AESAN

Engineering Handbook

......*Environmentally responsible evaporative cooling solutions*

Content

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Cooling Tower Water Treatment

Maintaining Water Quality

Cooling towers work by evaporating a small portion of water, approximately 1.8 gallons per hour are evaporated per every ton of tower capacity. As water evaporates, the concentration of dissolved solids increases rapidly and can reach unacceptable levels. In addition, airborne impurities and biological contaminants are introduced into the recirculating water because the cooling tower operates pretty much like an air scrubber.

If impurities and contaminants are not effectively controlled, they can cause scaling, corrosion, sludge, which reduce heat transfer efficiency and increase system operating costs. Biological control is also required to reduce the growth of bacteria and algae.

Following are the water quality parameters for any conventional cooling tower:

- pH 6-8.5 for FRP towers and 8-8.5 for metal towers
- Calcium Hardness 800-1000 mg/l
- Total Alkalinity 200 mg/l
- Chloride 1000 mg/l
- Silica 150 mg/l
- Fe (iron): 2 ppm maximum
- TDS 8,000 mg/l (TDS = Total dissolved solids)

Tap water as initial tower filling or make-up is the most used and is considered rather reliable, however, if it is recycled water or from a river or lake or even rain water collected on the surface, attention should be paid to the water quality; especially the influence of the water on the other chemicals in the water treatment system and corrective measures should be taken.

Startup Conditions

In new installations, the water should be cleaned and treated with biocides by a water treatment expert before start-up. Remove any and all accumulated debris from tower. Pay particular attention to inside areas of cold water basin, hot water basins, louvers and drift eliminators. Make sure that cold water suction strainers are clean and properly installed.

Blowdown

The blowdown rate will depend on the cycles of concentration required to maintain recirculating water quality and the evaporation rate.

The cycles of concentration (C) is defined as the ratio of the total dissolved solids in the recirculating water to the total dissolved solids in the make-up water (TDSr/TDSm).

To keep solids concentration under control in the cooling water and to prevent precipitation and depositing on system components, a portion of the recirculating water is removed from the system and replaced with the make-up water. The recirculating water removed from the system is referred to as blowdown (B). Cycles of concentration are controlled by the amount of blowdown.

The blowdown will depend on the cycles of concentration and the evaporation rate (E), use the equation as:

$$B=E/(C-1)$$

Evaporation can be estimated for the system using the following expression:

Evaporation Rate (GPM) = Water Flow Rate (GPM) x Range (°F) x 0.001

This expression indicates that the evaporation rate (E) is approximately equal to 0.1% of water circulated over the tower for each 1° F of temperature drop ΔT (T2-T1) .

Cycles of concentration is an important consideration in the operation of an open recirculating cooling system. The greater the number of cycles of concentration, the less water (or treatment) the system must lose to blowdown.

Example:

At a flow rate of 100gpm and a cooling range of 10 F, the evaporation is 1% (.1%×10=1%), the rate of evaporation is 1gpm(100gpm ×1% =1gpm).

C is determined by the silica concentrations, example now C is 4, then Blowdown here is 0.33% (1% / (4-1) = 0.33%), the rate of blowdown is 0.33gpm(100gpm×0.33%=0.33gpm).

Chemical Treatment

There are two main aspects of water cooling treatment, scaling control and biological control.

Scaling is the accumulation of calcium composites on the wet surfaces of a cooling tower and if not controlled they drastically reduce the tower efficiency and capacity.

Biofilm can directly cause corrosion problems (microbial induced corrosion), pathogen concerns (Legionella), increased pump pressure, heat-transfer problems, dermatological effects, and foul odors.

- Water treatment chemicals or non-chemical systems need to be compatible with the materials of construction used in the cooling system including the evaporative cooling equipment itself.
- In case of chemical water treatment, chemicals should be added to the recirculating water by an automatic feed system. This will prevent localized high concentrations of chemicals, which may cause corrosion. Preferably the water treatment chemicals should be fed into the cooling system at the discharge of the recirculation pump. The chemicals should not be fed in concentrated form, nor batch fed directly into the cold water sump of the evaporative cooling equipment. Special care must be taken to prevent sodium hypochlorite tablets from being thrown into the cold water basin in galvanized steel towers.

- Acid water treatment is not recommended in galvanized steel towers. However for FRP towers consider using acid treatment such as sulfuric, hydrochloric, or ascorbic acid. When added to recirculating water, **acid can improve the efficiency of a cooling system by controlling the scale buildup** potential. Acid treatment lowers the pH of the water and is effective in converting a portion of the alkalinity (bicarbonate and carbonate), a primary constituent of scale formation, into more readily soluble forms. Make sure workers are fully trained in the proper handling of acids. Also note that acid overdoses can severely damage a cooling system. The use of a timer or continuous pH monitoring via instrumentation should be employed. Additionally, it is important to add acid at a point where the flow of water promotes rapid mixing and distribution. For this reason FRP towers are better due to their inherent resistance to low pH water which translates on higher thermal efficiency (less scaling).
- Install a conductivity controller to automatically control blowdown. Working with your water treatment specialist, determine the maximum cycles of concentration you can safely achieve and the resulting conductivity (typically measured as microSiemens per centimeter, uS/cm). A conductivity controller can continuously measure the conductivity of the cooling tower water and discharge water only when the conductivity set point is exceeded. Installing a conductivity meter also earns 2 LEED points towards Green Building Certification.
- Install flow meters on make-up and blowdown lines. Check the ratio of make-up flow to blowdown flow. Then check the ratio of conductivity of blowdown water and the make-up water (you can use a handheld conductivity meter if your tower is not equipped with permanent meters). These ratios should match your target cycles of concentration. If both ratios are not about the same, check the tower for leaks or other unauthorized draw-off. If you are not maintaining target cycles of concentration, check system components including conductivity controller, make-up water fill valve, and blowdown valve.
- Read conductivity and flow meters regularly to quickly identify problems. Keep a log of make-up and blowdown quantities, conductivity, and cycles of concentration. Monitor trends to spot deterioration in performance.
- Due to increased government pressure to reduce the amount of chemicals used for cooling tower treatment, several alternate technologies have emerged in the market such as UV-lights, Ozone and Pulsed-power technology. They all claim to be very effective at biological control and chemical usage reduction.
- Select your water treatment vendor with care. Tell vendors that water efficiency is a high priority and ask them to estimate the quantities and costs of treatment chemicals, volumes of blowdown water, and the expected cycles of concentration ratio. Keep in mind that some vendors may be reluctant to improve water efficiency because it means the facility will

purchase fewer chemicals. In some cases, saving on chemicals can outweigh the savings on water costs. Vendors should be selected based on "cost to treat 1,000 gallons make-up water" and highest "recommended system water cycle of concentration." Treatment programs should include routine checks of cooling system chemistry.

Cooling Tower Water Filtration

In addition to chemical and/or any other types of water treatment, the most effective way to keep the amount of solids in suspension under control in the system is filtration.

Filtration keeps the entire loop cleaner, thereby minimizing dirt load and any likelihood of a fouled condenser, or exchanger bundle.

The biggest benefit received is the savings realized through efficient electrical consumption with the cleaner chiller condenser running within design specifications.

Filtration can be done inline (larger equipment) or side-stream (smaller equipment), and from a manufacturer's standpoint, “any” filtration is always better than no filtration, so regardless of the type of filters chosen, it is always recommended to use one, to extend the life of the system, keep its efficiency high and reduce maintenance downtime.

Layout Guidelines

Introduction

Cooling towers' performance depends on an adequate supply of fresh ambient air to achieve design parameters. The installation location should be chosen considering this fundamental requirement, mainly based on maintaining manufacturer recommended spacing and clearances to adjacent walls, obstructions, or other equipment, including other cooling towers.

As the size of a system increases, the total amount of air being moved and heat being rejected to the atmosphere also increase. All this makes designing spaces for cooling towers installation an architectural challenge where the HVAC Consultants must be closely involved to prevent adverse consequences and poor performance of the chiller plant as a whole. Manufacturer support is also vital and as a general rule, any job involving 3 or more cells and anything other than a flat open field should be reviewed by a factory representative for verification purposes during the design stage.

General Considerations

The following factors shall be considered when choosing the location for cooling towers:

- Discharge air is warm, humid and has the potential to carry pathogens, so this air must be kept away from any fresh air intakes or populated areas of any surrounding buildings. Attention to prevailing winds direction is vital.
- Plume formation typically occurs at low ambient temperatures and it affects buildings' glass surfaces, and under certain circumstances can act as heavy fog and affect the visibility for traffic and pedestrians and become a hazard. Also over the last years with the collective awareness about Legionnaire's Disease, it could even create a panic situation for people being too close or even surrounded by the towers' plume, even if the towers have adequate water treatment, just the public's perception is negative. In areas with seasonal low ambient temperatures plume control is advisable and sometimes legally mandated.
- The easiest way to provide adequate supply of fresh, ambient air to the air intake is by allowing plenty of open unobstructed space around the towers Also avoid conditions that promote recirculation of discharge air back into the tower's air inlet (short-circuiting), such as:
  - a) Walls or structures that might deflect some of the discharge air stream back into the air intake.
  - b) Other equipment's air intakes like boilers or O.A. make up air units, which would "compete" for air and even starve the towers of air.
  - c) Building eaves or roofs protruding into the fan cylinder's vertical projected area. These may force the discharge air to bounce back down into the towers inlet, increasing the wet bulb and affecting the towers performance.
- Provide adequate space around the unit for piping and maintenance.
- Different tower types require different layout considerations, for instance:

a) Towers with only one air intake.
b) Towers with two air intakes.
c) Towers with four air intakes.
d) The top of the fan cylinder, recovery stack, or discharge silencer must be at least level with, or higher than any adjacent walls or buildings.
e) Consider the prevailing wind and try to make it blow the discharge air away from the air intakes of the tower (not valid for round towers or towers with 4-side air intakes).
f) In the event that it's impossible to meet the recommended layout guidelines, and there is a possibility of short-circuiting of discharge air, the design/selection criteria must be modified to reflect the real-life conditions, generally accomplished by increasing the wet-bulb design temperature.

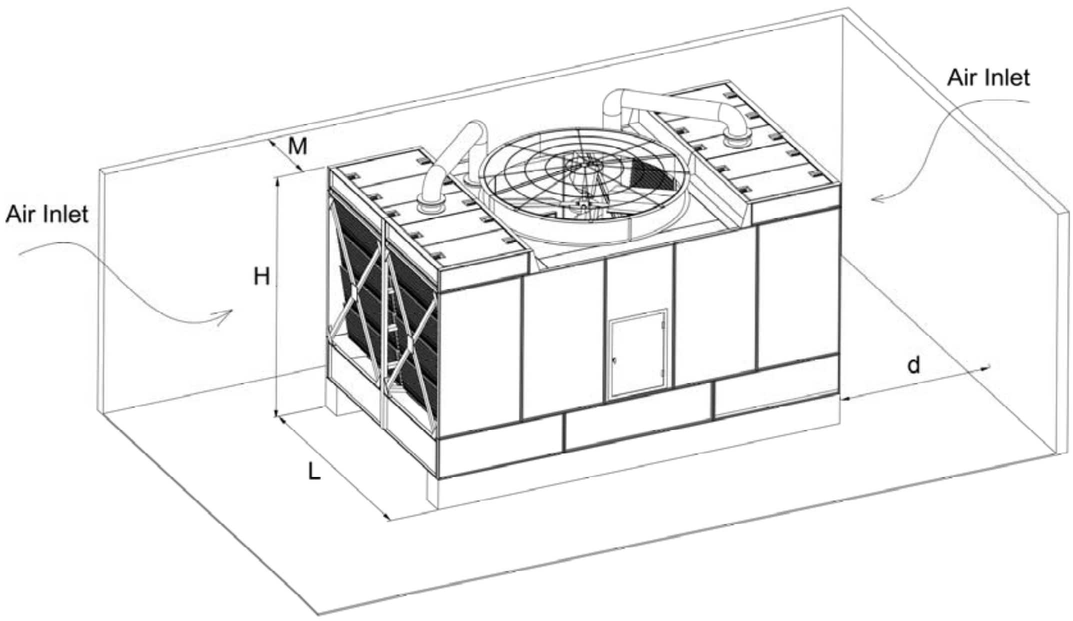
Adjacent Building or Wall

When a unit is located near a building wall, locate the unit with the blind or closed facing the obstruction.

Should it be necessary to install a unit with the air intake facing a wall, provide at least distance "d" between the air intake and the wall, as illustrated in the figures that following.

Below is the method for determining the minimum acceptable distance "d" for a unit located with the air intake facing a solid wall:

$$d = \frac{H \times L}{(1.6 \times H) + L}$$



where:

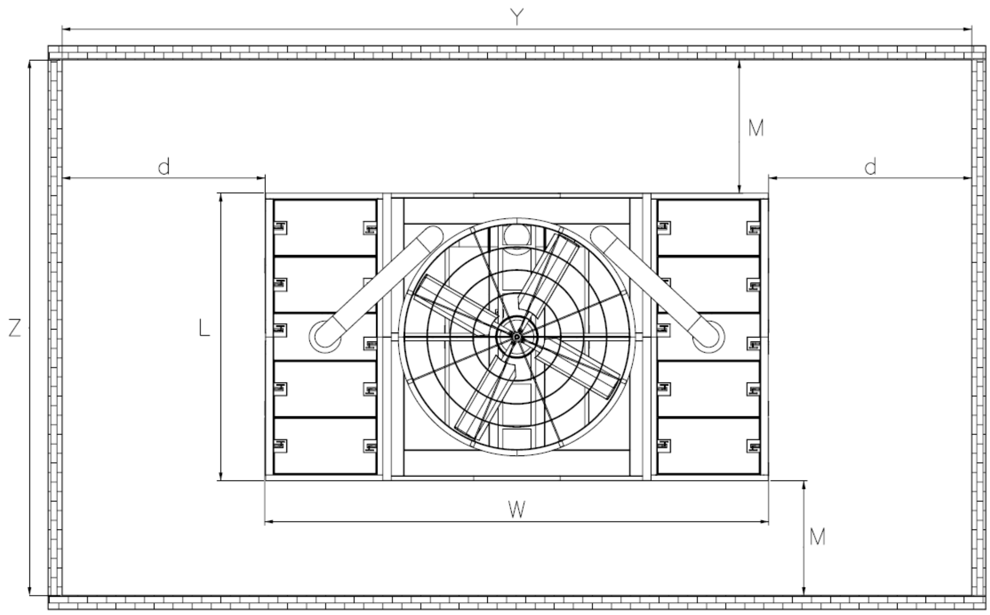
H = Total height of the tower from the ground to the top of fan cylinder in feet and decimals, not inches (16.5ft for example). This parameter is in our catalogs and submittal drawings.

L = length of the air intake in feet and decimals, not inches. This parameter is also in our catalogs and drawings.

d = minimum recommended distance between the wall and the air intake face in feet.

Well Installation

The following method is used to determine the minimum acceptable dimension “d” for units installed in a well (surrounded by 4 walls).



$$d = \frac{H \times L}{(1.6 \times H) + L}$$

Additionally a dimension “m” must be considered for maintenance and service access to the unit. The recommended distance for maintenance access is 3’ on each side of the unit (for single cell towers), but in situations where “m” is less that 3 ft, an additional calculation is required in order to verify the air downward velocity going into the tower. Such velocity shall not exceed 400 ft/min:

V < 400 ft/min

The calculation is as follows:

Deduct the footprint area of the tower from the well’s floor area: (refer to figure 2 above) (my second hand sketch)

A = (Y x Z) – (W x L)

Where:

A = Net free area for air intake

Y = Length of the well, parallel to access side of the tower

Z = Width of the well, parallel to the tower’s air intake openings

W = Width of the tower (from catalog)

L = Length of the tower (from catalog

Once this area is calculated, proceed to verify the downward velocity, as follows:

V = Q / A < 400 ft/min

Where:

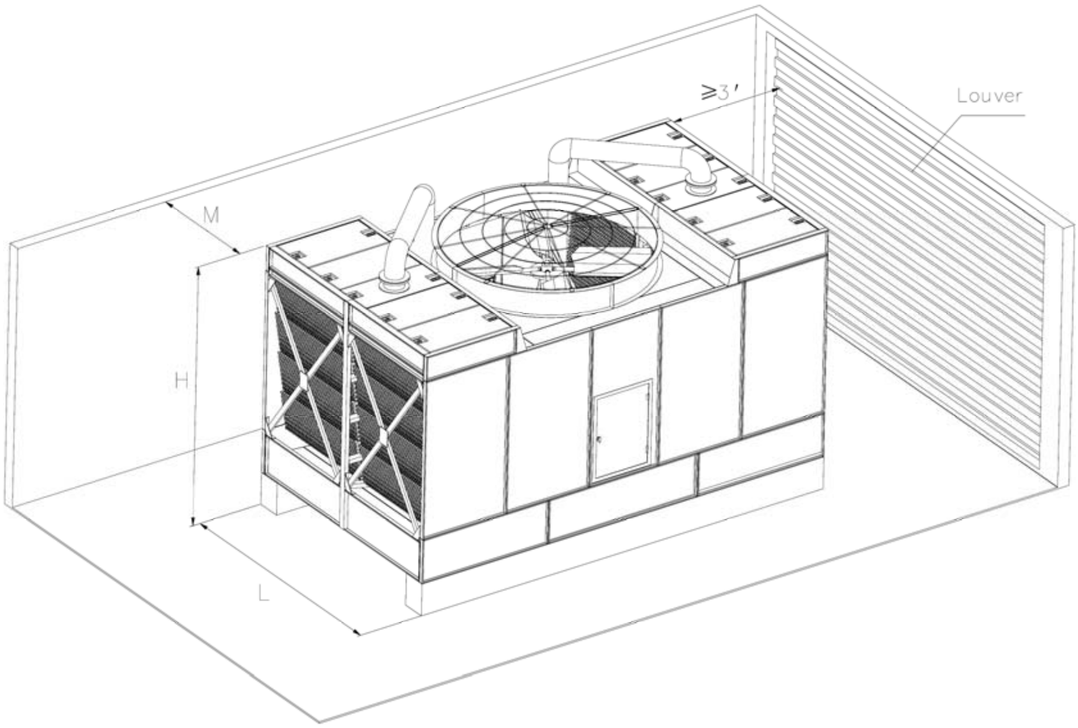
V = Downward air velocity

Q = Total airflow rate of the tower
A = Net free area of the well

If "V" is higher than 400 ft/min, additional corrections to the well size are required, either by increasing its width (Z) or length (Y), until the downward velocity falls within the recommended value. In none of these parameters can be increased then, louvered walls are recommended for the well. (See next chapter)

Louvered well installation

When nothing can be done to increase the net free air intake area of a well installation, wall intake louvers are recommended, and the criterion is as follows:



- Louvers must face the tower's air intake openings
- Minimum separation between the tower and the louvered wall is 3 ft
- Louvers recommended net free area shall be 50% but if different it can also be worked out
- Intake air velocity through the louvers is 600 fpm or less (measured through the louver net free area, NOT the louvers face velocity)
- It's desirable that the overall height of the louver does not exceed the height of the tower

To calculate the louver's size the following formula is used:

- First we need to calculate the louvers net free area or LA:

LA = Q / V

Where:

Q = the tower's airflow rate (divide by 2 for towers with 2 air intakes) in ft3/min or cfm

V = recommended air velocity through the louver V < 400 ft/min

- Once “LA” is calculated, we look in any louvers catalog for sizes that match or exceed this “LA” value, always considering that overall louver height must not exceed the tower’s height.

Multiple Cells or Multiple Towers

Since the variables are many and too different from each other, whenever a multi-cell installation faces space constraints other than an open free space, please consult MESAN for technical support.

Solutions for Noise Sensitive Applications

Sound and noise control is a very complex science that involves many variables, and only qualified acoustics engineers should get involved with. We as manufacturers will only talk about the solutions that MESAN offers to reduce sound levels in our products.

The three alternatives we offer are:

1. MESAN's SILENT-CHOICE fans: These fans use what is known as wide-chord blades (a.k.a. "Elephant Ears"), they are manufactured in Italy by Cofimco and can be ordered with any of our cooling towers. They can reduce sound pressure level between 9 and 15 dbA depending on the application.
2. Discharge sound attenuators: These add some extra height to the tower and can reduce the sound pressure level by 3 dbA. They also reduce the tower performance by about 2% because of the additional resistance to the air flow.
3. Inverters or Variable Frequency Drives (VFDs) as well as dual-speed motors, by reducing fan speed, also reduce noise but only under part-load conditions. They also save energy.

As an additional measure, consider oversizing the tower in order to reduce fan speed and as a side benefit also reduce power consumption.

In order to facilitate the analysis of the Acoustical Engineers MESAN also provides complete sound data for its products including, sound power level and sound pressure at several distances from the unit. Consult your MESAN representative for special applications.

Make-up Water Calculations

Evaporation Loss "E"

E = Water Flow Rate (GPM) x Range (°F) x 0.001

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Example:

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Drift Loss "D"

The drift loss consists on tiny water drops carried away by the airstream and it's not more than 0.1% of total operating water flow rate. MESAN high efficiency drift eliminators ensure the lowest possible drift losses.

Total Loss

The make-up water shall be the total sum of above three types of water loss.

M (%) = E + B + D

eg. E for evaporation loss is 1%,

B for blowdown loss is 0.33%,

D for drift loss is 0.1%

Hence, M = 1.43%. (Average)

As a result, it is appropriate to set **M** no less than 1.5% when designing a cooling tower.

* The best way to precisely control bleed or blowdown and the only method that ensures earning 2 LEED points for the building, is by installing a conductivity meter in the cold water basin and a controller with a motorized valve to modulate bleeding based on electrical conductivity. It's a fact that conductivity varies with solids concentration in the water.

Freeze Prevention

Tower operation in freezing weather is always a difficult challenge, and in some applications there is a year-round demand for cooling, even at reduced loads, so the tower must remain operational through the winter even under freezing conditions. Here we will discuss ways to deal with freezing on different types of towers.

Among all the different types of towers, forced-draft ones have a slight advantage on the fact that their fans do not have to handle the humid discharge air but the dry outside air. Induced draft towers are susceptible to get icing on the fan blades because of the moist air they have to move. Counterflow towers, are better for freezing conditions because the entering air interacts with constant temperature water (after it passed through the infill), while crossflow towers have a temperature gradient in the water (hotter at the top and colder at the bottom of the infill), which tends to cause icing at the bottom sections of the infill pack.

It is not the intention of this document to provide solutions to specific applications but to explain what is available to help dealing with this issue of freezing in cooling towers. It is the designer's responsibility to specify the correct product with the correct accessories and options for each application.

The most popular tower accessory offered for freeze prevention is the electric basin heater, quantity and power depends on the water volume in the cold water basin and the design conditions and although they are a common and practical method, they only perform well when the tower is operating and water is circulating. If the tower is off, under freezing conditions the basin heaters cannot keep up with the heat loss and ice will eventually form. Hot water or steam coils are also offered and installed inside the cold water basin, but great care must be exercised when using steam coils in galvanized basins as steam condensate is very corrosive and will damage the basin in case of any leak from the coil.

The weight of the ice built-up on the fan blades of induced draft towers can be enough to cause unbalance, vibration and consequent failure of the fan. MESAN's TowerMizer control panels have a "de-icing" function to spin the fan backwards and remove the ice.

What in our opinion is the best way to deal with freezing conditions is to add a remote sump to the system. A remote sump is nothing but an additional water storage tank located inside the building, under warmer conditions, where water from the tower is drained to by gravity, so no water is accumulated in the cold water basin and freezing cannot happen.

The use of inverters or VFDs in the tower fan also helps under low or part load conditions. In general reducing the airflow retards the formation of ice under freezing conditions.

Another alternative is to use closed circuit cooling tower and a glycol solution in the closed circuit loop, plus any of the methods mentioned above for the open side of the tower.

For more specific technical advice on any particular application, please consult your MESAN representative.

MESAN USA

www.mesanusa.com

sales@mesanusa.com

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