INNOVAS TECHNOLOGIES

Technical White Paper

Improving Chiller Efficiency Through Automatic Tube Cleaning System Technology

- For organizations researching solutions for improving chiller energy efficiency by reducing fouling of shell and tube heat exchangers.
- Multiple case studies are provided demonstrating the positive impacts of tube cleaning system technology implementation.

Improving Chiller Efficiency Through Automatic Tube Cleaning System Technology

Chiller fouling is a common problem that directly impacts sustainability.

ABSTRACT

In this paper, solutions for improving chiller energy efficiency by reducing fouling of shell and tube heat exchangers are discussed. Sponge-ball type automatic tube cleaning system technology is introduced and discussed as a solution for improving chiller energy efficiency and tube cleaning system operating principles are presented. Multiple case studies are provided demonstrating the positive impacts of tube cleaning system technology implementation.

INTRODUCTION

Shell and tube condensers and heat exchangers are core to a wide range of processes including power generation, oil refining, industrial processing, and HVAC comfort cooling. Unfortunately, this means that "fouling" of these heat exchangers (the accumulation of efficiency-killing deposits) is also pervasive—at extremely high economic and social costs.

The expenses associated with fouled heat exchangers and condensers are significant, and include increased power consumption, increased fossil fuel consumption, reduced production, and frequent condenser cleaning costs. Heat exchanger fouling costs have been estimated at 0.25% of the gross domestic product (GDP) of highly industrialized countries in several studies, which, based on estimated U.S. GDP of $15 trillion, translates to fouling-related costs of $37 billion a year. [1]

In HVAC applications, fouling of the chiller condenser tubes has substantial impact on the power consumption of the compressor. Even with good water treatment programs, it's not uncommon to find chillers that appear to be in good working order operating at a fouling factor of 0.0025 hr-ft2-F/Btu or higher — causing compressor power consumption to increase by 25% or more.[2]

Fouling occurs because cooling water contains minerals, such as calcium and magnesium that precipitate to form deposits on heat transfer surfaces. Cooling water systems are also commonly plagued by biological growth that forms slime or algae on heat transfer areas. Additional foulants include mud, silt, corrosion products, petroleum products, etc. All of these foulants reduce the heat transfer efficiency of even the best-designed heat exchangers, induce localized corrosion leading to early equipment failure, and force shutdowns of the power generation, refining, or cooling process.
Several methodologies are commonly used to mitigate or reduce fouling in various plants and industries. Typically these include off-line mechanical or chemical cleaning, or on-line mechanical cleaning systems.

Off-line cleaning methods require periodic shutdown of the process for heat exchanger cleaning via hydro blasting, scrapers, nylon or metallic brushes, or chemical cleaning. Major drawbacks and disadvantages of an off-line cleaning approach are that the process unit has to be removed from service for cleaning, and that the process efficiency immediately degrades after being placed back into service.

New technology provides a solution to solve shell and Tube fouling related losses.

The entire cleaning process is automated, freeing a facility team to attend to other priorities.

Every 20-minutes, Helios:

- Prevents Heat Exchanger Tube Fouling
- Improves Chiller Efficiency
- Reduces Energy Costs
- Increases Sustainability

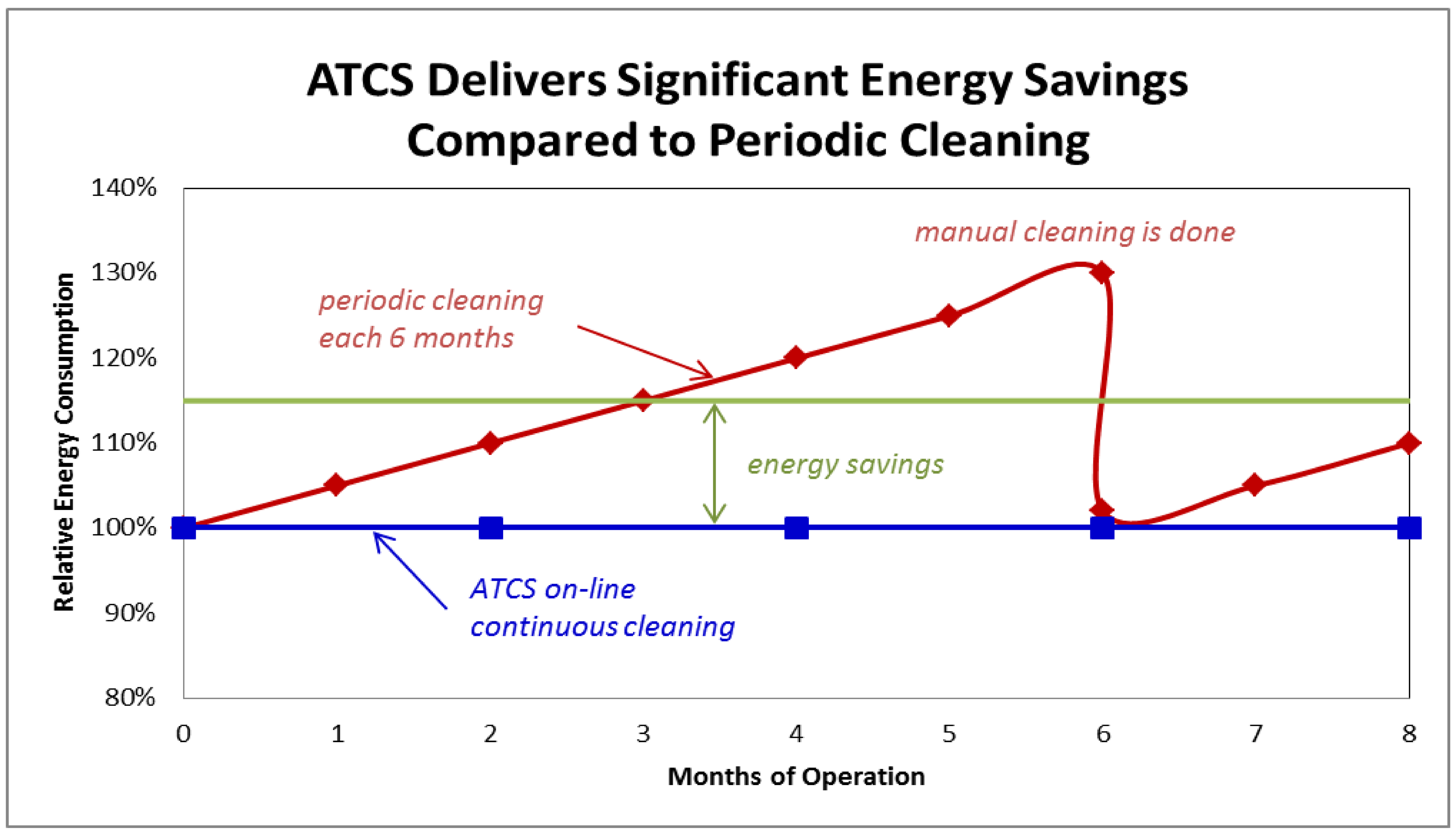

Figure 1. Continuous Tube Cleaning Technology Improves Chiller Efficiency

On-line heat exchanger cleaning methods typically involve mechanical cleaning that fall into a category commonly referred to as Automatic Tube Cleaning Systems. Of these systems, the most commonly applied are sponge-ball type tube cleaning systems.

Sponge-ball type automatic tube cleaning systems were originally conceived by German engineers in the 1950s for application in the power generation industry. Because they are effective at maintaining the heat transfer efficiency of large-scale condensers, and applicable to once-through cooling systems that may have limited or no chemical treatment, they have been widely adopted in power generation stations around the world.

Globally, more than 15,000 sponge-ball type tube cleaning units have been placed in service in the power generation sector alone, with 50% of total generating capacity in Europe and 40% of generating capacity in Japan being equipped with automatic tube cleaning systems.3, [4]

Operating Principle

Helios lowers daily energy consumption with a new way to become more energy efficient.

The operation of sponge-ball type automatic tube cleaning systems is based on the passage of elastomeric balls through the heat exchanger tubes. The balls are slightly larger than the tube diameter, and prevent the deposition of scale, biofilm, silt, or other foulants. The sponge balls are periodically injected into the cooling water inlet line and are circulated through the condenser tubes by the cooling water flow. The balls are designed and injected in a method that enables a uniform distribution of balls across the tube sheet. Since the diameter of a ball is slightly larger than the inner diameter of the tube, accumulation of deposits in the condenser tube is prevented by shear forces between the ball and tube wall and the wiping action of the cleaning balls. The balls are constructed of material that is much softer than the tubes, preventing tube erosion.

The balls are collected at the outlet of the condenser in a ball trap, which includes a strainer or screen that allows water flow to continue but prevents balls from escaping downstream. Early designs of ball traps utilized mechanically actuated clamshell-like screens, and these systems are still in use today. However, these designs are sometimes prone to mechanical failure leading to ball loss and decreased condenser efficiency. Newer ball trap designs utilize perforated screens of unique geometry that require no moving parts and can guarantee that no balls escape to downstream processes.

After the balls are accumulated in the ball trap, the balls are returned to a ball collector via operation of a recirculation pump, which supplies the necessary pressure differential for conveying the balls. Again, early designs required the balls to pass through the recirculation pump, where they could be damaged by the pump impeller, but more recent ATCS designs prevent the balls from contacting the pump impeller, which helps extend the life and effectiveness of the balls. The collector serves as a holding vessel between ball injections as well as a method for replacing balls in the system.

The entire injection and collection process is fully automated and controlled by means of a single programmable logic controller. The controller also provides monitoring and alarm functions to ensure the system is continuously operating optimally.

Figure 2. Installed Innovas Ball Trap

Case Studies

The tube cleaning system yielded energy efficiency gains of approximately 12% for the **UNLV Center for Energy Research**.

"The benefits include energy cost savings, reduced greenhouse gas emissions, and elimination of workload associated with tube fouling in the Central Heating and Cooling Plant chillers."

In August of 2012, a sponge-ball type tube cleaning system was installed in one of two identical 300-ton chillers at The Plaza Hotel and Casino in Las Vegas, Nevada. The tube cleaning equipment was installed on Chiller 1 while Chiller 2 served as the control. The two chillers shared a common cooling tower, eliminating potential differences of environmental variation on the chillers.

The UNLV Center for Energy Research conducted a 3-month study on the impact of the tube cleaning system on chiller energy efficiency, overseeing monitoring equipment installation and operation as well as data analysis, and Figure 3 below demonstrates the tube cleaning system yielded energy efficiency gains of approximately 12%.

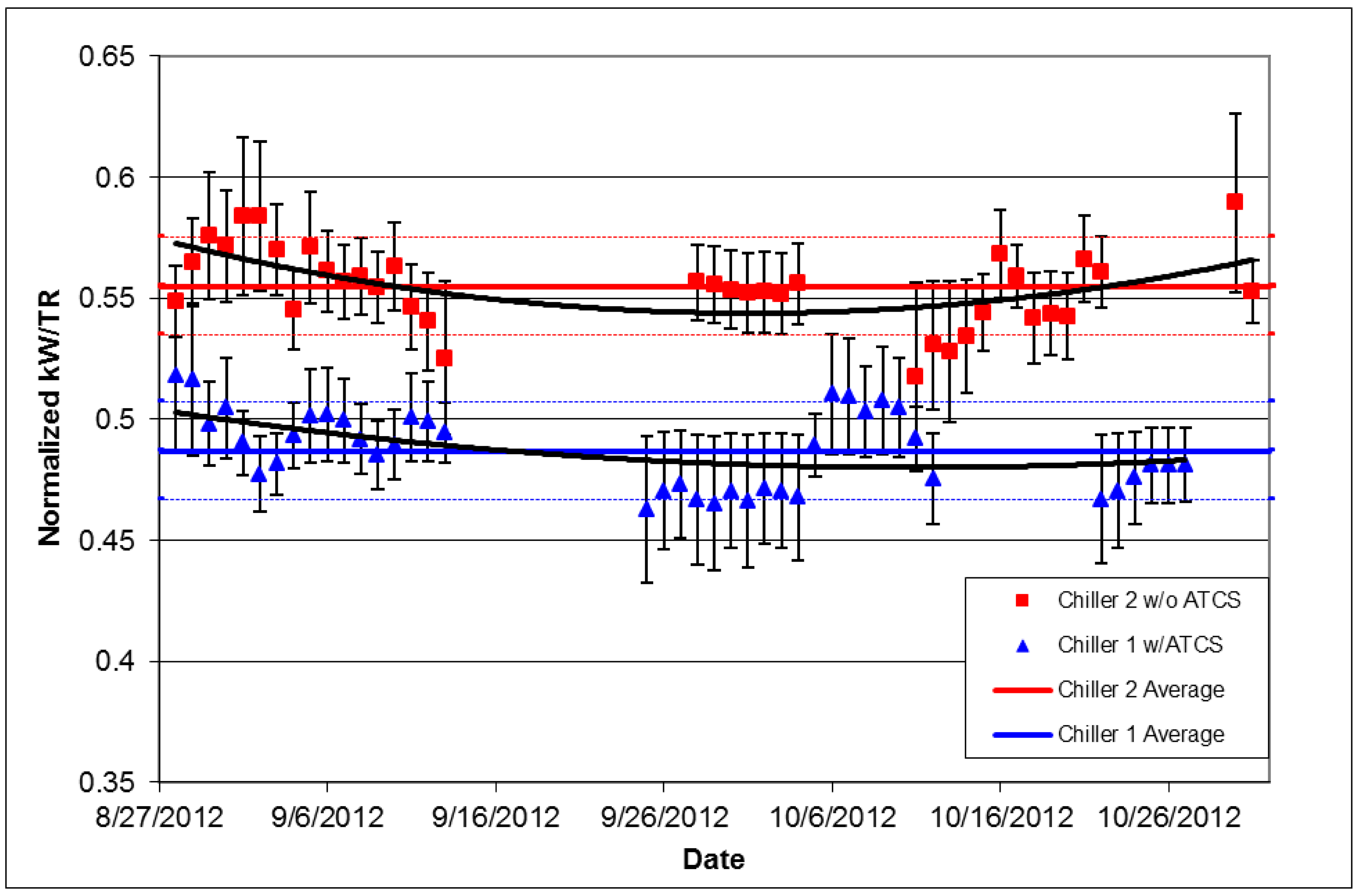

Figure 3. Chiller Energy Efficiency Improved 12% by Tube Cleaning Implementation [5]

UNLV engineers also concluded that "after the data is normalized, it is clear that the chiller with the tube cleaning system is not only outperforming the chiller without the tube cleaning system, it is also maintaining its lead by preventing fouling."[5]

Data collection from the Plaza was continued beyond the conclusion of the UNLV study, and analyzed according to ASHRAE Guideline 14-2002, Measurement of Energy and Demand Savings. Figure 4 below shows the continued positive efficiency impacts of the tube cleaning system.

Case Studies

UNLV Center for Energy Research

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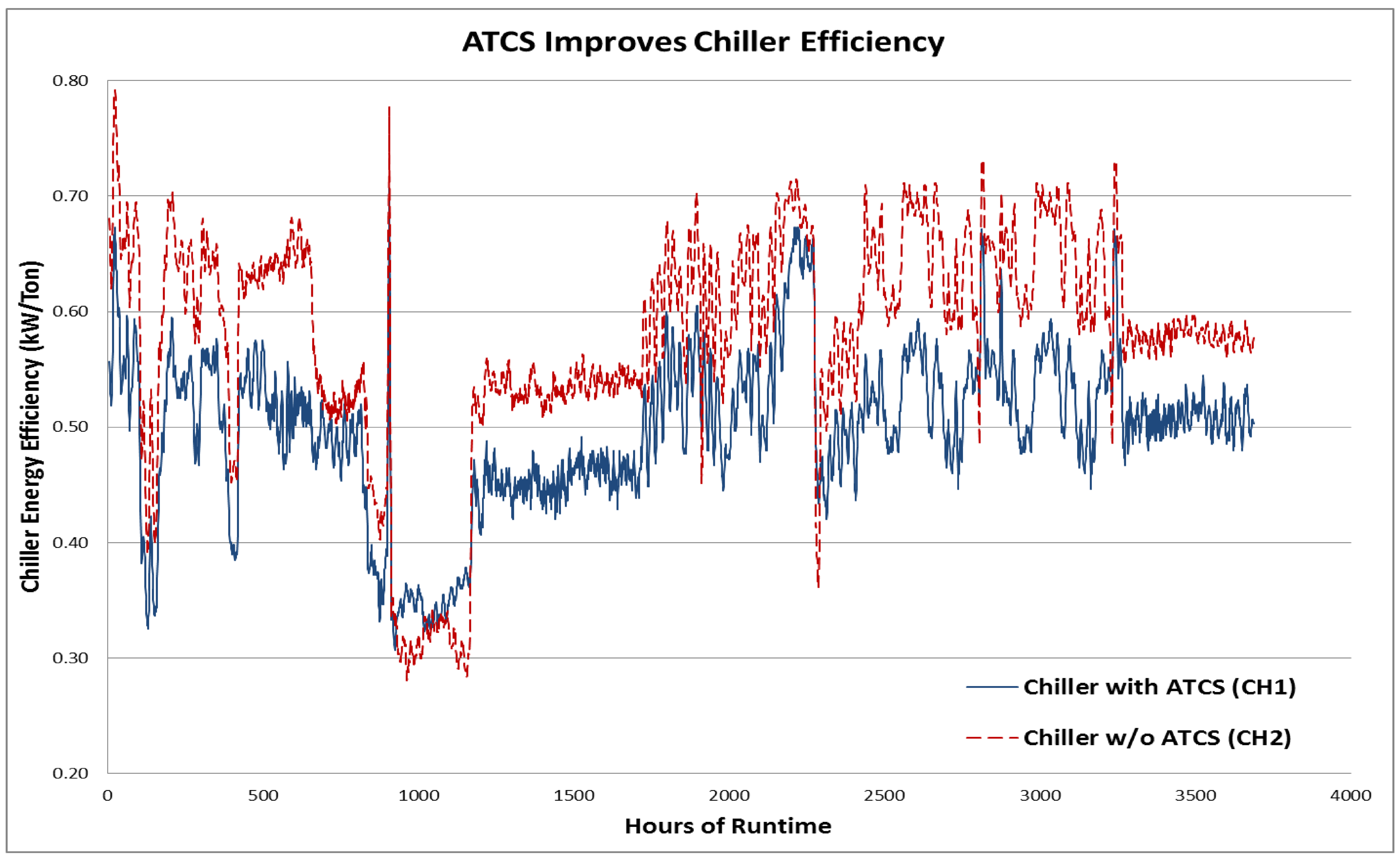

Figure 4. Tube Cleaning System Provides Continued Chiller Energy Efficiency Advantages

After more than 3500 hours of operation, the chiller with the tube cleaning system continued to demonstrate significant energy efficiency advantages, and the average energy efficiency advantage rose to more than 13%.

In the late 1980s, manufacturers of HVAC equipment began employing "internally enhanced" chiller tubes instead of the smooth tubes originally used. These enhanced tubes, widely utilized today, do provide improved heat transfer efficiency when clean. However, these same design enhancements also contribute to more rapid fouling, as the lower water-side flow rates and internal ridges in the tubes provide the perfect niches for deposition. In fact, condensers with enhanced tubes are more susceptible to fouling and corrosion than smooth tubes.[6]

As demonstrated in Figure 5 (right), application of sponge-ball cleaning systems can substantially reduce fouling factors and improve heat transfer efficiency and is especially effective in condensers with enhanced tubes.

Note the fouling factor reduction resulting from a single sponge-ball passage at 18 hrs.

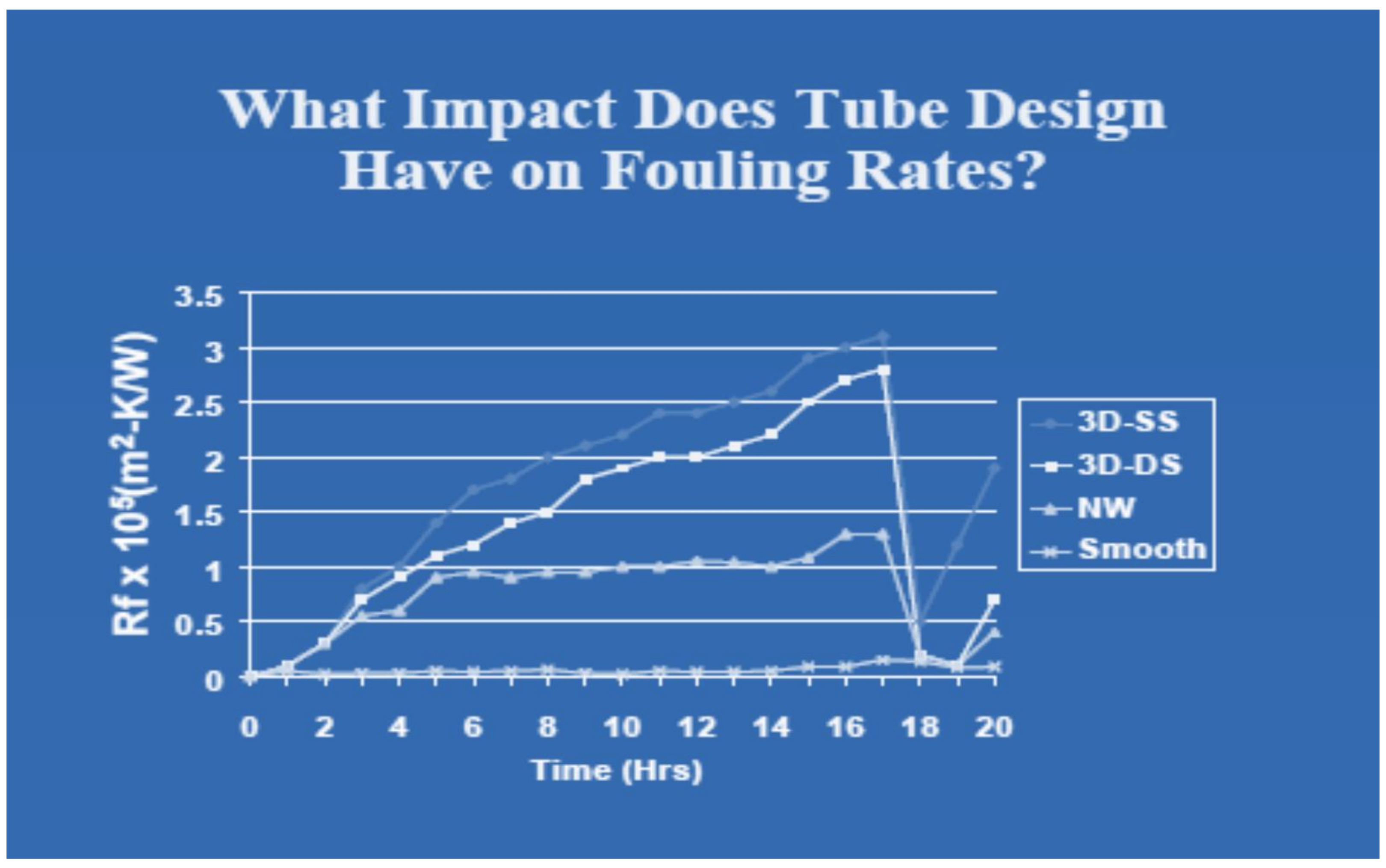

Figure 5. Sponge-ball Tube Cleaning Decreases Enhanced-Tube Fouling Resistance7

Case Studies

Winneshiek Medical Center in Decorah, IA

Advances in tube cleaning system technology have resulted in more effective and reliable systems with enhanced scalability.

In 2010, a sponge-ball type tube cleaning system was installed in one of two identical 200-ton chillers at Winneshiek Medical Center in Decorah, IA. Both chillers were cleaned at the time of tube cleaning system installation, and a short-term single point evaluation was performed after six weeks of operation to verify energy consumption in the chillers. For the test, both chillers were operated at 100% capacity until the temperatures, pressures, and power consumption stabilized.

Parameter	Chiller #1 with ATCS	Chiller #2 No ATCS	Difference
Load	**100%**	**100%**	**NA**
Average Amps	**196.1**	**233.6**	**37.5**
Average Voltage	**491.3**	**491.3**	**NA**
Entering Cond. Water Temp (F)	**91**	**92**	**NA**
Leaving Cond. Water Temp (F)	**97**	**98**	**NA**
Condenser Approach (F)	**2.4**	**2.8**	**0.4**
Condensing Pressure (psig)	**125.4**	**140.5**	**15.1**
Chiller Power Consumption (kW)	**150.0**	**178.7**	**28.7**
Chiller Energy Efficiency (kW/Ton)	**0.75**	**0.89**	**0.14**

Table 1. Tube Cleaning System Preserves Chiller Efficiency After Six Weeks of Operation

SUMMARY

Sponge-ball type tube cleaning system technology has been a widely-adopted best practice for optimizing condenser performance in the power generation industry for decades. Advances in tube cleaning system technology have resulted in more effective and reliable systems with enhanced scalability.

Case studies from across the US demonstrate realized energy efficiency gains up to 15% or more in HVAC applications. Coupled with increasing energy costs and intensifying focus on energy conservation, sponge-ball type ATCS technology represents a good opportunity for facility managers to save energy, reduce maintenance costs, and lengthen chiller life expectancy.

Literature

1. Meuller-Steinhagen H., Malayeri M.R., Watkinson A.P., "Fouling of Heat Exchangers--New Approaches to Solve an Old Problem." Heat Transfer Engineering, 26(1): 1-4, 2005.

2. Piper, James E. Operations and Maintenance Manual for Energy Management. Sharpe Professional. New York, 1999.

3. Neuburg, H.H. "Heat Exchanger Cleaning Systems." Special Print, Taprogge.

4. Someah, Kaveh. "Automatic Tube Cleaning Systems For Condensers and Heat Exchangers". ESL-IE-91_06-02. Proceedings from 13th Nation Industrial Energy Technology Conference, 1991.

5. Hurt, R., Sahm, A., and Boehm, Dr. Robert F. "CQM Automatic Tube Cleaning System" University of Nevada, Las Vegas. The Center for Energy Research. October 31, 2012.

6. Kim, N.H. and Webb, R.L., "Particulate Fouling in Enhanced Tubes", National Heat Transfer Conference, HTD-Vol 108, 1989.

7. Zimmerman, Kerry. "Optimizing Performance of Chillers With Enhanced Tubes." Technical Paper. GE Infrastructure Water and Process Technologies. http://www.gewater.com/pdf/tp437en.pdf. Accessed 08/02/2013.

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