Choosing The Right Filtration System Will Help Maximize Your Cooling Tower Efficiencies

Presented by Vortisand® Michael Ditton
TODAY’S AGENDA ANSWERS IMPORTANT QUESTIONS ON COOLING TOWER EFFICIENCIES

1. What are the negative impacts suspended solids can have on chillers and water loop systems.
2. Review key trends driving the use of side stream filtration systems in the facilities management industry.
3. What is the difference between TSS and particle size and the relationship with fouling.
4. How to select the right filtration solution for your application.
5. Review recent case studies where the total operating costs, maintenance costs, chemical usage and water consumption were reduced.
THE NEGATIVE IMPACT OF SUSPENDED SOLIDS

Basin

Fill

Tower

Heat Exchanger
TSS CAN BE DEVASTATING TO HIGH EFFICIENCY FILL
FOULING LEADS TO LOSSES IN HEAT EXCHANGER EFFICIENCIES
FOULING PREVENTION

Prevention
  • Good control of scale, corrosion, and microbio
  • Legionella Prevention
  • Treatment of make-up water

Reduction
  • Side-stream filtration
  • Increase tower blowdown
COSTLY SOLUTIONS TO FOULING
INDUSTRY CHALLENGES

1. Heat Transfer Efficiencies
2. Under-deposit Corrosion
3. Maintenance & Cleaning labor
4. Chemical & Make-up Water costs
5. Operator Health and Safety
6. Legionella Risk Assessment Programs
UNDERSTANDING WATER QUALITY IS CRITICAL

- Turbidity
- TSS
- pH
- Hardness
- Anions/Cations
- Particle Size
TSS DOES NOT GIVE THE FULL PICTURE

1 PPM
1 particle
3 mm size

1 PPM
256 Billion Particles
2 micron size

Are these two the same?
THE FULL PICTURE: TSS AND PARTICLE SIZE
FOULING IS DEPENDENT ON PARTICLE SIZE

1. Metal surfaces are rough on a microscopic level

2. Large particles will not attach initially

3. Fine particles (1-5 µm) are first to cling to surfaces

FOULING RATE: A FUNCTION OF CONCENTRATION AND PARTICLE SIZE

- Fouling rate increases and particle concentration have a linear relationship (until particles begin to agglomerate).
- If the sub 5-micron particle concentration is unchanged after filtration, the fouling rate will also remain unchanged.

## FOULING VS. HEAT TRANSFER

<table>
<thead>
<tr>
<th>Material</th>
<th>Thermal Conductivity (W/m²K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>398</td>
</tr>
<tr>
<td>Calcium Carbonate</td>
<td>2.26 – 2.93</td>
</tr>
<tr>
<td>Calcium Sulfate</td>
<td>2.31</td>
</tr>
<tr>
<td>Calcium Phosphate</td>
<td>2.60</td>
</tr>
<tr>
<td>Magnesium Phosphate</td>
<td>2.16</td>
</tr>
<tr>
<td>Magnetic Iron Oxide</td>
<td>2.88</td>
</tr>
<tr>
<td>Biofilm</td>
<td>0.63</td>
</tr>
</tbody>
</table>

### FOULTLING FACTORS CHART

<table>
<thead>
<tr>
<th>Fouling</th>
<th>Energy Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0001</td>
<td>1 %</td>
</tr>
<tr>
<td>0.0005</td>
<td>5 %</td>
</tr>
<tr>
<td>0.001</td>
<td>11 %</td>
</tr>
<tr>
<td>0.002</td>
<td>22 %</td>
</tr>
<tr>
<td>0.003</td>
<td>33 %</td>
</tr>
<tr>
<td>0.004</td>
<td>44 %</td>
</tr>
</tbody>
</table>

Source: CTI Paper No TP239A
FINE PARTICLES PROMOTE BIOLOGICAL GROWTH

Contaminants Enter System
- Airborne
- Make-Up
- Process Leaks

Adhesion to Wetted Surfaces
- Cooling Tower Fill
- Distribution Basin
- Condensers
- Piping

Growth & Colonization
- Heat
- Sunlight
- Nutrients

Oxidation, Disruption & Dispersion
- Cells ruptured
- Dead cells are carbon source for re-growth
### DIFFERENCE BETWEEN REMOVAL BY WEIGHT AND COUNT

<table>
<thead>
<tr>
<th>Size</th>
<th>Total counts /cc</th>
<th>Counts percent</th>
<th>Mass percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td>1,769.78</td>
<td>0.91%</td>
<td>0.00%</td>
</tr>
<tr>
<td>1-5</td>
<td>185,040.11</td>
<td>95.44%</td>
<td>11.62%</td>
</tr>
<tr>
<td>5-15</td>
<td>6,751.37</td>
<td>3.48%</td>
<td>16.80%</td>
</tr>
<tr>
<td>15-30</td>
<td>117.99</td>
<td>0.06%</td>
<td>4.57%</td>
</tr>
<tr>
<td>30-50</td>
<td>131.09</td>
<td>0.07%</td>
<td>25.76%</td>
</tr>
<tr>
<td>50-100</td>
<td>52.44</td>
<td>0.03%</td>
<td>41.24%</td>
</tr>
</tbody>
</table>

**Majority of Particles**

- **10 PPM**: 90% Removal By weight
- **1 PPM**: Majority of Mass

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FINE PARTICLE (<10 μm) ARE ONE OF THE LARGEST CONTRIBUTORS TO FOULING

- In general, 90% of particles in a cooling tower are <10 micron\(^{(1)}\)
- Sub 1-micron particles lodge at the surface\(^{(2)}\)
- Fouling layer is comprised of 1-5 micron particles\(^{(2)}\)
- >5 micron particle don’t participate in the deposition process\(^{(2)}\)
- Each 0.001-in increase in fouling represents 10% increase in power\(^{(3)}\)

Sources:
(2) Cooling Tower Institute. Scanning electron micrograph study of foulants. 1994 annual meeting in Houston Texas.
(3) ASHRAE Standard 550-98.
Filtration Technologies
AVAILABLE WATER FILTRATION SOLUTIONS

1. High Efficiency Filtration Systems
2. Screen Filters
3. Traditional Media Filtration Systems
4. Bag & Cartridge Filters
5. Centrifugal Separators
WHERE DOES FILTRATION TECHNOLOGY FIT

PARTICULATE

TECHNOLOGIES

High Efficiency Cross-Flow Microsand Technology

Bag & Cartridge Filtration

Screen Filtration

Media Filtration

Centrifugal Separator

Human Hair

Plant Spores

Pollen

Red Blood Cell

Bacteria

Asbestos

Atmospheric Dust

Beach Sand

0.1  0.2  0.5  1  5  10  20  50  100  200  500  1000 (1mm)
FILTRATION TYPES

Cartridge and bag filters
- Sub-micron filtration capabilities
- Require high maintenance (cartridges must be changed manually)
- Cannot handle very large flows/systems
- Best fit for low flow chilled loops

Centrifugal separators
- Uses Vortex principal to separate solids from liquids
- Performance driven by inlet pressure
- Usually require a booster pump (adds complexity and electrical demand)
- Separation varies depending on density of particulates
- Effective for systems that only have larger, denser debris
- Not effective on systems containing smaller particles
90% REMOVAL BY WEIGHT PROVIDES INEFFECTIVE PROTECTION

Centrifugal Separator

10 PPM

1 PPM
FILTRATION TYPES

Disc Filters

- Solids are trapped between a series of disks as water passes through
- Small footprint
- Cannot be used for fibrous wastes
- Limited throughput
- Can be difficult to clean if fouled
- Pressure thru filter is critical, booster pumps often used

Self-Cleaning Screen Filters

- Utilize a screen/sieve type filtering mechanism
- Continuous filtration down to 10 micron
- Small footprint and low water use
- Automated, self-cleaning
- High throughputs available
FILTRATION TYPES

Media Filters (traditional sand & MMF)
- Filtration down to 10 micron
- Use for open and closed water systems
- Self-cleaning (backwash)
- Have a larger footprint, may be difficult to install due to space limitations
- Typically require a booster pump
- Require large amounts of water for backwash
TRADITIONAL MEDIA FILTER – FILTRATION PROCESS

Challenges:

- Inefficient for removal < 15 µm
- Low flux rates ➞ Large size needed
- Deep bed ➞ high backwash flow

Free board (40%)

Support Media

Sand Media

Anthracite
CROSS-FLOW HIGH EFFICIENCY FILTRATION
DIFFERENCES BETWEEN TRADITIONAL vs. HIGH EFFICIENCY CROSS-FLOW FILTRATION

Dead-End Filtration

Cross-Flow High Efficiency Filtration
VORTISAND FILTRATION PROCESS

Principles of Crossflow

- Large particles stay in suspension
- Prevents surface blinding
- Reduces resistance through media
- Small particles trapped in microsand

Support Media

Microsand Media
BENEFITS OF HIGH EFFICIENCY CROSS-FLOW FILTRATION

- Submicron performance
- High flux rate (20-25 gpm/ft²)
- Reduced footprint
- Up to 50% reduction in backwash water usage (compared to traditional media filtration)
# FILTRATION COMPARISON MATRIX

<table>
<thead>
<tr>
<th>Technology Comparison Chart</th>
<th>High Efficiency Media Filter</th>
<th>Self-Cleaning Screen Filter</th>
<th>Cartridge &amp; Bag Filter</th>
<th>Centrifugal Separator</th>
<th>Traditional Media Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submicron Performance</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Can be Used in Sidestream or Full</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Effective for High Volume of Solids</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Flow Rates &gt;1000 gpm Available</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Self-Cleaning</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Effective for Low Mass/Light Particles</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Low Water Use (for Backwash)</td>
<td>✓</td>
<td>✓</td>
<td>(no backwash)</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Small Footprint</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Low Electrical Demand</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Effective in Oily Waters</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>No Solid Waste Disposal Needs</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Low Maintenance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Resistant to Blinding/Pluggage</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
APPLICATION CHECKLIST
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WHERE DO I START?

Analytical Tests to Perform:
- PSD (Particle Size Distribution)
- TSS (Total Suspended Solids)
- Dissolved metals (ppm)
- Oil & Grease

Site Data Collection:
- Total system Volume (gal)
- Recirculation Flow (gpm)
- Cycles of Concentration
- Chiller Tonnage (tons)
- Makeup water source
- Clean water BW source
PARTICLE SIZE DISTRIBUTION

<table>
<thead>
<tr>
<th>Bin</th>
<th>Size</th>
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<th>Counts percent</th>
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<td>1</td>
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</tr>
<tr>
<td>2</td>
<td>5-15</td>
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<td>3.48%</td>
</tr>
<tr>
<td>3</td>
<td>15-30</td>
<td>117.99</td>
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<tr>
<td>5</td>
<td>50-100</td>
<td>52.44</td>
<td>0.03%</td>
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Total counts: 193,889.00/cc
MEDICAL CENTER – COOLING TOWER

**Project Overview**

- Installation: 31,800 sq ft Central utility plant
- Cooling Towers: (4) 1,000 ton
- Recirculation Rate: 3,000 gpm
- Filter Solution: 4 Vortisand Classics
- Year: 2015

**Customer Challenge**

95% of all system water TSS were smaller than 5 microns. The ultimate reduction of fouling was a key consideration along with space restrictions. Centrifugal separators were already in place.
SIDE STREAM FILTRATION

The U.S. Department of Energy recommends sidestream filtration as a Best Practice

Filter sizing: 3-5% of recirculation flow (7-10 Turnovers per day) in an open system can:

- Reduce filter size, energy requirements, water consumption
- Improve effectiveness of biological control program
- Reduce fouling and under-deposit corrosion potential
- Improve heat exchanger efficiency

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## MEDICAL CENTER – COOLING TOWER

### RESULTS

After just 60 days of replacing the centrifugal separators with the Vortisand system a 90% removal of particles less than 5 microns was achieved.

<table>
<thead>
<tr>
<th>Size (microns)</th>
<th>Start up of 2 Vortisand® filters (2 Centrifugal Separators Still Active)</th>
<th>After 60 days of only Vortisand® (Inlet)</th>
<th>After 60 days of only Vortisand® (Outlet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Counts/cc</td>
<td>Counts %</td>
<td>Size (microns)</td>
</tr>
<tr>
<td>&lt; 1</td>
<td>401,271</td>
<td>55.8</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>1-5</td>
<td>291,213</td>
<td>40.5</td>
<td>1-5</td>
</tr>
<tr>
<td>5-15</td>
<td>26,059</td>
<td>3.7</td>
<td>5-15</td>
</tr>
</tbody>
</table>
# INTERNATIONAL AIRPORT: CASE STUDY

## Project Overview
- Central utility plant (CUP) replacement – Cooling Tower
- Client: International Airport
- Solution Type: Vortisand 36” systems
- Year of Completion: 2014
- Capacity: 60,000 gpm condenser water recirculation rate

## Customer Challenge
95% of all system water TSS were smaller than 5 microns. The ultimate reduction of fouling was a key consideration along with space restrictions.

## Solution
A high efficiency microsand filter that filters down to the submicron level on a consistent basis, while requiring minimal maintenance and downtime. An overall solution that will fit their strict space requirements.

5% sidestream filtration was installed allowing for a reduction in particle counts of < 20,000 counts/cc and a turbidity of <2 NTU.

## Scope of work
- Laser Particle Analysis
- Design & engineering
- Equipment supply
- Project management
- Supply of initial reagents and supplies
- Startup & commissioning
- Training
SUMMARY

• Fine filtration is a crucial component in keeping your system operating efficiently.
• 90% of particles found in cooling systems are <10 microns.
• Removal by weight provides inefficient filtration. Focus should be placed on particle count removal.
• *An efficient process can help improve your organizations bottom line!*
QUESTIONS

Thank you for attending today’s session! Vortisand is offering a *free laser particle count analysis and a review of the results with an applications engineer.

E-mail vortisand@evoqua.com for more information.

*Subject to review and approval by a Vortisand® application engineer