Filtration Guide

Introduction

Often, owners and operators overlook the impact that evaporative cooling equipment efficiency can have on profits. Even a marginal improvement in the efficiency of evaporative cooling equipment, heat exchangers, and chillers can offer owners significant savings over the lifespan of the cooling system. Improving the water quality in the cooling loop is a simple, cost effective method of realizing efficiency gains.

In evaporative cooling equipment, airborne debris like silt is entrained in the fluid flow. Dirty make-up water can also contribute to the build-up of contaminants. Other issues may arise from scale that builds up and flakes off inside the tower, treatment chemical residue, and algae that can build-up and contaminate the circulation water. These are just a few sources of unwanted contaminants that can build-up over time and lead to poor water quality.

BAC recommends a mechanical filtration system and a water treatment program specifically tailored for each installation to ensure high water quality. Both must be used in order to effectively treat the water in a cooling system. Properly treating water in a cooling system leads to cost savings and higher efficiencies allowing evaporative cooling equipment to operate as specified by the manufacturer.

Benefits of Clean Water

1. **Reduced energy consumption**
   As little as a 1/16" layer of dirt, scale, or biological deposits on heat transfer surfaces results in a loss of cooling tower efficiency, increasing energy costs.
2. **Improved chemical performance**
   Dirty water requires more chemicals to treat than clean water because a build-up of solid contaminants provides a buffer that reduces the effects of treatment chemicals. Additional chemicals are then necessary.
3. **Lower maintenance cost**
   Frequently draining a tower and cleaning sediment increases labor requirements, and results in added costs to replace lost water in the system and provide additional chemicals.
4. **Improved productivity and less downtime**
   Fouling a cooling system slows production because machines cannot run efficiently. A fouled heat exchanger could take a system down for an extended period of time until repairs are complete, resulting in less production per day and lost profits.
5. **Control of biological growth that can lead to health problems**
   Legionella, bacteria that thrives in improperly maintained cooling tower environments, is particularly important to control because it poses significant health risks. Reducing outbreaks of the disease Legionellosis is discussed in ASHRAE Guideline 12-2000, entitled "Minimizing the Risk of Legionellosis Associated with Building Water Systems." Visit www.BaltimoreAircoil.com to secure a copy of this important document.

NOTE: Ultimately, achieving clean water on a daily basis when using a filtration system requires routine water analysis, an effective water treatment program, and a training program for maintenance employees. Water treatment programs are application specific, please contact your local water treatment specialist to diagnose the needs of a system.

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Successful Filtration

A typical 200 ton cooling tower operating 1,000 hours a year may assimilate upwards of 600 lbs. of particulate matter into the water supply from airborne dust and makeup water. The tower basin or remote sump provides a perfect environment for unwanted particulate matter to settle and accumulate (ASHRAE handbook, 2008 Ch 39.13). The wet and warm conditions of the basin or remote sump encourage bacteria growth. Chemical water treatment does control the effects of these microbial organisms, but alone it does not serve to eliminate the habitat that promotes the proliferation of organisms. Using a mechanical filtration system does not supplant chemical treatment. Nonetheless, chemicals cannot reduce particle build-up. Reducing the build-up of particulate contamination, the breeding grounds for microbial organisms, can be achieved via proper mechanical filtration.

Successfully filtering cooling tower water depends on the system designed. Successful design is dependent on how well the owners and system designers understand their contaminant problems. Understanding the contaminant problem is a function of knowing the size and type of contaminants that must be filtered in order to achieve system protection. The method of filtration is generally cost driven; there exists a clear best choice in method but sometimes at a cost premium. Once the method of filtration is known, the most appropriate filtration equipment to filter the system can then be determined based on the properties of the contaminant.

NOTE: Mechanical filtration systems are not to be used alone. In addition to filtration, water treatment is necessary to ensure high water quality. For more information please see the “Water Quality Guidelines” section on **page J253.**

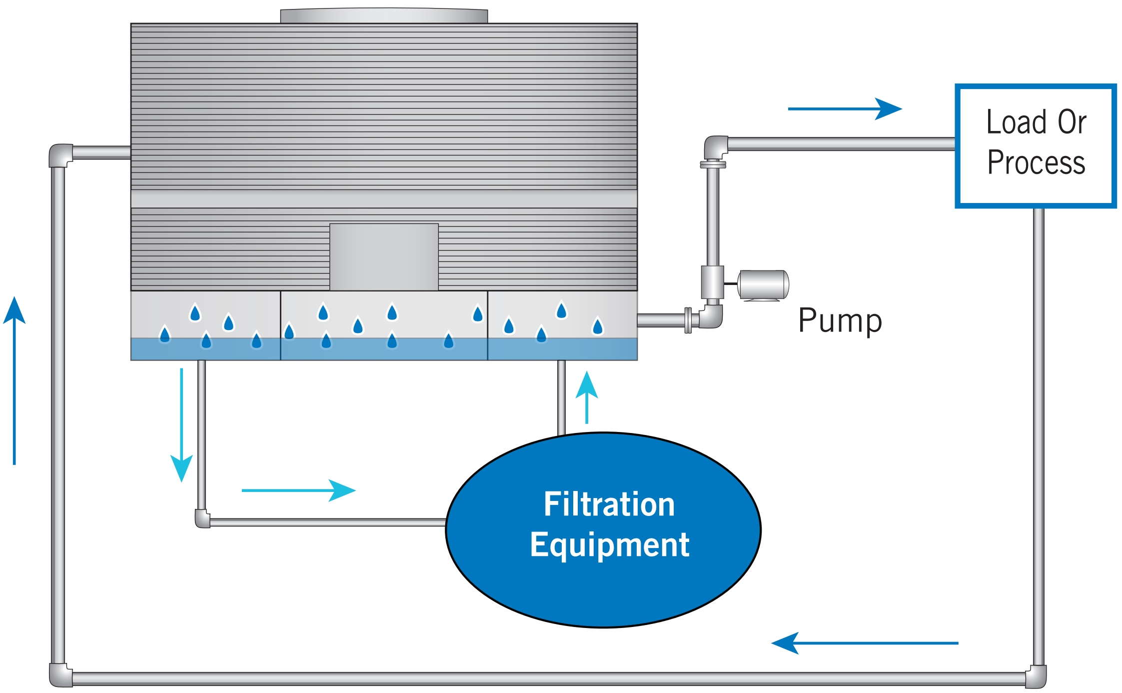
Methods of Filtration

The following methods of filtration are not to be confused with the use of pump suction strainers, which must be used on every cooling tower. Pump suction strainers are standard on properly designed cooling towers and are just the beginning of filtration for a system. Pump suction strainers are located on the outlets of units and prevent large debris, such as sticks and stones, from entering the system. BAC provides pump suction strainers standard on all units with the exception of remote sump applications.

Basin Cleaning

Basin cleaning is a common method of filtration that directly prevents solids accumulation in the unit basin or remote sump. One method of applying basin cleaning as a means of filtration involves drawing water from the unit basin/sump to the filter package and then pumping the filtered water directly back to the tower basin (**Figure 1**).

Without a mechanical system, basin cleaning is often done by hand using maintenance crews. This requires a high level of maintenance and is not as efficient as using a mechanical system. Furthermore, a mechanical system provides continuous maintenance while a maintenance crew can only provide interval maintenance; continuous maintenance ensures a cleaner system. Also, the maintenance crew faces health risks if the crew is cleaning a contaminated system. Basin cleaning is best achieved via a pattern of specialized nozzles that create a directed turbulence of flow designed to influence particles toward the basin cleaning package's pump intake. An important element to making this approach work effectively is adhering to the flow and pressure requirements (20 psi or 1.4 bar minimum at the nozzle header) of the chosen nozzles in order to achieve the necessary flow to sweep the solids in the basin/sump and prevent troublesome accumulation. Inadequate flow/pressure to these nozzles dramatically reduces their effectiveness and the ability of the system to direct solids toward the pump intake and into the filter. The size of a basin sweeping filtration package is based on the planned area of the unit's basin or remote sump.



Basin Cleaning Protection

Figure 1. Basin Cleaning

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A simple guideline is:

Water Depths	USGPM Filtration Flow Rate[1]
Less than 3 feet or 0.9 meters	1 USGPM per square ft (2.44 m^3/hr per m^2)
Greater than 3 feet or 0.9 meters	1.5 USGPM per square ft (3.66 m^3/hr per m^2)

NOTE:

1. Refer to the submittal for the product specific flow rate.

This approach takes control of getting the solids to the filtration system and virtually eliminates solids build up in the tower basin. However, basin cleaning does not directly filter the water that is pumped into the heat exchangers and chillers. From a maintenance standpoint, basin cleaning improves the cycles of maintenance for cooling towers but does not address maintenance issues in the heat exchangers or chillers. Full flow and side stream filtration are methods that do provide direct protection to the heat exchanger and chillers, but do not prevent solids accumulation in the tower basin.

Full Flow and Side Stream Filtration

Full flow and side stream filtration are the two most common methods that are used to directly protect the heat exchangers and chillers. Full flow filtration utilizes a filter installed after the cooling tower on the discharge side of the pump. This filter continuously filters the entire system flow, meaning that the filter must be sized to handle the system's design flow rate. Thus, a flow rate of 300 USGPM requires a filter sized to treat 300 USGPM. Full flow filtration reduces heat exchanger and chiller maintenance significantly and improves the operating cycles of the equipment as well. Full flow filtration is the preferred method of filtration but is not cost effective for systems with high flow rates. For example, a 400 ton cooling tower with a flow rate of 1,200 USGPM would require a filter sized to treat 1,200 USGPM. This requires a system that must be very large to accommodate the 1,200 USGPM flow rate; a system this large will incur high expenses. Also, for a system this large, decreases in flow rates may not be detected easily. This decrease could result in an increase in pressure on the pump discharge and not allow fluid to flow to the heat exchanger properly, leading to a decrease in heat transfer. Furthermore, full flow systems cannot run and be cleaned at the same time, which means that maintenance results in some planned downtime. Although full flow filtration reduces the overall solids concentration in the water pumped to the heat exchangers and chillers, this method does not address the problem of solids accumulation in the tower basin or remote sump.

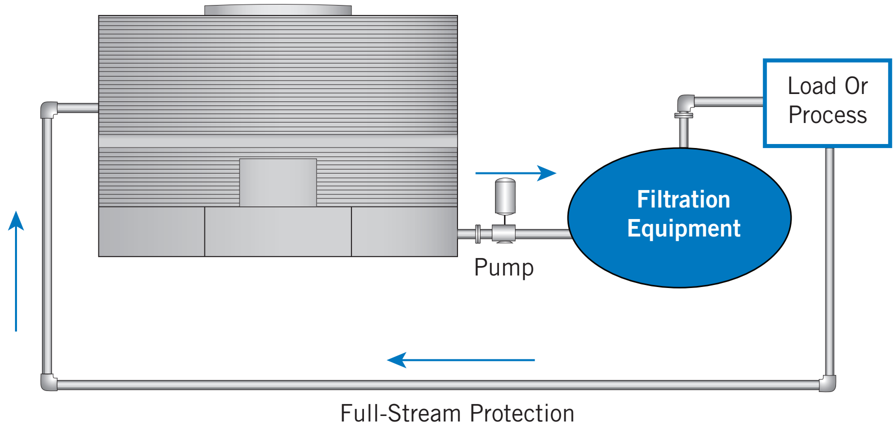

Figure 3. Full Stream Filtration

Side stream filtration is a cost-effective alternative to full flow filtration because it continuously filters a percentage of the flow instead of the entire flow. Side stream filtration can reduce maintenance and improve operating cycles of equipment in the cooling loop. This method involves removing particles at a higher rate than accumulation. The water is pumped from the cooling tower cold water basin, through the side stream filtration system, into the heat exchangers and chillers, and then returned back to the cooling tower basin. This method is used most often when full flow is extremely high, causing full flow filtration to be financially infeasible. One key advantage over full flow filtration is that the side stream filtration system can be cleaned without having to go offline, resulting in no planned downtime for maintenance. Like full flow filtration, this method reduces the overall solids concentration but does not address the problem of solids accumulation in the tower basin or remote sump.

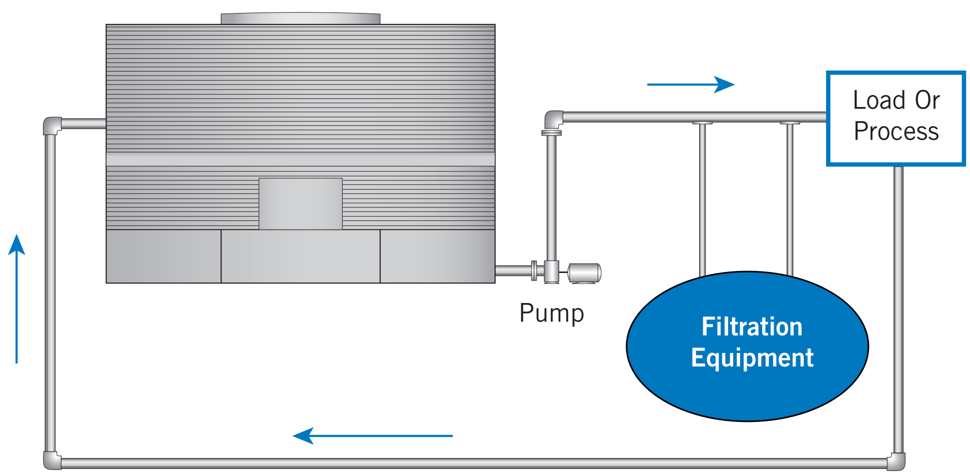

Figure 4. Side Stream Filtration

Properly sizing a side stream filtration system is critical to achieve optimum filter performance. An often used guideline is to size a filter that can handle a flow rate that turns the system volume over once an hour. This flow rate generally ranges from as low as 3% up to 10% and is typically determined by the turnover rate of the system volume per hour. For example, consider a 400 ton cooling tower with a flow rate of 1,200 USGPM. The estimated system volume will be approximately 3,500 gallons. In order to turn this system volume over once an hour, a 58 USGPM flow rate will be required, as demonstrated below.

Approximate system volume = 3,500 gallons

In order to turn the entire 3,500 gallon system volume over once an hour: 3,500 gallons/hr * 1 hr/60 min = 58 USGPM side stream flow rate.

A 58 USGPM side stream flow rate is 4.83% of the 1,200 USGPM flow rate for a 400 ton cooling tower (58 USGPM/ 1,200 USGPM * 100 = 4.833%). Side stream filtration percentages at 3% or less of the total circulation flow rate have been shown to severely damage HVAC systems, promoting fouling throughout the cooling loop. Therefore, the best designs avoid using low filter specifications. For the same level of purity, side stream filtration does bring the water to the same level of purity that full flow filtration does but the process just takes longer. Since only a percentage of the water is filtered at a time, some solids do bypass the filter and remain in the fluid flow, but eventually these solids reach the filter again and are removed as water is re-circulated through the cooling loop. Keeping in mind that the entire system volume is turned over once an hour, particulates that escape the filter the first time are caught in subsequent rounds of filtration.

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At first glance it would seem that full flow is preferable over side stream filtration because full flow filtration, comparatively, reduces heat exchanger and chiller maintenance more significantly and creates larger improvements in the operating cycles of this evaporative cooling equipment. However, full flow filtration cannot be justified financially for systems with high flow rates and requires planned downtime for maintenance of the filtration equipment, making side stream filtration a more desirable choice in most applications. Regardless, side stream filtration easily improves the water quality to an acceptable level that will ensure proper protection of the heat exchangers and chillers. Neither the full flow nor side stream method of filtration addresses solids accumulation in the tower basin or remote sump.

The very best filtration practice is to employ basin cleaning (as discussed on **page J243**) along with full flow or side stream filtration. Basin cleaning ensures that particulates are directed towards the filter inlet and that these solids do not accumulate in the cooling tower basin. Once the particulates reach the filter inlet, the equipment chosen for full flow or side stream filtration will remove the remaining unwanted particulates, thus providing clean water to the heat exchangers and chillers. Using basin cleaning with full flow or side stream filtration directly protects the cooling tower, heat exchangers, and chillers, providing the ultimate reduction in maintenance while improving the efficiency of equipment in the evaporative cooling loop.

Common Filtration Equipment

Common filtration technologies that are applied to full flow and side stream HVAC applications include screen (self cleaning filters), centrifugal separators, cartridge filters, bag filters, sand media filters, and disc filters. Aside from proper filtration, the best filters require the least maintenance and use the least energy, satisfying cost efficiency.

Screen (Self Cleaning) Filters

Also known as self cleaning filters, strainers are used often in full flow filtration. Screen filters employ steel mesh screens that remove large, heavy particulates such as sediment. Bypass piping needs to be installed with screen filters to allow the screen to be removed for cleaning. In areas of poor water quality, screens should be oversized to provide a larger surface area to operate, which minimizes the frequency of maintenance related to not having a large enough screen. Screen filters have moving parts that allow a backwash cycle to self clean the filter. Because of these moving parts and how the screen filters are designed, they require frequent maintenance.

Centrifugal Separators

Centrifugal separators, commonly known as separators, are often used in full flow filtration. Separators create a vortex that spins particle contaminants out of the entering fluid. A downside to this turbulent spinning is that it causes separators to operate at a pressure loss, usually about 5 to 10 psi. A separator does not need to be replaced often because it is not trapping any particles that clog or damage its system, making separators an economical option for filtration. In the HVAC industry, separators are preferred over screen filters because separators require less maintenance and replacement, but are just as effective at achieving the proper level of filtration.

Cartridge, Bag, and Sand Filters

Cartridge filters, made of polypropylene (a plastic), trap particle contaminants as water passes through the filter media. One advantage of cartridge filters is that once the filter becomes dirty, an automatic backwash cycle is initiated to clean the filter. Nonetheless, these cartridge filters must be replaced over time as they wear out. Bag filters, generally made of polyester, are widely used in the HVAC industry because bag filters are low in cost. Like cartridge filters, bag filters must often be replaced. Sand media filters distribute contaminated water over a sand medium bed capable of filtering out particles. The sand filter steel media does not require regular replacement. Sand filters use an automatic backwash cycle to clean the filter media, which lends to fewer maintenance intervals.

Cartridge and bag filters are relatively inexpensive, but their filter elements are consumable and require regular replacement. This incurs high costs, as the owner must continuously replace the cartridges and bags along with paying for labor each time. In comparison, the media of sand filters does not have to be replaced as often, making sand filters less expensive in the long run. The sturdiness and self cleaning feature of sand filters further eliminate maintenance errors related to not replacing filters often enough or at the right time, a problem that can plague owners of cartridge and bag filters.

Disc Filters

Another side stream filtration technology is a disc filter. Disc filters, made of polypropylene, use a series of stacked discs compressed together that are grooved to filter a specific micron size. Like screen and sand filters, disc filters have an automatic backwash cycle for self cleaning, which provides reduced maintenance. Another advantage to using a disc filter is that it uses much less water than other self cleaning filters that utilize backwash cycles. These energy savings can be offset, however, by a comparatively higher pump horsepower required for disc filter backwash cycles. Furthermore, the discs are consumable elements that have to be replaced often. Nonetheless, disc filters are a viable option for side stream filtration.

Summary

The remainder of the article will focus on the specific characteristics of centrifugal separators and sand filters, currently the most commonly used filtration equipment in the HVAC industry. Due to the reduced maintenance requirements (resulting in lower operating costs) of separators, sand filters, and disc filters, owners typically prefer these filters over others. The disc filter is a newer technology that has proven successful and could eventually become as popular as separators and sand filters in the industry. Screen, cartridge, and bag filters have been found to require a high level of maintenance, which makes it difficult to justify these options as long term filtration solutions.

NOTE: Mechanical filtration systems are not to be used alone. In addition to filtration, water treatment is necessary to ensure high water quality.

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Particle Size: Separators vs. Sand Filters

Centrifugal separators work well for both full flow and side stream applications. Sand filters are generally used for side stream applications as sand filters used for full flow can come at a considerable cost for high flow rate systems. The determination of whether to use a centrifugal separator or sand filter typically depends on the size of the particles to be removed, amongst other economic and design factors. The comparison between centrifugal separators and sand filters is addressed in greater detail in the **Appendix**.

When making a decision on which equipment to use, one item of focus is the size of the particles to be removed, because the two types of filtration equipment discussed here have distinct capabilities in this regard. Centrifugal separators, for example, are proven capable of removing relatively large (over 40 micron) particles, but not lightweight contaminants. Centrifugal separators remove suspended particles out of fluid by relying on the velocity of a vortex that exerts force on the suspended particles to remove them from the fluid. The effectiveness of this process depends on the size and density (measured in specific gravity) of the particle relative to the density and viscosity of the fluid. As particles become smaller than 40 micron, the particles require too much force for a centrifugal separator to efficiently remove them. Sand filters, on the other hand, perform well at removing these lightweight particles. However, particles larger than 25 micron can be problematic for sand filters because these larger particles are difficult to remove from the media bed. The efficiency of a sand filter is affected by particle size only, ignoring the effects of specific gravity.

Use of either centrifugal separators or sand filters is application specific. Applications involving larger, heavier particles (based on their specific gravities) typically dictate the use of a centrifugal separator. When particles that are less than 25 micron in size need to be removed, use of a sand filter is recommended. Consult a water treatment specialist to help determine what options are available for a specific application.

NOTE: A simple method to determine the size of contaminants in a system is to take a water sample from the system, put the sample into a clear container, and then shake the water up. If the particles settle in three minutes or less, then a centrifugal separator can be used. If the particles settle in over three minutes then it is better to use a sand filter.

Particle Removal Analysis

Knowing the size of particle contaminants in the system is important, and it is necessary to differentiate between the size of particles and the quantity of particles. To clarify, designing a filtration system to remove less than 1% of the total particle volume would not be effective, even if a large quantity of particles are removed. It becomes clear why understanding the site specific characteristics of the water being pumped is crucial to specifying the proper equipment, separators or filters, to use in a filtration system. Therefore, when analyzing the size of particles found in a system, it is important to know the total volume of particle matter that needs to be eliminated, not the total number of particles. When it comes to mechanical filtration, a very small percentage of larger particles (10 to 75 microns in size) are of more concern than a high percentage of smaller particles (5 microns or less). Even the Water Quality Association, an authority on drinking water standards in the U.S., recognizes that any contaminants below 5 microns in size are most commonly identified as bacteria, a contaminant that is not removed by filtration, but by disinfection.

Table 1 below offers a comparative and hypothetical example, taking a sample of one trillion particles, and shows the portions of that sample for several particle sizes. As can be seen, if only 15% of the total numerical count of particles is greater than 10 microns, those 15% represent over 99% of the total volume. In an actual cooling water loop, there may be many times this amount, but the relative ratio is still valid and important to consider in terms of which contaminants to be most concerned about. This example shows that even a relatively small quantity of particles 10-75 microns in size can represent a very large total volume of particles. This fact should be considered when determining the particles that are capable of fouling a heat exchanger's small orifice, clogging a nozzle or accumulating in a unit's fill, basin or remote sump.

Size of Particle	Quantity of Particle	Total Volume
0.45 microns	212.5 billion particles	0.006 cubic inches
1 micron	212.5 billion particles	0.007 cubic inches
3 microns	212.5 billion particles	0.190 cubic inches
5 microns	212.5 billion particles	0.890 cubic inches
Sub-total:	**850 billion particles**	**1.088 cubic inches**
10 microns	37.5 billion particles	1.3 cubic inches
25 microns	37.5 billion particles	18.5 cubic inches
50 microns	37.5 billion particles	150.1 cubic inches
75 microns	37.5 billion particles	504.1 cubic inches
Sub-total:	**150 billion particles**	**674.0 cubic inches**

Table 1. Particle Size vs. Volume for a Sample of Particles

Aside from the size of particles to be removed, there are other economic and design factors related to determining the right equipment for filtration. These factors can often influence the equipment purchasing decision depending on the circumstances. The economic factors are the cost of replacement parts, maintenance requirements, space requirements, and the training of personnel. The design factors include the size of the particles to be removed and the allowable levels of the filtration equipment's flow range, pressure loss, and liquid loss. These economic and design factors are highly variable and change dramatically for any given cooling tower application. Whether or not certain factors influence a purchasing decision is based on the application.

Conclusion

As noted earlier, high water quality can only be achieved with the use of a professional water treatment program used alongside a properly designed mechanical filtration system. Determining the right equipment and method for filtration is a key component of designing a mechanical filtration system that works. Proper filtration can reduce energy consumption, improve chemical performance, reduce the amount of necessary maintenance, improve machine productivity, and limit bacterial growth. The system improvements that result from a good water treatment program will lead to cost savings. Deciding on the type of filtration equipment to use depends on the application and economic desires of the purchaser.

Acknowledgement:

BAC extends its sincere appreciation to Kathy Colby of LAKOS Separators and Filtration Solutions for her contributions to this article.

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Appendix: Common HVAC Filtration Equipment

Sand Filters

Widely known, sand filters direct fluid into the top of their tank(s) and onto the surface of a bed of specified sand or other media. As the fluid passes through the bed of sand media, the contaminants are captured within the upper layer of media. The fluid ultimately makes its way downward, passing into some form of under drain at the bottom of the filter tank and discharging through an outlet pipe or manifold. The cleaning procedure reverses flow upward from the outlet/manifold (either from other filter tanks in the system or from the main system flow), fluidizing the sand media and back washing the contaminants through the tank's inlet to a backwash line for disposal discharge. Sand filters are most commonly installed in side stream applications. Care must be taken before installing a full flow or basin sweeping configuration because of the potential for interrupted flow during backwash or fouling of the media.

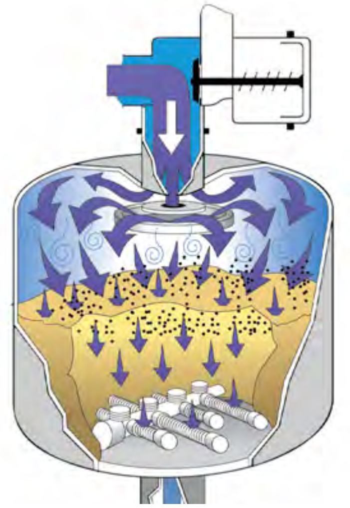

Figure 5. Sand Filter Principle of Operation

Solids Removal – This type of device is most appropriate for lightweight solids, organics and other floating contaminants. Though capable of removing heavier solids, the cleaning/backwash procedure makes it very difficult to rid the sand filter of these solids which may result in a residual build-up and an increasing pressure differential across the filter or excessive back washing frequency. When specified for removing very fine solids, sand filters must either be oversized to reduce the flow rate per-square-foot or the sand media must be upgraded, adding cost and increasing pressure loss through the filter.

Flow Range – The total surface area of a sand filter's media bed and the specified flow rate per-square-inch (20 USGPM/sq ft is typical) dictate the size (diameter) and/or quantity of tanks in a sand filter system. Though some makers use only one large tank, others use multiple smaller diameter tanks. Unlimited flow range capability is offset by the logistics of the size and/or configuration of the overall sand filter system.

Pressure Loss – Pressure loss varies from low (1 psi typical) to high (11 psi). A very low pressure loss through a clean sand filter can be rapidly lost in high solids loading applications.

Liquid Loss – It is not uncommon to lose hundreds or even thousands of gallons of fluid during a backwash cycle. Significant make-up water may also require significant chemical treatment. As a general rule, some sand media is also regularly lost during back washing, resulting in periodic media replacement.

Solids Handling – Solids handling is usually automated as the solids are carried away in the backwash water. Due to the high liquid content handled during a backwash cycle, increasing the concentration of solids in the water is not usually practical.

Replacement Parts – Typical parts manuals for sand filters number eight or more pages. The moving parts and electromechanical hardware for automatic back washing account for most of this requirement. Sand media must be monitored and periodically disposed and replaced. Improper back washing can also lead to contaminant build-up in the sand bed, providing the opportunity for troublesome bacteria to breed and/or accumulate. If oils or grease are present in the system, frequent sand media replacement will be necessary and may be designated as hazardous waste, complicating disposal procedures.

Maintenance Requirements – Back washing can be manually initiated or automatic. Manual operation creates the risk that pressure differential may become excessive and disruptive to the system if not performed regularly and at appropriate intervals. Additionally, infrequent back washing drives the contaminants deeper into the sand bed, making it more difficult to completely backwash the sand filter and resulting in residual build-up, which increases the frequency of back washing/liquid loss.

Periodically, even when properly monitored, it is necessary to shutdown the system and dispose and replace the sand media. In high calcium (hard water) content waters it is also not unusual for mineral build-up to induce the sand media to become a hardened cake, incapable of back washing.

Inspection is recommended monthly in order to sustain proper operating conditions.

Space Requirement – Expect sand filters to demand 10 to 20 times more space than other types of filtration for a given flow rate. Sand filter configurations are also limited for specific ceiling or piping restrictions.

Advantages:

- Sand filters remove fine and light particles
- Improved water clarity
- Easily automated
- Requires no solids handling
- Wide range of particles removed
- Effective over a wide range of flows and pressures

Disadvantages:

- Prone to changing or interrupted flow with solids collection
- Handling of backwash water volume
- Can be maintenance intensive
- Heavy, or precipitated solids pack into sand requiring frequent changing of the sand
- Space can become an issue
- Backwash water volume can be excessive in high solids loading applications

Separators

Separators use centrifugal action to remove solids that are heavier than water by use of a tangential inlet that starts the centrifugal action. More efficient designs utilize internal accelerating slots to increase the velocity, and then allow for settling in a low flow area necessary for the removal of the separable solids. Separated particle matter spirals downward along the perimeter of the inner separation barrel and into the solids collection chamber, located below the vortex deflector plate. Solids removal performance varies widely depending on the design.

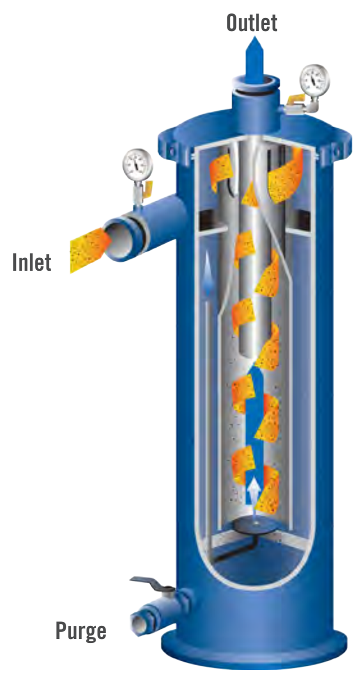

Figure 6. Centrifugal Separator Principle of Operation

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Solids Removal – Separators are proven capable of 5-75 micron performance for particles that are heavier than water. Since the tested performance of centrifugal action separators varies widely among different manufacturers, we encourage third party testing to confirm actual performance at flow rates representing particular site requirements.

Flow Range – Separators feature individual units for 3 USGPM (0.7 m^3/hr) up to 12,750 USGPM (2895 m^3/hr). They can be designed for even higher (or variable) flow rates.

Pressure Loss – Separators operate continuously (no fluctuations) at a steady pressure loss of only 3-12 psi (0.2-0.8 bar). This is an acceptable loss compared to screens and barrier filters, which build-up to very high pressure losses.

Liquid Loss – Separators require no back washing. Low-flow periodic purging or a controlled bleed technique can achieve zero liquid loss. Selected solids collection options ensure minimum liquid waste and easy disposal/recovery of solids collected.

Solids Handling – Evacuation of separated solids should be accomplished automatically by the use of an electrically-actuated valve programmed at appropriate intervals and duration in order to efficiently and regularly purge solids from the separator's collection chamber. Solids can also be concentrated by the use of a solids recovery vessel. In a solids recovery vessel, separated solids are continuously purged under controlled flow into a vessel equipped with one (or three, depending on the separator size needed) 1-50 micron fiber-felt solids collection bag(s). The bags are then manually removed and cleaned or discarded.

Replacement Parts – Separators have no moving parts, and no filter elements or sand media to clean or replace. The purge options (bag filter, or motorized ball valve) for the separator may have replacement parts.

Maintenance Requirements – Separators are purged of separated solids without system interruption. They are easily automated, require no filter cleaning, and no duplicate equipment is needed.

Space requirements – Separators are compact. Larger models may be specified at low or vertical profile and/or with alternate inlet/outlet configurations to accommodate limited space or piping needs.

Advantages:

- Removes a wide range of particles
- No moving parts
- Very minimal to no maintenance requirements;
- Constant pressure drop is better for basin sweeping applications
- Can be installed full flow with low risk for interrupting flow to the main heat exchangers
- Can be automated

Disadvantages:

- Primarily removes only solids that are heavier than water

	Particle Size Removal	Pressure Loss	Maintenance Requirements	Liquid Loss
Sand Filters	Best for fine light particles; avoid heavy coarse particle applications	Low, variable	Back washing; periodic inspection; sand replacement, electromechanical parts	Potentially excessive
Separators	Fine to coarse inorganics only with a specific gravity greater than water	Low and steady	Purge components only - periodic inspection/servicing	None to minimal

Table 2. Advantages and Limitations of Sand Filters and Separators