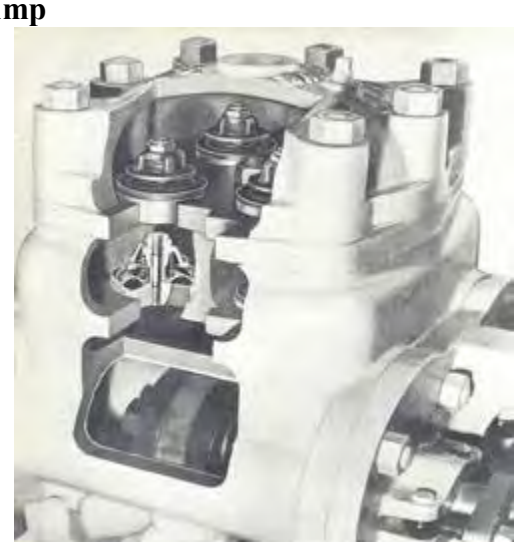


(source: TS7 Study Zone)

Cavitation, or the formation of bubbles or vapor cavities in a liquid, results from rapid fluctuations in pressure. On the suction stroke, as the plunger recedes away from the suction chamber, the bottom suction valve opens and liquid is pulled into the middle chamber. Naturally occurring areas of high and low pressure develop within the suction chamber. If the suction side of the pump is starved and incoming fluid pressure (NPSHa) falls below the liquid's vapor pressure, vapor bubbles will form. If left unresolved, cavitation will cause damage to metal surfaces in the fluid end and to fluid end components. Cavitation damage can be observed most often inside the fluid end around the end of the plunger and on the surface of the valve member or disc in the suction valve assembly. Common signs of severe cavitation include loud banging noises and vibration, as severe implosions can break valve springs, break wedge shaped segments off valve discs and blow valve discs in half! (You can learn more about cavitation by watching our video: https://youtu.be/Vu8yqXR_4aw). Both vibration and cavitation are destructive forces to the pump, pump valves, plungers, and suction and discharge piping. (*For more information on identifying and correcting vibration and cavitation issues, read our recent blog post:* https://info.triangle-pump.com/blog/vibration-and-cavitation-as-related-to-reciprocating-pump-valves-0).

Obviously there can be other contributing factors to pump problems besides the pump valves, but most operators could avoid the issue altogether by choosing a pump valve that is already engineered to minimize lag time and match the pump's mechanical efficiency.

Valves that Match the Peak Mechanical Efficiency of a Pump



Believe it or not, engineers designed a pump valve to match the mechanical efficiency of a pump about a hundred years ago! That's right! Back in the early 1900's, when steam pumps were the dominant technology in manufacturing plants, problematic issues with steam pump valves motivated engineers to design a whole new pump valve. The problem they were having in the steam pump valves was a disc on the valve that did not last very long. It would crack and fragment under service. So the Durabla® valve line was created and engineered specifically to (1) function reliably and (2) to offer peak mechanical efficiency.

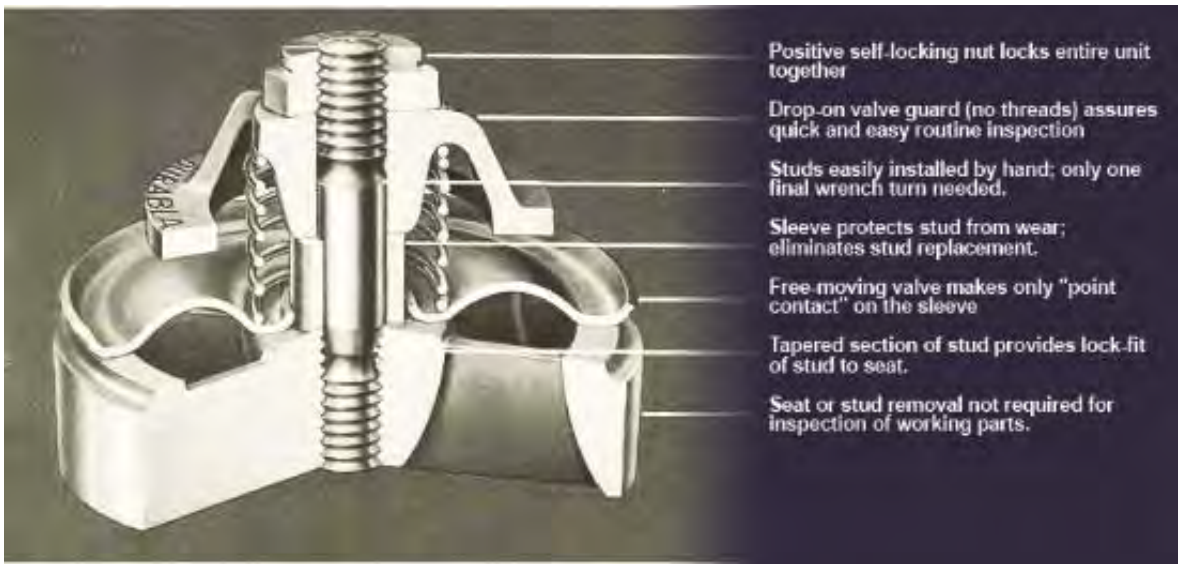
So how does the Durabla® valve match the mechanical efficiency of the pump? The Durabla® valve is designed to open and close in rhythm with the pump - mirroring the mechanical efficiency of the pump. It operates perfectly in sync with the pump. Now we know that, mechanically, nothing runs at 100% efficiency – but we do know (as it's been proven time and again) that the Durabla® valve matches the pump's efficiency, wherever it stands. The design of the valve is such that it provides a very generous flow area. Triangle Pump Components, who has been manufacturing this valve unlike any other for the past several decades, matches the spring to the disc. We match

the spring to the flow areas of the valve where the spring is extremely efficient. In valves from other manufacturers, their springs are mismatched to the weight of the valve member and to the pressure of the fluid and the flow area within the valve – which is why those other valves lose much of their efficiency. When the Durabla® valve was originally designed, this was one of the attributes that they paid attention to - the spring rate against the force of the fluid, and against the diameter of the opening, as well as the flow barricade. Acknowledging these concepts and designing this highly engineered valve means having a valve that can keep up with the pump, regardless of whether or not the pump is running at a low or high RPM.

Durabla® Valves – The Best Plunger Pump Valves on the Market

Model	Applications	Pressure Range	Speed	Port Sizes	Special Feature(s)
Durabla® V7 	Steam pumps	800 PSI	Up to 200 strokes per minute	1.5 to 7.75 inches	*can be furnished in one of three ways: threaded for screw fit, tapered for press fit, or rough for customers to use as a cast for matching
Durabla® V7H 	Low NPSH	600 PSI	Up to 600 RPM	1.5 to 6 inches	The lightweight metal valve disc ensures exceptional service life. Due to its "point contact" with the sleeve, the V7H pump valve opens faster than other styles and is ideal in rigorous environments.
Durabla® V7F 	Higher volumes	6500 PSI	Up to 750 RPM	1.5 to 5 inches	The taller profile of the V7F provides good lift and a spill area for fluid. Its heavier spring provides a prompt valve closure to seal off the flow.
Durabla® V7FD 	Higher volumes	2500 PSI	Up to 750 RPM	1.5 to 5 inches	In place of the traditional metal formed disc, the V7F is available with an optional Delrin® Disc, which contributes to "zero wear".

Designed for supreme operating efficiency and a long service life, Durabla® pump valves consist of several key components – so let's look at the form and function of each part.



The components you will find in every Durabla® valve include:

- **Self-locking nut**: the corrosion-resistant locknut, unique to the Durabla® valve, has close tolerance threads and provides positive, secure assembly of the entire unit.
- **Retainer**: The Durabla® valve has a drop-on 316 Stainless Steel guard retainer that houses one or two springs and speeds up valve assembly and disassembly.
- **Stud or Bolt**: the "V" taperlock 316 Stainless Steel stud / bolt involves simple installation and provides rigid alignment of the sleeve and disc.
- **Sleeve**: The Durabla® valve's 316 Stainless Steel sleeve protects the stud while providing a polished surface to the contact disc. The sleeve endures a lot of wear but is inexpensive and easily replaced, requiring only a one-piece assembly with the retainer.
- **Springs**: The spring can be mounted on the inside or outside of the valve member depending on NPSH and valve style. Springs can be made of 316 Stainless Steel or Inconel® – depending on the specific requirements.
- **Valve Plates**: The Durabla® valve comes standard with a 316 Stainless Steel or Delrin® plate, specially formed from stainless steel or alloy sheet into an arched cross section, making it the lightest weight, lowest inertia, yet strongest disc available.
    - **The Delrin® Plate** (*only used in the Durabla® Model V7FD) is machined from high strength engineered plastic. Suitable for 2500 PSI, its point contact with the sleeve minimizes friction and permits instant response to pumping forces.
- **Valve Seat**: The Durabla® valve seat provides optimum flow through the port. Available in various metallurgies for maximum service life, the seat face is carefully machined to supply proper support and seating surface for the valve disc. Where applicable, the outside diameter is machined for press or screw fit to install in the pump port, and some seats may be supplied rough as cast for machining by the user.

Conclusion

Efficiency should be a priority for owners. Durabla® Pump Valves are built for efficiency and are versatile, which means they can (and should) be uses in most makes and models of reciprocating pumps (except for applications where there exists high abrasion – but that's another story!). These valves are engineered to open freely during the time the plunger is pumping liquid into the discharge line, and to close quickly and tightly while the plunger returns for the next filling of liquid. Durabla® Valve Units are carefully designed, precisely made, and accurately fitted by Triangle Pump Components. When properly installed and given reasonable care, they will provide many years of efficient service under a wide variety of operating conditions.

Contact us today to see if these pump valves might be the best solution for you!

About Triangle Pump Components

The mission of Triangle Pump Components, Inc. is to manufacture the best, most durable pump valves, plungers, packing and stuffing box components and to provide the best pump component solutions to global pump users. Since 1919, TPCI has empowered its employees to produce the highest quality pump components and to deliver confidence to their customers through long-term relationship development. If a pump component is durable, of high quality, and made with integrity, it is a Triangle product. Learn more at triangle-pump.com.