SUBJECT: WATER DEMOND AND SUPPLY CODE 652

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Q.1:

Desalination:

It is the process that take away mineral components from saline water. More generally, desalination refers to the removal of salts and minerals from a target substance as in soil desalination which is in issue for agriculture.

Distillation:

.

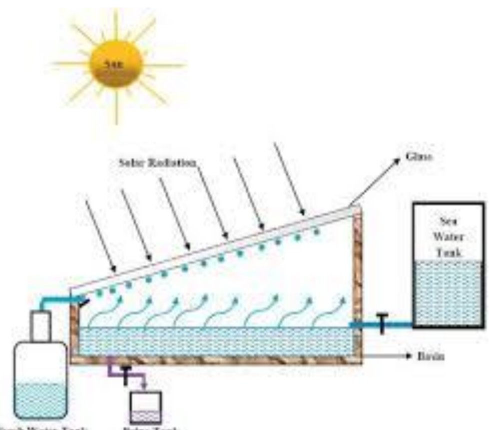
Methods of desalination:

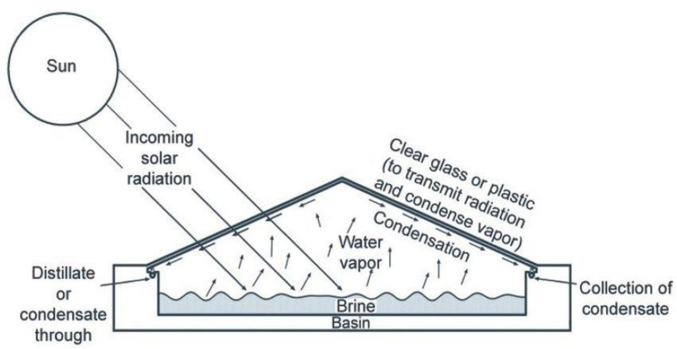
There are several methods. Each has advantages and disadvantages but all are useful. The methods can be divided into membrane-based (e.g., reverse osmosis) and thermal-based (e.g., multistage flash distillation) methods. The traditional process of desalination is distillation, i.e. boiling and re-condensation of seawater to leave salt and impurities behind.

Solar distillation:

Solar desalination is a technique to produce water with a low salt concentration from sea-water or brine using solar energy. There are two common methods of solar desalination. Either using the direct heat from the sun or using electricity generated by solar cells to power a membrane process.

There are two types of solar desalination. The former one is using photovoltaic cells which converts solar energy to electrical energy to power the desalination process. The latter one utilises the solar energy in the heat form itself and is known as solar thermal powered desalination.

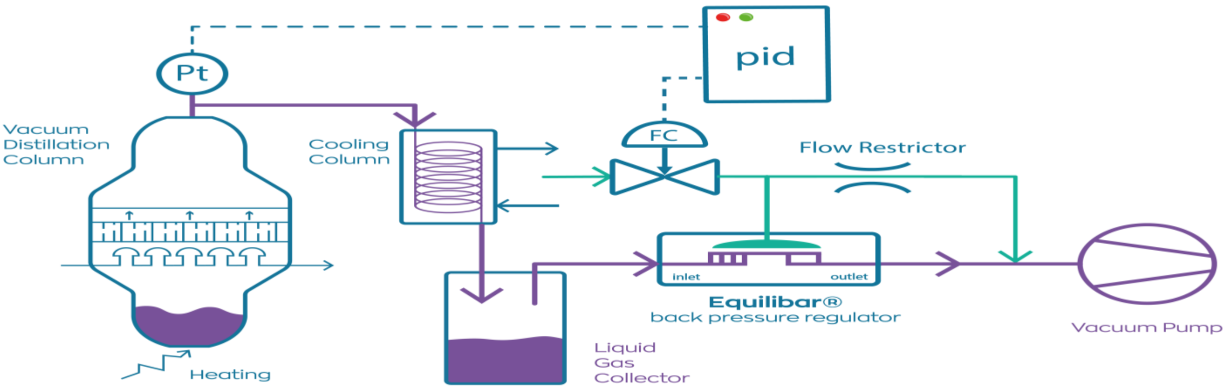




Solar distillation schematic

Vacuum distillation:

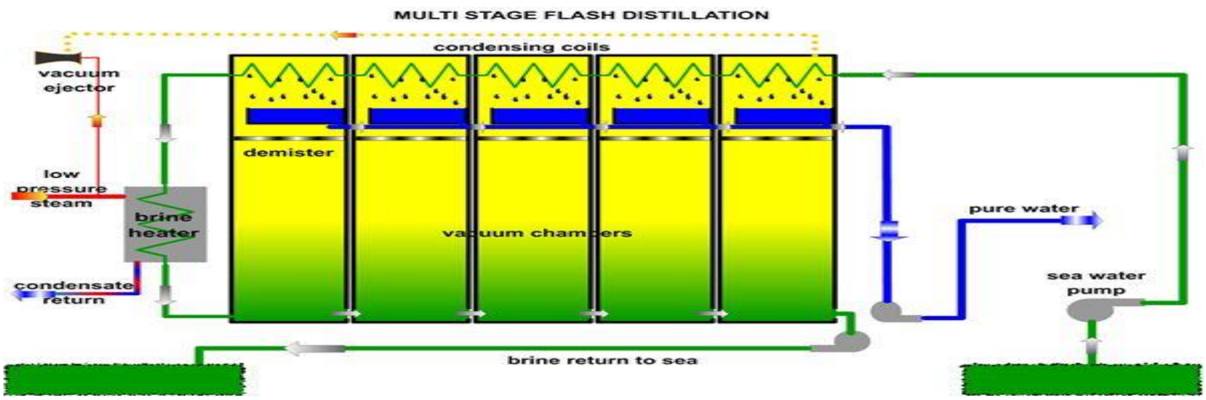
Vacuum distillation is distillation performed under reduced pressure, which allows the purification of compounds not readily distilled at ambient pressures or simply to save time or energy. This technique separates compounds based on differences in boiling point.



Vacuum distillation process schematic diagram

Multi-stage flash distillation:

Multi-stage flash distillation (MSF) is a water desalination process that distills sea water by flashing a portion of the water into steam in multiple stages of what are essentially countercurrent heat exchangers. Multi-stage flash distillation plants produce about 26% of all desalinated water in the world, but today virtually all new desalination plants use reverse osmosis due to much lower energy consumption.



Multi stage flash distillation schematic diagram

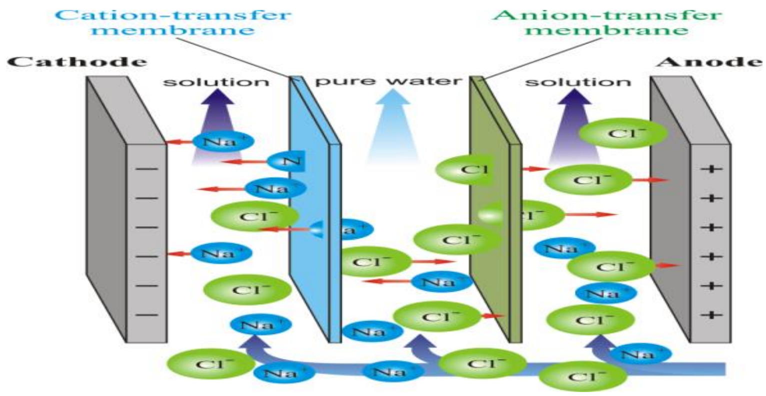
Electrodialysis:

Electrodialysis systems use a selectively permeable membrane to move ions from one side to the other under the influence of an electric potential. In almost all practical electrodialysis processes, multiple electrodialysis cells are arranged into a configuration called an electrodialysis stack, with alternating anion and cation exchange membranes forming the multiple electrodialysis cells.

In normal potable water production without the requirement of high recoveries, RO is generally believed to be more cost-effective when TDSs are 3000 parts per million (ppm) or greater. Electrodialysis is more cost-effective for TDS feed concentrations of less than 3000 ppm or when high recoveries of the feed are required when it is properly developed.

It is however not a robust technology.

The process requires extensive pretreatment, including removal of all particles bigger than 10 µm, as well as hardness, large organic anions, colloidal matter, iron, and manganese oxides.



Electrodialysis schematic diagram

Freezing Method:

It is based on the principle that water excludes salts when it crystallizes to ice.

It involves three steps:Ice formation,ice washing,and ice melting to obtain fresh water with subsequent removal of contimination.

Reverse Osmosis:

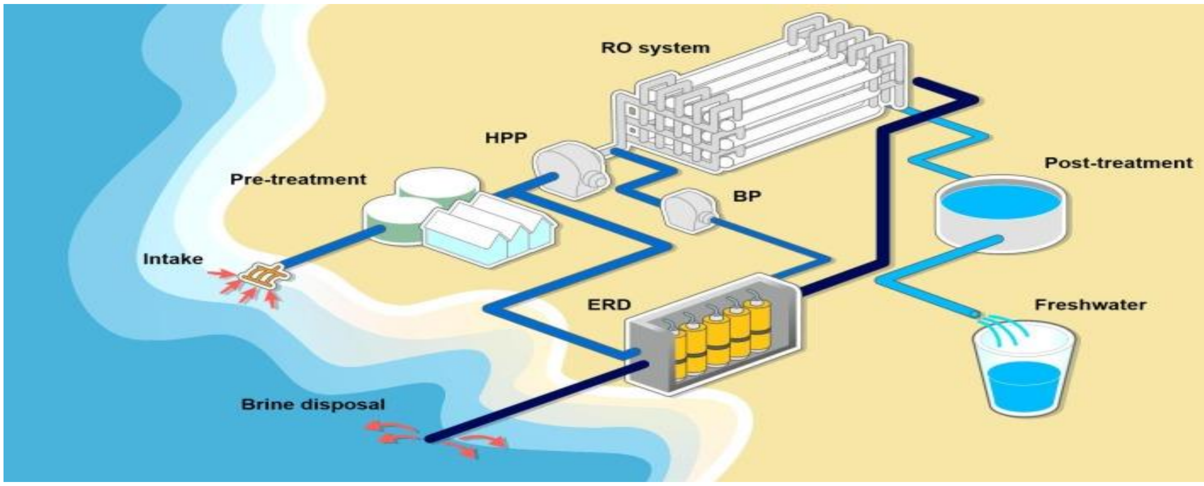
Definition: The movement of fresh water through a semipermeable membrane when pressure is applied to a solution (such as seawater) on one side of it.

Reverse osmosis is a water purification technology/method that causes a semi- permeable membrane to remove ions,molicules and larger particles from saline water.

Reverse osmosis can remove many types of dissolved and suspended species from water, including bacteria, and is used in both industrial processes and the production of portable water.

It significantly decreases the salts and other potential impurities in the water resulting in an

high quality and great tasting water.



Reverse osmosis Schematic diagram

Steps involved in Reverse Osmosis

Step-1:

Removal of sediments from the water. In this step all the sediments like clay, silt and stones are removed from the water.

For this, a 5-micron filter is used. The sediments are filtered in order to make sure that no damage is done to the membrane.

The micron filter does not let these particles pass by and thus they are suspended.

Step-2:

In the second step carbon filter is used to remove the chlorine and other harmful chemicals that enter the water sources.

These chemicals are harmful to human health and thus it is necessary to remove them.

Step-3:

The third step focuses on passing the water from a dense and compacted carbon filter. Most of the contaminants are removed here.

Step-4:

Water passes through the membrane and all the heavy metals present in the water are removed.

Along with the metals, radioactive metals too are removed. In this step, the impurities are drained out of the reverse osmosis system and clean water is separated.

Step-5:

In this last stage, the bacteria, chlorine, and bad odour are removed from water. After water passes from this stage, it comes out of the faucet and is perfect for consumption.

This step involves tertiary treatment or polishing.

Reverse osmosis is an effective means to desalinate saline water, but it is more expensive than other methods. As prices come down in the future the use of reverse osmosis plants to desalinate large amounts of saline water should become more common.

There is no single "most economic" desalination method -whether a technology is economic will depend on water chemistry, energy source, process scale and a variety of other factors. Reverse osmosis is very economic for sea water desalination when ~50% recovery is required and there is an inexpensive source of electrical energy, but for brackish/brine salt concentrations or other desired energy sources, alternate technologies can economically out-compete RO. The following article, though a few years old, is a good resource to learn about different technologies that exist for desalination.

Refrence:https://www.researchgate.net/publication/51547620_The_Future_of_Seawater_Desalination_Energy_Technology_and_the_Environment.

Q2. Briefly describe merits and demerits of 4 types of water distribution layouts? Which layout will you recommend for newly proposed township in hilly area? Support your answer with justification?

1:Dead-end or tree distribution system

In the dead end system (also called tree system), one main pipeline runs through the Centre of the populated area and sub-mains branch off from both sides. The sub-mains divide into several branch lines from which service connections are provided.

Merits.

- The design calculation is simple and easy.
- A smaller number of cut-off valves are required and the operation and maintenance cost is low.
- Pipe laying is simple

De Merits.

The system is less successful in maintaining satisfactory pressure in remote areas and is therefore not fvoured in modern waterworks practice.

One main pipeline provides the entire city, which is quit risky.

The discharge available for firefighting in the streets is limited due to high head loss in areas with weak pressure.

2. *Gridiron distribution system*

In this system the main supply line runs through the centre of the area and sub mains branch off in perpendicular directions. The branch lines interconnect the sub-mains. This system is ideal for cities laid out on a rectangular plan resembling a gridiron. The distinguishing feature of this system is that all of the pipes are interconnected and there are no dead ends. Water can reach a given point of withdrawal from several directions, which permits more flexible operation, particularly when repairs are required.

Merits.

- Because of the interconnections water is available at every point with minimum loss of head.
- Enough water is available at street fire hydrants, as the hydrant draws water from the various branch lines.
- During repairs, only a small area of distribution is affected.

De Merits.

- A large number of cut-off valves are required
- The system requires longer pipe lengths with larger diameters.
- The cost of pipes laying is higher

3. Circular or ring distribution system

In a circular or ring system, the supply main forms a ring around the distribution area. The branches are connected cross-wise to the mains and also to each other. This system is most reliable for a town with well-planned streets and roads. The advantages and disadvantages of this system are the same as those of the gridiron system. However, in case of fire, a larger quantity of water is available, and the length of the distribution main is much higher.

Merits.

Simplest as fed at only one end.
• The initial cost is low.
• It is useful when the generating is at low voltage. It has a low maintenance

De Merits

The end of distributor near to the substation gets heavily loaded.
• When load on the distributor changes, the clients at the distant end of the distributor face serious voltage fluctuations.
• As users are dependent on single feeder and distributor, a fault on any of these two causes interruption in supply to all the users connected to that distributor

4. Gravity System.

Suitable when source of supply is at sufficient Height.

- Most reliable and economical distribution system.
- The water head available at consumer is just minimum required
- The remaining head is consumed in the frictional and other losses.

Recommendation of Water distribution system for Newly Town ship in Hilly Area.

ANS. I will recommend gravity water distribution system for newly township in hilly areas because of following reasons

1. *Gravity water distribution system is Cost effective over pumping systems as no external power is required to maintain the flow.*
2. *Real Time controlled Sustainable.*
3. *Suitable source of supply for marginal heights.*
4. *Most reliable and economical.*

Question no: 3

What are different type of reservoirs used in water supply system? Briefly describe its importance and how its storage capacity be calculated?

Types of Reservoirs:

Types of Reservoirs

Depending upon their elevation w.r.t ground it may be classified into:

1. Surface reservoirs

2. Elevated reservoirs

Types of Reservoirs

1. Surface reservoirs:

- These are also called ground reservoir.
- Mostly circular or rectangular tank.
- Under ground reservoirs are preferred especially when the size is large.
- In case of gravity system, underground reservoirs are generally constructed on high natural grounds and are usually made of stones, bricks, plain or reinforced cement concrete.

1**. Surface reservoirs:**

- The side walls are designed to take up the pressure of the water, when the reservoir is full and the earth pressure when it is empty.
- The position of ground water table is also considered while designing these reservoirs.
- The floors of these reservoirs may be constructed with R.C.C slab or stone blocks with sufficient water profing.
- To obtain water tightness bitumen compounds are used at all construction joints.
- For aeration of water and inspection, manholes, ventilation pipes and stairs are provided.

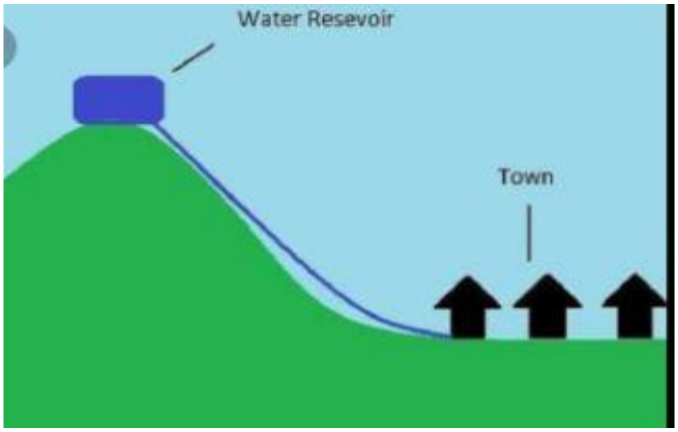


Figure 1: surface reservoir

2. Elevated Storage Reservoirs:

- Elevated Storage Reservoirs (ESRs) also referred to as Overhead Tanks are required at distribution areas which are not governed and controlled by the gravity system of distribution.
- These are rectangular or circular in shape.
- If the topography of the town is not suitable for gravity system, the elevated tank or reservoir are used to provide sufficient pressure head.
- They are constructed where combine gravity and pumping system of water distribution is adopted.

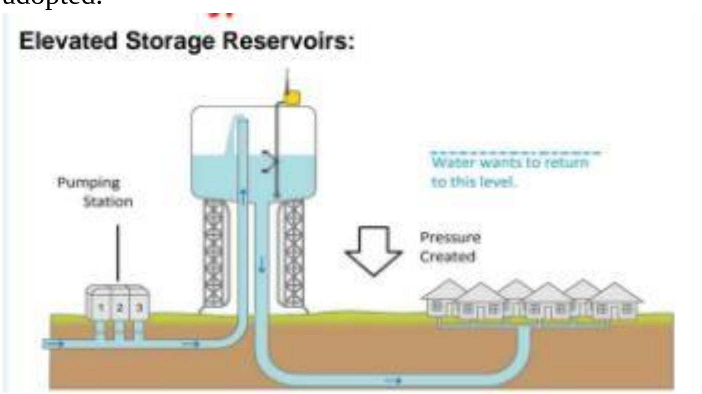


Figure 2:elevated storage

How to calculate capacity of reservoirs?

The total storage capacity of a distribution reservoir is the summation of:

1. **Balancing Storage:**

- The quantity of water required to be stored in the reservoir for equalizing or balancing fluctuating demand against constant supply is known as the balancing storage (or equalizing or operating storage). It is calculated as :

  P=E+Q

Where “Q” flow of water . E is evapotranspiration.

2. **Breakdown Storage:**

- The breakdown storage or often called emergency storage is the storage preserved in order to tide over the emergencies posed by the failure of pumps, electricity, or any other mechanism driving the pumps.
- A value of about 25% of the total storage capacity of reservoirs, or 1.5 to 2 times of the average hourly supply, may be considered as enough provision for accounting this storage.

3. Fire Storage:

- The third component of the total reservoir storage is the fire storage.
- This provision takes care of the requirements of water for extinguishing fires.
- Fire demand maybe calculated by the given formulas:

$$Q = 4640\sqrt{P}\left(1 - 0{\cdot}01\sqrt{P}\right)$$

(2) Freeman's formula

$$Q = 1135{\cdot}5\left(\frac{P}{10} + 10\right)$$

(3) Kuichling's formula

$$Q = 3182\sqrt{P}$$

(4) Buston's formula

$$Q = 5663\sqrt{P}$$

where Q = Quantity of water (in litre/minute)

and P = Population of town (in thousands)

Note: The total reservoir storage can finally be worked out by adding all the three storages.

Question on 4:

Ans:

Pumping system is suitable in area where high residential pressure and continues flow is demoded. Normally electrically or solar energy is used for pumping. Operational cost of this iss much higher hen gravity system.

The main advantage of pump used in water supply schemes especially centrifugal pumps are low maintenance cost higher reliability along life time and sample construction which all insure that the water pumped is hygienically pure. The pump unit is commonly driven by an electrical motor or desial engine. the latter being and alternative in case of electricity failure an remote areas not connected at all to the electricity network .

b) How to calculate pump curve to meet water demand?

WHAT IS A PUMP CURVE?

Curves typically include performance metrics based on pressure, flow, horsepower, impeller trim, and Net Positive Suction Head Required (NPSHr).

Pump curves are useful because they show pump performance metrics based on head (pressure) produced by the pump and water-flow through the pump. Flow rates depend on pump speed, impeller diameter, and head.

WHAT IS HEAD?

Head is the height to which a pump can raise water straight up. Water creates pressure or resistance, at predictable rates, so we can calculate head as the differential pressure that a pump has to overcome in order to raise the water. Common units are feet of head and pounds per square inch. As Figure 1 illustrates, every 2.31 feet of head equals 1 PSI.

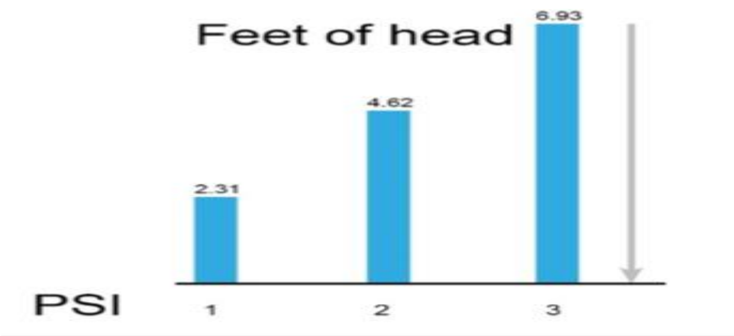


Fig.01 Head graph

THE FORMULA FOR PSI: FEET OF HEAD/2.31 = PSI

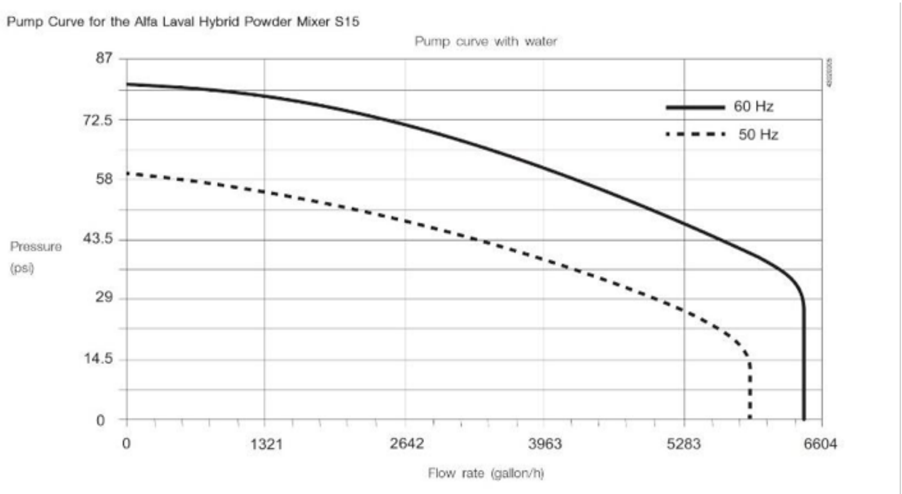


Fig.02 .Pump curve

A basic pump curve shows a pump's performance range. In this curve, head is measured in PSI; flow is measured in gallons per hour.

WHAT IS TOTAL DYNAMIC HEAD?

While pump curves help you select the right pump for the job, you first have to know the total dynamic head for the application.

Total Dynamic Head (TDH) is the amount of head or pressure on the suction side of the pump (also called static lift), plus the total of 1) height that a fluid is to be pumped plus 2) friction loss caused by internal pipe roughness or corrosion.

TDH = Static Height + Static Lift + Friction Loss

Static Lift is the height the water will rise before arriving at the suction side of the pump.

Static Height is the maximum height reached by the pipe on the discharge side of the pump.

Friction Loss (or Head Loss) are the losses due to friction in the pipe at a given flow rate.

HOW TO USE PERFORMANCE PUMP CURVES IN SELECTING EQUIPMENT: THE BASICS

Let's say you want to know the flow rate you can achieve from the pump in Figure below at 60 Hz when the design pressure is 80 PSI. In this case, the curve shows that the pump can achieve a flow rate of 1321 gallons per hour at 80 PSI of discharge pressure.

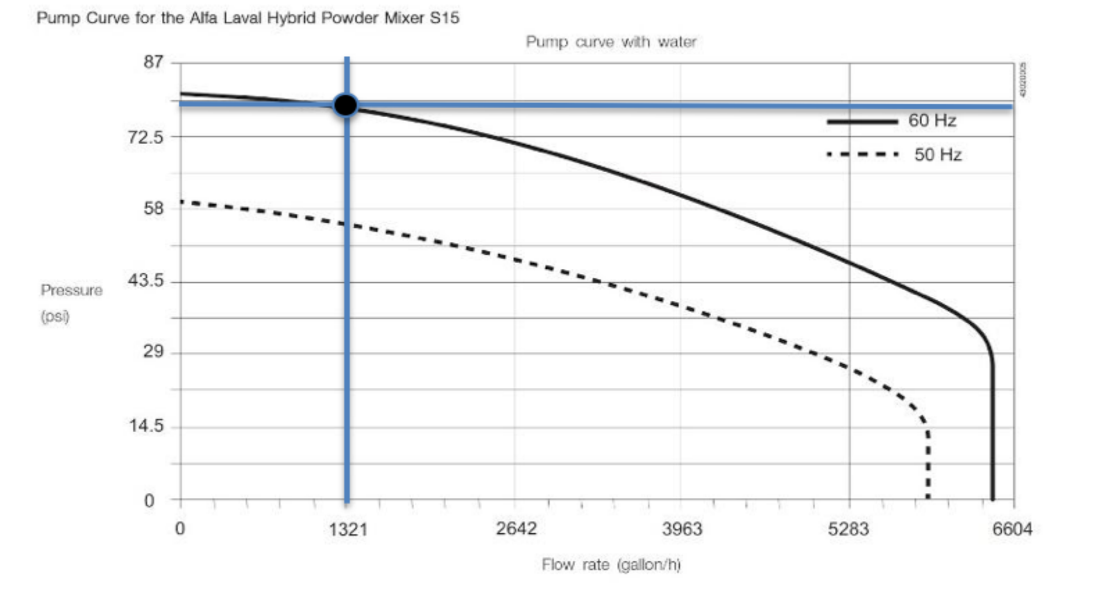


Fig.03

The pump represented in this curve can generate 80 PSI of discharge pressure at a flow rate of 1321 gallons per hour.

READING PUMP CURVES THAT CONTAIN ADDITIONAL INFORMATION:

Because some pumps operate across a range of horsepower, their curves will include additional information. In the below Fig, for example, features a pump that can operate from 2 to 10 horsepower depending on desired performance.

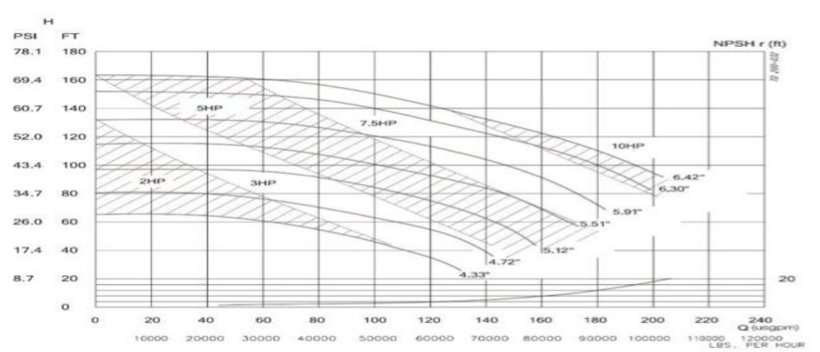


Fig.03

Variable Horsepower pumps can operate at a range of head/flow combinations and impeller trim sizes.

IMPELLER TRIM SIZE:

Impeller trim size is another variable for meeting performance requirements.The curve above shows impeller trim sizes,at the end of each curve,ranging from a minimum of 4.33" to a maximum of 6.42".

Reducing impeller size enables you to limit the pump to specific performance requirments.The curve above shows maximum pump performance with a full-trim impeller,minimum pump performance with a minimum-trim impeller,and performance delivered by the design-trim impeller,or the impeller trim closest to the design condition.Impellers are typically trimmed 0.20 inches (or 5mm) at a time.

Impeller size is a factor when handling shear sensitive liquids,or liquids that change viscosity when under pressure.

NET POSITIVE SUCTION HEAD REQUIRED/AVAILABLE:
In addition to pressure and flow,the curve at the bottom of figure 4 indicates NPSHr.Which stands for Net positive suction Head required.NPSHr is the minimum amount of pressure required on the suction side of the pump to avoid cavitation,or the introduction of air into the fluid stream.NPSHr is determined by pump.You always want NPSHa>NPSHr.

NPSHa, With "a" standing for available, is determined by the process piping.You always want NPSHa to e greater than NPSHr.Without enough net positive suction, the pump will cavitate, which affects performance and pump life.

EFFICIENCY AND PERFORMANCE VARIABLES:
Good pump efficiency means that a pump is not wasting energy in order to maintain its performance point. No pump is 100% efficient,However,in the work it has to do to transfer liquids.

When selecting a pump and motor combination,consider not only the total current demand but future forcast is also be the part of your selection to meet the changing requirements.TO that end,sizing the pump for performance variables rather than the peak efficiency is common practice.