Question 1

Define desalination

Desalination in context of water supply is the method adopted for removing salts from the seawater or saline water.

Briefly describe various desalination methods?

Basically there are two major techniques used for desalination of water that is Thermal technology and Membrane technology.

Thermal technology

Hydrological cycle concept is used in this type of method where water is heated to a boiling point resulting in water evaporation and the solid particles such as salt is left behind. The evaporated water is condensed to get fresh water excluding the solid particles and salt.

The major factor involved in this technique is considering the temperature, pressure, energy given to the water to make them vaporize and also avoiding the scale formation and controlling it.

Multi-stage flash distillation: In this method water is passed through different chambers operating at different pressures relatively from high pressure to lower pressure.

In this method water is feed in to the first chamber after heating it. Then it passes through the other flashing (evaporating) chambers where it is condensed and fresh water is obtained. The water obtained is then passing through more treatment in which minerals are added and is declared safe for drinking purpose.

Multi-Effect Distillation In this method water is passed through different vessels and then the same heating and condensation technique is applied for heating and cooling of the water.

Water boils at lower temperatures as pressure decreases, so the water vapor of the first vessel or effect serves as the heating medium for the second, and so on. The more vessels or effects there are, the higher the performance ratio.

Vapor pressure distillation In this method the heat given for evaporation of water comes from pressure vessels (vapor compressor) instead of direct heating and the remaining process is same like the other thermal distillation processes.

Membrane technology

Electro dialyis/Electro dialysis Reversal (ED/EDR), and Reverse Osmosis (RO) are the two major categories of membrane technology.

Electro Dialyis: In this method water is passed through a direct current of high voltage where the ions(mostly the salts) are attracted by the opposite charges through membrane

Reverse Osmosis: This method works with a simple concept that water is passed through a membrane with very small tiny holes smaller than the dissolved solids in the water through pressure and the water obtained on the other side of the membrane is treated with minerals and is made suitable for drinking purpose. This method doesn't only remove salts and other suspended and dissolved solids but also filters bacteria and other microorganisms.

Which method is more effective, please elaborate briefly?

Keeping in view the energy requirement, removal efficiency and performance ration, corrosion scaling and fouling, quality of feed water and economics of desalination it is very hard to decide which method is more effective so mostly it is decided on the basis of feasibility or availability of the method that is suitable for your project. Thermal techniques are exposed to corrosion and scaling while the distillation process consumes huge number of energy. In case of distillation water is not pre-treated comparing to RO and EDR as you have to do it in the later one because of keeping the membrane clean.

The unit capital cost in desalination of brakish water is lower than desalination of seawater and the cost is lower when RO and EDR methods are used. So in the developing countries the main concern is the energy and brakish water so it is good to use RO and EDR in such countries.

Question 2

Briefly describe merits and demerits of 4 types of water distribution layouts?

Dead End System: This system is composed of supply main and sub-mains and its tributaries are connected to the end users.

Advantages

- The discharge and pressure at any point in the distribution system can be easily calculated.
- The design calculation is simple and easy.
- Lesser number of cut-off valves is required in this system.
- Laying of pipes is easy and simple.
- It is cheap and can be extended or expanded easily.

Disadvantages

- During repairs, a large portion of the distribution area is affected.
- There is numerous dead end in this system, which prevent the free circulation of water
- The water may be polluted at the dead end due to its stagnation.
- It gives limited supply during the fighting.

Radial System: The system consist of laying pipeline radially end of the periphery of the area of the zone. In end zone elevated service reservoir is placed at it center from where water is admitted to this radially laid pipe known as branches.

Advantages

- This system of layout ensures high pressure in distribution and it gives quick and efficient water distribution.
- The calculations for design of pipe sizes are also simple.

Disadvantages

- As every zone required a separate service reservoir number of reservoir required more and hence the systems become costly.

Grid Iron System: A main pipe is laid along main road and submain branches are laid along inner road and interconnected so that water remains in circular and there are no dead end.

Advantages

- There are no dead ends so water is not stagnated.
- Size of pipe is reduced.

Disadvantages

- More number of valves is required.
- Costly
- Longer length of pipe required.

Ring or Circular System: In this system the area is divided into blocks. Water mains are laid around the blocks from all side. The branches submain are taken along inner road and interconnected.

Advantages

- Water is available for fire demand.
- Designation of pipe is simple and easy.

Disadvantages

- The system is costly to construct.
- It is required more length of pipe and more number of slice valves.

Which layout will you recommend for newly proposed township in hilly area?

Being a water designer I would opt for Dead End System in order to facilitate the end users with portable water without any hindrance. The reason being its design is easy at the hilly areas in comparison with other distribution system. Labor skill required for installation of the Dead End System is minimal. Moreover, the utility of the dead end system is more as long as the system is maintaining a minimum pressure of 1 bar. If the threshold pressure point is not achieved the Grid Iron System is preferred. However Grid Iron System is integrated system and is preferred in planned housed not for scattered population.

Question 3

What are different types of reservoirs used in water supply systems?

Surface Reservoir: These are also called ground reservoir. They are generally in plane area with mostly circular or rectangular shape storage tanks. For storing the excess water underground reservoir is preferred with bigger size. This can be made from stones, bricks PCC or RCC while the floor is made out of RCC slab or stone masonry while for water proofing and water fighting the bitumen compound is added at the joints. . The side walls are design in such away that it can accommodate the water pressure inside the tank. While designing water table is also considered.

Elevated Storage Reservoirs (ESRs): They 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 as well. While in hilly areas the storage tanks is a place on the hilly area where the supply main is distributed to the end population by gravity. They are constructed where the water is first pump into the overhead tanks and then by gravity it is transferred to the population.

Briefly describe its importance and how its storage capacity be calculated?

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

Balancing Storage: The quantity of water required being stored in the reservoir for equalizing or balancing fluctuating demand against constant supply is known as the balancing storage (or equalizing or operating storage).

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.

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:

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

$$Q_F= 53\ sqrt(P)$$

$$Q_F=320*Csqrt(A)$$

Where Q_F is the fired demand, P is population in thousand, A is areas of all the stories of the building and C is constant depending on the type of construction.

The total reservoir storage is the summation of three storages.

Question 4:

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

Pumps are actually used in water supply scheme when there is a difference in elevation between sources to its customers. i.e. source it a lower elevation than the user so the water must be raised to a high level.

Beside this it is also used for a constant steady flow of water at a constant pressure for any given set of condition.

Example: Centrifugal pumps are ideal for delivering water to consumers. They are suitable for use in the distribution system because as they do not produce an uneven flow and unbalance wave while water moving in a close conduit.

Characteristics of pumping system:

Pumping system are generally designed for:

1. Head: sum of kinetic and potential energy of liquid expressed in unit of length i.e. meter per feet.
2. Flow / Discharge: Quantity of water required per unit time. It is expressed in gallons / day, litters per minute etc.
3. Pressure: The flowing liquid / water should have sufficient pressure at the destination and it is normally expressed in pound / square inch (PSI).

Calculation of pump curve:

A pump performance curve is simply a graph or chart that represents the performance capabilities of a given water pump. A pump manufacturer conducts a variety of tests and the findings are then reflected on a graph, which we refer to as the pump curve. A pump curve will typically show not just the maximum capabilities of the pump, but just as important, many pump curves will give information helpful in determining the best efficiency point (BEP) for flow rates as well as reflecting the preferred operating range (POR) of the water pump.

Curves are typically including performance of flow, horsepower, metric based on pressure and Net positive Suction Head Required (NPSHR).

Pumps curves are useful as they show pump performance metric based on head / pressure produced by the pump and water flow through the pump.

For a calculation of pump curve to meet the water demand, we have to calculate the following

Total Dynamic Head:

Total dynamic pump head, most commonly referred to as total head, concisely stated is the height that a water pump is capable of raising a liquid. It is the total vertical distance that the pump is capable of 'pumping'. It answers the question, "How high can it pump?" The greater the pressure, the higher the head. The lower the pressure, the lower the head.

Flow Rate

Flow rate, or rate of flow, is the total maximum amount of liquid flow that a pump can produce during a specified period of time. It is almost always measured per minute and most pump curves will show either gallons per minute (GPM) or liters per minute (LPM), or commonly both. Flow rate answers the question, "How many gallons can I expect?" The greater the pressure, the higher the flow rate. The lower the pressure, the lower the flow rate.

NPSHr (Net Positive Suction Head Required)

Net positive suction head required is the minimum amount of pressure or force of energy that is required at the suction port (inlet) to overcome the losses from friction that are caused between the suction head/nozzle (inlet) and the eye of the impeller, without causing vaporization (cavitation) of the liquid being pumped.

Best Efficiency Point

Every pump has a best efficiency point (BEP) and many pump curves will clearly show the BEP. BEP is the rate of flow and the total head at which a pump efficiency is at a maximum at a given motor speed and impeller diameter.

BEP is a combination of the head/flow rate as it corresponds to the highest efficiency. BEP directly corresponds to the input horsepower of the motor required to drive the pump and the horsepower created by the flow of water created by the pump.

For a pump to be 100% efficient the input horsepower needed would be equal to the water horsepower being created. No pump is capable of 100% efficiency and as a result every pump will require more horsepower input from the motor than it is capable of generating in water horsepower.

Think of the BEP as what a baseball player would refer to as the "sweet spot" of the bat! Studies have shown that by operating within the BEP, the pump/motor life is extended. This not only minimizes the cost of repairs, maintenance, and replacement, but also the costs incurred during a down time of production for a pump that is no longer operational.

Preferred Operating Range (POR)

Referred to as the preferred operating range or preferred operating region. A pump will run best the closer it is to the BEP. For this reason, The Hydraulic Institute has determined that the preferred operation range as it pertains to water flow is between 70%-120%. Most manufactures will recommend a POR that is between 80% and 110% as operation in the POR has direct implications on the life of the pump as well as power consumption.

Pump manufactures give a variety of information on their pump curves. Some are more detailed than others. However, most manufacturers will offer more detailed specs, requirements, additional curves, etc. in their product manuals. But the most basic information that the average consumer needs typically boils down to 2 items: Total Pump Head & Gallons per Minute

Reading a Pump Curve

Let's look at an example situation to help you pick out the right pump for your application using just pump head and gallons per minute to help us come to a decision on the right pump.