# Iqra National University
## Department of Civil Engineering

## FINAL-TERM ASSIGNMENT

**Discipline:** MS Civil Engineering

**Course Title:** Water Demand Supply and Distribution

**Course Code:** CE- 562

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Q1. Define desalination and briefly describe various desalination methods? Which method is more effective, please elaborate briefly? (15 Marks)

**Ans:**

Desalination is any process that removes excess salts and other minerals from water. In most desalination processes, feed water is treated and two streams of water are produced:

- Treated fresh water that has low concentrations of salts and minerals
- Concentrate or brine, which has salt and mineral concentrations higher than that of the feed water

The feed water for desalination processes can be seawater or brackish water. Brackish water contains more salt than does fresh water and less than salt water. It is commonly found in estuaries, which are the lower courses of rivers where they meet the sea, and aquifers, which are stores of water underground.

**Desalination technologies**

Two distillation technologies are used primarily around the world for desalination: thermal distillation and membrane distillation.

Thermal distillation: technologies are widely used in the Middle East, primarily because the region's petroleum reserves keep energy costs low. The three major, large-scale thermal processes are multistage flash distillation (MSF), multi-effect distillation (MED), and vapor compression distillation (VCD). Another thermal method, solar distillation, is typically used for very small production rates.

Membrane distillation: technologies are primarily used in the United States. These systems treat the feed water by using a pressure gradient to forcefeed the water through membranes. The three major membrane processes are electrodialysis (ED), electrodialysis reversal (EDR), and reverse osmosis (RO).

**Thermal technologies**

Multi-stage flash distillation: Multi-stage flash distillation is a process that sends the saline feed water through multiple chambers. In these chambers, the water is heated and compressed to a high temperature and high pressure. As the water progressively passes through the chambers, the pressure is reduced, causing the water to rapidly boil. The vapor, which is fresh water, is produced in each chamber from boiling and then is condensed and collected.

Multi-effect distillation: Multi-effect distillation employs the same principals as the multi-stage flash distillation process except that instead of using multiple chambers of a single vessel, MED uses successive vessels. The water vapor that is formed when the water boils is condensed and collected. The multiple vessels make the MED process more efficient.

Vapor compression distillation: Vapor compression distillation can function independently or be used in combination with another thermal distillation process. VCD uses heat from the compression of vapor to evaporate the feed water. VCD units are commonly used to produce fresh water for small- to medium-scale purposes such as resorts, industries, and petroleum drilling sites.

**Solar desalination** is generally used for small scale operations. Although the designs of solar distillation units vary greatly, the basic principals are the same. The sun provides the energy to evaporate the saline water. The water vapor formed from the evaporation process then condenses on the clear glass or plastic covering and is collected as fresh water in the condensate trough. The covering is used to both transmit radiant energy and allow water vapor to condense on its interior surface. The salt and un-evaporated water left behind in the still basin forms the brine solution that must be discarded appropriately

**Membrane technologies**

A membrane desalination process uses a physical barrier—the membrane—and a driving force. The driving force can be an electrical potential, which is used in electrodialysis or electrodialysis reversal, or a pressure gradient, which is used in reverse osmosis. Membrane technologies often require that the water undergo chemical and physical pretreatment to limit blockage by debris and scale formation on the membrane surfaces.

Electrodialysis and electrodialysis reversal: The membranes used in electrodialysis and electrodialysis reversal are built to allow passage of either positively or negatively charged ions, but not both. Ions are atoms or molecules that have a net positive or net negative charge. Four common ionic molecules in saline water are sodium, chloride, calcium, and carbonate. Electrodialysis and electrodialysis reversal use the driving force of an electrical potential to attract and move different cations (positively charged ions) or anions (negatively charged ions) through a permeable membrane, producing fresh water on the other side. The cations are attracted to the negative electrode, and the anions are attracted to the positive electrode. When the membranes are placed so that some allow only cations to pass and others allow only anions to pass, the process can effectively remove the constituents from the feed water that make it a saline solution. The electrodialysis reversal process functions as does the electrodialysis process; the only difference is that in the reverse process, the polarity, or charge, of the electrodes is switched periodically. This reversal in flow of ions helps remove scaling and other debris from the membranes, which extends the system's operating life

**Reverse osmosis**: Reverse osmosis uses a pressure gradient as the driving force to move high-pressure saline feed water through a membrane that prevents the salt ions from passing. There are several membrane treatment processes, including reverse osmosis, nanofiltration, ultrafiltration, and microfiltration. The pore sizes of the membranes differ according to the type of process.
Because the RO membrane has such small pores, the feed water must be pretreated adequately before being passed through it. The water can be pretreated chemically, to prevent biological growth and scaling, and physically, to remove any suspended solids. The high-pressure feed water flows through the individual membrane elements. The spiral RO membrane element is constructed in a concentric spiral pattern that allows alternating layers of feed water and brine spacing, RO membrane, and a porous product water carrier. The porous product water carrier allows the fresh water to flow into the center of the membrane element to be collected in the product water tube. To enable each pressure vessel to treat more water, the individual membrane elements are connected in series. After the water passes through the membrane elements within the pressure vessels, it goes through post treatment. Post treatment prepares the water for distribution to the public.

Concentrate management options Both thermal and membrane desalination processes produce a stream of brine water that has a high concentration of salt and other minerals or chemicals that were either removed during the desalination process or added to help retreat the feed water. For all of the processes, the brine must be disposed of in an economical and environmentally friendly way. Options for discharging the brine include discharge into the ocean, injection through a well into a saline aquifer, and evaporation. Each option has advantages and disadvantages. In all cases, the brine water should have a minimal impact on the sur-rounding water bodies or aquifers. Specific considerations for the water quality include saline concentration, water temperature, dissolved oxygen concentrations, and any constituents added as pretreatment.

The most effective method in my point of view will based on the above analysis
As from the above mentioned method of desalination
As high-quality freshwater resources decrease, more communities will consider desalination of brackish and salt water to produce drinking water. All desalination technologies have advantages and disadvantages based on site-specific limitations and requirements. Small-scale desalination of brackish water using **solar stills** is a promising method in remote locations where good-quality water for drinking and cooking is unavailable.

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)

**Ans:**

The purpose of distribution system is to deliver water to consumer with appropriate quality, quantity & pressure. Distribution system is used to describe collectively the facilities used to supply water from its source to the point of usage.

LAYOUTS DISTRIBUTION NETWORK

The distribution pipes are generally laid below the road pavements, and as such their layouts generally follow the layouts of roads. There are general, four different types of pipe networks; any one of which either single or in combinations, can be used for a particular place.

Dead End System
Radial System
Grid Iron System
Ring System

**DEAD END SYSTEM:**

It is suitable for old towns and cities having no different pattern of roads.

**Advantage:**

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

**Disadvantage:**

The disadvantages of the dead end system are:

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

**RADIAL SYSTEM:** The area is divided into different zones.

The water is pumped into the distribution reservoir kept in the middle of each zone. The supply pipes are laid, rapidly ending towards the periphery.

**Advantages**:

1. Simplest as fed at only one end.
2. The initial cost is low.
3. It is useful when the generating is at low voltage.

4. Preferred when the station is located at the center of the load.

**Disadvantages:**

1. The end of distributor near to the substation gets heavily loaded.
2. When load on the distributor changes, the clients at the distant end of the distributor face serious voltage fluctuations.
3. 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.

**GRID IRON SYSTEM:** It is suitable for cities with rectangular layouts, where the water mains and branches are laid in rectangles.

**Advantages:**

1. In case of repairs a very small portion of the distribution system area will be affected
2. In case of fire , water is available from all directions
3. As there are no dead ends , water circulates freely
4. Loss of head is minimum at all points in the system

5. Water is kept in good circulation due to absence of dead ends In the case of break down in some section.
6. Water is available from some other direction.

**Disadvantage:**

1. Maintenance cost is very high
2. As every zone requires a separate service reservoir , number of reservoirs required are more and hence the system becomes costly

3. Exact calculation of sizes of pipes is not possible due to provisions of valves on all branches.

**RING SYSTEM:** The supply main is laid all along the peripheral roads and sub mains branch out from the mains. This system also follows the grid iron system with the flow pattern similar in character to that of dead end system. So determination of the size of pipes is easy.

**Advantages:**

1. In ring power is supplied from both ends as compared to radial.
2. In case of a fault in the radial circuit the entire system goes off unlike in ring where by incase one end gets a fault the other end still keeps on supplying power.
3. Compared to the radial system, the voltage drop is less along the distribution line.
4. More subscribers can be installed to the system than the radial system.

5. Less voltage fluctuations can be seen at client's terminals. Voltage fluctuations in high loaded areas can be reduced using a tie line.
6. Water can be supplied to any point from at least two directions

**Disadvantages:**

1. Ring is very expensive n requires more materials than radial.
2. Radial circuit is more economical.
3. High maintenance cost.
4. It is not usable when the client is located at the center of the load

**Type of layout used in newly proposed township in hilly area:**

In hilly areas, mostly the areas are unplanned. So the dead end system are to be used in hilly area.

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)

**Ans:**

Reservoirs are those water bodies formed or modified by human activity for specific purposes, in order to provide a reliable and controllable resource.

**TYPES OF RESERVOIRS:**

Reservoirs may be classified according to their function, their relative position with respect to the earth's surface, manner of operation, and the type of material of construction.

**Elevated Reservoirs:**

Reservoirs are constructed in elevated or hilly areas. In case of flat areas, a supporting frame or tower is installed to support the storage tank. This is known as an elevated reservoir. Standpipes are reservoirs with height greater than their diameter.

**Ground Level Reservoirs:**

Ground level reservoirs may be made of reinforced concrete pipe, fiber glass, concrete hollow blocks, steel or ferro-cement. These may be single ground level tanks or multiple type tanks.

**Operation of Reservoirs:**

Reservoirs may be operated on the following basis:

Floating-on-the-Line Reservoir: Water is pumped both into the reservoir and to the consumers; water goes up the tank when the water demand is low or if there is a residual water supply. During peak demand, water goes to the customers directly from the source and from the tank. This system requires fairly continuous pumping at low pumping capacity.

**Fill-And-Draw Reservoir:**

Water flows or is pumped directly into the reservoir and from the reservoir, water supply is distributed to the consumers through gravity flow. The tank is usually installed near the water source to minimize head losses due to friction losses. In the fill-and-draw system, however, water is conveyed to the storage tank at high pumping capacity at shorter time duration, and always against the maximum head.

**Importance of Reservoirs:**

In water supply distribution systems, whether water is obtained by gravity or by pumping, reservoirs are usually necessary for the following reasons:

- To balance the supply and demand in the system. In small distribution systems, variations in demand may be three or more times the average hourly consumption.
- To maintain adequate and fairly uniform pressure throughout the distribution system.

- To avoid the total interruption of water service when repairing pipes between the source of supply and the reservoir.
- To allow pumps to be operated uniformly throughout the day. Such pumps may be much smaller than would otherwise be required.

**<u>Storage Capacity of reservoir:</u>** As a rule of thumb, the storage Reservoir volume should be at least equal to one-fourth (25%) of average day demand of the community.

The formula is:

$$Cr = (1/4)\ (ADD)$$

**Where:**

**Cr**=Reservoir capacity in liters

**ADD**= Average Day Demand in liters per day

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

**Ans:**

In any water supply scheme system, the role of the pump is to provide sufficient pressure to overcome the operating pressure of the system to move fluid at a required flow rate. The operating pressure of the system is a function of the flow through the system and the arrangement of the system in terms of the pipe length, fittings, pipe size, the change in liquid elevation, pressure on the liquid surface, etc. To achieve a required flow through a pumping system, we need to calculate what the operating pressure of the system will be to select a suitable pump. Water is pumped from the reservoir into a receiving tank. This kind of arrangement is used to lift water from a reservoir, or river, into a water treatment works for treatment before the water goes into the supply network. The water level in the reservoir varies but the discharge level in the receiving tanks remains constant as the water is discharged from a point above the water level. The pump is required to pass forward a flow of 2500 m 3 /hr to the receiving tank.

**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. Once you know how to read a pump curve you will be able to determine **what to expect from your water pump:** how many feet is it capable of pumping, how many gallons per minute, and what will be the ideal operating performance for efficiency, as well as other important information.

The Most Common Information a Pump Curve Provides

**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 (cavitations) 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 pump efficiency is at a maximum at a given motor speed and impeller diameter.

**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.

-----------------------------------------------THE END-------------------------------------------------------------