The Evolution and Evaluation of Cooling Towers: Successfully navigating today’s challenges

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Historical 80/20 Evaluation Criteria

- Installed fan HP
- Footprint
- Lowest cost
Today’s Challenges

- Airborne dirt and sand
- Alternate water sources and water conservation
- Larger rooftop applications
- Corrosive environment
- Legionnaires’ Disease
- Rapidly growing and changing demand
- Overall system energy conservation
- Lowest total installed cost possible
Airborne Dirt and Sand

- Decreased effectiveness of water treatment
- Reduced condenser tube life
- Increased maintenance
- Less thermal performance

Conventional Approach
Deal with it after ingested
- More frequent cleaning
- Basin sweeper system
- Larger filtration system

New Tech Approach
Water Collection System
Bottom Mounted Fan System
Water Conservation

- Executive Order No. 27 in Dubai
  - Sea water or TSE for all new District Cooling plants
- 10,000 TR average load
  - 200 million US gallons or 750,000 M³ of water annual consumption

Conventional Approach
- Non-corrosive materials
- 0.002% drift emissions
- Water softeners (+10% waste)
- Basin sweepers
- Filtration & Separators
Variable Flow Technology

- Variable flow orifice ensures optimum coverage of fill surface area during part-load operation.

- Coverage of fill surface with an improved spray pattern results in lower operating cost and reduced maintenance – Square not Round.

- Spreading the water volume over more fill improves the KaV/L and reduces evaporation.
Large Rooftop Applications

• Costs
  – Building footprint
  – Cooling Tower
  – Installation
  – Civil work

Conventional Approach
  – Cheapest “cooling tower” cost
  – Smallest footprint possible
  – Fewest cells possible

Tower Tech Approach
  - Arrives fully assembled
  - 50% less weight and height
  - Bottom vs. side air inlets
Corrosive Environment

- Sunny, hot, humid, sea air
- Gritty and/or TSE water with chemical

Common Approach
- Pultruded FRP with SS hardware
Legionella

- Grows in cooling tower basins
- Transmitted from drift emissions
- Host breathes it in

**Conventional Approach**
- Thorough cleaning at least quarterly
- Basin sweeper system
- Filtration system
- 0.001-0.002% drift rate

**New Technology Approach**
- Annual cleaning
- High velocity, self cleaning basin
- Filtration system
- 0.0004% drift rate
Legionnaires’ Disease

Quebec City public health officials say they’ve found the likely source of the outbreak of legionnaires’ disease that has killed 13 people and made nearly 170 others ill since July.

Queensland Health says it will have to set up a permanent disinfection system at three hospitals in the state’s south-west to prevent recurring outbreaks of legionella.

Legionnaires disease outbreak in Ohio retirement community causes infections and deaths

Since June 1, there has been a larger legionella cluster within Milwaukee County representing 48 total cases, with 31 in the City

The currently accepted theory is that multiple cooling towers in and around downtown Milwaukee are the source of the legionella bacteria, according to Rausch.

Neshannock Township business closed after bacteria found in water cooling tower

Published: Aug 18, 2013 1:19 PM CST

A further case of Legionnaires’ disease linked to the Renfrew area has been confirmed, bringing the total to 11.

Published: Wednesday, July 31, 2013, 12:01 a.m.
Updated: Friday, August 2, 2013

Officials at the state prison in Somerset have traced the illnesses of four inmates to Legionella, a potentially dangerous bacteria found in the facility’s cooling tower, state Department of Corrections officials said Tuesday.

Hagerstown inmate tests positive for Legionnaires’ disease

No other cases known to state officials as they test facility’s water, air-conditioning systems

Jul 29, 2013 | Vote 0 0 0

Peel Health sees jump in legionnaires’ disease

August 16, 2013 | By Scott Dance, The Baltimore Sun
Evolving Demand

- New plants built based on anticipated demand
- Operate at partial capacity
- Uncertain future demand and timing

**Conventional Approach**
- Packaged galvanized towers
- Build out full tower and/or civil now

**New Tech Approach**
Overall System Efficiency

- Total installed fan HP
- Minimum fan motor frequency allowed with VFD
- Pump head
- Variable-flow turndown capability while efficiently covering all fill media within the cell

Warning: Maintain at least 85% pressure for proper distribution
Efficiency Comparison

• 30,000 TR system operating range example
  – 90,000 GPM - 105°F HWT / 95°F CWT / 87°F WBT
  – 6 x 5,000 TR chillers
  – 5,000 TR to 30,000 TR operating range; Equal time at each 5,000 TR increment

• Comparison
  – Most efficient fixed orifice tower
    • 6 x 5,000 TR cells
    • 110 kW/cell = 660 kW total
    • Minimum VFD frequency = 25 Hz
    • 33’ pump head
  – Variable flow Tower Tech design
    • 30 x 1,000 TR cells
    • 29 kW/cell = 870 kW total
    • Minimum VFD frequency = 6 Hz
    • 13’ pump head

Pump HP = \( Q \) (Flow) * HD (Feet)
3960 * Pump Efficiency (85%)

\[
kW = \_\_\_\_\_\_\_ HP \times 0.745699872
\]
30,000 TR Operation
90,000 GPM / 105°F HWT / 95°F CWT / 87°F WBT

Fixed Orifice Nozzles
- Fan kW = 660
- Pump kW = 649
- Total kW = 1,309

Variable Flow Nozzles
- Fan kW = 870
- Pump kW = 256
- Total kW = 1,126

14% Savings
25,000 TR Operation
75,000 GPM / 105°F HWT / 95°F CWT / 87°F WBT

Fixed Orifice Nozzles
- Fan kW = 550
- Pump kW = 541
- Total kW = 1,091
- Total kW/Ton = 0.044

Variable Flow Nozzles
- Fan kW = 420
- Pump kW = 213
- Total kW = 633
- Total kW/Ton = 0.025

42% Savings
20,000 TR Operation
60,000 GPM / 105°F HWT / 95°F CWT / 87°F WBT

Fixed Orifice Nozzles
- Fan kW = 440
- Pump kW = 432
- Total kW = 872

Variable Flow Nozzles
- Fan kW = 180
- Pump kW = 171
- Total kW = 351

60% Savings

Fan kW/Ton = 0.022
Pump kW/Ton = 0.022
Total kW/Ton = 0.044

Fan kW/Ton = 0.009
Pump kW/Ton = 0.009
Total kW/Ton = 0.018
15,000 TR Operation
45,000 GPM / 105°F HWT / 95°F CWT / 87°F WBT

Fixed Orifice Nozzles
- Fan kW = 330
- Pump kW = 324
- Total kW = 654

Variable Flow Nozzles
- Fan kW = 87
- Pump kW = 128
- Total kW = 215

Fan kW/Ton = .022
Pump kW/Ton = .022
Total kW/Ton = .044

Fan kW/Ton = .006
Pump kW/Ton = .009
Total kW/Ton = .015

67% Savings
Fan kW/Ton = .022
Pump kW/Ton = .022
Total kW/Ton = .044

Fan kW/Ton = .007
Pump kW/Ton = .009
Total kW/Ton = .016

Fixed Orifice Nozzles
- Fan kW = 220
- Pump kW = 216
- Total kW = 436

Variable Flow Nozzles
- Fan kW = 73
- Pump kW = 85
- Total kW = 158

64% Savings
Saudi Aramco: Non-Business Use

5,000 TR Operation
15,000 GPM / 105°F HWT / 95°F CWT / 87°F WBT

Fixed Orifice Nozzles
- Fan kW = 110
- Pump kW = 108
- Total kW = 218

Variable Flow Nozzles
- Fan kW = 35
- Pump kW = 43
- Total kW = 78

Fan kW/Ton = .022
Pump kW/Ton = .022
Total kW/Ton = .044

Fan kW/Ton = .007
Pump kW/Ton = .009
Total kW/Ton = .016

64% Savings
## Total Energy Consumed

### Fixed Orifice Nozzles
- Fan kW = 2,310
- Pump kW = 2,270
  - Total kW = 4,580

### Variable Flow Nozzles
- Fan kW = 1,665
- Pump kW = 896
  - Total kW = 2,561

### SAVINGS
- Fan kW = 28%
- Pump kW = 61%
  - Total kW = 44%

### Energy Consumption per Ton
- Fan kW/Ton = .022
- Pump kW/Ton = .022
  - Total kW/Ton = .044

### Energy Consumption per Ton
- Fan kW/Ton = .016
- Pump kW/Ton = .009
  - Total kW/Ton = .025
Water Savings

• Annual Tower Tech Makeup 240.147 Mil US Gal or 909,564 M³
• Annual Conventional Makeup 321.345 Mil US Gal or 1,217,216 M³
• Total Water Savings with Tower Tech 81.198 Mil Gal or 307,568 M³
• 25.27% Savings
Today’s Evaluation Criteria

- **Basin sweeper system or High-Speed-Flow-Thru-Basin**
  - Minimize sand/dirt build up; Improved chiller life/performance; Legionella risk mitigation; Improved chemical treatment effectiveness

- **Heavy-duty non-corrosive construction**
  - Flexibility with alternate water sources; Life expectancy; ¼” or thicker pultruded FRP with SS metal

- **Total initial cost**
  - True comparison of actual cost; Building cost with footprint required differential + cooling tower cost + civil work for tower + parapet wall + tower installation cost

- **Add operating cost for best ROI**
  - Ensure best return on investment for ownership; Total installed cost + [water + chemical + maintenance + energy * X years] = Total evaluated cost

**Additional Project Specific Consideration**

- **Lowest possible drift emissions**
  - Water conservation; Legionella risk mitigation

- **Modularity consideration**
  - Flexibility for evolving demand
New Technology Summary

• Less maintenance and reduced down time
• Able to handle any water source while conserving water
• Longer serviceable life
• Exceptionally low risk for Legionella and bio growth
• Easy to match cooling needs with evolving demand
• Most energy efficient system for lowest operating cost
• Total installed cost minimized due to smart evaluation
• Best return on investment