

Cooling Tower Bypass Filtration

A Green, Proven Cost Reduction Technology

TAB 01/09



Due to the large air-water interface needed to obtain good evaporative cooling, the water in a cooling tower is always contaminated with various airborne debris. In addition to airborne debris, various solid contaminants can get into cooling water from process leakage, the makeup water, and internal system corrosion. These various contaminants (suspended solids) form what is commonly referred to as waterborne deposits within the cooling system. Waterborne deposits are a major problem as they substantially reduce heat transfer efficiency, cause accelerated corrosion under the deposit, and increase pumping energy due to restriction of water passages.

Waterborne deposits reduce heat transfer efficiency which substantially increases the energy cost for operation of chillers. For instance, a deposit thickness of just 0.015 inch on a chiller heat exchanger reduces its heat transfer efficiency by about 12.5%, which on a 500 ton annual cooling load will increase electrical power costs by approximately \$36,000/yr.

The corrosion rate under a deposit is generally from 5 to 20 times higher than clean surfaces. This effect is caused by the creation of an electrochemical cell between the area under the deposit and adjacent clean surfaces, with the under deposit area becoming the metal losing anode in the cell. Corrosion rates are also increased under a deposit as waterborne corrosion inhibitors are restricted from reaching the deposit covered metal surface, thus reducing their effectiveness.

Suspended solids in cooling tower systems have traditionally been controlled by system blowdown and use of effective polymer dispersants. Due to the increasing concerns with water use and the desire to reduce wastewater discharges, many cooling towers are now being operated at higher cycles of concentration than in the past. Operation at higher cycles increases the problems presented by suspended solids due to reduced blowdown and subsequent higher concentration of suspended solids in the cooling water leading to increased deposition.

Suspended solids can be effectively removed from cooling water via bypass (sidestream) filtration, allowing high cycle operation while avoiding deposition problems. While bypass filtration will improve operation of any cooling tower system, its use is mandatory when cooling systems are operated above six (6) cycles of concentration or in a dusty environment such as Phoenix, AZ. Unfortunately, many of the filtration devices currently marketed for this purpose are marginal in their efficacy and, in some cases, may actually degrade overall cooling system performance and increase operating costs due to excessive backwash.

Cooling Water Suspended Solids

To determine which filtration device(s) are best applied to filtration of cooling water, the size of the suspended solids causing the problem must first be determined. In treated cooling waters, suspended solids below the size of 2 microns (clays) are readily dispersed by the polyacrylate and polymaleic polymers commonly used for this purpose and are thus of little or no concern as they remain suspended in the water and thus will not form deposits.

Particles above 60 micron are very uncommon in most cooling water applications due to their weight, which makes them difficult to entrain in the cooling tower air stream and thus enter the cooling water system. Accordingly, we find that the critical size range for filtration of cooling water is suspended solids of 2 to 60 microns in size. Based on extensive analysis of many cooling water, we believe that a good control point for operation of cooling tower systems is to maintain the suspended solids level in the treated cooling water at less than 5 mg/l.

Filtration Device Review

Looking at the devices commonly specified for cooling water filtration, we find various automatic screen filters, hydrocyclones, cartridge filters, sand filters, and multimedia filters.

Screen Filters: These devices consist of a screen through which the cooling water is passed, suspended solids larger than the screen openings being retained on the screen. When sufficient suspended solids have accumulated on the screen to result in a set pressure drop, it is cleaned by either mechanical means or backflushed. Both cleaning methods result in discharge of a wastewater containing the removed higher suspended solids.

We do not recommend use of screen filters for cooling water applications because in the critical size range of 2 to 60 microns they require frequent backwashing to remain on-line. This required frequent backwashing has been observed in many installations to actually reduce cycles of concentration below that desired, wasting water and treatment chemicals and increasing wastewater discharge.

The frequent backwashing is a result of the fact that screen filters are a surface filter, when the surface becomes loaded, it stops filtering. Put another way, the suspended solids loading capacity of a screen filter is very low.



Hydrocyclones: Suspended solids are removed from water in a hydrocyclone by the centrifugal force developed as the water passes through the device. Solids removal capacity is a function of particle size, shape, density, and device design. Removed solids are generally discharged by an intermittent flow from the bottom of the unit.

Hydrocyclones marketed for cooling water use are limited in that the minimum size particle they can remove is about 25 microns, leaving the critical size particle range between 2 and 25 microns in the cooling water to form deposits. Due to their inability to remove suspended solids in this range, hydrocyclones are not recommended for cooling water filtration.

Cartridge Filters: A cartridge filter is basically a screen filter without mechanical cleaning or backwash ability. As a surface filter, they suffer from the same low solids loading capacity as screen filter with the major difference being that once the cartridge loads up with retained suspended solids, it must be removed and cleaned, or replaced with a new one. While not commonly recommended, properly sized cartridge filters can be used for small cooling towers with low suspended solids load or zero discharge systems.



Sand Filters: Suspended solids are removed from water in a sand filter by retention on a porous bed of sand media. The units operate with a combination of surface and depth filtration dependent upon the size(s) of the sand media used and the suspended solids present. They are relatively popular for cooling water filtration and, in general, do a good job as long as the solids loading is not too high and smaller particles, less than 10 microns in size, are not a major problem. Retained solids are removed from the media bed by backwashing based on either time on line or differential pressure across the bed.



Multimedia Filters: These are a variation on the sand filter in that several different sized media are used to obtain maximum depth filtration with very high removal efficiency for suspended solids in the critical size range of 2 to 60 microns. The filter media bed consists of layers of filter anthracite, silica sand, and garnet sand with a bottom gravel support. Use of a layered filtration bed gives a much higher solids loading as compared to sand filters, thus minimizing water and chemical use as the unit will backwash fewer times for the same solids removal. The size differential between the various media gives excellent retention, particle removal down to less than 0.5 micron with 90% of particles 5 micron and larger and 98% removal of particles at and above 10 microns. The density of each media varies so that the different sizes used will self sort when cleaned by backwashing. As with sand filters, retained solids are removed from the media bed by backwashing based on either time on line or differential pressure across the bed.

Multimedia filters are highly recommended for cooling tower bypass filtration use due to their high efficiency in the critical suspended solids range and high solids loading capacity, which minimizes use of backwash water and costly water treatment chemicals.

Bypass Filter Sizing

For typical operating conditions, a cooling tower bypass filter should be sized to flow at the lower rate of either 10% of overall system flow or to provide a system volume turnover in 12 hours. Accordingly, looking at an example 500 ton thermal capacity cooling tower system operating at 1,500 gpm with a system volume of 7,500 gallons:

$$\text{filter flow rate on system flow rate} = 1,500 \text{ gpm} \times 0.10 = 150 \text{ gpm}$$

or

$$\text{filter flow rate on system volume} = 7,500 \text{ gal}/12 \text{ hr} \times 60 \text{ min} = 10.4 \text{ gpm}$$

We would thus select a bypass multimedia filter with a flow rating exceeding 10.4 gpm.



Operation

Bypass multimedia filters can be operated using water supplied by the cooling system if adequate flow and pressure is available. Generally, a bypass filter will require the water to be filtered at its rated flow rate with a minimum water pressure of 30 psi. In the event that sufficient flow at this pressure cannot be provided by the cooling system, a separate appropriately sized pump should be supplied.

Backwash is initiated when the differential pressure across the media bed reaches a value of 10 to 15 psi and generally utilizes cooling system water. Fiberglass media tanks are generally good for operating pressures up to 100 psi, stainless steel, or coated steel, tanks are recommended for higher pressure use.



Large dual tank, PLC controlled multimedia filter as manufactured by ProChemTech

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