Refrigeration and Air conditioning Engineering.

3rd year – refrigeration and Air conditioning Course

WATER PIPING SYSTEMS DESIGN Part1

Lecture -14-

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Chapter Four

WATER PIPING SYSTEMS DESIGN

4.1 WATER PIPING CLASSIFICATION

There are two primary classifications of water piping systems:

1. Once through type where water goes from a reservoir through piping to the equipment and is relieved to a different reservoir.(Example: City water system, water cooled condenser of air conditioner with regulating value discharging water to drain)
2. Re-circulation type where water flows from a reservoir through piping to the equipment and is returned to the original reservoir for re-circulation.

Systems are further classified as:

1- Open, when water is brought in close contact with air in the reservoir.(example: Water cooled condenser of air conditioner operated with cooling tower).
2- A closed system is one in which the flow of water is not exposed to the atmosphere at any point. This system usually contains an expansion tank that is open to the atmosphere but the water area exposed is insignificant (Example: Water chiller with coil heat exchanger for cooling and de-humidifying the air, Hot water boiler with coil heat exchanger for heating the air.)

All piping systems have at least one point where atmospheric pressure is exerted on the surface of the water. This is the reference point for determination of hydrostatic lift imposed on the pump. The hydrostatic lift is the vertical distance in feet between the water level on the suction side of the pump and the highest water level on the discharge side of the pump.

In an open system, the suction reservoir may be at a different elevation than the discharge reservoir. The pump must overcome the **frictional losses of the system, plus the hydrostatic lift**, or the difference in elevation between the two reservoirs., as shown in Fig. 1

In a closed system a pump must overcome **only the frictional resistance of the system**. The discharge reservoir is also the suction reservoir so there is no difference in elevation and consequently no hydrostatic lift for the pump to overcome, as shown in Fig. 2

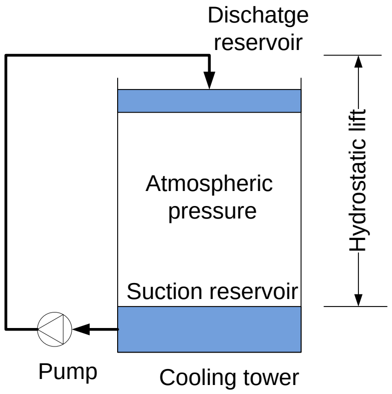


Fig. 1 Open Water system

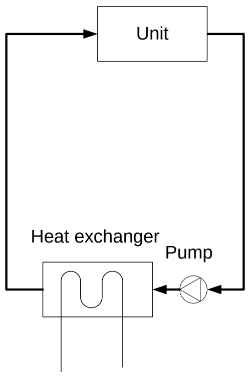


Fig. 2 Closed water system

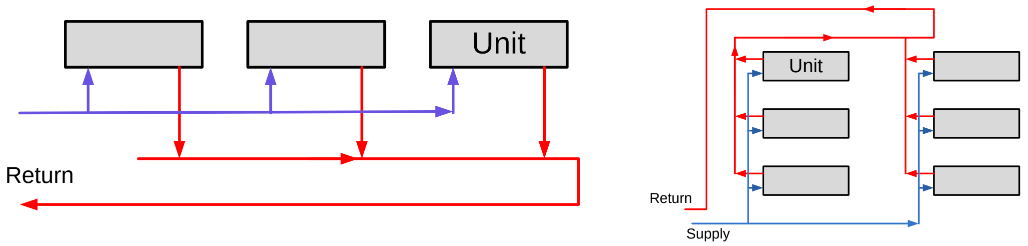
4.2 Water Piping System Return Arrangements:

The recirculating system is further classified according to water return arrangements. When two or more units of a closed system are piped together, one of the following piping arrangements may be used:

1. Reverse return piping.
2. Reverse return header with direct return risers.
3. Direct return piping.

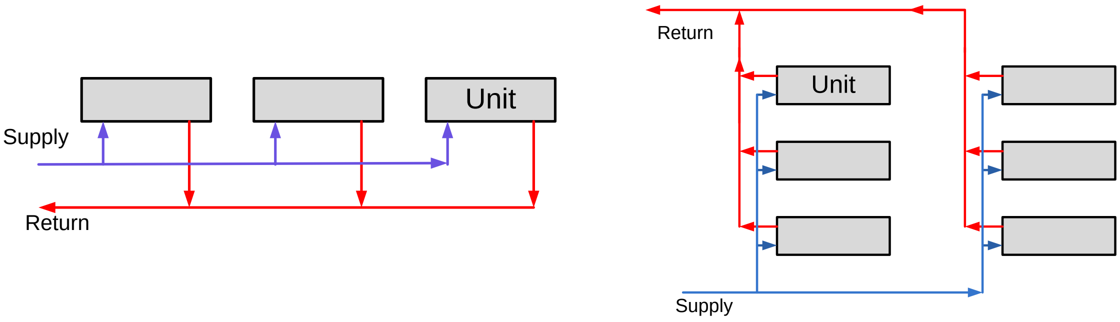
If the units have the same or nearly the **same pressure drop through them, one of the reverse return methods of piping is recommended**.
However , if the units have **different pressure drops or require balancing valves, then it is usually more economical to use a direct return**.
Reverse return piping is recommended for most closed piping applications. It is often the most economical design on new construction. The length of the water circuit thru the supply and return piping is a same for all units. Since the water circuits are equal for each unit, the major advantage of a reverse return system is that it seldom requires balancing. Fig. 3 is a schematic sketch of Reverse return piping system with units piped horizontally and vertically. While Fig. 4 shows a schematic sketch of. Direct return piping system with units piped horizontally and vertically.

The pressure drop across the riser includes the following:
(1) the loss through the supply and return run outs from the unit,
(2) the loss through the unit itself,
and (3) the loss through the fittings and valves.



a- Horizontally b- vertically

Fig. 3 Reverse return piping system with units piped horizontally and vertically



a- horizontally b- vertically

Fig. 4 Direct return piping system with units piped horizontally and vertically

The direct return piping system is inherently unbalanced and requires balancing valves or orifices, and provisions to measure the pressure drop in order to meter the water flow. Although material costs are lower in this system than in the two reverse return systems, engineering cost and balancing time often offset this advantage.

Normally all water piping systems must have adequate treatment to protect the various components against corrosion, scale, slime and algae. Water treatment should always be under the supervision of a water conditioning specialist. Periodic inspection of the water is required to maintain suitable.

4.4 PIPE SIZING

The design of a piping system is limited by:

1. Maximum velocity permissible which is established by:
   - (a) Noise generated by water flowing through piping.
   - (b) Erosion of piping by water and entrained sand, air and other foreign particles.
2. Friction loss:

(a) Once through systems must be sized to provide the required flow at a pressure loss within the pressure available after all other losses (Condenser Pressure Drop, Hydrostatic and Line, Valve and Fitting Losses) have been deducted.

(b) Re-circulating pump systems are sized to provide a reasonable balance between increased pumping horsepower due to high friction loss and increased piping first cost due to larger pipe sizes.

4.4.1 DESIGN LIMITATIONS:

1. Velocity — between 1 and 3.6 m/s, as shown in table 1and table 2.
2. Friction Loss - maximum 300 kPa. per 100 meter equivalent length.

The system should be laid out with **valves, fittings, length of runs and water quantities shown for all mains and branches**. The size of the mains should be determined first and tabulated as shown in Table 5.

The pressure should be indicated at the points in the system where branch run outs are taken.

It will then be possible to determine the available pressure drop across each unit being fed from the main system so that pipe, valves and fitting sizes may be determined.

In this way, it may be possible to use smaller sizes of branch run outs than would normally be considered good practice.

All available pressure drop should be used in the branch to require a minimum of adjustment to equalize pressures and volume of flow.

Each pipe size selection should include a comparison between the initial installation cost and the operation and maintenance cost. Good engineering practice may permit the selection of more than one size for a given rate of flow.

4.4.2 Water Velocity:

The velocities recommended for water piping depend on two conditions:

1. The service for which the pipe is to be used.
2. The effects of erosion.

Table 1 lists recommended velocity ranges for different services. The design of the water piping system is limited by the maximum permissible flow velocity.

Table 1 Recommended velocity ranges for different services

Service	Velocity m/s
Pump discharge	2.5- 3.6
Pump suction	1.3 – 2.2
Drain line	1.3 – 2.2
Header	1.3 – 3.6
Riser	1 - 3
General service	1 – 3
City water	1 – 2.2

Since erosion is a function of time, water velocity, and suspended materials in the water, the selection of a design water velocity is a matter of judgment. The maximum water velocities presented in Table 2 are based on many years of experience and they insure the attainment of optimum equipment life under normal conditions.

Table 2 maximum velocity to minimize erosion

Normal operation hr/ year	Velocity m/s
1500	4.6
2000	4.3
3000	4.0
4000	.3.7
6000	3
80000	2.5

4.5 WATER PIPING FOR COOLING TOWER SYSTEM

To select the proper water piping for a cooling tower system, the following information must be available:

1. Volume flow rate of water to be circulated.
2. Total length of piping.
3. Pressure drop across condenser (this varies widely and must be obtained from equipment manufacturer).
4. Hydrostatic lift of tower.
5. Number of valves, fittings and any other resistances in piping system.
6. Type of pipe used (Copper Tubing or Iron Pipe).

Example 1:

Size the pipe system for a cooling tower shown in Fig. 4 with the following information:

1- Total length of piping 25.5 m

2- Water flow rate 2 lit/s
3- Pressure drop across condenser at 5 lit/s = 79 kPa.
4- Hydrostatic lift across tower = 1.5 m
5- 6 standard 90^o elbows
6- 2 Gate valves
7- 1 standard tee through side outlet
8- 1 standard tee straight through.

Solution:

1- From table 1, the recommended velocity for header and riser are between 1 to 3.6 m/s, let the velocity is 2 m/s.
2- From chart (2) for fairly rough pipe, the intersection between 2 lit/s and 2 m/s, the recommended pipe diameter is 40 mm, and the pressure drop is 181 kPa./100m.

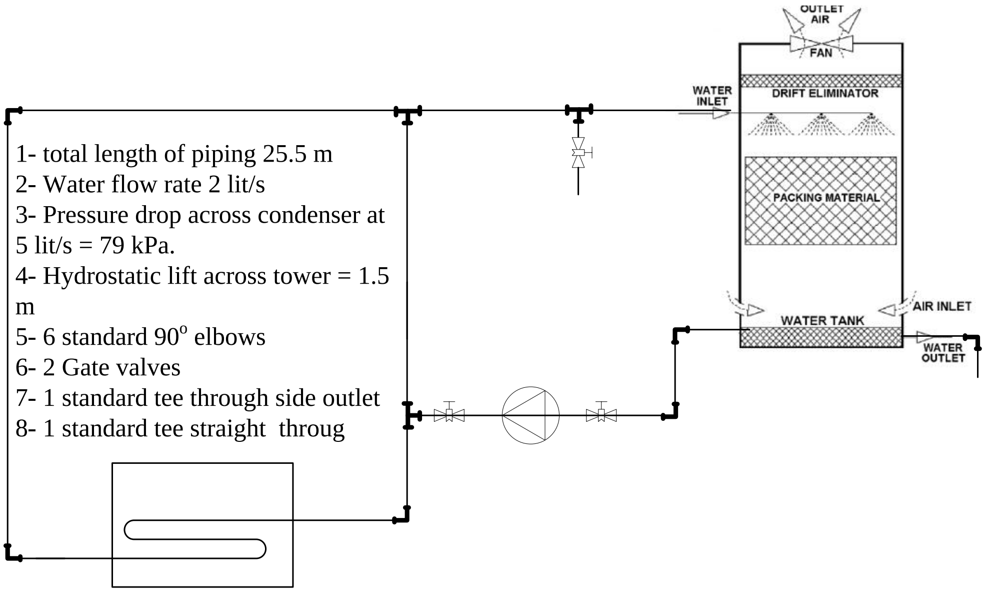


Fig 4 cooling tower piping system layout

Solution of example 1

No.	Type		No. or length	Length	Net length
1	Straight pipe	1	25.5	25.5	25.5
2	standard 90^o elbows (table 4)	1.22	6	6×1.22	7.32
3	Gate valve (table 3)	0.549	2	2×0.549	1.1
4	standard tee through side outlet	2.44	1	1×2.44	2.44
5	standard tee straight through	0.793	1	1×0.793	0.8
6	Hydrostatic lift across tower	1	1.5	1.5	1.5
	Total				38.99 m

Pressure drop due pipe length, valves and fittings=$39 * \frac{181}{100} = 71\ kPa.$

Total pressure loss= 71+79=150 kPa.