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

Desalination is a water treatment process that removes salts and other dissolved minerals and contaminants e.g. dissolved metals, radionuclide, bacterial and organic matter from high salinity to produce fresh water. Desalination is used to improve the quality of hard waters (high in concentration of calcium and magnesium),

Type of saline water	Salinity value (ppm)
Fresh water	<1000
Slightly saline Water	1000-3000
Moderately saline Water	3000-10,000
Highly saline water	10,000-35,000

There are several method of desalination few methods are discussed below

1. Natural process

Evaporation of water over the oceans in the water cycle is a natural desalination process.

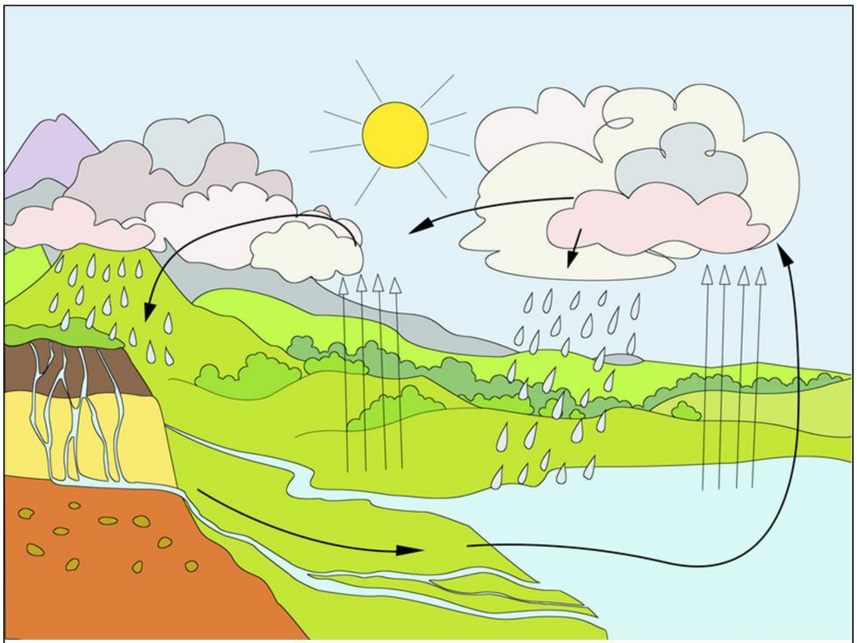
The process include

1.Evaporation

2. Condensation

3. Precipitation

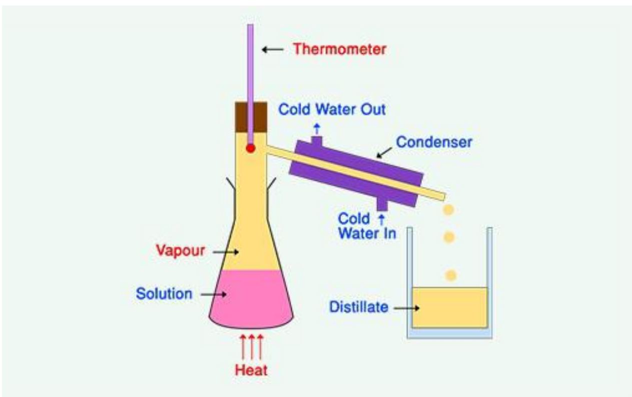
4. Collection



Desalination is not modern science, it is a natural process:
Sun or solar desalination is used by nature to produce rain which is the main source of fresh water on earth. All available man-made distillation systems are duplication on a small scale of this natural process.

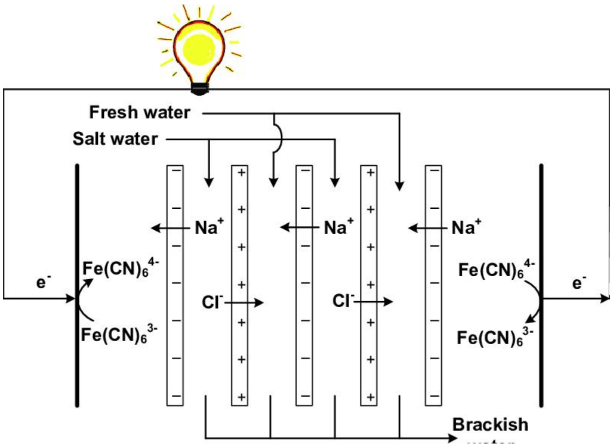
2. Distillation (Evaporation)

- Salt water is heated in one container to make the water evaporate, leaving the salt behind.
- The desalinated vapour is then condensed to form water in a separate container.
- Although long known, it has found limited applications in water supply because of the fuel costs involved in converting salt water to vapour is very high.



3. Electrodialysis

Electrodialysis is an electrochemical process in which ion transfer separates salt from water. It is effective only for substances that can be ionized: for example, salt (NaCl) becomes, in solution, a mixture of Na+ and Cl− ions. (Silica, on the other hand, does not ionize and hence is not removed by electrodialysis. It could, however, be removed by reverse osmosis.) When electrodes, connected to a suitable direct current supply, are immersed in a salt solution, current will flow, carried by the ions. The ions with a positive charge are attracted towards the negative cathode and are called cations. Negatively charged anions flow towards the positive anode.



4. 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,
- ice melting to obtain fresh water with subsequent removal of contaminants

5. Reverse Osmosis (RO)

- Reverse osmosis (RO) is a water purification technology / method that uses 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 potable water.
- It significantly decreases the salts and other potential impurities in the water, resulting in a high quality and great-tasting water.

Basic steps involve in Reverse osmosis process of desalination

I. 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.

II. 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

III. Step 3

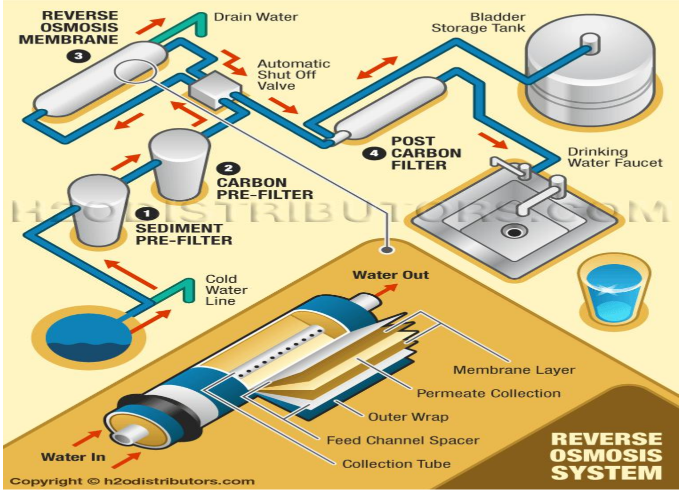
- The third step focuses on passing the water from a dense and compacted carbon filter. Most of the contaminants are removed here

IV. 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.

V. **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.



In my point of view the Reverse Osmosis (RO) Method is most effective the that of others

- Reverse osmosis (RO) water purifier is the best solution for treating hard water.
- RO water purifier removes toxin such as lead, mercury, Fluoride, Arsenic, Chlorine which case human body to be ill. Lead metal can cause brain damage and anemia.

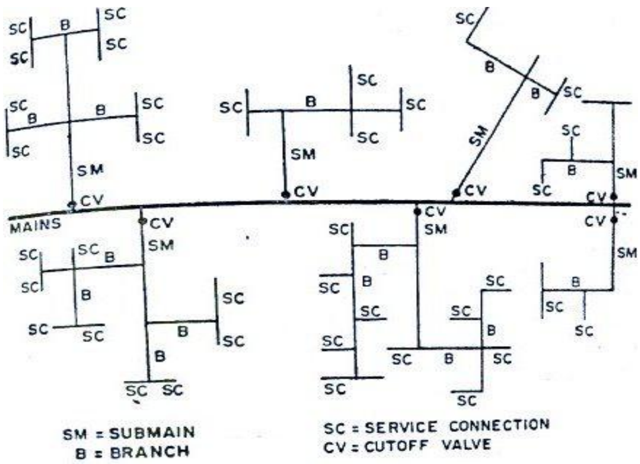
- RO water filter is great for removing commonly found Cryptosporidium in lake, river and public supply water.
- Water scarcity can be easily handled.
- Availability of Water in Areas of Drought.
- Alternative Source of Water
- Production of a High Yield of Water

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

The distribution of water means delivering treated water to the user from the source. The distribution should take place in such a way that the users or consumers should meet their demand of water with sufficient quantity and quality.
There are mainly four type of water distribution system which are discussed below

1. 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 days, this system is not preferable.



Advantages

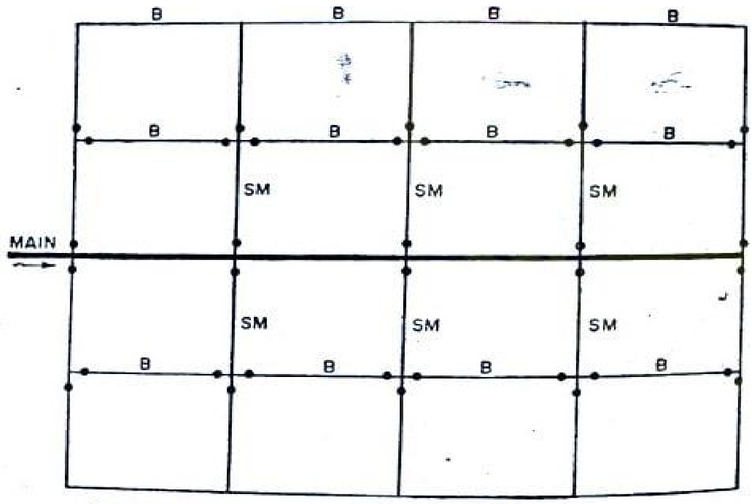
- Pipes in this network can be laid easily.
- The pressure and discharge in each pipe can be determined very easily and accurately which makes design calculations very simple.
- The diameters of pipes of main, sub mains and branches can be designed based on the required demand of population. So, cost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

2. 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.



Advantages

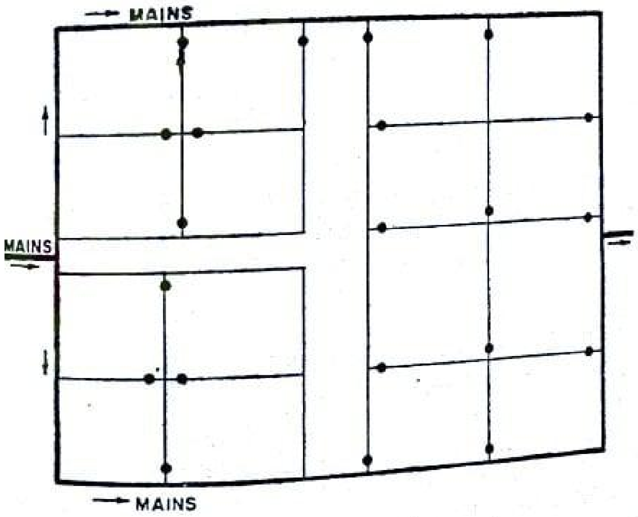
- Water will flow continuously without any dead ends or sediment deposits.
- Head loss is minimum in this case because of interconnection of pipes.
- The discharge will meet the required discharge for firefighting.
- Repair works can be easily done just by closing cutoff valve in that line which do not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

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.



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.

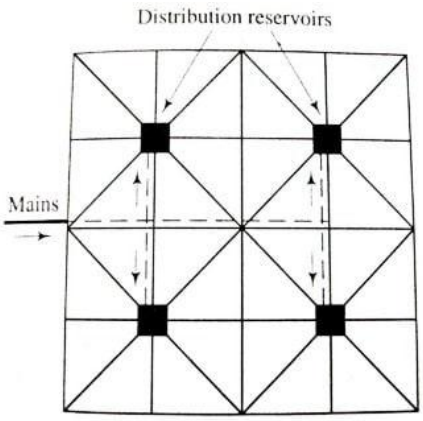
Disadvantages

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

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

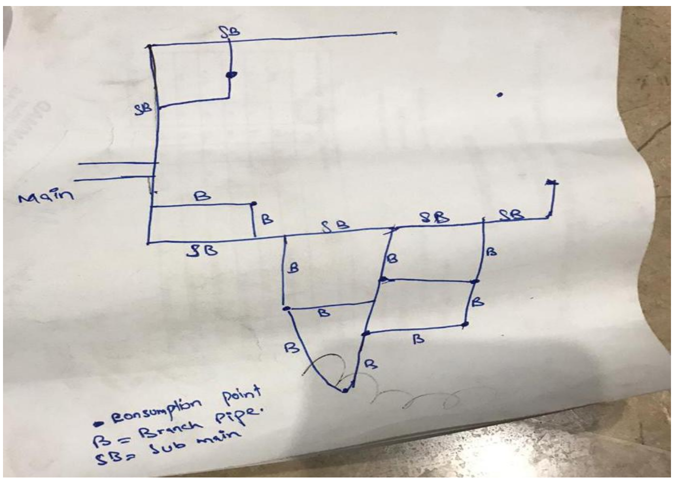
- The water distributed with high velocity and high pressure.
- Head loss is very small because of quick discharge.

Disadvantages

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

Conclusion

in my opinion the combination of dead end and radial system will be preferred in hilly areas as due to terrain difference the proper radial or grid cannot be made for which dead end system is suitable but for water demand during fire-fighting the water from different pipes will full fill the requirement it will reduce the chances of water stagnation as well as water head losses the layout can be



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

Storage facilities, or distribution reservoirs, provide clean drinking water storage to ensure the system has enough water to service in fluctuating demands (service reservoirs), or to equalize the operating pressure (balancing reservoirs). They can also be temporarily used to serve fire fighting demands during a power outage. There can be many types of distribution reservoirs. A surface reservoir is a larger storage facility built on the ground with the wall lined with concrete, shotcrete, asphalt, or membrane. When a surface reservoir at the ground level cannot provide a sufficient hydraulic head to the distribution system, an elevated water tower can also be used. A standpipe is slightly different from an elevated water tower in that the standpipe allows water storage from the ground level to the top of the tank. The bottom storage area is called supporting storage, and the upper part which would be at the similar height of an elevated water tower is called useful storage. Storage facilities are typically located at the center of the service locations. Being at the central location reduces the length of the water mains to the services locations. This reduces the friction loss when water is transported over a water main

Reservoir storage capacity calculation

The reservoir storage capacity can be calculated by the multiplying the area of reservoir to its height

For example

Let consider the the rectangular reservoir having length 3 meter and width of 1.5 meter while its height is 1.8m but it can store water upto 1.5m the storage capacity of reservoir can be calculated by

Area of reservoir = Length x Width

= 3m x 1.5m

= 4.5 m^2

Storage capacity of reservoir in cubic meter can be calculated as

Storage capacity = 4.5m^2 x 1.5m

= 6.75m^3

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

Intro.

Pumps are considered part of turbo machines, which convert mechanical energy into water energy, or it absorb power to raise pressure head to transfer water from low level to high level. These machines are classified as centrifugal, reciprocating, pneumatic, jet and rotor types based on the purpose and type of fluid used. The centrifugal pumps involving, radial, axial or mixed are the common types of pumps used for water transfer, due to presence of impeller and centrifugal action. Fluid enters the impeller in the center portion, called eye and discharges around the entire circumference in a casing. During rotating, the liquid receives energy from the vanes and resulting in an increase of pressure and absolute velocity. The larger part of the energy is kinetic and then it is transformed into pressure head. This is accomplished in the volute casing surrounding the impeller. The demand for greater capacity without increasing the diameter resulted in an increase in the dimensions parallel to the shaft. This requires an increase in the eye diameter to accommodate the larger flow and corresponding change in the vanes at entrance. A further increase in specific speed is obtained with the propeller or axial flow pump

Importance

The main function of water pumps is to transmit water from reservoir to the consumption point. In arid and semi arid regions, ground water considers the major source for drinking and other uses, due to the shortage of rainfall and lack of surface water. Pumps are the suitable tools of lifting water from, the ground basins and wells, but, centrifugal pumps are the proper types for doing this job, because of their high pressures and velocities. Therefore, it is necessary to study its characteristics, specially design, speed, discharge and efficiency

Pumping is a vital method for supply water from some resources, which the gravity system cannot be enough due the effect topography and side levels. This method may also locate at surface sources including rivers, canals, lakes, as well as groundwater basins and wells.

Pump curve calculation

:

$$P = \rho Q(U_2.r_2\text{-}U_1.r_1)\omega \quad (1)$$

Where:

ρ = Density kg/m3,

Q = Discharge m3/s,

U2 = Outlet velocity m s-1,

r2 = Radius outlet m,

U1 = Inlet velocity m s-1,

r1 = Radius inlet m,

ω = Angle velocity 1 s-1.

For pump analysis, it is convenient to use head product rather than the power input. But, the head H represents the energy per unit weight. Then

$$H = \frac{P}{\rho g Q} \quad (2)$$

by inserting Equation 1 into Equation 2 :

$$H = \omega \frac{(U_2 . r_2 - U_1 . r_1)}{g} \quad (3)$$

but, ω.r1 = V1 , ω.r2 = V2

where:

V1 = Tangential velocity of blade at inlet,

V2 = Tangential velocity of blade at outlet.

then,

$$H = \frac{(U_2 . V_2 - U_1 . V_1)}{g} \quad (4)$$

The general arrangement of a centrifugal pump shows that the water enters the casing in an axial direction, but it is turned through 90° before entering the impeller, then passes after that through the blades to enter the volute chamber. At inlet to the impeller, the water velocity has no component in the tangential direction (U1=0.0) and the velocity triangle is right angled. Hence:

$$H = \frac{U_2 . V_2}{g} \quad (5)$$

Based on that, the Euler head is greater than the actual head produced due to the losses. But the actual head comprises the suction head (Hs), the discharge head (Hd), the friction losses in the suction (Hfs), the friction losses in discharge (Hfd) and the discharge velocity head (Vd2/2g). This head is known as manometric head (Hm). In other words,

$$H_m = \frac{H_s + H_d + H_{fs} + H_{fd} + V_d^2}{2g} \quad (6)$$

from that, the ratio of the manometric head to the Euler head is called the manometric efficiency, ηm, or

$$\eta m = \frac{H_m}{H} = \frac{H_m . g}{U_2 . V_2} \quad (7)$$

If the velocity head is neglected and the impeller losses are considered the efficiency of the pump is affected. Then the total head must be developed to overcome the impeller and the system losses in the pipe lines and pipe lifting. But efficiency of pumping suction depends much on the piping system used to convey the fluid.
In other words, losses are overcomes by the pump characteristic, which is a function of discharge and is expressed mathematically as

$$H = AQ^2 + BQ + C \quad (8)$$

Also, the performance of the pump is interrelated which external pipe, which is given by

$$H = H_s + KQ^2 \quad (9)$$

where:
A, B and C are constants depend on discharge used to specify a pump curve,
Hs=static head or suction head and K=constant depends on discharge and the external pipes.

The analytical of the equation 8 and 9 gives the duty point at which the pump delivers the required discord coinciding with the peak efficiency and economical manner. Figure 1 represented the pump characteristics as well as the pipe lines system.

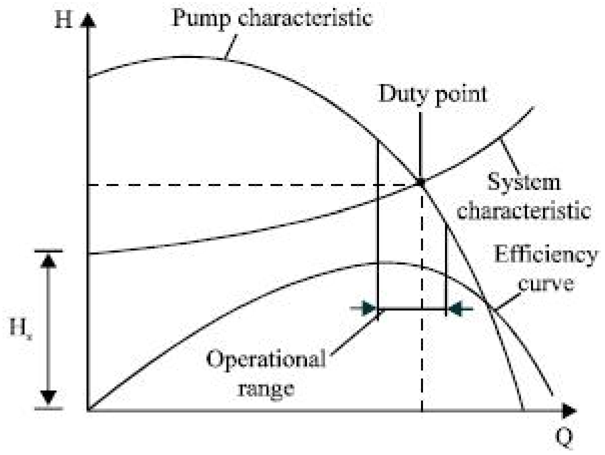


Fig. 1: Pump and pipeline characteristics

Besides that, the pump may be operated under various speeds in order to reply with the need and characteristics variation according to that. There fore, the corresponding discharge, head and power can be giving as following

$$Q_2 = Q_1 \frac{N_2}{N_1} \tag{10}$$

$$H_2 = H_1 \left(\frac{N_2}{N_1} \right)^2 \tag{11}$$

$$P_2 = P_1 \left(\frac{N_2}{N_1} \right)^2 \tag{12}$$

In addition to that, several pumps can be operated in series or in parallel in order to increase the head and discharge, respectively. These pumps can be located individually or in multistage. But to avoid cavitation for these pumps, the suction head omitted so that the pressure at the inlet is equal to the allowable vapor pressure, where the critical cavitation number is suggested as:

$$C_m = 0.103\left(\frac{Ns}{1000}\right)^{4/3} \tag{13}$$

Where: Ns specific speed of the pump.