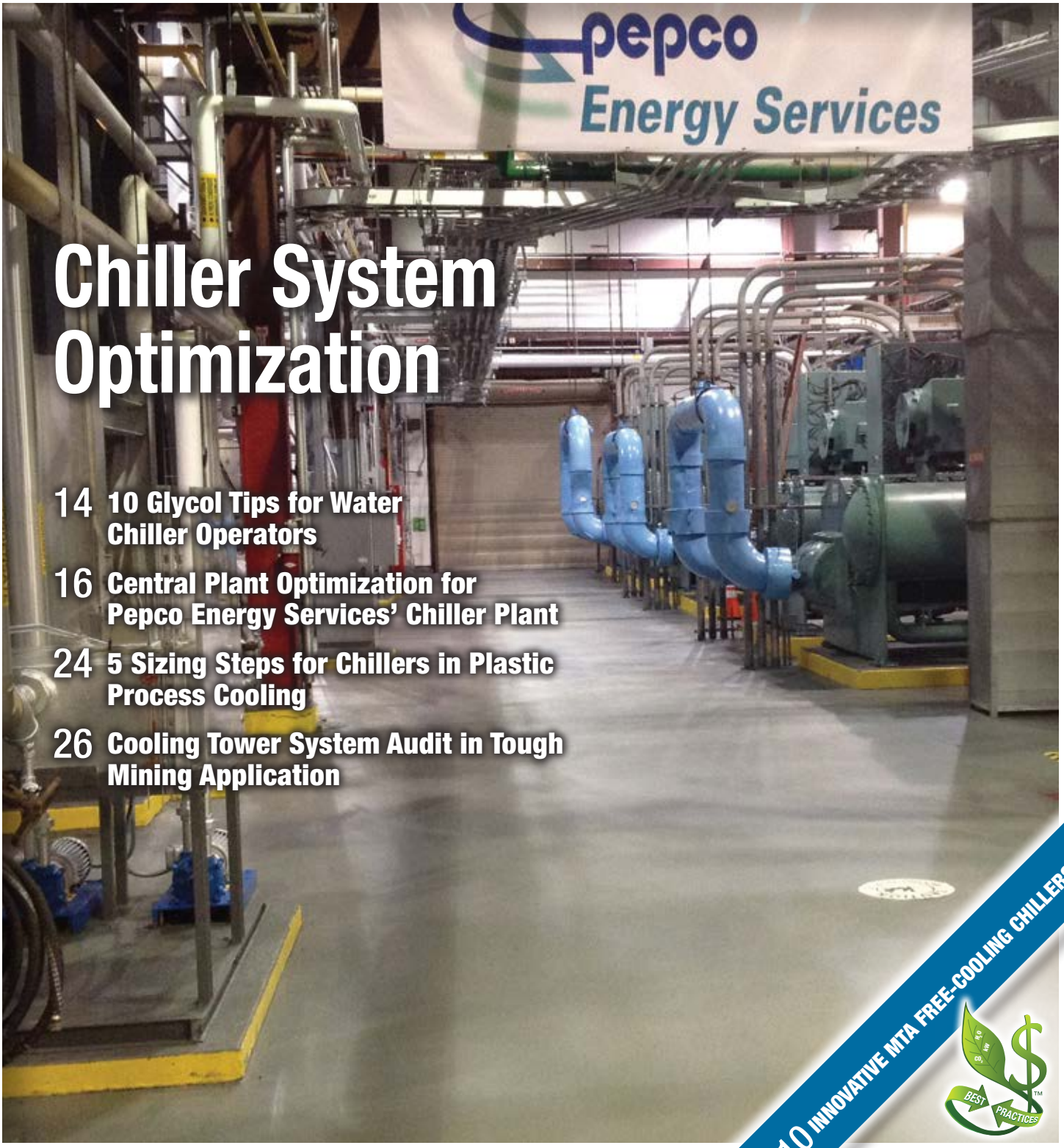
The Magazine for ENERGY EFFICIENCY and WATER CONSERVATION in Industrial Cooling Systems

CHILLER & COOLING BEST PRACTICES

coolingbestpractices.com

March 2015



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FROM THE EDITOR | Chiller System Optimization

Over the years, we've interviewed many Energy Managers at multi-factory corporations. After discussing energy management and compressed air best practices, these subscribers have often asked if we could provide similar system assessment and optimization case studies relating to their chiller and cooling systems. Their machines have both compressed air and cooled water/fluid connections! We hope to have answered their question positively with our new *Chiller & Cooling Best Practices Supplement.*

MTA's John Medeiros and Don Joyce have built a strong chiller business in the U.S. and interestingly have trained many "air compressor people" to "turn off the blinders" and look for chiller applications with their clients. Don has written an excellent article on the energy-efficiency benefits of free-cooling and featured installations carried out by Bob Copell of Scales Industrial Technologies.

Glycol prevents freeze-ups and protects heat exchangers from losing heat transfer efficiencies due to the build-up of minerals or algae on their surface areas. Katlyn Terburg, from Dimplex Thermal Solutions, provides us with advice in an article titled, "10 Glycol Tips for Water Chiller Operators."

We have two excellent system assessment case studies on chiller system optimization. The first is titled, "Central Plant Optimization for Pepco Energy Services' Chiller Plant," by Tus Sasser, President of The Tustin Group. The second is titled, "Cooling Tower System Audit for a Tough Mining Compressed Air Application," by Tim Dugan, President of Compression Engineering Corp.

A case study on water filtration is provided by Marcus Allhands, from Orival, in his article, "Tobacco Producer Protects Chillers with Self-Cleaning Filtration System." Bob Casto, from Cold Shot Chillers, provides handy chiller sizing information in his article, "5 Sizing Steps for Chillers in Plastic Process Cooling."

Last but not least, Thomas Mort from Mission Point Energy (Thomas is on our Editorial Board and formerly Archer Daniels Energy Director and Association of Energy Engineers' Energy Manager of the Year) writes, "Using 4 Waste Heat Sources for HVAC Optimization."

I'd like to welcome and thank many new readers from the chiller industry for investing their time and knowledge with us. Our editorial mission is to help create high-ROI projects for factories, based upon energy and water consumption savings, by increasing awareness. This can only happen through the sharing of expertise from within the chiller industry. As we begin this journey, thank you for investing your time and knowledge with *Chiller & Cooling Best Practices* – and please look for our second *Supplement* coming in July!

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CHILLER & COOLING SYSTEM INDUSTRY NEWS

MTA Introduces New LWT Series Low-Temperature Water Chillers

MTA-USA, LLC. has developed a special range of air-cooled chillers designed for industrial applications to provide fluid temperatures down to -4 °F. The entire LWT range is equipped with a high-efficiency, single-pass counter-current flow, shell & tube evaporator and a new high-efficiency, semi-hermetic piston compressor featuring the integrated diagnostic technology module. In support of an environmentally friendly refrigerant, the LWT range utilizes the more sustainable refrigerant R-407F instead of R-404A.

The LWT Series features a new semi-hermetic piston compressor, featuring the CoreSense™ integrated diagnostic module and unique valve technology for higher energy efficiency. Piston compressor features include standard suction and discharge valves, crankcase heater, oil pressure sensor, muffler, vibration damper, and enclosure for adequate acoustic insulation.

Comprehensive safety equipment includes phase monitor, HP pressure switches, antifreeze sensors, and an active control system of the compressor oil level. Further features include an electronic expansion valve for refrigeration circuit control and a EC inverter controlled axial fans with permanent magnets and integrated inverter speed control.

This water-chiller is designed for the following extended operating limits: T water in max = 25 °F, T water out min = -4 °F with glycol, T ambient max = +113 °F; T ambient min = -4 °F. In addition, the IP54 electrical protection rating makes LWT chillers suitable for outdoor installation.

Visit www.mta-usa.com

"In support of an environmentally friendly refrigerant, the LWT range utilizes the more sustainable refrigerant R-407F instead of R-404A."

CHILLER & COOLING SYSTEM INDUSTRY NEWS

Mokon Earns ISO 9001:2008 Certification

Mokon, a leader in the design and manufacture of advanced heating and cooling equipment for industrial markets, has been awarded ISO 9001:2008 certification for its Quality Management System. Mokon earned this key accreditation by demonstrating its total commitment to providing both the highest quality products and outstanding customer service.

"We are proud and excited about our ISO 9001:2008 certification, which we feel is an essential tool when working with customers in global markets," Robert Kennery, general manager of Mokon, says. "We are continually seeking ways to ensure our customers receive the highest quality and safest products in the industry".

According to the International Organization for Standardization (ISO), the ISO 9001:2008 certificate is "based on a number of quality management principles, including a strong customer focus, the motivation and implication of top management, the process approach and continual improvement." Over one million companies and organizations in over 170 countries have earned ISO 9001:2008 certification.

Mokon received its Certificate of Registration from NSF International Strategic Registrations, an accredited registrar that performs assessments of management systems against the requirements of national and international standards for quality. The scope of Mokon's registration is associated to all aspects of its processes relating to the design, development, manufacturing and service of standard and custom systems.

For 60 years, Mokon has designed and manufactured its circulating liquid heating and chilling equipment in the United States. Mokon consistently demonstrates its ability to foresee the evolving needs of customers in industries such as plastics, die casting, food processing, pharmaceutical, composites, chemical processing, rubber, converting and more. One of Mokon's primary goals is to continually improve the design, quality, delivery and durability of its products and reach a high level of customer satisfaction.

Visit www.mokon.com

Chillers at FABTECH 2014

The depth and breadth of manufacturing's reach into the U.S. and global economies was on display at the recent FABTECH 2014 exposition and conference in Atlanta. FABTECH, held November 11-13, 2014 at the Georgia World Congress Center, is the largest annual metal forming, fabricating, welding and finishing event in North America. Visit www.fabtechexpo.com for information on the November 2015 event in Chicago.

More than 30,800 attendees from over 70 countries attended FABTECH 2014. During the three-day expo, attendees visited 1,477 exhibitors to see live equipment demonstrations and find cost-saving solutions. The exhibits covered more than 550,000 net square feet.

The chiller industry is very well represented at the show. Chillers play a critical role in the robotic resistance welding and the metal-cutting processes of the metal fabrication industry.

Haisar Shehadeh and Whitney Mayo at the Semyx booth. The hydraulic systems on their water jet cutting machines are cooled by chillers.

I enjoyed meeting Haisar Shehadeh and Whitney Mayo from Semyx. Semyx is a global company specializing in water jet cutting machines. Based in Dalton, Georgia, Semyx water jet machines provide precise cutting of steel and other metals. A system component is the "Intensifier" which increases water pressures to between 60,000 and 90,000 psi. Stay out of the way! Semyx uses chillers to cool the hydraulic systems (www.semyx.com).

T.J. Snow is a manufacturer of resistance welding equipment and accessories. Based in Chattanooga, they pride themselves on training and offer their clients and employees significant training resources. Their welding system knowledge has also led them to help their clients better manage their utilities — so they also offer compressed air dryers and chillers. This is a great example of why our publication is expanding to cover chillers.

Chillers provide temperature control to the spot welding process. If things get too cool, weld quality can be impacted. Too hot and the life of the electrode tips is impacted. Meanwhile, pneumatic air cylinders provide force for the rocker arm. The T.J. Snow Company often places air storage and refrigerated air dryers to ensure reliable performance.

Aside from the fact he's a pilot (as are half his management team) who flies himself to business meetings, Thomas J. Snow is one of those business founders who has forgotten more than I'll ever know about his expertise (welding) — yet he never makes one feel that way. The success of their premium welding equipment systems have the company on an amazing growth path and they are a heck of a feel-good "Made in the U.S.A." story (www.tjsnow.com).

The Parker FAF Division had a booth where they displayed the Hyperchill Series chiller able to support the innovations the Parker Automation people provide the resistance welding market. The RIP Robot Install Partner designed for resistance welding machines features a WRA water return actuator and a double-air cylinder that creates a vacuum to pull water off a piece. The WBB water block reduces water consumption and the air preparation units ensure air quality (www.parker.com/faf).

Cold Shot Chillers had a nice booth featuring their chiller line ranging from ½ to 150 ton chillers. Mark Johnson and Bob Casto spoke knowledgeably about their target markets in plastic processing, metalworking high temperature applications, bakeries, and other food and beverage applications. Please take a look at their interesting article in this issue on chiller sizing for plastic processing applications (www.waterchillers.com).

Johnson Thermal Solutions caught my eye as Sales Director Denise Klaren explained their focus is on mission-critical design of custom chillers. Based in Coldwell, Idaho, they were founded ten years ago by a group of chiller industry veterans. They provide chillers for medical MRI and CT Scanner equipment, to the dairy industry, and for critical HVAC applications such as data centers. They've built chillers ranging from three to thousands of tons of cooling capacity. At the show they were

Thomas J. Snow and Mark Pepping (left to right) at the T.J. Snow booth with their new Rocker-Arm spot welding machine rated to consume five gallons per minute of chilled water.

MTA exhibited their chiller technologies. Pictured left to right are MTA executives; Angelo Mastrangelo, John Medeiros, Bob Copell (Scales Industrial Technologies), Don Joyce, Lewis Rains, and Andy Poplin (Atlas Machine & Supply).

CHILLER & COOLING SYSTEM INDUSTRY NEWS

Parker displayed the Hyperchill chiller along with their Robot Install Partner program for resistance welding equipment. Pictured (left to right) are: Phil Kubik, Dale Zimmerman, John Schuster, Tim Ritter and Allan Hoerner.

Denise Klaren from Johnson Thermal Solutions with their new ET Series chiller.

showcasing their new 3 to 30 ton ET Series engineered for high flow pumps used in welding (www.johnsonthermal.com).

MTA is on quite a roll with their chiller business. John Medeiros and Don Joyce are finding success supplying their TAE Series chillers to welding applications and with air compressor distributors learning to apply chillers. As Bob Copell from Scales Industrial Technologies said, "We used to have blinders on and went straight to the compressed air system. Now, we are also assisting our clients with their cooling, blower and vacuum systems." Andy Poplin from Atlas Machine was also working the MTA booth and learning about the welding and metal fabrication applications. Please take a look at Don Joyce's article on free-cooling in this issue (www.mta-usa.com).

Mark Johnson and Bob Casto from Cold Shot Coolers.

SMC was also present with their HRS Series thermo chillers kept in inventory at their headquarters in Indianapolis. According to Product Manager Scott Maurer, chillers are one of many products they offer clients to support arc welding processes. Other products include spatter-resistant pneumatic cylinders, flow meters for air and gas, and digital flow meters to control water flow at the weld tips (www.smcusa.com).

Frigel Displays Innovative 3PR Controller for Process Cooling at NPE 2015

Visitors to the Frigel booth W7991 at NPE 2015 will get a close look at the world's most efficient and sustainable plastics process cooling system — now more adaptable to meet plastics processors' specific needs.

Among the latest Frigel innovations on display will be the new 3PR Intelligent Control System, which provides processors with even easier and more precise control over their Frigel cooling systems. Featuring a unique 7", full-color touch screen interface, 3PR allows processors to achieve better closed-loop process cooling system accuracy with more data points at their fingertips.

As a next-generation controller, 3PR automatically adjusts the integrated Frigel cooling system to ensure optimum performance based on a wide range of system operating parameters. The controller provides users with extended functionality for monitoring and adjusting system

parameters using real-time data to further enhance system performance. Troubleshooting features, combined with remote access capability, help operators quickly resolve issues and minimize downtime associated with routine maintenance. The controllers' onboard memory further aids in troubleshooting and uptime by continuously storing key operating conditions, which can be downloaded for detailed analyses.

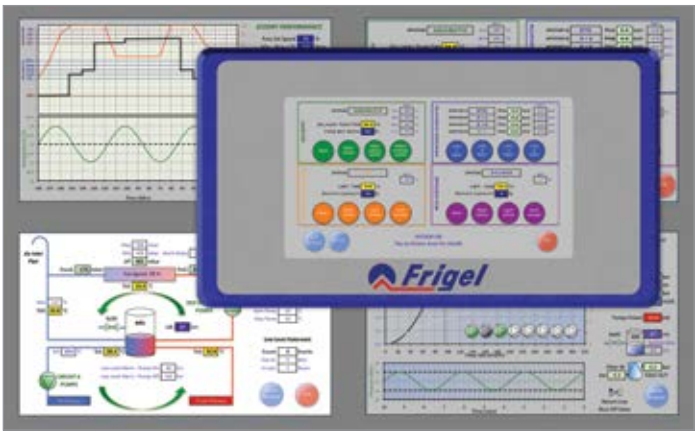
"The new 3PR Intelligent Control System allows processors to gain more control of the process cooling system with an intuitive HMI that relays information in the language specific to the user, versus software codes," said Al Fosco, Global Marketing Manager at Frigel. "The controller is also easy to use and it allows for more efficient tracking of real time data to ensure optimal system performance.

Visitors to the booth will be able to experience 3PR's intuitive controls first hand via an interactive touch-screen app.

Other Frigel innovations on exhibit include:

- **Ecodry 3DK Closed Loop Adiabatic Liquid Cooler:** The next generation of Frigel's patented adiabatic system is easily adaptable to any climate, system or process. The system gives processors the ability to increase water and energy savings, improve cooling precision, reduce maintenance and save space.
- **Microgel Chiller/TCUs:** Frigel's compact, portable units are available as single- or dual-zone models with water- or air-cooled options, which allow users to maintain precise, microprocessor-controlled temperature at molding machines. When compared to central chillers, Frigel Microgel units save 60 percent of energy costs and also conserve space.

Frigel's exhibit will also showcase the VFD Pump Set, HB-Therm Temperature Control Unit and the Turbogel Temperature Control Unit.



Shown is a selection of data screens available on the new 3PR Intelligent Process Control System from Frigel. The intuitive display provides processors with even easier and more precise control over their Frigel cooling systems.

Digital presentations will be available on all of these products, also including Frigel's complete line of central chilling systems.

For more information on what to expect from Frigel at NPE, visit www.frigel.com/npe.

About Frigel

Based in Florence, Italy, Frigel Firenze SpA designs, manufactures and services advanced process cooling equipment for customers worldwide. Foremost among Frigel's products is the Ecodry system, a unique, closed-loop intelligent cooling system, which is proven to dramatically reduce water and energy use and maximize production in thousands of installations. Frigel also provides high-efficiency central chiller units as well as a full range of precise machine-side temperature-control units to meet specific needs of diverse applications. Visit www.frigel.com for more information.

"Chillers play a critical role in the robotic resistance welding and the metal-cutting processes of the metal fabrication industry."

Innovative MTA Free-Cooling Chiller Systems

By Don Joyce, MTA-USA Inc.

Process cooling system applications experiencing constant production loads generating high process fluid temperatures are particularly good candidates to take advantage of low ambient temperatures. Low ambient temperatures can be used as a "free" energy source, replacing the electricity required to run refrigeration compressors, in what is known as a free-cooling chiller system.

Free-cooling systems are not new although differences in design efficiencies exist. Partial-mode, free-cooling, which is fully automated and integrated into the chiller system is an innovation.

Traditional free-cooling systems are "all or nothing" systems where the process fluid is either cooled by low temperature ambient air or by the refrigeration compressors. An innovation in free-cooling has been developed with the introduction of partial-mode free-cooling, allowing for a significantly broader range of application temperatures and significantly increased energy savings.

Total Free-Cooling Only

A total free-cooling system, normally used only during very cold winter months, takes advantage of low ambient temperatures to cool the fluid (water) in the circuit in what's known as a dry cooling system (ambient air to water heat exchanger). The evaporator (refrigeration to water heat exchanger) is bypassed and the refrigeration compressors in the chiller are OFF and energy is saved.

The process cooling system will automatically switch to the total free-cooling mode, when ambient temperatures are in a range up to 18 °F lower than the required fluid outlet temperature. Under these conditions, all the refrigeration compressors, in the condensing section of the chiller, will be switched OFF. Under even lower ambient temperatures, the

The MTA Aries Free-cooling Chiller Systems

> "Low ambient temperatures can be used as a "free" energy source, replacing the electricity required to run refrigeration compressors, in what is known as a free-cooling chiller system."
>
> — Don Joyce, MTA-USA Inc.

electronic controller reduces step-by-step the rotation speed of the fans of the free-cooling section, all the way to shutting the fans down under extremely low temperatures.

In case the ambient temperature falls to extremely low levels, the 3-way valve modulates and will by-pass part of the flow by mixing it with the outlet fluid from the coil, always maintaining the perfect control of the fluid outlet temperature.

Traditional free-cooling process cooling systems will stack heat exchangers (the evaporator and the ambient air-to-water heat exchanger) with both connected to one set of oversized fans able to provide free-cooling and support the condenser.

Fig.1 Free-cooling solution of MTA with the independent air-to-water heat exchanger and smaller, separate fans.

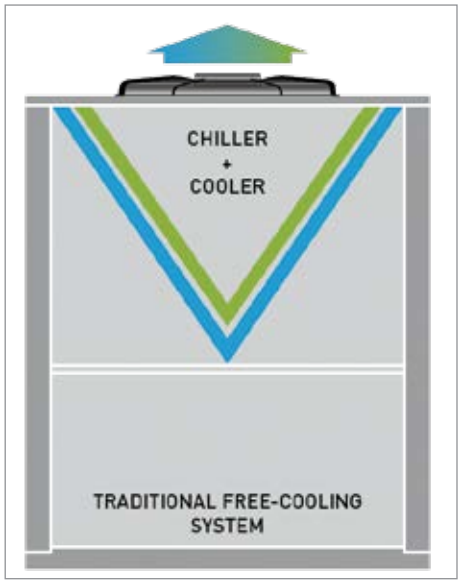
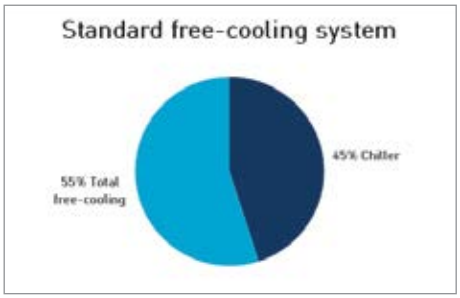
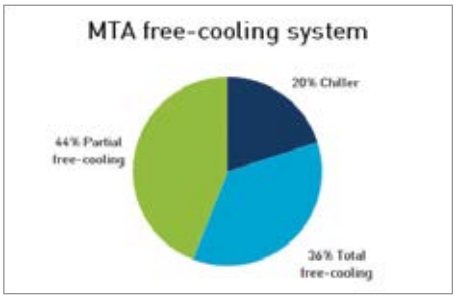


Fig.2 Traditional free-cooling solution with stacked heat exchanger coils using one over-sized fan.

Partial and Total Free-Cooling Modulation

MTA Process Solutions, has introduced partial-mode free-cooling. This allows free-cooling to offer it's energy-saving benefits to applications experiencing the ambient temperatures often seen during the transitional seasons of Fall and Spring. Integrated into one chiller system, the system automatically decides, based upon





Ratio of usage of the free-cooling system during one year (data referred to shift of total 24h/day at temperature of the fluid in/out = 59/68 ˚C)

INNOVATIVE MTA FREE-COOLING CHILLER SYSTEMS

ambient temperatures, whether to operate as a chiller or as a partial or total free-cooler.

When working in free-cooling mode, these chillers use a modular operating logic and the free-cooling of the water can be done in all seasons of the year, either with the refrigeration compressors "ON" (Partial Free-Cooling) or with the compressors "OFF" (Total Free-Cooling).

Partial-mode free-cooling is made possible by separating the chiller and free-cooling systems — each heat exchanger sets using their own fans. In the partial free-cooling mode, the system starts to "free" cool when the ambient temperature is 3.6 °F below the fluid inlet temperature. Water is routed via a three-way valve first to the free-cooler and then it goes to the chiller. The controller automatically reduces the work of the compressors by throttling the cooling capacity by controlling the 3-way valve (which controls where the inlet water goes). During the transitional months of Fall and Spring, free-cooling acts as a pre-cooler and significantly reduces the work (and energy consumption) of the chiller.

Case Studies from the Northeast U.S.A.

Scales Industrial Technologies helps industrial and medical clients maintain the reliability and quality of chiller, blower, vacuum and compressed air systems — while always keeping an eye out for how to reduce a client's operating expenses.

"If our customers don't succeed in their businesses, neither will we," says Bob Copell, Process Cooling Specialist covering several New England states. "It's rewarding to help customers take a longer-term view on reducing operational costs associated with maintenance and decreased energy and water consumption."

A growing plastic injection molding plant needed 65 °F water to cool their plastic molds. The existing chiller system wasn't going to be able to handle the growing demand for chilled water, and the plant was receiving proposals for new chillers.

"While the maintenance manager and I were discussing the air compressor system design for the new facility, we were leaning on the existing chillers inside. I just happened to notice that the chiller fluid temperature was 65 °F and it was only 20 °F outside and snowing," Copell explained, "I asked if they would consider a proposal for a high efficiency, cycling free cooling chiller. I explained that this type of packaged chiller would utilize the outside air to cool their process for at least five months out of the year which would save them considerable operating costs."

To make a long story short, the client installed an MTA free-cooling system using both partial and total free-cooling modes. The local utility helped finance the purchase, and the simple ROI was achieved within 14 months.

The success and growth of a company will place strains upon the utilities required by the facility to support production equipment. A manufacturer of point-of-use commercial and residential water heaters required cool water to test their heaters. The existing testing method used four five hundred gallon tanks supplying approx. 70 °F water to the heaters being tested. The water would return to the tanks at 140 °F. They would then add city water to temper it and try to bring the temperature down.

"The factory was consuming significant amounts of city water while delivering inconsistent water temperatures to the test lab," according to Mr. Copell, "We installed a MTA free-cooling system with one glycol loop and we're running on free-cooling 6-7 months a year." The project qualified for incentives from the local utility. The plant has also reduced their water consumption, the cost of their sewer bill — all while improving the quality and reliability of their test process by now delivering a consistent 65 °F water temperature to the lab.

A Case Study from the U.K.

A large company wanted to replace the existing chiller systems on two three-story office buildings at their main campus. They run a 24-hour, seven day a week operation and needed an air conditioning system to match. The old system was out of date, oversized and did not have the capacity to handle the requirements of modern air conditioning.

The MTA chillers offered the client reduced noise levels, due to the availability of three differing acoustic versions. There are high EER levels, especially at part loads (ESEER). They are ideal for large hydronic air conditioning installations in public and private surroundings and allow start up and operation even in the most severe conditions.

The engineering contractor was looking for an ambient temperature in each room of 68-69 °F. The customer wanted the most energy efficient, cost effective and easy to install solution — so they decided to replace the existing roof-top chillers with MTA chillers featuring 9 and 12 compressors each, delivering chilled water for air conditioning. Importantly, the MTA chillers featured integrated free-cooling.

The MTA distributor realized free-cooling would make a significant difference in cutting energy bills for the client. The chillers were designed with a water temperature of 54 °F. Here the system cut-in with free-cooling at two degrees below this level. When this happens no refrigerant is required and energy use begins to tumble. The MTA distributor estimated this could lead to energy savings during the winter months of as much as 70 percent. During the warm summer months, the system can offer savings of up to 40 percent.

The first system was installed over the Easter weekend by the MTA Distributor. Two McQuay 1Mw chillers were replaced by:

- 2 pieces **GALAXY Tech 270 N** with S&T evaporator and electronic fan speed control
- 2 pieces **AFV 300 N** with electronic fan speed control. Emerson Crane Hire of Dagenham assisted with the rooftop work.

Four weeks later two McQuay 1Mw chillers were removed from the second building and replaced by Polar Cooling Services Ltd with:

- 2 pieces **GALAXY Tech 285 N** with S&T evaporator and electronic fan speed control
- 2 pieces **AFV 300 N** with electronic fan speed control

The new chillers were installed, fixed to the water and electrical circuits, and commissioned ready for the start of the working week. The new chillers run on R410a, replacing the outdated R22. Each MTA system offers remote monitoring.

The free-cooling showed its' worth immediately. During the first week the building was cooled by the free-cooling system only, as the temperature outside was very cold — saving seventy percent in energy costs. Since then whenever the ambient temperature has reached 68 °F there have been energy savings of at least forty percent over the prior system.

Summary

The use of free-cooling technology allows users to reach a reliable pay-back time on the investment compared to traditional water chillers. Depending on the weather conditions and on the fluid temperatures, the return on investment is almost always close to one year. An innovation in free-cooling has been developed with the introduction of partial-mode free-cooling, allowing for a significantly broader range of application temperatures and significantly increased energy savings.

A MTA Free-cooling Chiller System

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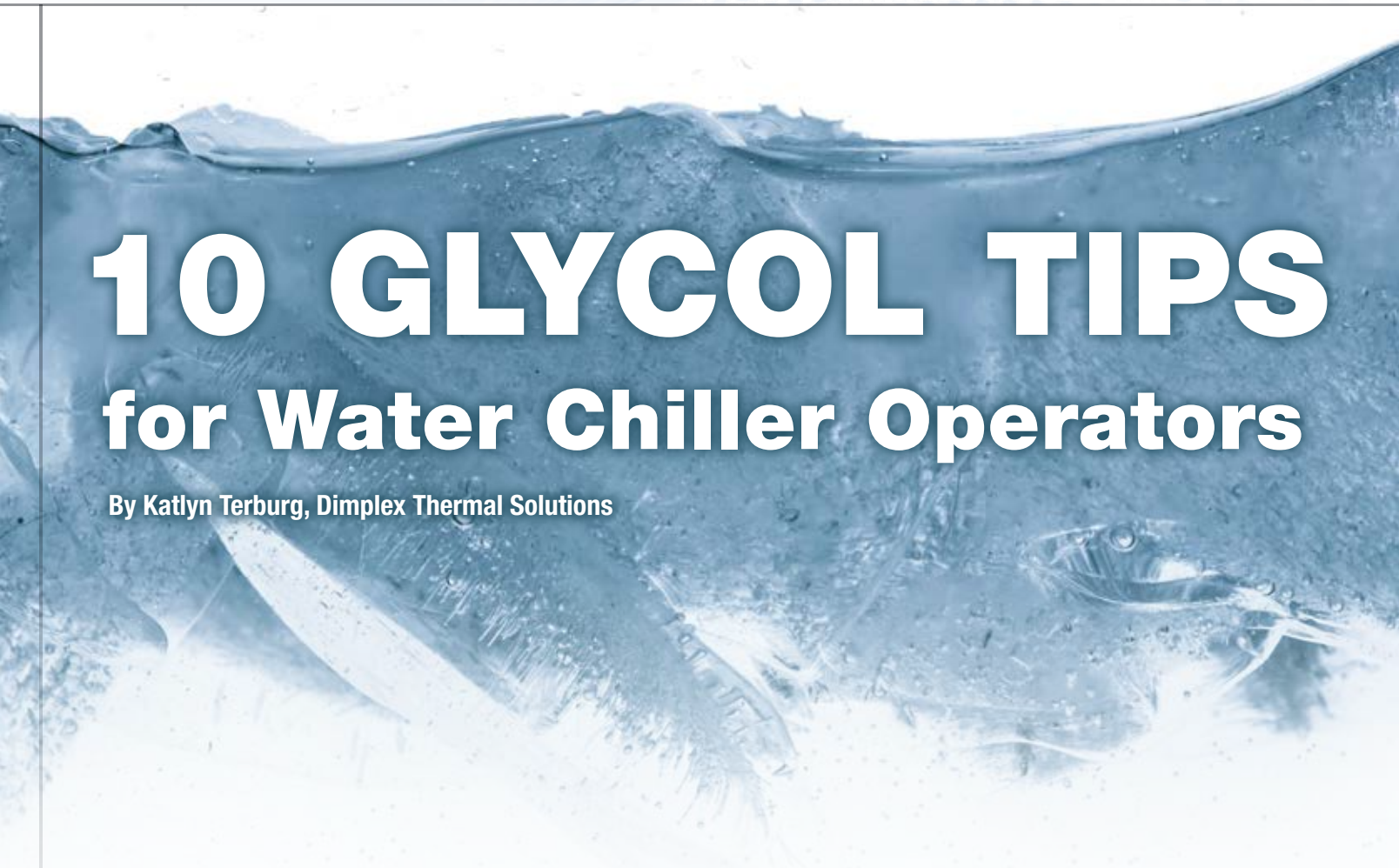
For more information also contact Robert Copell, Process Cooling Specialist, Scales Industrial Technologies, tel: 800-627-9578 x 3117, email: bcopell@scalesair.com, www.scalesair.com



10 GLYCOL TIPS for Water Chiller Operators

By Katlyn Terburg, Dimplex Thermal Solutions

The use of an industrial inhibited glycol and water mixture is recommended in most water chiller systems. Ethylene and Propylene are the two standard types of inhibited glycols commonly used.

The main job of glycol is to prevent freezing of the process fluid and ensure consistent flow at the operating temperature. Inhibited glycols will also prevent formation of scale and corrosion while protecting metals such as brass, copper, steel, cast iron and aluminum. Water systems treated with an inhibited glycol will also be protected from algae and bacteria that can grow and degrade the fluid system performance. This brief provides ten basic tips for glycol users in water chilling operations.

1 Don't Mix Glycols

Do NOT mix different types or brand names of glycol. This can result in some inhibitors precipitating out of the solution. Mixing glycols will also gel and clog filters and prevent proper flow rates. If switching glycol types, it will be necessary to run a thorough flush and clean of the fluid system. Once that's done, it's okay to change over.

2 Don't Use Automotive Grade Anti-Freeze

Do not use automotive grade anti-freeze in the chiller process. These types of glycols are not designed for industrial applications and may cause problems with heat transfer or fluid flow. Many automotive glycols contain silicate-based inhibitors that can coat heat exchangers, attack pump seals, or form a flow restricting gel.

3 Check Local Environmental Regulations

Check state and local codes when selecting the process fluid. Certain areas may have environmental regulations concerning the use and disposal of glycol or other additives.

4 Ethylene Glycol for Most Standard Industrial Applications

Ethylene glycol is the standard heat-transfer fluid for most industrial applications. This type of glycol can be used in any application where a low-toxicity content is not required.

Ethylene glycol has moderately acute oral toxicity and should not be used in processes where the fluid could come in contact with potable water, food, or beverage products.

5 Propylene Glycol for User-Contact Applications

Propylene glycol maintains generally the same freeze protection and corrosion/algae prevention levels as ethylene glycol – but has a lower level of toxicity. This type of glycol is more readily disposable than ethylene and safer to handle. Propylene glycol is commonly used in the food industry and in applications where the user may come in frequent contact with the fluid.

6 Difference Between Ethylene and Propylene Glycol

At very cold temperatures, propylene glycol become more viscous, changing the heat exchange rate slightly. Some chillers are designed for that compensation so that either glycol type can be used. Ethylene is more widely known due to its lower purchase price, making it more economically feasible for factories with significant purchasing volumes.

Koolant Koolers recommends propylene as its MSDS (Material Safety Data Sheet) handling is less rigorous, making it easier for facility maintenance staff if they ever need to fill or clean up a glycol spill. Please note that some U.S. states prohibit the use of ethylene glycol for environmental reasons.

7 Use Distilled or Reverse-Osmosis Water

Thought and planning should be dedicated to selecting the water to mix with glycol. Water should come from a good quality, filtered source meeting the requirements of the process machine manufacturer. Koolant Koolers recommends the use of distilled or reverse-osmosis water for the glycol/water mixture.

8 Beware De-ionized and City Water

De-ionized water can be used to fill the chiller process initially, but should not be maintained at a de-ionized state thereafter. Unless the chiller has been ordered and designed for use with water that is continually de-ionized, the fluid will actually attack certain metals within the chiller and cause damage to some components. Check with the chiller factory before using de-ionized water to check for compatibility.

Neither is the use of regular tap water recommended. Water from "the city" or "the ground" contains deposits and additives which can decrease component life and increase maintenance requirements.

9 Applications Drive Water/Glycol Mix Percentages

The location of the chiller and environmental concerns must be taken into account when selecting the proper mixture of glycol and water for the chiller process. A process located completely indoors, with no chance of freezing, will require less glycol than a system located outdoors where low temperatures can cause the fluid to freeze and piping to burst. Applications with a very low operating temperature (below 20 ˚F) should use a glycol mixture equivalent to an outdoor system. After selecting the proper glycol and water types, use the following chart to determine the recommended mixture depending on the application and location of the process. The glycol percentage figures in the chart below will apply to any brand of ethylene or propylene glycol.

Application	Glycol %	Water %	Freeze Point
Indoor Chiller and Process	30	70	5 ˚F / -15 ˚C
Outdoor Chiller/Low Temperature	50	50	-35 ˚F / -37 ˚C

*Figures based on the performance of Koolant Koolers K-Kool-E brand of ethylene glycol.

10 Fluid Maintenance and Filtration

Maintaining clean process water and the proper glycol content will extend the life of the system and reduce costly down-time. If the chiller was not equipped with a fluid filter from the factory, it is highly recommended to install some sort of filtering system to remove unwanted dirt and debris. BP

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CENTRAL PLANT OPTIMIZATION YIELDS UP TO 25% EFFICIENCY IMPROVEMENT FOR PEPCO ENERGY SERVICES' CHILLER PLANT

By Tus Sasser, The Tustin Group

Pepco Energy Service Midtown Chiller Plant. The chiller plant operates 24 hours per day, 365 days per year, providing essential chilled water via a 42" header to numerous Atlantic City casinos, Pier Shoppes and the Atlantic City Boardwalk Hall and Visitors Center. The 16,200 Ton plant has 4-York 4160v series counter flow chillers and 10-York 480v VSD series counter flow chillers. System pumping capacity is 40,000 GPM. A total of 14 chillers are in the plant—16,200T

Pepco Energy Services' (PES) Midtown Thermal Control Center (MTCC) in Atlantic City, New Jersey, sells chilled water and steam to multiple Atlantic City casinos, Boardwalk Hall and Pier Shops. PES is also responsible for stand-alone remote heating and cooling plants for the Atlantic City's major casino's as well as the Atlantic City Convention Center including its 2.4 Mw solar array.

Patrick Towbin, VP of Asset Management for PES, was brought on board to improve the performance of the MTCC plant. It didn't take long for him to see that the 16,200 Ton chiller equipment accounted for a large portion of the MTCC's production costs, and that there were opportunities to improve the efficiency of the operation of this equipment. He hired John Rauch to head the plant's operational management team. The new mandate, under the direction of Towbin and Rauch, was to seek cost effective ways to improve the operations of the MTCC, especially the larger contributors to production costs.

Holistic Approach Needed

Within a short time of his arrival, Rauch, as the new PES Plant Operations Manager, saw that MTCC was relying on the same equipment and processes that were put in place when the plant was

built over 15 years ago. "We started our review by asking ourselves how can we produce chilled water more efficiently so that we can improve our bottom line. With this as our guide, we identified many opportunities for improving efficiency at the plant. Not only in the chilled water production process, but also in measuring and monitoring the output of the production process."

Rauch's investigation showed that the plant was being operated and maintained with a series of independent components and controls, many of which had been modified over the years. From experience, Rauch knew that even the most efficient components fail to meet their promised efficiency over time. He believed it was essential to look beyond component-based efficiency and employ a holistic approach where components work optimally as part of a networked interrelated system.

Rauch lost no time in contacting Brad Pappal, General Manager of Tustin Energy Solutions (TES), a commercial energy management company headquartered in Norristown, Pennsylvania, to help evaluate the situation and submit a proposal for improvements. Rauch had worked with Pappal's team in the past on projects that successfully and significantly reduced energy consumption. What neither party knew at the time was the amount of effort it would take to compile the data necessary to develop a baseline and prepare a proposal for improvements. Once the initial survey and site assessment was complete, it was clear that the largest opportunity for cost effective energy reduction was in the chilled water production process. However, the opportunity was not simply replacing or adding equipment. It was modifying the controls strategies with which chilled water was produced. TES then reached out to Kiltech, Inc., their partner for central plant optimization, to review the opportunity.

Developing a Baseline

"Without good data and a good control system, how do you know if, or what, you need to optimize?" explained Rauch. "For over 10 months in 2012 we worked with TES and Kiltech, Inc. on the data collection/validation phase in order to understand what we had so that we could very accurately portray what we could gain by implementing a central plant optimization system. We reviewed all prior electric bills and upgraded many flow and temperature transmitters to make sure we got accurate baseline data." Rauch understood that improvements in the chilled water production process would be evaluated in competition with other capital expenditure options under consideration by management. Because capital budgets are limited, it was vital that he accurately quantify the benefits to be achieved with the expenditure to gain approval to proceed.

Once the development and costing process was complete, Towbin spent countless hours reviewing the financial implications of the project. However, before he would submit the proposal to the corporate decision makers in Virginia, he asked to see a working site and to speak to the end users. Kiltech, Inc. scheduled several site visits for Towbin to review, assess, and interview which provided the confidence he needed to move the proposal forward.

The proposal showed that PES could reduce its chilled water production costs by well over 20% by implementing the proposed chiller optimization changes and other energy efficiency measures. "Over twenty percent is a big number and management was initially skeptical," said Rauch. "It took almost four months of additional validation to address their questions and to demonstrate that the calculations were accurate." For Towbin, who had been involved with similar projects before, the fast payback was obvious. Towbin relied upon his expertise in analysis, engineering, and asset management to convince his management of the excellent economics associated with the project. The project qualified for a half-million dollar rebate from the New Jersey Office of Clean Energy's NJ SmartStart Buildings® Program, and also resulted in nearly 25% improvement in operating efficiencies. In the end, and after thorough due diligence on their part, Towbin and Rauch prevailed and the project was approved.

Optimization Measures

The proposal called for TES to make numerous energy efficiency upgrades including VFDs, and to utilize a non-proprietary automated plant optimization application from Kiltech, Inc. called CPECS (Central Plant Energy Control System). "When CPECS is deployed (either in new construction or retrofit) it routinely achieves annual averages of 0.55 kW/ton and lower for the entire chiller plant, (depending on the application), thus translating to significant annual energy and cost savings," explained Pappal. TES application engineers and programmers worked closely with Kiltech, Inc. to customize the system's software that automatically sequences the operation of the entire chilled water plant. The CPECS networked optimization software was designed to take advantage of the Plant Control System (PCS) to maximize central plant efficiency. "We were able to interact with the plant's existing Allen Bradley Rockwell Plant Control System to fully optimize the mechanical systems in the plant," added Pappal.

CENTRAL PLANT OPTIMIZATION YIELDS UP TO 25% EFFICIENCY IMPROVEMENT FOR PEPCO

The CPECS' networked onsite server that is deployed on the backbone of the current PCS, receives data, processes and models the data and provides historical, real-time, and predicted data. The data outputs from the CPECS provide the operational strategies that are automatically implemented by the plant control system. Based upon the energy efficiency measures developed during the initial verification process, TES upgraded various motor starters and system critical instruments required for optimization.

All About the Algorithms

"The CPECS platform uses a non-proprietary, open protocol and fully modeled methodology. The approach is model and simulation driven and is customized to PES' plant and operations. At the heart of the software is an algorithm that is computing all possible chiller, pump and cooling tower sequencing permutations, modified flows, set points and load limits. These calculations find the combination of equipment and speeds that result in the lowest kW input and/or the lowest instantaneous cost of production," explained Joshua Kahan, General Manager for Kiltech, Inc. "All of this is recorded, reported and implemented in real time."

"It's all about the algorithms," explained Rauch. "The system has what's called a Brute Force Optimizer algorithm that constantly calculates the most efficient operation scenario. Algorithms run every 15 minutes, 24/7. They make real- time automatic adjustments to the system based on real-time building loads. The optimization software then simulates that data and directs the PCS for adjustments needed to maximize the system performance. The software has complete knowledge of compressor, tower and pump performance characteristics, which it uses in real time to modulate control levels to all VFDs, pumps and machines."

"If you have the right algorithm and you work with the details that go through it, then it's pretty straightforward," explained Towbin. "The program's successful implementation is largely due to how much patience Rauch and the operators had to make sure the algorithm was programmed correctly."

The program's continuous feedback loops provide detailed, real-time and historical performance data so operators can quickly detect, diagnose and resolve system faults. "They can see the data via easy-to-read graphs and charts that allow for quick diagnosis of faults," said Rauch. "If a chiller goes down for maintenance, the software recalculates, and readjusts, and reassigns the process workload accordingly."

Concern Over Job Security

Plant operators were initially skeptical about a "Hands Off" system taking over completely. "The idea of a plant running relatively 'hands free' in terms of operating efficiency led to a concern about job security," explained Rauch. "However, the way things have worked out, operators are now more available to do maintenance, shutdowns, and system analysis, and can do so without missing critical control changes.

The system's automated demand response, used for balancing supply and demand, allows operators to program the optimization system so it stays under a predetermined plant electrical load. "The optimized control program will now do the adjustments for them," said Rauch. "This is a long way from the days when operators had to stare at a

"The chiller plant optimization enabled PES to obtain a $500,000 rebate through the New Jersey SmartStart Buildings® program — the maximum allowable rebate."

— Tus Sasser, The Tustin Group

ENERGY SERVICES' CHILLER PLANT

Baseline Performance Data: October 1, 2013 – July 31, 2014 (Total electric savings for the period 5,370,000 kwh)

screen and stress over all the things that had to be tweaked, or turned on or off, to meet a demand response number at peak hours. Many of the MTCC's customers are event driven and when there are large events, usage can increase dramatically. The CPECS can now help PES better manage these peak usage episodes."

Side Benefit

"In addition to achieving operational efficiencies and savings, this central plant optimization project clearly demonstrated how automated optimization of a complex plant like MTCC can help the owners meet their operational goals by helping them achieve production reliability, as well as enhanced visibility into operations and equipment that enables them to foresee challenges that may impact performance or operations," said Kiltech's Joshua Kahan.

One of the things about the CPECS that impressed Towbin was actually finding new opportunities for additional efficiencies. "You start to see things that you never knew were acting as a drag on our production efficiency," he said. "The side benefit is that it helps you optimize your plant and your operations because the system brings to light situations that you had never questioned before. In the end, it was a very deductive way to implement improvements in our plant."

Annual Savings, Energy Rebate and Additional Benefits

The chiller plant optimization was completed in 2013. Since deployment, it has become commonplace to see daily savings of 30% relative to baseline. Going forward, savings are expected to be 20-25% annually. "The Midtown plant operates at near maximum cooling capacity during the summer months and there are limits to the optimization based on weather conditions and customer occupancy," explained Pappal. "PES benefits most during shoulder and winter months. The demand is much lower and the maximum benefits of optimization are realized. Regardless, the first priority of cooling is always met." In addition, Towbin added that "now we have people from all over the company coming here to see the efficiencies we have gained."

The chiller plant optimization enabled PES to obtain a $500,000 rebate through the New Jersey SmartStart Buildings® program — the maximum allowable rebate. The NJ program makes financial incentives available for projects that provide significant long-term energy savings.

During the chiller plant optimization, TES repurposed two additional aging proprietary control systems at MTCC and remote mechanical plant for the Atlantic City Convention Center. Along with upgrades and equipment, TES/ Kiltech combined services will save PES over $500,000 annually in energy, repair, and unnecessary services.

"Plant optimization where components work optimally as part of a networked, interrelated system has allowed us to reach a new level of plant efficiency," said Rauch. "With the right team, you can make the technology work seamlessly. And that is what we have here, optimization 24/7, helping us save upwards of 25% annually." BP

For more information contact Tus Sasser, President, The Tustin Group., email: tsasser@thetustingroup.com, tel: 610-539-8200. The Tustin Group is a provider of advanced HVACR mechanical services, building energy management solutions, water management services, fire protection systems and retrofit construction services for commercial, industrial and institutional customers. Visit www.thetustingroup.com.

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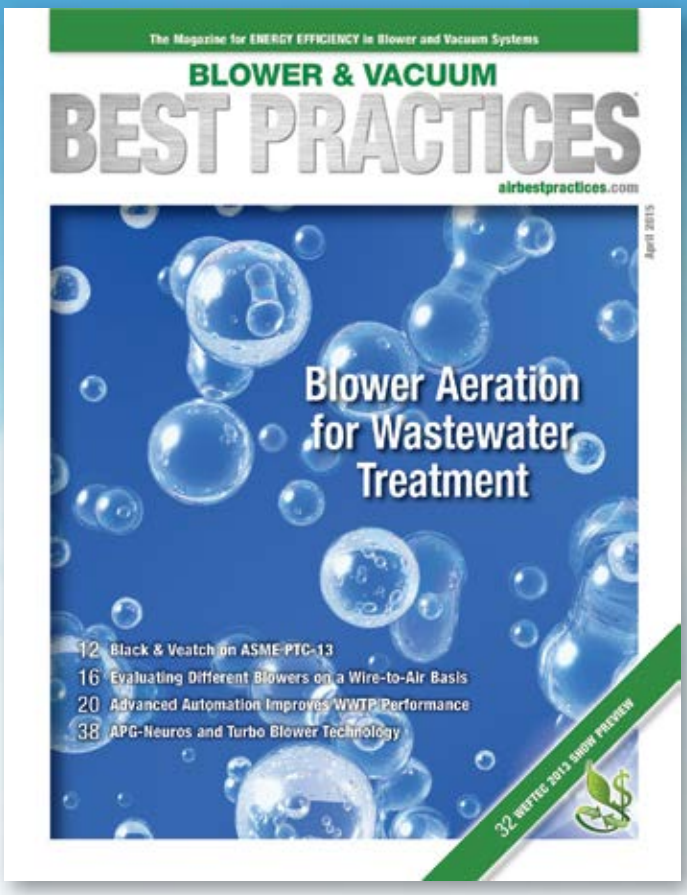

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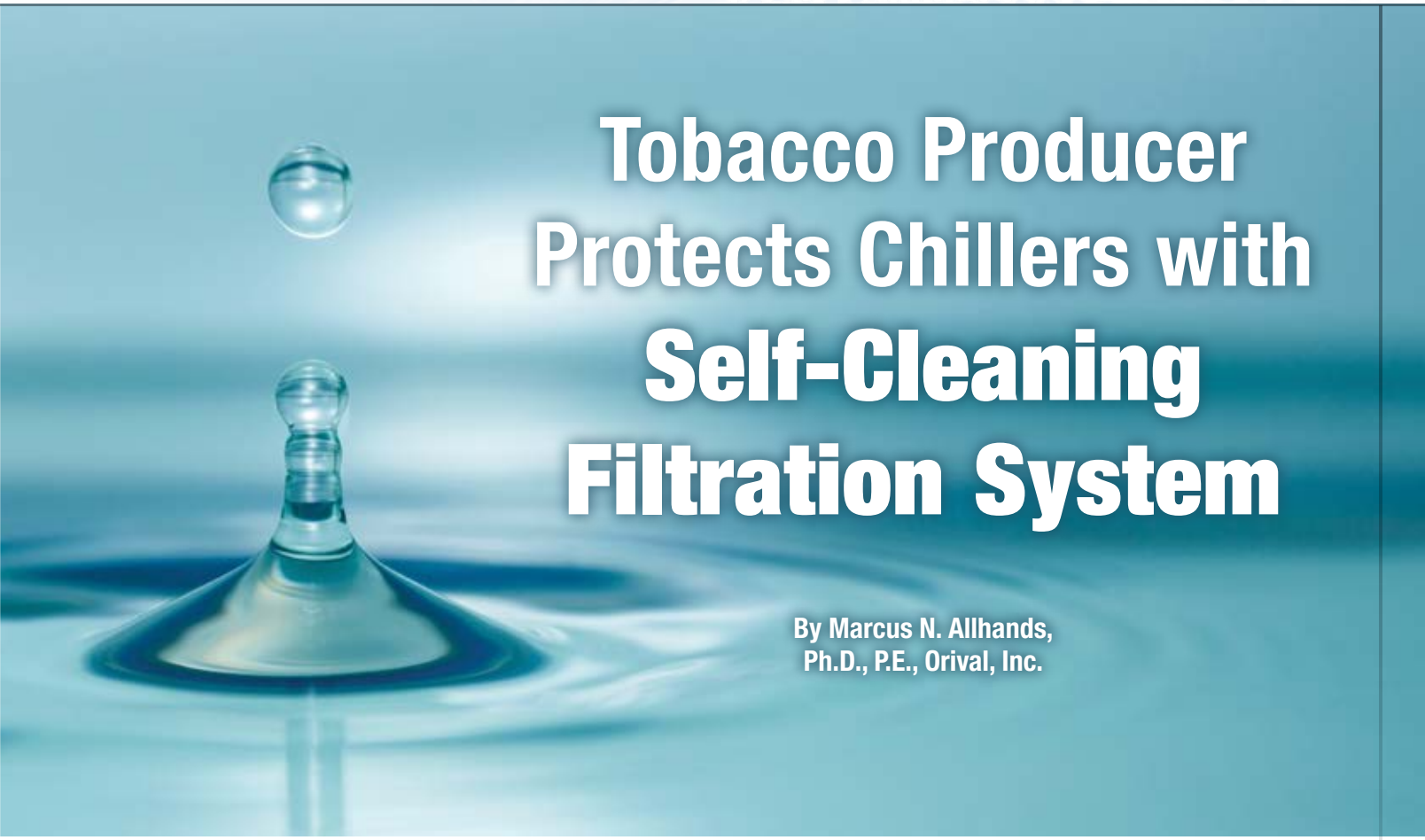


Tobacco Producer Protects Chillers with Self-Cleaning Filtration System

By Marcus N. Allhands, Ph.D., P.E., Orival, Inc.

Cooling towers dissipate both ambient and process heat in most large manufacturing facilities. These structures facilitate the transfer of unwanted energy (heat) from a transport liquid (usually water) to the atmosphere. Problems with efficient heat transfer, equipment protection and pathological risks to employees can most often be traced back to an issue with suspended solids. These solids can originate in the process, in the piping, from the atmosphere or from internal biological growth.

Side-stream filtration is the most commonly used method of maintaining minimal suspended solids in a cooling system. Side-stream filtration takes a portion of the flow from the system and filters it to remove suspended solids. It then returns the clean water back to the system, usually through the cooling tower reservoir or sump. This method maintains general control of suspended solids. It does not filter all the water going to the process.

Historically, cooling systems have relied heavily on the two following established methods for removing suspended solids. Cyclonic devices are highly efficient at removing high specific gravity inorganic solids, while granular media filtration is generally more effective at removing low specific gravity organic solids.

Automatic self-cleaning screen filter technology provides a positive barrier to both organic and inorganic solids regardless of specific gravity and requires very little energy to operate. In addition, they conserve coolant additives by using very little coolant liquid for the self-cleaning process. The unwanted loss of coolant can be completely eliminated by incorporating the cleaning cycle into the blow-down process of the cooling system.

Applications

A large producer of cigarettes and fine-cut tobacco manufactures, packages and ships billions of cigarettes per year. The plant installed a new production line recently with all new equipment. One new piece of equipment was a state-of-the-art, 150-ton magnetic chiller on the evaporator loop of the cooling system.

Chillers are expensive components in a cooling system that must be supplied with a continuous flow of clean water from a cooling tower. Therefore, all the flow going to the chiller had to be filtered to protect it from the possibility of damage induced by suspended solids. For this application, a side-stream system was not appropriate.

Cyclonic separators could remove the heavier solids, such as sand and pipe scale, but not the lighter organic and wind-blown materials. Granular media filters could remove the organic fraction of suspended solids, but would have trouble with sand particles since they would tend

TOBACCO PRODUCER PROTECTS CHILLERS WITH SELF-CLEANING FILTRATION SYSTEM

Figure 1: Filter Installation

to stay in the filter vessel during the cleaning cycle. Also, these filters need to be taken offline during each cleaning cycle and require an appreciable amount of water for cleaning.

Solution

An internationally known manufacturer of filtration equipment was asked to recommend a filtration system to protect the chiller from airborne debris scrubbed from the atmosphere by the cooling tower and other solids originating within the cooling system. The solution had to take into account that the system was likely to contain both organic and inorganic solids, and that a continuous flow of water must be delivered to the chiller at all times. Pressure losses had to be kept to a minimum and flow rates could not vary appreciably.

A fully automatic self-cleaning filter with a 6-inch inlet and outlet flanges and a 200-micron stainless steel screen element was recommended for the application. The filter has a built-in bypass system that will automatically open a bypass line around the filter element, should anything cause the filter to fault. A filtration degree of 200-microns was determined to be the most appropriate for this application to remove particles capable of causing damage to the new chiller. This meant that the openings in the screen were a little larger than the diameter of a human hair and could remove airborne particulates, microbiological growth, pollen and other materials found in most cooling towers. Figure 1 shows the final installation with the built-in bypass system.

Operation

The filtration unit consists of two stages of filtration. The components of a typical filter of this type are depicted in Figure 2. The first is a coarse cylindrical pre-filter (1) that removes rigid particles too large to pass through the nozzles of the dirt collector during the cleaning cycle. The second stage is a cylindrical stainless steel weave-wire fine screen element (2) that is the real workhorse of the filter. The openings of this element are of a specific size, representing the filtration degree of the element (200 microns in this application).

Dirty water enters the inlet flange (3) and then passes through the coarse screen described above, from the outside in. It then passes into the center of the fine screen element. Water passes through this fine screen from the inside out and exits through the outlet flange (4).

Unwanted solids accumulate on the inner surface of the fine screen element. As this debris layer builds, energy is dissipated, causing a pressure differential across the screen. When the control system senses this differential pressure reaching a pre-set threshold (7 psi or 0.5 bar in this case), the cleaning cycle is initiated. The first step in the cleaning cycle involves the automatic opening of the rinse valves (5) to atmosphere. A pipe carries this flush water to a drain, but oversized piping is used to prevent backpressure against these rinse valves. When these valves open, the pressure in the hydraulic motor chamber (6) and the dirt collector (7) drops abruptly.

The pressure just inside the nozzle openings on the dirt collector is nearly zero gauge pressure, since these nozzles are connected through the dirt collector, hydraulic motor chamber and rinse valves to the atmosphere outside the pressurized filter body. Water inside the filter

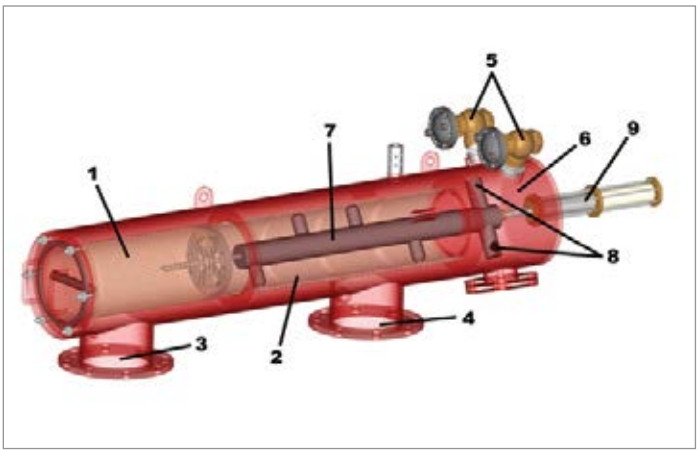


Figure 2: Filter Components

> **"Full stream protection, automatic self-cleaning process, automated bypass system and low maintenance were just the qualities the engineers were looking for in a protection system for the new magnetic chiller."**
>
> **— Marcus N. Allhands, Ph.D., P.E., Orival, Inc.**

rushes into the nozzles at very high velocity. It then passes through the dirt collector into the hydraulic motor chamber and out the rinse valves. The nozzle openings on the dirt collector are within a few millimeters of the fine screen surface, causing water to pass backward through the screen in a very small area at very high velocity. This dislodges the filter cake (debris built up on the inside screen surface) and sucks it into the dirt collector.

Since only a very small area of the screen is being cleaned by each nozzle (an area about the size of a dime), there is plenty of energy available for vacuuming debris from the screen. This debris is discharged along with a small amount of water through the rinse valves to the drain. As water rushes out of the dirt collector into the hydraulic motor chamber, it passes through the hydraulic motor (8), imparting a rotation to the dirt collector and thus moving the cleaning nozzles around the inside surface of the screen. A hydraulic piston (9) then slowly moves the dirt collector linearly, giving the rotating nozzles a spiral movement. It moves in such a way that every square inch of screen surface is passed by a suction nozzle, assuring that the entire filter cake is vacuumed from the screen during the cleaning cycle. This entire process takes less than 10 seconds and does not interrupt the flow of clean water downstream.

Summary

Fully automatic self-cleaning screen filters provide an economical means of removing suspended solids from cooling tower water. The use of weave-wire screens as the filtering media provides a positive removal system that eliminates all particles larger than the filtration degree of the screen from the cooling system. It also removes many smaller particles due to the filtration effect of the filter cake that builds on the screen element surface between cleaning cycles.

This phenomenon of filtration improvement can be loosely quantified as removing particles down to about one tenth the size of the screen filtration degree when the filter cake is at its thickest. This 1:10 relationship is called the capture ratio as employed in screen filtration systems. The efficient suction cleaning principle allows the filter cake to be removed completely from the screen surface within seconds without physically touching the cake or screen. During the suction cleaning cycle, the filtration process is uninterrupted, which provides filtered water downstream of the filter at all times and eliminates the need for redundant equipment.

Water and chemical losses are kept to a minimum, and organic and inorganic solids are removed with equal efficiency. Since only a small pressure differential occurs across the screen element, the extrusion of soft organic material through the screen is prevented. If any problem should occur with the filter, the controller will sense this and open the built-in bypass valve to provide a continuous flow of water to the new chiller. The controller will then send a signal to notify personnel of the problem for resolution.

Routine maintenance is minimal, and it consists of a monthly inspection of the rinse valves to see that they are seating properly and an annual inspection of the screen and hydraulic piston. An occasional manually induced cleaning cycle by maintenance personnel is recommended to assure proper operation. Full stream protection, automatic self-cleaning process, automated bypass system and low maintenance were just the qualities the engineers were looking for in a protection system for the new magnetic chiller. BP

For more information, please contact Marcus N. Allhands, Ph.D., P.E., Vice President of Business Development, Orival, Inc. 213 S. Van Brunt Street Englewood, NJ 07631 Tel: (201) 568-3311 Email: filters@orival.com www.orival.com

5 SIZING STEPS FOR CHILLERS IN PLASTIC PROCESS COOLING

By Bob Casto, Cold Shot Chillers®

No matter what your application, there is a single formula for determining the size of chiller you need. Before you begin, you must know three variables:

1. The incoming water temperature
2. The chilled water temperature required
3. The flow rate

For our example, we will calculate what size chiller is required to cool 40 GPM (gallons per minute) from 70 °F to 58 °F? Use the following five steps and general sizing formula:

A 20 ton cooling-capacity chiller from Cold Shot Coolers®

1. **Calculate Temperature Differential (ΔT °F)**

   ΔT °F = Incoming Water Temperature (°F) — Required Chilled Water Temperature.

   – Example: ΔT °F = 70 °F - 58 °F = 12 °F

2. **Calculate BTU/hr.**

   BTU/hr. = Gallons per hr x 8.33 x ΔT °F

   – Example: 40 gpm x 60 x 8.33 x 12 °F = 239,904 BTU/hr.

3. **Calculate tons of cooling capacity**

   Tons = BTU/hr. ÷ 12,000

   – Example: Ton capacity = 239,904 BTU/hr. ÷ 12,000 = 19.992 tons

4. **Oversize the chiller by 20%**

   Ideal Size in Tons = Tons x 1.2

   – Example: 19.992 x 1.2 = 23.9904

5. **You have the ideal size for your needs**

   – Example: a 23.9904 (or 25-Ton) chiller is required

Plastic Process Cooling Applications

There also industry-specific, rules-of-thumb for chiller sizing. These may vary depending upon the application. The below guidelines and formula may be used for sizing chillers for plastic process cooling applications. In our example, we will calculate what size chiller is needed for a

CHART 1: PLASTIC MATERIAL PROCESS COOLING REQUIREMENTS	
INJECTION MOLDING	
30#/hr H.D. Polyethylene	1 ton
35#/hr L.D. Polyethylene/Polypropylene	1 ton
40#/hr Nylon	1 ton
50#/hr Polystyrene or ABS	1 ton
65#/hr PVC or Polycarbonate	1 ton
70#/hr P.E.T	1 ton
EXTRUSION	
50#/hr Polyethylene/Polypropylene	1 ton
75#/hr Polystyrene	1 ton
80#/hr PVC	1 ton
BLOW MOLDING	
35#/hr Polyolefins	1 ton

Source: www.waterchillers.com

CHART 2: AUXILIARY EQUIPMENT AND EXTRUDER COOLING REQUIREMENTS	
EXTRUDER COOLING	
Gear box cooling	1 ton/100 hp
Feed throat: 3" screw or less	1 ton
Feed throat: larger than 3" screw	2 ton
Barrel or screw cooling (per inch of screw diameter)	1 ton/inch
AUXILIARY EQUIPMENT COOLING	
Air compressor (no aftercooler)	0.16 ton/hp
Air compressor (with aftercooler)	0.2 ton/hp
Vacuum pump	0.1 ton/hp
Hydraulic cooling	0.1 ton/hp
Hot runner mold	0.1 ton/hp
Water pump in circuit	0.1 ton/hp
Feed throat: less than 400 ton	0.5 ton
Feed throat: greater than 400 ton	1 ton

Source: www.waterchillers.com

polypropylene molding operation that incorporates a 6 oz. "Shot Size" and a 18 second cycle time with a 3 H.P. hydraulic motor. We will use Charts 1 and 2 as references.

1. Calculate the pounds of material per hour being processed.
   - Example: 6 oz / 18 sec = 19.99 oz/min (20.00 oz/min)
   - 20 oz / min x 60 min. = 1200 oz/hr
   - 1200/16 = 75 lbs / hr
2. Determine how many pounds per hour are required for each ton of cooling capacity using Chart 1.
   - Example: Polypropylene requires 1 ton of cooling capacity for every 35 lbs/hr processed
   - 75 lbs. ÷ 35 lbs = 2.14 tons of cooling
3. Determine if the extruder or any auxiliary equipment will require chilled water using Chart 2. If not, go to step #5.
   - Example: A hydraulic motor requires 0.1 ton/HP of cooling capacity
   - 3 HP x 0.1 ton/HP = 0.3 ton of capacity
4. Combine the process and auxiliary equipment cooling requirements.
   - Example: 2.14 tons + 0.3 ton = 2.44 tons
5. Size your chiller by rounding up to the closest standard unit.
   - Example: This application will require a 3-ton unit

About Cold Shot Chillers®

Based in Houston, Texas, Cold Shot Chillers® manufactures economical, ruggedly dependable industrial air cooled chillers, water cooled chillers, portable chillers and central chillers. Our industrial water-cooled chillers and air-cooled chillers serve a variety of different industries and applications.

Cold Shot Chillers® began in the late 1970s as an HVAC repair company in Houston, Texas. In 1980, the company began manufacturing new chillers for the plastic process industry and refurbishing used chillers for an assortment of industries. As our new chiller sales grew the company emphasis shifted from service to 100% manufacturing. Primary industries served include plastic processing, food & beverage, and metal finishing. BP

For more information contact Bob Casto, Business Development Manager, Cold Shot Chillers®, cell: 281-507-7449, office: 281-227-8400, email: bcasto@waterchillers.com, www.waterchillers.com

COOLING TOWER SYSTEM AUDIT

for a Tough Mining Compressed Air Application

By Tim Dugan, P.E., President, Compression Engineering Corporation

Air compressors are very effective heaters. Over eighty percent of the energy input from the motor is converted into compression heat. That heat must be rejected from the compressor package in a way that maintains a variety of temperatures in a reliable manner. The laws of physics demand that the air temperatures go up with compression.

Since the most efficient compression is "isothermal" (constant temperature), it is important to reduce temperature during compression, either by heat being absorbed into oil with oil-flooded compressors, or by using multi-stage compression and intercooling with oil-free compressors. Maintaining temperature in the correct range is the most important reliability issue in compressors, ensuring that it is not too high and not too low. It also indirectly affects air quality, since high air temperature overwhelms dryers with water vapor.

Compressed air cooling systems come in two types: liquid-cooled and air-cooled. While liquid cooling with clean, chilled water is the most effective, many industrial plants don't have this capability, particularly in mining and material processing. They typically resort to either air-cooled or fluid-cooled using a cooling tower, which is still essentially air-cooled. With the heavy dust load, this makes for a challenging application.

The goals of this article include describing a large mining compressed air system case study, and, from a cooling perspective, discussing the limiting factors and performance issues of each of the cooling subsystems. Additionally, the article will provide recommended improvements to the project that will make the system much more reliable.

Mining Application System Description

Current Compressed Air System Design

- Three oil-free, two-stage screw compressors, 600 hp, 2,400 acfm, water-cooled, with open drip-proof motors, 25-years-old
- Three regenerative air dryers, heated type, 2,200 scfm (with and without blower)
- Filtration and storage
- Distribution
- High-pressure boosters

Current Cooling System Design

- Water/glycol solution is the primary compressor coolant.
- Glycol is pumped in a closed-loop system to two parallel plate-and-frame intermediate heat exchangers. It is then pumped to the compressors (in parallel) and back to the pump inlet.
- Glycol is cooled on the other side of the intermediate heat exchanger by water. The water is pumped through the heat exchangers, and then to an open cooling tower and back to the pump inlet (Refer to Figure 1 and Table 1).

Audit Results

The audit identified the following issues as the primary problems with the supply side of the current system:

- The compressor had high temperature shutdown issues during the summer.
- Compressors could not run fully loaded for a long time, requiring all three to cycle (not efficient).
- There was water and condensation in the compressed air lines.
- There were reliability issues in the booster pumps, which served the SAG mill clutches.

The first two issues are directly related to the cooling system.

Cooling System Components, Limits and Performance

The components of the compressed air system that are dependent on the cooling system include:

- **Air Compression Elements:** The heat is generated in the first and second stages through heat-of-compression. Due to the lack of heat transfer out of the compression chamber and slippage between rotors, the temperature rise is too high for compression to occur in one stage. Thus, two stages are used.
  - **Limitations:** Maximum temperatures are about 428 °F at the second stage discharge and about 380 °F at the first stage discharge. These limits are based on thermal growth and reliability.
  - **Performance:** The case study compressors are 25-years-old, and have worn rotors with more leak-back than a new compressor. Thus, their

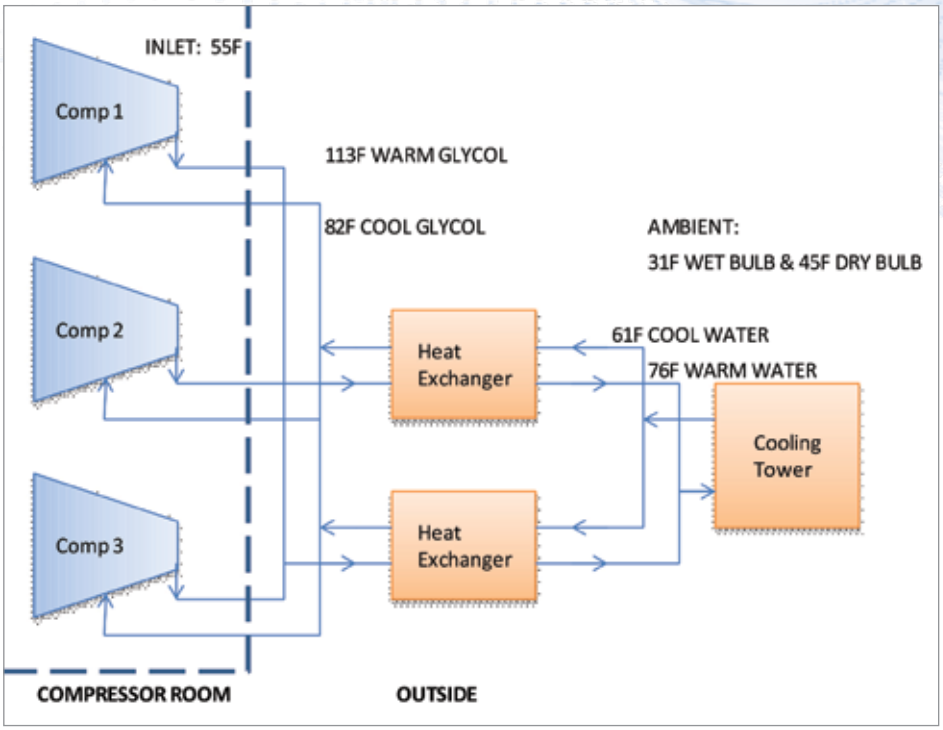


Figure 1: Existing System Diagram

CURRENT SYSTEM SUMMARY	
OPERATING COST	
Electrical Energy	Approximately $326,000 per year*
Maintenance	Approximately $175,000 per year
Total	$500,000 per year
*Assuming $0.04 per kWh	
PERFORMANCE	
Peak Flow (July 2011)	6,886 acfm
Average Flow (Jan. 2012)	4,225 acfm
Average Pressure	114 psig

BASELINE

		FULL LOAD CAPACITY, ACFM	AVERAGE FLOW, ACFM	PEAK FLOW, ACFM	AVERAGE PRESSURE, PSIG	AVERAGE POWER, KW	PEAK POWER, KW	ENERGY CONSUMPTION, KWH/YR
COMPRESSOR	320-AC13	2402	1497	2402	111	298.1	429.0	2,611,375
COMPRESSOR	320-AC14	2402	1485	2402	121	279.4	416.9	2,447,216
COMPRESSOR	320-AC18	2402	1491	2402	113	319.2	444.9	2,796,015
COMPRESSOR	3350-AC01		1	124	111	9.1	58.3	79,353
DRYER	DRO2	2567	1491	2028		9.6	25.9	84,294
COMPRESSOR	DRO3	2567	1491	2028		9.1	27.1	79,800
DRYER	DRO5	2567 (EST)	1491	2028		6.5	32.6	57,015
TOTAL		**7206**	**4474**	**6085**	**114**	**931**	**1435**	**8,155,069**

Table 1: Current System Baseline Data

COOLING TOWER SYSTEM AUDIT FOR A TOUGH MINING COMPRESSED AIR APPLICATION

temperature rise per stage was higher than when new, making them more vulnerable to overheating.

- **Dryers:** The dryers in the case study were regenerative heated compressed air type. They use adsorption to dry the air. In a mine with ambient temperatures below freezing, this is the necessary type of dryer for avoiding freeze-ups.
  - **Limitations:** Dryers are designed for 100 ˚F inlet at 100 psig (100 percent saturated air). If the dryers are marginally sized (as they are in this case), the air temperature should be lower than 100 ˚F to the dryer.
  - **Performance:** Two of the three case study dryers are not achieving dew point. This is partly due to compressed air being higher than 100 ˚F (even in January).

The components of the cooling system include:

- **Cooling Tower:** Cooling towers are available in "open" or "closed" configurations. Open-type evaporative coolers are the simplest, merely pumping the cooled water to the top of a heat exchanger. The cooling from airflow blows counter to the coolant, falling with gravity to the sump. The cooled water is in direct contact with the ambient air. Closed-type evaporative coolers separate the cooled fluid (inside a heat exchanger) from the air and spray water on the outside of the heat exchanger. Open towers are the lowest energy cost cooler (per BTU), but they are more vulnerable to fouling from dirty air. The dirt in the air is "scrubbed" and ends up in the sump. It is then pumped throughout the system (See Figure 2).
  - **Limitations:** The limits of a clean open tower are the "wet bulb" temperature (dew point) and the "approach temperature," or designed-in differential between outlet temperature and wet bulb temperature. More area and air flow result in a lower approach temperature and higher cost. A new open tower is usually sized for with 15 ˚F of the wet bulb, or closer.
  - **Performance:** The cooling tower from the case study had an approach of 30 ˚F, delivering 61 ˚F water out on a January day in Utah. The dampers were wide open. This is indicative of fouled heat exchangers.
- **Intermediate Heat Exchangers:** Plate-and-frame heat exchangers are used to isolate the dirty water from the cooling tower and the compressor coolers. It is a good selection from a maintenance perspective, as it can be taken apart and cleaned. Heat exchanger capacity can be increased by merely adding new plates.
  - **Limitations:** The limit of this heat exchanger is also area, and the approach temperature is inverse to the area and cost. A new plate-and-frame heat exchanger can be designed economically for a 5 to 10°F approach.
  - **Performance:** The case study heat exchanger delivered 82 ˚F glycol with 61 ˚F water from the cooling tower. It was a 21 ˚F approach, which was over double what it should be. This is likely from internal fouling on the water side.
- **Compressor Intercooler:** Custom tube-and-shell exchangers are used to cool the air after the first stage of compression to the level needed at the inter-stage (not too low to avoid condensation). The heat exchangers have removable tube bundles, and typically are water in the shell, air in the tubes and counter-flow.
  - **Limitations:** The limit of this heat exchanger is also area, and the approach temperature is inverse to the area and cost. A new intercooler can be designed economically for 15 ˚F approach.
  - **Performance:** The case study heat intercoolers delivered an average of 109 ˚F air out, with peak temperatures as high as 122 ˚F. The average approach temperature was 27 ˚F. That high of an approach is usually from fouling. The coolant is supposed to be clean and isolated from the outside air. However, it is possible that

Figure 2: Open Cooling Tower Heat Exchangers

WINTER READINGS

	COOLANT				AIR							LOAD		COMPRESSOR THERMAL PERFORMANCE		HEAT EXCHANGER PERFORMANCE			
	COOLING TOWER WATER TEMPS		WATER/COOLANT HEAT EXCHANGER WATER TEMPS		OUTSIDE AMBIENT TEMPS		COMPRESSOR 1ST STAGE AIR TEMPS		COMPRESSOR 2ND STAGE AIR TEMPS		AFTERCOOLER AIR TEMP	COMP AVG PRESSURE	COMP AVERAGE % LOAD						
	INLET WATER TEMP	OUTLET WATER TEMP	INLET COOLANT TEMP	OUTLET COOLANT TEMP	WET BULB	DRY BULB	INLET	OUTLET	INLET	OUTLET	OUTLET			1ST STAGE TEMP RISE	2ND STAGE TEMP RISE	COOLING TOWER APPROACH TEMP	COOLANT HEAT EXCHANGER APPROACH TEMP	INTERCOOLER APPROACH TEMP	AFTERCOOLER APPROACH TEMP
COMP 1			116				55	365	86	368	104	111	62%	310	282			4	22
COMP 2			114				55	370	120	403	100	121	62%	315	283			38	18
COMP 3			109				55	338	122	347	108	113	62%	283	225			40	26
OVERALL/ AVG	**76**	**61**	**113**	**82**	**31**	**45**	**55**	**358**	**109**	**373**	**104**	**115**	**62%**	**303**	**263**	**30**	**21**	**27**	**22**

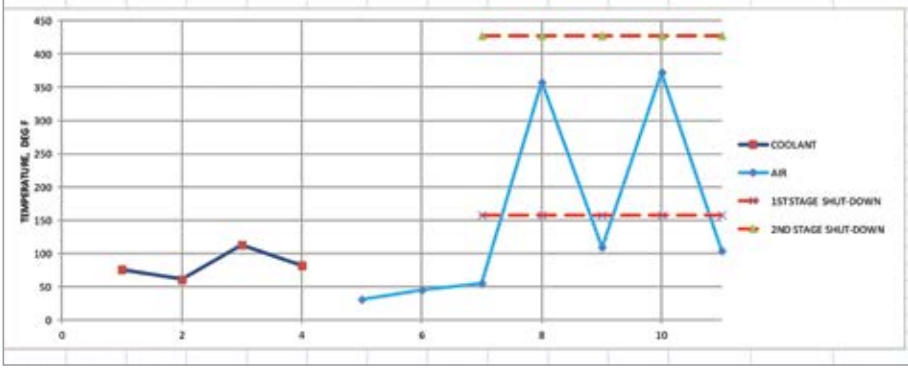


Table 2: Winter Temperature Measurements and Calculation

PROJECTED SUMMER PERFORMANCE

	COOLANT				AIR							LOAD		COMPRESSOR THERMAL PERFORMANCE		HEAT EXCHANGER PERFORMANCE			
	COOLING TOWER WATER TEMPS		WATER/COOLANT HEAT EXCHANGER WATER TEMPS		OUTSIDE AMBIENT TEMPS		COMPRESSOR 1ST STAGE AIR TEMPS		COMPRESSOR 2ND STAGE AIR TEMPS		AFTERCOOLER AIR TEMP	COMP AVG PRESSURE	COMP AVERAGE % LOAD						
	INLET WATER TEMP	OUTLET WATER TEMP	INLET COOLANT TEMP	OUTLET COOLANT TEMP	WET BULB	DRY BULB	INLET	OUTLET	INLET	OUTLET	OUTLET			1ST STAGE TEMP RISE	2ND STAGE TEMP RISE	COOLING TOWER APPROACH TEMP	COOLANT HEAT EXCHANGER APPROACH TEMP	INTERCOOLER APPROACH TEMP	AFTERCOOLER APPROACH TEMP
COMP 1			132				110	420	136	418	154	111	62%	310	282			4	22
COMP 2			132				110	425	170	453	150	121	62%	315	283			38	18
COMP 3			132				110	393	172	397	158	113	62%	283	225			40	26
OVERALL/ AVG	**95**	**80**	**132**	**101**	**50**	**100**	**110**	**413**	**159**	**423**	**154**	**115**	**62%**	**303**	**263**	**30**	**21**	**27**	**22**

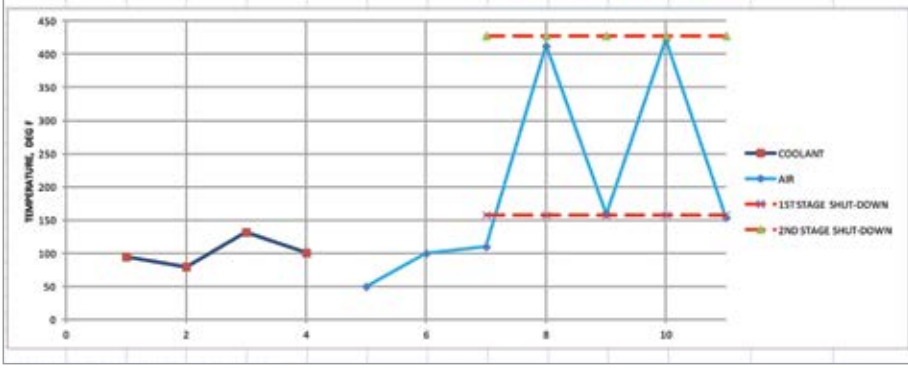


Table 3: Summer Temperature Calculations

COOLING TOWER SYSTEM AUDIT FOR A TOUGH MINING COMPRESSED AIR APPLICATION

the air-side is fouled from dirty compressed air entering the compressor.

- **Compressor Aftercooler:** These are the same type and design as the intercoolers, designed for 100- to 125-psig air and a lower approach temperature.
  - **Performance:** The case study heat intercoolers delivered an average of 104 °F air out. The average approach temperature was 22 °F, which is too high.

We found that the total "approach temperature" of the system, which is the difference between the primary coolant, ambient air dew point, and the final air temperature out of the compressor, is 73 °F.

From the measurements in this system, we projected what the system temperatures would be on a summer day. The compressors would shut down on high second stage outlet temperature (428 °F) and high second stage inlet temperature (158 °F). Dryers would not achieve their dew point. Oil temperatures would be high as well (See Tables 2 and 3).

Cooling System Modification Recommendations

In the audit, we recommended the following changes:

1. **Lower maintenance compressors:** Since the compressors were close to the end of their useful life, the mine was interested in replacing them. Though they are highly reliable, two-stage, oil-free screw compressors have significantly higher long-term maintenance costs than oil-flooded rotary screw and centrifugal compressors. Additionally, in the dusty environment, the current units had unique problems. Because of the high noise level of the compressor, the mine required the sound enclosures to be closed all the time. Because of MSHA rules, the sound enclosures are a "confined space," which limited access. The motors were "open drip-proof" (ODP) and not visually inspected. The motor rotors became encrusted with dirt and overheated repeatedly. An open-type compressor package was recommended. That all said, the current supplier has had this type of compressor in mining applications all over the world, and could support the project with differently designed oil-free screw compressors.

2. **Dedicated, closed-loop fluid cooler without intermediate heat exchangers:** This would eliminate dirty air being scrubbed into part of the coolant, and reduce frequent maintenance to merely the external side of the cooling tower heat exchanger. The approach temperature from wet bulb to compressor inlet could be reduced from 51 °F to 15 °F, eliminating the overheating problems.

3. **Comprehensive monitoring and control:** There are transmitters in the system that we saw in the drawings, but they were not being trended in the plant data historian. Nor did the maintenance and engineering staff have access to graphical display of the compressed air system showing key performance indicators. We recommended a comprehensive monitoring and control system, integrating compressors, dryers and a cooling system.

4. **Comprehensive Maintenance:** One compressor OEM had a maintenance contract for the compressors only. For unknown reasons, they were not also responsible for the dryers and cooling system. As a result, the dryers and cooling systems were neglected. We recommended a comprehensive maintenance approach, either in-house or outsourced.

In conclusion, cooling systems for compressed air systems in mining environments need to have special attention given to minimize the possibility of cooler fouling. Otherwise, the system will become unreliable, vulnerable to shutdowns and provide poor-quality air. BP

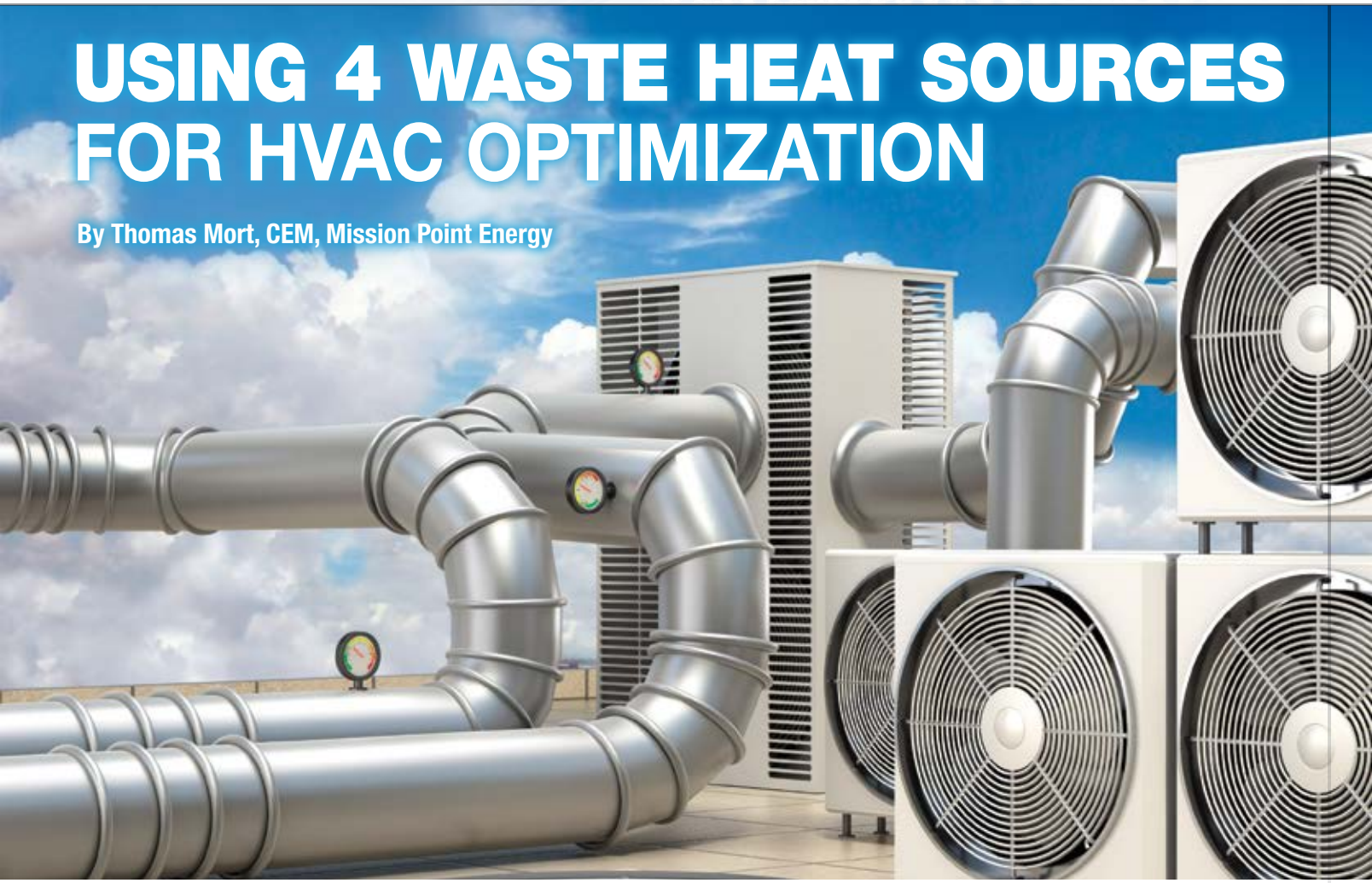
For more information, contact Tim Dugan, P.E., President, Compression Engineering Corporation by phone (503) 520-0700, or visit www.comp-eng.com.

"Cooling systems for compressed air systems in mining environments need to have special attention given to minimize the possibility of cooler fouling."

— Tim Dugan, P.E., President, Compression Engineering Corporations

USING 4 WASTE HEAT SOURCES FOR HVAC OPTIMIZATION

By Thomas Mort, CEM, Mission Point Energy



The Big Picture

Heat recovery opportunities have resulted in the largest amount of savings of our common projects our industrial energy management teams have implemented. It is not the easiest type of project to implement but the amount of savings and the reduction of emissions makes this project very worthwhile.

The first question I ask in workshops is: What is the purpose of the cooling tower located outside of your plant? The answer: To remove waste heat. Second question: Does it make sense to use a system to remove heat from your plant and then use expensive natural gas to provide heat for makeup air?

Many times I usually get the response: The low grade heat from the coolant loop is not sufficient to provide the heat we need for our factory. My answer: Is the coolant loop temperature >10 degrees F warmer than the outside winter air temperature? Then warming the incoming air will reduce the heating load. Look at this table of weather data from Ohio. There are 4,000 hours where the average temperature is less than 37 degrees F!

Project Review

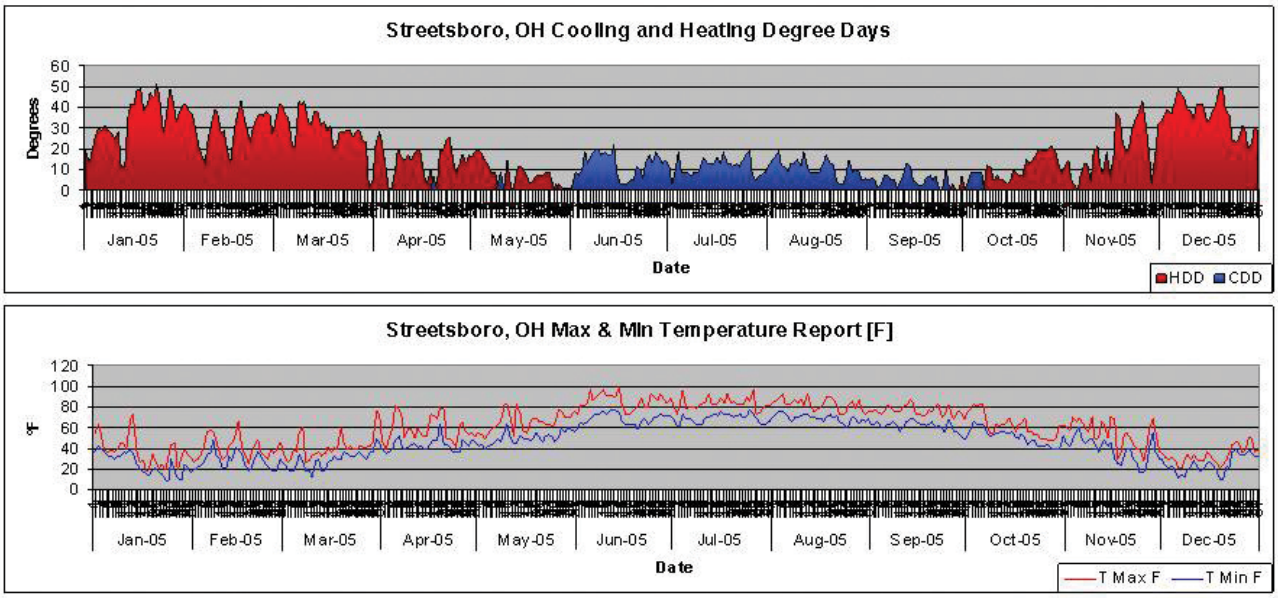
Let's begin the review of this project. Symptoms which can help identify the opportunities for this project include:

1. The facility has sources of waste heat such as cooling towers or furnace or equipment exhaust.
2. The facility has a large amount of air exchange such as exhaust hoods, filtration systems, ceiling or wall exhaust fans.
3. Winter heating is required such as natural gas forced air, steam, or hot water systems.

Cooling Tower

Dry Cooler

USING 4 WASTE HEAT SOURCES FOR HVAC OPTIMIZATION



Weather									
hrs/yr <46[F]	Avg[F] <46[F]	hrs/yr <56[F]	Avg[F] <56[F]	HDD/yr	CDD/yr	hrs/yr >65[F]	Avg[F] >65[F]	hrs/yr >75[F]	Avg[F] >75[F]
3,168	32	4,464	37	5,452	1,251	3,072	75	1,320	80

Weather Charts

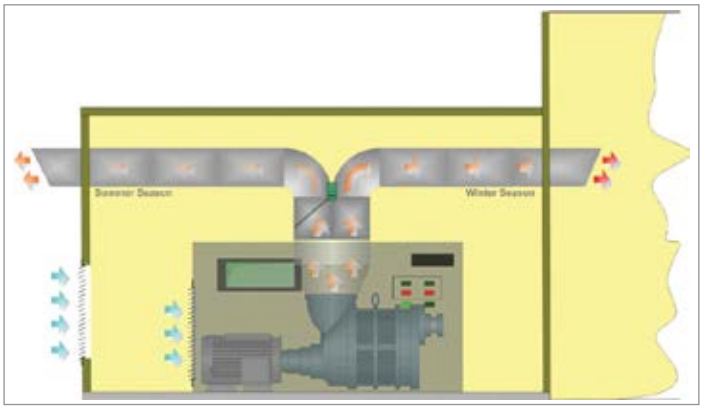
Heat Source #1: Air-cooled Air Compressors

One of the simplest projects to get waste heat is from an air cooled compressor. This is a common project but I continue to find plants where this source of free heat is not being utilized.

A key to the success of this project is to be sure to use outside makeup air for the intake and discharge the warmed air into the ceiling area of the facility, not directly blowing on an individual.

To calculate the value of this free heat use this simple formula:

Air Cooled Air Compressor	Average kw/hr	hours/year requiring winter hear	mmbtus/kwh	$/mmbtu	recoverable heat	$Savings per year
Compressor #1	100	4000	0.00341214	$10,000	90%	$12,284



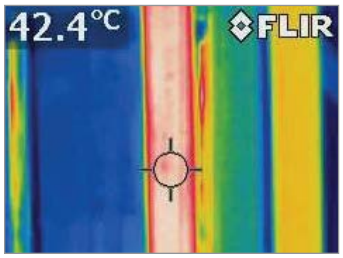
Air-cooled Air Compressor

Heat Source #2: Coolant Loop of an Injection Molder

Another method to recover waste heat is from the coolant loop. By intercepting the water at its warmest point before it arrives to the cooling tower and passing it through a radiator the heat in the water can be used to provide warmed make up air.

This photo shows the coolant water from an injection molding machine. The thermal image shows the temperature of the water. As you can see the temperature of the coolant water is significantly above the outside air temperature in the winter.

Injection Mold Coolant



Injection Mold Coolant

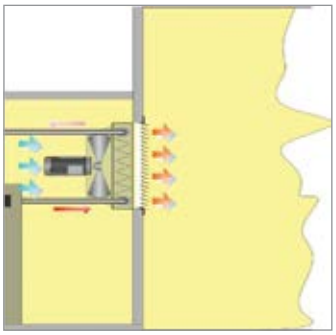
Here is the formula that can help to determine the value of heat available:

Heat Recovery from Coolant Loop	Differential Temperature	hours/year requiring winter hear	GPM Flow	Conversion to mmbtus	$/mmbtu	$Savings per year
Water to Air Heat Exchanger	10	4000	100	0.00501	$10.00	$20,021

Heat Source #3: Various Heat Wasters

The next diagram and shows a typical installation drawing. As with the air cooled compressor it is important that this system be set up to bring in outside makeup air and then exhaust the air into the ceiling area of the facility.

Here is a photo of what I call a "Heat Waster". This is exactly the type of unit that could have the discharge air ducted into the plant during the winter for free heat.



Water-to-Air Heat Exchanger

Water-to-Air Heat Exchanger Photo

Many plants have been able to reduce their winter heat loads using this concept. Many, even in Michigan and Wisconsin have been able to eliminate the need for natural gas heat during production hours.

I have found a company that supplies this type of heat recovery device along with some electronic measurement equipment which provides details of the amount of energy and savings that is being recovered from the coolant water. (www.amsenergy.com) This 100 gpm radiator unit with a metering system can cost around $25 to $30,000.

Heat Source #4: Free Cooling

Another area to find savings is called "free cooling". The concept of "free cooling" is that when the outside temperature is more than 10 degrees below the required coolant temperature the electric chiller can be bypassed and the cooling tower can be used to provide the cooling with a much lower energy use. Many facilities, especially those with injection molding processes use electric chillers to cool molds and hydraulics. A common temperature for the cooling loop ranges from 55 to 75 degrees. Refer to the chart above and you can see there were more than 3,000 hours with an average temperature of 32 degrees in Ohio.

"Many plants have been able to reduce their winter heat loads using this concept. Many, even in Michigan and Wisconsin have been able to eliminate the need for natural gas heat during production hours."

— Thomas Mort, CEM, Mission Point Energy

USING 4 WASTE HEAT SOURCES FOR HVAC OPTIMIZATION

Free-cooling Plate-and-Frame Heat Exchanger

Calculating the savings is based upon the following formula:

Free Cooling	kw/hr	hours/year temperature is < 46 °F	Electric $/kwh	$Savings per year
Electric Chiller	150	3000	0.085	$38,250

Free Cooling projects can often be combined with heat recovery projects and allow using much of the same equipment and getting two types of savings, electric from shutting down an electric chiller, and gas from reducing the load on the makeup air heating units.

Summary

Combining heat recovery projects together with HVAC projects described in the earlier article makes a combination where you can significantly reduce winter heat costs and have projects meeting our target of 1 year or less. BP

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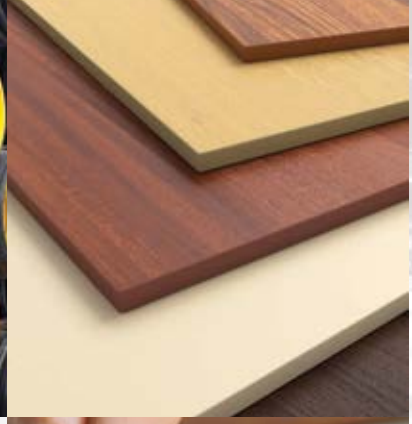

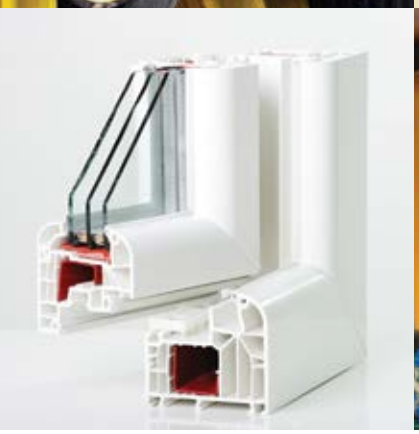

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