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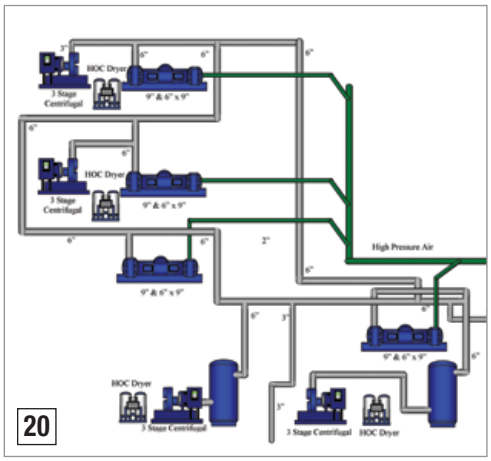

SAFETY & RELIABILITY

EVERY ISSUE

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FROM THE EDITOR

Thank You!

Our entire team would like to thank our subscribers for such a strong turn-out to the Best Practices 2022 EXPO & Conference, recently held in Atlanta. We had a record turnout of air compressor/chiller/vacuum system sales engineers and manufacturing plant personnel – the people for whom we dedicate our magazines and the event! The conference featured highly technical presentations, from over 60 expert speakers, and the trade show floor was extremely busy with exhibitors unveiling many new "world-premiere" technologies! Thanks to the momentum this strong attendance level has created, we now have momentum as we announce the unprecedented Best Practices 2023 EXPO & Conference co-location with Process Expo, in Chicago's McCormick Place, October 23-25, 2023 – start planning today!

High-tech electronics manufacturing is a demanding user of all the technologies we cover. SMC Corporation of America is a major supplier of pneumatic automation equipment to this market and the subject of our lead article, written by our own Mike Grennier. We thank SMC for allowing me to visit their magnificent campus in Indiana, to help with research for this article, and for their manufacturing and technology investments in the United States.

A different high-tech industry is the high-speed blow molding industry. Our thanks go to Hank van Ormer, from AP Energy, for his calculation-laden article titled, "PET Plants Using Boosters for High Pressure Air." This article will help those trying to figure out whether to use a booster to get to those higher pressures around 565 psig.

High-tech electronics manufacturing is a significant user of process vacuum systems. Bryan Jensen, from Rogers Machinery, has sent us an excellent article titled, "Boosting Process Vacuum Performance at a High-Tech Electronics Plant." I'll forewarn readers this is a long article, but I couldn't bring myself to remove a single section.

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

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Compressed Air Industry News

UCA to Supply Compressed Air to Imerys

Universal Compressed Air (UCA) is pleased to announce that it has entered an agreement with Imerys to provide PIPELINE AIR™ to their plant in Sylacauga.

UCA will design, build, own, operate and maintain a state-of-the-art facility to provide compressed dry air to Imerys.

UCA will design, build, own, operate and maintain a state-of-the-art facility to provide compressed dry air to Imerys under its long-term PIPELINE AIR™ performance contracting model. The PIPELINE AIR™ contract will combine UCA's compressed air supply expertise with oil-free dry air, a master control system and long-term performance guarantees. UCA will execute the design, construction, commissioning, startup, maintenance and operations of the new plant with startup expected in early 2023.

PIPELINE AIR™ is designed to allow companies to outsource compressed air needs as a utility, reduce energy and carbon footprint, preserve capital, and focus on their core business. UCA looks forward to supporting Imerys' goal of efficient and reliable compressed air.

About UCA

Universal Compressed Air is a privately-owned and thriving high-technology business in Pennsylvania's Lehigh Valley focused on compressed air systems for industry. UCA brings decades of Industrial Gas expertise to Compressed Air Supply Systems. The systems are optimized to deliver compressed air as a utility and, in every case, an efficient and reliable solution will be designed and built to maximize savings. As a compressed air supplier, the systems are proven, trusted, and designed to optimize the end user's success. For more information, visit https://universalcompressedair.com/.

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Compressed Air Industry News

Frank Notz, Festo Management Board Member; Bill Gerbig, President of Ralph W. Earl; and Mark Snyder, Director of Festo North America Channel Management (left to right).

Festo Marks 50 Years in the U.S. with Major Expansions

Festo U.S., celebrating its 50th anniversary year, announces expansion plans for its 47-acre campus in Mason, Ohio. A new production facility and the expanded research and development center will be dedicated to U.S.-centric automation components, systems, and solutions. Festo, a $3 billion family-owned company, is a global innovation leader in pneumatic and electric automation systems.

The campus, 30 miles north of Cincinnati, will be the site of a new Festo Global Production Center (GPC), the designation for the company's most advanced automated manufacturing facilities. The GPC will focus on flexible automation in a direct response

to Festo customers who want custom solutions that serve to maximize performance and differentiate their machines and systems from the competition.

The Mason GPC is scheduled to begin production by year end and will be the first of its kind in North America for Festo and the twelfth within the company. The most recent GPC was dedicated in Suncun, China, in 2019 and is a leader in high-volume automated production.

The Mason campus is also the location of the newly expanded Festo Technology Engineering Center (TEC). The expansion is expected to be complete by the end of September. Festo TECs are research and development centers where customers collaborate with Festo personnel to co-develop solutions. Festo personnel also engage in market-focused product and system development at a TEC.

This is the second Festo TEC in the U.S. The first facility opened in 2018 in Billerica, Mass., and is devoted to Life Science solutions, including precision liquid handling and mechatronic systems for high-speed automated laboratory equipment. Personnel at the Billerica TEC developed solutions for automating COVID vaccine production and high-speed automated testing for COVID infections.

The 47-acre Festo Mason campus is currently comprised of three buildings totaling 565,000 square feet. The seven-year-old complex houses the Festo North America logistics and warehouse center. This fully automated replenishment and inventory facility receives, stores, and ships a large selection of the 30,000-item Festo catalog throughout North America. Systems within the center can pick 10,000 products per day without an error. The storage capacity end-to-end is 35 miles long with automated material handling equipment that can accelerate faster than a sports car.

The Mason campus is also the site of the Festo North America production center where products are assembled and customized. These products include valve terminals, gantry robots, robotic surgical arms, automated pipettes for laboratory devices, and systems for semiconductor manufacture to name a few. Personnel at the production center have the expertise and the digitized systems available that enable a high level of customization. The new GPC will expand these capabilities exponentially through flexible automation.

Festo Didactic North America recently relocated to the Mason facility. Festo Didactic supports educators, educational institutions, and industries to develop the workforce of today and tomorrow through both hands-on and digital learning experiences.

"As Festo builds on its remarkable past as an automation innovator, we confidently forge ahead toward the future," said Carlos Miranda, CEO, Festo Business Region North America. "Festo U.S. is growing year over year. We are penetrating new markets as we continue to build on our strong position in the U.S.

"The post-Covid world is changing," Miranda said. "Supply-chain issues and other disruptions are causing regionalization and localization to rise. This means the U.S. must expand manufacturing. With a shortage of skilled labor, automated production and

Compressed Air Industry News

training of automation technicians will play an increasing role in U.S. manufacturing growth. As an automation provider and training specialist, Festo's mission is to support our customers in becoming more productive, more efficient, and more competitive."

Festo was founded in 1925 by Gottlieb Stoll in Esslingen, Germany, near Stuttgart. Festo started as a machine shop that manufactured specialized woodworking machinery. In 1950, Gottlieb's son, Kurt, realized the potential of pneumatics while at a U.S. trade show. Rapid growth followed due to the company's capabilities in automation.

Festo U.S. was established in Port Washington, New York, in 1972 to provide parts and services for the company's woodworking equipment and line of pneumatic automation components. Eleven years later Festo U.S. began producing pneumatic cylinders in the U.S. and launched mobile showrooms that demonstrated the company's automation technology. Investments in distribution, manufacturing, personnel development, and training steadily followed from then to now.

In the 2000s, Festo U.S. has come into its own as one of the most respected automation suppliers in the United States based on the expertise of its people, the quality of its products, and its innovations in training, distribution, e-commerce, and custom solutions. Festo U.S. headquarters is located in Islandia, New York, on Long Island.

"Being an automation provider requires more than just supplying components," Miranda said. "Competitiveness for our customers means aiding them in lowering engineering costs and speeding time to market. Adding value requires a supplier that can speak intelligently with customers about their markets and applications in order to offer the components and solutions that are suitable for their end-use customers. Everyone who engages with Festo U.S. knows these are our qualities."

Currently Festo U.S. is developing automated solutions for the commercial space industry, electric vehicle manufacture, warehouse automation, and the fast-food industry. Festo U.S. continues to support industries already using automation for assembly, testing, food and beverage processing, packaging, and automotive manufacturing to name just a few.

As part of its 50th Anniversary, Festo U.S. held a gala in Cincinnati, Ohio, in July and will host a second celebration in New York City in October. Members of the Stoll family, government dignitaries, customers, distributors, and team members will attend.

About Festo

Festo is a leading manufacturer of pneumatic and electromechanical systems, components, and controls for process and industrial automation. Celebrating 50 years in the U.S., Festo Corporation has continuously elevated the state of manufacturing with innovations and optimized motion control solutions that deliver higher performing, more profitable automated manufacturing and processing equipment. Through advanced technical and industrial education, Festo Didactic Learning Systems and its partners prepare workers for current and future manufacturing technologies. For more information, visit www.festo.us.

Atlas Copco Acquires Oxymat

Atlas Copco has acquired Oxymat A/S, a Danish supplier of on-site oxygen and nitrogen solutions. Oxymat is a privately owned company headquartered in Helsinge, Denmark, with production facilities in Denmark and Slovakia. The company has 146 employees, and in 2021, they had revenues of approximately MDKK 301 (MSEK 411*).

Oxymat specializes in on-site gas generation solutions for a wide range of industries including aquaculture, water treatment, medical, marine and mining. By converting bulk or cylinder supply of gas to on-site generation, the need of frequent truck transport can be avoided, thereby reducing the carbon footprint.

"Oxymat is a strong brand with a global presence in on-site nitrogen and oxygen markets," said Vagner Rego, Business Area President Compressor Technique. "Their product portfolio and knowledge in industrial gas generation make them a good fit for us."

The purchase price is not disclosed. The acquired business will become part of the Industrial Air division within the Compressor Technique Business Area.

About Atlas Copco Group

Our industrial ideas empower our customers to grow and drive society forward. This is how we create a better tomorrow. Atlas Copco is a global industrial group, founded in 1873 in Stockholm. In 2021 we had revenues of BSEK 111 and at year end about 43 000 employees. For more information: www.atlascopcogroup.com.

CAGI Launches New Website

The Compressed Air & Gas Institute (CAGI) is pleased to announce the launch of the new CAGI website. It was redesigned to be modern and mobile-friendly. Improved functionality and navigation will help visitors find information more easily.

The website is a robust repository of educational and technical resources, including how to optimize compressed air systems, determining the cost of compressed air, selecting the right compressed air equipment, and much more.

Share the URL with others in your organization so they have a direct link to valuable educational material on compressed air systems.

CAGI Compressed Air & Gas Institute www.cagi.org

About the Compressed Air and Gas Institute

For more than 100 years, the Compressed Air and Gas Institute has been the leading source on all matters related to compressed air. As the united voice of the Compressed Air Industry, CAGI commits to developing educational material to benefit the users and producers of compressed air. For more information, visit www.cagi.org.

Compressed Air Industry News

Ingersoll Rand to Acquire SPX FLOW's Air Treatment Business

Ingersoll Rand Inc., a global provider of mission-critical flow creation and industrial solutions, has entered into an agreement to acquire SPX FLOW's Air Treatment business for approximately $525 million.

With expected revenue of approximately $180 million in 2022, the Air Treatment business is a leading manufacturer of reliable and energy efficient desiccant and refrigerated dryers, filtration systems and purifiers for dehydration in compressed air. The business has manufacturing capabilities in the U.S., Germany and South Korea with nearly 500 employees and goes to market through the highly recognized brands of Hankison®, Pneumatic Products®, Jemaco, Deltech® and Delair®.

"We are excited to welcome the SPX FLOW Air Treatment team into the Ingersoll Rand family," said Vicente Reynal, chairman and chief executive officer of Ingersoll Rand. "Our customers lean on us to deliver innovative technologies that drive reliability, efficiency, performance and excellence. Compressed air dryer and filtration equipment helps increase the production and process reliability of the compressor and continues our strategy of expanding our product offerings in the broader compressor ecosystem. The business is highly complementary and we expect it to be driven by the same sustainability trends that we see as a tailwind for our compressor business."

Reynal said, "Not only does the acquisition add a highly complementary product portfolio, nearly half of its revenue is from recurring aftermarket offerings – one of our critical strategic acquisition criteria. We expect the strong strategic fit to quickly yield adjusted EBITDA margins accretive to the IT&S segment and drive significant synergies that are expected to result in adjusted EBITDA margins greater than 30% by year three."

"I'd like to thank the team for their dedication in developing a high-quality business and for their commitment to serving customers," said Marc Michael, president and chief executive officer of SPX FLOW. "Being a part of Ingersoll Rand is an exciting next step for the business."

The all-cash transaction is expected to close in the fourth quarter upon obtaining required regulatory approvals. Upon transaction close, the SPX FLOW Air Treatment business will join Ingersoll Rand's IT&S segment.

About Ingersoll Rand

Ingersoll Rand Inc., driven by an entrepreneurial spirit and ownership mindset, is dedicated to helping make life better for our employees, customers and communities. Customers lean on us for our technology-driven excellence in mission-critical flow creation and industrial solutions across 40+ respected brands where our products and services excel in the most complex and harsh conditions. Our employees develop customers for life through their daily commitment to expertise, productivity and efficiency. For more information, visit www.IRCO.com.

Energetics Compressed Air Expands Territory

Energetics Compressed Air, a division of EMS Industrial, was recently selected by Gardner Denver to acquire additional territory as an authorized distributor through the entire state of Wisconsin, upper Michigan, and parts of Iowa and Illinois.

Energetics Compressed Air
A Division of EMS Industrial, Inc.

Energetics Compressed Air has been a proud distributor of Gardner Denver air compressors since 1975. The company offers sales, parts and service support on all Gardner Denver compressed air products, as well as parts and service for all other major brands. Energetics serves its customers through its five locations in Madison, Janesville, Milwaukee and Appleton, Wisconsin; and Dubuque, Iowa.

"Energetics Compressed Air is excited to now offer Gardner Denver products and service to all of our customers throughout the Midwest," said Pat Troge, Compressor Sales Manager, Energetics Compressed Air.

About EMS Industrial

EMS was established in Madison in 1933 by Carl Sutherland Sr. and his wife Magda. We are still family owned-third generation and we have since grown to over 100 employees and five locations. We are committed to providing excellent on-time and quality electric motor repair services, solutions and new products to our customers. We also offer engineering services, predictive maintenance services, compressor repair and service, on-site repairs and panel building services. For more information, visit www.emsindustrial.com.

Brehob Welcomes Denver Caudill to Air Compressor Division

Indianapolis-based Brehob Corp. has hired Denver Caudill to join its air compressor division. He will support customers in the manufacturer-dense Columbus, Ohio territory – serving companies from Mansfield in the north and Circleville in the south, and from Marysville to the Ohio River.

Caudill brings a tested background in sales to the role. In his more than 10 years as a sales manager for Clayton Homes he won 27 awards, including the company's Circle Award – an award given for being in the top 10% of sales. Caudill is eager to help Brehob grow its services in this largely untapped, opportunity-rich territory.

"Five years from now, I want to look back and say, look at what we turned this market into. I want to grow this market," said Denvir Caudill.

Caudill is a graduate of University of Louisville, where he studied occupational training and development. He is also a U.S. Army Sergeant and former tank commander.

About Brehob

With operations in seven cities and four states, Brehob has been a one-stop shop for industrial equipment service needs since 1953. From motors to maintenance, compressors to customer service, and hoist to help, Brehob has the machines, resources and expertise to help your business run smoothly and efficiently, while keeping your downtime down and your bottom line strong. Learn more at brehob.com.

OTC & Quincy Partner to Expand into Southwestern U.S.

OTC Industrial Technologies (OTC), an industrial equipment service provider and distributor headquartered in Columbus, OH, partnered with Quincy Compressors in the expansion of two OTC locations in Phoenix, AZ and Las Vegas, NV. Quincy Compressors is a leading manufacturer of reciprocating and rotary screw air compressors headquartered in Bay Minette, AL.

Due to the continuing success between OTC and Quincy, the opportunity has been identified to align strategic focus and deepen the partnership. With expansion into the Southwest U.S., OTC's geographic presence in the region will continue to amplify. This investment also supports Quincy's market growth in a key territory. With this newest collaboration, OTC and Quincy, will be poised to deliver superior solutions to customers in the Southwest U.S.

"I'm very excited to gain a footprint in the Southwest compressed air market. Partnering with Quincy over the past five years has been an outstanding experience," said Daniel Knapp, Director of Sales, OTC. "I have no doubt we will see the same success as we enter Arizona and Southern Nevada. We're excited to not only expand our compressed air distribution business, but leverage resources to grow our DIRECTAIR solution in the Western portion of the US. It's a fun time to be a part of the OTC family."

"As OTC continues to expand west, partnering with Quincy provides opportunities to offer best in class support for compressed air services for Arizona and Nevada," said Adam Gibbs, President – Air Supply, OTC. "With Quincy's full line of compressed air products and OTC's vast expertise, I have no doubt we will have a winning combination well suited to help the industrial market grow in the Southwest."

"This is a great opportunity for Quincy Compressor to build upon our relationship with a fantastic partner in the Southwest U.S. After five successful years of collaboration in the Southeast, this new Quincy/OTC venture is a win for both of us, ensuring a high level of satisfaction for compressed air customers in this market. Great time to expand our footprint with a consistently successful organization. We're very excited to see this grow!" said Chris Scarborough, Vice President – Distribution, Quincy Compressors.

About OTC Industrial Technologies

Established in 1963, OTC Industrial Technologies is one of the largest industrial distributors and service providers in the United States. OTC provides expert solutions for industrial motion control, factory automation, fluid power, pumping systems, spray finishing, power transmission, and compressed air systems. OTC operates a broad geographical footprint and delivers value to customers through its primary operating brands and divisions. For more information, visit otcindustrial.com.

SMC Innovates Pneumatic Solutions for Sustainable Automation

By Mike Grennier, Compressed Air Best Practices® Magazine

Located in Noblesville, Indiana, SMC Corporation of America's campus encompasses 2.6 million square feet of manufacturing and warehouse space.

Manufacturers looking to optimize their compressed air systems to further protect the environment and improve profitability are increasingly turning to solutions in the form of pneumatics. And thanks to industry leaders like SMC Corporation of America, they're having success.

SMC delivers not only solutions but innovation and expertise in pneumatic systems in order to ensure automated production equipment uses less compressed air and delivers peak performance in the process.

Exponential Growth in North America

Headquartered in Noblesville, Indiana, SMC Corporation of America (www.smcusa.com) has grown exponentially since the company began operations in the United States in 1977. Today, the Noblesville campus occupies 345 acres and encompasses 2.6 million square feet of manufacturing and warehouse space.

Manufacturing areas at the campus feature a host of technological advancements, including an assortment of CNC machines and multiple cleanrooms engineered to manufacture pneumatic assemblies for use in high-tech industries. Recent investments, meanwhile, include the addition of a one-million-square-foot distribution facility to the campus. The state-of-the-art distribution center features an AutoStore™ storage and retrieval system. The new system manages 128,000 bins with a full grid storage capacity of 161,000 bins and is supported by 64 robots, 12 picking ports, five receiving ports, four automated carton erectors, and 8,842 feet of new conveyor lines.

The new warehouse facility, like a number of other company initiatives, is designed to enhance customer service, said Andy Thedjoprasetyono, New Product Marketing Manager of SMC Corporation of America.

"The facility contributes to our goal of growth in North America and the improvement of ensuring on-time deliveries for our customers and partners," Thedjoprasetyono said. In all, SMC Corporation of America employs 1,500 people in North America.

Taking a cue from its parent company in Japan, the Noblesville operation is also committed to

SMC Corporation of America's state-of-the-art distribution center features a technically advanced storage and retrieval system.

sustainability in every aspect of business, said Tak Takahashi, Special Projects Manager, SMC Corporation of America.

Takahashi points to the company's ongoing initiatives to manufacture automated control equipment products that deliver improved energy conservation performance with reduced size and weight. Takahashi said the initiative contributes to SMC Corporation's global sustainability goals, as well as those of its customers.

"We're deliberately using the least amount of material in our products for the function, while also ensuring the same products deliver quality performance," Takahashi said. "Lower weight also contributes to the efficiency of the automated production equipment where it's used."

Multiple Factors Fuel Interest in Pneumatics

Efficiencies in the form of less compressed air use, coupled with optimal performance, is the goal, said Jon Jensen, Energy Conservation Manager, SMC Corporation of America.

Jensen, who chaired a session on "Improving Industrial Energy and Water Conservation" at the Best Practices EXPO 2022 in Atlanta, Georgia, in October, said there are multiple reasons behind the growing interest in innovative pneumatic methodologies and technologies as a way to reduce compressed air consumption and improve efficiencies in automated production equipment.

"Some of it goes back to the corporate pronouncements where companies have said things like, `We'll reduce our CO_2 footprint by 2030,'" Jensen said. "Consumer goods companies and especially food producers want to be seen as green. Plus, there's the economic benefit since the cost of air per item produced can be lowered."

The level of sophistication in compressed air best practices and production equipment optimization is also increasing, Jensen said. To that end, he said many companies have compressed air systems in place that are highly capable of efficiently delivering a supply of compressed air. In many cases, he said the focus is now on the demand side of the compressed air equation.

"Some are far enough down the road where they have Variable Speed Drive (VSD) air compressors and a flexible system with a main control that handles their air compressors," he said regarding a common configuration for an efficient compressed air system. "The next target is reducing demand for air with each machine on the factory floor. "

Pneumatic Strategies and Methods Abound

From adjustments in pressure delivered at each machine to more efficiently designed production equipment with advanced pneumatics at the outset, the possibilities for reductions in compressed air use and energy savings throughout a manufacturing plant are as diverse as they are plentiful.

"Sometimes, it's simply getting the right pressure in the right place," Jensen said, as an example of a strategy that involves the right mix of expertise and innovation. Another is the

SMC Innovates Pneumatic Solutions for Sustainable Automation

use of technology to reduce the pressure on the non-working side of a cylinder. "A linear actuator or cylinder doesn't often need the same force in both directions. Adjusting the pressure from the working stroke to the non-working stroke is a technology that's very easy to employ."

The application of two-pressure pneumatic circuits is an example of how companies can take things even further to achieve efficiencies and energy savings, Jensen said.

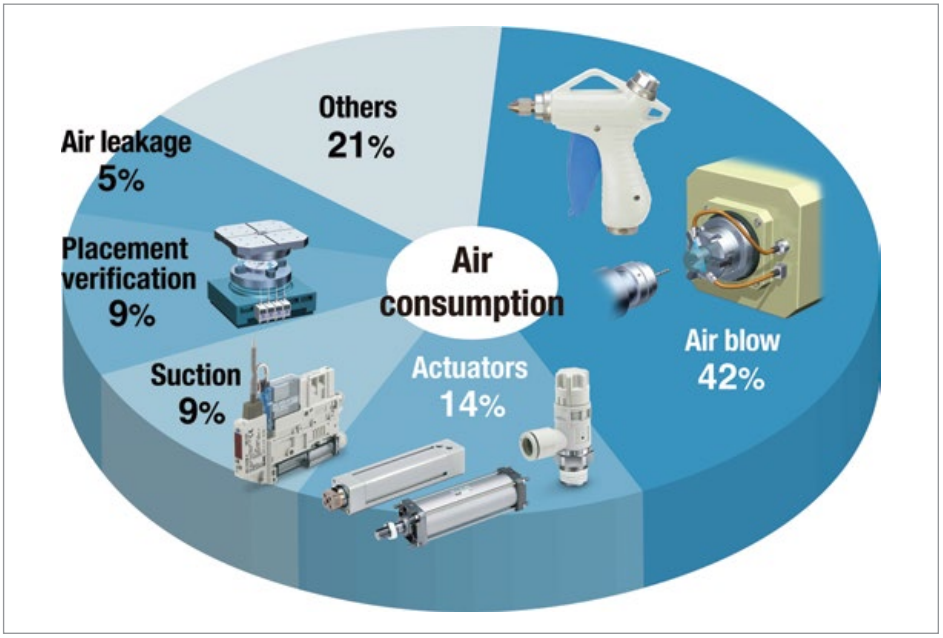
"We're moving toward not only adjusting the return stroke pressure, but we're in the development of ways to recirculate the working stroke high pressure and recirculating it to retract the cylinder with no additional air. We're building those into the actuator so it's easier to employ," he said.

Jensen cited pneumatic cylinder bore sizes as another innovative approach to reducing air consumption. Often, it's as easy as "rightsizing," he said.

"Traditionally, there are standard bore sizes, and a designer might say, 'If I need a certain force, I might go to the next size actuator because it makes me more comfortable,' " Jensen said. However, he said, going to larger bore sizes that require more air isn't always necessary. "If the 40-millimeter bore is too small and the 50-milimeter bore is too large, we make a 45-millimeter bore. If you're designing a machine, why not have exactly the right size?"

In addition to a plethora of techniques with actuators and cylinders are numerous innovations involving pneumatic valves to reduce energy consumption. One example, he said, are valve configurations that reduce or eliminate compressed air use when a machine is idle.

"Can machine pressure be removed when the machine is idle? That has been key," he said regarding valving technology that can be designed into production equipment to accomplish it. "Or maybe it's not feasible to zero pressure when the machine is idle.



SMC develops eco-friendly pneumatic technologies designed to reduce air consumption in a variety of applications.

But if we can go from 80 psi to 30 psi or 20 psi when the machine is idle, then that reduces usage right there."

The Advent of the "Four-Bar Factory"

Whether the technology is engineered into automated production equipment or retrofitted to existing machines, the use of advanced pneumatics generates incremental savings that add up – especially given the general rule of thumb that 1% of required brake horsepower (bhp) is conserved for every two psi of pressure reduced.

And while Jensen is quick to point out the general energy savings rule is contingent upon a number of factors associated with the supply side of compressed air in addition to the demand side of things, SMC Corporation of America is seeing companies achieve significant results.

Jensen says some companies in Europe have succeeded in operating "Four-Bar Factories," which means overall plant pressure required for normal operation is four bars (approximately 60 psi) versus pressures that can range anywhere from 90-125 psi.

"The amount of savings, of course, depends on how compressed air is produced. But in many cases, dropping pressure by 15 psi generally results in around seven to eight percent less power being needed in the air compressor room," he says. Another caveat, he says, is the production machinery itself.

Air-saving cylinders developed by SMC supply the non-working side of the cylinders with air exhausted from the working side of the units to achieve energy savings.

"Those looking into a Four-Bar Factory initiative understand it's going to require

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machine rework," Jensen says. "You're not likely to be able to simply turn down the regulator at the machine level without affecting performance. But we've had success with it."

Collaboration and Measurement Key

Jensen said implementation of pneumatic systems on the scale of a Four-Bar Factory, as well as any other results-driven initiative, requires collaboration among all involved – including compressed air users and machine designers/builders in addition to the suppliers of pneumatic systems.

"It requires a lot of three-way and four-way meetings to get all stakeholders on board and engaged with the process, "Jensen says, adding that someone in the C-suite typically serves as the driving force behind the process.

"A corporate energy manager tasked with reducing energy realizes that one of the targets for that is compressed air," Jensen says as an example. "Then, the energy folks get to the operations people involved, and they look at specific targets. They then bring in the OEM to make sure changes don't affect performance. It really becomes a collaborative process."

Improvements also hinge on the monitoring and measurement of compressed air use. Jensen noted the company's Air Management System as an example. The technology monitors and measures pressure, airflow, and temperature to provide efficient process control and reduce demand on air compressors. The data it provides can also be used to improve production machine uptime.

"Reducing flow requires the production of less air," Jensen said, adding that airflow monitoring also contributes to predictive maintenance. "Most pneumatic failures can be predicted by a leak. If average flow is going up by 10 or 20 percent, you know something has happened."

Monitoring also prevents the potential for air compressors striving to meet artificial demand, he said.

"Raising pressure, of course, adds to flow. But if we haven't raised the pressure to produce any more product, it's compensating for something in the machine. Pressure and flow need to be monitored, and by doing so you can prevent unplanned downtime. We're definitely starting to see interest in data that will let you know what's happening at each machine."

A Combination for Success

Combining a host of innovative technologies with thought-leadership in the application of pneumatic systems has clearly led to success for SMC Corporation of America. With a laser focus on sustainably meeting the increased need for automation – and doing so with pneumatic systems that enhance production with optimal use of compressed air – there is little doubt the company will prosper in the years and decades ahead. BP

All photos courtesy of SMC Corporation of America.

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PET Plants Using Boosters for High Pressure Air

By Hank van Ormer, Technical Director, AP Energy

➤The use of high performance boosters to raise low pressure air (100 psig) to high pressure air (500-600 psig) for blow molders is very power efficient and offers good operating performance and reliability when well applied.

Selecting A Booster

How many stages? From a durability standpoint, the booster should be selected to handle the required volume of air (scfm) and raise it to the final discharge pressure (nominal 550 psig) from the nominal inlet pressure (115 psig) with reasonable compression ratios per stage (2.5 to 3.5 ratios per stage).

With the above example the CR (compression ratios) would be:

- Final pressure (550 psia +14.5 psia) = 564.5 psia ÷ Inlet pressure (115 psia + 14.5 psia) = 129.5 psia or 4.36 compression ratio, which is somewhat high using a single stage unit for continuous industrial duty.

- This is about 2.09 compression ratios each in a 2-stage booster (square root of 4.36) and is very conservative and well applied.

Other Considerations: There are other considerations that the booster manufacturer will consider in recommending a unit for this application such as:

- Rod load acceptability
- Cooling capability
- Proper valve action and operation

What Size Booster-What Basic Layout?

The size selection is dependent on the basic demand profile. For example, apply one primary air compressor for each booster and separate low pressure air compressors to serve the low pressure system -or- put all the low pressure air into one central low pressure supply (headers and receivers) and allow the boosters to pull the air as needed with the remainder of the low pressure air serving the low pressure system.

Dedicated primary air compressors for each booster offers a very safe design as the low pressure air supply will always be there for the booster or both will be off. The booster has very little chance of receiving too low entry pressure entry air with potential damaging results. It probably will not have optimum power efficiency.

Properly installed, a well designed central low pressure compressed air supply collected together offers a great deal of flexibility and ability to optimize both low and high pressure electrical energy operating costs.

Primary low pressure can be selected for performance and suitability rather than have the size limited by the booster inlet capacity. Larger horsepower well applied 3-stage centrifugals will generally be more power efficient than smaller units.

During emergencies, low pressure rental compressors can be tied in without affecting the high pressure air input. Efficient low pressure air supply will also improve the operating efficiency of the low pressure system.

Boosters can be selected on operating performance rather than convenient sizing. The most commonly used boosters for these applications would be 2-stage double-acting, horizontal balance opposed, water-cooled reciprocating compressors.

Booster Size and Efficiency

Usually a larger unit will be more power efficient. For example:

- A typical 150-hp class, 2-stage, 7" & 4" x 74 unit at about 485 rpm will deliver about 648 scfm (.82VE) at 143 BHP, at 600 psig (5.74 scfm/kw).

PET Plants Using Boosters for High Pressure Air

- A typical 300-hp class, 2-stage, 9" & 6" x 9" unit at 429 rpm will deliver about 1884 scfm at (.90VE) 291 BHP at 600 psig (8.202 scfm/kw).

The larger reciprocating unit has a better VE (Volumetric Efficiency) and overall is 30% more power efficient (5.74 scfm/kW ÷ 8.202 scfm/kW). With the exibility of a central low pressure supply the proper booster selection can have a very positive impact.

A single central low pressure supply system requires careful piping and storage design. Be sure there is plenty of supply for both the low and high pressure requirements. All boosters should be equipped with low inlet pressure safety controls.

Table 1 shows the relative efficiency of a 3-stage low pressure centrifugal primary combined with 9" & 6" x 9" booster compared to traditional 4-stage centrifugal and 4-stage double-acting reciprocating unit.

Summary

Well applied primary compressor and boosters deliver about the same operational efficiencies ($176.92 scfm/yr) as the 4-stage double acting reciprocating high pressure unit (179.54 scfm/yr). The 4-stage reciprocating unit use 2.55 ratios per stage compared to the 2.09 CR per stage of the booster. Properly applied, both are well within limits. Either of theses units are about 25% more power efficient than a typical 4-stage high pressure centrifugal under the same conditions. The centrifugal offers some other significant benefits in initial cost, projected maintenance cost, and installation cost.

Qualifying this part of the application requires significant investigation. However, a properly selected and applied booster can be an excellent choice as would any of the other

	Primary to Booster		Atmospheric to High Pressure	
	Three Stage Centrifugal	2 Stage Double Acting Booster	Four Stage Centrifugal	4 Stage Double Acting Recip.
Model	Typical	9' & 6" x 9"	Typical	Typical
Unit Type	Centrifugal 3-stage	TS Double-acting	Centrifugal 4-stage	Balanced opposed
Inlet Pressure (psig)	14.5 psia	115 psig	14.5 psia	14.5 psia
Full Load Horsepower (bhp)	421	291	855.8	624.7
Full Load Motor Efficiency (.me) (est)	.95	.945	.93	.93
Full Load Pressure (psig)	115	600	600	600
Full Load (input) kW at 600 psig: Calculated	330.5 kW	229.7 kW	686.5 kW	465.6 kW
Full Load Specific Power (scfm/kW)	5.7 scfm/kW	8.202 scfm/kW	2.48 scfm/kW	3.31 scfm/kW
Flow Each at Rated PSIG	1,884 scfm	1,884 scfm	1,704 scfm	1,543 scfm
Total Input kW Combined	560.2		686.5	465.6
Specific Power (scfm/kW) Combined	3.36 scfm/kW		2.48 scfm/kW	3.31 scfm/kW
Annual Electric Cost ($/scfm) at 600 psig	$176.92 scfm/yr		$239.71 scfm/yr	$179.54 scfm/yr

Based on $0.07 / kWh operating for 8,500 hours per year.

Table 1. Comparison of Primary to Booster and High Pressure Compressor Ratings

options, depending on the installation and maintenance situation.

Installation Guidelines for Booster Applications

Check Valves: A high quality check valve should be installed on the inlet to and the discharge from the booster compressor.

The inlet check valve, which would be installed up stream of a pulsation tank, or receiver tank on the inlet line to the booster, will stop the pulses from entering the main distribution line from the centrifugals and having a negative effect on the controls. It will also protect the main air system from any high pressure "back feed" if there are inlet valve problems with the booster.

The discharge check valve, which should be installed down stream of a pulsation tank or receiver tank, will stop any high pressure air from bleeding back into the booster when the machine unloads. This is an extra precaution, in case of a leaking discharge valve on the booster.

With the inlet check valve upstream of a receiver and the discharge check valve downstream of a receiver, correctly selected valves should not cause any abnormal maintenance problems. The receivers will dampen most of the pulsations going to and coming from the booster compressor.

Inlet (low pressure) check valves (be sure to check with vendor):

- May be designed for 2 psid on 2000 scfm of air at 134.5 psia of pulsating flow
- Discharge (high pressure) check valve

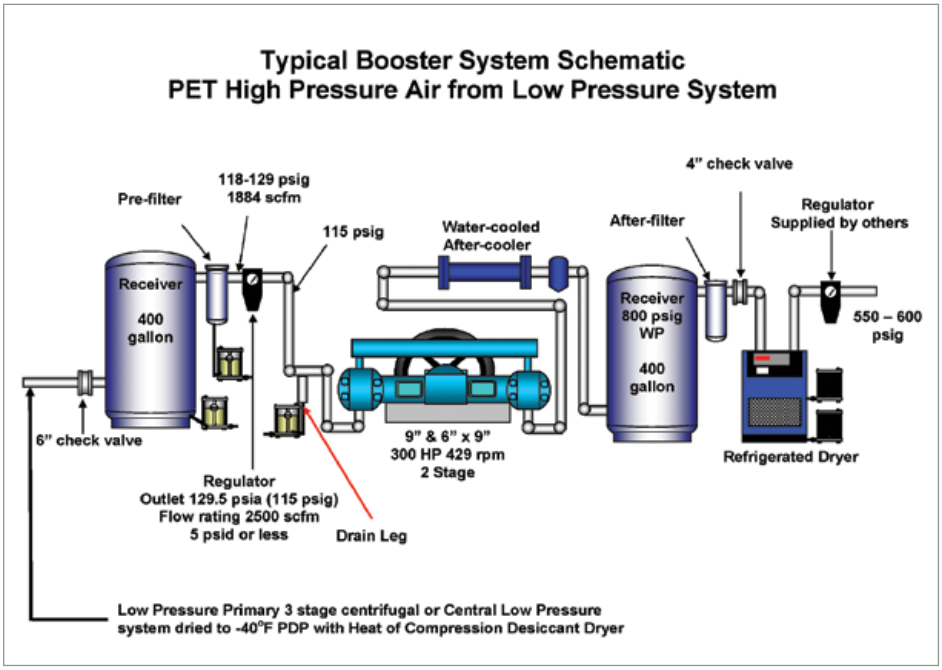

Figure 1. Installation Guidelines for Booster Applications

PET Plants Using Boosters for High Pressure Air

- May be designed for 2.1 psid on 2000 scfm of air at 614.7 psia of pulsating flow
- Materials – as recommended by vendors

Pulsation Tanks (Receiver Tanks)

The receiver tanks will slow down the air and dampen the pulses of the booster compressor. On a reciprocating compressor, there is about a 10% change in pressure on the inlet and discharge of the unit. This is caused by the inlet air filling the cylinder and by the discharge air leaving the compressor.

The receivers allow the pressure changes to occur in them instead of the piping. This is critical on the inlet to the booster, to not allow the pulses to possibly back pressure the centrifugal and cause it to surge. The discharge receiver will allow the regulator to receive a relatively stable flow of air with minimal fluctuations in pressure.

Air Receivers Example

- Inlet (low pressure) – 400-gallon vertical receiver with a 200 psi MWP with a 200 psig rated safety valve – gauge and automatic condensate drain.
- Note: 200 psig is standard in the 400-gallon class receiver and is recommended in case of a back pressure problem.

Discharge (high pressure) – 400-gallon vertical receiver with a 800 psi MWP, with a 800 psi rated safety valve, gauge and appropriate automatic condensate drain (high pressure).

Final Specification

There should be an inlet and discharge regulator installed in the booster system.

The inlet regulator is there to provide a consistent pressure to the booster. If the pressure is too low, it will create too many compression ratios and

potentially cause damage. If the inlet pressure is too high, it may cause internal damage to the unit and excessive heat.

This also allows the piping and receivers to create effective storage to handle random spike demands caused by the many pulses per minute in both directions.

The discharge regulator is there to provide a constant pressure to the process. The constant pressure will allow the process to operate more effectively with the regulator in place operation personnel can effectively "dial in" the best pressure in which to operate without changing the settings on the compressor. This regulator may also be installed at or near the process or blow molder rather than near the discharge of the receiver or check valve.

The inlet regulator should be pilot operated. This gives a much finer response time over other types. It may be a rotary vee-notch valve with pilot operated actuator.

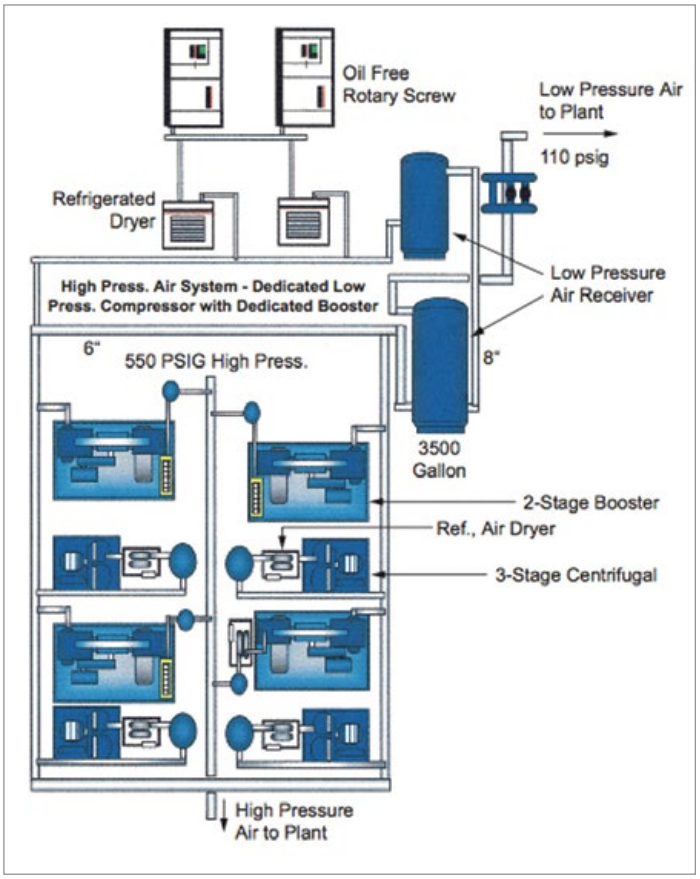

Figure 2. Typical High Pressure System with Dedicated Primary High Pressure Compressor and Separate Compressor for Low

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Air Compressor Component Function, Troubleshooting & Maintenance

Presenter Loran Circle, Senior Consultant, Circle Training & Consulting – *Sponsored by BEKO Technologies*

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Compressed Air Piping System Sizing & Design

Presenter Tim Dugan, P.E., President and Principal Engineer, Compression Engineering Corporation – *Sponsored by Trace Analytics and Unipipe*

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On-site Nitrogen Generation Replacing Bulk Liquid Nitrogen

Presenter Antonio Mayne P.E., Utilities Optimization Engineer, Molson Coors Beverage Company – Toronto Brewery – *Sponsored by Atlas Copco*

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MAR 24

How to Hunt for Vacuum Leaks: Is it Worthwhile?

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APR 28

Air Compressor Cooling, Water- or Air-Cooled?

Presenter Tom Taranto, Owner, Data Power Services – *Sponsored by Kaeser Compressors*

Thursday, April 28, 2022 – 2:00PM EST

Bert J. Wesley
Sr. Principal Industrial Plant Engineering Practice Leader, Woodard & Curran

Antonio Mayne, P.E.
Utilities Optimization Engineer, Molson Coors Beverage Company

MAY 12

IIot Solutions for Multiple and Multi-brand Compressors Remote Monitoring

Presenter Tim Dugan, P.E., President and Principal Engineer, Compression Engineering Corporation – *Sponsored by Kaishan*

Thursday, May 12, 2022 – 2:00PM EST

MAY 19

ASME PTC 13 Wire-to-Air Performance Test Code for Blower Systems Part 1

Presenters Julie Gass, Lead Mechanical Process Engineer, Black & Veatch, Fred Constantino, S&C Project Engineering Advisor, ASME and Andrew Balberg, President, Lone Star Blower and Compressor – *Sponsored by Lone Star Blower & Compressor*

Thursday, May 19, 2022 – 2:00PM EST

JUN 09

Sizing and Maintaining Compressed Air Systems

Presenter Loran Circle, Senior Consultant, Circle Training & Consulting – *Sponsored by Kaishan*

Thursday, June 9, 2022 – 2:00PM EST

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Compressed Air System Design for Lowest kW/100scfm

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Applications for Adiabatic Cooling Technology

Presenter Bert J. Wesley, Sr. Principal Industrial Plant Engineering Practice Leader, Woodard & Curran – *Sponsored by Evapco*

Thursday, July 21, 2022 – 2:00PM EST

JUL 28

ASME PTC 13 Wire-to-Air Performance Test Code for Blower Systems Part 2

Presenters Hiran de Mel, Senior Project Manager and Principal Technologist, Jacobs and Lloyd Slezak, Consulting Engineer (ret), Brown and Caldwell – *Sponsored by Howden*

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AUG 18

VFD Vacuum Pumps Do's and Don'ts

Presenter Ron Marshall, Chief Auditor, Marshall Compressed Air Consulting – *Sponsored by Busch Vacuum Solutions*

Thursday, August 18, 2022 – 2:00PM EST

AUG 25

Avoiding Production Downtime: Realtime Compressed Air Quality Monitoring and Audits

Presenter: Francisco Lara, Manager, Airtec Global LLC – *Sponsored by SUTO-iTEC*

Thursday, August 25, 2022 – 2:00PM EST

SEP 15

Using CAGI Data Sheets for Optimal Efficiency

Presenter Ron Marshall, Chief Auditor, Marshall Compressed Air Consulting – *Sponsored by Kaishan*

Thursday, September 15, 2022 – 2:00PM EST

OCT 20

How to Determine the Ideal Physical Location of a Cooling Tower

Presenter Nick McCall, P.E., Technical Manager, Woodard & Curran – *Sponsored by SPX Cooling Technologies, Inc.*

Thursday, October 20, 2022 – 2:00PM EST

OCT 27

Compressed Air: What You Don't Know Can Hurt You

Presenter Ron Marshall, Chief Auditor, Marshall Compressed Air Consulting – *Sponsored by VPInstruments and Kaeser Compressors*

Thursday, October 27, 2022 – 2:00PM EST

NOV 10

ASME PTC 13 Wire-to-Air Performance Test Code for Blower Systems Part 3

Presenters John Conover, Consultant, Mark Addison, Senior Engineer, Artesian Water Company, and Fred Constantino, S&C Project Engineering Advisor, ASME – *Sponsored by APG-Neuros*

Thursday, November 10, 2022 – 2:00PM EST

DEC 08

Compressed Air: Reliable Source for Nitrogen Generation

Presenter Loran Circle, Senior Consultant, Circle Training & Consulting – *Sponsored by Rogers Machinery and Parker*

Thursday, December 8, 2022 – 2:00PM EST

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PET Plants Using Boosters for High Pressure Air

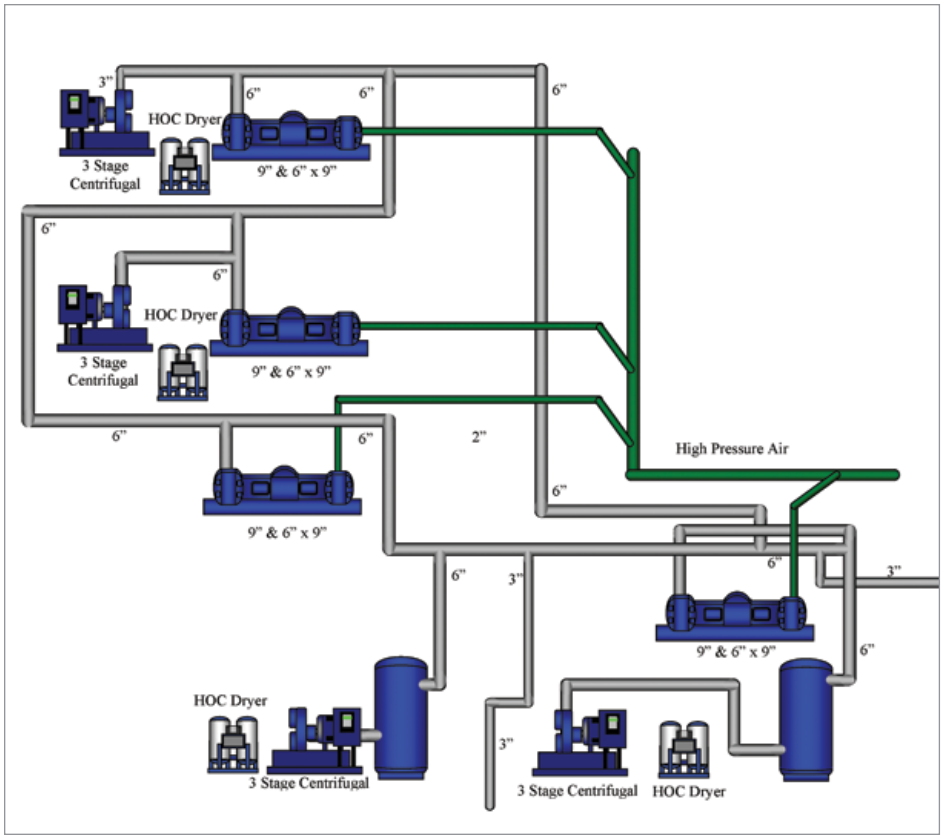

Figure 3. Typical Single Low Pressure Collector Header to Supply the High Pressure Boosters and the Low Pressure Air Demand

Inlet air to the booster should be dry and clean. With centrifugal or oil free rotary screws we usually recommend heat of compression from descent twin tower dryers which will dry the incoming air enough to not require any further drying or cooling of the air delivered to the high pressure systems.

The schematic in Figure 3 shows two different high pressure booster installations.

The heat of compression dryer will deliver very dry air (to -40˚F PDP) with little or no significant electrical energy use. BP

NOTE: These schematics are taken from actual compressed air audits performed by Air Power USA. They are not to be construed as recommending particular pipe sizing, receiver sizing and location, etc.

For more information contact Hank van Ormer, Technical Director, or Don van Ormer, Senior Auditor, AP Energy (formerly Air Power USA) at tel: 740.862.4112, Visit https://apenergy.com

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Boosting Process Vacuum Performance at a High-Tech Electronics Plant

By Bryan Jensen, Corporate Projects Manager, Rogers Machinery Company

➤Background: Electronics Manufacturer in New Mexico

A loyal client, "Sam", at an electronics manufacturer in New Mexico called in with a problem. They'd been adding some process vacuum demands onto their centralized vacuum system and had plans for more in the near future. He had recently noticed their fifth of five 150 horsepower process vacuum (PVAC) pumps had been starting to turn on and run more frequently. Historical data also showed they were also not able to consistently meet their vacuum target set-point of 23.5 "HgV.

Electronics applications typically run their tooling requiring Process Vacuum based on differential pressure from barometric; that is, they control their PVAC pumps to "Inches of Mercury Vacuum". This is because the parts and pieces being manipulated by vacuum are of certain sizes, shapes, and weights. If the differential pressure across the part is not great enough, then the tooling will fail and result in a loss of product, adverse impact to quality, and production downtime. This amounts to millions of dollars in unrecoverable expense.

With their PVAC system no longer fully redundant and intermittently unable to provide production with its requirements, something had to be done. When Sam called, his proposed solution was one we hear quite often, "We're out of vacuum! We need another vacuum pump. Can I get price and availability for an identical RVS.LR system?"

Here, we'll note that another extremely important thing to consider is the application. In the electronics industry there is a need for oil-free air and gas compression systems.

Clean Dry Air (CDA) systems in electronics facilities are the rule nearly without exception. Designed around two-stage oil-free rotary screw air compressors and multi-stage centrifugal compressors with dual tower desiccant/ molecular sieve dryers operating at -80F or -100F PDP. Then finished with filtration elements targeting particulate size to the hundredths of a micron. This extremely high-quality requirement is based on the need for completely oil-free air to be entering the clean-rooms of the world via the tooling.

The fine vacuum requirements of the clean-room have long utilized oil-free rotary screw or oil-free multi-stage claw vacuum pumps operating to the mTorr. Entire business sectors dedicated to the manufacture and support of these oil-free vacuum pumps are required.

House Vacuum systems, including Wet Vacuum & Arsenic Vacuum and their related applications are all supplied as inherently Oil-Free multi-stage turbines.

Figure 1. A water-sealed liquid ring process vacuum pump.

And so it goes with the electronics industry's Process Vacuum systems. Similar to CDA, the pitfalls of a lubricant-sealed compression element carry many costs and risks. Semiconductor Fab design engineers have for decades agreed that these risks exceed the value provided by decreased power costs and a marginally decreased one-time capital expense.

The risks of an oil lubricated design:

- Oil back-streaming toward critical fab-level production equipment, either by natural occurrence or inevitable mechanical valve failure, causing irreparable harm to the product
- Oil carry-over from lubricant-sealed pumps into the fab's scrubbed exhaust system
- The aggressive, solvent-based nature of the Process Vacuum application's gas mixture creating a documented, rapid degradation of oil, internal and critical to the reliable and low-cost operation of a lubricant-sealed vacuum pump

It has been, and remains to be clear, that PVAC systems should maintain an oil-free design.

There are plenty of fantastic application fits for lubricant-sealed vacuum pumps out there in the world, it just doesn't make sense to risk oil-sealed technology in this one.

The nature of the water-sealed liquid ring vacuum pump makes it an ideal fit for the PVAC application where multiple processes with varying process gasses and condensable vapors are simultaneously being conveyed toward the vacuum pump inlet.

The relatively large internal clearances, coupled with the natural gas "scrubbing" action which occurs within the liquid ring chamber as it is constantly being flushed with treated, industrial water, make for extremely reliable operation, so long as the water quality is monitored and kept within tolerances.

A full-recirculation service fluid system coupled with introduction of new industrial water as driven by real-time conductivity analysis of the onboard water quality, will reduce the overall chilled water requirement of a liquid ring pump to that of any other water-cooled vacuum technology.

Once a liquid ring system is properly commissioned and put online, it can be kept operating for decades with little more than regular motor and pump bearing grease maintenance and intermittent heat exchanger cleanings, when coupled with the afore mentioned water quality package.

In talking with Sam, it was apparent he understood the reliability benefits of a liquid ring vacuum pump in his specific process application. After a site visit to New Mexico and a walking tour of the system, we dove into the performance specifics.

Like all vacuum pumps, Sam's Rogers Vacuum Systems' RVS.LR PVAC pumps operate on a performance curve that is dependent on the inlet pressure to the pump. The pumping capacity, given in terms of volumetric flow (ACFM), is relatively stable over the range of possible sub-atmospheric inlet pressures until which time that pressure becomes too low for the pump to be able to maintain the differential pressure across the pump. It is at this point that the vacuum pump loses pumping efficiency and the capacity of the pump degrades, sometimes quite dramatically, as it continues to attempt to pull deeper and deeper into vacuum.

This area on any vacuum pump is often referred to as the "knee" of that vacuum

Boosting Process Vacuum Performance at a High-Tech Electronics Plant

Process Vacuum System BEFORE Upgrade Project

- Two interconnected sides of the vacuum distribution system
- Five 150 hp process vacuum systems running at 100% with zero redundancy
- Unable to meet vacuum target set-point of 23.5 "HgV in many barometric conditions

Process Vacuum System Net Gains AFTER Upgrade Project

- Four 150 hp process vacuum systems running, each at 50%
- On average, 2 ½ vacuum systems have been "given back" to the facility for an average of N+2 redundancy installed in place. Often N+3 in periods of barometric high pressure
- Able to meet and exceed vacuum target set-point of 23.5 "HgV in all barometric conditions
- Current capacity operating at set-point: ~9300 ACFM. Maximum system design capacity at set-point: ~17,500 ACFM. Currently operating at 53% of maximum system design capacity
- Approximate Current Power Consumption: 2,800,000 kWHrs/year and Chilled Water Consumption: 68 Million gallons/year
- **Approximate Annual Power Savings: 2,100,000 kWHrs/year**
- **Approximate Annual Chilled Water Savings: 87,000,000 gallons/year**

pump's performance curve. Every positive displacement vacuum pump has one. Depending on the pumping technology, operating speed, pump design or other factors, the knee can be more or less shallow with the drop in pumping capacity falling more sharply, certain pump technologies have an ability to retain pumping capacity deeper in vacuum than others while other types have the capability to have a higher overall flowrate.

The Rogers Vacuum System had been supplied for this application utilizes a SIHI liquid ring compression element in its design. The performance curve of each of the identical five vacuum pumps appears in Figure 2.

Please take note that this performance curve is appropriately displayed in terms of Absolute Pressure at the inlet of the vacuum pump and not in terms of Differential Pressure, eg. "HgV. Recall that the tooling in Sam's fab requires a certain differential pressure at the vacuum pump in order to safely maintain production operations.

Sam's fab's PVAC set-point is targeted to be 23.5 "HgV. At site installations at Sea Level, that probably wouldn't seem like much; given that the barometer at sea level reads 29.92 "Hg-Absolute (or 1013 mbar). In fact, if this installation were at sea level, in order to achieve a differential pressure of 23.5 "Hg, the inlet of the pump would need to operate at 6.42 "Hg-Absolute (or ~217 mbar). At this high of a pressure, the RVS.LR would have a pumping capacity of just under 2500 ACFM.

But recall that Sam's system is installed in New Mexico, situated at an altitude of about 5,300 feet above sea level where the barometer on a typical weather day reads around 24.9 "HgA (or ~843 mbar). There is about 170 mbar less barometric pressure available to work with at this site elevation than at Sea Level, therefore instead of maintaining an easy 217 mbar of pressure at the inlet of the RVS.LR PVAC pump, the system must instead maintain a significantly lower 47 mbar pressure in order to maintain the same differential of 23.5 "HgV between pump inlet and local barometric pressure.

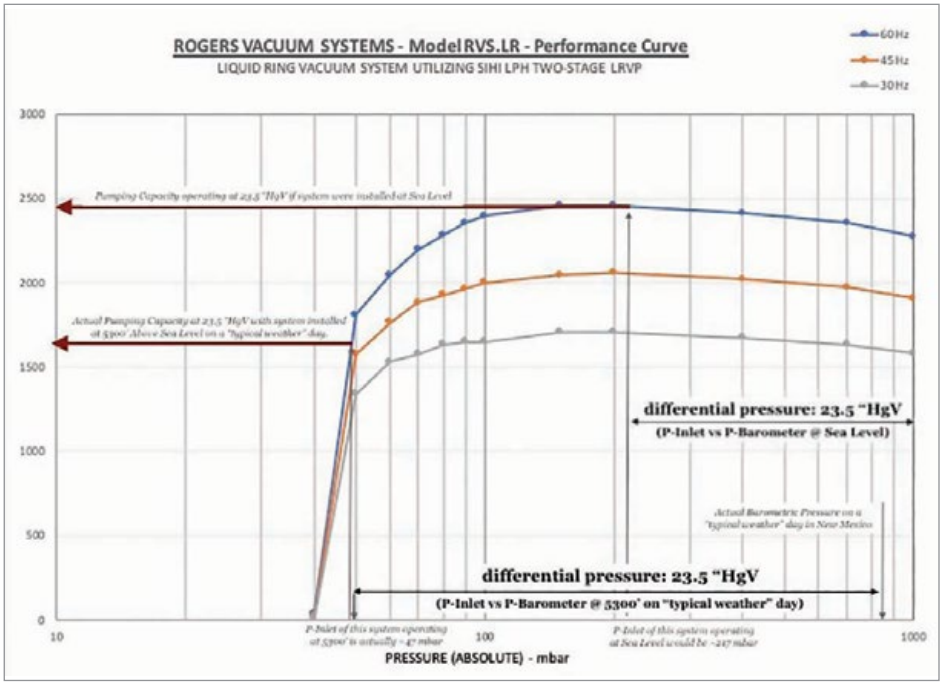

Figure 2. The performance curve of each of the identical five vacuum pumps.

From the chart in Figure 3 you can see that the lower pressure at which Sam is required to operate his system has resulted in significantly less pumping capacity, now around 1700 ACFM, than if the system were installed at sea level.

Now let's consider the matter of work to be done on the process gasses that are being conveyed to the inlet of the RVS.LR. Specifically, the rarified mass of gas that must be compressed up to local atmospheric pressure so that it can be carried away from the pump exhaust. If we look to the Ideal Gas Law of PV = nRT, we can quickly draw out the inverse relationship of Pressure to Volume through a little algebra.

Let's now divide both sides of the equation by time and consolidate the IGL constant with the recognition that our gas mixture will be the same molecular make-up regardless of its operating temperature or pressure. These modifications to the equation allow us to tease out the relationship of flow rates to each other, in this case Volumetric Flow as it relates to Mass Flow.

$$\text{Specifically....}\ \frac{V}{t} \propto \frac{m\,T}{t\,P}$$

or

$$\dot{V}\,(cfm) \propto \dot{m}\left(SCFM\ or\ \frac{lbs-gas}{hr}\right)\cdot\frac{T}{P}$$

This last form of the equation gets us to the point, that Volumetric Flow is inversely proportional to Pressure when assuming that Mass Flow and Temperature are fixed.

$$\text{Specifically....}\ V = \frac{nRT}{P}$$

Specifically, if the inlet pressure at the vacuum pump is halved, then the Volumetric Flow must double so that the same amount (mass) of process gasses at the same temperature can be compressed up to atmospheric pressure and carried away through the exhaust.

Notice now that Sam's five existing RVS.LR PVAC systems are quite often operating "past the knee of the curve" in the vertical portion of this vacuum technology's capacity range.

Putting these two thoughts together, we can see that Sam is in double trouble. As Sam is requiring ever increasing volumetric flow from his vacuum system in order to just process the same amount of mass flow at a lower pressure; he is in fact getting less and less volumetric flow from the pump as it dives closer toward perfect vacuum.

Unfortunately for Sam, we were still not even done with the bad news yet. You may know that Hot Air Balloon enthusiasts who flock to Sam's area enjoy the cold morning rare air, as nature creates the large temperature differentials desired to provide lift to the Wizards of Albuquerque.

What you may not know is that there are also relatively stable wind currents due to the prevailing weather systems and the surrounding mountains which also make exploration of the skies by Hot Air Balloon somewhat less difficult.

Criss-crossing wind currents at varying altitudes allow the balloon's pilot to rise to one altitude and head out east. Go a little higher, now perhaps you're headed Northwest. Drop down below the pair of these breezes and now say you're headed South returning to your starting point.

Now imagine these same winds as they push and pull on the atmosphere in the entire area, and not from the expansive and breathtaking view of a basket, but instead from Sam's office chair as he watches the barometer trend create a roller coaster profile as it marches on minute by minute.

As it turns out, Sam's site has one of the most active barometers in North America. Often seeing fluctuations of 10 to 12 mbar in just a few hours' time.

Boosting Process Vacuum Performance at a High-Tech Electronics Plant

So, what does this have to do with the PVAC System? Well, actually, quite a lot. Dare I even say; because of what Sam is asking of his PVAC system, nearly everything related to performance and control of his five RVS.LR's revolves almost exclusively around the weather. Here is why.

If one of the five RVS.LR systems, on a "typical weather" day is performing at about 1700 ACFM volumetric flow; then what happens on a "high pressure" day, as was the case on December 30th from the trend shown above?

The PVAC controls have, say around 10 mbar more atmospheric pressure to work with; and therefore for the dP of 23.5 "HgV to remain constant; the inlet pressure to the vacuum pump will rise the same 10 mbar. This seemingly small change in the barometer allows the RVS.LR to gain pumping capacity to around 2050 ACFM, or just over a 20% increase in performance.

Now what about the other direction? What happens if the weather turns sour, and a "low pressure" system moves in? Should the barometer drop the same 10 mbar from "typical", the PVAC system now has 10 less atmospheric mbar available and, in order to maintain the same 23.5 "HgV differential pressure between the vacuum pump inlet and the now-lower local atmospheric pressure, the inlet pressure must drop by the same amount.

You can see the result above on the performance curve. Dropping the inlet pressure at the inlet of the RVS.LR PVAC system to 40 mbar would require the removal of the entirety of the gas mass demand load being processed by the vacuum pump.

Alternately put, the volumetric pumping capacity of the system falls to Zero (0) ACFM at 40 mbar inlet pressure. With all of the right operating conditions besides, the pump might actually be able to achieve such a low pressure; but it would have to be completely blanked off at its inlet in order to get there.

So here was the rub. We had found our dilemma. A half dozen or so years previous, Sam recalls having had increased the target setpoint up to 23.5 "HgV. It was able to get there much of the time, so it seemed a fine place to operate. But the system had been designed for a higher inlet pressure (lower dP) in order to perform to the peak of its ability.

Whether it was a new line that was added that had a slightly higher pressure drop and the setpoint had to be increased in order to accommodate, a new demand that required a higher differential, or some other circumstance which caused the change, Sam found himself with a system that was being asked to do something that it wasn't perfectly and efficiently designed to do.

The Analysis

Sam's intuitive question in our first phone call, "Can I get price and availability for an identical RVS.LR system?" is plenty justifiable. Having all existing units online and running 100% and unable to meet setpoint, he was, indeed, "out" of vacuum. They no longer had full redundancy in their system. It only stands to reason that Sam needed another vacuum pump to add into the mix.

Let's play that solution out, on paper, while looking again at the performance curve. This time, however, we'll put all five (5) PVAC systems online and running at full capacity (60Hz) instead of looking at just one on its own. Pretty simple multiple to do this, totaling all their pumping capacities together and displaying the sum on the y-axis.

Let's also assume we are operating on one of the "low-pressure" days that we're worried about. Maybe not the lowest low, but a 'normally occurring' low pressure day. Looking up the historical trends of the site, we see the local barometer over the previous 12 months ranging from 24.15 "HgA to 25.33 "HgA (or about 821 to 858 mbar). Let's pick the below-average value of 835 mbar for our performance analysis.

Also, from Sam's own analysis of his trends, we know that his system is regularly unable to meet

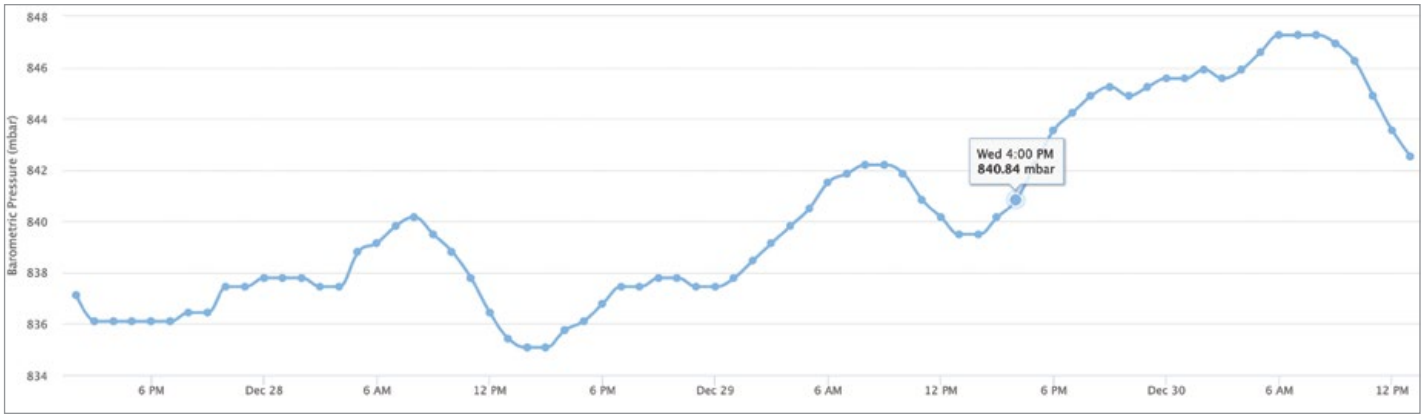

Figure 3. Barometer Vs Time

the target setpoint dP of 23.5 "HgV. On these low pressure days, we commonly see the vacuum system achieve somewhere around 23.2 "HgV instead. Putting all of that together, we got a typical total system performance as shown below.

So with all five (5) of Sam's RVS.LR systems online and operating below the desired setpoint of 23.2 "HgV; we see that the whole system has a combined volumetric pumping capacity of about 9600 ACFM.

We can now calculate the mass of gas that these pumps are compressing up to local atmospheric pressure by converting volumetric flow (ACFM) to mass flow (SCFM or # of air/hour). Again using the Ideal Gas Law as the root of this calculation and assuming room temperature gas of 68F & gas inlet pressure of 50 mbar, we estimate that the total mass flow load of the entire PVAC system at Sam's facility commonly sits somewhere around

466 SCFM
or
2,140 equivalent pounds of air per hour

Next, we'll look at what will happen should we add that 6th RVS.LR PVAC system into the mix.

Let's assume that all the facility's tooling and vacuum requirements remain unchanged during the installation of the 6th vacuum system. That is the same as saying that the load, always given in terms of mass flow, remains unchanged. The only thing we're hoping to do is hit the vacuum set-point on a regularly occurring "low-pressure" day while still having the new, larger, vacuum system processing the same 2,140 #-air/hour.

As you can likely already tell from the "new and improved" six-system performance chart above; there really isn't much improvement that a sixth system will provide. If one were to trust operating in this steep portion of the vacuum pump's performance curve, you might be able to have a little load (calculated to be about 43 #-air/hour) with 6 units online while maintaining 23.5 "HgV; but nowhere near the 2,140 #-air/hour the facility's PVAC system demands.

Let's look at this another way. Recalling from earlier that the lower in pressure the inlet of the pump drops requires that the volumetric capacity gets ever and ever proportionally larger; just how much volumetric pumping capacity does the system need to provide in order to compress the 466 SCFM (or 2,150 #-air/hour) up to local atmospheric pressure?

Reversing the calculation and starting with mass flow load in SCFM to calculate ACFM-Required, we find that in order to do the work demanded by Sam's facility, we need a PVAC system volumetric pumping capacity of about 12,350 ACFM when operating at 39 mbar.

By taking this value and then performing a mass flow balance to the actual performance curve of the system with a future 6th PVAC pump, we can model that the actual operating point of that system would be at a pumping speed of just under 10,000 ACFM while holding an inlet pressure of about 48 mbar, or about 23.25 "HgV as it relates to the barometer on our "normally occurring" low pressure day.

Put a different way, adding a 6th RVS.LR process vacuum pumping system would only see gains in vacuum of about 0.05 "HgV over the 5 PVAC system arrangement.

Boosting Process Vacuum Performance at a High-Tech Electronics Plant

Additionally, because Sam would be still operating his system in the extreme vertical portion of the speed curve and past the knee, it is very difficult to understand exactly what will happen since extremely minor changes in inlet pressure result in vastly increased or decreased pumping capacities. This is without discussing the other negative ramifications of operating a liquid ring pump too low in pressure which includes harmful cavitation and even freezing the service fluid into ice.

While we are vastly undersized at the desired operating pressure, it is also easy to see that we're also not far off. If only the inlet of the vacuum system could operate at just a couple dozen mbar of increased pressure, then even the existing system of five would have adequate and even excess pumping capacity to meet the system demands.

The inlet pressure to Sam's liquid ring pumps simply needed a bit of a boost.

The Solution

Contrary to how some folks attempt to describe the nature of vacuum and vacuum pumping equipment; vacuum is NOT "negative pressure", and a vacuum pump is NOT an "air or gas compressor running-in-reverse."

Vacuum pumps are, in fact, also compressors, taking a low (sub-atmospheric) pressure into their inlets, compressing that gas internally and then discharging to a higher (atmospheric) pressure. The parts and pieces of a vacuum pump and an air compressor are therefore very similar and laid out in a similar order internal to the equipment skid.

There are aspects of each, however, that are quite different. The mass of gas that a vacuum pump compresses through it is extremely low as compared to a similarly sized gas compressor, while the compression ratio demanded of a vacuum pump is conversely much higher. There are a huge number of compression technologies available in both the positive pressure and sub-atmospheric realms for targeting specific application needs and commercial concerns.

Rotary lobe blowers have long been a solution for low to moderate pressure gains at a wide range of flow rates. They have an oil-free compression chamber, as is required by Sam's application & site maintenance requirements and can be manufactured in extremely large sizes rather economically, due to their simple design and relatively large internal clearances.

Known most commonly throughout industry for their positive pressure applications such as wastewater aeration, pneumatic conveying or that turbocharged AMX in your neighbor's driveway, they have also been applied for vacuum applications with increasing regularity.

While rotary lobe blowers are commonly used as a standalone vacuum solution for vacuum conveying of materials such as grain or powders; they have also been applied in multi-staged vacuum systems serving process-related functions for decades.

When engineering a new Custom Process Solution, Rogers Machinery utilizes several different manufacturers' compression elements within their designs. The Rogers Vacuum System packages (MODEL RVS.RL) designed and supplied for Sam and his fab, utilize Aerzen HV vacuum boosters.

A typical "Hybrid" vacuum solution is composed of some type of mechanical or "backing" vacuum pump which provides the proverbial heavy-lifting and then some number of stages of "High Vacuum Boosters" installed upstream of the backing pump.

In building out such a multi-stage hybrid vacuum system in your mind, it may be helpful to first think of the stages of compression of a high-pressure air compressor system for reference.

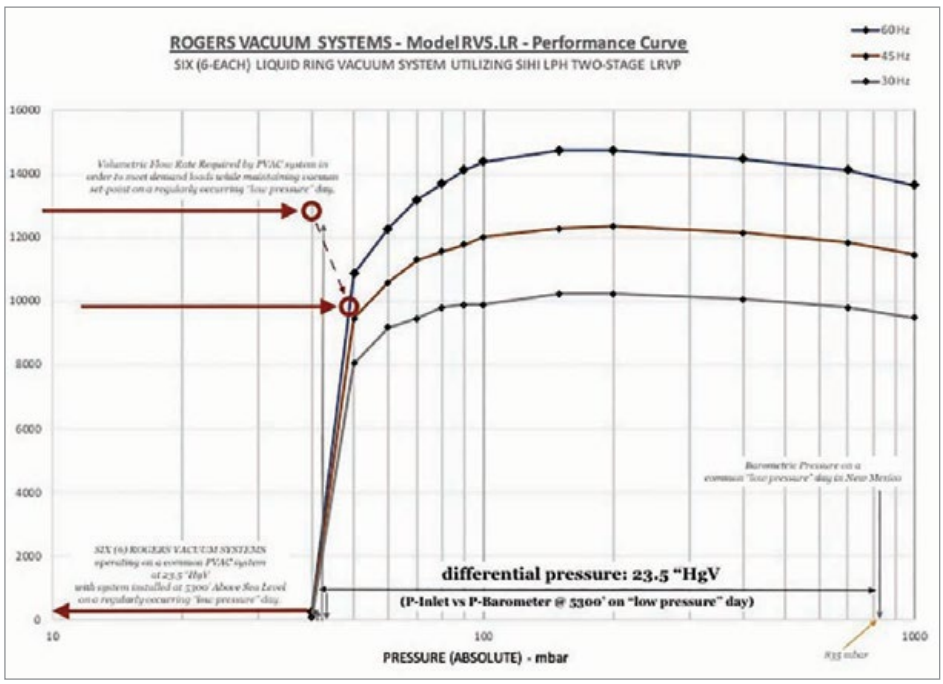

Figure 4. The performance curve of a liquid ring vacuum system.

If an application were to call for six or seven hundred PSIG, very likely, a standard 100 or 150 PSIG air compressor, possibly supplied with standard filtration and drying systems. Then downstream of that, somewhere following in the system, would be a reciprocating booster compressor. The job of the booster compressor would be to take the 150 PSIG air pressure into its inlet and increase to the ultimate pressure of 700 PSIG, or whatever the application demanded.

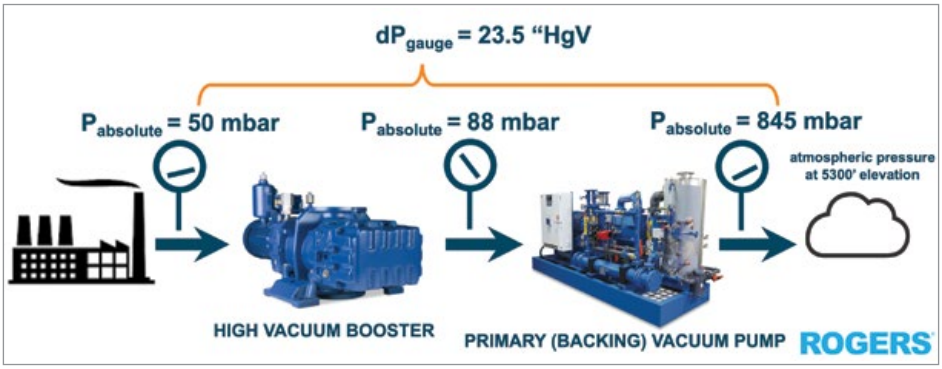

Figure 5. The various stages of the hybrid vacuum system.

The converse for a Hybrid High Vacuum system is also true. Just as with the multiple-staged compressor system, the primary backing vacuum pump is furthest away from the factory floor with ever increasing stages of vacuum boosting occurring the nearer that the process requirement becomes. The weird trick here is the direction of gas flow is opposite than that of the compressor system above. Shown above, the boosters in a compressor system are downstream of the primary compressor, as the gas nears the process application.

The boosters in a Hybrid vacuum system are upstream of the primary backing pump, as the gas load emitting from the process application progresses toward atmospheric discharge. This is, of course, due to simple physics. High pressure always flows to low pressure; and we use compressors to increase the low pressure to high in order to propagate that flow. It can seem confusing since we so often speak in terms of differential pressure while calling it "vacuum".

When you look at this same chart in terms of absolute pressure, instead of differential pressure from atmosphere (aka vacuum), it clearly becomes the same situation as with the gas compressor. That is, low pressure is increased to ever higher pressure through the various stages of the hybrid vacuum system.

A little bit more on vacuum booster compression ratios.

In "fine" vacuum process applications, say a reaction chamber operating at 5 to 10 mTorr, it is not uncommon to see compression ratios of 10:1 or even 25:1 or maybe even higher. Boiling it down, these high compression ratios are allowable at these low pressures because the gas is so extremely rarified that there is very little mass to compress and subsequently generate heat.

With increasing vacuum booster inlet pressures, the gas is becoming more and more dense and therefore the opportunity for higher and higher temperature rise. We therefore see lower booster compression ratios, such as 3:1 or even down to 1.5:1 with booster design inlet pressures in the roughing realm of 30 to 60 mbar.

At some point, the inlet pressure to the vacuum booster becomes high enough that the allowable compression ratio falls too near to 1:1 for the booster to be an economically viable solution.

Back to Sam...

If you recall, he needed more volumetric flow while operating deeper in vacuum but was getting substantially less. To be specific, he needed 12,350 ACFM when operating at 39 mbar. Let's throw the above demand requirement onto his existing five (5) RVS.LR system's combined performance chart. Let's also assume that we safely select a booster sized for performance at a 1.75:1 compression ratio.

By increasing the operating pressure at the inlet of the backing pump through the use of a rotary lobe vacuum booster by a factor of 1.75, we have also decreased the volumetric flow required from the backing system by the same factor if we assume that the mass flow load required by the factory doesn't substantially change.

The results on the chart in Figure 4 show the extreme benefit of a vacuum booster in this situation. Without boosters, the five (5) RVS.LR systems all running at 100% cannot meet the demand requirement while maintaining set-point. The desired operating point of 12,350 ACFM at 39 mbar is **outside** (above and to the left) of the vacuum systems performance capability.

With a booster installed upstream of and increasing the inlet pressure to the liquid ring systems, however, not only is the new desired operating point ~7,060 ACFM at ~68 mbar inside (below and to the right) the maximum capability of the RVS.LR system; it is also **inside the minimum capability** of the five (5) vacuum pumps running at their minimum

Boosting Process Vacuum Performance at a High-Tech Electronics Plant

speeds. This means that all liquid ring systems will need to run to their minimum speed while some shut down completely, in order to match vacuum capacity to demand.

All Together Now

Sam's situation is dynamic and complex. The desired operating vacuum, site elevation and variable barometer create (ahem) a perfect storm of circumstances which greatly impact the performance and operation of his process vacuum system.

It goes even deeper than this, though, when you realize that the five (5) RVS.LR process vacuum pumps we've been speaking about are installed on two separate, semi-independent, sides of a combined vacuum system. Side A uses two (2) RVS.LR units while Side B uses three (3).

In sizing and applying the appropriate vacuum boosters, it was desired to have like components for continuity of the installed equipment. Just as with the five (5) identically supplied RVS. LR systems, Sam wisely didn't want dissimilar boosters for maintenance personnel to need to manage. He also, of course, required full redundancy on all sub-systems.

Lastly, because of the possibility of aggressive solvents and other process gasses in the process vacuum gas stream (Recall that these are the same gasses which would solve and break down vacuum pump oil internal to any lubricant-sealed vacuum pumping technology); Sam's RVS.LR vacuum pumps cannot exhaust directly to atmosphere. The gas stream must first be treated prior to atmospheric discharge.

An automated control scheme for the new boosters needed to be created to include all the design goals of the subcomponents that we'd selected.

Control System Requirements

- Complete Redundancy
  - Able to accommodate any system subcomponent, Booster or Backing Pump, faulting offline without warning…
  - …or purposefully being turned off for maintenance
- Variable and Unknown Exact Demand Load
  - Side A: ~1000 lbs-air/hour (~220 SCFM) … plus or minus?
  - Side B: ~1150 lbs-air/hour (~250 SCFM) … plus or minus?
- Variable Barometer … a Roller Coaster!
  - LR backing pump utilities affecting LRVP performance
  - Potential exhaust pressure fluctuations
  - Potential for variable Chilled Water
  - Potential for full-recirculation heat exchanger fouling
- Multiple combinations of boosters online with backing pumps online
  - (1) RVS.RL Booster 'ON' & (1) RVS.LR Backing Pump 'ON'
  - (1) RVS.RL 'ON' & (2) RVS.LR 'ON'
  - (1) & (3); (2) & (2); (2) & (3); etc. etc...
- Save utility cost by running RVS.LR Backing Pumps at reduced speed
  - Electrical energy is saved by operating at or near minimum speed
  - Chilled water demand is decreased at or near minimum speed
- Single Control Input
  - Entire system to have Variable Speed Control
  - Targets a fixed differential pressure setpoint of 23.5 "HgV

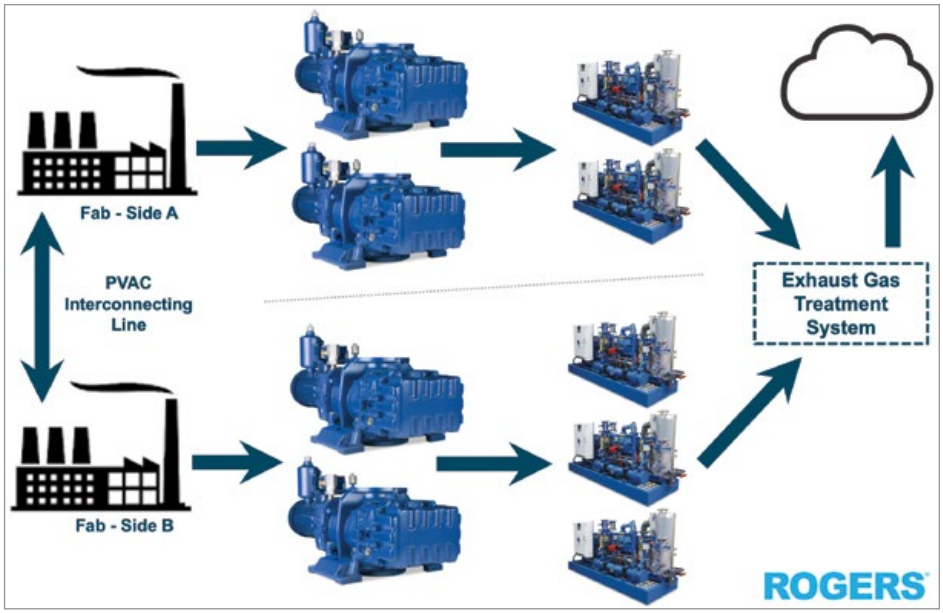

Figure 6. Two separate, semi-independent, sides of a combined vacuum system.

When talking control of a Hybrid Vacuum System, the order of operations and control of

the staged components is critically important. To build this up, let's first consider initial start-up of a completely offline system, one that has yet to establish any vacuum because the "GO" button has not yet been pushed.

In the multiple staged high-pressure compressor system, which we previously discussed; it is relatively logical to understand that operators of that system would need to start the primary gas compressor first to establish the 150 PSIG initial pressure that the secondary booster compressor requires at its inlet. Only then would the booster compressor be allowed to start, ingesting the previously compressed gas at its inlet and then compress up to the final desired pressure of 700 PSIG. In this case, the starting sequence is in order according to gas flow direction.

The Hybrid Vacuum System is the same; almost. Startup sequence is just as critically important. You'll see, however, in the image below that the starting sequence in the case of Hybrid Vacuum systems is opposite of the gas flow direction. That said, the underlying methodology is identical.

The RVS.LR backing vacuum pump must start first, evacuating the vacuum distribution lines of air and process gas upstream to a predetermined design cut-in pressure. Only then can the upstream booster safely start and operate. You can see this cut-in pressure on the attached combined Hybrid System performance curve below, showing one (1) RVS.RL Booster online and running at 100% (below 200 mbar inlet pressure) and backed by a single (1) RVS.LR backing vacuum pump online and also running at 100%.

Incidentally, in this performance chart you can also easily see the total system benefits of adding a booster to this backing pump.

At a time when this system needed increased volumetric flow while also operating at a lower pressure (deeper vacuum), the RVS.RL rotary lobe booster provides exactly that. In effect, the booster acts as a multiplier to the RVS.LR backing pump.

So regarding controls, it's the same; except different. In compressor systems, the compressor is looking just downstream of itself for control input. In vacuum systems, the vacuum pump is looking just upstream of itself for control input. And in multi-stage hybrid vacuum systems, with multiple sets of boosters upstream of the backing pump, each successive upstream booster is started at the time that each new permissive cut-in pressure is reached.

Now that the system is online and maintaining the target vacuum setpoint, we needed to ensure Sam's system was prepared for change. A change in demand load coming from the fab, a change in barometer, one or more of the subcomponents turning on or off or any combination of the above or other factors.

Further, because the existing RVS.LR liquid ring backing pumps were variable speed controlled and targeting a fixed differential pressure, Sam's new RVS.RL vacuum boosters must also be VFD driven. This is because if we were to slow down Sam's backing pump while leaving the booster operating at full speed, we would certainly over compress the gas at the inlet of the backing pump. This would create too high a pressure in between the two system

Boosting Process Vacuum Performance at a High-Tech Electronics Plant

subcomponent stages and the high compression ratio across the booster would induce a high temperature and fault out the booster.

In a joint effort between Rogers Machinery Automation Technology and project engineers, Sam's onsite Instrumentation & Control consultant and his own onsite operators and maintenance personnel, a control scheme was developed and commissioned to accomplish the design goals.

Like a symphonic conductor bringing in more wind, strings or low brass at the just right moments to the enjoyment of the clean-room, vacuum tooling audience, this controller watches the combinations of subcomponents online at any one point and adjusts the speed relationship of booster to backing pump accordingly.

For example...

Let's say Side A is operating with two (2) boosters online with both backed by (2) RVS. LR vacuum pumps. The speed relationship between booster and backing pump is matched. For every speed increase or decrease in the backing pump, the booster has a similar proportional speed adjustment.

Imagine Sam wants to do some heat exchanger maintenance on one of his RVS.LR backing pumps. When he shuts it down, the controller recognizes that the combination of two (2) boosters with one (1) backing pump won't work because there would be too much of a good thing. Both boosters would over-heat and high temp out. So the controller shuts down one of the boosters automatically and the Hybrid pair left online maintains the 1:1 speed relationship.

But what about Side B? Let's say at that moment a single booster is online but is backed by all three (3) RVS.LR vacuum pumps on that side. With all three online, they're all now running at their minimum speed of 50% because of the multiplication effect of the booster. The single booster, however, is running somewhere closer to say 85% of its speed while processing the entire load from Side B.

Because Sam flipped off one of the backing pumps on Side A, he suspects some of the fab's

demand load might need some additional help, so he makes the long walk to Side B to turn on the second booster on that side. Once online and running, the controller sees the 2:3 relationship and adjusts its speed proportions again. Now with both Side B boosters online, the unit which had been running at around 85% drops to, say 65%, while the second booster speeds up to match it. Perhaps the backing pumps speed up a few ticks to 55% or so while the Side A pump is offline for maintenance.

Even in this configuration, with a system down for maintenance, the newly boosted vacuum system still has full redundancy sitewide. That is, with (3) Side B backing pumps running at 55%, Sam could unexpectedly have one of these system subcomponents drop offline and the other two would pick up the slack without breaking much of a sweat. If that were to happen, the controller would see it and adjust the multiplication effect of the upstream boosters to the appropriate new speed relationship, now 2:2.

With high temperature safeties in place, the system controller has accomplished the many design goals for which it was designed.

Completion And Savings Highlights

When Sam rang us awhile back, he was in a pickle. With all his vacuum pumps online and running, he was out of redundancy. He couldn't even turn off a pump to properly maintain it. What's worse, he couldn't meet the vacuum demands of the plant, which were subject to, literally, which way the wind was blowing.

By giving his existing vacuum pumps a boost with an intelligent system-based solution and customized controls; Sam now has, on average, 2 ½ spare vacuum pumps available while meeting and exceeding the plant demanded vacuum set point, all regardless of the weather.

These gains translate to:

- Over 2,000,000 kilowatt-hours of annual saved electrical energy
- 87,000,000 gallons of reduced chilled water consumption on site
- Associated cost savings easily over **$200,000 per year**

Not to mention the improved production and equipment reliability due to the vacuum maintained in the clean-room, and the improved maintenance capabilities of the PVAC system subcomponents.

These savings are about the equivalent of powering 185 average US homes and enough water to fill about 132 Olympic-sized swimming pools every year. All of this for a project that cost about 25% more than the project Sam thought he was signing up for when he called. The insanely short Return-On-Investment of the capital expense was the cherry on top. BP

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Vacuum and Compressed Air Systems at IWF 2022

By Roderick Smith, Compressed Air Best Practices® Magazine

A Becker vacuum system supporting a FELDER CNC Router.

The IWF 2022 International Woodworking Fair was held August 23-26 at the Georgia World Congress Center in Atlanta, Georgia. This was the first global woodworking fair since 2018. The Show attracted announced the attendance of thousands of verified buyers of woodworking equipment. IWF is the largest woodworking technology trade show in North America and is held every other year at the Georgia World Congress Center in Atlanta, Ga. It is ranked among the largest trade shows in the world.

Festo air preparation and pressure regulators support pneumatic automation in the Wemhöner 3D Variopress® Plus system.

A vacuum system supporting a Thermwood Model 43 CNC Router.

Both Blower & Vacuum Best Practices and Compressed Air Best Practices® Magazines were pleased to be in the literature bins!

There were a number of air compressor and vacuum technology vendors exhibiting equipment. Vacuum pumps are everywhere at this show, flanking all the CNC panel-cutting and routing machines. Roaming the aisles, it was fun to see the vacuum pumps supporting each piece of equipment as the machines worked and the on-board pneumatics directing the use of compressed air for automation.

Vacuum hold-down force depends upon a few variables including tool characteristics on the router. An average hold-down force for a single piece is around 2,000 pounds. The fiber board is where pieces to be cut are placed and the vacuum force goes through it. Some newer CNC routers can now shut off vacuum supply when the unit is not in use and also identify what section of the fiber board requires vacuum – and only supply vacuum to that section. Traditional models, supplying the entire board usually use a vacuum system that can deliver a minimum of 300 ACFM with as much depth of vacuum as possible. Generally, a vacuum level between 18 to 24 inches mercury (Hg) is considered normal.

Vacuum and Compressed Air Systems

The Atlas Copco booth featured both compressed air and vacuum pump systems for woodworking shops. An interesting brochure and presentation of vacuum pump systems grouped them into two categories: point-of-use and centralized. Products displayed were the oil-sealed rotary screw vacuum pump with VSD (GHS VSD+ Series), the dry mono-claw vacuum

Dave Raffin and Andy Ricci (left to right) at the Atlas Copco booth.

Michael Camber, Greg Garner, Lisa LeViness, Eva Johnson and Michelle Teekasingh at the Kaeser Compressors booth (left to right).

A Vmax oil-sealed liquid ring vacuum system supporting a HOMAG CENTATEQ CNC Machining Center at the STILES Machinery booth.

A dry rotary vane vacuum system provides the hold-down force for a fiber board on a CNC router.

Show Report: Vacuum and Compressed Air Systems at IWF

Adam Schmitz, Chris Smith and Daniel Cole (left to right) at the Prevost booth.

Laurel Praeter, John Kopsidas, Brad Hughes, Mick Wentzel and Wendy Hoffert at the Becker Vacuum booth (left to right).

Vacuum Specialist Monroe Glover and Scott Stejskal at the Quincy Compressor booth (left to right).

pump with built-in VSD (DZS VSD+ Series) and the oil-sealed rotary vane vacuum pump (GVS A Series). Atlas Copco Vacuum Marketing Manager Dave Raffin said the general idea being taught is that point-of-use pumps can be a better choice for smaller woodworking operations with only a few CNC machines. Larger manufacturing facilities are encouraged to consider a centralized vacuum system. Representatives from recently acquired and local to Atlanta, Compressed Air Products, Inc. were also on hand at the Atlas Copco booth. They talked about the rotary screw air compressor product line offering with integrated refrigerated dryers and their aluminum piping system.

Kaeser Compressors has a long history of providing their positive displacement blowers to the CNC routing machine industry for vacuum hold-down applications. "We are very effective with spoiler-board systems in routers running at 11-13 HgV," said Marketing Manager Michael Camber. "We often find energy-saving opportunities of 50-60% by reducing the vacuum specification while increasing flow." The booth featured the Kaeser tri-lobe, fully-enclosed, quiet blower which they recommend for routing machines.

Also on display were rotary screw air compressors with integrated refrigerated dryers (AirTowers and AirCenters), aluminum piping (SmartPipe) and smart controls such as their Sigma Air Manager 4.0.

Becker vacuum system products are widely used in the woodworking industry. The CNC routers in particular, seemed to have two 10 or 15 hp rotary vane Becker pumps in every booth next to their machines. I always enjoy speaking with Becker's Mick Wentzel. "Our dry (oil-less) rotary vane vacuum pumps have been the technology of choice by U.S. and European OEM's for many years," Wentzel said. "The combination of extremely low maintenance requirements along with the benefits of oil-less technology are the decision drivers." On display at their booth was a Duplex 250 vacuum system, featuring two VTLF 2.250 dry, rotary vane pumps with filtration.

Dekker Vacuum Technologies had a nice booth displaying a 40 hp Vmx oil-sealed liquid ring vacuum pump system. JD Ziegler explained the system comes with the Titan pump, a motor, patented DX oil separators, optional VFD, and a PLC able to control up to 9 pumps. Capacities range from 35 to 5,400 cfm. I also saw this system over at the STILES Machinery booth working away.

The PneuTech and UniPipe booth was very busy. Derrick Taylor was speaking with a group of Amish woodworkers about the RK Fixed Speed Air Compressor Series (5-20hp) with integrated refrigerated dryer mounted on a horizontal receiver tank. A feature catching my eye was the oversized air-oil separator tank and element allowing for less than 3ppm oil carryover and less than 0.02 bar pressure drop. The UniPipe aluminum piping system was also generating a lot of interest for shop piping upgrades.

I spent some time talking with Director of Sales, Adam Schmitz, at the Prevost booth. He showed me their versatile PPS aluminum piping system for use in compressed air, vacuum and inert gas in sizes ranging from ½" to 4" pipe diameters. We also looked at their OSHA compliant prevoS$_1$ blow guns, premium quality prevoS$_1$ safety fittings with single press decompression and disconnection, STOFLEX anti-static hoses and their compressed air filtration modules for protecting paint equipment. This company has premium solutions for all those problems with connections and piping we see in the "last 30 feet".

ELGi had a booth displaying their EN Series belt-drive air compressor, which is tank-mounted with a refrigerated dryer. ELGi Regional Manager Kevin Ray also showed me a 25 horsepower premium EG Series direct drive air compressor. Steve Briscoe and other Patton's team members were talking about service and auditing capabilities to folks from woodworking shops visiting the booth.

Quincy Compressor sent their vacuum specialist, Monroe Glover, to the show and she talked to me about the new QSV E-Series rotary screw vacuum pumps featuring VSD control and a wider vacuum range from 0 to 29.89 HgV". She also showed me their QGS-10 compressed air package featuring a rotary screw compressor and refrigerated dryer mounted on a horizontal tank. BP

For more information on IWF 2022 visit www.iwfatlanta.com

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Steve Briscoe, Brad Shinkle, Kevin Ray and Cody Brown at the ELGi booth (left to right).

Derrick Taylor at the PneuTech/Uni-Pipe booth.

JD Ziegler with the Vmax oil-sealed liquid ring vacuum system at the Dekker Vacuum Technologies booth.

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Compressed Air Technology News

Atlas Copco Introduces Energy Efficient GA VSD^S Compressor

Atlas Copco announces the launch of a new generation of its variable speed drive (VSD) compressors. Offering energy savings of up to 60%, the GA VSD^S leads the way in energy-efficient, sustainable compressors. Thanks to its pioneering smart features, the GA VSD^S can adapt and optimize its operation for each customer. The new technology will be available first in the 30-50 horsepower (22-37 kW) GA oil-injected screw compressor range.

The GA VSD^S is the third generation of Atlas Copco variable speed drive (VSD) compressors. VSD compressors significantly reduce energy consumption by adjusting their motor speed to the fluctuations in compressed air demand. When Atlas Copco introduced the technology, a first-generation VSD compressor achieved energy savings of up to 35% compared to a fixed-speed compressor. That number increased to 50% when the VSD$^+$ update was launched. Now, the GA VSD^S offers energy savings of up to 60%. In 2020, Atlas Copco celebrated the 25th anniversary of their first VSD compressor launch.

Its unrivaled energy efficiency gives the GA VSD^S industry-leading sustainable credentials. A recent survey conducted by Atlas Copco in the United States highlighted that the United States could save around 13 billion kWh annually in electricity associated with compressed air – which would remove ~9 million metric tons of CO_2 annually. The launch of the VSD^S is an important step in being able to continue to deliver savings to compressed air customers.

Sustainability was also a guiding principle in the design of the GA VSD^S. In addition to its minimal number of components, it is the first compressor to feature an IE5 ferrite-assisted synchronous reluctance motor, eradicating the need for the use of increasingly precious and rare earth materials.

"The VSD^S offers true sustainable innovation," said Stef Lievens, Vice President Marketing of the Atlas Copco Industrial Air Division. "As climate change affects us all, Atlas Copco has made sustainable productivity our number one focus. There is no better example than the GA VSD^S meeting not just today's standards but also those of tomorrow. It's a truly transformative compressor for a rapidly changing industry."

The GA VSD^S is a powerful compressor with up to 20% higher free air delivery (FAD) than a fixed-speed equivalent. This provides customers a unique opportunity to select a lower horsepower compressor and still get the air they need.

The VSD^S introduces several smart features that allow it to adapt and optimize its performance to each customer's applications, requirements, and conditions. The most important example is the Smart Temperature Control (STC) system, which ensures that the compressor operates with an optimal oil temperature at all times. As a result, it eliminates the risk of condensation while ensuring maximum compression efficiency.

The GA VSD^S also comes with the all-new Boost Flow Mode, which gives customers the freedom to exceed their compressor's maximum capacity temporarily and safely.

The GA VSD^S comes with industry-leading connectivity features. These include its advanced Elektronikon® Touch controller, the EQ2i multiple compressor control (integrated as standard), SMARTLINK remote monitoring and analysis, and OPC UA integration for connected production environments.

With sound levels as low as 63 dB(A), the GA 22-37 VSD^S does not require a compressor room. It can be installed on the production floor. Thanks to Atlas Copco's now familiar vertical, compact design, the compressor takes up very little space.

About Atlas Copco Compressors

Atlas Copco Compressors LLC is part of the Compressor Technique Business Area, headquartered in Rock Hill, South Carolina. Atlas Copco Compressors provides innovative solutions, including world-class compressors, air blowers, industrial coolers, vacuum pumps, quality air products, and gas generation systems, all backed with full service, remote monitoring, and auditing services. With a nationwide service and distribution network, Atlas Copco Compressors is your local, national, and global partner for all your compressed air needs. Learn more at www.atlascopco.com/air-usa.

Atlas Copco's next-generation VSD compressor offers up to 60% energy savings and smart, flexible operation.

Compressed Air Technology News

Schulz of America Launches Two-Stage Piston Air Compressor

Schulz of America, headquartered in Atlanta, GA, introduced the AUDAZ MCSV20AP, two-stage, 5 hp, direct-drive, 80-gallon vertical tank-mounted air compressor. Its exclusive patented IC-TECH technology allows integrated connection between its high efficiency compression stages.

This technology allows lubricating oil to be changed every 300 hours* (which represents a gain of 50% in the durability of the oil). The direct coupling reduces the loss of energy and enhances safety. From mechanical workshops to small companies, its productivity will be greater, with less maintenance expenses. This compressor of 20 cfm (cubic feet/min) has an integrated 5 hp motor, a plastic cover specially designed to increase the cooling efficiency of the compressor pump and an oil sight glass for monitoring of oil levels.

The compressor also has an optimized drive system (available in 220V Single Phase or three phase, both versions with Magnetic Starter included), and a maximum operating pressure of 175 psi.

*considering 200 hours as a market reference

The Schulz of America AUDAZ MCSV20AP, two-stage, 5 hp, direct-drive, 80-gallon vertical tank-mounted air compressor.

About Schulz of America

Schulz Compressors is the largest manufacturer of air compressors in Latin America with one of the most comprehensive air compressor plants in the world. The company has operated in the North American market since 1980 and offers the residential, professional and industrial segments a full product line of compressors. Reliability, safety, durability and efficiency have been trademarks for decades, since its foundation in Brazil in 1963. For more information, visit www.schulzamerica.com.

Emerson Introduces PACSystems RXI HMI

Machine builders in any industrial application can now use Emerson's PACSystems™ RXi HMI, a next-generation machine visualization solution designed to help set their systems apart for customers. The new system easily helps users overcome the limitations of lower budgets, fewer people and higher productivity demands. This highly intuitive human-machine interface (HMI) addresses the needs of today's industrial workforce with easy-to-use, smartphone-like graphical displays without sacrificing rugged, industrial performance.

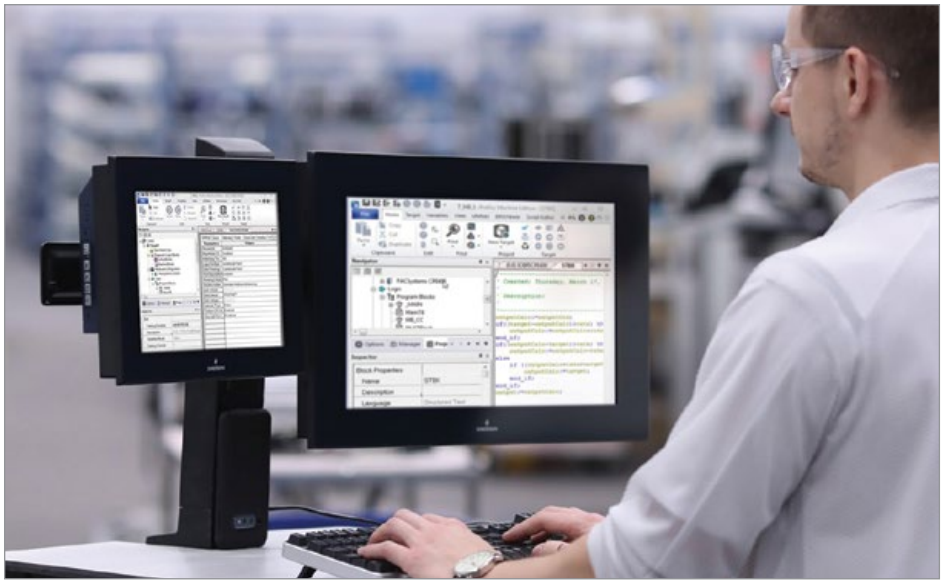
Unlike traditional resistive displays, PACSystems RXi HMI is designed with projective capacitive touchscreen technology that allows users to interact with the visual display with 10-point multitouch capabilities like swipe, pinch or zoom to move to the next screen or expand a chart, enabling easy operation by a wide range of personnel with varying levels of training and experience.

PACSystems RXi HMI comes pre-loaded and pre-licensed with the advanced Movicon™ WebHMI software, so the device is conveniently ready to operate out of the box, saving customer time. PACSystems RXi HMI is HTML5-ready which allows users to collaborate from anywhere, so that the operations, management and maintenance teams can all view the same screen at the same time, no matter the distance. This immediate sharing of information and access to expertise reduces maintenance costs and improves productivity.

In addition, customers will value the faster access to data-based operational insights to maximize overall equipment effectiveness. The PACSystems RXi HMI, with Movicon WebHMI at its core, is IIoT-ready for data analysis, troubleshooting and diagnostics, placing the operational insights customers need at their fingertips. A data trending tool provides a clear snapshot of productivity and quality. The SQLite database tool and PAC analyzer help users troubleshoot problems and minimize downtime. In addition, it provides extensive protocol support with OPC UA for better data contextualization and MQTT for easy cloud connectivity, so the solution goes far beyond visualization.

"Machine builders and OEMs are no longer 'one and done' suppliers to their customers. Today, they become long-term collaborators by developing new and better ways to solve customer problems," said Jeff Householder, president of Emerson's machine automation solutions business. "The new PACSystems RXi HMI is an easy, cost-effective way to add significant customer value to a system by enabling new levels of ease of use, increasing productivity, speeding communications, improving analytics and business intelligence capabilities, and easing the move into IIoT. In every way, the RXi HMI is built for real industrial environments as well as the next-generation of industrial workers."

PACSystems RXi HMI protects against both physical and digital risks. It offers protection in wet applications with certifications for both high-pressure water jets and marine use with an IP66 water resistance rating, as well



Emerson's PACSystems RXi HMI next-generation machine visualization solution differentiates OEM systems and improves user operations.

as being approved for use in a wide range of temperatures from minus 20 to 65 degrees Celsius. In addition, the device is resistant to chemicals, impact, scratches and dust. It is also designed in accordance with IEC 62443 Global Automation Cybersecurity Standards to support end users' overall digital security strategy.

More information on PACSystems RXi HMI is available at https://www.emerson.com/IndustrialDisplays.

About Emerson

Emerson, headquartered in St. Louis, Missouri (USA), is a global technology and software company providing innovative solutions for customers in industrial, commercial and residential markets. A leader in industrial automation, Emerson helps process, hybrid and discrete manufacturers optimize operations, protect personnel, reduce emissions and achieve their sustainability goals through its Automation Solutions and AspenTech businesses. Emerson's Commercial & Residential Solutions business helps ensure human comfort and health, protect food quality and safety, advance energy efficiency and create sustainable infrastructure. For more information, visit www.Emerson.com.

FS-Elliott Launches FS-Connect

As industry and technology continues to evolve, FS-Elliott announced its recent entrance into the remote monitoring landscape with the launch of FS-Connect. Using a 4G cellular, web-based connection, FS-Connect has been designed to provide you clear surveillance of your compressor activity, alongside troubleshooting support, from any remote location.

"We believe that this new remote monitoring solution can be a powerful addition to any of FS-Elliott's Regulus Control Panels, as it provides our users the ability to not only monitor the operational status of their compressed air system but will also help improve efficiency and compressor uptime through remote notifications and reporting. As an addition to FS-Connect, we are also excited that the FS-ConnectedServices

FSCONNECT
Product of FS-Elliott

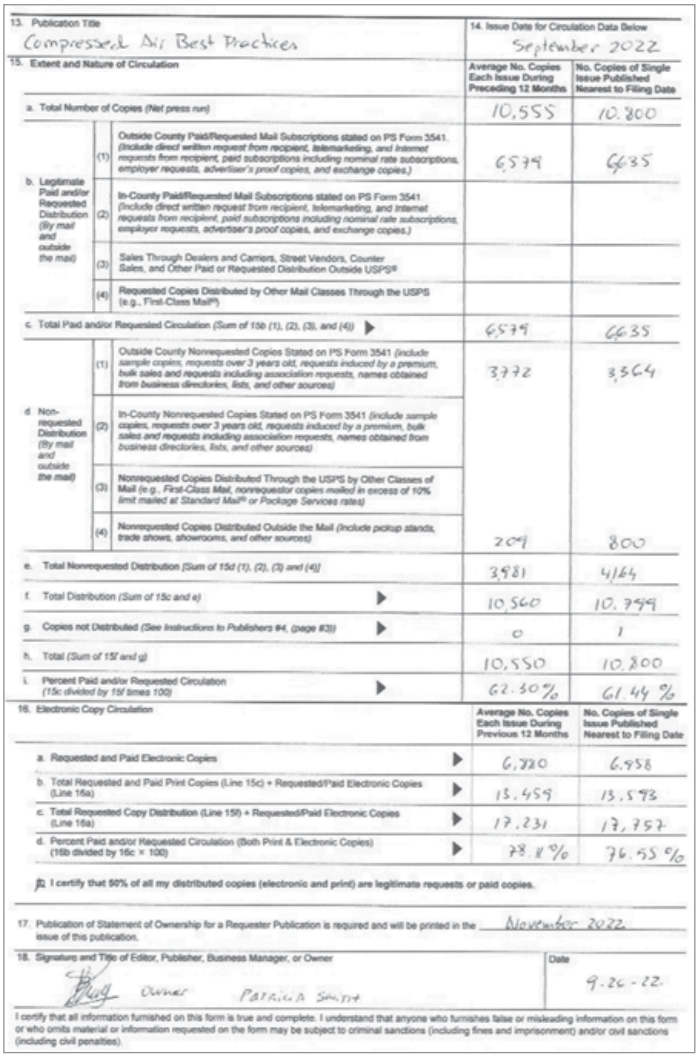
FS-Connect has been designed to provide you clear surveillance of your compressor activity.

Compressed Air Technology News

option will provide a new level of service offerings to FS-Connect users, helping them troubleshoot on-site issues in a productive and timely manner, " said Justin Johnson, Product Manager, Controls.

With this new product offering, you'll gain a live view of your compressor(s) status, including items such as pressure/vibration/temperature monitoring, alarm/trip data, and valve positioning. Operational and maintenance notifications, as well as monthly summary reports, will help keep you on track for any maintenance services and provide energy-saving recommendations through our Energy Advisor.

FS-Elliott will offer three different subscription plans (Basic, Plus, and Pro) depending on your monitoring needs. Each plan grants you the choice to add in the additional FS-ConnectedServices option. This offering lets our experienced Controls Engineers troubleshoot your issues live and provide support when requested.



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15. Extent and Nature of Circulation			Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
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b. Legitimate Paid and/or Requested Distribution (By mail and outside the mail)	(1)	Outside County Paid/Requested Mail Subscriptions stated on PS Form 3541. (Include direct written request from recipient, telemarketing, and Internet requests from recipient, paid subscriptions including nominal rate subscriptions, employer requests, advertiser's proof copies, and exchange copies.)	6579	6635
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e. Total Nonrequested Distribution (Sum of 15d (1), (2), (3) and (4))			3981	4164
f. Total Distribution (Sum of 15c and e)			10,560	10,799
g. Copies not Distributed (See Instructions to Publishers #4, (page #3))			0	1
h. Total (Sum of 15f and g)			10,550	10,800
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a. Requested and Paid Electronic Copies	6,720	6,958
b. Total Requested and Paid Print Copies (Line 15c) + Requested/Paid Electronic Copies (Line 16a)	13,459	13,593
c. Total Requested Copy Distribution (Line 15f) + Requested/Paid Electronic Copies (Line 16a)	17,231	17,757
d. Percent Paid and/or Requested Circulation (Both Print & Electronic Copies) (16b divided by 16c × 100)	78.11%	76.55%

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17. Publication of Statement of Ownership for a Requester Publication is required and will be printed in the November 2022 issue of this publication.

18. Signature and Title of Editor, Publisher, Business Manager, or Owner: Owner Patricia Smith — Date: 9-26-22

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About FS-Elliott

FS-Elliott is a global leader in the engineering and manufacturing of oil-free, centrifugal compressors with operations in over 90 countries. Building on a 60-year tradition of excellence, FS-Elliott combines an unwavering commitment to quality with the desire for advancing technology to bring value to our customers, allowing them to increase their productivity and lower system operating costs. For more information, visit www.fs-elliott.com

Hertz Introduces Impetus Series Two Stage Screw Compressors

Hertz Kompressoren products are built around core competences with a body of knowledge and a set of capabilities which enable new and innovative solutions. The most recent is the IMPETUS series products. Impetus, the driving force, power, and energy solution to your compressed air needs.

HERTZ Impetus Series provide two stage screw air compressors suitable for your needs with its superior technological equipment, modern design, and increased energy efficiency. With the Impetus VSD (variable speed drive) Series, we can meet your compressed air needs with energy savings up to 35%. Take a look at the Impetus Series air compressors next time you need a 90 to 315 kW air compressor.

HERTZ Impetus Series provide compressed two stage screw compressors.

About hertz Kompressoren USA

hertz Kompressoren USA, Inc. is the premium brand of Dalgakiran Group Company. The global sales and service network of Dalgakiran has developed into one of the leading air compressor producers in the world. Founded in Germany, hertz Kompressoren, began providing reliable, innovative products and compressed air solutions combined with exceptional customer experience. Our ISO 9001 certified manufacturing facility assures the highest quality standards. Hertz Kompressoren is providing world class customer satisfaction, ensuring the most reliable, energy efficient products with the lowest life-cycle cost in the industry. We

believe in keeping customers happy and providing them with competitively priced products. For more information visit Hertz Kompressoren at https://www.hertz-kompressoren.com/US_en.

SWEP Launches Double Wall Heat Exchanger for Heat Recovery

Double wall technology is mandatory in such applications in some countries, including Benelux, France, Canada and Australia.

SWEP launched the B8DW unit as the latest addition to the range of double wall heat exchangers, designed for applications requiring improved leak protection.

The B8DW unit is the most compact double-wall unit optimized for small to medium capacity applications. Double wall technology ensures that fluids do not mix by protecting one circuit from contamination in the event of internal leakage if a channel plate for any reason breaks. The protective double wall prevents any hazardous fluid from entering the water side, and instead it will be drained outside the heat exchanger.

The technology provides safety assurance in a range of applications, including tap water stations, where the potable water side must be protected from poisonous glycol, or dirty water from the district heating grid. Other applications where fluids must not mix include heat pumps, boilers, transformer cooling, desuperheaters and heat recovery from air compressors.

"SWEP is the market leader in the thermal efficiency of double wall exchangers. With the launch of the compact B8DW to join alongside the existing B16DW medium -size range and the B35TDW large range, we can offer a double wall technology with high thermal length for all sizes and types of heat recovery applications that calls for tight temperature approach and required leak protection," said Hampus Castengren, SWEP Segment Manager, District Energy.

For more information, visit www.swep.net.

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