Submersible Pumps

The submersible pump is a centrifugal pump. Because all stages of the pump end (wet end) and the motor are joined and submerged in the water, it has a great advantage over other centrifugal pumps. There is no need to recirculate or generate drive water as there is with jet pumps, therefore, most of its energy goes toward "pushing" the water rather than fighting gravity and atmospheric pressure to draw water.

Impeller / Diffuser Stack

Virtually all submersibles are "multi-stage" pumps. All of the impellers of the multi-stage submersible pump are mounted on a single shaft and all rotate at the same speed. Each impeller passes the water to the eye of the next impeller through a diffuser. The diffuser is shaped to slow down the flow of water and convert velocity to pressure. Each impeller and matching diffuser is called a stage. As many stages are used as necessary to push the water out of the well at the required system pressure and capacity. Each time water is pumped from one impeller to the next, its pressure is increased.

The pump and motor assembly are lowered into the well by connecting piping to a position below the water level. In this way the pump is always filled with water (primed) and ready to pump. Because the motor and pump are under water they operate more quietly than above ground installations and pump freezing is not a concern.

A.Y. McDonald can stack as many impellers as needed; however, the horsepower of the motor is limited. For instance, numerous pumps have 1/2 HP ratings - pumps that are capable of pumping different flows at different pumping levels; they will, however, always be limited to 1/2 HP. Another way to look at it is that a pump will always operate somewhere along its design curve.

To get more flow, the exit width of the impeller is increased and there will then be less pressure (or head) that the pump will develop because there will be less impellers on a given HP size pump. Remember, the pump will always trade-off one for the other depending on the demand of the system. If the system demands more than a particular pump can produce, it will be necessary to go up in horsepower; thereby, allowing more impellers to be stacked or to go to a different design pump with wider impellers.

Pump Curves

A pump curve is a curved line drawn over a grid of vertical and horizontal lines. The curved line represents the performance of a given pump. The vertical and horizontal grid lines represent units of measure to display that performance.

Let's think of a well full of water. We want to use the water in a home. The home is at a higher level than the water in the well. Since gravity won't allow water to flow uphill, we use a pump. A pump is a machine used to move a volume of water a given distance. This volume is measured over a period of time expressed in gallons per minute (GPM) or gallons per hour (GPH).

The pump develops energy called discharge pressure or total dynamic head. This discharge pressure is expressed in units of measure called pounds per square inch (psi) or feet of head (ft).

NOTE: 1 psi will push a column of water up a pipe a distance of 2.31 feet. When measuring a pump's performance, we can use a curve to determine which pump is best to meet our requirements.

Figure 1 is a grid with the unit of measure in feet on the left hand side. We start with 0 at the bottom. The numbers printed as you go up the vertical axis relate to the ability of the pump to produce pressure expressed in feet. Always determine the value of each grid line. Sometimes the measure will say feet head, which is what most engineers call it.

With the pump running a reading was taken from the gauge in psi and converted to feet (1 psi = 2.31 feet).

We show another unit of measure in gallons per minute across the bottom. You start with 0 on the left. The numbers printed as you go to the right relate to the ability of the pump to produce flow of water expressed as capacity—in gallons per minute (GPM). Again, always determine the value of each grid line.

To establish a pump curve we run the pump using a gauge, valve, and flowmeter on the discharge pipe. We first run the pump with the valve closed and read the gauge. This gives us the pump's capability at 0 capacity and maximum head in feet.

Figure 2 - We mark the grid point 1. Next we open the valve to 8 GPM flow, and read the gauge. We again mark this point on the grid 2. We continue this process until we have marked all the points on the grid.
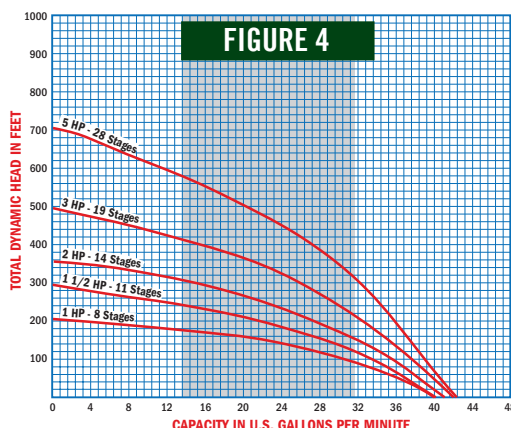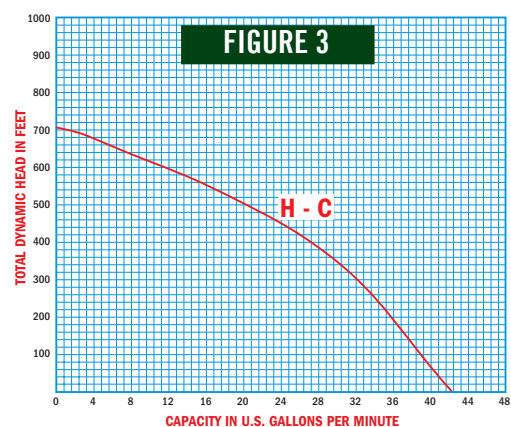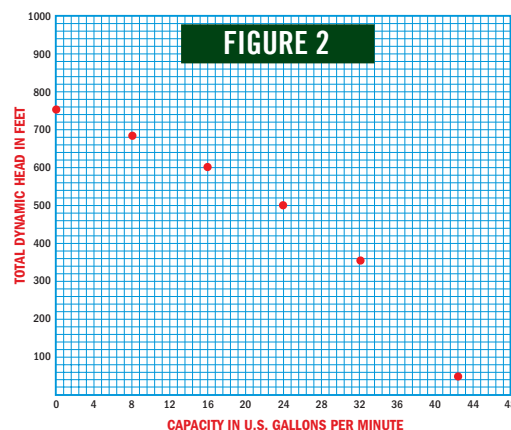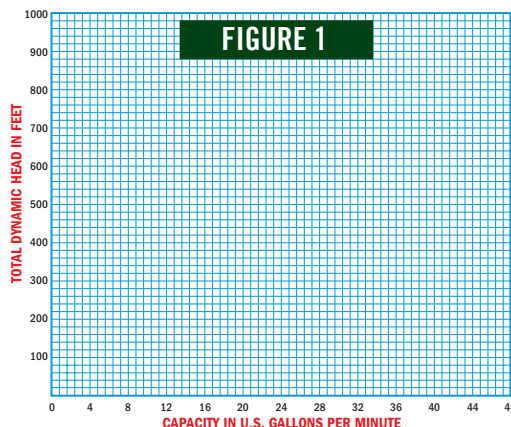
Figure 3 - We now connect all the points. This curved line is called a head/capacity curve. Head (H) is expressed in feet and capacity (C) is expressed in gallons per minute (GPM). The pump will always run somewhere on the curve.

When the total dynamic head (TDH) is known, read vertically up the left hand side of the curve to that requirement, for example, 300 feet. Then read horizontally to a point on a curve that connects to the capacity needed, for example 26 GPM. It is then determined that a 3 HP 19 stage pump is needed.
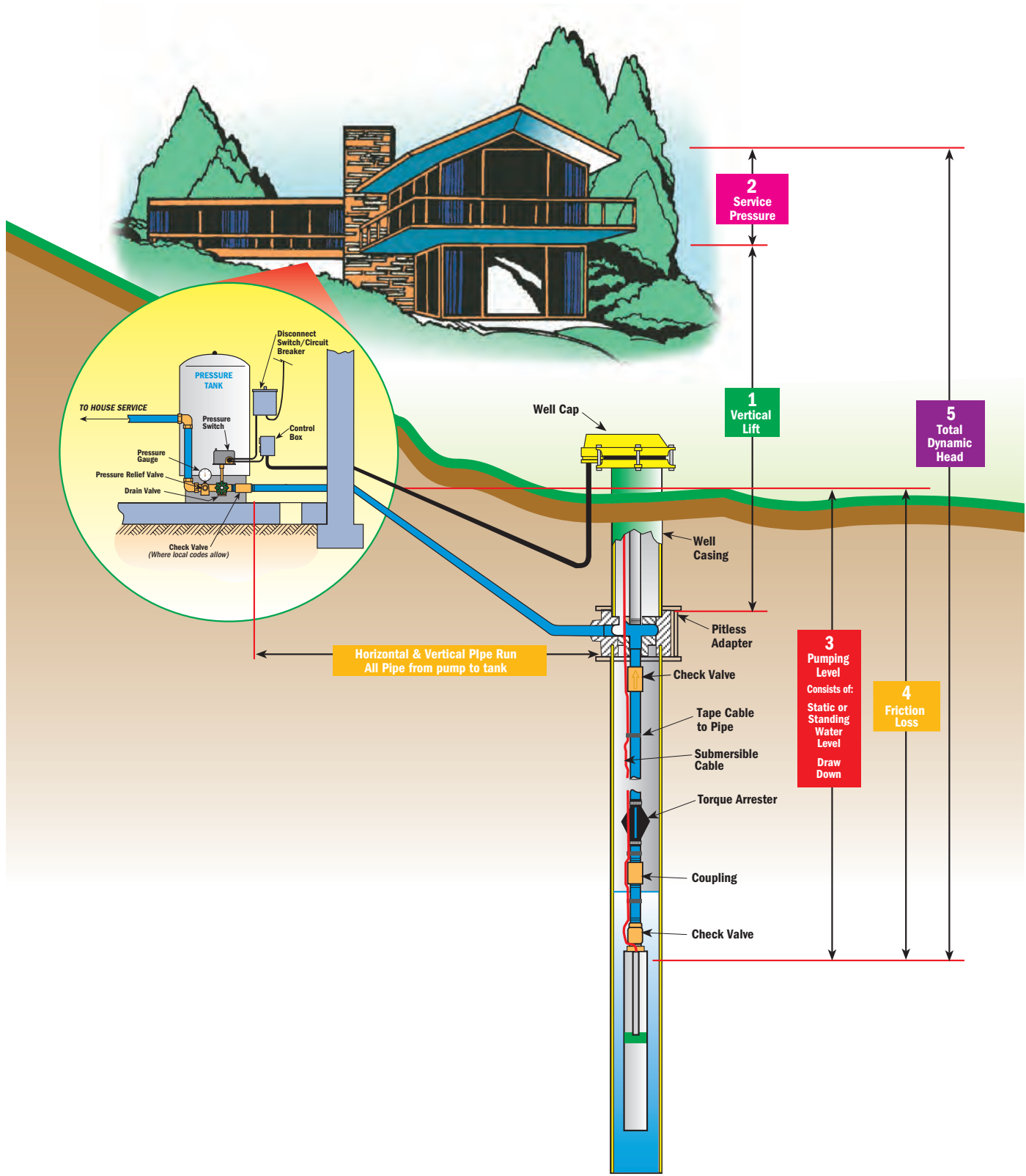
There are many different type curves shown in our catalog. Figure 4 is a composite performance curve (more than one pump) for the submersible. There is a separate curve for each horsepower size. Let's compare two sizes:

1. First look at the 1 HP, 8 stages (impellers and diffusers). At 20 GPM capacity this model will make 160 feet.

2. Now look at the 5 HP, 28 stages. At 20 GPM capacity this model will make 500 feet.

When you add impellers, the pump makes more pressure (expressed in feet). This allows the pump to go deeper in a well, but also takes more horsepower.

FIGURE 1

FIGURE 2

FIGURE 3

H - C

FIGURE 4

5 HP - 28 Stages
3 HP - 19 Stages
2 HP - 14 Stages
1 1/2 HP - 11 Stages
1 HP - 8 Stages

Typical Submersible Installation

2 Service Pressure

1 Vertical Lift

5 Total Dynamic Head

Well Cap

Disconnect Switch/Circuit Breaker

PRESSURE TANK

TO HOUSE SERVICE

Pressure Switch

Control Box

Pressure Gauge

Pressure Relief Valve

Drain Valve

Check Valve
(Where local codes allow)

Well Casing

Pitless Adapter

3 Pumping Level

Consists of:

Static or Standing Water Level

Draw Down

4 Friction Loss

Check Valve

Tape Cable to Pipe

Submersible Cable

Torque Arrester

Coupling

Check Valve

Horizontal & Vertical Pipe Run
All Pipe from pump to tank

Pump Sizing - Submersible Pumps

MORE ABOUT...

VERTICAL LIFT/ ELEVATION
The vertical distance between the well head and the level at the point of use. It must be added to the TOTAL DYNAMIC HEAD if the inlet is lower than the outlet and subtracted if the inlet is higher. As a rule of good installation practice, however, pipes should slope continuously upward from the inlet to the outlet to prevent entrapment of air.

SERVICE PRESSURE
The range of pressure in the pressure tank during the pumping cycle.

PUMPING LEVEL
The lowest water level reached during pumping operation. (Static level – drawdown)

STATIC OR STANDING WATER LEVEL
The undisturbed level of water in the well before pumping. Not as important as pumping level.

DRAWDOWN
The distance that the water level in the well is lowered by pumping. It is the difference between the STATIC WATER LEVEL and the PUMPING LEVEL.

FRICTION LOSS
The loss of pressure or head due to the resistance to flow in the pipe and fittings. Friction loss is influenced by pipe size and fluid velocity, and is usually expressed in feet of head.

HORIZONTAL RUN
The horizontal distance between the point where fluid enters a pipe and the point at which it leaves.

TOTAL DYNAMIC HEAD or TDH
TDH and capacity required determines pump size. The total pressure or head the pump must develop is the sum of the VERTICAL LIFT/ELEVATION, THE SERVICE PRESSURE, PUMPING LEVEL, and THE FRICTION LOSS. All of these measurements must be expressed in the same units, usually feet of head or pressure (PSI), before adding them together.

Determining Total Dynamic Head

1 **Vertical Lift / Elevation**
The vertical distance in feet from the pitless adapter to the top of the pressure tank

2 **Service Pressure**
The average (pump shut-off) pressure switch setting x 2.31'. Example for a 30/50 switch: 40 x 2.31' = 92.4 feet

3 **Pumping Level**
The vertical distance in feet from the pitless adapter or well seal to the water drawdown level in the well that yields the flow rate required by the pump

4 **Friction Loss**
Water flowing through piping will lose head depending on the size, type and length of piping, number of fittings, and flow rate. Example: Pumping 20 GPM through 500 ft. of 1 1/4" plastic pipe with three elbows will cause a friction loss equal to:

$$\frac{500 \text{ ft.} + 21 \text{ ft. (elbow loss)}}{100 \text{ ft.}} \quad X\ 6.00 \text{ ft (loss per 100')} = 31.26 \text{ ft.}$$

Feet of Pipe _____ Diameter of Pipe _____

Type of Pipe _____

See Friction Loss Charts on Page 16

5 **Total Dynamic Head**
After determining TDH, match this number with capacity required on pump curves of specific pumps in this catalog to select the correct pump.

Gallons Per Minute (or Hour) Needed

Well Size
(inside diameter in inches)
_____

HEAD

+

Convert PSI to feet
(X 2.31)

+

+

=

Ft.

Determining Flow Rate

Although methods will vary, in general, the Water Systems Council bases pump flow selection for a residential system on total gallon usage during a seven minute peak demand period. This can be supplemented by using a properly sized pressure tank.

Farms, irrigation, and lawn sprinklers demand more water.