



PathShield™ Antimicrobial Filter Media for Industrial Water Applications

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INTRODUCTION

A S Filtration™ is pleased to introduce PathShield™ Antimicrobial Filter Media for the reduction and control of coliform bacteria in industrial water treatment applications. PathShield™ is registered with the U.S. Environmental Protection Agency (EPA) in accordance with Federal law for its intended antimicrobial uses. PathShield™ media can be employed in batch or continuous operation treatment systems for industrial discharges and process water (excluding potable water).

PathShield™ effectively reduces coliform bacteria without releasing, discharging, or leaching any antimicrobial agents, chemicals, or heavy metals. PathShield™ kills coliform bacteria as the organisms physically move over the hostile surface of filter media granules (Figure 1). Efficacy is achieved at high filtration loading rates up to 20 gallons per minute per square foot (gpm/ft²). PathShield™ filter media is not consumed, requires no power source, has no moving parts, is non-corrosive, and is unaffected by seasonal temperature changes as a drop in replacement in industrial sand filter systems.



Figure 1. Bacteria is killed upon contact with hostile surface of PathShield™ media.

LABORATORY TESTING

A summary of three independent laboratory efficacy testing programs are described below. All testing was performed by a NELAP accredited laboratory using stock solutions of *E. coli*, Total Aerobic Bacteria, Sulfate Reducing Bacteria and Iron Fixing Bacteria.

E. coli Laboratory Testing

Table 1 summarizes the results of laboratory challenges using *E. coli* concentrations ranging from 150 to 36,000 colony forming units per 100 milliliters (cfu/100 ml) and loading rates of 9 to 118 gpm/ft². Various influent surface area loading rates and test cartridges simulated over 400,000 gallons of water passing through 24 cubic feet of PathShield™ media on an annual basis. Efficacies of >99.9%, or log three reductions, were achieved for these eight simulations.

Table 1. Summary of Laboratory *E. coli* Simulations

Influent <i>E. coli</i> (cfu/100 ml)	Loading Rate (gpm/ft ²)	Efficacy (%)
150	19	>99.9
1,180	30	>99.9
2,120	9	>99.9
2,150	22.5	>99.9
3,000	10	>99.9
3,500	10	>99.9
4,300	18	>99.9
36,000	10	>99.9

Additional independent long term laboratory efficacy challenges against *E. coli* were performed using 15 separate quality control PathShield™ filter media samples. Table 2 summarizes testing results using an average target influent *E. coli* concentration

of 16,500 cfu/100 ml and an influent loading rate of 10 gpm/ft². Over 99.99% removal efficiency, or greater than a log four reduction, was consistently achieved for this long term testing program.

Table 2. Long Term Laboratory Efficacy Testing

Influent <i>E. coli</i> (cfu/100 ml)	Effluent <i>E. coli</i> (cfu/100 ml)	Efficacy (%)
15,900	0.5	99.997
15,900	0.5	99.997
16,100	0.5	99.997
16,200	0.5	99.997
16,200	0.5	99.997
16,300	0.5	99.997
16,500	0.5	99.997
16,500	0.5	99.997
16,600	0.5	99.997
16,800	0.5	99.997
17,100	0.5	99.997
17,200	0.5	99.997
17,200	0.5	99.997
17,700	0.5	99.997
17,900	0.5	99.997

Total Aerobic Bacteria Laboratory Testing

A laboratory challenge was performed against Total Aerobic Bacteria (TAB) in a closed loop configuration designed to represent treatment in a side-stream filter. Figure 2 illustrates the TAB influent and effluent concentrations over 24 hours and 48 hours for the side-stream simulation.

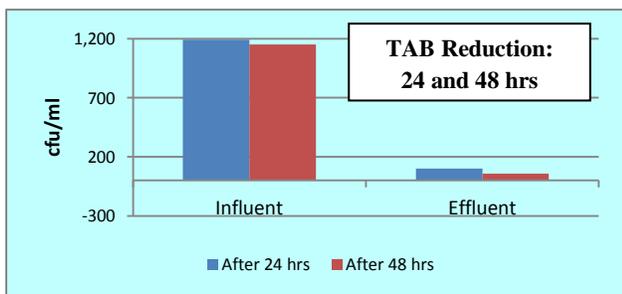


Figure 2. Total Aerobic Bacteria reduction was maintained over a 48 hour test simulating a side-stream filter system.

This challenge was performed over a 48 hour period which simulated 1,250 gallons of treated water at a loading rate of 20 gpm/ft². Corrections to influent concentrations were made based on natural drops in concentrations of the control stock over 24 and 48 hours. Natural concentration reductions were 13%

over 24 hours and 16% over 48 hours. The corrected 24 hour influent concentration was 1,192 cfu/ml and the effluent concentration was 100 cfu/ml, representing a 92% reduction in TAB. After 48 hours the corrected influent concentration was 1,151 cfu/ml and the final concentration was 57 cfu/ml, resulting in a 95% TAB reduction.

SRB and IFB Laboratory Testing

Efficacy of the PathShield™ antimicrobial filter media was tested against Sulfate Reducing Bacteria (SRBs) and Iron Fixing Bacteria (IFBs, inclusive of anaerobic Iron Reducing Bacteria and aerobic Iron Oxidizing Bacteria). Raw water samples collected from a groundwater extraction well known to be impacted by SRBs and IFBs was gravity fed through a filter cartridge at a loading rate of 10 gpm/ft². Both chemical reactions and direct microscopic examinations were performed to confirm efficacy results. Table 3 summarizes the influent and effluent concentrations with calculated SRB and IFB removal efficiencies of 98.7 and 92%, respectively.

Table 3. Laboratory SRBs and IFBs Efficacy

Bacteria	Influent (cfu/ml)	Effluent (cfu/ml)	Efficacy (%)
SRBs	684,000	8,680	98.7
IFBs	74,500	5,960	92.0

COOLING TOWER FIELD TESTING

Four field performance tests of the PathShield™ filter media are described below for warm weather cooling tower field testing programs. Table 3 summarizes the cooling tower size, average Total Coliform (TC) and Total Aerobic Bacteria (TAB) counts, positive change in temperature (ΔT) and number of test period days.

Table 3. Summary of Cooling Tower Field Testing

Test	Size (tons)	Avg. TC (cfu/ml)	Avg. TAB (cfu/ml)	+ ΔT (°F)	Days
1	200	0.49	NA	NA	90
2	300	NA	614	NA	16
3	200	16.6	3,660	NA	88
4	200	NA	NA	2.4/4.3	39

Field Test #1

PathShield™ filter media was installed in a 200 ton cooling tower at an urban north Georgia manufacturing facility for the purpose of providing disinfection in lieu of chemical treatment. Prior to PathShield™ installation, independent laboratory analysis of water samples collected during a 62 day baseline period determined an average Total Coliform concentration of 424 cfu/ml. Following installation of the PathShield™ media, independent laboratory analysis of 18 water samples collected over a 90 day test period determined an average Total Coliform concentration of 0.49 cfu/ml (Figure 3). A 99.88% reduction, or greater than a log two reduction in the Total Coliform concentration was achieved for the duration of the testing period.

Field Test #1: Total Coliform Suppression

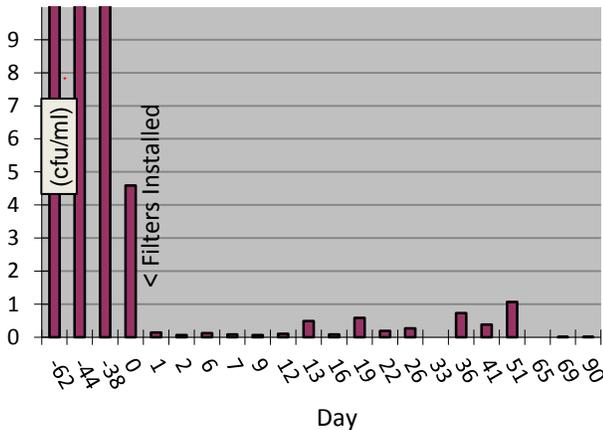


Figure 3. Total Coliform suppression for a 200 ton cooling tower was maintained for a 90 day test period and 80 million gallons of treated water.

NOTE: Maximum desired level of Total Aerobic Bacteria in cooling tower water is 10⁴ (10,000) cfu/ml as illustrated below in Figure 4 (Test #2) and Figure 5 (Test #3).

Field Test #2

PathShield™ filter media testing was performed in a side-stream filter system on a 300 ton cooling tower at a rural north Georgia manufacturing facility. This system uses well water and is rated at 30 gpm, while the system water volume is approximately 1,350 gallons. Testing was initiated following a thorough tower cleaning. Over a 16 day testing period, the TAB count average was 614 cfu/ml for 700,000

gallons of water (Figure 4). The TAB count did not exceed 10³ cfu/ml.

Field Test #2: TAB Suppression

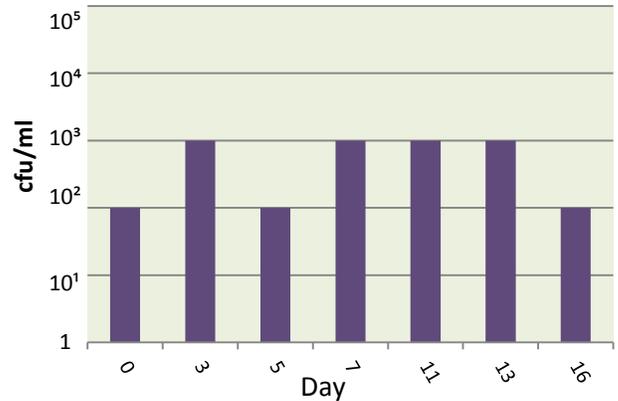


Figure 4. Total Aerobic Bacteria suppression for a 300 ton process cooling tower was maintained over a 16 day test period. Note log scale for TAB count.

Field Test #3

As a means to study the effects of seasonal weather conditions on performance, a second round of testing was performed on the first urban test site cooling tower. PathShield™ media was reinstalled after a 163 day period whereby no treatment other than one chemical shock occurred. The system was measured for TAB and Total Coliform bacteria over 88 days and a treated water volume of 76,032,000 gallons. The TAB average was 3,660 cfu/ml and did not exceed the target maximum of 10⁴ cfu/ml (Figure 5). The Total Coliform concentration average was 16.6 cfu/ml (Figure 6).

Field Test #3: TAB Suppression

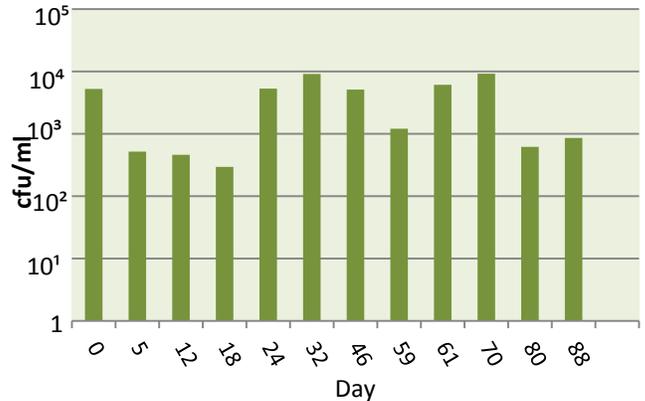


Figure 5. Total Aerobic Bacteria suppression for a 200 ton cooling tower (first test site) was maintained for a test period of 88 days. Note log scale for TAB count.

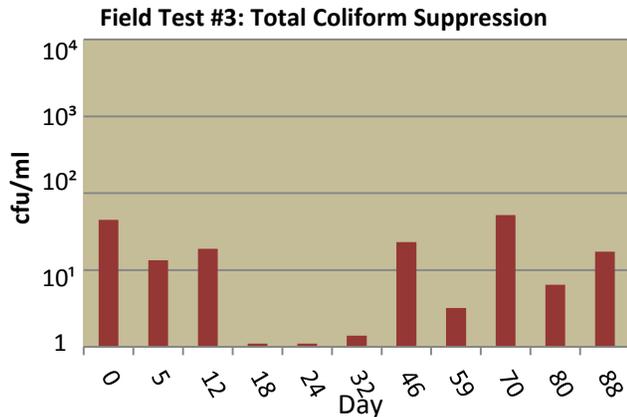


Figure 6. Total Coliform suppression for a 200 ton cooling tower (first test site) was maintained for an 88 day test period. Note log scale for TC count.

Field Test #4

A 200 ton multi-stack cooling tower positioned on a highrise hotel roof in Washington D.C. was tested over 39 days to document the change in water temperature (ΔT) between the inlet and outlet flows in the cooling tower (open) loop and chiller (closed) piping loops of the system. The purpose of this test was to document the enhancement of cooling system operational efficiency with the inclusion of PathShield™ antimicrobial filter media. The system includes side-stream filters containing PathShield™ filter media in both piping loops. The open piping loop uses makeup water for the cooling tower structure while the closed piping loop provides air exchange for the chiller and building cooling.

As illustrated in Figure 7, the open loop cooling tower side of the system exhibited a net water ΔT gain of 2.4°F (4.9° - 2.5°) and averaged 5.5°F. The closed loop for the chiller exhibited a net water ΔT gain of 4.3°F (5.4° - 1.1°) and averaged 3.3°F. Gains in ΔT correspond to improved system performance.

System performance was significantly enhanced from prior operations as evident with net ΔT gains for both the cooling tower and chiller piping loops. Furthermore, improved system efficiency provides for increased energy savings and a reduction in operational costs. It is regarded that the PathShield™ filter media serves to improve cooling tower system performance when using side-stream filter configurations.

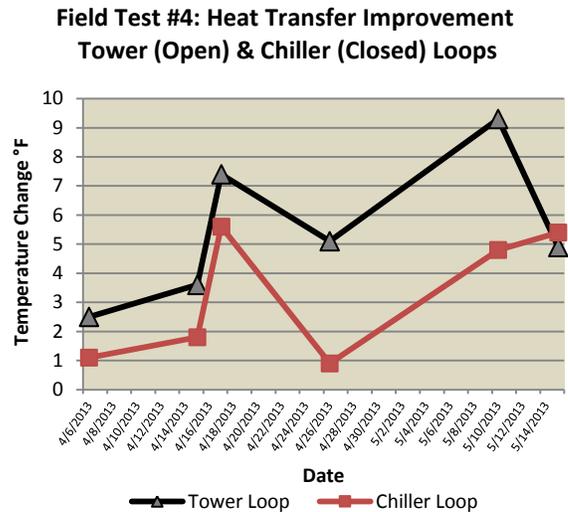


Figure 7. Increase in ΔT over 39 days for open and closed loops of 200 ton multi-stack cooling tower unit.

CONCLUSIONS AND BENEFITS

Significant operational and environmental benefits can be realized through the use of PathShield™ antimicrobial filter media including:

- Use of an EPA registered filter media,
- Media does not discharge, release or leach any antimicrobial agents
- Long term and high level of performance
- Does not rely on physical trapping
- No external power source or moving parts
- Media is non-corrosive and is not consumed
- Unaffected by seasonal temperature changes