Thermal Performance For Different Evaporative Coil Technologies Over the Product Life

Abstract

BAC recently introduced a new line of counterflow closed circuit cooling towers featuring an innovative coil/fill technology, the patent-pending OptiCoil™ System. This white paper summarizes the results of extensive laboratory tests for closed circuit cooling towers featuring conventional coil only technology and the patent-pending OptiCoil System.

The main conclusions are that units with the OptiCoil System, when compared to conventional coil only designs:

- Offer thermal capacity increases of up to 30% or more
- Ensure optimal lifetime efficiency by reducing the thermal performance degradation through the life of the product by almost 50%

These dramatic increases in initial thermal performance and efficiency over the life of the product will not only reduce system energy costs, but can also increase the life of the equipment.

Introduction

Since the introduction of evaporative cooling equipment, manufacturers have continuously improved thermal performance through various technologies, such as using different coil configurations with bare tubes to optimize the thermal performance with only slight improvements and no drastic changes.

In the 1980's, the first coil configurations with an externally enhanced heat transfer design were introduced in the evaporative cooling industry. These finned coil configurations were designed to give the optimum dry performance and achieve as many hours of dry operation as economically possible. Tests indicated that these configurations also increased wet (evaporative) thermal performance. However, when claiming an increased wet performance compared to conventional coils, the dry switch points of these finned coils remain very low (often below freezing), which nullified the initial intent of this design. In addition, the finned coil technology did not allow an intelligent control sequence to realize water savings during wet operation, which limited its water saving to "all or nothing" resulting in a limited success of this costly finned coil technology.

Manufacturers have also attempted to improve heat transfer through internal tube designs, such as grooved tubes or tubes with inserts. Again, for typical evaporative cooling applications, the performance improvements were limited.
With the recent introduction of a new line of counterflow closed circuit cooling towers featuring the patent-pending OptiCoil System, BAC now offers its customers drastically increased wet performance with a much faster payback compared to finned coil systems. This innovative coil/fill technology is the most efficient counterflow heat transfer solution available on the market, meeting the true primary customer need: the overall lowest total cost of ownership (consisting of costs for the initial investment, water and overall system electricity consumption).

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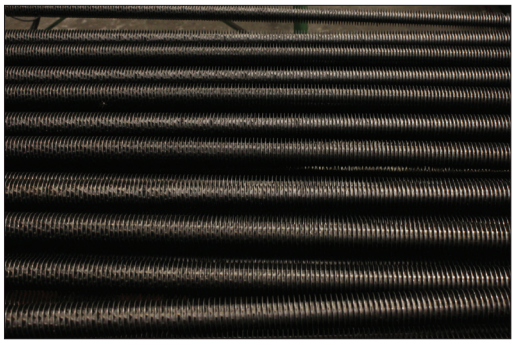


Figure 1. Finned Coil

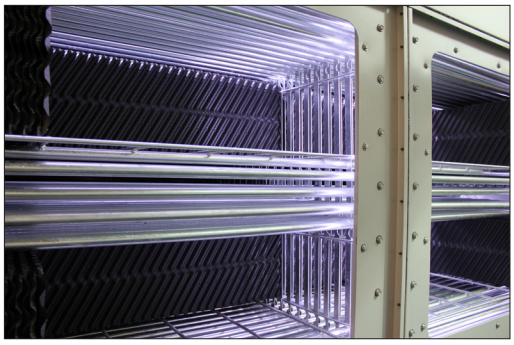


Figure 2. Unit with OptiCoil System

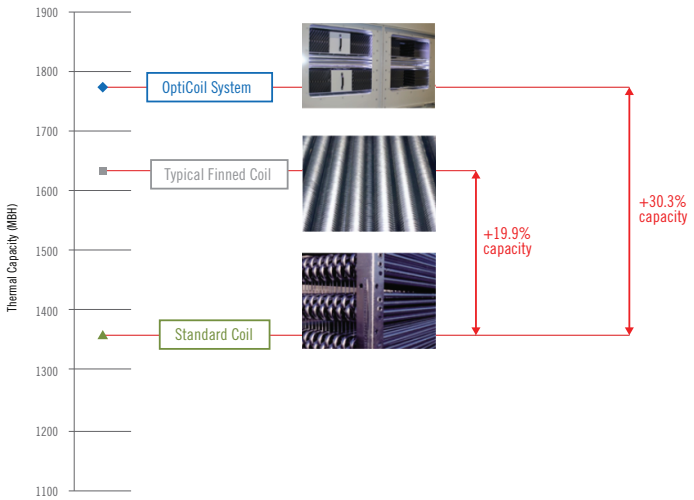
During the development of the OptiCoil™ System, BAC carried out an intensive design and prototyping program with independent third-party testing. This white paper summarizes the test results of the OptiCoil System and quantifies:

- The initial thermal performance improvement
- The end-of-test thermal performance changes for towers with both the OptiCoil System and the conventional coil only design

Initial Thermal Capacities of Units With Standard Coil vs. OptiCoil System

Through the OptiCoil System, BAC is able to increase the **initial thermal capacity by more than 30% when compared to standard coil units** with identical footprint, number of passes, and motor power.

The following graph compares the thermal capacity of a 4' x 12' counterflow unit with a standard coil vs. an OptiCoil System (equal number of passes) under design conditions (102/90/78°F). The thermal capacity of a typical finned coil unit has been added for reference.



Graph 1. Thermal Capacity of Different Coil Technologies (Equal Number of Passes)

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Laboratory Test – Thermal Capacity of Different Coil Technologies Over Product Life

Through experience and based on the feedback from customers who are using BAC's FXV / CXV crossflow products, BAC has seen that coil/fill units retain a higher percentage of their thermal performance through the life of the product by reducing the amount of scale growth on the coil, compared to standard coil only products.

With the introduction of the OptiCoil™ System, BAC started an extensive laboratory test with a third- party oversight to objectively quantify this effect. The goals of this testing program were:

- Measure and compare the scale formation between a unit with standard coil versus a unit with the OptiCoil System
- Measure and compare the thermal performance loss between a unit with standard coil and a unit with the OptiCoil System, as scale forms over time

Test Protocol

Sheppard T. Powell Associates, Consulting Engineers and Chemists (STPA) was hired to help design and supervise the testing, then analyze the results.

BAC manufactured two axial fan, induced draft, counterflow closed circuit cooling towers with similar thermal capacities and equal footprint (4' x 12') and fan motor power. The only physical difference between the two units was in the coil section:

- The first unit used a standard coil
- The second unit used the OptiCoil System

Both units were exposed to the same thermal operating conditions, including identical entering fluid temperatures, with identical make-up water and recirculating spray water chemistry for 67 days. To maintain the same water chemistry in the two units, each unit had a sump pump installed in its basin that pumped water to the other unit so they both experienced the same spray flow.

To promote scale formation, severe water chemistry conditions were produced by minimizing blowdown and feeding sodium phosphate. No dispersants or antiscalants were applied.

Both units were operated continuously at 100% fan speed with the spray pumps on at a constant heat load.

Figure 3. Test Setup

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Each unit had the following dedicated instrumentation:

- Thermocouples for entering and leaving wet bulb temperatures, entering and leaving dry bulb temperatures, entering and leaving coil water temperature, water basin temperature, make-up water temperature
- Flow meters for coil water, spray water and make-up
- Gauges to measure kW or amps

During the test:

- Water was collected and analyzed on a daily basis
- Physical tube dimensions (with scale) were collected on a bi-weekly basis
- Thermal data was recorded

After the test: 27 coil samples (in total) from both units were selected by STPA for evaluation and metallurgical study, to determine the impact of the OptiCoil™ System on the resistance to scaling. Selected samples represented the top, middle and bottom tubes of both units.

Laboratory Test Results

Scale Formation

Based on visual examination of the coil samples, STPA stated that there was a substantial difference between the appearance of the tubes between the standard coil unit and the OptiCoil System.

- **Standard Coil**: tubes were all covered with a continuous white, calcium-rich deposit layer
- **OptiCoil System**: middle tubes show no continuous layer on the external surfaces

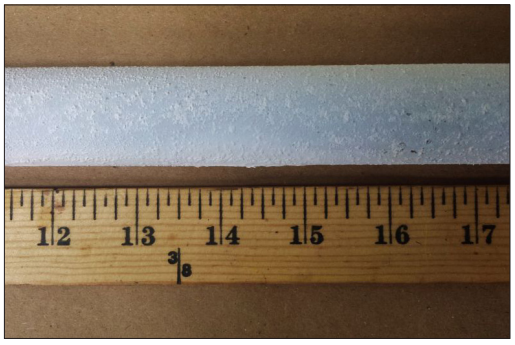

Figure 4. Standard Unit Coil Sample

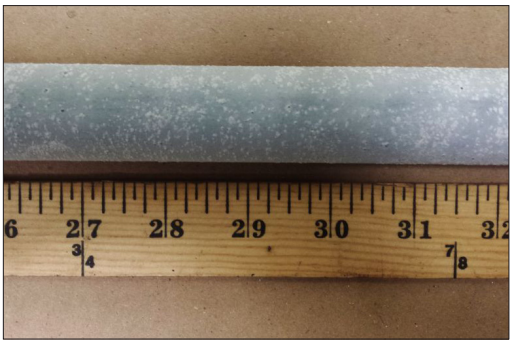

Figure 5. OptiCoil System Unit Coil Sample

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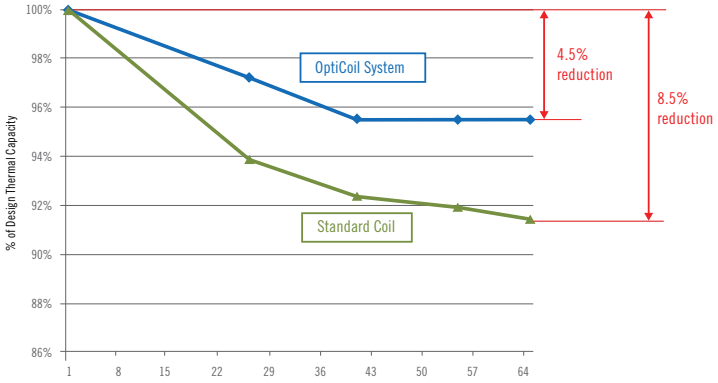
In order to verify this difference, tube samples from the top, middle and bottom sections of each unit were also examined with an optical microscope. Photomicrographs were taken around the entire tube circumference in order to determine variations in scale thickness.

NOTE: This examination confirmed the results of the visual inspection; tubes from the standard coil unit have thicker deposit layers than those of the unit with the OptiCoil™ System.

Thermal Data

The graph below shows the thermal performance changes for each system over the 67 day test period. The data confirms the difference in deposit between a standard coil and the OptiCoil System.



Graph 2. OptiCoil System vs Standard Coil: Effect of Scale Formation on Thermal Capacity

The thermal capacity of the standard coil unit reduced 8.5% while the OptiCoil System only reduced 4.5% over the same test period, an approximate 50% improvement.

NOTE: These laboratory test results confirm that units with the OptiCoil System retain a higher percentage of their thermal performance through the life of the product by reducing the amount of scale growth on the coil, compared to standard coil only products.

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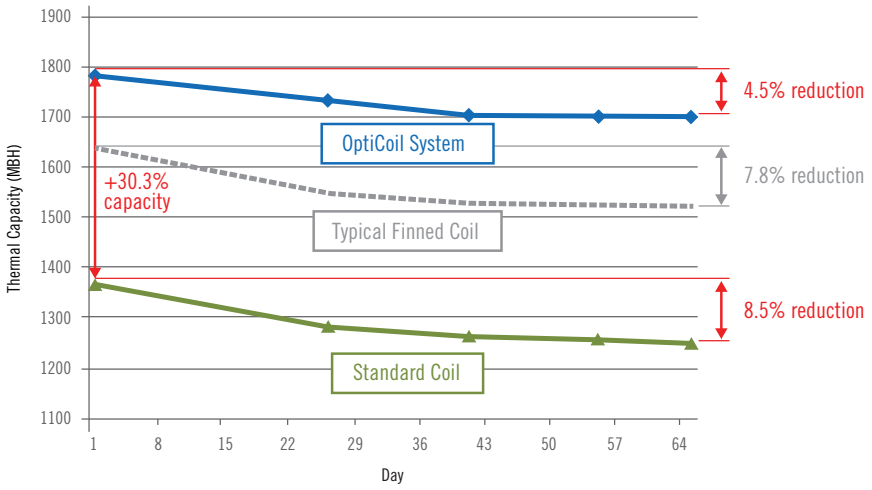
Conclusions

With the recent introduction of new counterflow closed circuit cooling towers featuring the patent-pending OptiCoil™ System, BAC is able to offer its customers drastically improved thermal capacity.

Additionally, laboratory test results prove that units with the OptiCoil System reduce the thermal performance degradation through the life of the product by almost 50% compared to standard coil only products, by minimizing the amount of scale growth on the coil thus reducing energy costs.

When compared to the typical finned coil technology, the OptiCoil System also exhibited a significant improvement with thermal performance degradation, according to published data.

Consequently, the OptiCoil System ensures an optimal lifetime efficiency when compared to traditional coil only designs.



Graph 3. OptiCoil System vs Standard coil and Typical Finned Coil (equal number of passes): Effect of Scale Formation on Thermal Capacity

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