

Cooling Tower Sidestream Filtration

A Green, Proven Cost Reduction Technology

TAB0411



Typical crossflow cooling tower installation

Due to the large air-water interface needed to obtain good evaporative cooling, the water in a cooling tower is always contaminated with 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 sidestream filtration, allowing high cycle operation while avoiding deposition problems. While sidestream filtration will improve operation of any cooling tower system, its use is mandatory when cooling systems are operated above eight (8) 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 30 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 30 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 suspended solids.

We do not recommend use of screen filters for cooling water applications because in the critical size range of 2 to 30 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 30 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.



Skidded automatic sand filter



Automatic multimedia filter

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 30 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 sidestream 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.

The following data was obtained before and after installation of a sidestream multimedia filter on a large energy plant cooling tower in Arizona. On a volume basis, this installation reduced the suspended solids loading from 8,793 cmm/100l to 233 cmm/100L. (cmm= cubic millimeter)

Before Filter Micron Range	Particle Count			Particle Volume		
	per 100 ml	Range %	Cumulative %	cmm/100 L	Range %	Cumulative %
0.5 - <1.0	1,379,480,200	96.6	96.6	156	1.8	1.8
1.0 - <5.0	38,051,200	2.7	99.3	116	1.3	3.1
5.0 - <10	5,262,400	0.4	99.7	595	6.8	9.9
10 - <15	2,681,000	0.2	99.9	1,868	21.2	31.1
15 - <20	1,223,600	0.1	100.0	2,623	29.8	60.9
20 - <30	616,400	0.0	100.0	3,435	39.1	100.0

turbidity of cooling water sample = 55 ntu

After Filter Micron Range	Particle Count			Particle Volume		
	per 100 ml	Range %	Cumulative %	cmm/100 L	Range %	Cumulative %
0.5 - <1.0	85,894,610	96.4	96.4	10	4.3	4.3
1.0 - <5.0	2,724,042	3.1	99.5	8	3.6	7.9
5.0 - <10	351,058	0.4	99.9	40	17.1	25.0
10 - <15	81,366	0.1	100.0	57	24.4	49.4
15 - <20	23,302	0.0	100.0	50	21.4	70.8
20 - <30	12,224	0.0	100.0	68	29.3	100.1

turbidity of cooling water sample = 2.3 ntu

This data clearly shows that the major volume of cooling tower water suspended solids was in the range of 5 to 30 microns and that installation of a multimedia sidestream filter substantially reduced the overall volume of suspended solids capable of forming deposits in the cooling system. It is clear from this data that the common practice of using a hydrocyclone as a sidestream filter for cooling towers is a waste of money as most of the suspended solids present are too fine to be captured by such devices.

Sidestream Filter Sizing

For typical operating conditions, a cooling tower sidestream 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 sidestream multimedia filter with a flow rating exceeding 10.4 gpm.

Operation

Sidestream multimedia filters can be operated using water supplied by the cooling system if adequate flow and pressure is available. Generally, a sidestream filter requires a minimum pressure of 30 psi for proper operation. 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 on either differential pressure, when it hits 10 to 15 psi across the bed, or by time on-line, and can use either cooling system water or fresh 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.

We have found that controlling backwash by time on-line gives better control of the filter unit and makes for a generally more reliable, simpler to maintain installation.



400 gpm dual tank multimedia filter - PLC controlled as manufactured by ProChemTech

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