Biofilm Control in HVAC & Cooling Systems

Ionic Nano Copper kills bacteria, prevents algae and reduces corrosion.
Indication of Biofouling – How to detect

• Visual and tactile observations: colored or slippery slime deposits
• Diagnostics: Bacterial counts (plates, dipslides), indicating cultures (e.g., SRB), ATP, on-line biofilm monitors, deposit sample analysis by loss on ignition
• System performance: inefficient cooling, reduced heat transfer, electrical load
What biofilm could cause at HVAC System

- Energy cost increase
- Hard Maintenance work
- Electrical overload of pump (trip off)
- Health danger (Legionella)
- Equipment life time (Corrosion)
Cost Impact of Microbial Fouling

- Biofilm thickness (fins)
  - 0.3 mm
  - 0.6 mm
  - 0.9 mm

- Energy usage increase
  - +10.8%
  - +21.5%
  - +32.2%

HVAC uses 60% of a building’s energy
On Condenser
Biofilm forms an insulating layer
1 mm biofilm thickness > 13 % energy loss

Chiller Condenser
Potential Health Danger

Legionella Bacteria
THE KILLERS IN THE MIST

July 12 First South Bronx Legionnaires' case is diagnosed.
July 18 The number of diagnosed cases grows to 12.
July 20 City officials begin interviewing patients to determine what they have in common and pinpoint a source of the outbreak.
July 27 The number of diagnosed cases grows to 40.
July 28 City begins to sample and test water from cooling towers in the South Bronx.
July 29 The city tells the public about the outbreak and discloses that two patients have died. The first towers to test positive for Legionella bacteria are cleaned.
July 30 The number of new cases peaks, as 13 are diagnosed in a single day.
July 31 City gets test results for all 17 cooling towers in the outbreak area. Five cooling towers test positive: at Lincoln Hospital, Concourse Plaza Mall, the Opera House Hotel, Streamline Plastics Co. and a Verizon building.
Aug. 1 City reveals a fourth Legionnaires' patient has died and that reported cases have risen to 65. Cleaning is completed in all five contaminated buildings.
Aug. 3 City announces that the outbreak's death toll has climbed to seven.
Aug. 4 The number of reported cases grows to 86.

WHAT YOU NEED TO KNOW

Q What is Legionnaires' disease?
A It's a severe form of pneumonia caused by a bacteria grown in warm water – for instance, in hot water tanks and cooling towers.

Q How do you get Legionnaires' disease?
A When you breathe in a mist containing the bacteria. You do not catch it from another infected person.

Q What are the symptoms?
A Victims suffer shortness of breath, high fever, muscle aches, headaches and coughing.

Q What are treatment options?
A The disease can be treated with antibiotics.

Gram-positive | Ex. Staphylococcus
Thick peptidoglycan layer absorbs surrounding materials, even toxins. Easier to kill, develops resistance slower.

Gram-negative | Ex. E. coli
Thin peptidoglycan layer covered by multiple thin layers of membrane which eject toxins. Harder to kill, quick to develop resistance.
Biofilm in the water system
Microorganisms settle on wet surfaces and over time form a biofilm there. After several days, a biofilm can have already reached its stationary phase when continuous release of germs takes place.
Biofilm in Industrial Process Cooling
Microbial Influenced Corrosion

- APB – Acid Producing Bacteria
- IRB – Iron Depositing Bacteria
- Sulfate Reducing Bacteria
Remove existing biofouling deposits
Prevent the formation of new deposits
Ionic Nano Copper stops biofilm build up everywhere
Ionic Nano Copper

<table>
<thead>
<tr>
<th>Common Name of Active Ingredient</th>
<th>Copper Sulphate Penta-Hydrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Name of Active Ingredient (IUPAC I designation)</td>
<td>Present as Copper Sulphate Penta-Hydrate</td>
</tr>
<tr>
<td>Formula (empirical and structural)</td>
<td>CuSO4·5H2O</td>
</tr>
<tr>
<td>Production Date</td>
<td>08/12/2016</td>
</tr>
<tr>
<td>Expiry Date</td>
<td>08/12/2026</td>
</tr>
</tbody>
</table>

- **Copper Sulphate Penta-Hydrate CAS# 7758-98-7**: 5% to 5.3%
- **Sulphuric Acid CAS # 7758-99-8**: 2.8% to 3.1%
- **Odor**: Mild
- **Appearance: (Physical state, & color)**: Clear, blue liquid
- **Odor threshold concentration: (ppm)**: Not applicable
- **Density/specific gravity: (H2O = 1)**: 1.19
- **Vapor pressure at 200 C: (mmHg)**: 0.1
- **Vapor density: (Air = 1)**: 1
- **Evaporation rate**: N/A
- **Boiling point: (C/F)**: 104°C
- **Freezing point: (C/F)**: 00°C
- **pH**: 1.2 (buffered)
- **Lead (as Pb)**: ND
- **Cadmium (as Cd)**: ND
- **Arsenic (as As)**: ND
Objective of Ionic Nano Copper

- Improved Biofouling Control
- Cost effective biofouling control
- Enhanced Corrosion Control
- Enhanced Scale Control

The evidence from decades of scientific research is very clear. *Legionella pneumophila* resides primarily in biofilms in building and industrial water systems.
90% of bacteria lives in biofilm

- Biofilms protect the pathogenic bacteria, making them hard to kill.
- Hiding in biofilms, bacteria can spread throughout the body.
- Large, sticky biofilms resist the attack of the immune system and antibiotics
Ionic Nano Copper stops biofilm formation
Biofilm growth

<table>
<thead>
<tr>
<th>Phase</th>
<th>Time</th>
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</thead>
<tbody>
<tr>
<td>Colonization</td>
<td>15 minutes</td>
</tr>
<tr>
<td>Growth detection</td>
<td>2 days</td>
</tr>
<tr>
<td>Biofilm formation (minimum)</td>
<td>5 days</td>
</tr>
<tr>
<td>Maximum biofilm growth (8-10 cells thick)</td>
<td>14 days</td>
</tr>
<tr>
<td>Full Mature Biofilm Matrix</td>
<td>31 – 40 days</td>
</tr>
</tbody>
</table>

Destroying the biofilm support the goal of getting a more effective cooling towers in two ways.
1. Control biofilm growth is equal to Legionella control.
2. Control biofilm growth increase the efficiency
Legionella in the Water System

- evaporative cooling water systems,
- evaporative condensers
- closed-circuit fluid coolers
- cooling towers.

Colorized scanning electron micrograph (8000X) depicting a large grouping of Gram-negative Legionella pneumophila bacteria (Source: Centers for Disease Control).
Ionic Nano Copper as biocide, fungicide and algaeicide
Typical nano copper particle is 5 nm = 0.00000005 m = 5x10^{-8} m

Ionic copper's copper ions are 30 times smaller
Smaller size causes higher electrostatic

“Disruptive force for breaking cell membrane”
Ionic Nano Copper – Seek & Destroy Mission

1. Copper ions are collected at the membrane of bacteria cell
2. On their way to the inside of the cell, it blocks the enzyme system of bacteria
3. Reproduction of micro-organism is terminated

Before

After
# Comparison of Technologies

<table>
<thead>
<tr>
<th></th>
<th>UV</th>
<th>Sodium Hypochlorite</th>
<th>Chlorine Dioxide</th>
<th>Ozone</th>
<th>Ionic Nano Copper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prophylactic effect</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Destroys biofilms</td>
<td>No</td>
<td>Limited</td>
<td>Yes</td>
<td>Limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Safe for operators</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Effective against legionella colonization</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Environmentally safe</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
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</table>
Ionic Nano Copper targets bacteria & algae

Most suspended solids are made up of inorganic materials, though bacteria and algae can also contribute to the total solids concentration.3
The Effect on bacteria & algae reduction

<table>
<thead>
<tr>
<th>Water analysis Parameter</th>
<th>Untrested Sample</th>
<th>Sample treated with INC (3days)</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>70</td>
<td>5</td>
<td>93 %</td>
</tr>
<tr>
<td>Turbidity</td>
<td>11.2</td>
<td>3.55</td>
<td>68 %</td>
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<tr>
<td>pH@25 C</td>
<td>8.4</td>
<td>7.67</td>
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<tr>
<td>Total Alkalinity</td>
<td>64</td>
<td>11.4</td>
<td>82 %</td>
</tr>
<tr>
<td>Total Suspended Solid</td>
<td>78</td>
<td>5</td>
<td>94 %</td>
</tr>
<tr>
<td>BOD5</td>
<td>7</td>
<td>4</td>
<td>43 %</td>
</tr>
</tbody>
</table>

Water source: man made lake

Sample Treated with Ionic Cupric Copper After 3 day

Sample Untreated
Dilution Method and Dosage

Cost Effective Prevention of Biofilm and Corrosion
<table>
<thead>
<tr>
<th>Water in M3</th>
<th>Water in Liter</th>
<th>Ionic Nano Copper in mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100,000</td>
<td>1,667</td>
</tr>
<tr>
<td>200</td>
<td>200,000</td>
<td>3,333</td>
</tr>
<tr>
<td>300</td>
<td>300,000</td>
<td>5,000</td>
</tr>
<tr>
<td>400</td>
<td>400,000</td>
<td>6,667</td>
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<td>500</td>
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<td>8,333</td>
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<td>600</td>
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<td>13,333</td>
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<td>900</td>
<td>900,000</td>
<td>15,000</td>
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<tr>
<td>1000</td>
<td>1,000,000</td>
<td>16,667</td>
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<tr>
<td>2000</td>
<td>2,000,000</td>
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<td>3001</td>
<td>3,001,000</td>
<td>50,017</td>
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<tr>
<td>4000</td>
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<td>66,667</td>
</tr>
<tr>
<td>5000</td>
<td>5,000,000</td>
<td>83,333</td>
</tr>
</tbody>
</table>

1 M3 = 1000 L
1 L = 1000 mL

**Ratio 1:60,000 (concentration 1 ppm)**

<table>
<thead>
<tr>
<th>Water in M3</th>
<th>Water in Liter</th>
<th>Ionic Nano Copper in mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,000</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>2,000</td>
<td>33</td>
</tr>
<tr>
<td>3</td>
<td>3,000</td>
<td>50</td>
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<tr>
<td>4</td>
<td>4,000</td>
<td>67</td>
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<tr>
<td>5</td>
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<td>6</td>
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<td>100</td>
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<tr>
<td>7</td>
<td>7,000</td>
<td>117</td>
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<td>8</td>
<td>8,000</td>
<td>133</td>
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<tr>
<td>9</td>
<td>9,000</td>
<td>150</td>
</tr>
<tr>
<td>10</td>
<td>10,000</td>
<td>167</td>
</tr>
<tr>
<td>11</td>
<td>11,000</td>
<td>183</td>
</tr>
<tr>
<td>12</td>
<td>12,000</td>
<td>200</td>
</tr>
<tr>
<td>13</td>
<td>13,000</td>
<td>217</td>
</tr>
<tr>
<td>14</td>
<td>14,000</td>
<td>233</td>
</tr>
<tr>
<td>15</td>
<td>15,000</td>
<td>250</td>
</tr>
</tbody>
</table>

1 M3 = 1000 L
1 L = 1000 mL

- Administer & maintain 1 ppm
- Don’t go below 0.1 ppm
Dilution Methode

To obtain 1 ppm, add 1 part of INC ®-IONIC NANO COPPER to 60,000 parts of system water or 1:60,000 dilution.
Example 1: For 1,000 liters of pool water, use 17 ml of INC (QuaDrop).
Example 2: For 100 M3 (100,000 L) of system water, use 28 ml to 1.667 ml of INC (QuaDrop)
Ionic Nano Copper is self mixing

No precipitation
(No settling of Cu++)

Water soluble
1 ppm of stable copper ions

5000 ppm
Ionic Cupric Copper does not dissipate

it is ONLY used up by biological demand & no other matters
Ionic Cupric Copper is uniformly self dispersing
When is periodic disinfection necessary?

It is for systems that:

• That have process leaks
• That have heavy biofouling
• That use reclaimed wastewater as makeup
• That have been stagnant for a long time
• When the total aerobic bacteria counts regularly exceed 100,000 CFU/ml
• When Legionella test results show greater than 100 CFU/ml
After a biofilm control program treatment, you should also see *an increase in suspended solids, ATP, and bacterial counts in the bulk water as deposits are released.* After removal of the released deposits by filtration or blowdown, repeated treatment should show decreasing evidence of biofouling.
**SOLIDS CLASSIFICATION**

- **Portion refrained on filter paper**
  - Suspended Solids
  - Nonsetttable Solids
  - Colloidal Solids
  - Dissolved Solids

- **Total Solids**

- **Portion passing through filter paper**
  - Filterable Solids

- **Suspended Solids**

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**Suspended Solids**

- Filter paper
- Suspended Solids
Advantage of Ionic Nano Copper

One agent for two challenges – it fights the planktonic bacteria and the biofilm
Ionic Nano Copper Benefit

- High efficacy in very low dosage
- Removes and prevents biofilms
- Totally Chlorine Free (TCF)
- Inhibits Microbiologically induced corrosion
- Non-foaming
- Compatible with glycol and brine systems
Ionic Nano Copper’s penetration into biofilm

Corrosion is evidence of biofouling

INC penetrates into biofilm & kill bacteria
INC destabilizes biofouling deposits & removes from surface
Cleaner surfaces with less MIC & better heat transfer
Existing Practice – The use of two chemicals

- Special handling & storage of chemicals
- Dosing and balancing of two chemicals – hassle
In practice higher concentration of biocide is used – higher cost
Last but not Least...

“When using Ionic Nano Copper, Please verify your previous system setting”
Distribution with partners

Advanced Greentech Solutions Pte. Ltd - Manufacturer