The Magazine for ENERGY EFFICIENCY and WATER CONSERVATION in Industrial Cooling Systems

CHILLER & COOLING BEST PRACTICES

coolingbestpractices.com

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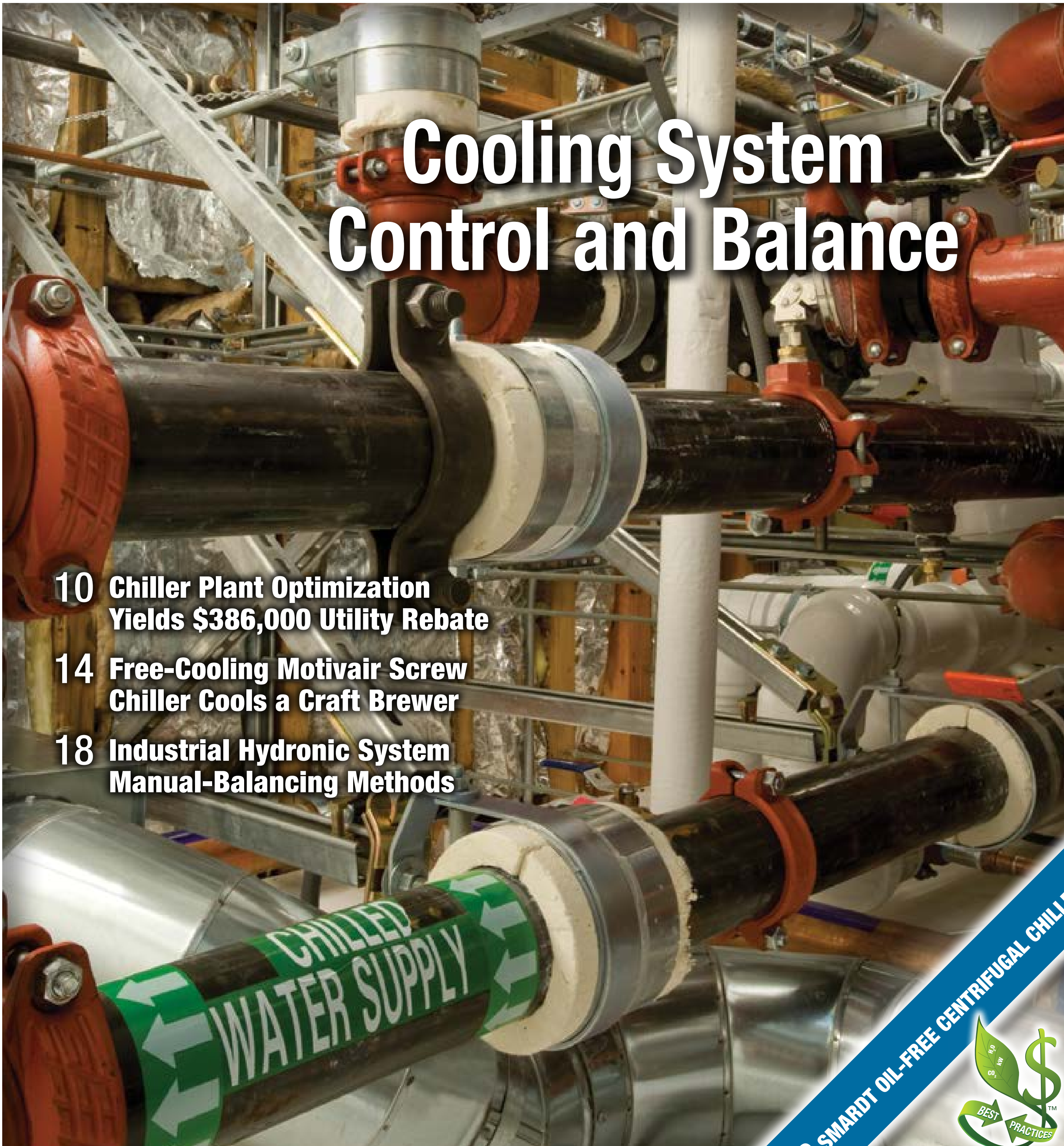

Cooling System Control and Balance

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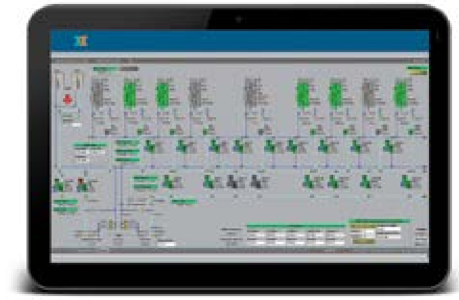

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FROM THE EDITOR | Cooling System Control and Balance

This issue is loaded with "energy retrofit" ideas and projects. A great place to start is by reading Mike Flaherty's article on how tekWorx master chiller controls optimized a large multi-chiller installation at a major manufacturing campus. Teaming up with the installation of VFD's and piping changes, this energy retrofit saved 4.5 million kWh annually and receive a $386,000 utility rebate for their energy retrofit project.

Controls can help plants save energy during low ambient temperature months. Rich Whitmore writes about how the VonTrapp Brewery in Vermont installed a Motivair screw chiller and saw the benefits of free-cooling apply to over 50 percent of their working hours. Energy retrofits are exciting, but reliability can never be sacrificed. Therefore, some custom-engineering enabled 100 percent free-cooling at 5˚F, but also protected the refrigeration circuit from the cold, avoiding low refrigerant head pressure and startup problems.

Brandon Aitken ME, P.E., from Blackhawk Equipment, writes that hydronic balancing in industrial heating and cooling systems is an often overlooked final step in startup and commissioning of new and modified hydronic systems. In his article, Brandon talks about manual-balancing using calibrated balancing valves and reverse-return piping.

I had the opportunity to interview Roger Richmond-Smith, the Founder and CEO of the Smardt Chiller Group-a global leader in oil-free centrifugal chillers. Roger tells quite a tale about how they started the company, came up with the Turbocor oil-free refrigeration compressor, patented digital controls for magnetic bearings, journeyed from Australia to Quebec to conquer the new world, and in 2015 celebrated their 10,000th installed unit.

Also from Australia, Dr. Davide Ross and Dr. Adina Cirtog, from Pangolin Associates, present their paper, "Online Automatic Tube Cleaning System (ATCS) Creates HVAC System Energy Savings." Full of interesting data (large chillers can have more than five miles of condenser and evaporator tubes), the article focuses on the negative impacts of heat exchanger fouling on efficiencies. It then reviews how to use the ATCS to realize significant energy savings.

Thank you for investing your time and knowledge with *Chiller & Cooling Best Practices* and please remember to visit www.coolingbestpractices.com.

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CHILLER & COOLING SYSTEM INDUSTRY NEWS

SPX Cooling Technologies Announces Recold® Vector™ Adiabatic Cooling System

SPX Cooling Technologies, Inc., a full-line, full-service industry leader in the design and manufacture of cooling towers and other specialized heat exchangers, announces the Recold Vector™ Adiabatic Cooling System, for halocarbon refrigerant condensing or CO_2 gas cooling applications in supermarket refrigeration systems. The Recold Vector provides lower energy usage and a smaller footprint than an air-cooled condenser and up to 60 percent or more reduction in site water usage compared to an evaporative condenser. Designed as a once-through system, the Recold Vector Adiabatic Cooling System minimizes water treatment requirements.

With a condensing capacity of 25-295 tons and a CO_2 gas cooling capacity of 32-372 tons, the Recold Vector system enhances the utility of an air-cooled system with the efficiency boost of a wet system during peak conditions. Evaporative pads precool air only on peak days and coils remain dry to maintain efficiency and life expectancy. Electronically commutated (EC) motors help ensure reliable and efficient operation.

The Recold Vector system is equipped with the HydroBLU energy management control system featuring automatic motor programming and either standalone or remote interface control. The control system can be used with setpoint changeover and/or a nighttime limiter. Operational and fault signaling, remote monitoring capabilities, and bypass operations are all provided.

The integral water distribution system provides even water distribution across the cooling pads' entire surface area, minimizing dry spots. With their fluted angles, the pads direct water flow towards their air inlet side, where most evaporation takes place. A certain amount of water is not evaporated, which helps to continuously rinse the pads. This minimizes inlet scaling and clogging and reduces dirt accumulation on the heat exchanger's finned surface area.

For more information, visit the Recold Vector Adiabatic Cooling System product page at www.spxcooling.com/products/recold-vector-adiabatic-cooling-system

Daikin Europe Certifies its Engineers as CEAs

Daikin Europe hosted a Certified Energy Auditor CEA® program at its offices in Brussels in January 2016. A total of 15 engineers attended the seminar, from 8 different countries: Italy, Greece, Belgium, Netherland, United Kingdom, France, Spain and Portugal.

The CEA® program includes topics needed to understand energy auditing including: Energy Auditing Methodology; Energy Audit Instrumentation; Auditing Tools; Economic Analysis; Building Systems; Lighting; Building Envelope; HVAC; Controls; Boilers and Steam Systems; Water Auditing; Reviewing Auditing Reports.

CEA® certification allows engineers to manage energy audits in their facilities and with their clients. The Association of Energy Engineers would like to thank DAIKIN Europe for trusting AEE certification programs and congratulations for the outstanding performance of your engineers!

For further information please contact the Association of Energy Engineers at www.aeecenter.org or visit Daikin Applied at www.daikinapplied.com

The Recold Vector system has a condensing capacity of 25-295 tons.

Daikin Europe hosted a Certified Energy Auditor CEA® Program in Brussels.

CHILLER & COOLING SYSTEM INDUSTRY NEWS

CTA to Open North American Operation

CTA of Chaponost, France is proud to announce arrival into the North American compressed air treatment and process cooling market.

Don Joyce is the Director of Sales and Marketing for CTA North America

CTA was founded as a sales and service business in the process cooling and compressed air treatment markets in France in 1987. Throughout the 90's, CTA experienced rapid growth both organically and through strategic acquisition. Engineering and production of refrigeration dryers led to a solid European market presence and eventually to the acquisition of Euroklimat, an industrial process chiller manufacturer based in Milan, Italy.

Development has always been at the core of the CTA philosophy. CTA brought the first propane chiller to the European cooling market. Recently, CTA has redesigned their process chillers and refrigeration dryers to bring significant improvements for both products to market…the unique and patented 'No Frost' process chiller utilizing the OPTIFLUX evaporator and an improved two-stage DryMass cycling dryer. By separating the air-to-air exchanger from the air-to-refrigerant exchanger, the CTA cycling dryers react more quickly to changing compressed air conditions while consuming less energy. These improvements mean more consistent dew points, increased energy savings and utility rebate qualification for end-users.

With products now ready for the North American market, the key task remaining was to hire the correct person to manage sales for North America. With compressed air and process cooling experience spanning 20+ years and having succeeded on every level from distributor to manufacturer, Don Joyce was the natural choice to lead CTA into the North American market. Don has the application experience ranging from thermal spray to MRIs and welders to linear accelerators while CTA has the expertise and reliable portfolio of products to serve a wide variety of applications.

CTA North America will be based in the Charlotte, NC area and plans are in place to open an office and warehouse in Q3 2016. Process chillers along with both thermal mass and direct expansion dryers will be stocked in the North Carolina facility. In 2017, CTA will introduce other key products including filtration, condensate treatment and market-specific process cooling products.

For further information please contact Don Joyce, Director Sales and Marketing, CTA North America, tel: 980-241-3970, email: djoyce@cta-na.com or visit www.cta.fr/GB/home.php

RETA Chapter to host a Regional Conference in Orlando

The Central Florida Chapter of RETA (Refrigeration Engineers & Technicians Association) will host a Regional Conference devoted to ammonia safety and industrial refrigeration training/education. "The concept of Regional Conferences is not new to RETA," said Chairman of the Central Florida Chapter Board, Ernest Leavell (Leavell Consulting) when he recently announced the Chapter will produce and host a two-day Regional Conference.

"There just hasn't been one in our area for more than a decade. We've revived the concept with two-day Conference devoted to the ammonia refrigeration industry. It is scheduled for November 3-4, 2016 at the Caribe Royale in Orlando, FL." The Central Florida Ammonia Refrigeration Regional Conference features a variety of opportunities for attendees including a 24,000 square foot exhibit hall, industrial refrigeration training, sessions focused on ammonia safety, technical sessions and a live ammonia release demonstration. "As a true RETA Chapter event, it also offers hands-on training," stated Leavell.

The faculty of presenters draws from across the United States and features such notables as:

- **Retired Battalion Chief Charles Gluck** (currently a Safety Consultant to the University of Tennessee)
- **John (Jack) Piho, PE** of Piho Engineering
- **Lee Pyle, CARO** of SCS Tracer Environmental
- **Kent Harmon** of Industrial Consultants; Harold Paul of Air Treatment Corp.
- **Joseph Crisp** of RC&E
- **Vern Sanderson, RAI, CIRO** of Kelly Refrigeration Services
- **Arlie B. Farley, CIRO, CARO** of Farley's Frigeration.

"We're particularly excited to be able to produce an event that allows attendees to register for a fee of only $40," said Chapter President **George Johnston** of Center Mark Contracting. "The Conference provides 14 hours of training during the two-day schedule. There are many folks in the industrial refrigeration industry who want quality training but have time or budget restrictions. In short, we saw a need. We believe this Conference meets that need by providing affordable, quality training plus a terrific networking opportunity. So much so that we anticipate welcoming 500 or more attendees."

Mr. Leavell agreed stating "Our goal is to meet the RETA Mission Statement – 'To enhance the professional development of industrial refrigeration operators and technicians' and this Conference does just that. We are grateful for the foresight and generosity of our exhibitors and sponsors who have made it possible to offer such an expansive program at such an extraordinarily low cost."

This is the second Regional Conference in 2016; the first held April 14-15 in Arlington, TX. RETA HQ supports the Regional Conferences as they directly serve the RETA mission. "The Dallas Fort Worth (DFW) Chapter put on a great Regional Conference, which I feel was one of the best educational programs that I have had the pleasure to participate in." said Executive Director, **James Barron,** "Knowing that the Central Florida Ammonia Refrigeration Regional Conference is following a similar format, I'm really looking forward to being a part of it in Orlando this November!"

The $40 Regional Conference fee includes:

- 2 full days of educational programming – attendees may earn up to 14 PDH
- Daily box lunch and breaks plus Thursday reception
- Hands-on workshops and Manufacturer-specific workshops
- 4-hour compressor tear-down workshops
- Live release ammonia demonstration
- 24,000 sq. ft. exhibit hall
- Technical sessions
- Attendee materials

About the Central Florida Chapter (CFC) of RETA (Refrigerating Engineers & Technicians Association): The CFC is comprised of more than 179 members of RETA. As one of 41 RETA Chapters throughout the US, the CFC is devoted to providing educational and networking opportunities to those in the industrial refrigeration industry in Central Florida. The CFC works with both the South Florida and North Florida Chapter to keep their members up-to-date on new developments in equipment and operating procedures, practical aspects of everyday engine room operations, troubleshooting and emergency situations. For more information, visit www.reta-cfc.com

York Predator Rooftop Units to be Installed at 225 Target® Stores

Johnson Controls announced today it is partnering on an initiative to replace HVAC rooftop equipment at 225 Target stores. The initiative is a three-year project that entails installing 3,600 York Predator series packaged rooftop units to maximize energy savings through more efficient HVAC equipment at stores eight years or older.

The York rooftop units feature energy-saving technologies including variable-speed drives, California Title 24-compliant economizers and new Energy Recovery Ventilators (ERV) specifically designed for retailers.

The project is delivered by the YORK National Accounts team in partnership with Minneapolis-based Midwest Mechanical Solutions. The

CHILLER & COOLING SYSTEM INDUSTRY NEWS

units are made with American quality and will help set the standard for Johnson Controls commercial packaged rooftop equipment offered to national accounts like Target.

"We provide our customers with dependable, easy-to-maintain systems that reduce energy costs and total cost of ownership," said Dominic Ticali, National Accounts sales manager with Johnson Controls' Building Efficiency. "By teaming up with Target, we're continuing to showcase our unmatched customer service and strong product portfolio."

About Johnson Controls

Johnson Controls is a global diversified technology and industrial leader serving customers in more than 150 countries. Our 150,000 employees create quality products, services and solutions to optimize energy and operational efficiencies of buildings; lead-acid automotive batteries and advanced batteries for hybrid and electric vehicles; and seating components and systems for automobiles. Our commitment to sustainability dates back to our roots in 1885, with the invention of the first electric room thermostat. Through our growth strategies and by increasing market share we are committed to delivering value to shareholders and making our customers successful. In 2015, Corporate Responsibility Magazine recognized Johnson Controls as the #14 company in its annual "100 Best Corporate Citizens" list. For additional information, please visit www.johnsoncontrols.com or follow us @johnsoncontrols on Twitter.

About Johnson Controls' Building Efficiency

Johnson Controls' Building Efficiency has an unmatched portfolio of HVACR products and solutions to create more comfortable, safe and efficient buildings. Operating in more than 150 countries through a strong network of distribution channels, Building Efficiency's breadth of offerings help building owners, operators, engineers and consultants impact the full life cycle of a building. Its market leadership is established through trusted brands such as YORK®, Sabroe®, Hitachi and Metasys® as well as its smart building integration capabilities and energy financing solutions. For more information, visit www.johnsoncontrols.com or follow @JCI_BEnews.

ASHRAE and American Institute of Architects Work Together

Building on past outreach, ASHRAE and the American Institute of Architects (AIA) have signed a Memorandum of Understanding, committing them to working together in a variety of built environment areas.

The MOU recently was signed by ASHRAE President David Underwood and AIA President Russ Davidson. The agreement states the two organizations will work jointly in areas related to development of young professionals, advocacy and public outreach, publications, education, technical activities and research.

"ASHRAE and AIA share many common technical interests, including health and safety, energy efficiency, and resilience," David Underwood, ASHRAE president, said. "This agreement formalizes our plans to foster technical cooperation in these areas, providing needed guidance to the industry."

"We are at a pivotal juncture as an industry to address the growing number of design challenges," said AIA President, Russ Davidson, FAIA. "The extension of this agreement is important for our organizations to continue to work together to further sustainable design strategies, to be active on building codes related issues, as well as for providing tangible resources that are useful for our respective members in their daily practice."

In past projects with a focus on improving energy efficiency of buildings and systems, ASHRAE and AIA are part of a group that is developing a new version of the _International Green Construction Code_ (IgCC) sponsored by the International Code Council (ICC), the Illuminating Engineering Society (IES) and the U.S. Green Building Council (USGBC). The code, scheduled to be released in 2018, will be powered by ANSI/ASHRAE/ICC/IES/USGBC Standard 189.1, _Standard for the Design of High-Performance, Green Buildings Except Low-Rise Residential Buildings_ developed using the American National Standards Institute (ANSI) approved ASHRAE consensus process.

ASHRAE and AIA also joined together with IES, USGBC and the Department of Energy (DOE) in developing the Advanced Energy Design Guide series. The nine books in the series provide recommendations for achieving 50% and 30% energy savings over the minimum code requirements of ANSI/ASHRAE/IESNA Standard 90.1, _Energy Standard for Buildings Except__Low-Rise Residential Buildings_

ASHRAE, founded in 1894, is a global society advancing human well-being through sustainable technology for the built environment. The Society and its more than 50,000 members worldwide focus on building systems, energy efficiency, indoor air quality, refrigeration and sustainability. Through research, standards writing, publishing, certification and continuing education, ASHRAE shapes tomorrow's built environment today. More information can be found at www.ashrae.org/news.

Cooling Tower Institute 2016 Annual Conference Highlights

More than 400 attendees from around the globe participated in the Cooling Technology Institute's ("CTI") Annual Conference in Houston in late February. Twenty-eight technical papers were presented on topics of interest to the Industry in the fields of engineering standards, maintenance, thermal performance, and water treatment. Seminars were held for owners and operators of heat rejection equipment as well as an informative "Ask the Expert" session. Over 56 vendors exhibited their products at the trade fair held on Tuesday evening. In addition, CTI technical committee meetings were held in support of the CTI's thermal certification program as well as to maintain and develop numerous CTI codes, standards, and guidelines.

A key highlight of the conference was an informative Educational Seminar focused this year on the control of Legionellosis, which has always been an important topic to the CTI and its members and has drawn national attention with the recent outbreaks in New York City and Flint, Michigan. The seminar, "Legionnaires Disease (Legionellosis) – Detection, Risk Reduction, and Control Methods", was presented by a panel of scientific, technical, and industrial water experts. The Seminar covered the following topics:

- Basics of Cooling Water Chemistry Microbiological Control
- Development of a Water Management Plan (WPM) for Building Water Systems
- ASHRAE Legionella Standard - Risk Management for Building Water Systems
- Managing Heat Ejection Equipment Relative to the Risk of Legionnaire's Disease

Two of the technical papers presented at the conference focused on Legionellosis including one addressing the current situation in New York City which experienced several outbreaks of Legionnaires Disease in 2015. As a service to the Industry, both of these technical papers, the associated slide presentations that accompanied the papers, and the CTI Legionellosis Guideline, "Best Practices for Control of Legionella (WTP-148)", are all now available as free downloads from the CTI website.

In addition, a special CTI committee, comprised of many of the same experts that participated on the ASHRAE Standard 188 Committee, is currently in the process of completing CTI GDL-159, a new guideline on Legionella risk management specifically for evaporative heat rejection equipment. The CTI anticipates that the new guideline will be published later this year.

For further information on the CTI in general, including how to become a member, please visit www.CTI.org or contact Vicky Manser, the CTI Administrator, at vmanser@cti.org or 281-583-4087.

For more Industry News visit www.coolingbestpractices.com

Chiller Plant Optimization Yields $386,000 UTILITY REBATE

By Mike Flaherty, General Manager, tekWorx

A northeastern U.S. manufacturing site was able to maintain cooling production during a major hydronic system and adaptive control system update, saving over 4,500,000 kWh annually and earning a $386,000 energy rebate from the local utility.

A manufacturing site's central utility plant (CUP) provides 24/7 cooling for critical R&D laboratories, critical manufacturing processes, data centers and office space. Over a period of several years, campus growth had significantly increased facility energy consumption, raising costs dramatically. Simultaneously, the host state enacted a legislation to deregulate utilities, a move potentially doubling the cost of electricity.

In an effort to rein in costs and improve profitability, a global program was implemented. The policy declared the company's intention to reduce operational GHG emissions and the consumption of energy (relative to sales) by integrating energy efficiency considerations into all aspects of its business - including transportation and investment decisions. According to the site energy manager, the Central Utility Plant had the potential to save $500,000 annually in operating

> "According to the site energy manager, the Central Utility Plant had the potential to save $500,000 annually in operating expenses."
>
> — Mike Flaherty, General Manager, tekWorx

expenses. The question was how this could be done. According to the design firm, optimizing a plant of this size and type was unheard of so there was no roadmap to follow.

The economic climate had created strict requirements on capital projects, so only those projects with demonstrated compliance in energy payback/ROI and carbon footprint reduction would be considered. Working within these parameters, the energy team solicited proposals from several potential partners on how to optimize the CUP.

tekWorx was hired after inviting the plant energy manager to tour the chiller plant at a complex hospital installation that included both chiller and boiler plants. The design firm had also worked with tekWorx on two similar manufacturing plants, "tekWorx did their homework and presented a proposal on how to reduce the total plant kW per ton and actually quantified the expectations. No one else could give me numbers or go beyond packaged software and VFDs."

Original Plant Configuration

The manufacturing plant had a total cooling capacity of 10,636 tons consisting of eight centrifugal chillers and one absorption chiller. Chilled water distribution was provided by ten constant-speed pumps to two independent distribution loops containing a total of 83 cooling coils with two-way valves. The condenser water system linked twelve constant-speed headered chilled water pumps with fifteen variable-speed cooling towers.

Prior to the project, there was no automation. Operators could turn equipment ON/OFF from a screen on the ABB Infi90 system, but all control decisions were manually determined. For example, chilled water pumps were manually sequenced to maintain a supply pressure of 80-100 PSIG regardless of other factors. And since the instrumentation and plant equipment (such as chiller control panels) was not integrated with the campus information system, there was no way to track the effectiveness of these manual actions.

Mechanical Solutions

Upon identifying the plant deficiencies, the design team determined that both mechanical and control/ instrumentation modifications would be necessary to achieve the energy savings projections.

The first step was to convert the hydronic system to full variable flow so water would be circulated through both the chillers and the load. This required the installation of variable frequency drives on all chilled water pumps to regulate flow with load. Since there

CHILLER PLANT OPTIMIZATION YIELDS $386,000 UTILITY REBATE

could potentially be instances in which the flow required for the cooling load may not be enough to maintain minimum chiller flow, a bypass line with a control valve was installed. The valve opens during light load conditions to ensure minimum evaporator flow; otherwise, the valve is closed (which is the case most of the time) so there is no flow through the bypass.

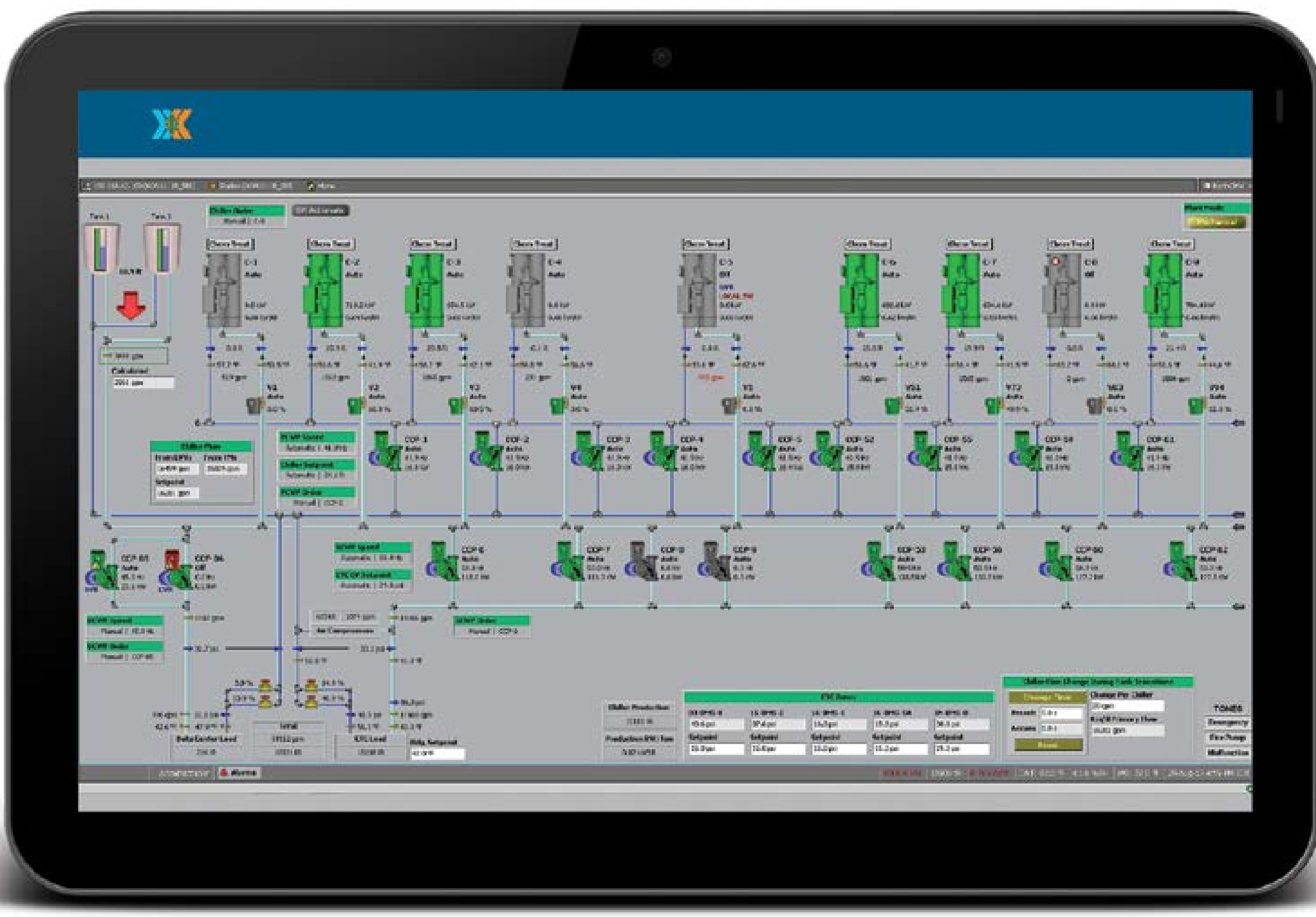
Because the chillers varied in tonnage, modulating valves were installed at each chiller so that machines with differing evaporator pressure drops could be efficiently operated together. The valves' position would be controlled based on the evaporator differential pressure, allowing them to load proportionally.

All chiller control panels were retrofitted with new on-board control panels with Modbus communication interface to be able to receive chiller operating data.

After the team conducted a thorough review of the site, they determined that a combination of the planned minor mechanical modifications and adaptive automation would reduce total plant energy consumption by the target of 4,450,000 kilowatt hours.

Instrumentation/Control Solutions

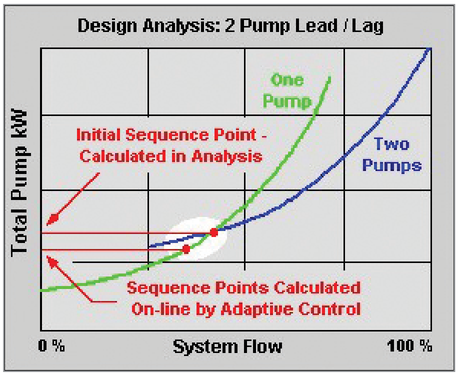
tekWorx determined the minimum chilled water pressure differentials and the optimum number of pumps needed at varying demands to optimize pumping production and efficiency in the pharma facility. Using design parameters (flow, head, friction loss), tekWorx would generate a Pump kW Consumption Analysis for the system.



tekWorx CEO® User Interface has provided the energy team with a window into their entire cooling system. Operators are able to use an industrial HMI to oversee both plant operation and optimization.

The curves illustrate the point above which the kW required to operate one pump is actually more than that required for two pumps to deliver the same flow. The corresponding kW value is loaded in the control program and used to sequence the lag pump ON / OFF in the initial operation. The adaptive control algorithm then analyzes the actual system behavior during each sequence operation, and makes an on-line adjustment to the sequence point for the following operation. The result is that the optimal setpoint is continuously used, thus dramatically reducing pump energy consumption.

With mechanical modifications complete, the final step was fully automating the site's optimized operations via tekWorx CEO® (Control and Energy Optimization) system. tekWorx control system delivers the lowest CHW plant energy by continuously monitoring and adjusting the chiller, tower and pump operation to produce the required cooling (CHW flow and temperature) that will cool the building at the lowest kW/ton. This is done without affecting comfort and humidity and regardless of the occupancy, usage, hydronic design, mechanical equipment condition, availability, location or weather for a given chilled water supply temperature and remote DP sensor.



tekWorx generated a Pump kW Consumption Analysis for the system, similar to the example shown above. The curves illustrate the point above which the kW required to operate one pump is actually more than that required for two pumps to deliver the same flow.

The algorithms were implemented on an Allen Bradley PLC-based hardware platform, the client's standard. The VFDs, chiller panels, valves & miscellaneous pressure, temperature and flow instruments were connected to this platform. At the energy manager's request, tekWorx went a step further and integrated the CEO® system with the site's ABB Infi90 facility management system to facilitate remote monitoring and maintenance.

Results

As a result of the project, this manufacturing site is saving approximately 4,450,000 kWh on 19,000,000 ton-hours of annual cooling production. This tremendous efficiency gain equates to $425,000 in energy annual savings and earned the site a $386,000 PECO utility rebate.

The site's chillers are now sequenced based on efficiency. All pumps are variable speed and they are sequenced to meet the flow demand at the lowest total pumping energy. Consequently, the system pressure has been reduced from over 100 PSI to approximately 78 PSI.

"tekWorx really understood the issues we were facing in the plant and more importantly, how to correct them,"' said the site energy manager. Not inconsequentially, the energy team has an improved understanding of entire system, particularly due to the fact that they now are able to capture operational data and trending. Supplemental chillers have been eliminated and the wear and tear on the pumps and AHU valves has been significantly reduced. At the same time, the chiller operating and loading times have been optimized and operator intervention with the system has been simplified. BP

For more information please contact Mike Flaherty, General Manager, tekWorx, tel: 513.373.4287, email: mike.flaherty@tekworx.us, www.tekworx.us

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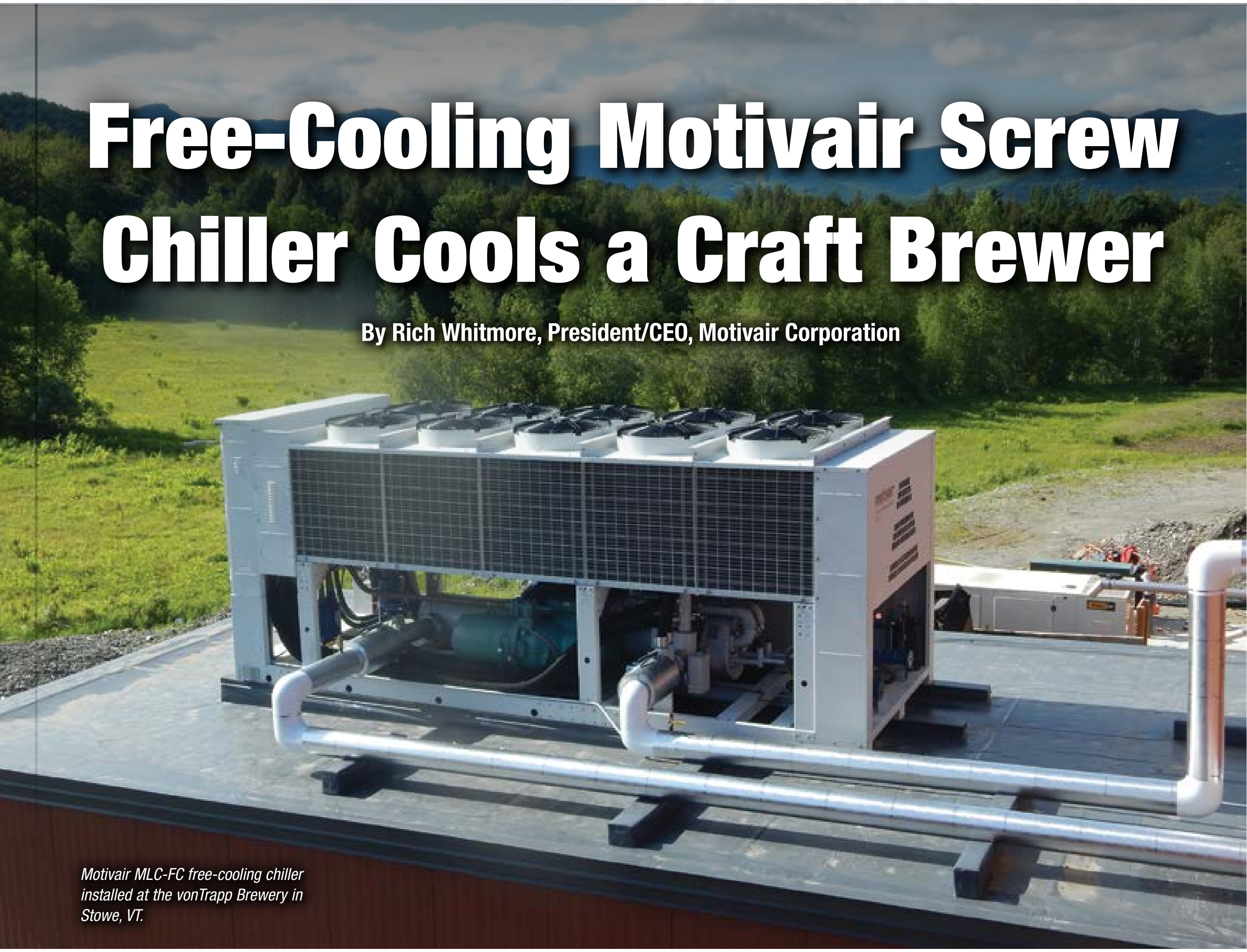
"This tremendous efficiency gain equates to $425,000 in energy annual savings and earned the site a $386,000 PECO utility rebate."

— Mike Flaherty, General Manager, tekWorx

Free-Cooling Motivair Screw Chiller Cools a Craft Brewer

By Rich Whitmore, President/CEO, Motivair Corporation



Motivair MLC-FC free-cooling chiller installed at the vonTrapp Brewery in Stowe, VT.

It's no secret the craft beer market has grown dramatically in North America. Local breweries and brewpubs are popping up across all regions of the United States as consumers seek unique, flavor-rich brews. In fact, according to the Brewers Association, the trade association representing small and independent American craft brewers, in 2015 the number of operating breweries in the U.S. grew 15 percent, totaling 4,269 breweries – the most at any time in American history. With more breweries than ever before, small and independent craft brewers now represent 12 percent market share of the overall beer industry*.

> "Because of the brewery's geographical location in the northeast, a low-temperature chiller that could operate year round without any issues was critical."
>
> — Rich Whitmore, President/CEO, Motivair Corporation

As the number of breweries in the United States continues to rise, so does the need for equipment designed to handle critical process operations in brew houses. Motivair Corporation, based in Buffalo, New York, recently completed the installation of a large screw chiller with integrated free-cooling for von Trapp Brewing in Stowe, Vermont. The brewery, which opened its new 30,000 sq. ft. facility in 2015, is capable of producing up to 60,000 barrels of beer annually, according to its website.

A Refreshing Solution for Optimal Energy Savings

Because of the brewery's geographical location in the northeast, a low-temperature chiller that could operate year round without any issues was critical – a substantial design range to ask of a low-temperature air-cooled chiller. The solution? A free-cooling chiller offers optimal energy savings and reliable performance in varying ambient temperatures. Thermal Environment Sales worked with design firm Pearson & Associates, Inc. (Stowe, VT) who selected Motivair Corporation's MLC-FC large screw chiller for the job because of its free-cooling capability.

The free-cooling option, available on all Motivair MLC models, comes standard with an advanced programmable logic controller (PLC). The high efficiency screw compressor plant is designed to cool the designated heat load during the summer months and then when ambient temperatures fall overnight or during cooler seasonal weather, the integrated free-cooling system is automatically activated. The change from mechanical to partial or full free cooling is both seamless and transparent to the operator.

The system operates by directing the return chilled glycol through the free-cooling coil, before it enters the evaporator. This is achieved via an automatic motorized valve, controlled by the PLC, whenever the ambient falls below the return chilled glycol temperature set point. The glycol is either partially or completely cooled in the free-cooling coil for maximum energy savings.

Motivair's proprietary design provided the von Trapp Brewery with year-round energy savings, but especially in the cooler months. The free-cooling feature allowed for 100 percent free cooling at 5˚F, but also protected the refrigeration circuit from the cold, sometimes frigid temperatures in Vermont, since the refrigeration plant does not need to be utilized below 5˚F. This avoided low refrigerant head pressure and startup problems. Allowing the compressors to stage off in cooler weather drives overall chiller efficiencies and dramatically reduces natural wear and tear on chiller components. Automatic switching between mechanical cooling and free cooling provides for optimal performance year round, and there is an added level of redundancy should any mechanical refrigeration components fail in the cooler months.

Also, the proprietary chiller design places the free-cooling coils in the front of the condenser coils, allowing the largest possible free-cooling-coil face area with low airflow resistance. This ultimately minimizes required fan power on the chiller.

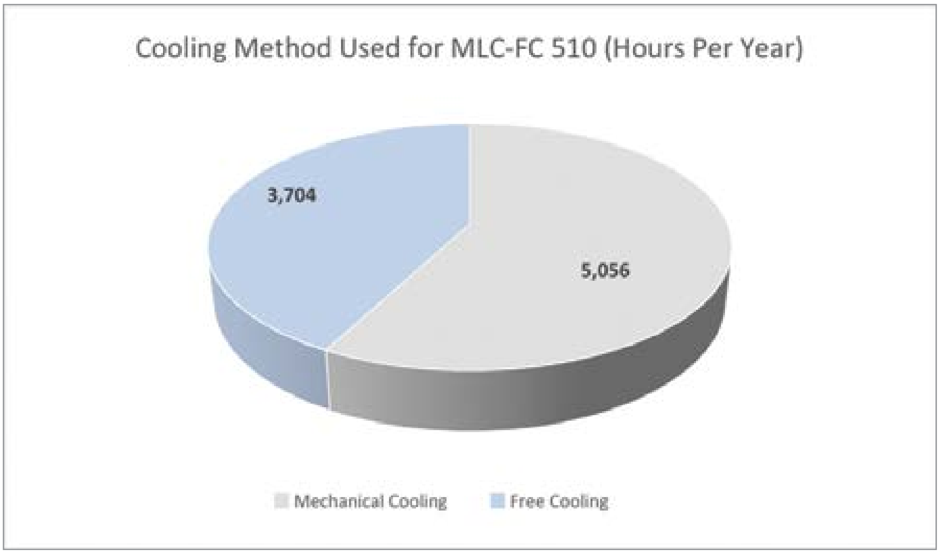
Distinctively Different

Microbreweries are famous for putting their own twist on a standard beer. Due to the nature of their business, von Trapp Brewing required 28˚F chilled water temperature, which is lower than what could be achieved

Energy savings are substantial, in geographical areas with cooler winter months such as Stowe, VT, with a free-cooling chiller. The compressors stage off in cooler weather, further driving overall chiller efficiencies. Wear and tear on chiller components are significantly reduced, due to fewer start-ups and running hours during winter months. Automatic switching between mechanical cooling and free-cooling is seamless, which allows optimal performance year round.

FREE-COOLING MOTIVAIR SCREW CHILLER COOLS A CRAFT BREWER

In 2010, von Trapp Brewery officially opened at the Trapp Family Lodge in Stowe, Vermont. The brewery moved into its new 30,000 sq. ft. facility in 2015 and currently brews around 60,000 gallons of lager each year.



from commercial-grade equipment and still operate properly. Motivair was up for the engineering challenge.

The low leaving water temperature required a custom design for an industrial chiller with proper refrigerant selection and oil lubrication systems integrated to allow for safe and efficient operation for the life cycle of the chiller. One of the added benefits of working with Motivair is the ability to design and create optimized performance packages that can tailor free-cooling output and efficiencies to best suit the customer's unique needs.

Cost Savings Worth Celebrating

As mentioned previously, geographical areas with cooler seasonal weather are ideal for utilizing free-cooling and it is these areas where customers will see true cost savings. For example, Vermont spends approximately 3,337 hours per year at 10˚F to 40˚F (partial free-cooling) and 367 hours per year at -20˚F to 10˚F (100 percent free-cooling). This translates to 42% of the year in either partial or 100 percent free-cooling mode. Motivair's free-cooling chillers are designed to produce 50-percent free cooling at ambient temperatures approximately 10˚F below design chilled-water temperatures and 100-percent free cooling at approximately 20˚F below chilled-water supply temperatures.

The MLC-FC 510 used in this application featured two semi-hermetic screw compressors, each of which absorbs 110 kW (at 90˚F design ambient air temperature). At an average commercial power cost of $14.39 per kilowatt-hour in Vermont**, vonTrapp Brewing is estimated to save approximately $30,000 per year, compared with the costs associated with a standard winterized chiller. Eliminating winter compressor operation and using a free-cooling chiller, savings are estimated at approximately 85.3 percent of the power costs normally associated with mechanical cooling during the coldest months.

The only requirements for free-cooling chillers are an outdoor location and the addition of glycol to the cooling loop. Installation cost is minimal and the only connections required are those for chilled glycol and electrical power.

Motivair's free-cooling chillers will continue to be the optimal solution for year-round critical cooling loads that depend on systems to provide a reliable source of chilled water, which can improve overall system uptime and efficiencies. BP

For more information please contact Rich Whitmore, President/CEO, Motivair Corporation, tel: 716.691.9222, email: rwhitmore@motivaircorp.com, www.motivaircorp.com

About Motivair Corporation
Motivair Corporation, based in Buffalo, NY (USA), is a globally recognized supplier of specialty chillers and cooling systems providing innovative solutions for customers in industrial, commercial, public and private sectors around the world. For more information, visit www.MotivairCorp.com

About von Trapp Brewery
It was more than a decade ago when Johannes von Trapp started thinking about starting a brewery at his family's lodge in Stowe, Vermont. He had a dream to brew an American version of the tasty lagers he enjoyed so much during trips to the countryside near his ancestral Austrian home. With this dream in mind, Johannes worked to start a brewery at Trapp Family Lodge. It became a reality in the spring of 2010, when von Trapp Brewery officially opened. The brewery was originally located in the lower level of the Trapp Family Lodge, and then moved to its new 30,000 sq. ft. brewery on Luce Hill Road in 2015. The new facility currently brews around 60,000 gallons of lager each year, with brews available year-round and seasonally. For more information, visit www.vontrappbrewing.com

*Source: March 22, 2016. Brewers Association Releases Annual Growth Figures for American Craft Brewers https://www.brewersassociation.org/press-releases/small-independent-brewers-continue-grow-double-digits/

**Source: May 25, 2016. Average Price of Electricity to Ultimate Customers by End-Use Sector by State, March 2016 and March 2015 http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a

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Industrial Hydronic System MANUAL-BALANCING METHODS

By Brandon Aitken, ME, P.E., Engineering & Fabrication Manager, Blackhawk Equipment Corporation

Hydronic balancing in industrial heating and cooling systems is an often overlooked final step in startup and commissioning of new and modified hydronic systems. Insisting on a complete system balance upon startup of a new or modified system is an inexpensive insurance policy for any design engineer or installation contractor to protect their reputation against a system that is not performing to design conditions. There are several methods of hydronic system balancing utilized in commercial and hospitality buildings, however, they are rarely found in the manufacturing and industrial environments.

Manual-Balance Using Calibrated Balancing Valves and Reverse-Return Piping

The most common of the various methods of system balance, found in industrial and manufacturing facilities, is manual-balance using

> "Insisting on a complete system balance upon startup of a new or modified system is an inexpensive insurance policy for any design engineer or installation contractor."
>
> — Brandon Aitken, ME, P.E., Engineering & Fabrication Manager, Blackhawk Equipment Corporation

calibrated balancing valves and reverse-return piping. Manual-balance utilizes calibrated balancing valves to restrict and meter flow to a coil. A calibrated balancing valve is an adjustable orifice flow metering device. The valve manufacturer develops flow characteristics of the valve by creating a flow/pressure relationship allowing flow to be accurately measured and controlled via pressure drop across the valve. The flow rate can be infinitely adjusted and set via graduated markings, or set points on the valve body.

Reverse-return systems, where the first process equipment supplied cooling water is the last equipment to be returned, are elegant and a simple means of balancing cooling water systems. However, they are implemented less often in manufacturing and industrial systems due to their added upfront costs of additional pipe and they are not always practical if heat loads are scattered in a non-uniform pattern around the facility. This article focuses on the ill effects of a hydronic system that is out of balance and the corrective steps to balancing a system using manual-balance method.

Case Study

Blackhawk Equipment Corp. recently completed a study at a manufacturing facility experiencing severe problems with their cooling process and support equipment. These issues had become so significant they were negatively effecting production resulting in increased scrap rates and intermittent shutdowns of production.

The facility had recently undergone a major project where a new manufacturing line was installed. The project design engineers had determined the existing cooling tower was adequate to reject the additional heat load the new production equipment would produce but the system pumps and main header were upsized to accommodate additional flow. Shortly after the new manufacturing line was brought online, problems cooling the new and existing equipment began.

In an effort to increase cooling to the production equipment, additional heat exchangers were added to the production equipment and pump and cooling tower efficiencies were investigated and adjusted. These actions resulted in minimal improvements cooling the production equipment. The plant management was ready to replace their entire cooling water system when Blackhawk Equipment was solicited to analyze the cooling water system and provide observations and corrective actions.

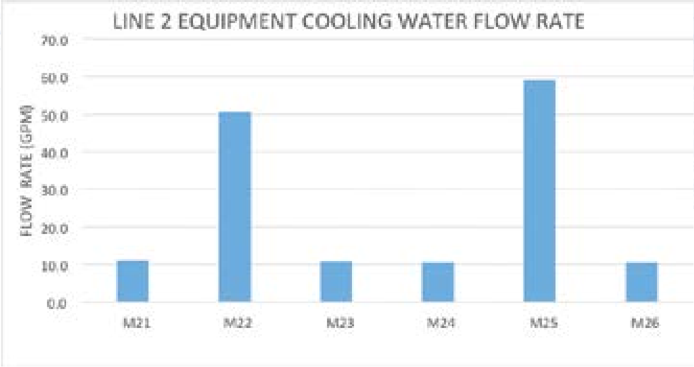

Figure 1: The average cooling water flow varied drastically between manufacturing lines.

Blackhawk's Observations

- There was a lack of balancing valves present in the distribution piping. Balancing valves were not installed at the process equipment heat exchangers nor in the main branch piping
- Return water pressure varied greatly between production lines (3psi – 5 psi on the legacy production lines, and 24psi on the new production line)
- The average cooling water flow varied drastically between manufacturing lines. (see figure #1)
- Flow between identical pieces of production equipment varied significantly (See figures #2, #3, & #4)

Imbalanced Cooling Water Distribution Piping

It was concluded the cooling water distribution piping was in a state of severe imbalance. The pipe installed during the installation of the new manufacturing line was found to be short cycling the cooling water system, reducing the flow to the legacy manufacturing lines. In addition, the distribution pumps were operating on the far right part of their flow curves producing more flow but less pressure then how they were designed to operate, another negative effect of an out of balance system. The unrestricted flow of cooling water to the new production line wasn't allowing the system distribution pumps to build enough pressure to adequately circulate water to the legacy production equipment which were located ~200+ feet further away from the cooling water pumps than the new line.

Blackhawk Equipment recommended the installation of over 30 calibrated balancing valves from ¾" to 3" to be installed on the return water side of all production and support equipment that required cooling water.

INDUSTRIAL HYDRONIC SYSTEM MANUAL-BALANCING METHODS

Once installed Blackhawk spent several days observing and balancing the system. After which the system flow was being evenly distributed between production lines and individual pieces of equipment. The overall pumping power was reduced, scrap rates were decreased and stops in production from overheating equipment were eliminated.

A 5-Step Process to Use Manual–Calibrated Balance Valves

If utilizing a test and balance firm is not in the budget a few simple steps during the startup and commissioning of a new or modified hydronic system can provide a rough system balance to help insure the new system will perform up to design conditions and end user expectations. The procedure for balancing using manual calibrated balance valves can be boiled down to a simple 5 step process:

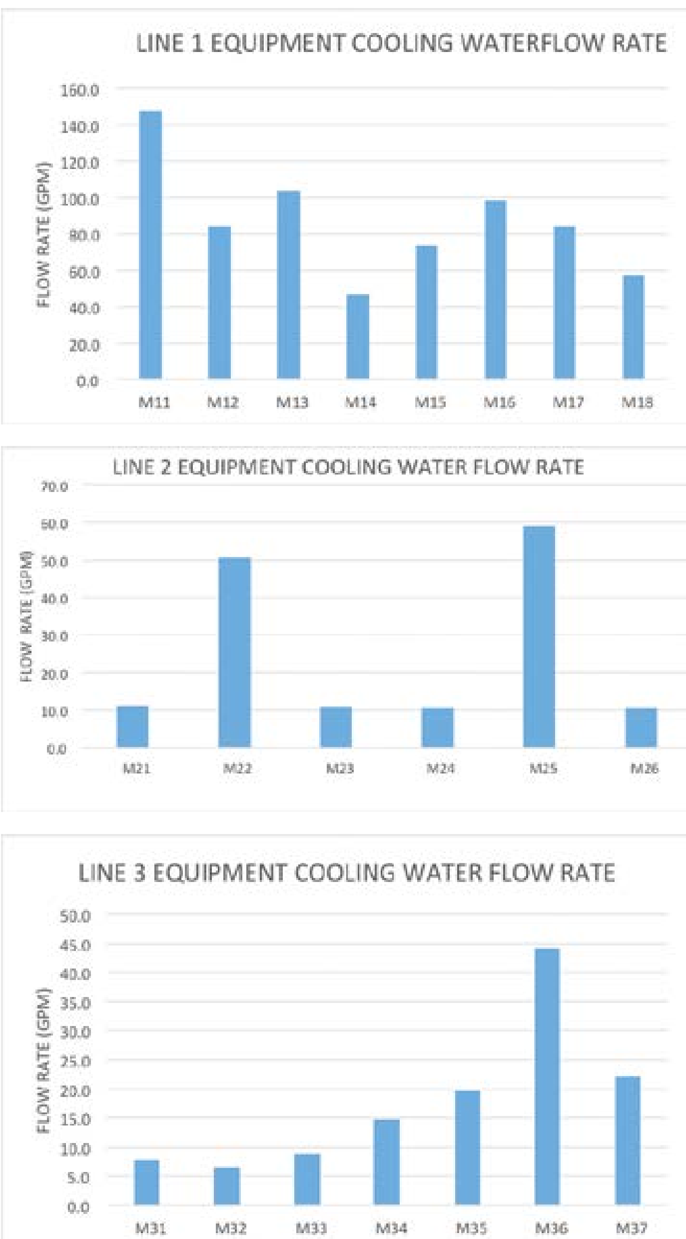

Figure 2-4: Flow between identical pieces of production equipment varied significantly.

1. Open all balance valves 100%, verify all air has been evacuated from the system, and verify heat exchangers are properly plumbed.

2. Check the system pump current, inlet pressure and outlet pressure and record. This will help establish the pre-balance pump operating point and system flow rate.

3. Starting at the heat exchanger/coil nearest the pumps and using manufacturer tables or phone app. set the flow at 80% of design. (There are many good choices of valves on the market but my calibrated balancing valve of choice is the Bell & Gossett Circuit Setter, this is a robustly built valve equipped with upstream and downstream pressure ports and the SystemSyzer phone application works well for setting up flow through the valve quickly).

4. Moving away from the pumps increase the percentage of full flow equally for each coil from the first to the end of piping then return to the first coil and check the flow.

5. Measure and record the final pump pressure current and inlet and outlet pressures. The system pressure should have risen and the flow should be reduced from the starting point.

Conclusion

When trouble-shooting over-heating equipment, hydronic system balancing should always be considered during the root cause analysis. Often times fouled heat exchangers or failing cooling water equipment are misdiagnosed and the underpinning cause is actually a system balance issue. Hydronic system balancing should be completed on new systems and any time a significant system modification takes place.

Side note: Balance valves and flow control valves should always be installed on the return side of heat exchangers. This keeps the pressure in the heat exchanger higher, preventing air entrained in the cooling water from coming out of solution and building up in the heat exchanger. BP

For more information please contact Brandon Aitken P.E., Engineering & Fabrication Manager, Blackhawk Equipment Corporation, tel: 303.421.3000, email: BA@blackhawkequipment.com, www.blackhawkequipment.com

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PROFILE: Smardt Oil-Free

By Roderick Smith, Chiller & Cooling Best Practices Magazine

Smardt's 120,000 sq ft facility in Montreal houses the Group's global headquarters as well as the production base for North American and 60 Hz oil-free centrifugal chiller production. Production operations are closely integrated with those at Smardt's Plattsburgh, New York facility two hours away by road.

➤ Chiller & Cooling Best Practices interviewed Smardt Chiller Group CEO, Roger Richmond-Smith.

Good morning! Can you describe your global manufacturing operations?

Good morning. The Smardt Chiller Group has manufacturing operations in North America, Asia Pacific, China and Europe. Our main North American plant and headquarters is in Dorval (Quebec) complemented by our Plattsburgh (New York) plant which serves government and other clients requiring a "Made in the U.S.A." certificate. Asia Pacific manufacturing is done in Melbourne (Australia) and we have launched a manufacturing plant in Guangzhou to serve China. The European market is served out of our plant in Stuttgart (Germany). North America and Asia Pacific make up 80% of our business with the balance coming from Europe and China –which are our fastest-growing geographies.

Smardt COO Vince Canino, Danfoss Turbocor CEO Ricardo Schneider and Smardt CEO Roger Richmond-Smith at Smardt's impromptu milestone event in early 2015. Richmond-Smith is the founder of Smardt and co-founder of Turbocor

I detect an Australian accent. How did Smardt headquarters end up in Quebec?

My ex-partner Ron Conry and I started Turbocor in Australia in 1992, and took this breakthrough technology through five prototype generations before working out that we needed to be based in the largest chiller market in the world – in those days, North America. After finally recruiting the necessary development capital, we brought 20 Australian engineers, their families, dogs, cats and one parrot to Quebec in 2000. Everybody fared wonderfully with Quebec's snow and learning French – except for the parrot who rumor has it didn't take to the new language too well! We launched Turbocor technology in 2003 at AHR Expo in Chicago, then at Mostra Convegno in Milan. Takeoff in this very conservative industry was slow, so after a worldwide search we formed a joint venture with Danfoss in 2004. In 2013 Turbocor became wholly-owned by Danfoss.

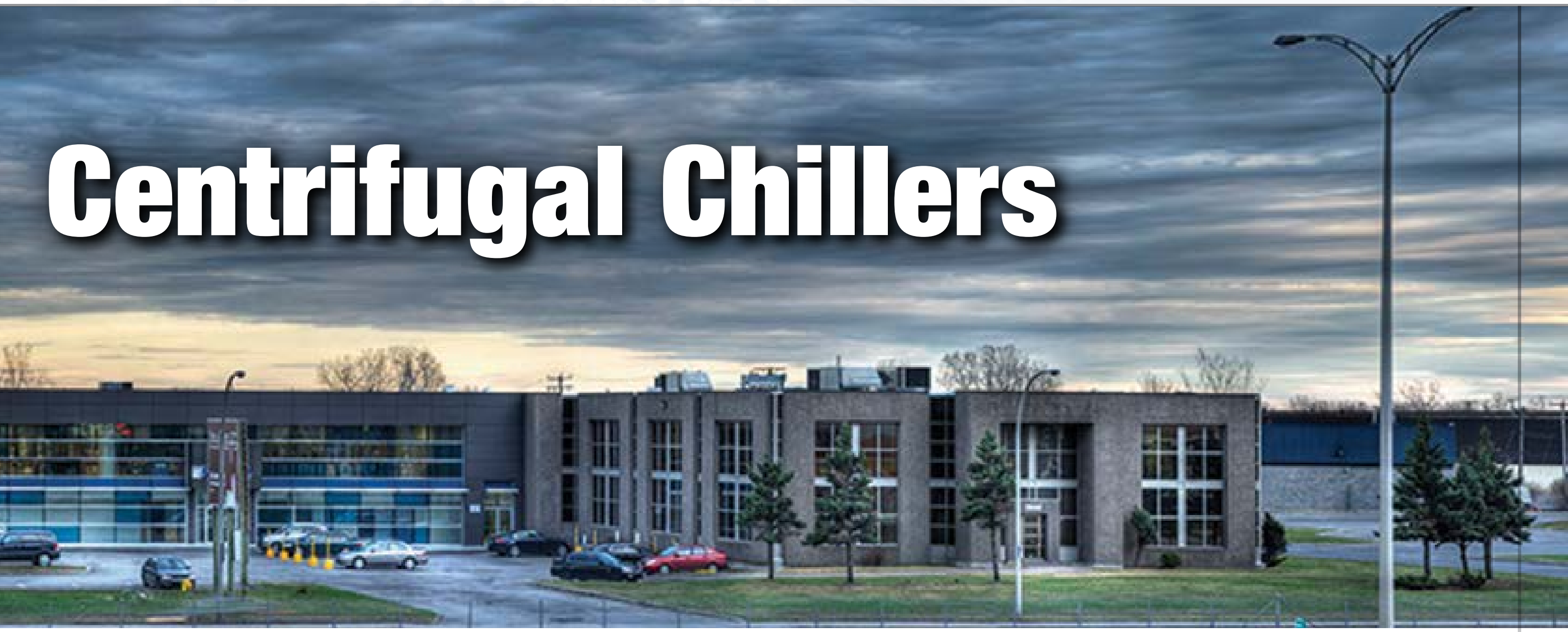
Smardt is all about oil-free centrifugal technology, why?

Yes we are and it's a long story! I was running the Multistack chiller company, in 1992, when we lost a huge Singapore hotel job because we couldn't find a refrigeration compressor, anywhere in the world, able to solve the problem with the miscibility of ester lubricants with what was then the new refrigerant R-134a.

Because of this, my technical partner Ron Conry, began work in 1992 to come up with a solution to simply leave lubricants out of the equation. After three generations of Australian government grants and five generations of prototypes, we ended up with the new Turbocor oil-free centrifugal technology! Revolutionary not only in its part-load energy efficiency but also in the lifetime reliability advantage of needing no oil return.

It's the long installed chiller history since then which gives me and gives Smardt the confidence to say, if you can live without oil, you

Centrifugal Chillers



should, due to the enormous benefits. The benefits include significant improvements in reliability and reductions in maintenance costs. If you can halve maintenance costs over the 25 year life of the chiller those are big savings. Oil-free means no need to check or change oil, no need for crankcase heaters, no purge systems. Some 70% of reliability issues, with refrigeration compressors, are related to oil-return. Maintenance needs and costs with oil-free centrifugal are cut in half compared with a lubricated chiller. If you are an owner and can complement these reliability gains with significant energy savings, then you are laughing.

How are energy-costs reduced by the oil-free high-speed magnetic bearing technology?

Before we start with the magnetic bearings let's finish saying oil-free design also optimizes heat transfer. There is a well-known ASHRAE study (Research Project 751) concluding that typical lubricated chiller circuits show reductions in design heat transfer efficiency of 15-25%, as lubricant accumulates on heat transfer surfaces. No oil equals zero heat transfer blockage.

On now, to your question relative to magnetic bearings. Back in 1992, we looked at gas bearings, air bearings and magnetic bearings. The most difficult challenge with magnetic bearings relate to digital control challenges. We spent a lot of money and time (and made some mistakes) working through that. Due to the tonnages required in HVAC, magnetic bearings work better due to the laws of physics. Once you've sorted out the control issues (five of the nineteen Turbocor patent families are dedicated to controls) and figured out bearings and shaft design, you've got a durable system that works!

Electronics are more complicated than in an orthodox lubricated centrifugal compressor. Our advanced electronics automatically measure and adjust the shaft position 120 times per revolution. At

Early in 2015, Smardt shipped its 10,000th Turbocor compressor in an oil-free centrifugal Smardt chiller, confirming its leadership of the global oil-free centrifugal chiller category. Smardt is Danfoss Turbocor's largest customer worldwide and now has over 5000 chillers installed across the globe. Turbocor was founded in 1993 by Smardt CEO Roger Richmond-Smith and his then-partner Ron Conry. Its acquisition by Danfoss was completed in 2013.

PROFILE: SMARDT OIL-FREE CENTRIFUGAL CHILLERS

Water moving slowly through the external medium lowers the temperature of the incident air on the condenser coil so that these Smardt oil-free centrifugal chiller energy efficiency levels rival those of a water cooled system while entirely removing any risk of legionella. Little wonder that hospital campuses in warmer/drier climates have been major early adopters of this adiabatic range.

Smardt's large water cooled oil-free centrifugal chiller range is crowned by its 2500 TR "Pony Express", where a combination of 350 TR compressors with one 200 TR compressor echoes the orthodox chiller plant room, but actually incorporates the orthodox low-load or "pony" chiller function into the main chiller. The range offers superb redundancy and the very unusual ability to operate safely and efficiently at 2% capacity or 50 TR.

a maximum operating speed of 48,000 rpm, this equals six million adjustments per minute!

Compared to a new screw chiller, Smardt IPLV energy efficiency is routinely more than 35 percent better. Compared with older lubricated reciprocating, screw, scroll or centrifugal chillers, year-round energy savings can exceed 50 percent.

Smardt today is the top global supplier of oil-free centrifugal chillers and in early 2015 we celebrated our 10,000th installed compressor. Each chiller has not only delivered energy-savings, but beginning even with our early prototypes, has been remarkably reliable due to the simplicity of the design. If you have a simple, elegant and robust oil-free design – and you don't have to worry about oil-return, building owners end up with the lowest life cycle cost in the industry.

Are most chiller installations using fixed-speed controls? Is demand growing for variable speed?

Absolutely. People are beginning to understand that the vast majority of industrial and HVAC installations are part-load applications. It's not just due to climatic variations and comfort cooling, it's changes in process demands as well.

AHRI estimates that there's a very large population of over 30,000 installed chillers aged 25+ years old of over 400 tons in North America. These are most certainly not using VSD's and represent a major energy retrofit market opportunity.

When looking at energy retrofits, lighting tends to come first followed by HVAC. Some of our Reps have seen that putting the work into energy retrofits pays dividends. You have to qualify your customer, find the right people, speak the right language and talk about a life-cycle perspective rather than a lowest first cost.

"AHRI estimates that there's a very large population of over 30,000 installed chillers aged 25+ years old of over 400 tons in North America. These are most certainly not using VSD's and represent a major energy retrofit market opportunity."

— Roger Richmond-Smith, CEO, Smardt Chiller Group

There are convergences of interests occurring in the manufacturing plants which nobody is doing anything about. It's encouraging to hear some people have worked out that cooling, compressed air, lighting, combined heat & power are all the same side of the coin. Energy management and energy cost management require a long perspective rather than a quick fix. Vertical Systems, in Los Angeles, is a Rep of ours who is very active in the energy retrofit market.

What are your main market segments in Europe?

In Germany and Northern Europe, where comfort cooling often means opening a window, we are very involved with process cooling. Over half our business in Europe comes from process cooling in the manufacturing environment. These manufacturing segments value oil-free and energy-efficient technology. They include the food and beverage, electronics, chemical, pharmaceutical and automotive segments.

The segments we serve drive our strong presence in Germany. Our German operation was an acquisition in 2011. It has doubled in size since then and moved to our new facility in Wendlingen (near Stuttgart) in 2013. It has two divisions. One division is custom-built systems made for German companies globally.. They need consistent training and support. We work with our German key accounts in countries all over the world.

The second division supplies our standard oil-free centrifugal chillers through distributors all over Europe and the Middle East.

What are your main market segments in North America?

In the U.S., our largest customer segment (and fastest growing) is data centers, whether using evaporative-cooled chiller plants in warm areas to free-cooling installations in northern markets. Anyone speaking on the phone has a direct relationship with a datacenter – whose major challenge is cooling.

The next key segments are healthcare, government, hotels (hospitality industry), institutions (schools, universities and colleges), and office buildings. Energy retrofits are important as are district-cooling solutions for university campuses covering halls of residence, laboratories, stadiums and lecture theaters. They are big energy consumers who value our engineered solutions.

Smardt's air cooled range 60TR to 600 TR can be specified in single large machines or in modular configurations. It can also be specified with a range of different low-GWP refrigerants; with free cooling; or even with a solar boosting, enabling a fast-payback hybrid-powered chiller whose value does not depend on utility incentives.

Healthcare is pretty important as well. Current hospital engineers certainly understand the need to manage partial loads and the benefits of oil-free technology. But they are often faced with older equipment installed years ago when the system design tendency was to oversize chillers by 20 percent -condemning them to run inefficiently throughout their working lives..

The healthcare sector prizes flexibility. Flexibility means the ability to re-configure chiller plants within the 25 year life of a water-cooled chiller – due to changing situations at the healthcare campus. They deal with not only operating rooms, specialist suites and neo-natal care units, but they have a large range of conditions they want to have design flexibility on.

The Smardt split design and our modular range are all about flexibility in solving difficulties of access. There are installations where it's impossible to get a 2500 double-barrel machine into a passenger lift and then down 8 stories. Modular chillers do cost more but the very large savings on access can often justify them.

Thank you for your insights and your time. BP

For more information contact the Smardt Chiller Group, tel: 514.426.8989, email: sales@smardt.com, www.smardt.com

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Online Automatic Tube Cleaning System Creates HVAC SYSTEM ENERGY SAVINGS

Dr. Davide Ross[1] and Dr. Adina Cirtog[1], Pangolin Associates

We are certain it comes as no surprise to the readership of this journal that a third of the total energy end use for commercial buildings in the U.S. is consumed by HVAC (DOE 2008). Chillers are usually the single largest individual user of electricity in commercial and institutional HVAC facilities. Maintenance and engineering managers have three primary options to improving chiller performance: replacement, control strategies and maintenance. As chillers are required to reject heat to complete the vapor-compression cycle, a condenser heat exchanger is used which allows heat to migrate from the refrigerant gas to either water or air. Heat transfer has the greatest single effect on chiller performance.

Large chillers can have more than five miles of condenser and evaporator tubes, therefore high heat transfer is fundamental to maintaining efficiency (Piper, 2006). Water-cooled chillers incorporate the use of cooling towers, which improve the chillers' thermodynamic effectiveness as compared to air-cooled chillers. One of the most common types of water-cooled refrigerant condensers is the shell-and-tube, where the chiller refrigerant condenses outside the tubes and the cooling water circulates through the tubes in a single or multi-pass circuit. An almost unavoidable consequence of using water is that fouling of the heat exchanger surface may result from sediment, biological growth, or corrosive products. Scale can also result from the deposition of minerals from the cooling water on the warmer surface of the condenser tube. As stipulated in the Guide to Best Practice Maintenance & Operation of HVAC Systems for Energy Efficiency, "It is estimated that a build-up of a 0.6 mm thick layer of fouling on the condenser water tubes will reduce chiller efficiency by 20%. For larger chillers, the installation of automatic tube cleaning systems may be cost effective". The formation of process-related deposits on heat transfer

> "Maintenance and engineering managers have three primary options to improving chiller performance: replacement, control strategies and maintenance."
>
> — Dr. Davide Ross and Dr. Adina Cirtog, Pangolin Associates

surfaces bears an estimated economic price tag of about 0.25% of the GDP of industrialized countries.

What may come as a surprise to readers of this journal is the impacts of fouling on heat transfer surfaces is generally already considered in the design of heat exchangers by using a so-called "fouling factor" in the calculation of the overall heat transfer coefficient, U. Fouling will reduce the overall heat transfer coefficient and thus leads to the reduction of the heat duty of an existing heat exchanger or to additional surface area requirements in the design of new heat exchangers. The prevalence of fouling in heat exchangers has been clearly demonstrated by several surveys that have reported that more than 90% of industrial heat exchangers suffer from fouling problems (Muller-Steinhagen, 2011; Steinhagen et al., 1992; Garrett-Price et al.,1985). Figure 1 clearly shows the consequence of fouling in a water cooled condenser tube array operating at a hotel in Adelaide, South Australia.

When a water-cooled condenser is selected, anticipated operating conditions, including water and refrigerant temperatures, have usually been determined. Standard practice allows for a fouling factor in the selection procedure. The major uncertainty is which fouling factor to choose for a given application or water condition to obtain expected performance from the condenser. As fouling is a major unresolved problem, it is normal practice to oversize the heat transfer surface area to account for fouling. Design engineers frequently over compensate by arbitrarily increasing the fouling resistance or by multiplying the calculated overall heat transfer coefficients with a "safety factor" (Muller-Steinhagen, 2011). This has been exemplified in practice whereby over specifying fouling resistances has increased the heat transfer surface above clean conditions in the range of 20–300%! (Garrett-Price et al.,1985). This was confirmed by a major Heat Transfer Research, Inc. (HTRI) study into the fouling-related excess area of 2000 recently designed heat exchangers (Muller-Steinhagen, 2011). In layman terms, your chiller's condenser heat exchanger is very likely to be way over sized by the chiller OEM.

Figure 1: Severe fouling of water cooled condenser tubes.

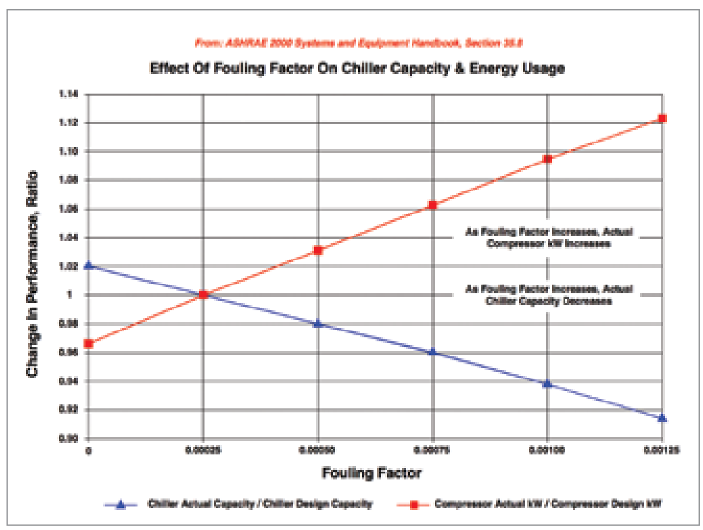

Figure 2: Effect of Fouling on chiller Capacity and Energy Usage (ASHRAE, 2000)

As fouling builds up in a condenser, the condensing temperature and subsequent power consumption increases while the unit cooling capacity decreases. This effect can be seen in Figure 2. At some point in the operating cycle, the increased cost of power will be offset by the cost of cleaning. A number of general techniques exist for fouling mitigation of heat exchangers. Chemical inhibitors are commonly introduced to the water loop to reduce and/or mitigate the deposition rates of selected fouling problems. While chemical cleaning is effective, as water is bled from the cooling tower and or evaporated from the cooling tower, there is continual requirement to top up the chemical dosage as fresh water is introduced into the system.

Use of chemicals adds to the plant operating costs, and their application may be restricted by environmental legislation or by product specifications (Muller-Steinhagen et al., 2011). As alternative to chemical inhibitors, mechanical treatment of the heat exchange surface may be undertaken. The most common mechanical method is the use of projectiles that are propelled through the heat exchanger

ONLINE AUTOMATIC TUBE CLEANING SYSTEM CREATES HVAC SYSTEM ENERGY SAVINGS

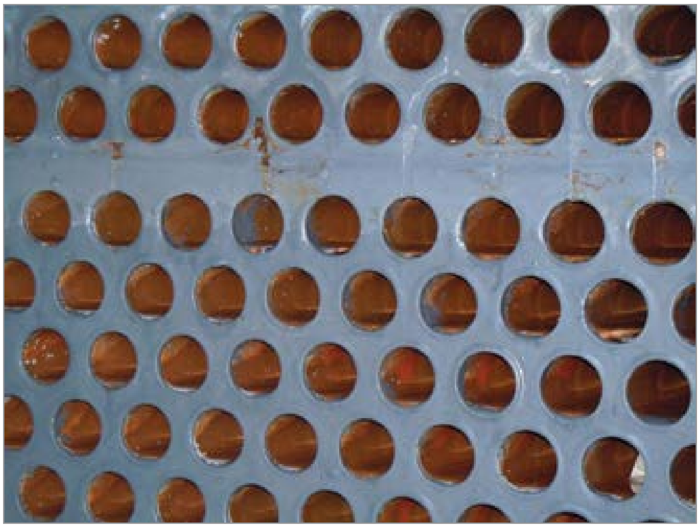

Figure 3: ATCS at work, tubes free of fouling.

Figure 4: A view of the condenser shell end

tubes to remove deposits. Commonly referred to as an automatic tube cleaning system (ATCS), this mechanical method of cleaning heat exchanger tubes occurs while the equipment remains in operation and in full production. There are two types of ATCS: the brush and basket type and the more common recirculating sponge ball type. Recirculating sponge balls consists of slightly oversized elastomer balls that are periodically or continuously injected upstream into the condenser cooling water inlet. The balls are passed through the tubes by the water flow. A strainer or ball collector is installed at the water piping exiting the condenser. The outcome of using ATCS on tube condition can be seen in Figure 3. This chiller had been in service with the ATCS at a major Sydney hospital for three years. A striking contrast to Figure 1. Clearly these tubes do not require any additional manual cleaning.

Further evidence of the cleaning performance of the sponge ball ATCS is highlighted in Figure 4. As part of the annual AS/NZS-3788 pressure equipment inspection, the hospital chillers are opened for an internal inspection to occur by an independent examiner. Aside from preventative maintenance tasks, preparation for inspection had involved the internals and tubes to be cleaned by brushing and flushing with water to remove any deposits in order that the surfaces of the vessel are presented in an inspectable condition. Since the installation of ATCS, the improvement to the condition of the tubes has been commented on by both the maintenance technicians and the pressure vessel inspector to a standard where the tubes clearly did not require additional manual cleaning for the inspection to occur. [Hely, 2014].

The photograph in Figure 4, supplied by the hospital's mechanical maintenance supervisor, shows the opposite shell-end of the double pass condenser to the injection side. It shows the appearance of staining due to calcium deposits from the condenser water system [Hely, 2014]. There is a clear zone free from staining in the central region across the shell-end where the sponge balls are impacting the plate. One can note the 'mottled' appearance from the impaction of the balls removing the calcium deposits. It can be seen from the impact distribution profile, the balls are focusing in a central band across the full face of the shell end. This demonstrates the balls are travelling radially across the whole diameter of the tube bank.

Before discussing the results, a quick overview for those not familiar with ATCS. The featured case studies in this discussion have the common components that constitute an installation of this type; injector, strainer and recycle pipe work which connects the strainer to the injector to return the sponge balls. An actual installation of the sponge ball ATCS for Case 1 is shown in Figure 5. In the foreground the injector can be seen. In the background is the strainer with connecting pipework coming to the foreground.

The standard operating procedure for the injector is to hold the equivalent number of sponge balls equal to a third of the number of tubes in a single pass. Sponge balls are released from the injector on set intervals of every 30 minutes. The sponge balls ought to be replaced every 1000 hours of chiller run time. In practice, this may not occur if the site has poor maintenance scheduling and will impact the results as shown in Case 3. Table 2 summarizes key aspects for each Case number. Sponge balls are generally 1mm larger in diameter than the I.D. of the condenser tube.

The dominant independent variable on cooling load is the outside weather. Weather has many dimensions, but for whole-facility analysis, the outside air temperature is sufficient. The standard practice of using a referenced base temperature cooling degree day (CDD) was used in the present study. Cooling degree days are based on the average daily

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Chiller & Cooling Best Practices is a technical magazine dedicated to discovering Energy and Water Savings in industrial chiller and cooling systems. Our editorial focus is on case studies and technical articles where application and system knowledge drives technology selection, creating energy savings in projects delivering excellent ROI's.

Energy Management – The Next Era for Lean

Our core audience is comprised of those engineering pioneers implementing energy management in their multi-factory organizations or municipalities. Practitioners of Lean Management and Kaizen Events, our readers have embraced energy management practices as the next step in their lean journey. Our key subscriber and editorial sources come from the U.S. Environmental Protection Agency's ENERGY STAR for Industry Program and members of the Association of Energy Engineers.

"Corning launched a formal Global Energy Management program in 2006. U.S. operations consist of nearly 50 facilities. These management practices have saved more than $328 million in cumulative energy costs."

– Patrick Jackson, Director of Global Energy Management, Corning Inc.

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Figure 5: The sponge ball ATCS installed in Case 1

temperature. The average daily temperature is calculated as follows: [maximum daily temperature + minimum daily temperature] / 2. As HVAC load is seasonal, one full cycle is required for analysis thus, a minimum of 12 months.

Degree days are a simplified form of historical weather data - outside air temperature data relative to a base temperature, and provide a measure of how much, and for how long, the outside temperature was above that base temperature. In degree-day theory, the base temperature is effectively the *"balance point"* of a building when the outside temperature is below which the building does not require cooling. Naturally different buildings will have different base temperatures depending on its thermal performance. For this analysis, a reference base temperature of 18°C was used. Climate data was referenced from the BOM, Sydney Observatory Hill, weather station ID 94768 (151.21E,33.86S). A simple linear model was used to correlate energy consumption without any adjustments, to a single independent variable, CDD. Daily CDD data is summed into monthly totals. Energy consumption is then computed such that the best fit linear regression equations fitted to the baseline and post ATCS installation data are multiplied by the 10 year average degree-day value for the corresponding month.

The difference between the adjusted baseline and the post ATCS normalized consumption totals is the normalized energy saving based

	Case 1	Case 2	Case 3	Case 4
No. floors	24	32	20	25
Building type	Category A office building	Category A office building	Category A office building	Category A office building
NABERS energy rating	3.5	4.5	4.5	3.5
Net Lettable Area	-	39,398	26,271	-
No. Chillers installed with ATCS	2	2	3	2
Chiller Make/	Trane	Carrier/Trane	Trane	Powerpax
Condenser Type	Double pass	Double/single pass	Double pass	Double pass -split system
Tube I.D. (mm)	15	22; 15	2x 22; 1x 15	16
ATCS unit size	2 x 6"	10"/6"	2 x 10" / 1 x 6"	1x 12"
Date of installation	04/2010 & 10/2010	12/2008	06/2010	08/2013

Table 2. A summary of the ATCS Case studies 1 to 4

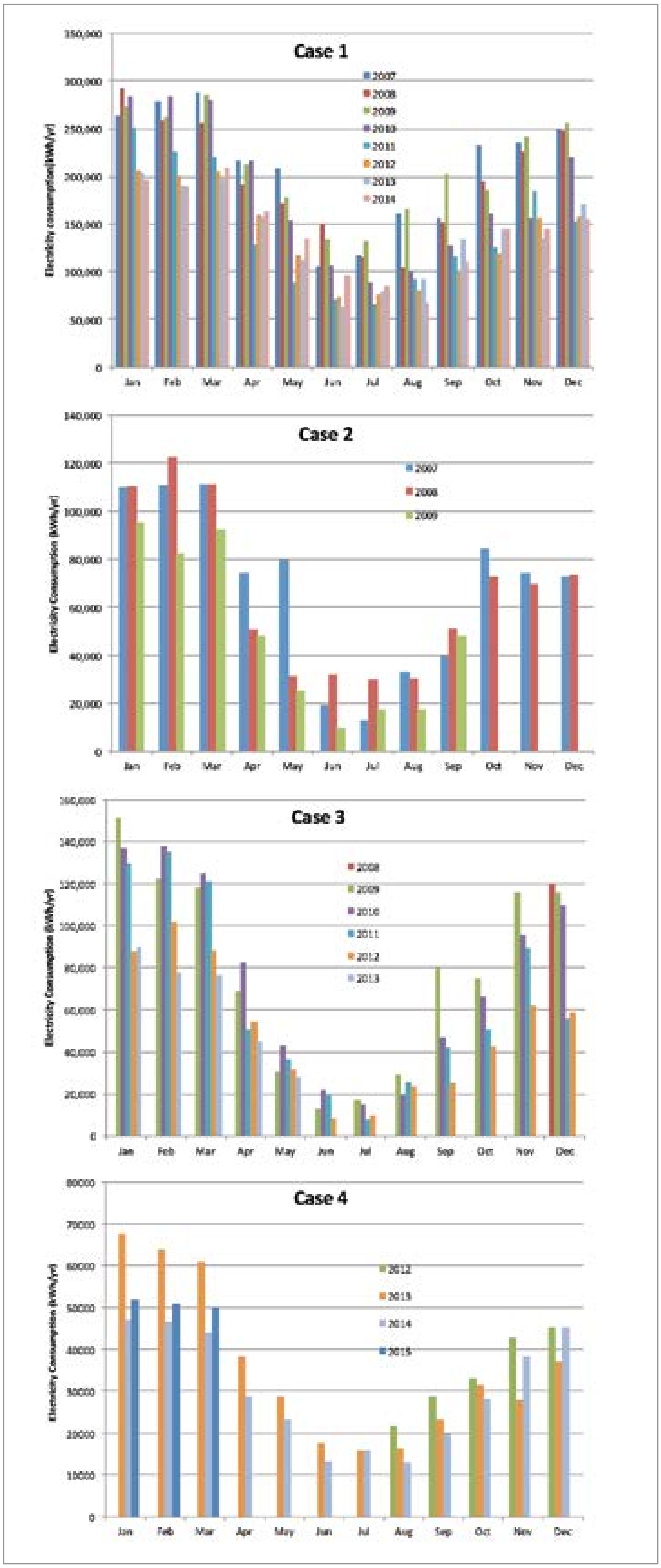

Figure 7: Yearly electricity consumption profiles for Cases 1 to 4

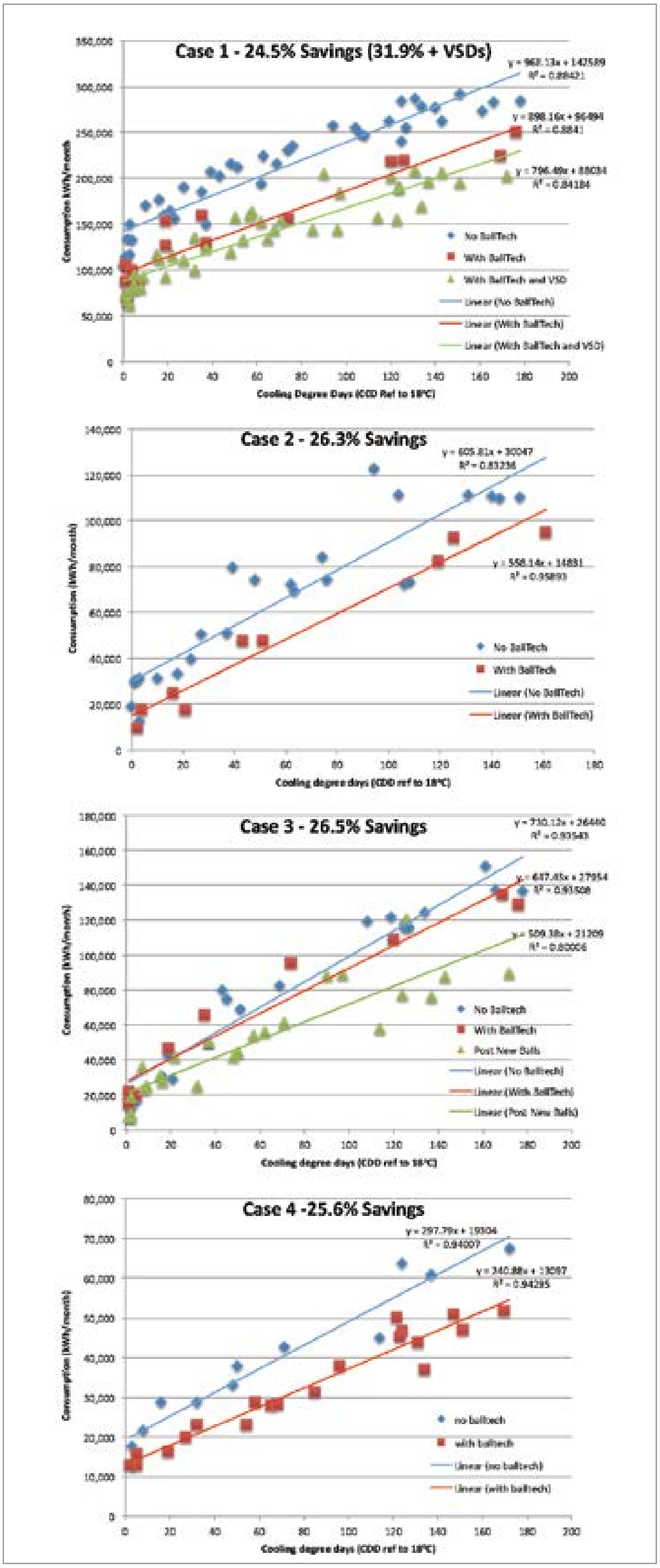

Figure 8: Monthly consumption versus CDD for Cases 1 to 4

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on the 10 year average degree-day. Figure 6 summaries the year to year monthly electricity consumption data for the four buildings. A comparison of the energy consumption versus CDD for all four commercial office buildings is displayed in Figure 7. In all cases there was an observed reduction in net energy consumption following installation of the ATCS. The normalized energy savings resulted in a decrease ranging between 24.5% to 26.5%. These results compare favorably with theoretical and experimental results reported by Lee and Karng (2002) for a similar sponge ball ATCS. The authors determined a predicted theoretical maximum energy saving for the ATCS of 28%, with an average energy saving of 24%. Their field data measured a saving of 26% for the year.

Results for Case 1 were also uniquely affected by additional energy conservation measures post the ATCS installation. This initiative saw the installation of VSDs to the numerous pump motors in the plant room, including the condenser water pump. In order to segregate the impact of the introduction of the various energy conservation measures, the post ATCS data was further separated to pre and post VSD installation.

The results for Case 3 were impacted by several events. The energy savings anticipated for the summer months of December 2010 to February 2011 were below expectations. Following a basic investigation, it was identified that the ATCS was not serviced as required since commissioning in June 2010 by the mechanical service contractor. The major factor being the non-replacement of the sponge balls at the maximum of every 1000 hours of chiller operation. At the very most, a fifteen-minute task. New sets of balls were inserted into the system on March 2011. In May 2011, the Investa Property group acquired the site from ING property, which affected the service regime due to a change in the site mechanical contractor. A new service regime was established in September 2011 and maintained since then on a regular basis.

For Case 4, monthly kVA demand data was supplied and analyzed for savings. The maximum monthly demand has been plotted against CDD in Figure 8. On average, the demand has been decreased by 55kVA. Placing this into context, each Powerpac WA096.2H.22N twin compressor chiller has a nominal cooling capacity of 960kW with a full load COP of 5.5. This equates to an approximate full load

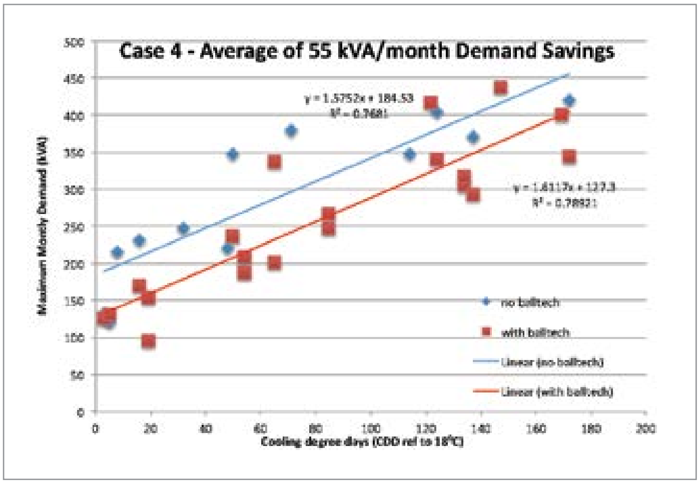

Figure 9: Maximum monthly demand versus CDD

electrical draw of 175kWe or 218kVA (assuming an average power factor of 0.8). It is noted that variations are higher with demand and reflected in the lower regression coefficients (below 0.8) when compared to energy consumption. This confirms natural expectations where maximum demand (kVA) and overall energy consumption do not have to correspond. The resulting financial savings from an ATCS will depend on the regional demand price structure. For some locations this may be the maximum demand recorded over the previous 12-month period. The rational being the network must have spare capacity to meet this demand as it could happen anytime thereafter once achieved. Under this pricing regime, from Figure 8 no kVA demand benefit would accrue with the ATCS.

However, elsewhere network operators that charge based on the highest demand calculated coincident over a 30-minute clocked interval during the billing period. Under this pricing structure, on average, an ATCS would save the customer additional money.

By keeping your condenser tubes clean, it's no wonder why such large efficiency gains will be extracted; improved heat transfer in combination with full utilization of the available surface area likely to be inherited from the original over-specified design. Hopefully this paper sheds some light that there is no mystifying logic to how and why such significant savings can be made with ATCS when added to your chiller's condenser. BP

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"The prevalence of fouling in heat exchangers has been clearly demonstrated by several surveys that have reported that more than 90% of industrial heat exchangers suffer from fouling problems."

— Dr. Davide Ross and Dr. Adina Cirtog, Pangolin Associates

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