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August 2016

Measurement

- 12** Managing Pressure Regulator Artificial Demand, Part 1
- 18** The Importance of Bi-directional Compressed Air Flow Measurement
- 24** Assessing the Impact of Compressed Air Quality on Food Products

36 AUTOMAKER PROTON SAVES ENERGY



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12 Managing Pressure Regulator Artificial Demand, Part 1

By Murray Nottle, Working Air System Engineer, The Carnot Group

18 The Importance of Bi-directional Compressed Air Flow Measurement

By Pascal van Putten, VP Instruments

24 Assessing the Impact of Compressed Air Quality on Food Products

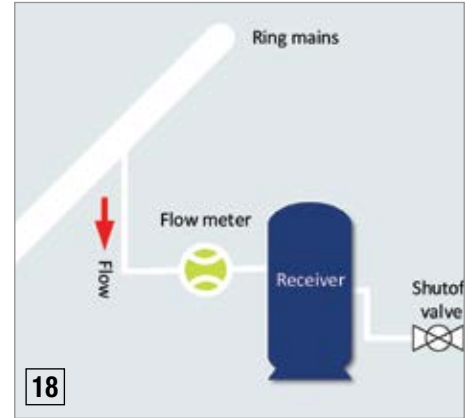
By Dick Smith, Trace Analytics

30 Sparks Dynamics Optimizes NIST Compressed Air System

By Mac Mottley, Sparks Dynamics

36 Automaker PROTON Attacks Compressed Air Waste

By Abdul Azeem bin Mohamed Mohideen, PROTON
Edited by Ron Marshall, Compressed Air Challenge®



COLUMNS

4 From the Editor

6 Industry News

44 Resources for Energy Engineers Technology Picks

47 Advertiser Index

49 The Marketplace Jobs and Technology





FROM THE EDITOR

Compressed Air Measurement



We dedicate one issue per year to this important topic as demand for compressed air system measurement continues to grow. Plants want to measure the kWh consumption of the air compressors. They now want to “audit” their compressed air system all year, by owning tools to measure compressed air leaks and by installing compressed air flow meters, pressure gauges and other instruments able to measure quality metrics like pressure dewpoint and oil content.

We have received an exciting compressed air system optimization case study all the way from Malaysia’s automaker PROTON. Taking measurements was their first step and identified compressed air as their third largest Significant Energy User (SEU). With a production capacity of 150,000 cars per year, their Electrical Energy Manager describes the process and actions taken to reduce compressed air consumption by 31 percent and generate saving of 3.8 million kWh equaling \$255,000 per year.

Bi-directional flow is a little-understood topic presenting a challenge to accurate compressed air flow metering. VP Instruments CEO, Pascal van Putten, provides us with two very interesting case studies, where they encountered bi-directional flow, and details how they were able to nevertheless provide accurate information.

Pressure regulators are installed on most pieces of production equipment. They often are part of a FRL (filter-regulator-lubricator) package installed to assist the pneumatic circuits. In the first installment of a two-part article, Murray Nottle, from The Carnot Group in Australia, writes about how regulators can be “big wasters” of compressed air. The primary waste issue he describes is artificial demand – regulators forcing the compressed air system to operate at higher pressures than necessary.

Measuring compressed air quality is critical in the food industry. Trace Analytics Technical Director, Dick Smith writes, “Being aware of the composition of compressed air used in your plant is key to avoiding product contamination. Your task is to assess the activities and operations that can harm a product, the extent to which a product can be harmed, and how likely it is that product harm will occur.” Readers will find this article worth filing.

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

ROD SMITH

Editor

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

▶ Join Mike Flaherty and Chiller & Cooling Best Practices Magazine to review issues with traditional chilled water system design and control strategies – by signing up for our free August 31st Webinar titled, “How Traditional Chiller Plant Design and Operation Reduces System Efficiency” at www.airbestpractices.com/magazine/webinars.

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INDUSTRY NEWS

Nano-Purification Solutions Appoints Adam Wright

nano-purification solutions ltd. (n-psl), the Gateshead, U.K. - based compressed air treatment specialists owned by nano-purification solutions Inc. (n-psi) have hired an experienced sales professional to head sales strategy in the UK and Europe. Adam Wright was appointed Business Development Director in June, 2016 and bringing a wealth of compressed air purification experience into the business. Adam has worked in the compressed air treatment market for over 10 years, formerly heading up the sales organization for a world leading air treatment company.

Michael Eccles, UK Technical Director, commented "We are extremely pleased to have Adam on board. He brings with him vast



Adam Wright was named Business Development Director for the U.K. and Europe for nano-purification solutions ltd.

worldwide distribution and OEM experience and a fresh approach to our sales and marketing efforts. We have no doubt that this

significant addition to our team will maximize our growth potential in Europe and beyond."

Adam also commented, "These are exciting times at nano. The innovative and proven desiccant dryer and gas generation products are a sales professional's dream and, with production in a state of the art manufacturing facility where the test equipment is second to none, quality is assured. I am delighted to be part of a team where the company is firmly focused on exceptional customer service."

When Adam is not extolling the virtues of nano, he can be found toiling up the significant hills of the North Pennines on his bicycle.

For more information, visit www.n-psi.com/.

FS-Elliott Unveils New Interactive & Educational Website

FS-Elliott Co., LLC, a leading manufacturer of oil-free, centrifugal air compressors has announced the launch of their new, redesigned website, www.fs-elliott.com. The site boasts a clean layout, improved navigation, and educational resources aimed at providing visitors with a more comprehensive understanding of FS-Elliott's range of compressed air solutions.

"Our new website is part of ongoing efforts to provide users with quick and easy access to product information as well as resources to help them better understand centrifugal compressor technology and what decisions they can make to lower their costs," stated Neil Owen, Global Marketing Manager. Key features of the site include interactive product images, white papers educating users on how to select an air compressor and lower their operating costs, and case studies from current customers. For first-time visitors, a list of industries displayed on the home page will take them down a path of learning how an FS-Elliott compressor could suit their specific compressed air application.

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The newly designed site introduces FS-Elliott's AirCompare® Life-Cycle Costs Calculator developed to give compressed air users a tool for making informed decisions about their compressed air system. By entering their existing units into the AirCompare calculator, users can uncover what they are spending compared to what they can expect to save in energy and maintenance costs with an FS-Elliott centrifugal air compressor.

"Over the past 50 years we have seen firsthand the challenges our customers are facing in their specific industries; by sharing the solutions customers are adopting, we hope to empower others to apply a similar scenario at their plant," added Sue Benes, Polaris+ Product Marketing Manager. "Personalizing the experience of visiting our website and providing access to tools like AirCompare provides compressed air users the resources necessary for making the best decisions for their local plant."

About FS-Elliott Co., LLC FS-Elliott Co., LLC, is a leading manufacturer of centrifugal air and gas compressors with sales, service, and manufacturing locations around the world. First introduced to the market over 50 years ago their energy-efficient machines incorporate the latest aerodynamic and control system technologies to ensure optimum performance.

*For more information,
visit www.fs-elliott.com.*

Trace Analytics Appoints David Snee as CEO

Trace Analytics LLC, a compressed air testing laboratory out of Austin, Texas, appointed David Snee as their Chief Executive Officer. After 27 years of continued success, Trace warmly welcomes David, trusting in his acumen to increase operational efficiency

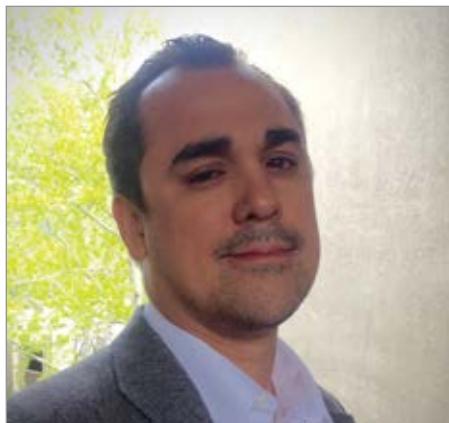
in preparation for scaling initiatives and explosive growth, as well as expansion into related products and services.

Snee joins Trace Analytics out of the Harvard Business School MBA program. He earned a Liberal Arts degree from the Great Books program at St. John's College (the coursework equivalent of majors in History of Math and Science and Philosophy and minors in Comparative Literature and Classical Studies) and a Creative Writing certificate from Exeter College at Oxford University.

Prior to this, Snee served in the United States Army, Military Intelligence, deploying in support of Operation Enduring Freedom and Operation New Dawn. During this time, he earned a certificate in Emergency Management from the Federal Emergency Management Agency. He is originally from the Maryland-Pennsylvania area, where he served as a Market Trainer for independent retailers of Cingular and T-Mobile.

As CEO of Trace Analytics, David plans to advance global safety and quality standards of compressed air testing for the health and well-being of end users worldwide.

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Trace Analytics appointed David Snee as CEO

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INDUSTRY NEWS

Atlas Copco Rental Provides Quick Solution for Dominican Gold Mine

Atlas Copco Rental provided a quick solution when unscheduled compressor maintenance posed a risk to processing for a Dominican gold mine. A trio of stationary air compressors produce 630,000 m³/hr of air for the oxygen plant at the Pueblo Viejo gold mine in the Dominican Republic. The oxygen is used by its autoclave processing facility to treat roughly 24,000 tons per day of refractory ore for the 60/40 joint venture between Barrick and Goldcorp Inc., operated by Barrick as Pueblo Viejo Dominicana Corporation.

Normal compressor maintenance at the mine takes one of its three units offline. The remaining two units share the load while one

compressor undergoes maintenance, though production dips slightly.

In late 2015, while one compressor was down for repair, an unexpected motor failure in another compressor reduced production capability by 30%. It was too risky to rely on just one compressor. The plant needed a backup plan. The failure had occurred right in the middle of the holiday season, a time of extended vacations and a burdensome surge on the international shipping industry.

Barrick's Capital Project Manager, Barry Hummer, called the Atlas Copco Rental sales representative, Paul Morgan, in Florida. Hummer was relieved to learn Atlas Copco Rental had an immediately available solution: seven ZH6000 and seven ZH9000 portable air compressors complete with a

technical team. The units are rented by a variety of industries for scheduled stationary compressor maintenance or for emergency bypass, as in Pueblo Viejo's case. Response time was quick. Morgan contacted Clayton Jones, key account manager of Atlas Copco Rental centrifugal air compressors. Jones immediately assembled a four-man technical team led by David Moessinger, who built the ZH-series compressors.

"We fill a sort of niche with this product," Jones said, explaining that truly oil-free, centrifugal compressors capable of 6,000 and 9,000 cfm are hard to find outside of Atlas Copco.

Atlas Copco ZH6000 and ZH9000 units are self-contained, 100 percent oil-free, three-stage centrifugal air compressors that fit completely within a standard 40-foot shipping



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container. Electrically powered, the units have zero risk of exhaust contamination that can be a problem with diesel units.

Jones added: “And, technically, Atlas Copco is one of a few manufacturers of truly 100 percent oil-free air compressors. Others reduce oil to a minimum and then filter it out. But our air has zero oil. There’s no need for a filter. And as for volume, you just can’t compress that much air with a screw or piston. A centrifugal is just so much more efficient.”

The fundamental components of a centrifugal compressor are stainless steel impellers, efficient turbines that provide constant positive pressure. The three-stage ZH compressors have one low pressure impeller closest to the intake, which feeds primary stage compressed air to be stepped up by two high-pressure




Atlas Copco ZH6000 and ZH9000 units are self-contained, 100 percent oil-free, three-stage centrifugal air compressors that fit completely within a standard 40-foot shipping container. Electrically powered, the units have zero risk of exhaust contamination that can be a problem with diesel units.



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INDUSTRY NEWS

impellers. From inlet to discharge, neither coolant nor lubrication ever comes in contact with the compressed air. To manage heat from compressions, the system uses integrated stainless steel inter- and after-coolers.

It took just 31 days from the time Hummer contacted Morgan for the first compressor to be up and running, with much of that time taken up by shipping and site prep. Having determined the job's specifications and logistics during onsite visits, the Atlas Copco team was ready at Pueblo Viejo before the compressors arrived. The containerized units make installation and start up simple. Only a few connections need to be made at each compressor: the electrical hook up in back, with hoses for water in/out and an air discharge pipe in front.

After setup and motor alignment, the Atlas Copco Rental technicians served as supplemental labor, joining Barrick's team in a time of operational need. They worked around the clock in two-man 12-hour shifts right through Christmas and well into the new year.

The containerized units provided plenty of room to work in comfort, protecting technicians from the elements while they cleaned filters, monitored gauges, tuned performance with digital controls and logged six-hour readings. Elektronikon control and monitoring systems are integral to the units, mounted just inside at eye level for ease of use.

Hummer said, "We've worked with Atlas Copco before. I had no doubt this would work. And I would do this again, no problem

whatsoever. The self-contained units just make it go so smoothly. The Atlas Copco team deserve credit. I can't say enough about how this was managed, administrative level on down. They did very good work and should be complimented for it."

For 50 days the ZH compressors ran full capacity, sustaining a steady 105,000 cfm flow of ISO-quality, 100-percent-pure air at 75 psi. Production was maintained throughout the repair. And then as easily as they were installed, when the original overhauled stationary compressors came online, the Atlas Copco containerized compressors were unplugged and shipped back to the U.S.

About Atlas Copco

Atlas Copco is a world-leading provider of sustainable productivity solutions. The Group serves customers with innovative compressors, vacuum solutions and air treatment systems, construction and mining equipment, power tools and assembly systems. Atlas Copco develops products and service 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.

Specialty Rental is a division within Atlas Copco's Construction Technique business area. It serves customers in the industry segments around the world with temporary air, nitrogen, steam and power rental solutions. The specialty rental services are offered under several brands. The divisional headquarters is located in Houston, USA.

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recognition for its ongoing progress in energy performance and support of ENERGY STAR. Key 2015 accomplishments include:

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- Setting an industry-leading record of 73 plants achieving the ENERGY STAR Challenge for Industry. These plants have saved more than \$237 million in energy costs while reducing over 1.8 million metric tons of greenhouse gas emissions.
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Managing Pressure Regulator ARTIFICIAL DEMAND, Part 1

By Murray Nottle, Working Air System Engineer, The Carnot Group

► Introduction

Pressure regulators are everywhere compressed air is used. These simple devices, essential for safe and steady equipment operation, can be a big waster of compressed air. This article shows how with proper regulator selection, installation and setting management you can save compressed air

and lower system pressures. This article looks at regulators on production equipment not central regulators or Process Flow Controllers.

Artificial Demand

When walking around your factory, look at what the regulator pressure gauges are doing.

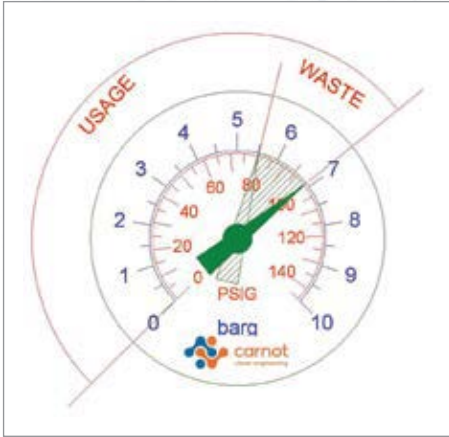
As equipment downstream of a regulator cycles, is the gauge steady, moving quickly, or moving up and down slowly? Video fast-moving gauges then watch in slow motion.

Think of a regulator pressure gauge as a compressed air use meter. The higher the pressure the more air is being used. The



“Think of a regulator pressure gauge as a compressed air use meter. The higher the pressure the more air is being used. The more the needle moves, the more air is being wasted as artificial demand.”

— Murray Nottle, Working Air System Engineer, The Carnot Group



more the needle moves, the more air is being wasted as artificial demand.

The amount of compressed air used by actuators, including air motors and diaphragm pumps, varies with gauge pressure. For nozzles (holes, vacuum venturis, leaks) compressed air use varies with absolute pressure (gauge + 14.7 psi).

The table below shows relative compressed air use at different pressures.

PSIG	Actuator	Nozzle
100	100 %	100 %
90	90 %	91.3 %
85	85 %	87 %
80	80 %	82.5 %

For most actuators, the actuator port and regulator outlet pressures that matter most are while the actuator is moving, not when it is stopped. This is the lowest pressure value shown on a gauge during the cycle. Air is wasted when the pressure rises after the actuator stops.



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150 psi

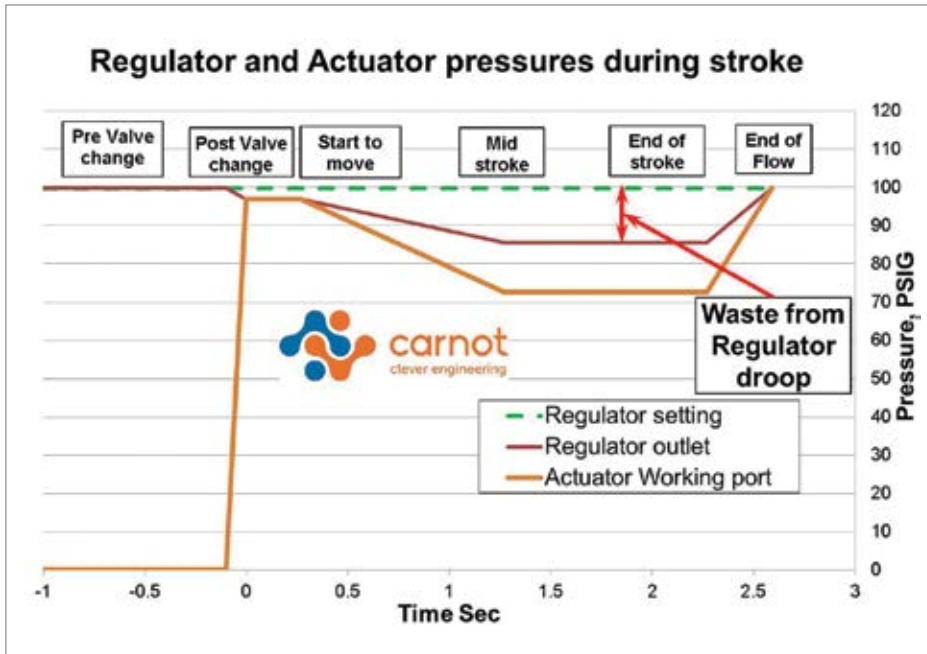
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MANAGING PRESSURE REGULATOR ARTIFICIAL DEMAND, PART 1



Regulator Droop Observations

Droop:

- Is how much the regulator outlet pressure changes with flow. A regulator outlet pressure set at 100 psig with “no flow” that drops to 85 psig “with flow” has a “droop” of 15 psi. It “droops” from 100 to 85 psig.
- Is due to how the regulator valve is piloted, where pressure feedback is sensed (internally or externally), the regulator valve design (balanced or unbalanced) and internal pressure drop.
- Wastes air
- Forces the air compressors to operate at a higher pressure. The minimum system pressure is the “with flow” regulator outlet pressure plus droop. Less droop allows a lower system pressure.

Understanding How Regulators Work

The regulator valve is a “hole” whose size changes with a pressure difference. The pressure difference is the “no flow” outlet pressure setting minus the “with flow” outlet pressure i.e. the regulator droop.

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As the upstream pressure rises and falls, so the compressed air flow through the “hole” will rise and fall. As a hole is a nozzle, air flow varies with absolute pressure. A hole with 100 psig upstream will flow 28% less air than if supplied with 150 psig.

How quickly the “hole” size changes with pressure difference, depends upon the “spring rate” of the pilot force opening the valve. Opposing the pilot force (to keep the valve closed) is the feedback force. The feedback force is usually the outlet pressure acting on the regulator diaphragm.

Spring rate means a spring compressed to say 2" will have less force if only compressed to 2 ¼". If this same spring creates the pilot force on a regulator valve, for the valve to open ¼" (spring extends from 2" to 2 ¼") the feedback force (downstream pressure) needs to be less than if the valve was closed. As flow through the regulator starts and stops, the valve needs to open and close. To allow this, the downstream pressure must go up and down.

Most general regulators use coil springs so their droop is mainly due to spring rate. Air pilot regulators have no spring and so no droop due to spring rate. This is why they're used for precision regulators.

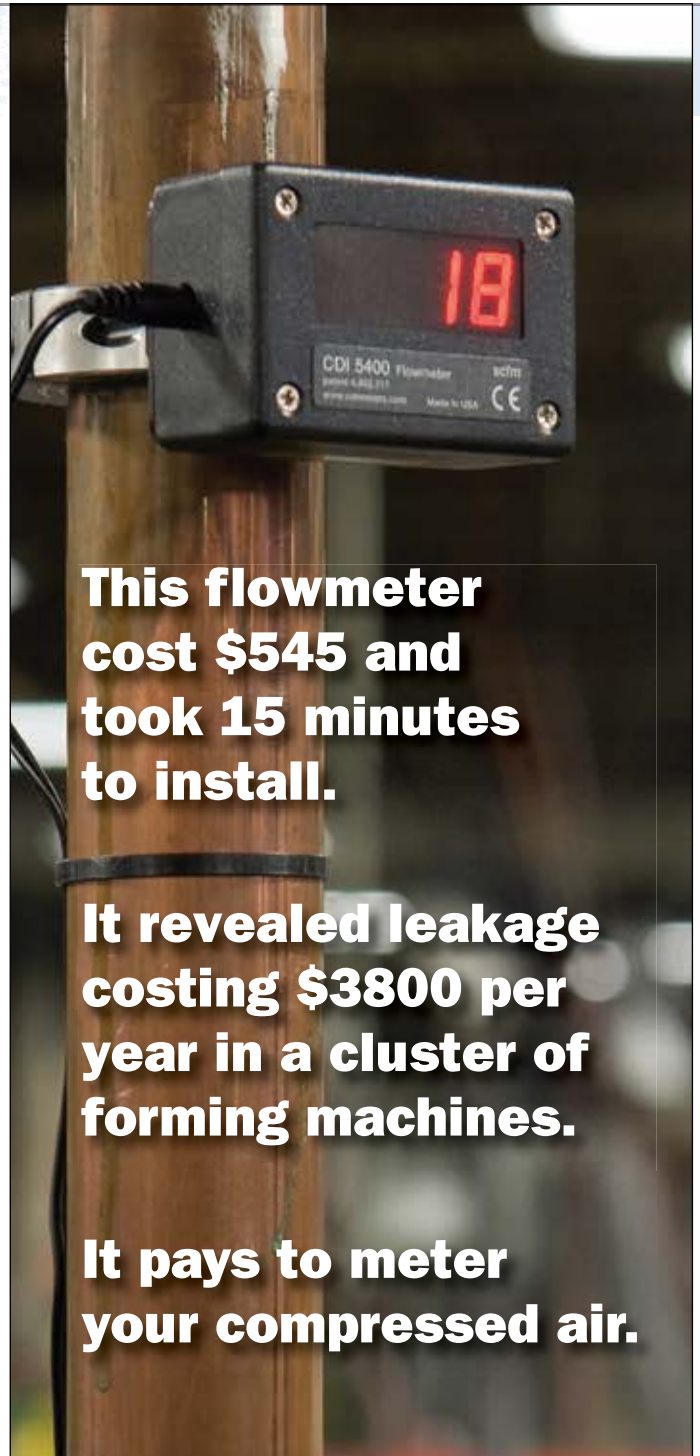
A regulator valve can only open so far. With a fully open valve, the regulator can't control the downstream pressure and has “lost regulation”.

Did you know that if you measure the regulator “no flow” pressure setting and “with flow” inlet and outlet pressure, you can use the regulator catalogue curves to estimate how much air is flowing i.e. as a flow meter. Not so good for air pilot regulators due to the very low pilot spring rate.

What affects a regulators ability to keep a steady outlet pressure?

How well a regulator can keep a steady outlet pressure depends upon many factors.

You've already read about spring rate effects and that other parts of a regulators' design affects how it operates. These will



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MANAGING PRESSURE REGULATOR ARTIFICIAL DEMAND, PART 1

be discussed further in a later article. Supply pressure effects and the original regulator sizing are discussed here.

Supply Pressure

Remember that a regulator is part of and affected by the wider compressed air system and that a regulator valve is like a “hole”. If the supply pressure at the regulator drops, less air will flow through the “hole” so its size needs to increase. For the hole size to increase (valve open further), the outlet pressure needs to droop further below the no flow setting. So drops in supply pressure increase droop from spring rate effects. Large drops in supply pressure can cause “lost regulation”.

Pneumatic components have much higher pipe air speeds at rated flows than are acceptable in air mains. Based on 43 regulators of different design, manufacturer and size, port air speeds are between 200 and 300 ft/sec (60 - 90 m/sec) compared to the < 20 ft/sec (<6 m/sec) considered as best practices for air mains. Low air speeds result in low pressure drop, efficient system operation and stable regulator supply pressure.

Using plastic tube of the same nominal bore as the regulator port (¼" bore tube with ¼ NPT port), will result in unsteady supply pressure to the regulator. This in turn will increase droop and may result in lost regulation, all of which will result in air waste and affect equipment operation.

As a guide the pipe bore, either side of a regulator, should be 3 to 4 times the port size of the regulator. This is except where the regulator is between an actuator and its control valve where small tube should be used. If the regulator is part of a service unit with a filter, the filter element pressure drop lowers the supply pressure drop to the regulator.

So before blaming and changing a regulator for poor pressure control, change the filter element of its service unit and check the pipe sizes either side of it. Otherwise a different regulator may do no better.

Sizing

For easier regulator selection, manufacturers provide “rated” flows and flow curves - but at what “rating” conditions?

- Most spring-piloted regulators are based on the outlet pressure drooping from 90 psig to 75 psig. But:
 - Some manufacturers test flow using a 100 psig supply.
 - Others use a 145 psig supply.
- Remember a hole supplied with 145 psig air will flow around 30 % air more than if supplied with 100 psig.
- So a smaller (cheaper) regulator tested on a 145 psig supply could have the same rated flow as a bigger (more expensive) regulator tested on a 100 psig supply.
- Which one do you think is more likely to be bought ? The smaller, cheaper one.

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- Which one will have more droop, is more likely to “loose regulation” and will waste more air? The smaller, cheaper one.

If you select a spring pilot regulator near its “rated flow” then, you are designing your equipment to waste compressed air, have operational problems and need high compressed air system pressures.

- Air pilot regulators (low spring rate) rated flows are with a fully open valve. However as with the spring piloted regulators some are tested with a 145 psig supply while others a 100 psig.

You can see how easy it is to select an undersized regulator by not considering the test supply pressure compared to the supply the regulator will use. Before rushing out to replace a regulator you know is undersized, make sure you know what, balanced valve, internal and external feedback and aspirator tube relate to and how they affect regulator selection. These terms will be covered in the following article.

Are Your Regulators Properly Set?

Often over time, the regulator no-flow settings increase and sometimes regulation is lost. The regulator doesn’t drift but it is machine operators trying to keep their equipment working reliably.

The pressure drop of air compressor room filters increases, as they clean the air, resulting in the system pressure falling. Droop increases and low pressure affects production equipment operation. To immediately fix the problem,

the operator increases the regulator setting pressure but the “with-flow” setting is a guess or a “memory”.

Eventually air compressor settings are increased and filter elements replaced, but are the regulator settings adjusted back down? Best practice would have a regulator supply pressure gauge fitted and the supply pressure, minimum “no flow” and “with flow” pressure settings recorded and displayed at each regulator. This will help the operator and maintenance staff to keep the correct “with-flow” regulator setting.

Conclusion

This article has provided an introduction to regulators and how you can recognise the

air wasted by artificial demand from their operation. Some of the causes of this have been discussed.

A following article will explain more about the different types of regulators and where and why you would use them. It will also describe what “regulator management best practice” is. **BP**

For more information please contact Murray Nottle, The Carnot Group. mnottle@carnot.com.au, www.carnot.com.au

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The Importance of Bi-directional Compressed Air Flow Measurement

By Pascal van Putten, CEO, VP Instruments



► Introduction

Technology is available which enables a compressed air flow meter to measure not only the magnitude of the flow, but also the direction. Why is this important? In this article we will describe two case studies where bi-directional compressed air flow measurement plays a key role to come to the right conclusions. In the first case study, we

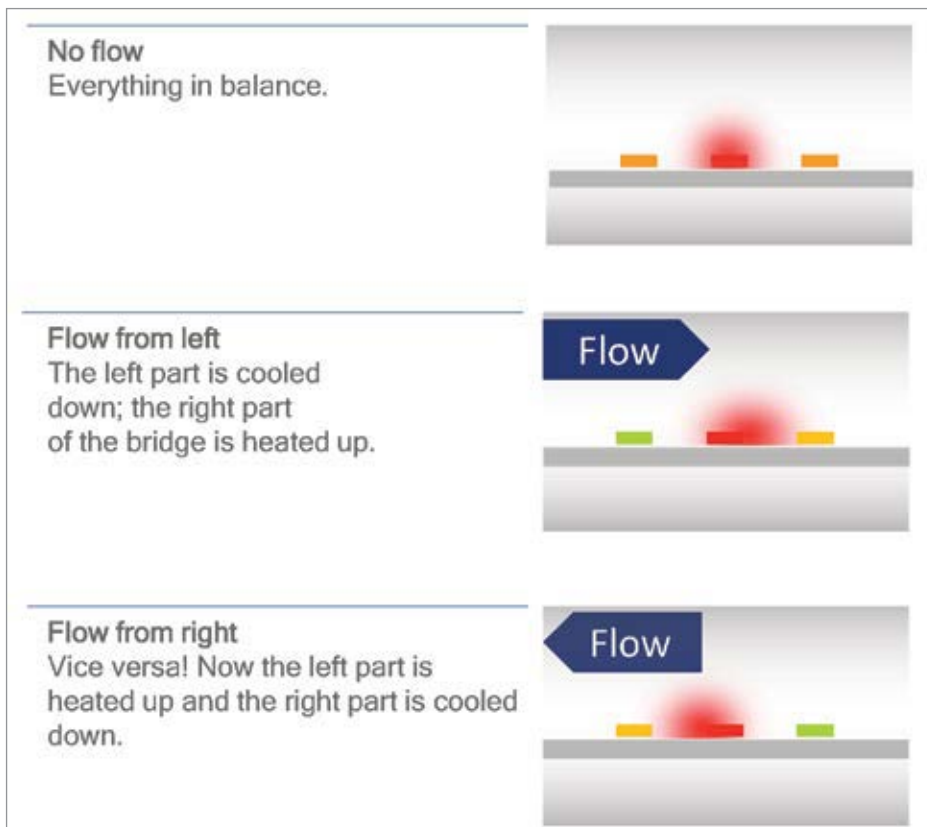
will describe an electronics manufacturing plant, which has a large interconnected ring network with two air compressor rooms located in different buildings. The two air compressor rooms are about five hundred feet apart. In the second case study, the effect of compressed air flow measurement upstream of a local receiver tank is described.

Thermabridge™ Technology

The world's first thermal flow sensor made in a silicon (not silicone!) chip was invented forty years ago by one of our founders, Anton van Putten, back in 1974. His unique design can be seen as the blueprint of many thermal mass flow sensors, found in automotive, HVAC and industrial applications. The original Thermabridge™ sensor combines flow direction measurement with thermal mass flow sensing over a full 0...150 m_n/sec range. This enables you to measure flow in complex ring networks, where any other flow meter would deliver very unreliable measurement results. Who would have thought that his invention would become so important for accurate compressed air measurement?

Case 1. Two Air Compressor Rooms

At a large electronic component manufacturer, compressed air is used for the entire production process including injection molding machines, the handling and packaging of products, picking and placing of components, and the plating and galvanizing of metal parts. An energy management program had been initiated to reduce the overall energy consumption of the plant. Compressed air was one of the utilities that needed attention. The air compressors in the factory were quite old (> 10 years) and there was room for improvement, from



Thermabridge™ sensor technology responding to bi-directional flow

an efficiency point of view. To select the right compressor, the demand profile of the factory needed to be measured. But the company realized that permanent monitoring is key to long-term savings. So instead of hiring an audit firm to perform a temporarily audit, they choose to implement a permanent compressed air flow monitoring solution - which could eventually be expanded towards other utilities. The initial goals for phase 1 of the project were:

- Establish a base line profile
- Select a replacement air compressor combination based upon this profile
- Identify waste and reduce the air demand of production areas

During phase 1 of the project, we installed four compressed air flow meters, to get a clear picture of the average demand. But after a couple of months, we encountered an interesting situation where standard uni-directional compressed air flow meters would provide useless results. In this particular situation, back-flow towards the receiver tanks caused wrong readings, resulting in severe measurement errors.

System description

The drawing below shows a simplified layout of the compressed air system. The compressed air system consisted of two compressor rooms (A and B). A compressed air ring network is supplied from these two separate compressor rooms. The compressor rooms are controlled with a pressure-based control system.

At compressor room B, two flow meters are installed in a ring network to measure the air delivered to the network by a compressor. Between this compressor and the network, a large receiver tank (5 m³) is installed.

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THE IMPORTANCE OF BI-DIRECTIONAL COMPRESSED AIR FLOW MEASUREMENT

In room A, three rotary screw air compressors were installed. The machines were used for the daily base-load. Each air compressor is fitted with a heat of compression drum dryer. Between the pipes and the compressors,

two large receivers are installed, 5 m³ each. From the receivers, two separate pipes supply compressed air to the production processes.

One pipe is connected to another building where compressor room B is located. The

distance between the two compressor rooms is approximately 500 feet.

In compressor room B, one relatively new air cooled ZT 145 machine is located. Air leaves the air compressor and enters a heat of compression drum dryer and then into another large receiver tank. Due to space limitations, it was not possible to install a single flow meter between the 5m³ receiver tank outlet and the network. Instead, two flow meters were installed further away, in the ring network, just after a T-junction, where the compressed air was fed into the ring. Initially, these standard VPFloScope flow meters were unidirectional. In other words: they would not see the difference between forward and backward flow. After a couple of days, strange measurements were observed. The flow meters were showing considerable measurement values when the compressor was turned off.

Reverse Flow or Not?

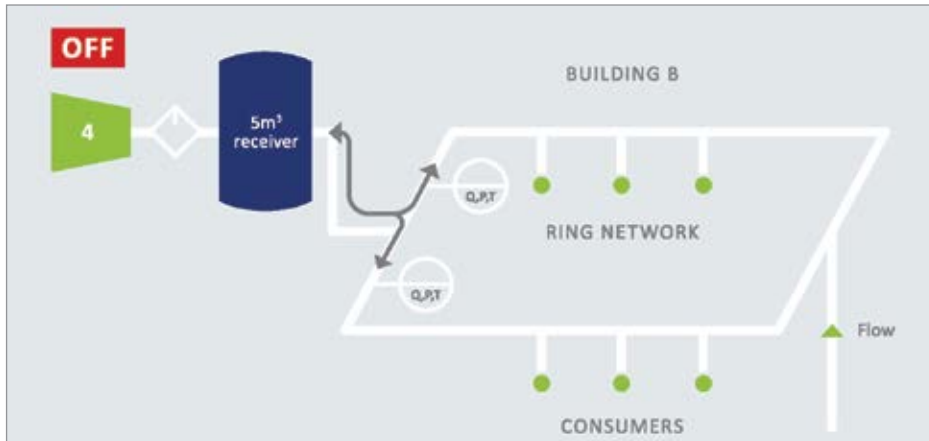
After taking a closer look into compressor room B's configuration, we came to the conclusion that there had to be reverse flow when the air compressor was turned off. The following pictures explain this effect in detail.

During unload and off hours, the two unidirectional flow meters showed consumption, while one would expect zero flow. The large receiver tank is filled by the other compressors (from room A) when the local air demand in the ring network is low, and it delivers air to the network when the local demand is high. You can see the receiver tank as a big balloon interacting with the network.

When the compressor is running loaded, compressed air is fed into the ring network. In the T-junction, the flow merges with existing "traffic" based on how the consumption in the ring mains is balanced. If the consumption is well balanced, it might be perfectly symmetric (50% left, 50% right), but when



Figure 1: System overview



Room B Air Compressor Off: Receiver Tank Behavior



Room B Air Compressor in a "merging traffic" Situation

the consumption on one side is much higher, the air flow will distribute differently. Pulsating demand can also change the flow distribution for a short period of time.

The compressed air coming from the air compressor merges with the air which was already flowing through the ring network. This can result in a high or low reading, depending on the actual demand and the resulting flow direction.

Uni-directional versus Bi-directional

A uni-directional compressed air flow meter does not have a clue where the air is coming from. This results in large errors. This applies to most thermal mass flow meters based on thermal dispersion, constant temperature anemometry and so on. Other examples of uni-directional flow meters are vortex meters and turbine meters, which read-out via a standard pulse transmitter (the actual counter on the turbine meter will turn backwards). Venturi's are also uni-directional. The differential pressure signal will not change to negative when flow is reversed. Orifice meters can also measure reverse flow, but they are not so suitable for compressed air due to their permanent pressure loss.

By turning on the bi-directional sensing feature of the VPFlowScope, the changing of flow direction is instantaneously revealed. Now the reverse flow shows up in the graphs as negative values. Lets take a look at some real data: In the graphs below, we zoom into a specific period of the measurements in compressor room B. The original data, from the bi-directional flow meters, has been processed to show the difference between bi-directional and uni-directional flow.

At the end of this period, the effect can be seen very clearly: The compressor turns off, in the left graph where the two bi-directional flow meters cancel each other out, and the resulting

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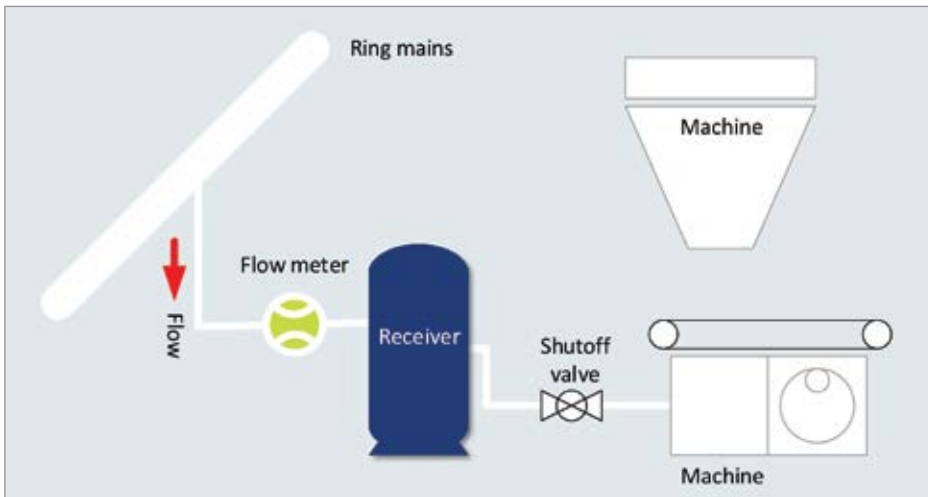
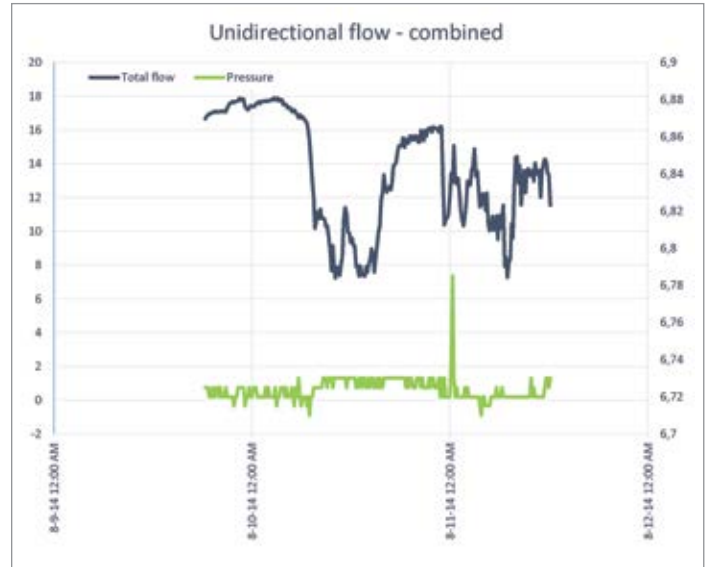
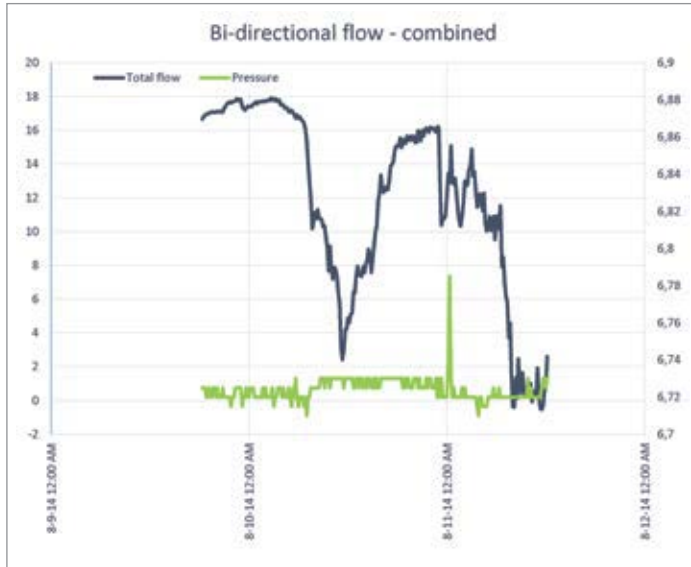
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THE IMPORTANCE OF BI-DIRECTIONAL COMPRESSED AIR FLOW MEASUREMENT



Case 2. Decentralized Receivers

In some cases, a decentralized receiver tank is used to “shave off” the peak load on the network. For example, when a machine has a large intermittent consumption profile. A question is often asked: where to place the flow meter, and what will the flow meter show us when the machine has been turned off? This part of the article is based on an older audit at a potato food-processing plant, where we used a standard thermal mass flow meter without bi-directional sensitivity. The picture below shows the setup.

The auditor called us after a couple of days, to discuss the results. The compressed air flow meter showed significant consumption while the machine was isolated from the network. The receiver tank was simply acting as a local buffer for machines further downstream the line. It was filled, and emptied at the pace of their consumption, causing significant readings on the thermal mass flow meter. In this case, the issue was finally resolved by ignoring the data during the period when the machine was shut off. But in other cases, there might not be a way to correlate local actions or events with data. In those cases, when looking at data from a

flow is nearly zero. In the right graph, the flow is not cancelled out, resulting in a ghost signal of nearly 13 m³/minute.

Is Uni-directional Good Enough?

One could say, why not correlate this with load/unload data from the air compressor? When the compressor is in unload or off-state, you know the flow is zero, so you can compensate for it. We think this is not the best way to solve the reverse flow problem, as there might be other (real) reasons for

reverse flow, which would remain unnoticed. For example, a leaking non-return valve, a leaking seal or blow-off valve. In this particular case, we found a leaking compressor seal. This leak cost 1,314 Euro per year and it took only 500 Euro to fix it. Another leak was found in a dryer. Again, this compressed air dryer leak was upstream of the flow meter, so it would have remained unnoticed if the flow meter was uni-directional. The result was a leak savings of 2,102 Euro per year fixed with a cost of only 100 Euro by replacing a hose.

uni-directional flow measurement device can lead to wrong conclusions.

Other Issues You Can Discover with Bi-directional Sensors

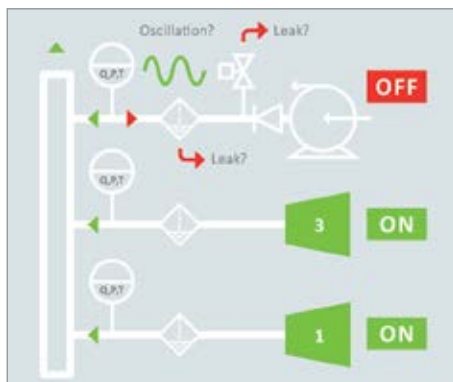
Bi-directional flow meters can reveal important issues in many compressed air systems. In this article we described two cases where bi-directional sensors were crucial to draw the right conclusions.

Other examples where you can reveal issues: Leaking non-return valves just after the compressor, or leaking condensate drains. The bi-directional flow meter will tell you when it happens.

- Leaking drains in the oil-demister or under the wet receiver tank
- The non-return valve does not shut off completely
- The blow-off valve does not close completely
- Oscillations in the pipe network are seen as consumption instead of near zero flow

Combining the Results Using Virtual Channels

In the central VPVision energy monitoring software, using a virtual channel, data of two (or more) flow meters can be combined into one signal. The channel adds/ subtracts



Using a virtual channel, data of two (or more) flow meters can be combined into one signal.

all measurement values, based on their flow direction. The resulting values can be used in real-time graphs and reports.

Conclusions

- For flow measurement in ring networks, bi-directional flow meters are key to correct results.
- Only bi-directional flow meters can provide correct data when installed between receiver tanks and the compressed air network.
- Uni-directional flow meters will show a positive flow when reverse flow occurs, which can lead to wrong conclusions about the system behavior.
- With modern energy monitoring software, bi-directional flow meters can be combined in a virtual channel.

About VPInstruments

Founded in 1999, VPInstruments offers energy management solutions for compressed air and technical gases. Our flow meters are based on the original Thermabridge™ technology, as invented in 1974 by our co-founder Anton van Putten. Thanks to our monitoring solutions and flow meters, companies worldwide measure, monitor and manage their compressed air system, from supply to demand side. **BP**

For more information contact Pascal van Putten, VP Instruments, tel: 31-15-213-1580, email: pascal.van.putten@vpinstruments.com, www.vpinstruments.com

To read similar *Compressed Air Measurement* articles visit <http://www.airbestpractices.com/technology/instrumentation>

Assessing the Impact of Compressed Air QUALITY ON FOOD PRODUCTS

by Dick Smith, Technical Director, Trace Analytics



► Compressed air is a critical utility widely used throughout the food industry. Being aware of the composition of compressed air used in your plant is key to avoiding product contamination. Your task is to assess the activities and operations that can harm a product, the extent to which a product can be harmed, and how likely it is that product harm will occur. Assessing product contamination is a multi-step process in which you must identify the important risks, prioritize them for management, and take reasonable steps to remove or reduce the chance of harm to the product, and, in particular, serious harm to the consumer.

Source of Potential Product Harm

Normal ambient air contains millions of inert particles, 5-25 grams of water, 1-5

micrograms of oil, and tens to hundreds of bacteria per cubic meter. In addition, the system itself can be a source of possible contamination, including pipe scale and rust, polymer shredded particles, rubber gasket pieces, sealing tape, metal shavings from



Dick Smith is the Technical Director for Trace Analytics

pipe cuts, and even particles from charcoal filters and desiccant canisters. Sometimes condensed water or liquid oil already present in the system forms into an aerosol or vapor, creating yet another source of contamination.

Risk Assessment

Generally, the steps of assessing the risks of product contamination are as follows:

1. Identify potential hazards
2. Assess the risk of harm
3. Assess existing control measures for adequacy
4. Assess if extra controls are needed
5. Schedule regular reviews to see if the controls are working

TABLE 1. ISO 8573-1:2010 — PART 1: CONTAMINANTS AND PURITY CLASSES

CLASS ^a	PURITY CLASSES FOR PARTICLES MAXIMUM NUMBER OF PARTICLES PER CUBIC METER (m ³) AS A FUNCTION OF PARTICLE SIZE, d ^b				PURITY CLASSES FOR HUMIDITY AND LIQUID WATER		PURITY CLASSES FOR OIL (LIQUID, AEROSOL, AND VAPOR)	
	MAXIMUM NUMBER OF PARTICLES PER m ³				CLASS	PRESSURE DEW POINT °C	CLASS	Concentration of Total Oil mg/m ³
	0.1 < d ≤ 0.5 µm	0.5 < d ≤ 1.0 µm	1.0 < d ≤ 5.0 µm	> 5 µm				
0	As specified by the equipment user or supplier and more stringent than class 1							
1	≤20,000	≤400	≤10	None	1	≤-70	1	≤ 0.01
2	<400,000	≤6,000	≤100	None	2	≤-40	2	≤ 0.1
3	not specified	≤90,000	≤1,000	None	3	≤-20	3	≤ 1
4	n/s	n/s	≤10,000	None	4	≤+3	4	≤ 5
5	n/s	n/s	≤100,000	None	5	≤+7	5	> 5
—	Particles by Mass Concentration, CP, mg/m ³				6	≤+10	Class Concentration of Liquid Waterb, CW g/m ³	
6	0 < CP ≤ 5				7	CW ≤ 0.5		
7	5 < CP ≤ 10							
X	CP >10							
					8	0.5 ≤ CW ≤ 5		
^a To qualify for a class designation					9	5 < CW ≤ 10		
^b At reference conditions: 20°C, 100 kPa; 0 rel. water vapor pressure					X	CW > 10		
^c See ISO 8573-1:2010 A.3.2.2								

Identifying Hazards

A number of the components of ambient air become contaminants once they enter the compressed air stream. For the sake of this discussion, we will omit airborne microbes, as they were thoroughly discussed by Lee Scott in the Jan/Feb 2016 Issue of Compressed Best Practices® Magazine: <http://www.airbestpractices.com/standards/food-grade-air/compressed-air-gmps-gfsi-food-safety-compliance>.

When a compressed air component has a deleterious effect on the product, it is considered a compressed air contaminant. ISO 8573.1:2010 contains purity classes for components/contaminants in compressed air as shown in Table 1. Further, the British Retail Consortium (BRC) and the British Compressed Air Society (BCAS) have worked together to author a code of practice for the food and beverage industry. This code

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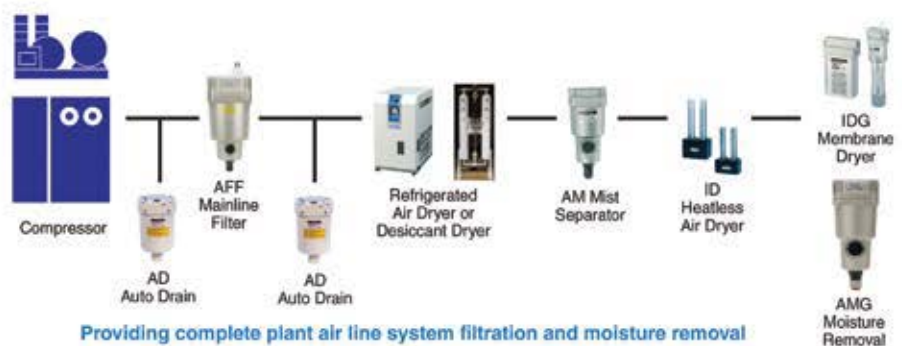
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ASSESSING THE IMPACT OF COMPRESSED AIR QUALITY ON FOOD PRODUCTS

**TABLE 2. A BRIEF SUMMARY OF FOOD AND BEVERAGE GRADE COMPRESSED AIR BEST PRACTICE GUIDELINE 102
PRODUCED BY THE BRC AND BCAS, JULY 18, 2013**

PRODUCT CONTACT	PARTICLES, MAXIMUM NUMBER PER CUBIC METER BY PARTICLE SIZE RANGE				HUMIDITY (WATER VAPOR), PDP °C	TOTAL OIL, mg/m ³	ISO 8573-1 :2010 EQUIVALENT
	0.1-≤0.5 µm	0.5-≤1 µm	1-≤5 µm	>5 µm			
Direct	≤400,000	≤6,000	≤100	None	≤-40	≤0.01	2:2:1
Indirect	≤400,000	≤6,000	≤100	None	≤+3	≤0.1	2:4:2

incorporates selections from the ISO 8573-1:2010 purity classes to arrive at recommendations for compressed air that comes into **direct contact** with the product, as well as compressed air that comes into **indirect contact** with the product, as seen in Table 2.

These two specifications encompass most identifiable hazards. According to the Guideline, compressed air quality shall be tested and verified at least twice per year or per the manufacturer's recommendations. Additional testing is also warranted whenever maintenance work or any activity that may affect the air quality is performed on the compressed air system. The Guideline recognizes the importance of compressed air quality and states that compressed air should now be part of the Pre-Requisite Program (PRP) in addition to the Hazard Analysis & Critical Control Points (HACCP) plan. Whenever maintenance is performed a representative selection of the air outlets shall be tested to confirm that the compressed air meets the relevant Purity Classes.

Assessing Risk of Harm

It may be helpful to catalog the elements of the compressed air system using something like the checklist in Table 3 below. The table allows you to assign the level of risk for each element

with a numerical value (0 being no risk and 5 being certain risk).

In order to implement a monitoring plan, we must take stock of the compressed air system. Table 3 (pg. 28) shows information that is not atypical of first-time air testing customers, although many of the entries made relating to piping, seals, sealants, and valves are not

usually discovered prior to initial sampling. Based on this information, sampling can begin.

Table 4 (pg. 29) lists materials for parts of a compressed air system, in order of what creates the best sampling environment. This table may be useful in assessing a system's current risk of exceeding specifications.

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ASSESSING THE IMPACT OF COMPRESSED AIR QUALITY ON FOOD PRODUCTS

TABLE 3. COMPRESSED AIR SYSTEM RISK ASSESSMENT CHECKLIST

AREA	ITEM	DESCRIPTION	PER SOP ^A	OTHER ISSUES	RISK
Compressor Room	Air Compressor		Yes	What about regularly scheduled maintenance or lack of maintenance, food grade oil vs non-food grade oil	2
	Make	PJ's Compressors			
	Model				
	Serial Number	4592222			
	Compressor Hours	22,600			
	Hours Per Week	Unknown			
	Inlet Filtration	Yes	Unknown		2
	System Pressure	130 psig			
	Aftercooler	Yes			
	Air Receiver	Yes			
	Bulk Liquid Separator	Yes	Yes		2
	Particle Filtration 1	5 micron			
	Particle Filtration 2	0.01 Micron	Yes		2
	Refrigerated Dryer	Yes			
	Refrigerated Dryer Pressure Dew Point	38°F	Yes		2
Desiccant Dryer	No				
Pressure Dew Point	N/A	N/A		3	
Piping	Air Compressor		Unknown		4
	Piping & Fitting	Cast Iron			
	Fitting Type	Threaded			
	Seal Type	Thread to Thread			
	Sealant Type	Pipe Putty			
	Valving	Ball Valve			
	Pipe Chase/Run		Unknown		4
	Piping & Fitting	Unknown			
	Seal Type	Thread to Thread			
	Sealant Type	Tape & Pipe Putty			
	Valving	Ball Valve	Unknown		1
	Point of Use				
	Piping & Fitting	Stainless Steel			
	Seal Type	SS			
Sealant Type	SS Ferrules				
Valving	Ball Valve				
Point of User Application	Point of Use Tubing	Yellow Hose	Unknown		4
	Point of Use Filtration	None			
	Point of Use Desiccant Dryer	No			
	Point of Use Pressure	50 psig			
	Number of Outlets	16			
Sampling Connection	Fittings	Quick Connect	N/A	Sampling not yet performed	1
	Valves	SS Ball Valve			
	Tubing	Particle Free Polymer			
				Total	25

Assessing Existing Controls

Staying current on regulations and publications will ensure knowledge of relevant standards. As for the present state of existing controls, there are two ways to monitor the quality of compressed air, either by testing all critical points of application, or by testing a random representative portion. While it can cost more to test all points, it is the only completely accurate method, since contamination can occur at any specific point without effecting others nearby. It may happen that the one point that isn't tested ends up being the one that is contaminated.

Sampling strategies should be robust to ensure that the air provided to all points of use is of consistent quality. There are several sampling options to consider when assessing your system and its controls:

- Determine the percentage of sampling points to be tested over a given time period, e.g., 100%, 50%, 25%, etc.
- Take three samples: one close to the compressor, one midway through the system, one as far away from the purification as possible
- Sampling immediately before and after filter changes to weigh worst case scenarios against best case scenarios. Data obtained after 3-4 filter changes can be used to establish a trend analysis.

Reviewing Efficacy of Controls

After receiving air sample test results, control efficacy will be made apparent. If the contaminant quantity falls within an acceptable threshold, by industry, then controls are adequate. However, if contaminants meet or exceed set standards, the options are to either

^A Operated and maintained per written SOP

^B Risk, 0-5; 0 being no risk and 5 being a certainty that the specification will be exceeded

TABLE 4. MATERIAL PREFERENCES FOR BETTER AIR SAMPLES

BASED ON LASER PARTICLE COUNTER AND CUSTOMER EXPERIENCE	
ITEM	BEST > BETTER > GOOD > NOT SO GOOD > POOR
Piping & Fittings	Stainless Steel > Conductive Polymer > Nylon > Polyester > Vinyl > Polyethylene > Copper > Glass > PTFE > Aluminum > Black Iron
Seal Type	Welded > SS Compression > Rubber O-Ring Compression > Threaded
Sealant Type	Welded > SS Ferrule > Polymer O-ring > PTFE Tape > Putty
Valving	Particle Free SS > SS Shut-off > Ball Valve w/ Conductive Polymer Seal > Ball Valve w/ Rubber Seal > Valve with Rubber Seal

(Mostly relating to particles, but has some applicability to water and oil.)

reassess if the limits were set inappropriately, or to add additional controls, such as point of use filters.

Assessing Whether Additional Controls Are Needed

If, in the previous step, control efficacy proved inadequate to achieving the desired air purity rating, additional controls are, obviously, called for. Information about options may be available by industry or across industries, but the principle is to either add controls where none are in place, like adding a refrigerant dryer where there is none, or to add controls to existing controls, like adding a desiccant dryer to a refrigerant dryer. If, in the previous step, even the bottommost standards aren't met, then basic controls need to be implemented immediately.

Scheduling Regular Review

This pertains to periodic reviews, the timeframes of which are designated by industry standard setters (BCAS recommends semi-annual). Quarterly testing is a good place to start in industries and geographies where testing is not strictly enforced. This can provide a baseline where no historic data exists, or, in cases where records already exist, can provide an accurate current assessment. Compressed air systems are not static, but dynamic—always changing. Component parts breakdown and malfunction, requiring maintenance or replacement, and there is not always an obvious indication that a device which is plugged in and running is not performing to standard. Regular testing hedges against the possibility of underperformance or non-performance.

Compressed air quality is a critical aspect of sanitation in the food industry. While regulation is still in its infant stages in some places, the core desire to protect consumers is enough to warrant regular air testing, as well as to ensure that equipment and processing environments are operating efficiently. Testing, while it does cost, stands to safeguard against the possibility of greater cost of damage or incident. **BP**

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“Quarterly testing is a good place to start in industries and geographies where testing is not strictly enforced. This can provide a baseline where no historic data exists, or, in cases where records already exist, can provide an accurate current assessment.”

— Dick Smith, Technical Director, Trace Analytics



Sparks Dynamics Optimizes NIST Compressed Air System

By Mac Mottley, CEO, Sparks Dynamics

► The National Institute of Standards and Technology (NIST), founded in 1901 is a measurement standards laboratory, and a non-regulatory agency of the United States Department of Commerce. Its mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life. NIST employs about 2,900 scientists, engineers, technicians, and support and administrative personnel.

Sparks Dynamics, a leading cloud based remote monitoring and data analytics technology company, entered into a Cooperative Research and Development Agreement (CRADA) with NIST researchers to develop industrial compressed air pattern analysis to enhance system efficiency and reliability. The following is the CRADA objective from the statement of work:

“The objective of this project is to help the building automation industry develop novel products that more cost-effectively identify faults (unwanted conditions) and inefficiencies in the operation of the compressed air plants of industrial facilities. More cost-effective fault detection and diagnostics (FDD) products can come to the building automation marketplace only after that industry makes very significant advances in the state-of-the-art of its FDD software tools from what it currently offers. Those advances require making common practice of rules-based artificial intelligence (AI) methods that the building automation industry has shown little to no familiarity with in its technology so far. This project will utilize, under controlled conditions, the compressed air plant of the NIST campus as a facility for test and development of an embedded rules-based FDD tool based upon NIST expertise.”



“During the first 30 days of monitoring, Sparks Dynamics developed algorithms with NIST researchers to detect system anomalies. At the Sparks Server, an analyst can use the ViewMaster software application to perform an analysis of the existing system.”

— Mac Mottley, CEO, Sparks Dynamics

ReMASTER Monitoring Installation

As part of the CRADA, Sparks Dynamics installed a ReMASTER remote monitoring and data analytics system to measure system KPIs in the compressed air plant, which supports the compressed air needs in the research labs as well as control air for the facility-wide HVAC system and control air for the operation of the boiler and chilled water plants. It is a critical utility to maintain the operational status of this federal laboratory.

The ReMaster system uses the Tridium (Honeywell) Niagara AX data acquisition system at the plant level where all sensor data is collected in a JACE (Java Application Control Engine) processor. Initial Sensor data included compressed air mass flow (SCFM), pressure and temperature downstream of the drying / cleanup equipment and actual KW meters on each compressor. A value of specific power is also calculated in the JACE by dividing total system kilowatts by total system CFM/100. Data is collected every second by the JACE and then every 30 seconds three values for each data stream (average, max, and min) are pushed to Sparks Dynamics cloud servers. For seven data streams that amounts to 42 points of data a minute or over 1.8 million data points a month.

Baseline Situation

The existing system at the NIST compressed air plant included (4) four Cameron TA-2000 centrifugal air compressors rated for 550 ICFM @ 125 PSIG using 150 HP motors. They were installed in 2002, had been overhauled and in 2014 had new Maestro control panels installed. At least three air compressors operated continuously and at times all four air compressors were necessary. The compressed air plant also included (4) four Zeks refrigerated cycling compressed air dryers.

During the first 30 days of monitoring, Sparks Dynamics developed algorithms (system rules) with NIST researchers to detect system anomalies. At the Sparks Server an analyst can use the ViewMaster software application to perform an analysis of the existing system. The NIST FDD analytics software is under continuous development utilizing Bayesian probability theory to be a "learning" tool that adaptively becomes better at what it does as it gains "experience"... that is, as it gains user feedback concerning its "classifications" (detection calls).

One of the available system views is a chart of all Key Performance Indicators (KPI) over a specified time selected by the user (Figure 1, pg. 33).

This chart reflects the month of May 2015, the ReMaster system has been streaming data for over a year as of the writing of this article. The total month's data is represented by the blue bar near the top

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Mike Flaherty is the General Manager of tekWorx.

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SPARKS DYNAMICS OPTIMIZES NIST COMPRESSED AIR SYSTEM



Commissioning of the ReMaster System at NIST

of the screen, the main viewer shows an exploded view of the data in more detail as defined by the user designated viewing window represented by the triangle sliders and grey area on the blue bar. This area also shows in more detail identified anomalies using data analytics such as flow or pressure moving outside of a predefined window for that time period or an abnormal operating condition such as compressor short cycling. A few basic patterns emerged:

- System flow fluctuated between 1100 – 1550 SCFM, the compressed air system runs 24/7/365 days out of the year – a critical campus utility
- Each centrifugal compressor seemed only to be generating approximately 450 SCFM (seems low even taking into account ICFM to SCFM conversion, seal losses, and manufacturer's typical performance tolerances)
- The air compressors had within the last year been retrofitted with new control

panels that allowed them to be centrally controlled through a sequencing system internal to the new panels (they would act in a master / slave role). This allowed for the reduction in wasted air through bypass control as they moved to a control scheme that would base load three machines and trim with the fourth in an online/offline type of mode. The customer established a system pressure control of 102 to 108 psig - but since they had a relatively small receiver tank (1,000 gal) for the system when the system called for the fourth compressor it went into a short cycling mode which was about half the time.

- The system specific power averaged 33 to 38 KW/100 CFM which is relatively high for this sized compressed air system.

Optimization

NIST Facilities Management was getting ready to write a requisition to rerate or add a new air compressor because they were concerned that at times all four compressors had to run and if they lost a compressor they could not maintain the pressure on campus without having to source a rental compressor. Sparks Dynamics used the energy analysis / report tool to develop a plan to replace the entire system taking advantage of the Pepco (local utility) rebate program.



“Sparks Dynamics used the energy analysis / report tool to develop a plan to replace the entire system taking advantage of the Pepco (local utility) rebate program.”

— Mac Mottley, CEO, Sparks Dynamics

Centrifugal air compressors by design are a good application for larger compressed air systems that have relatively stable flow demand ranges that can be met within the throttle limits of the compressors. They have the advantage of providing oil free air at constant pressure and have relative good specific power performance over 300 HP or so. The installed air compressors and their control systems, however, were not matched appropriately to this load profile resulting in a high system specific power range of 33 to 38 kW/100 cfm.

A compressed air system was designed that would replace the existing inefficient system with a system that would incorporate fixed speed and variable speed drive (VSD) oil-free rotary screw compressors. Using manufacturer’s published CAGI data sheets it was engineered so that the system could always operate in an efficient specific power

envelope of approximately 20 -21 KW/100 CFM. The actual data for 30 days is used to model a new system by entering energy cost, demand reduction, and new system projected specific power. (In this case there was no reduction in projected demand – a follow up project will sub meter compressed air in major air user buildings.)

Implementation

The new installation consists of two (2) 150 HP oil-free rotary screw air compressors rated for 674 CFM @ 125 PSIG and two 200HP VSD oil-free rotary screw air compressors. The system is rated for 849 CFM @ 125 PSIG @ MAX RPM and 272 CFM @ MIN RPM.

The proposed (now installed) system will continuously run one fixed speed 150 HP oil-free rotary screw air compressor and trim with one 200HP VSD oil-free rotary screw

compressor. During periods of increased demand a second 150 hp fixed speed air compressor will become part of the base load. The units are controlled through a manufacturer supplied integral sequencer. The plant air is critical so there must be at least one back up VSD air compressor available at all times. The project to replace all four air compressors was done under “hot conditions” where the compressed air system was operated continuously and one compressor replaced at a time.

Project Finance Structure

Sparks Dynamics funded this project through two separate sources to ensure a total replacement compressor system complete with controls and monitoring could be provided. Sparks Dynamics submitted the energy analysis report as part of a Pepco custom rebate application on behalf of the

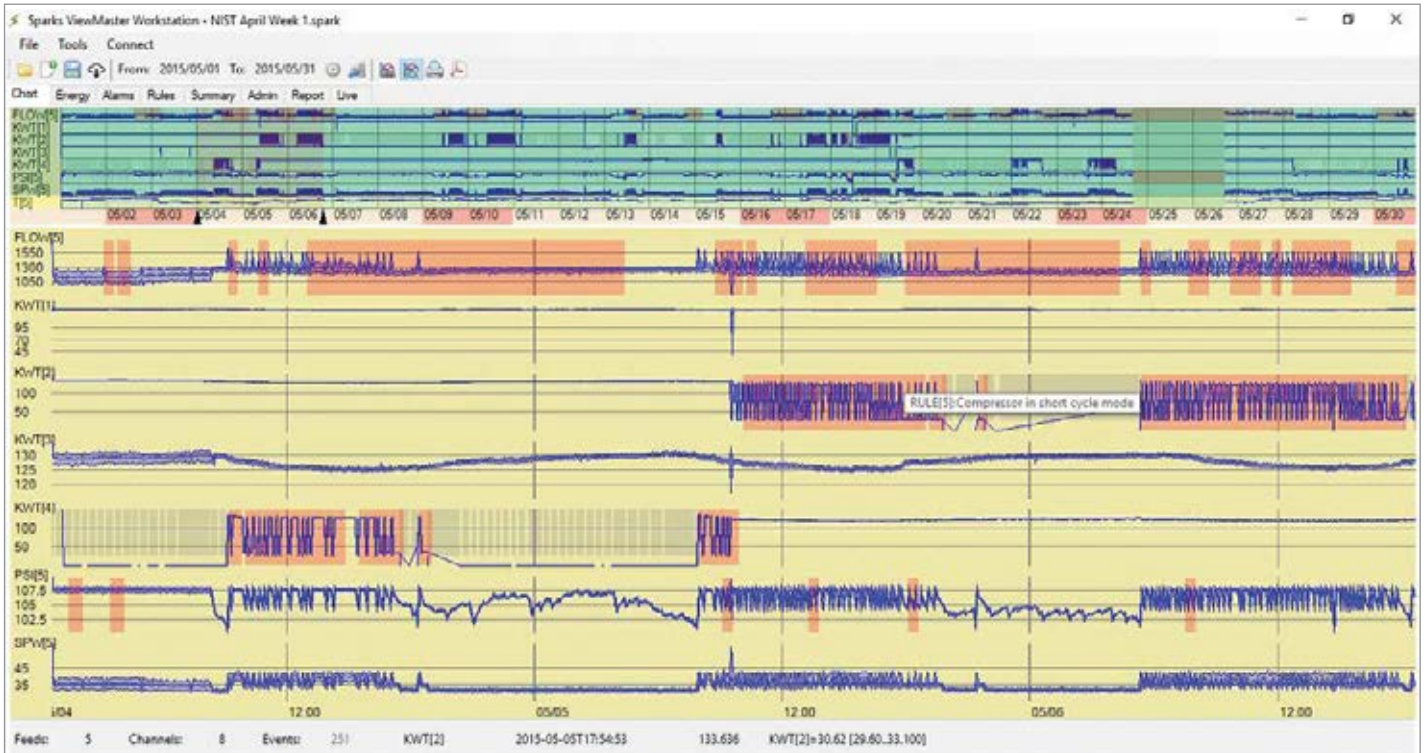


Figure 1: Key Performance Indicators from the ViewMaster Reporting Tool

SPARKS DYNAMICS OPTIMIZES NIST COMPRESSED AIR SYSTEM



New Air Compressors at NIST

customer. The customer assigned the rebate to Sparks Dynamics allowing us to provide the compressed air system solution at half the price of the previously budgeted proposal. A NIST certified small business contractor provided the turn-key installation of the project.

NIST Compressed Air Replacement Project Summary

The total cost of the oil-free rotary screw air compressor equipment and turnkey Installation was \$875,000. This cost was reduced by the

Pepco Rebate of \$375,000 to make the total NIST project costs \$500,000. The annual savings (confirmed with post installation monitoring) were \$144,000 with a simple payback of 3.5 years.

Verification

After system installation, the ReMaster monitoring system confirmed the projected energy savings and continues to monitor the system. Additionally the compressor control panels were integrated into the ReMaster

System through the Modbus interface and now all of the compressor panel data is streamed to the Sparks cloud service for continuous monitoring and anomaly identification for predictive maintenance purposes. **BP**

For more information call tel: 443-543-5420 or email info@sparksdynamics.com or visit www.sparksdynamics.com

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AUTOMAKER PROTON ATTACKS COMPRESSED AIR WASTE

By Abdul Azeem bin Mohamed Mohideen, Electrical Energy Manager, PROTON

Edited by Ron Marshall for the Compressed Air Challenge®



► Project Background

PROTON Tanjung Malim Sdn Bhd (PTMSB) is an automotive manufacturing plant located at PROTON City, a ten minute drive from the Tanjung Malim town of Perak, Malaysia. It is one of three manufacturing facilities owned and operated by Perusahaan Otomobil Nasional Sdn. Bhd. (PROTON) with a production capacity of 150,000 cars per annum.

Measurements were taken as a result of PTMSB's adoption of the ISO 50001 Energy Management System (EnMS) tool from United Nations Industrial Development Organization (UNIDO), which revealed annual electricity consumption from compressed air as the third largest Significant Energy User (SEU). This accounts to about 12 GWh or 18 percent of 66 GWh total facility annual electricity consumption (Figure 2).



Figure 1: PTMSB Plant Layout

As a result of this insight, the company's management set a goal to optimize the compressed air system by reducing compressed air leaks, artificial demands, and inappropriate uses in the plant.

Key Findings

Compressed air optimization measures adopted by PTMSB have reduced the consumption of compressed air by 31 percent resulting in savings of about 3,761,000 kWh per year in energy consumption. The monetary savings are MYR 1,090,627 per year (\$255,000 USD). The CO₂ reduction is estimated at 2,735 ton per year.

Overview of Air Compressors in PTMSB

There are eight large water-cooled centrifugal air compressors located in the Energy Centre of PTMSB. These units are not connected to any type of control system and are manually operated on a schedule controlled by the system operators.

Energy Conservation Opportunities Identified through Compressed Air System Optimization (CASO)

The PTMSB plant maintenance & services set specific goals in addressing their compressed air system. They include:

- To reduce energy consumption (electricity) of compressed air system through Compressed Air System Optimization (CASO).

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- To reduce electricity cost and energy consumption by 10% from year 14/15. (baseline)
- To reduce carbon footprint of PTMSB through CO₂ emission reduction.

CASO activities that were carried out, are as follows:

- Energy Saving Awareness & Compressed Air Leak Rectifications
- Compressed Air Leak Monitoring & Air Leak Isolation at certain production shops
- Compressed Air Conservation (reduce number of compressors running at one time)
- Compressed Air Pressure Reduction from 7 bar to 6 bar (100 psi to 87 psi)
- Improvement on Control Panel Cooling (To replace Vortex Cooler using compressed air with Force Convection Fan)

Results of Implementation of CASO activities

Figure 4 shows that the efforts of the energy management team caused a progressively decreasing reduction in energy consumption at the Energy Centre.

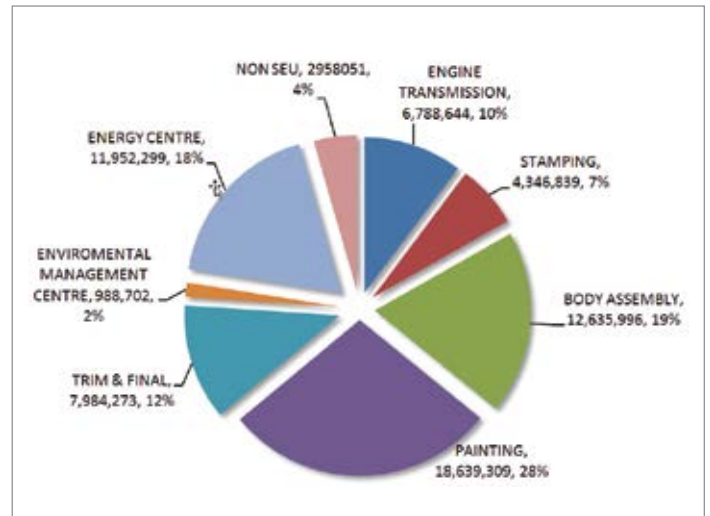


Figure 2: PTMSB Energy Consumption (kWh) for 2014/15

Loc.	Serial No.	Brand	Model	Power Capacity	Air Flow Capacity	Pressure Capacity
				(kW)	(m ³ /hr)	(bars)
Energy Centre	#1	UMW COOPER	TA 3000	522	6,000	7
	#2			522	6,000	7
	#3			522	6,000	7
	#4			522	6,000	7
	#5			522	6,000	7
	#6			522	6,000	7
ETM	#1			336	3,400	7
	#2			336	3,400	7

Figure 3: Specification of air compressors in PTMSB

AUTOMAKER PROTON ATTACKS COMPRESSED AIR WASTE

Energy Savings Awareness & Compressed Air Leak Rectifications

As part of the UNIDO training in Energy Management, PTMSB staff learned that Energy Conservation is the first step towards Energy Efficiency, and from past studies it was proven that behavior changes of people and reducing wastage in current practices can lead to 10% or more savings.

Hence, PTMSB launched the PROTON Green Policy and rolled out awareness campaign to all workers on conserving energy. PTMSB trained their staff to inform maintenance team whenever they find any air leaks nearby their work areas. The maintenance team also organized dedicated sub-groups to aggressively find all leaks and fix compressed air leaks found in all areas.

Compressed Air Leak Monitoring & Air Leak Isolation

Since you can't manage what isn't measured, PTMSB installed thermal mass flow meters with data loggers at all production shops to monitor the compressed air flow during non production weekends. As a result of this monitoring method, PTMSB managed to identify which production shop had high compressed air leakage levels and focus their energies on those areas. They then arranged to isolate the compressed air supply for any particular shop not requiring compressed air during non-production weekends by closing motorized valves at the outlet of air receiver tanks. As a result, this approach has enabled PTMSB to run only one 336 kW air compressor instead of two large 522kW units during non-production operation on weekends and holidays.

Air Compressor Optimization

Furthermore, by running only three air compressors during day shifts instead of five units, and smaller total capacity during

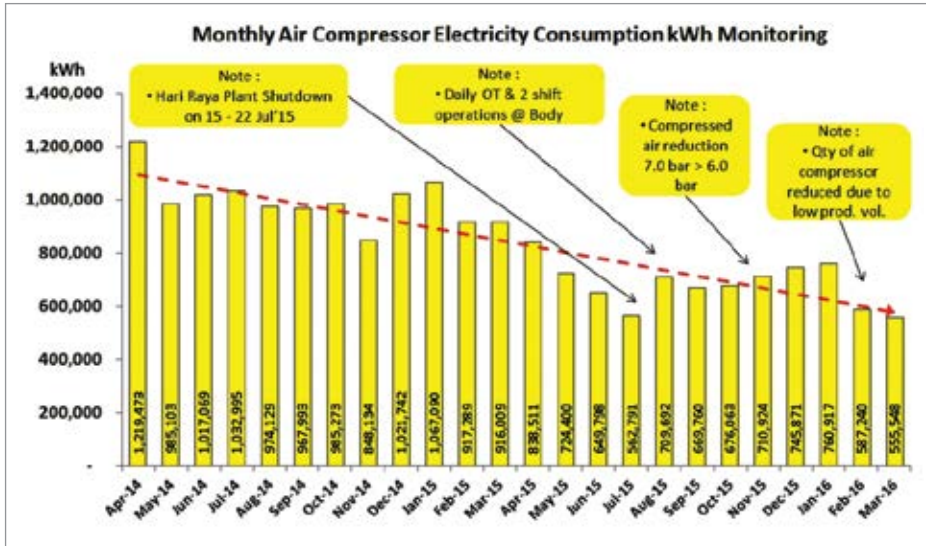


Figure 4: Savings from CASO Initiatives



Figure 5: The PTMSB Maintenance Staff are serious about reducing waste!

Best Practices for Compressed Air Systems Second Edition



Learn more about optimizing compressed air systems

This 325 page manual begins with the considerations for analyzing existing systems or designing new ones, and continues through the compressor supply to the auxiliary equipment and distribution system to the end uses. Learn more about air quality, air dryers and the maintenance aspects of compressed air systems. Learn how to use measurements to audit your own system, calculate the cost of compressed air and even how to interpret utility electric bills. Best practice recommendations for selection, installation, maintenance and operation of all the equipment and components within the compressed air system are in bold font and are easily selected from each section.

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night shift, PTMSB managed to achieve better compressed air production efficiency and reduced blow-off. Add to this the benefit of reduced maintenance costs due to lower number of operating hours.

Compressed Air Pressure Reduction

PTMSB also studied the demand side requirements for the compressed air pressure. Initially, the air compressors at the Energy Centre were supplying compressed air at a pressure of 7 bar (100 psi) to the whole plant. It was thought this level could be

reduced. However, when reducing the supply pressure from 7 bar to 6 bar (100 to 87 psi), it was found that some pneumatic machines in the Painting shop and Trim & Final shop started to malfunction, affecting the quality of the painting process due to low pressure events. Some machines in the two production shops required higher pressure than other production shops. In order to save energy for the air compressors, PTMSB purchased and installed compressed air powered boosters that compress 6 bar compressed air to the required 7 to 9 bar pressure for the Painting

shop, spray robots and Trim & Final shop's pneumatic manipulators.

This initiative resulted in PTMSB being able to reduce the overall header pressure in the plant by 1 bar (14.5 psi). The reduced pressure and the changes as a result of other energy conservation measures reduced the flow of compressed air to the point where the number of running centrifugal air compressors could be reduced. The system was reconfigured so that the air compressors can run based on actual demand of plant.

Improvement on Control Panel Cooling

PTMSB also identified the usage of vortex coolers which have been using compressed air at a flow rate of 6,000 m³/h (3,500 cfm) to cool down accumulated heat from the circuitries inside the control panels. The plant engineers came up with a replacement cooling method, using a Force Convection Fan (see the "Control Panel Cooling" article in the July 2016 Issue of Compressed Air Best Practices Magazine) to cool down the control panel instead of using a vortex cooler powered by compressed air.

The impact was that PTMSB could shut down one unit of 522kW air compressor by improving the control panel cooling using the Forced Convection Fan method which does not require compressed air to cool the panels. Management asked for a detailed financial analysis on the return of investment (ROI) and technical evaluation to be conducted before deciding to go for a full scale replacement of all vortex coolers in the plant by Forced Convection Fan. Upon the completion of the study, it was found the vortex cooler, for normal control panels, could be replaced with a low-cost forced convection fan cooling system. This concept will use hi-delivery of clean ambient air at 32°C forced entry into the control Panel at 235CFM and exit at 210CFM. This will

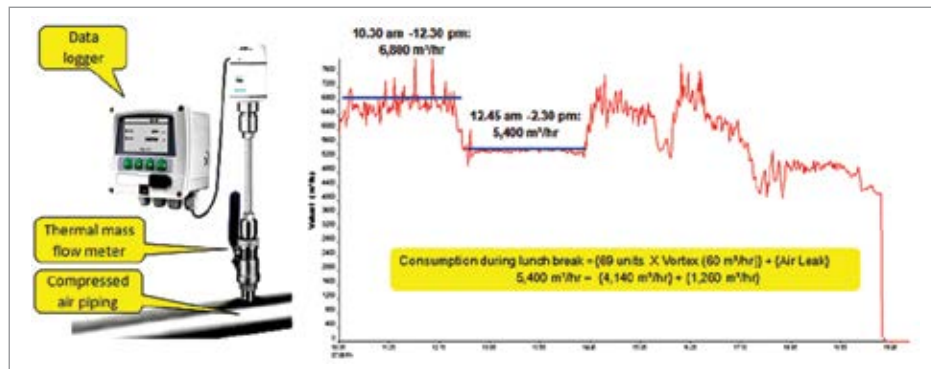


Figure 6: Compressed air flow monitoring system identified problem areas

Description	S/N	Status Day Shift		Status Night Shift		Status Weekends	
		Before	After	Before	After	Before	After
Location: Energy Centre Capacity per unit: 522 kW Flow Rate per unit: 5,000 m ³ /h	EC 01	RUN		RUN			
	EC 02	RUN	STDBY	RUN	STDBY		
	EC 03	RUN				STDBY	
	EC 04	RUN	RUN				
	EC 05		RUN			RUN	STDBY
	EC 06		RUN			RUN	
Location: Engine Transmission Capacity per unit: 336 kW Flow Rate per unit: 3,400 m ³ /h	ETM 01	STDBY		STDBY			
	ETM 02	RUN	STDBY		RUN	STDBY	RUN
Total	Qty	8	5	3	2	2	2
	m ³ /h	42,800	27,400	18,000	12,000	9,400	12,000
							3,400

Figure 7: Fewer air compressors run as a result of conservation measures.

Interview with the Author

Why has your company embarked on this energy management effort?

Our company embarked on the energy management effort as part of our cost savings initiatives. The increase of energy cost in Malaysia is a result of a reduction of energy subsidies by the government of Malaysia starting 1st Jan 2016 caused by incomes that are badly affected by the oil crisis (Malaysia is a net exporter of oil). Our management has decided to push ahead for cost savings and Proton's high utility cost (RM 75mil per year based on 2014/15 utility bill) is another reason for embarking on the energy management effort.

Why have you chosen the compressed air system for study?

Compressed air is the third largest significant energy user in our production plant after the painting shop, which consists of few systems. Hence, if we look at just a single system alone, the compressed air system is the largest energy user. A reduction in energy usage for compressed air will translate to immediate huge savings for Proton as we run some of our compressors 24/7 a day to maintain pressure to some equipment like the stamping machines. Furthermore, quick fixes such as identifying and rectification of the compressed air savings will result in immediate savings without huge investment.

What is your role in this program?

As an Energy Manager registered under the Energy Commission, I played the role of planning and coordinating the implementation of energy savings projects such as the compressed air optimization programme that Proton embarked on since January 2015. Furthermore, I also monitored the monthly energy consumption for the

whole plant and provide energy reports with energy consumption trending graphs and breakdown of energy usage on a monthly basis to the management. Under EMEER 2008 (Efficient Management of Electrical Energy Regulation 2008), our plant is a big user of electricity which consumed over 3mil kWh consecutive 6 months and we need a Registered Electrical Energy Manager (REEM) to report to Energy Commission on the energy saving initiatives and energy consumption, etc. Hence, it is my role to prepare this report, sign off, and submit to Energy Commission every 6 months.

sister plants in Shah Alam and Casting plant in Glenmarie, we managed to start the Green Initiatives Campaign ("Kempen Hijau" in Malay language) and slowly we get more and more participation from all levels of people. Currently, most of our maintenance people and our management are aware of our green initiatives and energy savings programme in particular. We are slowly gaining momentum as when people started seeing the savings in monetary terms, their awareness level increased and so are their interest in pursuing or supporting the energy savings programme.

"When we started our energy savings initiatives on compressed air system, we never expected to have monetary savings over RM 1 Million in utility bills just from this project."

– Abdul Azeem bin Mohamed Mohideen, Electrical Energy Manager, PROTON

What is the biggest surprise you encountered?

When we started our energy savings initiatives on compressed air system, we never expected to have monetary savings over RM 1 Million in utility bills just from this project.

Has it been easy to persuade your personnel to improve your system?

As with all organization, change is something not everyone is comfortable with. The challenge lies in motivating and getting the people around you to move out of their comfort zone and change the way they use and operate the equipment and machines. I would not say it is easy but with concerted efforts from other energy managers in our

What will you focus on next?

We are just half way through the compressed air system optimization programme as there are yet many air leaks not fixed along the distribution pipes and in the production floor. We also planned to change all vortex cooler for panels in our plants to conventional force convection fan (FCF) which will bring further savings by reducing the demand for compressed air. I would say our focus this year (2016 to 2017) would be to focus on identifying more air leaks and rectifying them and to reduce overall compressed air demand by changing the vortex cooler to FCF fan system.

AUTOMAKER PROTON ATTACKS COMPRESSED AIR WASTE

keep a positive pressure to eliminate dust entry and maintain the temperature inside the control panel at $34 \pm 2^\circ\text{C}$. It was estimated the electricity bill to operate a Forced Convection Fan is around RM14 per Month (\$3 USD per month). Furthermore, the replacement of the vortex cooler by the Forced Convection Fan method also provided the added benefit such as a reduction of noise providing a quiet work environment to workers.

For the High Inductive Distribution (HID) panels, we required higher cooling capacity above the cooling capacity generated by the Forced Convection Fan. Hence, PTMSB decided to install industrial air conditioning systems for all the HID panels in the plant because these HID panels produce large amounts of heat and the electronic components are vulnerable to overheating.

Conclusion

In short, the important element contributing to the success of the Compressed Air System Optimization (CASO) project at PTMSB in reducing both energy consumption of 3,760,784 kWh and monetary savings of MYR 1,090,627 was the continuous support extended by the UNIDO Energy Management System (EnMS) and System Optimization (SO) program operating in Malaysia, coordinated by Ms. Kaveta Chelliah. With the training and guidance provided by UNIDO EnMS, Mr. Bill Meffert and Erik Gudbjerg; and CASO international trainers, Ron Marshall and Bo Kuraa, with local experts, Ahmad Zafuan and Ch'ng Eng Yong, PTMSB Energy Manager, En. Azeem and other staff were able to implement the EnMS tools to monitor and track the plant's electricity costs through a proper method in accordance to the ISO 50001 system. The EnMS system also helped in measuring and verifying savings made through

the CASO project and other various initiatives carried out in the plant.

Note from Ron Marshall: The UNIDO CASO awareness program was conceived and written using the Compressed Air Challenge's training materials and methods as guidance. This successful effort at PTMSB, still not yet complete, is a shining example of what awareness and focused efforts can achieve! The physics of compressed air knows no international boundaries. What works to save money in Malaysia will work in North America. **BP**

For more information about the Compressed Air Challenge®, contact Ron Marshall, email: info@compressedairchallenge.org.

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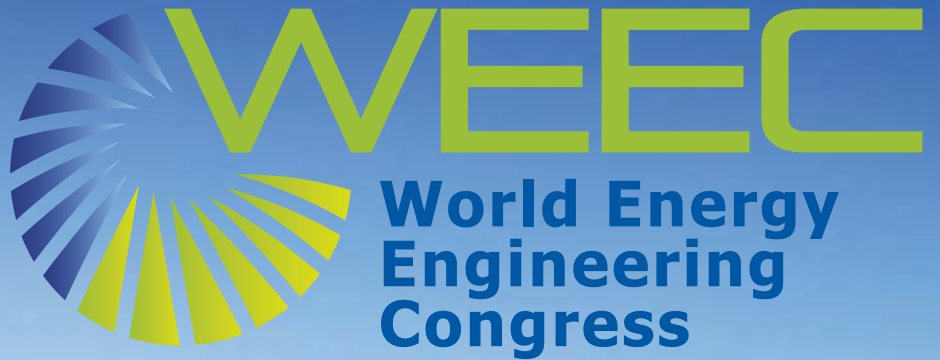
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Atlas Copco Expands VSD+ Technology to GA 37-75

Atlas Copco has added their ground-breaking variable speed drive plus (VSD+) technology to its entire range of GA oil-injected rotary screw compressors. VSD+ is now available worldwide in all pack and full feature versions of GA compressors. The technology was previously only offered on the GA 7-37 models.

“The GA series is already a customer favorite,” said Erik Arfalk, vice president of communication and branding for Atlas Copco Compressors, LLC. “Adding VSD+ technology drastically decreases operational costs by providing up to 50% more energy savings compared to traditional compressors.”

VSD compressors adjust motor and element speed to meet the demand of a plant or facility, making them ideal for applications with variable demand. Because they are only running at the minimum required speed, VSD compressors cut energy use and associated



Atlas Copco has added VSD+ technology to the entire range of GA oil-injected rotary screw compressors.

costs. Atlas Copco VSD+ compressors offer further advantages, including an iPM (Permanent Magnet) motor, a new compression element and a sentinel valve, allowing them to deliver significantly improved energy savings. With free air delivery (FAD) and specific energy requirement (SER) both improved by 9%, customers get 9% more air while using up to 9% less energy than with first generation VSD compressors.

The GA VSD+ line provides a smaller footprint than traditional GA VSD compressors and produces low noise levels of only 67dB(a), making them ideal for a range of facilities and applications.

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

Atlas Copco Compressors LLC is part of the Compressor Technique Business Area, and its headquarters are located in Rock Hill, S.C. The company manufactures, markets, and services oil-free and oil-injected stationary air compressors, air treatment equipment, and air management systems, including local manufacturing of select products. The Atlas Copco Group, which celebrated its 140th anniversary in 2013, is among the Top 100 sustainable companies in the world and a member of the Dow Jones World Sustainability Index. Atlas Copco has also been recognized by Forbes, Thomson-Reuters and Newsweek, among others, for its commitment to innovation and sustainability. Atlas Copco Compressors has major

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sales, manufacturing, production, and distribution facilities located in California, Illinois, Massachusetts, North Carolina, South Carolina, and Texas. www.atlascopco.us

For more information and a GA VSD+ energy savings calculator, visit http://webapps.atlascopco.com/Industrial_air_animations/accalculator/#.

Kaeser Launches New Secotec TE Refrigerated Dryer Models

Kaeser Compressors, Inc. has expanded their high-efficiency Secotec line of refrigerated dryers with the addition of three new TE models. Available in three sizes—TE 102 (325 cfm), TE 122 (410 cfm) and TE 142 (470 cfm)—these new TE dryers feature the same Secopack LS thermal storage system as our larger, award-winning Secotec TF models.

Kaeser's innovative Secopack LS thermal storage system contains a phase-changing material (PCM) with 98% higher thermal storage capacity than conventional storage media. Thermal energy is stored as the PCM cycles from a solid to a liquid state that maintains a more stable outlet dew point for better moisture control. This also makes the Secotec TE units much lighter than other thermal storage dryers and reduces package footprint. In addition to reducing refrigerant compressor run time, the dryers' internal design also makes it possible to reduce pressure loss across the dryer to 1.8 psi (compared to 2.9 and higher for conventional models).



Secotec TE dryers feature Kaeser's innovative Secopack LS thermal storage system.

These dryers also include Sigma Control Smart, a micro-processor based controller which controls the thermal storage process. It has an alarm and service message memory, as well as remote on/off control capability. An optional Ethernet interface for connecting to a master control system is also available.

To learn more about the new Secotec TE dryers or to be connected to your local representative for additional information, please call 877-586-2691.

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

New Vaisala viewLinc Wireless Monitoring System

Vaisala viewLinc Environmental Monitoring System has been redesigned to offer long-range wireless communication, ease of use, and fast deployment.

"The previous version of the viewLinc system has long been used by pharmaceuticals, but it is also ideal for monitoring other high-value assets that are affected by environmental conditions, such as air temperature or humidity. It is used in museums, galleries, and in IT server rooms," says Vaisala Product Manager Jon Aldous.

viewLinc provides trends, alarming, and customizable reporting that ensures accurate environmental information via a wide selection of Vaisala devices that monitor temperature, humidity, CO₂, and other variables. For GxP compliance, validation documents are available.

The new viewLinc system leverages cutting-edge wireless communications capabilities in order to utilize logging devices that communicate reliably in obstructed environments.

"We licensed a new long-range wireless specification to create VaiNet, a proprietary wireless technology for viewLinc," tells Aldous. The

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Sustainable Energy Savings with Compressed Air Best Practices®

Compressed Air Best Practices® is a technical magazine dedicated to discovering **Energy Savings** in compressed air systems — estimated by the U.S. Department of Energy to represent 30% of industrial energy use. Each edition outlines **Best Practice System Assessments** for industrial compressed air users — particularly those **managing energy costs in multi-factory companies**.

“We’re in 75 to 80 locations. We’ve done literally hundreds of compressed air modifications, changes, upgrades and audits.”

— William Gerald, CEM, Chief Energy Engineer, CalPortland
(feature article in August 2015 Issue)

“Compressed air is essential to any manufacturing process, particularly in the automotive industry, and it accounts for about 23 percent of total energy costs at our powertrain facility.”

— Mike Clemmer, Director/Plant Manager-Paint & Plastics, Nissan North America (feature article in October 2015 Issue)

“Demand Side” and “Supply Side” information on compressed air technologies and system assessments is delivered to readers to help them save energy. For this reason, we feature Best Practice articles on when/how to correctly apply **air compressor, air treatment, piping, storage, measurement and pneumatic control technology**.

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

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

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

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signal strength between network access points and data loggers can travel over 100 meters indoors. It's not affected by walls, equipment, Wi-Fi networks, or other usual signal impediments.

"We worked with several long-time customers, collecting a wish-list of system functions that could be either simplified or automated. We eliminated or improved aspects of system deployment that were time-consuming or complex, and updated the software interface with embedded help to guide users through common tasks," says Aldous.

The result is a monitoring system that can be installed in minutes, maintains compliance for years, and eliminates almost every issue related to wireless data logging.

To view a 3D Video on the new wireless viewLinc system visit www.viewlinc.vaisala.com

New ASCO Numatics 651 Series FRL

ASCO has introduced the new ASCO Numatics 651 Series filter, regulator, and lubricator (FRL) line of air preparation products. This new FRL line broadens the company's high flow-rate 650 Series family to include products with 1/8-inch and 1/4-inch port sizes.

"The 651 Series FRLs require less space and are designed to fit in compact applications and in machines that require less air



The new ASCO Numatics 651 Series filter, regulator, and lubricator (FRL)

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Company	Page	Web Site
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Atlas Copco	Inside Front Cover	www.atlascopco.us
DV Systems	Inside Back Cover	www.dvcompressors.com
ELGI Compressors	5	www.elgi.us
Nano Purification Solutions	7	www.n-psi.com
Relevant Solutions	8	www.relevantolutions.com
BEKO Technologies	9	www.bekousa.com
FS Curtis	10	us.fscurtis.com
JORC Industrial	11	www.jorc.com
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CDI Meters	15	www.cdimeters.com
SKF	16	www.skfusa.com
VP Instruments	17	www.vpinstruments.com
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Anest Iwata	23	www.anestiwata.com
Compresyn Lubricants	25	www.compresyn.com
SMC	26	www.smcusa.com
ENMET	27	www.enmet.com
IWF 2016	35	www.iwfatlanta.com
WEFTEC 2016	39	www.weftec.org
World Energy Engineering Congress 2016	43	www.energycongress.com

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consumption,” said Robert W. Kemple, Jr., executive vice president, sales and marketing – Americas, ASCO. “With the highest flow rates for their sizes, these highly reliable air preparation products are ideal for packaging and other applications that require space-saving designs.”

The 651 Series extended high- and low-temperature capabilities (-40°C to 80°C) permit its application across a broad range of operating conditions, including those with harsh environments. The modular FRL products feature robust construction and are easy to assemble, mount, and position. New manifold endplate flanges allow a maintenance technician to pull the manifold assembly out of service without disconnecting the piping. Front-facing, low-profile gauges are easy to read, and the 651 Series is the only product of its type that comes with these gauges on its shut-off isolation valves and slow-start/quick exhaust valves.

Optional integral pressure range indicators added to the low-profile gauges allows users to easily set the red/green color indicators to the desired pressure range.

Additionally, an optional 3-micron pleated pre-filter has been added to the line’s coalescing filters and coalescing filter/regulator combination units. This filter eliminates the need for a separate particulate filter unit, reducing cost, size, and weight.

About ASCO

ASCO, an Emerson company, offers comprehensive solutions of fluid automation products for a broad range of process and manufacturing industry applications. The company’s global scale increases speed to market, its deep expertise across applications transforms ideas into measurable outcomes, and its people create solutions that maximize efficiencies and optimize customer applications. ASCO’s fluid control and pneumatic product lines include a full range of solenoid valves, angle body piston valves, valve manifolds, cylinders, filters, regulators, lubricators and a complete range of accessories. For more information, visit www.asco.com.

About Emerson

Emerson (NYSE: EMR), based in St. Louis, Missouri (USA), is a global leader in bringing technology and engineering together to provide innovative solutions for customers in industrial, commercial, and consumer markets around the world. The company is comprised of five business segments: Process Management, Industrial Automation, Network Power, Climate Technologies, and Commercial & Residential Solutions. Sales in fiscal 2015 were \$22.3 billion. For more information, visit www.Emerson.com.

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A Publication of: Smith Onandia Communications LLC
37 McMurray Rd. Suite 106
Pittsburgh, PA 15241

Compressed Air Best Practices® (USPS# 17130) is published monthly except January-February combined by Smith Onandia Communications LLC, 37 McMurray Rd., Suite 106, Pittsburgh, PA 15241. Periodicals postage paid at Pittsburgh, PA and additional mailing offices. POSTMASTER: Send address changes to: Compressed Air Best Practices®, 37 McMurray Rd, Suite 106, Pittsburgh, PA 15241.

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SOLUTION:

Kaeser ran a KESS (Kaeser Energy Saving Simulation) using supply side audit data and designed a complete system solution that would dramatically reduce the specific power from 62.0 kW/100 cfm to 17.5 kW/100 cfm. New energy efficient compressors, an air receiver, as well as a system master controller were installed. The new system has the same number of compressors and total horsepower as before, but it provides even more flow.

RESULT:

The Sigma Air Manager (SAM) master controller monitors the four new compressors and selects the most efficient combination of units to meet the plant demand. With its built-in SAC *Plus* software, SAM continually tracks energy consumption so the plant benefits from having an ongoing compressed air energy audit. As a matter of fact, the specific power has been reduced more than anticipated—all the way down to 16.7 kW/100 cfm.



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