purchaser regardless of subsequent adjustments made by the manufacturer. The capability of a cooling tower should be evaluated prior to purchase, and acceptance tests conducted during the warranty period.

TOWER LOCATION

Small cooling towers are frequently located on the roof or offset of a building, but large towers must be located on the ground. Proper location and orientation are needed in either case to insure satisfactory performance. A most important factor is to provide for a free flow of air to and from the tower. The air flow to a tower can be obstructed by adjacent structures or by screening walls in the case of roof installations. Such walls must be provided with openings that are at least equal to the inlet area of the tower. If the opening in the wall is not immediately adjacent to the tower inlet, the wall must be set back far enough to allow the air to flow around or under the tower to the inlet.

Downdrafts are created by wind blowing over a cooling tower or adjacent structures. The exhaust air is carried downward and can re-enter the tower from the leeward side. Since such recirculation raises the entering wet-bulb temperature a location should be selected that results in the least loss of performance during the hottest weather. Recirculation is usually the least with an end wind unless the tower is over 300 ft long. Adjacent structures and topography affect the wind. They should be considered carefully together with U. S. Weather Bureau data for the locality. A cooling tower should not be located where the prevailing summer wind will carry heat to it from an external source or from another cooling tower.

A properly designed cooling tower will have a drift loss not more than 0.2 percent of the circulating rate. A small amount of water in the exhaust air is unavoidable, but it can be objectionable if the droplets fall on parked automobiles, nearby windows or power lines. Evaporation leaves a deposit of the dissolved solids.

The moisture content of the air passing through a cooling tower is increased due to the evaporative cooling of the water. Condensation is unavoidable if the vapors strike a cool surface and cause a hazard that can be serious during freezing weather. During periods of high relative humidity, fogging occurs as the exhaust air mixes with the atmosphere and is cooled below its dew point. Fogging is usually worse in the spring or fall when the ambient air is humid and cool but not too cold. Warm air during the summer is capable of absorbing the excess moisture without producing a fog. Less water evaporates in the tower during extremely cold weather because the humidity ratio is reduced, so the fog is dissipated rather rapidly.

The drift nuisance is usually confined to an area immediately adjacent to the tower although high winds can carry it several hundred feet at times. Fogging, however, is less localized and can occur close to the tower or settle to the ground a considerable distance away.

Noise problems occur when cooling towers are located in congested areas. This applies particularly to small towers rather than large industrial installations. The sound is created by the falling water or fans and air movement. The water noise does not carry far but is quite noticeable adjacent to a tower. The sound of the fans may be audible at a considerable distance away from the tower if it is not deflected by intervening structures. Deflecting screens are of some value, and acoustical treatment is quite effective but expensive. It is commonly believed that objectionable noise can be eliminated by a reduction in the tip speed of the fan. This is seldom successful because the sound is a function of horsepower as well as tip speed. Both of these must be reduced to lower the sound level.

OPERATION AND MAINTENANCE

Most cooling tower manufacturers issue operating and maintenance instructions. These bulletins should be placed in the hands of operating personnel for their guidance.

Water Treatment

The general discussion of this subject in Chapter 55 offers detailed information on scale deposition, corrosion, and control of biological fouling. The dissolved solids in a circulating system are concentrated as water is lost by evaporation. The evaporation averages 0.8 percent of the circulating rate for each 10 F deg of cooling range. Excessive concentration is prevented by wasting a portion of the circulating water as blowdown. The make-up water, replacing losses due to evaporation, drift and blowdown, introduces dissolved solids into the system. An equal amount of solids must be removed by the drift and blowdown. Expressing all terms as a percentage of the circulating rate, the number of concentrations in the system is:

$$\text{No. of Conc.} = \frac{\text{Evaporation} + \text{drift} + \text{blowdown}}{\text{Drift} + \text{blowdown}} \quad (8)$$

The form of Equation 8 shows that a small amount of blow down is highly effective, but higher rates are of little advantage. Drift loss alone will maintain about 15 concentrations. This is rapidly reduced to 3 or 4 concentrations with 1 per cent blowdown, but an increase to 100 per cent blowdown brings the system down to one concentration. Draining the system periodically is a poor substitute for continuous blowdown, because the concentration builds up to the maximum within a few hours.

Towers operating continuously are usually arranged for blowdown by maintaining a water level in the collecting basin that allows the desired quantity to be wasted at the overflow connection. Placing the blowdown connection in the hot-water line adjacent to the tower inlet prevents unnecessary waste when the pump is stopped. This is recommended for intermittent operation.

Many small installations rely on blowdown for water conditioning, and use no supplementary water treatment. Larger installations find it desirable to use chemical treatment in the system, and most of these processes require a controlled blowdown rate. Chapter 55 discusses the chemicals used to control scale, corrosion and biological fouling.

Wood Deterioration

Wood is one of the most durable materials, but it can be destroyed by chemical action or by organisms producing decay. Until 1950, the deterioration of cooling tower lumber was looked upon as the result of chemical action, but later investigations indicate it is largely due to micro-biological attack.[14] Deterioration can be expected if sodium carbonate is present in the water. This was formerly classed as a chemical attack although sodium carbonate is a rather poor pulping agent. The deteriorated wood almost invariably contains wood-destroying organisms, so the actual cause of the deterioration can be chemical, micro-biological or a combination of the two.

Chlorine is frequently used to control the growth of slime and algae that foul the circulating system. This is a powerful oxidizing agent that attacks the wood if used excessively. The action bleaches the surface of the wood and loosens the fibers, allowing them to wash away and collect in the heat exchangers or on the screens. A more common type of surface attack, however, is caused by soft rot organisms. The more durable species of wood contain fungicidal materials that are removed by oxidizing agents such as chlorine. These materials are also removed by normal leaching.

Decay organisms are widespread in nature, serving a useful and necessary purpose in sewage disposal systems or in the disintegration of dead trees in the forest. The same process is highly undesirable when it occurs in structural lumber. It is prevented by impregnating the lumber with preservatives that are toxic to the organisms. The use of treated lumber in cooling towers has been increasing since 1953. Service records accumulated since that time indicate that the service life of cooling tower lumber can be economically extended by preservative treatment. The use of treated wood increases the initial cost of a cooling tower about 10 percent. Preservatives can be applied by the double diffusion method to existing cooling towers built of untreated lumber.[14]

Winter Operation

The basin and piping must be drained, or otherwise protected, if a cooling tower is shut down during freezing weather. Towers that are shut down frequently are preferably operated with a *dry basin*. The tower is installed at an elevation that allows the basin to drain into an indoor tank to which the circulating pump is connected.

Water-cooling towers operating in freezing weather are subject to ice formation, particularly at the air inlet. This is not influenced by the temperature of the circulating water since the icing occurs where fine drops splash out and strike relatively dry surfaces in the entering air stream. Stopping the fans temporarily allows the water to fall vertically across the inlet, and much of the ice is melted. Ice that is not melted in this manner can be removed by reversing the fans for 15 or 20 minutes. Air flow is obstructed by the ice, causing water temperatures to increase drastically. Since the water temperature increases when icing occurs, it is not possible to use thermostatic controls to stop or reverse the fans.

CONTROL OF COOLING TOWERS

Other than the usual electrical interlocks with the refrigeration system, few automatic controls are used on cooling towers. Sometimes the fan is turned off automatically to reduce capacity in cool weather. Towers not of the dry-basin type may have drain valves controlled by outdoor thermostats to prevent freeze-up of the water in the pan.

EVAPORATIVE CONDENSERS

The evaporative condenser combines the functions of the condenser and cooling tower by using a minimum amount of water on a surface, cooling it to approximately the wet-bulb temperature of the surrounding atmosphere.

The end view of a typical evaporative condenser is shown in Fig. 10. The fan draws the air over a condenser surface which is kept wet by a water spray. The discharge refrigerant gas from the compressor enters the top of the condenser coil. The liquid refrigerant is drained from the bottom of the coil into a liquid receiver, and then circulates through the remaining portion of the system in the usual way.

The water is circulated through the spray nozzles and drops into the sump where its level is maintained by means of a float valve. The eliminator plates are placed in the path of the water-air mixture so as to remove the entrained water. Since the air leaving the unit is almost completely saturated, care must be taken in locating discharge ducts to prevent condensation.

Evaporative condensers are available in sizes up to 300 tons or more. These units use only a small portion of the water required for a waste-water cooled condenser. The water is vaporized by the heat of the refrigerant. Each pound of water used extracts approximately 1000 Btu from the refrigerant, whereas under commonly used rating conditions where the water temperature rise is 20 F deg, each pound of water extracts only 20 Btu from the refrigerant. The water used including the loss by entrainment in the discharge air, the blow down, and the evaporation, amounts to about 3 to 5 percent of that which would be required for a water-cooled condenser.

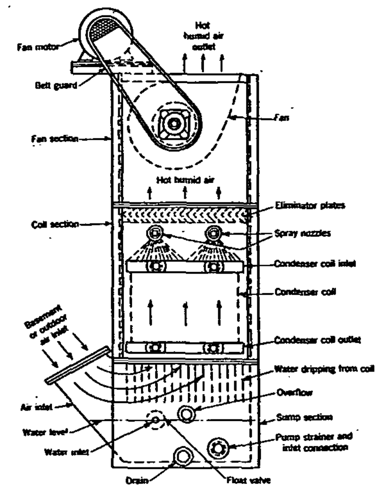

Fig. 10 . . . . Schematic View of an Evaporative Condenser

The evaporative condenser requires more maintenance, occupies greater space (must be located where air is available), and has a higher first cost than the water-cooled condenser, but where the use of water is restricted or expensive, the evaporative condenser has become widely accepted. Compared with a water-cooled condenser and cooling tower, which have about the same heat dissipating capacity, the evaporative condenser has the advantage of lower cost and smaller space requirements.

Control of Evaporative Condensers

An electrical interlock is usually provided to prevent the refrigeration system from operating until the pump and fan