ARTICLE

WHY INDUSTRY NEEDS TO REDEFINE SOLIDS FILTRATION IN PROCESS WATER

Steve Cupples, managing director of process water filtration engineering firm Industrial Purification Systems (IPS), together with John A Lewis, microbiologist and group director of Waterman Environmental Group and Chris Mutch, managing director of M & S Water Services Ltd and M & S Water Services (Envirotec) Ltd discuss why industry is still prepared to accept a poor quality of process water filtration, what are the risks of not doing so and why advanced media filtration technology is the answer.

Engineers, manufacturers, utilities, public and private enterprise, commerce in fact any one that uses water for temperature control are, in the most part, quite comfortable in the belief that they are operating an effective and safe water system – but how safe are they really?

The general guidance is that a chemical treatment regime must be put in place with adequate monitoring and that this treatment programme must provide the control of four key elements that can affect any cooling water system.

These elements are listed in the figure below.

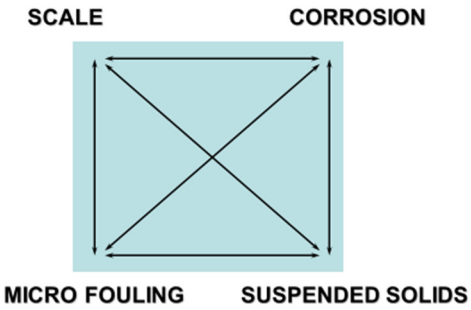


Figure 1. Water treatment Square

Generally water treatment chemicals used together with pre-treatment plants will adequately control the potentials for scale, corrosion and biological fouling.

But what about suspended solids control? Due to the air scrubbing effect of, for example, cooling towers the potential for suspended solids to increase is always present and suspended solids contamination can come from many sources, such as wind blow dust and seeds, pipework corrosion, system contamination from process, changes in raw water make-up or other local issues.

Of equal importance is the potential for air born microbiological spores to be sucked into the cooling water as air is either induced or forced through the tower. Most cooling tower operators are unaware of the

number of air born spores that are present at their particular cooling tower location, the types and number of spores will vary on a seasonal basis as well as a geographical basis. There is a distinct difference between rural and industrial locations as well as coastal and inland installations.

Table 1. Illustrates the typical numbers of fungi and bacteria that can be found adjacent to an industrial building, these counts are produced by leaving an agar plate exposed to atmosphere for twenty minutes. Any fungi or bacteria that are then grown are from spores that happen to fall on the exposed agar plates by simple gravity. One should therefore consider the air flow characteristics of each cooling tower and then an estimate of biological loading can be theoretically calculated. Typically in the summer months each cooling tower has the potential to ingest thousands of spores every hour.

Sample Time	Fungal count cfu/plate	TVC 3D @ 30oC cfu/plate
Summer	66	8
Summer	33	96
Summer	14	324
Summer	>340	345
Summer	16	69
Summer	7	48
Summer	73	68
Winter	1	8
Winter	0	16
Winter	2	4
Winter	3	8
Winter	5	8
Winter	2	12
Winter	6	4

Table 1. Counts of air born fungal spores and bacteria from agar plates exposed for 20 minutes

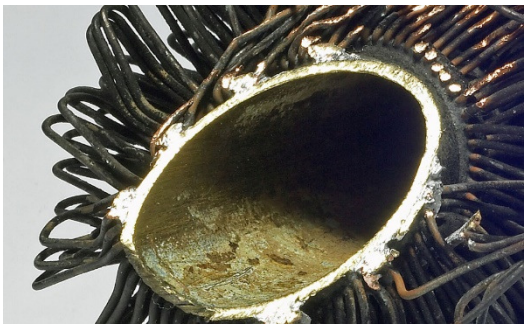
A common practice to enhance the performance of the total water treatment programme is the inclusion of side stream filtration this being the standard practice for the reduction of solid loading in a system.

In reality very few cooling systems are fitted with any form of filtration device, apart from strainers that are usually designed to protect the circulation pumps. Those that employ filtration tend to be operating larger systems or have problematic units when, commonly, filtration is retrofitted once fouling has become established. The majority of medium or small systems tend not to have any filtration, either side stream or otherwise, in spite of widespread support and advise by the HSE and industry specialists.

Operational benefits of effective filtration in cooling water are very significant, not only contributing to good microbiological maintenance but also to maximise heat exchange efficiency and reducing maintenance costs.

As in all technologies, water treatment and cooling systems have advanced so we now have systems that operate with cooling water that will stop production if the temperature or pressure of the water is not within defined limits. Arguably it should therefore be best practice for good water quality maintenance to be taken into account during the design and planning phase of a cooling water process. Dealing with cooling water fouling is much more difficult and costly than preventing it in the first place, not to mention problems associated with unscheduled down time.

MICROSCOPIC FOULING IN COOLING SYSTEM PIPEWORK CAN CAUSE A MAJOR SHUT DOWN



We need to fully understand the implications of what is within the cooling water, many of us are feeling very safe having installed traditional technologies such as side stream filters, typically these are kinetic or centrifugal separators, or other technology such as self-cleaning screen filter, disc filters or even conventional media filters – such a system combined with chemical treatment is accepted as standard practice.

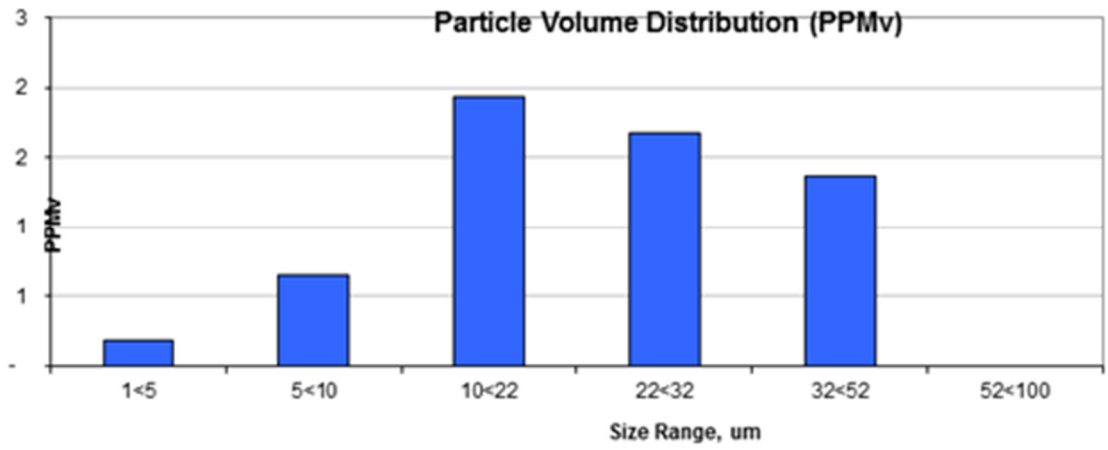
All of these technologies filter to their limits which is at best around 15-20 micron, when we have examined water samples from many systems they all typically show a solids loading from anywhere from 10 mg/l to 80 mg/l of physical matter (some even more if the make-up water is not mains water, ie, borehole water, river water or lagoon).

The issue is that when cooling water is sampled with an accurate laser analyser they all show remarkably the same graphic profile

Here are two examples

The first is what would be deemed clean water with a solids loading of only 6 mg/l, yet the particle count is 18,195. Examine carefully the charts below, the horizontal axis shows the micron range 1-5 through to 52-100 micron, these are from a laser analyser used specifically for this type of water evaluation. The charts show particle number and also associated mass of the range. The issue is in the detail, if we look at what a typical side stream filter would remove. Even at assumed 100% performance at its top limit of 20 micron it would remove, well lets be generous let's say 10 micron, the loading removed by mass would be 5 mg/l out of a total of 6 mg/l some 84% of the total solids load, which is impressive , but in reality not achievable. Up to recent times this would be accepted as good. But we need to remember that existing technologies employed as side stream filtration don't perform at 100% efficiency.

Graph 1



But now let us examine the counts/ml in the table and graph below, what we see is that the NUMBER of particles in each sector of size is the reverse picture of that in the mass graph.

Graph 2

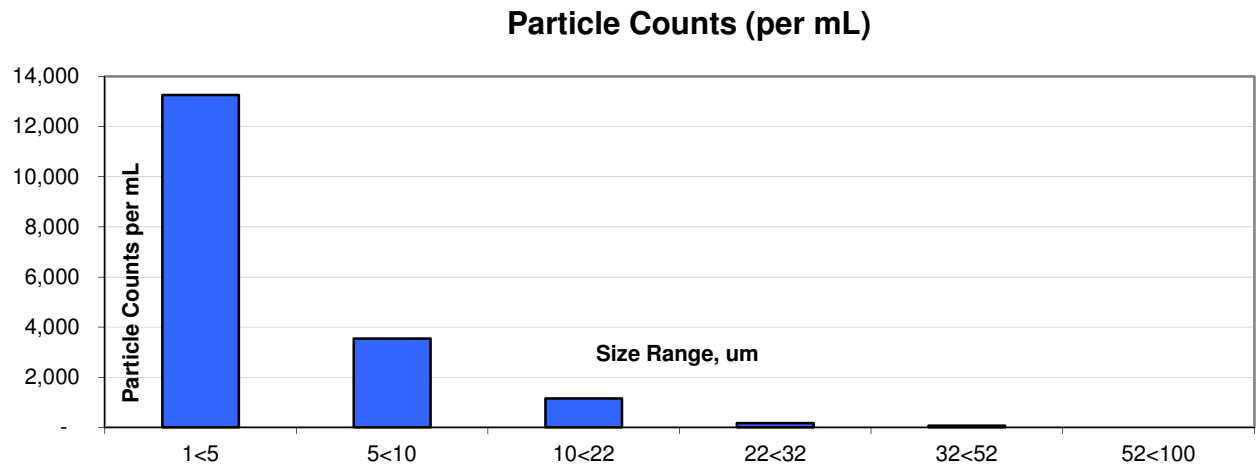


Table 2

Size Range, um	Counts/mL	PPMv	Distribution	
			Count %	Volume %
1<5	13,258	0	72.9	3.2
5<10	3,544	1	19.5	11.3
10<22	1,154	2	6.3	33.2
22<32	175	2	1.0	28.8
32<52	64	1	0.4	23.6
52<100	-	-	0.0	0.0
Total	**18,195**	**6**	**100.0**	**100.0**

This is simple to explain, the larger particle weighs more than the fine particles e.g. how many bacteria weight 1 mg? But it only takes a few grains of sand to weight 1 mg, so in our first example, a good traditional side stream filtration, whilst removing >84% of the mass (assuming 100% removal efficiency at 10 micron again, which is not normally possible), has only removed some 1390 particle counts from a total count

in the sample of 18,195 i.e. an efficiency of less than 8% removal. We therefore have a situation that allows a constant build-up of smaller particles within the recirculating water.

What is the real adverse effect of these smaller elements, many of which are microorganisms, have on the system? Well in most systems the process cooling water is passed through the system in pipework and then if a cooling tower is present, it's passed over the cooling area of the tower, or through a chiller or heat exchanger.

Now even in the best of systems, and most don't fall into this category, the pipework will be plastic, steel, stainless or as in many systems a combination. All of these pipe have a single thing in common, their internal surfaces are not completely smooth, looking though a microscope we will see surface inclusions and roughness, these are the very locations that these smaller elements affix themselves to, the larger particles don't as they have a larger surface area and so mass, and as such are swept along through the system by the water flow.

The process which is happening, is that these smaller particles typically less than 5-6 micron lodge themselves in the pipework surfaces and system cooling surfaces, now some of these may well be dispersed by water treatment chemicals but many hold their position, (typically in areas of low flow) and start to build up what is in effect a slightly smoother surface. These particle holding areas then provide a suitable habitat for biological colonisation which will lead to bio-film formation.

These Bio-films then provide an enhanced environment for further colonisation and act as a filter for further inorganic salts to build too. Whilst many of these bio-films are invisible to the naked eye they can increase the corrosion potentials at the metal surface and provide areas for rapid bacterial growth. Biofilms will ultimately provide an environment where water treatment chemicals cannot function and can enable huge numbers of different bacteria species to proliferate. A mature bio-film will be a very complex structure with contains both aerobic and anaerobic bacteria together with protozoa, the inclusion of protozoa is a major factor in the ultimate colonisation of a system by Legionella bacteria. *Legionella* are protozoonotic in that they live, reproduce and survive within certain free-living amoebae and ciliated protozoa as facultative intracellular parasites.

In this relationship, the protozoa are obligate cellular hosts in which *Legionella* replicate and thrive, as well as gain protection from harsh, natural or man-made, environmental conditions. If the particulates contain iron, this will also act as a major food source for Legionella.

So what is the answer to minimising the potential for these small particles to cause water treatment problems and significant biological issues?

The answer is effective and reliable side stream filtration that can remove these smaller elements and minimise their contamination of the system.

Hence why IPS invested in the design and development of the CrossFlow AMF - advanced high efficiency media filter technology - which, for a number of years now, has been installed with great success, delivering spectacular increases in system efficiency in industries worldwide.

CROSSFLOW AMF HIGH EFFICIENCY FILTER UNIT IN SITU

Such technology can filter to better than 0.5 micron, fully automatically and can be installed on a side stream of any cooling system whether a cooling tower or a chiller.

Case study one

In a high capacity plastic moulding shop, curing time had risen from an accepted design of 12 second to 16 seconds. Not much of a difference to the non-industry onlooker. However, to an expert if you are producing a plastic item every 3 seconds this equates to 1200 units per hour. If the curing time increases by 4 seconds that is effectively an increase of 25%. From the manufacturer's point of view, production is now down by 25% which equates to a decrease to 900 units per hour which is a huge loss. In many cases manufacturers will simply accept this loss because they don't realise where the problem lies having overlooked process cooling water quality. They then buy more equipment to bring production back up to previous levels which in turn becomes a vicious and expensive circle.

The solution in this case was to replace the existing centrifugal separators with the CrossFlow AMF technology on a side stream loop to enable the mass water to be filtered to less than 1.0 micron. Following the installation the system water quality improved to the point where the curing time was brought back to its original specification, saving the company the high investment of purchasing another three moulding machines which would have been required to meet orders.

Case study two

In UPVC extrusion, many clients experience chemical control issues with their large re circulation water systems (200,000 – 500,000 lphr typical recirculation rates) after a change in EU law banned a traditional component in the raw material used for achieving a smooth surface finish on the produce. When the new formulations started to be used there was a major increase in the biological content of the water, necessitating shock dose to very high levels, at very regular intervals. The level of shock dosing was too high for on-site safety so a solution was sought.

The main extrusion line already had main full flow filtration down to 20 micron, so there was little to be gained at this point by installing traditional side stream technology. The solution was to install CrossFlow AMF technology to enable the removal of solids down to below 1.0 micron.

Many UPCV manufacturers are now using this technology, which has proven to save money and maintain a high quality of recycled process water, whilst at the same time reducing scrap and improving productivity thereby reducing energy per ton manufactured.

In conclusion, by not properly understanding, treating and filtering out the finer particles found in process water, the effect on cooling systems is minimal with biofouling still an issue. By installing the correctly sized side stream high efficiency filter, which should also be a self-cleaning, the user benefits in a number of ways:

- Substantial increase in biological control
- Less chemical use but more effective control
- Reduction in the potential for erosion corrosion
- Reduction in the potential for bio-film proliferation
- Enhances the efficiency of conventional water treatment chemicals
- Cleaner heat transfer systems
- Reduction of energy by as much as 20% has been achieved
- Greater security and Peace of mind for the operator and user

-ENDS-

Editor's Note

INDUSTRIAL PURIFICATION SYSTEMS

For over 30 years Industrial Purification Systems Limited (IPS) has developed experience in the field of industrial and commercial water filtration. Its broad product range of filters enables the company to offer equipment solutions that are not only the best technically, but also commercially and environmentally acceptable. The varied filtration solutions that have been applied world-wide across all business sectors include commercial, industrial, manufacturing and public and private utilities.