Total Suspended Solids (TSS)

The importance of particules count
…and their size,
for an energy efficient
cooling system

ASHRAE Qatar Oryx Chapter

October 3rd, 2012 Doha

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To Save Energy, water and chemicals on cooling systems

Multiple efforts deployed by the HVAC designers, except one which is often overlooked or misunderstood….

Water Quality

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The Challenge

Most Designers feel that the water quality should be left to the Chemical Companies…

They are right… except when it comes to **Suspended Solids: TSS**

Why?

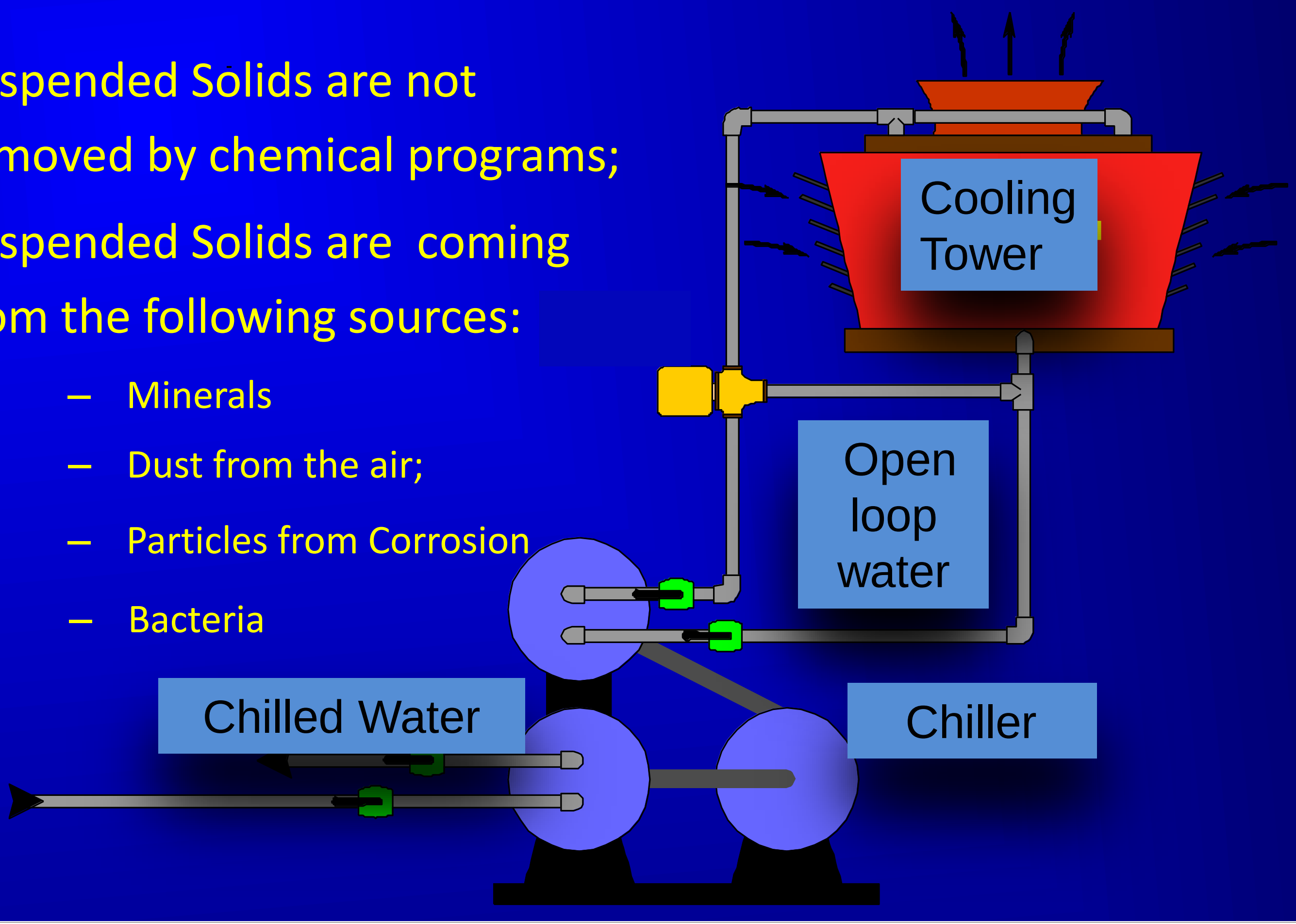
The Challenge

Where do Suspended Solids come from?

Suspended Solids are not removed by chemical programs;

Suspended Solids are coming from the following sources:

- Minerals
- Dust from the air;
- Particles from Corrosion
- Bacteria



The Challenge

- *''With the introduction of high-efficiency film fill, **deposit accumulation** in the cooling tower packing has **become an area of concern**.''*

As per GE Technical Handbook (http://www.gewater.com/handbook/cooling_water_systems/ch_25_deposit.jsp

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The Challenge

Dust entering the cooling systems (at 60 µg/m3)

Cooling capacity (Tn)	Air Flow (CFM)	Weight of dust after 90 days
240	62 790	31 lbs (14 kg)
400	103 700	50 lbs (23 kg)
828	203 230	99 lbs (45 kg)
1300	302 580	147 lbs (67 kg)

http://www.epa.gov/airtrends/pm.html

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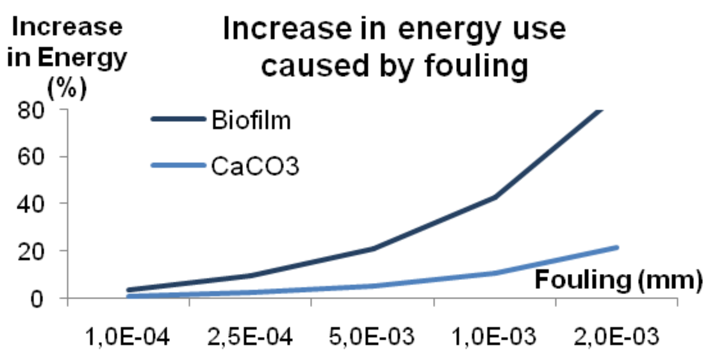
Suspended particles cause resource waste, health risks, and environmental impact

Energy waste

Fouling (insulating layer inside pipes) by unfiltered mineral & organic particles and bacteria

- Reduces energy exchange
- Reduces service life of system



Water waste

Unfiltered Total Suspended and Air Solids limits Cycles of Concentration at cooling towers

- Increasing blow down water waste
- Increasing risk of cooling tower failure
- Increasing need for filter backwash

Poor filtration and biological loading limit the use of grey water for cooling

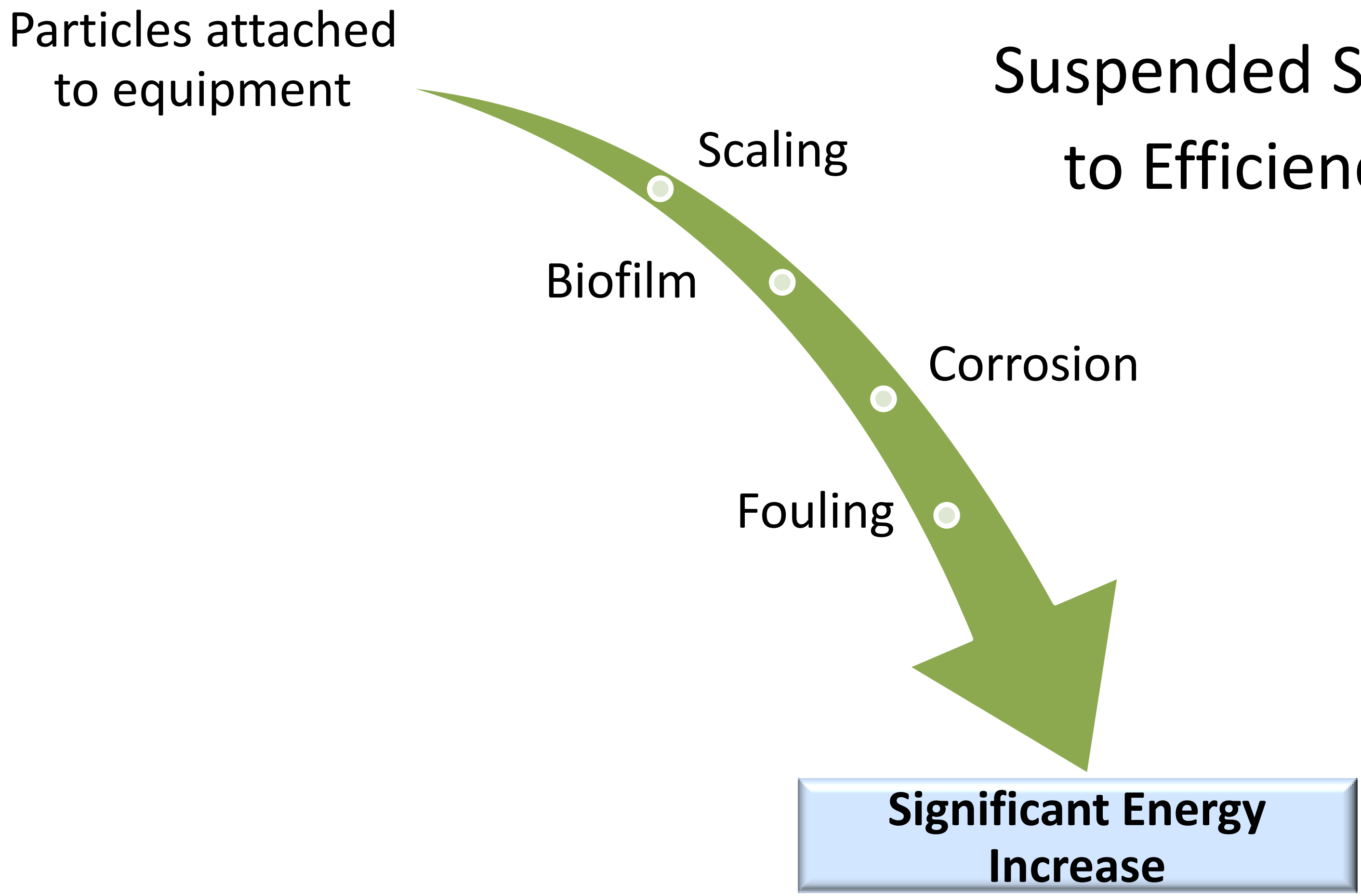
Health risks

Legionella feeds on unfiltered organic solids and bio particles

- Increased need of biocides, dispersants and maintenance

The Challenge

Suspended Solids leads to Efficiency loses.



The Challenge

As per GE Technical Handbook (http://www.gewater.com/handbook/cooling_water_systems/ch_25_deposit.jsp)

''Deposit formation is influenced strongly by system parameters, such as water and skin temperatures, **water velocity**, residence time, and system metallurgy. The most severe deposition is encountered in process equipment operating with high surface temperatures and/or low water velocities.''

Figure 25-7. Iron and silt fouling of plate cooler

Figure 25-6. Calcium and iron phosphate fouling due to low water velocity (GE Handbook).

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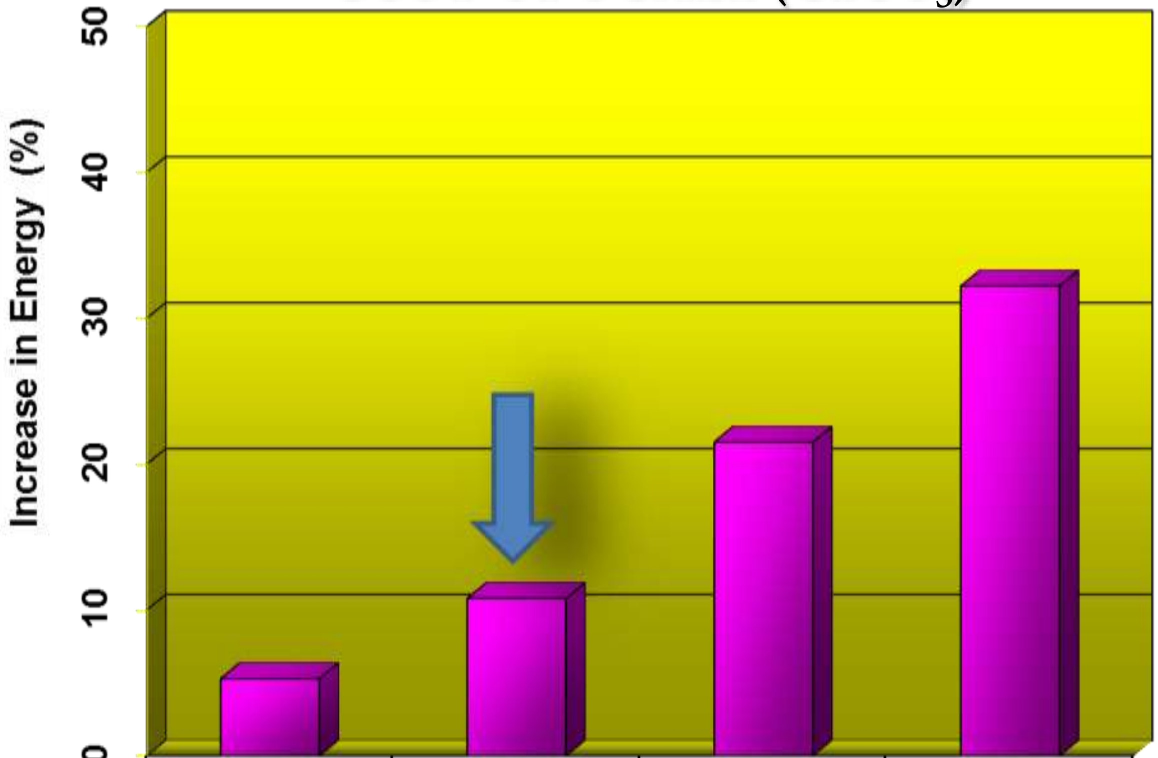
The Challenge

Scale	Thermal Conductivity (W/MK)
Copper	**398**
Calcium Carbonate	2.26 – 2.93
Calcium Sulfate	2.31
Calcium Phosphate	2.60
Magnesium Phosphate	2.16
Magnetic Iron Oxide	2.88
Biofilm	0.63

Source: CTI Paper No TP239A

The Challenge

COST OF SCALE ($CaCO_3$)



	0.006 (150 microns)	0.01 (300 microns)	0.02 (600 microns)	0.03 (900 microns)
Increase in Energy	5.3	10.8	21.5	32.2

Scale Thickness inches (microns)

Source: Ondeo-Nalco

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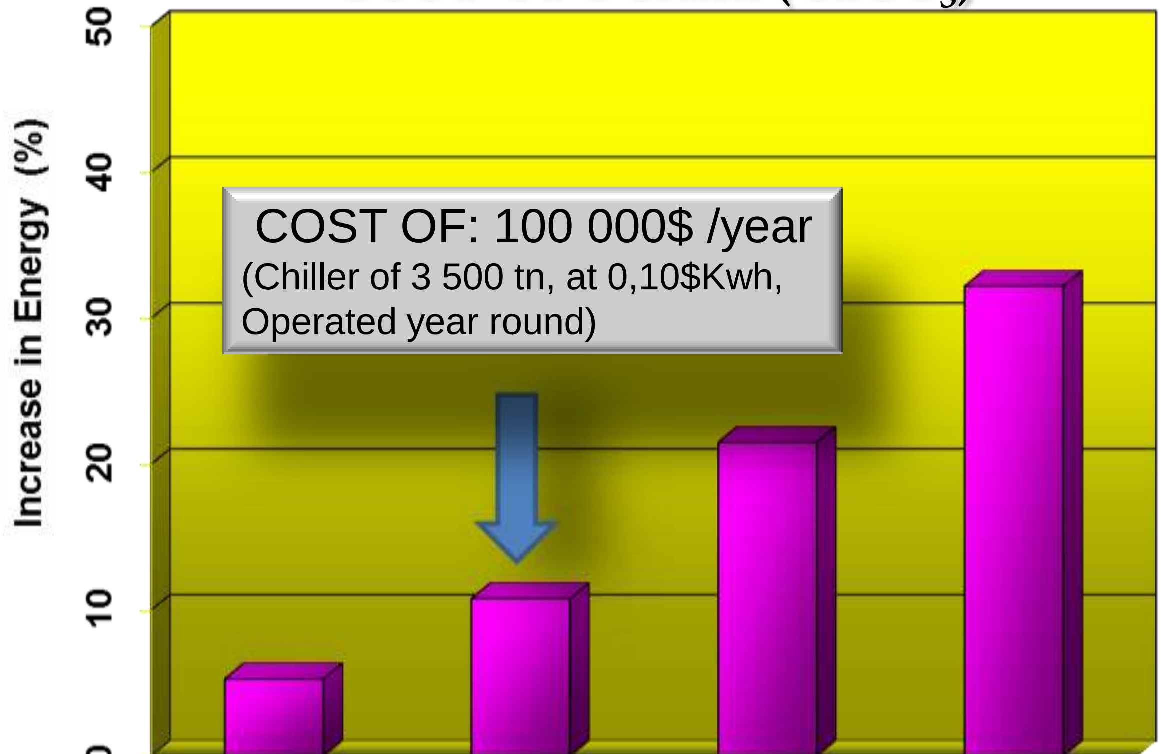
The Challenge

COST OF SCALE ($CaCO_3$)



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Increase in Energy	5.3	10.8	21.5	32.2

Scale Thickness inches (microns)

Source: Ondeo-Nalco

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The Chalenge

A physical treatment is required

*''**Removal of particulate does matter***

*The amount of particulate entering a cooling system with the makeup water can be reduced by filtration and/or sedimentation processes. Particulate removal can also be accomplished by **filtration of recirculating cooling water.***

***The level of fouling experienced is influenced by the effectiveness of the particular removal scheme employed**, the water velocities in the process equipment, and the cycles of concentration in the cooling tower.''*

As per GE Technical Handbook)

http://www.gewater.com/handbook/cooling_water_systems/ch_25_deposit.jsp)

Common filtration devices

From 1 to 100 micron range

Hydro cyclones or centrifugal separators…

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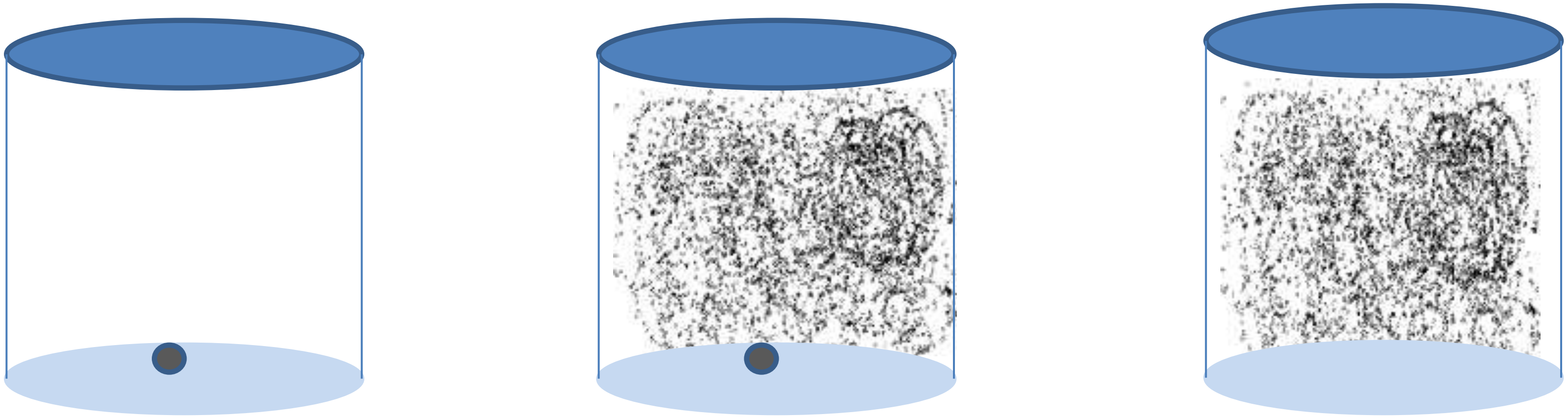
PPM:A weight measurement

PPM Can be misleading

One 13mm marble = 256 **Billion** particles of 2 μ

Removing the marble means:
50% removal on a ppm basis
Inefficient on a particle count basis



“Size does Count !”

- Based on our 20+ years experience, the particles larger than 5 micron make up for more than 90 % of the weight.
- Typically, 85-90% of the particles found in the recirculation water are smaller than 5 micron in size.

Therefore comparing technologies on a ppm basis will not give you the real picture …

look for a Particle Size Distribution Report

before choosing the technology

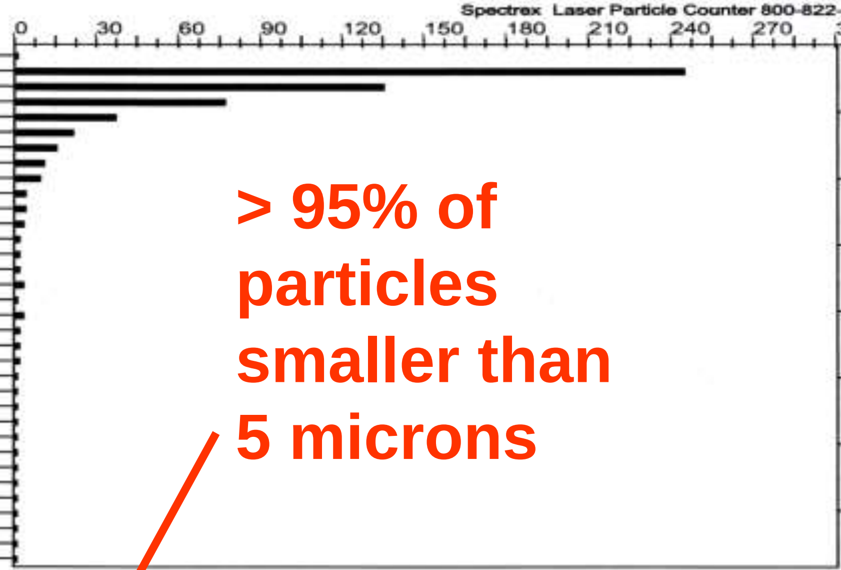
Particule Size Distribution

SAMPLE: #1 COOLING TOWER
FEDERAL RESERVE BANK
DATED: NONE TIME: NONE
SPECTREX #: 1664A

Cooling Tower Sample

Spectrex Laser Particle Counter 800-822-3940 v8.1

#	um	%	Interim Count
	<	0.00	0
1	1	42.96	245
2	2	23.77	135
3	3	13.46	76
4	4	6.31	36
5	5	3.50	20
6	6	2.54	14
7	7	1.81	10
8	8	1.50	8
9	9	0.62	3
10	10	0.58	3
11	11	0.50	2
12	12	0.23	1
13	13	0.19	1
14	14	0.19	1
15	15	0.38	2
16	16	0.08	0
17	17	0.46	2
18	22	0.20	1
19	27	0.26	1
20	32	0.20	1
21	37	0.13	0
22	42	0.00	0
23	47	0.00	0
24	52	0.00	0
25	57	0.00	0
26	62	0.07	0
27	67	0.00	0
28	72	0.00	0
29	77	0.00	0
30	82	0.00	0
31	87	0.07	0
32	92	0.00	0
	>	0.00	0



Filter 0%
A-T 0 s
S-T 48 s
Dilut'n 201.0:1
Offset 0.00V
Gain 5.55x
Counts 114905
NSF Groups

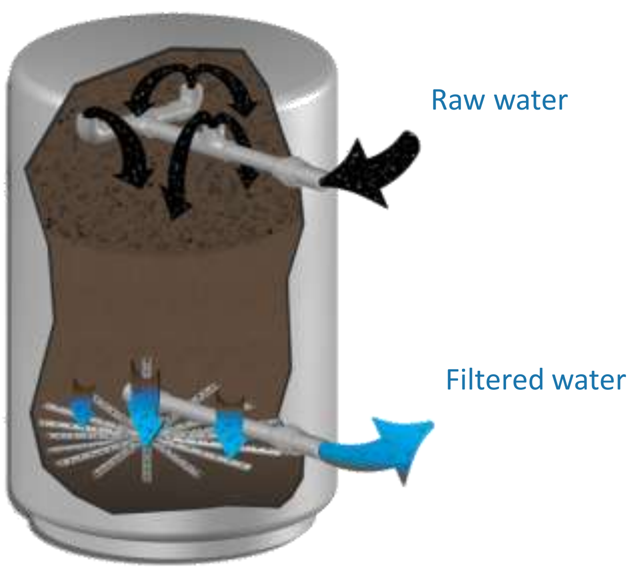
> 95% of particles smaller than 5 microns

NSF Class	Size	Total counts /cc	Counts percent	Surface area percent	Volume percent	Mass/bin ppm
#1	< 1	0.00	0.00%	0.00%	0.00%	0.0000
#2	1-5	99,392.82	86.50%	13.55%	2.23%	0.4599
#3	5-15	13,390.85	11.65%	23.89%	9.14%	1.8887
#4	15-30	1,590.99	1.38%	19.85%	15.10%	3.1187
#5	30-50	[illegible]	0.33%	14.41%	15.82%	3.2690
#6	50-100	151.52	0.13%	28.31%	57.71%	11.9223

Total counts: 114,905.00/cc
Total suspended solids: [illegible] (mg/liter)
Dilution factor: 201.00:1
Spec. gravity: 1.00
Mean size: 2.86um
Standard dev: 4.29um

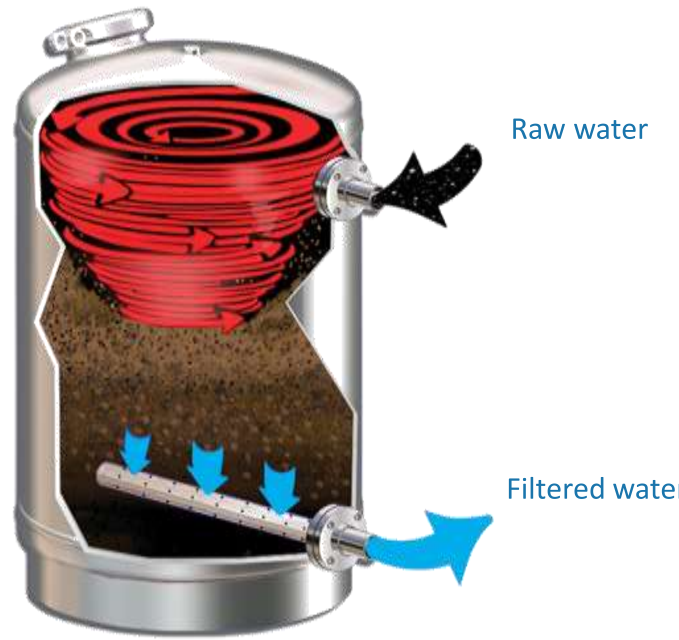
REGULAR SAND FILTER

- **Downflow filtration**
- **10 to 20 micron filtration by weight**
- **Ideal Flow rate of 5-10 gal \ sqf.**
- **10% of flow rate is a minimum**



VORTISAND®

- **Crossflow filtration**
- **Down to 0.45 micron by particle count**
- **Ideal flow rate of 15 to 20 gal/sq.**
- **5% of flow rate is usually sufficient**



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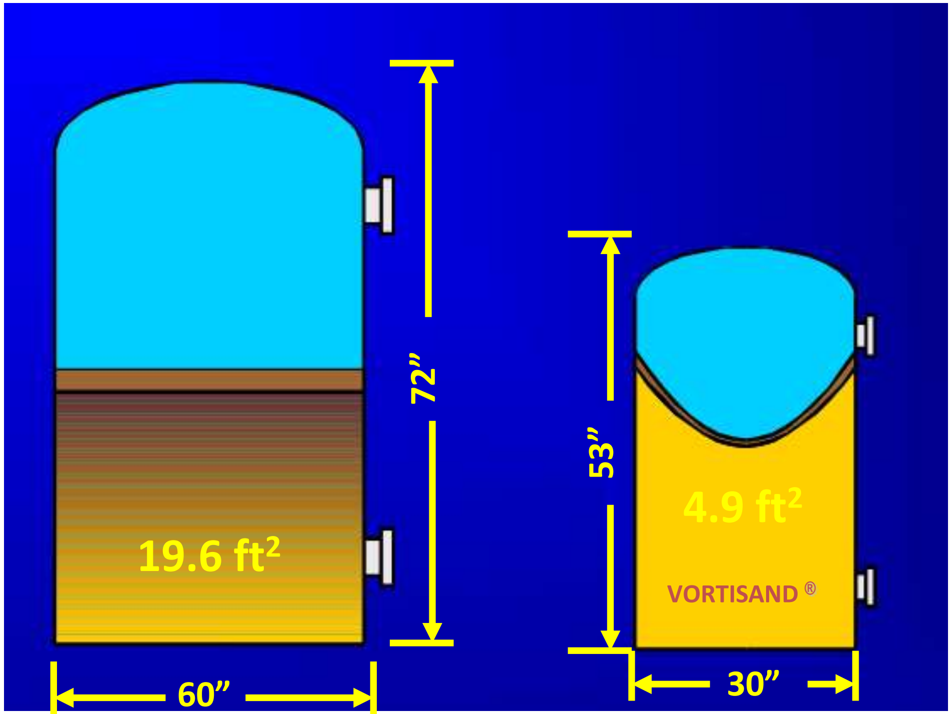
BACKWASH WATER REQUIREMENTS
Footprint \ Space savings

Process Flow Rate 100 gpm



Regular Sand Filter	Cross Flow Filtration VORTISAND
Backwash Flow Rate	**Backwash Flow Rate**
250 GPM @ 12 min.	50 GPM @ 4-8 min.
3 000 Total Gallons	300 Total Gallons
Backwash Piping Supply / Discharge	**Backwash Piping Supply / Discharge**
4” dia.	2” dia.

Benefits Of Vortisand:

- Less foot print - easier to locate area for installation
- Less backwash rate – possible limited feed flow / pressure
- Less backwash volume – waste water to treat and discharge (90%)
- Lower installation cost – foot print and piping dia. requirements

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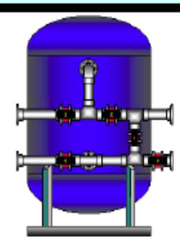
FILTRATION TECHNOLOGIES – OPERATING COST

FILTER COMPARISON

Water Cost / 1000 Gal.	$ 1.75	Cycles of Concentration	4	Centrifugal
Sewer Cost / 1000 Gal.	$ 1.75	Operational Hrs / Day	24	Separator
Electrical Cost / KWHr	$ 0.06	Operational Days / Yr	365	*Purge Time / Sec.*
Chemical Cost - Monthly $ / Ton	$ 3.00	Cooling Tower Tons	1000	5
Media Cost Cu / Ft	$ 15.00	Recirc Rate GPM	3000	*Purge Cycle / Min.*
Labor Cost / Hr	$ 35.00	Vortisand Flow Rate @	5%	15

			
	Vortisand Cross Flow	Typical Depth Filter	Centrifugal Separator
Vortisand Model	AWT1-36	72 x 60 x 1	
Micron Removal Rate	0.45 - 2.0 Micron	10 - 20 Micron	20 - 40 Micron @ 2.6 SG
Estimated Volume Gallons	10000	10000	10000
Estimated Turnovers / Day	20	40	81
Recirc %	5%	10%	20%
Flow Rate GPM	140	280	560
Backwash Rate GPM	70	420	33
Backwash / Purge Volume / Day	1120	6300	3200
Est. Backwash Volume / YR	817600	2299500	1168000
Tanks / Vessels	1	1	1
Media Requirement	24.1	61.0	0
Filter Pump Hp	3	7.5	15.0
Foot Print	3'7" x 4'2"	73" x 90"	94 1/2" x 40"
Installation Feed Pipe Requirements	3"	5"	6"
** Agitation Recommended	No	Yes	Yes
Annual Water Cost	$ 1,431	$ 4,024	$ 2,044
Annual Sewer Cost	$ 1,431	$ 4,024	$ 2,044
Annual Chemical Cost / Cooling Tower Backwash	$ -	$ 9,828	$ 4,992
Annual Electrical Cost	$ 1,176	$ 2,940	$ 5,879
Annual Media Replacement Cost (Every 5 Years)	$ 157	$ 397	$ -
Operation Total Annual Cost	$ 4,194	$ 21,212	$ 14,959

- Vortisand Filter = Backwash 2 every 24 hrs.
- Typical Filter = Backwash 1 every 24 hrs.
- Typical Media Filter design is based on 15 -18 gal / sq using tower water
- Centrifugal Separator purge 5 sec. every 15 min
- Centrifugal Separators are S.G. dependant – 2.6
- Centrifugal Separators use five times the electrical cost
- Sump sweeper systems are recommended for Typical Depth and Separator to improve filtration efficiency

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Company:	Monte Carlo #7074
Total Cooling Capacity	5000
Recirculation Flow - GPM	15000
Average Load (estimated):	50%
Vortisand Filter Model:	AWT3-36-SP
Filtration flow - GPM	420
Vortisand Filter Motor HP	10.0
Hours/Day Operation	24
Days/Year Operation	365
Electrical Cost per KWH	$ 0.10
Chemical Cost Per Month / Ton	$ 1.50
Number of Cleanings per Year	2
Number of Workers Used	2
Total Time per Cleaning (Hours)	20
Personnel Cost per Hour	$ 60.00

System Cost Includes: Vortisand SI, Skid, Startup, Shipping
Shipping estimated at $1,200 cost.

VORTISAND

A. ENERGY SAVINGS	
Total Tons for Centrifugal Chillers	*5000*
KW/TON (Average)	0.7
Hours/Day Operation	24
Days/Year Operation	365
Hours of Operation per Year	8760
Electrical Cost per KWH	*$0.10*
% Load	*50%*
Total Yearly Operating Cost of System	**$ 1,533,000**
SAVINGS: (Based upon a minimum reduction in system fouling of 0.001", thus providing savings of 5%)	**$ 76,650**

B. CHEMICAL SAVINGS (CONDENSER)	
Annual Water Treatment Cost for Cooling Tower at Ton per month	*$ 91,250*
Minimum water treatment saving	**$ 13,688**

C. OPERATION & MAINTENANCE SAVINGS (COOLING TOWER LOOP)	
Number of Cleanings per Year	2
Number of Workers Used	2
Total Time per Cleaning (Hours)	20
Personnel Cost per Hour	$ 60
Total Annual Maintenance Cost	$ 4,800
Minimum Maintenance Savings: Savings of 50% in maintenance costs are gained due to the elimination of sump cleaning and maintenance programs	$ 2,400
Total Operation and Maintenance Savings	**$ 2,400**

Here's how ...

VARIOUS ANNUAL SAVINGS		
Minimum **Energy** Savings	$ 76,650	
Minimum **Water Treatment** Savings	$ 13,688	
Minimum **Maintenance** Savings	$ 2,400	
Operational Cost Savings (See Proposal Page 14) Currect Filtration Technology vs. Vortisand Technology		
Water Savings	$ 5,557.00	
Sewer Savings	$ 5,557.00	
Chemical Savings	$ 23,040.00	
Electrical Savings	$ 19,597.00	
Media Service Cost	$ (470.00)	
Total Annual Savings	$ 146,019	
Vortisand Annual Power Supply Cost	*$ (6,532)*	
Net Annual Savings	→	**$ 139,486**

(See over section A, B & C - for details)

VORTISAND SYSTEM COST		$ 73,383
VORTISAND INSTALLATION	(est)	$ 48,000

PAYBACK PERIOD		
Total Annual Net Savings	$ 139,486	
Vortisand Filter Cost	$ 121,383	***PAY BACK***
Return on Investment, (Yrs).	→	**0.87**

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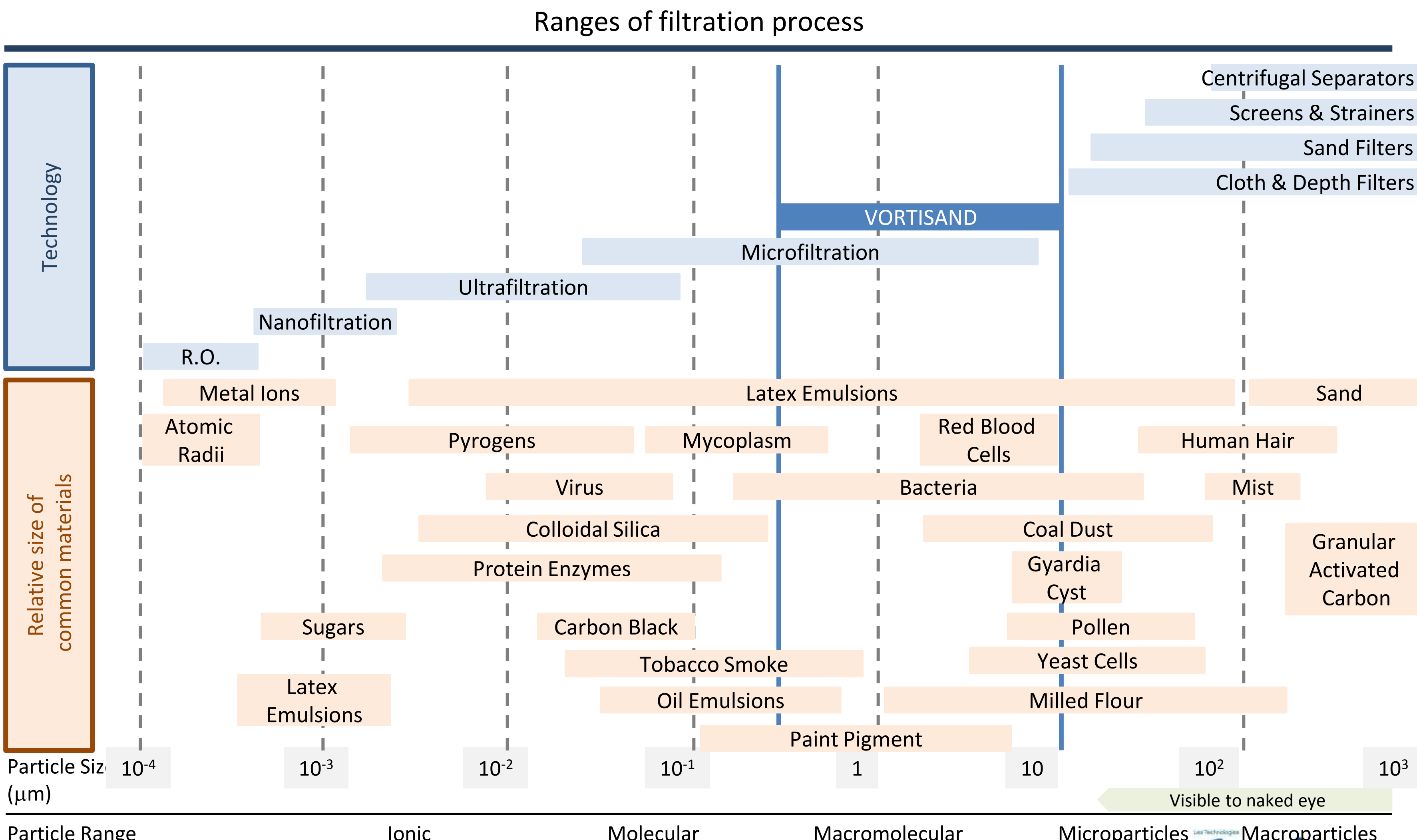
VORTISAND® RANGE ENABLES TO FILTER PARTICLES SMALLER THAN 1 MICRON



VORTISAND® FOR VARIOUS APPLICATIONS

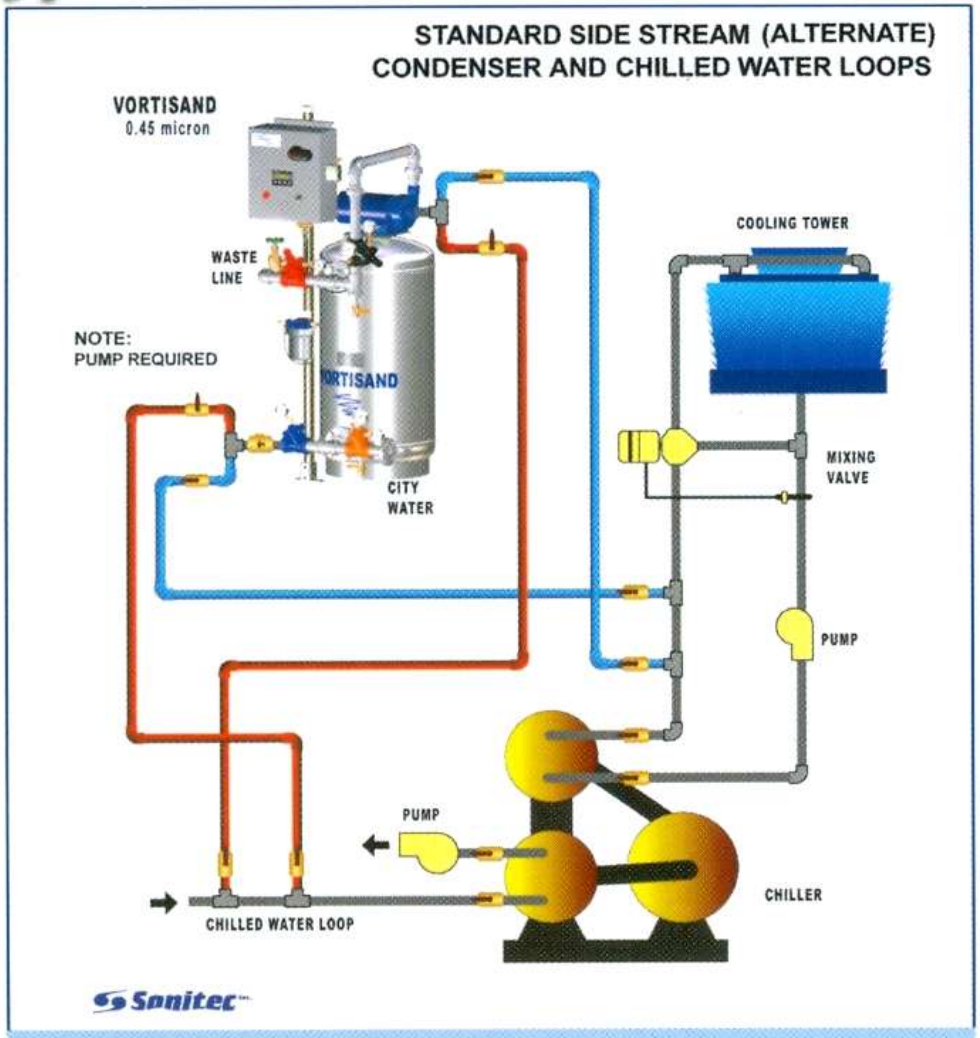
More than 2,500 systems worldwide

Les Technologies Sonitec vortisand inc. Technologies

Clients Sample of the Vortisand® system

Datacenters

Typical Side Stream Installation



Alternate Water Loop – Filter can be used on both open and closed loop systems. Primary filtration on cooling tower loop and secondary (alternate) filtration on closed loop when required.

CONTROL OF LEGIONELLA IN COOLING TOWER

Best Practices for Control of Legionella

Reduce Protected Environment & Reduce Nutrients

- Minimize Water Stagnation
- Minimize Process Leaks into the Cooling Tower which can provide nutrients for bacteria
- Minimize the buildup of sediments
- Apply scale and corrosion inhibitors
- Use High-efficiency mist eliminators
- Control the overall microbiological population

PAPER NO: TP10-04

CATEGORY: MATERIALS

COOLING TECHNOLOGY INSTITUTE

SIMULTANEOUS REMOVAL OF WATERBORNE BACTERIA AND TOTAL SUSPENDED SOLIDS USING AN ANTIMICROBIAL MEDIA IN A CROSSFLOW FILTER SYSTEM

JAMES W. STEPHENS

SONITEC, INC.

Simultaneous Removal of Waterborne Bacteria and Total Suspended Solids Using an Antimicrobial Media in a Crossflow Filter System

James W. Stephens, Sonitec, Inc., 226 Wintergreen Drive, Noblesville, IN 46062, (317) 770-4197.

REFERENCE: CTI Annual Conference, Houston, TX, February 7-11, 2010.

ABSTRACT

This paper describes the results of laboratory challenges supported by a series of field demonstrations here an innovative filtration technology is applied for the simultaneous removal and suppression of aterborne bacteria and total suspended solids (TSS). The media includes an EPA-registered timicrobial agent which permanently bonds to a silica-based substrate. The filter media instantaneously troys both gram positive and negative bacteria on contact without relying on physical trapping, mical reaction, or the addition of chemical disinfectants. The media is neither consumed nor dispersed e treatment stream, leaves no *in-situ* or downstream residue, and is safe to handle. Independent acute our toxicity tests, combined with NSF/ANSI 61 certification, supports that the filter media does not or produce toxic metabolites in the effluent water. Laboratory efficacy tests conducted against *E. Legionella pneumophila*, sulfate reducing bacteria (SRBs), iron fixing bacteria (IFBs), and total c bacteria achieved removal efficiencies ranging from 92 to >99.9%.

ccessful cooling tower case studies using a crossflow sand filter containing the antimicrobial e described. Effective bacteria suppression was maintained and simultaneous TSS reduction rates 95% were achieved while filtering particles down to 0.25 microns. A third field application was using the crossflow sand filter containing the antimicrobial media, where treated effluent ter from extraction wells that achieved removal efficiencies in excess of 99% against high ncentrations of SRBs and IFBs.

n the laboratory challenges and field demonstrations support that the antimicrobial filter media for the removal of harmful waterborne bacteria. Furthermore, the use of the antimicrobial in a crossflow filter device can be used for a variety of applications where both bacteria and n are simultaneously required. The use of this integrated treatment approach can provide for rating efficiency while reducing operating costs.

MICROBIAL FILTRATION TECHNOLOGY

n ever increasing environmental concern associated with harmful bacteria, an innovative

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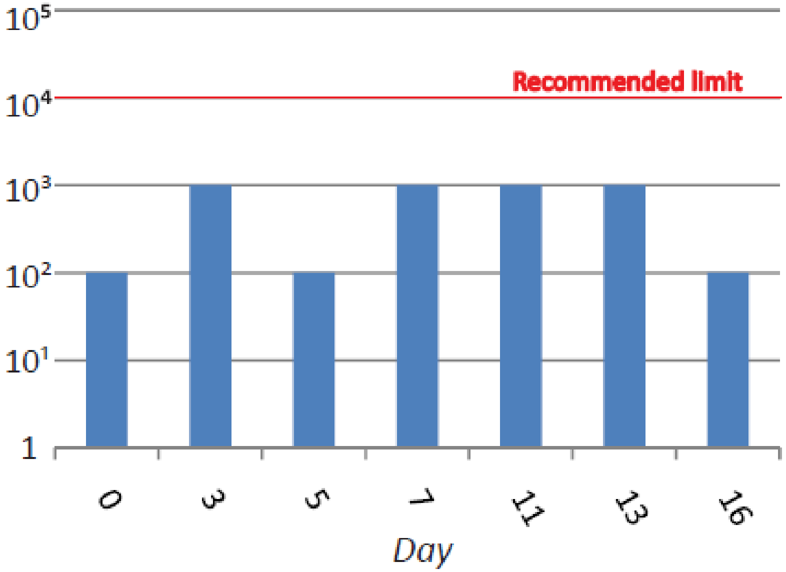
Microbial Control Media

NEW ! Scientificaly proven effective

Total Aerobic Bacteria vs. Time



Total Aerobic Bacteria versus days of treatment for a 300 ton process cooling tower using the Vortisand MCM technology. Note: graphic is on a log scale.

Summary of Legionella Efficacy Tests

	Influent Concentration (col/ml)	Effluent Concentration (col/ml)	Removal Efficiency (%)
	650	30	95.4
	570	<10	99.1

- 4 field sites tested for 4 years
- No presence of CFU ≥ 10^3
- Some without any biocide !
- Unique – simple - innovative

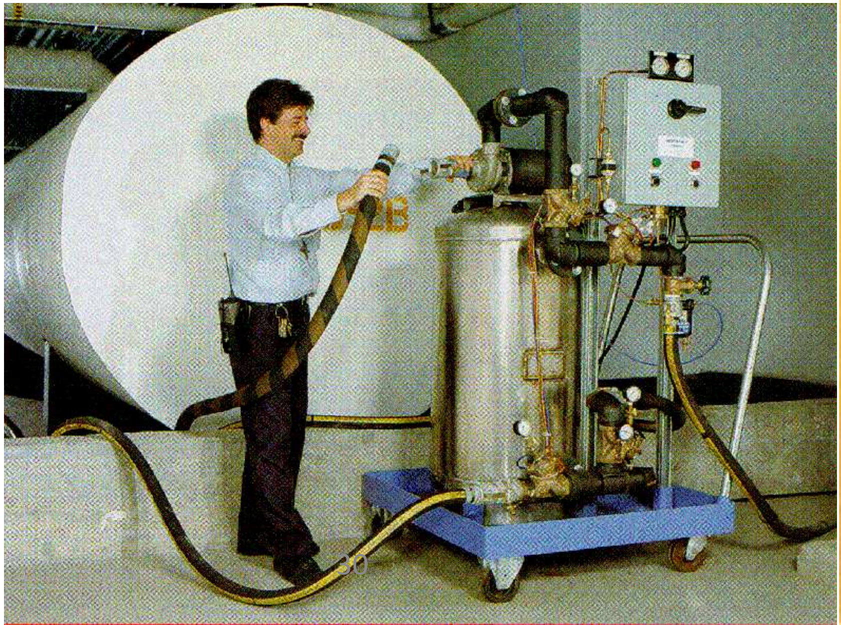
CHILLED LOOPS CLEANUP WITH PORTABLE VORTISAND
1000 LA GAUCHETIERE BUILDING, MONTREAL, CANADA

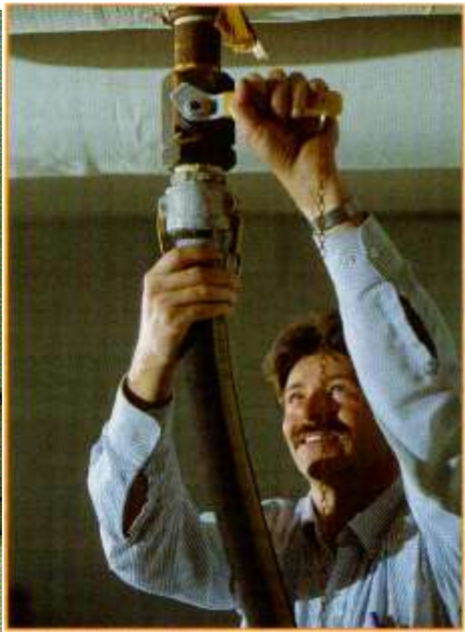
1000 Gauchetière. Montréal
Canada

PORTABLE UNIT MOUNTED

ON SKID ON WHEELS

- ✓ Quick connectors
- ✓ Various sizes (20, 30, 60 ,75 gpm)
- ✓ Multi loops applications (chilled and hot water loops)



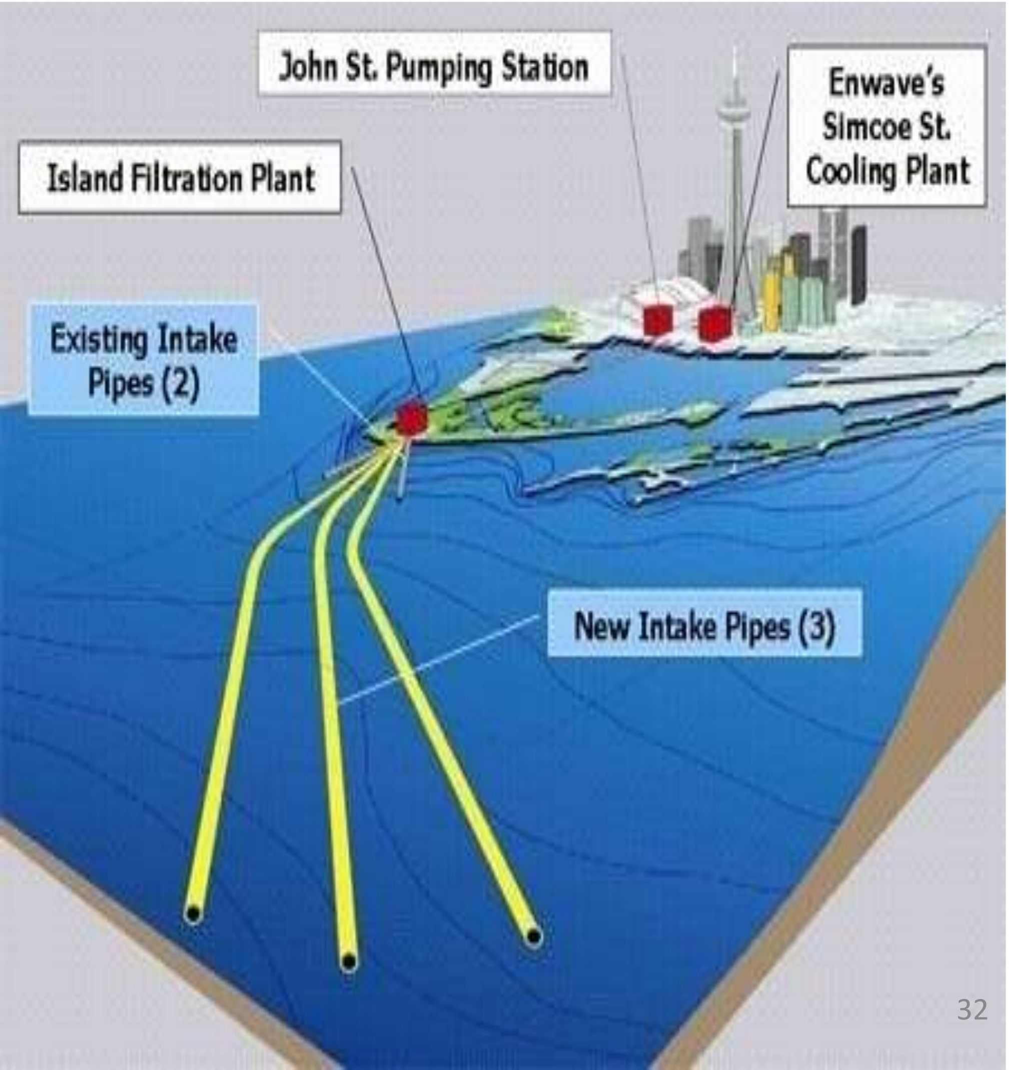


1000 LA GAUCHETIERE BUILDING, MONTREAL, CANADA
IRON REMOVAL EFFICIENCY

43 ppm Iron removed after only 56 days
Improved Chemical Efficiency

Date:	20 oct.	4 nov.	11 nov.	18 nov.	2dec.	9 dec.	15 dec.
Iron:	45 ppm	20 ppm	18 ppm	15 ppm	10 ppm	5 ppm	2 ppm
Molyb:	65 ppm	70 ppm	70 ppm	70 ppm	70 ppm	70 ppm	70 ppm

DISTRICT COOLING - ENWAVE CORP. , TORONTO, CANADA



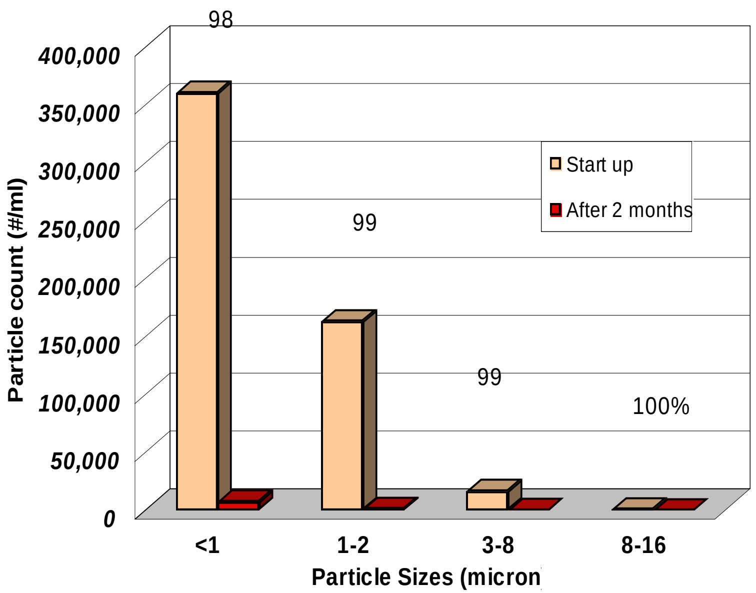
Enwave and the City of Toronto have created an innovative cooling system that brings an alternative to conventional air conditioning to cool Toronto's downtown core — one that is clean, price competitive and energy efficient.

A permanent layer of icy-cold (4°C) water 83 meters below the surface of Lake Ontario provides naturally cold water.

This water is the renewable source of energy that Enwave's leading-edge technology uses to cool office towers, sports & entertainment complexes and proposed waterfront developments.

DISTRICT COOLING - ENWAVE CORP. , TORONTO, CANADA

ENWAVE Chilled Water Loop
Particle Count - Start up / After 2 months



90% TSS Reduction after 4 weeks

CHILLED WATER LOOP

suspended particle counts shows that most suspended solids are smaller than 5 microns.

District Cooling
Vortisand model AWT6-30-SI

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Petro-Chemical Industry

Conoco Phillips - Baker, Montana
Application: Water injection well - 2011

LAX airport comparative technologies as per original specs : Combined sand filter +bag filters/cartridges

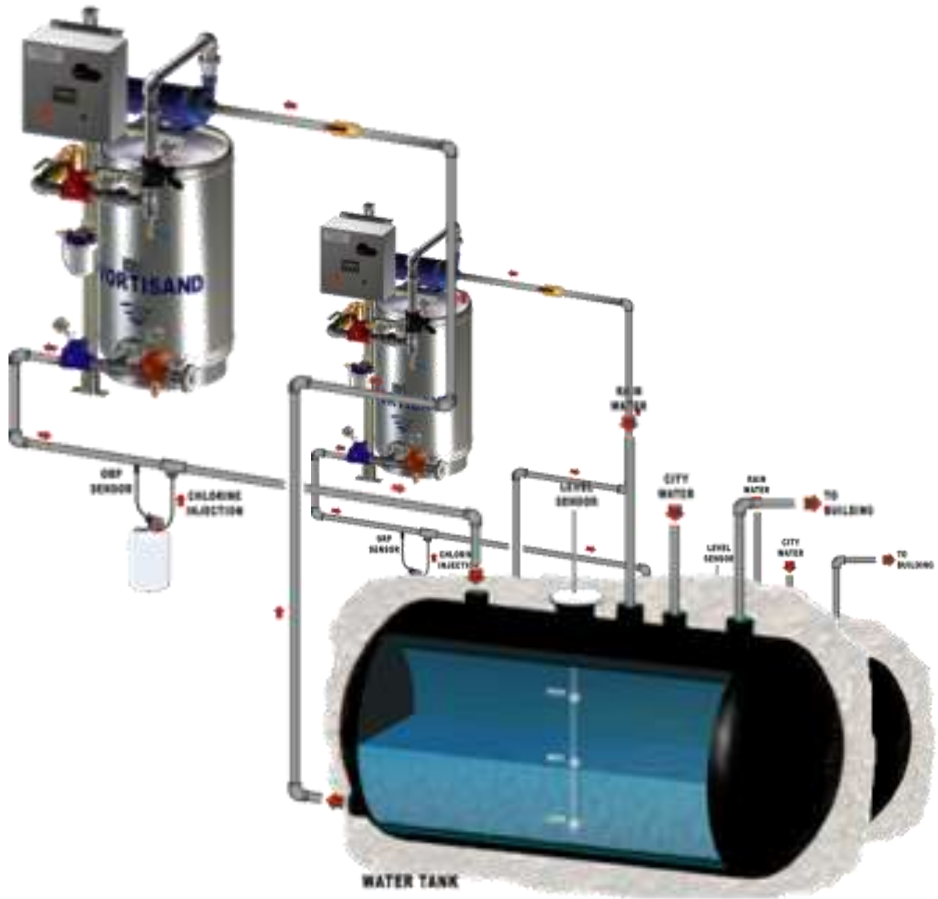
	Alternate Filter	As per Technical Specs	
	Vortisand	Traditional filter + sweeper piping	Cartridge filter
Flowrate	**2,800 gpm (5%)**	**4 x 2,100 gpm (15%)**	**3,000 gpm (5%)**
Filtration Efficiency	0.45 micron	20 microns (at best)	1 micron
Technology	Centrifugal Sand Filter - Automatic Backwash	Traditional Sand Filter Automatic Backwash	Disposable Cartridge Filter
Backwash Flowrate	75 gpm (5)	1,000 gpm	n/a
Backwash Volume	5,625 gallons/day (2,000,000 g/year) $ 9,000/year (1)	25,200 gallons/day 9,100,000 g/year $ 41,400 (1)	n/a
Filter Pump	45 HP (30 kW)	4 x 60 HP (180 kW)	75 HP (56 kW)
Electrical Usage (based on 6,000 hrs)	270,000 kWh $ 40,500 (4)	1,072,000 kWh $ 160,800 (4)	335,000 kWh $ 50,250 (4)
Additional Cost of Chemicals (use of CT water for BW)	n/a	$ 30,000 (2)	n/a
Cartridge replacement Frequency	n/a	n/a	1/week min. (3)
Cost per replacement	$ 10,000 for 5 years or $ 2,000 / year (media)	$ 10,000 / year (media)	160 cartridges @ $ 7 ea. ($ 1,120 /wk or $ 58,240 $ /yr)
Media Disposal Cost	1 every 5 years (10 tons / 5 years)	1 every year (10-12 tons / year)	Once a week (10 -12 tons year)
Storage Cost	n/a	n/a	TBC
Total Operating Costs (estimated)	$ 60,500	$ 242,200	$ 108,290

Combined $ 350,490

VORTISAND

Pre RO Applications

Rain water Harvesting



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Rain Water Harvesting

- UQAM Sciences Building – Received the prestigious LEED-NC Silver USGBC Certification - 2007;

- Ecole Polytechnique de Montreal, LEED-NC Gold Project – 2005;

Les Technologies Sonitec vortisand inc. Technologies

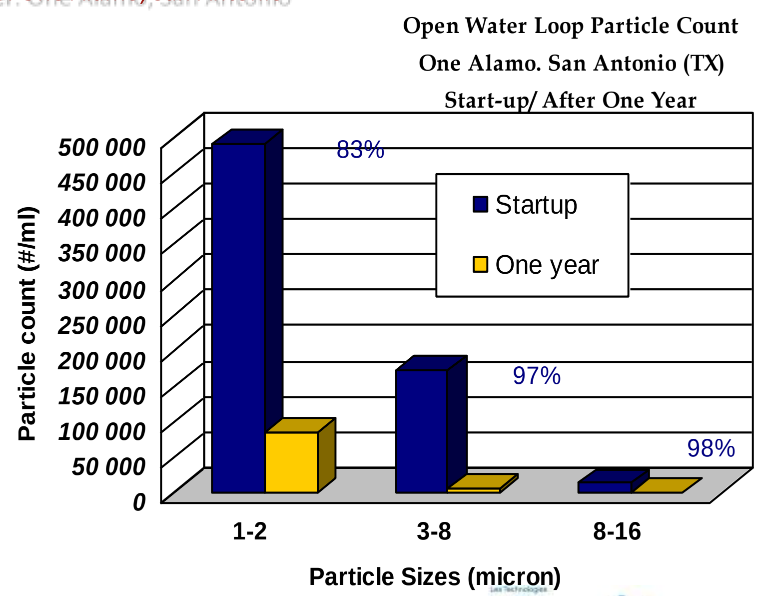
COMMERCIAL BUILDINGS - ONE ALAMO BLDG, SAN ANTONIO, TX

Winner the 2005 SanAntonio Water System WATER SAVINGS AWARD

“Cycle of concentration raised from 3.7 to 5.5 resulting from reduced suspended solid loads. 50% makeup water reduction allowed the use of underground water instead of City water. Great water savings which resulted to SAWS Water Saving Award in 2005.

Basin cleanup frequency has been reduced from twice a year to once every two year. Basin water is crystal clear. We also made great savings on strainers maintenance “

Jerry Lovell, Chief Engineer. One Alamo, San Antonio



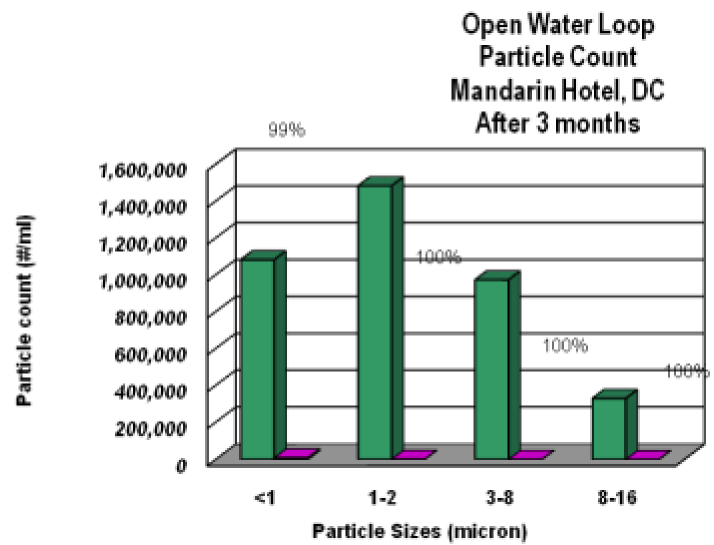
TSS load reduced by 99 %

COMMERCIAL - MANDARIN ORIENTAL HOTEL, WASHINGTON, D.C.

"The hotel doesn't consumer nearly as much cooling tower chemistry now because the Vortisand has made the water much cleaner,"

"We're now realizing a roughly 45% savings on chemistry verses the amount we spent, pre-instalment. Water usage has gone down substantially as well. We've enjoyed a 35% use reduction over last year, the majority of the savings occurring since the Vortisand system has been on line."

- Kevin Sharp, Mandarin Oriental Energy Manager



In 21 months of run time the NET RESULT IS:
Electrical Savings -- $152,689.00
Water Savings -- $117,843.00
Chemical Savings -- $14,175.00

Grand TOTAL savings of -- $284,707.00
for an Installed Investment of $75,000

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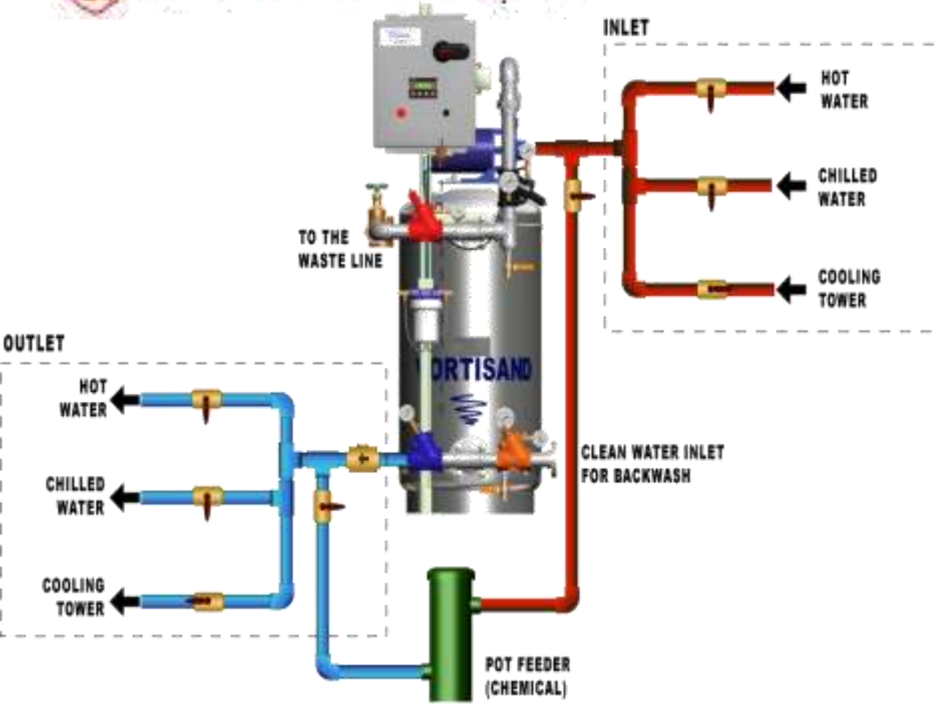
INSTUTIONAL - MCGILL UNIVERSITY, MONTREAL, CANADA




Mr. Andre Thompson, Facilities Management Supervisor

Since 1995, more than 20 Vortisand filters installed on the Campus.
Each filter is used for a minimum of 3 chilled/hot water loops.
The largest loop volume to be 20,000 gallons. **Alternate loop filtration**

- SONITEC JOINED USGBC IN 2004
- SONITEC JOINED CAGBC IN 2005
- GREENSPEC LISTED PRODUCT CERTIFICATION (2007)
- SONITEC GREEN REPS NETWORK - GLOBAL
- GREENBUILD EXPO *(First Water Filter Manufacturer)*
  - ✓ ATLANTA 2005
  - ✓ DENVER 2006
  - ✓ CHICAGO 2007
  - ✓ BOSTON 2008
  - ✓ PHOENIX 2009
  - ✓ CHICAGO 2010
  - ✓ TORONTO 2011

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Thank You !

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