Best Management Practice: Cooling Tower Management

Cooling towers regulate temperature by dissipating heat from recirculating water used to cool chillers, air-conditioning equipment, or other process equipment. Heat is rejected from the tower primarily through evaporation. Therefore, by design, cooling towers consume significant amounts of water.

This page outlines cooling tower best management practices across:

- Overview
- Operations and Maintenance
- Retrofit Options
- Replacement Options
- Resources

Overview

The thermal efficiency and longevity of the cooling tower and equipment used to cool depend on the proper management of water recirculated through the tower. Water leaves a cooling tower system in any one of four ways:

1. **Evaporation**: This is the primary function of the tower and is the method that transfers heat from the cooling tower system to the environment. The quantity of evaporation is not a subject for water efficiency efforts (although improving the energy efficiency of the systems you are cooling will reduce the evaporative load on your tower).
2. **Drift**: A small quantity of water may be carried from the tower as mist or small droplets. Drift loss is small compared to evaporation and blow-down, and is controlled with baffles and drift eliminators.
3. **Blowdown or bleed-off**: When water evaporates from the tower, dissolved solids (such as calcium, magnesium, chloride, and silica) are left behind. As more water evaporates, the concentration of dissolved solids increases. If the concentration gets too high, the solids can cause scale to form within the system or the dissolved solids can lead to corrosion problems. The concentration of dissolved solids is controlled by blowdown. Carefully monitoring and controlling the quantity of blowdown provides the most significant opportunity to conserve water in cooling tower operations.
4. **Basin leaks or overflows:** Properly operated towers should not have leaks or overflows.

The sum of water that is lost from the tower must be replaced by make-up water:

Make-up = Evaporation + Blowdown + Drift

A key parameter used to evaluate cooling tower operation is "cycles of concentration" (sometimes referred to as cycles or concentration ratio). This is calculated as the ratio of the concentration of dissolved solids (or conductivity) in the blowdown water compared to the make-up water. Since dissolved solids enter the system in the make-up water and exit the system in the blowdown water, the cycles of concentration are also approximately equal to the ratio of volume of make-up to blowdown water.

From a water efficiency standpoint, you want to maximize cycles of concentration, which will minimize blowdown water quantity and reduce make-up water demand. However, this can only be done within the constraints of your make-up water and cooling tower water chemistry. Dissolved solids increase as cycles of concentration increase, which can cause scale and corrosion problems unless carefully controlled.

In addition to carefully controlling blowdown, other water efficiency opportunities arise from using alternate sources of make-up water. Water from other equipment within a facility can sometimes be recycled and reused for cooling tower make-up with little or no pre-treatment, including the following:

- Air handler condensate (water that collects when warm, moist air passes over the cooling coils in air handler units). This reuse is particularly appropriate because the condensate has a low mineral content, and typically is generated in greatest quantities when cooling tower loads are the highest.
- Water used in a once through cooling system.
- Pretreated effluent from other processes, provided that any chemicals used are compatible with the cooling tower system.
- High-quality municipal wastewater effluent or recycled water (where available).

Operation and Maintenance

To maintain water efficiency in operations and maintenance, Federal agencies should:

- Calculate and understand your "cycles of concentration." Check the ratio of conductivity of blowdown and make-up water. Work with your cooling tower water treatment specialist to maximize the cycles of concentration. Many systems operate at two to four cycles of concentration, while six cycles or more may be possible. Increasing cycles from three to six reduces cooling tower make-up water by 20% and cooling tower blowdown by 50%.
- The actual number of cycles you can carry depend on your make-up water quality and cooling tower water treatment regimen. Depending on your make-up water, treatment programs may include corrosion and scaling inhibitors along with biological fouling inhibitors.
- 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.

- 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.
- Consider using acid treatment such as sulfuric, hydrochloric, or ascorbic acid where appropriate. When added to recirculating water, acid can improve the efficiency of a cooling system by controlling the scale buildup potential from mineral deposits. 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. Be aware that you may have to add a corrosion inhibitor when lowering pH.
- 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."
- Consider measuring the amount of water lost to evaporation. Some water utilities provide a credit to the sewer charges for evaporative losses, measured as the difference between metered make-up water minus metered blowdown water.
- Consider a comprehensive air handler coil maintenance program. As coils become dirty or fouled, there is increased load on the chilled water system to maintain conditioned air set point temperatures. Increased load on the chilled water system not only has an associated increase in electrical consumption, it also increases the load on the evaporative cooling process, which uses more water.

Retrofit Options

The following retrofit options help Federal agencies maintain water efficiency across facilities:

- Install a sidestream filtration system composed of a rapid sand filter or high-efficiency cartridge filter to cleanse the water. These systems draw water from the sump, filter out sediments, and return the filtered water to the tower. This enables the system to operate more efficiently with less water and chemicals. Sidestream filtration is particularly

helpful if your system is subject to dusty atmospheric conditions. Sidestream filtration can turn a troublesome system into a more trouble-free system.
- Install a make-up water softening system when hardness (calcium and magnesium) is the limiting factor on cycles of concentration. Water softening removes hardness using an ion exchange resin and can allow you to operate at higher cycles of concentration.
- Install covers to block sunlight penetration. Reducing the amount of sunlight on tower surfaces can significantly reduce biological growth such as algae.
- Consider alternative water treatment options, such as ozonation or ionization, to reduce water and chemical usage. Be careful to consider the life-cycle cost impact of such systems.
- Install automated chemical feed systems on large cooling tower systems (over 100 tons). The automated feed system should control blowdown/bleed-off by conductivity and then add chemicals based on make-up water flow. These systems minimize water and chemical use while optimizing control against scale, corrosion, and biological growth.

Replacement Options

The following replacement options help Federal agencies maintain water efficiency across facilities:

- Get expert advice to help determine if a cooling tower replacement is appropriate. New cooling tower designs and improved materials can significantly reduce water and energy requirements for cooling. However, since replacing a cooling tower involves significant capital costs, you should investigate every retrofit, operations, and maintenance option available and compare costs and benefits to a new tower.
- For specifics on this technology, consult with experts in the field. Your first resource should be local or headquarters engineers, but do not overlook input from experienced contractors or other Government agencies.

Cooling Tower Resources

The following resources provide guidance on water best management practices. Some of the following documents are available as Adobe Acrobat PDFs. Download Adobe Reader.

- **General Services Administration Water Management Guide** (PDF 3.6 MB): Comprehensive approach for facility managers explaining new water conservation requirement under Executive Order 13123.
- **Cooling Technology Institute**: Organization dedicated to encouraging the wise use of water resources.
- **North Carolina Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities** (PDF 2 MB): Water conservation resource developed and presented by the North Carolina Department of Environment and Natural Resources.
- **Optimizing Cooling Tower Performance Tech Brief**: Overview of cooling tower performance optimization best practices offered by the Western Area Power Administration, an agency of the Department of Energy.