Cooling Tower Fills to Optimize CT Performance

Presented by Richard Aull, PE
Director of Engineering
Brentwood Industries
Presentation Summary

- Modern Fill Designs
- Fill Scaling & Fouling
- In-Situ Fouling Testing at Plant Bowen
- Case Studies
- Product Innovations
Modern Fill Designs
Cooling tower fill should maximize heat transfer but not at the expense of severe fouling.

Selection is extremely dependent upon the quality of make-up water.

More frequently, poor quality water is being utilized for plant make-up.
Factors That Influence Fill Performance

• Flute size (air & water flow pathways)
• Pathway configuration (cross-flutes, offset-flutes, vertical-flutes)
• Surface features (micro-structure)
General Types of Counter-Flow Film Fill

Cross-Flute Design

Offset-Flute Design

Vertical-Flute Design

Decreasing tendency to clog

Increasing performance
• The designed-in surface features (micro-structure) formed on the polymer fill sheet

• Keeps the water film mixed & turbulent for maximum heat transfer
Surface structure enhances air/water contact

Microstructure’s Performance Improvement

w/o microstructure

w/ microstructure

Fill

35C

Air

Water Film

33C 31C

28C

Fill

Water Film
Cross Flute (CF)

- Large specific surface area
- High performance
- Poor anti-fouling characteristics in fouling waters

Thermal Performance

<table>
<thead>
<tr>
<th></th>
<th>Good</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fouling resistance in dirty water systems</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
High-Efficiency, Low-Fouling Film Fill

- Large specific surface area
- High performance
- Moderate anti-fouling characteristics

Offset Flutes (OF)

Thermal Performance

Good

Fouling resistance in dirty water systems

Poor
Anti-Fouling Film Fill

- Lower specific surface area
- Moderate performance
- Excellent anti-fouling characteristics

Thermal Performance

- Good
- Poor

Fouling resistance in dirty water systems
Fill for Severe Fouling Applications

- High droplet surface due to integral drip points
- Moderate performance
- Excellent anti-fouling characteristics

Integral Drip Points

Thermal Performance

Good

Fouling resistance in dirty water systems

Poor

Compact Droplet (Splash)
High Performance Droplet Generating Fill

Droplet Formation video
Fill Scaling & Fouling
Scaling

• Scale is formed when the concentration of dissolved solids (minerals) exceeds the solubility of that particular scale-causing mineral.

• When this situation occurs scale will form on any surface in contact with the water in an untreated cooling water system.
Scaling

- Calcium and magnesium salts, are more soluble in cold water than in hot water
  - Will form on heated surfaces

- Most other salts, including silica are more soluble in hot water than in cold water
  - forms in low temperature areas, as in the cooling tower fill
Causes of Fill Scaling

• Cycles of Concentration too high

• Poor or fluctuating water distribution

• Chemical treatment upsets
Good Water Distribution is Key

• The nozzles must provide uniform and continuous water entering all flutes of the fill

• If not, deposits will accumulate in poorly wetted areas

• Forms an excellent base for biofilm growth

• Causes the accelerated accumulation of both suspended solids & scaling minerals
Fouling of Fills

• Fouling is the deposition of materials that are normally held in suspension in the cooling water such as:
  • Mud, silt, and other solids brought into the system with the makeup water
  • Dust, dirt, and debris scrubbed out of the air passing through the tower
  • Product leakage such as oils, corrosion products from the system, and biological organisms, both living and dead
Causes of Fill Fouling

- High suspended solids
- High bacterial count
- High nutrient level
- Process contamination
- High concentrations of oils & grease
Examples of Fill Fouling

Fouling due to mud and silt accumulation
Biofilms

• Clusters of microorganisms adhering to surfaces
• Encased in an extracellular polysaccharide (glue) that they synthesize
• Found on surfaces in which sufficient moisture is present
• Develops rapidly in flowing systems where nutrients are available
Effect of Water Film Velocity on Biofilms

![Graph showing the relationship between mean water velocity and biofilm thickness.](image)

Biofilm Accumulation*

Film Fill Design Strategy To Minimize Fouling

- **Orient flutes vertically**
  - Maximizes water film velocity

- **Create large flute openings**
  - Increases film velocity
  - Reduces chance for airborne solids to accumulate
  - 19mm or larger

- **Eliminate flute passage restrictions**
  - Reduce crossover points
Water Film Velocities of Fills

Results from Brentwood testing at 20 m3/hr/m2 water loading
In-Situ Fouling Testing at Plant Bowen
In-Situ Fouling Testing at Plant Bowen

3500 Mw Coal Fired Power Plant in southeastern USA
In-Situ Fouling Testing at Plant Bowen

Fill Test Beds
Test Packs Weighing Procedure
Test Results

SCS Fouling Tests
Plant Bowen Unit 4 Cooling Tower Fill Fouling Test

- **VF19Plus**
  - 3 layers of 23.6" modules
  - Last Test Weighing 9/9/10

- **CF1900**
  - 3 layers of 12" modules
  - Test Ended, Packs Pulled

**Net Fouulant Weight Gain (lb/ft³)**

**Test Duration (Days)**

10/1/1998
Effect of Fill Fouling on Performance

Estimate of Performance Loss vs. Fouling

Performance Loss (%)

Net Weight Gain (kg/m³)

Source: CTI Technical Paper TP93-06, “Research of Fouling Film Fill”
## Guidelines for Tower Fill Selection

<table>
<thead>
<tr>
<th></th>
<th>19mm CF</th>
<th>21mm OF</th>
<th>19mm VF</th>
<th>25mm Droplet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Allowed TSS w/good microbial control (ppm):</strong></td>
<td>&lt;100</td>
<td>&lt;200</td>
<td>&lt;500</td>
<td>&lt;1000</td>
</tr>
<tr>
<td><strong>Allowed TSS w/poor microbial control (ppm):</strong></td>
<td>&lt;25</td>
<td>&lt;50</td>
<td>&lt;200</td>
<td>&lt;500</td>
</tr>
<tr>
<td><strong>Allowed Oil &amp; Grease concentration (ppm)</strong></td>
<td>None</td>
<td>&lt;1</td>
<td>&lt;5</td>
<td>&lt;50</td>
</tr>
</tbody>
</table>

‘**Good**’ biological control means oxidizing biocide supplied continuously with bactericidal residuals maintained, with total aerobic bacteria (TAB) maximum plate counts not exceeding 100,000 cfu/ml.

‘**Poor**’ microbiological control implies little or no microbiological control or control subject to severe disruption, with average TAB plate counts consistently over 100,000 cfu/ml. Other airborne contaminants should be considered also, such as fine dust, dirt & debris.
Case Studies
Brentwood Products in 6 Cell FRP CF Tower

- Repacked tower serves a 250 MWe sub-bituminous coal fired power plant in southwestern USA
- 2,350m³ HTP-25 fill
- CTI 3rd party thermal test: Passed

Tri-States/Escalante Generating Station
Brentwood Products in 12 Cell FRP CF Tower

• New tower serves the new second unit of a 1,200 MWe coal fired power plant in mid-central USA
• 5,000m³ OF21ma fill
• 3,350m² CF80MAx drift eliminators
• CTI 3rd party thermal test: Passed
• CTI 3rd party drift test: 0.0004% (0.0005% contracted target)
Brentwood Products in 10 Cell FRP CF Tower

• New tower serves a 520 MWe combined cycle power plant in eastern USA
• 3,425 m$^3$ OF21ma fill
• 1,875 m$^2$ CF150MAx drift eliminators
• CTI 3$^{rd}$ party thermal test: Passed

Calpine/York Energy Center
Brentwood Products in Concrete ND Tower

- Repacked counterflow natural draft tower serves Units 3 & 4 of a 2,822 MWe coal fired power plant in southeastern USA
- 18,000m³ VF19Plus fill
- Owner thermal test: Passed

Alabama Power/Miller Steam Plant
Product Innovations
Mechanically Assembled (MA) Fill

- Special tabs are molded into the individual fill sheets
- Pairs of sheets have their tabs crimped together
How MA Works
How MA Works

NEW core assy-DISPLACE:: Static displacement
Units: in  Deformation Scale: 1

©2012 Brentwood Industries, Inc.
New ACCU-Shield Anti-Microbial

• Inhibits the growth of bacteria, which contribute to fouling
• Environmentally safe both EPA & FDA approved
• Not a coating, will not wear off
• Available for all fills & drift eliminators
New ACCU-Shield Anti-Microbial

• ACCU-Shield recorded a 70% reduction in weight gain compared to the standard PVC media after one year.
• Lower weight gain is from reduced bio growth on the fill which “sticks” airborne matter and suspended solids to the fill media.
Thank you for your attention!