# Don't Forget Double Volute Pumps

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## Your operating conditions may warrant the use of such designs.

With today's emphasis on pump efficiency it's easy to forget about double volute pumps. More importantly, looking at manufacturers' data, it isn't always clear whether the pump under consideration is a single or a double volute unit. While many engineering specifications allow either design, because double volute pumps can be less efficient and more expensive, they're a tough choice if a single volute model is available for the application.

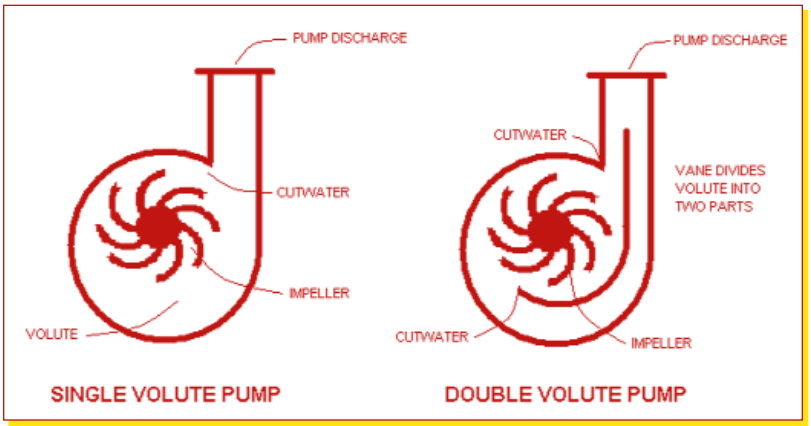


**Figure 1. Schematic of single and double volute pump designs**

## So, Why Buy Them?

There are several reasons to select double volutes:

- A double volute pump may be warranted by the operating conditions of the application. And, it may make up for its efficiency deficit and higher purchase price with lower maintenance costs.
- Double volute designs are not available in small pumps. Likewise, for larger pumps, it's not feasible to build single volute models.
- Double volute pumps hold the promise of better operation over a wide range of operating heads. *(The Hydraulic Institute (HI) Standard for Operating Range does not offer an extensive look at double volute pumps vs. single volute styles.)*

## What They Are

The volute of a pump is designed to convert the velocity imparted by the impeller into potential energy. Under ideal conditions, the pressure within the volute is equal on all sides of the impeller. When the pump operates away from its design point, however, the pressure within the volute varies, resulting in a radial load on the impeller and the pump shaft.

To limit shaft stresses and subsequent shaft deflection, many pumps are designed with a double volute. The pump volute is partitioned into two flow ways. There are actually two cutwaters in the volute, 180° from each other. When the pump is operated away from its best efficiency point (BEP), the radial forces are equalized and the stress on the pump shaft is almost unchanged. Figure 1 shows a schematic of a single volute and double volute pump.

## Availability

If the pump is very small and has a relatively low head, a double volute pump is probably not available. On the other hand, large pumps and high head pumps are usually available only in the double volute design. There is, however, a sizeable range where either a single or double volute pump is available. A review of several pump vendor catalogs shows a range where both single or double volute design is available for between the bearings pumps (see Figure 2). Figure 3 shows a range where either single or double volute pumps are available for overhung impeller type pumps.

The range of availability

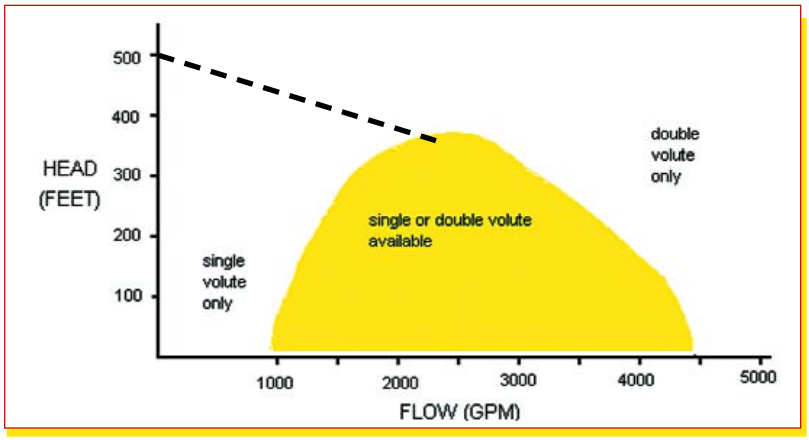


**Figure 2. Double/single volute pump availability for between the bearings pumps**

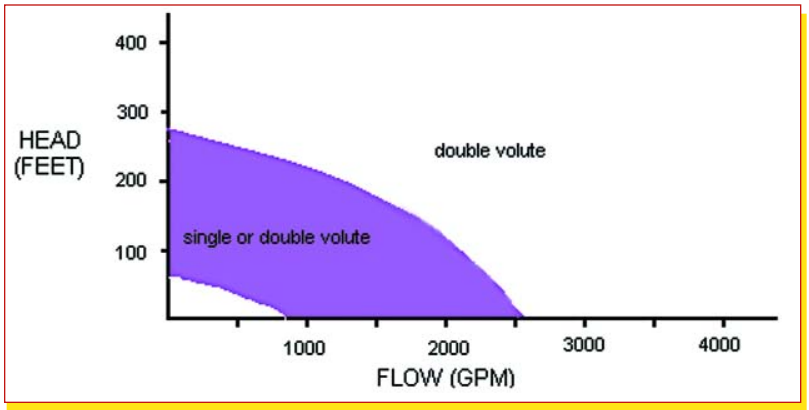


**Figure 3. Double/single volute pump availability for overhung impeller pumps**

covers many applications with moderate flow ranges and discharge heads. In almost every case, the single volute option can be had at less initial cost. Furthermore, the single volute pump will be more efficient at the BEP than the double volute alternative. If the only criteria are cost and efficiency, the single volute pump will be selected over a double volute alternative.

## Left & Right of the BEP

In most applications, the pump will not operate at its BEP. While the preferred situation is to never stray from the BEP, in practice, pump users often find themselves operating either to the right or the left of it.

Operation to the left of the BEP, toward shutoff head, can generate substantial radial forces on a single volute pump. Some manufacturers indicate a minimum flow on their curves to avoid overstressing the rotating elements of the pump. The forces developed as a result of operating to the right of BEP are not as extreme, but are still sufficient to affect the mechanical operation of the pump. In some installations, the radial force generated when to the right of the BEP is additive to the weight of the rotor.

A pump may be operated to the left of the BEP as a result of trying to get maximum capacity from an undersized piping system, pumps that are discharging to pressure filters or strainers, or parallel pump applications that attempt to maintain a range. For pumped liquids other than water, variations in viscosity can affect the operating head of the pump.

It is important to analyze the pump at start-up to see how long it operates to the left of its design point. When the pump is started against a pressurized system, it must impart momentum to establish movement of the contents of the discharge pipe. How quickly it can do this depends on the characteristics of the pump, the mass of the discharge column and the velocity of the discharge column that must be achieved for steady-state operation. The unit may operate at higher that normal heads for several seconds before momentum is established in the contents of the discharge pipe. This is usually nothing to worry about if large volumes of fluid don't need to be accelerated. However, it should be taken into account in, for example, pipeline applications where large amounts of fluid need to be accelerated.

Operation to the right of the BEP is also fairly common. Pumping units are usually designed for worst-case conditions, resulting in a higher discharge head than encountered in the field. Pump units are specified to the right of the BEP to allow for wear in the unit. Piping systems are sized up for greater operating efficiency, resulting in flat system curves. Often, supply or process systems operate at partial capacity, resulting in lower dynamic heads. Fluid viscosity also can be a factor on this side of the BEP.

As published by the Hydraulic Institute in 1997, *ANSI/HI 9.6.3 Centrifugal and Vertical Pumps for Allowable Operating Region* set a "Preferred Operating Region" in terms of flow through the pump. For most pumps the Preferred Operating

Region is 70 percent to 120 percent of the flow at the BEP.

This standard goes on to describe an "Allowable Operating Region" that is to be determined by the pump manufacturer. It should be understood that a reduction in equipment life would be anticipated in this area, but that "service life of a pump is not seriously compromised."

It must be emphasized that the preferred and allowable operating regions are specified by flow, and not by discharge head.

## Effects of Operating Away from the BEP

Operation on either side of the BEP will result in additional radial loads on the pump shaft. The force generated is much higher for a single volute pump than a double volute design. The calculation for the actual force applied is shown in HI Standard 1.3.4.7.2 and is dependant on the discharge head and the width of the impeller. Figure 1.81 and Figure 1.83 of HI Standard 1.3.4.7.2 give a good comparison of the relative force for each type of pump. Note that the coefficient curves for calculating the axial load is dependent on the Specific Speed of the pump. Specific Speed becomes an important factor when evaluating whether a double volute pump is needed. (For additional information, visit www. pumps.org.)

The effects of this radial force applied to the rotating elements of the pump are as follows:

### *Impeller*

The pump shaft deflects as a result of the radial load. The impeller then runs out of balance and induces vibration. There is potential for the impeller to contact the casing at the wear rings.

### *Pump shaft*

The pump shaft deflects and is cyclically loaded as it turns. Vibration of the rotating assembly aggravates the situation. There is potential for fatigue and breaking of the pump shaft.

### *Seals*

The pump shaft is deflected through to stuffing box. This can result in uneven wear on mechanical seal faces. Exessive vibration can also damage the seals.

### *Bearings*

There is additional load placed on the bearings. Calculated bearing life decreases exponentially with the applied load. If the bearing load is doubled the calculated bearing life can decrease by almost a factor of ten! In addition to the calculated load effects, the vibration induced by imbalance will also affect bearing life.

Keep in mind that a single volute pump will almost always be more efficient than a double volute pump with the same operating characteristics. It is possible, however, that at extreme limits of the operating range, the efficiency of the double volute pump will approach the efficiency of the single volute unit.

Double volute pumps generally produce steeper pump curves. The HI standards for Preferred Operating Range use flow through the pump as a maximum/minimum criteria. Most of the time, the range of the operating head drives pump selection. With a steeper pump curve, a double volute pump will yield a better hydraulic operating range in the practical terms of operating head. This attribute can result in better hydraulic performance (i.e. cavitation, blade pass, etc.) in the range of discharge heads that the pump will encounter.

## When to Use a Double Volute

The double volute pump will demonstrate its value when a pump has to operate away from the BEP for extended periods of time. The design of the volute will result in less radial force on the pump shaft and improve mechanical performance in several ways. Hydraulic performance may also improve.

For the engineer specifying a pump for an application, a double volute pump should be considered if the following conditions exist:

- The pump will run away from BEP for extended periods of time.
- The pump Specific Speed is relatively high.
- The application is not within the Preferred Operating Range as defined by the Hydraulic Institute.

There are many pumps in operation that have been selected based only on efficiency and first cost. It should not be uncommon for operating personnel to request a different type of equipment based on maintenance experience. Therefore, a pump mechanic should consider replacing a single volute pump with a double volute unit if the following conditions exist:

- The pump is not operating at its BEP.
- High vibration in the imbalance frequencies is present.
- The shaft is bent or broken.
- Bearing life is too short.
- Seal life is too short.
- Indications of internal rubbing are present.

## Conclusion

The point of this article is not to highlight all of the possible solutions available when it comes to selecting or upgrading a pumping system. It is simply to raise a practical awareness regarding the appropriate specification of single or double volute styles. There are several reasons why a single volute pump is a good choice for many applications. Conversely, a double volute pump will perform better for other applications. What's more, there are significant differences in efficiency, first cost and mechanical performance between single volute and double volute pumps. When there is a choice between the two, a deliberate decision is needed based on the requirements of the application. **P&S**

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