The Magazine for ENERGY EFFICIENCY in Compressed Air, Pneumatics, Blower and Vacuum Systems

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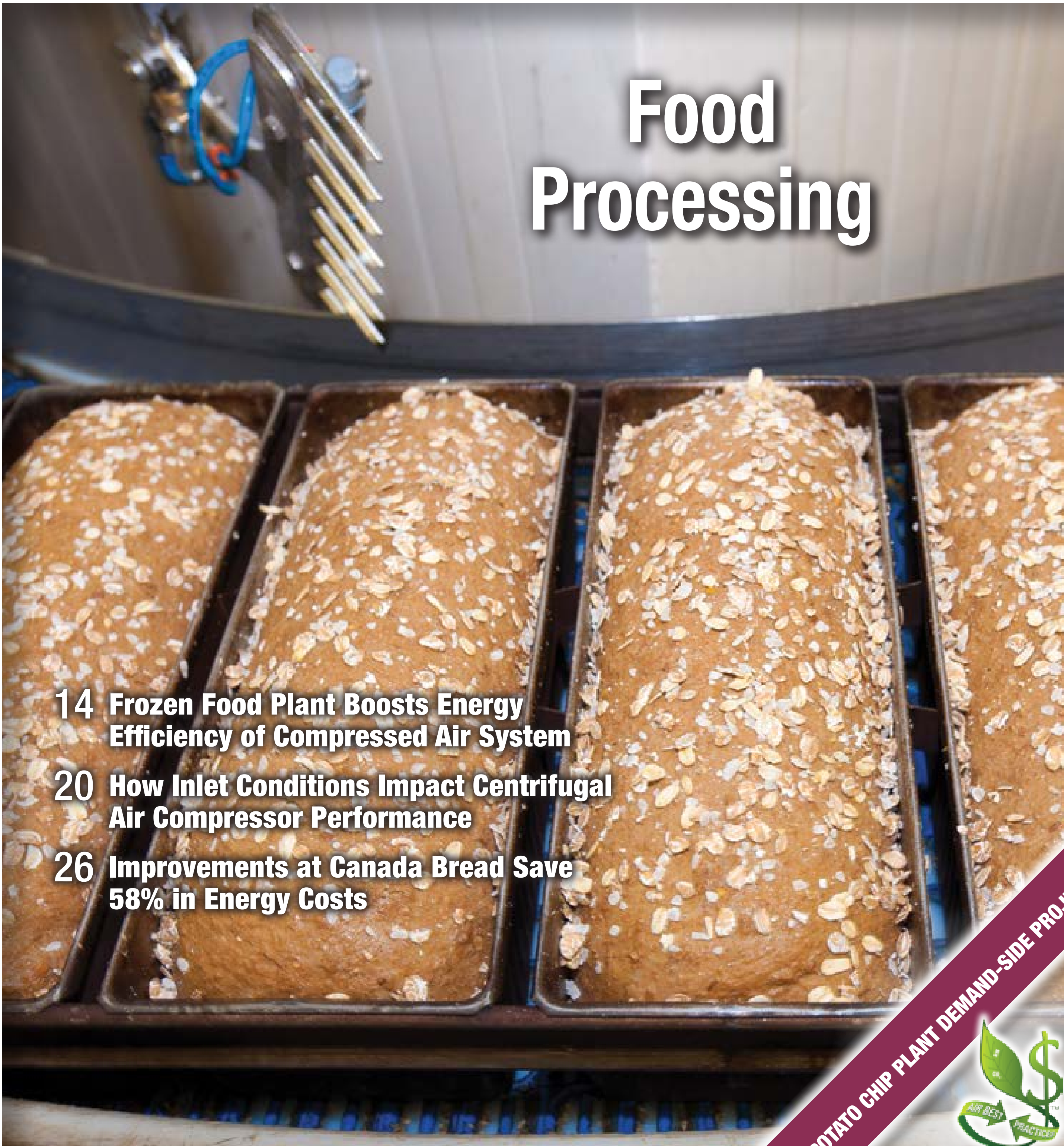

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FROM THE EDITOR | Food Processing

Part of a worldwide organization, a Calgary plant produces frozen-food products for large retailers throughout Canada. Don Dyck, from CAPS Inc., provides us with a case study of how this plant, which experienced compressed air quality issues, went from using three air compressors totaling 200 horsepower down to one 100 horsepower VSD unit. Reducing what he calls "ancillary demand" and changing piping, storage, and air treatment system components allowed this plant to realize $70,000 in annual energy savings while improving air quality and pressure reliability.

The Compressed Air and Gas Institute (CAGI) is celebrating their 100-year anniversary this year. An association representing the manufacturers of compressed air system equipment, CAGI is receiving accolades for their work protecting the interests of compressed air system operators. A provider of unbiased technical information and technical standards, CAGI has many programs and tools in place helping ensure end users receive high quality products meeting rigorous quality and energy efficiency performance standards. Rick Stasyshan and Neil Breedlove, representing CAGI, provide us with a good technical article titled, "How Inlet Conditions Impact Centrifugal Air Compressor Performance."

Canada Bread makes high quality bread and buns for the Winnipeg market. Having recently acquired the factory, Canada Bread decided to audit the compressed air system. Ron Marshall, on behalf of the Compressed Air Challenge®, details how this plant's specific power, per 100 cfm of compressed air, was improved from 77 kW to the target of 20-25 kW. Two key system improvements involved modifying the bread-crumb blowing process and reducing the high leakage rates in the plant.

Nitrogen generators ensure potato chip shelf life and quality. Hank van Ormer, from Air Power USA, provides us with an excellent article on five demand-side projects in a potato chip plant. One project upgraded the plants original PSA nitrogen generation system to a newer PSA unit providing 98.7% nitrogen purity. In order to produce 1 cfm of nitrogen, the new PSA system required only 2.5 cfm of compressed air versus the 4.4 cfm of the older unit. This project alone produced a 4% reduction in air compressor total inlet power requirements.

Last but not least, Tim Dugan from Compression Engineering Corporation, reviews the technical truths behind, "Inlet Air Temperature Impacts on Air Compressor Performance." Not a fan of "rules of thumb," Tim reviews how the type of air compressor and the compressor controls used will significantly affect the impact of inlet temperatures. He concludes with a recommendation saying factories considering inlet temperature and filtration improvement projects should do so primarily from a maintenance and air/oil quality perspective — not for energy savings.

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

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INDUSTRY NEWS

Aggreko Expands Oil-Free Compressor Footprint Throughout North America

Aggreko, a provider of temporary power, heating, cooling and oil-free air compressors, is now the preferred rental channel partner for Relevant Solutions LLC, formerly known as Industrial Compressor Services (ICS).

Relevant Solutions specializes in the design and packaging of large centrifugal oil-free air compressors for the rental market. Aggreko's manufacturing, air separation, petrochemical and refining customers often utilize these types of compressors for permanent utility installations.

Aggreko has a large customer base throughout North America. Through this strategic partnership, Aggreko's North American division is able to expand its fleet size across 60 service centers, providing additional coverage to industries that require large volumes of 100 percent oil-free air as a part of their process. The joint fleet

An Aggreko centrifugal oil-free air compressor

"It is gratifying to get a formal agreement in place that allows both of our companies to seamlessly meet the needs of customers."

— Mark Shedd, Aggreko, North America

offering gives Aggreko the ability to meet high demands with the very best solutions offered in the industry.

"After several years of operating on a project-specific basis, it is gratifying to get a formal agreement in place that allows both of our companies to seamlessly meet the needs of customers," said Mark Shedd, Head of Oil-free Air Compressors, Aggreko, North America.

Aggreko's customers are already realizing the benefits of this partnership. For example, the company has just completed the installation of 165,000 scfm of oil-free compressed air and 33 MW of power, along with associated accessories. The installation will allow a major refiner to replicate the feed air blower for one of its coker units, and support continued daily operations without experiencing costly downtimes.

For more information, visit www.aggreko.com.

Intertape Polymer Group Honored by EPA as a 2015 ENERGY STAR Partner of the Year

The U.S. Environmental Protection Agency (EPA) has recognized Intertape Polymer Group (IPG) with the 2015 ENERGY STAR Partner of the Year — Energy Management Award for its outstanding efforts to improve the energy efficiency of U.S. buildings and facilities through its actions. This is the second consecutive year IPG has been given this award.

IPG, an ENERGY STAR partner since 2009, was honored for its work to integrate and promote ENERGY STAR tools and resources within its energy management program to help lower energy use and greenhouse gas emissions.

"We value this achievement with high regard in our company," said Greg Yull, CEO & President, IPG. "I'm proud of the effort of our employees to be more energy efficient and protect the environment. IPG is honored to be recognized as Partner of the Year and thanks ENERGY STAR for its support to provide the tools and resources that continue

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to improve our energy management throughout the company."

IPG received ENERGY STAR recognition for broadening its energy program throughout the corporation while strengthening its partnership with ENERGY STAR. Key 2014 accomplishments include:

- Reducing energy intensity by 2.5 percent in 2014 and by 24 percent since becoming an ENERGY STAR partner in 2009
- Achieving the ENERGY STAR Challenge for Industry at its Carbondale facility for the second time, enabling IPG to avoid over 34,000 metric tons of carbon emissions. Overall, six plants have achieved the 10 percent energy intensity reduction.
- Launching a sophisticated energy data management system to improve tracking and analysis of energy performance.
- Engaging plant staff through energy treasure hunts and supporting energy champions to become Certified Energy Managers (CEM).
- Building a state-of-the-art tape manufacturing plant that will eliminate use of solvents while operating more efficiently.
- Supporting the ENERGY STAR Change the World Tour by conducting an energy treasure hunt at the Danville Boys and Girls Clubs to identify significant savings opportunities.
- Integrating energy strategies into IPG's lean manufacturing performance system.

"Becoming more energy efficient is more than just a goal, it's the way we conduct business at IPG," said Mike Jones, IPG Corporate Energy Manager. "ENERGY STAR has supported us in our journey for energy efficiency improvements, sustainability, and reduction of greenhouse gas emissions in our plants. Partnering with ENERGY STAR has proved to be extremely beneficial, and we look forward to building on our success in the future."

About Intertape Polymer Group® Inc.

Intertape Polymer Group® Inc. is a recognized leader in the development, manufacture and sale of a variety of paper- and film-based, pressure-sensitive and water-activated tapes, polyethylene and specialized polyolefin films, woven coated fabrics and complementary packaging systems for industrial and retail use. Headquartered in Montreal, Quebec and Sarasota, Florida, the company employs approximately 1,950 employees with operations in 16 locations, including 11 manufacturing facilities in North America and one in Europe.

For more information, visit www.itape.com.

About ENERGY STAR

ENERGY STAR is the simple choice for energy efficiency achievements. For more than 20 years, people across America have looked to EPA's ENERGY STAR program for guidance on how to save energy, save money, and protect the environment. Behind each blue label is a product, building, or home that is independently certified to use less energy and cause fewer of the emissions that contribute to climate change.

For more information, visit www.energystar.gov.

EVO Trillium Opens New CNG Station in Fort Worth Texas

EVO Trillium LLC, the joint venture partnership between EVO CNG and Trillium CNG™, celebrated the grand opening of their new compressed natural gas (CNG) fueling station located in Fort Worth, Texas with a ribbon cutting ceremony.

Dignitaries in attendance included the Honorable Betsy Price, Mayor of Fort Worth, Susan Shifflett, Regional Coordinator of the Railroad Commission of Texas, and John Esparza, President and CEO of the Texas Trucking Association.

The station is open to the public 24 hours a day, seven days a week. It has four dual-hose dispensers with NGV-1 and T-5000 nozzles

(Left to Right) Damon Cuzick, COO of EVO CNG; Mary Boettcher, President of Trillium CNG; Danny Cuzick, President of EVO CNG; Mayor Betsy Price, Mayor of FT Worth; Don Orr, President of Central Freight Lines; John Exparza, President and CEO of Texas Trucking Association; Theril Lund, CFO of EVO CNG; and Susan Shifflett, Regional Director of Texas Railroad Commission.

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and features Trillium CNG's proprietary fast-fill hydraulic intensifier compressor (HY-C). The station has been designed to accommodate Class 8 tractors and trailers, as well as smaller vehicles.

"EVO CNG is extremely excited about the opportunity to work with Central Freight Lines in their effort to become a clean fleet," said Danny Cuzick, President of EVO CNG. "We recognize its pioneering efforts in the field of alternative fuels and look forward to working with Trillium and Central in their clean fuel endeavors. We'd also like to thank our Trillium partners for their continued support and expertise as we expand the population of EVO Trillium stations. And, we appreciate the significant financial and regulatory assistance of the State of Texas Commission of Environmental Quality."

"This is a proud moment for Central Freight Lines," said Don Orr, President and CEO of Central Freight. "We made a commitment to a clean air initiative because we knew it was the right thing to do. We feel confident with our newest CNG equipment, our drivers are the safest drivers on the road today, and we are supporting not only the state but many of our customers who are entrenched in the oil and gas industry. This Fort Worth CNG fueling station helps us close the infrastructure gap that existed in servicing the Texas triangle efficiently."

"It is only fitting that the Grand Opening of the Fort Worth station be celebrated on Earth Day, " said Mary Boettcher, president, Trillium CNG. "Compared to diesel, CNG is less costly, burns cleaner and is an abundant domestic transportation fuel. We strongly support Central Freight Lines' decision to add CNG powered trucks to their fleets. It is a privilege to be working with EVO CNG and Central Freight Lines, who are committed to CNG as a fuel source to power the nation's heavy-duty fleets."

This project is funded in part by the State of Texas through a Clean Transportation Triangle Grant from the Texas Commission on Environmental Quality.

For more information, visit www.evocng.com, www.trilliumcng.com, and www.centralfreight.com.

Atlas Copco's Climate Initiatives Recognized During United Nations' Business and Climate Summit

Atlas Copco, an industrial group with world-leading positions in sustainable productivity solutions, was recently recognized for its climate initiatives, including its goals to impact emissions through energy-efficient products and to decrease the carbon footprint of its operations, during the United Nations' Business and Climate Summit held in May in Paris, France.

The UN Business and Climate Summit is a unique forum for business and government leaders to demonstrate innovative and ambitious strategies that combat climate change. The purpose of the Summit is to identify solutions and forward-thinking strategies with the potential for global impact ahead of the UN Climate Change Conference in December 2015.

"We have long been committed to sustainable business practices not only because it makes good business sense, but because it positively impacts the environment, the industry and our customers," said Jim Levitt, president, Atlas Copco North America LLC. "We are honored that the UN has recognized our efforts to reduce our carbon footprint through innovative and energy-efficient products and operations."

Atlas Copco's variable speed drive air compressors

Atlas Copco's energy-saving products include variable speed drive (VSD) compressors, representing one of the most energy-efficient compressor designs in the industry since its introduction in 1994. Fitted with an intelligent drive system, a VSD compressor continuously changes the motor speed to match air demand and eliminates the compressor running in an unloaded state. This simple concept yields significant energy and cost savings. Customers can achieve average energy savings of 35 to 50 percent and an average 22 to 37 percent reduction in life cycle cost.

Earlier this year, Atlas Copco was ranked 23rd among the 2015 Global 100 Most Sustainable Corporations in the World index — a list presented at the World Economic Forum in Davos, Switzerland. The company was also listed first overall in the machinery industry.

To see the list of companies and organizations highlighted by the UN for their commitment to long-term climate action, visit http://climateaction.unfccc.int/.

For more information about Atlas Copco, visit www.atlascopco.us.

FROZEN FOOD PLANT Boosts Energy Efficiency of Compressed Air System

By Don Dyck, President, Compressed Air Performance Specialists

Compressed Air Performance Specialists (CAPS Inc.) is a compressed air consultancy located in Calgary, Alberta. In its most recent compressed air project, the company reduced a 200-hp, multi-compressor system down to a single, 100-hp variable speed drive (VSD) air compressor utilizing 75 hp of compressor energy (kWh), resulting in $70,000 in annual energy savings.

In this particular project, the client was a worldwide organization with a Calgary facility that produces frozen food products for various large retailers throughout Canada. The facility's management contacted CAPS Inc. to perform a compressed air performance evaluation (CAPE) for its compressed air system.

Figure 1: The 100-hp VSD air compressor along with the 75-hp machine

A comprehensive, on-site CAPE was performed, followed by a detailed final report. In-depth discussions followed regarding the report's findings, which included performance data, analysis tables, graphs and drawings. The report provided recommendations and an initial capital equipment budget estimate. It also estimated opportunities for annual energy savings (kWh) within the compressed air system compared to the facility's existing annual operational costs. From this point, the facility obtained capital equipment and project funding approval, initiating a very successful project.

The facility management involved in this project was onboard and supportive. With their unwavering support, the end results to-date have far exceeded the baseline estimates initially provided, while greater opportunities for energy savings are being continually pursued and achieved.

The Existing Compressed Air System

The original system consisted of three individual, air-cooled, oil-flooded enclosed rotary screw air compressors with dual refrigeration air dryers and limited in-line air filtration units aft of the dryers. This was followed by a singular 200-gallon remote air receiver positioned in front of the plant's primary 4-inch air header (loop) system. The production floor sub-piping systems were generally undersized and/or had lengthy linear service distances with additional associated issues, such as high Delta P service connections and air management devices for individual production equipment.

The compressed air system operated on a 24/7 basis, with two of the three air compressors running continually, while one of the air compressors (75 hp) ran almost constantly. The air compressor configuration consisted of a 100-hp VSD, a 75-hp and a 25-hp (tank-mounted) rotary screw compressor, which collectively totaled 200 hp connected.

Operating mode and operating pressure set-points were adjusted in such a manner that two of the three compressors would run constantly, and the remaining 75-hp compressor would automatically stop/start as required via a system low air pressure set-point. However, this auto stop/start capability was generally manually overridden to maintain a final discharge air pressure of 116 psig to the 4-inch air header, which was necessary due to frequent demand events (surges) on the production floor.

High Energy Costs, Inconsistent Air Supply, and Air Quality Issues

The three air compressors annually consumed over 996,000 kWh of energy at a cost of more than $88,000.00/year, excluding the energy consumption attributed to the dual refrigerated dryers. General day-to-day performance issues included frequent alarm-triggering low air pressure events, frequent demand surge events, and large amounts of oil/condensate contamination downstream in the plant piping system and production equipment. Additional general issues included seasonal high ambient temperatures in the utility/compressor room, and high operating temperature conditions for individual air compressors. Hence, normal operational practice was to run all three air compressors. Finally, no reliable compressed air system performance verification capability excluding the low air pressure alarm device was present in the existing system.

During the extensive on-site period, CAPS Inc. completed the CAPE, including investigation, testing, measurement and data analysis. These investigative procedures included, but were not limited to, the following:

- Installing accurate metering/data logging systems at strategic locations, which simultaneously logged the downstream compressed air demand (cfm), compressed air pressure/temperature, and the compressor room ambient temperature and relative humidity — all in real time
- Installing individual power meters/loggers to each air compressor's electrical line side, ensuring all demand

FROZEN FOOD PLANT BOOSTS ENERGY EFFICIENCY OF COMPRESSED AIR SYSTEM

Figure 2: Dual 1060 gallon vertical air receivers with aluminum piping

and power measurements included both the air-end/exhaust cooling 3-phase drive motors

- Utilizing highly accurate, multi-orifice flow measurement (acfm) devices for each air compressor's package discharge air port

Establishing a Comprehensive Baseline

The CAPS Inc. initial analysis tested and measured each compressor's acfm output capacity at a baseline of 100 psig, with the same site altitude and temperatures. Simultaneously, during these individual capacity tests, the performance data logging of the 3-phase voltage, current, power factor, and individual 3-phase demand (kW) to each compressor was performed. During each of these full-load performance test periods (acfm at 100 psig), CAPS Inc. also conducted further testing at modulating conditions, varying acfm/psig demands and varying temperatures of ambient inlet compression air and cooling air.

Having attained very accurate individual compressor performance profiles at virtually every operational variable available at that time period (summer), the extensive investigation, observation and overall system performance profiling began with simultaneous data measurement and logging at all key areas, including the entire downstream compressed air system. This lengthy period also included firsthand shift period observations of production equipment, along with other items that required further testing.

The completion of the full CAPE and final report analysis illustrated the following technical information:

The existing three compressors collectively delivered 801.2 acfm at 100 psig full load. This was at a 70˚F baseline discharge air temperature with a 172 kW demand line side, equaling 226.3 hp. Normally, the 100- and 25-hp compressors would deliver 530.8 acfm at 100 psig full load, operating at a 70˚F baseline discharge air temperature with a 116.3 kW demand (151.6 hp). The remaining 75-hp compressor delivered 270.4 acfm at 100 psig full load, with a 70˚F baseline discharge air temperature and a 55.7 kW demand (74.7 hp).

Figure 3: Refrigerated dryer connected to aluminum piping

It is important to note that the 100-hp VSD and the 75-hp compressors each had a 3-hp cooling exhaust fan drive motor, while the 25-hp compressor had a direct drive configuration. The compressors were operated to maintain 116-psig plant air pressure downstream, after the refrigerated dryers, filtration assemblies and Delta P losses.

Ancillary Air Demand Issues, Pressure Surges, and Air Leaks

CAPS Inc. defines ancillary air demand as follows: "Compressed air volume/demand (acfm) that is not directly associated to manufacturing the product/service, but is used to overcome a production process, function or

> "Based on $0.08/kWh at the time of the original CAPE report, the estimated annual energy reduction for the facility was more than 667,000 kWh — with an estimated $54,000 to $61,000 in operational energy savings."
>
> — Don Dyck, President, Compressed Air Performance Specialists

equipment design deficiency." Ancillary acfm demand performance testing to four individual ancillary devices/systems verified a range of 84.2 to 116.5 acfm of constant demand. Six additional individual ancillary devices/systems collectively tested and measured a 189.1 to 266.9 acfm intermittent demand range contingent on the number of ancillary devices/systems being utilized. Sanitation air demand volume would fluctuate depending on the period of completion, and would normally equate to 84.6 acfm or greater.

Average weekly air demand was 438.2 acfm at 100 psig. There were also frequent surge events, averaging 650 acfm — with a 700 acfm maximum peak recorded. The surges caused the 75-hp air compressor to come online and assist during all demand events. Weekend periods had partial production and non-production hours, including intermittent sanitation air demands ranging from 150 to 275 acfm. Further testing verified that the system's air leaks equaled 155.5 to 175.4 acfm, including production equipment, air lines, fittings, valves, tubing, hoses, air control and treatment devices, and other unspecified leaks.

What Caused the Ancillary Demand?

When reviewing the above air leak and ancillary acfm demand values, important clarifications must be indicated to fully understand the relevant factors of the overall compressed air demand (kW) and energy (kWh) consumption. The compressed air leak acfm was indeed an accurately tested and measured value from the facility's compressed air demand profile. The ancillary compressed air acfm values reflected both the high and low acfm potential of ancillary demand. Examples of potential demand include two production lines having a blow bar, and dual blow guns being utilized to blow off debris from product trays. The blow bar utilized 61.6 acfm during production, and the blow gun application would utilize 90 to 120 acfm, depending on the number of guns in use. Additional examples included a dust collection system that required its filter purge cycles to operate, which consumed 19.9 acfm every 20 seconds (24/7). Electrical cabinet cooling guns also contributed to ancillary demand — with four total units and a constant demand of 23.2 acfm for two units, and 55.5 acfm for all four cooling guns.

Changes to the Compressor Room Improve Energy Efficiency

The following briefly outlines some of the opportunities available and the specific initiatives that the facility pursued to date.

The following improvements were made to the compressor room air system:

- Installed dual 1060 gallon vertical air receivers (wet air receivers-twinned) (Figure 2)
- Installed appropriately sized in-line air filtration assemblies
- Installed a single, appropriately sized refrigerated air dryer (Figure 3)
- Installed in-line compressed air flow regulator (Figure 4)
- Installed new 63-mm piping throughout the compressor room (Figures 2, 3)

FROZEN FOOD PLANT BOOSTS ENERGY EFFICIENCY OF COMPRESSED AIR SYSTEM

Figure 4: Compressed air flow regulator

- Utilized both no air loss and timed solenoid condensate auto drains
- Installed scfm flow and data logging systems

In order to address the compressors' operating temperatures and the compressor room ambient temperature, the following projects were implemented:

- The 100- and 75-hp compressors' fresh air inlet/hot air exhaust ducting systems were upgraded and improved. The facility envelope did not need any additional heating capacity.
- Individual fresh air inlet/hot exhaust/warm air mixing louvers with electric actuators for open/close and/or modulating operation were installed for the 100- and 75-hp compressors, ensuring ±513,000 BTUs/hour was ejected outside and 114,000 BTUs/hour was eliminated (25-hp compressor disconnected).

The following changes were made to the compressors:

- Shut off and disconnected the tank-mounted 25-hp compressor
- Serviced, installed and retrofitted (as required) new control devices for the 75-hp air compressor, complete with operating mode "auto start/stop" and operating pressure set-point adjustments
- Serviced and adjusted operating mode/pressure set-points to the 100-hp VSD

System-Wide Improvements Help Reduce and Control Pressure

Other system-wide efforts have started to reduce and eliminate ancillary compressed air demands. A few examples include the redesign and installation of new compressed air product tray debris blow-off nozzle systems. The final acfm air consumption total for both of the two new systems is 28 acfm — a reduction of 62 to 92 acfm. Additional reductions included the shut off of three electrical cabinet cooling guns for more than 35 acfm, and the minimization of dust collector filter cleaning cycles when not needed for a 19.9 acfm reduction.

In addition, the following system upgrades have contributed to the success of the project:

- Installed a new flow controller aft of refrigerated dryer, prior to main 4-inch plant air header with 63-mm aluminum piping throughout the compressor room, connecting to the existing main 4-inch plant air header loop
- Installed CDI flow meters with LED displays and USB programmable data logging devices
- An air leak minimization program was initiated, which to-date has an approximate 75-acfm reduction
- At critical locations, existing undersized schedule 40 sub air service pipes are being upgraded to aluminum 63-, 40- and 25-mm pipe as deemed appropriate

"The annual opportunities for energy savings affiliated with the compressed air system can be very dramatic, and can also dramatically reduce downtime and significantly improve throughput."

— Don Dyck, President, Compressed Air Performance Specialists

- Utilized and relocated original 200-gallon air receiver to dust collection system
- Installed new remote 120-gallon vertical air receiver common to dual product packaging lines
- Installed additional high flow/low Delta P point-of-use compressed air filtration assemblies
- Retrofitted/reconfigured several point-of-use compressed air control systems
- Replaced, upgraded and improved several production areas where existing service line tubing was undersized and/or aged with larger diameter tubing and fittings

The aforementioned upgrades, retrofits and repairs resulted in significant reductions in air leaks and ancillary demand, while reducing operating pressures at key locations. Additionally, many areas with high Delta P issues have been eliminated. Finally, a significant reduction in compressed air demand during non-production periods is also being experienced, and the system comfortably operates at a primary plant air header pressure of 105 psig.

Making the Return on Investment Tangible

Based on $0.08/kWh at the time of the original CAPE report, the estimated annual energy reduction for the facility was more than 667,000 kWh — with an estimated $54,000 to $61,000 in operational energy savings.

Within a 7-month period, the compressor room project was completed — with several plant production floor projects underway as well. Later projects focused on several point-of-use areas on the production floor, and the positive energy savings continue to increase significantly from the original estimates. In cooperation with facility management and personnel, CAPS Inc. has continued completing plant production floor projects that have the compressed air system's annual energy savings potentially exceeding $70,000.

Once again, I would like to stress the importance of having highly motivated management and personnel, as with this facility. The annual opportunities for energy savings affiliated with the compressed air system can be very dramatic, and can also dramatically reduce downtime and significantly improve throughput. For capital equipment and new compressed air line supply/installation, the facility and CAPS Inc. worked with Central Air Equipment (Calgary, AB Canada). Their involvement was also crucial to the success of the project. BP

For more information, contact Don Dyck, President of CAPS Inc., via email at caps.inc@shaw.ca, or visit www.compressedairperformancespecialists.ca.

To read more about ***System Assessments,*** please visit www.airbestpractices.com/system-assessments.

How Inlet Conditions Impact Centrifugal Air Compressor Performance

By Rick Stasyshan, CAGI Technical Consultant,
and Neil Breedlove, Atlas Copco

Compressed Air Best Practices® (CABP) Magazine recently spoke with Rick Stasyshan, Compressed Air and Gas Institute's (CAGI) Technical Consultant, and Mr. Neil Breedlove of CAGI's Centrifugal Compressor Section and member company, Atlas Copco Compressors, about centrifugal air compressors. Specifically, the discussion outlined how various inlet conditions can impact the performance of centrifugal air compressors.

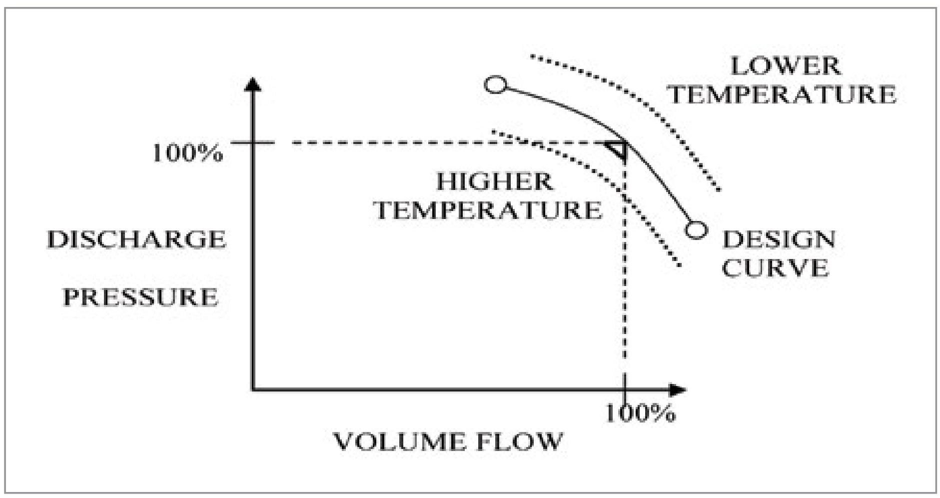

Figure 1: Density of air increases with reduction of air temperature.

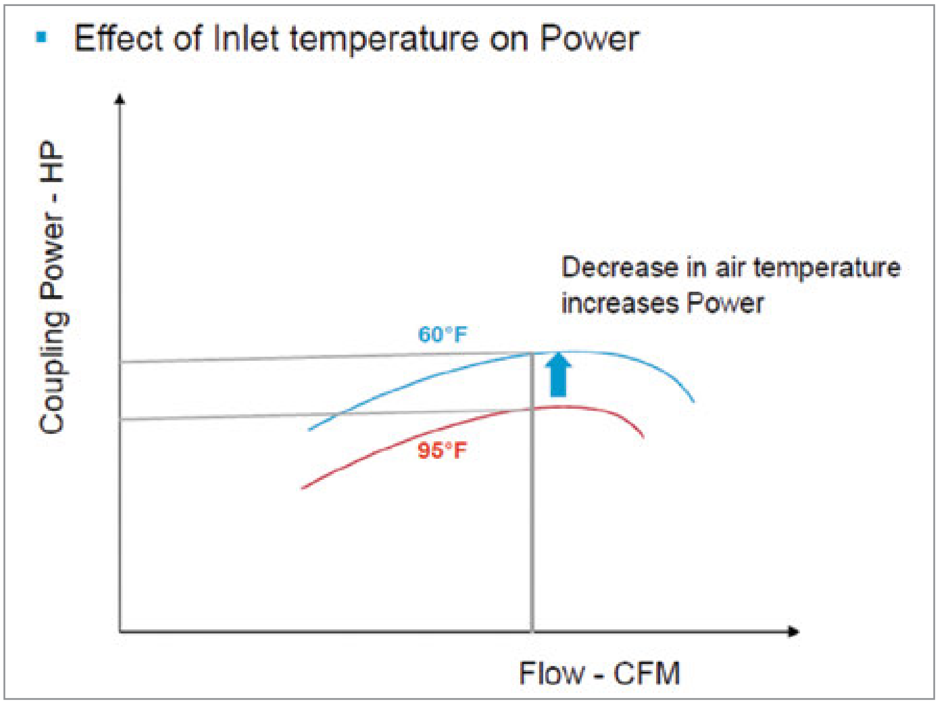

Figure 2: How inlet temperature affects power

Environmental Parameters Influence Centrifugal Performance

CABP: Gentlemen, our readers are always anxious to learn more about how their compressor systems are impacted by environmental conditions. Can you shed some light on how inlet conditions can impact a centrifugal compressor system's performance?

CAGI: Centrifugal technology is based on dynamic compression. In dynamic compressors, air is drawn between the blades of a rapidly rotating impeller and accelerates to high velocity. The air is then discharged through a diffuser, where the kinetic energy is transformed into static pressure. Most dynamic compressors are turbo compressors with an axial or radial flow pattern and are designed for larger volume flow rates.

The performance of a dynamic compressor is very much dependent on environmental conditions. We will explain the impact of the different environmental parameters and their effect on performance below. When considering an investment in a centrifugal type of compressor, it is critical to consider the yearly extremes as well as the average conditions when sizing the equipment for the application to achieve maximum performance.

The environmental parameters that influence the performance are:

1) Inlet temperature
2) Inlet pressure
3) Relative humidity (RH)
4) Cooling water temperature

CABP: Can you provide our readers with an understanding as to how each of these parameters might impact performance?

CAGI: To understand the impact of these parameters, we need to first look at the performance curves of a dynamic compressor and see how performance is impacted with changing environmental parameters.

Inlet Temperature

The inlet temperature of the air has an impact on the density of the air at the intake of the compressor and will influence the kinetic energy transferred by the blades to the air. Increased density at *lower intake temperatures* will result in a *higher free air delivery (acfm)* and also *higher power consumption of the compressor.*

Another effect of the change in air or gas density is the available turndown of the compressor. That is the flow range where efficient regulation through use of a throttle valve or inlet guide vanes is possible. From the illustrations on page 20, it is clear that with *lower temperatures,* a *higher turndown* range is available.

Figures 1 and 2 show the effects of inlet temperature on the performance of a turbo compressor.

Changes in inlet temperature produce large changes in performance. In cold weather, a centrifugal can deliver much more weight flow of air than in warm weather — if the drive is sized to provide the additional power required.

Lower inlet temperature:

- Increases the surge pressure.

HOW INLET CONDITIONS IMPACT CENTRIFUGAL AIR COMPRESSOR PERFORMANCE

- Increases the maximum capacity (weight flow) at a given discharge pressure.
- Increases the power consumption (horsepower).

Higher inlet temperature:

- Decreases the surge pressure.
- Decreases the maximum capacity (weight flow) at a given discharge pressure.
- Decreases the power consumption (horsepower).

The mentioned parameters have similar effects on compressor performance. The impact of these parameters can also be understood from the aforementioned performance graphs.

Inlet Pressure

A decrease in inlet pressure will reduce the density of the air at the compressor intake. As with higher temperatures, it will result in lower free air delivery and power. Changes in inlet pressure can be caused by fouled inlet filters or changing barometric pressure. The same goes for the available turndown — lower intake pressure will result in smaller available turndown (See Figure 3, pg. 24).

Lower inlet pressure:

- Decreases the discharge pressure along the entire curve.

Incoming CAGI President, David Prator from Atlas Copco, presents outgoing President, Dan Ryan from Parker Hannifin, with a distinguished service plaque.

CAGI Celebrates 100 Years of Service

By Rod Smith, Compressed Air Best Practices® Magazine

The Compressed Air and Gas Institute (CAGI) recently celebrated their 100 year anniversary during their Spring Meetings in Scottsdale, Arizona. One of the nation's oldest trade associations, CAGI was formed in 1915 to serve the manufacturers and users of compressed air and blower systems. Today, I'm happy to report CAGI is a dynamic association providing the market with unbiased technical information and technical standards designed to serve the ever-changing needs of the industrial market.

It all starts with the fact CAGI provides a structure and venue encouraging cooperation among its members. This may sound simple, but I've worked in countries where this was and continues to be impossible. Managers from companies, who compete vigorously in the market, get together twice a year (and more often than that at the sub-committee level) to work on projects aimed at improving the service provided to everyone's mutual customer — the end users of compressed air and blower systems.

When an end user purchases an oil coalescing filter to protect their food packaging application, how can they be sure the claimed 0.01 ppm oil removal rating quoted and printed in the product literature will be realized? If a manufacturer is designing a product, how should they test it's performance in order to make a performance claim? If a plant engineer wants to compare multiple air compressor quotes for partial load and full load conditions, how can they sort through all the quotes easily? How much energy will my aeration blower system consume?

The CAGI Standards Committee has answered these and other questions. The Standards Committee's objective is to coordinate the development of standards to ensure that products, as they enter the market, are tested and perform to established uniform minimum levels for user satisfaction and protection. CAGI maintains close liaison with other bodies concerned with standards, including ISO, PNEUROP in Europe and ANSI, ASME and other industry groups in the United States.

In addition, CAGI has created a Third Party Verification Program. Participation is voluntary and is open to all manufacturers, whether a CAGI member or not. The current program covers rotary air compressors

David Welch, Werner Rauer, Wayne Perry, Robert Haseley and Frank Mueller (left to right) have long exemplified the CAGI spirit of working together to help users of compressed air systems.

- Decreases the maximum capacity (weight flow).
- Decreases power consumption or horsepower (due to reduced weight flow).

Relative Humidity (RH)

An increase in relative humidity (RH) reduces flow and power, and a decrease in RH will increase flow and power. The addition of water vapor to the air makes air humid and reduces the density of the air. This is due to the molar mass of water being less than that of air (See Figure 4, pg. 24).

Higher relative humidity:

- Decreases the discharge pressure at surge.
- Decreases the maximum flow capacity (weight flow).
- Decreases the flow at which surge occurs.

from 5-200 HP, and stand-alone refrigerated compressed air dryers from 200-1000 SCFM. Participating manufacturers and the results of the verification tests are posted on the CAGI website. Participating manufacturers that pass the verification program test procedures are allowed to utilize the CAGI Program Verification label on the models' specification sheets and product literature.

On the energy-conservation front, in addition to being a founding sponsor of the Compressed Air Challenge®, CAGI has been applauded for developing CAGI Performance Data Sheets backed by the aforementioned third party verification program. These simplified data sheets permit end users to develop "apples-to-apples" product comparisons, on energy consumption, at two standardized load profiles. End users also know that the performance data being presented to them, for these specific load profiles, comes directly from the manufacturer's test labs. We at Compressed Air Best Practices® Magazine believe the CAGI data sheets are an extremely valuable resource for end users.

CAGI also provides excellent, unbiased educational materials. CAGI educational resources include e-learning coursework on the SmartSite, selection guides, videos and the Compressed Air & Gas Handbook. For more information, contact the Compressed Air & Gas Institute, tel: 216-241-7333, email: cagi@cagi.org, or visit www.cagi.org.

The British Compressed Air Society (BCAS) sent a delegation to congratulate CAGI on the anniversary and CAGI honored retiring BCAS Technical Director Greg Bordiak. Pictured are Greg Bordiak, Robert Haseley, Chris Johnson and Rick Stasyshan (left to right).

CAGI President Dan Ryan recognized the many years of excellent service and professional association management delivered by John Addington (40+ years!), Chris Johnson and Leslie Schraff (left to right).

HOW INLET CONDITIONS IMPACT CENTRIFUGAL AIR COMPRESSOR PERFORMANCE

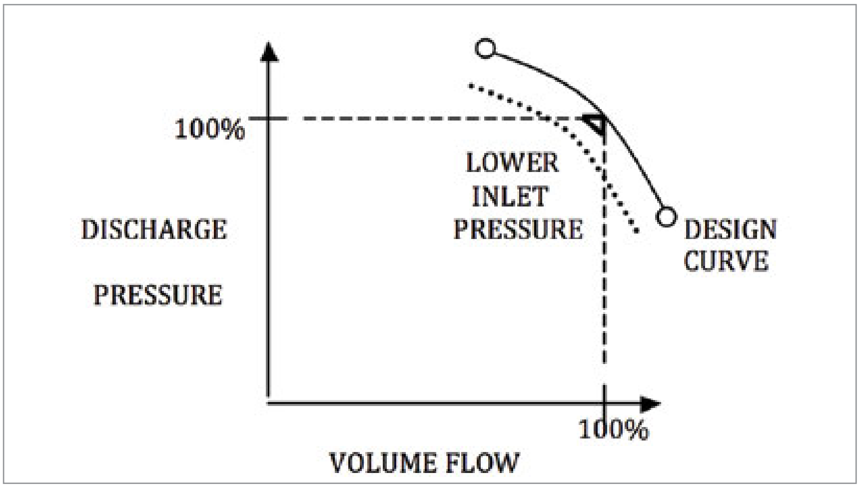

Figure 3: How inlet pressure impacts centrifugal compressor performance

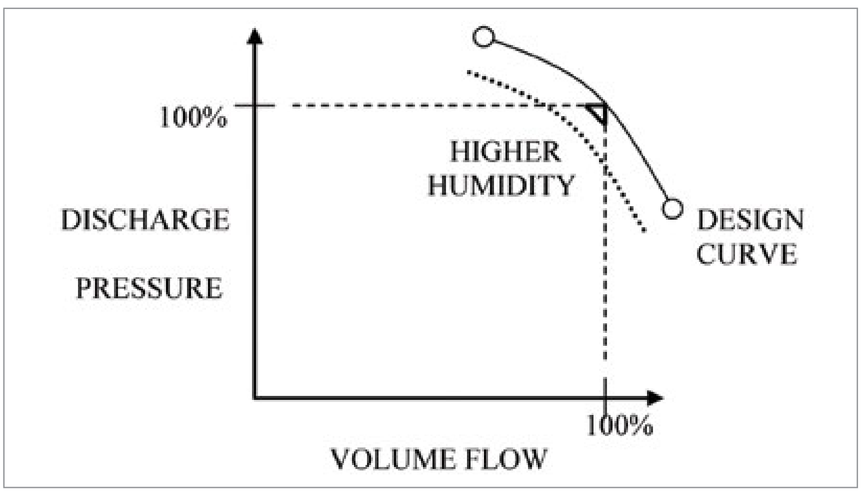

Figure 4: How relative humidity impacts centrifugal compressor performance

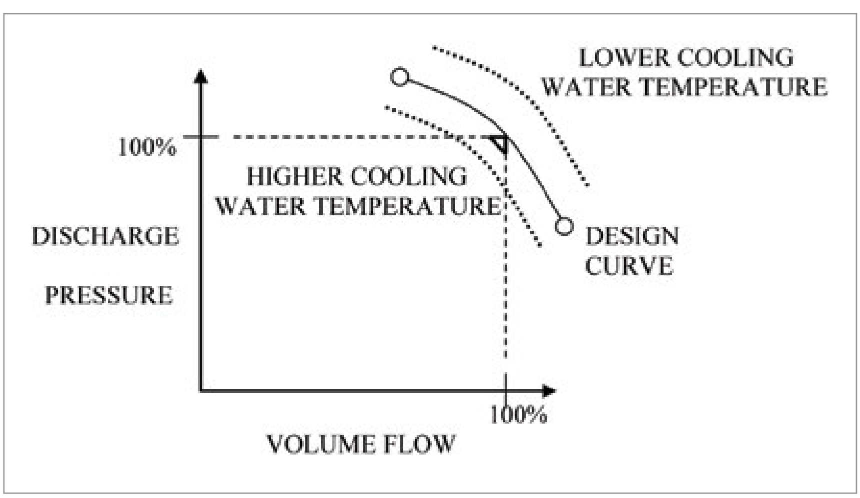

Figure 5: The effect of cooling water temperature on centrifugal performance

- Decreases power consumption (horsepower).

The higher condensate losses on high humidity days result in reduced flow delivered to the plant air system.

Cooling Water Temperature

The cooling water temperatures will affect the intake temperatures to the second stage and any further stages — if present. Colder water increases flow and power, and warmer water reduces flow and power.

CABP: So how do you suggest our readers take this into consideration when sizing their centrifugal compressor?

CAGI: To size a centrifugal compressor, you should consider the demand flow pattern of the user's job site, and consider the site inlet conditions (minimum/average/high) for optimum performance.

Another important point of consideration is motor sizing. If the motor/driver is selected based on performance at lower inlet temperatures, it will ensure that even during low inlet temperatures, the motor has sufficient power available to take care of flow increases. The customer can take advantage of increased flow available from their compressor (See Figure 5).

Cooling water temperature will affect the performance of the compressor stage after the first stage. The affect in performance is similar to that of inlet air temperature. This, of course, is true because cooling water temperature variations will directly affect the temperature of the air entering the second, third and subsequent stages, where there are intercoolers located between stages.

Lower cooling temperature:

- Increases discharge pressure.
- Increases maximum capacity (weight flow).
- Increases power consumption (horsepower).

Higher cooling water temperature:

- Decreases discharge pressure.
- Decreases maximum capacity (weight flow).
- Decreases power consumption (horsepower).

Learning More About Centrifugal Compressors

CABP: From this brief explanation, our readers will probably want to better understand these elements and how they specifically impact their operations. How can our readers get more information and assistance from CAGI and its Centrifugal Compressor Section members?

CAGI: CAGI and its Centrifugal Compressor Section Members, which include Atlas Copco, Cameron, FS Elliott and Ingersoll Rand, have trained engineers to assist and guide users through selecting the correctly sized compressor for their operation. A compressor system assessment is recommended when upgrading and/or replacing existing systems to assure that system performance is maximized.

For more detailed information about CAGI, its members, compressed air applications, or answers to any of your compressed air questions, please contact the Compressed Air and Gas Institute. CAGI educational resources include e-learning coursework on the SmartSite, selection guides, videos and the Compressed Air & Gas Handbook. BP

For more information, contact the Compressed Air & Gas Institute, tel: (216) 241-7333, email: cagi@cagi.org, or visit www.cagi.org.

To read more about ***CAGI,*** please visit www.airbestpractices.com/standards/iso-cagi.

IMPROVEMENTS AT CANADA BREAD SAVE 58% IN ENERGY COSTS

By Ron Marshall for the Compressed Air Challenge®

Replacing air compressors, dryers and filters with more efficient models has saved electrical costs and improved compressed air reliability at the Canada Bread plant in Winnipeg, Manitoba. In addition to this, plant personnel found some additional savings by reducing air leakage and eliminating inappropriate uses. As a result, the plant reduced its compressed air electrical costs by 58 percent and qualified for a utility incentive.

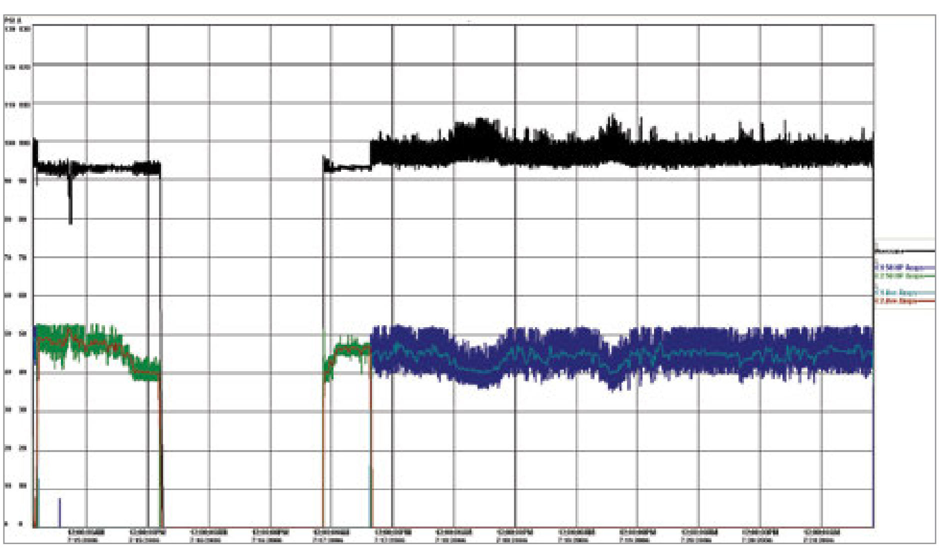

Figure 1: The original pressure and amp profile showed the system to be inefficient.

Low-Pressure Problems Disrupt Production

Canada Bread bought the bakery in Winnipeg from Sobeys in the latter half of 2014. The facility makes high-quality bread and buns for the local market. The project started with a routine compressed air scoping study done by the local utility, Manitoba Hydro. Subsequently, a more detailed study was done by a compressed air consultant. The utility audit personnel placed pressure and amp loggers on the two 50-hp, water-cooled screw compressors for a period of one week to determine the system energy performance characteristics. The data logging showed that while running in alternating mode, each compressor ran in load/unload mode but was rapidly cycling due to lack of storage capacity. Since this operating mode is very inefficient (Figure 1), the system specific power, with the evaporative cooler included, worked out to about 77 kW per 100 cfm of compressed air produced at an average discharge pressure of about 95 psi. Typical optimized systems should be able to produce air at between 20 and 25 kW per 100 cfm, so this indicated there was a high potential for savings if the compressor operating mode could be changed.

An end-use walkthrough audit was done and identified various blowing applications on the production line where holes were drilled in copper tubing to clear crumbs from the conveyor lines and product pans (Figure 2). These applications were constant demands during production activities that consumed compressed air even when the production line

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was stopped, but they were manually turned off during clean-up activities. Leakage load was estimated at about 30 percent of the average compressed air flow produced.

Over a period of time, from the initial scoping study to before the project was approved, a number of changes were implemented in the production area that required even more air. As a result, regular low-pressure occurrences were being experienced that were affecting production activities. This new, higher load was due to higher leakage levels and more blowing activities. Because of this, it was becoming necessary to run two air compressors, or purchase a larger unit to maintain pressure.

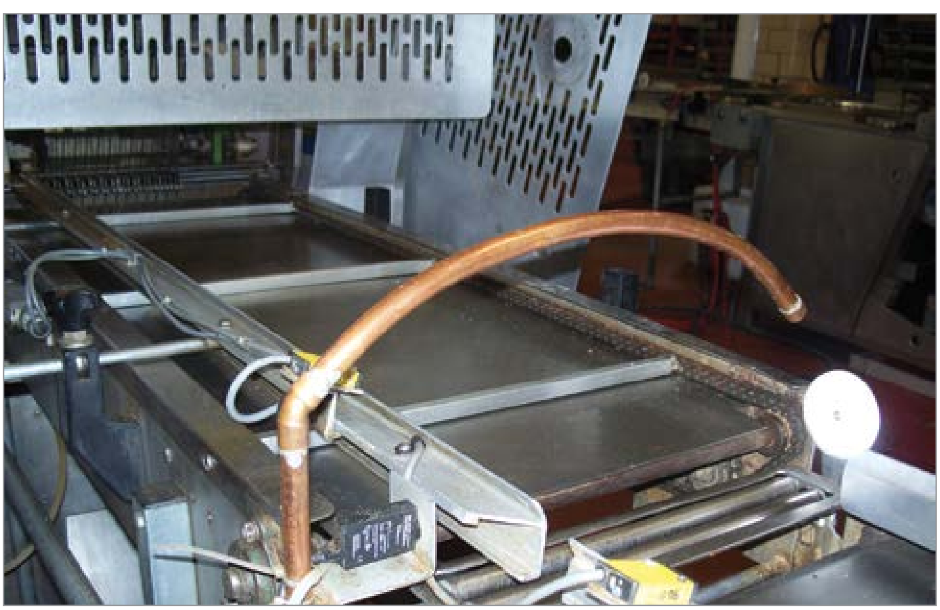

Figure 2: Typical locally designed blowing using copper tubing with holes drilled in it consumes expensive compressed air when other, more economical methods could be used.

IMPROVEMENTS AT CANADA BREAD SAVE 58% IN ENERGY COSTS

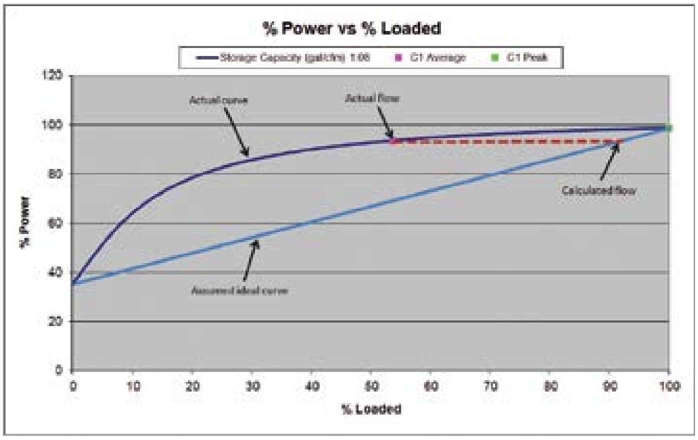

Figure 3: Using the assumed curve can make flow calculation from amps or power very inaccurate.

Flow Estimation Versus Measurement

When lubricated screw compressors are running in modulation or in load/unload with rapid cycling, it is difficult to estimate the actual flow they are producing simply from amp or power readings. In these modes, a small change in input amps can result from a large change in flow.

Traditional estimating methods calculate the average power consumed by a compressor and then use straight-line approximation along a line drawn from no load to full load to estimate the output flow of the compressor. In actual fact, a lubricated screw compressor flow versus power curve varies depending on site conditions. Figure 3 shows one source of the typical estimation error, using an assumed ideal curve for a screw compressor rather than the actual non-linear curve that accounts for blow-down time and higher cycle frequency caused by dryer and filter drop. For Canada Bread's original estimate, the use of traditional methods would have showed average loading in the 93 percent range. The actual loading was about 55 percent.

In addition to this error, the typical calculations also assume that the compressor produces rated nameplate flow and consumes normal power. If the actual output flow is lower, due to internal wear or control problems inside the compressor, then there is an additional error introduced. To gain more accurate readings at Canada Bread, a thermal mass flow meter was installed to measure the flow pattern. The meter showed that the compressors were producing 23 percent lower than rated flow — about 160 cfm compared to the rated 208 cfm. In addition to this, the unloaded power consumption of the compressors was abnormally high due to problems with the blow-down circuit.

If the project payback was calculated for a change in compressor control mode to variable speed drive (VSD) control using the flows estimated in the traditional method, the project would have looked like it had low potential for savings and would have yielded a small utility incentive. However, once more accurate flow meter data was introduced, it revealed that changing the compressor control mode would have good economic benefit.

Final Equipment Configuration

Canada Bread's compressed air production equipment was completely changed. The original location of the compressors was in an area that had hot ambient conditions and was subject to flour contamination of the cooling air. This required water-cooled compressors. The two new air-cooled VSD compressors, one main and one backup, are now located away from the heat and flour in a cooler loading bay where the heat of compression can be used to displace gas-powered space heaters (Figure 4). The new units are sized so that only one unit is required to run at a time. The air dryers purchased are an energy-saving cycling style that reduces the input power in relation to reduced moisture loading. Air filters are mist eliminator type, resulting in lower pressure differential. Local finer filtration is oversized for lower pressure differential. Large storage and flow control has been applied so that the plant pressure can be kept at a minimum level, reducing artificial demand and allowing stored air to feed various plant peak flows rather than turning on a second compressor and incurring higher peak electricity demand charges.

Canada Bread maintenance personnel addressed plant leakage and inappropriate uses through some focused attention. Better control of blowing applications and use of appropriately designed nozzles were recommended to lower the average airflow.

Figure 4: The new air-cooled compressors do not require an external cooler and heat an area of the plant displacing natural gas heat.

IMPROVEMENTS AT CANADA BREAD SAVE 58% IN ENERGY COSTS

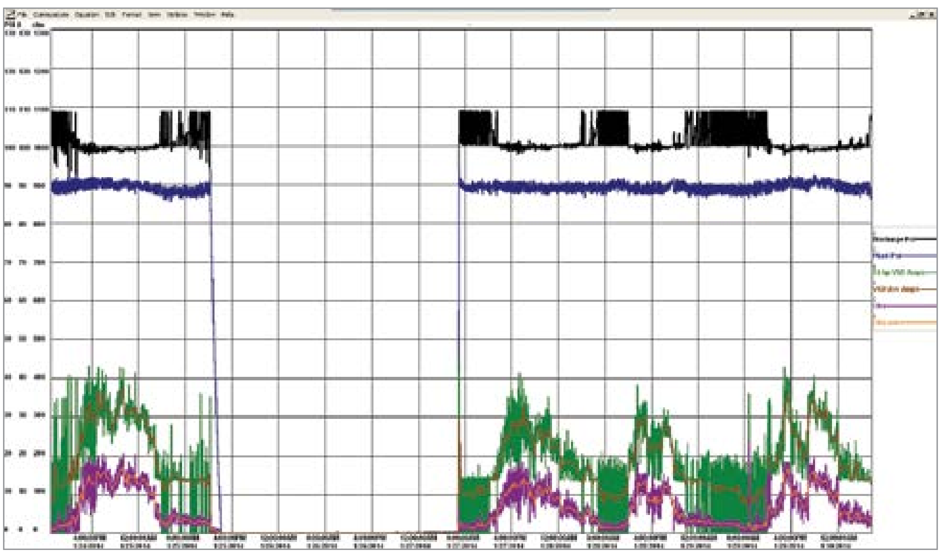

Figure 5: Final profile shows the compressor power tracks the actual flow and is much lower than the original profile.

Compressed Air System Improvements Result in Dramatic Cost Reductions

Overall, the project was successful in stabilizing the plant production pressure and providing reduced operating costs. The compressed air system has been renewed and now has adequate backup to withstand any future unplanned equipment failure or required maintenance activities. In summary, the improvements gained for this project include:

- Compressed air equipment was located in a cooler and cleaner location in the plant where air-cooled compressors could be used.
- VSD control and cycling refrigerant dryers were used to minimize operating costs at partial loading. This reduced the system specific power to 23 kW per 100 cfm from the original value of 77 kW/100 (Figure 5).
- Low pressure differential filtering is used to allow more efficient lower discharge pressures.
- Large 1500 gallon storage was installed to aid supply of plant peaks without starting a second compressor. A pressure/flow controller was installed to reduce average plant pressure while maintaining the required level of stored air.
- Inappropriate uses were reduced or eliminated, and leakage was repaired.
- Operating cost reductions gained resulted in a 58 percent reduction in direct compressor operating costs. Further cost reductions were gained by shutting down the associated compressor water cooler. BP

For more information, contact Ron Marshall at info@compressedairchallenge.org.

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Five Demand-Side Projects AT A POTATO CHIP PLANT

By Hank van Ormer, Air Power USA

A major snack food manufacturer spends an estimated $148,220 annually on energy to operate the compressed air system at its food processing plant located in the Mid-Atlantic area. As electric rates rise from their current average of 8 cents per kWh, their annual expenditure will only increase.

In this compressed air audit, a group of projects were identified that — when implemented — will reduce these energy costs by an estimated $40,785 or 28 percent of the facility's current use. In addition, these projects will help production quality and lower maintenance costs. The estimated costs for completing the recommended projects are about $185,000, which represents a simple payback period of 54 months.

While the audit comprehensively evaluated the plant and identified energy-saving projects across both the supply and the demand sides of the compressed air system, this article focuses specifically on five of the demand-side projects identified at this food processing plant.

About the Facility's Compressed Air System

This particular plant has two production lines that produce potato chips. The plant usually operates one to two production lines, depending on the time of year and the production demand.

The facility's compressed air system is divided into two separate feed lines — one to the plant air and one to the chip transport and nitrogen generation lines. The plant feed is regulated from an average discharge pressure of 87 psig to 88 psig by a Zeks pressure flow controller. The chip transfer and nitrogen systems are fed from the unregulated side of the system, which normally runs from 97 to 105 psig.

The main compressed air supply is provided by two Atlas Copco 125-hp oil-free rotary screw compressors. One is a variable speed drive unit, while the other is a standard two-step controlled unit. An Ingersoll Rand 250-hp two-stage centrifugal is used as an emergency backup. For a look at the full schematic, refer to Figure 1.

The system has two Ingersoll Rand water-cooled refrigerated dryers to handle the air demand. During the hot summer months, plant personnel operate both of the dryers due to increased condensate migration downstream to production.

The air system operates 8,760 hours per year. Annual plant electric costs for compressed air production are $141,998 per year. If the electric costs of $6,222 associated with operating ancillary equipment are included, the total electric costs for operating the air system are $148,220 per year. These estimates are based upon a blended electric rate of $0.08 /kWh.

Establishing the Baseline of Compressed Air Use

The following actions were taken to establish baseline measures for flow and pressure (Measurements can be seen in Table 1):

1. Temperature readings were obtained on all units using an infrared surface pyrometer. These were observed and recorded to correlate to the unit's performance, load conditions and integrity.
2. Critical pressures, including inlet and discharge, were measured with single digital calibrated vacuum and pressure test gauges with extremely high degree of repeatability.
3. Trended data was measured with plant/corporate kW meters,

and trended data was sent to data loggers set for 30-second data points for two days for diagnostics. It was sent again at 70-second data points for two weeks for longer averaging.

4. Two-step controlled compressor operating performance was calculated as a percentage of full load capacity by identifying the total time at full and no load. The percentage of full load in acfm was then calculated to arrive at a very accurate average peak and minimum flow demand over time.

5. The same basic measurement and logging activity was carried out for system pressure, using self-contained pressure transducers and loggers. These units are all calibrated to a single test gauge, and each is set to start logging pressure simultaneously. This delivers an accurate operating pressure profile.

Demand-Side Projects for Improving Energy Efficiency

In the following section, five of the demand-side projects that were identified during the audit are described. Collectively, these projects have the potential to save the company $40,777 annually on energy costs associated with the compressed air system.

TABLE 1: KEY AIR MEASUREMENTS OF THE CURRENT SYSTEM

	PRODUCTION LINES			
MEASUREMENT	NO LINE PRODUCTION	PACKAGING #1	PACKAGING # 2	NITROGEN
Average System Flow	250 scfm	380 scfm	292 scfm	488 scfm
Average Compressor Discharge Pressure	97 psig	97 psig	97 psig	97 psig
Average System Pressure	88 psig	88 psig	88 psig	88-96 psig
Input Electric Power	59.36 kW	88.48 kW	71.68 kW	98.8 kW
Operating Hours of Air System	645 hrs	7,194 hrs	6,593 hrs	6,352 hrs
Specific Power (scfm/kW)	4.21 scfm/kW	4.29 scfm/kW	4.07 scfm/kW	4.94 scfm/kW
Electric Cost for Air /Unit of Flow	$12.25 /cfm yr	$134.00 /cfm yr	$129.47 /cfm yr	$102.88 /cfm yr
Electric Cost for Air /Unit of Pressure	$15.32 /psig yr	$254.61 /psig yr	$189.03 /psig yr	$251.03 /psig yr
Annual Electric Cost for Compressed Air	$3,063 /year	$50,922 /year	$37,807 /year	$50,206 /year
	$141,998 /year			

*Based upon on a blended electric rate of $0.08 per kWh and 8,760 hours/year.

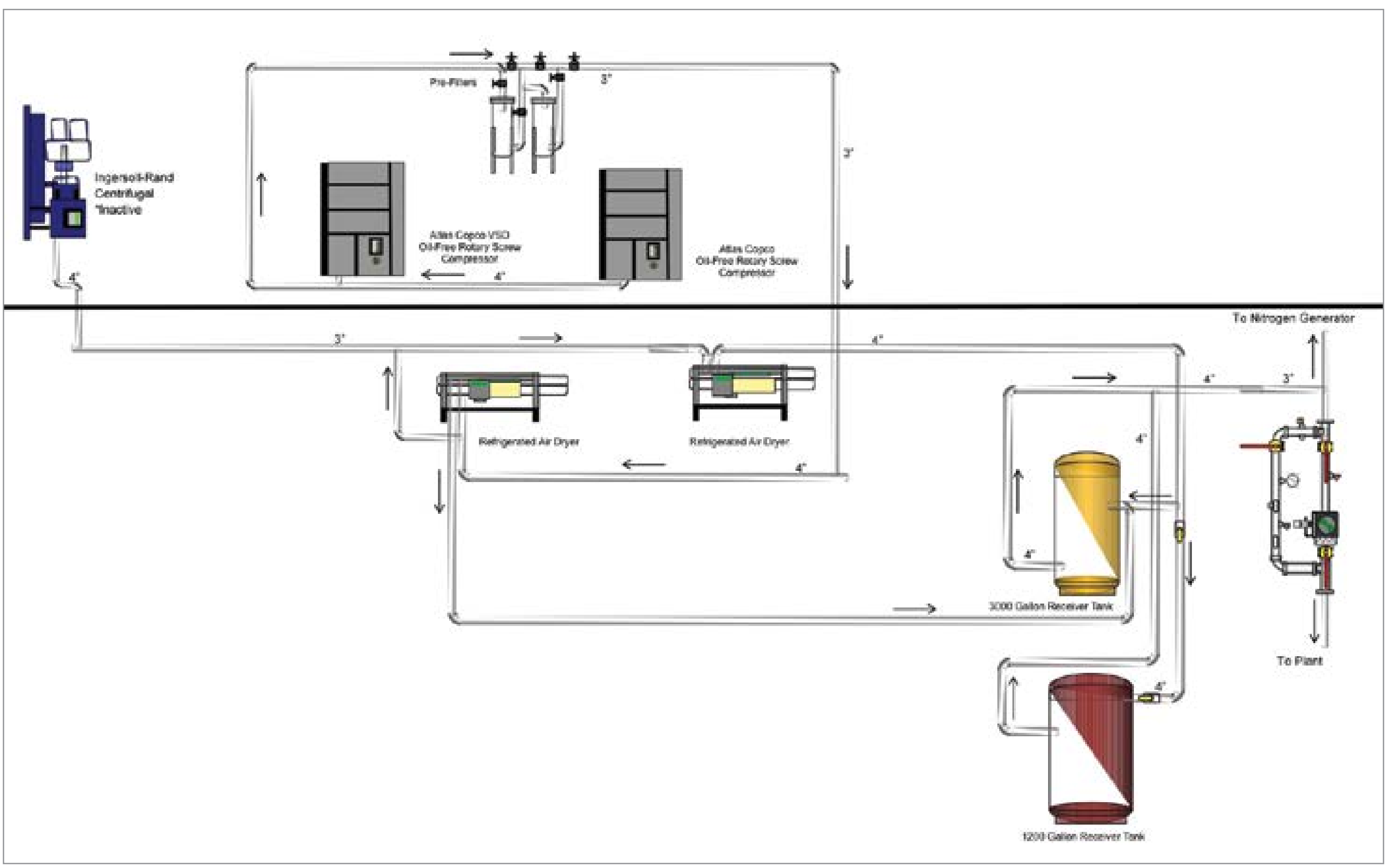

Figure 1: The food processing plant's initial compressed air system

FIVE DEMAND-SIDE PROJECTS AT A POTATO CHIP PLANT

TABLE 2: COST ANALYSIS OF THE DEMAND-SIDE PROJECTS

DEMAND-SIDE PROJECT COST ANALYSIS						
		ENERGY AND OTHER SAVINGS				
PROJECT	SAVINGS PROFILE	AVG. KW	KWH	ANNUAL SAVINGS ($)	TOTAL PROJECT COST (ESTIMATED)
Correct the Main Distribution Header Piping	This is a production project with pressures falling to 77 psig due to in-line filters and regulators at packaging.				$500
Install Additional Storage (2500 gallons)	This additional 2500 gallons will provide enough storage to reduce discharge pressure to 85 to 90 psig.				$9,000
Repair Eight Air Leaks	24 scfm	5.56 kW	48,750 kWh	$3,900	$800
Replace Two Air-Driven Vibrators	14 scfm	3.24 kW	28,439 kWh	$2,275	$1,000
Install an Efficient Nitrogen Generator	130 scfm	41.31 kW	264,075 kWh	$21,128	$118,000 + Installation
Total	12 psig, 7.06 kW, 168 scfm	69.17 kW	453,889 kWh	$40,777	$184,800

1. Correct the Packaging Header Piping

It is the job of the main header system to deliver compressed air from the compressor area to all sectors of the plant, with little or no pressure loss. If there is a significant pressure drop anywhere, then corrective actions are likely needed. A pressure loss of no more than 1 to 2 psid is a reasonable target for main header performance.

It is also desirable that the compressed air velocity in the main headers be kept at below 20 fps to allow effective drop out of contaminants at pre-determined drain points and to minimize pressure losses through excessive turbulence. The magnitude of the turbulence effect depends on the compressed air velocity, piping configuration and pipe size.

Typical header projects include adding pipe, replacing pipe with large diameters, re-orienting or re-directing airflows, and sometimes creating oversized "collector" or "storage" headers.

During the audit, the headers were logged simultaneously at appropriate points with multiple calibrated transducers. In the current system, there is an apparent pressure loss of 1 to 2 psig. The header system can apparently deliver the required air to any area without any significant pressure loss. If low-pressure problems are encountered, they are likely caused by the feeds from the header to the packaging area or extra, marginally applied filters and/or regulators in the lines to the processes.

Therefore, the first part of this project was to correct the main distribution header piping in the packaging area of the plant by removing the filters and regulators on two, 2-inch sub-headers. Those sub-headers were feeding multiple packaging lines, and were experiencing random, low-pressure problems at full loads.

The other part of this project included completing the loops between the ends of all four of the sub-headers. The potato chip packaging lines each have two, 2-inch sub-headers that are fed from one end and are a dead head at the other. Completing the loop allowed these headers to be fed from a different direction when needed. This piping project created two loops within the bigger loop.

The combined projects eliminated the excessive operating pressure loss.

2. Install Additional Air Storage to Lower Plant Pressure

The air system will be most efficient if it uses the lowest possible flow and the lowest effective pressure. Therefore, pressure regulators can be leveraged to effectively use the air receiver capacity and sustain a stable airflow in the system at the lowest effective pressure with varying demands. This avoids pressure spikes that can create increased flow to all unregulated air uses.

Plant personnel have already installed a Zeks flow controller on the distribution header — between the compressor room and production area — which delivers the compressed air at 87 to 88 psig. The product transfer and the nitrogen generator are fed from a line before the flow controller at a higher pressure (normal 97 psig). The current control band is approximately 1 to 2 psi at the flow controller discharge. We measured 87.7 psig at the packaging header, and other locations had similar readings. This would indicate the main distribution header system is capable of handling the demand of the plant to the production areas.

The process at the pneumatic transfer has a short duration and a high peak flow of 427 scfm over 2.25 minutes. This results in a "rate of flow" of 190 scfm during the period. The cycle time between peak surges is 15 minutes. The current storage pulls down 25 psig during the 2.25-minute run.

This establishes an effective "buffer" for typical air demands in the PSA nitrogen generator and pneumatic transfer lines.

There is 4200 gallons of storage to handle this cycle rate of flow, which eliminates excessive pressure fluctuation. In order to effectively lower the plant pressure while covering peak demands, an additional 2500 gallons of effective shortage is required to hold the losses to the desired levels. The desired level is 15 psig, which will allow the air compressors to run at a lower pressure.

Establishing the Net Flow into the Receivers

Calculating net flow out:
Time = (volume) (P_2-P_1) / (Net Flow) (14.5)

$$2.25 = \frac{561\ (95\text{-}70)}{NF\ (14.5)} = \frac{14{,}025}{32.85} = 427 \text{ scfm net flow out}$$

Storage calculation for lower system pressure:

$$2.25 = \frac{\text{Vol.}\ (85\text{-}70)}{427 \times 14.5}$$

$$2.25 = \frac{\text{Vol.}\ (15)}{427 \times 14.5} = \frac{13{,}930}{15} = 928 \text{ cu ft.} \times 7.48\ (\text{gal/ft}^3)$$

$$= {}^{*}6941 - 4200 \text{ gal.} = 2741 \text{ gal.}$$

*Storage required to hold a maximum pressure loss of 15 psig (4200 is the current storage, and 2741 gal. is the additional storage required).

Pump up time current storage:

$$8 \text{ minutes } T_{pu} = \frac{516 \text{ cuft}\ (25)}{NF\ (14.5)} = \frac{12{,}900}{116} = 111 \text{ scfm}$$

Pump up time recommended storage:

$$T_{pu} = \frac{928(15)}{111(14.5)} = \frac{13{,}920}{1609} = 8.65 \text{ minutes}$$

The future refill rate for the new storage capacity will increase from 8 minutes to approximately 8 minutes and 39 seconds.

Thanks to the additional storage, the flow controller can operate effectively, maintaining consistent plant pressure at 85 psig.

3. Implement a Leak Identification and Repair Program

Most plants can benefit from an ongoing air leak management program. Generally speaking, the most effective programs are those that involve the production supervisors and operators working in concert with the maintenance personnel. Accordingly, it is suggested that all programs consist of the following two phases:

- **Short-Term Program:** Set up a continuing leak inspection program for maintenance personnel so that each primary sector of the plant is inspected once each quarter to identify and repair leaks. A record should be kept of all findings, corrective measures and overall results.
- **Long-Term Program:** Consider setting up programs to motivate the operators and supervisors to identify and repair leaks. One method that has worked well with many operations is to monitor/measure the airflow to each department and make each department responsible for identifying its air usage as a measurable part of the operating expense. This usually works best when combined with an effective in-house training, awareness and incentive program.

Shutting off or valving off the air supply to the identified leaks when the area is idle would save significant energy use from leaks. Reducing the overall system pressure would also reduce the impact of the leaks — when air to the machine cannot be shut off. Repairing the leaks can save additional energy. The estimated savings associated with a leak management program are based on the unloading controls of the compressors being able to effectively translate less airflow demand into lower cost.

Air Power USA recommends an ultrasonic leak locator be used to identify and quantify the compressed air leaks. With a few minor exceptions, most of the leaks in this audit could not have been found without the use of an ultrasonic leak detector and a trained operator. Locating leaks during production time with the proper equipment is very effective and often shows leaks that are not there when idle. However, a regular program of inspecting the systems in "off hours" with "air

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>
> — Hank van Ormer, Air Power USA

FIVE DEMAND-SIDE PROJECTS AT A POTATO CHIP PLANT

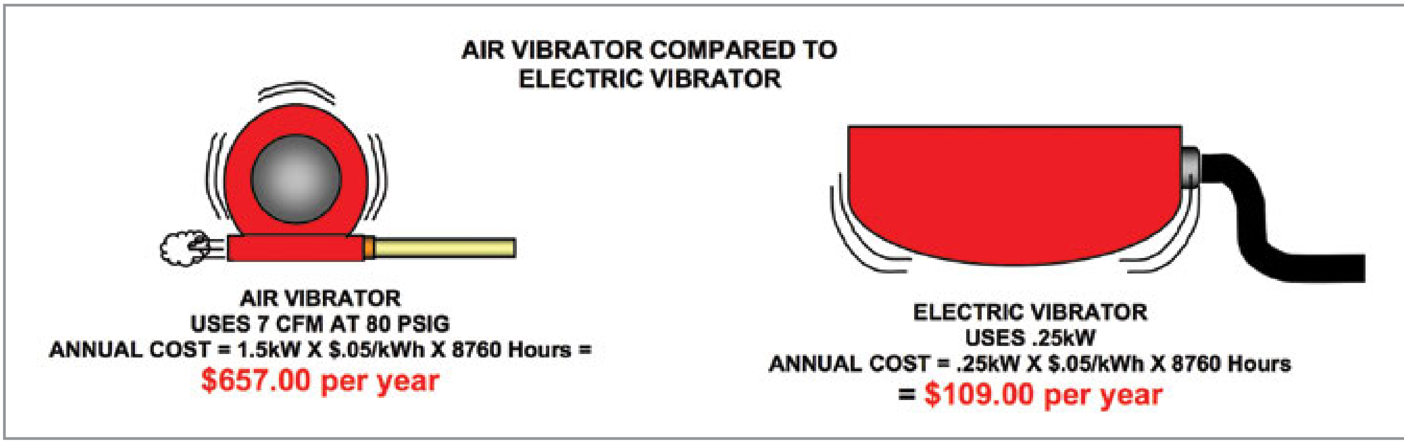

Figure 2: The annual costs of air-driven vibrators are significantly greater than that of electric vibrators.

powered up" is also a good idea. In a system such as this one, some 80 to 90 percent of the total leaks will be in the use of the machinery, not in the distribution system.

4. Replace Air-Driven Vibrators with Electric Units

Air vibrators are used to keep product or packaging moving or separated (e.g. keeping lids separated prior to sealing). If a plant employs air vibrators that use about 10 cfm each, they will require about 2.5 hp or more to produce the same as a similar electric vibrator, which might use about 0.25 hp of input energy.

By simply replacing two of the plant's air-driven vibrators with electric units, this facility could reduce its annual costs by $548.00 (Figure 2). In general, air vibrators can almost always be replaced with electric vibrators, except in foundry sand mold operations.

5. Improve the Efficiency of the Nitrogen Generation System

In this plant, nitrogen is used to purge the ambient air from the packaging bags before they are filled and sealed. When the lines are not running, the nitrogen generator is shut down. This particular plant uses a PSA nitrogen generator (purge oxygen) to produce its nitrogen on-site. This facility's original perceived purity requirement was 99.999 percent.

Nitrogen generation and its purity are dictated by the flow and pressure of the compressed air, and you can control the cost of nitrogen by controlling the volume and pressure of the compressed air. When you use more purity than you need, the compressed air costs are higher. Therefore, it is important to understand the required purity of nitrogen, since that dictates the flow and pressure of compressed air. You should also know the ratio of compressed air to nitrogen for each type of generator to meet the required nitrogen flow, pressure and purity.

Purity requirements for nitrogen in packaging vary with the product itself and the expected "shelf life."

The facility's original PSA nitrogen generation system produced *1 scfm of nitrogen for every 4.4 scfm* of compressed air at 95 psig inlet pressure. The generator switches every minute, and the compressed air flow rate is based on the nitrogen demand. Consequently, it will vary with the number of production lines running.

Investigation by plant engineering and production personnel determined that 98.6 percent nitrogen purity would be a more optimal requirement. With this information, plant staff and Air Power personnel worked with several vendors and identified a PSA unit that could supply the required nitrogen flow with 85 psig inlet pressure, delivering a consistent purity of 98.7 percent.

The new system delivers *1 cfm of nitrogen for every 2.5 cfm of compressed air.* This is a 56 to 57 percent reduction in air volume. Combined with the increased storage project, it allows a significant reduction in compressor discharge pressure (8 to 9 psig), providing an energy reduction of 4 percent of the total inlet power. BP

For more information, contact Hank van Ormer, Air Power USA, at hank@airpowerusainc.com, or visit www.airpowerusainc.com.

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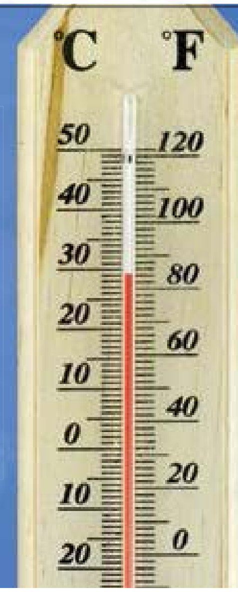

INLET AIR TEMPERATURE Impacts on Air Compressor Performance

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

There is a partly true idea floating around some plant maintenance circles that "compressed air is free." Readers of this journal know that isn't true. But, what if non-compressed air could be seen as "free?" Is there something we can get for free from nature to reduce the cost of our compressed air? What if lower temperature intake air was nature's gift? What if all we need is a bit of tin to duct air from a different source?

The answer is: "It depends."

The goal of this article is to debunk a few misconceptions, and show how inlet air temperature actually affects compressor efficiency in three kinds of systems. In summary, inlet air temperature has a modest impact on compressor efficiency, depending on the situation. This article will discuss the following two factors that impact efficiency: (1) The Type of Compressor, and (2) The Compressor Controls.

Definitions

Before I launch into the article, let's define several key terms:

Inlet cubic feet per minute (icfm): This is the airflow rate in actual volume per time units at the intake of a compressor. It is at actual conditions, uncorrected for density. This is what you could measure at the inlet of a compressor using a velocity measurement like a pitot tube.

Standard cubic feet per minute (scfm): This is the delivered airflow in volume, converted to a standard reference point that doesn't exist in the actual compressed air system. It is essentially mass flow divided by a constant. This is what you would measure with a mass flow meter at the discharge of a compressor that compensates the measurement with pressure and temperature.

Isentropic (or Adiabatic) Compression: This is an ideal model of compression when no heat is transferred out of the compressor, as if the walls of the compression chamber are insulated, and temperature goes way up. It is reversible. Interestingly, it is not particularly "efficient" to compress this way. This is closer to the way a single-stage, oil-free screw compressor works. Two-stage, oil-free compressors with inter-cooling have good efficiency, but they behave like "adiabatic" compressors as far as the inlet temperature is concerned. Adiabatic efficiency is the ideal adiabatic power divided by the actual power.

Isothermal Compression: This is an ideal model of compression when all the heat is transferred out of the compressor, and temperature is constant through compression. Interestingly, it is quite "efficient" to compress this way. This is closer to how an oil-injected screw compressor works, particularly a multi-stage unit or a centrifugal with many stages and inter-cooling between stages. Isothermal efficiency is the ideal isothermal power divided by the actual power.

Volumetric Efficiency: This is the inlet volume flow (icfm) divided by the ideal flow with no slip or "displacement."

How Inlet Air Temperature Impacts Different Types of Compressors

There are three common types of compressors in most plants, including positive-displacement, screw (oil-injected and oil-free), and dynamic (centrifugal). We will generalize their efficiencies for the purpose of understanding how inlet temperature affects it. I realize these are generalizations, and there are exceptions. The goal of this article is not to compare compressor efficiencies between these types of compressors, but to examine the impact that inlet air temperature has on the efficiency of each.

Oil-Injected Screw

This type of compressor is designed for general industrial applications where trace amounts of oil can be in the air stream. There is very little slip between the rotors, resulting in high (and constant) volumetric efficiency. Also, significant internal cooling occurs during compression. As a result, the temperature rise per stage is the lowest of the three, and the compressor behaves closest to the *"isothermal"* compression model. In a simplified sense, power and flow vary with inlet temperature in an oil-lubricated screw compressor as follows:

- Volume (icfm) is constant with inlet temperature.
- Delivered flow (scfm) is directly proportional to inlet temperature. A 10˚F decrease in inlet temperature will result in about a 1.9 percent increase in mass flow.
- Required power in isothermal compression is independent of inlet density, and only dependent on pressure ratio and speed. So, in an oil-injected screw compressor, which isn't perfectly isothermal, power only goes up a small amount with lower inlet temperature.

NOTE: Some discussions in the literature attribute the insensitivity of power to inlet temperature in this type of compressor to the constant oil temperature control.[1] They claim that inlet flow is essentially constant because of the constant oil temperature. In my view, that it not the case. It is unlikely that the inlet air reaches thermal equilibrium temperature with the oil in the very short time before cut-off. Oil temperature does have an impact on power, but it is due to viscosity. Low viscosity reduces drag, but increases slip between rotors. So higher ambient temperature in an air-cooled unit that had high oil temperature could actually reduce capacity, but it would reduce viscous drag at the same time (and vice versa). In a water-cooled unit, there would be no impact on volume flow.

Conclusions:

1. Efficiency (scfm/kW) increases with inlet air temperature reduction, because mass flow goes up while power barely does.
2. Ambient temperature is primarily an oil-quality and maintenance concern.

Oil-Free Screw

This type of compressor is designed for pharmaceutical and high tech applications where no oil can be in the air stream. There is some slip between the rotors, and no cooling in the compression stage — just cooling between the two stages. As a result, the temperature rise per stage is the highest of the three, and the compressor behaves closest to the "adiabatic" compression model. At higher pressures, volumetric efficiency drops, also resulting in lower adiabatic efficiency. In a simplified sense, power and flow vary with inlet temperature in an oil-free screw compressor as follows:

- Volume (icfm) is constant with inlet temperature.
- Delivered flow (scfm) and inlet density (lb/min) are both directly proportional to inlet temperature. A 10˚F decrease in inlet temperature will result in about a 1.9 percent increase in mass flow.
- Required power in isentropic compression is also roughly proportional to inlet density and pressure ratio (at constant icfm).
- The compressor is temperature-sensitive in two ways:
  - High inlet temperatures cause outlet temperature of the first stage to rise uncontrolled, which could result in shutdowns.
  - Low inlet temperatures cause the outlet temperature of the first stage to drop uncontrolled, requiring temperature control at the intercooler to keep from condensing moisture and hurting the second stage.

Conclusions:

1. Efficiency (scfm/kW) doesn't change with inlet air temperature, all other things being equal.
2. Temperature rise considerations make it best to run with a cool inlet, as long as the intercooler is controlled.

"The goal of this article is to debunk a few misconceptions, and show how inlet air temperature actually affects compressor efficiency in three kinds of systems."

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

1. http://www.compressedairchallenge.org/library/tipsheets/tipsheet14.pdf

INLET AIR TEMPERATURE IMPACTS ON AIR COMPRESSOR PERFORMANCE

Multi-Stage Centrifugal

This type of compressor is designed for general industrial applications where no amounts of oil can be in the air stream and higher airflows are needed. Inlet air temperature (and thus density) affects the compression significantly. Flow changes with pressure like a centrifugal pump — low flow at low pressure and low flow at high pressure. In addition, compressor efficiency changes based on the point on the curve. It behaves like an adiabatic compressor, but with varying flow due to intake changes. In a simplified sense, power and flow vary with inlet temperature in a centrifugal compressor as follows:

- Available head (pressure) changes with inlet density. Lower intake temperatures allow the compressor to increase pressure, pushing out an uncontrolled compressor's curve (wide open inlet) almost as if the speed increased, and vice versa.
- Since the pressure changes with inlet temperature, the inlet guide vanes (IGVs) will have to cut back to keep the pressure from rising (see controls). However, the inlet flow still rises.
- Since the curve rises, the range between the full open and minimum throttled "surge line" increases at lower intake temperature, allowing more turndown before surge (if controls are set up properly).
- Power increases with inlet mass about the same as the flow increases. The compressor motor current needs to be controlled at a maximum amp level to keep it from overloading in cool intake scenarios.
- This type of compressor is very inlet temperature sensitive. Power increases and flow increases, more so than in an oil-free screw. However, power and flow change by about the same amount.

Conclusions:

1. Efficiency (scfm/kW) is fairly constant. Based on a recent analysis we performed with several models and makes, changing the inlet temperature by 20˚F only changed efficiency by 0.2 percent.
2. Ambient temperature is primarily an air delivery, motor load and surge protection issue.

Leveraging Compressor Controls to Take Advantage of Inlet Air Temperature

The above discussion is mostly theoretical. Unless the real system controls allow at least one compressor in the system to respond efficiently to the increased flow that the lower intake temperature provides, there will be no energy savings. In fact, it can go backwards. We will briefly discuss how controls in the three types of compressors can take advantage of the intake air temperature effect, or make it worse.

Oil-injected Screw

These are modulation, load-unload or variable speed drive (VSD) compressors. If a higher flow from a lower intake temperature occurs, the following will happen in the two types of control (I will assume a two-compressor system, including base and trim):

- **Modulating Trim Compressor:** Increasing flow from a lower inlet air temperature is roughly like increasing the speed of the compressors. Increasing flow rate of compressors will cause the pressure to rise in the system and leaks to consume more. The trim compressor will respond to the increased pressure by modulating more, which reduces its efficiency. In addition, the increased pressure will raise the power of the compressors. The increased efficiency from inlet air temperature reduction can be all given away by these increased losses.

> "Unless the real system controls allow at least one compressor in the system to respond efficiently to the increased flow that the lower intake temperature provides, there will be no energy savings."
>
> — Tim Dugan, P.E., President, Compression Engineering Corporation

INLET AIR TEMPERATURE IMPACTS ON AIR COMPRESSOR PERFORMANCE

- **Load-Unload Trim:** The trim compressor will then have to unload more often, reducing loaded. However, its idle time will increase, reducing the potential increase in overall system efficiency.

- **VSD Trim:** The trim compressor will reduce speed, reducing loaded power without increasing the base-load compressor power. Efficiency will be better, similar to the ideal calculations.

Oil-Free Screw

These are load-unload or variable speed drive (VSD) compressors. If a higher flow from a lower intake temperature occurs, the following will happen in the two types of control (I will assume a two-compressor system, including base and trim):

- **Load-Unload Trim:** Increasing flow from a lower inlet temperature is roughly like increasing the speed of the compressors. The trim compressor will then have to unload more often, reducing loaded kWh by about the same as the increased kWh of the base-load compressor. However, its idle time will increase, reducing overall system efficiency.

- **VSD Trim:** The trim compressor will reduce speed, reducing loaded kWh by about the same as the increased kWh of the base-load compressor. Efficiency will be about the same as with a warmer inlet.

Centrifugal

These are typically inlet modulation with blow-off compressors. Inlet modulation can be for constant pressure or constant mass. Constant pressure is most common. If a higher flow from a lower intake temperature occurs, the following will happen (I will assume a two-compressor system, including base and trim):

- Increasing flow from a lower inlet temperature is roughly like increasing the speed of the base-load compressor(s). Increasing the flow rate of compressors will cause the pressure to rise in the system and leaks to consume more. The trim compressor will respond to the increased pressure by modulating more, which reduces its efficiency slightly. In addition, the increased pressure will raise the power of the compressors. In the worst case, the trim compressor will start to blow off (or increase blow off, if it already is doing so sometimes). System efficiency will probably stay the same, or decrease.

Will Inlet Temperature Drop Increase Energy Efficiency?

I'm not trying to rain on anyone's parade — I am just trying to provide a dose of reality. If you have an oil-injected rotary screw compressor system with a VFD running as trim, then inlet temperature drop will definitely save energy. It won't provide huge energy savings, but it will be enough to make the project worthwhile — if it's just ducting changes. In all other cases, savings are questionable, and can actually go negative.

If you're considering inlet temperature reduction, or inlet filtration improvement, I recommend doing it from a maintenance and air/oil quality perspective. However, keep in mind the increased motor current that can result, and the potential over-cooling and condensation that can occur. BP

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

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"If you're considering inlet temperature reduction, or inlet filtration improvement, I recommend doing it from a maintenance and air/oil quality perspective."

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

RESOURCES FOR ENERGY ENGINEERS

TECHNOLOGY PICKS

BOGE Unveils New High Speed Turbo Compressors

BOGE recently unveiled its new High Speed Turbo compressors at the 2015 Hannover Fair. "We are more than happy with the results of the fair," said BOGE managing director Thorsten Meier. "We succeeded in surprising and captivating the industry and trade show visitors with our new High Speed Turbo technology."

BOGE representatives were on hand at Hannover Messe to demonstrate how the new High Speed Turbo compressor's design has radically reduced the number of components and applied an intelligent design principle, resulting in fundamental improvements in weight, size, noise emissions, energy efficiency, and, of particular interest to manufacturers that are trying to maintain a competitive edge, cost efficiency. BOGE expects their new High Speed Turbo compressor to create a 30 percent savings in overall costs through the life cycle of the machine, compared to traditional oil-free compressed air technology.

BOGE's New High Speed Turbo compressors on display at Hannover Messe

According to Meier: "This is like a quantum leap for manufacturing, and it signifies a paradigm shift within the sector. Our interdisciplinary team has developed a highly efficient machine. We are particularly proud of the fact that everything — including motors, frequency converters, controls and even the software — is made by BOGE."

The oil-free technology is particularly relevant to the food, pharmaceutical, chemical and electrical engineering sectors. "With this development, we are setting new standards in the sector," Meier said with enthusiasm.

BOGE's High Speed Turbo compressors were the highlight of their display at Hannover Messe. Visitors got to wear 3D Oculus Rift glasses to see the compressors from the inside and experience the advantages of the new technology during a visual roller coaster ride through the machine. Live demonstrations also allowed visitors to witness the low vibration and quiet running of the compressors.

For more information, visit www.boge.com/us.

Kaeser Launches New Variable Speed Drive Compressor

Kaeser Compressors Inc. recently announced the SFC 22. This variable speed drive rotary screw compressor delivers best-in-class performance with an efficiency advantage of up to 26 percent over the competition.

With a flow range of 36 to 152 cfm at 125 psig, the SFC 22 features the "built-for-a-lifetime" reliability, simple maintenance, and sustainable energy savings you expect from the Kaeser name, as well as the latest in Siemens drive technology.

TECHNOLOGY PICKS

Kaeser has improved the SFC's specific power through a combination of true direct drive design, premium efficiency motors, lower internal pressure differential, and optimized airends. Additional built-in heat recovery options provide even more energy savings potential.

Kaeser's new variable speed drive rotary screw compressor, the SFC 22

New features include an enhanced cooling design, eco-friendly filter element, integral moisture separator with drain, and an Electronic Thermal Management system. Units also come standard with Sigma Control 2™ — an intelligent controller that offers unsurpassed compressor control and monitoring with enhanced communications capabilities for seamless integration into plant control/monitoring systems. The SFC 22 is also available with an integrated dryer for premium compressed air quality.

For more information, visit www.us.kaeser.com.

FS-Curtis Launches New Line of Nx Air Compressors

FS-Curtis, headquartered in St. Louis, MO, recently launched its Nx series rotary screw air compressor with iCommand-Touch.

"The Nx ups the ante in our industry, changes the game," said Robert Horneman, Global Product Manager for FS-Curtis. "But the real spotlight is on our new touchpad controller, the iCommand-Touch. That's the brains of the compressor."

The controller's intelligent technology stretches far beyond simple input/output and sequencing operations. It's programmable in 17 languages and has automatic startup capabilities for when temperatures drop below 37˚F so the oil in the unit does not freeze. The iCommand-Touch controller features touch screen capabilities with full-color graphics. The bright LED screen displays trending and graphing information in real-time and also stores historical data for up to a full month.

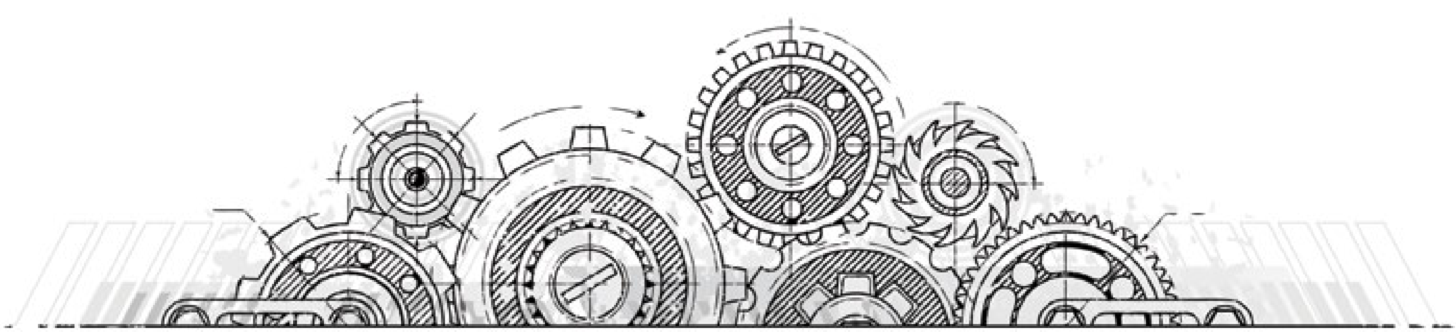
"At a glance, you can see exactly how your system is operating at any given time, including pressure, air quantity, temperature, usage, air circuit and oil circuit, and maintenance intervals," Horneman said. "This sophisticated level of monitoring capability will save maintenance costs and prevent potential shutdowns and downtimes for their customers."

And simple maintenance tasks like changing oil and filters will be faster with the Nx because of the well thought-out design of the spin-on/spin-off oil filter. Air delivery has also been substantially increased due to longer airend and optimized RPM range.

The new Nx units range from 4 kW (5 hp) to 37 kW (50 hp). FS-Curtis' SEG, SE and GVS lines will be phased out, eventually making room for Nx's larger, industrial units with kilowatt ratings reaching up to 250 kW.

The Nx series rotary screw air compressor

For more information, visit www.fscurtis.com.



RESOURCES FOR ENERGY ENGINEERS

TECHNOLOGY PICKS

Atlas Copco Launches 'Two-in-One' Coalescing Compressed Air Filters

UD+ Coalescing Compressed Air Filter

Atlas Copco recently introduced UD+ coalescing compressed air filters available with capacities of 19 scfm to 16,950 scfm, which combine two filtration processes into one product.

"Our customers look to Atlas Copco to provide the highest quality compressed air solutions throughout the entire compressed air system, including the air treatment equipment," said Robert Eshelman, Vice President, Industrial Air Division, Atlas Copco Compressors. "The UD+ represents a major filter innovation that results in energy and cost savings without compromising reliability or air quality."

The two-in-one UD+ filter utilizes wrapped filter technology — an innovative glass fiber filter media package wrapped around the filter core. Compared with traditional pleated filters, one UD+ filter is more efficient and reliable than two in-line filters that were previously required to bring oil aerosol and solid particles in the compressed air down to levels that meet ISO 8573-1 Oil Class 1 and 2 and ISO 8573-1 Solid Particle Class 1 standards.

"The UD+ is unique in the market and offers energy savings, efficiency gains and reliably clean compressed air," said Eshelman. "Extensive testing has shown that the UD+ can achieve the same excellent air quality of two traditional filters. The unique design also results in a more reliable filter than traditional pleated filters which are prone to cracking."

The UD+ comes equipped with the highest quality protection layers and a thick package of wrapped, enhanced glass fiber filter media. The UD+ is certified according to ISO 12500-1:2007 and ISO 8573-2:2007 standards by TÜV Rheinland.

For more information, visit www.atlascopco.com/us.

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TECHNOLOGY PICKS

Gardner Denver Launches New Rotary Vane and Rotary Screw Compressors

Gardner Denver recently introduced several new series of compressors, including the hydrovane rotary vane HR compressor series, and the L and LRS rotary screw compressors.

The hydrovane rotary vane HR Series builds on the legacy of the reliable and energy-efficient rotary vane HV Series, which is available in fixed-speed configurations from 4 to 7 kW and variable speed configurations at 7 kW. The new HR Series delivers a host of intelligent design and performance improvements.

Gardner Denver also recently launched the highly competitive, expertly designed L and LRS rotary screw compressors. The L and LRS products expand the already robust product portfolio of Gardner Denver rotary screw products. The L and LRS Series compressors are well-positioned in the industry with competitive footprint, serviceability and performance.

For more information, visit www.gardnerdenver.com.

The new HR Series hydrovane rotary vane compressor

Gardner Denver's new L Series rotary screw compressor

The new LRS Series of rotary screw compressor

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"Compressed air is very important to our manufacturing process and managing its reliability and energy-efficiency is critical."

– Patrick Jackson, Director of Global Energy Management, Corning Inc. (feature article in June 2014 Issue)

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– Doug Barndt, Manager Demand-Side Energy & Sustainability, Ball Corporation

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Industrial energy managers, utility incentive program managers, and technology/system assessment providers are the three stakeholders in creating energy efficiency projects. Representatives of these readership groups guide our editorial content.

"Each of our 10 production plants has an Energy Coordinator who is part of the corporate energy team."

– Michael Jones, Corporate Energy Team Leader, Intertape Polymer Group (feature article in July 2014 Issue)

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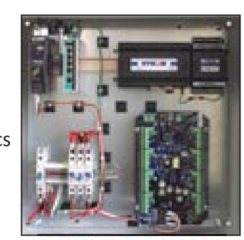

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