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Power Generation | Industrial Process

FULL SPECTRUM GLOBAL SOLUTIONS
Important Criteria When Considering Cooling Towers for Your DCP

Georges Hoeterickx
Director Business Development

Jelle Wagelmans
Sales Manager Middle East
Important Criteria When Considering Cooling Towers For Your DCP

- Film Fill Types – Materials – Maintenance
- Cooling Tower Layout
- Thermal Performance Certification (CTI)
Film Fill types – Materials – Maintenance

• Types of Fill & Selection Criteria
• Thermal Performance Ratings
• Material and Mechanical Properties
• Fill Life Time and Maintaining Tower Efficiency
• The water droplets generated by splashing
• Heat exchange between water droplets surface and air
Fill Selection Criteria

Film Type

- Heat exchange between water film surface on PVC sheet and the air
Fill Film Selection

- Fill is a media to create more **water surface** exposed to the air
- Fill increases the time air-water contact by retarding the progress of water

Increased heat transfer
Fill Selection Criteria

- Film Fill
- Perforated Sheet
- Splash Bars
- Splash Grids

Water Quality

FULL SPECTRUM GLOBAL SOLUTIONS
Fill Selection Criteria

The selection of the FILL TYPE depends on the circulating water characteristics:

- Type of water: sea, TSE, potable water
- Type of industry: power, chemical, paper, steel, DCP ...
- Water availability (concentration factor)
- Type of water treatment
Water Quality

Fill Fouling Directly Related to Total Suspended Solids (TSS) & Biological Activity

• Origin Suspended Solids in the circulating water:
  – TSS of make up water
  – Dust and airborne particles washed by the cooling tower
  – Dispersants used to control the scaling

• Biological activity controlled with biocides injection

TSS maximum concentration for each fill is only valid if the Biological activity is controlled!
Film Fill Types

Cross-Flutes
High Efficiency
Cross Corrugated Film Fill Type

- Cross corrugated flutes require (very) good water quality
- Highest specific heat transfer
- Slow water / long air travel → risk for fouling
- Crossed sheet design = high structural rigidity
Film Fill Types

Cross-Flutes
High Efficiency

Offset-Flutes
Efficient Low-Fouling
Vertically Offset Flute Film Fill Type

- Offset flutes require good water but more forgiving than cross corrugated
- Highly efficient sheet texture and transitions
- Moderately fast water vs. air travel = low fouling risk
- Lower efficiency compensated by low pressure drop
Film Fill Types

Cross-Flutes
High Efficiency

Offset-Flutes
Efficient Low-Fouling

Vertical-Flutes
Anti-Fouling
Vertical Flute Film Fill Type

- Vertical flutes handle severe water quality well with proper bacterial control
- Efficient sheet texture = very low fouling risk
- Fast water / air travel = very low fouling risk
- Very low pressure drop = better than splash
# Water Quality Comparison

## Biological / Bacteria and Total Suspended Solids

<table>
<thead>
<tr>
<th>Fill Type</th>
<th>High Performance film fill 12 mm or 19 mm Spacing Cross Fluted (EVAPAK®)</th>
<th>Low Fouling film fill 25 mm Spacing Vertical Fluted (TechClean™)</th>
<th>Anti-fouling film fill 19mm Vertical Flow (VertiClean™)</th>
<th>Splash Fill Bars / Grids (Opti-Bar™ Arch-Bar™ Opti-Grid™)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTS (ppm)</td>
<td>&lt;25</td>
<td>&lt;50</td>
<td>&lt;100</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Bacteria Count (ppm)</td>
<td>&lt;10,000</td>
<td>&lt;100,000</td>
<td>&lt;1,000,000</td>
<td>&gt;1,000,000</td>
</tr>
<tr>
<td>Bio &amp; Scale Control</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
<td>Lower to none</td>
</tr>
</tbody>
</table>

Note: Fill spacing function of TDS
Film Fill types – Materials – Maintenance

- Types of Fill & Selection Criteria
- Thermal Performance Ratings
- Material and Mechanical Properties
- Fill Life Time and Maintaining Tower Efficiency
Thermal Performance Ratings

Counterflow Film Fill and Spray Test Cell

1. Forced draft fans
2. Airflow nozzle wall to measure volumetric airflow
3. Turning vanes
4. Cold water collecting troughs and mixing box
5. Counterflow fill test section
6. Hot water distribution pipes and spray nozzles
7. Drift eliminators
Thermal Performance Ratings

Counterflow Film Fill and Spray Test Cell
Thermal Performance Ratings

- KaV/L
- ΔP

Air rate:
1.5 → 5.0 m/s (300-1000 FPM)

Water rate:
45 → 160 m³/h (200-700 GPM)

Production testing:
- Film fills
- Splash fills
- Drift eliminators
- Spray nozzles
Thermal Performance Ratings

Fill Data

- KaV/L vs. Fill Air Velocity, FPM
- ΔP Fill, lnWG vs. Fill Air Velocity, FPM
Thermal Performance Ratings

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**Thermal Rating Sheet (CTI Summary)**

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Watts Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>Proposal Date</td>
<td></td>
</tr>
<tr>
<td>Selection ID</td>
<td></td>
</tr>
</tbody>
</table>

**Selection Criteria:**

- **Type:** Induced Draft
- **Flow Type:** Counterflow
- **Operation Mode:** Normal
- **Water/Cold Water:** Water
- **Tubing Per Meter:** 24" PVC, 34 gal, 1.5" PVC

**Geometric Conditions:**

- **Tower Elevation:** 49 ft (15 m)
- **Cell Quantity:** 3
- **Cell Length:** 11.50 ft (3.51 m)
- **Cell Height:** 11.50 ft (3.51 m)
- **Quantity Parts Per Cell:** 1

**Geometric Heights:**

- **Air Inlet Height (TOC):** 6.00 ft (1.83 m)
- **Air Inlet Diameter (BA):** 8.00 ft (2.44 m)
- **Fan Deck Height:** 16.00 ft (4.88 m)
- **Fan Stack Height:** 10.00 ft (3.05 m)
- **Total Height:** 80.00 ft (24.38 m)

**Facilities:**

- **Fan Manufacturer:** Other
- **Fan Type:** [Fan Type]
- **Fan Model:** [Fan Model]
- **Fan Diameter:** [Fan Diameter]
- **Fan Blades:** [Fan Blades]
- **Fan Blade Pitch:** [Fan Blade Pitch]
- **Fan Blade Area:** [Fan Blade Area]
- **Fan Blade Efficiency:** [Fan Blade Efficiency]
- **Fan Blade Area Efficiency:** [Fan Blade Area Efficiency]

**Drive & Expansion:**

- **Motor Speed:** 1,755 RPM
- **Drive Motor:** 175 hp
- **Drive Ratio (Horsepower):** 12.1
- **Fan Speed (In):** 1,050 (98.3 in)
- **Fan Speed (RPM):** 1,050 (98.3 in)

**System Temperature:**

- **Predicted Wet:** 98°F (36.7°C)
- **Predicted Dry:** 90°F (32.2°C)

**Airflow:**

- **Airflow:** 45,000 CFM

**Air velocities:**

- **Air Velocities:** 821 fpm (410 mm/s)

**Power Consumption:**

- **Predicted Fan P (Watts):** 225.00 HP (165.00 kW)

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Company: Evapco, Inc.
Address: 6917 Quaker Road, Box 314
Phone: 609-233-6796
Website: evapco.com
Thermal Performance Ratings

- Field data analysis
- Competitive analysis
- KaV/L
- ΔP
Film Fill types – Materials – Maintenance

- Types of Fill & Selection Criteria
- Thermal Performance Ratings
- Material and Mechanical Properties
- Fill Life Time and Maintaining Tower Efficiency
This CTI specification covers the most common fills, splash fills, louvers, drift eliminators, nozzles, and other small components for use in standard properties, burning properties, and recommended testing procedures employed to determine the defined values, whether processed from virgin or reground material.

Revised June 2010
ASTM E 84 tests for flame spread rating (FSR).

• Red oak flooring has FSR of 100
• Fiber cement board has a FSR of 0

Historical number Flame Spread Rating PVC Fills was 25.

Today: material with Flame Spread Rating of 5
Material and Mechanical Properties

Film Fill Material Thickness & UV Protection

• Material thickness & UV protection determines life time of the fill

• Specify the fill material thickness “before” and “after forming”!
  The forming process thins the material and
  **15 mills** PVC fill before forming (can) become **10 mills** after forming!
Material and Mechanical Properties

Remark

*How we know that specified numbers and qualifications are valid for the materials supplied?*

Ask specific test reports
### Material and Mechanical Properties

#### Materials

<table>
<thead>
<tr>
<th>PVC fill</th>
<th>PP fill</th>
</tr>
</thead>
<tbody>
<tr>
<td>• High strength (CTI STD 136)</td>
<td>• Durable but high creep rate, need</td>
</tr>
<tr>
<td>• Extremely durable</td>
<td>50% thicker than PVC</td>
</tr>
<tr>
<td>• Self - extinguishing</td>
<td>• Very Flammable</td>
</tr>
<tr>
<td>• Surface wets – out well</td>
<td>• Poor wetting characteristics</td>
</tr>
<tr>
<td>• Can be glued in bundles</td>
<td>• Cannot solvent bond</td>
</tr>
</tbody>
</table>
• Types of Fill & Selection Criteria

• Thermal Performance Ratings

• Material and Mechanical Properties

• Fill Life Time and Maintaining Tower Efficiency
Water Treatment: Scaling

Langelier saturation index: Recommended range

-0.5  0.0  1.0  2.0

Aggressive water  Scaling water

Corrosion inhibitors recommended

Safe zone: Acid

Typical: Limit pH at 8.5-9 maximum

Scaling inhibitors or dispersants recommended
Fill Life Time and Maintaining Tower Efficiency

Scale Build-Up on PVC Fill Sheets

• Maintenance:
  Assure fill remains in good condition

• Water treatment important to control scale build-up
Fill Life Time and Maintaining Tower Efficiency

Effect of Fouling on Fill & Cooling Tower Performance

- Clean Fill (48 kg/m³)
- 1.6 mm Fouling (448 kg/m³)
- 3.2 mm Fouling (848 kg/m³)
Fill Life Time and Maintaining Tower Efficiency

Estimate of Performance Loss vs. Fouling

![Graph showing the relationship between weight gain and increase in approach](image-url)
Important Criteria When Considering Cooling Towers For Your DCP

- Film Fill Types – Materials – Maintenance
- Cooling Tower Layout
- Thermal Performance Certification (CTI)
Cooling Tower Layout

• Arrangement

• Type of Enclosures

• Influence on Thermal Performance

• Clearance

• Type of Influence
Arrangement

Single Row
Arrangement

Back to Back (Double Row)
Arrangement

Two Rows – Not Ideal for Recirculation!
Arrangement

Two Rows – Not Ideal for Recirculation!

Prevailing Wind

Min 2 cells Width
Arrangement

Stairway ➔ Space Required!
Type of Enclosures

Free Field Installation
Type of Enclosures

Solid Walls Enclosures
Type of Enclosures

Louvered Walls Enclosures

- % Free open area louvers
- Pressure drop through louvers
- Orientation
Type of Enclosures

Louvered Walls

Effective louver wall height

\[ = 1.2 \times \text{air inlet height} \]
Type of Enclosures

Louvered Walls

- Air flow takes the path of least resistance.
- Equilibrium Point: vertical downward air flow through louvers

<table>
<thead>
<tr>
<th>Wall Type</th>
<th>Louver</th>
<th>Solid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Vertical Air Velocity ≤</td>
<td>600 FPM</td>
<td>400 FPM</td>
</tr>
<tr>
<td>Net Louver Air Velocity ≤</td>
<td>500 FPM</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Influence on Thermal Performance

• Net free open area

• Air flow obstruction
  – Enclosure structural framing
  – Piping
  – Walkways

• Clearance
Clearance

Case 1

- Minimal impact
- No correction required
Clearance

Case 2

- 2 x air inlet height < clearance < air inlet height + wall height
- Add 5 Pa (0.02 in WG)
- Risk for recirculation!
Clearance

Case 3

- $1 \times \text{air inlet height} < \text{clearance} < 2 \times \text{air inlet height}$
- Add 10 Pa (0.04 in WG)
- High risk for recirculation!
Type of Influence

- Increased pressure drop
- Mal-distribution of air
  - Increased static pressure
  - Hot water bypass
- Recirculation
  - Height of enclosure
  - Solid or louvered wall
  - Clearance
IF YOU OBSTRUCT THE AIR TO THE COOLING TOWER

THE COOLING TOWER DESIGN / THERMAL PERFORMANCE WILL BE AFFECTED
Important Criteria When Considering Cooling Towers For Your DCP

- Film Fill Types – Materials – Maintenance
- Cooling Tower Layout
- Thermal Performance Certification (CTI)
CTI Standards

• STD-105
  Code/Procedure for CT Thermal Performance Testing on Site

• STD-201
  Certification Program: Thermal Performance of Packaged CT’s

• STD-202
  Voluntary Program for Custom/Field Erected Cooling Towers
CTI STD-105

• Test Conditions: max. variations
  – Wet-bulb: +/- 8.5°C (15°F)
  – Range: +/- 20%
  – Water flow: +/- 10%

• Instrumentation
• Measurements
• Evaluation of results
**CTI STD-201**

- Certification Scope:
  - Wet-bulb: 12.8°C to 32.2°C (55°F to 90°F)
  - Range: ≥ 2.2°C (4°F)
  - Approach: ≥ 2.8°C (5°F)
  - Inlet T: ≤ 51.7°C (125°F)

- Standard models
- Accessories
Participants allow CTI to publish thermal performance test results
Field test must be executed by CTI licensed test agency

Participants:
- Composite Cooling Solutions, L.P. (CCS)
- Evaptech Inc. (Evapco Inc.)
- SPX Cooling Technologies, Inc (Marley)
## CTI STD-202

<table>
<thead>
<tr>
<th>Participating Manufacturer</th>
<th>Composite Cooling Solutions, L.P.</th>
<th>EvapTech, Inc.</th>
<th>SPX Cooling Technologies</th>
<th>All Multi-Agency Acceptance Tests for the previous year*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testing during the Period:</td>
<td>8/21/2013 to 08/16/2016</td>
<td>10/26/2013 to 10/18/2016</td>
<td>05/20/2015 to 08/30/2016</td>
<td>2015</td>
</tr>
<tr>
<td>Percentage of tests at or above 100% Capability</td>
<td>N.A.</td>
<td>100</td>
<td>60</td>
<td>62</td>
</tr>
<tr>
<td>Percentage of tests at or above 95% Capability</td>
<td>N.A.</td>
<td>100</td>
<td>100</td>
<td>82</td>
</tr>
<tr>
<td>Average Capability of tests below 95% Capability</td>
<td>N.A.</td>
<td>None</td>
<td>None</td>
<td>89.4</td>
</tr>
<tr>
<td>Average Water Flow Rate</td>
<td>N.A.</td>
<td>74,059</td>
<td>108,282</td>
<td>58,583</td>
</tr>
</tbody>
</table>

N.A. = At the time of this publication the minimum number of CTI licensed tests required to publish results by STD-202 have not been performed.
Benefits for Owners/Operators

• Performance tests demonstrate the actual thermal performance

• Lower outlet water temperature ➔ chiller efficiency increases

• More efficient DCP ➔ lower energy consumption
Innovations for LIFE

- Taking
- Quality & Service
- to a Higher Level