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# SUSTAINABLE MANUFACTURING FEATURES





# COLUMNS



# FROM THE EDITOR | Compressed Air IoT (Internet of Things)

I'm not crazy about the IoT term. I don't know if it's better or worse than Industry 4.0, the term commonly used in Europe. Using instrumentation and controls to send compressed air key performance indicator (KPI) data through the internet, however, is very exciting. We've had more than one story this year about a factory where the long-delivered message regarding optimization, was only understood and acted upon once they saw it on their computer screen at their desk.

Ingersoll Rand's Ian Barnard brings us a great example of this with an article about their work helping a terrycloth towel manufacturer named 1888 Mills. They use 31 air-jet looms (pretty cool application) in their Georgia plant. By studying the system and analyzing a lot of data, Ingersoll Rand helped them reduce energy and maintenance costs by $140,000. Willing to challenge specifications and habits, they replaced older rotary screw air compressors with oil-free centrifugals and replaced a desiccant dryer (with lots of purge air) with a refrigerated dryer.

Bay Controls has provided us with an excellent story about their work upgrading compressed air system controls for a major corporation. This company had made a decision to focus on reducing energy consumption and compressed air was one of their first targets. The data monitoring and visibility to KPI's this project provided, paved the way for $977,000 in annual savings across ten plants.

IoT creates high-ROI projects because the data is now visible and reliable. North American Lighting's plant in Paris, Illinois, allowed Airleader and Brabazon Pump, Compressor & Vacuum to team up and do a compressed air project with a ROI of less than one year. We hope you enjoy this project story.

Air compressor control gap is real and it can be conquered! I hope you enjoy Ron Marshall's article on how this was taken care of at a food processor in Western Canada. Hank van Ormer returns for installment eight of his series of articles on demand-side opportunities. His very detailed article is on a PET blow-mold and filling operation.



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

**ROD SMITH,** *Editor*
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# INDUSTRY NEWS

## Anest Iwata Air Engineering Expands Into New Cincinnati Facility

ANEST IWATA Air Engineering (AI-AE), a subsidiary of ANEST IWATA Corporation in Japan, has recently moved into a 53,000 sq. ft facility in West Chester, OH, just north of Cincinnati, OH. The NEW facility is centrally located near I-75 and utilizes over 43,000 sq. ft for manufacturing/assembly space and 10,000 sq. ft for office space. The NEW facility is home to over 31 employees and is designed to accommodate the impressive sales growth AI-AE has seen since its incorporation in 2010.

AI-AE designs, assembles and tests oil less air compressors and vacuum pumps in West Chester, OH. Oil less scroll & piston air compressors are available from 1-40HP in many configurations, such as, open, enclosed, tank-mounted or base mount. The Company also has oil less scroll vacuum pumps ranging from 3CFM to 42CFM. The industries served by the oil less scroll and piston design are medical, dental, industrial, pharmaceutical, food & beverage, analytical, R&D, university and high-quality printing and coating.

ANEST IWATA Corporation is a global company with approximately 1,400 employees and has been listed on the Tokyo Stock Exchange since 1973. We located in over 42 countries and have 3 major divisions: Air Compressors and accessories, Spray Equipment & Systems and Vacuum Pumps and equipment.

Any questions or if you wish to inquiry about the products or becoming a distributor, please call 800-440-0282 and ask for Tom Fermann. Visit www.anestiwata.com


*ANEST IWATA Air Engineering's new 53,000 square foot facility.*

## Ozen Air Technology Enters North and South America

Ozen Air Technology, LLC announced its entry into North and South America with its low- and medium-pressure piston and screw air compressors, air dryers, air tanks and air accessories. The company's facility in Charlotte, NC, serves as the center for all Ozen Air Technology business operations, compressor assembly, warehousing and training for distribution partners and OEMs.


*An Ozen Air Technology OABC D Series screw booster air compressor.*

Ozen Air Technology was founded in 1970 by Mehmet Özen in Konya, Turkey. The company's half a century of industrial machinery manufacturing experience started with the production of welding machines and air compressors. The company, which manufactures and installs compressed air equipment from its state-of-the-art production plant, serves a wide range of industries, such as automotive, chemical and petrochemical, textile, food, energy, health, logistics, and glass.

Ibrahim Ozen, President of parent company Ozen Kompressor, said the entry into North and South America market supports Ozen's strategic business decision and global growth strategy. He added that Ozen Air Technology will achieve rapid product delivery with the utilization of demand flow assembly lines and stand by its customers in the United States with a comprehensive range of spare parts and service support.

# INDUSTRY NEWS

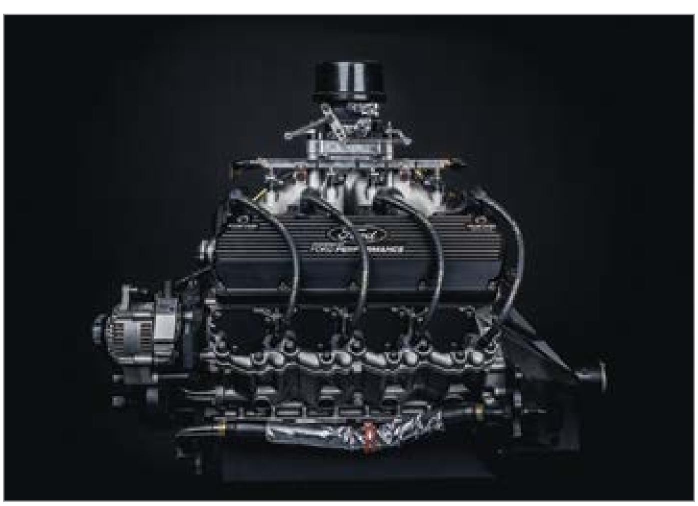
### About Ozen Air Technology

Ozen Air Technology is one of the leading producers in Eastern Europe and the Middle East. It has sales and service activities in over 45 countries, through a distribution network of more than 100 distributors. Exports of air compressors and air compressor equipment constitute over 30% of all sales. For more information, visit www.ozenairtech.com.

## Atlas Copco Official Compressed Air Provider of Roush Yates Engines

Atlas Copco Compressors, a leading provider of sustainable productivity solutions, and Roush Yates Engines announced a newly formed partnership, naming Atlas Copco the official compressed air provider of Roush Yates Engines. Roush Yates Manufacturing Solutions, a division of Roush Yates Engines, has expanded into a new 88,000-square-foot CNC machining facility and worked with Atlas Copco to determine the most efficient and productive air compressor system to support the new facility. It was a natural fit with Atlas Copco Compressors, headquartered in South Carolina.

"We are proud to have Atlas Copco as our partner," said Doug Yates, President and CEO, Roush Yates Engines. "Atlas Copco not only provides premium products and services but is also a leader in innovation. By supplying quality compressed air with the latest technology, it allows our facility to operate in the most energy efficient manner possible while reducing overall environmental noise pollution, which is a true win-win."



With over 140 years of experience, Atlas Copco is globally recognized as a leader in innovation and manufacturer of premium compressed air products. Atlas Copco engineers consistently develop world-class products and services that truly create advantages for their customers and the environment.

"Our new Atlas Copco compressors arrived in perfect condition and ready to work," commented Jeff Smith, Building Supervisor, Roush Yates Manufacturing Solutions. "Installation was simple, and the integration and communications between the compressors in the installation are superior to any other set-up I have worked with. The Atlas Copco service technicians are second to none. Their attention to detail, product knowledge, professionalism and willingness to answer our questions are top notch."

Atlas Copco's product innovation is the result of hard work, dedicated strategies and meaningful interaction with all customers. Understanding the customer's needs and operating environment is key for Atlas Copco to develop and map out the perfect solution for any customer. To meet customer needs, Atlas Copco has developed a comprehensive selection of products, from compressors to vacuum pumps, blowers, quality air solutions and gas generation systems.

"We are very excited to announce our partnership with Roush Yates Engines. Our companies are truly aligned by our core values of innovation, commitment and interaction," said Robert Eshelman, President and General Manager, Atlas Copco Compressors LLC. "The automotive industry is always evolving and an important sector for

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## INDUSTRY NEWS

Atlas Copco. This partnership bears testament to our commitment to customers in this industry and all across the United States."

### About Atlas Copco

**Atlas Copco** is a world-leading provider of sustainable productivity solutions. The Group serves customers through its innovative compressors, vacuum solutions, generators, pumps, power tools and assembly systems. Atlas Copco develops products and services focused on productivity, energy efficiency, safety and ergonomics. The company was founded in 1873, is based in Stockholm, Sweden, and has a global reach spanning more than 180 countries. In 2017, Atlas Copco (excluding Epiroc AB) had revenues of BSEK 86 (BEUR 9) and about 34,000 employees.

**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, vacuum pumps, air blowers, 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

# INDUSTRY NEWS

and global partner for all your compressed air needs. Learn more at www.atlascopco.com/air-usa.

**Roush Yates Engines** is a cutting-edge engine development company, with 3 state-of-the-art facilities based in Mooresville, NC; which include Roush Yates Engines, Roush Yates Performance Engines Group, focused on road racing and Roush Yates Manufacturing Solutions, a world class manufacturing center and ISO 9001 / AS9100 Rev D certified. The company's two core businesses include; designing, building, and testing purpose-built race engines and producing machined parts for the aerospace, military and automotive industries. Ford Performance in partnership with Roush Yates Engines is the exclusive engine builder of the NASCAR FR9 Ford V8 engine and twin-turbo EcoBoost Ford V6 race engine that powers the Ford GT super car in the IMSA and FIA racing series. With an unparalleled culture of winning and steeped in rich racing history, Roush Yates Engines continues to follow the company's vision to lead performance engine innovation and staying true to the company's mission, provide winning engines through demonstrated power and performance. Learn more about Roush Yates Engines at www.roushyates.com and www.roushyatesmfg.com.

## Festo Acquires Pneumatic Automation Component Manufacturer Fabco-Air

Festo has acquired Fabco-Air, Gainesville, Fla., a leading manufacturer of pneumatic automation components. Festo officials said Fabco-Air's automation components complement Festo solutions and its expanding portfolio of products.

Fabco-Air's NPT pneumatic cylinders are applied by Original Equipment Manufacturers (OEMs) on new machinery and systems. They are also used as replacement components in the Maintenance, Repair, and Operations (MRO) market. Like Festo, Fabco-Air provides custom solutions that bring machines and systems to market faster with less engineering required by equipment manufacturers.

Fabco-Air, which recently celebrated its 60th anniversary, will continue to operate independently and will remain in Gainesville. Festo and Fabco-Air implementation teams are working together on sales channel and product catalog integration strategies.

"This new association with Festo provides Fabco-Air with the resources to grow larger and faster than otherwise possible," said Scot LaMar, Fabco-Air General Manager. "Importantly for our employees and customers, Festo has a similar culture that comes from being a family owned business. It was a key consideration in the decision to join the Festo team."

"Festo customers and sales channel partners are excited to have the expanded product range available for their applications," said Michael Zakrzewski, Vice President of Marketing Management – North America. "The acquisition of Fabco-Air quickly broadens our product line, creating opportunities to fulfill more customer requirements with a strong focus on customer satisfaction."

### About Festo

Festo is a leading manufacturer of pneumatic and electromechanical systems, components, and controls for process and industrial automation. For more than 40 years, 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. For more information, visit www.Festo.com/us and www.Fabco-Air.com.

*Compact round body cylinders from Fabco-Air are perfect for space-constrained applications, or anywhere high force and shorter stroke are required.*

# 1888 MILLS SAVES $140,000 in Energy Savings and Maintenance Costs

By Ian Barnard, Ingersoll Rand® Compression Technologies and Services

Most of us mindlessly use terrycloth towels. In the bathroom, kitchen or garage, we use towels every day in homes, hospitality and healthcare. But most of us don't work at 1888 Mills where towels are the livelihood. Eight million pounds every year to be precise.

After getting its start manufacturing cost-effective products to the healthcare industry, 40 years later, 1888 Mills (www.1888mills.com) has become the fourth largest towel manufacturer in the world, and the largest towel manufacturer in the U.S. With facilities in the United States, Pakistan and Bangladesh, 1888 Mills' towels are used in almost every corner of the world. 1888 Mills is recognized as a leader in innovation in the textile industry and produces 176,000 pounds of towels per week.

To offer some perspective, 176,000 pounds of towels is equivalent to the weight of about 54 compact cars. That is a lot of towels and consistently producing that volume of towels requires the optimal performance of air-jet looms. An air-jet loom is a shuttleless loom that uses air to shoot a projectile that forces the yarn through the weft. This repeated process weaves products like sheets, clothing items and towels. An air compressor powers the air-jet loom with enough pressure to move the yarn. In its North America facility in Griffin, Georgia, the 1888 Mills weave shop is equipped with 31 air-jet looms that weave processed yarn into towels.

*1888 Mills' air compressor room equipped with two Ingersoll Rand C700 Series 600-horsepower Centac centrifugal air compressors.*

### Compressed Air System a Top Priority

"Our top priority is to meet production needs, and we can't run effectively without functioning air compressors," said Brian Bailey, Facilities Engineer for 1888 Mills.

Over the last two years, 1888 Mills has had increasing demand. At the same time, production downtime came from compressed air inefficiencies. Bailey needed a bold approach with enduring value. That led to a compressed air system upgrade that allowed 1888 to save more than $80,000 per year in energy costs. The company also no longer needed to invest approximately $60,000 to maintain and service the older units. The reduction in maintenance-related costs and new service plans, combined with energy savings, resulted in a total project savings of $140,000.

It's commonly known that clean, efficient air compression is essential in manufacturing. Once 1888 Mills' 25-year old air compressor equipment began to fail, they tried several repairs to maintain production. After three years and more than $52,000 in annual maintenance costs, their production still suffered.

### Always Have a Contingency Plan

Bailey phoned vendors to get the shop back to peak production. One, Ingersoll Rand®, pitched a contingency plan idea. An air compressor contingency plan is a plan for the deployment of temporary rental equipment in the event of an air compressor shutdown. Because 1888 Mills was still weighing its air compressor options, a contingency plan provided the flexibility it needed to take its time making a decision. While 1888 Mills didn't experience downtime that required an air compressor rental during the purchase evaluation process, the contingency plan provided the security of having a plan in place that ensured operations could continue in the event of downtime.

## 1888 MILLS SAVES $140,000 IN ENERGY SAVINGS AND MAINTENANCE COSTS

That prefacing step of developing the contingency plan, coupled with an existing working relationship, ultimately led Bailey to the decision to partner with Ingersoll Rand to replace their compressed air equipment.

### Out With the Old, in With the New

With the contingency plan in place, Bailey explored a long-term solution. The team assessed a number of air scenario studies to help him make the decision.

*An aluminum manifold provides even air distribution throughout the 1888 Mills facility.*

**TABLE 1**

| MONTH | TOTAL MONTH KWH | PEAK DEMAND KWH | ENERGY COST – NEW EQUIPMENT | ENERGY COST – OLD EQUIPMENT |
|---|---|---|---|---|
| January | 1,147,903 | 2,257 | $46,834 | $49,858 |
| February | 1,085,319 | 2,291 | $41,752 | $51,678 |
| March | 1,150,575 | 2,287 | $49,360 | $52,396 |
| April | 1,109,663 | 2,243 | $47,404 | $55,700 |
| May | 1,160,510 | 2,288 | $49,248 | $55,459 |
| June | 1,306,461 | 2,355 | $53,110 | $58,765 |
| July | 1,048,324 | 2,462 | $66,203 | $71,263 |
| August | 1,341,852 | 2,453 | $66,793 | $75,131 |
| September | 1,032,552 | 2,489 | $46,736 | $54,724 |
| October | 933,793 | 2,426 | $41,379 | $48,036 |
| Nov | 887,499 | 2,310 | $40,243 | $45,596 |
| Dec | 835,639 | 2,210 | $36,685 | $46,844 |
| **Totals** | **13,040,090** | | **$585,747.70** | **$665,450.00** |
| **Avg. Cost/¢ per kWh** | | | **4.492** | **5.103** |

*As shown above, 1888 Mills uses 13,040,090 kWh of power plant-wide per year. Peak demand varies between 2,210 and 2,462 kWh per month. The company's annual electric cost is now estimated at $585,747.70 versus $665,450 before the air compressor system upgrade.*

The studies looked at the life expectancy of the existing equipment's airend, which is where the actual compression takes place and reviewed critical factors such as system demand and pressure.

Test data and analysis recommended 1888 Mills replace five antiquated rotary screw air compressors with two Ingersoll Rand C700 Series 600-horsepower (hp) Centac® air compressors and one 100 hp oil-free air compressor. 1888 Mills also installed an NVP 7200 refrigerated air dryer because their previous heatless desiccant dryers required a certain amount of dry air, necessitating them to purge 10 to 20 percent of the capacity. The new refrigerated air dryer eliminated wasted air, ultimately saving energy.

With its old air compressors, 1888 Mills needed 597 kilowatts (kW) to achieve the pressure required to power its compressed air equipment. This is equivalent to $28.16 per hour. The new air compressor systems use 404 kW, which is equivalent to $19.16 per hour.

Previous air compressors were set at 125 psi to account for the pressure loss that is typical with outdated equipment. The new air compressors are set lower at 115 psi because they distribute pressure evenly across the entire facility. This pressure level keeps the looms operating at the required rate to meet 1888 Mills' production goals.

### Service for the Long Haul

Bailey was immediately pleased with the evaluation, contingency plan and long-term solution for the plant. Yet he knew the equipment would require periodic maintenance to keep it running at peak

## 1888 MILLS SAVES $140,000 IN ENERGY SAVINGS AND MAINTENANCE COSTS

performance. That's when 1888 Mills decided to protect the new equipment with service plans. The comprehensive plans, named PlannedCARE™ and PackageCARE™, provide scheduled maintenance and tools to help prevent unexpected interruptions.

"We weren't just looking to buy expensive equipment for the short term. We needed a long-term service plan with service techs we could trust to keep our plant running 24/7," said Bailey.

### Added Efficiency

It was essential to take a system approach. Along with air compressors and a service plan, Ingersoll Rand also proposed the installation of aluminum piping to increase efficiency and distribute air evenly throughout the facility. The surface of the piping directly impacts how much energy an air compressor system uses. Black iron piping, for example, has rough surfaces, which causes a slowdown in airflow rate, requiring more air pressure and energy to mitigate the pressure drop.

*The cooling tower and pump skid at the 1888 Mills facility.*

In contrast, aluminum piping has a smooth surface, so there is low restriction and pressure drop providing better energy efficiency. The aluminum piping addition helped the air-jet looms run efficiently enough to maintain the necessary pressure to produce the required volume of towels.

### Saving Money

With the new equipment and maintenance services, 1888 Mills received an unexpected rebate from Georgia Power because of the energy savings and achieved a cost reduction of $7,000 per month, which equates to a savings of more than $80,000 when compared year-over-year as depicted in Table 1.

1888 Mills was originally looking for a solution to maximize uptime yet ended up with so much more. Saving time, energy and cost along with peace of mind was priceless to Bailey and the 1888 Mills team. After all, keeping customers comfortable with terrycloth towels is their livelihood. BP

***About Ingersoll Rand®***

*Ingersoll Rand® is a $14 billion global business committed to a world of sustainable progress and enduring results. A global leader in compression technologies and services, Ingersoll Rand, develops products that range from complete compressed air and gas systems and services to power tools, material handling and fluid management systems. Diverse and innovative products, services and solutions enhance Ingersoll Rand customers' energy efficiency, productivity and operations.*

*All photos courtesy of Ingersoll Rand. For more information, visit www.ingersollrand.com or www.ingersollrandproducts.com.*

***About the Author***

*Ian Barnard is an Account Manager and Centrifugal Specialist at Ingersoll Rand where his primary responsibility is equipment sales and service for the compression technology and services business customers in the Greater Atlanta Area.*

To read more ***Air Compressor Technology*** articles, visit www.airbestpractices.com/technology/air-compressors.

# Controls Upgrade in 10 Plants SAVES $977,093 ANNUALLY IN ENERGY COSTS

By Stephen Parry, Bay Controls

To address a mandate for cutting operations energy usage at facilities by 25 percent without major capital expenditures, a major manufacturing company set its sites on better control of its compressed air systems. The project, implemented at 10 manufacturing plants over the course of three years, saves the company $977,093 annually in energy costs – and was completed with zero out-of-pocket costs.

## Background

As with many large operations, the manufacturer views compressed air as a major energy user and cost center. The company uses compressed air at production facilities in North America for a wide variety of end uses, such as paint spraying, material handling, and equipment operation (stamping presses, hand tools, etc.).

Knowing compressed air would play a key role in its energy-savings initiative, decision makers at the manufacturer opted to focus on maximizing the efficiency of their compressed air assets through a combination of controls retrofits, system networking and scheduling, and a monitoring solution powered by hardware from Bay Controls (www.baycontrols.com) and Tridium Niagara (www.tridium.com).

To minimize upfront project costs, Bay Controls implemented the project as an energy services agreement. This approach uses the cost savings generated by the compressed air system optimization project to finance it over the term of the agreement with zero out-of-pocket costs to the customer.

## Energy and Cost Savings Analysis

In the initial phase of the project, the team conducted a thorough assessment of the compressed air systems to establish a baseline for system performance, energy consumption, and energy costs.

Although the layout differs from plant to plant, all of the facilities involved in the compressed air system controls project utilize a plant air configuration where air compressors in one or more compressor rooms distribute air throughout the plant.

While a typical assessment or audit of this scale – 12 plants spread throughout the United States, Canada, and Mexico – would

*An Ingersoll Rand centrifugal air compressor equipped with a Bay Controls Control System at one of the manufacturer's 10 plants.*

be enormously expensive and take the better part of a year to complete, the Bay Controls team conducted a comprehensive analysis at no cost and in very little time using BayWatch, the company's cloud-based monitoring, alerting, and analysis platform for industrial compressed air systems. The manufacturer had used the platform for years before the decision to leverage it fully to optimize its compressed air system on a larger scale.

BayWatch gives plants the ability to record data at an individual monitoring point level, such as discharge pressure, motor power, blow-off valve position, loaded/unloaded, etc., for every air compressor in each plant. Using the platform's historical data logging and analytical capabilities, the team was able to thoroughly analyze a year's worth of historical compressed air system operating data for each of the plants in a matter of weeks.

Specifically, the team was able to efficiently assess the historical operation and performance of each individual air compressor and each plant air system to identify savings opportunities in the following areas:

- System pressure reduction.
- Unloaded compressor runtime reduction.
- Centrifugal compressor blow-off reduction.

To determine the potential for savings, the team looked primarily at the following historical data points:

- Minimum required pressure (as stipulated by plant personnel).
- System pressure (during production and non-production periods).
- Loaded versus unloaded air compressor run time.
- Plant production hours (compared to loaded/unloaded air compressor run times).
- Centrifugal air compressor blow-off valve position (to determine when centrifugal air compressors were venting air).

By utilizing the reporting tools built into the platform, the team also quickly sifted through the plants' historical operating data and identified those plants where one or more of the following trends were apparent:

- Large difference between system pressure setpoint and minimum required system pressure.
- Long periods of unloaded air compressor run time.
- Long periods of centrifugal air compressor blow-off.

From there, they calculated the potential energy and energy cost savings for each of the 12 plants in the following categories:

- Unloaded operation reduction.
- Centrifugal air compressor blow-off reduction.
- System pressure reduction.
- Leak loss reduction due to lower system pressure.

Once the potential savings for all 12 plants were annualized, the team determined only 10 of the 12 plants would achieve sufficient savings to offset the total project cost within the required payback period.

# CONTROLS UPGRADE IN 10 PLANTS SAVES $977,093 ANNUALLY IN ENERGY COSTS

### Defining Project Scope

Based on the analysis results, Bay Controls determined the most cost-effective savings measures for the project would be the following:

- Compressor Controller User Interface Module (UIM) retrofits at all plants.
- Compressed air system network surge testing and tuning at all plants.

In addition to the energy-saving upgrades, the other major component of the project was the integration of the plants' compressed air systems onto the Tridium Niagara platform. This was necessary since the manufacturer had standardized on the Niagara platform for centrally tracking utility (gas and electric) data and wanted to integrate the compressed air monitoring and data capture abilities of BayWatch into their existing Tridium platform.

### Project Implementation

During the course of the next 24 months, the team completed the UIM retrofits and conducted compressed air network surge tuning at the 10 plants in North America.

All of the plants involved had existing Bay Controls air compressor controllers in place, but in many cases, the UIMs were outdated and functioning poorly. The UIMs serve as the touchscreen interface for localized control by plant operators. All of the old UIMs were replaced with the latest version to ensure that plant personnel could effectively monitor and operate the air compressors and to enable the Bay Controls team to surge-tune them.

In all, Bay Controls engineers surge tested and tuned 56 centrifugal air compressors and configured each plant's air compressor network to most efficiently meet plant demand for air as observed from the historical performance data.

Surge occurs in centrifugal air compressors when inlet flow is restricted to the point that the flow through the air compressor can no longer overcome the pressure at the discharge of the air compressor. In extreme cases, it can actually entail a flow reversal through the various centrifugal air compressor stages and cause severe damage to the unit. To avoid this, control systems for centrifugal air compressors typically have some sort of surge protection built into their control logic.

Bay Controls air compressor controllers feature advanced surge protection that simultaneously protects the unit from damaging surge and maximizes their turn down range, which is the ability to reduce flow relative to their rated design flow. The controllers utilize air compressor-specific surge curves, which are defined through the surge testing and tuning process.

During surge testing and tuning, a Bay Controls engineer runs the air compressor at a variety of operating conditions intended to mirror its behavior as it approaches its natural surge curve. At each point, the controller logs the conditions and uses them to create its own surge threshold, which effectively serves as a new surge curve with a safety margin built into it for that particular air compressor.

Table 1 shows the 60 compressors that were part of the project. The air compressors ranged from 300 hp to 3,000 hp.

By surge testing and tuning all 56 centrifugal air compressors, Bay Controls was able to maximize their turndown range, which results in two main benefits: greater flexibility (and often efficiency) in air compressor network control and reduced blow-off.

In addition to surge testing and tuning, the team developed a new Tridium Niagara driver/connection protocol that would allow the existing Bay controllers to effectively communicate with the manufacturer's Niagara network, which is used for utility monitoring and data logging.


*Above are blow-off flow readings displayed on the BayWatch platform for six centrifugal air compressors. Each color represents an air compressor. Blow-off for two air compressors exceeds 500 cfm as indicated by the maroon and beige lines, indicating the need to surge-tune the units. The remaining air compressors do not need attention since they are consistently showing zero blow-off, except for isolated instances with one air compressor as shown by the single green line.*

After developing the driver, all Bay compressor controllers were updated with new software that enabled them to communicate with the Tridium networks already in place. From there, Bay Controls Tridium-certified system integrators began the process of connecting all of the plants' compressed air networks and controllers to each plant's existing Tridium network utilizing the Bay-Controls-built Tridium driver.

## Energy Savings and More

In all, the project involved retrofitting 60 air compressor controllers, surge tuning plant compressed air networks, and fully integrating all 10 plant compressed air systems into the Tridium Niagara network. All of this was completed with no out-of-pocket costs.

Based on the savings analysis completed by Bay Controls and the improved energy performance of project plants to-date, the manufacturing operation has reduced its compressed air energy costs by $977,093 annually across all 10 plants involved in the project.

**TABLE 1**

| | | |
|---|---|---|
| Plant 1 | 5 centrifugals (1000 hp) | |
| Plant 2 | 5 centrifugals (900-3000 hp) | 1 dryer, 1 Cooling Tower |
| Plant 3 | 2 centrifugals, 2 recips (1750-3000 hp) | |
| Plant 4 | 2 rotary screws, 11 centrifugals (450-1100 hp) | |
| Plant 5 | 5 centrifugals (300-1500 hp) | 5 dryers, 1 Cooling Tower |
| Plant 6 | 5 centrifugals (800-2000 hp) | 4 dryers, 1 Cooling Tower |
| Plant 7 | 5 centrifugals (600-1000 hp) | 3 dryers, 1 Cooling Tower |
| Plant 8 | 5 centrifugals (500-1000 hp) | |
| Plant 9 | 6 centrifugals (500-2500 hp) | |
| Plant 10 | 7 centrifugals (1000 hp) | Monitoring 3 dryers |

In addition to realizing significant energy savings, the manufacturer gained the ability to centrally (and remotely) monitor and control the compressed air systems in the 10 plants via the Niagara/Bay Controls integration.

With the migration of the compressed air data and analysis to Niagara, the company can now see all of its utility data (water, gas, electric) side by side with compressed air metrics. As such, decision makers can easily monitor and benchmark plant performance from a total efficiency and energy perspective. BP

***About Bay Controls***

*For 35 years, Bay Controls has been providing control and monitoring solutions to a broad range of industrial, commercial, and government customers in the U.S. and 60+ countries across the world. The Bay Controls suite of cloud-ready hardware, and a state-of-the-art, cloud-based analytics platform deliver the actionable intelligence companies need to make smart, data-driven decisions about compressed air system operations, energy savings, and maintenance. All photos courtesy of Bay Controls. For more information about Bay Controls, visit www.baycontrols.com.*

***About the author***

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# COMPRESSED AIR SYSTEM CONTROLS SAVE North American Lighting $91,000 in Energy Costs

By Warwick Rampley, Compressed Air Alliance

By finding a better way to control and manage its compressed air system, North American Lighting, Paris, Ill., has reduced its total compressed air energy use by 27 percent – and in the process – saves over 1,100,000 kWh/year for a total annual savings of $91,000. The project also achieved a payback of less than one year.

## Background

Compressed air is expensive, which is something many hear in the industry. It's also said that the cost for compressed air is around 0.02 cents per 33 cfm ($1m^3$), but this is far from the truth. There are many factors that come into calculating the cost of compressed air on any specific site that can make this value vary greatly. In particular, how the air compressors are controlled can add significant cost to the operation of a system.

There are a number of methods used to control air compressors, but as systems get larger and more air compressors are added, efficiently controlling the system becomes more difficult. The problem gets even worse when a combination of air compressor sizes, brands, locations and types starts to add complexity to the overall system. Sadly, this is often the reason why many companies stick to one air compressor size, brand or type, despite better options being available or increased operational costs to their system.

In reality, having a variety of sizes and types of air compressors is a good thing for the efficiency of a compressed air system, provided you can control it. For instance, during low demands, users will want to be run their smallest compressor. In moderate demands, they might want to run a large base load air compressor and a small trim air compressor. Ideally, companies will run the air compressors that most closely match the system demands at any given moment. Unfortunately, most controllers on the market can only sequence the order in which air compressors run without selecting the best combination for the current demand. This is what North American Lighting discovered at its plant in Paris, IL.

*North American Lighting Maintenance Service Manager Michael Westerfield (left) stands next to the Airleader Master Controller with Sean Wisner of Brabazon Pump, Compressor and Vacuum.*

## Energy Savings Targeted

North American Lighting (www.nal.com) has been manufacturing automotive lighting systems for vehicle manufacturers since 1983. Today, they are the largest lighting supplier to automotive OEMs in North America. North America Lighting (NAL) designs, engineers and manufactures state-of-the-art automotive lighting systems for major automotive manufacturers in North America and around the world.

At the Paris facility, compressed air is used throughout the plant to operate production lines, primarily for pneumatic controls, cylinders and actuators. Compressed air is generated in two compressor rooms located approximately 1,000 feet apart. The first room has two Gardner Denver 200 horsepower (hp) fixed-speed air compressors and one Sullair 200 hp fixed-speed air compressor. All three are controlled with a sequencer. The second room has two 200 hp Sullair variable speed air compressors operating on standard internal controls. Both compressor rooms supply the factory via pressure flow controllers, however, due to issues trying to get both compressor rooms balanced, these have been put on bypass.

"At North American Lighting, the two compressor rooms were not able to communicate with each other causing them to run more air compressors than needed," said Sally Struckman of Brabazon Pump, Compressor and Vacuum. "They were trying to control the plant off the pressure in each holding tank via two pressure flow controllers, but were running more horsepower than they needed. They wanted to save on electricity and improve their system."

The biggest issue NAL faced had to do with the compressor rooms being so far apart. It would take time for air compressors to react to the demands of the plant. This forced the need to set up some of the air compressors in modulation mode in order to try and improve the reaction time of the air compressors and keep the system pressure relatively stable. This lead to very inefficient operation of the compressed air system, which in turn, resulted in the consumption of significantly more energy than necessary.

### Analysis Reveals Potential Savings

Michael Westerfield, NAL Maintenance Service Manager, was aware these issues were causing the operation to use more energy than was necessary, but had been unable to find a suitable method of control for the system. That's when the Brabazon team got involved.

"When we came in North American Lighting told us about some of the issues they were having with their system," said Struckman. "We took a walk around the plant and noticed we could help manage their compressed air system for them. We told them about the Airleader control system and said we could audit their system and show them a simulation of how their air compressors would run using this master control and how much money they could save."

Brabazon proposed a supply-side compressed air system survey to identify the issues, establish a baseline of energy use, confirm the flow demand for the plant, identify additional opportunities and establish potential savings.

# COMPRESSED AIR SYSTEM CONTROLS SAVE NORTH AMERICAN LIGHTING $91,000 IN ENERGY COSTS

Data logging equipment was then installed across the site in July 2017 for a period of one week. Once analyzed, the results revealed a number of previously unknown facts about the system as can be seen in Figure 1. Of particular interest was:

- On any given day the plant demand would fluctuate by around 1,500 cfm.
- The variation in demand over the entire week is approximately 3,000 cfm (lowest to highest).
- Average flow for the period was approximately 2,200 cfm

*Figure 1*

*Figure 2*

Additionally, Brabazon established a solid baseline for the system operation and costs. As shown in Figure 2, which captures a one-day period, North American Lighting was spending over $330,000 per year in compressed air energy. Almost 23% of the total was in unloaded energy use ($75,500/year). In addition, system pressure was fluctuating by 20 psi.

As both NAL and Brabazon had suspected, the wide variation in demand was proving challenging for the existing system to adapt and provide compressed air reliably and efficiently.

"We could see from the data, the problem the customer was having is that they were running too many air compressors at the same time and their large VSDs were running fully loaded instead of trimming," said Struckman.

## Simulation Software Demonstrates Controller Advantages

The team from Brabazon used Airleader's simulation software to demonstrate how a master controller could reduce the wasted unloaded energy to less than $5,000/year, resulting in an estimated saving around $70,000/year.

"We initially monitored with the Airleader equipment because we liked that it could run a simulated report. We monitored the system for one week and used the data from their data logger in the simulation software," said Struckman.

Brabazon proposed the use of an Airleader Master II Controller to control the entire system of air compressors. The Master Controller offered a number of advantages because it could:

- Match air demand and supply.
- Control multiple air compressor load/unload and a VSD unit from various air compressor OEMs.
- Use only one Master Controller to manage two locations via an Ethernet network, reducing installation and cabling costs.
- Ensure the system ran efficiently now and into the future, as well as providing the ability to make adjustments to the air compressor system settings remotely and providing historical data for further analysis when required.

The Airleader unit, including kW meters on each air compressor, took about four weeks in total to connect to the compressed air system primarily due to the site not wanting to interrupt production and the need for a constant supply of air.

## Immediate and Long-term Results Achieved

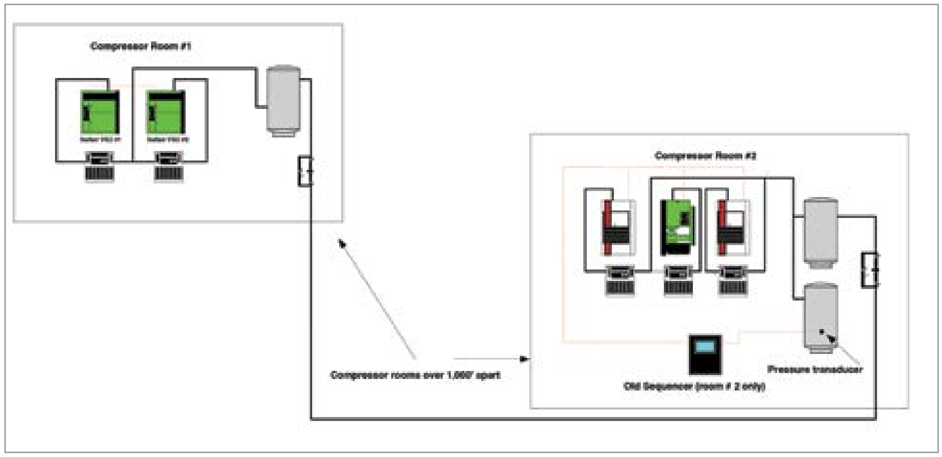
Once installed it, the controller monitored the system for a few weeks and established an up-to-date baseline before taking full control over the compressed air network. By Mid-March 2018, it switched to full automatic control, allowing the plant to immediately notice improvements in the reliability of the compressed air supply.

Ongoing results are continuously updated through the software. The table below shows a summary of the weekly results after several months of operation using the new controller. On the right is the total kWh consumption for each week. The red bar depicts energy consumption during the audit in July 2017. The orange bars show the period prior to the Master Controller taking control. The blue bars show the kWh for each week. The line graph illustrates annualized kWh consumption throughout all three time periods.

"It's a relatively straightforward system actually," said Jan Hoetzel, Airleader North America. Based in Grand Rapids, Mich., Airleader USA, (www.airleader.us) is a provider of compressor energy management software and tools to reduce compressed air costs.

"Our master controllers can control anywhere up to 32 compressors in multiple locations. We install a control module into each air compressor that is connected to the master controller. Depending on the compressor locations, we can either wire them directly to the controller or utilize the existing Ethernet network to control the compressors remotely, as was the case with the North American Lighting project."

According to Hoetzel, the control module uses the existing air compressor inputs, and does not need to interfere with the existing control panel. If needed, the air compressor can immediately be switched back to manual control. The module provides the air compressor with information from the master controller on when to start, load and shutdown, or in the case of a VSD, the system target pressure.




*Shown are North American Lighting's compressor rooms as originally operated without a master controller, which was needed to control the entire system of air compressors – and in the process – save energy.*

# COMPRESSED AIR SYSTEM CONTROLS SAVE NORTH AMERICAN LIGHTING $91,000 IN ENERGY COSTS

## Brabazon Pump, Compressor & Vacuum

Brabazon Pump, Compressor & Vacuum is one of America's largest distributors of compressed air, pump, and vacuum products. Since 1978, Brabazon has been a leader in providing comprehensive air solutions to our customers. We are dedicated to providing innovative, reliable, and efficient products and service solutions.

Brabazon is headquartered in Green Bay, Wis., and has seven stocking warehouses across the Midwest including Wisconsin, Illinois, Minnesota, U.P. of Michigan, and Missouri. Its inventory and coverage allows it to respond to our customers' service needs very quickly.

Customers tell Brabazon its service makes the difference. Brabazon's service centers are staffed with over forty factory-certified technicians who are experienced with working on equipment from every manufacturer in the market today. Brabazon employs a full-time service trainer to ensure a consistent level of service for customers and a progression path for technicians.

Brabazon's goal is to identify substantial savings for customers' overall operating costs. It focuses not only on reducing energy costs, but also minimizing their total costs including production losses and maintenance. Brabazon's audits have identified tens of millions in savings for customers. Its partnership with Airleader allows customers with multiple air compressors to efficiently control their air supply within a tight pressure band, resulting in substantial savings to their bottom line.

Whether its air compressors, air treatment solutions, air control systems, pumps and piping, or vacuum and blowers, Brabazon offers an extensive line of products and services. For more information, visit www.brabazon.com.


*Brabazon Service Manager Andy Frehse.*

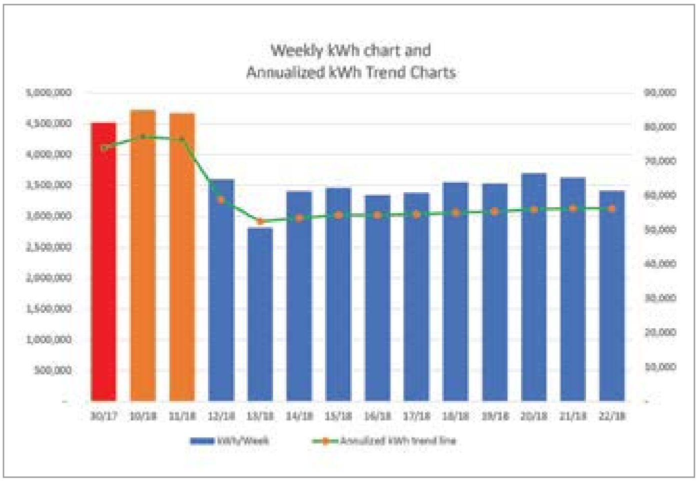
"We use a special adaptive algorithm that matches the running air compressors with system demand. The master controller will select the best compressor combination, which in turn reduces or eliminates unloaded running time and ensures the most efficient combination of air compressors is being utilized at any given moment," Hoetzel said. "This reduces the wasted energy of the system, the running hours of the air compressors and avoids the sequencing issues found with other controller. It's the elimination of waste that ultimately saves the customer money."

Hoetzel said North American Lighting also improved system stability and reliability by better controlling its VSD's and controlling both air compressor rooms with one master controller – and it eliminated modulation of the other air compressors.

"And because our algorithm is adaptive, as North American Lighting makes improvements to their demand side of the system, the controller will adjust which air compressors to run to ensure they maximize any future potential savings, which of course, they will be able to see as it happens through the Web Server that is part of each master controller."

Since the project has been completed, North American Lighting has saved 27 percent of the total energy use of its compressed air system, which is over 1,100,000 kWh/year for a total saving of $91,000/year. In addition, it resulted in a total project a payback of less than one year.

As seen by North American Lighting, having a complete picture of how a compressed air system operates at any given point in time through detailed monitoring, as well as having a robust control strategy in place, makes it possible to significantly reduce waste energy consumed by a system. It also improves system reliability and performance. BP




*Graph 1*


An Airleader control module installed on an air compressor at North American Lighting.

***About the Author***

*Warwick Rampley has performed a wide variety of compressed air system audits in industries from food and beverage to pharmaceutical, automotive, packaging and semiconductor industries to name a few. Recently he founded the Compressed Air Alliance, through which he has joined forces with Airleader to bring more efficient compressor control to the Asian market. For more information, contact Warwick Rampley, email: warwick@compressedairalliance.com, or LinkedIn: www.linkedin.com/in/warwickrampley/*

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# ASSESSMENT REVEALS Air Compressor Control Gap Issues

**By Ron Marshall, Marshall Compressed Air Consulting**

A food processor in Western Canada hired an auditor to assess the energy efficiency of its compressed air system. The results revealed surprises about the operation of some important elements of the system, and detected that the air compressors were having control gap problems. Additionally, the audit led to initial energy savings of $20,000 – and identified the potential to achieve overall operational savings of 45%. The following details some of the audit findings and results.

## Background

The plant system consisted of three 75 horsepower (HP) air-cooled lubricated screw air compressors, one of which was a Variable Speed Drive (VSD) version. All three air compressors were connected to a sequencing controller to orchestrate the efficient operation of the air compressors during variations in compressed air demand.

A single heated blower-type desiccant dryer with pressure dewpoint control (EMS) was installed to produce dry compressed air for plant operations. The system also has a mist eliminator filter and high-efficiency coalescing filter installed before the air dryer, with a particulate filter after the dryer.

Two medium-sized 660-gallon storage receivers are located in the air compressor room as wet and dry control storage. A pneumatically operated pressure/flow control valve regulates plant pressure, however, it was not set to regulate at the time of the assessment.

The compressed air is delivered to multiple production areas through a 2-inch-piping header from which various branches are tapped to supply each production machine. The piping is arranged in a radial feed for the two main production areas. Data loggers showed minimal pressure loss across the piping system. Most of the pressure loss is across the drying and filtering system.

The shape of the compressed air flow demand curve at the end of the data logging period can be seen in the green line on Figure 1.

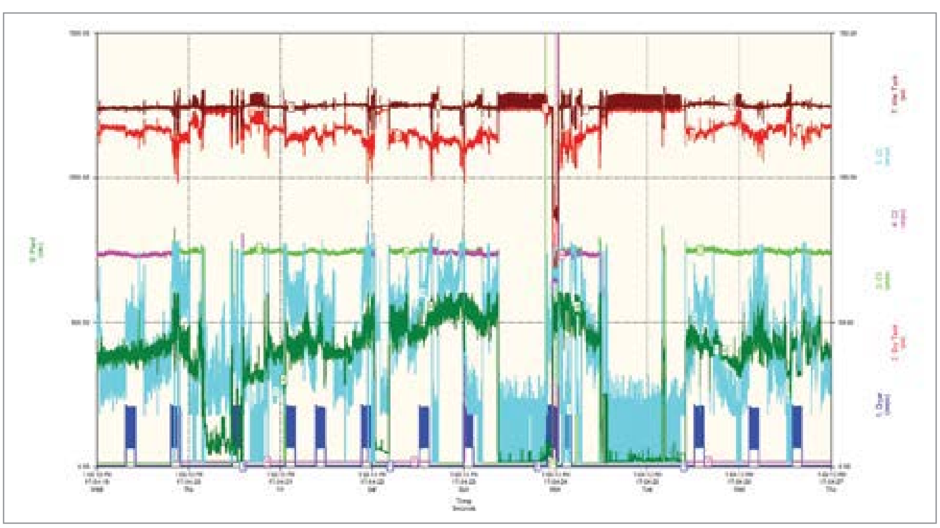

*Figure 1: Shown is the shape of the compressed air flow demand curve.*

The profile shows a somewhat random pattern during production activities and very low flows during shutdown periods. The highest peaks were seen during nighttime cleanup activities where the air-powered vacuum and blow wands might be used at the same time the dryer cooling purge is flowing. These peaks required all three air compressors to run. The pressure profile shows very good pressure regulation on the upstream side of the dryer, but poor regulation of plant pressure especially during peak flows on the downstream side. This is associated with the air dryer and filters, and made worse by undersized air compressor room header piping.

Amp loggers were used to monitor the compressed air system's electrical consumption. Kilowatt readings were performed for both active air compressors using a handheld meter to calibrate amps to power. System flow was recorded by placing a logger on a newly installed main flow meter at the output of the pressure/flow controller. Pressure loggers were located at the wet receiver, dry receiver, after the pressure/flow controller, at the bagging area and near one of the end uses. The baseline shown in Figure 2 was determined over a five-week period.

| Baseline | Units | Average | Annual kWh |
|---|---|---|---|
| Discharge ave | psi | 123 | |
| Dryer Out ave | psi | 118 | |
| FC Out ave | psi | 117.5 | |
| Bagging | psi | 117.3 | |
| Sorters | psi | 117 | |
| C1 GA55 | kW | 43.9 | 330,348 |
| C2 GA55 | kW | 23 | 173,075 |
| C3 GA55 VSD | kW | 27.4 | 206,185 |
| Dryer | kW | 1.83 | 13,771 |
| Total | kW | 96.13 | 723,378 |
| Peak | kW | 171.5 | |
| Specific Power | kW/100 cf | 22.4 | |
| Flow | cfm | 430 | |
| Operating | hours | 7525 | |
| Cost | | | $ 83,763 |

*Figure 2: The baseline collected during initial measurement period.*

The readings and observations during the measurement period show the compressed air system was producing air at fairly good efficiency (22.4 kW/100 cfm with dryer excluded). Yet problems with the air dryer cooling purge flow, higher-than-needed discharge pressure, some small leakage and drainage issues, and some inappropriate

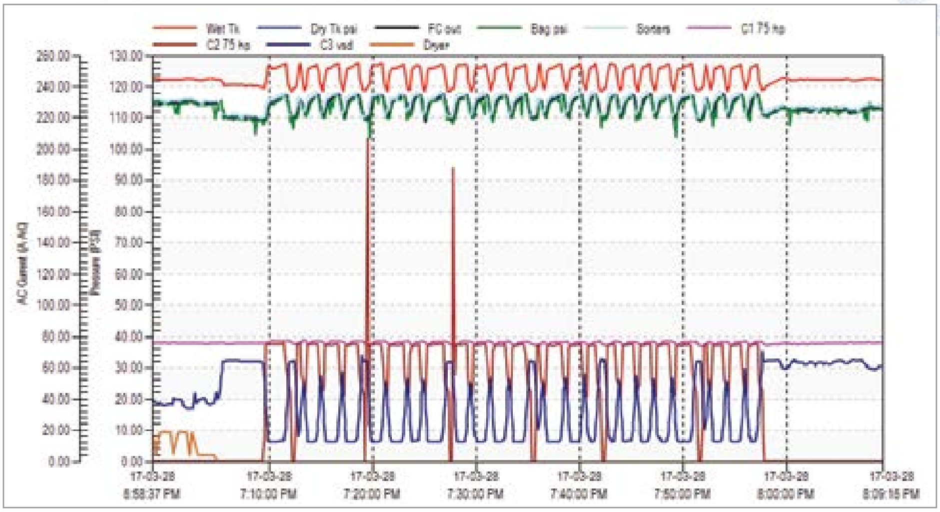


*Figure 3: A control gap problem shows the air compressor fighting for lead control.*

# ASSESSMENT REVEALS AIR COMPRESSOR CONTROL GAP ISSUES

high-flow uses are causing higher than desired operating costs and occasional pressure issues. The study found that significant improvements were possible.

A survey of the demand-side of the system was done including leakage. A total of 10 leakage points were found, estimated at 20 cfm. The survey also found one end-use involving an air-powered vacuum consuming 180 cfm, which might be classed as an inappropriate use.

## Air Compressor Control and Control Gap

Early into the assessment the auditor found periods of time where a control gap was causing the air compressors to fight for control.

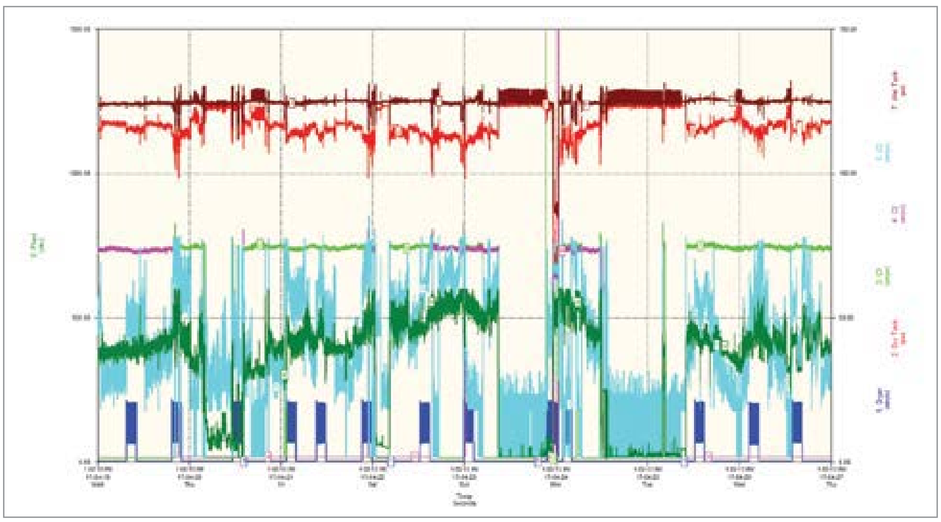

*Figure 4: Shown is the baseline once the control gap was corrected.*

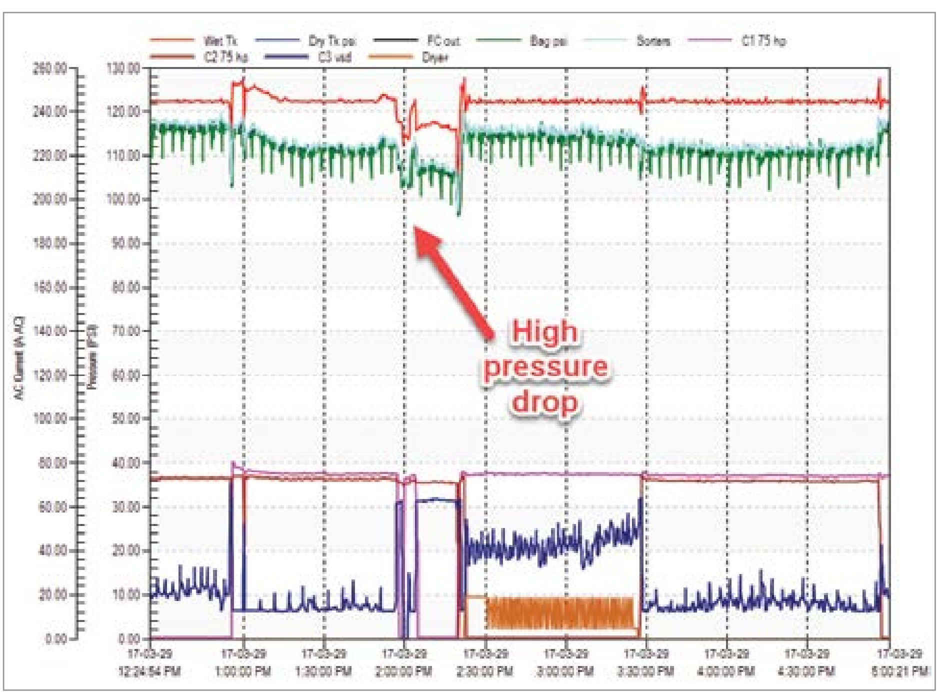


*Figure 5: High flow was causing excessive pressure drop.*

The graph (Figure 3) shows the VSD alternating between full load and minimum speed at the same time the fixed-speed air compressors are loading and unloading. This is caused by a sizing mismatch between the capacity of the system variable and fixed-speed air compressors. In order to avoid control gap, the size of the variable capacity range for VSD air compressors must be equal to or larger than the size of the fixed- speed air compressors with which it must work. In this case, since the VSD unit has an 80 percent turndown (80% x 75 hp = 60 hp of variable capacity) and the fixed-speed capacity is 75 hp, the sizing rule is broken. The correct sizing would have been a 100-hp variable air compressor. As a result of the mismatch, there are flow ranges where a fixed-speed (or a combination of multiple fixed speeds) machine is too large for the flow, but where any combination including the VSD unit is too small. This causes the air compressors to fight for control, causing inefficiency and excessive swings in pressure.

This condition can be almost totally corrected by allowing the full capacity of the VSD to be used, but doing this may allow the unit to run in start/stop mode below minimum speed for extended periods, not a recommended way to operate variable units. The full range of the VSD is used by adjusting the stop point of the VSD so it is lower than the unload point of the fixed- speed units, which in this case, are controlled by a central system controller.

The air compressor controller purchased with the units would not allow the variable air compressor to run in start/stop mode, so the unit had to be removed from the central controller with only the fixed-speed units left to run on a single pressure band. This corrected the problem, allowing the units to run without control gap. Due to the characteristics of the plant flow profile, there are currently no periods of extended operation below minimum speed.

## Air Dryer Problems

As part of the compressed air assessment, a main flow meter was installed to capture the flow profile with data loggers. From the initial installation, some strange results were noticed. The plant flow was averaging between 200 cfm and 600 cfm during main production, yet three 320 cfm-rated air compressors were sometimes required to run. As part of the assessment the auditor typically tests desiccant dryers and noticed that whenever the dryer was placed in standby mode for test, with no cooling purge flow, one air compressor unloaded and turned off.

Typically, when a heated blower style dryer re-pressurizes, after a regeneration cycle, air for pressurization transfers from the active side to the other tower through a large valve sized so the operation takes only a few seconds. After a heating cycle ends, a smaller cooling purge valve opens to send a low flow of air, about 7½ % of the dryer rating, to the side being regenerated.

A careful inspection of the dryer found that, likely since installation, the operation of these two control valves were reversed, allowing a very large flow of compressed air into the depressurized side for the cooling cycle. In addition to this, the cooling purge valve was stuck open, allowing even more air into the

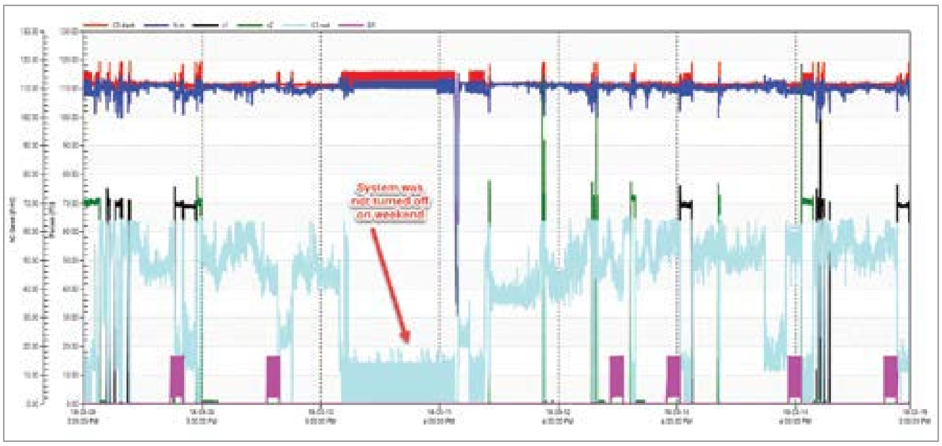


*Figure 6: Shown is the baseline after the dryer issue was corrected. Only two air compressors are required to meet peak demand.*

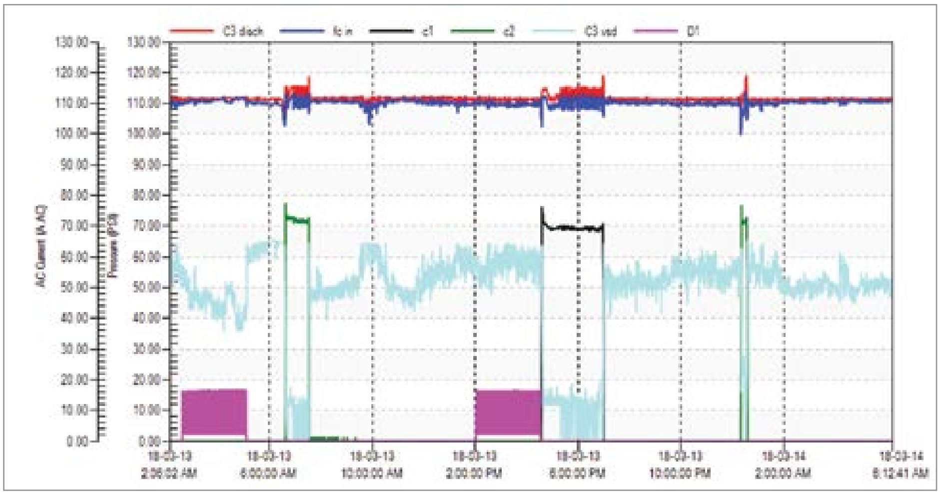


*Figure 7: The final profile shows the air dryer still has significant effect, starting an extra air compressor to feed cooling purge, but the air compressors are not fighting in control gap.*

# ASSESSMENT REVEALS AIR COMPRESSOR CONTROL GAP ISSUES

regenerating side, even when no air was to be flowing during operation of the heated blower cycle. Enough air was flowing to require one extra air compressor at peak.

The extra air required for the dryer was causing excessive pressure loss across the dryer and filters, reducing the pressure available to the plant. The data loggers showed that about a 12 psi differential was developing across the air dryer and filters. This low pressure required the air compressor discharge pressures to

| | | | Annual |
|---|---|---|---|
| Baseline | Units | Average | kWh |
| Discharge ave | psi | 112 | |
| Dryer Out ave | psi | 110 | |
| Plant | psi | 110 | |
| C1 GA55 | kW | 5.4 | 47,304 |
| C2 GA55 | kW | 3.9 | 34,164 |
| C3 GA55 VSD | kW | 43.2 | 378,432 |
| Dryer | kW | 0.74 | 6,482 |
| **Total** | kW | 53.24 | 466,382 |
| Peak | kW | 92 | |
| Specific Power | kW/100 cfm | 18.9 | |
| Flow | cfm | 282 | |
| Flow Peak | cfm | 490 | |
| Operating | hours | 8,760 | |
| Cost | | | $ 53,634 |

*Figure 8: The final baseline shows $20,000 in energy savings and better system efficiency.*

*Figure 9: This compressed air powered drum vacuum adds to plant peak.*

be boosted to above 120 psi to compensate, causing the air compressors to consume more energy per-unit output.

This condition was corrected by repair of the dryer, and as a result only two air compressors now run during peak, saving the third air compressor as a standby unit. This correction greatly reduced operating costs.

## Recommended measures

Other energy reduction measures recommended:

- Reduce air compressor discharge pressure settings and lower plant pressure by adjusting the flow control valve to regulate.
- Correct air compressor controller to allow VSD to be centrally controlled.
- Increase the size of air compressor room piping.
- Reduce plant leaks.
- Eliminate a number of timer drains that were wasting compressed air.
- Correct air dryer purge.
- Eliminate a compressed air powered drum vacuum that was causing a high plant peak.
- Properly maintain main filters to eliminate pressure loss.
- Consider refrigerated drying (only one end-use was located outdoors, all other end uses were in heated conditions).

The estimated potential energy reduction for these measures would result in 45% lower energy consumption and better-stabilized pressure.

## Interim Results

As part of an energy program offered by the local power utility, the compressed air assessment was funded at 100% with 50% after the final report and 50% when significant energy efficiency measures were adopted. A baseline was taken after the plant took some action, although not all recommended measures. This resulted in the baseline shown in Figure 8.

The results showed lower energy consumption for a savings of about $20,000 in operating costs. Additionally, because the control was corrected, and discharge pressures are lower, the specific power of the system dropped from 22 kW per 100 cfm down to 19 kW per 100 cfm. These results were enough for the local utility to grant funding for the full cost of the study. A further energy program for projects awaits completion of the remainder of the work.

## Conclusion

The results of this study, and the additional baseline, show that assessing a system can find unexpected items of concern. This system was fairly new, with newer cutting-edge air compressors with excellent efficiency, a modern control system, and energy-efficient air dryer, yet problems were occurring that were unknown to system operators. It was only after the system was measured with monitoring instruments, and analyzed, that the items of waste were discovered.

There are problems and potential savings hiding in almost every compressed air system. If a plant isn't regularly monitoring your system there could be some unpleasant surprises waiting. Bringing in an auditor for an assessment is a good start on the road to improvement. BP

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

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# Missed Demand-Side Opportunities Part 8
# OPTIMIZING A PET BLOW MOLD AND FILLING PLANT FOR A BALANCED SYSTEM

By Hank van Ormer, Van Ormer Consulting

On a recent project, at a polyethylene terephthalate (PET) blow-mold and filling operation, a very effective measurement plan resulted in a full synchronization of the supply side air to blow molds with significant reduction in total air use and increases in productivity and quality.

## Identifying the Issues

The demand side of the system consisted of four blow molds feeding three separate filler lines. The plant had some significant operational issues they had not been able to resolve.

For beginners, the blow-molds are faster than the filler lines, and during most operations the molds had to stop and start every five to seven minutes. The plant was told they could not adjust the line speeds. On the restart the blow molds would often fault out, or produce rejected bottles.

In the meantime, the total air supply to the blow molds came from two – 800 horsepower (HP) Class 4 stage centrifugal air compressors capable of delivering 1,726 scfm each (3,452 total) at 550 to 580 psig. This airflow was more than ample for four blow molds of which only three operate at any one time. These two air compressors run 24 hours/day, five days a week (6,240 hr/yr). Both units need to remain on whenever there is production due to limited start and stop capabilities.

One question plant decision-makers wanted answered was the size and type of air compressor to add to the system to be able to load and unload as required, without having to constantly run two 800 HP centrifugal air compressors. They also wanted to know the proper size trim unit needed to be able to effectively unload and save energy when the air demand is lower.

A four-stage double acting, water cooled, reciprocating 500 HP air compressor rated to deliver 1,100 to 1,200 scfm at 550 – 580 psig as a trim unit was recommended. The demand was perceived to be too high for the two 800 HP units because of the falling pressure when they were at full load. The plan was to have the centrifugal air compressors at base and trim with the new reciprocating unit.

The plant manager felt the plant needed more definitive support data to make this large capital expense and called in consultants to implement a full evaluation.

**TABLE 1**

| BLOW MOLD LINE / MODEL | #5 (24 OZ.) 48,000 BPH | #4 (2 LITER) 22,000 BPH | #3A (20 OZ.) 30,000 BPH | #3B (20 OZ.) 30,000 BPH |
|---|---|---|---|---|
| Blow Air (scfm) – 32 Bar | 1007 | 1042 | 524 | 524 |
| Pre-blow (scfm) – 7 Bar | 406 | 184 | 208 | 208 |
| Stretch (scfm) – 7 Bar | 270 | 474 | 180 | 180 |
| Service (scfm) each – 7 Bar | 125 | 100 | 100 | 100 |
| Air Required at 464 psig / 32 Bar (scfm) | 1,007 | 1,042 | 524 | 524 |
| Air Required to 100 psig / 7 Bar (scfm) | 801 | 836 | 488 | 488 |
| Total Delivered at 464 psig / 32 Bar (scfm) | 1,808 | 1,878 | 1,012 | 1012 |
| **Projected Blow Air Recovered (scfm)** | **(403)** | **(416)** | **(210)** | **(210)** |
| **Projected Net High Pressure Required with 40% Blow Air Recovery** | **1,405** | **1,461** | **802** | **802** |

## Developing an Action Plan

The consulting team conducted an analysis and recommended a number of steps to gather the data needed to optimize the compressed air system and achieve energy savings.

As a first step, the plant needed to install input kW loggers on each operating air compressor. It also needed to install flow meters in the air compressor room, and AFTER the refrigerated dryers. Additionally, the plan called for the installation of pressure transducers and loggers at the air compressor discharge; at the dryer entry; at the dryer exits; at the entry to the blow mold and after the blow mold high-pressure inlet regulator discharge inside each blow mold.

The team then instructed the plant to set this measurement equipment to record all data simultaneously with one-second data prints for diagnostics.

Next, the plant needed to establish an accurate best-case demand scenario for the measured conditions. To do so, it needed to identify the calculated air demand of each operating blow mold while considering operating pressure, production level in bottles/ hour, container size, and blow air recovery. The following table outlines how this was accomplished.

## Bottling Blow Mold Calculated Air Demand Profile with Blow Air Recovery

There are four blow-mold machines at the plant. Lines #3A and 3#B always run together. Either line #4, or line #5, runs with lines #3A and #3B.

The calculated maximum demand for high-pressure air use with 40% recovery to the blow air would be between 2,500 scfm to 2,600 scfm at 550 psig to cover both of these conditions.

Utilizing the Control Board Flow Data on each blow mold (Table 2) shows that lines #4 and #5 run just a little lower than the calculated flow. However, lines #3A and #3B each run almost 300 scfm higher than calculated.

With the current piping arrangement the team could not determine if the 210 scfm of blow-air recovery from each mold was actually being utilized. The maintenance indicators all said it was. Observation of the operation identified very significant leaks within line #3A and #3B blow molds.

## Gaining Accurate Insights

The team gained invaluable insights that led to an accurate flow-pressure operating profile.

Very critical data is shown in Table 3. One highlight of the data is that *maximum flow* into the system is 2,700 scfm and the pressure falls. The two centrifugal air compressors at full load together are rated at 3,532 scfm, but can only deliver 2,700 scfm. Also, the blow molds start and stop with continuing four– to six-minute cycles. The blow mold production speeds are too far ahead of the filler speed.

As shown in Table 4, blow mold #4 is measured at 1,461 scfm compared to a calculated 1,405 scfm; blow mold #3A is measured at 1,200 scfm compared to a calculated 800 scfm; and blow mold #3B is measured at about 1,300 scfm compared to a calculated 800 scfm.

Table 5 shows the discharge pressure of each air compressor with two of three blow molds operating. The most the system can hold is 520 to 530 psig. When all three blow molds are operating together *both compressors fall to **465 psig.***

The measurements led to a number of important conclusions. Beginning with the evaluation of

**TABLE 2**

| BLOW MOLD* NET SCFM DEMAND (470 PSIG OR MORE TO BLOW MOLD / 464 PSIG INSIDE BLOW MOLD) | | |
|---|---|---|
| | CALCULATED (SCFM) | MEASURED ACTUAL (SCFM) |
| #5 | 1,405 | 1,380 |
| #4 | 1,461 | 1,390 |
| #3A * | 802 | 1,100 |
| #3B * | 802 | 1,100 |

* Net flow includes 40% blow air savings.

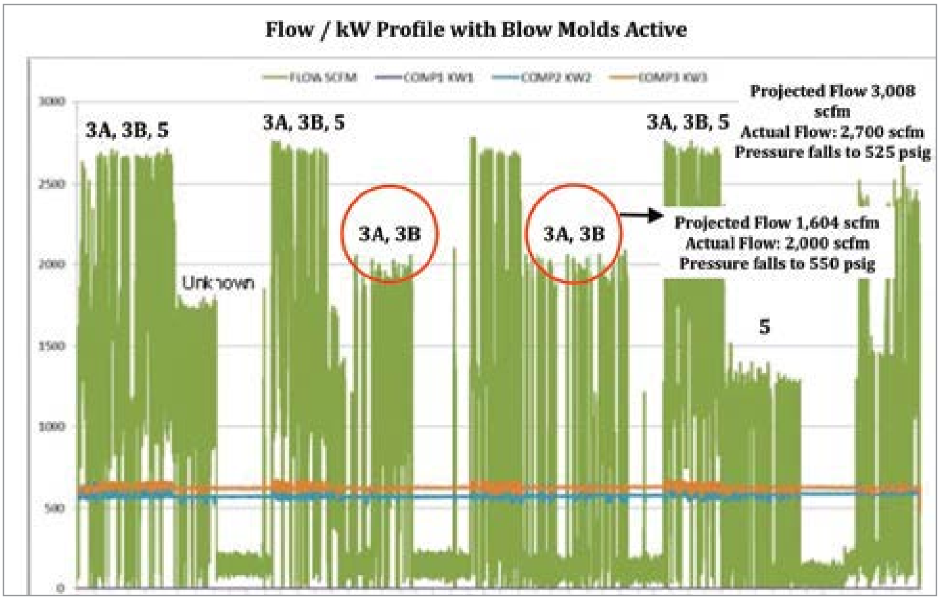



*Table 3*

# OPTIMIZING A PET BLOW MOLD AND FILLING PLANT FOR A BALANCED SYSTEM

air demand, blow molds #4 and #5 appear to confirm that the calculated net flow, including the blow air recovery, are accurate. Blow molds #3A and #3B running together measure 2,200 scfm to about 2,400 scfm compared to a calculated 1,600 to 1,700 scfm.

Recommended action to be taken included an investigation and repair of leaks. When the leaks are repaired the plant needed to stabilize at the proper demand. In addition, it needed to monitor the airflow and inlet pressure to all blow molds. An evaluation of the air supply concluded:

- Total air supply required at 550 to 580 psig with one centrifugal air compressor delivering rated flow, one centrifugal in backup and one correctly sized trim at *3,200 to 3,300 scfm.*
- Total maximum calculated load with monitored and well maintained blow molds operating either line #4 or #5, and both #3A and #3B.
- The proper type and size for the trim unit would be a three-step unloading, double-acting reciprocating water cooled unit delivering 1,500 to 1,600 scfm at 550 to 580 psig.

This will deliver a total 3,250 to 3,350 scfm with the maximum demand from 3,000 to 3,100 scfm, with one centrifugal air compressor at base load and the other in back-up mode. Doing so will reduce the total input energy significantly. The original suggestion of a 1,050 to 1,100 scfm trim unit would have been too small.

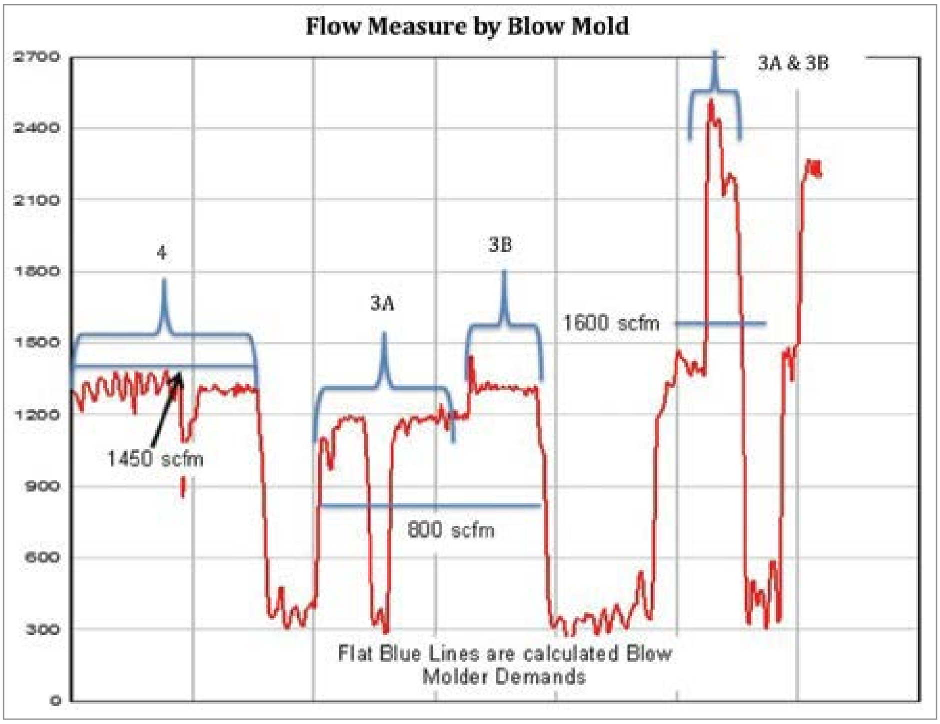



*Table 4*

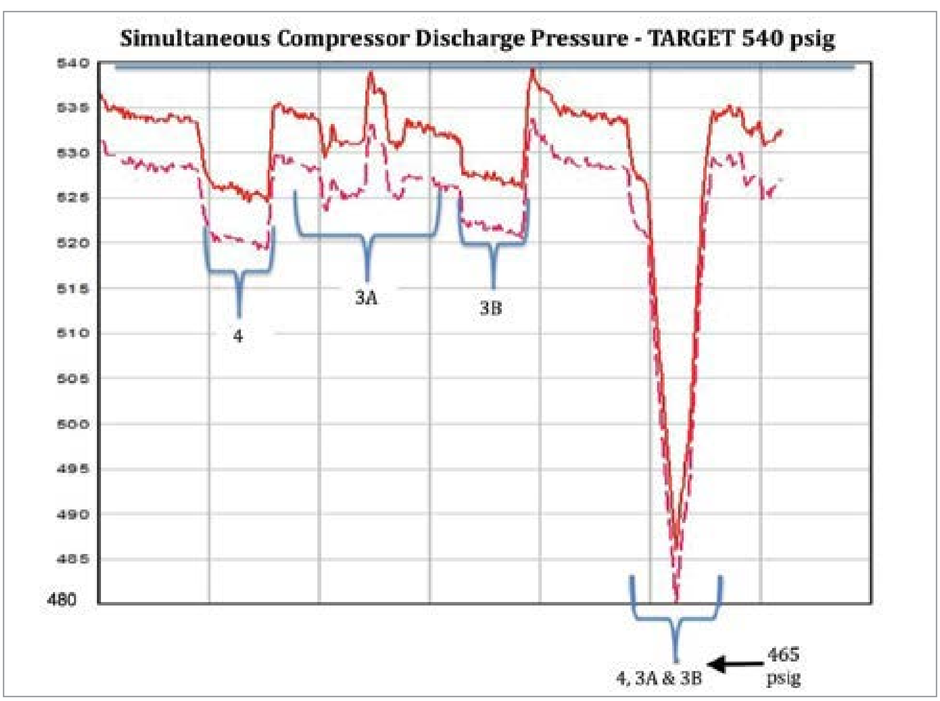



*Table 5*

## Addressing Key Questions

The project addressed three key questions:

1. What can be done to eliminate the frequent starts and stops? One solution is to increase the bottle storage convey line. Another is to lower the blow mold speed closer to the filler speed. This not only will lengthen the run times but will also *reduce the air demand.* In other words, **lower the speed 10%, reduce the air demand 10%.** This speed adjustment was accomplished by adjusting the speed, controls, and the ovens properly.

2. Why can't the two centrifugal air compressors deliver their full capacity? This is a question that speaks strictly to a piping issue.

Figure 1 shows the basic piping size and configuration. The red circles identify a “crossing tee” and “dead head” with converging flows to the 6-inch header, which creates turbulent resistance to flow and backpressure and reduces the full load mass flow from 3,532 scfm to 2,700 scfm to 2,800 scfm.

Figure 2 shows the correct way to eliminate this basic piping issue. More importantly the system uses a positive displacement trim unit with a dynamic centrifugal air compressor. The team also eliminated any interference to the centrifugal air compressor by running the positive displacement unit to a receiver and tying the discharge line downstream at an angle into the primary air receivers.

Note the centrifugal collector headers for the discharge were increased from six inches to 20 inches to reduce the transfer of velocities.

3. What is the basic cause and correction for the extreme pressure drop (465 psig)?

This condition is depicted in Figures 3 and 4.

Figure 3 shows pressure before and after the dryer. The ΔP is an approximate constant five psig, which may seem high, but since it is a steady differential it probably is not a fouled dryer, or filter separator, causing the pressure loss.

Figure 4 shows pressure after the dryer and at blow mold entry. The blow molds require a minimum entry pressure of 480 psig, however, this cannot be delivered with the three blow molds running constantly. At 465 psig and lower the blow mold shuts off.

## Identifying the Problem

Storage: Total current effective storage 3,100 gallons (414 cu. ft.) at 550 psig maximum. Allowable pressure loss to avoid low-pressure problem in blow mold = 480 psig.

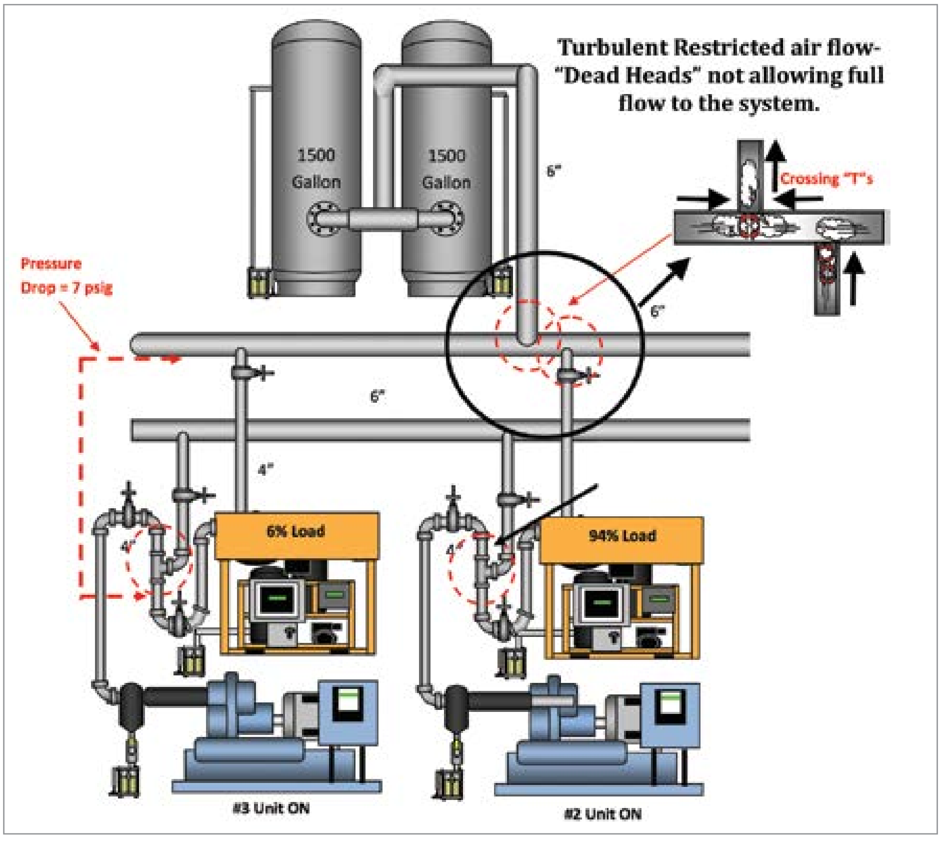
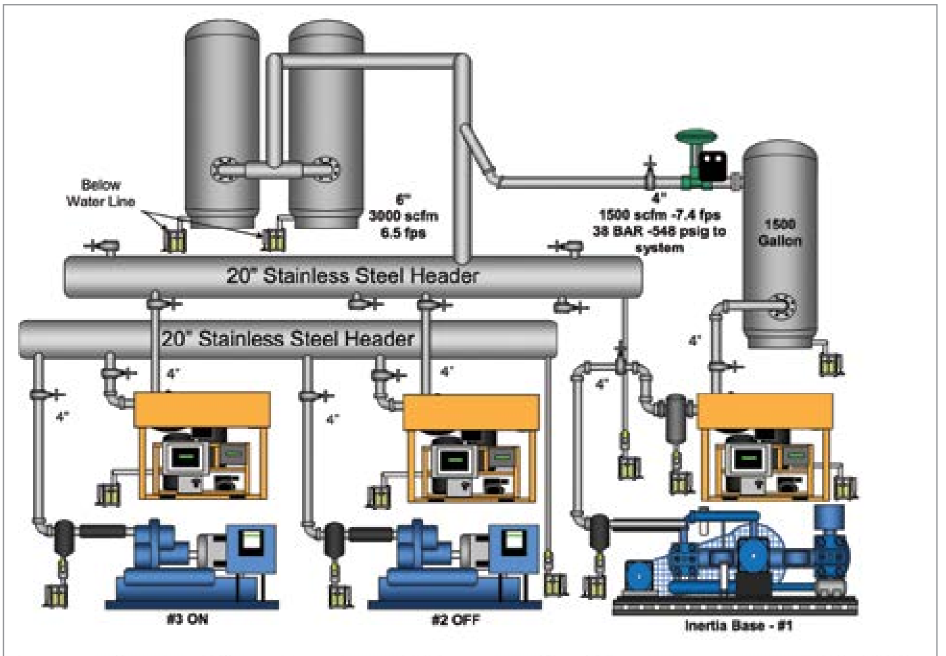



*Figure 1*




These modifications will smooth out the total flow pattern from the compressor room and should be able to handle more demand, if required. Future changes will be able to handle a reasonable increase without major modifications; there will be little or no abnormal resistance to flow.

*Figure 2*

# OPTIMIZING A PET BLOW MOLD AND FILLING PLANT FOR A BALANCED SYSTEM

The formula to calculate decay time:

$$\text{Time} = \frac{(414 \text{ cu. ft.})\ (550 - 480 \text{ psig})}{(400 \text{ cu. ft.})\ (14.38 \text{ psig})}$$

With 400 scfm net flow out

Net flow currently delivered from air compressors (best possible) = 2,700 scfm with demand of 3,100 gallons.

The total 2,700 delivered was 400 scfm short. The calculated tank holding time was five to six minutes in a best-case scenario by applying the stored air to the shortage.

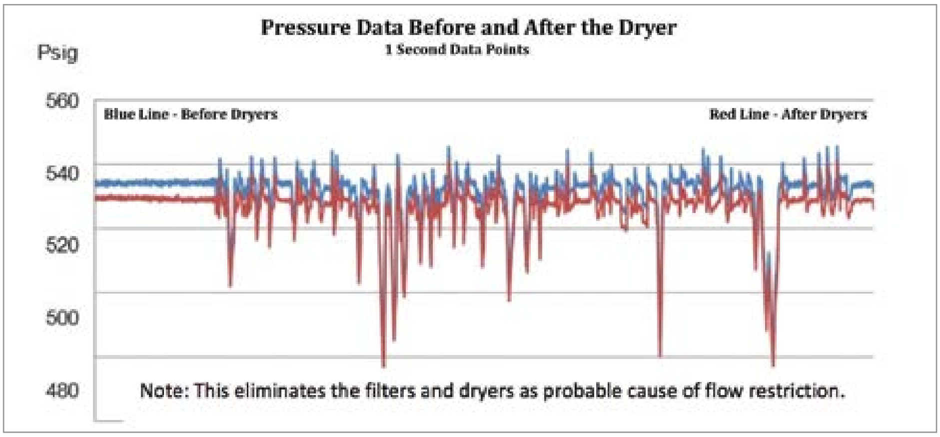



*Figure 3*

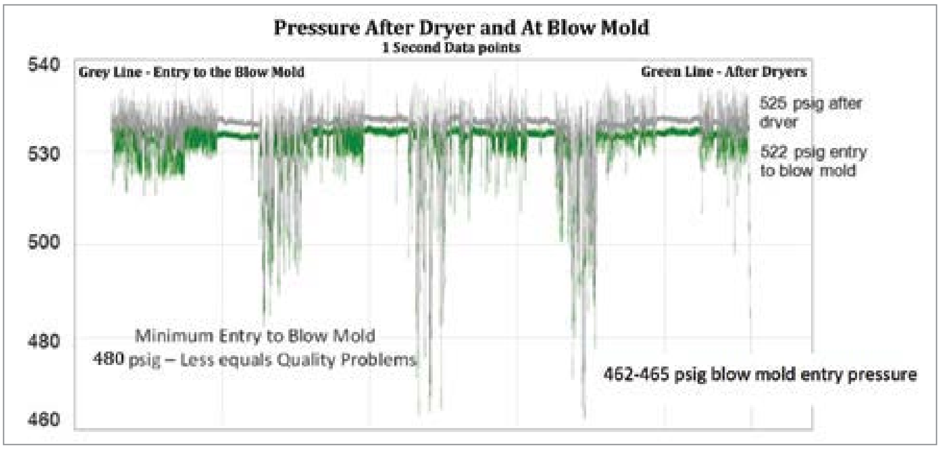



*Figure 4*

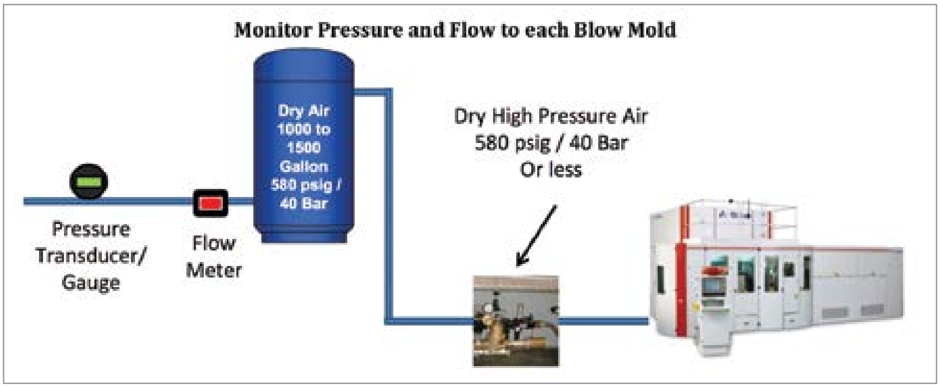



*Figure 5*

If the blow molds continue to run more than six minutes, the system pressure will fall below 480 psig as it is now doing.

## Lack of Effective Storage

Another issue to address was the lack of effective storage. The current storage cannot sustain a continuous three- or even two-blow mold run. It is also too small to allow the system to hold pressure during the **permissive reload time** for the centrifugal air compressor to unload and then load in during stoppages and reload.

Based on observations and according to plant personnel, the plant is currently experiencing bottle rejects due to low-pressure issues particularly during the blow mold startup run.

To address the issue, storage increased from 414 cu. ft. to about 1,000 cu. ft. The probable worst-case scenario is with three blow molds on and with both #4 or #5 blow molds remaining off. The flow drops about 1,400 scfm and there is only the 1,600 scfm demand left of lines #3A and #3B (after repairs). Currently one centrifugal air compressor goes to full blow off, but will have to reload once the blow mold starts up.

A blow mold takes 1.5 minutes from start to full flow demand and to activate the blow air recovery system. The initial demand will be low and then it increases to about 1,800 scfm, then finally falling to 1,400 scfm as the blow air recovery system engages.

The high-pressure centrifugal air compressor blow off/inlet value control requires about three minutes from full blow off to full load. Any signal delay from the blow mold start to the air compressors will add to this permissive load time.

The new reciprocating unit's permissive reaction time from no-load, to 50% load, to 100% load is much less than a minute, but short cycling of less than one minute isn't wanted since it could cause higher maintenance issues. The modified storage increase will allow this, regardless of which units are online operating the trim from 550 psig to 580 psig and regulating the flow to 548 psig. With the centrifugal air compressor set at 550 psig at full load during three blow molds the operation should do well.

Under these given conditions:

$$\text{Time} = \frac{(1{,}000 \text{ cu ft.})\ (550 - 480 \text{ psig})}{(1{,}400 \text{ cu ft.})\ 14.38 \text{ psig}}$$

Time = almost 3.8 minutes even at a 1,400 scfm net flow out

Holding the maximum pressure discharge from 550 psig to 480 psig, this storage allows over 3.5 minutes in the worst-case scenario. In the anticipated one-minute cycle time of the reciprocating unit, the pressure will only fall about 2 psig.

Since the high-pressure air system is dedicated to the blow mold process, if a central air monitoring and management system is installed, a combination load/unload signal can be set up to activate from the blow mold start/stop signal, further enhancing the timing between compressed air supply and the blow molds.

## Final Thoughts

With proper data and understanding of the various operating dynamics of key equipment processes – what was deemed almost incomprehensible – became clear and a path to success became obvious.

After the system is balanced, it is important to monitor the key performance indicator, set the "red flags" and take timely corrective action. For PET blow mold monitoring we recommend at the every least monitoring pressure and flow to each blow mold. Then, compare it to the calculated standard. Do not allow demand to grow. Proper flow measurement to the blow mold should be ahead of the air receiver as shown in Figure 5. If not available on the control board, the air receiver will help eliminate low internal pressure problems in the blow mold.

Keep in mind this exercise involved a high-pressure PET production process, yet it does not matter what the pressure, production, or the process is. The strategy works when the goal is to balance any system with proper measurement and data. BP

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

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# RESOURCES FOR ENERGY ENGINEERS

## TECHNOLOGY PICKS

### BOGE America Launches CLDR Series Rotary Screw Air Compressors

BOGE America has launched a new line of fully packaged, industrial grade tank-mounted CLDR Series rotary screw air compressors available from 5 to 20 hp.

According to Jerry Elsen, General Manager, BOGE America, the CLDR Series air compressors offer BOGE America customers a true industrial alternative to commodity grade, tank-mounted air compressors designed for sale on the Internet, or through mass merchandisers.

"We've designed our CLDR tank-mounted air compressor packages with direct-drive technology using larger airends operating at low rotational speeds mounted on ASME/CRN-rated air receivers with ball valve drains, 115 V refrigerated air dryers with auto drains, 1.0 micron pre-filters with auto drains and PSID indicators, along with mounting isolators for the air receivers all as standard," Elsen said. "CLDR Series air compressors are truly designed for the toughest duty cycles and include high-quality industrially packaged features that our customers demand to ensure reliable operation."

The CLDR Series all-in-one packaging provides clean, dry compressed air in a very small footprint for installation and maintenance. The air compressor packages also offer a high-level of performance with a lower specific power requirement. Larger size airends, TEFC IE3 premium efficiency motors, wye-delta starters, and automatic sleep mode when there is no demand for air, all contribute to additional energy savings.


*BOGE America's fully packaged CLDR Series rotary screw air compressors are available from 5 to 20 hp.*

Air compressors with tank, dryer and pre-filter are available with simple Base Control or Focus Control 2.0, which offers many additional convenient features including load efficiency status, adjustable control parameters, maintenance advisories, maintenance log book, operating pressure, operating temperature, operating status, leak detection function, low ambient protection, dual control, auto sleep mode, language selection, auto restart capability, hour meters, sequence capability up to four air compressors without the use of additional controllers and more.

BOGE also has an experienced global network of distributors with factory trained and certified technicians who assist customers with compressed air system installation, commissioning, maintenance, inspections, and recommendations to ensure smooth operations.

#### About BOGE America

BOGE America, Inc., is the United States of America's daughter company of BOGE Kompressoren GmbH based in Bielefeld, Germany. BOGE manufactures a comprehensive range of oil-lubricated and oil-free rotary screw, scroll and piston air compressors used by all sectors of industry to supply compressed air for a wide range of manufacturing processes. The company also supplies a complimentary range of filters, dryers and condensate management equipment. The product is sold and serviced through a dedicated network of over 70 distributors in North and South America. For more information regarding BOGE America and superior oil-free air compressors, visit https://us.boge.com

### Sauer Marks New Family of Controls with ecc 4.0 Air Compressor Control

Sauer Compressors now offers a new range of controls for fully automated monitoring and control of air compressor functions, starting with its first model: The ecc 4.0 – a control for universal use in all air compressor series for applications in the naval, shipping, offshore and industrial fields.

The design of ecc 4.0 follows an intelligent modular principle tailored to the air compressor type and version. The modular system can be configured over various expansion levels, from the economical basic version to complete monitoring of all measured values in the fully featured version. The software, which was completely developed by Sauer Compressors, enables it to be adapted precisely to the relevant requirements. Features can be added and customized for

## TECHNOLOGY PICKS


*The new Sauer ecc 4.0 air compressor control is universally compatible and adaptable.*

specific projects. In addition, the control can connect up to twelve air compressors, communicating via all standard interfaces. In terms of Industry 4.0, it can be integrated into higher-level systems.

The ecc 4.0 control is operated using a 7-inch color touch screen display. The latest generation resistive display is extremely robust and can be operated wearing gloves. Users benefit from the user-friendly intuitive menu system and step-by-step instructions in 30 languages. All relevant parameters are visible at a glance, represented visually by pressure gauges and texts. In case of faults, the control provides detailed alarm and fault messages including remedial suggestions. A numerical keypad allows easy adjustment of values. Operator login is based on direct code entry.

### About Sauer Compressors

Sauer Compressors is a medium-sized German group of companies with twelve international subsidiaries. The company was founded more than 130 years ago, and has over 80 years' experience in compressed air technology. Today, it focuses on the development, production and sale of medium- and high-pressure compressors for applications in the naval, shipping, offshore and industrial sectors. Its modern reciprocating compressors for the compression of air and neutral and inert gases reach pressures of 20 to 500 bar. It offers customized solutions for individual customers, OEMs and companies that operate on a global stage. With a global network of agents and representatives, Sauer maintains close proximity to its customers. By enhancing its range of compressors with high-quality accessories, engineering services, installation and service concepts, Sauer can offer end-to-end system solutions and compressed air modules, including complete turnkey installations. For more information, visit www.sauercompressors.com.

### Aggreko Unveils New Fuel-Efficient, 100% Oil-Free Air Compressor Fleet

Aggreko plc unveiled a new fleet of 100% oil-free air (OFA) compressors for industrial and commercial applications. The new line of CARB and EPA-certified tier 4 final diesel and electric air compressors are compliant with the toughest emissions standards in North America.

Compressed air is used in multiple industries and process applications from heavy industries like petrochemical plants, manufacturing, steel mills and oil refineries to industries as diverse as food and beverage, agriculture, health care, pharmaceuticals and electronics. The ability to deliver 100% oil-free air provides a vital support component for these industries' processes to maintain a safe, clean working environment and smooth-running, reliable operations.

"As global energy markets change, the challenges our customers face around limiting emissions and accessing reliable utilities are becoming ever-more complex. Aggreko's commitment to evolve our oil-free air compressor line ensures our customers can deliver their highest standard performance, with the peace of mind they are running a viable solution that includes the latest emissions reduction technology," said Terry Dressel, VP of Central Operations, Aggreko North America.


*An Aggreko oil-free air compressor.*

## RESOURCES FOR ENERGY ENGINEERS

### TECHNOLOGY PICKS

Aggreko offers CARB and EPA-certified tier 4 final (Tier 4F) diesel and electric oil-free air compressors beginning with the 1,600 cfm models. The Tier 4F diesel engine provides a significant increase in run time, reliability and fuel efficiency with extended service intervals. This results in lower fuel and maintenance costs and longer uninterrupted runtimes for customers. The electric air compressor is built with totally enclosed, fan-cooled motors allowing it to be used in a wide array of locations, both industrial and commercial.

The new oil-free air compressors, assembled in the United States, are compliant with the toughest emissions standards in North America, feature ISO class 0 air out and deliver 1,600 cfm at air pressures to 55-150 psi.

"Aggreko's certified 100% oil-free air compressors, air drying and air cooling equipment provide customers with the clean air needed to protect equipment, products, and the safety and comfort of their employees," said Fernando Arce-Larreta Aggreko Head of OFA.

"In industries where downtime can cost hundreds of thousands of dollars per day, customers can be assured that Aggreko will quickly deliver the exact system they need, while minimizing and eliminating the risks airborne oil and contaminants can cause to their valuable revenue-generating processes," he said.

Available for short or long-term needs, Aggreko's 100% oil-free air equipment is now in operation. Aggreko Remote Monitoring (ARM) is provided on all Aggreko compressed air equipment. The units provide operating parameters to the Remote Operations Center (ROC) where teams of field-experienced engineers and technicians monitor air compressor performance 24/7 and are ready to respond to potential

## TECHNOLOGY PICKS

problems immediately. Performance data, alerts and service information are available to customers via an ARM smartphone app.

**About Aggreko**

Aggreko is the world's leading provider of modular, mobile power and heating and cooling. We've been in business since 1962. We have more than 7,300 employees, operating from more than 200 locations in 100 countries. With revenues of approximately GBP 1.6bn (USD 2.6bn or Euros 2bn) in 2016, we are listed on the London Stock Exchange (AGK.L) and have our headquarters in Scotland.

Our business helps transform the lives and livelihoods of individuals, organizations and communities across the globe, in both developed and developing countries and markets.

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For more information, please visit our website at: aggreko.com

### Siemens Announces MindSphere – Siemens Cloud for Industry

Siemens introduces MindSphere – Siemens Cloud for Industry, a platform as a service (PaaS) concept in which Siemens bundles a wide range of services for manufacturing companies on the path to Industry 4.0.

MindSphere is an open operating system for IoT, allowing a customized platform for recording and analyzing large volumes of plant-wide production data. A customer can integrate with Siemens or third-party providers for a variety of predictive maintenance services, energy data management and resource optimization development applications.

Siemens reports that customers can easily look for other options online if they are dissatisfied with a current supplier and manufacturing companies are feeling the effects of tougher competition. It said the answers to this challenge are to cut throughput times, increase flexibility, and enable individual mass production, while optimizing energy and resource consumption patterns. This means companies

# RESOURCES FOR ENERGY ENGINEERS

## TECHNOLOGY PICKS

must perfect their entire value chain from design, production planning, engineering and manufacturing to a full range of after-sale, maintenance and upgrade services. Siemens supports this process with its Digital Enterprise Software Suite, which includes MindSphere.

MindSphere interlinks physical products and production facilities with digital data, enabling the implementation of innovative solutions plus the ability to bring products onto the market faster and more efficiently. It also offers industrial enterprises an open infrastructure based on SAP HANA and allows the creation of new digital services ongoing for the customer. Additionally, it serves as a comprehensive, cost-efficient data hosting platform that combines device management, easy connectivity, all necessary data storage and the associated infrastructure, providing virtualized data management that can be quickly deployed.

*With MindSphere, Siemens offers a cost-effective, scalable cloud-based Platform as a Service (PaaS) for the development of applications.*

Siemens support services for platform partners include data recording, transmission and safe storage, plus the framework for a development environment in which applications can be created swiftly. Siemens technical experts are ready to provide advice and assistance for the implementation of the service.

### About Siemens Corporation

Siemens Corporation is a U.S. subsidiary of Siemens AG, a global powerhouse focusing on the areas of electrification, automation and digitalization. One of the world's largest producers of energy-efficient, resource-saving technologies, Siemens is a leading supplier of systems for power generation and transmission as well as medical diagnosis. With approximately 351,000 employees in 190 countries, Siemens reported worldwide revenue of $88.1 billion in fiscal 2016. Siemens in the USA reported revenue of $23.7 billion, including $5.4 billion in exports, and employs approximately 50,000 people throughout all 50 states and Puerto Rico. For more information, visit www.siemens.com.



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