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January/February 2021

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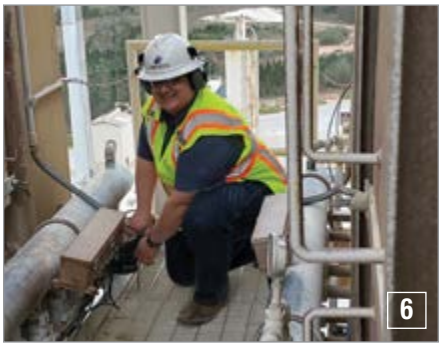

PRODUCTIVITY, SUSTAINABILITY & ENERGY CONSERVATION FEATURES

INDUSTRY & TECHNOLOGY NEWS

EVERY ISSUE

SUPPLEMENT ON PAGE 45!

COVER PHOTO. This month's cover features the Imerys S.A. calcine plant in Sandersville, Georgia.

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FROM THE EDITOR

How reliable are compressed air and chilled water systems at your plant? Are they reliable *and* optimized for efficiency?

Quality, Safety and Reliability

Desiccant compressed air dryers are a critical component in many compressed air systems. We have two articles this month providing advice on how to proactively maintain and troubleshoot them to ensure reliable service.

Understanding the basics of the lubrication system in an oil-flooded rotary screw air compressor is the focus of an article sent to us by lubricant manufacturer, Isel.

Engineering firm Woodard & Curran allowed us to interview them to learn about their work designing a cooling system for plastics recycler rPlanet Earth. The resulting precise temperature control ensures quality while allowing the firm to reduce cycle times.

Atlas Copco has entered the process cooling chiller market. We interviewed them to understand the strategic reasons behind this big step.

Productivity, Sustainability & Energy Conservation

The Imerys calcine plant, in Georgia, is on our magazine cover as they were willing to share with us the results of their work optimizing dust collectors. The actions are being rolled out to all their plants with a projected energy savings of 16 GWh of electricity!

Optimizing the pneumatics on production equipment can improve worker safety, reliability and efficiency. Emerson has sent an article sharing three real-world applications using IIoT.

StudioJAED is an architectural, engineering and facilities consulting group who designed an advanced-efficiency cooling and heating system for an elementary school in Maryland. Our article provides the details on how they worked with Building Systems & Services, Inc. and with mechanical contractor Ralph G. Degli Obizzi & Sons to make it happen.

HGA is a major engineering firm and we are very pleased they sent us a technical article titled, "Full Heat Recovery Engagement: Using Current Technology to Electrify Heating Loads." Last but not least, long-time subscriber Tom Pagliuco, from AbbVie, has sent us a great article titled, "Sustainable Chilled Water Systems in Pharmaceutical Plants."

Thank you for investing your time and efforts into ***Compressed Air and Chiller & Cooling Best Practices®.***

ROD SMITH, *Editor*
tel: 412-980-9901
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PRODUCTIVITY, SUSTAINABILITY & ENERGY CONSERVATION

Dust Collector Pilot Program Points to 16 GWh of Energy Savings at Imerys Minerals Processing Facilities

By Mike Grennier, Compressed Air Best Practices® Magazine

The Imerys S.A. calcine plant in Sandersville, Georgia, implemented a pilot program demonstrating how optimization of dust collectors can save up to 16 GWh of electricity across its plants in North America and reduce CO_2 emissions by more than 7,500 metric tons.

For Imerys S.A. there's little question about the importance of managing dust collection systems it uses to control and reduce harmful particulates in its worldwide minerals processing facilities. And now there's zero doubt about the tremendous energy savings it stands to save by reducing the amount of compressed air needed for these same dust collectors.

Thanks to a best practices pilot program at the company's calcine plant in Sandersville, Georgia, the company stands to save upwards of 16 GWh of electricity across North America – and reduce CO_2 emissions in the process by more than 7,500 metric tons by optimizing its dust collectors.

Robin Davis of Imerys Performance Mineral Americas and the engineer who led the pilot said it didn't take long for dust collector best practices to catch on at other plants after seeing the possibilities at the Sandersville operation.

"I was initially looking at this from the perspective of one plant, but I can't even keep up with how fast this is rolling out and how everybody is taking to it," Davis said. "Now we're all thinking, 'this is a no brainer.' It's easy to do and it's cost-effective."

Sustainability a Big Priority

The dust collector pilot program at the Sandersville plant is one example of Imerys' promise to take action on climate change and protect the environment.

Based in Paris, France, the multinational company launched its SustainAgility program in 2018 to meet its commitment to Science Based Targets – committed to reducing Scope 1 and 2 greenhouse gas emissions by 36% relative to revenue by 2030 from its 2018 base-year. Imerys, which specializes in the production and processing of industrial minerals for use in diverse manufacturing and construction industries, operates 230 industrial facilities across 50 countries. The company, which employs 19,000 people, operates 40 plants in North America.

The sustainability program at Imerys includes "I-Nergize" teams dedicated to finding and implementing initiatives aimed at energy and CO_2 reduction. The teams, which are divided between The Americas, Europe, Middle East and Africa (EMEA) and Asia, work with various processing plants to conduct regular energy assessments and identify energy-savings opportunities. Each plant subsequently implements any number of projects based on the roadmap established, along with continued help from the corporate team when needed.

The goal, said I-Nergize team member Davis, is to identify energy savings that can be achieved with little to no cost, or with projects that have an attractive ROI.

Imerys Performance Minerals North America

Imerys Performance Minerals North America extracts different types of minerals at its mines, which are then processed for use in a wide range of industries and applications including construction, hygiene products, paper, paint, plastic ceramics, telecommunications and beverage filtration.

At its processing facilities, Imerys relies on compressed air for conveying materials, as well as powering a host of pneumatic systems and devices. By far the biggest user of compressed air are the plants' baghouse dust collectors, which filter, separate, and capture dust and particulate matter in various processes and then release clean air. The dust collectors play a critical role in the company's ability to maintain environmental compliance, while helping it maintain product quality.

A typical compressed air system at an Imerys processing facility includes any number of rotary screw air compressors and the occasional centrifugal unit, combined with wet receiver tanks, and dryers. The configuration of each

Dust Collector Pilot Program Points to 16 GWh of Energy Savings at Imerys Minerals Processing Facilities

compressed air system is dependent upon the size of the operation and the minerals processed. Additionally, the setup for each system differs from plant to plant.

Less Pressure is Better for Dust Collectors

World-class is the aim of the Sandersville operation, which uses a calcination process to produce kaolin clay. The clay is used in numerous products such as paper, rubber, and paint. When the plant experienced problems with the reliability of several pulse jet dust collectors, Davis and plant decision-makers dove in and formulated plans for a pilot program aimed at optimizing the dust collector systems.

The team closely examined how compressed air is used with the plant's 72 dust collectors 24 hours per day, seven days a week and explored strategies for improvement. One particular area of interest was the level of pressure used to pulse dust collectors. The team found the plant's compressed air system was delivering pressure to the dust collectors at 100 psi, which was unnecessary and problematic. Supplying more pressure than needed was simply due to antiquated methods, Davis said. "It's how the plant did it for 20 years," he said. "It's the old adage of, 'If you've got pressure at 80 psi, 90 psi is better, and if you have 90 psi, 100 psi is better.' Of course, that might be able to help with leaks, but it really just helps cover them up. And after we talked with some of our vendors, we realized too much pressure can cause problems in terms of reliability and the life of the dust collector bags."

The team discussed whether to reduce the level of compressed air pressure at length but couldn't agree on whether to lower it. Ultimately, the plant manager opted to experiment with the concept of lower pressure as part of the pilot program. The experiment meant shutting off one of the plant's seven air compressors, which in turn, lowered the pressure supplied to the plant from 100 psig to 85 psig. It also meant gauging the reaction of those on the team against lowering pressure.

"We hit the off button on one of the air compressors and waited for the alarms and complaints from people," Davis said. "We didn't hear anything right away so we went the rest of the day and still didn't hear anything."

One day of shutting down one of the plant's air compressors led to several more days of having the machine offline and operating at lower pressure – all without any complaints. Afterwards, Davis shared the results of the experiment with the full team at the plant, some of whom were not aware that pressure had been lowered.

"Once the group saw the data and the technical information about how we shouldn't be pulsing the bags at 100 psi anyway, things started to click," he said.

New Control Method and Pulse Valves Prove Worthwhile

As part of the pilot at Sandersville, Davis and the team also explored various methods of pulsing compressed air to clear the bags, as well as technologies used to do it more efficiently.

Research led to the installation of differential pressure monitors in place of manual gauges and the implementation of a pulse-on-demand approach for managing various dust collectors. The approach includes the use of electronic timers installed on each dust collector system and tied to a Programmable Logic Controller (PLC), which in turn, initiates pulsing and stops it when it's not needed based on differential pressure settings.

"In a lot of cases, for example, we have dust collectors that are primarily used for environmental compliance and they don't see a lot of material, which means we might be able to reduce the pulsing by as much as

Imerys Performance Minerals North America extracts a wide range of minerals at its mines and processes them for use in a host of industries and applications.

Dust Collector Pilot Program Points to 16 GWh of Energy Savings at Imerys Minerals Processing Facilities

70%," Davis said. "That's a 70% reduction in energy consumed for that dust collector and we've extended the bag life. It's a no brainer."

The use of differential pressure monitors also allows the plant to measure the performance of dust collectors and make ongoing improvements for the purposes of environmental compliance, in addition to providing troubleshooting capabilities to help bolster plant uptime.

"If we find we didn't get a good number on one of the dust collectors for a given week we just pull the history on it," he said. "The plant can also make the necessary adjustments to achieve efficiencies and strengthen system reliability."

The pilot program also considered efficiency of pulse valves used on the dust collectors. More research led to the installation of a newer valve design that uses spool technology rather than diaphragm-style technology for pulsing several bags. The technology showed promise for better performance and reduced compressed air consumption.

Robin Davis of Imerys Performance Mineral Americas installs a technically advanced pulse valve that has proven to improve dust collector performance and reduce compressed air consumption.

"The diaphragm on a traditional valve is generally a rubber-type material and it can basically have microfractures that allow air through, which requires a lot more work since less air is getting through. Instead of having that rubber constantly flexing, a valve with a mechanical spool goes back and forth to allow the transfer of air. You get a cleaner, crisper pulse and less air consumption," Davis said, noting that one collector with the newer valve technology has proven its ability to lower compressed air use by as much as 40% while maintaining bag life.

Standardization Saves Energy and Improves Reliability

Davis said the dust collector pilot program at Sandersville is in addition to a corporate-wide initiative to standardize on technologies and systems as a way to increase efficiencies, enhance plant reliability, and maintain environmental compliance.

"I can easily say 90% of our industrial plants have dust collectors in them, but we have varying levels of standardization for reliability for the equipment," Davis said. "Additionally, we know we need to be in environmental compliance, so we thought, let's start with standardization of dust collectors in North America."

Part of standardization for Imerys means documenting best practices and technologies used to improve energy and plant reliability and making the information easily available and accessible to all Imerys operations.

"You might go to one dust collector system that's been in service for 30 years and it will have five different pulse valves," Davis said. "With all of these little design differences you don't get as reliable of a system as you could have."

Davis said another example of standardization to enhance plant efficiencies and reliability is related to the quality of air delivered by any given plant's compressed air system.

"Introducing water into a dust collector either makes mud or concrete, depending on the mineral. It's very bad for quality, and plant uptime if we get water in our compressed air," he said. "So we're working to address it by doing things like adding water separators to compressed air systems and developing recommendations for target pressure dew points for specific dryers and filters. This is the next big focus area for us."

Dust Collector Optimization Best Practices Put to Work

The dust collector pilot program has been deemed a tremendous success, which is proven by the results – and the decision to continue implementing dust collector best practices at the Sandersville plant and other facilities.

Results of the program are seen in the ability of the plant to save $68,000 per year in annual energy savings. In addition, the project earned Imerys a 2020 Better Practice Award from the Department of Energy (DOE) Better Plants® program.

Today, the Sandersville facility typically uses only five of its seven air compressors to supply the plant and its dust collectors with compressed air at 85 psig. It's also working to implement a capital project to replace all traditional diaphragm-style pulse valves on its pulse jet collectors with the new, spool-style valves. Additionally, it's moving forward with its pulse-on-demand control system for all of its dust collector systems.

Davis said he's especially excited about the longer term impact of the dust collector pilot for Imerys and its ability to protect the environment. Toward that end, Imerys has the realistic opportunity to reduce its annual electric use by 16 GWh and eliminate over 7,500 metric tons of CO_2 emissions by following the same best practices of those in play at the Sandersville pilot and optimizing nearly 600 dust collectors across North America.

"As we implement more and more of these best practices and we start seeing the true numbers, I think our efforts will have a big impact on our sustainability goals. We just have to start applying this across our different sites," Davis said. BP

All photos courtesy of Imerys.

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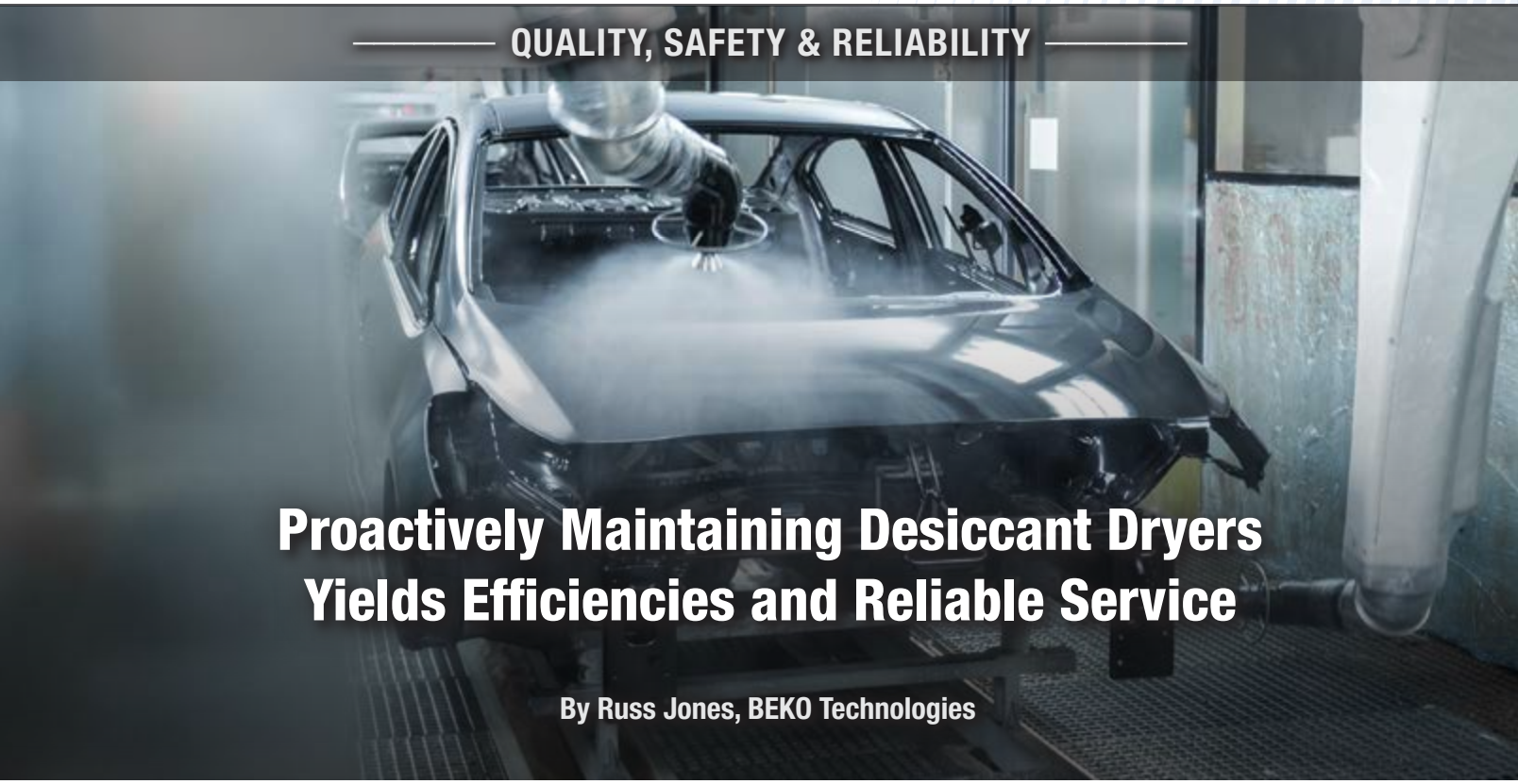


Proactively Maintaining Desiccant Dryers Yields Efficiencies and Reliable Service

By Russ Jones, BEKO Technologies

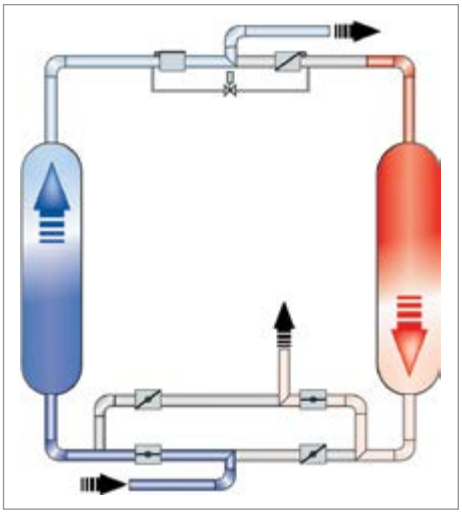
Moisture in compressed air is almost never a good thing. It can damage a compressed air system by causing corrosion, rust and scale buildup. It can damage downstream equipment with these moisture byproducts or with the moisture itself. It can negatively affect processes and products that require dry compressed air.

There are many ways of reducing moisture in compressed air but if you need to do more than just eliminate liquid water at normal indoor temperatures, it's probably a desiccant dryer you will be using. What follows is advice on care and maintenance of these dryers with close attention paid to twin-tower desiccant dyers.

Moisture Spells Trouble

Problems related to moisture in compressed air can range from someone slipping on a puddle of water leaking from compressed air piping to a flawed paint job to damaging a piece of multimillion-dollar equipment or contaminating a batch of product. This is well known to users and suppliers of compressed air equipment, many of whom have learned these lessons the hard way.

Desiccant dryers reduce moisture via the process of adsorption and are also known as adsorption or regenerative dryers. One of the primary instances when desiccant dryers are employed is when the compressed air will be exposed to below freezing temperatures, either due to outdoor conditions or while passing through refrigerated areas. But there are also certain materials, processes and equipment that require very dry air. Here, we are defining "very dry" as air with a pressure dewpoint of -40˚F (-40˚C) or less which is ISO 8573.1 Class 2 or better.



Valves used to direct air on desiccant dryers must be maintained to ensure reliability and proper performance.

If only a small portion of the compressed air supply needs to be very dry, this can sometimes be handled with point-of-use dryers to suppress the dew point to the required levels after the air is pre-dried with a refrigeration type dryer. These are often membrane dryers or small desiccant dryers. If the majority of the compressed air needs to be very dry, a twin tower desiccant dryer is by far the most common solution.

Pre- and Post-filters for Twin Tower Desiccant Dryers

The three most common types of twin tower desiccant dryers are heatless, heated purge and heated blower purge. All use some type of adsorption media or desiccant in bead form which fills the towers to remove moisture as air passes through it. They operate with

one tower drying while the other regenerates (desorbs/removes the captured moisture from the desiccant).

Another thing these dryers have in common is that they all require maintenance to provide consistent and reliable operation. Specific and detailed information on maintenance intervals and procedures should be available in the operator's manual for the dryer. The manual should be made readily and easily available to everyone involved in the dryer's operation and maintenance. Most twin tower desiccant dryers require both pre- and post-filtration.

The pre-filter protects the dryer, particularly the desiccant itself, from contamination in the airstream like dirt ingested by the air compressor or air compressor lubricant which bypasses the air compressor's lubricant separation system. The pre-filter can also protect the dryer from ingesting bulk moisture, especially if a "wet" air receiver is not installed. Since this protection is so crucial, the pre-filter is generally rated at .01 mg/m^3 ISO 8573.1 Class 1. With this fine of a filter, it is often advisable to add a more coarse (larger micron rated) filter upstream of this filter to reduce maintenance intervals.

The post filter keeps any dust or residue from the desiccant from traveling downstream. This dust is produced by the desiccant beads rubbing against each other as the air passed through the desiccant bed.

Filter Maintenance

Though the engineering that goes into filter design is very sophisticated, their operation and maintenance is fairly straightforward. The element within the filter housing captures contamination in the air and will need to be replaced when the contamination begins to impede the airflow causing pressure drop across the filter to rise.

Some filters are equipped with differential pressure gauges which can be a useful, but they're not a foolproof way of determining element change intervals. Overall, the contaminant load in the air stream will determine how often the elements need to be changed. As mentioned earlier, dual pre-filters, from coarser into finer, will divide the contaminant load and extend the change interval. A good rule of thumb is that filter elements should be changed no less frequently than every 8,000 hours of operation.

It is also crucially important to maintain the auto drains on the pre-filter(s). Any liquid contamination captured by the pre-filter(s) will drop to the bottom of the filter housing and need to be drained. Drain failure in a pre-filter can lead to liquid contamination entering the

Russ Jones, Northeastern Regional Sales Manager, BEKO Technologies.

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dryer and damaging the desiccant media. On smaller systems, the pre-filter drains tend to be the internal float-type units, while larger systems usually use some type of external drain: mechanical, pneumatic or electronic. Drains on post filters are usually manual since if the dryer is operating properly, there will be no liquid in the post filter.

Valve Maintenance

Also common among these three desiccant dryer types (heatless, heated purge, and heated blower purge) is the use of valves to direct air flow within the dryer. These valves allow the incoming wet compressed air to "switch" from one tower to the other as the towers cycle between drying and regenerating so they are often referred to as "switching valves." These valves also direct the purge air from the regenerating tower to the purge mufflers for exhaust to atmosphere.

There are numerous types of switching valves based on the size and style of dryer but they are all critically important to the operation of the dryer. These valves are usually air-operated so there are also solenoid valves on the dryer package that direct the control air to the valves so each switching valve has three maintenance points for the user to be aware of: the mechanical valve itself, the pneumatic actuator for the valve and the solenoid that directs the control air.

All three of these components should be regularly inspected and maintained as should the control air filter/regulator which uses dry air from the downstream side of the towers and prevents control line contamination from desiccant dust.

A switching valve failure can lead to desiccant over-saturation, poor dew point performance and even dryer failure. Many dryers can be equipped with "failure to switch" alarms which are usually pressure transducers that monitor the tower pressure to confirm that each tower is being pressurized for the drying cycle and de-pressurized for the regeneration cycle. There are also check valves at the compressed air discharge of each tower to prevent back-flow and safety relief valves (one per tower or a shared valve) that also require regular inspection and maintenance. Always refer to the operator's manual as well as local codes (particularly for the pressure relief valves) for specific information regarding maintenance and inspection intervals.

Desiccant Material Maintenance

Another important maintenance item for desiccant dryers of all types is the desiccant material itself. Various types of desiccant are used in compressed air dryers, sometimes multiple types in a single dryer. The three most common desiccant types in compressed air dryers are activated alumina (aluminum oxide), silica gel (sodium silicate), and molecular sieve (zeolite).

BEKO Technologies' DRYPOINT XCp desiccant dryer offers efficient low dew point heatless desiccant drying.

All three types mention have a service life and will require replacement at some point. Desiccant is degraded through bead-to-bead abrasion from movement caused by the passage of air through the bed and also by repeated adsorption (drying) and desorption (regeneration) cycles. It can also be damaged by contamination, most commonly air compressor lubricant and/or liquid water. When a significant contamination even has occurred, like an air compressor separator element failure or an upstream drain failure, the evidence of damage is often obvious: lubricant in exhaust mufflers and/or post filters or lubricant and moisture downstream. In these cases, complete desiccant replacement is necessary.

The gradual breakdown of desiccant due to normal "wear and tear" is more difficult to ascertain. It can be determined by the degradation of dryer performance but since this performance degradation can happen fairly quickly leading to damage to the dryer or even then entire system before service can be performed, desiccant is often changed proactively based on operating hours or elapsed time (two to three years for heated and heated blower purge dryers and three to five years for heatless dryers).

With larger dryers where a desiccant change can be an expensive and time-consuming procedure, desiccant sample testing can be used to determine change intervals. Desiccant sample testing can include measuring heat of adsorption (adsorption is an exo-thermic or heat producing reaction), moisture adsorption by weight, and measurement of surface area to determine the level of bead abrasion. This information can be used to estimate the remaining life of desiccant material to avoid unnecessary maintenance expense.

Purge Exhaust Mufflers

Other components requiring maintenance in desiccant dryers are the purge exhaust mufflers. These mufflers, as their name suggests, reduce the noise caused by the release of air passing through the off-line tower during the tower de-pressurization and regeneration/purge cycles. As this air flows directly through the desiccant bed and into the muffler, it carries desiccant dust along with the moisture it is removing from the tower. This dust can clog the mufflers over time which can cause back-pressure and reduce the effectiveness of the regeneration.

Upon initial start-up, there can be a fair amount of desiccant dust released due to vibrations and movement during the shipment of the dryer to the job site and/or the initial loading of the desiccant into the dryer towers. Most dryer manufacturers recommend running the dryer without the exhaust mufflers for a period to allow any excess dust to exhaust without clogging the mufflers. Most mufflers have internal elements that can be changed out when necessary but there are some, particularly on smaller dryers, where the entire muffler assembly is replaced. Maintenance intervals can vary based on the duty cycle of the dryer among other factors but the mufflers should be inspected regularly and most manufacturers recommend annual replacement.

Heated purge and heated blower purge dryers are more complex devices than heatless desiccant dryers and so require additional maintenance. Important is the need to regularly inspect electrical connections and the overall condition of the heating elements as directed by the manufacturer and in compliance with all applicable safety codes and regulations. The blowers on heated blower purge dryers also require regular inspection. The inlet filters for these blowers are a maintenance item. The filters prevent the ingestion of ambient contaminants that could damage the blower as well as the desiccant. Like all filters, the maintenance interval for blower inlet filters is dependent on ambient conditions so should be inspected regularly and changed as needed.

Dew Point Quality Monitoring

Most desiccant dryers use at least some sensors and the use trend is definitely upwards as more users want more data available to them through the dryer controller. These sensors measure values including pressures, temperatures, humidity and pressure dew point. The sensors provide data to help govern the operation of the dryer but also provide reference information for the user. Luckily, most of these sensors do not require calibration but dew point sensors generally do, usually on an annual basis, or after 8,000 operating hours. In addition to measuring outlet dew point to confirm dryer performance, dew point sensors can be used as energy saving devices as part of a purge control system on a desiccant dryer.

Monitoring the outlet dew point can allow the dryer to extend its drying cycle beyond the time needed to regenerate the off-line tower thus providing purge-free operation which saves compressed air and, of course, energy and money. In short, the dryer can continue to operate on the on-line tower until the outlet dew point begins to degrade. At that point, the towers can switch.

A best practice is to monitor both outlet dew point and mid-tower humidity in the drying tower and use both data points to define the

Proactively Maintaining Desiccant Dryers Yields Efficiencies and Reliable Service

length of the drying cycle with outlet dew point being more accurate as you are directly measuring what you want to achieve in terms of dryer performance and mid-tower humidity being faster reacting as it gives the dryer more time to react before performance degrades.

While dew point sensors on a dryer package do provide valuable data, that data does not tell you if you are getting the required pressure dew point downstream at point of use. Even the best compressed air systems will experience some dew point degradation as the air travels downstream due to moisture re-entrainment.

Whenever there is very dry air on one side of a pipe and relatively moist atmospheric air on the other side, the universe will be trying to equalize those moisture levels through every pipe fitting, drop, and leak in the piping system. If you have a critical air use downstream that requires a specific dew point, it makes sense to monitor the dew point in that area of the system to make sure you are getting the air quality that you need.

After spending the time and money to install and properly maintain a desiccant dryer, it would be a shame to experience an issue caused by downstream piping. The most basic solution would be a stand-alone dew point monitor (sensor and display) that shows the local dew point visually and has a programmable alarm to trigger action if a certain threshold is reached.

A more elaborate solution, and one that might make sense in an environment where air quality needs to be monitored for regulatory compliance, would be a system that allows the dew point data to be downloaded, stored and trended as needed, either as a separate system or integrated into a larger central monitoring system.

Take a Comprehensive and Proactive Approach

A comprehensive, proactive maintenance program guided by both manufacturers recommendations and site-specific historical data will go a long way towards making sure that twin tower desiccant dryers provide many years of reliable service supplying the dry air that many compressed air systems require. Downstream dew point monitoring can confirm both dryer and air system performance and give users the

Stand-alone, programmable dew point monitors help ensure desiccant dryers deliver the air quality needed at critical use points.

visibility required to keep things running smoothly. BP

Russ Jones is Northeastern Regional Sales Manager with BEKO Technologies. Jones has been working in the compressed air industry at both distributor and manufacturing levels for over 30 years and has been with BEKO Technologies since 2015, email: russjones@bekousa.com.

BEKO Technologies develops, manufactures, and distributes components and systems for the treatment and management of compressed air and compressed gas. The independent family-owned company with headquarters in Neuss, Germany was founded in 1982 and is now internationally positioned with over 500 employees and 14 sales offices and production facilities in the USA, India, and China. BEKO Technologies advises manufacturing companies in all industries to find the optimum solution for their compressed air treatment and to ensure that the required quality and energy efficiency in the process are maintained. For more information, visit www.beko-technologies.us. All photos courtesy of BEKO Technologies.

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PRODUCTIVITY, SUSTAINABILITY & ENERGY CONSERVATION

Three Real-World Applications for Pneumatics and IIoT

By Enrico De Carolis, Emerson

The integration of data-driven predictive maintenance with preventive maintenance is one example of how IIoT-enabled pneumatics can solve ongoing challenges.

Industrial operations and manufacturers using pneumatics have access to more Industrial Internet of Things (IIoT) technology than ever before, from position sensors on cylinders to system flow sensors and edge gateways that operate independently from the machine controller with globally accepted communication protocols.

However, the rich data these tools produce also presents a challenge for machine builders and OEMs: How do we put the Industrial Internet of Things (IIoT) to work in a way that makes the most of opportunities in a digitized, highly connected world?

Let's explore real-world applications that leverage IIoT-enabled pneumatics to solve fundamental challenges faced on an ongoing basis.

Improving Safety to Protect People and Equipment

Pneumatics have long provided efficient and cost-effective motion and actuation with reliable technology and a proven record of equipment safety. Now, IIoT technology, along with related European trends like Industry 4.0, creates new opportunities for pneumatics to further improve safety. Additional functional insights also allow users to monitor a machine's safety characteristics to better protect people and equipment from harm.

Consider a machine using a safety light curtain to disable a pneumatics valve system when an operator is loading or unloading a part to be processed into the machine. Historically, safety applications have relied on statistical calculations to define a safety component's mission time replacement cycle.

Mission time defines the number of cycles when a safety component requires replacement regardless of whether it is functioning or not, in order to keep the calculated statistical safety

function valid. While the valve may seem to be okay according to its rated mission time, there are other measurable factors that may not be considered (for example, changes in valve response time). A response time that changes from 30 to 70 milliseconds could create a serious safety hazard by allowing an operator to move further into the machine's dangerous motion area before a safety response event is triggered.

A system using new IIoT technology would proactively capture, analyze and report the decline in the valve's response time, as well as the corresponding alert response time before the safety function is compromised. This type of actionable safety information creates a safer workplace.

Improving Predictive and Preventative Maintenance

Dealing with wear and tear is a daily challenge in any manufacturing setting. Predictive and preventive maintenance programs are critical to effectively managing machine lifecycles and maximize Overall Equipment Effectiveness (OEE).

For example, maintenance technicians can analyze appropriate data from IIoT sensors. They can then use that information to predict that a shock absorber at the end of an actuator is deteriorating by sensing a millisecond's increase in its stroke speed. This can trigger predictive maintenance protocols to replace the worn shock absorber. As a result, there are shorter or fewer machine stoppages and a reduction in unplanned downtime, or complete or unrecognized failures.

In addition, IIoT-enabled pneumatics can monitor functionality at a valve's location. A valve's state of wear can be hard to determine from the outside of a machine. If additional internal sensors are not an option, an IIoT gateway can evaluate valve life by tracking the valve's cycle counts. The user can then enable a cycle counter algorithm to determine how much of the valve's life cycle has been used and to predict how many operating days and hours it has left. This allows machine operators or end-users to plan downtime.

Data-driven insights for predictive maintenance can also help to improve the

Three Real-World Applications for Pneumatics and IIoT

scheduling of preventive tasks for pneumatics components. The data can be analyzed and used as information to guide plant management teams as they predict and address issues before they cause injury, damage, failure or production losses.

The integration of data-driven predictive maintenance with preventive maintenance also allows just-in-time part replacements, decreasing the need to purchase and warehouse a full inventory of system-critical, "just-in-case" parts. When pneumatics work together with IIoT, it creates a system that facilitates early detection and prediction of potential issues. Maintenance technicians can place orders to ensure parts are delivered when they are needed. In the future, this, too, could become an automatic step where the IIoT system itself autonomously sends the order to parts suppliers.

Improving Machine Efficiency

The real-world value of a certain technology ultimately equates to how well that technology boosts the bottom line and creates a return on investment. IIoT offers significant opportunities to improve pneumatics operations in several ways, including:

Regulating upstream/downstream flow: Combining the traditional strengths of a pneumatics system with IIoT-based technology can maximize process control and monitoring, particularly for upstream/downstream flow. The result is enhanced OEE and lower Total Cost of Ownership (TCO).

Consider a plant using a system that allows only fully open or fully closed positions on pneumatically actuated gates on a hopper or silo that dispenses bulk material for packaging. Uneven product flow and traffic jams can inundate or starve downstream processing stations. The inability to vary the dispensing gates' position based on downstream demand creates inefficiencies and bottlenecks throughout the plant. The results range from damages to the bulk material to overtime costs for personnel to make up production quotas.

A retrofit solution, without disturbing the existing controller or its program, can address the issue at a fraction of the cost required for new controller equipment or work process modifications. An intelligent, IIoT-based, closed-loop system, with appropriate sensors on IIoT-enabled pneumatics components, allows each gate's position to vary from zero to 100% of the opening – not just the two positions of opened or closed. The flexibility results in much better flow control for bulk material, without the need to change the controller program.

By adding additional components, such as an extremely precise pneumatic positioning system for control and IIoT gateway to analyze functionality, the system enables more efficient control of the bulk material, preventing starvation of the packaging system downstream as well as optimizing OEE. In addition, data from the IIoT system can be leveraged for additional system improvements. It could, for example, measure valve life so the operator understands whether a valve is performing to specification and, if necessary, change the component during scheduled maintenance while alleviating any unplanned downtime.

The Emerson RXi2, an edge gateway, allows analysis independent of the controller via local data collection and pre-installed analysis modules.

An intelligent, IIoT-based closed-loop system, including sensors on IIoT-enabled pneumatics components, allows for more flexibility in machine operation positioning.

Boosting energy efficiency: Smart energy usage is a key consideration for machine manufacturers and end-users alike. Data generated by IIoT-connected sensors can be converted into actionable information, allowing manufacturers to more fully understand and better manage energy usage.

For example, smart sensors can monitor pressure losses within the system and an IIoT gateway can analyze this data and send alerts when leakage becomes the predominant contributor to energy consumption. Users could then identify excessive leaks caused by a worn seal, for example, and mitigate them before they become a major concern. This functionality can also be achieved without changing the machine controller's program or process.

Additionally, smart technology can minimize air consumption, not only to save money but also to reduce wear on components. For instance, by monitoring and analyzing compressed air pressure with respect to cycle time, the end-user can reduce the preset system pressure at the point of use to the work side of a cylinder and determine the optimal operating point where the cycle time can be maintained with the least energy consumption. This also decreases component wear by optimizing generated forces and reducing vibrations.

Enabling manufacturing flexibility: From product customization to packaging variations, manufacturers increasingly require the flexibility to change equipment without sacrificing quality. Connected components can be engineered to easily and seamlessly supply different pressures for different tooling positions and sequences. A directional control valve system, for example, can support simple, on-the-fly changes and tooling positions for quick product variations and changeovers.

Build a Path Forward

Data is only as useful as its ability to provide insights, guide decisions and help justify investment. And while OEMs and end-users understand the potential to capture, aggregate and use sensor data, it's time to turn that potential into reality.

From creating a safer workplace to predicting failure before it happens and building flexible production lines, IIoT-enabled technology can generate real-world results in pneumatics operations. BP

Enrico De Carolis is Vice President of Global Technology, Fluid Control and Pneumatics at Emerson. Emerson is a global technology and engineering company providing innovative solutions for customers in industrial, commercial and residential markets. Emerson Automation Solutions business helps process, hybrid and discrete manufacturers maximize production, protect personnel and the environment while optimizing their energy and operating costs. Emerson Commercial & Residential Solutions business helps ensure human comfort and health, protect food quality and safety, advance energy efficiency and create sustainable infrastructure. For more information, www.emerson.com/en-us. All photos courtesy of Emerson.

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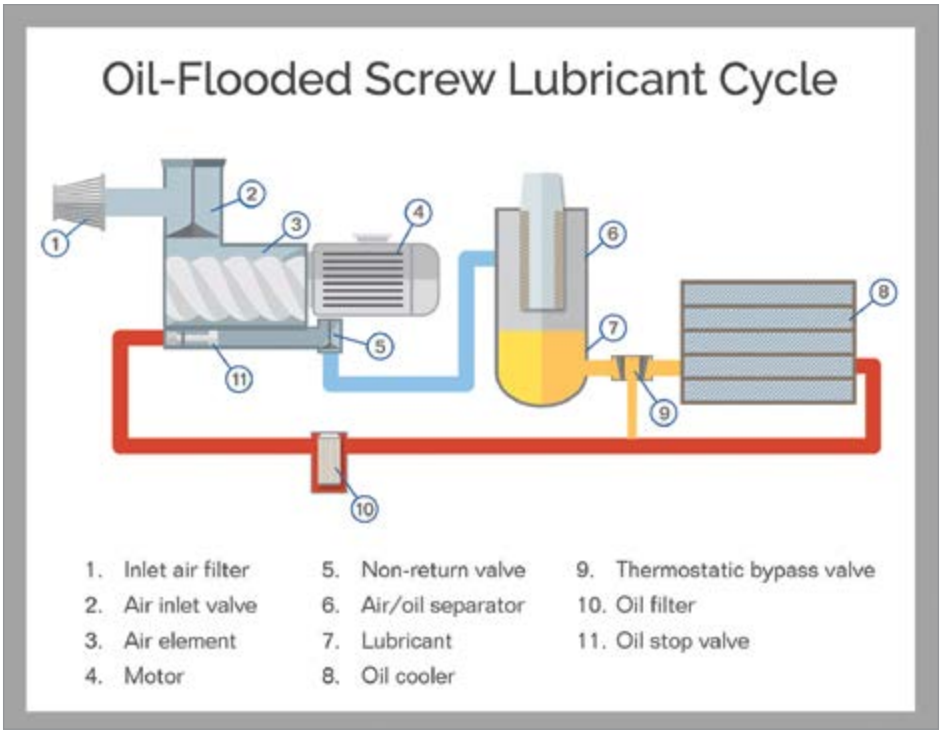
QUALITY, SAFETY & RELIABILITY

Rotary Screw Air Compressor Oil System Components

By Dave Brockett, Isel Inc.

There are many critical components involved in rotary screw air compressors, and the lubricant we use is of vital importance in the process. Screw machines rely heavily on these fluids for bearing lubrication, system cleanliness, water removal, sealing, as well as heat transfer. These fluids work in a very unforgiving environment and must function well in circumstances that would normally be deemed torturous in other lubricant applications. We run it at high velocities, through scorching temperatures, while we blast it with water. Over the years the airends have continued to shrink in size, and turn faster, and oil sumps grow ever smaller, pushing up internal temperatures and increasing the loads these lubricants must endure.

Understanding the basics of the oil system can help us to understand the importance of the lubricant and offer some hints when there are



Shown are the major components of an oil system in an oil-flooded rotary screw air compressor. Image courtesy of Isel Inc.

signs of trouble. In this article, we will go through the major components in the oil system, and some common problems associated with them. The major components can all be found in oil-injected screw machines, but depending on the manufacturer, there may be differences in their order of operation in the loop.

The Sump

We will start our trip through the loop at the same place we will finish: The oil sump. This reservoir is where oil is stored for use in the system. It is usually located in the lower section of a tank-like cylinder, that also houses components used in the air/oil separation process.

This is normally a trouble-free component on the sump side, though certain conditions can cause premature failure, and contamination. Most problems related to the sump are borne from water. If an access amount of water accumulates in the sump due to low oil temperatures, or the separation process fails to vaporize the water from heat of compression, it can continue to adversely affect the lubricant over a long period of time.

This buildup of water can not only damage the machine by replacing oil in critical lubricated areas, but it can cause corrosion in the sump, leading to particle contamination and unwanted metals. The sump is normally our low spot in the system, so there is also risk of airborne contaminants or particulate picked up through the inlet, separating and accumulating in the bottom of the sump. When this occurs, the lubricant can show high particulate counts, or unwanted metals on an oil analysis – and it can mislead technicians even after fresh lubricant changes. Since these particulates have time to settle in the sump, oil changes do not remove them very effectively. We can care for the oil sump by watching oil analysis for water content, making sure to minimize the entrainment of too much moisture, and periodically cleaning and inspecting the reservoir area where possible.

Oil Filter

Our first component outside of the sump is usually an oil filter. In most cases we have a spin-on automotive style centrifugal oil filter, which is designed for high flow and excellent particulate filtration.

Oil from the sump flows through small entry passages around the outside of the filter base and is forced through an opening near the closed side of the filter casing, where it passes through a filter median, then out the threaded center port, and downstream of the filter. These filters are very effective at removing particulate which may be ingested from the outside air as it is pulled in through the inlet. Other contaminants can also get

Rotary Screw Air Compressor Oil System Components

An internal thermostatic valve component. Photo courtesy of Ozen Air Technology.

caught in the media, preventing damage to the air compressor. Examples include solids that may have formed from a lubricant in the process of breaking down, wear materials like metals from wetted parts that are starting to degrade and failing sealing materials.

Many of these filters contain a spring-loaded valve internally at the media entrance, which will open and bypass the media when the oil is too thick to effectively pass through the filter media. This type of filter has the added benefit of protecting the machine from oil starvation while the lubricant is cold and at a higher viscosity. As the oil works its way up to operating temperature, the valve seals, sending the fluid through the media.

These filters are a key maintenance item and must be changed regularly to ensure a particulate-free oil sump. If these filters become completely clogged, they will starve the system of lubricant, and can cause catastrophic damage. They also represent a common leak point if the O-ring seal around the flange fails, or the filter fails to seat properly.

Thermostatic Valve

This is our first stop in our trip through the system. This valve will direct our lubricant towards its next component based on temperature.

Just like the engine oil in a car, air compressor lubricant works best within a certain temperature range. Air compressor lubricants

at room temperature have a viscosity or thickness much higher than desired at operating temperature. As we are going to operate this machine at a constant duty cycle, the fluid is manufactured to be at optimal performance once it reaches its operating temperature.

When the air compressor is first started, and the oil is cold, this valve will direct our oil straight into the airend and bypass the oil cooler. This will ensure the lubricant heats up quickly and can effectively perform all the tasks we demand of it. Once the lubricant reaches an acceptable operating temperature, this valve will direct the oil flow out to the oil cooler to maintain that operating temperature and ensure the oil does not overheat.

These valves are normally rather robust, and typically offer years of reliable service, though they do present some leak points. There are occasions where this valve may become clogged with foreign material which may be present in the lubricant. This is rare, as this component is typically downstream of the oil filter, but the accumulation of small particles on the wetted parts of this valve can cause it to clog or jam. Fortunately, modern rotary screw air compressors have controls that will shut the machine down if a loss of lubricant or high temperatures are detected, preventing catastrophic damage to the airend.

Another possible but uncommon failure could be related to a valve unable to cycle or move to its alternate position. This type of failure could be related to the valve's actuator, communication issues with the controller, or caused by debris preventing the valves movement. This can cause the lubricant to remain bypassed away from the cooler, causing high temperature of the lubricant fairly quickly, or the valve may continually send the fluid to the cooler regardless of temperature, causing access accumulation of water in the sump, by preventing the lubricant from preheating properly.

Oil Cooler

Our next stop, assuming our lubricant has reached its operating temperature will be to the oil cooler. As our lubricant has been subjected to extreme friction and bears the brunt of temperature gain from heat of compression, the lubricant will be very hot.

Temperature will have many negative affects on the lubricant. It shortens the life of key additives that are designed to increase shear strength, modify viscosities, prevent excessive foaming, and countless other additives could be present.

High temperatures affect almost all these additives. Another challenge lies in the base stocks themselves, which will turn acidic if overheated. Acid leads to varnish which can clog components, decrease efficiency, and cause severe damage. All these circumstances can be avoided by an effective oil cooler.

Air-cooled Air Compressors

This component, like the radiator in your car, passes the fluid through tubing encased in a block of baffles, designed to optimize heat transfer.

Most air-cooled air compressors have a high capacity fan which will force air through the baffles, and out of the cabinet, removing large amounts of heat from the lubricant. These fans have the added benefit of removing heat

Rotary Screw Air Compressor Oil System Components

from all the components inside the cabinet, and a good bit of engineering is typically involved in the design of the cooler, its fan, and the cabinet itself, to ensure the airflow is optimized to remove heat.

These coolers must be cleaned and maintained to ensure proper heat transfer is achieved. When the external surfaces of these coolers collect an excessive amount of dust or other debris from the air being forced through them, the heat transfer can be disrupted, causing high oil temperatures. Simply blowing clean air through a cooler – and removing this buildup – can have a drastic effect on an air compressor's operating temperature. Internally, the coolers can collect varnish or sludge, which can build up on the cooler walls, and insulate the lubricant from the much cooler inner wall of the tubing. This can often be removed with a cleaner solvent additive, or the cooler can be removed and cleaned with a chemical bath.

The thermostatic bypass valve on this unit is built into the oil filter housing. Photo courtesy of Ozen Air Technology.

Water-cooled Air Compressors

These machines use a liquid heat exchanger instead of an air/oil cooler. The lubricant passes through a series of tubes that run horizontally through a cylinder which is filled with a cooling medium. The cooling medium works on a pressurized loop, so that the cooling liquid is constantly flowing through exchanger.

As the cold fluid passes over the tubes of hot oil, the heat is transferred to the cooling liquid, and is removed from the lubricant. This is a less-common method of oil cooling as it requires a great deal of ancillary equipment in most applications and is typically only used in environments where air cooling the lubricant may not be feasible, or the cooling water system is used for other applications, making water cooling a practical option.

Common issues with water cooling may include corrosion from cooling water that is not properly treated. This can lead to failure of barrier between the lubricant and the cooling water, causing a mixture in the air compressor. Another concern is cooling water temperature. It can be too cold, causing accumulation of water from heat of compression, or not cold enough, causing high oil temperatures.

Oil Stop Valve

Our oil system is under pressure during normal operation, and flows through the oil stop valve, typically on its way into the airend. This is normally an in-line pilot valve that closes upon shutdown and helps to maintain some oil pressure in the airend. Without this valve, we could run very low or completely out of lubricant in the airend as we wind down, or the oil could flow backwards as pressure is lost.

Airend

All our components thus far have fulfilled

A centrifugal oil/water separator element. Photo courtesy of Ozen Air Technology.

their purpose, so now our lubricant is going to do its job.

The lubricant is going to bathe our rotating element bearings in warm, clean oil, forming a film between the rolling elements within the bearing and the bearings race, preventing direct metal to metal contact. The entirety of the rotating assembles will ride on top of this film, drastically reducing friction and optimizing efficiency.

As the oil is injected into the casing, it will form a thin film over the rotor tips and will become the primary sealing method to ensure that air is compressed between the rotors, as our now compressed air exits the airend. At this point the lubricant is emulsified with water, which has been squeezed from the moisture in the outside air during compression, and the compressed air itself. At this point in the process the primary concerns of our lubricant

are temperature and water.

The lubricant is going to pick up extremely high temperatures through this process, and it will relieve the rotors and bearings of this extreme heat by carrying the temperature out, and away from the airend. The lubricant needs to be very close to its design viscosity or thickness for this to take place effectively. If the oil is to thick, it may not transfer the heat fast enough. This can lead to high temperatures in the airend which may be difficult to troubleshoot.

Lubricants that have become acidic may form solids in the gaps of the rotors, which can be extremely detrimental to performance and efficiency. Another less-common failure that can be catastrophic is starvation of the lubricant from entering the inlet. In this rare occurrence, the element functions without the presents of the lubricant at all. The bearings will only function for a short time without lubricant separating the moving pieces, and with no heat transfer taking place. In most cases, well under a minute, the extreme heat will cause the rotors to swell and contact the inner casing. This usually results in destruction of the airend itself.

Air/Oil Separator

The airend has discharged an emulsion of extremely hot air, oil, and water, and it's time to separate out our finished product of compressed air, get our lubricant back to the sump, and remove the water we picked up in the airend.

All these tasks will be performed by the separator. We are going to inject this mixture into the same cylinder-shaped tank that our oil is stored in. Our cylinder contains a large separator/filter element at the top, near the inlet port where our mixture will enter, under pressure. This is a coalescing-type filter that will prevent the lubricant from leaving the system, help trap impurities and provide a barrier to give our lubricant no other alternative but to return to sump.

The mixture will spin around the outside of our separator creating a centrifugal effect, causing most of our lubricant to separate and drip down the interior of the cylinder and back to the bottom. Our separator element in the middle of this spinning mixture will only allow our compressed air to squeeze through the final filter median, creating a coalescing effect, and prevent oil and water from escaping downstream.

This process also vaporizes water from heat of compression and allows it to pass back to atmosphere. The medium is much too dense to allow the lubricant to pass, and it will form larger droplets as it gathers in the base of the element, and will fall downward back to lower area of the tank, where it will begin the cycle again. Some of the lubricant will be piped from the center of our separator, back to the air end via a scavenger line. This scavenger line is connected via tubing to the airend and is under vacuum and will collect any lubricant which passes through our separator and return it directly to the air end.

Newer air compressors, especially the smaller machines, utilize a spin-on-type unit, like the oil filter, instead of a large separator element. These spin-on separators have significant maintenance advantages as they are much easier to change. These separators function in much the same way, but are typically mounted

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inverted, and the scavenge line still pulls access lubricant from a port at the bottom of the filter housings casing.

Larger machines, usually over 100 horsepower (HP), typically use the traditional large separator element, and this arrangement can process a much higher volume of mixture. Some manufacturers still use this arrangement throughout their entire offering, though spin-on separators have become extremely popular for their cost savings and ease of maintenance.

At this point our lubricant is back in the sump and ready to make another loop through the system. Many of the components present in an oil-flooded screw air compressor are related to the oil, as it has so many roles to fill as it is manipulated by these components to provide compressed air. Some of these components are in combined units, where up to three of these jobs are performed by a single assembly, and others are separated completely.

Know your Oil-side Systems

This guide should serve as a roadmap to the oil-side components of your air compressor and can be used to develop an understanding of the oil side systems. As an operator, familiarizing yourself with these components in your machine can be very helpful. The principles and importance of clean, warm lubricating oil are the same for all flooded rotary screw-type air compressors, so though there may be a variance on the operational order in your air compressor, the principles and required components remain the same. BP

Dave Brockett of Isel Inc. is an Air Compressor Product Manager with over 20 years in the air compressor business, starting as an air compressor technician following military service. His experience includes project management, product development, maintenance management, and industrial equipment sales. *The author extends special thanks for technical and media assistance from Steve George of Ozen Air Technology and Clint Staples of Katy Equipment.*

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QUALITY, SAFETY & RELIABILITY

Troubleshooting Heatless Desiccant Dryer Proves Challenging Yet Successful

By Chris E. Beals, Air System Management, Inc.

➤ One of the most satisfying parts of being a compressed air system auditor is resolving compressed air system reliability issues. This article exposes a seldom, if ever, mentioned problem that can occur when air dryers are dedicated to air compressors. It examines a real-world application and discusses the action taken to remedy the situation.

Dryer Not Maintaining Pressure Dew Point

A portion of the general contractor's project was to purchase and install a lubricated rotary screw air compressor along with a heatless desiccant dryer, a 1,060-gallon wet air receiver, and "no-air loss" auto drains. The air compressor was rated for 518 acfm at 110 psig, while its dedicated dryer was rated for 500 scfm at inlet conditions of 100˚F (38˚C) and 100 psig.

The equipment was installed indoors at sea level and the no-air loss auto drains were installed on the air receiver and the dryer pre- and after-filters. *The reader would be correct to question the dryer sizing along*

"The specified 500 scfm dryer was undersized; however, after the distributor increased the size of the dryer to 600 scfm by installing additional desiccant, it was sized properly."

— Chris E. Beals, Air System Management, Inc.

with specifying an auto drain for the dryer's after-filter. The project specifications required the dryer to deliver air at -40˚F (-40˚C) pressure dew point (PDP). The equipment was commissioned by a local distributor owned by the air compressor manufacturer. Three weeks after the commissioning the dryer wasn't maintaining -40˚F (-40˚C) PDP, which was a problem for the contractor because they wouldn't receive their final payment until it met the specification.

The distributor responded quickly and found the mufflers plugged along with an eight-psig drop across the pre-filter. The service person cleaned the mufflers, removed the balance line on the pre-filter's no-air loss drain because it was connected downstream of the pre-filter, and adjusted the purge pressure. The pre-filter element was clean so it was assumed that the differential indicator was bad.

Return Visits Yield Few Results

The PDP never recovered so the service person returned two weeks later. He reinstalled the balance line on the pre-filter no-air loss auto drain, moved the control air for both drains from the dry side of the dryer to its wet side and decided to order a new pre-filter and differential gauge. When he left the site the PDP was improving while the dryer was cycling with its upstream air compressor turned off, but it never reached -40˚F (-40˚C) PDP.

The service person returned nine days later and replaced the pre-filter and differential gauge. The service person also replaced the pre-filter's no-air loss drain with an electronic drain, but he left the float drain in the pre-filter housing. *Float drains should be removed whenever an auto drain is installed.* A factory engineer thought the dryer inlet temperature may be too low for the dryer to function properly. In addition, the service person noticed that while the dryer was delivering air at -23˚F (-31˚C) PDP the system PDP was only at -7˚F (-22˚C). Therefore, the service person theorized the downstream PDP may be affecting the dryer's PDP reading.

The service person returned again nine days later and replaced the pre- and after-filters with larger ones and verified that the purge orifice was correct. *It appears the original filters were undersized because the new ones have the same model number as shown in the dryer's parts manual.* He also disconnected the new equipment from the system and vented its air to the atmosphere but the PDP didn't improve so he decided the desiccant should be replaced.

The service person returned once again 18 days later to change the dryer desiccant. He installed enough desiccants to increase the dryer's rated capacity to 600 scfm. He didn't find any sign of oil or water in the dryer's towers. He also found the oil level in the air compressor to be okay. After the dryer was put back online the PDP read -54˚F (-48˚C), but three days later it was worse than the required -40˚F (-40˚C).

Dew Point Problem Persists

A week later the service person brought the air compressor manufacturer's system engineer along to review the system. The service person changed the purge mufflers, increased the dryer purge pressure, and installed an air coupon at the inlet to the air compressor to test the quality of the air flowing into the

Troubleshooting Heatless Desiccant Dryer Proves Challenging Yet Successful

air compressor. The system engineer discussed several options with the contractor but they didn't want to proceed with any of them until receiving the results from the air coupon.

The service personnel returned three weeks later to change out the dryer purge mufflers and download the air compressor's SD card. The data on the SD card showed that, at times, the air compressor's discharge pressure dropped to 90 psig. A month and a half after the air coupon was installed it showed airborne contaminants so the manufacturer and the distributor said all warranty claims would be denied. *Studies have shown that approximately 80% of airborne contaminants are washed out of the air by the air compressor lubricant. While the airborne contaminants shorten the life of the lubricant; thereby, requiring more frequent oil changes, if they even affect the dryer performance, they aren't going to affect it that quickly.*

Oil also found on the after-filter element meant the plant didn't shut off the dryer when it shut off the air compressor. This strongly suggested it was the reason the dryer wasn't maintaining the proper PDP.

In addition, the manufacturer's system engineer said the engineering firm had undersized the air compressor and dryer. *The specified 500 scfm dryer was undersized; however, after the distributor increased the size of the dryer to 600 scfm by installing additional desiccant, it was sized properly. They said the air compressor was undersized because it couldn't maintain a discharge pressure of 100 psi, but the low discharge pressure was actually due to the setpoints of the other air compressors.* So six months after commissioning the air compressor and dryer, the dew point issue remained unresolved and the contractor could not get any more support from the distributor.

Remote System Assessment Only Goes So Far

Approximately two months later the contractor called and asked for my help. Due to the COVID-19 pandemic it was decided to attempt to resolve the issue remotely, even though most compressed air system issues can't be resolved remotely. After reviewing the communications between the engineering firm, the equipment supplier, and the contractor the following facts were gathered:

Oil in the compressed air piping downstream of the dryer pointed to the potential problem with the desiccant dryer's inability to maintain the proper PDP.

- There was a no-air loss auto drain installed on the air receiver, but the others had been removed.
- The system contained four air compressors each having a dedicated dryer.
- All the air compressors were air-cooled lubricated rotary screw air compressors that exhausted their hot air into the air compressor room.
- The new air compressor's discharge temperature sometimes reached 110°F (43°C).
- The new air receiver and dryer, located approximately 50 feet downstream of the new air compressor were installed in a separate room where the ambient temperature was 87°F (30°C).
- The plant only operated four days a week.
- The plant operated the new air compressor along with one other air compressor.
- On the weekends the plant shut off the new air

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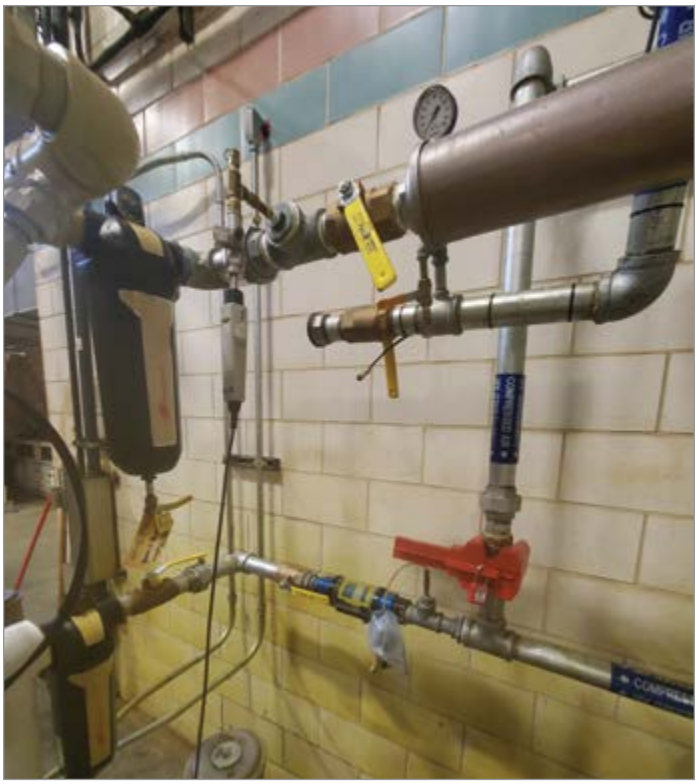
compressor but they didn't shut off the new dryer.

- Over the weekends the plant continued to operate the larger air compressor in order to support their nitrogen generator.

Our initial thoughts were:

- The dryer may be operating in energy savings mode, which reduces the PDP the dryer is capable of producing.
- The dryer's purge exhaust mufflers may be plugged.
- The dryer may be undersized.
- One or more of the drains aren't working.
- Condensation may be causing moisture and oil to reach the desiccant. Condensate can reach the desiccant if it slugs the pre-filter, or if it condenses between the pre-filter and the dryer inlet.



Shown is the test setup used to help validate the cause of the dryer problem.

- The purge pressure may be set too low.

The contractor investigated these possibilities and found:

- The dryer was working in fixed mode and there wasn't any backpressure on the offline towers.
- The dryer inlet temperature varied between 95˚F (35˚C) and 100˚F (38˚C), which meant the 600 scfm dryer was large enough for the existing dryer inlet conditions.
- The wet air receiver was found nearly full of condensate because the no-air loss drain wasn't working. This suggested that condensate may be slugging the pre-filter.

After removing the air receiver's auto drain and draining the water out it was decided to try and regenerate the desiccant once again. The contractor shut off the air compressor over the weekend and increased the purge airflow to help with the regeneration. The PDP improved to -42˚F (-41˚C) by the end of the weekend, but shortly after the air compressor was put back online it worsened.

Site Visit Reveals Potential Problem

We decided a site visit was required and the following would need to be done in preparation for the visit:

- We couldn't risk having anyone questioning our PDP readings so we had our two dew point monitors calibrated and shipped to the site along with a flow meter and large exhaust muffler.
- The contractor would order new desiccant and filter elements, replace the float drains with ¼-turn ball valves, and insulate the piping between the pre-filter and the dryer inlet.

In order to get familiar with the compressed air system I arrived a day prior to the plant shutting down. I found:

- The setpoints of the other air compressors were set too low for the system to maintain a dryer inlet pressure of 100 psi so the plant increased their setpoints.
- Oil in the main header that was installed near the floor below the dryer discharges.

One of our calibrated dew point monitors was installed downstream of the dryer and it read between -25 (-31.6˚C) and -35˚F (-37.2˚C) PDP, which appeared to agree with the dryer's dew point monitor.

The next day the contractor removed the desiccant from the towers and no moisture or oil was found in the towers. The old desiccant appeared to be slightly grayer than the new pure white desiccant. Then sections of the

Troubleshooting Heatless Desiccant Dryer Proves Challenging Yet Successful

A second calibrated dew point monitor verified the accuracy of the PDP reading and showed the oil had damaged the dryer's dew point monitor.

piping upstream of the pre-filter and downstream of the after-filter were removed so the flow meter and exhaust muffler could be installed. At the same time the pre- and after-filter housings were removed so the filter elements could be replaced.

It was at this time we noticed oil on the after-filter element and we began to suspect the cause of the dryer problem. There wasn't any oil in the piping upstream of the dryer, but we did find oil in the downstream piping. At this point we were pretty sure the reason dryer couldn't maintain -40˚F (-40˚C) PDP was because the plant didn't shut off the dryer when they shut off the air compressor.

With the upstream air compressor shut off the dryer's purge air had to come from the main header that contained oil. Hence, the purge air from the main header flowed backwards through the after-filter leaving oil residue on the after-filter element and then into the offline tower contaminating the desiccant before it was exhausted out through the mufflers. However, we still had to prove our theory.

Theoretical Solution Met with Success

In order to prove our theory we completed the test setup after installing the new desiccant and then opened the valve upstream of the exhaust muffler, until the flow meter upstream of the dryer read 500 scfm, and the new air compressor stopped cycling. To our disappointment the dew point monitor on the dryer only read -41˚F (-41˚C) PDP. We installed our dew point monitor downstream of the dryer, but upstream of the ¼-turn ball valve used to exhaust the air to the atmosphere.

To our surprise the PDP read -80˚F (-62˚C). The PDP of compressed air improves when it's expanded to a lower pressure so we weren't sure the -80˚F (-62˚C) PDP reading was accurate. In order to verify the PDP reading our second calibrated dew point monitor was installed just upstream of the dryer's dew point monitor. Our second monitor also read -80˚F (-62˚C) PDP so we knew the dryer's dew point monitor had failed. The dryer maintained -80˚F (-62˚C) PDP throughout the three-day test and when the dryer's new dew point monitor arrived and was installed it also read -80˚F (-62˚C) PDP.

After the site visit the plant installed a check valve, downstream of the after-filter and started shutting down the dryer whenever they shut down the new air compressor. It's been a few months since the test was conducted and the dryer is still maintaining -80˚F (-62˚C) PDP. BP

Chris Beals is President of Air System Management, Inc. He is also a founding member of the Compressed Air Challenge and has been solving compressed air system problems for 22 years. Chris can be reached at email: cbeals@earthlink.net, tel: 303-881-8870. All photos courtesy of Air System Management, Inc.

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COMPRESSED AIR INDUSTRY & TECHNOLOGY NEWS

Kaeser Expands US Headquarters

Kaeser Compressors, Inc. broke ground on a new 30,000 sq. ft. facility expansion. The virtual ceremony was led by Frank Mueller, president of Kaeser Compressors, and included representatives of Lifecycle Construction Services, McKinney Architects, and the Spotsylvania County Economic Development Department. "At this critical time, we are increasing capacity to serve our customers' needs in the many essential industries throughout the country," said Mueller. "This new and exciting project will allow us to better support our national distribution network and our ever-expanding business in the US. And like our original building which we opened 25 years ago, this new addition is dedicated to our employees, Kaeser's most valuable resource." The new space will accommodate an additional 100 people and provide enhanced amenities for all employees. Construction should be complete by November 2021.

Kaeser Compressors, us.kaeser.com

Portable Air Compressor

The all-new Sullivan-Palatek D185PKR Kohler powered portable air compressor is a 185 CFM/100 psi unit featuring a durable but light-weight composite clam shell canopy design for access to all routine serviceable components, such as the spin on oil filter and separator. Easy to tow and compact in design, the unit is equipped with a foldable drawbar to minimize overall footprint in shipping and storage. It is powered by a 48.8 hp Tier 4 Final Kohler engine and a Sullivan-Palatek factory-made 108 mm rotary screw air end. Features side by side coolers for the compressor and engine, a large curbside toolbox for storage, a 12-hour full shift 30-gallon composite fuel tank with fuel level visibility, and a state-of-the-art controller.

Sullivan-Palatek, www.sullivan-palatek.com

ELGi North America Opens New Headquarters

ELGi North America a subsidiary of ELGi Equipments Limited, a global supplier of compressed air solutions, announced it recently held a grand opening and ribbon cutting ceremony for the company's new, expanded North American headquarters, located in Charlotte, NC. The ribbon cutting event was attended by ELGi employees and included speeches by David Puck, President, ELGi North America and, Dr. Jairam Varadaraj, Managing Director, ELGi Equipments Ltd. Puck and Dr. Varadaraj cut the ribbon to officially mark the company's relocation from Continental Blvd. to a larger space on Entrance Drive.

ELGi North America, www.elgi.com/us

Modular Desiccant Dryers

A new range of Hankison HSHD Series small, low flow, modular desiccant air dryers for critical air quality applications has been launched by SPX FLOW. The HSHD Series are pressure swing adsorption dryers delivering pressure dew points to ISO 8573-1:2010 Air Quality Class 1 (-94˚F/-70˚C) and Class 2 (-40˚F/-40˚C) with flow rates of 7 to 40 scfm (12 to 68 m³/h).

Units are delivered as standard with an oil removal pre-filter and particulate after-filter.

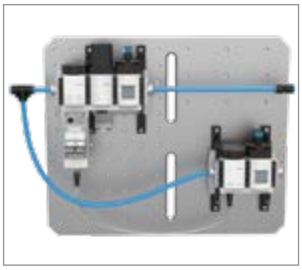
The dryers feature a controller with Modbus communication protocol and a 7" color touchscreen for optimized viewing and to facilitate navigation. Operators may also select pressure dew point performance for maximum application flexibility.

SPX FLOW, www.spxflow.com

COMPRESSED AIR INDUSTRY & TECHNOLOGY NEWS

Compressed Air Energy Saving Platform

Festo has expanded its intelligent pneumatic energy savings platform with two new modules – the MSE6-C2M (C2M) and the MSE6-D2M (D2M). They automatically shut off the compressed air supply to a machine when in standby mode, thus reducing energy consumption. They monitor system pressure and flow information in real time and enable faster response to compressed air leaks. These units flow up to 5,000 liters of compressed air per minute; program easily; connect to Festo MS series air preparation units, including the MS6-SV safety valve; and are suitable for new as well as existing machines. The new C2M is an intelligent combination of a proportional pressure regulator, on/off valve, sensors, and fieldbus communication. Similar to the C2M, the D2M intelligent module monitors the compressed air supply and automatically shuts off the compressed air during breaks in production. Unlike the C2M, the D2M completely depressurizes the system.



Festo, www.festo.us

Xebec Acquires The Titus Company

Xebec Adsorption Inc., a global provider of clean energy solutions, announced it has entered into an agreement effective October 30, 2020, to acquire all of the outstanding shares of "The Titus Company" (Titus). Titus' principals will remain with Titus after the acquisition to optimize their integration into Xebec's Industrial Service and Support business and to grow the operation over the coming years. With this acquisition, Xebec's Cleantech Service Network (CSN) coverage will increase to include Eastern Pennsylvania, Delaware and New Jersey. Total consideration payable by Xebec is approximately $8.0M, subject to certain holdbacks, adjustments and time-based payments. Titus had revenues of $12.3 million for FY2019 with an EBITDA margin of approximately 13.5%. "We're happy to welcome another member to the Xebec family. Titus has a stellar track record in the compressed air service industry with several Fortune 500 companies and the U.S. Navy as customers. Their expertise and presence will be helpful in rounding out our capabilities on the U.S. East coast as more customers explore decarbonization pathways that include renewable gases," said Dr. Prabhu Rao, Chief Operating Officer at Xebec Adsorption Inc.

Xebec Adsorption, www.xebecinc.com

Rugged Pleat Baghouse Dust Collector

Donaldson Company introduced the Donaldson Torit Rugged Pleat (RP) baghouse industrial dust collector. The collector is designed to capture heavy and abrasive dust inherent to woodworking, mining, grain processing and other industries. The new RP baghouse collector features the SuperSep inlet which pre-separates up to 97% of the dust before it hits the filters and the PerfectPulse cleaning system focuses cleaning energy directly over the filters, supporting long life. With its new Ultra-Web Spunbond filters, the collector is capable of providing up to 94% fewer emissions as compared to baghouses equipped with standard 16-oz. singed polyester bags, which makes it ideal for heavily regulated industries and operations that recirculate conditioned air in their facilities. The new RP baghouse dust collector utilizes 44% fewer filters than traditional baghouse collectors, resulting in a 72% reduction in change-out times. It also includes the iCue connected filtration monitoring service.

Donaldson Company, www.Donaldson.com

T6-1000 PRO Electrical Tester

Troubleshooting electrical systems can be time-consuming and potentially dangerous because it requires access to metallic contact points. The new Fluke T6-1000 PRO Electrical Tester measures voltage and current – without test leads – and displays both readings simultaneously, saving time and keeping workers safe. The product measures voltage up to 1000 V ac and current up to 200 A ac, all through the open fork and without test lead contact to live voltage. It also measures resistance 1 Ω to 100 kΩ and frequency 45 Hz to 66 Hz through open fork. It works with most wire up to AWG 4/0 (17.8 mm/0.7" jaw opening). The HOLD button temporarily freezes the large display screen with backlight for easy viewing.

Fluke, www.fluke.com

CHILLER & COOLING INDUSTRY & TECHNOLOGY NEWS

TCX4-90A Process Cooling Chillers

Atlas Copco is launching its first process cooling chiller range in the U.S. The TCX 4-90A range features a compact, all-in-one water chiller with an air-cooled condenser and integrated hydro module, with units available in a variety of sizes. TCX chillers are specially designed for cooling water (or a mixture of water and glycol) with state-of-the-art microchannel condensers requiring 30% less refrigerant. Atlas Copco entered the industrial cooling market through the May 2019 acquisition of Eurochiller S.r.l., an Italian manufacturer and distributor of industrial cooling equipment and related products. The TCX range is Atlas Copco's first range of industrial cooling equipment in the U.S. There is a plan to introduce more new products to the market in 2021, extending the portfolio to 500 tons of cooling capacity.

Atlas Copco, www.atlascopco.com

AquaEdge 19DV Chiller Line Expanded to 350 Tons

Carrier announced it has expanded its AquaEdge 19DV water-cooled centrifugal chiller capacity range in North America by an additional 150 tons. With the capacity range now starting at 350 tons – previously 500 tons – the 19DV can accommodate customer requirements of smaller applications. The top of the range remains at 800 tons. The 19DV's unique EquiDrive two-stage back-to-back compression allows for effective heat recovery, which enables its excellent cooling efficiency at standard conditions to flex up to 120°F (49°C) for energy-saving hot water production. The 19DV also provides free cooling, a strategy for leveraging natural air temperatures and includes a Variable Frequency Drive (VFD) protecting the chiller against abnormalities in power quality. Carrier SMART Service, a wireless technology allows for remote diagnostics, long-term performance trending and benchmarking.

Carrier, www.carrier.com

SPX Appoints Executive Officer and President – Global Cooling

SPX Corporation announced that Ankush Kumar, who joined the company in 2018 as President of the company's HVAC Cooling business, has been appointed as an Executive Officer of the company. Mr. Kumar will also now assume leadership for SPX's Process Cooling organization, giving him responsibility for all Cooling operations globally. "Ankush is an excellent addition to our strong team of executive leaders," said Gene Lowe, President and CEO of SPX Corporation. "He has been instrumental in driving substantial operational improvements across our global HVAC cooling businesses through his expertise in strategy development, operations, channel management, and strategic pricing. His demonstrated ability to implement process discipline and build organizational capabilities make him a tremendous asset to our culture of continuous improvement and value creation for shareholders."

SPX Cooling Technologies, www.spxcooling.com

Metasys Building Automation System

Johnson Controls, the global leader for smart and sustainable buildings, has released its latest version of the Metasys Building Automation System (BAS), Metasys Release 11.0, which delivers enhanced system performance and new cyber security capabilities. The system's new and updated features help owners and operators identify and solve issues to avoid equipment failure and energy waste, while also providing a flexible modernization path for aging system components. Metasys Release 11.0 introduces a new, licensable Fault Detection and Fault Triage feature suite. By identifying building system-related faults, in order of severity, and providing suggested possible causes and corrective actions, it helps operators of varying experience levels quickly and easily identify and troubleshoot issues to keep systems running optimally and building occupants comfortable.

Johnson Controls, www.johnsoncontrols.com

CHILLER & COOLING INDUSTRY & TECHNOLOGY NEWS

Compact Air Handlers

Daikin added a vertical configuration to its PreciseLine air handlers, which are designed to improve indoor air quality (IAQ) and comfort, and deliver energy savings – all in the most compact footprint available. The new vertical configuration gives engineers and contractors additional application flexibility, ideal for retrofits and applications such as individual classroom conditioning. Compliant with ASHRAE 62.1-2019 standards for high IAQ, PreciseLine air handlers include up to MERV 13 filters, which capture particles as small as .3 to 1 micron, such as legionella and spores. Its double-wall panel construction also keeps conditioned air in the cabinet until it's delivered to the intended space, reducing the potential for contact with contaminants. Direct-drive fan technology eliminates the possibility of rubber particles from entering the airstream as well, a common occurrence with belt-driven fans. Plus, an easy-to-clean cabinet and stainless-steel drain pan mitigate the risk of mold and mildew growth.

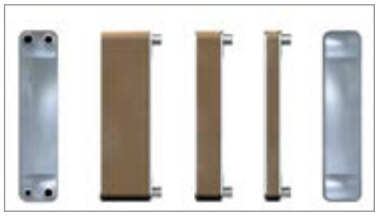
Daikin Applied Americas, www.daikinapplied.com

Humidity & Temperature Probe

Vaisala, a global leader in weather, environmental, and industrial measurements, has introduced a new HUMICAP Humidity and Temperature Probe HMP1. With its top-of-the-line accuracy and sensor purge functionality ensuring excellent stability over time, the HMP1 is an ideal choice for demanding humidity measurements in environments such as pharmaceutical facilities, data centers, cleanrooms, or any other environments that require strict humidity monitoring and control. The product features the recognized and space-proof HUMICAP sensor technology. The probe is compatible with any Vaisala Indigo series transmitter. The possibility to detach the probe from the transmitter allows efficient maintenance and calibration. With the Indigo200 series transmitter the HMP1 probe forms a single wall-mounted unit with no probe cable or probe holder needed.

Vaisala, www.vaisala.com

Micro Plate Heat Exchanger



Danfoss has extended its highly efficient range of Micro Plate heat exchangers – enabling more manufacturers of chillers and heat pumps to benefit from its efficient Z-design technology and address refrigerant and design changes. The new, R32-optimized range complements existing multi-refrigerant heat exchangers for R410A, R452B, and R454B, widening chiller manufacturers' options when reducing GWP. New single and dual-circuit versions are available to complete the existing range for chillers. The portfolio can now cover the entire range of light commercial and commercial chiller ranges. HDW44 is perfect for sanitary water heating, with a double-wall and a built-in interspace preventing water contamination in the event of a refrigerant leak. The Suction Gas Heat Exchanger (SGHX) can enhance efficiency in heat pump condensers and evaporators, counteracting the impact of high-glide refrigerant blends like R455A and R454C.

Danfoss, www.danfoss.com

Bacharach Names Matthew Toone as CEO

Bacharach has announced the appointment of Matthew Toone as Chief Executive Officer. Toone joins Bacharach from Emerson, where he served as Vice President of Sales, Service and Solutions for Emerson's Cold Chain Platform. The company said Toone will be responsible for the further integration of the Parasense and Neutronics brands and setting the company's strategy as it moves into its next chapter of market expansion and growth. "The board of directors selected Matt because of his leadership qualities, proven track record leading an international business and extensive knowledge of refrigeration and IOT solutions for the HVAC-R, food retail and healthcare markets," said Martin Carter, Chairman of Bacharach and CEO at Laurel Solutions.

Bacharach, www.mybacharach.com

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"We used to think of energy efficiency primarily as a means to save money, but that's changed. We believe there are a lot of benefits beyond that and it's become part of our identity."

— Sharon Nolen, Manager of Global Natural Resource Management, Eastman

"As an example, we were using higher pressure air compressors for an application that didn't need that amount of pressure so we installed a blower rated to deliver air at 15 psi, which saved $30,000 a year."

— Nick Waibel, Global Energy Lead, Tate & Lyle

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"Our commitment to sustainability is a corporate-wide effort and a plant wide-effort. We want the next generation to have the same or better experiences than we have now."

— Lora Gans, Environmental Health & Safety Manager, Stanley Black & Decker

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January/February 2021

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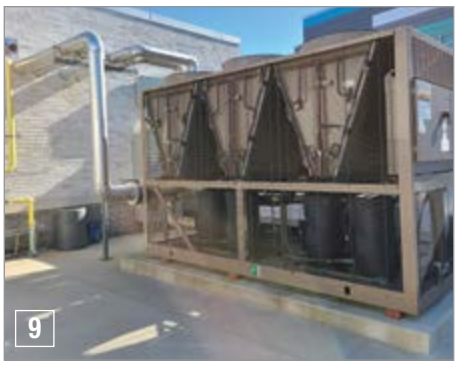
WATER TREATMENT & COOLING SYSTEM ASSESSMENTS

COOLING TOWER & CHILLER FEATURES

WATER TREATMENT & COOLING SYSTEM ASSESSMENT FEATURES

COVER PHOTO. This month's cover features rPlanet Earth, located in Vernon, California. As our lead article, this image is of their uniquely vertically integrated facility able to convert polyethylene terephthalate (PET) packaging waste into recycled PET (rPET) packaging for the food and beverage industry.



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Process Cooling System Helps rPlanet Earth "Close the Loop" on Recycling Post-consumer Plastics

By Mike Grennier, Chiller & Cooling Best Practices Magazine

rPlanet Earth in Vernon, California, is the only vertically integrated facility able to convert polyethylene terephthalate (PET) packaging waste into recycled PET (rPET) packaging for food and beverage industries such as bottle preforms, strawberry containers, and drinking cups. The plant's process cooling system delivers chilled water at precise temperatures at all times.

rPlanet Earth is a rarity in the plastics recycling and manufacturing industry. After all, its operation in Vernon, California, is the world's only vertically integrated facility able to convert polyethylene terephthalate (PET) packaging waste into recycled PET (rPET) packaging for food and beverage industries. Yet, rPlanet Earth is much like any other plastics company in one key aspect: it must maintain production efficiencies to meet growing demand for its high-quality products.

With a unique business model in place and clear goals for production, rPlanet Earth (www.rplanetearth.com) partnered with engineering firm Woodard & Curran to design and build its state-of-the-art facility in 2018. The plant features a host of advanced technologies including a process cooling system designed to deliver chilled water at the precise temperatures at all times. "The cooling system," said rPlanet Earth Vice President of Engineering Andrew Lopez, "plays a pivotal role in allowing our company to meet its production goals – and plans for growth."

"Cooling is a really huge factor in our overall efficiency. It also allows us to ensure consistency in our product, " Lopez said, adding the company is on track for strong growth. "Our long-term plan is to double our capacity at this plant by 2023 and also establish more high-volume plants around the United States."

High-quality Packaging with Lowest Carbon Footprint

Turning recycled plastics into containers and packages for the food and beverage industries traditionally involves separate facilities to perform the work. However, rPlanet Earth combined these disparate operations into one as it strives to "close the loop" for the recycling and reuse of post-consumer plastics.

"Everything we're doing at rPlanet Earth is typically done at three to five different facilities, depending on how you cut it. Our vertical integration and the use of post-consumer plastics as feedstock allows us to produce high-quality packaging with the lowest carbon footprint," Lopez said.

rPlanet Earth's 302,000-square-foot facility, which grew from ten employees in 2017 to 180 employees today, acts as a recycling operation

rPlanet Earth's 302,000-square-foot facility acts as a recycling operation and separate manufacturing facility under one roof.

and separate manufacturing facility under one roof. The plant operates 24 hours per day, seven days a week, and is capable of processing over 80-plus million pounds of post-consumer PET annually.

The recycling operation receives bales of post-consumer plastics from various curbside collection programs throughout California. It then sorts and grinds the material into flake, which is stored in silos until needed. The flake is subsequently washed and routed through a decontamination and solid stating process to convert the non-food grade material into flake that meets rPlanet Earth's own quality standards, which exceeds the Food and Drug Administration's requirements for direct food contact applications.

The manufacturing component of the facility is comprised of three primary production streams – injection molding machines produce bottle preforms; sheet extrusion machines produce rolled extruded sheet; and thermoforming equipment manufactures thermoformed containers, including rPlanet Earth's own brand of drink cups and deli containers.

"What's also unique about us is our ability to process B-grade, curbside bales," Lopez said. "Other companies in California recycle PET containers but they're only able to use bales supplied by deposit centers. If it wasn't for us, those B-grade plastics would be downcycled into lower quality applications and potentially end up in landfills. Our goal is to close the loop and have zero plastic waste on the planet."

Precise Temperature Control a Must

rPlanet Earth turned to Woodard & Curran to design and build its facility from start to finish, which included everything from site selection, utility and permitting considerations, to equipment selection.

The process cooling system at the plant is designed to ensure precise temperature control given its impact on cycle times, said Bert Wesley, Senior Principal and Industrial Plant Engineering Practice Leader at Woodard & Curran.

"The temperature of chilled water delivered to the machines needs to be exact to ensure uptime as the machines cycle from one process to the next," Wesley said. "For example, an injection molding machine will turn out 96 preforms every eight seconds. If that water is one-half degree out of spec it's going to make 96 defective preforms in eight seconds. It's easy to see how it adds up."

Lopez, like Wesley, said accurate temperature control of chilled water is crucial, especially when cycle times are decreased to meet production and quality goals.

"Precise temperature control is going to drive that cycle time down and give us consistent product," Lopez said. "If you speed up cycle times without precise temperature control then you can have quality defects in your product and you can lose valuable line time to troubleshoot an issue."

Working with a Limited Footprint and Varied Flow Rates

When designing the plant, rPlanet's desire to maximize the area for manufacturing meant there was limited room for utilities. Additionally, Woodward & Curran needed to prioritize storage for PET flake and process equipment versus utilities, such as the cooling system.

"As needs for production processes evolved in the planning phase, we began to explore how we could save space by not having both a hot tank and a cold tank for the cooling system in addition to the pumping systems that goes with it," Wesley said.

Process Cooling System Helps rPlanet Earth "Close the Loop" on Recycling Post-consumer Plastics

Woodard & Curran

Founded in 1979 and headquartered in Portland, Maine, Woodard & Curran is an integrated engineering, science, and operations firm born to address needs arising out of the Clean Water Act. Privately held and steadily growing, the firm specializes in water and environmental-related projects. It has more than 1,100 employees in offices and utility facilities who serve public and private clients across the country.

Woodard & Curran is a nationwide firm specializing in water and environmental-related projects.

The company's mission is to create a healthy work environment, deliver high-quality services, and promote environmental stewardship. These concepts guide the services it provides and the work it delivers across a range of sectors. In working with industrial clients, Woodard & Curran helps them do more with less, conserve resources, and minimize waste and emissions. The firm clearly understands that the more efficient and productive a company is, the more competitive it can be.

Utility systems essential to the manufacturing process are often a frequent source of inefficiency and avoidable expense. Woodward & Curran experts have decades of experience identifying opportunities to save energy, reduce waste, implement efficient generation technologies, and reuse heat or water to save money. The company helps clients in a wide range of manufacturing setting reassess utility systems and design infrastructure to get their best return on investment. To learn more, visit www.woodardcurran.com.

Woodard & Curran also wanted to guarantee delivery of chilled water at the proper temperatures, even with a wide range of demand for chilled water at the plant. Flow requirements at the plant range from as low as 100 gallons per minute (gpm) to 960 gpm based on the status of varied production process.

"We need the system to deliver a thermal sink that's always ready and always within spec as different machines come online," Wesley said. "When a line operator hits the start button on the machine, they expect chilled water at the proper temperature to be available in whatever volume they need to circulate through their machine and they need it immediately."

System Features Chillers with Enhanced-flow Management Technology

The cooling system at rPlanet includes a single, two-cell 1,380-ton EVAPCO open cooling tower, as well as two water-cooled Trane centrifugal chillers rated at 600 tons each. The chillers are arranged in a variable primary chiller plant design, using supply pumps with Variable Frequency Drives (VFDs) to adjust flow rate to meet production demand. Other key components include a 2,500-gallon surge tank, pump system and master Programmable Logic Controller (PLC). A single surge tank eliminated the need for a hot and a cold tank, as well as additional pumps.

The tower supplies cooling water at 80°F (26.6°C) to the two water-cooled Trane centrifugal chillers that lower the water temperature to 44°F (6.6°C) for delivery to process machines. The towers also supply water through a separate cooling circuit directly to the plant's compressed air system and manufacturing equipment since they do not require 44°F (6.6°C) water.

The chilled water loop uses solenoid valves to tie together the chilled water supply line with the hot water return line. At all times, temperature sensors keep tabs on the water temperature in the loop. When seeing an increase in temperature, the PLC opens the valves to allow chilled water from the supply line to flow to the return line until the proper temperature is reached, resulting in constant and proper water temperature regardless of demand.

Each chiller is equipped with Trane's exclusive Flow Management Package, which uses a variable water-flow compensation algorithm, to deliver chilled water at targeted temperatures even during an increase or decrease in flow of up to 50% per minute. Other chiller manufacturers are limited to a maximum of 10% per minute rate of change of flow and

increases beyond that will send those chillers into alarm, knock them offline, or produce off-target temperatures. By using the enhanced-flow management technology, the chillers can quickly ramp up when called upon and deliver water at the specified temperature without faltering, Wesley said.

"If every machine turns on immediately and starts calling for chilled water, the chillers are able to easily compensate for that rate of rise in flow and ensure water in the system stays at the set temperature," he said.

At the plant, cooling water is routed from the surge tank to the chillers and throughout the pipeline network for delivery directly to process machines. Pipeline valving allows the system to reroute additional chilled water generated by the chillers from time to time back to the surge tank. The surge tank, which contains hot water previously routed to it from the return line, serves as a way for the plant to pre-chill the water before it's routed to the chillers for further cooling as part of the continuous loop. The result is energy efficiency, Wesley said.

"We're able to send 100% water at the specified temperature to the manufacturing process while also having a reserve capacity in the surge tank available at all times," Wesley said. "It also means the chillers have to do less work with that same molecule of water when the water comes back around from the surge tank and flows through them before being sent to the process."

Getting It Right On the Front End

Wesley said the design of the process cooling system involved close collaboration to ensure the design and installation of an optimized system. The system also aligns with rPlanet Earth's goals tied to energy efficiency.

"We sat with Trane and EVAPCO to work through how to optimize the size of the equipment across the board and also ensure everything works together seamlessly," Wesley said, adding the system installed goes beyond the traditional system.

"What most would've done is to not have a chiller with a flow-management package, and instead, pump the water needed and let the chiller trim it every once and awhile and move on with it. But we didn't need to pump 960 gpm a minute, 24 hours a day, seven days a week," he said. "The plant only needs to pump the chilled water based on what's actually running, and therefore, it's very energy efficient from an electrical and refrigeration standpoint."

Trane's centrifugal chillers at rPlanet Earth's plant use an enhanced-flow management package, which allows them to deliver chilled water at targeted temperatures at an increase in flow of up to 50% per minute.

A 1,380-ton EVAPCO open cooling tower supplies cooling water to two water-cooled Trane centrifugal chillers, which further cool tower water for delivery to process machines at rPlanet Earth. The tower also supplies cooling water directly to the facility's compressed air system and equipment that doesn't need chilled water at a lower temperature than that provided by the chillers.

Wesley said Woodard & Curran specified chillers with an enhanced-flow management package to match its goals for ensuring chilled water at all times.

"Chilled water usage is not constant. It all depends on what complement of machines they're running," he said. "Without the package, the chillers wouldn't give us the guarantee we could deliver water at spec 100% of the time."

Process Cooling System Helps rPlanet Earth "Close the Loop" on Recycling Post-consumer Plastics

The cooling system overall satisfies the plant's process cooling goals and business objectives, Wesley said.

"It's a combination of giving the manufacturing process what they need all the time, while being energy efficient. And it gives them a lower lifecycle cost, which is worth spending the time and effort up front to get it right."

Another Step Closer to Zero Plastic Waste

Lopez said rPlanet Earth made the right choice in partnering with the Woodard & Curran, citing the cooling system as one example.

"We've had a very positive experience with temperature control with our entire cooling system for the plant," he said, adding rPlanet Earth anticipates a bright future.

"We're continuing to make significant progress in using previously landfilled post-consumer plastics streams in our process. We're now looking at re-using and recycling thermoformed containers, which is important because a lot of it ends up in the landfill, "Lopez said. "We've always worked toward a circular economy in plastics. We're very excited about our goal, which is to have zero plastic waste on the planet." BP

Chiller & Cooling Best Practices Magazine wishes to thank Bert J. Wesley, P.E. of Woodard & Curran for sharing invaluable insights for this article. All photos courtesy of rPlanet Earth.

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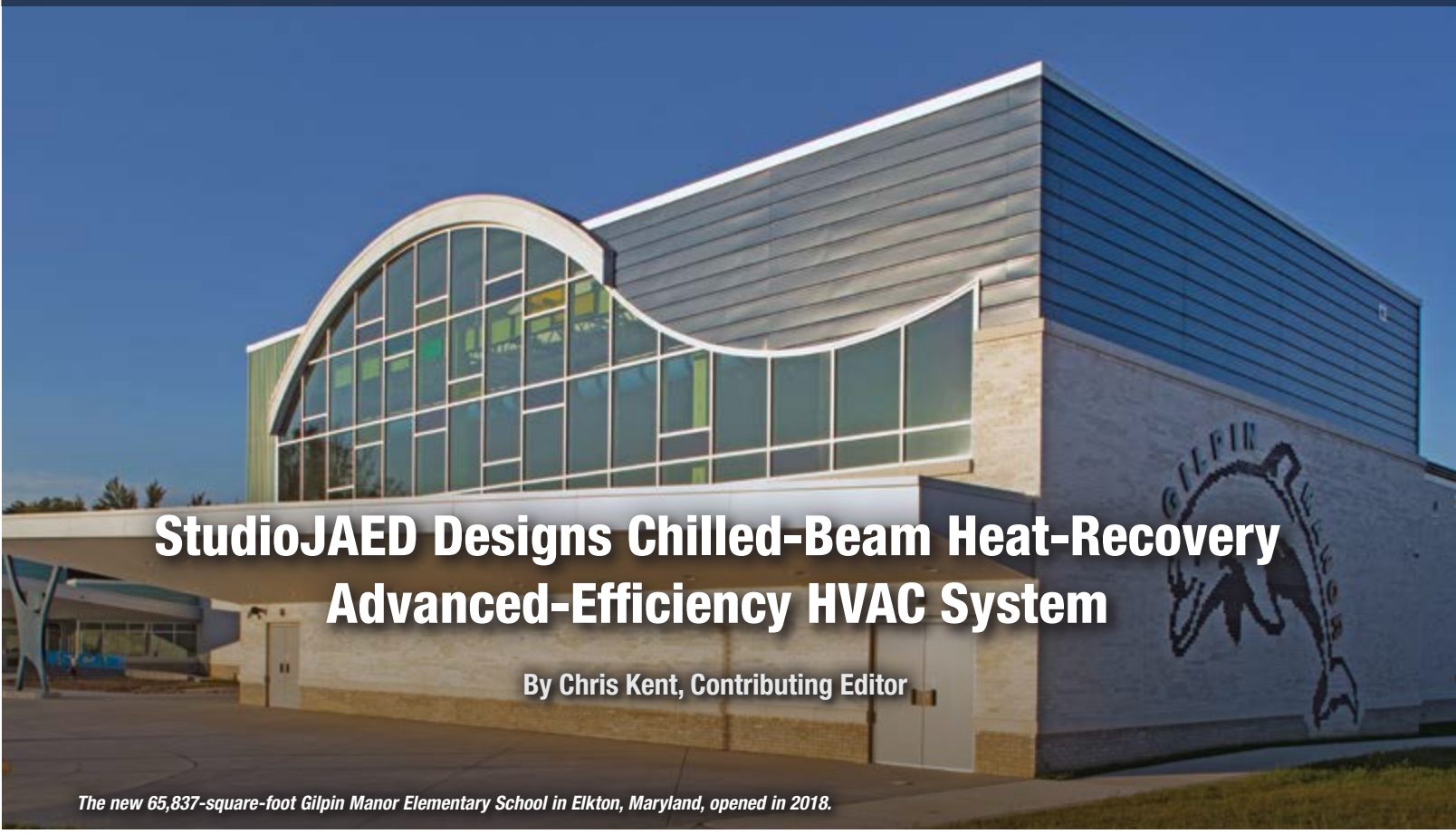
COOLING TOWERS AND CHILLERS



StudioJAED Designs Chilled-Beam Heat-Recovery Advanced-Efficiency HVAC System

By Chris Kent, Contributing Editor

The new 65,837-square-foot Gilpin Manor Elementary School in Elkton, Maryland, opened in 2018.

➤ Gilpin Manor Elementary School in Elkton, Maryland, was nearing the end of its useful life. Building infrastructure was failing and existing spaces had fallen behind in supporting 21st century teaching and learning.

Cecil County Public Schools (CCPS) commissioned StudioJAED of Bear, Delaware, to design and engineer a new school, which features a HVAC system that combines several advanced technologies – all of which enhance the new school's learning environment, while at the same time, exceeding energy-savings goals.

State-of-the-Art Facility for Learning

The original Gilpin Manor building had been in operation since 1952. Aged infrastructure, cramped learning spaces and a host of mechanical improvement needs all contributed to the decision to rebuild the school.

Opened in fall 2018, the new $19.3 million school building spans 65,837 square feet with a capacity to serve 500 students. The building serves students of pre-school age through Grade Five and is also designed to host groups of various sizes during summer months. It also serves as the campus gateway to the adjacent Elkton Public Library and the Elkton Middle and High Schools.

Gilpin Manor features the latest in design to support the best possible learning environment. Highlights include an integrated art studio with mirrors and rubber floors for activities and performances, hand-washing stations, extra space for community groups to use, motion-activated lighting, and many other aspects. In accordance with State of Maryland guidelines, it also meets Leadership in Energy and Environmental Design (LEED™) Silver certification.

Designing for Comfort and Energy Savings

Brian Zigmond, Vice-President with StudioJAED and the lead Mechanical Engineer on the project, said a number of factors contributed to the overall HVAC design. "School district officials were looking for a high-performance HVAC system that would deliver high efficiencies, good temperature and humidity control, and a low acoustical impact on the learning environment."

Comfort cooling was a priority given high temperatures and humidity levels in the spring and summer. The firm's goal for the HVAC system was to consistently regulate the air at a neutral 75˚F (23.9˚C), with 48% relative humidity (RH).

StudioJAED also took aim at energy usage, which is calculated using energy usage index (EUI) criteria. The firm specifically set out to

StudioJAED Designs Chilled-Beam Heat-Recovery Advanced-Efficiency HVAC System

meet or exceed CCPS's ambitious energy target of 25 kBTU/SF/Year, which is significantly lower compared to the national baseline average of 48 kBTU/SF/Year for similar public facilities.

The overall design also needed to account for partial or segmented building use when school was not in regular session for things like hosting large groups in the gymnasium or library, limited after-hours uses, or office-only operation during the summer.

Advanced Technologies Key to Project Goals

When designing the school's HVAC system, StudioJAED worked with Building Systems & Services, Inc. (BSS) to specify a variety of advanced technologies to best address the overall cooling and heating goals of the building. Located in Wilmington, Delaware, BSS (www.bssinc.net) is a leading provider of commercial and industrial HVAC equipment, service and building automation systems. Mechanical contractor, Ralph G. Degli Obizzi & Sons, Inc. (www.degli.com) installed the system and is also based in Wilmington, Delaware. Primary components of the HVAC system include:

- YORK/JCI Model YLAA Air-cooled scroll chiller: A single, multi-circuited 120-ton, air-cooled scroll chiller includes an integral heat recovery condenser with a heating capacity of 260 kW.
- YORK/JCI active chilled beams: 136 active, two-pipe chilled beams all in 24-inch width units, with varying lengths of 48, 72 and 96 inches.
- YORK/JCI Rooftop Solution Air Handling Units (AHUs): Three semi-custom AHUs condition 100% outside air and come with energy recovery capability.
- Johnson Controls Metasys® Building Automation System: A fully customizable programmable control system for automatically controlling the HVAC system.
- Pumps and valves: A series of water supply pumps with variable frequency drives (VFDs), as well as two-way Automatic Temperature Control (ATC) mixing valves.

At the school, the central cooling system runs during shorter months in fall and spring. The system defaults to cooling mode when the school is in session and the outside air temperature is above 55˚F (12.8˚C). It typically does not run in summer when school is out of session to save on energy costs.

If cooling is needed in summer for groups, a

About StudioJAED

StudioJAED is an award-winning architectural, engineering and facilities consulting group founded in 1978 to provide state-of-the-art planning, architecture and engineering services for educational, industrial, commercial and governmental clients.

For over 40 years in its offices in Maryland, Delaware and Rhode Island, its staff of 26 employees specialize in working extensively with agencies regionally and nationwide to modernize existing buildings and construct new facilities, with a focus on meeting project goals, timelines and budgets.

StudioJAED is also a leader in the utilization of technology and green design. It's in-house architecture, engineering and facilities group allows clients enhanced control of their project budgets and schedules. Its integrated design services use an in-house architectural/engineering team concept with active principal involvement. Its work plan allows for compact scheduling and maximizes face-to-face services provided to its clients. Its designs bring responsible innovation to buildings, which provides the highest quality, most creative state of the art concepts, solutions and engineered designs that are affordable within the project budget.

Services include:

- Architecture
- Facility condition assessment
- MEP engineering
- Master planning
- Educational planning
- Sustainable and high-performance design
- Community and staff management
- Interior architecture

By emphasizing quality, responsiveness and timelines, StudioJAED provides architectural and engineering solutions, personalized for its project. Its focus is saving its clients time and money while meeting the intent of all applicable codes. For more information, visit www.studiojaed.com.

separate system of high-efficiency stand-alone direct expansion air conditioning units cool the gymnasium and cafeteria, eliminating the need for the chiller to operate. In cooler months, the chiller is de-energized, and the central heating plant is in operation.

The cooling system uses a constant flow primary/variable flow secondary chilled-water-piping configuration. The primary loop pump circulates chilled water through the chiller at a constant flow rate and the chiller is controlled to maintain a leaving chilled water temperature setpoint of 42˚F (5.5˚C). The secondary loop uses a water pump with a VFD to modulate the chilled water flow rate to the AHUs at a constant temperature of 42˚F (5.5˚C). The secondary loop is designed to supply only enough flow of chilled water needed to meet the building's cooling load as an energy-saving technique.

The system also uses a control valve to connect the secondary heating and cooling loops to a tertiary loop, which is used to supply tempered chilled and heated water to the chilled beams located in key areas throughout the school. Before the chilled water reaches the chilled beams, a three-way ATC mixing valve allows the system to combine warmer return water from the tertiary loop with cooler supply water from the secondary loop in order to supply water to the chilled beams at a setpoint of 57˚F (13.9˚C). A dual temperature water pump with a VFD is also used in the process.

The AHUs, chilled beams, and chiller work together to satisfy all cooling goals with each contributing to energy savings along the way. The AHUs provide primary air to the chilled beams as 100% conditioned outside air with full temperature and humidity control, while the chilled beams regulate the air temperature within each classroom or designated space. The chiller – in addition to supplying chilled water to the system – incorporates the use of a heat recovery module to provide hot water to the AHUs for the purpose of reheating the outside air in dehumidification mode.

Shown are three air handling units on the roof at Gilpin Manor Elementary School.

AHUs Deliver Neutral Air Supply

At the school, the AHUs are used to bring in 100% outside air to meet building code ventilation requirements and handle the associated latent cooling load. This latent load control prevents condensation from occurring at the chilled beams which are designed to handle the space sensible cooling load.

The AHUs are specifically engineered to supply a neutral air supply at a setpoint of 75˚F (23.9˚C) dry bulb and 48% RH to the chilled beams and directly to other areas of the school. They also use energy recovery technology that utilizes outgoing building exhaust air to precondition the incoming outside air. This heat recovery preconditions the outside air with the cooler exhaust air in warmer months, which lessens the load on the chiller. Conversely, the preconditioned warmer air reduces the load on the central heating system during cooler months.

The AHUs, in combination with chilled beams, also save energy given the efficiencies of moving energy with water versus air, said Zigmond. "Using air handlers to only supply the required ventilation air at the desired setpoint to the rooms and allowing the chilled beams to handle temperature control is much more energy efficient when compared to the energy required for traditional airside systems, such as Variable Air Volume, that rely on air as the primary heat transfer medium, which is a key energy-saving feature of the system."

Chilled Beams Support the Learning Environment

The StudioJAED team decided to install chilled beams in the ceilings throughout the school because they best met HVAC energy-efficiency goals while also providing maximum comfort – all with minimal maintenance requirements.

An active chilled beam is an air distribution

StudioJAED Designs Chilled-Beam Heat-Recovery Advanced-Efficiency HVAC System

device with a primary air intake and an integral coil. The primary air, which in this case is 100% conditioned outside air from the AHUs, is injected into a diffuser at a high velocity via nozzles. This creates a pressure differential which induces air from the space across the chilled beam coil.

At the school, the chiller, through the tertiary loop, provides the chilled water to the chilled beams. The AHUs, in turn, provide 100% outside air for ventilation. Active chilled beams eliminate terminal unit fans, reducing noise and eliminating parts to replace or maintain. In addition, since the coils provide sensible cooling only, there are no filters or drain pans.

In all, 136 chilled beams are located in the classrooms and the library, as well as ancillary spaces. The chilled beams are specifically used to manage the space sensible cooling load, which consists of the building envelope, as well as lights, computers and people occupying any given space.

Zigmond said, "We introduced school district personnel to a previously completed facility our team had done with chilled beams, and they were exceedingly impressed with the quietness – in addition to the humidity control, and overall operational envelope – and wanted it for the educational spaces at Gilpin Manor."

Comfort Cooling with Heat Recovery Savings

Given the importance of energy conservation, StudioJAED specified the air-cooled chiller with a heat recovery module given its ability to reduce the school's overall energy consumption.

To do so, the chiller uses an integral heat recovery condenser as a separate heat exchanger to reject heat energy to the building's heated water loop.

"We selected this particular chiller with the heat recovery module installed to minimize the runtime the boilers would need to operate in the cooling season," said Zigmond. "The heat recovery module provides the bulk of the load needed by the air handlers to manage the dehumidification cycle and associated reheat for the supply air to the chilled beams."

Courtney Bauer, Sales Engineer with BSS, explained that an air-cooled chiller typically rejects all its heat to the ambient air. However, with this unique chiller design, the chiller first rejects heat to the heated water loop via the integral refrigerant-to-water heat recovery condenser and then rejects any remaining heat to the ambient air via the standard air-cooled condenser.

Zigmond added, "The heat recovery module can recapture up to 85% of the total heat rejection of the chiller, which offsets the need for the boiler system to simultaneously generate hot water."

Design Saves Energy and Becomes Prototype

Since it began operation, the HVAC system at the new Gilpin Manor school has addressed the needs for comfort cooling – and at the same time – helps CCPS more than meet its energy-savings goals.

Zigmond said CCPS officials are delighted with the performance of the HVAC system in helping teachers and students stay comfortable so they're able to focus on schoolwork. In the meantime, the HVAC system is projecting to deliver cooling and heating at approximately 17 kBTU/SF/Year – exceeding the established goals by over 30% and national average by 65%.

"The system met not only the client's expectations, but ours as well," Zigmond said. "This is one of the more sophisticated systems we've designed with the variety of equipment features interdependently working together to save on energy goals and provide a superior learning space."

Zigmond said the HVAC system at Gilpin Manor served as the design prototype for another CCPS elementary school in Chesapeake City, Maryland.

"The performance of the system at Gilpin Manor made it clear this type of engineered system would work very well at Chesapeake City Elementary," said Zigmond. "In addition to all of the comfort cooling and energy savings it provides, this also saves the school costs since the bulk of the proven HVAC system has already been designed."

The new school in Chesapeake City is currently completing construction and is set to open for the 2020-2021 school year, setting up another group of students and staff to benefit from an optimal learning environment thanks to the HVAC design at Gilpin Manor. BP

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COOLING TOWERS & CHILLERS

Atlas Copco Enters Process Cooling Chiller Market

By Mike Grennier, Chiller & Cooling Best Practices Magazine

Atlas Copco recently debuted its TCX4-90A chiller range to the U.S. industrial process cooling chiller market.

➤ Atlas Copco made headlines recently after introducing itself to the U.S. industrial process cooling chiller market with the launch of the TCX 4-90A chiller range. Chiller & Cooling Best Practices Magazine interviewed Robert Tucker to learn about Atlas Copco's strategy in the United States. Tucker, a business development manager with more than 30 years of industrial fluid dynamics experience, leads the U.S. process cooling chiller initiative within the Atlas Copco Compressor Oil-free Air Division.

Congratulations on this exciting news! Why has Atlas Copco decided to enter the U.S. process cooling chiller market?

Industrial machine and process cooling is an important market and one where we see a lot of opportunity and synergies with our compressed air business. We have a very strong brand presence in many strategic markets where we will market chillers, including food and beverage, machine cooling, medical pharmaceutical, plastics and printing. We can now add more value to customers as we assist them with engineering proper cooling systems.

Many of these markets use our oil-free air compressor technologies. These oil-free market segment applications tend to be more of an engineered solution, which is very much in alignment with the application and processes of industrial cooling.

"We want to provide customers with multiple solutions that best suit their needs, while giving them the most efficient cooling possible over the lifespan of the equipment with the lowest possible cost of ownership."

— Robert Tucker, Business Development Manager, Atlas Copco

StudioJAED Designs Chilled-Beam Heat-Recovery Advanced-Efficiency HVAC System

The TCX 4-90A chillers are available in a variety of sizes from one to 28 tons of cooling capacity.

What's driving this highly engineered approach to the industrial cooling market?

The job of an industrial chiller system is to remove waste heat from the production process. An engineered approach helps clients determine the right cooling water temperature and flows to optimize production. Fine-tuning temperature specifications represent a tremendous opportunity to increase production output and reduce chiller operational costs. We see many applications using lower than necessary cooling water temperature specifications.

For this reason, many industrial facilities have existing cooling systems too large for the application. In those instances, the system consumes more energy than needed because it's not thermodynamically balanced to match the production processes. We want to serve the market by providing customers with the experience and expertise needed to address their challenges and help them achieve their goals on an application-by-application basis. That's in addition to providing innovative products, such as the TCX 4-90A range of chillers.

The TCX 4-90A range features an air-cooled refrigerant condenser and an integrated hydro module within the same space-saving canopy.

Tell us about the TCX 4-90A chiller range and some of the innovation behind it.

This is a line of compact, all-in-one chillers initially available in a variety of sizes from one to 28-tons of cooling capacity. The chillers feature an air-cooled refrigerant condenser and an integrated hydro module, which means the refrigeration and water circuit (or module) are contained within the same space-saving canopy. The unit's state-of-the-art microchannel, cycling scroll, R-407C refrigerant condensing module is uniquely engineered with epoxy-coated aluminum, requiring 30% less refrigerant. This allows for maximum energy efficiency, while at the same time, reducing the refrigerant charge to a bare minimum. For the customer, it results in an environmentally friendly, very efficient chiller that saves space given its small footprint.

The chillers also include the Elektronikon® MkV Touch screen controller to provide control and monitoring at the user's fingertips. This controller includes our built-in SMARTLINK 24/7 remote monitoring capability as part of the chiller's total package. SMARTLINK collects operational data from the chiller and provides customer's machine data, in real time, in a clear format to ensure the TCX runs at optimal efficiency.

To further ensure years of reliable performance, the chiller's storage tank and hydraulic parts of the centrifugal pumps are stainless steel and are factory installed and tested. They prevent process water contamination with rust particles. This also provides a higher level of reliability and temperature control.

What process cooling products can we expect to see from Atlas Copco in the future?

The TCX 4-90A range, which represents the first of many products we're planning to launch, will be expanded to 64 tons of cooling capacity in 2021. Beyond that, our focus is to develop a steady stream of closed-loop process cooling solutions, ranging from multi-circuit process chillers with scroll and screw compressors to evaporative coolers, and more. We want to provide customers with multiple solutions that best suit their needs, while giving them the most efficient cooling possible over the lifespan of the equipment with the lowest possible cost of ownership.

Thank you for your insights. BP

For more information visit https://www.atlascopco.com/en-us/compressors/process-cooling-chillers. All photos courtesy of Atlas Copco.

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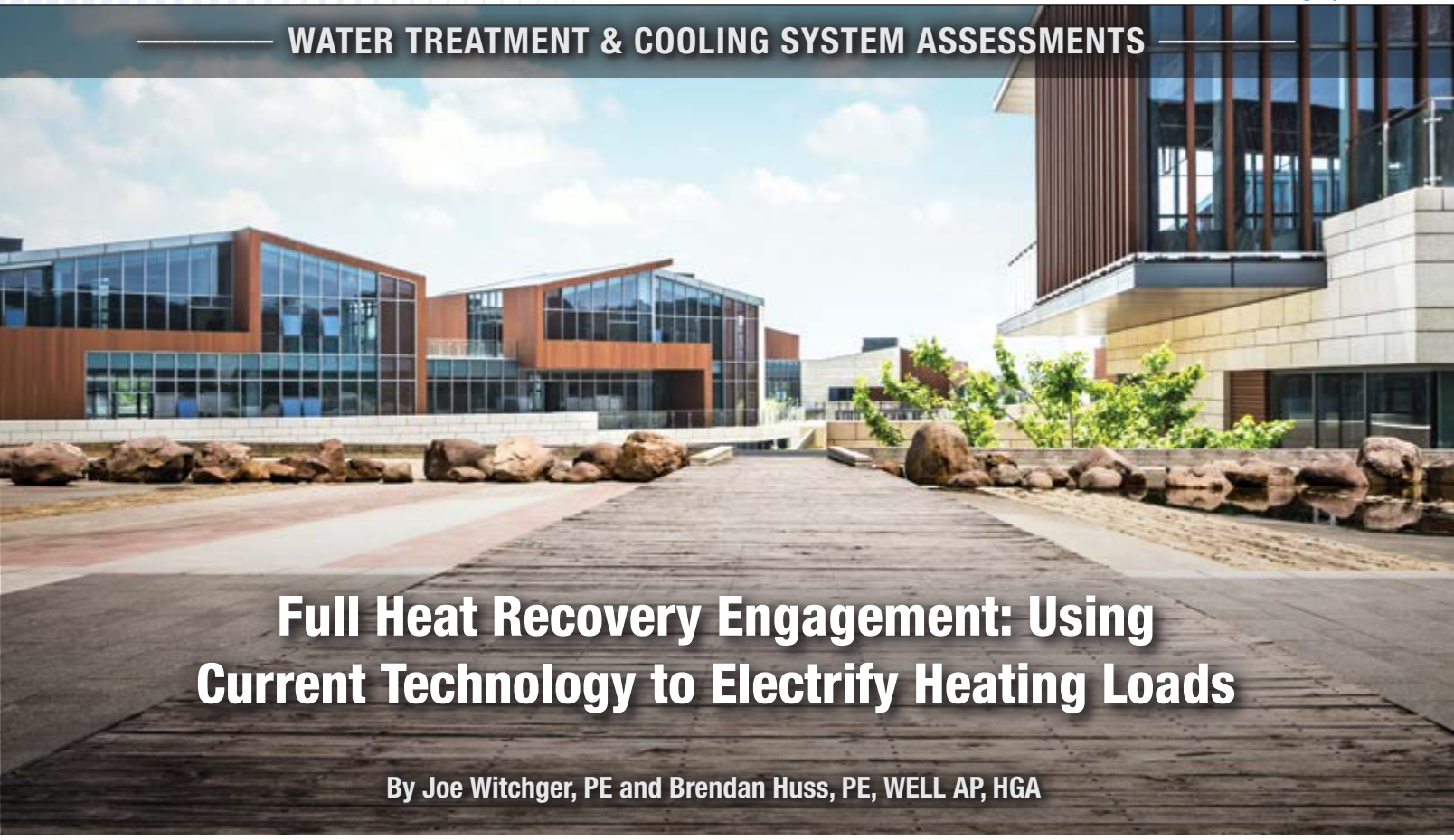
WATER TREATMENT & COOLING SYSTEM ASSESSMENTS



Full Heat Recovery Engagement: Using Current Technology to Electrify Heating Loads

By Joe Witchger, PE and Brendan Huss, PE, WELL AP, HGA

Reducing fossil fuel use is key to meeting the dual goal of carbon and energy cost reduction. A Full Heat Recovery Engagement (FHRE) approach can dramatically reduce both, through applying simple principles and using existing technology. Simple measures can help focus the design of both the buildings served and the systems used to achieve these goals.

The Integration of Heating and Cooling Systems

At one time, a common approach to heating systems was to run steam throughout a building and convert locally to hot water. Generating and distributing low-temperature Heating Hot Water (HHW or LTHW) cuts distribution losses by a factor of two or three. Generating at 130˚F (54.4˚C) can change boiler efficiency from 75 to 92 percent, saving more than 20% of gas use.

So, what does heat system efficiency have to do with cooling best practices? While condensing boilers were once the foundations of sustainable conversions, they are increasingly being considered a transition step to a fully renewable energy portfolio.

Integration is one of the most effective ways to achieve the aggressive sustainability goals that have been adopted across the country. In this case, integration means the coordination of heating and cooling production and distribution to reduce overall energy use. And reductions can be very significant. The key is the vapor compression cycle – heat pumps and heat recovery chillers. Many have recognized this for some time. The New York State Energy Research & Development Agency (NYSERDA), for example, has recognized that heat pump technology is the key to achieving their sustainability goals.

"Generating at 130˚F (54.4˚C) can change boiler efficiency from 75 to 92 percent, saving more than 20% of gas use."

— Joe Witchger, PE and Brendan Huss, PE, WELL AP, HGA

Full Heat Recovery Engagement: Using Current Technology to Electrify Heating Loads

A quick note on water source heat pumps and Heat Recovery Chillers (HRCHs). The primary difference between heat pumps and HRCHs is that heat pumps use reversing valves on the refrigerant side and keep the same water connections to a heat sink and source. HRCHs use fixed refrigeration circuit and evaporator while the condenser may reject heat to a HHW system, geothermal wellfield or cooling tower. Heat pumps can be used in many configurations. When the building is large enough, HRCHs provide improved reliability and efficiency. We will focus this discussion on HRCHs.

Conventional HRCH applications offset baseloads. The application of HRCHs requires an instantaneous balance of heating and cooling load, or a source/sink acting as a storage system to handle load mismatches. A geothermal wellfield is an example of long-term storage that can also improve the efficiency of the HRCHs. If we restricted operation to native cooling loads only, few buildings would see significant improvements in energy efficiency and meaningful reductions in gas use.

This may be why so many view HRCHs as a luxury that gets value-engineered out of a project. But we have available opportunities to go well beyond these limitations using FHRE. Two projects HGA recently designed include a Midwestern hospital that will see an 85% reduction in gas use, and a West Coast college with the potential to shift 100% of the heating load away from fossil fuels with little building modification.

$CR = Q_{COND} / Q_{EVAP}$ (Dimensionless)	
$COP_C = Q_{EVAP} / W_{IN}$	$COP_H = Q_{COND} / W_{IN}$
$Q_{COND} = Q_{EVAP} * (1+1/COP_C)$	$Q_{EVAP} = Q_{COND} / (1+ 1/(COP_H-1))$
$CR = 1+1/COP_C$	$CR = 1+1/(COP_H-1)$
$CR = 1 + (kW/ton) / 3.517$	

Table 1: Basic relationships of terms.

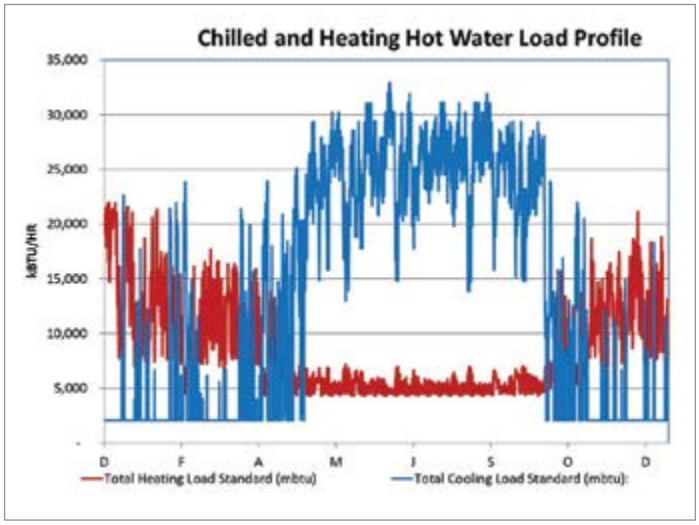


Figure 1: Native chilled water and heating hot water load profiles.

The Principles Behind FHRE

The most fundamental design factor for chillers is the Condenser Ratio (CR). This is the ratio of energy rejected in the condenser to the energy absorbed in the evaporator during the vapor-compression cycle. CR must be understood to effectively design and control the system. It is even more important when working with HRCHs. Table 1 shows the relationships of several key terms.

For a centrifugal chiller at typical design conditions CR is about 1.15, while a HRCH operating at 130˚F (54.4˚C) Leaving Condenser Water Temperature (LCWT) and 42˚F (5.5˚C) Evaporator out temperature (Tchws) with R-134A is about 1.36. Thus, for this HRCH example, a load match means Heating output, Q_H = Cooling output, Q_C * 1.36.

To successfully control this match we need to know how much heating we can derive from a given cooling load and vice versa. We call the degree of correspondence between Q_H and Q_C*CR its *coincidentality.* Creating and maintaining this balance between the heating and cooling loads across the HRCH is the means to achieving energy use improvements we are outlining.

On its own, coincidentality is a subjective term, but we can quantify it using the objective measure: Engageable Load Ratio (ELR). This term was developed to explain varying plant performance as we expanded a CUP at the University of Virginia. While defined for cooling and heating performance, we will only show heating ELR.

$$\text{Heating Engageable Load Ratio } ELR_H = \frac{\text{Engageable Heating Load}}{\text{Total Heating Load}}$$

ELR_H is a function of the building envelope and HVAC system. To calculate ELR_H using a peak load, total annual cooling and heating loads or even a bin analysis is meaningless because these energy estimating methods cannot capture the coincidentality of the loads. ELR_H must be calculated in an 8,760-hour analysis for the building or system served. When this is done, it becomes clear that we can manipulate ELR to the advantage of more recovered energy. The example of a hospital load profiles helps describe this concept.

Figure 1 is an 8,760-hour plot of the heating and cooling load profiles in kBtu/hr. The cooling load is reduced to a baseload of about 170 tons in

the winter and spikes on warm days. The base cooling load can serve hot water heating loads of about:

170 Tons x 12 kBtu/ton x 1.36 = 2,770 kBtu/hr.

Many would size the HRCH heating capacity as the lesser of the base cooling load * CR, or the summer heating load. This would result in a 170-ton HRCH in the heat recovery mode with 2770 kBtu/hr. heating output. For these profiles, $ELR_H = 0.50$ and $ELR_C = 0.18$.

If we stopped here, we would be missing an opportunity to have an even more significant impact on building energy use. Since ELR is a function of the building and HVAC systems, ELR_H can be improved if we reconfigure the systems.

Figure 2 shows a few options at the Air Handling Units (AHUs) that can be used to improve the ELR_H and take the first step toward a Fully Engaged Heat Recovery System. Examples include use of energy recovery at the AHU, adding a cooling coil in the exhaust and/or relief airstream and incorporating Mixed Air Temperature (MAT) reset to shift from airside economizing to water side economizing. Shifting the load from centrifugal chillers to HRCHs reduces plant condenser water pump and cooling tower fan energy and water use. Bypass dampers can be used to eliminate added pressure drop when the coil is not in use.

In Figure 1, we can see at present we are limited by the small cooling load below 50˚F (10˚C). At first, ELR_H looks reasonable and could result in a 30% reduction in heating hot water energy use. The ELR, however, cannot stand on its own. The system is limited by HRCH turndown, capacity, temperature limits and reliability, all reducing the savings that can be achieved. We need to know how the equipment will perform in the system. This leads to the concept of Achievable Load Ratio (ALR).

$$\text{Heating Achievable Load Ratio } (ALR_H) = \frac{\text{Achievable Engaged Heating Load}}{\text{Total Heating Load}}$$

If we take the ratio of the two measures, we get the ELR Efficiency – the ratio of Achievable Load to Engageable Load.

$$\eta ELR_H = ALR_H / ELR_H$$

This is a machine-dependent measure of how effective the selected equipment will be in capturing the potential for thermal energy recovery for a given building.

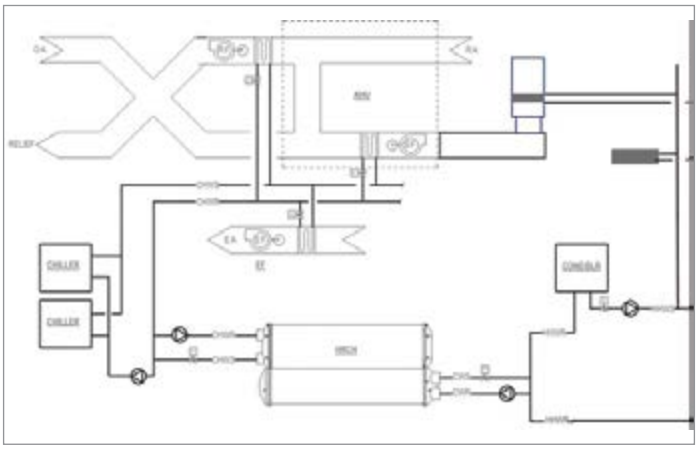


Figure 2: FHRE system configuration.

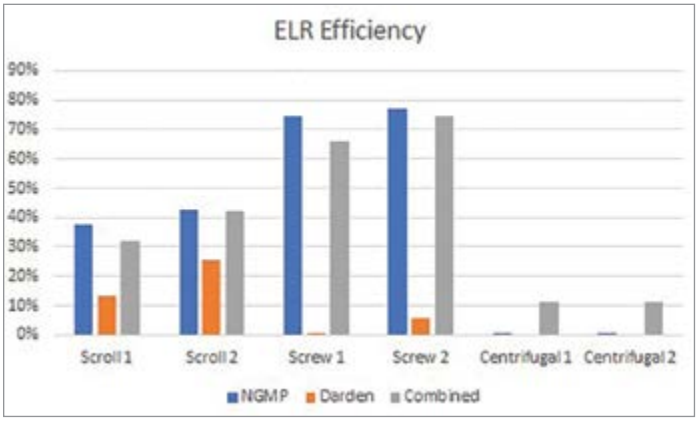


Figure 3: ELR efficiency of various HRCH applications.

When presented with lifecycle costs, the ηELR_H provides a full picture of the cost to achieve a given degree of energy recovery. It also reveals the incremental costs of drawing closer to the site goals.

Figure 3 compares ηELR_H for several equipment options that were considered for the University of Virginia. The scroll chillers showed poorly because of reliability problems experienced by the University. The centrifugal options were too large for the application.

Calculating ηELR_H allows the engineer to compare equipment and understand the source and magnitude of different load components. Taking short cuts reduces the potential for the system and blinds the designer to the insight needed to find potential innovations presented

Full Heat Recovery Engagement: Using Current Technology to Electrify Heating Loads

by the project.

In calculating the ηELR_H, we can envision the interactions between many different energy savings strategies and see how they would work in aggregate – we can see the impact on the whole system expressed as one factor. Calculating ηELR_H will reveal the benefit of a fully sized airside economizer, while providing for waterside economizing at the same time. It will show that adding a cooling coil and bypass to a centralized exhaust system has economic benefit. And we now have a tool to analyze the energy impact of decreasing outside air while increasing minimum volumetric airflow rate or increasing ventilation in response to COVID

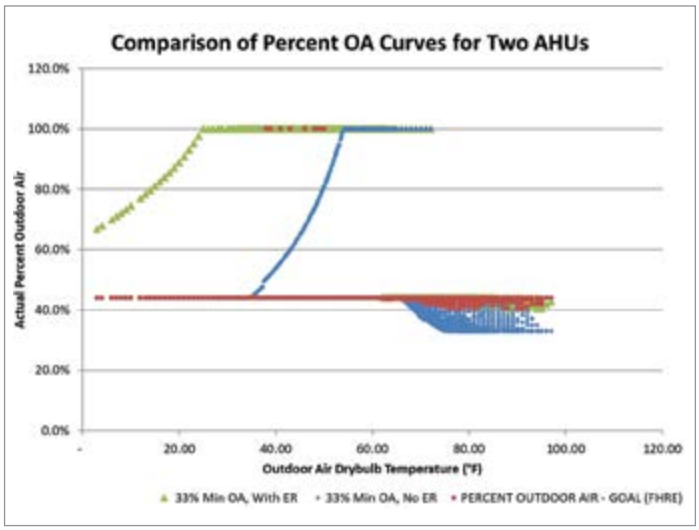


Figure 4: Outside air control strategies.

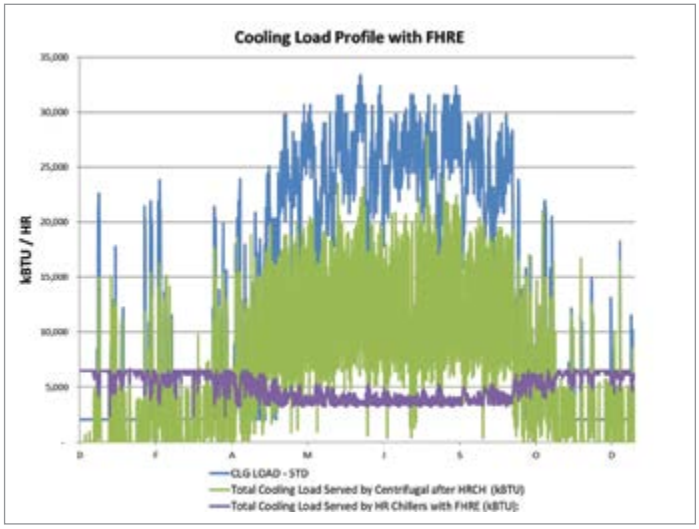


Figure 5: Cooling load profile manipulation.

or the next concern, which could be an external threat.

The steps taken to calculate ηELR_H may reveal that driving one factor to its minimum energy use may result in an overall higher energy use. This may be counter-intuitive and seems to violate both energy code and a principle of net zero buildings. When presenting this concept, an objection often raised is that energy code says we cannot use mechanical cooling where we could airside economize. So, why use energy (waterside economizing) when we can do it for free (airside economizing)?

The response is "environmental prudence." If the right thing to do is to reduce overall energy use, then judiciously creating a cooling load where there was none is the right thing. Using the relationships defined above, the HRCH CR corresponds to a COP_H of 3.78 and COP_C of 2.78. When serving native loads, the net COP is 6.56. When using waterside economizing instead of airside, the benefit is 3.78/0.92, the COP_H/the boiler efficiency. This results in a 75% reduction in energy use, including parasitic losses.

To obtain this benefit, AHU MATs must be coordinated with plant operations. When called for by the control system, a measured amount of Energy Recovery (ER) can be added to the chilled water system load by adjusting the MAT, enabling a response in heating output.

Figure 4 shows two AHUs, both with 33% OA at rated airflow. Outdoor air in the AHU without ER (blue diamonds) ramps down between 55˚F (12.7˚C)and 35˚F (1.6˚C)dry bulb. Because the supply airflow is reduced as load drops off, this unit requires 44% OA at reduced airflows and this limits our ability to recover energy from the installed cooling coil when outdoor air temperature is below about 35˚F (1.6˚C). The AHU with ER (green triangles) will have higher MATs if we don't bypass the ER device. This allows waterside economizing through the entire heating range. This cooling load can be engaged with native heating loads and this improves the ELR_H, ALR_H and ηELR_H. Reducing the OA recirculates humidified air back into the space, reducing humidification steam requirements.

One final comment on the implementation: many sites charge buildings for the heating and cooling energy used. Allowances or incentives may be needed to encourage building operators to provide the cooling load as a means of energy recovery when airside economizing is available.

When all opportunities incorporated into the design are modeled, we can see the impact of FHRE on the cooling loads served by the centrifugal

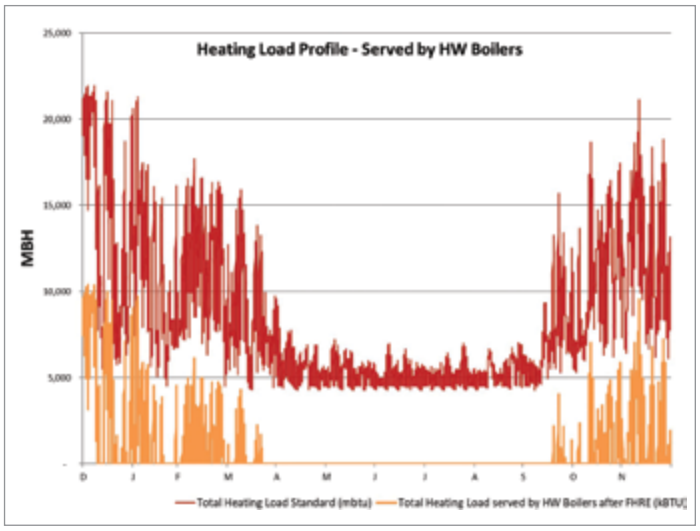


Figure 6: Boiler load profile after FHRE.

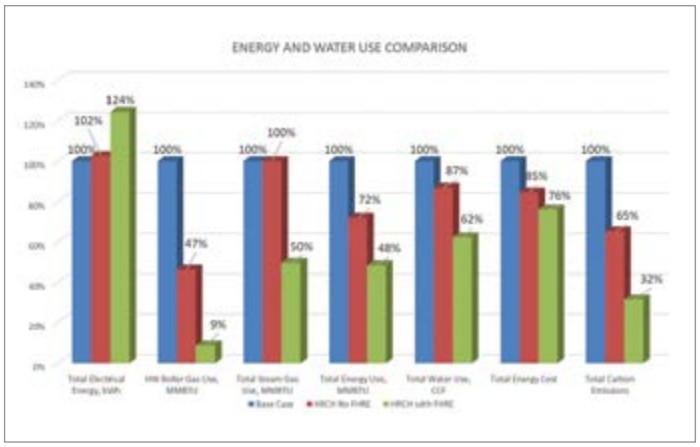


Figure 7: Energy and water use reduction.

chillers and the heating loads served by boilers.

Figure 5 is the Midwestern hospital example showing the peak cooling loads dropping and base and winter loads increasing (due to FHRE). Notice the increase in winter cooling loads with FHRE that become the sizing criteria for the HRCHs. Modeling will reveal the benefit of adding HRCHs that can be weighed against goals and added cost.

Figure 6 is the heating loads corresponding to Figure 5. It shows the dramatic drop in heating load served by the boilers that can be achieved.

Figure 7 shows the resultant energy savings and electrical energy increase for the FHRE. Each energy category is compared using the base case as the 100% value.

Simple Measures Generate Results

On your next project, when considering HRCH and heat pumps, show the team what you can accomplish for FHRE by taking simple measures that can help focus the building and system design to reduce carbon and energy costs. BP

About the Authors

Joe Witchger, PE, is a Senior Mechanical Engineer at HGA, where he specializes in high-efficiency central plants, energy management systems, and mechanical systems optimization.

Brendan Huss, PE, WELL AP, is a mechanical engineer at HGA, where he specializes in analysis and design of central boiler and chiller plants and district heating and cooling distribution systems.

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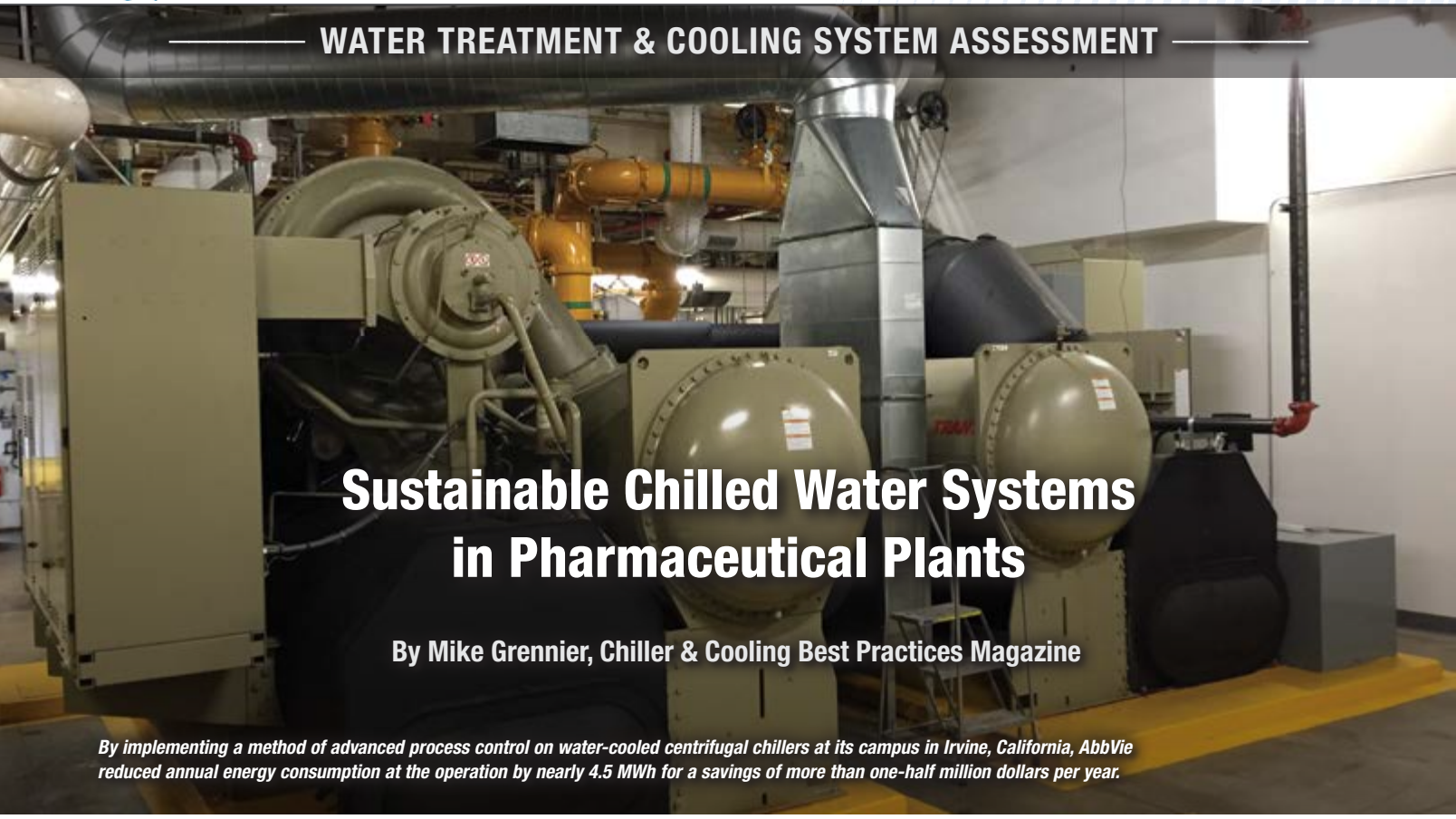

Sustainable Chilled Water Systems in Pharmaceutical Plants

By Mike Grennier, Chiller & Cooling Best Practices Magazine

By implementing a method of advanced process control on water-cooled centrifugal chillers at its campus in Irvine, California, AbbVie reduced annual energy consumption at the operation by nearly 4.5 MWh for a savings of more than one-half million dollars per year.

➤ Chiller & Cooling Best Practices Magazine spoke with Tom Pagliuco, Executive Director Global Energy Engineering at AbbVie, Inc. about best practices for optimizing chilled water systems in today's pharmaceutical operations.

Pagliuco has a wealth of experience in energy management having served in energy leadership roles at leading pharmaceutical companies such as Schering-Plough Corporation and Merck, as well as Allergan, which AbbVie recently acquired. He spearheaded numerous energy-initiatives that gained wide-spread recognition for several companies from the U.S. Environmental Protection Agency's ENERGY STAR® program – including earning eleven ENERGY STAR Partner of the Year Sustained Excellence awards since 2009.

Good morning! Please describe AbbVie.

We're a global biopharmaceutical company focused on discovering and developing innovative medicines that solve serious health issues. Our areas of focus include immunology, oncology, neuroscience, eye care, virology, women's health, gastroenterology, and Allergen Aesthetics. We're headquartered in Lake Bluff, Illinois, and we have manufacturing and research facilities in 14 countries. This includes eight research centers. We employ a total of 47,000 people.

Tom Pagliuco, Executive Director Global Energy Engineering, AbbVie, Inc.

Where are the biggest opportunities for sustainability at pharmaceutical manufacturing plants?

Electrical energy reductions are often the primary focus for conserving resources for a number of reasons. For one, they result in a reduction in greenhouse gas emissions. Second, energy is typically way more expensive than water. Pharmaceutical plants also tend to be located in areas where water is abundant, which is important since water is a significant raw material used for cooling processes and often the product itself.

When it comes to energy consumption, Heating Ventilation and Air Conditioning (HVAC) represents 65% of a typical pharmaceutical facility's total energy usage. There are a number of opportunities for optimization of HVAC systems and the components involved, such as chillers.

The Holy Grail for electrical energy savings with HVAC is to reduce the room air change rate, which is determined by the classification of a particular

room. But you can't change the process without proving those same changes won't affect the product. It gets very complicated, and in some cases, the easy answer is to say, "Don't mess with it."

So another excellent way to achieve energy savings is by producing chilled water more efficiently. Of course, you're still going to get some pushback as you would in any industry when it comes to making these changes, but there isn't the same level of reluctance as there is with room air change rates. It's why HVAC systems are a good target for energy efficiency.

How would you describe the challenges engineers face with HVAC systems?

The ideal is to get it right the first time and design the system to be as efficient as possible from scratch. That doesn't always happen, because if you're a process engineer, you're incentivized to meet the project budget and deadline and have the thing work. As an example, if the budgeting decision comes down to a super-efficient chiller, or a standard chiller, guess what's going to get installed? The standard chiller.

Another reason a highly efficient system doesn't always get installed has to do with the design process. Typically, design engineers don't want to take risks. That means things tend to get over designed because they want to build in a safety factor and make sure it works. That said, I've been on that side of the business so I get it. It's not easy. What should really drive decisions is total cost of ownership, but it takes a lot of engineering time to come up with that stuff, and even then, it's far from perfect.

What chilled water optimization control strategies have worked for you?

I've had a lot of success with advanced process control to achieve chilled water optimization. It essentially involves various levels of control for chillers.

On the first level you have instrumentation, such as temperature and pressure sensors and flow meters. That is all important stuff, of course, but it's a bunch of data and it doesn't deliver any savings, or very little savings, unless you do something with it.

The next level is what I refer to as distributed control. This is where you're taking all the data from instrumentation and controlling your process with a master control system, or a Building Management System (BMS). Now, you're able to achieve some energy and costs savings by using the data to control equipment like chillers. However, you're not really optimizing the system; you're only controlling it.

Pagliuco of AbbVie checks the status of equipment at one of the pharmaceutical company's many manufacturing and research facilities.

The top level of this control hierarchy is using advanced process control for optimization of things like chiller systems. This involves the integration of software that uses algorithms with a master control system to better control what's happening. So rather than just making chilled water, advanced control methodology generates the right amount of chilled water and pumps just enough of it to meet the cooling load, and no more and no less.

This is something we've decided to address and we've had success with it at our operations, including a very successful project at our research and development campus in Irvine, California.

What was involved with the Irvine chiller system optimization project?

The Irvine campus is one of the largest sites and energy users in the AbbVie portfolio with over one million square feet of laboratory, office and manufacturing space. At that time, the site used about 55,000 MWh per year of electricity.

The issue we wanted to tackle is not uncommon with many chiller installations. Many are operated as traditional constant primary loop, variable secondary loop systems. This creates a low operating delta T, resulting in over pumping of water in the primary and secondary loops. It also decreases chiller efficiencies and makes it seem like there

Sustainable Chilled Water Systems in Pharmaceutical Plants

is a lack of chilled water capacity.

The Irvine campus generates chilled water with cooling towers, along with five Variable Frequency Drive (VFD) water-cooled centrifugal chillers with a total installed capacity of 4,000 tons. The system is normally operated as a constant primary, variable secondary system. Most of the condensers, as well as the primary and secondary pumps and cooling tower fans, use VFDs.

While it's well designed and operated, a low delta T suggested the system was a candidate for optimization. So we partnered with tekWorx to improve the overall efficiency by using a more advanced method for controlling the chilled water plant. The company integrated its supervisory Control Engine Optimization system with the existing BMS, which converted the chilled water system to a full variable flow operation. It also improved efficiency through a better method of chiller sequencing and by operating the chillers based on updated setpoints, such as chilled water supply temperatures.

How would you rate the success of the project?

The initiative has reduced annual energy consumption by nearly 4.5 MWh, resulting in a yearly savings of more than one-half million dollars. Looking at it another way, it will lower the total electric power usage at the campus by 8%. We also received a utility incentive for the project, which resulted in a payback of just under six months.

This ties back to what I mentioned earlier with regard to capital costs associated with something like a highly efficient chiller. The campus chilled water system had almost everything it needed; we just needed to make it a little more efficient. The cost of replacing chillers that are not at the end of their life is going to be more expensive than implementing a more advanced method of process control.

This project was a homerun. We've since adopted it as a best practice methodology for optimizing chillers at other sites in our facility portfolio. We eventually did similar projects at operations in Westport, Ireland, and Waco Texas, as well as a smaller version at our Cincinnati, Ohio, plant. Our effort at the Irvine campus was a runner up for an ENERGY STAR Project of the Year award.

Congratulations on your success! What motivates you to be involved with the ENERGY STAR program?

I get a lot of value out of the comradery that goes along with being an ENERGY STAR partner because it gives me the opportunity to talk with my counterparts at other major pharmaceutical companies and swap stories and learn from others about ways to operate systems efficiently in order to reduce energy use.

The other thing I really like about the ENERGY STAR program is all of the benchmarking tools available, which is especially great since anyone can access them. You don't have to be an ENERGY STAR partner to take advantage of the tools. I also have to say the recognition an ENERGY STAR Partner of the Year award affords you is priceless.

Why is being named an ENERGY STAR Partner of the Year so beneficial?

I think the struggle of an energy manager in general is getting attention, getting people to put a priority on energy savings. It might not be as much of an issue with an energy-intensive industry like glass manufacturing where energy is a significant percentage of the costs of goods sold, but I think it's an issue with other industries like pharmaceuticals where energy is around two to three percent of the costs of goods sold.

As an energy manager I've learned that finding energy opportunities is easy when you've been in the business for a while. It's getting them implemented; that's the hard part. It's about trying to build a program, cutting through the clutter of day-to-day corporate life, having goals, and making things visible.

When I was at another company earlier in my career and we received an Energy Star Partner of the Year Award, all of the sudden it was like, "Wow. We just got this major award. Maybe this program is really good." It was kind of like, "Tom must know what he's talking about."

Getting an ENERGY STAR Partner of the Year Award stamps your program as a quality program and it helps you take things to the next level.

Thank you for these insights. BP

For more information, please contact Tom Pagliuco, email: Thomas.Pagliuco@Allergan.com. All photos courtesy of AbbVie, Inc.

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