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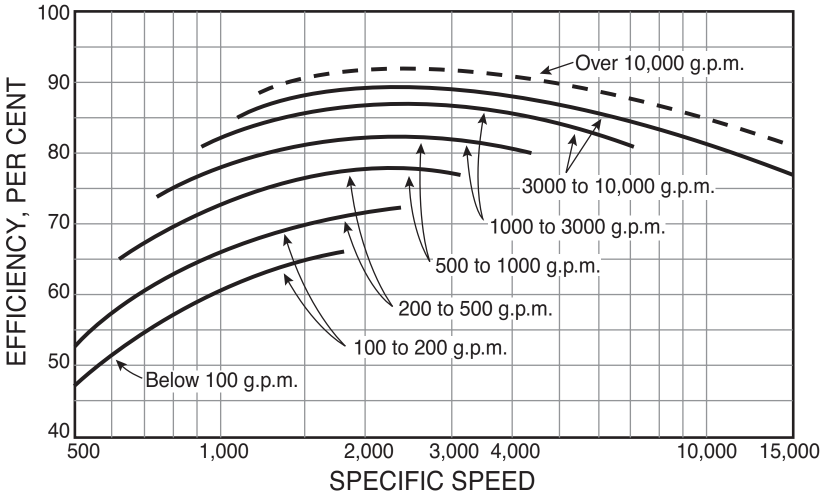
How to Select Practical and Efficient Centrifugal Boiler Feed Pumps

Centrifugal pumps can be up to 90% efficient, but to achieve this, flow rates must be on the order of 10,000 GPM and the specific speed must be about 2500. Obviously, boiler feed pumps are much lower capacity than this – so what about specific speed? What is it and how can we optimize it to help keep our selection efficient and practical?

Specific speed is a dimensionless number. $\left[n_s = \frac{RPM \sqrt{GPM}}{Hd(3/4)}\right]$ In practical terms this means that pumps of the same specific speed have the same ratio of diameter to vane width, with large diameters and narrow widths being low specific speeds, and small diameters with wide vane widths being higher specific speeds. Still higher specific speed pumps are mixed flow (part centrifugal flow and part axial flow) and the highest specific speed pumps are axial flow or propeller pumps.

The chart below shows the relationship over the range of specific speeds.



Boiler feed pumps tend to have specific speeds which are too low, but using 3500 RPM motors instead of 1750 RPM motors **doubles** the specific speed!

Even if you accept a few percent less efficiency and consider that 3500 RPM pumps generally require a little more NPSH, it is obvious that all but a few of the 1750 RPM pump selections are impractical and inefficient. Perhaps a specific speed of 1000 would be a good minimum to shoot for.

Even the higher pressure 3500 RPM pumps are inefficient. The most practical solution to this is to consider a two stage (or two single stage pumps in series) 3500 RPM pump. This raises the specific speed by a factor of 1.66 as the individual stages (or pumps) are half the total pressure. Going to two stages should be considered for specific speeds less than 700 or 800.

Multi-stage or regenerative turbine pumps should be considered for the lowest specific speeds. 1750 RPM regenerative turbine pumps are frequently preferred over 3500 RPM turbine pumps because both are more subject to wear than centrifugal pumps, due to critical close clearances, and the 1750 RPM turbine is a little more durable.

While 1750 RPM centrifugal pumps are efficient for low head high capacity circulating pumps, they are not generally ideal for boiler feed applications (higher head, lower capacity).

The following table shows the approximate diameter impeller and the specific speed for several heads and three flow rates for 1750 RPM and for 3500 RPM.

	1750 SPECIFIC SPEEDS				3500 SPECIFIC SPEEDS			
	DIA	n_s at 30 GPM	n_s at 90 GPM	n_s at 200 GPM	DIA	n_s at 30 GPM	n_s at 90 GPM	n_s at 200 GPM
10 PSI = 23.1 ft.	5½"	911	1574	2350	2¾"	1822	3148	4700
15 PSI = 34.7 ft.	6¼"	671	1161	1730	3⅛"	1342	2322	3460
20 PSI = 46.2 ft.	7"	541	936	1394	3½"	1082	1872	2788
30 PSI = 69.4 ft.	8½"	400	692	1031	4¼"	800	1384	2062
40 PSI = 92.4 ft.	10"	322	557	831	5"	644	1114	1662
60 PSI =138.5 ft.	12"	238	412	615	6"	476	824	1230
80 PSI =180.7 ft.	14"	194	336	501	7"	388	672	1002
100 PSI = 231 ft.	16"	162	280	418	8"	324	560	836
125 PSI = 289 ft.	18"	137	237	354	9"	274	474	708
150 PSI = 347 ft.	20"	120	207	309	10"	240	414	618
175 PSI = 404 ft.	22"	107	185	276	11"	214	370	552

Estimating the Discharge Head and Capacity of an Existing Pump

The best way to size a pump is to look at the system requirements. For example, the capacity of a pump feeding a boiler is best determined by the maximum steaming rate of the boiler. The pump must put as much water in (plus a safety margin) as the boiler vaporizes. The maximum boiler pressure (in ft.) plus the vertical distance from pump receiver water level to the boiler water level (in ft.), plus calculated pipe friction (in ft.), plus a safety margin is the discharge pressure (in ft.) required.

Another example – the capacity of a condensate pump, pumping to a vented boiler feed receiver from one portion of a building. Determine the EDR of the loads discharging to the condensate pump. The pump must pump as much out (plus a safety margin) as the maximum flow from the loads discharging to the condensate pump. The discharge pressure would be the vertical distance between receiver levels plus pipe friction, plus a safety margin.

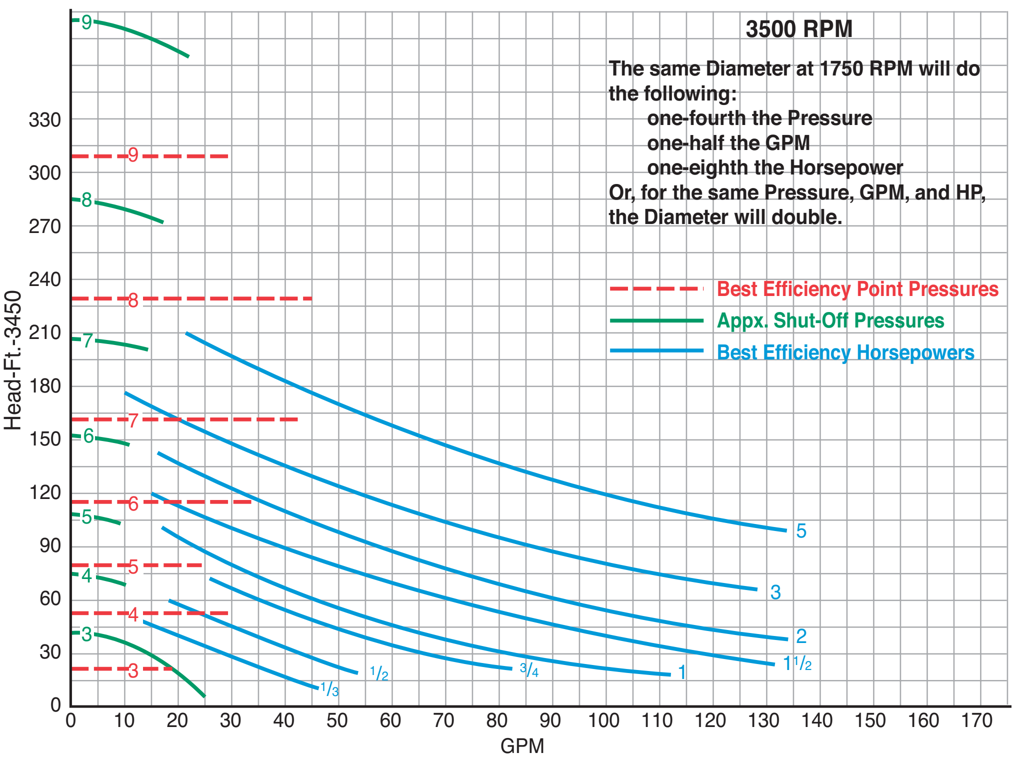
If the pressure and capacity of a proposed replacement pump cannot be determined by a better way, the pressure can be determined with fair accuracy from the impeller diameter and the RPM. The capacity can be determined with less accuracy from the diameter, RPM, and the HP and service factor.

The discharge pressure is proportional to the square of the diameter or RPM. However, the pressure at the best efficiency point is always lower than the shut-off pressure, about 75 to 83% of the shut-off pressure. The chart below shows the approximate pressure at the best efficiency point for various diameters at 3450 RPM. Diameters must be multiplied by 2 for 1750 RPM. A very low capacity pump will operate closer to the shut-off pressure, however.

The horsepower required for a pumping condition is equal to the pressure (ft.) times the GPM divided by 3960 x efficiency. $\left[HP = \frac{ft. \times GPM}{Eff.\% \times 3960}\right]$ If the efficiency is taken as 100% (1.0) the result is the theoretical water horsepower of the condition point. Actual efficiencies vary from about 45% (.45) for 10 or 15 GPM up to 80% or so for capacities of 700 GPM or more. Higher pressure conditions and 1750 RPM pumps tend to reduce efficiencies. Low or medium pressures and 3450 RPM pumps tend to have the better efficiencies. 60% is a good average.

If the discharge pressure in ft. is determined from the diameter, and the horsepower (with due consideration of service factor) is known, the GPM can be calculated by rearranging the formula. $\left[GPM = \frac{HP \times Eff. \times 3960}{ft.}\right]$ The accuracy is limited by how well the actual horsepower can be judged from the motor rating and whether the motor is loaded or not.

The chart shows approximate shut-off pressures and best efficiency point pressures for different diameter impellers. The horsepowers are the approximate best efficiency point horsepowers for a number of different capacity pumps.



FORM CBFP *Revised 8/14*

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