Desalination is a process that takes 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 an issue for agriculture.

- 1.Solar distillation
- 2.Vacuum distillation
- 3.Multi-stage flash distillation
- 4.Multiple-effect distillation
- 5.Vapor-compression distillation
- 6.Reverse osmosis
- 7.Freeze-thaw
- 8.Electrodialysis membrane
- 9.Membrane distillation
- 10.Wave-powered desalination

Solar distillation

Solar distillation mimics the natural water cycle, in which the sun heats the sea water enough for evaporation to occur. After evaporation, the water vapor is condensed onto a cool surface. 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 utilizes the solar energy in the heat form itself and is known as solar thermal powered desalination.

Vacuum distillation

In vacuum distillation atmospheric pressure is reduced, thus lowering the temperature required to evaporate the water. Liquids boil when the vapor pressure equals the ambient pressure and vapor pressure increases with temperature. Effectively, liquids boil at a lower temperature, when the ambient atmospheric pressure is less than usual atmospheric pressure. Thus, because of the reduced pressure, low-temperature "waste" heat from electrical power generation or industrial processes can be employed.

Multi-stage flash distillation

Water is evaporated and separated from sea water through multi-stage flash distillation, which is a series of flash evaporations. Each subsequent flash process utilizes energy released from the condensation of the water vapor from the previous step.

Multiple-effect distillation

Multiple-effect distillation (MED) works through a series of steps called "effects". Incoming water is sprayed onto pipes which are then heated to generate steam. The steam is then used to heat the next batch of incoming sea water to increase efficiency, the steam used to heat the sea water can be taken from nearby power plants. Although this method is the most thermodynamically efficient among methods powered by heat, a few limitations exist such as a max temperature and max number of effects.

Vapor-compression distillation

Vapor-compression evaporation involves using either a mechanical compressor or a jet stream to compress the vapor present above the liquid. The compressed vapor is then used to provide the heat needed for the evaporation of the rest of the sea water. Since this system only requires power, it is more cost effective if kept at a small scale.

Reverse osmosis

The leading process for desalination in terms of installed capacity and yearly growth is reverse osmosis (RO). The RO membrane processes use semipermeable membranes and applied pressure (on the membrane feed side) to preferentially induce water permeation through the membrane while rejecting salts. Reverse osmosis plant membrane systems typically use less energy than thermal desalination processes. Energy cost in desalination processes varies considerably depending on water salinity, plant size and process type. At present the cost of seawater desalination, for example, is higher than traditional water sources, but it is expected that costs will continue to decrease with technology improvements that include, but are not limited to, improved efficiency, reduction in plants footprint, improvements to plant operation and optimization, more effective feed pretreatment, and lower cost energy sources.

Reverse osmosis uses a thin-film composite membrane, which comprises an ultra-thin, aromatic polyamide thin-film. This polyamide film gives the membrane its transport properties, whereas the remainder of the thin-film composite membrane provides mechanical support. The polyamide film is a dense, void-free polymer with a high surface area, allowing for its high water permeability.

Reverse osmosis desalination plant in Barcelona, Spain

The reverse osmosis process is not maintenance free. Various factors interfere with efficiency: ionic contamination (calcium, magnesium etc.); DOC; bacteria; viruses; colloids and insoluble particulates; biofouling and scaling. In extreme cases, the RO membranes are destroyed. To mitigate damage, various pretreatment stages are introduced. Anti-scaling inhibitors include acids and other agents such as the organic polymers polyacrylamide and polymeric acid, phosphonates and polyphosphates. Inhibitors for fouling are biocides (as oxidants against bacteria and viruses), such as chlorine, ozone, sodium or calcium hypochlorite. At regular intervals, depending on the membrane contamination; fluctuating seawater conditions; or when prompted by monitoring processes, the membranes need to be cleaned, known as emergency or shock-flushing. Flushing is done with inhibitors in a fresh water solution and the system must go offline. This procedure is environmentally risky, since contaminated water is diverted into the ocean without treatment. Sensitive marine habitats can be irreversibly damaged.

Freeze-thaw

Freeze-thaw desalination uses freezing to remove fresh water from salt water. Salt water is sprayed during freezing conditions into a pad where an ice-pile builds up. When seasonal conditions warm, naturally desalinated melt water is recovered. This technique relies on extended periods of natural sub-freezing conditions.

A different freeze-thaw method, not weather dependent and invented by Alexander Zarchin, freezes seawater in a vacuum. Under vacuum conditions the ice, desalinated, is melted and diverted for collection and the salt is collected.

Electro dialysis membrane

Electro dialysis utilizes electric potential to move the salts through pairs of charged membranes, which trap salt in alternating channels.

Membrane distillation

Membrane distillation uses a temperature difference across a membrane to evaporate vapor from a brine solution and condense pure condensate on the colder side.

Wave-powered desalination

CETO is a wave power technology that desalinates seawater using submerged buoys Wave-powered desalination plants began operating on Garden Island in Western Australia in 2013 and in Perth in 2015

Reverse osmosis

"Reverse osmosis is least efficient when you're desalinating highly saline water, such as seawater. And it gets more and more efficient as feedwater salinity drops." This is an important consideration because not all desal facilities are processing seawater.

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? (15 Marks)

The layout of water distribution system tells us the network of pipes provided in the area and helps to determine the repair locations if any damages occurs. Here we will discuss about the different layout methods used in distribution system.

Methods of Setting Water Distribution System Layouts

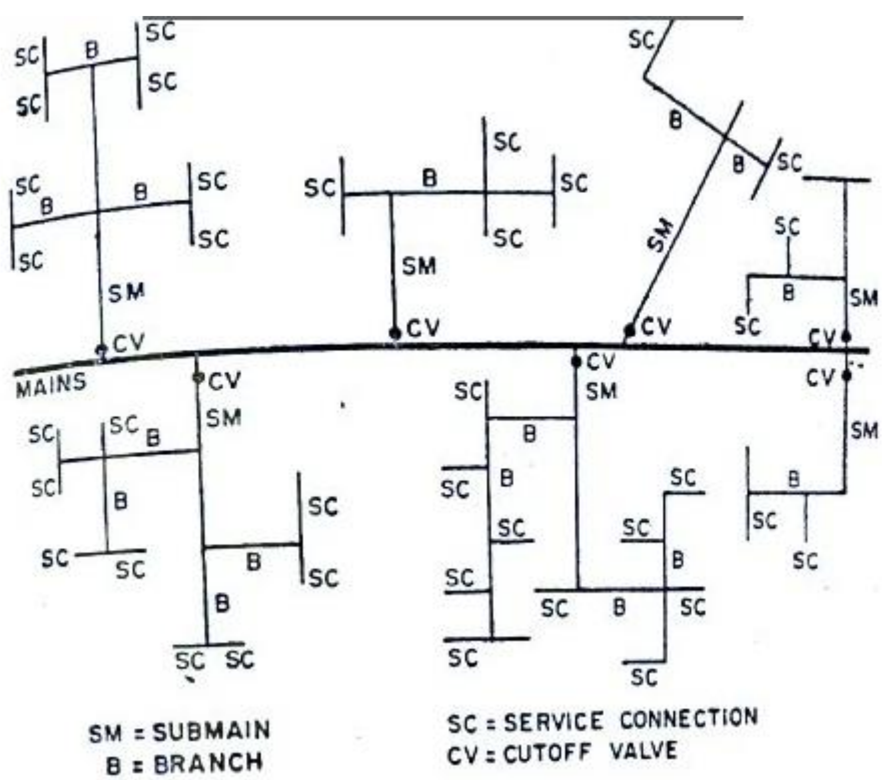
- **Dead end system**
- **Grid iron system**
- **Ring system**
- **Radial system**

Dead End Water Distribution System

Dead end system, the name itself defining that it contains dead ends in the pipe system. So, the water does not flow continuously in the dead end system. In this system the whole pipe network is divided into several sub networks. Those are namely main line, sub mains, branch lines and service connections.

Firstly, one main line is laid through the center of the city or area. Sub mains are laid on both sides of the main line and then sub mains divided into branch lines from which service connections are given. At every starting point of sub main line, a cut off valve is provided to regulate the flow during repair works etc.

On the whole, this network diagram will look like a tree shape, so it is also called as tree system. This type of system is used mostly for the olden cities which are built in irregular manner without any planning. Now a day, this system is not preferable.



Advantages of Dead End System

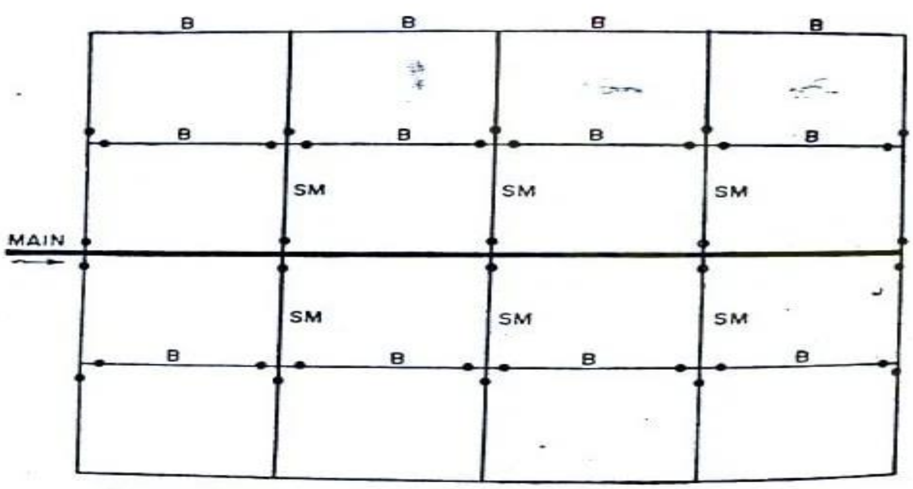
- Pipes in this network can be laid easily.
- The pressure and discharge in each pipe can be determined very easily and accurately which makes design calculations very simple.
- The diameters of pipes of main, sub mains and branches can be designed based on the required demand of population. So, cost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

Disadvantages

- 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.

Grid Iron Water 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.



SM=SUB - MAIN. B=BRANGH; • CUTOFF VALVE

Advantages of Grid Iron System

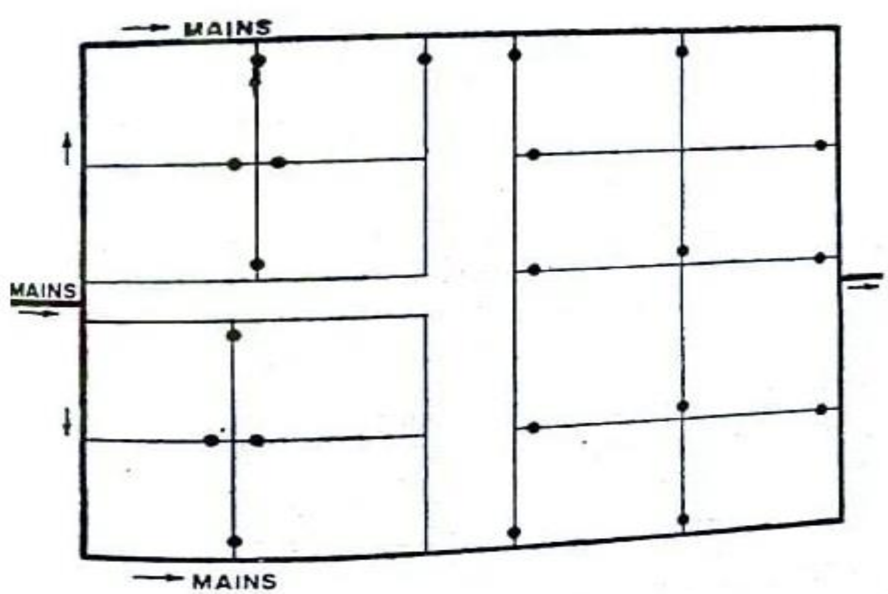
- Water will flow continuously without any dead ends or sediment deposits.
- Head loss is minimum in this case because of interconnection of pipes.
- The discharge will meet the required discharge for firefighting.
- Repair works can be easily done just by closing cutoff valve in that line which do not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

Disadvantages

- 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.
- Cutoff valves required should be more in this system.

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.



Advantages of Ring System

- No stagnation of water
- Repair works can be done without affecting larger network.
- Large quantity of water is available for firefighting.

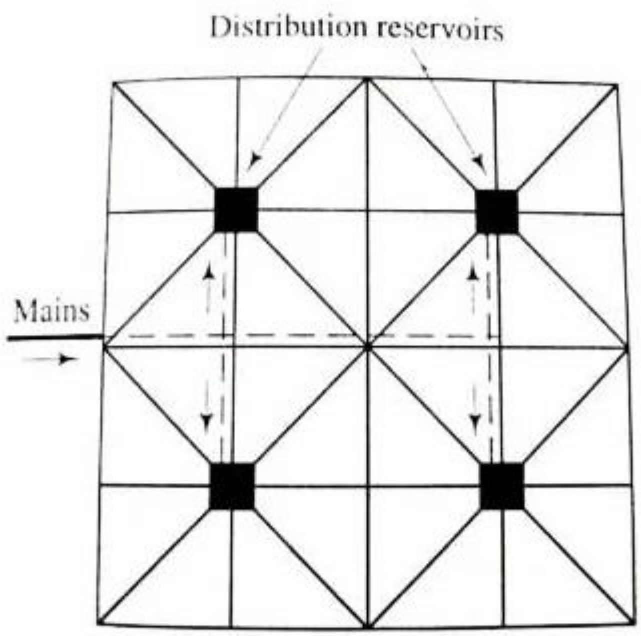
Disadvantages

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

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.



Advantages of Radial System

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

Disadvantages

Cost of the project is more because of number of individual distribution reservoirs.

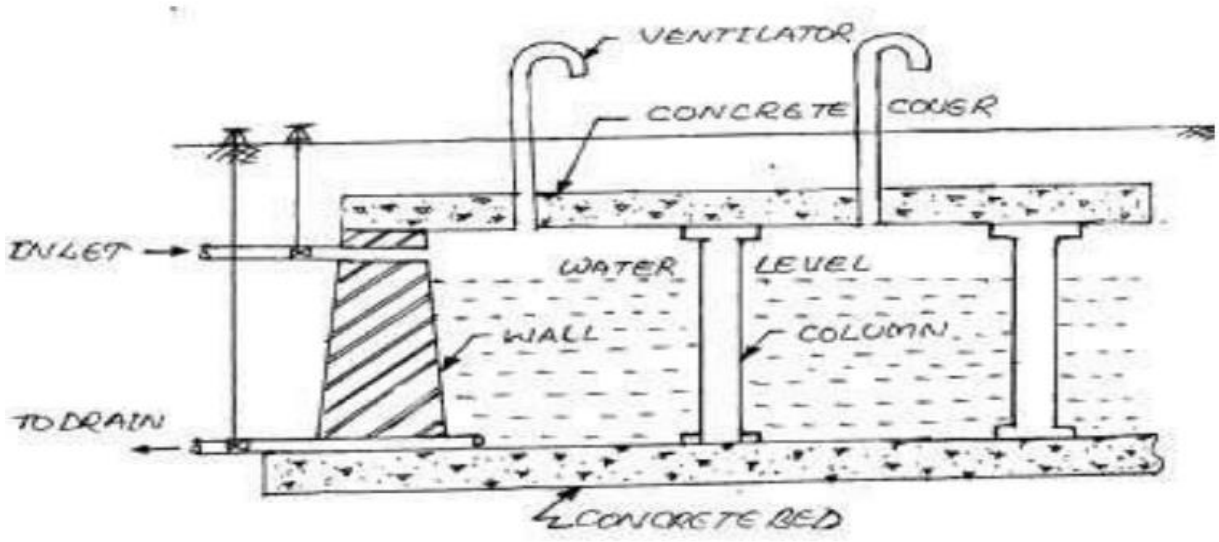
Radial Water Distribution System: as an explanation the layout of radial system recommend to the old cities its very useful for hilly area to support the water supply system.

Q3. What are different types of reservoirs used in water supply systems? Briefly describe its importance and how its storage capacity be calculated? (10 Marks)

1. Surface reservoirs

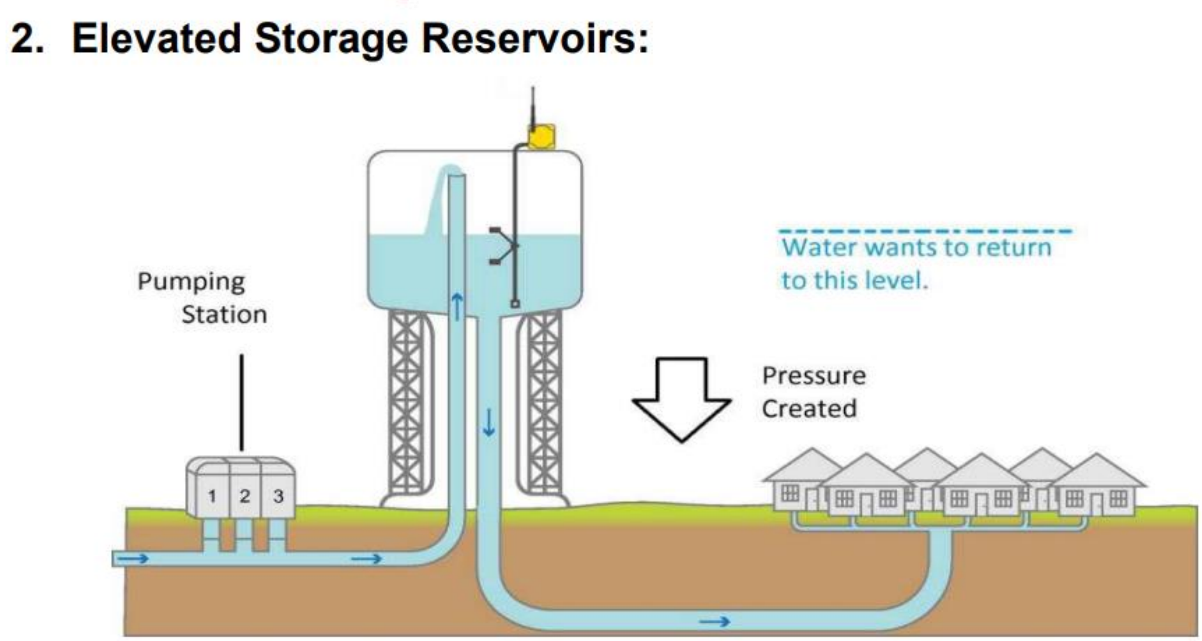
2. Elevated reservoirs

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 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.



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.



The total storage capacity of a distribution reservoir is the summation of **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). Storage Capacity Reservoirs. **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. Storage Capacity Reservoirs. **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: The total reservoir storage can finally be worked out by adding all the three storages.

$$Q_F = 65\sqrt{P}(1 - 0.01\sqrt{P})$$

Q_F = fire demand l/s
P = population in thousands

$$Q_F = 53\sqrt{P}$$

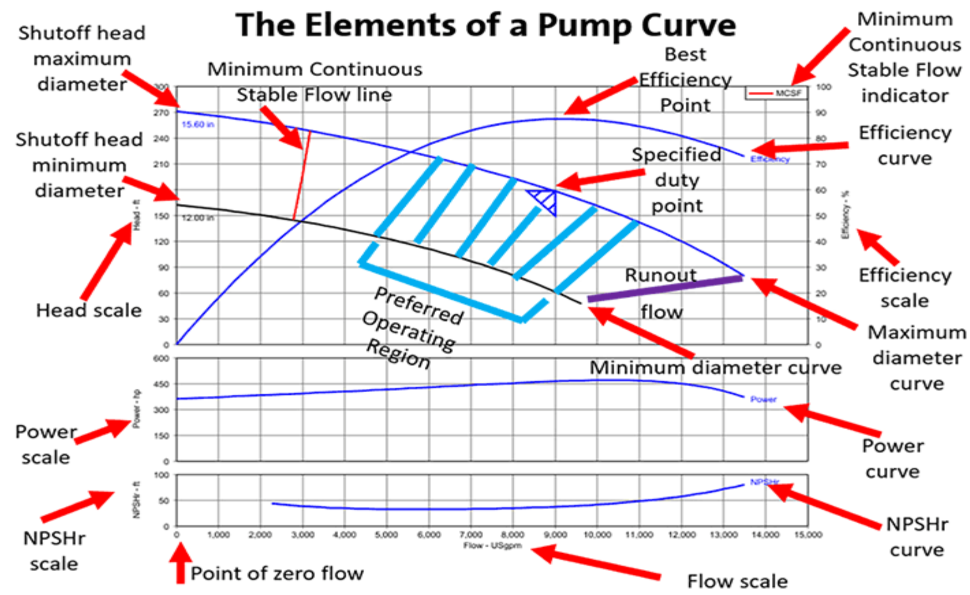
Q_F = fire demand l/s
P = population in thousands

$$Q_F = 320 * C\sqrt{A}$$

Q_F = fire demand flow m^3/d
A = areas of all stories of the building under consideration (m^2)
C = constant depending on the type of construction;

Q4. Why pumps are used in water supply schemes and how to calculate pump curve to meet water demand? (10 Marks)

A **pump curve** denotes flow on the x-axis (horizontal) and head pressure on the y-axis (vertical). The **curve** begins at the point of zero flow, or shutoff head, and gradually descends until it reaches the **pump** runout point or maximum flow rate.



Locate 9,000 gpm on the x-axis, and follow it up until it intersects with 180 feet of head on the y-axis. The intersection point would fall toward the middle of the curve and likely be within the POR, making the pump a good choice for this example application.

It would be important to confirm that it does in fact fall within the POR by checking the manufacturer’s guidelines.

Other Pump Curve Elements

n addition to plotting the pump and system curves, a pump curve graph provides other elements important for choosing the correct product for your application.

Efficiency curve: The pump efficiency curve represents a pump’s efficiency across its entire operating range. Efficiency is expressed in percentages on the right of the curve graph. The BEP is represented by the efficiency curve’s peak, with efficiency declining as the curve arcs away, either right or left, from the BEP. Knowing the efficiency percentage will also help calculate horsepower required for an application.

ISO efficiency lines: International Organization for Standardization (ISO) lines are concentrically elliptical curves indicating equal efficiency on a pump curve graph. They are used as another means of representing how efficiency levels change along a pump curve as it moves away from the BEP or if the impeller diameter is reduced.

Power curve: The power curve represents the load the pump imposes on the driver at a given point on the pump curve and helps with proper motor sizing. It is represented as a separate curve graph and gradually rises toward its peak load, which is typically close to the BEP with most rot dynamic pump types. Afterward, it declines as it approaches the runout point.

Net positive suction head curve: The net positive suction head required (NPSHr) indicates how much force is needed to push liquid into the eye of the pump impeller. It is displayed in feet beneath the main pump curve graph. Knowing the correct amount of NPSHr will prevent the pump from cavitating, vibrating and failing prematurely.

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