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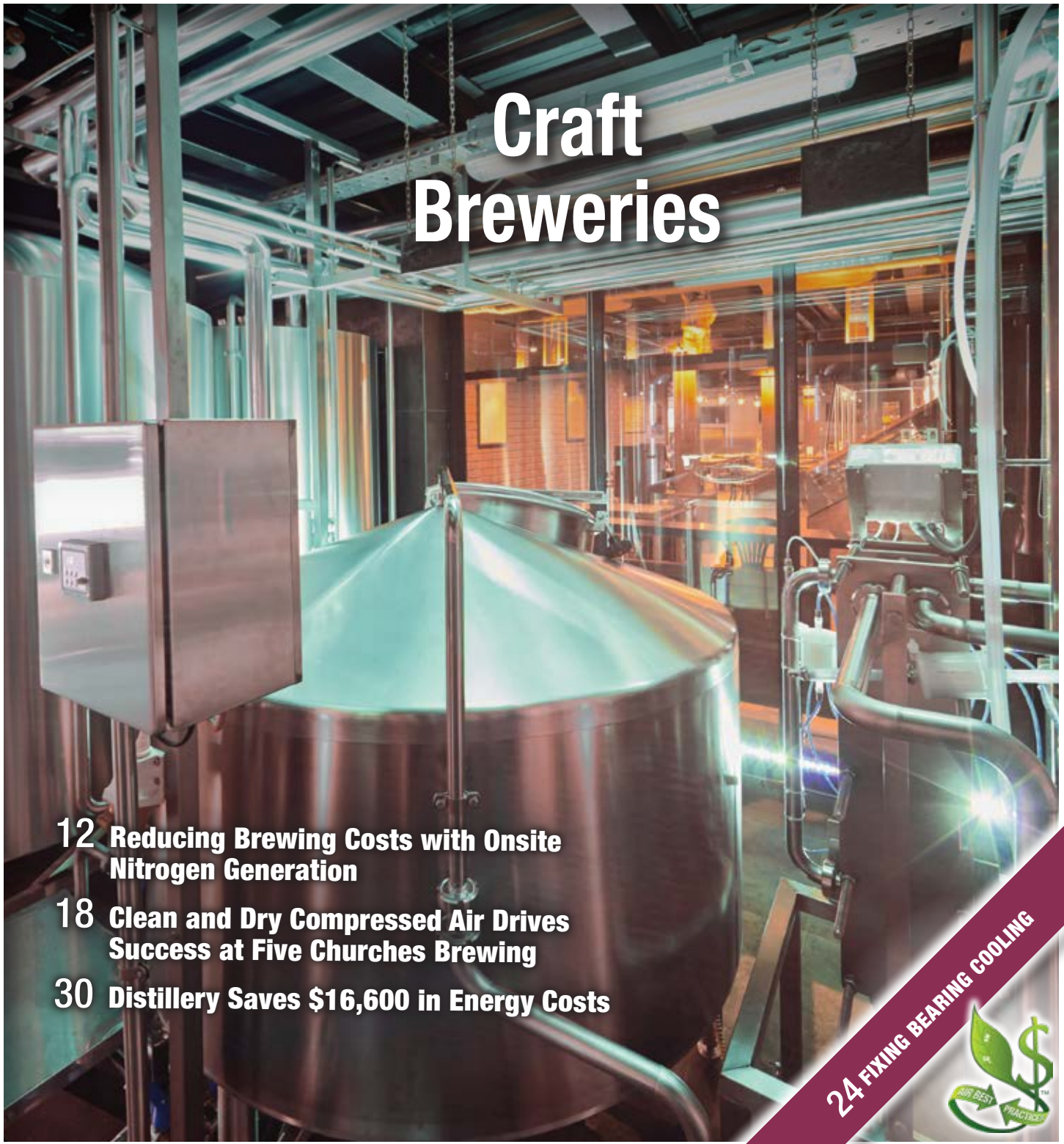

Craft Breweries

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FEATURES

12

QUALITY, SAFETY & RELIABILITY FEATURES

PRODUCTIVITY, SUSTAINABILITY & EFFICIENCY FEATURES


18

COLUMNS


30

FROM THE EDITOR | Craft Brewing

The booming craft brewery industry uses all the on-site utilities we write about. Brewers operate compressed air, nitrogen, chiller and vacuum systems on-site and are embracing opportunities to improve them.

Quality, Safety and Reliability

In this issue, we have three Quality, Safety and Reliability feature stories. Parker sends us a good article about how onsite nitrogen generation can reduce costs and improve the quality consistency in brewing.

Five Churches Brewing, in Connecticut, has built a strong business focused on brewing high quality products. They recently received the help of MidState Air Compressor, Inc. to design a "clean and dry" compressed air system to ensure quality brewing continues.

Productivity, Sustainability & Efficiency

A distillery uses compressed air in several applications. Ron Marshall provides us with an article about a distillery with many inappropriate uses. His audit identifies energy savings of almost $17,000 per year. A second excellent energy audit story is provided to us by Paul Edwards who details a bearing cooling misapplication of compressed air. More importantly he writes about how this was fixed and how the client saved energy.

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

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INDUSTRY NEWS

Vacuum Technology Saves Widmer Brothers Brewery Nearly $40,000 in Water, Sewer and Energy Costs

Atlas Copco, a leading provider of sustainable productivity solutions, recently partnered with Widmer Brothers Brewery, part of the Craft Brew Alliance (CBA), to improve the company's bottling process and eliminate excess water consumption with the first-known waterless vacuum pump in the craft beer industry. By replacing a liquid ring pump with an Atlas Copco GHS VSD+ rotary screw vacuum pump, the Portland, Oregon, brewery saves nearly $40,000 in water, sewer and energy costs.

Widmer Brothers Brewery originally used a liquid ring vacuum pump to bottle beers, but quickly realized the technology was consuming roughly 5,000 gallons of water per day at an average flow of 3.5 gallons per minute. After consulting Atlas Copco, Widmer Brothers Brewery decided to upgrade to the GHS VSD+ rotary screw vacuum pump.

"Unlike the liquid ring pump, the GHS VSD+ uses a foam dampening water trap to capture water and foam during the bottling process," said Greg Marciniak, Business Development Manager for the Industrial Vacuum Division at Atlas Copco. "Without the risk of liquid and foam entering the system, Widmer Brothers Brewery has peace of mind that their system will stay up and running without excess liquid potentially flooding the production floor. It not only keeps the area safe, it also drives down product waste."

Atlas Copco GHS VSD+ rotary screw vacuum pump at Widmer Brothers Brewery.

With the GHS VSD+, Widmer Brothers Brewery saves ample time and energy in the bottling process. By replacing the liquid ring pump, it has reduced water consumption by 5,000 gallons per day, which saves an annual $5,000 in water costs and $30,000 in sewer costs, including extra strength charges.

Although the equipment upgrade was originally driven by the desire to save water, Widmer Brothers Brewery has avoided wastewater impact and also saved on energy consumption. In switching to a Variable Speed Drive rotary screw vacuum pump, the system now produces a deeper vacuum with half the horsepower, saving the brewery close to $4,000 in energy costs.

"Widmer Brothers Brewery has a long history of supporting clean water and investing in innovative ways to protect beer's number one ingredient," said Julia Person, Sustainability Manager with Widmer Brothers Brewery. "We're excited to partner with Atlas Copco to pioneer the first waterless vacuum pump in the craft beer industry, and it's been great seeing how this innovation will lead to new energy and water saving technologies to be shared with our peers."

About Atlas Copco

Atlas Copco is a world-leading provider of sustainable productivity solutions. The Group serves customers with innovative compressors, vacuum solutions and air treatment systems, construction and mining equipment, power tools and assembly systems. Atlas Copco develops products and services focused on productivity, energy efficiency, safety and ergonomics. The company was founded in 1873, is based in Stockholm, Sweden, and has a global reach spanning more than 180 countries. In 2015, Atlas Copco had revenues of BSEK 102 (BEUR 11) and more than 43,000 employees. Learn more at www.atlascopcogroup.com.

About Widmer Brothers Brewing

Widmer Brothers Brewing – Kurt and Rob Widmer – founded Widmer Brothers Brewing in 1984 in a former mattress factory located in what is now the Pearl district in Portland, Oregon. It's hard to believe that the Oregon craft beer movement started with a cobbled together brewery including two fermenters built from old milk tanks, nuclear power plant parts, and farm equipment gathered in Oregon and Washington, but that's exactly how the Widmer Brothers began their story. Inspired by their German heritage, the first two beers they brewed were Altbier and Weizenbier. When a loyal local account requested a third beer, and with no way to increase tank space at their brewery, the brothers unfiltered their Weizenbier thinking it was a simple, one-time solution. Not so. The cloudy wheat beer, poured into a distinctive pilsner glass, and garnished with a lemon was about to become the Original American Hefeweizen. Today, Hefe remains Oregon's top selling craft beer for its distinctive great taste and hazy appearance. Hefeweizen has remained a NW staple beer and continues to win awards. Widmer Brothers continues to create quality craft beers and push the limits of Beervana. For more information, visit www.widmerbrothers.com.

Record Order Levels for Metal Cutting, Forming and Fabricating Machinery

Manufacturing technology orders (metal cutting, forming and fabricating machinery), posted in August and September, yielded the second largest two-month total in the program's history at $1.1 billion, according to the latest U.S. Manufacturing Technology Orders Report from AMT – The Association For Manufacturing Technology. The September surge of $609 million yielded a 50 percent increase over September 2017 and a year-to-date 27 percent increase over the first nine months of 2017. After a record-breaking August, the 17 percent gain seen in September was larger than

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INDUSTRY NEWS

expected and a testament to the industry's surge to increase capacity swiftly.

"We are seeing unprecedented demand for manufacturing technology as companies invest to drive up efficiencies and automate to back fill for skilled worker shortages. While we anticipated an overall uptick in orders due to IMTS, it was feared that a strong August meant companies would buy less at the show in September," said AMT President Douglas K. Woods. "Clearly, that was not the case. While there have been some concerns about tariffs, market swings, and the mid-term elections, none of it is swaying focus on growing the manufacturing base as both domestic and foreign manufacturers increase their capex investment in the United States."

The North Central West and South Central regions were down only in the sense that they were being compared to a much higher than average combined $500 million order total for August. The Southeast bounced back in September with a 155 percent improvement over August led by aerospace and medical equipment. The Northeast posted a 50 percent increase in orders in September built on substantial increases in orders placed by the job shop and the engines, turbines and power transmission sectors.

Nationally, industrial machinery represented the largest pickup in activity during September, climbing 152 percent over August. Job shops represented about a third of all orders, topping $200 million and up 65 percent from a strong August. Medical equipment orders were the second largest gross level of orders, something that has never happened in the history of the USMTO program. Orders from the medical equipment sector were four-fold typical monthly levels and were broad-based with significant activity in the Southeast, Northeast, and North Central West. Aerospace was the third-largest sector nationally, up 15 percent from August levels.

Most other key industry indicators were very strong. Durable goods orders had two strong months. Consumer confidence is hovering just below 100, and automobile sales are moving at a 17.4 million unit annual rate. Capacity utilization for the durable goods industries continues to edge upwards. The only negative sign is downward movement in the Purchasing Managers' Index, from 61.3 in August to 57.7 in October. While that suggests a continuation of expansion in purchasing trends, it also suggests that growth will slow. On the upside, it could also be that increasing backlogs in the supply chain have filtered through and created a traffic jam for manufacturers to deliver their products. As the supply chain catches up, there is a strong possibility the PMI will pick up as well.

The United States Manufacturing Technology Orders (USMTO) report

These numbers and all data in this report are based on the totals of actual data reported by companies participating in the USMTO program. This report, compiled by AMT – The Association For Manufacturing Technology, provides regional and national U.S. orders data of domestic and imported machine tools and related equipment. Analysis of manufacturing technology orders provides a reliable leading economic indicator as manufacturing industries invest in capital metalworking equipment to increase capacity and improve productivity.

About AMT – The Association For Manufacturing Technology

AMT represents U.S.-based builders and distributors of manufacturing technology – the advanced machinery, devices, and digital equipment that U.S. manufacturing relies on to be productive, innovative, and competitive. Located in McLean, VA, near the nation's capital, AMT acts as the industry's voice to speed the pace of innovation, increase global competitiveness and develop manufacturing's advanced workforce of tomorrow. With

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INDUSTRY NEWS

extensive expertise in industry data and intelligence, as well as a full complement of international business operations, AMT offers its members an unparalleled level of support. AMT also produces IMTS – The International Manufacturing Technology Show, the premier manufacturing technology event in North America.

IMTS – International Manufacturing Technology Show

The largest and longest running manufacturing technology trade show in the United States is held every other year at McCormick Place in Chicago, Ill. IMTS 2018 will run Sept. 10-15. IMTS is ranked among the largest trade shows in the world. Recognized as one of the world's preeminent stages for introducing and selling manufacturing equipment and technology, IMTS attracts more than 114,000 visitors from every level of industry and more than 112 countries. IMTS is owned and managed by AMT – The Association For Manufacturing Technology. www.IMTS.com

Measurement, Control & Automation Association (MCAA) Announces 2019 Board of Directors

The Measurement, Control & Automation Association (MCAA) announces their 2019 Board of Directors. MCAA President, Teresa Sebring, said, "I am pleased to welcome our newest Officers and Directors. The MCAA Board is comprised of individuals with diverse backgrounds and industry experiences that make them an asset to the organization."

Mike Waters, President & Chief Executive Officer of SOR Controls Group, Ltd. was elected Chairman. SOR Controls Group, Ltd. (SCG) is a global leader in the design and manufacture of measurement and control devices under the brands of SOR Inc., Smart Sensors Incorporated (SSi), SETEX Products, and SENSOR Sampling. SOR Controls Group actively serves all sectors of the process industry with particular strengths in the Oil & Gas, Petrochemical, and Power segments. SOR is headquartered in Lenexa, KS and has regional offices in Beijing, London, Houston, Chennai and Dubai, and manufacturing locations in Lenexa and Houston. Prior to joining SOR, Mike served in several senior leadership positions at CIRCOR International (NYSE: CIR) from 2006 to 2012, including Vice President & General Manager of Sagebrush Pipeline Equipment and Pipeline Engineering. Previously, Mike was the President of Flow-Zone LLC, a Gulf Coast-based oilfield supply company. Mike began his career with Emerson Electric Corp. (NYSE: EMR) as a member of the Rosemount Measurement & Control (Now Emerson Process Automation) organization. In addition to leading the MCAA Board, Mike currently serves on the Boards of Milbank Manufacturing, Inc., and Big Elk Energy Systems, LLC. Mike is a former Advisory Board member of the Petroleum Equipment & Services Association (PESA). Mike holds a Bachelor of Science in Engineering Technology/Industrial Distribution from Texas A&M University, and a Master of Business Administration in Finance from the University of St. Thomas in Houston, TX. Mr. Waters served as Vice Chairman in 2018 and has been on the MCAA Board since 2016.

Scott Saunders, President, Moore Industries International, Inc. will serve as Vice Chairman.

Mike Waters was elected Chairman of the MCAA 2019 Board of Directors.

He joined Moore Industries in 1999 and has held various leadership roles with the company until assuming the role of President/CEO in 2014. Acquisitions of Powers Process Controllers in 2000 and Hawke Fieldbus in 2005 have continued Moore Industries' position as a world leader in the design and manufacture of interface instruments for industrial process control, system integration, and the factory automation industries. Moore Industries is an international company headquartered in North Hills, CA with direct sales and support offices in strategic worldwide locations including the USA, Australia, Belgium, the Netherlands, the People's Republic of China and the United Kingdom. Scott holds a Bachelor of Science in Business Management from Winthrop University. Mr. Saunders has been on the MCAA Board since 2016.

2019 newly elected Directors-at-Large include:

- Deryl Bell, President, Carotek Inc.
- Russ Graybill, Director Product Marketing, Yokogawa Corporation of America
- Stephen Santangelo, President, Palmer Wahl Instruments, Inc.
- Colin Sheridan, President, Tel-Tru Manufacturing Co.

The remainder of the Board is comprised of:

Immediate Past Chairman:

- Bharat Naik, President of Reotemp Instruments

Directors-at-Large:

- Mike DeLacluyse, President, Lesman Instrument Company
- Bill Edinger, General Manager Process Instrumentation, Siemens Industry
- Gary Johnson, President, Azbil North America, Inc.
- Jim Winter, Director of Global Process Business, Rockwell Automation

Founded in the early 1940's, MCAA has been serving leading industry organizations for seventy-five years. MCAA is the trade association for manufacturers and distributors of instrumentation and systems associated with the Measurement, Control & Automation Industry. MCAA provides resources for business effectiveness and growth through unsurpassed market and business insights, unique networking opportunities, and unbiased, affordable market data. The Association is headquartered in Poquoson, VA. For more information about MCAA, visit TheMCAA.org.

QUALITY, SAFETY & RELIABILITY

Reducing Brewing Costs with ONSITE NITROGEN GENERATION

By Nathaniel Holliday, Randy Peccia, Jennifer Fiorello, Parker Hannifin

As a result of the craft beer movement, Americans are enjoying more beer than ever before. Although it may seem easy enough to go to your local beer market to pick up a six-pack, the process for brewing, bottling and taking that beer to market is quite extensive.

Brewing is normally broken down into four stages – malting, mashing, boiling and fermenting. The complex chemical processes begin with a few simple ingredients – hops, grain, yeast and water. Recently there have been technological advancements to safeguard that these steps are attained accurately, efficiently and with cost-savings. One particular improvement is the use of nitrogen during the brewing process. The addition of an onsite nitrogen generator allows brewers to reduce their nitrogen costs, eliminate downtime, and reduce safety risks related to bulk gas cylinder delivery and changeouts.

The Brewing Process

Let's examine the four stages of brewing: malting, mashing, boiling and fermenting. The first of the process is malting, which is broken down into multiple stages itself, but essentially this is where the ingredients of starch, enzymes, protein, vitamins, and minerals are combined to create the main raw material for the batch. Mashing then takes the created malt and mixes it with heated water, where the natural enzymes of the malt breakdown the starch into sugars. These sugars are then separated from the main mixture to create wort, which is then boiled to a controlled temperature to allow for a brewer to add additional ingredients specific to the type of beer being produced. After this step is finished, the mixture is cooled and separated. Once divided, the brewer adds in the yeast that is essential for the fermentation to begin. When the fermentation is finished, the beer is fully matured to deliver the taste intended.

Nitrogen in the Brewery Process

Nitrogen is commonly used throughout the brewing process because of its inert characteristics. Once a completed batch of beer is removed from the large tanks that are used throughout the process, nitrogen is used to purge the tanks of any leftover residual from the wort, beer and mash. The act of purging a tank with nitrogen eliminates the chances for the residual ingredients to oxidize in the tanks. If oxidation were to occur, it could create sour flavors in any subsequent batches.

Because nitrogen is capable of displacing oxygen and carbon dioxide in the air, brewers use nitrogen to help transfer the beer through different tanks during the process. Once all stages of brewing are complete, nitrogen is used to pressurize kegs and bottles to help maintain the freshness of the beer. This preserves the finished product from spoiling quickly by reducing the oxygen content that is in the final product.

As brewers are continuing to enhance the taste and flavors of beer for consumers, they have also started experimenting by adding nitrogen into the beer itself during the process to create carbonation. Typically, carbon dioxide is used to carbonate beer but by adding a larger percentage of nitrogen into the mix, the nitrogen creates a better taste and a smoother finish.

Shown is the Parker Hannifin NitroSource nitrogen gas generator. Photo courtesy of Parker Hannifin.

Return on Investment

Lower costs, reduced gas waste, on-demand supply, and reduced downtime are all examples of benefits of generating nitrogen onsite. When deciding to change over from delivered gas to onsite nitrogen generation, there are upfront costs that usually deter a brewer from making the switch. Once it is understood that the investment will save the brewery money in the long run, it's a much easier decision to make. Most can expect to see a return on their investment between 18 to 24 months after

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REDUCING BREWING COSTS WITH ONSITE NITROGEN GENERATION

startup, depending on the amount of nitrogen consumed and the cost paid for the generator.

Not every brewer pays the same amount of money for nitrogen, as many gas suppliers charge based off the type of nitrogen required, the distance away from the generation site and whether the nitrogen is delivered in cylinders, mini tanks, or as bulk storage. Costs usually include a standard rental fee for the storage medium, as well as delivery of the nitrogen. Once the brewery gets past the initial costs of procuring a nitrogen generator, the brewer will quickly start saving money because it is significantly less expensive to produce nitrogen onsite.

Eliminate Dependency

With gas delivery the brewer will only use about 90% of the nitrogen that is in the tank since about 10% of the gas is returned unused. Gas is also lost when the cylinders or tanks become hot. The pressure within the tank begins to rise, requiring "boil-off" of the gas. Boil-off is when the tank needs to be opened and gas is released into the atmosphere to reduce the pressure of the tank. With the installation of an onsite nitrogen generator, 100% of the gas that is produced can be used for brewing.

When dependent on cylinder or tank delivery, breweries may run into unplanned downtime. It can be quite difficult to estimate how much nitrogen is needed for production. If this is not estimated correctly, production can come to a standstill until the next shipment arrives. Gas suppliers may not always deliver nitrogen in a timely matter to meet the needs of the brewery, and they can be left without a nitrogen supply, which ultimately results in lost revenue. With an onsite nitrogen generator the brewer can maximize uptime and eliminate the dependency on a gas supply company.

REDUCING BREWING COSTS WITH ONSITE NITROGEN GENERATION

Increased Available Footprint

Depending on the type of storage medium used for the nitrogen, the brewer will need to clear space for cylinders, mini tanks, or even bulk gas. If multiple cylinders and tanks are required, it can reduce the amount of free space in the facility remarkably. If bulk gas is used, the brewery will be required to create the necessary foundations outside the facility to hold the weight of the heavy tanker. Onsite nitrogen generators are compact and have the capability to bank together to save storage space in the facility, and do not have any foundation specifications to support them properly.

How Nitrogen Generators Function

Nitrogen generators operate on compressed air by reducing the percentage of oxygen in the air to solely deliver nitrogen to the required application.

Nitrogen generators use compressed air that is "sieved" so that oxygen and other trace gases are removed, while nitrogen is allowed to pass through to the application. The compressed air supply could be from spare capacity from a central factory air compressor, or from an air compressor dedicate solely to the nitrogen generation system.

The compressed air quality used for nitrogen generation is important to maintain the purity and efficiency of the nitrogen generator. Compressed air contaminants, such as oil, particulate and water, must be removed from the compressed air supply prior to entering the inlet of the nitrogen generator.

The typical compressed air system consists of a compressor, air receiver tank and compressed air treatment package. A compressed air treatment package consists of varying levels of pre-filtration, a compressed air dryer and a post-filter. A typical pre-filtration package consists of a water separator for bulk liquid removal, a general purpose coalescing pre-filter and a high efficiency coalescing pre-filter.

Combined, this pre-filtration removes particulate, including water and oil aerosols, down to 0.01 micron and oil down to 0.01 mg/m^3. Downstream of the pre-filtration is a compressed air dryer, which removes water vapor from the compressed air. For PSA nitrogen generators, a desiccant dryer is most often required in order to provide pressure dewpoints of -40 ˚F or lower. Lastly, a general-purpose dust filter is installed downstream of the desiccant dryer to remove any dusting that may result from desiccant degradation.

Two Types of Nitrogen Generators

There are two main types of nitrogen generators, Hollow Fiber Membrane and Pressure Swing Adsorption. Hollow Fiber Membrane nitrogen generators operate by selectively allowing nitrogen gas to flow through the fibers of the membrane. Oxygen and other contaminants are then released back into the atmosphere through a port in the generator. The fibers of the membrane are sometimes made from Polyphenylene Oxide, which allow for permeability and robustness to the membrane fibers. The permeability of the fiber pulls the oxygen and other contaminants out of the compressed air, leaving only nitrogen to pass through.

Pressure Swing Adsorption (PSA) nitrogen generators function by utilizing the technology of carbon molecular sieve. The carbon molecular sieve adsorbs the oxygen and other contaminants from the compressed air

under pressure, ensuring that only nitrogen is delivered to the required application. Once the carbon molecular sieve is fully adsorbed with oxygen and other contaminants, the generator will go through a regeneration process to expel the contaminants into the atmosphere. The term Pressure Swing Adsorption comes from the generator's continuous operating pressures between 0 to 100 psi. Once the generator reaches 100 psi it begins the regeneration process.

Although there are two main types of nitrogen generators, the primary generator that is used in brewing applications is the PSA generator. The purity of the nitrogen gas is very important since it is being used in a food-based application. PSA nitrogen generators can achieve 99.5% and higher purity at the outlet, which is a great benefit to the user since FDA regulations for food applications require that the outlet gas is of high purity.

Most food and beverage application require nitrogen purities between 99-99.9%. Whether they use nitrogen gas to clean or blanketing tanks, inject it into kegs headed to storage, or infuse it into the beer itself, brewers typically use purities between 99.5%-99.9%. The exact purity used is up to the brewery.

Onsite Nitrogen Generation Maintenance

Maintenance for nitrogen generators is simple. The most important piece to keeping your nitrogen generator running at peak performance is maintaining the compressed air treatment package upstream.

Regular maintenance of the filter elements, pre-filtration drains and dryer valves ensure proper function of the dryer resulting in continuous clean, dry air to the nitrogen generator. As for the PSA nitrogen generator, annual maintenance requires any filter elements and exhaust silences are changed annually. If equipped with an oxygen analyzer, the analyzer cell requires replacement every two to five years, depending on the manufacturer. Outside of this basic preventive maintenance, most manufacturers recommend servicing of the valves and cylinders every three to five years. Even if operating properly, proactive maintenance prevents from future failures and costly downtime.

In Summary

When it comes to nitrogen use in brewing applications, there are multiple benefits that onsite nitrogen generators can bring to the table. With the simple installation of a nitrogen generator the brewer can take full control of the process and reduce costs of operation for many years to come. Ultimately brewers will see their bottom line grow due to the savings from nitrogen generation and in turn achieve a higher profitability. BP

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For more information about Parker Hannifin nitrogen gas generators, visit http://ph.parker.com/us/21056/en/nitrosource-psa-nitrogen-gas-generator

To read more ***Nitrogen Generation Technology*** articles, please visit www.airbestpractices.com/technology/air-treatment.

QUALITY, SAFETY & RELIABILITY

CLEAN AND DRY COMPRESSED AIR Drives Success at Five Churches Brewing

By Mike Grennier, Compressed Air Best Practices® Magazine

Compressed air is a critical aspect of brewing craft beer and no one understands that better than Five Churches Brewing, which recently looked to MidState Air Compressor, Inc. to recommend and install an appropriate compressed air system for virtually every aspect of beer production including brewing, canning and keg washing.

Together, Five Churches (www.fivechurchesbrewing.com) and MidState Air Compressor Inc. (www.midstateaircompressor.com) opted to install a rotary vane air compressor package at the microbrewery to reliably and quietly deliver clean dry air for its brewing operation. The compressed air system allows Five Churches to not only consistently produce quality beers customers have come to appreciate – but continue to grow its burgeoning business.

Craft Beer and Wood-Fired Pizza

Owned by the Lemnotis family and located in downtown New Britain, Connecticut, Five Churches Brewing is a combination microbrewery and taproom that typically offers 12 different craft beers at any given time. It also serves wood-fired pizza.

The brewery and taproom, which offers seating for 100, is unlike most since it's located on the second floor of building, providing panoramic views of the city's downtown. The first floor of the building houses the Lemnotis family's transportation business. Since it opened in March 2018, the microbrewery has gained increasing popularity.

Clean, Dry Air: A Top Priority

When planning the microbrewery, a priority for Five Churches' was the installation of a compressed air system able to provide clean, dry air used in multiple processes and do so with virtually zero potential for contaminants, including oil, water and particulates. The system also needed to operate reliably for years to come given the critical role compressed air plays in the brewing operation.

After analyzing plans for Five Churches' microbrewery and its compressed air needs, MidState Air Compressor, Berlin, Connecticut, recommended the installation a Mattei Blade

> "Breweries need to follow Five Churches' example and make compressed air a top priority. When the goal is an efficient and contaminant-free system, it's important to properly plan and budget for the right air compressor, dryer and filtration system."
>
> — Kyle Wicklund of MidState Air Compressor

7 SE Quality Air Station powered by a food-grade-oil lubricated 7.5 horsepower (HP) oil-flooded rotary vane air compressor rated to deliver up to 36 scfm at 115 psi.

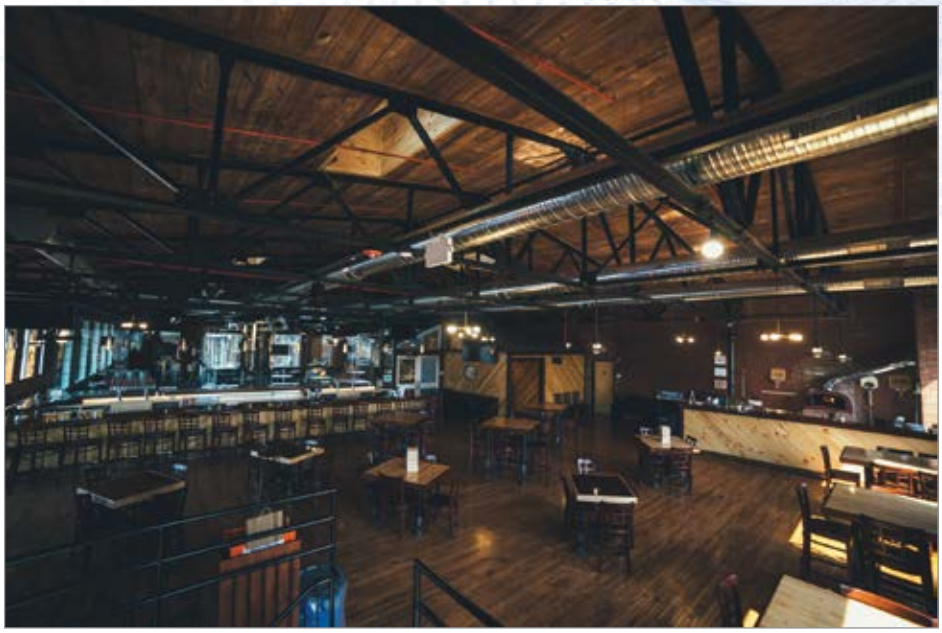
A rotary vane air compressor package was the best style of machine for Five Churches for multiple reasons, according to MidState Air Compressor Owner Sal Calvo.

"We work with a lot of microbreweries and many don't have the budget to support the upfront cost of an oil-free scroll air compressor," Calvo said. "Yet they need a reliable system that provides clean, high quality air in order to produce quality beer and prevent equipment damage. We took all of this into consideration with the system at Five Churches."

When considering reciprocating style air compressors for microbreweries, duty cycle capability of the air compressor is a major factor given the compressed air profile of a typical brewery operation, Calvo said.

"Brewery processes need consistent airflow," he said. "We decided against a reciprocating-style air compressor since that type of unit is designed for intermittent use and is not constructed for long duty cycles that breweries like Five Churches require." Inappropriate use of a reciprocating compressor can result in premature system failures, production halts, and require unnecessary service requirements, Calvo said.

The rotary vane air compressor package recommended for Five Churches also addresses the need for clean air, which is critical to the safety and quality of its craft beers. Toward that end, the unit at Five Churches, which is mounted on an 80-gallon air receiver tank, provides high efficiency, oil/air separation with minimal oil consumption and oil carryover in compressed air to a maximum 1 to 3 parts per million (ppm).



Five Churches Brewing is a combination microbrewery and taproom that typically offers 12 different craft beers at any given time, along with wood-fired pizza.

CLEAN AND DRY COMPRESSED AIR DRIVES SUCCESS AT FIVE CHURCHES BREWING

The air compressor package includes a built-in air-cooled aftercooler and a refrigerated air dryer with a 0.1-micron particulate filter mounted on the inlet. The dryer also features a moisture separator with a timer-operated auto drain. MidState Air Compressor also installed a 0.01 ppm oil coalescing filter together with an activated carbon 0.003 micron oil vapor removal filter downstream of the dryer to provide an even higher level of filtration ahead of the microbrewery's keg washer.

The air compressor package was provided with a refrigerated dryer and filtration system to provide dry and oil-free compressed air.

It's essential for small breweries to install a proper compressed air system given the application, said Kyle Wicklund of MidState Air Compressor who oversaw the compressed air system installation at Five Churches.

"Breweries need to follow Five Churches' example and make compressed air a top priority. When the goal is an efficient and contaminant-free system, it's important to properly plan and budget for the right air compressor, dryer and filtration system," Wicklund said.

In addition to the air compressor and filtration system, MidState Air Compressor designed and installed the piping system, which provides consistent air pressure and flow to various processes. The system is constructed of copper piping to further ensure the air delivered is clean and free of particulates. MidState Air Compressor also chose copper piping for aesthetics since the brewhouse is visible to customers.

The piping system routes air from the air compressor on the first floor of the building to a 1-inch wide header located on the second floor. From there, the system splits into ¾-inch wide copper lines to supply air to the brewhouse, canning line and keg washer. Also located on the first floor are two 750-pound $C0_2$ tanks that make up a separate system used to provide $C0_2$ to processes.

A steady and reliable flow of compressed air is crucial to the brewing process at Five Churches' 20-barrel (bbl) brewhouse.

Brewhouse Calls for Steady, Reliable Air

Compressed air is vital to Five Churches' 20-barrel (bbl) brewhouse, which typically brews beer several times per week. American Beer Equipment (A.B.E) supplied the equipment for the brewhouse and the brewer's other main operations. A.B.E (www.americanbeerequipment.com) is located in Lincoln, Nebraska.

A master Programmable Logic Controller (PLC) is used to control the brewing process at Five Churches. It typically takes eight to 14 hours to brew a batch of beer, depending on the product being produced.

Among the key components of the brewhouse are a series of tanks, beginning with 40-bbl tank used to store and heat water. Heated water is fed to a 20-bbl mash tun, which mixes the water and barley malt in a process called malt conversion. The process uses natural enzymes in the malt to break the malt's starch down into sugars. The mash tun also strains out the grain and converts the mixture into a liquid known as wort.

Wort is then transferred to a 20-bbl kettle where it is boiled for a set time period based on the beer being brewed. From the kettle, the sterilized mixture is fed to a fermenter where yeast is added to the process to convert the wort into beer by producing alcohol in various flavors. After maturation, the beer is carbonated and transferred to a bright beer tank, which feeds consumable beer to kegs and the operation's canning line.

Clean compressed air with the help of liquid sensors and the master PLC controller powers as many as 20 pneumatic valves used to carefully orchestrate the transfer of hot water, wort and beer from one vessel to the next. In all, the brewing process consumes 5-7 cfm of air at between 95 to 130 psi.

Five Churches' self-contained canning machine can fill, seam and lid up to 35 cans per minute.

CLEAN AND DRY COMPRESSED AIR DRIVES SUCCESS AT FIVE CHURCHES BREWING

Five Churches Head Brewer Austin Japs said a steady and reliable flow of compressed air is crucial to the brewing process, as is the quality of the compressed air.

"It's crucial for the valves to open and close instantaneously when called on since an interruption in the process could ruin an entire batch, costing us thousands of dollars and lost productivity. The air coming through those lines also needs to be as pure as possible since we're producing a consumable product," Japs said.

Canning System Optimized for Productivity

In addition to serving tap beer, Five Churches cans different varieties of beer for sale. The microbrewery is equipped to produce approximately 2,000 cans of beer per week.

An A.B.E.'s CraftCan35™ canning system is at the heart of the canning operation, which relies on compressed air for operation. The self-contained canning machine is rated to fill, seam and lid up to 35 cans per minute.

Primary components of the 8-foot-long by 2-foot-wide machine include a five-head/three-port in-line automatic filler with CO_2 purge control, a CO_2 gas tunnel, lid magazine, servo seamer, air knife and conveyor system. The PLC-controlled system, which rests on wheels for ease of mobility, features an HMI touchscreen and can also be manually controlled.

The canning process at Five Churches begins when a de-palletizer automatically loads empty aluminum cans onto the CraftCan system. The first station on the system rinses the empty cans with pure water to remove any potential dust or particles inside the cans. The cans are then conveyed to the filling station where they are purged with CO_2 to protect against dissolved oxygen and filled with beer.

The system then introduces another short microburst of CO_2 to the tops of the cans shortly before the machine places lids on the cans, which are then conveyed to the servo seamer for sealing. Once seamed, the cans move through an exterior rinsing process that includes the use of an air knife for drying. As a final step, Five Churches' crew manually applies labels and packages the cans for sale.

The compressed air system delivers 20 cfm of air at 105 psi for conveying, filling, lidding, and drying. An electronic motor controls the servo seamer, while a separate system supplies CO_2.

"The compressed air system does an excellent job at delivering a consistent supply of air at the proper pressure, which ensures the canning system operates as designed," Japs said, adding that productivity is essential given the company's small brewing crew that includes two brewing assistants who work closely with Japs. "The end result is properly filled cans at the needed rate without any waste of beer or cans."

A keg washer eliminates the need for manual keg cleaning, while also ensuring availability of clean kegs.

Keg Washer Expedites Keg Cleaning

Keg washing is another process that calls for clean, dry compressed air at all times. Five Churches typically devotes one full working day per week to keg washing.

The microbrewery uses an automatically controlled A.B.E Keg Commander™ keg washer to expedite the keg washing process. The keg washer is rated to clean and purge up to 30 kegs per hour using a 16-step cleaning cycle. Key components of the PLC-controlled machine include a dual-head system for cleaning two different sized kegs simultaneously, two separate tanks for the cleaning solution and water, low-liquid sensors inside the tanks, and an HMI touchscreen.

Japs said the importance of a consistent supply of clean, dry air for keg washing cannot be understated.

"Clean compressed air is essential since we're using it to eliminate any cleaning solution at the end of the cleaning cycle and then refilling the keg with beer to be consumed," Japs said.

Keg washing begins when two empty kegs are manually placed on the dual-head mounting system of the machine. The unit's electric pumps then fill the kegs with the cleaning solution and water. Next, the kegs are pressurized with compressed air to flush out the remaining solution, which then flows into a drainage pipe when upon completion of the cleaning cycle. In all, the keg washer uses 20 cfm of compressed air per keg at 75 psi to ensure thorough flushing. As a final step, a separate system is used to purge each keg and re-pressurize them with 20 cfm of CO_2 at approximately 15 psi.

"In addition to clean air, knowing we can rely on the compressed air system for keg cleaning is important because otherwise we would spend a whole week manually cleaning kegs," Japs said. "With this keg washer, all we need to do is drop the kegs on the machine and press start. The entire cleaning cycle is about seven minutes and we come out with clean kegs ready to refilled."

Making Beer and Having Fun

Since it opened for business Five Churches has experienced steady growth and increased interest in its taproom and craft beers. The early success is a strong indication of more success to come especially since Connecticut is home to a thriving craft beer industry built around high customer demand.

"The craft beer scene in Connecticut continues to grow as does the competition," Japs said. "All that means is that we're going to continue to produce top-quality beers that will make us stand out, while we also have fun in the process." BP

For more information about MidState Air Compressor, visit www.midstateaircompressors.com.

All photos courtesy of MidState Air Compressor and Five Churches Brewing.

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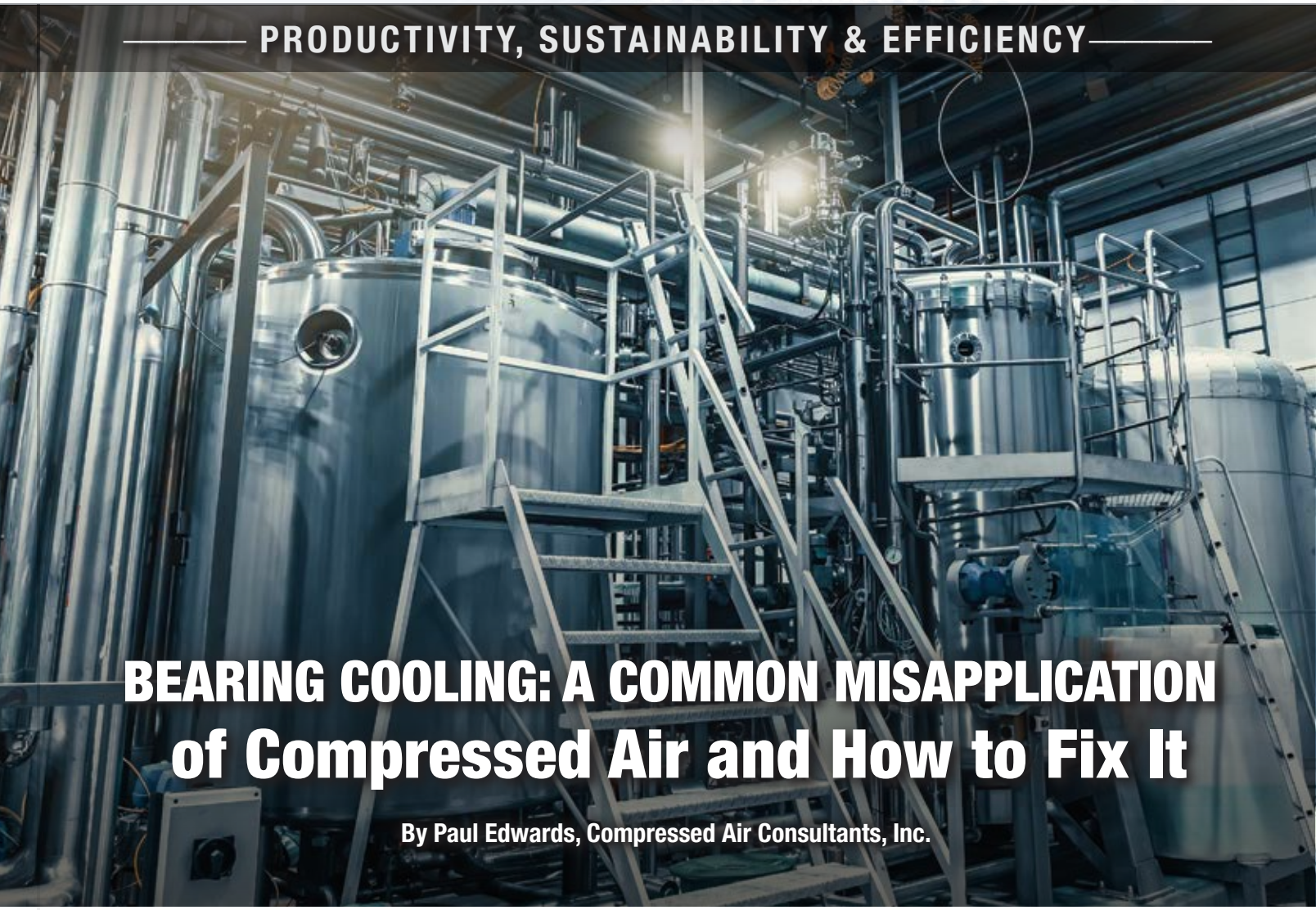
PRODUCTIVITY, SUSTAINABILITY & EFFICIENCY



BEARING COOLING: A COMMON MISAPPLICATION of Compressed Air and How to Fix It

By Paul Edwards, Compressed Air Consultants, Inc.

One observation I've made from 30 years of working with compressed air systems is to never underestimate the ingenuity of plant personnel when it comes to misapplying compressed air. We see something new in virtually every plant we visit, but one of the more common problems we encounter involves the use of expensive air for bearing cooling.

In a recent visit we identified the misuse of compressed air that was exacerbated by the installation. As illustrated in this photo, plant personnel ran a hose from the closest Chicago fitting. They didn't have enough hose and as a consequence, the end of the hose was 3 ½ feet away from the bearing. At that distance, the airflow dissipated significantly and perhaps only 10 of the 60

"Never underestimate the ingenuity of plant personnel when it comes to misapplying compressed air."

— Paul Edwards, Compressed Air Consultants, Inc.

scfm released from the hose was connecting with the targeted cooling area.

The lack of forethought in this particular instance is hardly surprising as the operators had a problem and came up with the fastest way they knew how to solve it. Unfortunately for the plant, it was also an exceedingly expensive way to do it.

Misuse Creates Multiple Problems

Bearing cooling is often applied to overheating bearings, as well as marginal bearings in hot environments. Typically, the operator grabs the nearest compressed air hose and ties it in some position over the bearing based upon whatever is most convenient. The operator generally closes the air feed valve somewhat to save air and does it based on sound

Shown above is a bearing housing cooled by compressed air over the course of eight years. At left is the housing during the first year of cooling. On the right is the same unit eight years later.

BEARING COOLING: A COMMON MISAPPLICATION OF COMPRESSED AIR AND HOW TO FIX IT

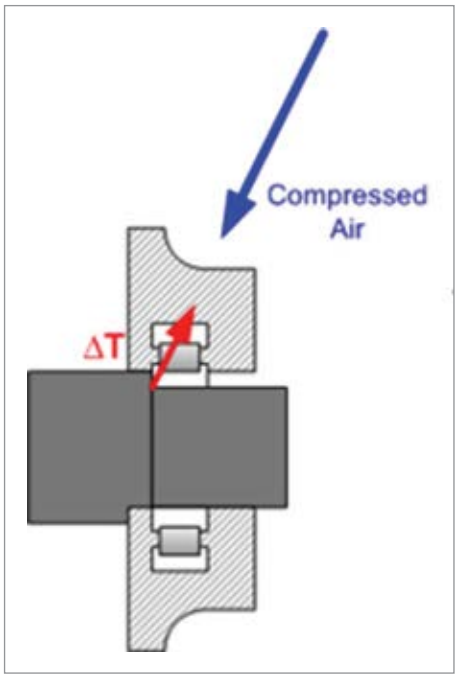


Figure 1: Bearing housing

rather than on having the correct bearing temperature. The problem with this strategy is threefold.

One major issue is cost. Compressed air is an expensive method of cooling a bearing – it's fairly common to see bearing cooling cost $10,000 if left on continuously. As an example, we audited a plant that used the method on a single bearing. Eight years later, the air was still in use but at a lower level. However, in those eight years the plant incurred an estimated $88,000 in operating costs to cool that bearing.

The second problem is reliability. If too much air is applied, reliability could become an issue if the bearing housing expands on one side while contracting too much on the other side. In this case, the heat source side expands while the compressed air cooled side contracts as illustrated in Figure 1.

The third issue is an even greater reliability problem that can occur since the air could defeat the temperature sensor protecting the bearings from overheating. In these thermal images, the operator aimed the air lance as best as he could at the bearing housing. Unfortunately, he succeeded in cooling the corner of the bearing and the temperature sensor to a lesser extent.

What was eye opening for plant personnel in this case was the root cause of the issue and the cost to fix it. The root cause was that the plant didn't purchase a specialized tool required to put the bearing on the motor shaft properly. That tool cost $2,000. The annual cost of using the air lance was $9,000.

Better Options for Bearing Cooling

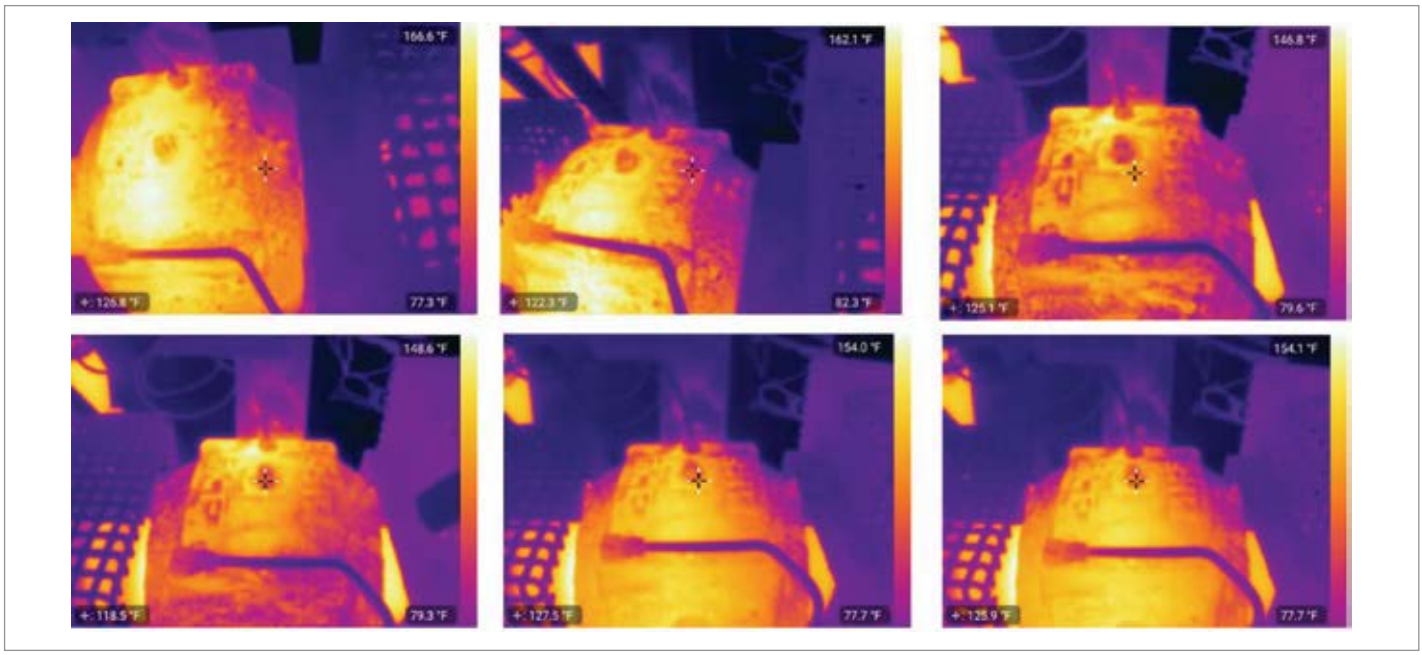
Here are four approaches to solving this issue all of varying degrees of cost and effectiveness in reverse order of efficiency.

The first method is to use an air mover for cooling, such as the one used by a Canadian plant as shown here. This particular air mover used 98 scfm of air.

A second method is to use an air amplifier, which is just a small air mover for all intents and purposes. Its virtue is just that: it uses smaller amounts of air. Many operators who use air movers are unaware of the existence of air amplifiers.

In one plant, for example, plant personnel installed a fairly large air amplifier as shown but only cracked the feed valve to it. The result was a cooler bearing and an airflow demand of six scfm.

A third option is to use an electric motor driven air mover, or fan. In most cases, these



Images 2 through 4 (from top left to right) show cooling as the air lance is moved to a central location on the bearing. Images 5 and 6 were taken one and two minutes after the air lance was moved to its original location. Notice how quickly the temperature builds up in the rest of the bearing housing.

tend to produce higher volumes of air. Shown is one such application.

This situation involves a 0.75 horsepower (hp) motor so it essentially uses half the energy that the air amplifier used in the previous example. This means there is an energy advantage to going all-electric. However, there is a cost differential to consider. Electric air movers range from $500 to $3,000 whereas air amplifiers are available in the $100 range. Interestingly enough, if the plant does not have an electric motor-driven fan, then the air amplifier in the hands of a knowledgeable professional may be the best choice financially and light years better than an open air hose.

The fourth option is based on the situation and alternate sources of air. In some plants, there may be a nearby source of low-pressure air that has excess capacity. If a small amount of air can be diverted from the source, then it may be enough to sufficiently cool the bearings. That is essentially cooling for free.

BEARING COOLING: A COMMON MISAPPLICATION OF COMPRESSED AIR AND HOW TO FIX IT

As shown, the bearings are used on a device called a lumpbreaker, which works in a system called a cooler. This device is powered by 10,000 cfm of fan air. Siphoning off 200 scfm for this application is a drop in the bucket that the system would never notice. At the cost of drilling a hole, adding some pipe and a couple of valves, the payback is measured in days to weeks.

Lessons Learned

There are several important lessons to take away from these experiences. One is that an analysis should be performed to understand the root cause. That in turn will allow the plant to make the most economically intelligent decision regarding on how to fix the problem. Secondly, plant personnel should be trained on the cost of all of these approaches to bearing

cooling. Finally, personnel should be equipped with the necessary tools to solve these issues as cost effectively as possible. This includes the use of a thermal imaging system. Given the availability of thermal imaging attachments for Smartphones at a cost of less than $400, the technology is a must for maintenance personnel in heavy industry. BP

For more information, contact Paul Edwards, President, Compressed Air Consultants, Inc., tel: (704) 376-2600, email: paul.edwards@loweraircost.com, or visit www.loweraircost.com

To read more ***System Assessments on End Uses*** in plants, please visit www.airbestpractices.com/system-assessments/end-uses.

PRODUCTIVITY, SUSTAINABILITY & EFFICIENCY

Distillery Addresses Inappropriate Compressed Air Uses SAVING $16,600 IN ENERGY COSTS

By Ron Marshall, Marshall Compressed Air Consulting

By addressing inappropriate uses of compressed air and making changes to the compressed air production side of their compressed air system, a distiller of fine alcohol products reduced its energy consumption by 30%, saving $16,600 per year in energy costs – with more potential savings possible.

Background

The facility has a fermenting, distilling, storage and distribution operations onsite, all of which use various amounts of 100 psi compressed air. The compressed air contacts various products at different stages of processing in the facility, so there is the need to produce the cleanest possible compressed air to maintain quality and product safety.

The compressed air system consisted of three water-cooled, oil-free air compressors of various ages, running in load unload mode. Air compressor sizes were 110 kW, 90 kW, and 160 kW. The operation typically used the 110 kW unit for base load with the 90 kW air compressor starting for peak duty. The 160 kW unit, being very old, was used for back-up.

"Further potential savings should be expected if this compressed air user follows up on additional leakage repair and addresses additional inappropriate uses of compressed air"

— Ron Marshall, Marshall Compressed Air Consulting

Figure 1: An air compressor has performed reliably for decades, but the aging unit needed to be replaced with a more modern, higher efficiency air compressor.

			Annual
Baseline	**Units**	**Average**	**kWh**
Discharge ave	psi	98.5	
Dryer Out ave	psi	98.3	
EOL ave	psi	95.5	
ZR110	kW	106	928,560
ZT90	kW	1	8,760
Dryer	kW	3.6	31,536
Total	kW	110.6	968,856
Peak	kW	177	
Specific Power	kW/100 cfm	21.7	
Flow	cfm	492	
Peak Flow	cfm	760	
Operating	hours	8760	
Cost			$66,420

Figure 2: The distillery pays $66,420 per year for electricity to power the compressed air system.

Drying is done using a heated blower style unit with dewpoint dependent switching to provide compressed air with - 40 ˚F pressure dewpoint. A refrigerated air dryer had been installed at one point for back-up duty, but was shut down due to maintenance issues.

The compressed air is directed throughout the plant through a system of steel piping. One medium sized 500-gallon storage receiver is located

DISTILLERY ADDRESSES INAPPROPRIATE COMPRESSED AIR USES SAVING $16,600 IN ENERGY COSTS

Figure 3: The heated blower style dryer maintains a -40 °F pressure dewpoint.

in the compressor room area as dry control storage, with various large receivers located out in the plant for peaking duty.

The compressed air is delivered to the multiple production areas through piping headers from which various branches are tapped to supply to each production operation. Installed data loggers showed minimal pressure loss across the piping system. Most of the pressure loss is across the drying and filtering system or across restrictor plates deliberately designed into the system.

System Baseline

The compressed air system electrical consumption was monitored as part of an extensive audit using amp loggers. Kilowatt readings using a hand held meter were taken for both the active air compressors to calibrate amps to power. System flow was recorded using the plant flow meter. Figure 2 shows the baseline during a two-week period.

The readings and observations during the measurement period showed the compressed air system was producing air at fair efficiency (21.7 kW/100 cfm). The assessment found problems with the air dryer cooling purge flow, higher than needed discharge pressure, some small leakage and drainage, and some possible inappropriate uses, were causing higher than desired operating costs and occasional pressure issues. The study found that significant improvements were possible.

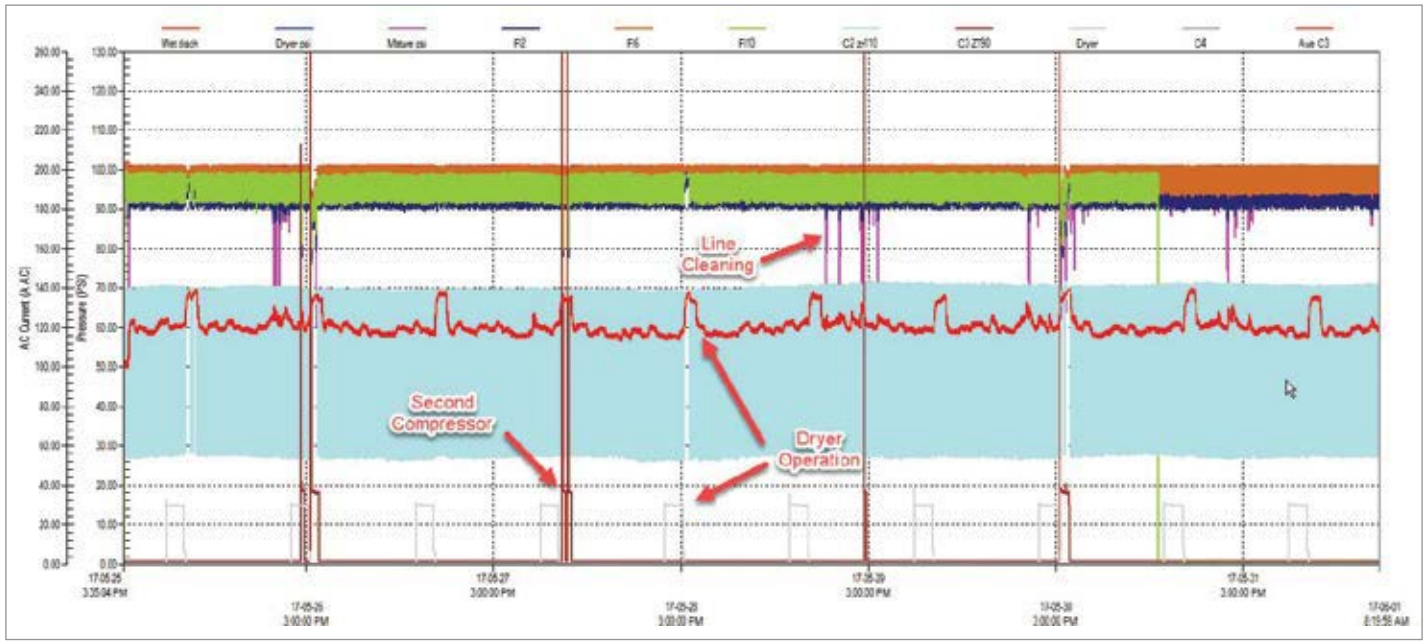


Figure 4: A typical baseline period shows the effects of dryer cooling purge.

Inappropriate Compressed Air Uses

A survey of the demand side of the system was done including leakage. A total of 49 leakage points were found, estimated at 87 cfm. Various compressed air uses, which could be classed as inappropriate, were found including star seal blowing, bin vibrators, poorly adjusted dust collectors, compressed air vacuum, air horn blowers and fume blowing.

Shown in the red line of Figure 4 is the shape of the compressed airflow demand curve during production over a one-week period at the end of the data logging. The pressure profile shows good pressure regulation when only one air compressor is required. Dips in pressure can be seen on occasion when two air compressors are required. The profile shows a somewhat flat pattern during production activities, with higher peak flows just after the air dryer heating cycle. This is caused by the dryer cooling cycle where a flow of compressed air is directed into the desiccant to remove the remaining heat. If this is not done, a dewpoint spike will develop when the dryer stitches sides.

Additional peak flows are somewhat random, associated with clearing of alcohol lines after transfer of product. Compressed air is injected into stainless steel transfer lines to remove the remaining product before another ingredient is pumped.

These dryer-associated peaks, with coincident line cleaning, required two air compressors on occasion to run to support plant pressure. Although the second unit barely loads, it and the dryer heater, contribute additional cost to peak electrical demand.

Careful analysis of this profile showed that the air dryer was consuming higher than normal cooling purge, something that can easily be adjusted. It was thought that reduction of this would reduce the requirement for two air compressors, saving on peak demand. Savings could also be gained if leakage and inappropriate use could be reduced.

Potentially inappropriate end uses found were as follows:

- Air vacuum – A compressed air-powered drum vacuum was being used for cleanup purposes in an area where there is potential for explosion if spark-producing devices are used. The vacuum is created using a compressed air vortex, something that is safe, with few moving parts, but consuming about ten times the equivalent energy than a explosion-proof vacuum.

DISTILLERY ADDRESSES INAPPROPRIATE COMPRESSED AIR USES SAVING $16,600 IN ENERGY COSTS

- Blow wands – The use of uncontrolled compressed air blow wands for cleaning out machines and plant areas contributed to the plant peaks and constituted a safety hazard. The hand-held wands are constructed using a pipe and ball valve control. They are not considered safe. Nozzles with dead man switch control and low-pressure nozzles were recommended because they use less air and meet with typical safety standards.
- Dust collectors – Reverse-pulse compressed air cleaners are installed on various dust collectors in the facility. These cleaners appeared to be controlled with the process and turned off when not required, which is excellent practice. The pulse duty when these units operate was undesirable, however, the pulse duration appears too long and the pulse frequency too high. As such, it wastes compressed air. Observation of the pressure gauge on each filter manifold revealed the problem This gauge should drop only about 10 psi on a quick valve operation for about one tenth of a second. The actual pulses are more like three quarters of a second, pulling the pressure down to about 35 to 45 psi each time with a pulse spacing of only six seconds. This problem is very common with these types of filters. A fix is to install a receiver at each filter with fill control to filter out the compressed air pulses as shown in Figure 7.
- Bin vibrators – Compressed air-powered vibrators were installed on the bottom of various bins to promote the flow of grain. These units consume six to 10 times the equivalent power of electric units.
- Star seal blowing – Various blowing nozzles have been installed to clean the internals of star seals located on the top of some cookers. The constantly rotating seals meter the amount of ingredients going to the cooker, but because the input grain is dry, and the star seal is wet due to rising steam, the product sticks to the seal material, eventually creating clogs. These operations appear to be controlled with the process and therefore will shut off when not required. These blowers were measured and found to consume a peak of 126 cfm and average of 72 cfm.
- Alcohol vapor blowing – A pipe with holes drilled in it has been installed over the area where the product barrels are unloaded. This appears to be an attempt to control fumes. This blowing was not in service the few times the Maturing area was visited but the operator there reported it is still used to provide "free air conditioning" on hot days. It appears that a fan-powered fume control system has been installed.

Figure 5: Devices like this compressed air-powered blowing horn were classed as possible inappropriate uses.

The distillery uses compressed air powered drum vacuums for cleanup, which is a inappropriate use of compressed air and not uncommon at many plants.

Shown are bin vibrators used in the distillery's process.

As such, the compressed air powered ventilation can likely be removed.

- Air motor pumps – The distillery uses two small pumps driven by air motors. Air motors are used to ensure safety since explosions are possible if spark-producing devices are used. The use of air motors to do the job of electric pumps is energy intensive as air motor power costs about 10 times more than a direct drive electric motor.

Air Compressor Control Savings

The existing air compressors were running in load/unload mode with coordinated cascaded pressure bands. With this type of operation there are periods of time where the air

Star seals are used on the cooker as shown to meter the amount of ingredients going to the vessel.

DISTILLERY ADDRESSES INAPPROPRIATE COMPRESSED AIR USES SAVING $16,600 IN ENERGY COSTS

compressor is unloaded running, consuming power, but producing no compressed air.

This area of inefficiency is identified in the red as shown in Figure 7, which is a profile of C3 air compressor amp logs sorted highest to lowest to form a histogram, also called a load duration chart. This area could be addressed by choosing an air compressor with a control mode that doesn't have unloaded run time (like VSD operation).

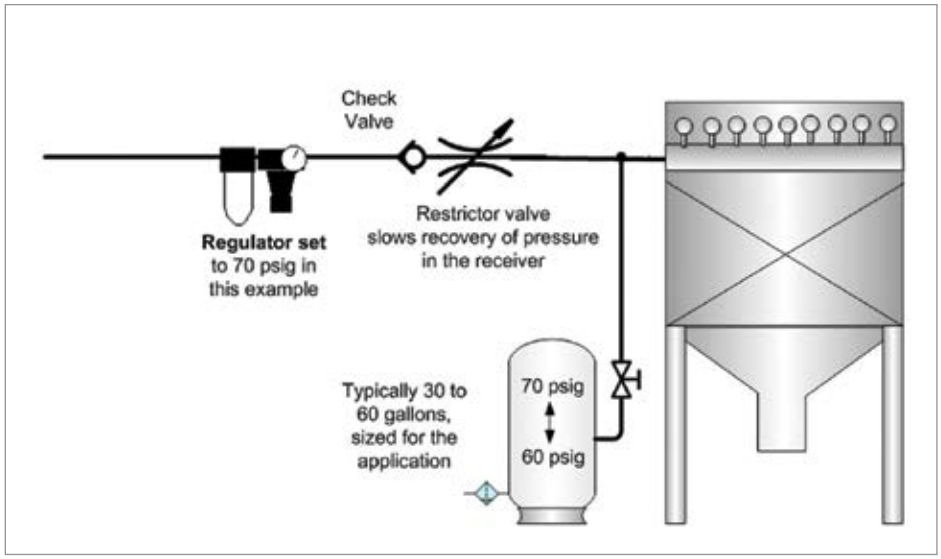


Figure 6: Dust collector operation can be improved using this solution (Source: Compressed Air Challenge.)

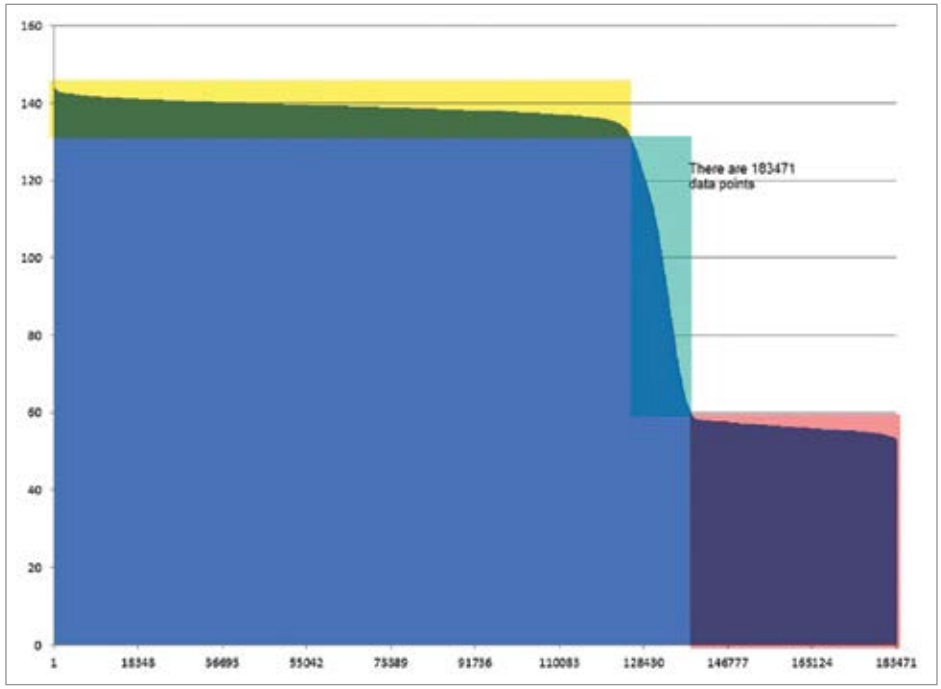


Figure 7: The load duration profile on the original air compressor power input shows areas of possible savings.

Further to this, due to air compressor cycling, there is a period of time where the air compressor is in transition between loaded and unloaded, or reverse, indicated with the green highlight. This can be addressed by eliminating air compressor cycles using VSD mode.

And, in addition, there is extra power consumed by the air compressor if it runs at pressure higher than required by the plant as indicated with the yellow portion of Figure 7. This can be addressed by reducing the air compressor discharge pressure by adjustment of the pressure bands. Use of a VSD air compressor would allow a constant, lower plant pressure, rather than operating with a saw toothed waveform using load/unload control.

Conclusion

At the distiller, the following action items were taken:

1. Installation of a new 132 kW oil-free VSD air compressor.
2. Adjustments to the dryer cooling purge.
3. Adjustments/repair of dust collectors.
4. Repaired leakage, where economical. It's estimated that 75% of repairs were completed.

Savings for these measures, based on air compressor histogram readings, are 257,000 kWh resulting in reduced electrical costs of $16,600 for a 30% energy savings. The initial studies were made possible with the financial and resource support of the local power utility. The final project was also partially funding with incentives from the power utility. Further potential savings should be expected if this compressed air user follows up on additional leakage repair and addresses additional inappropriate uses of compressed air. BP

For more information contact Ron Marshall, Marshall Compressed Air Consulting, tel: 204-806-2085, email: ronm@mts.net

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QUALITY, SAFETY & RELIABILITY

Lifting the Fog Surrounding HEAT OF COMPRESSION DRYERS

By Hank van Ormer, Van Ormer Consulting

Introduced in the 1960s and operated successfully worldwide, the Heat of Compression (HOC) Desiccant Dryer has been a viable and successful compressed air drying technology for over 50 years. In our ongoing series on missed-demand opportunities, we'll discuss basic operating parameters of HOC dryers and shed light on common misperceptions associated with the technology.

Misperceptions Shroud HOC Dryer Capabilities

For various reasons there are many misconceptions about HOC Dryer technology that often confuse its potential uses and capabilities. Many of these are caused by lack of understanding of the basic operating parameters and limitations.

The most significant limitation is the requirement for hot "oil-free" compressed air. During its early years, the oil-free air compressor population was relatively small compared to lubricant-cooled rotaries and lubricated-reciprocating units. This generated an understandable lack of interest from these systems in the HOC technology.

Over the last several decades demand for "oil-free" or "non-lubricated" compressed air has grown significantly, and in many markets, it is one of the fastest growing sectors. Consequently, interest in the dryer and the advantages it offers for low-energy-cost operations has grown significantly.

There are some very consistent misperceptions about the capabilities of this technology that interferes with a proper evaluation of its suitability. This often results in selecting an alternative type dryer with significantly higher operating energy and higher lifecycle operating costs without a full evaluation.

Before looking at specific misperceptions lets review the basic operating parameters of HOC dryers. The two most common types offered are:

- Fixed silica gel desiccant elements in split-stream and full-flow configurations (also called drum dryers).
- Twin Tower Regenerative designs, which normally use activated alumina desiccant beads. For the sake of brevity we will discuss the Twin Tower, Full Flow types in this article.

Basic Regenerative Twin Tower Operating Parameters

All regenerative desiccant dryers dry the air in the same manner: the aftercooled saturated compressed air enters the drying tower, which

has a low Relative Humidity (RH) in the activated alumina desiccant bed. The water vapor in the compressed air absorbs to the surface of the desiccant beads. This continues until the beads are saturated to the designated level, or switched by a timer control. There is no operating energy usage adjustment during the drying process.

All of these types of dryers dry in the same manner, but differ in the regeneration process. In order for the water vapor trapped on the surface of the desiccant to leave the bead there must be a difference in RH between the bed and the surrounding air.

A flowing air stream of low RH, which picks up the moisture from the bed and flows out of the tower to dry the bed, is the source of this difference. This is called "purge air." These dryers differ by how much purge air is used and how much is *lost compressed air.*

Heatless Dryers

Heatless dryers, which are also called heaterless dryers, use no auxiliary heat and will require 15 to 20 percent of the rated flow at full load in dried compressed air to the regenerating tower. This purge compressed air absorbs moisture and carries it out of the tower. The purge air does not go to the system. Most heatless dryers operate on a 5 to 10 minutes tower switch cycle.

External Heat Dryers

These dryers utilize an auxiliary heater to heat the dry purge air, further reducing the RH. This allows the removal of the moisture load with less dry compressed air – a normal of 7.5% of rated flow. This purge compressed air does not go to the system. Most external heat dryers operate on a nominal four-hour cycle for tower switch. The regenerative cycle is a nominal three hours of heating and one hour of cooling. The bed must be cooled to 130 ˚F or less in order to dry when switched.

Blower Purge Dryers

Blower purge dryers also utilize an auxiliary heater but *do not* use dry compressed air to purge. Rather, the purge air is supplied by a blower, which runs during the drying cycle. These dryers also use the nominal four-hour cycle; normal three hour heating; and one hour cooling.

LIFTING THE FOG SURROUNDING HEAT OF COMPRESSION DRYERS

HOC Dryer

The HOC Dryer is also a heated type desiccant that operates similarly, but quite a bit differently. The drying cycle *is the same,* but the regenerator cycle utilizes the captured heat of compression in the discharge air BEFORE the after-cooler to create the RH differential and remove the moisture from the compressed air.

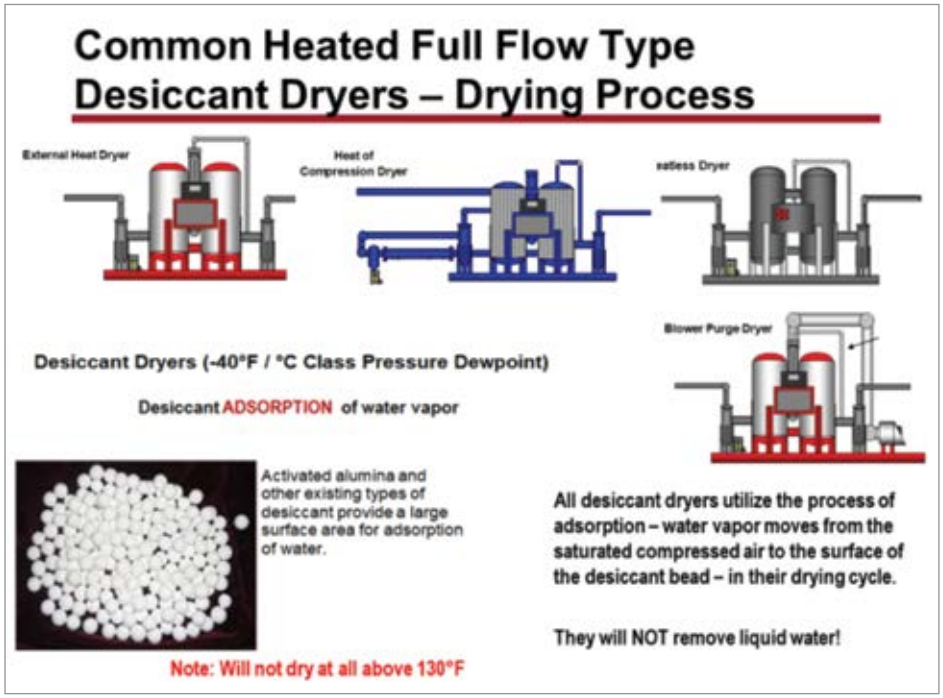

Figure 1. Four common types of twin tower desiccant dryers, and the activated alumina absorption process.

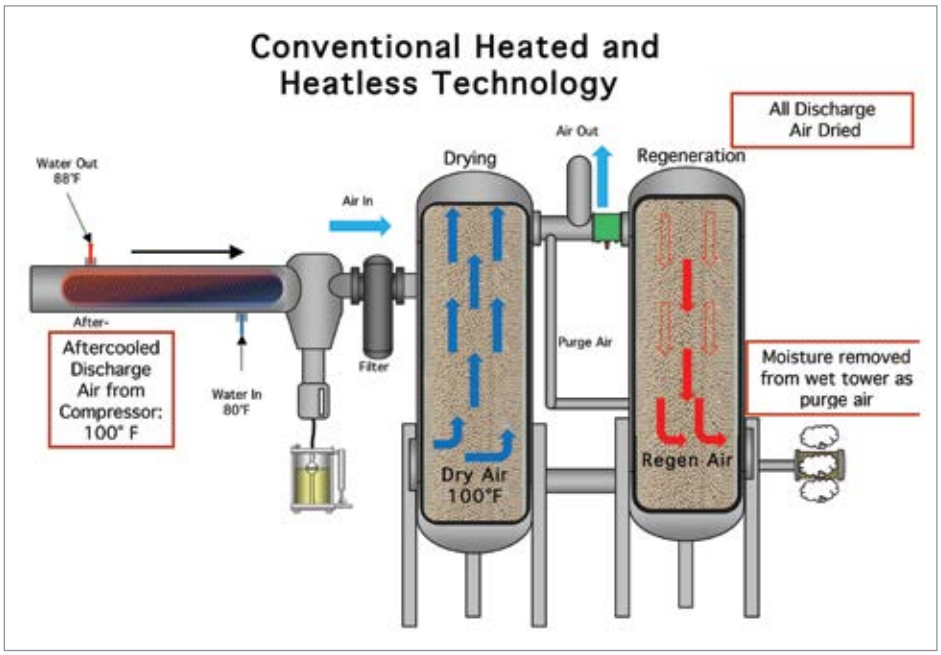

Figure 2 describes the basic drying process for these types of dryers. It is not meant to evaluate one or the other type of dryer. In all cases, proper application and selection requires much more in-depth information.

A question many ask is where the heat comes from for the regenerating cycle. Here's the answer:

The base heat load used in the regeneration cycle is the "heat of compression" in the compressed air generated during the compression cycle. Keep in mind that compressed air is inherently energy inefficient. All of the energy put into the compression process but not utilized in work shows up as heat.

Compressing air to 100-psig discharge pressure requires about eight horsepower (HP) of electricity to deliver one HP of work. The remaining seven input HP ends up as heat in the discharged compressed air, or 17,822 Btu per one hour of compressed air work.

Figure 3 illustrates this as the hot discharge air from an oil-free compressor, which is about **200 ˚F to 350 ˚F –** *before the after-cooler!* There is very low RH hot air from the heat of compression to remove the moisture from the beads into the "purge air." The HEAT was already in the energy cost of the compressed air – use it or lose it.

What we've described is simple HOC technology, which involves utilizing the hot air from an oil-free compressor to remove the moisture before it goes to the after-cooler.

Figure 4 outlines the HOC Dryer process:

1. The heat of compression supplies the temperature differential to create the "RH" imbalance and allows the removal of the water vapor to the regenerating bed to the "purge" air stream.

2. The "purge" air stream goes through the water-cooled after-cooler/separator where the moisture in the air stream is condensed to liquid and removed. The after-cooler is *mounted* on the *dryer.*

3. The "purge" air stream then goes to the drying tower where *all of the* discharge air is dried and sent to the air system. **No "purge" air is lost.**

Of note is that an HOC Dryer uses air BEFORE the after-cooler – other heated dryers use air AFTER the after-cooler.

There is nothing mystical here. It is a very simple system following basic desiccant dryer technology. Like all dryers, proper performance and reliability depends on well-informed and knowledgeable personnel to fit the best selection to the situation.

Eight (8) Common Misperceptions

Here is a closer look at common misperceptions about HOC dryers.

1. "There must be a 350 ˚F discharge temperature from the oil-free air compressor for it to work."

This is just not true – over the last 50-plus years there are many, many successful applications at 200 ˚F. Regeneration needs a significant difference in RH to remove the moisture from the bed.

The average multi-stage, non-lubricated air compressor will deliver a nominal 35 gram (gr)/cubic foot (cu. ft.) of moisture (due to the moisture removals or the intercoolers).

At 200 ˚F the compressed air will hold about 385 gr/cu. ft. RH = 35/385 = **9% RH**

At 350 ˚F the compressed air will hold 1,083 gr/cu. ft. RH = 35/1,083 = **3.2% RH**

Both of these levels are effective. If the loading and/or conditions require a very low, very stable pressure dewpoint, available options to the HOC may well be in order, such as auxiliary heating and/or dry air-cooling. Well controlled, they will only operate when needed.

2. "The air compressor must run 100% load 100% of the time."

This is a variation of Misperception No. 1 in that the operation will be successful at varying load. The air compressor must be loaded enough to deliver a minimum 200 ˚F to the dryer. If it doesn't, the same options described in Misperception No. 1 will correct the situation.

3. "If the air compressor is down, the dryer is down."

Many HOC dryers are integrally tied to the air compressor. If the air compressor is down for maintenance or repair and you need to dry compressed air from another source (such as a rental) there are HOC dryer manufacturers that offer an option to easily switch to the heatless mode. When appropriate, it can go back to HOC when the primary air compressor is on line.

4. "You can only run one air compressor to one dryer."

This is not accurate – when the system is well designed multiple oil-free air compressors can effectively feed multiple HOC dryers.

Figure 5 shows four 8,000 scfm-rated centrifugal air compressors and three 13,500 scfm-rated HOC dryers with well insulated piping and leaders. The screenshot of the control board indicates the following:

- Three compressors are OFF – one at full load
- Three dryers at 20% load each (8,000/ 39,000) and delivering a -56 ˚F to -63 ˚F with inlet air temp of -234 ˚F.

These numbers tell the tale!

5. "HOC dryers have high pressure drop."

This probably comes from some observations that make it appear to be true. In conventional desiccant dryers the after-coolers, separators, and pre-filters are all mounted on, or near, the air compressor discharge **BEFORE ENTERING THE DRYER** and the pressure losses here are not noticeable.

In the HOC the hot air comes off the air compressor – picks up the moisture in the

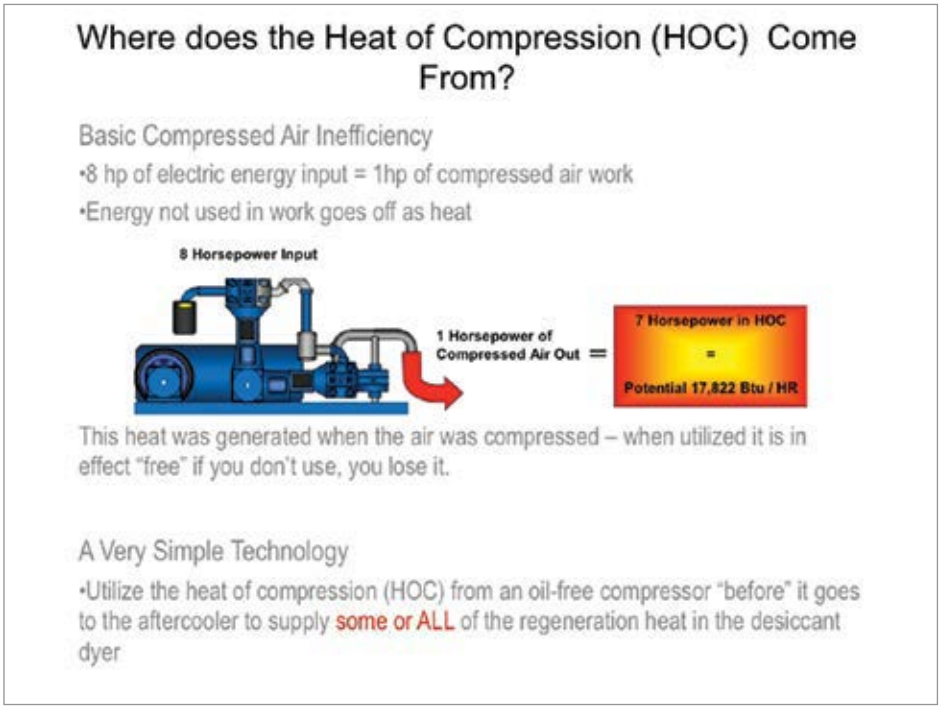

Figure 3.

LIFTING THE FOG SURROUNDING HEAT OF COMPRESSION DRYERS

drying tower – and then goes through the after-cooler and separators.

The pressure loss in a full-flow HOC unit with no trim heater is about the same as any other high-quality twin tower desiccant dryers and with the heater and dry air-cooling perhaps slightly higher.

Generally the net pressure loss should be about the same when similar pipe sizes, valves, and configurations are used.

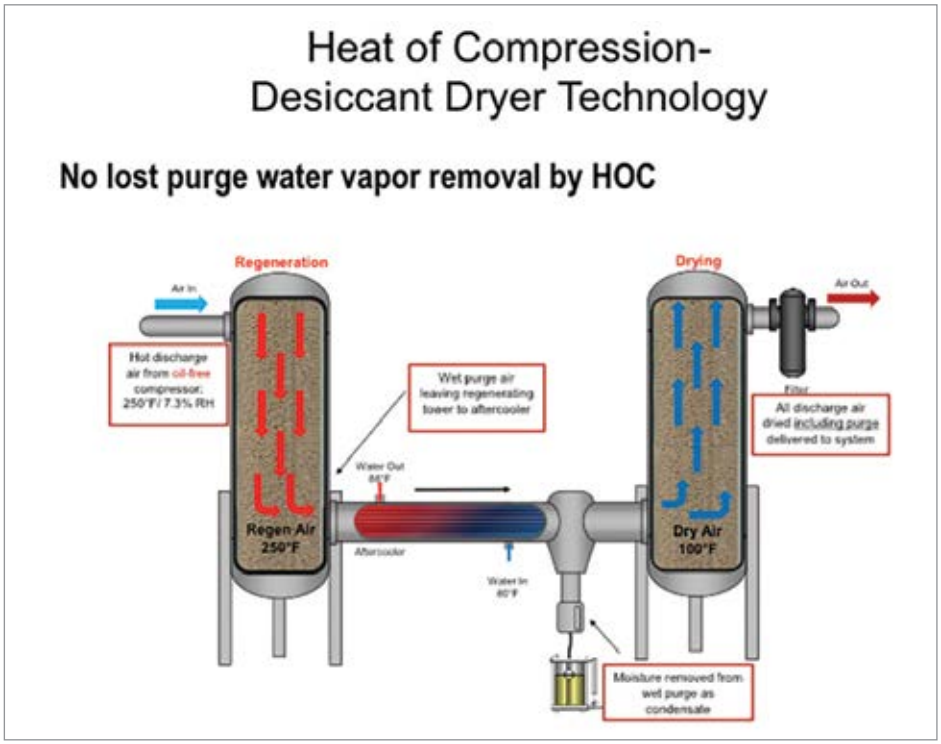

Figure 4.

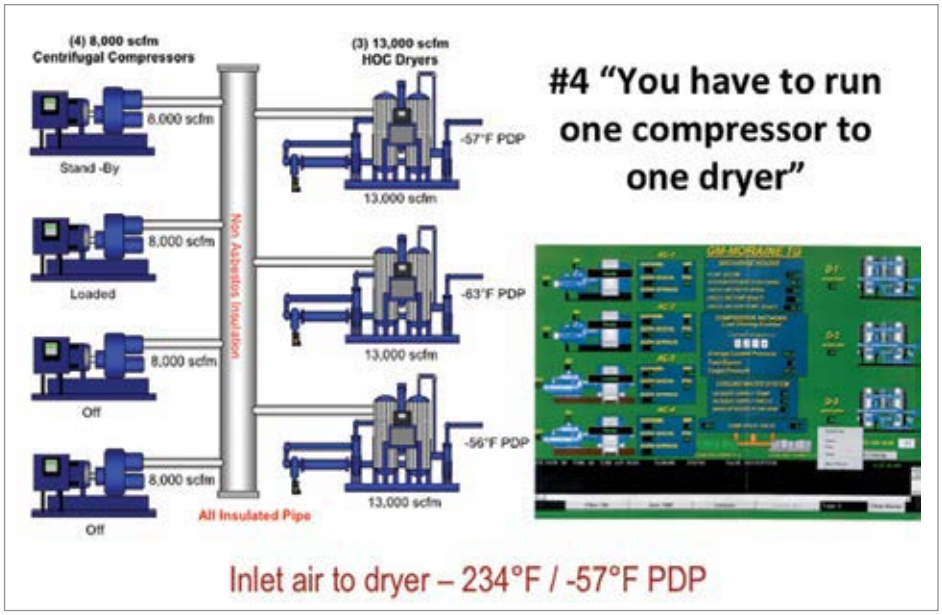

Figure 5.

6. "HOC dryers lose a lot of compressed air."

Nothing could be further from the truth. In most installations, "lost purge air" varies from an average of zero to two percent.

The basic flow model with no trim heater *loses no compressed air.* Other types of twin tower dryers lose approximately five to 15 percent of dry air with "purge sweeps" up to several hours. Some full-featured HOC dryers have a *stripping and cooling cycle to optimize performance.* Stripping is only 90 minutes with a typical air loss of *2%,* only during this time and when needed.

7. "If the air compressor discharge temperature is low you have to heat all of the inlet air."

If the air compressor discharge temperature is low and the application requires a lower Pressure Dew Point (PDP) – in some models a heater can be added to the stripping line. This heater would be comparable to other heated dryers but it *only operates for 90 minutes* of the cycle while still delivering energy-efficient dry air. This available option is relatively inexpensive and delivers full performance under virtually any operating conditions.

Heating the stripping line results in much lower energy cost than conventional heater dryer cycles because of the one-time, 90-minute cycle versus a nominal 180 minute (three hours) with other types.

8. "HOC dryers cannot deliver low-pressure dew points in most 100 psig-class air systems."

This misperception has been given life by a study that concluded, "HOC dryers with multi-stage air compressors cannot provide better than -20 ˚F below 180 psig."

This particular study based its conclusions on using "molecule sieve" desiccant in the drying bed and a 125 ˚F desiccant bed drying

HOC dryers can be optimized to deliver lower than -40°F / C on a continual basis throughout the year.

Figure 6.

temperature. The conclusions used the appropriate isosteres for the molecules sieve desiccant. The calculated answers are correct. The only problem is that **almost no one would use a full bed of molecular sieve in the HOC Dryer. Most HOC dryers use activated alumina desiccant, which has much different operating characteristics and works very well as many of these examples show.**

Molecular sieve is a synthesized product designed for specific uses and used often in the gas separator field. Industrially it may be used as a final drying agent at the tower exit, taking advantage of its ability to dry effectively in areas of low RH. The recommended regeneration temperature is usually 300 ˚F to 500 ˚F. The conclusion reached by this data is not relevant. Molecular sieve is not the bed desiccant used in HOC dryers. Most HOC desiccant dryers use a basic desiccant selection called activated alumina.

Figure 6 shows the control board of an HOC Dryer that had a set point of -20 ˚F with an actual PDP of -148 ˚F. HOC dryers can be optimized to deliver air at -40 ˚F/-40 ˚C on a continual basis.

Summary

There is no other dryer technology with lower operating energy costs and inherent low maintenance costs than heat of compression when conditions are correct. For many commercial air systems the HOC Dryer is a very viable choice when hot non-lubricated air is available. BP

We hope you've found this interesting and look forward to your comments! Contact Hank van Ormer, email: hankvanormer@aol.com, tel: 614.580.2711

To read similar ***Compressed Air Dryer Technology*** articles visit
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TECHNOLOGY PICKS

Atlas Copco Redesigns GA11+-30 Rotary Screw Air Compressors

Atlas Copco has released a redesign of its GA11+-30 line of oil-injected rotary screw air compressors. The new 15-40 horsepower (hp) models utilize a variety of technologies to reduce energy consumption while providing the same reliability Atlas Copco is known for delivering.

When compared to competitive units, per CAGI data of major U.S. suppliers, the newly-upgraded range provides an average 7.8% more free air delivery (FAD) and a specific energy requirement (SER) decrease of 7.6%. It also includes the most innovative fan from Atlas Copco's VSD+ technology, offering 13% more energy savings than the previous design.

The redesigned GA11+-30 range utilizes a super premium Siemens IE4 high efficiency motor – upgraded from the IE3 model – to increase efficiency, meaning less emissions and lower operating costs. Other features include a new, larger inlet filter repositioned to reduce pressure drop and provide easier serviceability, a new controller with easy-to-use touch screen technology, and SMARTlink remote monitoring and connectivity.

Atlas Copco's redesigned GA11+-30 line of oil-injected rotary screw air compressors is engineered to reduce energy and ensure reliability.

"The new GA11+-30 range is a testament to Atlas Copco's continued commitment to efficiency and innovation," said Ed O'Neil, Atlas Copco Product Marketing Manager - Oil Injected Screw Compressors <30kW. "With the upgrades made to this industrial staple, we are bringing greater energy savings to customers without sacrificing durability or performance."

The GA11+-30 line is available in full-feature with a built-in dryer or pack design without an integrated dryer. For more information about the GA11+-30, visit www.atlascopco.com/en-us/compressors.

About Atlas Copco

Atlas Copco is a world-leading provider of sustainable productivity solutions. The Group serves customers with innovative compressors, vacuum solutions and air treatment systems, construction and mining equipment, power tools and assembly systems. Atlas Copco develops products and services focused on productivity, energy efficiency, safety and ergonomics. The company was founded in 1873, is based in Stockholm, Sweden, and has a global reach spanning more than 180 countries. In 2015, Atlas Copco had revenues of BSEK 102 (BEUR 11) and more than 43,000 employees. For more information, visit www.atlascopcogroup.com.

About Atlas Copco Compressors LLC

Atlas Copco Compressors LLC is part of the Compressor Technique Business Area, and its headquarters are located in Rock Hill, S.C. The Compressor Technique business area provides industrial compressors, vacuum solutions, gas and process compressors and expanders, air and gas treatment equipment and air management systems. Atlas Copco Compressors has major sales, manufacturing, production and distribution facilities located in California, Illinois, Massachusetts, North Carolina, South Carolina and Texas. For more information, visit www.atlascopco.us.

TECHNOLOGY PICKS

Kaeser Unveils M82 Portable Air Compressor

The new M82 portable air compressor from Kaeser delivers up to 295 cfm at 100 psig and features a 37-gallon fuel tank for 10 hours of uninterrupted operation. The latest model in the portable Mobilair™ air compressor line, the versatile M82 is designed for heavy-duty civil and commercial construction, demolition, sand blasting and other site work applications.

The new portable air compressor is built with a rugged, powder-coated steel cabinet, protecting the machine from harsh environments and is sound proofed to provide extremely low sound decibels. The large gull-wing doors make all maintenance points easily accessible, making service work fast and efficient. A high capacity, cold-start battery ensures reliable operation even under extreme weather conditions. Plus, cooling features allow the M82 to operate in temperatures up to 122 ˚F.

The M82 comes equipped with the Sigma Control Smart controller, making compressor operation simple. The Kubota engine and diesel particulate filter make it compliant with Tier 4 EPA emission standards. For more information on the M82, or our complete range of portable compressors, visit us.kaeser.com/mobilair. To connect with a local authorized Kaeser representative, call 877-417-3527.

Kaeser's M82 portable air compressor boasts a 37-gallon fuel tank for 10 hours of uninterrupted operation.

About Kaeser

Kaeser is a leader in reliable, energy efficient compressed air equipment and system design. We offer a complete line of superior quality industrial air compressors as well as dryers, filters, SmartPipe™, master controls, and other system accessories. Kaeser also offers blowers, vacuum pumps, and portable gasoline and diesel screw compressors. Our national service network provides installation, rentals, maintenance, repair, and system audits. Kaeser is an ENERGY STAR Partner. For more information, visit us.kaeser.com.

Gardner Denver Unveils Hydrovane TX02 Transit Compressor

Gardner Denver has unveiled its new Hydrovane TX02 transit compressor, ideally suited to meet the demands of the latest hybrid-electric vehicles (HEVs) and fully electric vehicles (FEVs) for weight, size, noise, energy efficiency and sustainability.

Available from the company's Hydrovane brand, the new TX02 transit compressor is quiet, compact and reliable, complementing the newest commercial HEVs and FEVs being deployed to help reduce CO_2 emissions and noise pollution. The new transit compressor also delivers an optimized weight-to-air output ratio, therefore providing a lightweight and efficient solution. With vehicle manufacturers under increasing pressure from commercial operators to develop more environmentally friendly solutions, the Hydrovane TX02 transit compressor has been designed following the end of the European ECOCHAMPS initiative. A consortium of 26 partners, the project aimed to develop efficient, compact, low weight, robust and cost-effective hybrid powertrains for light, medium and heavy-duty trucks and buses.

Compressed air is a critical element in pneumatic braking systems, door operations and suspension in larger commercial vehicles, as well as kneeling systems for buses. According to Gardner Denver, many of the compressors on the market today are based on older technology, which is heavier and noisier, plus reliant on a larger capacity cooling system. It said this can result in additional costs when compared with its new solution, which is lighter and incorporates a modular cooling system.

The new transit compressor, which uses new optimized rotary vane technology, can be customized to meet individual vehicle requirements.

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TECHNOLOGY PICKS

Available in high- and low-voltage configurations, the TX02 unit is capable of running at variable speeds up to 3,000 rpm, with a pressure range of 100 - 200 psig, and volume flow up to 16 cfm, depending on the model selected. As a result, vehicle manufacturers can select a solution that meets their exact needs.

Gardner Denver's Hydrovane TX02 transit compressor.

Driven directly and compact, the TX02 transit compressor has been designed with easy vehicle integration in mind. Offering an air end weight of just 48 pounds, and a total package weight of less than 77 pounds, it also offers market leading noise and vibration characteristics, meaning it can be located anywhere on the vehicle without impacting the passenger or driver environment.

Mike Foster, Transit Market Sector Manager at Gardner Denver, explains: "Driven by our market knowledge and insight into future customer needs, we are extremely excited to launch this revolutionary new rotary vane technology that solves so many of the challenges faced by commercial vehicle operators and manufacturers. "It has been a privilege to work alongside the 26 partners involved in the European ECOCHAMPS project, to develop a solution that improves performance, comfort, safety and emission levels for the truck and bus industry. Having undergone rigorous testing, operators can be assured they are investing in a compressor technology that is built to last, offering unrivalled performance. It's an exciting time for the HEV and FEV market, and we are thrilled to be playing a vital role in improving the

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environmental performance of the commercial vehicles on our roads. Coupled with its efficiency and low noise level capabilities, the TX02 can deliver reliable performance, hour after hour and mile after mile."

For more information about the new TX02 transit compressor, please visit https://www.gardnerdenver.com/en/hydrovane/products/truck-and-bus-compressor-tx02 or www.gardnerdenver.com/hydrovane or www.gd-transport.com.

About Gardner Denver

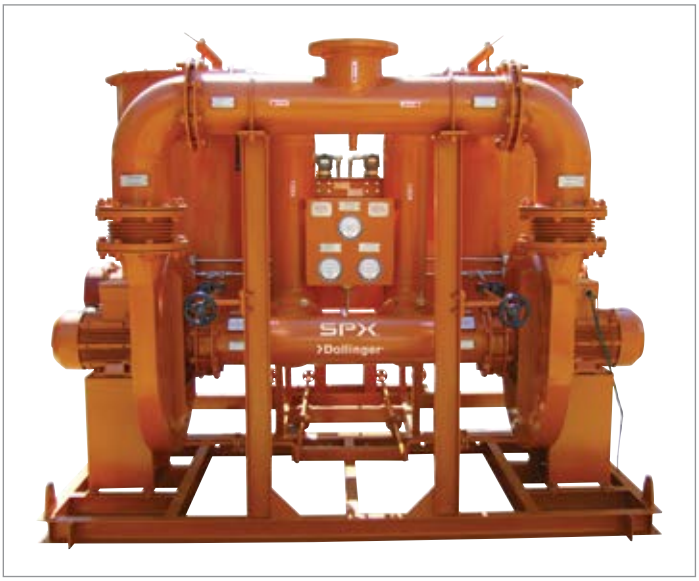
Headquartered in Milwaukee, Wis., Gardner Denver (NYSE: GDI) is a leading global provider of mission-critical flow control and compression equipment and associated aftermarket parts, consumables and, services, which it sells across multiple attractive end-markets within the industrial, energy and medical industries. Its broad and complete range of compressor, pump, vacuum and blower products and services, along with its application expertise and over 155 years of engineering heritage, allows Gardner Denver to provide differentiated product and service offerings for its customers' specific uses. Gardner Denver supports its customers through its global geographic footprint of 40 key manufacturing facilities, more than 30 complementary service and repair centers across six continents, and approximately 6,600 employees worldwide. For more information, visit www.gardnerdenver.com.

SPX FLOW Filters and Strainer Solutions Maximize Process Uptime

SPX FLOW, Inc. offers its Plenty brand of Backflush Filters – and its full line of Dollinger brand liquid and gas process filters and oil mist eliminators designed to maximize process uptime.

Backflush Filters

Designed specifically for water systems, Plenty Backflush Filters are available in a full range of sizes to suit most applications with a choice of stainless steel or cast iron housings. The filters easily install, are designed to minimize product loss during back flush action, and do not require any separate back wash supply. The filtration element is available in a large range of sizes with mesh or wedge wire options. Plenty Backflush Filters utilize system pressure for automatic cleaning, without interruption of the liquid flow or the need for an independent supply of clean water.



SPX FLOW's Dollinger Oil Mist Eliminator.

The filters operate in normal filtration mode until a timer initiates a regular cleaning cycle or the amount of contaminate accumulated inside the strainer tubes restricts the flow passage, causing an increase in the differential pressure. When the pressure drop reaches a pre-set trigger level, an automatic cleaning mechanism is actuated, and a sliding seal plate connected to the backwash outlet effectively blanks off each strainer element in turn from the inlet water. Since pressure within the strainer body is higher than the pressure in the backwash outlet pipe it induces a flow of clean water in the reverse direction through the isolated element, effectively flushing away all accumulated debris.

Liquid and Gas Process Filters

From its Dollinger range, the highly efficient LL-142 liquid filters are engineered to remove final traces of dirt, pipe scale and other solids from process liquids. They use a radial fin element to maximize the effective filtration area, which is up to 10 times bigger than equivalent tubular type cartridge filters. This minimizes pressure drop across the filter and increases its dirt holding capacity, thereby extending service life and reducing maintenance costs.

The LL-142 filter can be customized to match specific process needs and is available with up to 200 different filtering media and a selection of construction materials to handle process and installation conditions. The

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filtration basket has a standard collapse pressure of 1.5 to 4 bar, with higher pressures available if required. Dollinger GP-198 gas coalescing filters are engineered to remove entrained oil, water mist, other liquids and solid particles efficiently from gas streams and compressed air. These filters are rated at an efficiency of 99.97% on 0.3 micron.

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Oil Mist Eliminators

The Dollinger Oil Mist Eliminator efficiently removes oil mists to keep equipment and its surrounding environment cleaner and easier to maintain. It captures oil droplets and particles down to 0.3 micron and prevents the formation of dangerous and slippery work areas.

Once installed and running, it requires minimum maintenance with a filter element life of up to five years. The unit further increases economical operation by capturing escaping oil and recirculating it into the lube tank, reducing turbine and compressor oil consumption.

All SPX FLOW strainer and filtration solutions are designed for efficiency, exceptional performance, reliability and reduced total cost of ownership. They reliably protect valuable machinery and are backed by a full range of global, lifetime services. In addition to standard solutions SPX FLOW designs and manufactures complete, multi-technology skid solutions with fully integrated mechanical and electrical components.

About SPX FLOW, Inc.

Based in Charlotte, NC, SPX FLOW, Inc. (NYSE:FLOW) innovates with customers to help feed and enhance the world by designing, delivering and servicing high value solutions at the heart of growing and sustaining our diverse communities. The company's product offering is concentrated in rotating, actuating and hydraulic technologies, as well as turnkey systems, in the food and beverage, industrial and power and energy end markets. SPX FLOW has approximately $2 billion in annual revenues with operations in more than 30 countries and sales in more than 150 countries. To learn more, visit www.spxflow.com.

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