WATER TREATMENT

COOLING TOWERS

Cooling towers are a vital link in a complex system that transfers heat from one point to another. A common use of cooling towers is in air conditioning systems. The air conditioner draws heat from the air in the building and transfers it to water in the cooling tower system. The cooling tower system takes the hot water outside the building, cools it through contact with the air, and then recycles it.

The efficiency of this heat transfer system can be reduced in four ways:

(1) The dissolved chemicals found in most H_20 supplies can become "undissolved" over time and form a hard layer of scale in the system.

(2) Sludge can accumulate in the bottom of the system.

(3) The continuous passage of the water over the metallic surfaces of the tower system or a drop in the pH of the water in the tower system can cause corrosion.

(4) Algae and other organic material can actually grow in the system and foul it.

Why not use water from the city, or from a well, for cooling, and then discharge it into the drain? Water conservation is a primary consideration in operating a cooling tower to achieve tremendous savings in water bills and sewerage fees. For example, a 100-ton cooling tower, operating under average conditions, will use only 270 gallons of makeup water per hour, but the same system, operated on the basis of "once through" use of water, would require 18,000 gallons per hour. The difference amounts to almost 6,500,000 gallons per year.

In this continuous recycling of water across the tower, one percent of the circulating water will be lost by evaporation for each 10°F drop in water temperature. Another but lesser amount will be intentionally drained from the system by "bleed-off," a function used to limit the accumulation of solids in the tower water. This evaporative loss and loss of water by bleed-off must be replaced by new makeup water. (Refer to the makeup water gallonage mentioned in the above paragraph).

In the process of evaporation at the tower, only H_20 is discharged into the atmosphere as water vapor. All the hardness and other dissolved solids of the tower water are left behind. In addition, many varieties of airborne contamination (pollen, silt, flue gases, construction dust, etc.) will have been drawn into the system. The scale-forming tendencies and the corrosiveness of the tower water will have increased by these influences.

A major objective of a cooling tower treatment program is to prevent the deposition of hard water scale in small orifices, such as the condenser tubes. Another is prevention of corrosion. Scale and corrosion products constrict the flow of water, reducing the efficiency of the system. In badly neglected systems, pressure builds up in the system to overcome the insulating effect of scale. This will ultimately cause total system failure.

In cooling tower treatment, the water to the tower is fed into the top of the tower. Here, by virtue of evenly spaced orifices in the "distribution pan" the downflow of water is evenly distributed over the entire tower surface. As it falls downward across baffles, the water is broken into small droplets to accelerate the rate of evaporation and cooling. Evaporation is further increased by fans in addition to natural air drafts.

Strange as it may seem to you, the human body provides a very graphic illustration of cooling by evaporation. Here is a cooling system which, during the summer months, maintains the temperature of the body to within several tenths of a degree, regardless of the temperature of the air surrounding the body. It is done simply by cooling through EVAPORATION.

On a warm day when you work or play hard, your body heats up, and you begin to sweat. Because your skin is more moist than the air, the sweat EVAPORATES and it ABSORBS heat from your body. By absorbing heat from your body, the temperature of your body is lowered. It is the evaporation or the change from a liquid to a vapor of the water on your skin which causes the skin to be cooled. If you stand in a breeze, you feel cooler, even though the temperature of the breeze will be the same as the temperature of still air. The breeze STEPS UP the EVAPORATION process of the sweat and more rapidly cools the body. It is not the breeze alone that makes you feel cooler. It is the increase in the rate of evaporation which makes the body feel cooler.

Water used in cooling towers contains dissolved impurities because water is capable of dissolving a wide variety of solids and gases in infinite combinations and amounts. Water, although pure enough to drink, is usually not good enough for use in a cooling tower until it has been treated with scale and corrosion inhibitors.

Among other dissolved solids, water contains calcium and magnesium salts -- commonly referred to as "Hardness." These salts have only limited solubility -- that is, only a certain amount will be soluble in a given volume of water. As a sample of water evaporates, sediment begins to form at the bottom of the container. Only the water evaporates; all the solids stay behind. When sediment starts to form, we have reached the "limit of solubility."

The sediment which forms when the "limit of solubility" is reached causes scale formation. This scale can be very hard and difficult to remove. Scaling in the heat exchanger or compressor serves to insulate the system and reduces the cooling efficiency. Therefore, water must be "conditioned" to prevent this scale forming tendency.

In addition to dissolved "solids," water usually contains dissolved gases which it picks up from the air. The two most prevalent are oxygen and carbon dioxide. Other gases, such as sulfur dioxide or nitrogen oxides from exhaust fumes, can form acids when dissolved in water. These dissolved gases can, in time, completely destroy parts of the tower. Thus, the water must be conditioned to prevent acidic corrosion.

There is another problem with cooling towers that is not encountered in boiler water treatment. This occurs when air is brought into intimate contact with the cooling water as it passes over the cooling tower. Because of pollution, the air contains a wide variety of impurities -- both solids and gases. As it passes through the water in a cooling tower, the air is effectively "scrubbed," and the impurities are transferred to the water. Thus, the dirt picked up from the air along with precipitated Hardness and suspended solids make up the major cooling tower water contaminants. As these solids accumulate in the system water, they must be removed by bleed-off. If they were allowed to continuously concentrate in the cooling system, they would create sludge in critical areas and reduce the ability of the system to cool.

The problem of water impurity is controlled in two ways:

(1) By introduction of chemicals, which prevent the dissolved solids from precipitating as scale...and which prevent corrosion.

(2) By bleed-off, which limits the solids concentration at a level which can be successfully handled by chemical treatment.

Problems result when the moist surfaces of the tower are exposed to sunlight. This promotes the growth of algae, bacteria and fungal slime. Masses of slime or algae growth can accumulate, causing clogging, reduced flow, and reduced heat transfer. This "fouling" must be prevented. A microbial film of 1/64" can cause a 30% increase in energy use/electrical demand.

The operating efficiency of a cooling tower system is adversely affected by:

(1) Scaling, which must be controlled chemically and also held in check by bleed-off.

(2) Corrosion, which must be overcome by chemically neutralizing the acidity which has been picked up by air pollution, or which is present in the makeup water.

(3) Organic fouling, which must be brought under control by chemicals with algaecidal properties.

The amount of dissolved solids in the tower water is evaluated in terms of "cycles of concentration." This term is used to describe the ratio of tower water solids to raw water (makeup water) solids. To measure cycles of concentration, the chloride content of the tower water and the chloride content of the raw water are compared as follows:

$$\text{Cycles of Concentration} = \frac{\text{tower water chloride}}{\text{raw water chloride}}$$

For example, if the chloride content of the tower water is 120 ppm and the raw water chloride is 40 ppm, the cooling tower system is operating at three (3) cycles of concentration. Chloride is the most accurate titration to use for this purpose because:

(1) Chloride is present in all raw water.

(2) Chloride is the most soluble of the dissolved solids in water, and the last to precipitate; therefore, no other solid will concentrate more. This assures the accuracy of your measurement.

(3) No chloride is used in our treatment compounds, therefore, the titrations are not influenced by the presence of chemical treatment.

To maintain the cooling system water at a specific number of cycles of concentration, a regulated rate of bleed-off of tower water must occur. At three cycles of concentration, bleed-off is one-third of the makeup water volume. At four cycles of concentration, the bleed-off rate is one-fourth the makeup water, etc. The balance of the makeup (not leaving the system via the bleed-off drain) is evaporative loss. The actual rate of evaporation is easily computed. If two of the following factors are known this equation can be completed.

Bleed = Evaporation ÷ (Concentration - 1)

$$B = \frac{E}{(C-1)}$$

MakeUp = Evaporation + Bleed *or*

MU = E + B

EXAMPLE: Chloride tests have shown three cycles of concentration. Bleed has been measured at the rate of 8 GPM. Therefore:

B = E divided (C-1)
B = E divided (3-1)
8 = E divided 2
8 = 16 divided 2

and we can say that evaporation is 16 GPM and makeup (E + B) = 24 GPM.

If the rate of evaporation never fluctuated, there would be no need to change the rate of bleed-off. But more water evaporates at 2:00 p.m. on a hot day than at midnight on the same day. All three factors of tower management (evaporation - bleed - makeup) change as the "demand" increases or decreases. Over the entire cooling season or, in fact, during any 24-hour day, the "demand" will average 50% of the rated capacity of the system. At 2:00 p.m. on a hot day, the rate of evaporation, the rate of bleed-off and the rate of makeup may approach the figures shown below for operation of the tower at 100% capacity. During the nighttime, cooler hours of the same day, the "demand" decreases making the average hourly "demand" 50% of the full capacity "demand."

EVAPORATION, BLEED-OFF AND MAKEUP HOURLY RATES
FOR THE OPERATION OF A 100-TON

	Operation at 100% capacity					operation at 50% capacity				
cycles	2	3	5	7	10	2	3	5	7	10
gph evap.	180	180	180	180	180	90	90	90	90	90
gph bleed	180	90	45	30	20	90	45	22	15	10
gph makeup	360	270	225	210	200	180	135	112	105	100

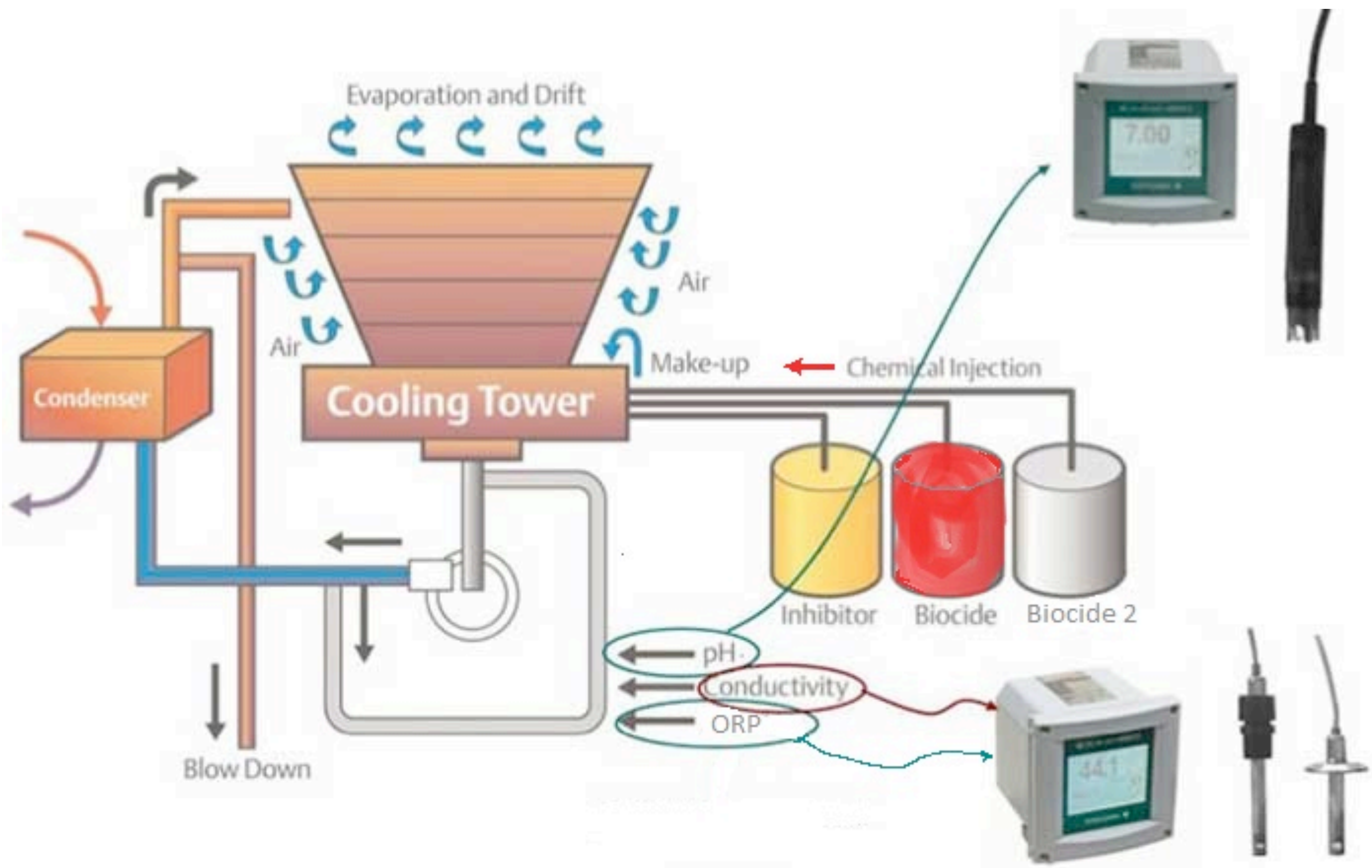
In the operation of a 100-ton tower at three (3) cycles of concentration, the rate of makeup will average 135 GPH, even though during part of the day the makeup may be as high as 270 GPH. The next page will be devoted to the use of automatic controllers to continuously balance the feed and bleed factors so that wastage is minimized and protection to the system is maximized.

The introduction of chemicals into a cooling tower is performed in a number of ways. The simplest, least effective method is "slug feeding." The operator throws a “can full” of compound into the tower basin when he thinks about it.

Somewhat more operator attention is given to a "by-pass feeder," another hand-operated batch feeder that is installed in the piping in the equipment room. This eliminates the need to go up to the rooftop tower to apply treatment; however, all of the obvious faults of "slug feeding" still exist. (This method is normally used for the “closed loop” side of the system that does not dump water but takes the heated water to the cooling tower to chill prior to contact with a heat exchanger.)

All such crude methods result in periods of wasteful overdosage followed by longer periods of severe undertreatment. These peaks and valleys have no relationship to the rate at which makeup water enters the system. With hand-feeding methods, the tower may be without protection when the need is greatest. Manual adjustment of the bleed-off also contributes to chemical and water wastage, or it allows excessive sludge to build up in the system.

The Milanco "Tower Controller" overcomes these inadequacies by bleeding water from the system when the solids and salts from the tower water increase to a value set on the controller. The “cycles” of concentration in a system will depend on the area of the country where the tower is located and the quality of water (such as the dissolved solids and hardness of the makeup water). Cooling towers can operate from 3 to 10 cycles of concentration. Never less than three -- no more than ten. Below is diagram of a Cooling Tower system.



HOW TO PREPARE THE TOWER CONTROLLER AND TOTAL TOWER CONCENTRATE FOR A COOLING TOWER

*** A SIDESTREAM LOOP SHOULD BE INSTALLED WHICH INCLUDES A CONDUCTIVITY PROBE, FLOW SENSOR, 3 INJECTION PORTS WITH CHECK VALVES AND A NORMALLY CLOSED SOLENOID VALVE***

(1) Mount the feed pump on the wall about 8 inches above the drum. Connect the siphon tube and insert it into the drum with a footvalve and weight on the bottom of the tubing. With the assistance of the equipment operator, select the **Total Tower Concentrate** injection port located downstream from the conductivity sensor in the sidestream loop. Connect the plastic tubing to the discharge port and then connect the other end to the chemical injector in the "T" of the sidestream loop.

(2) Move the **Total Tower Concentrate** drum to a location close to the sidestream loop with the conductivity sensor and flow sensor installed

(3) With the assistance a maintenance person, locate the tower bleed-off assembly. The discharge from this solenoid bleed valve should discharge down the sanitary sewer. Make sure that the solenoid valve is connected to the Tower Controller. It will automatically energize the bleed valve when the conductivity level is above 800, and leave it on until the conductivity drops to 700. These settings can be changed depending on the raw water quality. The bleed valve can be direct wired, or plugged into a plug from the unit. Electrical services should be performed by the electrician, and should conform to local code.

(4) You are now ready to add **Total Tower Concentrate**, as needed, to control scale and corrosion and also ready to bleed water from the system, as required, to maintain control over the total solids in the circulating water.

1. **<u>Initial Charge</u>**

To bring the tower water up to operating strength, put in **Total Tower Concentrate** at the rate of 2.5 pints per 1000 gallons of system water. Estimate 10 gallons of tower water per rated ton.
EXAMPLE: 300 tons = 3000 gallons = 7.5 pints.

This can be done at the tower basin or a holding tank. Get the operator to help choose the most convenient location. After two hours of operation, test the tower water for **Total Tower Concentrate** content, which is indicated by the orthophosphonate levels in the water. The reading should be between 10-20 ppm.

2. **<u>Interim Setting for the Feed Pump</u>**

To maintain the proper level of **Total Tower Concentrate** in the tower water, set the Feed Pump at a setting of 20% capacity of the pump. The Tower Controller will be set to bleed at a conductivity reading of 800 µmhos, and turn off at a conductivity reading of 700 µmhos. After 30 minutes, the **Total Tower Concentrate** will be added for 10 minutes. This will all be automated and controlled by the Tower Controller.

Instruct the operator how to run daily tests for **Total Tower Concentrate** level. Furnish a Test Kit and Log Sheets to record these readings. Tell him you will return in several days to inspect the Log Sheet and make recommendations based on the data recorded.

3. **Continuous Maintenance Feed Rate**

After 2 days, review the Log Sheet. See if the trend is for the concentration to maintain, drop, or increase. Adjust the pump in 10% increments until the concentration holds. Be sure to manually add additional **Total Tower Concentrate** if the orthophosphonate concentration drops below 10 ppm.

4. **Teach The Operator To Make Daily Tests**

The full cooperation of an operator makes the difference between success and mediocrity. Run through the two tests with any operators. Go over how the numbers will be added on the Log Sheet. Consistent chemical dosing protects the equipment and saves money in the long run.