5.2 Cooling Towers

Applicability

This BMP is intended for any water user which employs cooling towers to remove heat by the evaporation of water. Cooling towers are used extensively from relatively small facilities such as office buildings, schools, and supermarkets to large facilities such as hospitals, electric power generation plants, and manufacturing and industrial plants.

Description

Cooling towers can be among the largest water using systems in industrial and commercial settings. A cooling tower uses evaporation to lower the temperature of water that conveys heat from mechanical equipment such as air conditioning systems, heat exchangers, condensers, or process machinery. Although recirculated within the system, water is lost due to evaporation, "blowdown", and drift or other losses. Water is added through "make-up water." This BMP centers on the practices for water-use efficiency of cooling towers by optimizing the water quality and the amount of blowdown.

Four general types of measures can reduce the amounts of water used in cooling towers: improved system monitoring and operation, optimal contaminant removal from cooling water, use of alternative sources for make-up water, and reducing heat load to evaporative cooling by either good energy management or by combining air and water cooling.

As water evaporates, the concentrations of dissolved solids become greater, affecting the operation and integrity of the facility. The most significant opportunity for water savings in cooling tower operation is by reducing the amount of highly concentrated water removed from the system as blowdown. One measure of water-use efficiency in a cooling tower is the concentration ratio, also known as cycles of concentration, which indicates the number of times water is used before being released as blowdown. There have been significant recent advances in both chemical treatment and monitoring technology which allow the concentration ratios in cooling towers to be increased, thus minimizing the amount of required make-up water needed to replace blowdown.

Other operating efficiency techniques may include careful use of acid or other pH lowering agents to reduce scale formation, sidestream filtration to filter out sediment and suspended particles that may clog lines, prevention of biogrowth by use of biocides and limiting exposure to sunlight, and use of ozonation to reduce chemical use. The entire heat transfer process should be kept in good order including, as applicable, coils, fans, condensers, and feed equipment.

Optimum concentration ratios for operation are highly dependent on the quality of the make-up water used, which can vary significantly from region to region. For evaporative cooling towers that use potable quality water, the minimum cycles of concentration should be at least four (4). With the modern water treatment chemical and monitoring technology available today, the potential exists for systems to be operated continuously at six (6) to eight (8) cycles or even greater, contingent upon system metallurgy and allowable corrosion rates. In cases where reuse and other non-potable sources are used for cooling tower water, a lower goal for cycles of concentration may be used since these non-potable sources typically have higher TDS or hardness than potable water. However, using reuse water or alternative sources is encouraged in that it reduces potable water use.

Implementation

Implementation of this BMP should consist of the following actions:

1) Perform a water efficiency evaluation on each cooling tower system within a facility to identify areas of improvement for water savings and optimization of heat loads. The evaluation should review all aspects of cooling tower operations including heat load requirements, sources and amounts of water used for make up and released as blow-down, concentration ratios, treatment techniques and chemicals used, metering, use of automated monitoring and controls, repair and maintenance schedules and procedures, and water quality characteristics.
2) Cooling towers should be operated in a water efficient manner with consideration for:
    a. Calculation of and monitoring of cycles of concentration in order to optimize the blow-down rate;
    b. Optimal use of chemical additives and automatic blow-down techniques to optimize the cycles of concentration based on water quality. Use of contractors and vendors that specialize in cooling tower operations efficiency should be considered;
    c. Installation of meters to measure both make-up and blow-down water and daily monitoring of use;
    d. Location of blow-down points away from make-up supply and preferably in dead spots that have a minimal amount of circulation;
    e. Appropriate use of automated control procedures such as continuous blow-down, conductivity metering to control blow-down, pH monitoring, corrosion monitoring and automatic shutdown when the system is not use;
    f. Recovery for reuse of water that passes through cooling water instrumentation;
    g. Use of shielding or other equipment to minimize drift;
    h. Use of cooling water sequentially to cool a number of processes prior to being returned to the cooling tower;
    i. Evaluation of and utilization of alternative sources of water such as saline water, reclaimed water, harvested rainwater, gray water, or water used in other on-site processes; and
    j. Evaluation of the opportunities for reuse of the blow-down water for other processes on site. In many cases the reuse of cooling tower blow-down may require additional treatment of the water by processes such as lime softening

or reverse osmosis. Exceptions to that general rule would apply to waters used for dust suppression or plant wash down.

Schedule

1) The industrial water user should complete the efficiency evaluation of the cooling towers in a timely manner. Very large or complex evaluations should be completed within six (6) months of initiating this BMP.
2) The industrial water user should implement the opportunities for water savings from the efficiency evaluation within the normal budget cycle after completion of the efficiency evaluation in order that the maximum water efficient benefit can be achieved in a reasonable time frame. Water saving measures for very large or complex systems should be implemented within twelve (12) months of completing the evaluation.
3) If determined to be necessary for very large or complex facilities the schedule can be extended. BMPs should be initiated in the second year and continued until the targeted efficiency is reached.

Scope

To accomplish this BMP, the industrial water user should do the following:

1) Industrial water users with one cooling tower, or several towers which are operated with the same or very similar parameters, should perform an efficiency evaluation and perform upgrades or replacements as outlined in the schedule of Section D.
2) For industrial water users with multiple cooling towers, or multiple sites with cooling towers that have significantly different operational parameters, a progressive implementation schedule should be followed, implementing the BMP in successive facilities until all facilities have been evaluated and conservation measures implemented.
3) Cost-effectiveness considerations may result in partial implementation of this BMP at one or several of a large number of facilities.

Documentation

To track the progress of this BMP, the industrial water user gathers and maintains the following documentation and can utilize industry accepted practices:

1) Operating information on the cooling towers, including cooling capacity design heat loads for each tower, description of the process the cooling tower is used for, system requirements for cooling including temperature, volume, and duration of flows (hours/day). Operating information should also include cooling system metallurgical design information for maximum levels of contaminants that can be tolerated while maintaining an acceptable corrosion rate.

2) Water use records for each tower that include the number of gallons of blow-down and the number of gallons of make-up water used daily.
3) Number of cycles of concentration and calculation data.
4) Descriptions, operating manuals and procedures of any automatic controls used such as automatic meters and conductivity or pH sensors used to control blowdown.
5) Description of chemical compounds and amounts used to improve water quality for efficient cooling tower use to maximize cycles of concentration and optimize make-up requirements. Consideration must be given to system corrosion rates and scale forming potential.
6) Description of and amounts used of any alternate water source or system used or considered for composing make-up water, including an evaluation of both beneficial and detrimental effects.

Determination of Water Savings

Using historical records and manufacturers' data as appropriate, water savings due to increased concentration ratio and other implemented operating procedures can be calculated.

The concentration ratio (CR) is determined from the dissolved solids (or alternatively the conductivities) in the make-up water (CM) and blow-down water (CB):
CR = CB / CM
The percent of water expected to be conserved = (CR2 – CR1) / (CR2 x (CR1 – 1)

Where CR1 is concentration ratio before and CR2 is concentration ratio after increasing cycles.
Source: Handbook of Water Use and Conservation (Vickers, 2001).

The chart below gives a graphic representation of water use at different cycles of concentration.

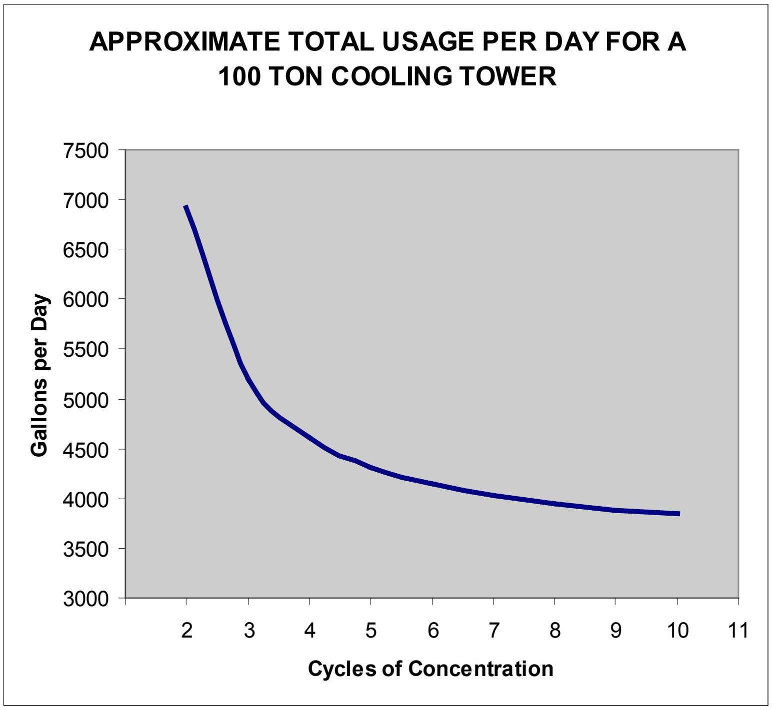

Figure 3.1 Cooling Tower Water User versus Cycles of Concentration

Cost-Effectiveness Considerations

A cost effectiveness analysis under this BMP should consider capital equipment costs, changes in staff and labor costs, chemical and treatment costs, additional costs or savings in energy use, costs for waste disposal, and potential savings in wastewater treatment costs. Many industries regularly use outside specialized consultants with fees starting at a few hundred dollars per month depending on the size and scope of the operation. Or the water treatment chemical suppliers may provide consulting services as part of the chemical costs.

The industrial water user should determine the cost effectiveness to implement each identified equipment replacement, upgrade, or change to its cooling tower operations, utilizing its own criteria for making capital improvement decisions. Many operating procedures and controls that improve the water use efficiency of cooling towers should be implemented simply as a matter of good practice.

References for Additional Information

There are many chemical vendors, equipment manufacturers, and consultants that specialize in industrial cooling towers. They can be an excellent source of information related to specific cooling tower applications. Many vendors have published literature available to assist an industry in optimizing its cooling water treatment systems.

1) Cooling Technology Institute, P. O. Box 73383, Houston, TX 77273 http://www.cti.org. The Cooling Technology Institute is a nonprofit self-

governing technical association dedicated to improvement in technology, design, performance, and maintenance of evaporative heat transfer systems.

2) *Process Cooling & Equipment,* magazine published by BNP Media. http//www.process-cooling.com
3) *A Water Conservation Guide for Commercial, Institutional and Industrial Water Users*, New Mexico Office of the State Engineer, July 1999. http://www.seo.state.nm.us/water-info/conservation/pdf-manuals/cii-users-guide.pdf