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

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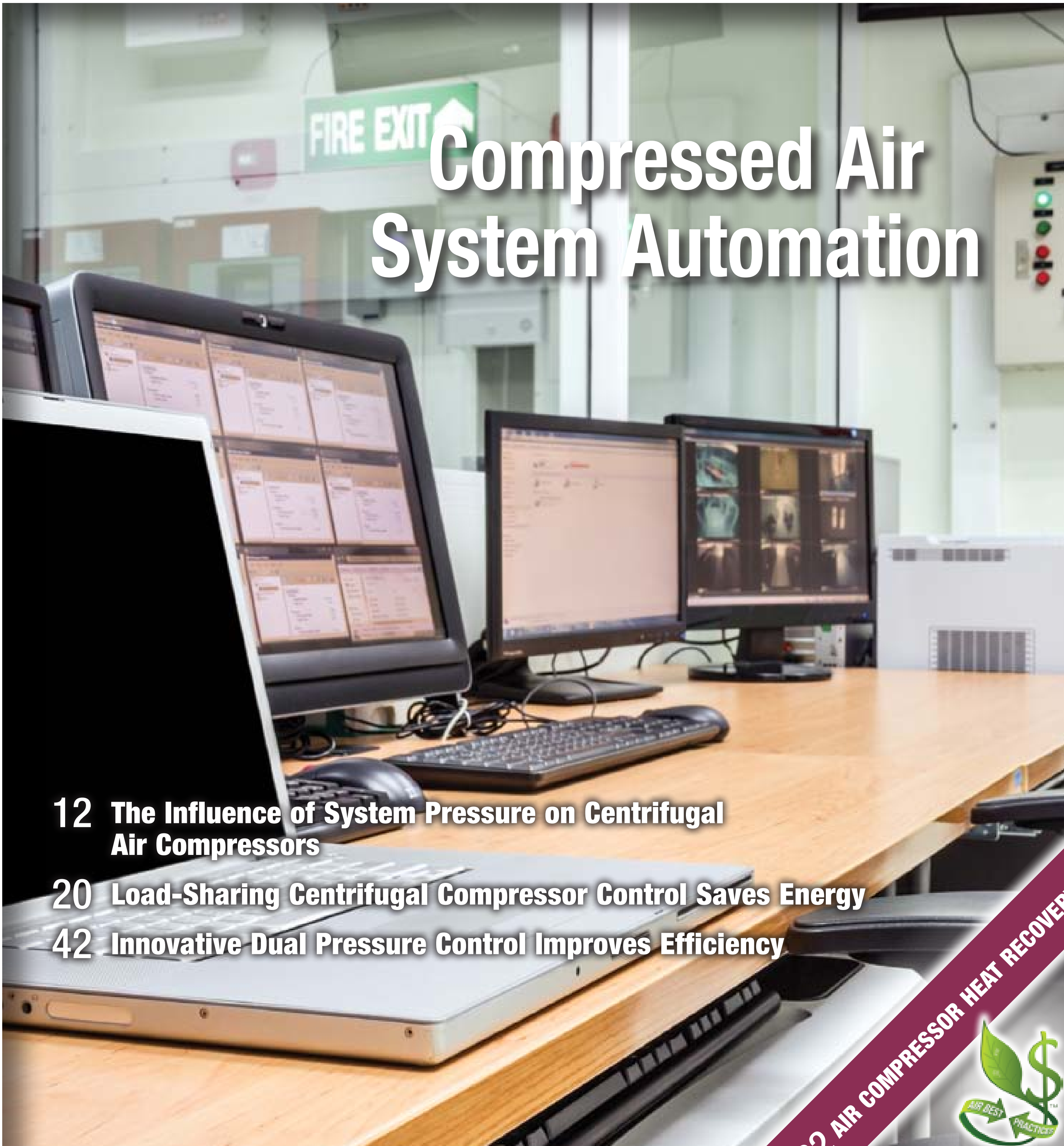
August 2013



Compressed Air System Automation

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In 2013, Atlas Copco celebrates our 140th anniversary. To celebrate, we're giving our customers game-changing, energy-efficient solutions. Let Atlas Copco demonstrate to you just why, year after year, we have been listed as one of the top 20 most sustainable companies in the world. Check out the new technology at **www.atlascopco.us/gamechangerusa** or call **866-688-9611**.

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- Consistent liquid and particulate removal with low pressure losses.
- Compact modular design for easy installation in confined spaces.

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- Integral filter and desiccant cartridges offers a space saving design for either floor or wall installation.
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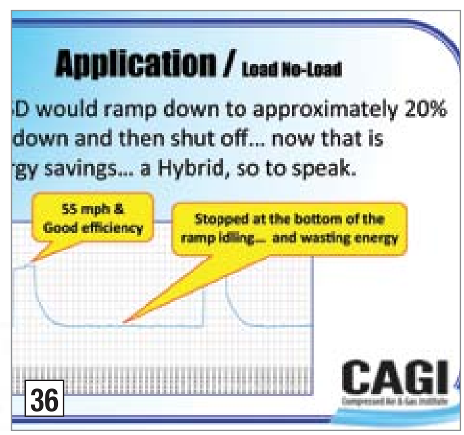

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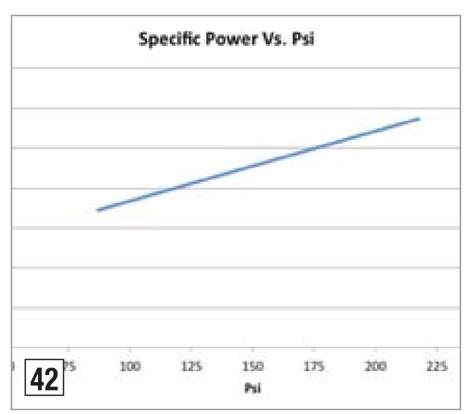

FROM THE EDITOR | Compressed Air System Automation

The impact of air system pressure, on energy costs and productivity, is tremendous. Our industry continues to educate factories on how higher system pressures increase air compressor energy costs. It gets even more interesting when factories increase production output by stabilizing inlet pressure to machines. Mark Krisa, from Ingersoll Rand, is an authority on this topic and we hope you enjoy Part 2 of his article series titled, "Air System Pressure Influences Compressor Power."

Centrifugal air compressors are featured in two articles this month. One is written by veteran compressed air system auditor, James McAuley P.E., and is titled, "Load-Sharing Centrifugal Compressor Control Saves Energy." Jim demonstrates how a factory implemented a compressor control strategy to save $78,000 per year in energy costs on their four centrifugal air compressors totaling 2200 hp in installed horsepower.

An Energy Manager from PepsiCo once asked me, "Are air compressors a sustainable technology given the inherent inefficiencies caused by heat-of-compression losses?" This question is answered eloquently in the article, "Air Compressor Heat Recovery", authored by Dr.-Ing. Uwe Kaiser from BOGE Compressors.

Understanding when to use Variable Speed Drive (VSD) Compressors is the subject of a Q&A Session we held with CAGI members. As with any technology, this VSD technology thrives in certain load profiles and it's important to apply it correctly. Last but not least, the Compressed Air Challenge® provides us with an interesting article titled, "Innovative Dual Pressure Control Improves Efficiency."

Thank you for your support and for investing in ***Compressed Air Best Practices***®. BP

ROD SMITH
Editor
tel: 412-980-9901, rod@airbestpractices.com

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FS-Elliott Ships Record Air Compressor

FS-Elliott Co., LLC has successfully tested and delivered the first production PAP PLUS® EH frame to a copper smelter facility in central Arizona. Two PAP Plus® EH units were shipped to the facility as part of an air separation expansion project. This order marks the largest shipment to leave the manufacturing facility located in Export, Pennsylvania, which currently employs approximately 300 individuals in Westmoreland County.

The PAP Plus® EH is the latest from the PAP (Plant Air Package) line. PAP Plus® delivers all the benefits that have made the air compressors an industry leader-exceptional reliability, high performance, ease of ownership, and exacting customization options. PAP Plus® EH compressors augment these features with higher flow ranges, greater horsepower, and maximum design flexibility to meet varied global industry needs as well as local codes and packaging requirements.

Designed with two to four stages of compression, PAP Plus® EH provides operating pressures up to 350 psig (23.1 BarG). Features include:

- Rub tolerant seal design with very low leakage and high reliability
- Stainless steel impellers that do not require disassembly to remove rotor(s) from casing
- Motorized oil mist eliminator preventing the need for seal buffer for operation and start-up
- Horizontally split casing design allows for quick maintenance without removal of rotors
- Optimized gear lubrication and cooling system for high efficiency and reliability
- Modular design that can be shipped globally via standard containers

"The advanced aerodynamic design allows wide operating ranges, while maintaining high efficiency levels," said Kevin Eads, Global Marketing Manager — Air Separation at FS-Elliott. Customers can expect flow ranges of 15,000 to 24,500 ICFM (26,340 to 41,700 m^3/hr) and 1,600 to 4,500 HP (1,200 to 3,400kW).

Visit www.fs-elliott.com

Gardner Denver Appoints Tom Zawacki as Product Manager, Clean Air Applications

Tom Zawacki has joined the Gardner Denver Industrial Products Group-Americas Product Marketing team. His role is Product Manager, Clean Air Applications and is based in Princeton, Illinois. Mr. Zawacki will be responsible for developing the

strategic direction for Gardner Denver's small horsepower oil-less reciprocating and scroll compressors utilized in clean air applications including the further development of Gardner Denver's product offering and value proposition.

Prior to joining Gardner Denver, Mr. Zawacki's past experience includes 30 plus years of experience in the compressed air industry and specifically with oil-less/oil-free and clean air applications. Former experience includes working for companies like Powerex Clean Air Technology, Aero-Vac Services and Champion Pneumatic.

Visit www.gardnerdenver.com

Atlas Machine & Supply Named Cameron's Indiana Distributor

Atlas Machine and Supply, Inc. has been named the distributor of Cameron Centrifugal Air Compressors for the entire State of Indiana, including counties that serve and support the Greater Chicago area. Atlas' selection broadens its representation of the Cameron centrifugal compressor line, which already encompasses Ohio and Kentucky. The expansion of Atlas' territory by Cameron builds on the solid partnership that has existed between the two companies for more than 25 years.

"Atlas has the proven knowledge and experience to provide centrifugal solutions across a diverse collection of industries and applications," says Dave Sullivan, the company's Vice President for the Compressed Air Division, of the selection. "Our extensive fleet of factory-trained service technicians and

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sales engineers is ready to meet industry's needs on an even greater regional level."

Cameron's compressed air systems are designed to handle the centrifugal requirements of a broad base of industries, such as automotive, food and beverage, power generation, textiles, aerospace, refineries, chemical, pharmaceuticals, steel, and more.

The expanded representation enables Atlas to provide sales and service on all types of centrifugal compressors ranging from 125 hp to 3,700 hp, and also specifically includes servicing of the Cameron Turbo Air Series Compressors TA2000 through TA11000 series. "Cameron and Atlas are well known in the industry for their commitment to engineered solutions, quality, and responsive service," says Sullivan. "We look forward to serving industry's growing needs throughout Indiana."

For more details about Cameron Centrifugal Compressed Air Systems, call 1-855-GO ATLAS or email info@atlasmachine.com. For more information about Atlas' Compressed Air Division, go to www.atlasmachine.com.

Festo to Build New Assembly/ Distribution Center in Ohio

Festo announced today it will build a state-of-the-art product assembly and distribution center in Mason, Ohio, about 20 miles northeast of Cincinnati along the I-71 technology corridor. The new Festo Regional Service Center, which is scheduled to open in 2015, will do double duty as a highly-efficient facility serving U.S., Canadian, and Mexican customers and as a showplace for the effectiveness of Festo automation solutions. Festo U.S. headquarters will remain on Long Island.

Ohio was selected as the site for the distribution center because it shortened the average distance to the customers of Festo and thereby will decrease delivery time of products. Plans call for a facility exceeding 170,000 square feet, a significant expansion over the present facility's size. The expansion reflects overall North American sales growth. Festo also anticipates expansion of product assembly activities, which will mean that a wider variety of components, electric and pneumatic motion actuation systems, and control platforms will be available to customers with improved lead times. Like the facility on Long Island, the new center will have Foreign Trade Zone status, which makes it faster and more efficient to support customers in the U.S., Canada, and Mexico from a central U.S. location.

"The Festo Regional Service Center in Mason, Ohio, builds on 40 years of service from the Long Island facility and is a natural progression in terms of needing more space and deploying products closer to customers," said Richard Huss, president and CEO. "One of the most exciting aspects of this major project will be an emphasis on customer visits, a new opportunity to demonstrate on a large scale Festo integrated automation systems in action."

For more information on Festo automation solutions, call Festo at 800-993-3786 and visit www.festo.com/us.

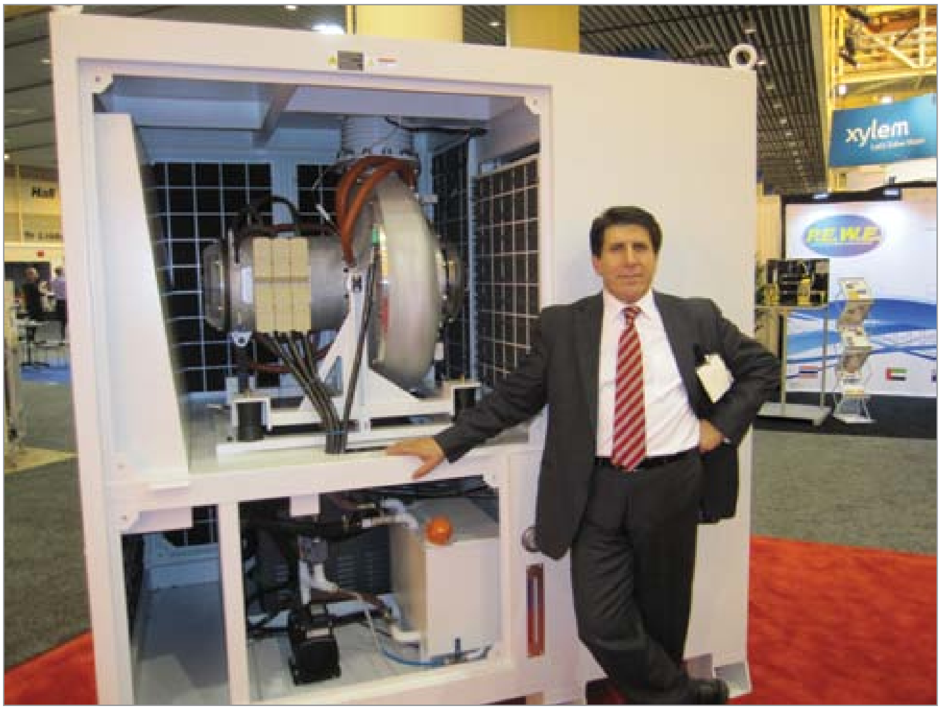
Blower Manufacturer APG-Neuros Ranked on List of Canada's Fastest-Growing Companies

PROFIT Magazine ranked APG-Neuros No. 66 out of the top 500 of Canada's Fastest-Growing Companies on the 25th annual PROFIT 500. Published in the summer issue of PROFIT Magazine and online at PROFITguide.com, the PROFIT 500 ranks Canadian businesses by their revenue growth over five years. APG-Neuros, manufacturer of high-speed turbo blowers for the municipal and industrial markets, made the PROFIT 500 list with a five-year revenue growth of 1082%.

"To celebrate the 25th anniversary of the Fastest-Growing Companies in Canada, the PROFIT 500 has expanded to recognize the entrepreneurial achievements of more than 500 Canadian companies," says Ian Portsmouth, Editor-in-Chief of PROFIT magazine. *"PROFIT is proud to now showcase Canada's forward-thinking small business entrepreneurs and honor their talents and innovations."*

"We are very honored to be recognized by the PROFIT 500. It has been a long road to success; through market education our product has increasingly gained acceptance by consulting engineers and end users alike. It is nice to see that our hard work and innovation have paid off. We are grateful to our team and sales representatives whose efforts have helped us achieve this recognition of our continued success. The recognition we received from our customers gives us further reassurance that we are on the right path to provide them product innovation and excellent service. We are very happy with the results" said Mr. Hammoud, APG-Neuros CEO.

APG-Neuros high efficiency turbo blowers use the most advanced technologies such as



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impeller, proven air bearing, motor and blower aeration control system technologies. Customer benefits include energy savings of up to 35%, no heat rejection from the blower, lower installation costs, smaller footprint as well as vibration-free, flexible and quiet operation compared to conventional products. By end of May 2013, APG-Neuros delivered over 670 units to municipalities across the USA, Canada, Mexico and Europe.

Visit www.apg-neuros.com

Production Started at Bosch Rexroth's Newly Expanded Hydraulics Manufacturing Campus in Fountain Inn

South Carolina Governor Nikki Haley joined Bosch Rexroth Americas President Berend Bracht and executives from Robert Bosch LLC to formally mark the start of production at the company's newly expanded hydraulics manufacturing campus in Fountain Inn.

Headquartered in Charlotte, N.C., Bosch Rexroth is investing $80 million over five years to expand production in the new campus and convert an existing 260,000-square-foot industrial warehouse into a state-of-the-art manufacturing facility that will initially produce the industry-leading Rexroth A10VO hydraulic pump. The pump is used in a variety of applications, including mobile construction and agricultural machinery, mining, materials handling, and heavy industries, such as steel and automotive production.

With the addition of the new building, "Building 103," Bosch Rexroth has doubled its production capabilities at the location, making the Fountain Inn campus its largest hydraulics manufacturing site in the Americas.

"The Bosch investment for expanded production in Fountain Inn increases our ability to serve the needs of our local and regional customers," said Bracht. "In turn, this enhances their opportunity to participate in industrial and mobile equipment markets on a global basis, drawing on the support of a partner like Bosch Rexroth that is recognized around the world for superior technology, reliability, applications expertise and service."

Governor Haley praised the company for its decision to invest in South Carolina. "We truly value the commitment Bosch has made to be a part of our state's business community, and

we are excited to see them invest in South Carolina," she said. "We celebrate the 160 new jobs the company will create with this campus and look forward to its continued success."

Building 103 is just the latest example of Bosch Rexroth's strategy to invest locally to serve global customers in key markets, and also to increase its market share in the Americas. Both strategies are seen as critical to long-term global growth for the company. Other recent programs contributing to The Drive & Control Company's growth include the expansion of its Charlotte, N.C., linear motion and assembly products facility; a new Houston Service Center dedicated to serving Gulf of Mexico oil and gas exploration; and the GoTo Focused Delivery Program, which provides industry-best lead times for delivery of more than 3,500 in-demand Rexroth drive, control and motion products.

Fountain Inn Building 103 is the largest investment by Bosch Rexroth in North America. To date, five assembly lines and multiple state-of-the-art machining centers have been installed for the production of the A10VO, along with one line for vane motor assembly. The entire facility operates utilizing a lean manufacturing and continuous quality improvement system called the Bosch Production System, which is used by Bosch production operations worldwide to ensure the highest levels of product quality.

The Fountain Inn project showcases Bosch Rexroth's desire to work cooperatively with local and state governments to improve U.S. manufacturing infrastructure.

Rexroth's commitment to local economic and workforce development was also highlighted through a $420,000 monetary and equipment donation from Bosch Rexroth together with the Bosch Community Fund to the Greenville Technical College to support the school's hands-on training program.

Visit www.boschrexroth-us.com

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AIR SYSTEM PRESSURE INFLUENCES COMPRESSOR POWER

Part 2: The Influence Of System Pressure On Centrifugal Compressors

This is the second article in a three-part compressed air series by Mark Krisa, Director – Global Services Solutions, Ingersoll Rand

It is common to see energy assessment specialists treat centrifugal compressors like positive displacement compressors when attempting to reduce compressed air system energy consumption. Unfortunately, centrifugal compressors are normally much larger, and miscalculations can easily represent hundreds of thousands of dollars in overestimated energy savings. These errors are not malicious; they result from oversimplified best practices perpetuated by individuals with limited centrifugal compressor knowledge. This type of knowledge is not readily available and most energy assessment specialists do not have access to engineering teams responsible for the technical development and design of centrifugal compressors. From a unit perspective, centrifugal compressors are a small part of the compressor market so technically knowledgeable resources are limited.

Identifying Technical Compressor Resources

It is important to recognize that compressed air sales people represent one of the largest sources of technical information associated with compressed air systems and components. Although some sales people are technically competent engineers, it is not uncommon to find the word "engineer" used as an adjective in a job title. Whether engineer is a title by education or job function, it does not guarantee technically accurate information. Similarly, experience is a term frequently used to imply great knowledge associated with years of practice. Experience may have value for functions with simple cause and effect outcomes or repetitive tasks where muscle memory can enhance performance. However, in an industry where results are rarely measured using accurate instrumentation in controlled environments, many technical myths fester and, through years of repetition, are assumed to be scientifically proven facts. For example, part one of this article that was printed last month, explained how the 1 percent power to 2 psi assumption is abused and why it is not correct.

Working at Ingersoll Rand, one of the world's largest manufacturers and innovators of compressed air products, facilitates opportunities for many technical discussions with talented engineers that design compressors for a living. Participation in many compressed air related technical teams with ISO, CAGI and CSA also provides opportunity for high level discussion with engineers from other compressor manufacturers. Interestingly, whenever discussing the topic of pressure and power for compressors, almost every engineer regurgitates the same 1 percent power to 2 psi

"Interestingly, whenever discussing the topic of pressure and power for compressors, almost every engineer regurgitates the same 1 percent power to 2 psi assumption."

— Mark Krisa, Director – Global Services Solutions, Ingersoll Rand assumption. After discussing systemic attributes and thermodynamics, all agree that the 2:1 statement is inaccurate but many assume it to be a fact, and relate it to how the compressor operates relative to pressure in the network piping. As young engineers new to the industry, the 2:1 statement was technical knowledge shared by senior engineers. Mistaking experience and age for scientific fact, many innocent assumptions went unquestioned.

For sake of closure, the theory appears to have originated in early 1900s as a reasonable estimate based on a complex equation used to calculate brake horsepower for large reciprocating compressors relative to pressure inside the cylinder. This is not applicable considering all the components and technological changes that make up modern compressors. The 2:1 theory is just like a rumor that iteratively morphs into a different

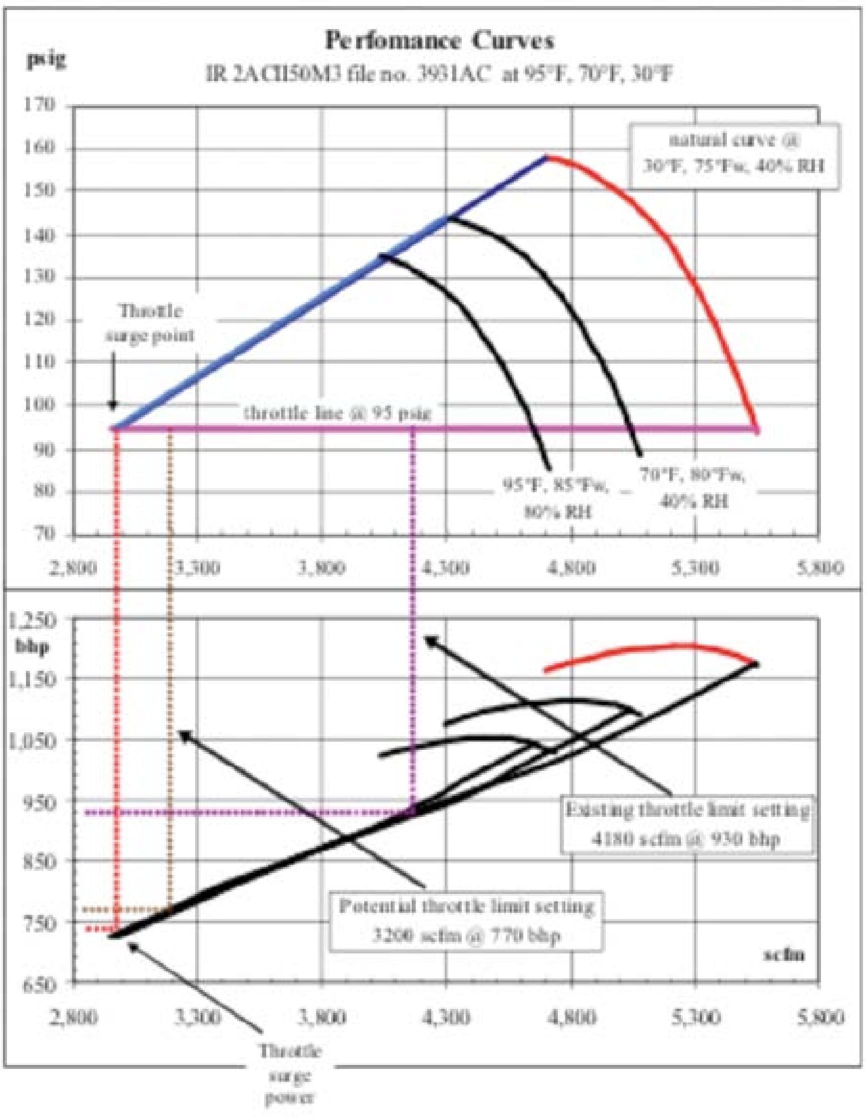

Figure 1 – Centrifugal Compressor Performance Curves

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story with every person's interpretation and subsequent sharing. This occurs when complex technical content is simplified and generalized before reaching the field sales people and other individuals disseminating compressor knowledge to the market.

Operating Characteristics of Centrifugal Compressors

Unlike positive displacement compressors in which pressure is a function of mechanical forces (power) acting on a surface that is physically reducing a closed volume, centrifugal compressors cannot increase their pressure capabilities by increasing power. A centrifugal compressor, also known as a dynamic compressor, generates pressure in a different way. A given mass of air is accelerated through an impeller, and imparts kinetic energy. The air goes through a diffuser, reduces the velocity and converts a portion of the kinetic energy into heat and potential energy. This manifests itself in the form of increased air pressure and temperature. Depending on the pressure requirements of the compressor, air goes through the same process through subsequent stages and builds toward the design pressure requirements. To improve efficiency, some or all stages cool the air before it enters the next stage. For discussion purposes, the operating explanation has been simplified in an effort to remain within scope. The pressure capabilities of a centrifugal compressor are dictated by aerodynamic design of the internal components, ambient conditions, rotating speed and cooling of the air between stages.

DESIGN POINT PERFORMANCE (STANDARD INDUSTRIAL TOLERANCES APPLIED) REFERENCE FLOWS WERE COMPUTED BASED ON DRY MASS FLOW			
CAPACITY DISCHARGE SCFM DRY	DISCHARGE PRESSURE PSIG	COUPLING POWER BHP	SPECIFIC BHP/100 SCFM DRY
5919.15	149.409	1473.80	24.899
6012.10	148.284	1480.02	24.617
6105.04	146.485	1485.14	24.326
6197.99	143.879	1489.06	24.025
6290.94	140.301	1491.71	23.712
6383.88	135.553	1492.95	23.386
6476.83	129.396	1492.61	23.045
------------- Specified Discharge Pressure -------------			
6528.88	125.125	1491.77	22.849

6569.78	121.546	1490.39	22.686
6662.72	111.688	1485.82	22.301
6755.67	99.496	1478.01	21.878
6848.62	84.698	1465.03	21.392
121 - 111 psi —> -5 hp + 100 scfm = -27 hp / 1490 hp = 1.8%			

Figure 2 — Sample Centrifugal Compressor Performance Data

The relationships between flow, pressure and power for a centrifugal compressor are normally expressed using a performance curve based on specified ambient conditions, cooling water and applied internal components. As a result, the performance — and most notably — pressure capabilities change as ambient conditions change throughout the year. A working curve that consists of overlapping data from three sets of ambient conditions is utilized to illustrate this effect in Fig. 1.

The performance curve is made up of two parts: the pressure-flow curve and the power-flow curve. The pressure-flow curve has pressure on the vertical axis and flow on the horizontal axis. The power-flow curve has power on the vertical axis and flow on the horizontal axis. The flow values for each horizontal axis align so each pressure-flow curve has a matching power-flow curve. Notice how the natural curve moves up and to the right as ambient temperature decreases. Looking at the red curves for power and pressure with respect to flow, moving from left to right, a vertical line intersecting both curves illustrates the design pressure and power for that specific flow and ambient conditions. Moving from left to right, notice how the power initially increases as pressure goes down and then decreases as one moves further to the right. This illustrates how power is not directly proportionate to a change in pressure. This relationship is based on the aerodynamic design of the internal components. Some compressors that use a radial design impeller have maximum efficiency at the top of the curve just before natural surge. A backward leaning design may increase efficiency as pressure decreases or may achieve peak efficiency at some point on the curve and then decrease at lower pressures.

Referencing the red pressure-flow curve, note that as the pressure decreases, the flow for the compressor increases. A centrifugal compressor performs relative to the natural curve when the inlet assembly is open 100 percent, or enough that opening the assembly more has no impact on inlet throat pressure. A compressor operating at the maximum state is sometimes referred to as operating at full load — or on the active part of the curve where flow changes with respect to pressure. Flow increases as pressure is reduced but notice how the slope of the curve changes as pressure decays. Eventually the curve becomes asymptotic — straight up and down — when the compressor moves into a region known as choke or stonewall.

At this point, dropping pressure has very little to no change on flow or power. The power does not decrease when the compressor operates at or below choke. When the compressor is in choke, velocity has reached a sonic threshold at some points within the compressor. Subsequently, the compressor retains internal pressure at a minimum value independent of discharge pressure external to the compressor. In essence, internal pressure decreases with respect to external pressure until it reaches a minimum internal pressure. Below this minimum value, pressure only decreases in the system while internal pressure stays at the minimum value constrained by the sonic velocity limit.

The upper pressure is limited by the compressor's ability to convert kinetic energy into pressure. At some energy balance, generated pressure is less than internal pressure, causing instability sometimes referred to as flow reversal or

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surge. Compressor operation is unstable at, or close to, the surge pressure. The pressure capability, or natural surge pressure, can only increase if inlet air density increases. This same phenomenon occurs at a minimum stable flow condition called the throttle surge. If demand for air is less than supply for a required pressure, the inlet assembly modulates, reducing inlet throat pressure and flow. This is commonly referred to as a compressor operating in modulation, on the throttle or at constant pressure.

The Influence of Pressure on Centrifugal Compressor Power

Looking at performance within the active part of the curve, Fig. 2 illustrates the detailed changes in flow and power relative to discharge pressure.

The data in Fig. 2 is based on tested performance for a specific centrifugal compressor. Looking at compressor performance at 121 psig and 111 psig, reducing pressure from 121 to 111 psig only lowers power by 5 horsepower. This represents less than 0.35 percent reduction in shaft power. The .5 percent per psig rule (described in *Part 1: Air System Pressure Influences Compressor Power* that ran in the July issue of *Compressed Air Best Practices*) does not apply. It would have predicted a 5 percent reduction in power with an estimated savings of $50,000 per year, as opposed to the $3,000 realized. In this example, savings estimates could be grossly exaggerated to more than 16 times the actual value.

Since the compressor in this example is operating within the active range of the curve, flow increases ~100 scfm. Assuming demand stays the same and the compressor power changes directly proportionate to the change in flow, the compressor shaft power is reduced by a total of 27 horsepower or 1.8 percent. This is less than 36 percent of the savings estimated using the .5 percent per psig rule of thumb, delivering $18,000 of savings as opposed to $50,000 using the incorrectly applied calculation. If the compressor normally operates in a modulated state using a correctly applied inlet guide vanes, shaft power is reduced 1.7 percent.

It is important to note that unlike rotary screw compressors, centrifugal compressor model numbers do not necessarily represent performance of the compressor. Several different impeller/diffuser combinations may be used for a given external casting, design and motor. The combination of impellers and diffusers is commonly referred to as the "aero" of the compressor. Several different aero packages can be used for a given compressor model number and each has its own unique performance ability. One cannot use a generic curve — or even a curve from the same model of compressor — unless the manufacturer confirms that the compressors were manufactured using the same aero.

It is equally important to ensure data is corrected for site conditions or a range of conditions if ambient changes with respect to time. Referencing Fig. 1, the three curves (from left to right) represent data from ambient conditions at 95 °F, 70 °F, and 30 °F. Based on how the performance curve shifts relative to temperature, it is not uncommon to find compressors that operate in choke for several months a year. This is significant since any estimates for energy savings associated with pressure must take into consideration time, temperature and location on the curve. Without this data, any attempt to estimate savings associated with pressure may be misleading. In some cases, power can increase as pressure is reduced.

Energy Savings for Centrifugal Compressors

Maximum pressure capabilities of a specific compressor are based on the aero package, ambient conditions and mechanical condition. The maximum operating pressure is limited by the compressor surging at the top of the curve. This point is called the natural surge pressure. Referencing Fig. 1, the pink horizontal line represents the constant pressure line. When demand is less than the maximum flow from the compressor, the inlet throttles to reduce flow. With inlet guide

> "In some situations, six figure savings can be realized by correcting a complex problem with a $100 investment."
>
> — Mark Krisa, Director – Global Services Solutions, Ingersoll Rand

vanes, the efficiency remains reasonably constant while the compressor is throttling. The throttled power is shown on the lower power–flow curve as the diagonal line. The minimum throttled flow for a centrifugal compressor is limited based on design. Following the pink horizontal line in Fig. 1 to the left, the minimum stable flow is dictated by the point where the constant pressure line intersects the throttle surge line. If the compressor attempts to limit flow to less than this intersection point, the compressor surges. For obvious reasons, this is called a throttle surge. The throttle surge line can be seen on Fig. 1 as the blue diagonal line on the pressure-flow plot.

If the demand for air is less than this minimum constraint, excess air is discharged to the atmosphere to compensate for the difference between minimum stable flow and demand requirements. Unfortunately, after the compressor stops throttling, the power does not change. Consequently all the air that is discharged into the atmosphere is wasted. For a compressor that operates frequently with air bypassed to the atmosphere, lowering pressure reduces the flow where throttle surge occurs. After adjusting control settings, a compressor that operates at minimum flow still reduces power by increasing throttle capabilities relative to the reduced throttle surge flow. This is only the case if the compressor bypasses air in to the atmosphere and the controls allow the compressor to modulate the inlet, which increases throttle capabilities and decreases power. Once again, the site corrected performance curves are required to quantify the potential savings.

The ability to operate a compressor close to throttle surge is limited by the complexity of the control algorithms, throttle variable used, and how the compressor PID loops are tuned relative to system dynamics. Fig. 1 illustrates the power reduction associated with adjusting the compressor throttle limit from a conservative setting to a more efficient setting by tuning the compressor PID loop so compressor reaction rates match the rate of demand changes. The change in power associated with adjustments in the system controls can be seen by looking at the two vertical dashed, purple and brown lines from the constant pressure line to the throttled power line in Fig. 1. For this compressor, power was reduced 160 hp with no capital investment. The compressor still bypassed air into the atmosphere, but the amount was reduced 980 scfm, associated with modulating the compressor closer to the throttle surge value. It is important to note that the throttle surge control limit is normally set high for a reason. Appropriate root cause analysis is required to define the problems that influence the elevated settings. As an organization that has audited hundreds of centrifugal compressor systems using advanced technical detail and analytics, Ingersoll Rand realizes corrective actions can vary significantly between systems. In some situations, six figure savings can be realized by correcting a complex problem with a $100 investment. Inversely, savings can require complex and expensive corrections that are not justifiable.

Centrifugal Compressor Performance Assessment

It is important to point out that the performance of a centrifugal compressor

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can change dramatically over time due to mechanical degradation of internal components. Although major issues with rotating assemblies can be identified through elevated vibration readings, erosion of impellers and diffusers can significantly reduce pressure capabilities, reliability and efficiency of a centrifugal compressor with negligible impact on vibration. For this reason, a performance assessment should be done for each centrifugal compressor on a regular basis and as part of any energy conservation project. Any compressed air system assessment that does not include detailed testing and analysis of compressor performance will have insufficient or questionable data and may be an indication of the auditor's centrifugal compressor competency.

It is also important to note that previous repairs to a centrifugal compressor may have significantly changed performance. Some aftermarket service providers replace internal aero components that do not match the original design. On some occasions, instead of replacing components, cost can be saved by grinding down impeller blades and rebalancing the assemblies. This addresses vibration issues but can dramatically alter performance.

Referencing the curve in Fig. 1, this compressor is capable of delivering 135 psig at the 95 °F condition. If this compressor is sold as a 90 psig unit, many centrifugal service providers test natural surge pressure and consider it a performance test. Having worked with many compressor aero-engineers on the development and verification of centrifugal compressor performance analytics and on-site nonintrusive test procedures, it is safe to say there is significantly more to assessing compressor performance than testing surge pressure and vibration. Common centrifugal compressor service assumptions consider a natural surge pressure greater than 10-15 percent above design pressure to be normal, regardless of temperature. Consequently, surge testing the compressor in Fig. 1 and achieving a natural surge pressure greater than 103 psig is considered positive verification of performance by many organizations. This is not done with malicious intent, it ties back to the beginning of this article and the issues associated with experience and perceived knowledge. Just as the misinformed engineer could innocently estimate $100,000 of savings when there are none, many field technicians would execute what they are told is a performance test, unintentionally neglecting to identify degraded compressor performance and reliability. BP

About the Author

Mark Krisa is director of global services solutions at Ingersoll Rand, and leads the company's compressed air audit program. This program is designed to deliver customer value by leveraging engineering and compressed air science to improve system reliability, quality and efficiency.

Krisa graduated from the University of Western Ontario in Canada with a degree in engineering science, and has worked in the compressed air industry for more than 20 years. His experience in the industry is diverse, ranging from compressor service technician to engineering and compressed air system auditor. Krisa is author of several papers and speaks regularly at conferences and training events across the Americas. You can contact Krisa with questions or comments at mark_krisa@irco.com.

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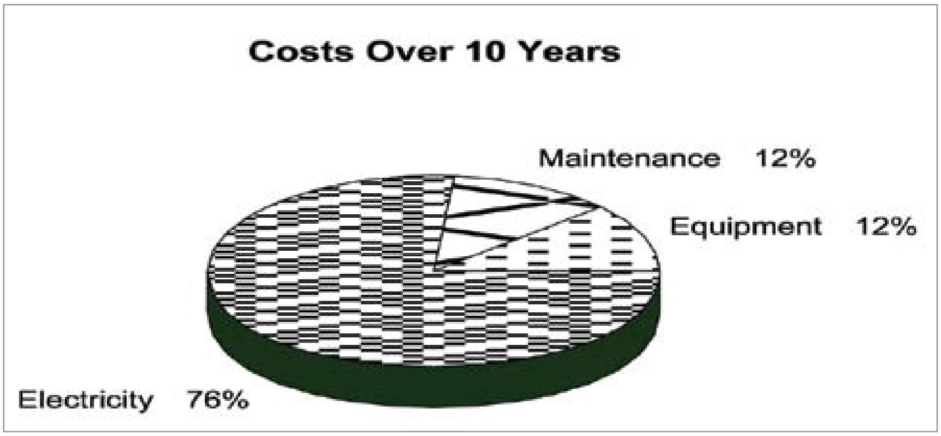
THE COMPRESSED AIR SYSTEM ASSESSMENT

Load-Sharing Centrifugal Compressor Control Saves Energy

By James G. McAuley P.E.

This article reviews portions of an audit report commissioned to survey the condition of a compressed air system in a factory located in the U.S. The objective of this study is to determine the current operating conditions and make recommendations for improvement based upon application of *industry recognized best practices.* Due to article space limitations, this article will focus on portions of the over-all audit report provided to the factory.

Below is a pie chart, developed by the Compressed Air Challenge®, used to dispel myths concerning the life cycle costs of a typical air compressor. Many operators are stunned to learn they may spend as much money, during the first year on power, as they spent on the capital appropriation of the compressor.



MANUFACTURER	MODEL	TYPE	HP
Joy/Cameron	TA48	Centrifugal	1250
IR	Centac	Centrifugal	1100
IR	Centac	Centrifugal	600
Joy/Cameron	TA2000	Centrifugal	250

The Compressed Air System

Plant production personnel agreed we should use 6,240 operating hours per year and a purchased energy cost of $0.0508 for the analysis.

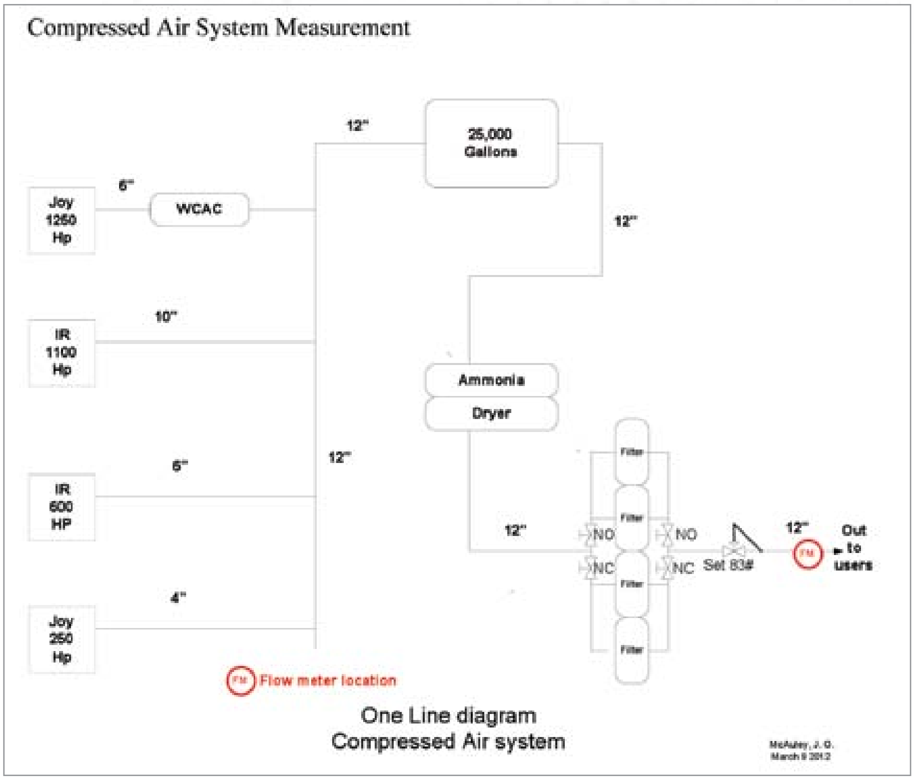
This plant has four centrifugal air compressors contributing compressed air to one 12" piping header. The compressed air goes into a 25,000-gallon receiver tank and then into a single ammonia dryer. Pressure dew point is at or near zero Fahrenheit. The compressed air then passes through a bank of particulate and coalescing filters. Installed in the 12" header at the filter outlet is a flow meter.

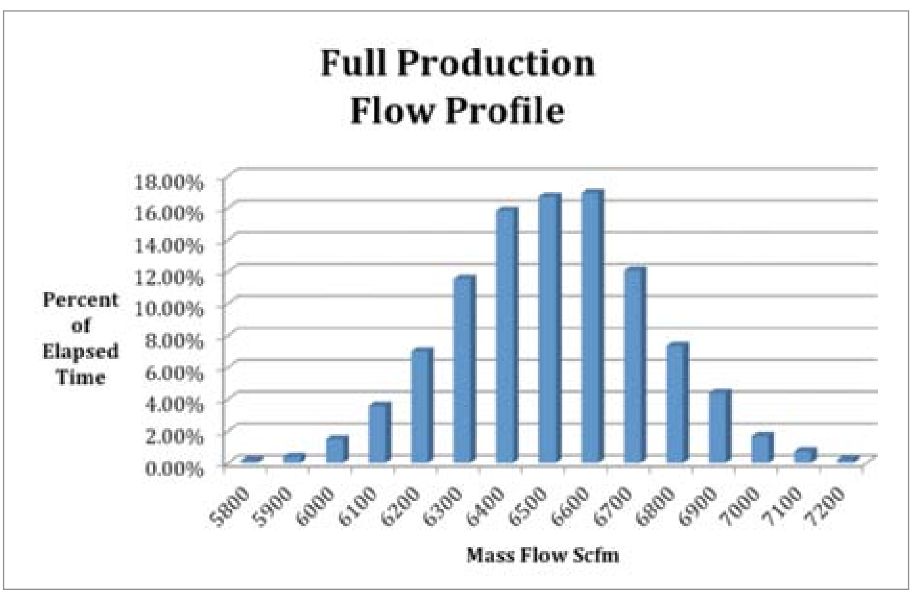
Compressed Air System Measurement

During the course of the audit, compressed air flow was directly measured (using a flow meter) at the outlet of the last compressed air filter in the 12" header. We also monitored compressor motor amperage on all operating compressors and common header pressure throughout the plant. This allowed us to measure the performance of the system in terms of Dynamic Efficiency (DE). Dynamic Efficiency is defined as scfm per kW. Dynamic Efficiency is a key indicator of system performance and is a readily and easily repeatable measurement. We use this audit measurement as a key benchmark to guarantee and measure improvement in system performance.

Below is a histogram representing the actually measured demand side flow data for a full production period of one week. This production period was chosen by plant personnel as a good representation of the yearly average production.

We directly measured the compressed air flow going out to the users (using a flow meter in the 12" header) at twelve-second intervals while continuously measuring the air compressor power in 12-second intervals for five days. We then compiled a frequency analysis of total system flow in 100 scfm increments.





In order to model the annual power required by the compressed air system, we measured both the flow out to the plant and the average amperage on each compressor over the course of the data collection period. We then extrapolate this data over a year. The annual cost-of-electricity calculations, for the compressed air system, were based upon an entire year of full production (6240 hours) and electricity cost of 5.08 cents per kWh.

THE COMPRESSED AIR SYSTEM ASSESSMENT | Load-Sharing Centrifugal Compressor Control Saves Energy

COMPRESSOR	MEASURED VOLTAGE UNDER LOAD	NAMEPLATE POWER FACTOR OR ASSUMPTION	MEASURED AVERAGE AMPS	CALCULATED POWER	REMARKS
Joy 1250 hp	4555	0.9	157	1113 Kw	Ran
Centac 1100 hp	4555	0.9	–	–	Did not run
Centac 600hp	4555	0.9	61	432 Kw	Ran
Joy 250 hp	4555	0.85	–	–	Did not run

LOAD-SHARING COMPRESSOR CONTROL ROI		
ITEM	**BASELINE FULL PRODUCTION**	**OPTION LOAD SHARE**
Equipment		$147,000.00
Installation	$-	$35,000.00
Tech Service	$-	$21,000.00
Total First Cost:	**$-**	**$203,000.00**
Annual kWH (model)	9,647,040	8,100,487
Electricity cost (model)	$490,069.63	$411,504.741
Maintenance cost (model)	$122,517.41	$122,536.50
Annual Operating Cost:	**$612,587.040**	**$534,041.241**
Simple ROI		**2.58**

The compressed air system at this plant has a relatively poor DE (dynamic efficiency) of 4.18 scfm/kW and week-day full production energy costs of $490,070.

A Load-Sharing Compressor Control System

Compressor power management has a significant impact on the cost of operating the compressed air system. This system normally operates with all manually energized compressors operating against their individual onboard controls. This will usually be the 1250 hp Joy and the 600 hp Centac. The Joy runs fully loaded and the Centac operates in blow-off mode just above the surge line. This strategy insures maximum capacity is available whenever it is required automatically without operator intervention.

During weekend periods only one air compressor operates (usually the Joy 1250 hp) and it operates in turndown around 120 amps. Obviously in this condition there is no opportunity to save energy by load sharing since only one compressor operates and it is not blowing off. Note the DE is fairly good at 5.03 scfm/kW. Total annual energy consumption for the two modes of Full Production and Weekends is about $604,000.

By introducing a master load-sharing compressor control system, two air compressors will be run in the most efficient manner possible — automatically. The proposed compressor control system will automatically and continuously closely match supply output with demand requirements under all load conditions, including future changes in production levels or compressed air utilization.

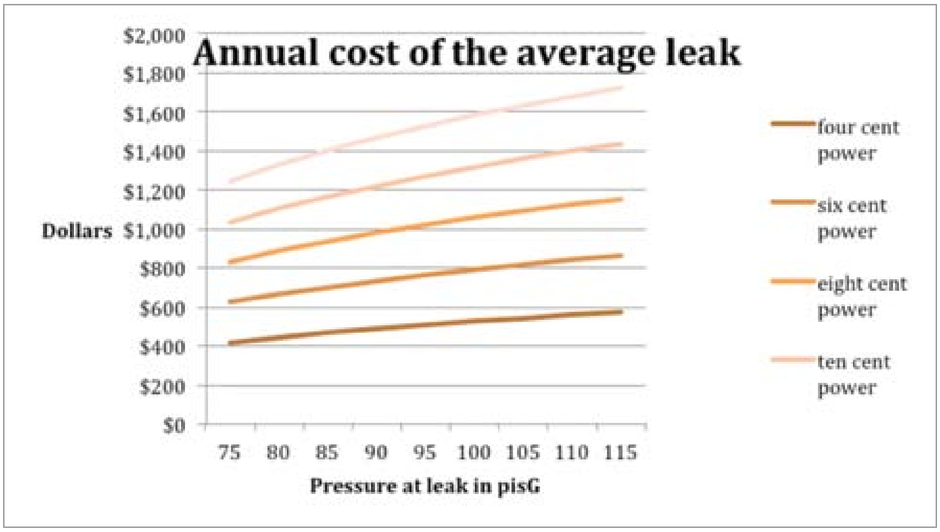
Included in the proposed load-sharing compressor control system are measuring instruments to help plant management monitor and manage the compressed air system in a persistent manner. Total system flow and power should be continuously measured and DE (dynamic efficiency) will be displayed on the HMI with the touch of one keystroke from the Main Menu screen. Instantaneous DE, average DE for the last 30 days, and DE since reset should be displayed. This will allow otherwise focused management the ability to quickly and accurately assess the performance of the system in real time continuously.

In this application, our analysis details the savings possible during the Full Production period by appropriately Load Sharing the 600 hp Centac and the Joy 1250 hp. We set the 600hp Centac just above blow off at 85% of Full Load and not blowing off. It will delivery approximately 2500 scfm and consume about 433 kW for a DE (dynamic efficiency) of 5.77. The Joy 1250 hp will deliver the rest of the required compressed air flow while in turndown. The DE will increase to 4.98 scfm/Kw and over 1,546,550 kWh/year will be saved during Full Production periods alone. The energy savings for this retrofit are $78,565 per year.

> "By introducing a master load-sharing compressor control system, two air compressors will be run in the most efficient manner possible — automatically."
>
> — James G. McAuley P.E.

Leak Management

We surveyed the entire plant with an Ultrasonic Detector over the course of two days and identified approximately 50 leaks that were tagged, documented, and lined up for correction by the responsible maintenance mechanics. We estimate each leak is on average approximately 5 scfm. At our efficiency rating of 4.18 scfm/kW this represents about 524,000 kWh/year in power. These leaks will be corrected very shortly and are estimated to be worth $26,619 per year in purchased power. Between leaks and inappropriate uses we calculate about 680,000 Kwh in savings with an ROI of under one year.



Leak Management must become a Standard Operating Procedure at the facility. Leaks were estimated at **about 20%** of flow. This is typical for an existing plant with lots of motion and heat. We noted many normal leak modes including push-pull connectors, connections subjected to excessive heat and vibration (behind the safety fence) and many final connections to applications including unions, pipe clamps, and FRL's.

We recommend the plant invest in an ultrasonic UE Systems Ultraprobe 3000 hand-held leak detector. These can be easily used by the average plant mechanic to quickly locate the most easily correctable leaks. The individual must be given time for proper training (hours not days) and assigned the task and responsibility to take corrective action up to and including changes in plant standard operating procedures, material and methods.(i.e. compression fittings in lieu of pipe clamps and push pull connectors). *Behind-the-safety-fence* leaks account for much of the plant leak load. During planned maintenance outages, an effort should be made to find and correct these leaks. Common leak modes can be identified and corrected on a regular basis. For instance, use of pipe clamps on flex hose will always result in leaks. Good quality compression fittings such as used in hydraulic systems may cost more but will reduce leaking permanently. Consult with the local Swagelok or Parker Hannifin outlet.

This monthly shift task, with the ultrasonic leak detector, can ultimately achieve a reduction in leak-loss levels to 10% of compressed air flow. In this plant, this could be responsible for up to $49,000 in yearly savings using our allocated cost model. The annual cost in manpower and parts is typically about ½ of this for a 6-month payback. This is a never-ending on-going effort. Total annual savings (and costs) can be expected to decline over time as the effectiveness of this practice improves.

6400 scfm x (.20-.10) x 1.23 $/100 scfm x 6240 hr/yr =$49,103

A simple weighing of the cost and benefit here will show you the way. With the automatic and continuous compressor power management system in place, lower leak loads will translate directly to lower power consumption and cost.

An effective leak management program is wholly contingent on plant management recruiting, not drafting, a *Plant Champion* who is committed, challenged and resourced to take on this part-time job with a full-time commitment. He/she must be someone with the knowledge and concern to follow through on this long term objective. Through a series of leak detection surveys over 12-18 months, leak modes and defective practices can be identified and eliminated and real leak levels reduced. The important fact to remember is the slow incremental nature of the fix and the potential to become distracted by bigger fish and lose interest and management commitment. This is not a full time job but requires a full time commitment.

Allocated Costs for Compressed Air

The *allocated* unit cost for compressed air at this factory is $1.23 per hour of operation per 100 scfm of usage. This number is derived from the total cost of compressed air operations, the average demand side flow rate observed in the system during full production (6400 scfm), and the total hours per year (6240). It is a useful number when comparing costs. This number is about average for a facility of this type and size in the United States and is partially explained by the comparatively low cost of energy at this plant.

The allocation of unit cost will allow plant management to estimate the financial impact of various management decisions including the operating cost associated with new equipment and the efficacy of better (more) intense maintenance practices. Caution: It is not the marginal cost of the next 100 scfm of use nor the savings derived from the last 100 scfm of use eliminated.

Condensate Drainage Practices

In order to provide cleaner and dryer air to the plant, efforts must be made to eliminate condensate from the saturated compressed air leaving the after-coolers, dryer and filters. The best way to accomplish this is through the use of a high quality, low maintenance, automatic trap that eliminates condensate only and not compressed air. Currently, there are Zero loss traps in use in the plant. This trap will give you a long period of service before requiring cleaning or replacement. **They are not, however, maintenance free.** We recommend all operating traps be tested daily and only when replacement is necessary they be replaced with an On Demand trap.

Every drain installation must include a manual bypass arrangement and ability to visually

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— James G. McAuley P.E.

LOCATION	DRAIN TYPE	STATUS	REMARKS
Compressor Joy 1250 inter cooler	Zero loss Trap	Ok	
Compressor Joy 1250 inter cooler	Zero loss Trap	Ok	
Compressor Joy 1250 after cooler	Zero loss Trap	Ok	
Compressor Centac 1100 inter cooler	Zero loss Trap	Ok	
Compressor Centac 1100 inter cooler	Zero loss Trap	Not ok	Leaking through
Compressor Centac 1100 after cooler	Zero loss Trap	Ok	
Compressor Centac 600 inter cooler	Zero loss Trap	Ok	
Compressor Centac 600 inter cooler	Zero loss Trap	Ok	
Compressor Centac 600 after cooler	Zero loss Trap	Not ok	Leaking through
Compressor Joy 250 hp inter cooler	Zero loss Trap	Ok	
Compressor Joy 250 hp inter cooler	Zero loss Trap	Ok	
Compressor Joy 250 hp after cooler	Zero loss Trap	Ok	
Ammonia Dryer	Zero loss Trap	Ok	
Filter 1A	Zero loss Trap	Ok	
Filter 1B	Zero loss Trap	Ok	
Filter 2A	Zero loss Trap	Ok	
Filter 2B	Zero loss Trap	Ok	
25,000 gallon Tank	Zero loss Trap	Ok	
IC	Zero loss Trap	Ok	

inspect the effluent (i.e. do not hard pipe into sanitary sewer).

All after-coolers require continuous automatic purging of condensate. A typical 200 hp after cooler will remove over a gallon of condensate per hour in summer conditions. We recommend on demand reservoir drains for every after-cooler.

All drains will require cleaning and de-fouling. Identifying this need **is the purpose of a daily or shift operational check.** We recommend spare traps, cleaned and ready to go, be maintained for immediate redeployment. We also recommend all drains be piped such that their operation can be visually confirmed during maintenance rounds. A manual bypass arrangement will allow the operator to confirm operation of each automatic trap.

Here is the complete inventory of automatic drain locations. Two traps need to be cleaned and have the valves reseated.

Summary:

The compressed air system at this factory is not operating near peak performance. In fact, it runs at a combined efficiency of about 4.18 scfm/kW during full production periods. The total existing annual energy cost of the compressed air system is $604,000.

The solutions recommended in the audit can boost this efficiency to 5.0 scfm/kW and save up to $113,154 in annual energy costs.

The total cost to implement these solutions is estimated at about $220,000. This provides a very attractive simple payback of about one year when factoring in an expected utility

MEASURE	ELECTRICAL SAVINGS	IMPLEMENTATION COST ESTIMATE	SIMPLE ROI
Load share	$78,565	$203,000	2.58 years
Demand side mitigation	$7970.00	$4,000	6 months
Leak correction	$26,619	$13,000	6 months
Total	$113,154	$220,000*	1.94 years*

*ROI expected to be improved to 1 year by $123,000 utility rebate.

rebate of approximately $123,000 based upon savings of over 1,500,000 kWh.

Nearby is a summary of the savings recommendations contained in this report:

Prioritized Action Plan

This is a step-by-step action plan to implement the recommended changes:

1. Apply for and gain approval for the Utility Rebate. This is $123,000 and will pay down the investment toward a very attractive one year simple ROI.

2. Fix documented leaks, including two leaking condensate traps in compressors room.

3. Mitigate open-blowing applications listed.

4. Institute daily operational checks on all automatic drainage points and after-cooler discharge temperatures. Keep records to spot over-heating trends and clean spare traps for immediate redeployment.

5. Implement load-sharing compressor control system. Add flow, power and DE calculations. Any mal-adjustments will be immediately indicated on the controller, one push-button from the main screen. Instantaneous DE, last 30 days, and since reset will be calculated and displayed. All this open protocol information can also be uploaded in real time to a plant network if desired and available.

6. Implement a leak management process to further reduce operating costs. Consider your recruits, select well, and delegate responsibility with authority. BP

For more information contact James G. McAuley P.E., tel: 832-563-6395, email: jgmcauley@comcast.net, www.JimMcAuley.com

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The information contained herein is general in nature and is not intended for specific construction, installation or application purposes.

AIR COMPRESSOR HEAT RECOVERY

By Dr.-Ing. Uwe Kaiser, Research & Development Manager, BOGE Compressors

Introduction

When compressed air is generated, heat is inevitably produced as a by-product.

Anyone looking to enhance efficiency can use this heat and increase the efficiency of compressors to about 95 percent as a result. To achieve this, there are easy-fit heat exchangers which can be fitted to existing air compressor stations. This investment often pays for itself within less than a year.

The issue of heat recovery in compressed air circles is not always tackled head-on. This may be explained by the fact that manufacturers of air compressors and suppliers of complete compressed air stations first of all need to look a rather unpleasant truth in the face before they can instill in users an awareness of this extremely efficient type of combined energy use: Whatever way you look at it, generating compressed air as a utility is not actually very efficient.

This property that compressed air has is shared with many other energy conversion processes. A coal-fired power station achieves an efficiency of about 45 percent. A wind generator, working at 50 percent, is not much more efficient, although this is not really an issue being a renewable source of energy.

Compressed Air Plus Thermal Energy — A Highly Efficient Combination

Similarly to coal-fired power stations, around 94 percent of the energy created during compressed air generation is converted to heat (fig. 1). This often dissipates before it can be used — a considerable failure where energy efficiency is concerned. If the heat is used for the production process, or to heat the premises, it is possible to achieve impressive

"In Boge's experience so far, investments in a heat recovery system pay for themselves within six months to twelve years; frequently, this occurs within less than twelve months."

— Dr.-Ing. Uwe Kaiser, Research & Development Manager, BOGE Compressors

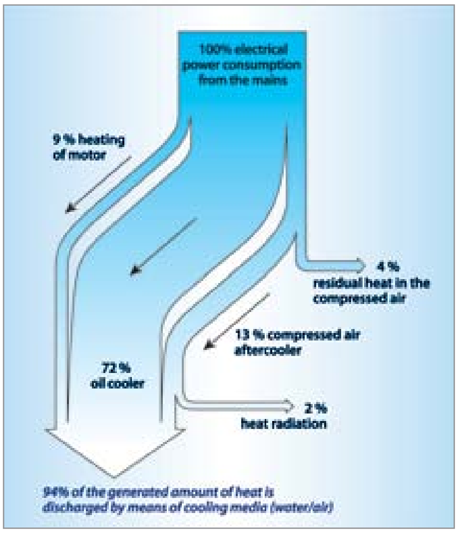

Fig. 1 Around 94 percent of the electrical energy consumed by an air compressor is given off in the form of heat. Using this waste heat is therefore an important criterion of the energy efficiency of a compressed air station.

efficiencies of well over 90 percent. In fact, of the 100 percent of the electrical energy consumed, some 94 percent is converted to heat, that can be put to good use after it has been recovered. This does not actually make compressed air cheaper per cubic meter, but the operator can make considerable savings in other respects, such as the cost of heating buildings or water.

Choosing the Right Process

It is a useful exercise at the outset to take a good look at the process parameters, and to select the process which is likely to benefit most from using the heat produced by the air compressor. Many chemical and foodstuff producers are at an advantage in this respect, since they use temperature controlled processes and therefore have a year-round demand for heat. Paint shops and electroplating operations also need a constant supply of heat for their processes. In plants that do not require process heat, the user has the choice between either heating premises or hot water heating.

Compressors As Energy Savers

Modern water-cooled compressors are already well-prepared for easily integrating a heat recovery system into the cooling circuit. There are a lot of much older compressor stations, though, that work without heat recovery. For stations such as these, Boge has a new Duotherm system, which can be used with existing BOGE systems as well as with other-brand systems. This makes the compressor into an "energy saver" with a surge in overall efficiency, no matter what the original model or output was.

This system is available in five power levels from 10 to 150 hp, for easy integration into oil-injection cooled screw compressors. The generously dimensioned heat exchanger in the Duotherm system is connected to the oil system of both the compressor and the hot water or process water utility mains. It efficiently transfers the heat from compressed air production to the desired process — without any additional energy input. Thanks

AIR COMPRESSOR HEAT RECOVERY

Fig. 2 Heat recovery systems are compact and easy to install.

to the compact design, the system requires very little space to achieve a lasting improvement in the energy efficiency of the compressor.

Pays For Itself in Next to No Time

The investment costs for heat recovery systems depend largely on the structural conditions at the site of use. These conditions need to be taken into account, since they have a considerable influence on the amortisation time. In Boge's experience so far, investments in a heat recovery system pay for themselves within six months to twelve years; frequently, this occurs within less than twelve months.

At its own premises, Boge relies on a combined model of thermal use: In winter, and in the transition periods between the seasons, the compressor heat is used for heating purposes, while in summer, it is used to heat hot water. This saves the company around 100,000 kWh of heating power per year.

Simple Equation

Users considering buying a heat recovery system should take the following into account: The Boge S 100-2 type compressor in the 75 kW class produces a usable heat of 60.6 kW. In a single-shift operation with over 2,000 compressor operating hours, and with a heating oil price of $1.04, this equates to a savings potential of $18,260.00 by using Boge Duotherm.[1] Constantly increasing energy prices make the procurement of a system such as this even more worthwhile.

1 This example is based on the following assumptions: Calorific value: 9.861 kWh/l; heating efficiency: 70 percent. The usable energy varies depending on the compressor and the actual situation of use.

Even for Air-Cooled Systems

Air-cooled systems can use the exhaust air to heat rooms or production facilities. This can also be very easily achieved using the outdoor thermostat control. In this case, from a defined temperature upwards, the exhaust air stream from the sound insulation hood is switched over to heat the production facility when temperatures drop — and all this at no extra cost.

Conclusion: Look at the Figures and See If They Stack Up

In view of the low investment, compressed air users should seriously consider the option of utilizing waste heat. This is particularly true for the smaller type of compressor station: Even waste heat from an 25 hp compressor provides enough to heat a domestic dwelling.

It is also a good idea to look into the fine tuning of other factors involved in the efficiency of compressed air supply. These include recommendations such as checking the pressure level, optimizing the regulation with as low a pressure range as possible, the use of variable speed compressors for peak loads, and reducing inefficient idle times. It is also advisable to set up regular leak testing, which can also be achieved electronically by modern control systems, through measuring the drop in pressure when the compressors are switched off. Boge supplies a tool for this purpose — the Leakage Monitor. BP

For more information contact BOGE, tel: 770-874-1570 or visit www.boge.com/us

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Fig. 3 Compressed air users should definitely check whether heat recovery "stacks up" for them. It generally pays for itself very quickly.

A COMPRESSED AIR & GAS INSTITUTE Q&A SESSION IS A VARIABLE SPEED DRIVE (VSD) COMPRESSOR

By Compressed Air Best Practices® Magazine

Compressed Air Best Practices® Magazine recently discussed variable speed drive (VSD) air compressors with the Compressed Air and Gas Institute's Technical Director, Rick Stasyshan and with CAGI member — Bob Baker of Atlas Copco. Their inputs should provide you with some insight to this energy-saving technology.

Where does one start with evaluating a system?

The simple economic model of matching supply with demand optimizes productivity and helps control costs. This makes sense not only in the economic world, but also when considering how compressed air is produced and used in a manufacturing facility.

Compressed air is critical to a wide range of functions within manufacturing. But poorly designed and maintained compressed air systems, by some estimates, account for significant energy losses and waste every year.

Figure 1: VSD inverter

One quick and easy way to ensure your facility is not squandering energy in its compressed air production process is to consider the benefits that can be provided by a properly sized variable speed drive compressor.

Is a VSD compressor a good trim compressor?

Variable speed drive compressors use an adjustable-speed drive or inverter (figure 1) to control the motor speed to modulate compressor's output. The simple advantage of this technology is that it allows the compressor to have relatively linear cfm output to kW input efficiency curve. This makes VSD compressors ideal trim compressors to supply a the variable demand in plant on top of the stable base compressed air demand.

While many plants require continuous, round-the-clock operations seven days a week, there likely are times when lulls in production present opportunities for energy savings. For example, there are 168 hours in a week and many compressed air systems only require full capacity between 60 and 100 hours, or about half the time. When this partial demand load event occurs, the air compressor output capacity must be regulated or stopped. With units 15 HP or larger, it is not feasible to stop and start the air compressor motor several times an hour throughout the day, so a form of inlet control regulation is the choice. Whether you run the unit with a Load/No-load control (fully loaded or a closed inlet for unload and bleed-down) or Modulation (cutting back the inlet throttle plate) to accomplish a partial load run-time, these control systems may not be the most efficient.

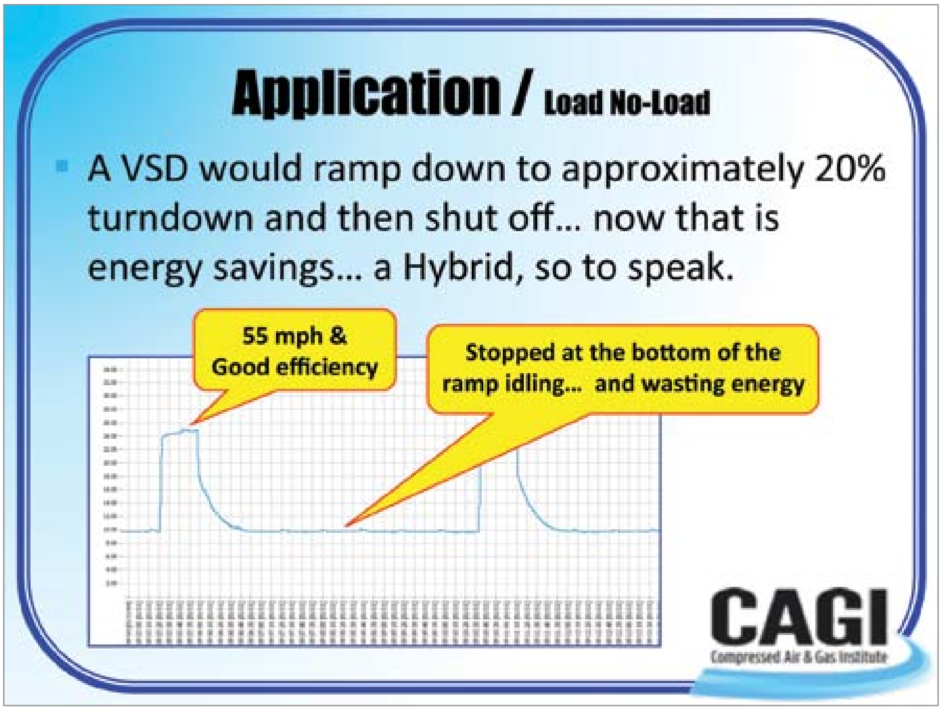

Figure 2

THE RIGHT CHOICE FOR YOUR FACILITY?

Operating a car is a very good example; when you exit the highway, you go from highway speed (let's say optimum full load at 55 MPH) and then you come to a stop at the bottom of the ramp. There, the car is idling and wasting energy as long as it sits at the stop sign. City driving is even worse or similar to a very fluctuating demand — starting and stopping, but idling at every stoplight. Now, think of your car sitting (idling) at stop signs and lights for 60 to 100 hours per week. (figure 2)

A compressed air energy audit or assessment including a review of the demand profile, compressed air usage patterns, available air storage capacity and piping network, and the operating environment, all play an integral role in determining if a VSD compressor can provide the energy efficiency that you desire.

Can VSD compressor power consumption match air demand?

Properly sized variable speed drive compressors, offer the capability to fine-tune a compressor output precisely to fluctuating compressed air demands. By varying the speed of its drive motor, as air demand decreases, the VSD lowers the delivered air flow as well as the electrical power consumption in that largely linear fashion. This reduces energy consumption to a minimum when fluctuating demand is the norm. In fact; due to the comparatively low in-rush currents inherent in variable speed drive motor designs, some VSD compressors will stop at the lower compressed air demands vs. idling at unloaded conditions. Even with several starts per hour there is not an issue, so wasteful energy (idling time) is virtually eliminated. (figure 3)

What is the business case for a VSD?

Statistics compiled through compressed air system assessments and performance analysis show that many air compressor applications are ideal for VSD. Compared to a fixed speed drive compressor, a VSD compressor, properly sized for the same end use, can yield significant power savings. In some cases, based on the demand profile, compressed air costs have been reduced by one-third. Another thing to remember is that, due economic cycles and shifting of manufacturing to other countries, many facilities have significantly reduced the volume of compressed air needed and are therefore operating oversized air compressors. This highlights the need to review the facility compressed air needs when significant production and compressed air demand profiles change. In addition, many local municipalities and state utilities

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IS A VARIABLE SPEED DRIVE (VSD) COMPRESSOR THE RIGHT CHOICE FOR YOUR FACILITY?

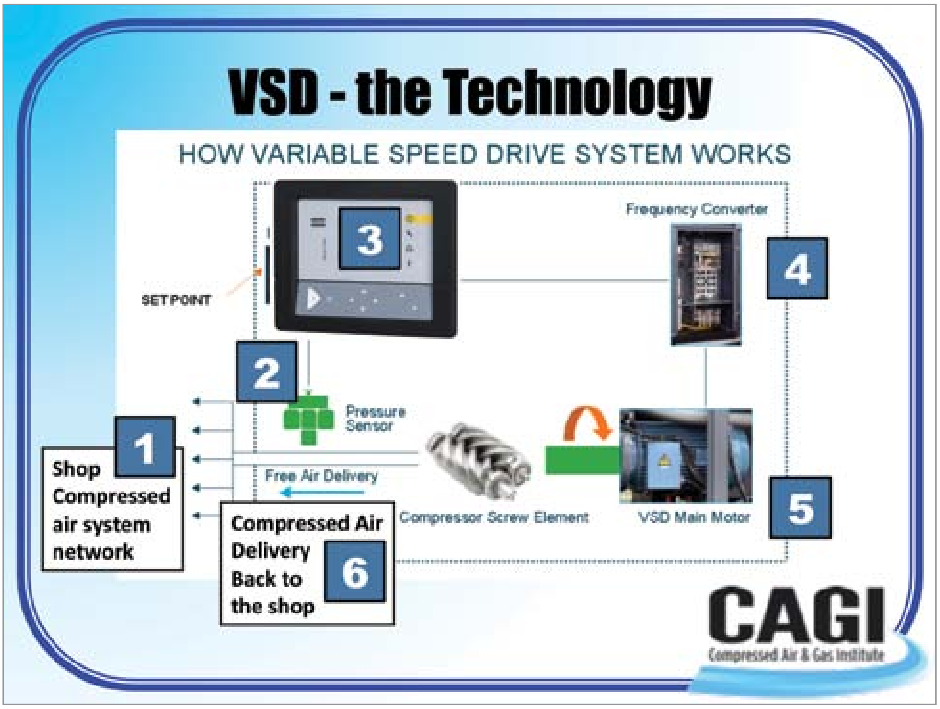

Figure 3

Figure 4

offer rebate incentives for energy savings compressed air solutions, of which VSD technology qualifies.

Energy costs, already on the rise in recent years, have garnered additional attention of late as facility managers are continually charged with finding new ways to cut costs. Many corporations have instituted "green" policies with aggressive annual energy reduction targets.

Let's consider a situation where a manufacturer's compressor system was running a single 200 horsepower air compressor. The operation has fluctuating compressed air demands 24 hours a day at 3 cents per kWh. These energy costs have doubled in the last five years, increasing in some areas to 8 cents per kWh or more. The annual cost to operate that compressor at 3 cents per kWh was $41,273. Today, at 8 cents per kWh, that same compressor costs $110,062 to operate every year, or more than a half a million dollars over five years. After a detailed compressed air demand assessment, it is determined that the fluctuations were within the control range and averaged 35% less than the full capacity of the compressor and the factory had inadequate storage. In this case, switching to a properly sized VSD compressor could potentially save this facility $38,521 annually or more than $192,000 in five years, if the current conditions remain similar over that time period.

Combine these savings with the greater efficiency that is realized when you replace older equipment with newer, more efficient machines and the return on investment with many of these installations is often realized in

IS A VARIABLE SPEED DRIVE (VSD) COMPRESSOR THE RIGHT CHOICE FOR YOUR FACILITY?

The Compressed Air & Gas Institute (CAGI) is an association of manufacturers of compressed air system equipment: compressors, blowers, air drying and filtration, and pneumatic tools. Links to member websites are provided on the CAGI site. The members' representatives are readily available to assist users in recommending the proper equipment to meet your compressed air needs. CAGI's mission is to be the united voice of the compressed air industry, serving as the unbiased authority on technical, educational, promotional, and other matters that affect the compressed air and gas industry.

For more detailed information about VSD technology applications, compressed air system audits or answers to any of your compressed air questions, please contact the Compressed Air and Gas Institute. The Compressed Air and Gas Institute is the united voice of the compressed air industry, serving as the unbiased authority on technical, educational, promotional, and other matters that affect compressed air and gas equipment suppliers and their customers. CAGI educational resources include e-learning coursework on the *SmartSite,* selection guides, videos and the *Compressed Air & Gas Handbook.* For more information, visit the CAGI web site at www.cagi.org

less than two years. Not every installation can yield this kind of payback, that is the purpose of a professional air demand assessment and proper compressor selection, but for sure...it is worth the consideration.

In summary, by varying output to meet compressed air demands, manufacturers who choose a properly sized VSD compressor as part of their infrastructure can realize immediate energy savings that will only compound over time.

So technically, how does it work?

The VSD concept simply measures the system pressure and maintains a constant delivery pressure within a narrow pressure band. This is achieved by regulating the motor speed of the compressor by frequency conversion, which results in a varying air flow delivery. With today's advanced VSD electronic controls the delivery pressure is kept within a + 1.5 psi band — this is another benefit of systems with a VSD compressor; systems with all fixed speed compressors typically have a minimum a 10-15 psig pressure fluctuation. Therefore, a lower air compressor delivery pressure can be used to maintain the required minimum working pressure of the system — which results in increased energy savings and profitability. Remember, for every 2 psi reduction in pressure, power consumption is reduced by 1 percent. That's more than a 6 percent energy savings just due to the lower operating pressure often made possible by having at least one VSD compressor.

The inverter in the VSD system performs a "soft" start operation by ramping up the motor speed, thus eliminating amperage draw peaks that are typical when a fixed speed motor is started. Power companies usually will impose penalties for these amperage peaks in the form of higher rates. The soft starting utilized by a VSD compressor also helps protect electrical and mechanical components from the starting mechanical stresses that can shorten the life of an air compressor.

In all cases, it suggested that the plant consider a compressed air system audit to best match the production compressed air equipment to the plant compressed air demands. This would also highlight potential production events that could be impacting the compressor system efficiency. (figure 4)

A closer look at this scenario and using a "car on the highway" analogy, we can see that the loaded time (55 mph) is approximately 20% of the time and… the unloaded (Idling time at the bottom of the ramp - stop light) is approximately 80% of the time. At this particular facility, the unit ran this way 5 days a week 50 weeks per year. Big energy wastes resulted.

Solution: A properly sized VSD would ramp down to approximately 20% and then turn off (a Hybrid so to speak). Also, VSD compressors virtually have unlimited starts per hour due to the low inrush current (Starting Amps) when starting and ramping up to operating speed. They can also start under load and the air-oil receiver tank does not have to bleed down, that is additional savings because you don't have to fill the air-oil receiver tank every time the unit starts. Due to this low inrush current, low or "no" current peak demand costs are also a fact.

The Technology is fairly simple; in the illustration above, the **Air Net (1)** is requiring more compressed air the **Pressure Sensor (2)** senses the drop in pressure and sends a message to the unit **Controller (3)** and the controller sends a message to the **Frequency Converter or Inverter (4)** to speed up the compressors **Variable Speed Drive Motor (5)** which drives the compressor element to add more **Free Air Delivery (6)** back into the system's air net. BP

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For more ***CAGI*** articles, visit www.airbestpractices.com/standards/iso-cagi

INNOVATIVE DUAL PRESSURE CONTROL IMPROVES EFFICIENCY

By Ron Marshall for the Compressed Air Challenge®

Grand Manufacturing, a small community owned Canadian agricultural products manufacturer, has upgraded their compressed air system as a result of a production expansion, yet increased the compressed air energy efficiency 61% by consolidating their system and implementing an innovative dual pressure control strategy.

Smaller Project Originally Considered

The project originally started as a routine request for a financial incentive to support the installation of a more efficient VSD controlled compressor instead of using a less efficient load/unload compressor to supply a new laser cutting machine being installed in the facility. The laser compressed air load profile is variable due to the variety of items being cut for production purposes. This type of profile is a good fit for a variable speed drive compressor and something that qualifies for Manitoba Hydro's Performance Optimization Program grants. One fairly unique requirement for this system was the pressure; the laser required a supply pressure of 200 psi for special cutting operations. For this reason Grand Manufacturing selected a screw compressor with a discharge pressure rating of 215 psi and planned to run the system at that level, which was similar to their two other existing laser systems.

As a basic customer service Manitoba Hydro visits the customer's site and assesses the characteristics of systems consuming significant energy. As part of this service a compressed air scoping audit was done on the existing compressed air system in the plant because an energy project was imminent. Data loggers were installed on the system for a week and a system baseline developed to assess how the system is meeting the customer's needs and to gauge the efficiency. The scoping audit showed some interesting facts about the plant air supply. Two load/unload compressors had been previously installed as part of two existing laser setups, but these units were lightly

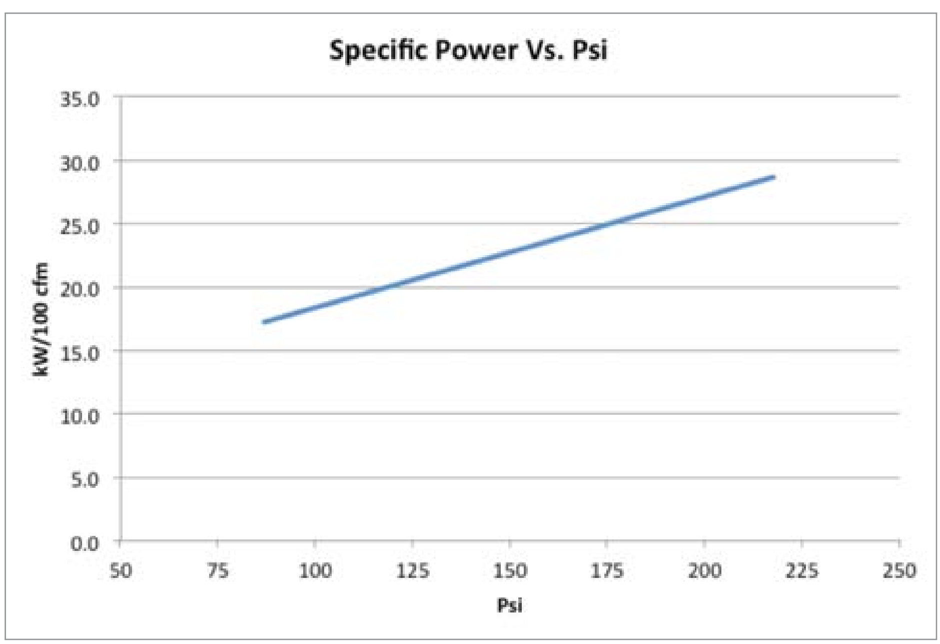
> "By limiting the high pressure operation to 10% of the time using better pressure control , Grand Manufacturing lowered the average pressure from 200 psi down to 128 psi and achieved excellent savings due to this specific power reduction."
>
> — Ron Marshall, Industrial Systems Officer, Manitoba Hydro

loaded and operating inefficiency due to a rapid cycling condition. The units were being run independently as separate systems and both were running at 200 psi. The average specific power, a measure of the kilowatt input per 100 cfm produced was a sky high 65 even though the compressors were rated at slightly less than 30 kW per 100 cfm.

Supplying air compressors as part of the purchase of compressed air powered laser cutting equipment is a common practice (often done with printing presses too). In this way the manufacturers of these very expensive machines can ensure they have enough compressed air of sufficient quality to work reliably. Unfortunately, the compressors are often supplied with little or no thought to how energy efficient the equipment will be. As a result, the storage receiver capacity required for efficient load/unload operation is often undersized or completely missing.

Analysis Finds Savings

Manitoba Hydro's analysis of the demand profile of both existing systems, and interviews with site personnel determined that the high pressure demand required for a specialized cutting operation only occurred about 10% of the time. Investigation of this demand determined that this was the only operation that required 200 psi compressed air pressure. The remaining time each laser could operate satisfactorily at 125 psi. Armed with this information Manitoba Hydro approached the customer with a proposal, to control the pressure so that the 200 psi pressure was generated only when special cutting operations were being performed. The rest of the time



Graph 1: Specific power increases with pressure

INNOVATIVE DUAL PRESSURE CONTROL IMPROVES EFFICIENCY

the pressure would be turned down to a lower level. Further to this the two old systems could be combined with the new VSD compressor to form a single well controlled three compressor system that would only require one or two running compressors. This would yield significant savings and better more reliable system operation.

Both Grand Manufacturing and Manitoba Hydro were concerned that the three compressors be properly coordinated whenever the pressure levels were changed. Since the compressor control programming required to adjust the pressure of all three compressors manually was somewhat complex there was a high probability that errors could be made that would affect the efficiency and effectiveness of the project. A simple way of setting the pressure levels was needed.

Some research was done into the specific electronic compressor control installed on all three compressors. Fortunately it was quickly determined that the controls had the capability of operating with two separate selectable pressure settings. Further research revealed that the pressure levels could be selected by closing an external contact, in this case a central switch. For Grand Manufacturing the switch was set up to normally select 125 psi operation, but when high pressure cutting operations are required the switch position is changed by the operator causing the second 200 psi pressure level to be used by all three compressors. After the cutting operations are completed the switch is returned to the normal position, lowering the pressure.

How the Savings Were Gained

A typical rule of thumb in the compressed air industry states that for every 2 psi increase in compressor discharge pressure the power requirement at the main compressor motor increases by 1 percent. For example, the manufacturer's data (Graph 1) shows the new VSD compressor installed at Grand Manufacturing has a specific power of 27.5 kW per 100 cfm at full load at 203 psi (14 bar). Decreasing the pressure to 116 psi

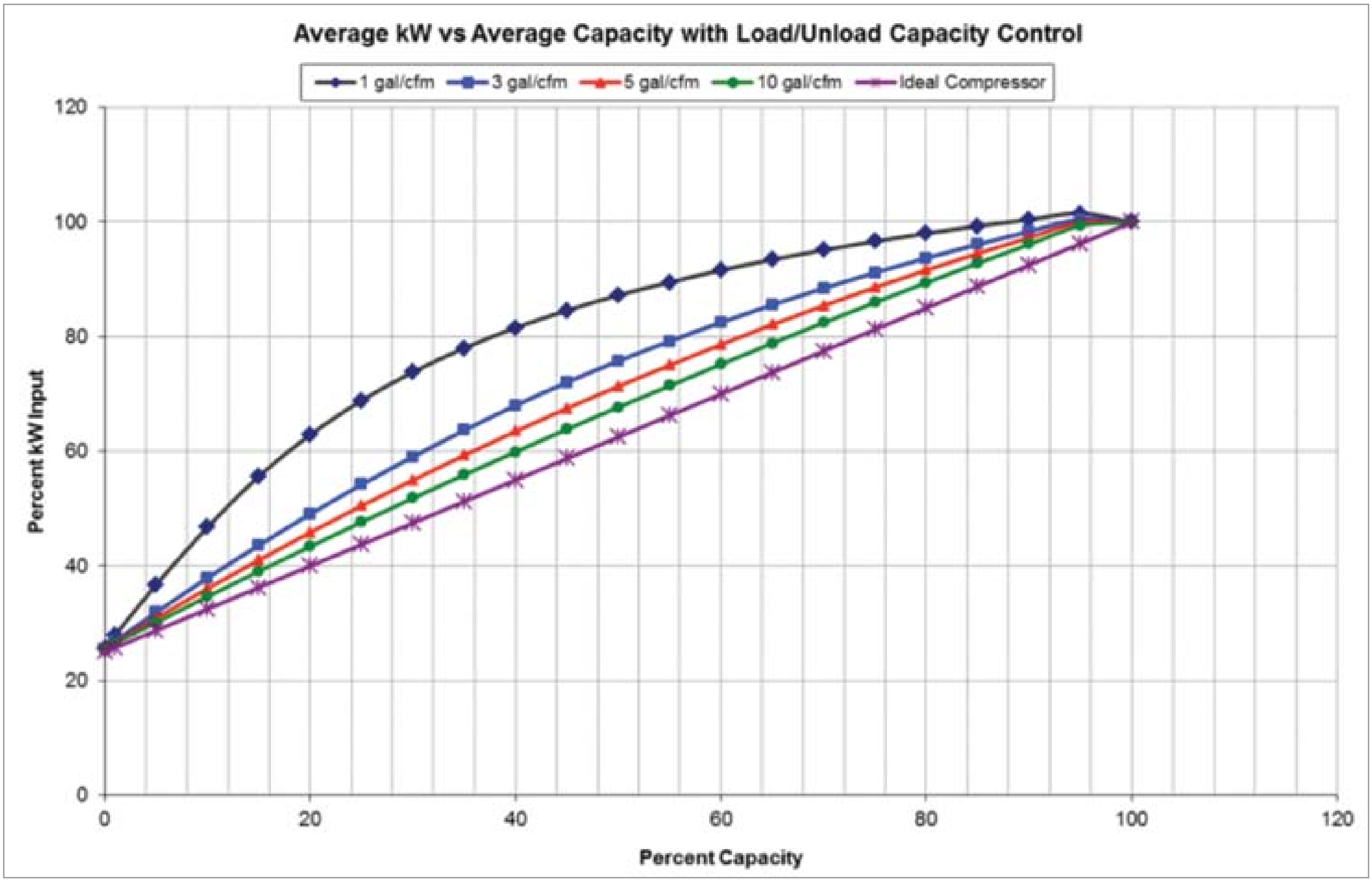


Chart 1: Lack of storage can cause compressor inefficiencies

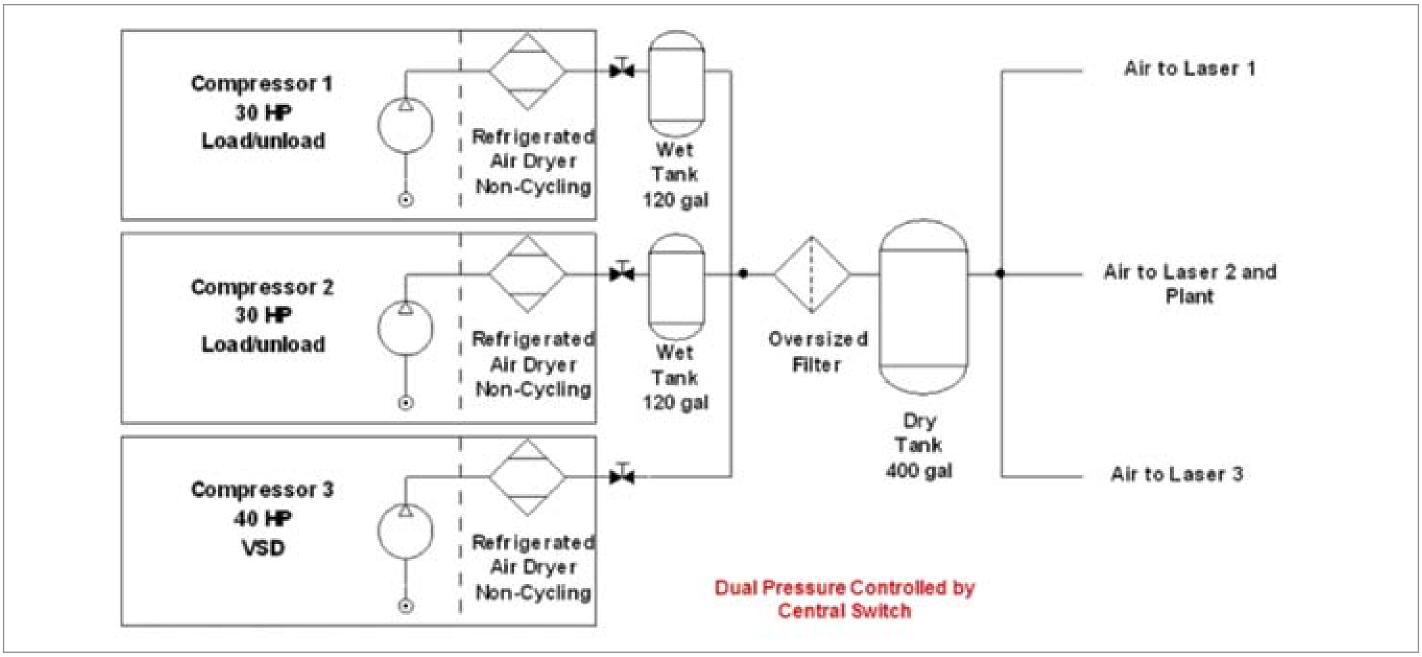


Figure 1: A third VSD compressor was added and systems were combined

INNOVATIVE DUAL PRESSURE CONTROL IMPROVES EFFICIENCY

reduces the specific power to about 20 kW per 100 cfm, a 38% reduction. By limiting the high pressure operation to 10% of the time using better pressure control , Grand Manufacturing lowered the average pressure from 200 psi down to 128 psi and achieved excellent savings due to this specific power reduction. The compressors run cooler, eliminating nuisance high temperature trips and produce slightly more air at lower pressure levels.

The original system was made up of two independently operating compressors running in load/unload mode. These units had very small control receivers which were sized about 1 gallon per cfm compressor capacity. There were coalescing filters located between each compressor discharge and its associated receiver tank. The pressure bands on the compressors were set to about 10 psi wide as is typical for this type of compressor. The filters caused significant differential, effectively narrowing pressure band at the storage tanks and lessening the effectiveness in slowing down the compressor cycles so that the compressors could run more efficiently. As a result the compressors were short cycling.

As seen by Chart 1 the energy consumption of a lubricated screw compressor operating in load/unload mode with smaller storage varies greatly from the ideal condition, which would be a straight line drawn between 100% loading and zero compressed air output. The Grand Manufacturing compressors diverged significantly from the ideal because of the lack of storage capacity. In addition to this, because there were two running compressors operating independently, the inefficiencies were multiplied.

By consolidating the systems, optimizing filters to decrease differential, increasing the amount of storage, and adding a third VSD controlled compressor, the efficiency of the two existing systems and the new one can be greatly improved. When system loading is at lower levels only the VSD compressor runs. When system loading is higher one of the two fixed speed compressors is run at full load, the most efficient point, while the VSD compressor supplies partial load (see Chart 2).

The addition of the new laser equipment increased the compressed air loading from a level of 75 cfm to an average of 120 cfm, however, the improvements to the system have decreased the system specific power from 65 kW/100 cfm down to a more acceptable 25 kW/100 a decrease of 61%. Had the third compressor been installed in the same manner as the previous existing units the

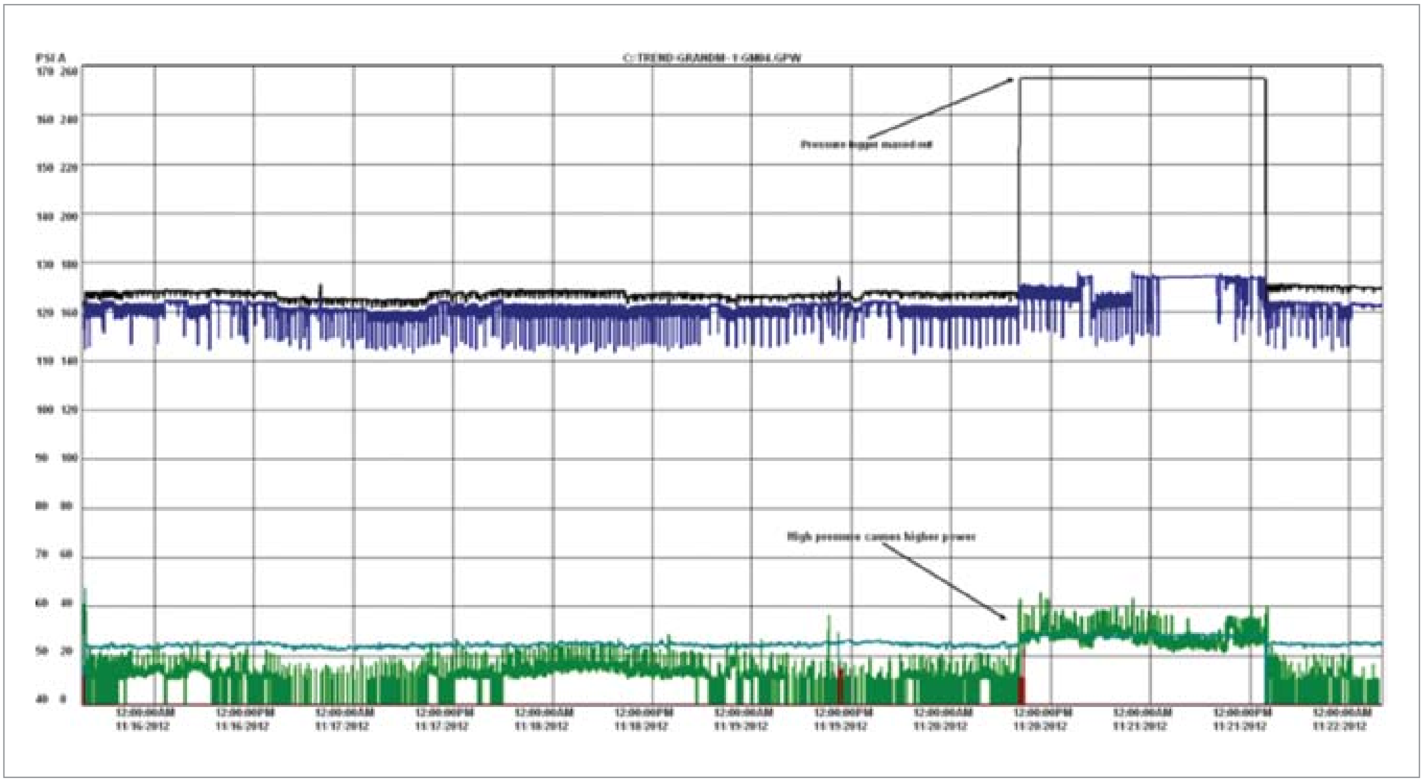


Chart 2: High Pressure is used only when required

energy consumption of three separate systems all running at 200 psi would have been much higher. The estimated energy savings over this worst case is about 270,000 kWh per year worth $14,000 per year in electrical charges.

Can Your Compressors Operate in Dual Pressure Control?

There are a number of manufacturers that offer compressor controls that can achieve dual pressure levels, on a switch controlled basis or on a time schedule. If you compressor supplier isn't one of them a compressor controller by be able to control your system from a central point, effectively achieving the same type of solution. Check with your supplier to determine the possibilities.

This project was made successful by:

- Baselining the existing system to determine system efficiencies
- Innovative use of available dual pressure control to reduce the average pressure
- Increase of storage receiver capacity
- Reduction of filter pressure differential
- Combining three separate systems into one well controlled system
- Use of timely technical advice and financial incentive to complete the project

CAC Training Available

Projects like this can by yours for the taking, all you have to do is apply some knowledge gained from a CAC training seminar. There are pre-qualified instructors available to help you host your own seminar. More information on CAC's many instructors is at http://www.compressedairchallenge.org/training/instructors/ BP

To read more ***Compressor Controls*** articles, visit www.airbestpractices.com/technology/compressor-controls

CAC® Instructor Profile

Ron Marshall
Industrial Systems Officer
Manitoba Hydro
360 Portage Ave (6)
Winnipeg, MB R3C2P4
Canada
Ph: 204-360-3658
rcmarshall@hydro.mb.ca

Ron Marshall C.E.T, C.E.M, has been employed with Manitoba Hydro, the crown owned electricity and gas utility in Manitoba, Canada since 1977. He is a Certified Engineering Technologist and has received certification as an Energy Manager, Demand Side Management and Measurement and Verification Professional through the Association of Energy Engineers.

Ron was the first Canadian participant to qualify as a DOE AIRMaster+ specialist. Ron has worked in the industrial compressed air field since 1995 as an Industrial Systems Officer for Manitoba Hydro's Customer Engineering Services Department. Ron is Manitoba Hydro's industrial compressed air systems expert and his efforts contribute to the utility's Power Smart Performance Optimization program, a utility incentive program that supports industrial customer energy audits and electrical and gas efficiency projects. Ron is a member of the Compressed Air Challenge's Project Development Committee and Chair of CAC's Marketing working group. Ron is a frequent contributor to various CAC related magazine articles.

RESOURCES FOR ENERGY ENGINEERS

TECHNOLOGY PICKS

Upgraded Standard Pneumatic Products Universal Autodual Controller

Air compressors smaller than 50 hp in size, particularly industrial reciprocating compressors, dominate the marketplace in the number of machines installed. Most of these operate air compressors operate with standard start/stop or constant-speed control and do not attempt high-efficiency operation.

Standard Pneumatic Products has been successfully innovating, for both new and aftermarket 50 hp and below compressor systems, with the patented Universal Autodual line of high-efficiency air compressor controllers since 1998. The compressor controller maximized the energy-efficiency of single or multiple (up to four units) reciprocating and rotary screw compressor systems.

The AutoSmart Controls feature automatic selection of either start/stop or automatic dual control (timed out), depending on the plant compressed air requirements, thereby operating the plant at its maximum efficiency. A compressor will never idle too long or start and stop too many times.

Automatic Lead/Lag Control automatically selects the lead machine and multiple lag positions based on the clock. The Universal Autodual controllers are available with or without starters. AutoSmart control on all multiple compressors indicates maximum efficiency operation for each individual machine. The controller will typically qualify a single compressor or multiple system for a utility rebate where available. The proprietary Mark III Microprocessor also includes:

- Unloaded Soft Starts
- Hour meters for each compressor
- Emergency shutdown with remote send-out
- Compressor automatic shut-off periods (weekends or nights)
- Pressure/Vacuum Controls. Pressure control by accurate pressure transducers and eliminates inaccurate, unreliable and problematic mechanical pressure switches.

Multiple vacuum pump systems are typically uncontrolled and operate all the pumps all the time. Using the Universal AutoDual Vacuum system controller when vacuum pressure is reached lag pumps are shut off and only come on when vacuum has deteriorated to a preset level. Energy savings is considerable and with reduced turning time maintenance periods are also reduced.

When installed on a new compressor, the Universal Autodual will easily connect to any existing reciprocating and some rotary screw compressors. Any reciprocating air compressor system, in the field, can easily be converted to high-efficiency operation by installing a Universal Autodual controller.

Multiple rotary screw compressors with standard mechanical pressure switches can readily be converted to automatic lead/lag operation by the use of the Universal AutoSync controller, an automatic lead/lag controller only.

The Universal AutoDual compressor controllers are designed and made in the USA and are installed in industrial and marine compressor plants worldwide.

Visit www.stdpneumatics.com, call tel: 203-270-1400, email: sales@stdpneumatics.com

TECHNOLOGY PICKS

New Kaeser TK-TM High Capacity Refrigerated Dryers

Kaeser Compressors, Inc. announces their new line of Modular High Capacity Refrigerated Dryers — the TK-TM series. These water-cooled dryers are the perfect solution for large compressed air systems and utilize digital scroll refrigeration technology to offer effective energy savings. The TK-TM series flow capacities can vary from 1250 scfm to 12,500 scfm, based on combinations of 2500 and 1250 scfm modules.

Each module has air-side isolation valves, a cooling water control valve, and cooling water isolation valves, allowing individual modules to be serviced without disrupting the system air flow. Service panels on the top, front, and back of each module make maintenance access quick and easy. Each has its own electrical disconnect switch, making it possible to safely service one module without de-energizing others.

Visit www.kaesernews.com/ModDryers or call (877) 586-2691

Atlas Copco Introduces New Nitrogen and Oxygen Generators

Atlas Copco introduced three ranges of nitrogen and oxygen generators for on-site gas generation. With these innovative gas generators, companies can expand their existing compressed air installation to generate their own nitrogen and oxygen. An independent supply of on-site gas can realize significant economies of scale as well as save on operational costs. Atlas Copco's new range of on-site gas generators are designed to meet the highest purity standards and run economically for both large and small applications.

On-site gas generation is more sustainable and cost-efficient than gas delivered in cylinders or bulk liquid supply, as it eliminates the operational and administrative costs of ordering, transporting, storing and delivering the bottles or bulk liquid into cryogenic tanks. With an independent supply of nitrogen and oxygen, companies' gas demand is always met in time, at the lowest cost. Koen Lauwers, Vice-President Marketing of Atlas Copco's Industrial Air Division comments: *"With these ranges of gas generators, our customers will dramatically increase their productivity. We help them to discover untapped saving potentials through economy of scale: combining their compressed air systems with the production of nitrogen and/or oxygen, serving their specific needs."*

Membrane nitrogen generators for easy, cost-efficient gas generation

Atlas Copco's membrane nitrogen generator (the NGM) is, thanks to its high efficiency and reliability, ideal for applications such as fire prevention, tire inflation, tank and pipeline cleaning, and many other oil and gas, mining and marine applications. The NGM uses membrane air separation to produce nitrogen. A bundle of polymer fiber acts as a membrane that allows nitrogen to pass and other gases (like oxygen, water vapor and

RESOURCES FOR ENERGY ENGINEERS

TECHNOLOGY PICKS

carbon dioxide) to permeate. Compressed air goes in at the inlet and enriched nitrogen comes out at the other end of your nitrogen generator. Membrane technology generates nitrogen with an adjustable purity and flows up to 500 m³/h.

PSA nitrogen generators for the highest purity

For those applications that demand high purities of nitrogen (up to 99,999%), the Nitrogen Generator (NGP) with PSA technology is the recommended solution. Based on the Pressure Swing Adsorption (PSA) technology, carbon molecular sieves adsorb oxygen molecules from compressed air. The Nitrogen Generator has two connected towers that work together to produce an almost continuous flow of nitrogen gas. The result: nitrogen purity levels up to 99,999% for flows up to 1100 Nm³/h. Typical applications of the NGP are packaging, plastic molding, metallurgy, purging analyzers, electronics, fruit storage and food and beverage.

PSA oxygen generators for reliable, on-site oxygen

Oxygen is vital to processes in the medical world, in waste water treatment, fish farming and ozone production. The OGP oxygen generator also makes use of PSA technology, with zeolite pellets that act as adsorbent. The output is oxygen with an adjustable purity between 90% and 95%, at flows up to 200 Nm³/h.

On-site nitrogen and oxygen as part of a total solution

Atlas Copco now offers on-site gas generators which can be directly combined with an existing compressed air installation. With an independent supply of nitrogen and oxygen, companies can start saving on the operational and administrative costs of bulk and cylinder gas delivery. These 3 ranges of nitrogen and oxygen generators offer exactly the flows and purities that different industrial applications need. This way, Atlas Copco becomes a one-stop-shop for compressed air, gas and service.

__Atlas Copco__ is an industrial group with world-leading positions in compressors, expanders and air treatment systems, construction and mining equipment, power tools and assembly systems. With innovative products and services, Atlas Copco delivers solutions for sustainable productivity. The company was founded in 1873, is based in Stockholm, Sweden, and has a global reach spanning more than 170 countries. In 2012, Atlas Copco had 39 800 employees and revenues of BSEK 90.5 (BEUR 10.5). Learn more at www.atlascopco.com.

__Industrial Air__ is a division within Atlas Copco's Compressor Technique business area. It develops, manufactures and markets oil-injected and oil-free air compressors, vacuum pumps, gas generators, air treatment solutions and compressor controls and monitoring under several brands. In addition to serving a wide variety of industries, dedicated solutions are also available for marine, railway and oil and gas customers. The division's focus and main drive is to further improve its customers' productivity. The divisional headquarters and main production center are located in Antwerp, Belgium.

Siemens Introduces Four-Weak Lead Time on Generation II Simotics® 1FK7 Servomotors

Siemens Industry, Inc. announces reduced lead times for its Generation II Simotics 1FK7 servomotors. Highly-configurable to suit a wide variety of applications, this new line features seven shaft heights, Quick-Connect power connector and high-accuracy 20- and 24-bit field replaceable encoders in 10 styles, all combined with a four-week lead time beginning July 1, 2013 — and ultimately reduced to three-weeks beginning January 1, 2014 on all models.

The Generation II servomotor offers three inertia versions — standard, high-dynamic for rapid acceleration jobs, and high-inertia for maximum smooth running. These motors are designed for operation without external cooling and the heat is dissipated through the motor surface. With 10 styles of field-replaceable encoders, the 1FK7 Generation II servomotors provide easy maintenance in the field, with reduced downtime and operating cost savings. Further, a 10 percent improvement in continuous (S-1) power is achieved since the encoders are mechanically and thermally decoupled from the motor. The mechanical decoupling also means the encoder is more resistant to vibration conditions on the machine. In addition, there is no need for battery back-up on the absolute encoders.

TECHNOLOGY PICKS

Generation II Simotics 1FK7 servomotors provide users with 3x overload, 2.5 percent torque ripple, cross profiling for easier mounting, Siemens Drive-Cliq interface for easier field commissioning and unit recognition with the Siemens Sinamics S120 drive family, plain shaft or keyway design, three IP ratings and are supplied with or without holding brake.

The full application engineering assistance and service of the global Siemens network supports this new line of servomotors.

For more information on these new Siemens servomotors, please visit www.usa.siemens.com/simotics

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Advertising & Editorial: Rod Smith
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Tel: 412-980-9901

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patricia@airbestpractices.com
Tel: 412-980-9902

A Publication of: Smith Onandia Communications LLC
217 Deer Meadow Drive
Pittsburgh, PA 15241

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THE MARKETPLACE

JOBS

Ingersoll Rand

SALES REPRESENTATIVE

DALLAS, TX

This position is responsible for driving market share growth of compressed air systems within key industries/markets in the North Texas and West Texas area with a large Dealer in West Texas. This includes quoting and strategizing, prospecting and developing relationships with key accounts to achieve revenue targets.

- Successful compressor sales experience is a must
- Bachelors Degree preferred
- Five years sales experience
- Excellent relationship-building skills

http://careers.ingersollrand.com/

FS ELLIOTT

AFTERMARKET TECHNICAL SALES REPRESENTATIVE

This individual is responsible for assisting in the development and managing the company's Aftermarket activities including business plans and sales activates in the assigned region. These responsibilities include building and maintaining relationships with the company's sales distributors, sales representatives and key account decision makers, early identification of opportunities, forecasting and the development of Strategic Sales Plans.

Interested candidates please submit resume to info@dareent.com

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SALES AND MARKETING MANAGER

Sales and Marketing Manager for specialized manufacturer located in Kittanning, PA. Reports to President and Board of Directors. Responsible for overseeing the successful growth and management of the sales and marketing functions. B.S. plus minimum of 5 years experience in sales / marketing in a manufacturing environment. Experience in Compressed Air Industry, Natural Gas or Renewable Resource markets preferred. Direct Hire. Resumes to: Joey Lerch, joeyl@specializedstaffinginc.com.

REGIONAL SALES MANAGER - EAST

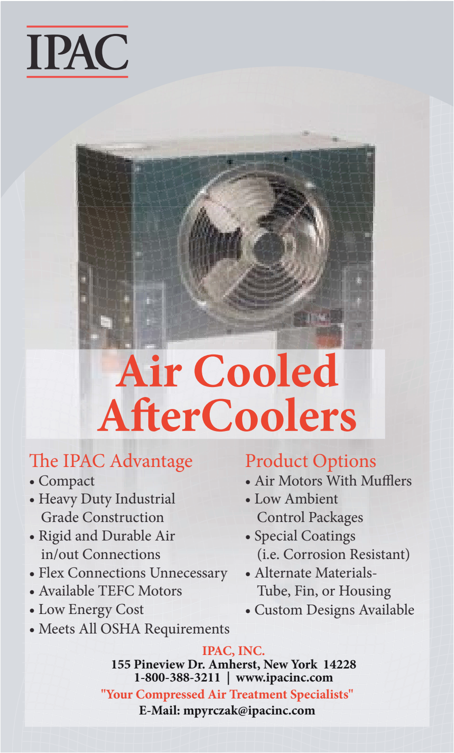
ENERGAIR, a world leader in supplying and implementing System Master Controls for compressed air networks, is looking for a Regional Sales Manager for the territory **East of the Mississippi River.** The successful candidate will be responsible for achieving regional sales goals through business development with new and existing distributor partners.

The Regional Sales Manager may reside anywhere within the territory and will be expected to travel extensively when not working from his or her home office. Experience in the compressed air industry is preferred.

Interested? Please send your resume with cover letter to nicolas.dedeken@energair.com

EnergAir

TECHNOLOGY



THE MARKETPLACE

TECHNOLOGY

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- *Networking Reception*
- *Awards Banquet*
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- *New Technologies Breakfast*
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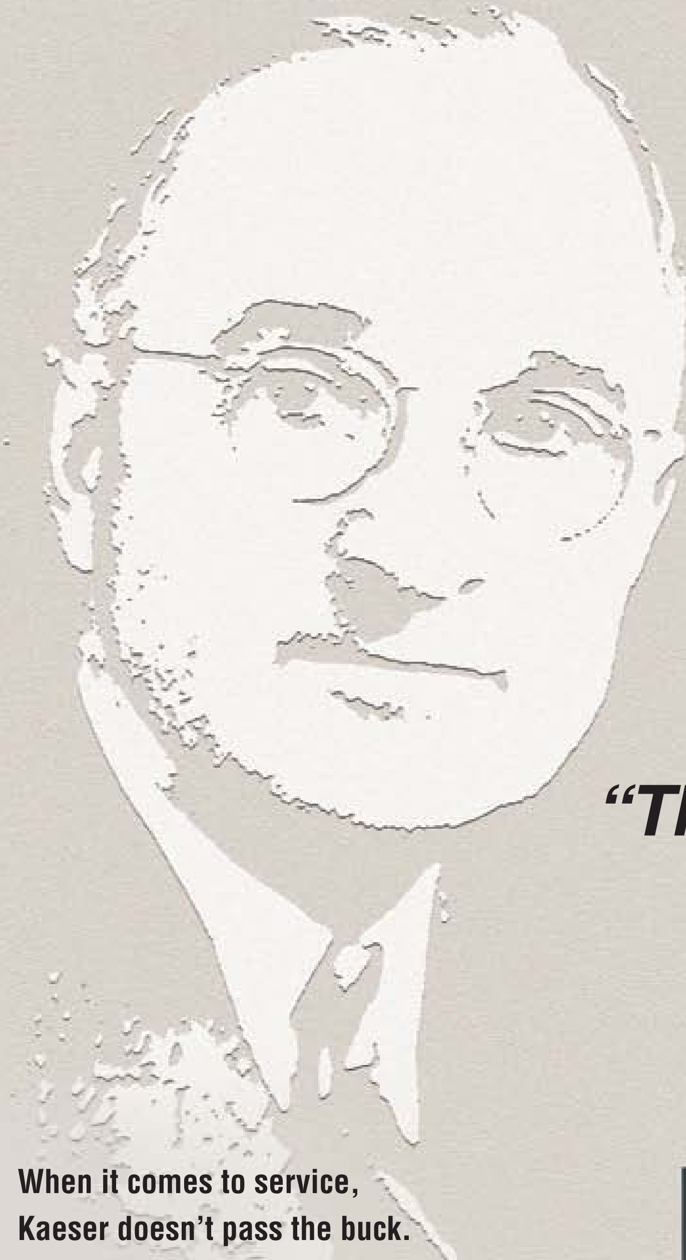

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