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Any amount of wasted water is too much. Perhaps it's time to compare your maintenance procedures to current best practices. Do they measure up?

Water is an undervalued utility. Since many consumers essentially view it as a “free” resource, many plants make little effort to conserve water the same way they try to conserve fuels and electricity. While countless opportunities to conserve Btus and kilowatts have been explored over the past 30 years, less attention has been paid to reducing water consumption. But things are changing…

Severe droughts, like those seen in the Southeast and Southwest, combined with rapid population and industrial growth in those and other water-stressed regions, have created a water crisis in many parts of the United States. The available supply of fresh water is decreasing as residential customers compete with industry for available water supplies. (Witness the lawn sprinkling and car washing bans in many communities. Agriculture, the largest consumer of water, increasingly relies on irrigation to offset drought conditions that limit yields. Residential customers accuse farmers of drawing down the water table and causing local shortages. Meanwhile, government regulatory agencies are hesitant to wade in to restrict water withdrawal rates or raise usage fees force conservation, since most consumers view the plentiful supply of safe, clean water as an inalienable right.

The conflict is intensifying. What’s worse, scientific and government forecasters predict no relief is in sight over the next decade. Blame it on global warming or not, the need to conserve water is here to stay.

On the bright side, most plants already have a water conservation program under way. It’s called a cooling tower. As shown in Fig. 1, cooling towers conserve water by recycling it through equipment such as mechanical chillers, turbine condensers, air compressors, oil coolers and

process heat exchangers. In the process, unwanted heat is removed and then rejected to the atmosphere by evaporative and convective cooling.

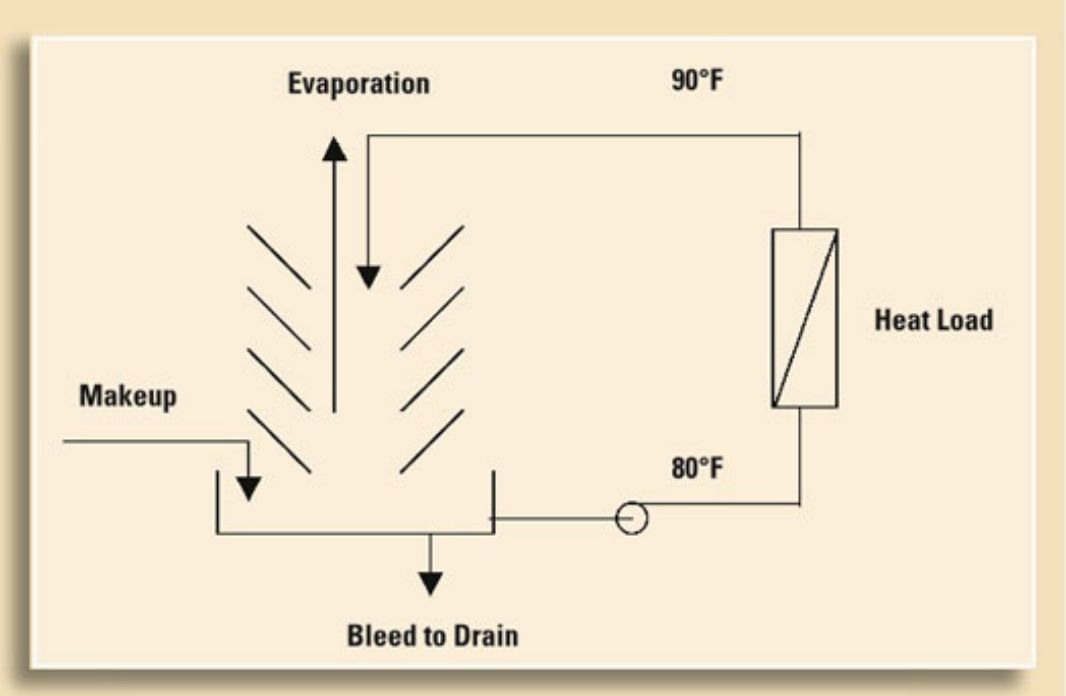

Fig. 1. Cooling towers conserve water by recycling hot water back to the tower where the heat is rejected to the atmosphere by evaporative cooling. The water lost to evaporation concentrates the dissolved minerals in the tower. The bleed controls the concentration ratio. Fresh makeup is added to replace water lost to evaporation and bleed.

It is estimated that over 1,000,000 cooling towers—that's one million—are in service. They are used in every conceivable application where water conservation is a concern, including electric utilities, oil refineries, steel mills, manufacturing facilities, pharmaceutical plants, food processing operations, hospitals, universities, commercial buildings and many more.

Interestingly, plant maintenance teams play a critical role in keeping their cooling towers operating at peak efficiency. They focus on keeping plant equipment clean by preventing mineral scale deposits, mitigating corrosion, limiting bacteria growth, and controlling fouling. Because of the growing importance of water conservation, however, best maintenance practices have been updated to cover the operation of cooling towers in a way that reduces fresh water withdrawal rates and produces less wastewater. That means if you are still maintaining your cooling tower the same way you did five years ago, it's time to upgrade to the newer water conservation format.

Cooling tower basics Cooling towers work by evaporative and convective heat transfer. As water flows over the tower, some of it (about 0.1% of the flow) is evaporated to the atmosphere. About 1000 Btus of heat is removed for every one pound of water evaporated. Removing this heat from the bulk of the cooling water decreases the temperature by 10 to 15 degrees. On average, 75% of the heat rejected at the tower is by the evaporative cooling process; 25% of the cooling occurs due to the direct contact of cooler air with the warmer water. This varies, of course, based on weather conditions. If the air temperature is warmer than the water temperature, for example, all of the cooling takes place by the evaporative process. When the air is colder, such as during the winter, more heat is removed by convective heat transfer.

The water that is evaporated from the tower is pure—that is, it doesn't contain any of the dissolved minerals present in the raw water supply. As the evaporation process continues, these minerals concentrate in the cooling water. If this is allowed to continue without limit, the dissolved minerals soon concentrate to a point where they can no longer remain in solution. Here the less-soluble minerals such as calcium and magnesium precipitate to form an insoluble sludge, or an adherent, dense scale in the tower basin or within plant equipment. For these reasons, cooling towers must be operated to keep the dissolved minerals soluble. This is accomplished by bleeding a small amount of tower water to drain while replacing the water lost by evaporation and bleed with fresh makeup. The ratio between the dissolved solids in the cooling water and the dissolved solids in the makeup is called the "concentration ratio," "cycles of concentration" or, more simply, "cycles." This is an indication of how efficiently the cooling tower is recycling water. A simple way to measure cycles is by calculating the ratio of the specific conductance of the cooling water to the specifi c conductance of the makeup. Alternatively, if the cooling tower has a water meter on the makeup and bleed lines, you can estimate cycles by computing the ratio between the gallons makeup to the gallons bleed. The cycles determined by either method should be in fairly good agreement assuming there are no uncontrolled water losses due to leaks or an overflow condition.

Establishing the proper operating limit for cycles is one of the supercritical decisions one faces in cooling tower maintenance. Towers that operate at high cycles use less water and produce less waste than towers that operate at lower cycles. The maximum permissible cycles of concentration are limited by the makeup water quality, bleed rate and uncontrolled water losses. Set the cycles too high and you risk running the tower under scale-forming conditions. Set it too low and you waste water, chemicals and energy.

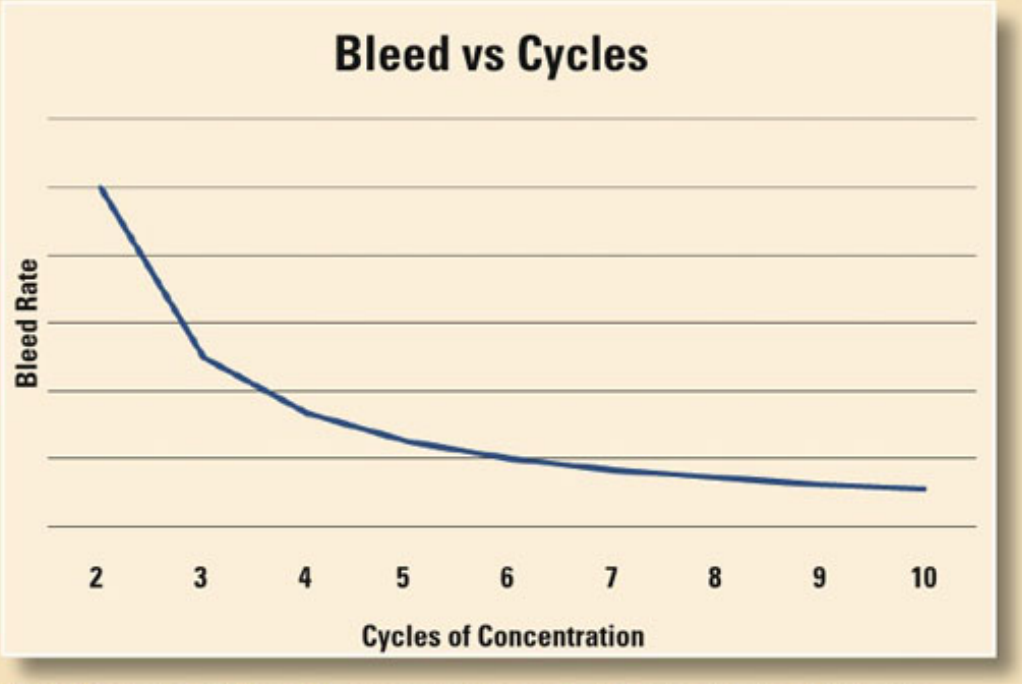

Fig. 2. The required bleed decreases as the cycles of concentration increases. Operating a cooling tower at high cycles minimizes the bleed rate and saves water.

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Table I. Efficiency Determined By Cycles Of Concentration

CYCLES OF CONCENTRATION	PERCENT WATER EFFICIENCY
10	100%
9	98.8%
8	97.4%
7	96.4%
6	93.8%
5	90.0%
4	84.4%
3	75.0%
2	56.3%

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