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ASSIGNMENT # 02/Final Term Paper

Water Demand Supply and Distribution

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Question # 1: Define desalination and briefly describe various desalination methods? Which method is more effective, please elaborate briefly?

Answer: Desalination refers to any of several processes that remove the excess salt and other minerals from water in order to obtain fresh water suitable for animal consumption or irrigation, and if almost all of the salt is removed, for human consumption, sometimes producing table salt as a by-product.

Methods of desalination:

There are several methods of desalination. Each has advantages and disadvantages but all are useful which are explained as under:

Solar desalination: 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.

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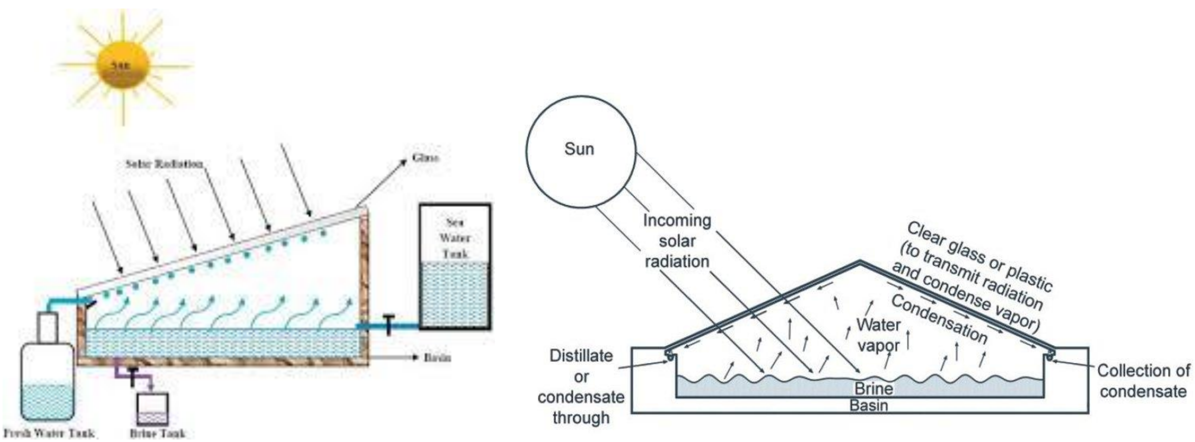
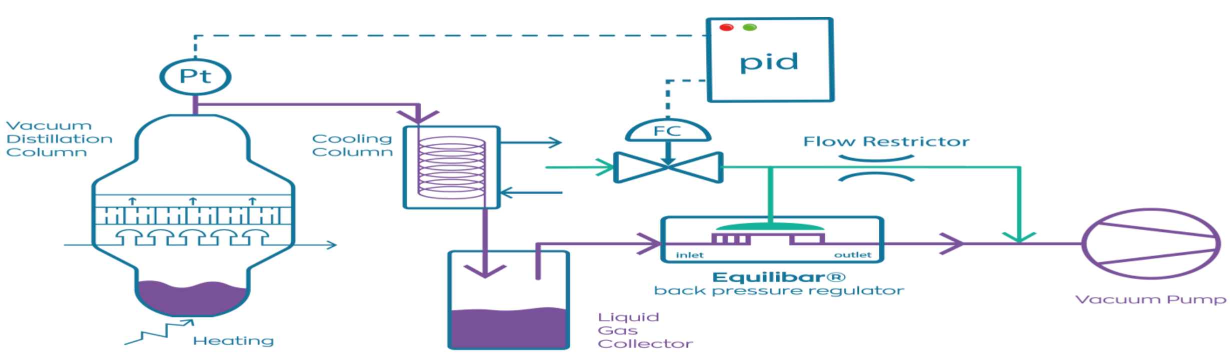


Solar distillation schematic diagram

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.



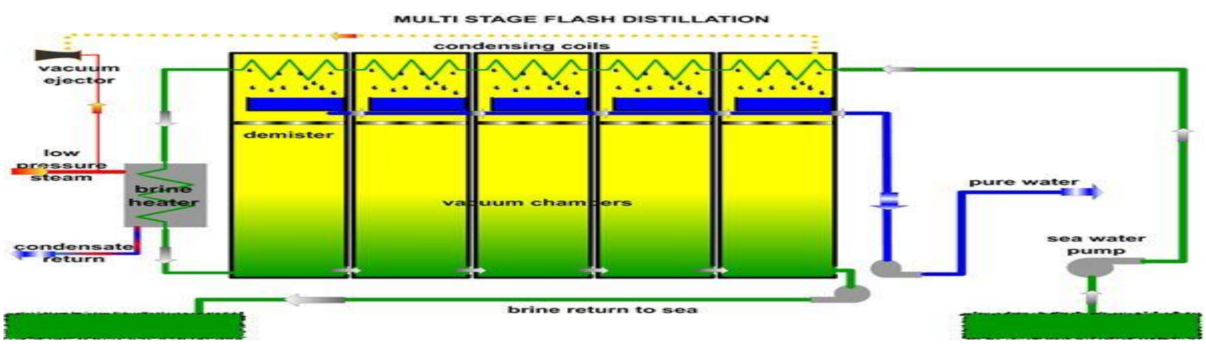
Vacuum distillation process schematic diagram

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.

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.

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

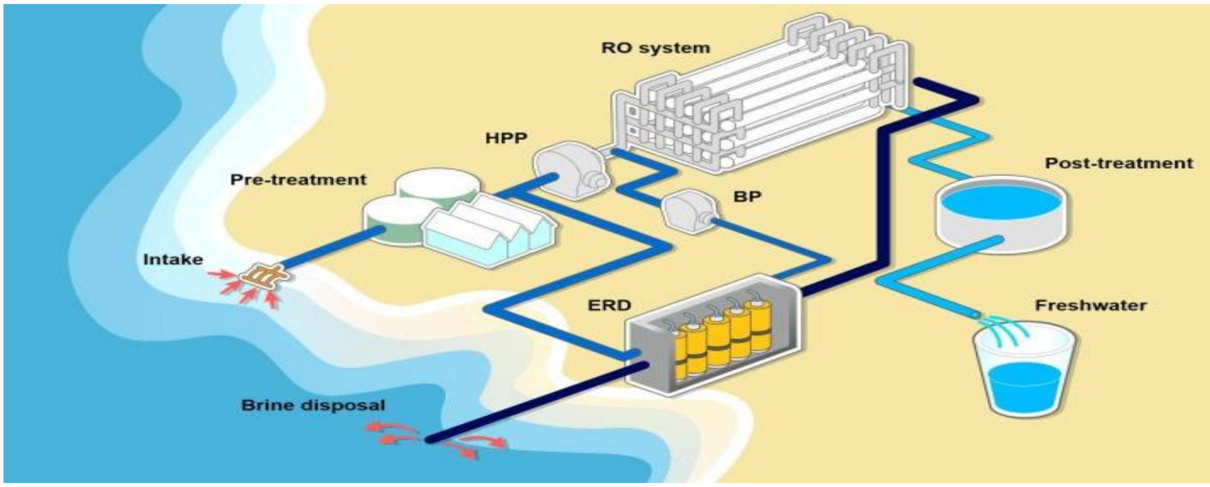
Freezing Method:

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.

<u>The most effective method is Reverse Osmosis which are briefly explain as under:</u>

Reverse Osmosis: Reverse osmosis is a water purification technology/method that causes a semi-permeable membrane to remove ions, molecules 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 a 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.

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.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.

Question # 2: 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?

Answer:

The four types of water distribution layouts and their merits and demerits are explained as under:

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. This type of system is used mostly for the olden cities which are built in irregular manner without any planning.

Merits.

- Pipes in this network can be laid easily.
- The pressure and discharge in each pipe can be determined very easily and accurately which makes design calculations very simple and easy.
- The diameters of pipes of main, sub mains and branches can be designed based on the required demand of population. So, cost of the project can be reduced.
- Dead end system requires less number of cutoff valves and the operation and maintenance cost is low.

De Merits.

- The system is less successful in maintaining satisfactory pressure in remote areas and is therefore not favored in modern waterworks practice
- One main pipeline provides the entire city, which is quite risky
- The pressure is not constant and is very less at remote parts.
- Because of dead ends water stagnation takes place which results in deposition of sediment. To remove this sediments, more number of scour valves are to be provided at the dead ends which increase economy.
- If there is any damage occurs in the branch line, the whole portion should be stopped to repair that which creates discomfort to the other users in that sub main line.
- In this system, Limited discharge is available for firefighting.

2:Grid-iron Distribution System

Grid iron system also contains main lines, sub mains and branch lines. But in this system dead ends are eliminated by interconnecting all the lines. Hence, the water flow continuously in this system without stagnating. So, this system is also called as interlaced system or reticulation system. It is more suitable for well-planned cities.

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.
- Water will flow continuously without any dead ends or sediment deposits.
- Head loss is minimum in this case because of interconnection of pipes.
- The discharge will meet the required discharge for firefighting.
- Repair works can be easily done just by closing cutoff valve in that line which do not affect the other users. So During repairs, only a small area of distribution is affected.

De Merits.

- A large number of cut-off valves are required.
- The analysis of discharge, pressure and velocities in the pipes is difficult and cumbersome
- Because of circulating flow from all directions, the pipes used in this system should be of large diameters and longer lengths.
- We cannot determine the accurate discharge, velocity or pressure in a particular pipe. So, design is difficult.
- Laying of pipes will be done by skilled workers which consume more cost

3:Ring Water Distribution System

Ring system, can also be called as circular system in which the main pipe line is provided around the city or area i.e., peripherally. From this main line, the branch lines are projected perpendicularly and they are also connected with each other. So, every street of the distributed area will get sufficient quantity of water. For a town with well-planned streets and roads, Circular system is more suitable.

Merits.

- The initial cost is low.
- It is useful when the generating is at low voltage. It has a low maintenance.
- No stagnation of water
- Repair works can be done without affecting larger network.
- Large quantity of water is available for firefighting.

De Merits.

- Longer length and large diameter pipes are required.
- More number of cutoff valves are necessary.

- Skilled workers are necessary while laying pipes.
- 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:Radial Water Distribution System

Radial system is quite opposite to the ring system. In this system, whole area is divided into small distribution districts or zones and an individual distribution reservoir is provided for each distribution zone. The reservoir provided is generally of elevated type. From this reservoir the pipe lines are laid radially to the surrounded streets.

All distribution reservoirs are connected with main line which is passing through center of the city. This type of system is suitable for areas with radially designed roads.

Merits.

- The water distributed with high velocity and high pressure.
- Head loss is very small because of quick discharge

De-Merits.

- Cost of the project is more because of number of individual distribution reservoirs
- The area is divided into different zones.
- The supply pipes are laid radially ending towards the periphery.
- The water is pumped into the distribution reservoir kept in the middle of each zone.

Layout to be proposed for newly proposed township in Hilly area:

For newly developed township it is very appropriate to use radial system. The reason for that are,

- The dead-end system may clog and may not work appropriately. In hilly areas it is also difficult to maintain the operational setup of dead-end system.
- The ring system would not work because of the max gradient which will make the ring system on the periphery of the town very inefficient.
- The grid system, as in case of ring system may also not work, due to the elevation gradient makes it inefficient.
- The radian system my cost much in hilly areas but it may be the only possible option.

Question # 3: What are different types of reservoirs used in water supply systems? Briefly describe its importance and how its storage capacity be calculated?

Answer: Types of Reservoirs

Depending upon their elevation w.r.t ground it may be classified into:
1. Surface reservoirs
2. Elevated reservoirs

1. Surface reservoirs:

- These are also called ground reservoir.
- Mostly circular or rectangular tank.
- Underground 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.
- 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 proofing.
- 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.

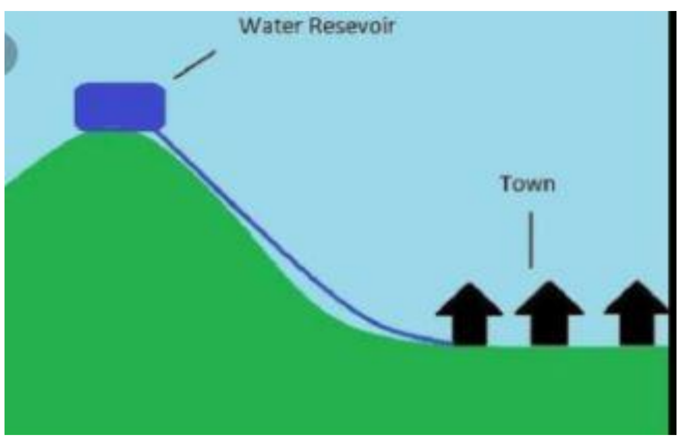


Figure 1: surface reservoir

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

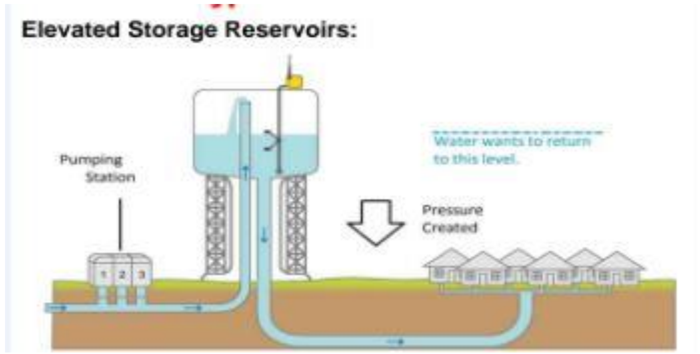


Figure 2: Elevated storage

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:

$$Q = 4640 \sqrt{P} \left(1 - 0.01 \sqrt{P}\right)$$

(2) Freeman's formula

$$Q = 1135.5 \left(\frac{P}{10} + 10\right)$$

(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)

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

Question # 4: Why pumps are used in water supply schemes and how to calculate pump curve to meet water demand?

Answer: Pumping system is suitable in areas where high residual pressure and continuous flow is demanded. Normally electricity or solar energy is used for pumping. Operational cost of this system is much higher than gravity system.

The main advantages of pumps used in water supply schemes especially centrifugal pumps are low maintenance costs, high reliability, a long lifetime and simple construction, which all ensure that the water pumped is hygienically pure. The pump unit is commonly driven by an electrical motor or a diesel engine, the latter being an alternative in case of electricity failures or in 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.

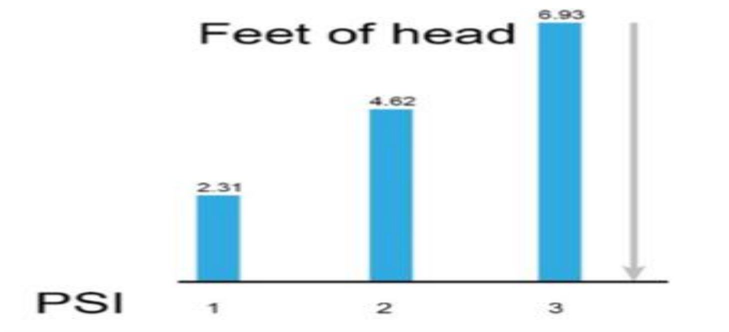


Fig.01 Head graph

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

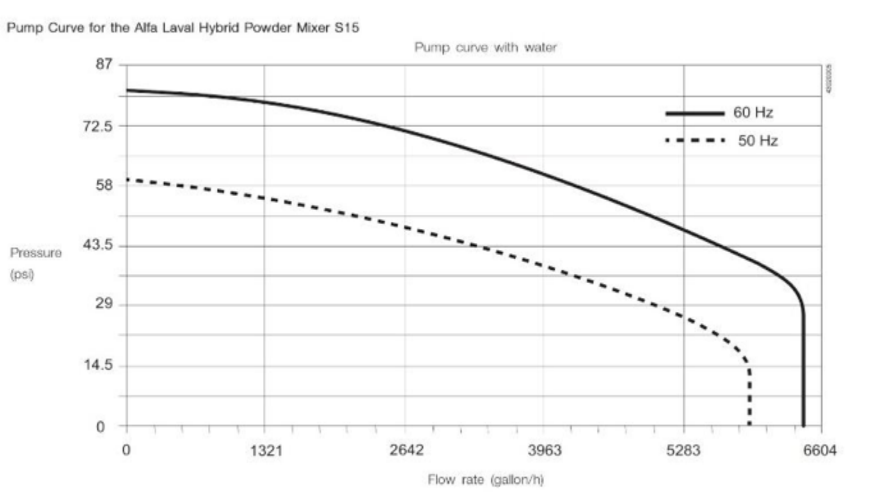


Fig.02 .Pump curve

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.

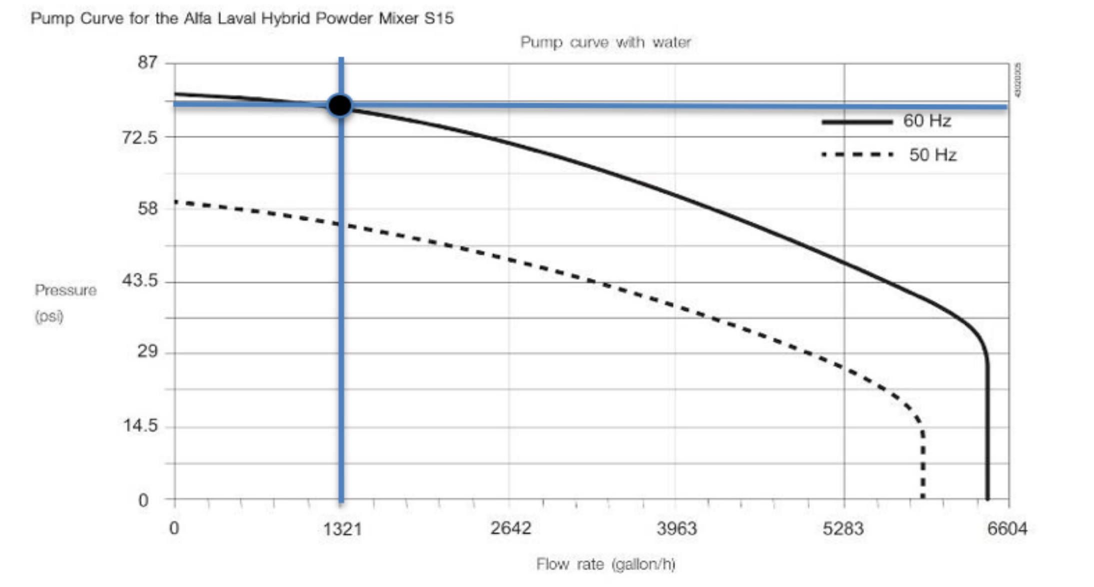


Fig.03

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.

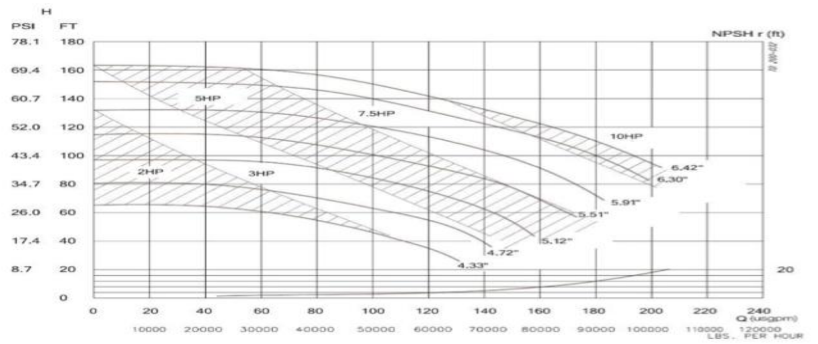


Fig.03

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 requirements. 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 be greater than NPSHr. Without enough net positive suction, the pump will cavitate, which affects performance and pump life.