B uilding owners and those responsible for the design, operation and maintenance of these facilities may often overlook the impact of cooling tower operation on their profit and loss picture.

It is not unusual to incur energy costs of hundreds of thousands of dollars to cool a large facility, to which must be added costs of equipment maintenance and downtime losses.

Even a small efficiency increase and reduction of maintenance requirements may save thousands of dollars each year. The most simple and cost effective method of obtaining these savings lies in improving the quality of the water in these systems.

Water quality has an impact on cooling system performance in several ways. Most aspects of water quality, such as pH, alkalinity, and hardness, can be predicted and controlled because they are governed by universal and invariable chemical mechanisms.

However, one variable, the amount of particulate contaminants or Total Suspended Solids (TSS), defies such easy prediction.

The air that is drawn through the fill of a cooling tower inevitably contains a wide variety of particulates, including dust, soil, soot, organic debris and numerous other materials. These particles are effectively scrubbed from the air as it is pulled through cooling water cascading over the fill, and are concentrated in the sump water.

Particle concentration varies continuously since it is determined by constantly changing factors. These include rain, wind direction, amount and type of traffic, and the activity of neighbors (construction, plant operation cycles etc.) among others.

Urban activities produce huge amounts of particulates and it is not unusual for air over a large city to have 100,000 particles in each cubic centimeter of air.

Compounding this problem, the system itself produces particles. These include corrosion products, mineral precipitates (e.g. iron and aluminum phosphates and silicates), microbial growth, and aggregates of organic polymers, with additional contamination from dissolved and particulate materials leaking from the process side of heat exchange equipment.

When bound together by precipitation of scale-forming minerals, these particles greatly increase the volume of scale and its rate of accumulation.

Similar effects result when particles are bound together by development of a biological fouling layer. These fouling layers decrease heat transfer efficiency, encourage corrosion and increase power consumption.

Suspended solids affect performance more than any other component of water quality. Therefore, removing particles from system water provides numerous benefits.

### Reduced energy consumption

Consider the following formula:

\[
\text{energy costs/annum} = \left(\text{AC tons} \times (\text{kwh/ton}) \times (\text{Load Factor}) \times (\$0.07/\text{kwh}) \times (2500 \text{ h/yr}) \times (\text{hours of operation/yr})
\]

For example, if a 400 ton chiller operating 2500 hours a year at $0.07/kwh were to develop a foul layer 1/1000 inch thick, energy costs would increase by about 10 per cent or $3,430 per year.

### Improved performance

Chemicals used to inhibit scaling and corrosion are adsorbed onto airborne particles instead of on the equipment surfaces that they are designed to protect.

As a result, airborne particles are detrimental to a water treatment program and require more chemicals to produce an effective treatment program.

With respect to microbiological control, suspended solids put an extra demand on some biocides, and if these solids settle out in low flow areas due to poor design, they provide growth sites.

Particles also adsorb biocides, allowing increased microbial growth. Additionally, airborne particles provide habitat and nutrients that stimulate further growth of bacteria and algae.

Water treatment should not be expected to protect surfaces it cannot reach if they are under accumulated sediment.

A filtration system that removes suspended particles allows a water treatment program to operate at maximum effectiveness while minimizing chemical use. The result is enhanced water quality at lower per ton chemical costs.

Traditionally, cleaning a cooling tower
entails draining the tower and removing the sediment from the sump. Frequency is determined by location and system history. This incurs costs for downtime, labour, lost water, lost productivity and water treatment chemicals.

Mechanical filtration reduces and often eliminates these costs. This translates to savings that will quickly justify the cost of a filtration system.

A successful water treatment program will, therefore, include steps to remove or reduce the volume of particles inevitably collected by any cooling system.

The Legionella problem

Today, anyone who operates a cooling tower must seriously consider the threat of Legionnaires’ disease. Research reveals cooling towers to be the one of the various vehicles for conveying this disease.

In 2000, at the Aquarium in Melbourne, 119 people were infected with legionella from the cooling system. Four of these cases resulted in death.

This year in Murcia, Spain, the world’s largest outbreak of legionella infection has occurred, and at last report, over 800 people have been found to be infected, with two deaths.

Although fourteen cooling towers in the surrounding area tested positive for legionella, none have been linked as the specific source.

Has much been done to improve this situation? In the US, the Centre for Disease Control and Prevention (CDC) reports that as many as 90 per cent of LD cases go unreported, and presently, routine checks for legionella are conducted in only one out of five hospitals.

Legionella is a widespread, water-borne bacterium that is found naturally in rivers, lakes, ponds and streams. Natural populations are, however, usually small.

Since make-up water is obtained from these natural sources, it is common for a cooling tower to be infected with legionella that have survived municipal water treatment.

These resistant survivors find the cooling tower a warm, nutrient-rich habitat where they can grow rapidly to form an unnaturally large population.

Cooling towers collect sediment, sludge, and organic materials that can harbour bacteria and promote growth of legionella.

Common microorganisms such as algae and other types of bacteria also promote the growth of LD. A coating of microorganisms and their slimy secretions, called a biofilm, will collect on submerged surfaces.

Legionella pneumophila, and other microbes growing within a biofilm, are shielded from the biocides used to control them.

Legionella concentrations

Studies show that 40 to 60 per cent of all cooling towers are contaminated with Legionella pneumophila, but often at concentrations too low to easily cause infection.

No quantitative estimate of legionella concentrations in cooling towers required to produce disease has been officially endorsed.

All of the recommended strategies for reducing risk have a common thread. First and foremost is “good housekeeping” — keep the system clean.

Get the debris out of the tower basin/sump. Keep the system free of sediment, sludge, and bacteria. Remove the food sources and treat with biocides.

There are two ways to remove dirt from a cooling system. It can be drained and flushed on a regular basis or it can be cleaned continuously by filtration.

The drain and flush approach has an inherent weakness. It allows the build-up of debris and the accompanying problems between cleanings. The system is only clean on the day it is refilled after being drained and flushed.

A filtration system, if designed correctly, removes debris as it collects. This prevents any accumulation of debris that might serve as habitat or nutrients for microbes.

Once the system is clean, a water treatment program should be used to control scale, corrosion and microbial growth. Control of biological growth is the most important of these, with oxidizing biocides reported to be most effective.

A water treatment program should be designed by a qualified specialist who understands the relationship between water chemistry, microbiology and the industrial setting and its possible sources of contamination.

Filtration for clean water

It is impossible to totally eliminate the risk, but it can be minimized with a proper water treatment program and some form of a filter system.

Control of suspended solids is easy to achieve by filtration. Just as a car uses a filter to protect the engine oil, a filter can be added to the cooling tower water to protect the cooling system.

Many think that filtration must treat the full system flow. However, like a car’s oil filter that treats a small portion of the oil at a time, side stream filtration is the most practical and effective way to treat cooling towers.

For example, in the treatment of the entire flow of a 400-tonne cooling tower system, 1200 gallons per minute would require a filter to handle that flow rate.

Due diligence

A Supreme Court judge has said that the victims of the 2000 Melbourne Aquarium outbreak deserve to have their legal claim for damages heard some time this year.

According to The Age, Justice Bernard Bongiorno said the court was prepared to accelerate the complex legal action involving 140 victims, the aquarium and a number of third parties in the construction and maintenance of the centre.

The victims have joined in a class action suit. The Aquarium has recorded a $3,000,000 loss due to the outbreak. Legal action has also been brought against the architect, mechanical engineer, air conditioner supplier, builder and the water treater.

Four people died in the April 2000 outbreak.

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However, it has been found that filtering a side stream flow equalling five percent of the total system flow is all that is needed to control suspended solids. Five percent of 1200 gpm is 60 gpm.

Since the finest particles represent the bulk of the surface area that stimulates undesirable chemical reactions and might be colonised by bacteria, removal of particles as small as five microns is required for effective water treatment and legionella control.

These fine particles are also easily incorporated in fouling and scaling of equipment.

There are several filtration technologies that can be used to accomplish this goal. They include cartridge filters, bag filters, permanent media filters (sand filter), and centrifugal separators.

Cartridge and bag filters are relatively inexpensive, but their filter elements are consumable and require regular replacement.

Centrifugal separators remove particles down to 50 micron, which is not fine enough for very small or low-density particles. However, each of the above is better than no filter.

Permanent media filters

By comparison, permanent media filters have a higher initial cost, but lower operating costs than bag or cartridge filters. This makes them much less expensive to operate and more economical in the long run.

Water entering a media filter is evenly distributed over the media surface, achieving even penetration of the media bed.

As the particles are removed they coat the surface of the media bed, creating a surface layer of particles or ‘Schmutz deck’. This layer of finer particles increases filtration efficiency, allowing removal of particles much finer than the media grain size.

In other words, the dirt removed becomes the filter media for removal of the next particle.

When the permanent media eventually becomes clogged, it is regenerated by backwashing the filter media bed.

This system requires little or no personal attention and can use the same media for years, producing substantial savings in material and labour costs when compared to disposable filter technologies.

Side stream media filters can be installed in two ways.

In an in-line filter installation, taps are put into the condenser circulation line. Here, water is drawn off, filtered, and the clean water returned to the circulation line.

Filter input and output lines should be at least 10 feet apart to avoid retreating the same water.

Sump/basin sidestream filtration removes water from the basin, cleans it, and returns the clean water directly to the tower sump.

This is the system of choice, since it allows use of sweeper jets to direct sediment to the filter inlet to sweep debris from the basin, also keeping the sediment off the basin floor and thereby helping to prevent under-deposit corrosion.

In America, most of the major manufacturers of cooling towers offer the sweeper jet system as a factory option.

Keep your water clean

If you ask yourself what is the goal of a cooling tower, the answer should be to provide the lowest possible cost product.

That product is cold water. Cold water that makes either cold air for creature comfort or cold water that is used to produce a commodity.

To achieve that goal, you need clean water. With both a filter system and well-run water treatment program, it can be done both economically, trouble free, and safely.

There is one simple way to maximise the efficiency of any cooling system, obtain the best economic return on your cooling system investment and protect against spreading disease and the legal exposure this may incur.

Keep your water clean.

Remember, the cooling tower did not cause legionella — dirty water and poor housekeeping did.