



Because Temperature Matters

Maintaining Cooling Towers

By **Glenn A. Babcock**, Member ASHRAE

The cooling tower is often the forgotten component of the water cooling system when it comes to maintenance. It's a good example of the phrase "out of sight, out of mind." A newly installed cooling tower reliably delivers the design fluid temperature and flow rate. However, since its heat transfer operation creates a hurricane-like environment and is a natural air-washer, the cooling tower needs routine inspection and maintenance to continue performing as designed. This article discusses routine maintenance and suggests ways to improve cooling tower performance.

Let's take a moment to recall how a cooling tower works. In an open-circuit cooling tower, warm water from the heat source is evenly distributed via a gravity or pressurized nozzle system directly over a heat transfer surface called fill or wet deck, while air is simultaneously forced or drawn through the tower, causing a small percentage of the water to evaporate. The evaporation process

removes heat and cools the remaining water, which is collected in the tower's cold water basin and returned to the heat source (typically a water-cooled condenser or other heat exchanger).

Similarly, in a closed-circuit cooling tower or evaporative condenser, the heat is rejected indirectly from a fluid or vapor flowing through the coil section by spraying recirculated water over

the coil section, again evaporating a small percentage of the water in the process.

The temperature at which the cooled fluid is returned to the system measures tower performance. This temperature can vary depending upon the actual cooling load, water flow, airflow, and the entering air conditions. Because temperature matters so much, owner confidence in cooling tower performance will be enhanced by selecting a tower model whose performance is certified by the Cooling Technology Institute (CTI).

Preventive Maintenance

Performing routine preventive maintenance is paramount for consistently achieving the desired temperature and flow rate, and plays an important role in maximizing cooling tower operating life. Manufacturers conscious of the importance of maintenance offer

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Cooling towers away from the building can be subjected to the “out of sight, out of mind” principle.

many features that simplify these procedures, saving time and money.

To perform properly, all tower components must be kept clean and free of obstructions. The following sections describe standard maintenance procedures for optimized circulating water system operation. These procedures can prevent loss of efficiency in the heat transfer section by maintaining proper water flow and airflow, as well as preventing corrosion in the cooling tower.

Maintenance frequency depends largely on the condition of the circulating water, the cleanliness of the ambient air used by the tower, and the environment where the tower is operating. More detailed information is provided by the specific manufacturer’s operating and maintenance instructions.

Strainer Systems

Fundamentally important to the performance of a cooling tower is a method to minimize contact between air- and water-borne debris and the system components. Strainers in the tower provide a means of keeping debris out of the

condenser system water loop. Strainers in the cold water basin outlet prevent debris from reaching the pump.

Some towers feature low-pressure drop pre-strainers upstream of the hot water basin to prevent clogging of distribution nozzles. This simple cleaning procedure eliminates the need to access the distribution nozzles. Both strainers should be routinely inspected and cleaned as necessary. Some tower designs allow external access to the strainers, which enables maintenance to take place without the need to turn off the unit.



Cold water basin strainer.

Water Distribution

The water distribution system should evenly distribute water over the fill package or coil section via either a gravity distribution system or a pressurized spray system, using an array of nozzles. If water distribution is found to be uneven, the nozzles need to be checked. Clogged nozzles should be cleaned in accordance with the manufacturer’s recommendations.

Since even water distribution is important to the performance of the tower, consideration should be given to the ease with which the

Operations and Maintenance

distribution nozzles can be accessed, inspected, cleaned and replaced when selecting a cooling tower model.

In a gravity distribution system, the nozzles can be externally accessed and visually inspected and cleaned by removing the hot water basin covers on the fan deck. Most pressurized spray distribution systems use nozzles and branches held in place by snap-in rubber grommets, which allow easy removal to clean and flush debris if necessary.

Cold Water Basin

Since some debris eventually will enter into the cooling tower, the unit design should facilitate debris removal. A well-designed cold water basin is sloped toward the strainer to keep dirt (which can accelerate corrosion) from accumulating throughout the cold water basin. The basin should be kept clean by occasionally flushing the dirt out of the system through the tower drain.

Another way to accomplish this is to install sump sweeper piping in conjunction with water filtration or separator devices. Water filtration saves maintenance costs by reducing dirt in the cooling water system, which reduces the time required to clean the cold water basins. It also reduces water treatment cost, as water treatment chemicals tend to work more effectively in clean water. Foreign particles in dirty water can absorb treatment chemicals, thus requiring the distribution of even more chemicals to properly treat the tower water.

Makeup

Although most of the water in the system is recirculated, some water must be added to replace what is lost by evaporation and by bleed, which is the water that is discharged to prevent the accumulation of solids in the cooling water. The makeup water system provides the means to replace the water via a mechanical float ball and valve assembly or an electronic water level probe assembly (with solenoid valve), which measures water depth in the cold water basin. The make-up water supply pressure typically should be maintained between 15 psig and 50 psig (103 and 345 kPa) to ensure proper valve shut-off and avoid “chatter.” If the supply pressure is higher than 50 psig (345 kPa), install a pressure reducing valve.

The operating water level of the cooling tower will vary with system thermal load (evaporation rate), the bleed rate used, and the makeup water supply pressure. Some tower designs offer access to the makeup assembly external to the cooling

tower, which allows easy basin water depth inspection and adjustment without the need to turn off the unit. The tower water level should be set in accordance with the manufacturer’s recommendations to ensure no air enters the pump suction, but not so high that water is wasted through the overflow when the tower is shut down.

Bleed

To prevent the accumulation of solids in the recirculating water, the tower should be equipped with a bleed line (including a metering connection and globe valve) connected to a nearby drain.

In a closed circuit cooling tower or evaporative condenser with a circulating pump, a metering valve to control the bleed rate should be provided at the pump discharge. While a manually adjusted bleed valve is the simplest system, getting the proper bleed rate can be a problem as cooling tower loads vary throughout the day. A conductivity meter connected to a solenoid valve solves this problem by maintaining the proper cycles of concentration at all times. Also, it is recommended that a separate meter be installed to measure bleed volume, since less water is discharged to drain than supplied to the cooling tower. This can reduce sewer water charges.

The bleed rate should be adjusted to prevent an excessive buildup of impurities in the recirculating water. This largely depends on the local water quality and the evaporation rate. Constant bleed and replacement with fresh water will prevent the accumulation of impurities. To obtain

specific recommendations, contact a competent water treatment professional.

Mechanical Drive System

The mechanical fan drive system has several components that should be checked regularly. Many of these components operate at high speed. So, to maximize safety, follow proper lock-out/tag-out procedures, including locking out all motor disconnect switches before working on the mechanical system.

Cooling tower fans typically are driven by belt- or gear-drive systems. Both require routine maintenance to ensure reliable, trouble-free performance. Belt-drive systems are popular, as they are inexpensive yet reliable, offer single point adjustment, and have no limit on turndown capabilities for variable speed applications. If a problem occurs, a simple change of the belt



Spray distribution nozzles.



Inspecting drift eliminator.

is usually all that is required, and replacement components are readily available.

Gear drives provide reliable operation as well, and perform consistently when properly maintained. If a problem occurs, resolution may be more involved if a gear box rebuild or replacement is required. Some manufacturers offer both systems to meet user needs or preferences. To ensure proper operation of a belt-drive system, tighten drive belts to manufacturer's specifications. In gear drive systems, the oil level and quality, as well as shaft alignment should be checked regularly in accordance with the manufacturer's recommendations.

When starting up a new unit, lubrication of the fan shaft bearings is typically not necessary, since most units leave the factory already greased. However, for seasonal startup, purge the fan shaft bearings with new grease (per manufacturer's recommendations). Fan shaft bearings should be lubricated after every 2,000 hours of operation or every three months (whichever occurs sooner). Motor bearings should be lubricated as recommended by the manufacturer's instructions. For maximum life, it is best to install motors with a "cooling tower duty" rating.

Importance of Clean Operation

Cooling tower components must be kept clean and free of obstructions, because temperature matters. Neglecting the cooling tower will lead to higher than desired return water temperatures to the system, which will result in higher energy use from two perspectives. First, the system (chiller) will consume more energy because it must operate at a higher than necessary condensing pressure (head) to satisfy the load, due to the higher fluid temperatures provided by the cooling tower. As little as 2°F (1°C) higher temperature can result in 6% more energy being consumed by the chiller. Second, the tower must operate longer at higher fan horsepower while trying to attain the design cold water temperature.

Common Problems: Causes, Effects, and Solutions

Regardless of how often routine maintenance is performed, like any other mechanical component, problems with cooling towers may materialize unexpectedly. These include elevated leaving water temperatures, drift, and corrosion. Should any of these problems occur, contact the cooling tower manufacturer's representative or water treatment supplier for assistance.

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High leaving water temperature will cause a drop in process cooling efficiency, increasing system power consumption, creating physical discomfort to people within an air-conditioned area, and have a detrimental effect on other system components. Major factors affecting cooling tower leaving water temperatures are cooling load, water flow, airflow, entering air conditions, and the condition of the tower itself.

Check cooling load. If the actual cooling load exceeds the design load for which the tower was selected or surpasses the certified thermal performance of the tower, the leaving water temperature will exceed the design specifications for the towers.

Check water flow and distribution. Visually inspect the water distribution system to ensure the spray distribution nozzles are clean and correctly installed and are distributing a uniform spray pattern over the wet deck surface. The cooling tower circulating water flow rate can be measured by either the pressure differential between the circulating pump discharge and suction or by measuring the pressure drop across the condenser, which should be relatively free of scale and fouling, and comparing it to the manufacturer's specifications. In counterflow towers, measure the pressure at the cooling tower inlet connection and compare it to the design pressure provided by the cooling tower manufacturer. For towers with a gravity distribution system, the operating level in the hot water basin (typically between 2 and 5 in.) (51 and 127 mm) can be correlated to a specific flow rate based upon the manufacturer's information.

Check airflow. Cooling towers should be located where an unimpeded supply of fresh air is available to the air inlets. The cooling tower air discharge also should be at least as high as any surrounding walls to reduce the possibility of hot, moist discharge air being recirculated into the air inlets, creating artificially elevated entering wet-bulb and leaving water temperatures. To ensure full design airflow, the cooling tower drive system must be adjusted according to the manufacturer's operating and maintenance instructions.

The cooling tower and surrounding area should be examined for airflow restrictions that may cause blockage of the air inlets. Check for clogging or improper distribution of water across the tower fill surface and check for proper operation of capacity control dampers in centrifugal fan towers to ensure proper airflow. The dampers, airfoil blades located in the discharge of the fan housing, help achieve tight temperature control and energy savings by matching cooling tower airflow to actual load requirements.

Although you may encounter dampers in older existing units, today's towers tend to take advantage of variable frequency drive technology (VFDs) to control capacity. VFDs

help save energy, do a better job of following the load, and help reduce wear and tear on the drive system.

Check ambient conditions. Cooling towers are selected to produce the required leaving water temperature at the design cooling load and entering wet-bulb temperature. Whenever the actual entering wet-bulb temperature is higher than design conditions, the leaving water temperature also will be higher. The result is decreased energy efficiency and possible downtime for the system.

Drift occurs as air flows through the cooling tower and carries water droplets out of the tower. Drift eliminators are installed in the discharge stream to strip entrained water droplets from the air. In a properly maintained system, efficient eliminators will reduce drift loss to a negligible percentage of the design flow rate.

If excess drift occurs, check drift eliminators for proper installation, spacing, and overall condition. Examine the wet deck surface for even spacing, inspect the wet deck surface or water distribution system to ensure no clogging or blockage, and check water and airflow as described previously. Repair or replace eliminators as necessary.

Corrosion is always a concern with cooling towers because of their ability to wash the air of impurities, leaving them on the wet deck surface or in the cold water basin. This can cause scale, corrosion, and eventually damage to system components after long-term exposure to these impurities.

Historically, galvanized steel construction has been commonly used for factory-assembled cooling towers. Its structural rigidity and corrosion-resistant properties are needed in the corrosive environment where recirculating water becomes oxygenated. Current industry standards use G-235 galvanized steel, which has 2.35 ounces of zinc galvanized coating per ft² (717 g per m²) of steel.

The formation of white rust is a type of corrosion that may be promoted because of recent changes in water quality and water treatment programs. White rust appears as a white and waxy adherent, non-protective deposit on steel surfaces. White rust forms on a new tower if it is operated at high pH levels (above 8.0) for an extended period of time before the zinc galvanizing can form a protective passivation layer. If white rust remains unchecked, the galvanized steel coating will continue to corrode, eventually leading to an early failure.

Many additional cost effective construction options are available to provide increased cooling tower protection and equipment longevity. For example, fuse-bonded thermosetting polymers that are electrostatically applied on galvanized steel can provide enhanced protection from corrosion. They also serve as a deterrent to white rust.

Stainless steel construction offers the ultimate in corrosion protection. Options of entire stainless steel units or units with only

stainless steel cold water basins are effective in negating corrosion damage. However, stainless steel is not “maintenance free.” Submerged surfaces must be kept reasonably clean to prevent under-deposit oxygen deprivation and rapid pitting. For areas of the cooling tower which do not provide structural support, such as the casing walls, fiberglass reinforced polyester (FRP) panels provide a non-corroding, cost-effective material of construction.

If a constant bleed of the system is ineffective to combat scale or corrosion, chemical treatment may be necessary. A successful chemical or water treatment program should satisfy the specific guidelines set by the manufacturer, provide effective microbiological control, and be compatible with the system’s materials of construction as an integral part of the total water treatment program.

Potential airborne impurities and biological contamination (such as *Legionella*) should be controlled through the use of biocides, and such treatment should be initiated at system startup and continued regularly. ASHRAE has taken proactive steps to understand and deal with *Legionella* through its publication, ASHRAE Guideline 12-2000, *Minimizing the Risk of Legionellosis Associated with Building Water Systems*. To obtain specific recommendations of water treatment programs, contact a competent water treatment supplier.

Although basic cooling tower problems can either be alleviated or avoided altogether by using the recommended maintenance procedures, the process of servicing and maintaining the factory-assembled cooling tower is by no means a simple, one step operation. Many interrelated factors must be considered, including periodic inspections and use of a competent specialist such as a water treatment service engineer. These factors serve as a valuable resource in the total service program and may represent the margin of success throughout the lifespan of the cooling tower.

Performance Improvements

Product improvements (retrofit kits) can improve the performance of yesterday’s cooling towers with today’s technology. Older, structurally sound cooling towers can be retrofitted with upgrade kits to: conserve energy; restore or improve performance; and facilitate maintenance.

To conserve energy, two-speed motors, VFDs and/or pony motors can be added to the mechanical drive system to take advantage of moderate operating conditions with lower horsepower. VFDs offer a range of speeds to more closely parallel operating requirements, and pony motors provide the added benefit of redundancy in the event of a motor failure. A popular energy conservation approach uses a pony motor system with a VFD controlling the lower horsepower motor.

To improve performance on water distribution systems, kits are available to replace older, smaller distribution nozzles or troughs with large-orifice, clog-free design replacements. Retrofit fill kits easily replace the original fill that may be clogged with scale or airborne debris. Access platforms also can be added to existing cooling towers to facilitate maintenance and improve worker safety.

Conclusion

Paying regular attention to the cooling tower, through a regular, comprehensive maintenance program can save time, money and energy while increasing the tower’s life expectancy. A well-maintained tower is a viable candidate for retrofit kits designed to enhance performance and lengthen its life.

Owners and operators with a working knowledge of cooling tower preventive maintenance and upgrade technology can take advantage of cost-saving ideas and procedures. If you are not regularly performing routine maintenance on your cooling, implement a comprehensive maintenance program today—because temperature matters. ●

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