Pharmaceutical Audit Oil-Free Compressors Dew Point

June/July 2008

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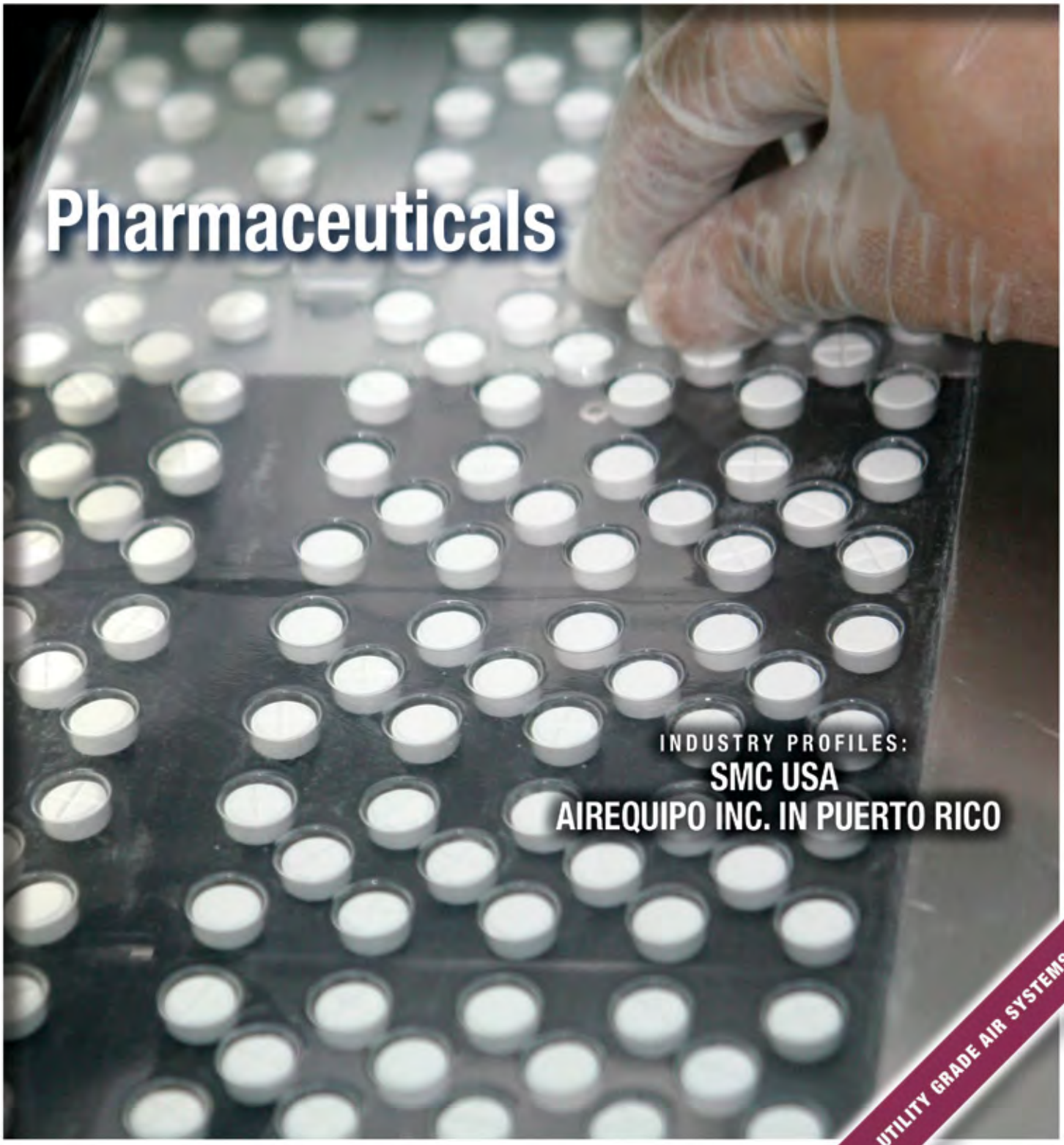

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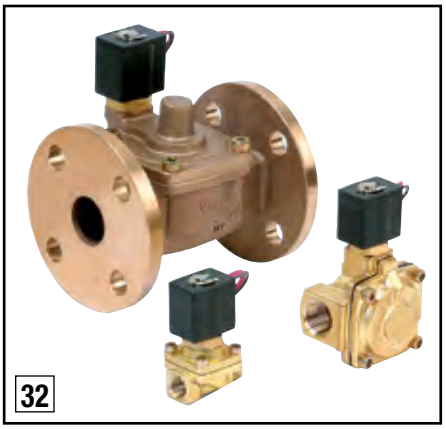

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FROM THE EDITOR

Pharmaceuticals

I just returned from the Energy Management Congress in Seattle. Hosted by the Association of Energy Engineers, this meeting was charged with the excitement of people who see the business opportunities behind saving energy.

I was particularly impressed by the professionalism of the utility companies and the focus they have on compressed air systems. Each utility has at least one person on staff who is very knowledgeable on compressed air systems and is able to participate in the compressed air audit process. One such person told me how in their county they have blanketed all "good-sized industry" and that they are now focusing on installations with 7.5 to 50-horsepower air compressors.

One of our goals with this magazine is to help the utilities that are NOT involved in compressed air rebate programs. We will be featuring stories about the successful utility programs (beginning with the August edition) in existence. Utilities can play an enormous role in helping a factory have the confidence that an "energy" project will work.

In our June/July Audit of the Month, Mike Nagy walks us through an audit of a pharmaceutical facility. It is very interesting to see how his understanding of pneumatics helped solve a very problematic situation the factory was having with moisture in the cylinders. Further, their demand-side focus is able to reduce air consumption dramatically in the plant.

Thanks go to Airequipo Inc. for sharing information with us on their home market of Puerto Rico. Did you know that the Top 20 prescription drugs used in the U.S. are all made in Puerto Rico?

Finally, Mr. Hank Van Ormer provides us again with a very thorough analysis, which he once provided to a plant engineer at a pharmaceutical company. If you want an oil-free air compressor, what is preferable — oil-free rotary screw or oil-free centrifugal compressors? Of course this is not easy to answer, but Hank provides great insights.

Thank you again for your support.

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UTILITY-AIR NEWS

Gardner Denver, Inc. Announces Executive Management Changes

Gardner Denver, Inc. announced in May the retirement of Ross J. Centanni, Executive Chairman of the Board of Directors, and J. Dennis Shull, Executive Vice President and General Manager, Compressor Division, effective January 2, 2009. Mr. Centanni has been appointed to serve in the role of Chairman Emeritus of the Board of Directors through his retirement. Mr. Centanni will then provide consulting services to the Company following his retirement in January 2009 through the annual meeting of stockholders in May 2009. Frank J. Hansen, previously the lead non-employee Director of the Company's Board of Directors, has been appointed to succeed Mr. Centanni as Chairman of the Board in a non-executive capacity, effective immediately. Barry L. Pennypacker, President and CEO of the Company, will now report to Mr. Hansen. Tracy D. Pagliara, currently the Company's Executive Vice President, Administration, General Counsel and Secretary, will succeed Mr. Shull following his retirement in January 2009.

Mr. Centanni served as the President and Chief Executive Officer of Gardner Denver from its incorporation in 1993 until the appointment of Barry L. Pennypacker as President and CEO in January 2008. Mr. Centanni has served on the Company's Board of Directors since 1993 and was elected Chairman of the Board in 1998. Prior to Gardner Denver's spin-off from Cooper Industries in 1994, Mr. Centanni was the Vice President and General Manager of Gardner Denver's predecessor, the Gardner-Denver Industrial Machinery Division, where he also served as Director of Marketing from August 1985 until June 1990. Under Mr. Centanni's leadership, Gardner Denver was transformed into a leading global manufacturer of compressor and vacuum equipment serving various industrial and transportation applications, pumps used in the petroleum and industrial market segments, and other fluid transfer equipment serving chemical, petroleum and food industries and its annual revenues have grown from $175 million to $1.9 billion.

Mr. Shull has been an employee of Gardner Denver since 1975 and has served as the Executive Vice President and General Manager of the Gardner Denver Compressor Division since November 2006. He previously served as Vice President and General Manager of the Compressor Division from January 2002 until his promotion and Vice President and General Manager of the Compressor and Pump Division from its organization in August 1997 until January 2002.

For more information, visit www.GardnerDenverProducts.com

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Experience Proven Results

ASCO Numatics Announces Industrial Automation Engineering Scholarships

In May, ASCO Numatics announced a new program that will award two $5,000 scholarships to U.S. engineering students who are pursuing careers in industrial automation-related disciplines. Additionally, ASCO Numatics will make $1,000 grants to the engineering departments of the colleges in which the winners are enrolled.

"Fluid control and fluid power technology will play a vital role in helping companies meet the dynamic business conditions of tomorrow's global markets. This work will require a new generation of engineering leaders with the skills and expertise to create advanced automation processes. We have implemented the scholarship program to recognize and assist students who show great potential and capability to solve tomorrow's industrial processing challenges," said Bob Kemple, executive vice president, sales and marketing ASCO Numatics-Americas.

The scholarships are merit-based and will be awarded on the candidate's potential for leadership and for making a significant contribution to the engineering, instrumentation, systems, electrical, mechanical and automation professions, particularly as they relate to the application of fluid control and fluid power technology. A panel of ASCO Numatics and independent judges will select the finalists.

Applicants must be enrolled full-time in an undergraduate or graduate program in instrumentation, systems, electrical, mechanical or automation discipline at an accredited U.S. educational institution for the 2008/2009 academic year. At the time of application, they must have completed at least their sophomore year in a bachelor's degree program, have at least a 3.2 GPA on a 4.0 scale and be a U.S. citizen or legal U.S. resident. Complete application details and forms are available at www.asconumatics.com/scholarship.

ASCO Numatics will present the scholarship awards at the ISA Expo on October 14, 2008 at the Reliant Center in Houston. The ASCO Numatics award presentation will be part of the annual ISA Young Automation Professionals Festival (YAPFEST) that ISA hosts for automation professionals between ages 18 and 30.

For more information about ASCO Numatics products, visit www.asconumatics.com.

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UTILITY-AIR NEWS

Aerzen USA Inaugurates Green Manufacturing Facility

In April 2008, Aerzen USA inaugurated its' new headquarters for North America. As a high-end manufacturer of industrial blowers, vacuum pumps and compressors, the new Aerzen USA plant in Coatesville, PA is one of the most environmentally friendly industrial buildings to date. By employing the LEED® Gold Certification criteria established by the U.S. Green Building Council, Aerzen was able to meet their goals of individual, social, environmental and economic responsibility.

From left: Pierre Noack, President of Aerzen USA, Klaus-Hasso Heller, CEO of Aerzener Maschinenfabrik and John Rafferty, Pennsylvania State Senator

Aerzen USA is seeking LEED® (Leadership in Energy and Environmental Design) Certification from the U.S. Green Building Council. LEED was established as a means to standardize 'green building' through universally understood and accepted criteria. The certification is voluntary and provides independent, third-party verification that a building offers substantial reductions in pollution and energy consumption.

"We have a commitment to our community and the environment. That is why having our new facility meet LEED criteria was important. It reinforces our motto, 'One Step Ahead'," said Pierre Noack, CEO and President, Aerzen USA.

Some of the eco-friendly features of the building include:

- Fire lanes paved with turf pavers to provide more green space
- Permeable paving, underground rock beds and rain gardens promote responsible use of rainwater
- Aggressive integration of Solar Energy Technology including solar tubes for lighting
- Earth tubes, which pass outside air underground, cool the shop space
- Nearly 100% of construction waste was recycled
- Recycled furniture was used in most office areas
- Straw bale construction of the conference room

"The Gold designation is extremely difficult to achieve and is rare for manufacturing buildings. However, we've devoted considerable attention to every detail and feel certain that our building will prove worthy of this distinction," continued Noack.

Aerzen USA is a wholly-owned division of the German manufacturer, Aerzener Maschinenfabrik GmbH, and is a recognized world leader in the production of rotary positive displacement machines since 1868.

For more information, visit http://www.aerzenusa.com.

New Production Center for BEKO

BEKO Technologies announced they will locate a new production facility in Atlanta, Georgia. The company plans to invest $4 million and create 35 jobs at their new Fulton County facility.

BEKO recently purchased a 50,000-square-foot facility in Fulton County. BEKO plans to produce several different product lines at the new plant, including their DRYPOINT® M membrane air dryers, the BEKO exclusive BEKOKAT® catalytic hydrocarbon removal systems, QWIK-PURE® emulsion separators and the CLEARPOINT® line of compressed air filtration. The company's current plans have them on pace to be fully operating in Atlanta in August of 2008.

"BEKO Technologies is a fast-growing company. By integrating our existing production facility, BEKO Membrane Technologies in Bend, Oregon, into BEKO Technologies Corporation, we needed a new place," said Tilo Fruth, general manager of BEKO Technologies.

For more information visit www.bekousa.com

Compressed Air Audit of the Month

A Pharmaceutical Compressed Air System Audit

By Mike Nagy

June/July Audit of the Month

Where:	Western U.S.
Industry:	Pharmaceutical
Issues:	Dew Point Problems and Energy Cost
Audit Type:	Supply and Demand Side

Financial Summary

Investment:	$20,000
Energy Cost Before Investment:	$85,398
Energy Cost After Investment:	$39,198
Energy Savings/Year:	$46,230
Elimination of Dew Point-Related Production Downtime:	est. $250,000 per year
Power Cost/kWh:	$0.125
Operating Hours/Year:	8,760

System Before Audit

Average Air Flow:	307.30 cfm
Average Working Pressure:	99.45 psi
Rotary Screw Compressor #1:	100% Loaded
Rotary Screw Compressor #2:	20% Loaded
1,080-gallon Storage Tank Two Refrigerated Air Dryers:	Dew Point 35–39° F
Dew Point Problems Downstream:	Yes

System After Audit

Average Air Flow:	121.3 cfm
Average Working Pressure:	75 psi
Rotary Screw Compressor #1:	0% Loaded
Rotary Screw Compressor #2:	37% Loaded
1,080-gallon Storage Tank Two Refrigerated Air Dryers:	Dew Point 35–39° F
Dew Point Problems Downstream:	No

A. Introduction

This West Coast pharmaceutical facility has a very clean and organized compressed air system. All equipment is in good working order in the compressor room. The compressor room itself is very clean and well ventilated. The management requested a compressed air system audit for two reasons:

1. Production problems and downtime resulting from the presence of moisture in the compressed air lines. The compressor room dryers were functioning properly so how could this happen?
2. Awareness of the high cost of compressed air and a desire to find ways to reduce compressed air demand.

This article will describe the actions taken to address these two issues. The facility operates "24/7" so we have 8,760 operational hours per year. The average electrical rate at this facility is $0.12 kW/h. The power cost formula used is based upon the facility's current operating conditions of 3.89 cfm/bhp and 95% average motor efficiency.

Power Cost = (bhp *0.746 * 8,760 hours x $0.12 per kW/h)/Avg. Motor Efficiency (95%)

The focus of this audit is on the "Demand Side" with the very top priority being to identify the root cause of the presence of moisture in the compressed air lines.

B. Compressor Room Review

The Compressor Room is extremely clean and well ventilated. There are two rotary screw compressors, which are oil lubricated and air-cooled. The air is dried by two parallel refrigerated air dryers. The air then goes into a common header and flows into a 1,040-gallon air storage tank. The air then flows into an Intermediate Flow Controller. From here, the compressed air leaves the compressor room and enters the facility. The average cfm per bhp between the two air compressors is 3.80 cfm per bhp.

ROTARY SCREW AIR COMPRESSORS	HP/BHP	MOTOR SERVICE FACTOR	WORKING/RATED PRESSURE (PSI)	FLOW (CFM)	CFM PER BHP RATIO	ROLE
Compressor #1 Brand X	75 hp/86.25 bhp	1.15	100/125 psi	360 cfm @ 110 psi	4.17 cfm per bhp	Back-up
Compressor #2 Brand Y	75 hp/90 bhp	1.20	125/135 psi	326 cfm @ 125 psi	3.62 cfm per bhp	Base Load

Upon entering the compressor room, we noted an audible air leak in Compressor #2. We found the leak to be coming from the air end and recommended that the air compressor service provider be contacted immediately. Both air compressors are operating via modulation control. Compressor #2 acts as the base load machine while Compressor #1 is the back-up machine when pressure falls to a predetermined set point.

The two refrigerated air dryers are in good working condition and functioning properly. They are designed to produce a dew point range between 33° F and 39° F at a maximum flow of 330 cfm at 100 psi. We took dew point measurements at the compressor room outlet (for one week) and found that the average dew point achieved was 36° F. This correct dryer performance is what has the facility bewildered by the presence of water in the compressed air lines in the factory. It is worth noting that the dryers are not capable of drying the full air output capacity of the air

COMPRESSED AIR AUDIT OF THE MONTH

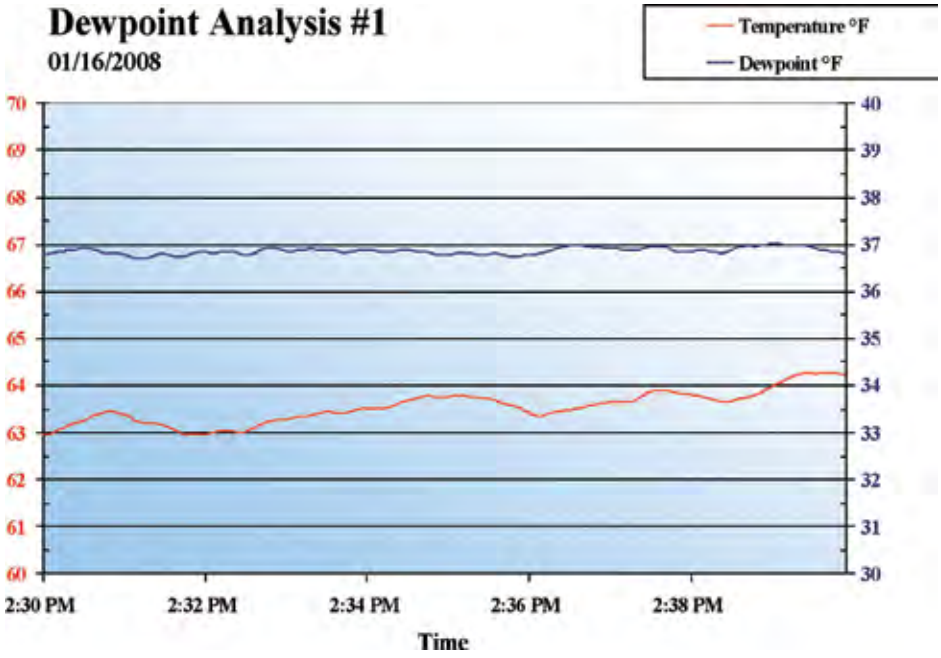
A Pharmaceutical Compressed Air System Audit

compressors if factory demand should increase. The dryers have integrated 1-micron particulate filters. **We recommend that the facility install a 0.01 ppm oil coalescing filter** to protect against oil contamination downstream.

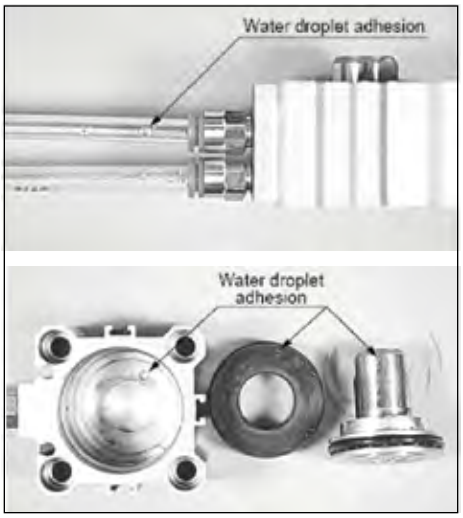
The 1,040-gallon air storage tank is adequate for the air demand in the facility. During production, we recorded an average airflow of 307.30 cfm, which means the tank is providing 3.38 gallons of storage per 1 cfm of air storage. The tank is also piped properly (after the air dryer) with air entering the bottom of the tank and exiting the top — providing more surface area for moisture to be separated and fall to the bottom of the tank.

C. Solving the Problems with Moisture

It was initially reported that the plant was "having problems resulting from an excess of water in the compressed airlines", with the primary area of concern being the small cylinders in the plant. As a standard part of our audit procedure, we took dew point readings. These tests showed a refrigerated drying system according to its specifications. The data depicted below shows a very steady dew point with less than half a degree fluctuation over a ten-minute time span. The 36° F average dew point is well within the expected range of performance for these dryers.



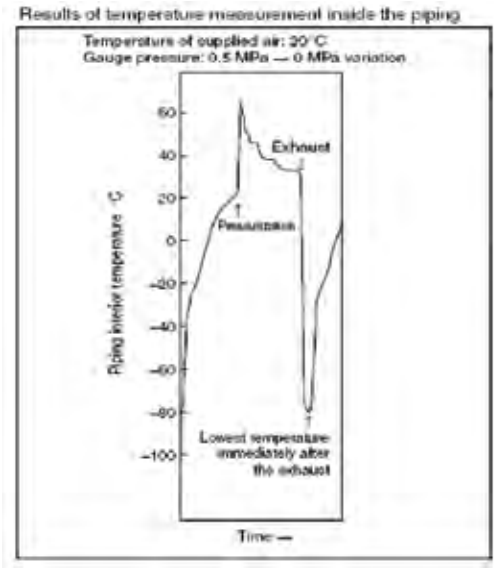
As a result of the ongoing condensation issues, the factory had taken some actions in hopes of remediating the problem. The solution the plant put into place was to install water separators on each line and open the drains on Filter-Regulator-Lubricators (FRLs) throughout the plant. We found a total of 18 FRL units with the drains open, exhausting approximately 2 cfm each worth of compressed air, totaling 36 cfm worth of compressed air. The problem with this is that the only thing exhausting through the drains was compressed air, thereby decreasing plant pressure at the same time.



Moisture in Pneumatic Cylinders Created Production Downtime

Adiabatic Expansion

Through further investigation we found the root of the problem. When air is discharged from the piping between the cylinder and the valve, the temperature of the air drops due to **adiabatic expansion**. If the atmospheric dew point of the supply air is **T1**, and the temperature of the air **T2** after adiabatic expansion falls below this value **(T1<T2)**, then mist formation occurs. Most of the mist is discharged through evaporation by the surrounding heat. However, a small amount of residual mist tends to adhere to the inner wall of the piping. The solenoid valve is switched again and new compressed air is supplied, so the residual mist in condition remains on the side of the cylinder. The second issue was the length of piping between the cylinder application and the valve. When the cylinder is small and the piping is long (that is, the volume of the piping is longer than that of the cylinder), air inside the cylinder cannot be exhausted at the time of the release and remains inside the piping. As the cylinder cycles, the mist accumulating near the cylinder increases, finally resulting in the formation of large water drops and condensation.



COMPRESSED AIR AUDIT OF THE MONTH

A Pharmaceutical Compressed Air System Audit

Moisture had cost hundreds of thousands of dollars in lost production.

The Solution to Moisture Problems in Pneumatic Cylinders

There is a very effective solution to this problem — the installation of quick-exhaust valves directly onto the cylinders. These will allow for the cylinder to fully exhaust on every cycle, thereby eliminating condensation buildup and save the cylinders. Along with saving the cylinders in the plant, there is no need to keep the drains of the FRLs opened in the plant. Leaving the drains opened is actually creating a larger pressure drop throughout the plant and wasting 36 cfm of compressed air.

Quick Exhaust Valves solved the problems with moisture

Understanding what is happening with the pneumatic cylinders was the key to solving this problem. The facility had been considering installing desiccant air dryers. This would have been a significant capital expense and would not have solved the problem. We were able to identify the adiabatic expansion occurring between the cylinder and the valve. The solution deployed of quick-exhaust valve was a minor expense and achieved with little effort.

D. Demand-Side Audit

Aside from solving the downstream moisture problem, our audit reviewed pneumatic circuitry in the facility and also included a compressed air leak audit. Below is a brief summary of some of the opportunities discovered and solved. The end result was that air demand was reduced by 186 cfm. This reduced the plant compressed air demand from an average of 307 cfm to an average of 121 cfm.

The Five Label-Aire Machines

We took note of five Label-Aire machines in the factory. These units were constantly being pressurized even when not being used. We conducted a point-of-use test on these machines and found that each machine consumed an average of 4.2 cfm even when not in use. We only sampled a fragment of time so we are not sure what percentage of the time the machines are idled, but plant personnel tell us that it is a significant percentage of time.

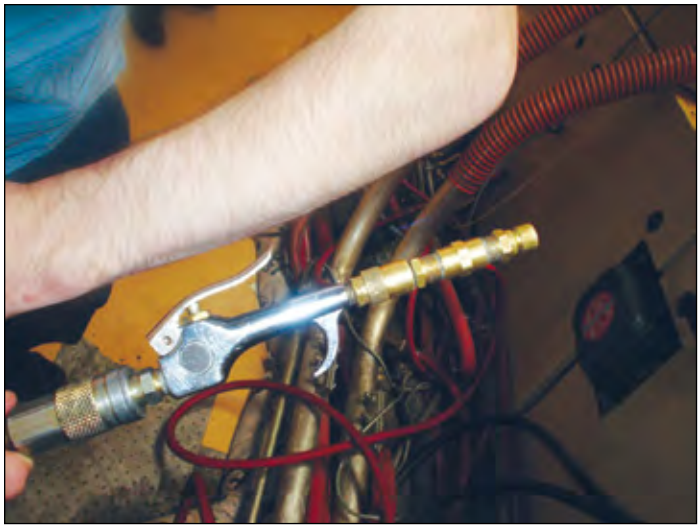
The solution here is to keep the Label-Aire machines from consuming air when idled. This is easily achieved by the installation of **two-positioned solenoid valves**. The solenoid of these valves will effectively actuate this application only when the product is present. The solenoid of these two-positioned valves can be actuated via several applications such as relay sensors and electronic signals. The table below shows the savings opportunity.

Table 2: Label-Aire Machines Air Consumption Costs when Idle

PERCENT IDLE	ONE MACHINE	THREE MACHINES	FIVE MACHINES
40%	$359.00	$1,078.00	$1,796.00
60%	$539.00	$1,617.00	$2,695.00
80%	$718.00	$2,156.00	$3,593.00

The Ten Blow Guns

There are ten blow guns at the facility which use inefficient nozzles. This can be costly in the long run due to the decreased impact pressure and increased waste of compressed air. We recommend using high-efficiency nozzles, which can reduce air consumption by 50–75% while increasing the impact pressure at the work surface. These high-efficiency nozzles utilize the Venturi effect to gain efficiencies.



High-efficiency nozzles on blow guns

The Cutter Machine Causes Plant Over-Pressurization

The cutter machine is causing the entire plant to run at 100 psig because it requires 95 psig. We conducted a point-of-use test on this machine to verify its' air usage. The machine was operating between 85 and 90 psig when we started the test. Actual pressure changed over time from 71 psig to 104 psig with 90 being the average. Airflow went from 20 cfm to 10.4 cfm with 4.3 cfm being the average. The cutter was actuating twice a minute, in one minute and 15 second cycles with an intermittent down period of approximately two and one-half minutes.

Due to the intermittent demand of this application, we are recommending the use of a pneumatic booster coupled with an air receiver. This will allow us to reduce the air pressure across the entire facility.

Air Leaks

We have identified and tagged 28 compressed air leaks in the facility. They account for 120 cfm equating to 39% of the plants' average airflow of 307 cfm. Leaks were found on the air end of one air compressor, and plant-wide on FRL's, fittings, gauges and pneumatic tubing.

COMPRESSED AIR AUDIT OF THE MONTH

A Pharmaceutical Compressed Air System Audit

It is important to have a leak remediation campaign in place to keep leaks from consuming unnecessary compressed air. A proactive approach to leak detection should include all individuals within the plant and the education of machine operators on the cost of leaks.

Machine operators could then combat leaks as they develop by immediately tagging them and notifying maintenance. This approach to leak remediation is perfect for leaks that can be easily felt and heard. Some leaks, unfortunately, cannot be detected by the human ear. We utilize ultrasonic leak detectors to find leaks that are out of range and hard to hear or feel.

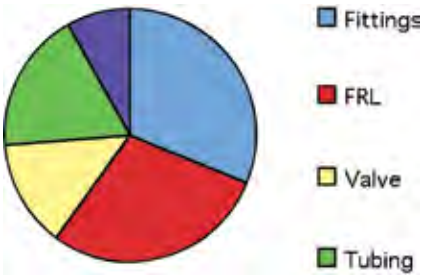
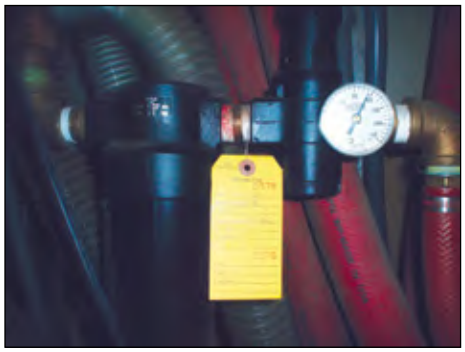


Chart 1: Leak locations in % at the facility

E. Capture the Savings

The demand-side audit made it possible for us to reduce average air demand from 307 cfm to 121 cfm. We fixed leaks (120 cfm), closed open drain valves (36 cfm) and will reduce overall plant pressure (30 cfm). We now need to look at how the compressors are operating and if the controls are set to capitalize on the new compressed air demand profile.



Air leak on FRL

The "Before" Situation was this to produce 307.3 cfm:

1. Compressor #1 ran 100% loaded in modulation mode. At 100% power it had 90 bhp, which equated to $74,292 in annual costs of operation.
2. Compressor #2 ran 20% loaded in modulation mode. At 78% of power it consumed 67.3 bhp equating to $11,106 in annual energy costs of operation.
3. Total annual energy cost of operation was $85,398.

The "After" Situation was this to produce 121.3 cfm:

1. Compressor #1 was placed on standby for emergency situations. $0 energy cost.
2. Compressor #2 was capable of having its' controls modified to Load/No-Load. We ran the machine 37% loaded to meet the demand. At 55% of power, it had 47.45 bhp equating to $39,168 in annual energy costs of operation.
3. Total new annual energy cost of operation was $39,168.

The new annual energy costs to run the air compressors represents a savings of $46,230 per year.

Multiple holes/leaks in tubing

Conclusion

Understanding pneumatics is core to conducting a strong demand-side audit. Pneumatic circuits were where the audit was able to discover the dew point problem and the opportunities to reduce air consumption and pressure. Understanding air compressors and air compressor controls then allowed the installations' energy costs to be reduced as a result of the demand-side improvements. BP

Air leak on hose/fitting connect

For more information, please contact Mike Nagy, SMC, tel: 216-406-5698, email: MNagy@smcusa.com, www.smcusa.com

Talking Dew Point

Compressed Air Best Practices discussed dew point with Steve Jiroutek (Application Engineer) of Vaisala Inc.

Please define dew point.

Dew point is defined as the temperature to which a gas (e.g., air) must be cooled, at constant pressure, for water vapor to begin to condense to liquid water. In other words, when the dew point temperature has been reached, the gas is fully saturated with water vapor. The term "pressure dew point" refers to the dew point temperature of a gas at pressures higher than atmospheric pressure. When addressing dew point in pressurized compressed air, the correct terminology is actually "pressure dew point," but this is often shortened to "dew point" in common usage.

Why is dew point so important in pharmaceutical applications?

Compressed air may be used for a number of applications in the pharmaceutical industry, such as raw material transport, processing equipment, pneumatic power sources and cleaning. The importance of knowing the dew point in a compressed air line may be critical for some applications but less relevant for others. For example, bulk solid and powder conveyers used for moving product rely on sufficiently dried and filtered air in order to perform their function properly and prevent product contamination. Continuous monitoring and control of dew point is often a requirement for instrument air, drying processes, packaging and actuating process control valves. The risks associated with letting dew point levels go unchecked can include equipment failure, condensation in process lines and on finished product and the potential for bacterial formation.

Why is dew point so important in laboratory environments?

Laboratory environments are often designed to maintain a controlled atmosphere in order to eliminate airborne contaminants and any sources of error that may interfere with testing. Dew point can be an important parameter to control. This is usually accomplished through the environmental control system and has little to do with compressed air. Some lab equipment, such as glove boxes, may require their feed gas to meet an established dew point level in order to maintain the inert atmosphere of the chamber.

TALKING DEW POINT

How is dew point measured and monitored in most facilities?

When discussing a typical facility's compressed air system, it's helpful to divide the entire network into two separate subsystems: the supply side and demand side. The supply side consists of the compressors and air treatment equipment up to the flow/pressure controller. The demand side consists of the distribution and storage systems or everything after the flow/pressure controller. On the supply side, dew point transmitters providing analog signals can be built into the dryer control system or can be installed in-line before or after the receiver tank. On the demand side, fixed mount instruments providing a local display, alarm relays and data logging capability are quite common throughout the distribution network and before critical end-use applications to give operators and plant personnel a quick assessment of dew point conditions at specific points in the system. This helps ensure that the dew point level of the air being produced at the dryers is maintained through the entire facility and to the end use points. Portable devices are an excellent tool for verifying dryer performance, conducting quality audits and checking the calibration of fixed mount instruments.

How is dew point measured by refrigerated air dryers?

Refrigerated dryers operate by using a refrigerant to cool the supply air with heat exchangers (usually to between 35° F to 40° F) and condense out water vapor for removal by a moisture separator and drain. Due to their relatively low initial cost, long-term reliability and minimal maintenance requirements, refrigerated dryers often do not integrate a dew point transmitter into their design for monitoring or control purposes.

How is dew point measured by desiccant air dryers?

Desiccant air dryers can benefit from a dew point sensor for monitoring dryer performance, controlling desiccant tower regeneration or both. Most regenerative desiccant type dryers (heated or heatless) produce a dew point of around -40°C/°F. Installing a dew point instrument with a display or with built-in alarm relays to measure the exit air from the dryer is a smart way to ensure good dryer performance. However, dryer efficiency can be significantly improved by using a dew point device to control the regeneration cycle — known as Dew Point Demand Switching (DDS). Desiccant dryers operate using two separate towers containing desiccant — one tower is always in operation while the other tower is being regenerated or purged using a portion of the dried exiting air. Some towers switch based on a timer, regardless of whether the desiccant has been fully saturated. By integrating a dew point sensor with the dryer control system, the towers will not switch until the dew point transmitter senses a degrading dew point temperature, thus ensuring full utilization of each desiccant tower and minimizing wasted purge air.

How is dew point measured in point-of-use applications?

For point-of-use dew point measurements, generally there are two options available — direct in-line insertion or sample extraction. Each method offers advantages and disadvantages that should be considered carefully. Direct insertion involves installing the probe through a threaded connection or "T" in the line. The benefits of this approach are ease of installation with no accessories required and no venting or loss of the compressed air. Line pressure fluctuations and sensor removal however can present drawbacks. The best installation for a dew point instrument isolates the sensor from the main line using a stainless steel sample line and sample cell. This setup allows for "valving off" from the main line and the ability to regulate the pressure, which has a considerable affect on the dew point reading. Easy installation and removal of the sensor can also be an important advantage.

What are the different prevalent technologies used to measure dew point?

With the vast number of different hygrometer technologies currently available on the market for measuring a wide range of dew points suited to different applications and industries, it would be difficult to cover all of them here in any detail. I'll limit the scope of the discussion to briefly address only the most common sensor types used in compressed air measurement.

Condensation hygrometers, often called "chilled mirrors" operate by cooling a surface in a controlled manner until condensation begins to form; this temperature is recorded as the dew point temperature of the air. The most common detection method for determining when liquid water has begun to form is optical reflectance, which uses a light source to measure the amount of reflected light from the surface. These devices are well known for their high accuracy (usually +/-0.2° C dew point) but generally require more maintenance to keep their reflective surface clean. They become prohibitively expensive for measuring very low dew point temperatures.

Aluminum oxide, silicon oxide and various other capacitive sensors share some common traits. In all cases, a capacitor is formed between two electrodes with a hygroscopic material serving as the dielectric of the capacitor. The hygroscopic material adsorbs or desorbs water vapor in proportion to the amount of water vapor surrounding the sensor. This changes the dielectric constant of the material and therefore the capacitance of the sensor. The choice of dielectric materials is critical to the performance of the sensor. Aluminum oxide is sensitive to very low dew points, but performs less well in atmospheric humidity levels. These sensors can be economical for low dew points when compared to chilled mirrors.

Thin film polymer capacitive sensors operate on the same principle as aluminum oxide sensors but use polymers instead of metallic oxides as the dielectric material. Many polymer sensors are optimized for use in atmospheric levels of humidity and are not suitable for the measurement of gases with dew point temperatures lower than -20° C. However, some polymer sensors are designed for low dew point measurement, and they typically distinguish themselves by implementing active, automatic self-calibration schemes to monitor and adjust the performance of the sensor. These sensors are cost competitive with aluminum oxide devices and offer the benefit of enhanced long-term stability.

What does Vaisala recommend for measurement and monitoring of dew point?

When selecting a dew point instrument for a particular application, it's important to consider the following about the installation:

- What is the expected dew point level at the intended measurement location?
- What is the pressure range?
- What is the temperature range?
- Will the probe be installed directly in the line or will a sample line be used for external measurement?
- Should the instrument be portable or fixed mount?
- What type of signal output is desired — local display, analog, serial communication?
- What other functionality is of interest — power supply, data logging, alarm relays?

With this information specified, the field of dew point instruments that fit these criteria will be significantly reduced. BP

Thank you.

For more information, contact Steve Jiroutek, Vaisala Inc., tel: 781-537-1065, email: steven.jiroutek@vaisala.com, www.vaisala.com

Puerto Rico, Pharmaceuticals and Airequipo Inc.

Compressed Air Best Practices spoke with Douglas Garrote-Arango (General Manager) of Airequipo Inc.

Good afternoon. How are things in Puerto Rico?

Good afternoon. Puerto Rico is the most wonderful place in the world (I'm definitely biased)! The island is 100 miles long by 37 miles wide. We belonged to Spain from 1493 to 1898 when we became a territory of the United States. We have a mix of cultures and a unique political situation, as we are neither an independent nation nor a state of the union. This is why they say "PR is the best of both worlds."

What is the current business climate?

Unfortunately our economy is a reflection of the economy in the U.S.A. with a six-month lag. It has worsened these past four years, among other things, because our government (Executive, House of Representatives (HR) and Senate) is divided between two parties and we have had little legislative action. This has created tremendous problems to legislate and move our own economy, not to mention the other indirect result of slow down in the U.S.A. economy. But with regards to our particular situation, it got to a point that our government was actually closed for two weeks.

What kind of industry exists in Puerto Rico?

In the 1940s, agriculture was the market driver in Puerto Rico. The crop industries of pineapple, coffee and sugar supported the economy. In the 1970s, we saw the strong entrance of the pharmaceutical industry. Today, we have a diverse industrial manufacturing base including pharmaceuticals, electronics, rum, beverage concentrates and medical equipment. Consolidation has occurred here — just like in the U.S.

What drove the growth of the pharmaceutical industry in Puerto Rico?

In 1976, a U.S. government incentive was created called the "936," after the U.S. Internal Revenue Code, Section 936. The "936 incentive" made it possible for any company manufacturing in Puerto Rico to repatriate profits without paying any taxes on their income. This is what brought the pharmaceutical industry here. When Bill Clinton won the election, there were concerns that U.S. jobs were being lost to Puerto Rico and they cut the "936 incentive" by 40%. The remaining 60% of benefits were phased out over the next ten years ending in 2005. In order to maintain its benefits and make their operations competitive, some companies where able to convert to "controlled foreign corporations" (CFC) another section of the IRS Tax Code, under section 956.

The 2008 Airequipo Booth at Interphex Puerto Rico: from left to right: Douglas [Macar] Garrote (VP & General Manager), Laureano Garrote (President), Raul Garrote (VP Service), Néstor Rivera (Parker Hannifin Corp,Territory Manager), Roberto Garrote (VP Sales) and Mario Bolivar — National Accounts Manager, Industrial Nitrogen Products.

The Top 20 prescription drugs sold in the U.S. are produced in Puerto Rico.

Today as we speak, the Puerto Rican government is holding hearings at the Senate and the HR to approve what will constitute the driving force of our economic development, our new industrial incentives law. Our current local incentives are due to expire this summer. That is why this is such a critical time politically in Puerto Rico.

The Top 20 prescription drugs sold in the U.S. are manufactured in Puerto Rico. The pharmaceutical industry grew here under a "twin-plant concept" with the idea to also develop the Caribbean market from here. We compete globally for the pharmaceutical industry with the Dominican Republic, Ireland and Singapore.

PUERTO RICO, PHARMACEUTICALS AND AIREQUIPO INC.

Pharmaceutical Manufacturing In Puerto Rico

Abbott

Abbott Labs

Amgen

Bristol Myers Squibb

Cordis

Glaxo SmithKline

IPR Pharma Canovanas

Ethicon J&J

Janssen Ortho McNeil

Janssen Products

Ortho Biological

McNeil Consumer Health Care

Lilly Del Caribe

Merck Sharp & Dohme

Novartis

Pfizer

Procter & Gamble

Schering Plough

Valeant

Warner Chilcott

Wyeth

What type of compressed air systems are used in the pharmaceutical industry?

The typical installation involves oil-free air compressors. Highly regulated by the FDA, pharmaceuticals will not allow anything but oil-free air compressors. We can offer both Atlas Copco oil-free rotary screws, lobe or scroll compressors. Airequipo has worked hard over the years to demonstrate the benefits of oil-free air compressors and today we can say we have 90 to 95% of the pharmaceutical industry. We currently have more than 500 oil-free air compressors installed.

Air treatment specifications are flexible depending upon the application. They may use a refrigerated air dryer or a drum (desiccant) air dryer. If they want to avoid the growth of bacteria, then they will use from -40 to -100° F dew point desiccant air dryer. Stainless steel filters for sterile filtration are still very common as are coalescing filters for other industrial applications. Since the introduction of the MD dryer, we have been identifying applications to fulfill. Today, a combination of energy savings and not extreme dew points has been ideal for it.

What is the cost of power in Puerto Rico?

We have few natural resources in Puerto Rico and an issue for our industry has been the ever-increasing cost of electricity. The Puerto Rico Electric Power Authority (PREPA) is the only producer of electricity. With oil as its mean of production and over $120 per barrel, you can imagine the problems we face. The cost per kW/h in Puerto Rico for a manufacturing plant, depending on contracted volume, can fluctuate between 19 and 21 cents. This cost of power does not help Puerto Rico compete globally. We cannot forget that in the Dominican Republic their electric costs can go as high as 24 cents, but our minimum wage as opposed to them is the minimum wage paid in the U.S.A., creating an incredible issue in cost reductions.

Atlas Copco Oil-free, water-cooled, rotary tooth compressor with integrated refrigerated dryer and Variable Speed Drive

The Puerto Rico Electric Power Authority (PREPA) does not offer any energy rebate programs. Some companies, like Abbott Labs, generate some of their own power and actually resell some of it to the city of Barceloneta. Probably, this summer too, a "net metering" legislation will be effective in Puerto Rico and renewable energy projects will arise from this opportunity. There are still some legal issues pertaining to the use of PREPA's infrastructure for distribution (distribution wheeling), but ample debate is taking place to make this happen.

The Island of Puerto Rico

Are there many compressed air audits being done?

Airequipo does do some audits. Customers like Pfizer and HP, have been able to access some DOE funding and they have trained their own people on how to do ultrasound compressed air leak detection. We are becoming more and more of an outsourced solutions consultant for our customers. Puerto Rico is still getting accustomed to audits — some simply want you to do it for free or credit the audit work against equipment purchases. This is hard to do for free because obviously in order to understand compressed air demand a lot of hours must be spent measuring the system. Acceptable payback ROI periods vary significantly from customer to customer. I attended a seminar, where Hewlett Packard will prioritize projects with ROI's of less than nine months while PepsiCo will do projects with 24 month ROI's. We are making progress though and we are training our customers to study their electric bills and figure out the cost of their compressed air system. We are also working with them to help them avoid peak usage periods.

Airequipo offers strong training programs right?

Yes. Airequipo has been a leader in conducting paid training seminars at the customers' site. We do a specialized seminar on their air compressors and spend some time in their parts books identifying maintenance items. We have professionalized this training and the operators come away with the ability to operate the controls of the machines and to do some maintenance functions. The maintenance staffs are interested in doing this in Puerto Rico. Right now, we are trying to get certified as a resource in the curriculum of continuing education for engineers. The International Society for Pharmaceutical Engineering (ISPE) has approached us to do some training for their student chapter, some of which are working already at internships at pharmaceutical plants.

What is the history of Airequipo?

The company was started in 1961 so we have a long history! Our roots were in supporting the agricultural and construction industries through equipment rental and service. Since 1989, Airequipo Inc. has focused on being an industrial equipment distributor for compressed air system products to the manufacturing plants of Puerto Rico. The pharmaceutical industry here, which accounts for the majority of those plants, has been our primary focus. Airequipo Inc. has worked very hard to standardize the pharmaceutical plants with oil-free air compressors.

Today, we have 90 to 95% market share. This doesn't mean that we don't have competition. Nothing is farther from the truth. Puerto Rico's relationship with the U.S.A. makes it possible for other companies in the mainland to compete against us. The fact that some of these pharmaceuticals have headquarters in the U.S.A. makes it natural for them to contact their local distributors. But the fact that we are celebrating this year our 47th anniversary speaks of why we are still offering our services. We focus on being competitive and servicing our customers with the utmost professionalism.

PUERTO RICO, PHARMACEUTICALS AND AIREQUIPO INC.

What is the size of Airequipo?

Airequipo employs 17 people of who seven are compressor technicians. We have a full-time auditor on staff and a full staff of sales and customer service personnel. Our shop is a full-service and compressor rebuild facility and we carry an inventory of spare parts and smaller machines to provide fast service to our customers through our rental fleet operation.

How is Airequipo changing?

We watch the market closely for technological advances and for changes. I remember telling you that your magazine was displaying on each cover something we were doing on our company or recently incorporating. One of those instances was the September 2007 issue where you covered the Results of a Tire Inflation with Nitrogen Study. We were signing up to represent the Parker TireSaver at the same time. Recently, your magazine expanded to include vacuum products, which we did also about eight months ago. We are looking for products that we can service with the same business structure and with service as our focus. This is why we have targeted hospitals as well. The revisions of the NFPA99 specification give us the opportunity to promote the oil-free technology we have been offering to manufacturing facilities. The standards before suggested or implied reciprocating compressors. Now those specifications include rotary compressors as well.

> "The cost per kW/h in Puerto Rico for a manufacturing plant, depending on contracted volume, can fluctuate between 19 and 21 cents."

At the US Hispanic Chamber of Commerce in PR Convention Center, from left: Mrs. Jacqueline Marie Matos, President PR Supplier Development Council, Mr. Douglas [Macar] Garrote, VP and General Manager Airequipo Inc. and Mr. Edwin Pérez, Director Strategic Business & Diversity Relations from Avis Budget Group while discussing the benefits of Nitrogen Tire Inflation.

How is the nitrogen generator business going?

Being an island, and with the necessity of importing the majority of our nitrogen needs (with the exception of some small cryogenic plants), it makes all the sense in the world to produce your own nitrogen and produce it as needed without the hassle of coordinating deliveries and encountering shortages. We sold our first nitrogen generator to Lilly del Caribe in Guayama. Nitrogen generators are picking up speed. Praxair, Linde and Air Products were here for years. We can compete when the application is liquid nitrogen, which is then converted to gas. If you are using nitrogen for blanketing and pipe purging, our system is very competitive. We have quotations into many of the big pharmaceuticals. We also are receiving great technical support from Parker-NNI Division. We have also sold some nitrogen generators for tire inflation including one to a Lexus dealer.

What lies ahead for Puerto Rico?

The leadership on the Island is saying that we have to do what we do best — and that is to manufacture prescription drugs, but we must concentrate on knowledge management as well. We have learned to produce these drugs, but in order to compete in the Global Market we must come to the forefront and develop (R&D) them. Our current Governor declared PR the Bio-Island and he is working hard on bringing research to PR. Pharmaceutical and Biotechnology manufacturing must lead our future. Our skill workers are ready to handle the "high-tech" prescription drugs. This is an important moment in Puerto Rico as the corporations are waiting to see what the new tax incentives will be — before they make their investment decisions. BP

> "The Top 20 prescription drugs sold in the U.S. are manufactured in Puerto Rico."

Thank you Airequipo for your insights.

For more information, please contact Douglas Garrote-Arango, Airequipo, tel: 787-720-9531, email: macar@airequipo.com, www.airequipo.com

Real World Best Practices

by Hank Van Ormer

EVALUATION GUIDELINES FOR TWO-STAGE, LUBRICANT-FREE ROTARY SCREW AND MULTI-STAGE (3) CENTRIFUGAL AIR COMPRESSORS

The following write-up compares operating parameters, design criteria and basic operating power efficiency of these two very popular "oil-free" compressors. When it is all said and done, they are both excellent products, and when well applied and maintained serve the user very well. There are areas of size (flow) where one and then the other are the most energy efficient and a wide operating area where the energy performance is very similar. To develop this baseline data we used the basic performance manufacturer's data from 200 to 900 horsepower (hp) covering nine manufacturers, some of which offer both types.

The summation of this data, along with the basic operating differences between a Positive Displacement and Dynamic compressor (Mass Flow), create some very interesting situations. Particularly with regard to the effect of inlet air conditions on both, and the basic turndown range and capabilities of both. The basic conclusion is that one technology is not "better" than the other, but certainly one may fit a given set of conditions better than the other.

I. Basic Operating Characteristics of the Oil-Free, Two-Stage Rotary Screw Compressor in the 100-Psig Industrial Compressed Air Markets

General Design — Whether lobe or screw, non-lubricated rotaries have some common design characteristics. These are positive displacement type.

- They are a positive displacement clearance type design and do not require lubrication in the compression chamber
- The lobes or screws do not drive one another while rotating, but are driven by some type of "bull gear" arrangement. This drive system also acts as a "timing gear" to maintain the accurate rotor or lobe profile relationship
- Depending on the performance and pressures desired, they can be packaged into single or two-stage configurations. In the 100-psig class market, most units are two-stage and can deliver very acceptable efficiencies
- Cooling is accomplished through the cylinder walls through water jackets or air-cooled cylinders. Injected oil is not used to cool or seal
- These units are referred to as "clearance type compressors" which means that the basic design has a constant leakage rate for any fixed set of conditions, clearance, pressure and temperature. Inlet is taken in, sealed and the volume reduced to raise the pressure — positive displacement
- The general critical internal clearances are:
  - Between end covers and rotor
  - Between rotor lobes
  - Between the rotor "OD" and the cylinder "ID"

- Lubricant for the drive train must be confined to the bearing and gear area and not allowed to travel to the compression chamber. This is accomplished in several different styles depending on the manufacturer and type of unit
- Because these are rotary units they enjoy all the advantages of rotaries over similar sized non-lubricated reciprocating units, depending on the application:
  - Compact size
  - Full stand-alone packages
  - Ease of installation
  - No high magnitude unbalanced loads
  - Simple maintenance

Applying Lubricant-Free Rotary Screw Air Compressor for the Commercial, the Industrial or the Plant Air User

Well-designed, packaged rotary screw stationary air compressor systems were specifically developed for plant use to combine the merits of two well-known concepts:

- The lubricant-free, continuous-duty, rotary screw compressor
- The package compressed air plant

These factory-packaged compressed air plants give the user a complete air system that can be installed in any suitable location and requires no foundation (merely a floor strong enough to support its weight). All internal wiring and piping is done at the factory. Installation requires setting the unit on the floor correctly, hooking unit discharge into the air system and bringing power supply to the starter box. The whole unit, including the compressors, is designed for an 8,000-hour "industrial year."

In selecting and applying a lubricant-free rotary screw compressor system, the user should always keep in mind the various systems that make up the whole package and how they impact on the application or installation.

- Compressor capacity control/pressure control/unit capacity control
- Electric motor drive system
- Electric motor starter system
- Enclosure type and function
- Environment and noise control
- Special adaptations such as: unit or compressor pre-filter, outdoor enclosure, cold weather package, hot weather package, skid or wheel mounting, heat recovery package (air or water), treatment of discharge air (i.e. after cooling, reheating, filtration)
- Compressor performance at low pressure, high pressure or altitude

Correct discharge piping and effective storage are critical to a continuing satisfactory operation with the standard two-step controls. Variable speed drives are available on most packages as an optional control. Like all VSDs, they are less energy efficient at full load than a comparable constant

REAL WORLD BEST PRACTICES

EVALUATION GUIDELINES FOR TWO-STAGE, LUBRICANT-FREE ROTARY SCREW AND MULTI-STAGE (3) CENTRIFUGAL AIR COMPRESSORS

speed drive, but offer better efficiency performance throughout the specific "sweet zone". VSD drives are less storage dependent to deliver proper operation, but to achieve optimum cycling, proper storage should be calculated and installed. The VSD drive delivers a constant, smooth, continuous flow and generally avoids cycling.

Two staged, lubricant-free rotary screw compressors are limited to a maximum compression ratio of 11:1 or 12:1. This may have a significant effect on the ability to deliver pressure at altitudes and under other varying conditions.

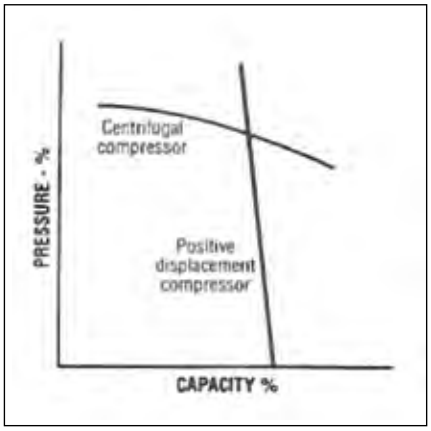
For example: The nominal maximum pressure will be 150 psig at 1,500 feet elevation, while at 5,000 feet elevation, the nominal maximum pressure will be 125 psig.

II. Basic Operating Characteristics of Multi-Stage Centrifugal Compressors in the 100-Psig Class Industrial Compressed Air Market

The centrifugal compressor used in industry is a dynamic compressor with rapidly rotating impellers accelerating the airflow. The air then passes through a diffuser section, which converts the velocity head into pressure through flow resistance.

In a dynamic or mass flow compressor like the centrifugal, the power to compress the air basically is a function of the weight of the air, the flow, volume and temperature and the head or pressure.

Once the impeller is designed and a speed set, the energy that a pound of air will absorb in passing through the impeller is established. This is true despite variation in inlet temperature, pressure level, throttling, etc. A pound of air will vary in cubic feet by temperature and pressure.



Performance characteristics of centrifugal versus positive displacement compressors.

A centrifugal compressor, therefore, will deliver a pound of air with a constant expenditure of energy, winter or summer. The actual volume of inlet air to be compressed will vary for a period of time with the inlet condition of pressure and temperature.

A centrifugal compressor therefore, will deliver a pound of air with a constant expenditure of energy, winter or summer. At this point, you must note that your "design conditions" for a centrifugal must be at your warmest temperatures to be sure you have adequate flow during those conditions.

As the pressure falls or rises in the positive displacement rotary screw, the flow stays relatively constant; the power to run the compressor is directly proportional to the discharge pressure.

The dynamic type centrifugal compressor reacts to a change in discharge pressure; indirectly as the pressure rises, the flow is reduced. As the pressure falls, the flow increases, all at similar input power.

Depending on design, the "surge point" limits the actual amount of turndown in a given unit. This unstable operating region is entered when system pressure exceeds that being developed within the compressor. Then flow reverses and air attempts to flow toward the compressor. This reduces system backpressure and normal flow is restored through another reversal. If operation in the surge region continues, these flow reversals also continue, resulting in surge. Surges create a temperature and pressure spike at the impeller discharge resulting in automatic shutdown to protect the unit. Units are normally applied with surge protection. A modern electronic control can very effectively monitor inlet conditions and keep the unit clear of operating within the surge range.

Some important points regarding "rise to surge":

- The surge point will vary with inlet conditions
- At colder temperatures and higher inlet pressure conditions, the density of the air increases, resulting in lower volume of inlet air (icfm or acfm) to reach the maximum design point of pounds of airflow. This means to hold the constant target discharge pressure, the inlet air flow will have to be reduced to avoid "running out on the curve" too far and reaching the stonewall area of potentially very unstable operation
- The opposite occurs at higher temperatures and lower pressure inlet air

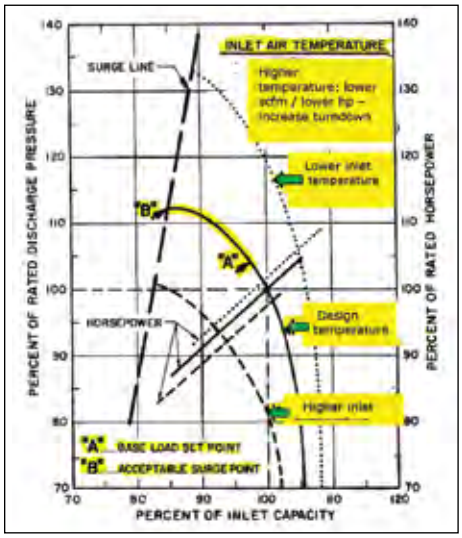
If the centrifugal compressor has to respond to a varying demand efficiently, it can usually only do this effectively throughout its "turndown range". After full turndown is reached, the unit either:

- Blow offs — all excess air produced beyond turndown. This results in less air delivered to production with no reduction in power (kW) or electrical energy (kWh)

— OR —

- The inlet valve can partially close and operate with the blow off or recirculation valve and run at idle 25–35% power draw with no flow to the plant. To be effective, this type capacity control is storage dependent

The more turndown available, the more flexible the unit is to meet varying demand profiles efficiently.



The three curves above compare operating characteristics with pressure and flow, including changes in surge point and horsepower requirements without a controlling device in the inlet and discharge

Inlet Guide Vanes (IGV) are much improved and relatively easy and economical to add to most existing units. Inlet guide vanes *do not* increase turndown, but they do allow the unit to operate throughout the turndown range at or near full load efficiency.

By smoothing out the inherent turbulence of a normal inlet butterfly valve, the IGV makes it much easier to set the turndown controls closer to the surge line.

Typical 3-Stage Centrifugal 2,500 scfm Class at 125 psig
Effect of inlet temperature and other ambient conditions on performance and turndown

	AVERAGE WINTER	EXTREME WINTER	AVERAGE SUMMER	EXTREME SUMMER
Max. icfm	2810	2830	2805	2810
Max. scfm	2871	3224	2612	2422
Min. icfm	1695	1504	1844	2004
Max. scfm/TD	1729/TD 41%	1711/TD 47%	1715/TD 34.3%	1726/TD 29%
Max. BHP at FL scfm	638	680	600	573

The above table reflects the particular data from a 2,500 cfm class, 125 psig, three-stage compressor and its performance and turndown calculated limits at various times of the year operating in the Midwestern part of the United States. The scfm rating reflects the relative density of the air. There are various elements all acting to establish that limitation:

- Effect of ambient temperature
- Effect of ambient pressure
- Limiting pounds per minute flow not overloading the motor
- Cooling water temperatures
- Limited maximum flow volume of inlet cubic feet per minute of ambient air

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This clearly shows the net effect of many normal operating variables resulting in BHP ranges from 573 Bhp to 680 Bhp. Full-load capacity ranges from 2,422 scfm to 3,224 scfm and turn down from 29% to 47%.

III. Comparing the Basic Performance Characteristics of Oil-Free Rotary Screw and Three-Stage Centrifugal Compressors

CHART 1: PROS AND CONS

	2-STAGE ROTARY SCREW	3-STAGE CENTRIFUGAL
Type	Positive Displacement	Dynamic
Continuous Duty	Yes	Yes
Specific Power (Approx. 2,500 cfm/500 hp)	6.47 cfm/kW	6.77 cfm/kW
Effect of cold temperature scfm volume and bhp	Slight increase	Significant increase
Effect of hot temperature scfm volume and bhp	Slight decrease	Significant decrease
Modulate	No	30% (+) IGV
On-line/Off-line	Yes	No
Variable Speed Drive	Yes	No
Blow down idle	Yes (20%–25%)	Yes (25%–35%)
Effective storage required for idle	Yes	Yes
Interface with networking or master control system	Yes	Yes
Multi-year warranty programs available	Yes	Yes
Type Main Bearings	Anti-friction	Oil Film/Journal
Drive Gears	Part of air end	Field replaceable
Seals pressure	Part of air end Load/No Load Band	Field replaceable/constant pressure
Effects of Higher Pressure:		
Flow	Slight decrease	Significant decrease
BHP	Significantly higher BHP	
(½% 1 psig)	Stays about same	
Effects of Lower Pressure:		
Flow	Slight increase	Significant increase
BHP	Significantly lower BHP	Stays about same
Efficiency General:		
New (depending on size and model)	About equal within ____	About equal for this unit
Part Load 100%/70%/60%	Less efficient	More efficient w/IGV
Below 70–60% without blow down idle	More efficient	Less efficient
Below 70–60% with blow down and idle	N/A	Somewhat less efficient with proper storage
Loss due to normal wear over time	Some	Some

Comments to Chart 1

1. **Specific Power** — The referenced 4.5% better specific power for a three-stage centrifugal is for the 500 hp class, 2,400 cfm units. As the sizes increase, this number will get a little better in favor of the three-stage centrifugal. As the sizes decrease, the two will be about even at 300–350 hp class and the two-stage, oil-free rotary screw will be more efficient down to 100 hp. (The smaller centrifugals are mostly two-stage.)

2. **Effects of Hot and Cold Temperatures** — The Centrifugal is a dynamic compressor, or a "mass flow" compressor and therefore its ability to deliver air and its input power is significantly altered by ambient conditions — particularly temperature. At colder temperatures, the unit delivers more air volume but also requires commensurate more horsepower.

   The positive displacement oil-free rotary screw will react as all positive displacement units to ambient temperatures changes — with slight increases or decreases in scfm flow and negligible changes in horsepower. The magnitude of these movements depends on several conditions but overall doesn't result potential in extra air and extra horsepower of the centrifugal.

3. **Control System** — Oil-free two-stage rotary screws are standard with a full load/no load two-step capacity control system. Modulation (which matches supply to demand by throttling the inlet) is not used due to (1) putting a higher percentage load in the second stage and (2) having to keep the total compression ratio at a maximum of about 11:1 or 12:1. Variable speed drive is also used, but with a much less favorable performance curve than on the lubricant cooled rotary screw.

   Often in a given frame size, extra turndown has to be offset with lower specific power by utilizing different impellers/diffusers with different aerodynamic characteristics. For example, following are the operating performances of a two-step, 500-hp class, 50-psig centrifugal:

TWO-STAGE WITH 3 COMPRESSION ELEMENT OPTIONS	
Option 1	Full Load — 3,319 scfm — 506 bhp — 397 kW — 8.36 scfm/kW Turndown — 2,589 scfm — 22%
Option 2	Full Load — 2,914 scfm — 448 bhp — 352 kW — 8.28 scfm/kW Turndown — 2,239 scfm — 24%
Option 3	Full Load — 2,900 scfm — 464 bhp — 362 kW — 8.01 scfm/kW Turndown — 1,829 scfm — 37%

   two-step controls are operated by "sensed" system maximum and minimum preset pressures. It is very power efficient when applied with adequate piping and storage to avoid "short cycling".

4. **Three-Stage Centrifugals** — Use a modulation or turn down capacity control, which reacts instantly by opening and closing the inlet to the compressor to match supply to "sensed" demand. Newer units offer a very power efficient turndown with Inlet Guide vanes from 100% to 70% load or better.

   If the centrifugal has to run any significant amount of time at loads lower than this, there is a full idle position available (similar to rotary screw), which also requires proper effective piping and storage. Normally, the full idle power draw will be between 25–35% of full load power.

   In all cases, centrifugal and rotary screw units will interface well with an effective networking or master control system.

Predictive Maintenance Compression Module: Two-Stage Lubricant-Free Rotary Screw

Most two-stage oil-free rotary screw compressors are machined to a critical tapered .064 metal-to-metal clearance, which is then effectively reduced to 0 with a coating application. Over the course of operation the 0 clearance widens, through erosion, deteriorating performance and ultimately requiring a compressor "air end" rebuilds. Various manufactures have specific recommendations but generally replacement occurs with normal use at about 45–55,000 hours or five to seven years. This time frame is optimized with proper inlet filtration.

(Continued on pg. 42)

SMC: MANAGING ENERGY AND DEW POINT IN PNEUMATIC SYSTEMS

Compressed Air Best Practices spoke with Kelly Ingoldsby (National Sales Manager-Compressed Air Purification (CAP) Products) and Mike Nagy (Energy Conservation Group Manager) of SMC Corporation of America.

Good morning. Please describe SMC Corporation for us.

Good morning. SMC is a global company with operations in over 49 countries. Founded in 1959, we are listed on the Tokyo Stock Exchange and have major production facilities in nine countries including two here in the U.S. Our business is focused on being the premiere supplier of pneumatic and air purification systems worldwide. This focus on pneumatic systems has allowed us develop premiere quality and technology which has driven our rise to a global market share of 26%.

Kelly Ingoldsby, SMC Compressed Air Purification Products

How long has SMC been involved with compressed air purification (CAP)?

We have long been one of the largest manufacturers of compressed air dryers in Asia. In 2006, for example, SMC sold 13,000 refrigerated air dryers in Japan. Being experts in pneumatic components, we are intimately familiar with the need for clean, dry, compressed air. Our customers have asked us to protect the SMC pneumatic components and that led us to start manufacturing air dryers over twenty years ago.

We have a full range of compressor-room air dryers and filters, but what makes our line-up unique is our range of point-of-use air treatment products. We supply membrane air dryers, which can manifold into a FRL (filter-regulator-lubricator) package, for example.

Factories often have dew point problems in the factory with their pneumatic applications — even when the compressor-room air dryers are functioning properly. The factory personnel will not understand why they still have dew point problems. This is where SMC's expertise in pneumatics adds value. By understanding the application of pneumatics, we can then design the appropriate compressed air purification solution.

How does SMC go to market with the CAP products?

We are building a nationwide distributor network of companies right now. We introduced the SMC full product line of compressed air dryers and filters in August of 2007. This first year has truly surpassed all of our expectations. Compressor distributors are choosing to work with SMC because of the quality of our products, breadth of product line and because of the access we give them to so many new customers. They also like the stock consignment programs we offer to ensure fast deliveries to customers.

SMC's UL-Listed Refrigerated Air Dryer

How do distributors get access to new customers?

SMC has a national sales force of almost seven hundred people. We are one of the top suppliers of pneumatic products in North America. When a distributor chooses to work with our compressed air purification (CAP) products, we start bringing them into our accounts. Our pneumatic product sales force will take these distributors to accounts where they have identified dew point issues or the need for air purification products. The pneumatics sales people are not in a different division and are motivated to bring in the compressor distributor. They are also, in this way, assured of service support if required.

We were in a regional meeting a few months ago talking about this and a distributor stood up and told the room that he had been handed approximately $14,000 worth of CAP product orders within two months of working with SMC's CAP product line! By working together, we are able to provide the customer with a truly complete air system survey from the air compressors to all the pneumatic components.

SMC's modular packaged membrane dryer, ideal for point-of-use applications

What specific CAP products do you offer?

We offer compressed air system demand-side and supply-side products. On the demand side, we offer flow meters and differential pressure monitors which can be tied into process management software via serial interface such as DeviceNet. We also make our chillers, valves, booster regulators, FRLs and other pneumatic products available to distributors.

On the supply side, we offer refrigerated air dryers from 10 to 4,000 scfm. They are UL-listed and use energy-efficient stainless steel heat exchangers which help the dryers have only a 1½ psig pressure drop across the unit. We are also able to package many options onto the dryers (condensate drains for example) at our shipping facilities in Indianapolis, Chicago, Los Angeles, Boston and Austin. SMC also offers heatless and heated desiccant dryers and a full range of ASME certified coalescing filters to 16,100 scfm.

Do compressor people need to know more about pneumatics?

Absolutely. We joke around that the only good compressor is one that has been turned off! Seriously, pneumatics people also need to know more about air compressors. This is why we have launched this initiative of bringing our pneumatic sales force together with compressor distributors who will represent our line of compressed air purification products.

What does SMC's Energy Conservation Group do?

Our vision of energy conservation starts with understanding the point-of-use pneumatic applications. SMC's Energy Conservation Group consists of a team of compressed air auditors with extensive experience in pneumatics and air compressors. This is unique in that most auditors only understand air compressors — or they just understand pneumatics. SMC's Energy Conservation Group will visit customers with the goal being to first understand how and why air is being used and then to act upon the most intelligent decisions.

SMC's VBA Booster Regulator can double plant air pressure at points of use

How can you save energy by understanding pneumatics on OEM equipment?

SMC is a major supplier of these pneumatic components to the OEM. We offer 11,000 products which can be configured into over a half million variations. The OEM will choose a pneumatic cylinder with the appropriate force (based upon a specific air pressure) to optimally perform the task in the machine. So far, so good.

SMC: MANAGING ENERGY AND DEW POINT IN PNEUMATIC SYSTEMS

Factories operate many pieces of OEM equipment with these pneumatic circuits. We continually find situations where a factory will have forty (40) machines with cylinders, which require 60-psig compressed air pressure. They will then have two (2) machines which each have two cylinders that require 105-psig air pressure. These two machines are then causing the entire area to be supplied with compressed air at 110 psig.

The SMC Energy Conservation Group will take this situation and affect the following changes:

- Replace the cylinders which require 105 psig with larger cylinders which can operate at 60 psig
- Review the air compressor and air storage strategy to lower the air pressure supply to only 65 psig air in this area of the factory
- Reducing pressure by 40 psig in this area will reduce compressed air energy costs by 20%

The audit discovered that the cylinders were moving so fast that the compressed air temperature on the retract stroke (exhaust stroke) was falling to 23° F — well below the dew point of 35° F.

How else can you solve this situation?

If we cannot up-size the cylinder, we will consider using a booster-regulator in low-flow situations. Some facilities may have a dedicated air compressor for a single application. The compressor may be short cycling (loading and unloading frequently). We can boost the plant air pressure with the booster-regulator product and turn off this air compressor.

A booster regulator is a pneumatic cylinder with a piston which can double the air pressure. It does consume a high percentage of compressed air so it is only recommended in low flow applications where an entire area is being forced to operate at higher pressures due to this one application.

SMC 2-Port Solenoid Valve for Process Applications

What unique dew point problems are encountered by pneumatics?

We just finished auditing a major pharmaceutical facility in Puerto Rico. They are paying the utility company 22 cents per kwh for their compressed air system! The compressor room dryers were functioning perfectly yet there was an identified dew point problem with the pneumatic micro cylinders in some machines. No one could figure out why moisture was appearing.

What we discovered was that the cylinders were moving so fast that the compressed air temperature on the retract stroke (exhaust stroke) was falling to 23° F — well below the dew point of 35° F. The expansion of the air was so quick that the temperature would plummet (adiabatic expansion). The valve is so close to the cylinder that there isn't enough air to evacuate the moisture. The solution was to install some point-of-use membrane air dryers.

Where do compressed air leaks exist most commonly with pneumatic components?

Fittings, pneumatic circuitry tubes, couplers and FRLs are the most common sites for leaks. Our team has probably tagged 20,000 leaks just over the past year. FRLs must really be examined in every facility for the following:

1. The "F" Filter often has a leak with the automatic condensate drain at the bottom of the bowl. It may be stuck in the open position and will just be venting air to atmosphere. We see this in roughly 30% of installations.
2. The "R" Regulator will leak through a ruptured or deformed diaphragm. Diaphragms get ruptured 50% of the time through normal wear and tear and 50% of the time because synthetic oils and moisture will attack the material and cause it to fail. We definitely see healthier regulator diaphragms in oil-free systems.
3. The "L" Lubricator is usually in good shape.

We test FRLs as part of our audits. They are usually over-pressurized. We usually see a 10-psi differential pressure as an average on FRLs. With oil-free systems, we tend to see a 7-psi differential or on the FRL because the filters are normally cleaner and fittings don't leak as much. BP

Thank you, SMC, for your insights.

For more information on SMC's pure air product line, please contact Kelly Ingoldsby, SMC, tel: 386-846-4638, email: kingoldsby@smcusa.com, www.smcusa.com Or your nearest SMC office at 1-800-SMC-SMC1 (1-800-762-7621)

For more information on the SMC energy conservation team, please contact Mike Nagy, SMC, tel: 216-406-5698, email: mnagy@smcusa.com, www.smcusa.com Or your nearest SMC office at 1-800-SMC-SMC1 (1-800-762-7621)

SMC's Modular Filter/Regulator/ Lubricator Series

UTILITY GRADE COMPRESSED AIR SYSTEMS

By:
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Abstract

Industrial companies are continually faced with increasing competition, rising costs and tighter margins. As manufacturers identify ways to reduce costs and improve their bottom line, one significant opportunity that is often overlooked is the compressed air system. Compressed air systems are typically the largest users of electricity in a manufacturing facility and need to be managed accordingly. Companies converting to a utility grade compressed air system have benefited greatly from increased production uptime while reducing energy and maintenance cost.

Introduction

Just as utility companies are committed to providing reliable, quality power, manufacturers need the same 24/7 "utility grade" compressed air system reliability and quality. *Utility grade systems provide compressed air at a constant demand side pressure and optimize energy efficiency under varying loads and situations.* Unfortunately, most manufacturers have not focused on this cost reduction opportunity. They tend to run their system in a manner as to keep the "phone from ringing."

Because compressed air systems are considered a "cost of doing business," their operational cost is typically not known. This specific overhead cost is rarely identified as a line item in production, maintenance or utility budgets. Therefore, inefficient use and waste of compressed air is common since operators, supervisors and directors are not accountable for these costs in their budgets.

Quality and reliable compressed air systems are a function of system design, operational parameters and maintenance. *With a utility grade compressed air system, operational costs can be* ***reduced by 50%.***

Typical Compressed Air System

Typical compressed air systems evolve as industrial companies expand their operations. Capital constraints, lack of system expertise, sales influences, change of manpower and inadequate procedures may lead to the following issues:

- Multiple Component Manufacturers
  - Increased maintenance cost
  - Increased parts inventory
  - Difficult to standardize operating and maintenance procedures
  - Non-integrated control systems
  - Sizeable knowledge base required
- Undersized Distribution Piping
  - Variability in pressure and flow rate
  - Increased operating pressure
- Poor Maintenance Practices
  - Increased downtime
  - Not distributing runtime uniformly over available compressors
- Inadequate Storage, Inappropriate Usage and Air Leaks:
  - Pressure fluctuations
  - Additional compressors required
- No Central Control and Monitoring System:
  - Inability to monitor, track and optimize system operations and performance
  - Inability to accurately assign budget responsibility
- No Pressure/Flow Controller
  - Inability to decouple supply from demand

These issues coupled with production demands result in costly, inefficient and unreliable systems.

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Utility and Energy Engineers, Utility Providers, and Compressed Air Auditors share techniques on how to audit the "demand-side" of a system — including the **Pneumatic Circuits** on machines. This application knowledge allows the Magazine to recommend "**Best Practices**" for the "supply-side" of the system. For this reason we feature **air compressor, air treatment, measurement & management, pneumatics, compressor cooling, blower and vacuum** technologies as they relate to the requirements of the monthly **Focus Industry**.

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UTILITY GRADE COMPRESSED AIR SYSTEMS

Plant managers demand production uptime without regard for compressed air operational cost. This leads to maintenance personnel responding to problems from the production floor by adding compressors, modify piping and/or increasing compressed air pressure to keep their "customers" happy. Unfortunately, this "band-aid" approach unnecessarily drives up costs by not addressing root causes. These changes become part of the system adding complexity and inefficiency.

A common practice is to turn on backup compressors when a pressure situation occurs on the production floor. These compressors often remain on even after the event is over, driving compressors to operate in a "modulated" mode. Air compressors are most efficient at 100% of full load or completely turned off. Air compressors are typically operated in a "modulated" mode (<100%). For example, a compressor running at 60% of its full load capacity may use 90% of its full load energy. Unloaded or idling compressors use 25% of their full load energy. This is an inefficient way to operate the system because of the amount of energy required to run in a modulated environment.

Some facility personnel will modify an existing compressor by adding a variable speed/frequency drive (VSD/VFD) and operate this machine in a trim configuration to address the issue of modulation. Operating in a trim mode attempts to balance output with energy input. Unfortunately, without an overall control scheme, the remaining operating compressors run partially loaded (modulated mode) and continue to waste energy.

Having multiple component manufacturers, maintenance and control personnel are at a disadvantage. This lack of standardization challenges maintenance staffs because they lack the extensive knowledge and expertise required to service and monitor the different machines. Without a central control system, it is necessary to rely on the individual controls of each machine. Machines from different manufacturers usually cannot communicate in an integrated, synchronous manner. This causes each machine to run independent of the other, leading to further significant pressure fluctuations in the distribution system and energy waste.

Characteristics of a Utility Grade Compressed Air System

The characteristics of a utility grade compressed air system are:

Decoupled Supply from Demand

- Pressure-Flow Controller and Adequate Storage
  - Allows compressors to operate and maintain storage pressure within a control band, independent of demand requirements
  - Ensures that distribution headers remain at constant pressure regardless of demand
  - Allows the efficient sequencing of base/trim load compressors

Supply Side

- Air Compressors
  - Trim unit(s) with VFD(s) modulate to ensure base units remain completely on or off
- Filtration
  - Pre-dryer filtration ensures impurities are removed prior to air entering the dryer
  - Post-dryer filtration ensures impurities are removed prior to air entering the distribution system
- Dryer
  - Adequately sized to ensure required dew point and flow rate
- Storage
  - Adequately sized to allow control system to efficiently operate the compressor(s)
  - Allows pressure-flow controller to stabilize pressure under high load conditions
  - Allows system to ride through demand events minimizing the running of additional base load compressors
- Auto-Drain and Oil Recovery
  - Reduces air loss
  - Protects environment
- Heat Recovery
  - Per needs of the facility
  - Saves heating costs
- Control and Monitoring System
  - Ensures reliability, efficiency and cost savings by optimizing the operation of compressors
  - May also be used for heat recovery, dryer operation, data collection and allocation of operating costs

Demand Side

- Loop-Configured Distribution System
  - Stabilizes pressure
  - Provides adequate flow/volume
  - Zoned for service
  - Designed not to exceed flow limits
- Distribution System Adequately Sized
  - Reduces pressure drops
  - Allows for future growth
- Point-of-Use Storage
  - Per needs of facility
- Identify and Eliminate Inappropriate Use
  - Reduces inefficient use of a costly resource
- Identify and Eliminate Air Leaks
  - Reduce compressor operation and costs
  - Prevent purchasing additional compressors and components
- Pressure and Flow Monitoring
  - Determines if system is operating optimally
  - Assists in allocation of operating costs to the end user

Maintenance

- Preventative maintenance program
- Adding or modifying system using predetermined policies and procedures
- Training and Best Practices
- Air leak program

Standardization

- Establish purchasing guidelines for compressed air supply and demand equipment
- Operating pressure for demand equipment

Reliability

- Backup equipment based on risk tolerance
  - Additional compressor/dryer for maintenance or failure of largest compressor/dryer
  - Power loss backup plan
  - Adequate inventory of critical components (filters, drains, belts, etc.)
  - Redundancy of control system with appropriate fail-safes

A savings of $802,000 per year resulted in a total system payback of less than 2 years.

Achieving a Utility Grade System

Knowing the baseline of the current compressed air system and the total cost of operation, companies can determine the path for achieving a utility grade compressed air system. The process for creating a utility grade compressed air system begins with establishing a baseline of the existing compressed air system and operating requirements. Baseline parameters should include:

- Equipment inventory
- Schematic of air system
- Inventory air needs (flow rates)
- Demand-side pressure requirements
- Storage capacity
- Dew points
- Record kW, cfm, pressure vs. time
- Inappropriate applications
- Amount of leaks
- Power requirements (cfm/kW)
- Facility limitations (floor space, power, ventilation, etc.)
- Monitor/control capabilities
- Anticipated production growth

UTILITY GRADE COMPRESSED AIR SYSTEMS

Collecting and analyzing the baseline data provides an understanding of the current system. Potential challenges encountered when creating a utility grade system are compressor manufacturers, risk management, project scope, compressed air leaks and determining operating cost.

Compressor Manufacturers

Over the years, compressor manufacturers have developed system strategies, which may or may not match the needs and requirements of your utility grade system. Based on experience, it can be very beneficial to use one manufacturer that can supply all major compressed air (supply side) components including integrated controls. While this can be challenging, the benefits can be seen in operation, maintenance, warranty, integration, purchasing power and technical support. In lieu of a single source for all components, another option is to negotiate a comprehensive warranty covering all components. Both of these options will help eliminate "finger pointing" when problems arise. Many compressed air systems are designed by the compressor manufacturer as part of the sales process. While they have a very strong knowledge of *their* compressed air components, they tend to make *their* equipment match your needs and requirements. This may result in a sub-optimized system.

Risk Management

This system uses rotating machinery and therefore, it will fail! One of the key questions is, "How much or how long can production be interrupted?" If production demands zero downtime (i.e. zero observed failure), this can be designed into the system but it will require a tremendous cost. In other words, "How much risk is tolerable?" Some options to reduce risk may include backup compressors, inventory of critical spare parts, redundant control scheme, alternate electrical power, universal power supply backup, strategic bypass of major components, on-site factory response time and a knowledgeable maintenance staff. Eliminating or reducing risk equates to higher system costs.

Project Scope

The biggest factor in developing the project scope is determining the decision makers and system owners. It is necessary to understand their goals and objectives as they may be based on perceptions and not facts. An assembly line decision maker may state the process requires 120 psi based on events that happened years ago. Another classic response may be, "that's the way it's always been." When in fact, the process only requires a constant pressure of 90 psi. As a rule of thumb, reducing overall operating pressure by 2 psi saves 1% in energy costs. The facts and information gathered in the baseline analysis will aid the decision makers in separating process needs from personal wants. Other examples may include facility limitations, future growth, air quality, dew points and return on investment.

Compressed Air Leaks

Typical leaks can account for upward of 30% of the overall compressor output. How much cost can be eliminated by just fixing half of the leaks? Knowing your leak rate and developing an aggressive leak detection program can prevent purchasing an unnecessary compressor thereby reducing overall project cost. A utility grade leak detection system strives to achieve a maximum of 5% of total system horsepower for leaks.

Determining Operating Cost

What is the true energy cost of running the current system? This is not an easy question to answer. It may require data logging along with reviewing and understanding utility rates and maintenance records. Typical compressed air performance is ~ 2.7 cfm/kW where utility grade system is ~ 5.5 cfm/kW (cfm = cubic feet per minute). This equates to a 50% reduction in operating costs.

Estimating energy cost: One horsepower (hp) compressor motor running 24/7, 365 days/year, at $0.10/kWh costs $650/yr to operate. From this, a simple rule of thumb is: 1 hp ≈ $650/yr. (Note: This does not include costs associated with support systems, depreciation, taxes, and maintenance.) Therefore, for each 1,000 hp of compressors in operation equates to an electrical cost of $650,000/yr. Recall a utility grade compressed air system can achieve 50% reduction in operating cost. *Is cutting energy cost by $325,000 and significantly increasing reliability and quality while reducing maintenance by achieving a utility grade compressed air system worth the investment?*

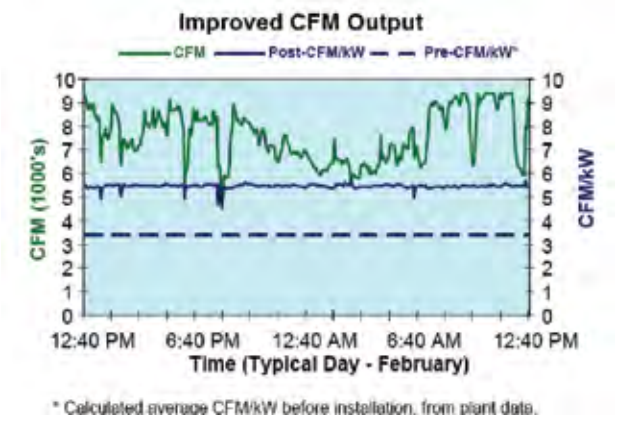
Case Study

Recently, a major US manufacturer installed a utility grade central compressed air system — perhaps one of the most energy-efficient systems in the country, if not the world. Their original compressed air system was similar to many other large industrial systems comprised of remote compressors by various manufacturers serving multiple points in a fragmented distribution system. The system included 24 compressors totaling 4,200 hp in seven different facilities located on a common campus. There was little or no control between compressors, insufficient system response, inadequate storage and significant leakage. These factors caused inadequate capacity, slow system response and pressure fluctuations during peak

demand. Based on age, lack of standardization, limited controls, inadequate storage, fragmented distribution, high maintenance and operating cost, the company concluded the cost-effective option was to install a new system.

The new system consists of five 300 hp two-stage, air-cooled, rotary compressors for base load; two 200 hp VFD compressors for trim load; and a 30,000-gallon storage tank. These seven compressors feed three 4,000 cfm pre-filters, three dual-circuit refrigerated dryers, three after filters, automated pressure-flow controller and finally feeds into the distribution system. The supply side components are controlled and optimized by a Web-based automated rate-of-change control system.

The original compressed air system performance was 3.5 cfm/kW. The utility grade system average is 5.5 cfm/kW, equating to an efficiency improvement of 57%. The system saves 1,079 kW of demand and 9.2 million kilowatt-hours (kWh) of electricity annually. The system produced consistent air pressure, +/- 0.3 psi, delivered throughout the distribution system. The new system met or exceeded all expectations. The graph below shows the load following characteristic of the new system.



In addition, flow meters were installed in each plant and connected to an energy management system allowing the facilities group to monitor, trend and allocate cost to each department based on their actual compressed air usage. The new system also included heat recovery units on all seven new compressors. The recovered heat displaces 135,000 therms of natural gas that the company would otherwise have to purchase for space heating — enough gas to heat 150 homes. Implementing an aggressive air leak detection program, the company eliminated 1,057 cfm in non-use air loss (leaks).

The total annual savings for the new system were:

- Electricity $541,000
- Heat Recovery $81,000
- Water Savings $60,000
- Parts/Inventory $100,000
- Maintenance $120,000

The total cost for the system was $1,850,000 ($300,000 funded by Wisconsin Focus on Energy grants). A savings of $802,000 per year resulted in a total system payback of less than 2 years.

Summary

Companies are constantly searching for ways to cut cost in order to stay competitive in a world market. A major opportunity that is often overlooked is their compressed air system. A utility grade compressed air system provides reliable 24/7 operations, improved air quality, constant pressure and reduced maintenance cost while optimizing energy efficiency regardless of production demand. A utility grade compressed air system has the potential to reduce overall costs by upwards of 50% when compared to the typical compressed air system.

About the Authors

Jerry Eaton, LaMonte Wilder and Richard Feustel are founding principals of Masters' Academy with over 75 years of experience in energy engineering and facility management. They have designed, engineered, installed and commissioned over 165 major projects for Fortune 500 companies, nationally and internationally. Masters Academy, LLC, located in Oakfield, Wisconsin specializes in consulting, training and project management. The authors can be reached at www.mastersacademy.biz or 800-390-4366. BP

REAL WORLD BEST PRACTICES

EVALUATION GUIDELINES FOR TWO-STAGE, LUBRICANT-FREE ROTARY SCREW AND MULTI-STAGE (3) CENTRIFUGAL AIR COMPRESSORS

(Continued from pg. 31)

Centrifugals

Within the compressor area there are no touching parts in a centrifugal. As long as the entering air is kept clean and the intercooler drains clear, there is no reason for a scheduled "Air End" replacement or overhaul. Machine performance can be easily monitored to assess current performance versus original performance and thus evaluate wear. It is not unusual for the centrifugal to run 10 years or more without any work in the "air end". Many full-service warranty programs recommend a 5-year scheduled cleaning of the impellers, diffusers and intercooler. Wear will occur with inlet debris and "dirt" buildup will affect the aerodynamic performance.

Basic Packaging

Oil-free two-stage rotary screws are sold as basic standard packages. They can be selected based on volume and pressure desired. The capacity control system, when correctly installed with appropriate effective storage, is very versatile and will perform well under almost any operating requirement from base load to "trim."

Dynamic centrifugal compressors are sold as more of an engineered product. To correctly apply these compressors, more solid information is needed on installation data, such as:

- Normal ambient pressure, temperatures, relative humidity
- Expected flow demand over all 3 shifts and weekends
- Ambient air make-up and/or condition
- Cooling water condition temperature etc.
- Lowest effective pressure required

Similar data is also required to correctly apply and install on oil-free two-stage rotary screw but usually it just has to fit within predetermined maximum and minimum limitations.

Proper selection and impeller design to the operating conditions has direct impact on performance and operation. Data acquisition must be accurate and analyzed by knowledgeable personnel to optimize the installation opportunities and more important avoid operational problems. For example:

- Be sure the highest operating temperatures are considered. Being too low on this could preclude "making full pressure" in hot weather.
- Be sure the coldest operating temperatures are considered. Being too high on this could cause a motor overload or cut back too much airflow during colder weather.

Summary

When selecting rotating air compressors for future "oil-free" applications, the following best practices guidelines based primarily on energy efficiency should apply. All selections should be investigated thoroughly as to operating costs, projected or guaranteed maintenance/overhaul costs, load profile and installed first cost, etc.

- **Below 1,500 cfm/90–135 psig**
  First Choice: two-stage oil-free rotary screw, exceptions: Base loaded applications may fit centrifugal
- **1,500 cfm to 2,500 cfm/90–135 psig**
  Somewhere between 1,500/2,500 cfm flow range, the specific power advantage shifts to a well designed three-stage centrifugal over the oil-free two-stage rotary screw. This is the gray area of selection and other selection criteria will be needed to make the optimum selection.
- **2,500 cfm to 3,000 cfm/90–135 psig**
  This is the 500 to 600 hp class range and the specific power advantage is to the three-stage centrifugal, which would make it the first machine of choice *unless* it was to be a dedicated *trim unit* and the load demand could not be fitted into the turndown the majority of the operating hours.
- **3,000 cfm and up/90–135 psig**
  In these sizes, the specific power advantage is to the three-stage centrifugal and improves as the size increases. This full-load, energy-efficiency advantage should be evaluated with all the other critical considerations.

Other Key Considerations:

Plant personnel training and capabilities — Centrifugals are a little more sensitive and require proper maintenance and knowledgeable operators. A plant can supply this either locally or remotely through outside contractors.

Plants that have less intense maintenance, suspect water, hostile operating environment, etc. would probably be better off with an oil-free rotary screw.

Part Load Performance Capacity Controls

The standard capacity control on the two-stage oil free rotary screw is the two-step or full-load and no-load control.

With this control, the compressor load and unload set points are used to activate a pressure that either opens or closes the inlet valve, which allows the unit to run fully loaded or fully unloaded (some bypass air

goes through the unit) over the full operating band which is usually 10 psig. This is very energy efficient throughout the total operating range. Full idle is usually 15–20% of normal input full load power.

This creates some application characteristics that should be addressed in all installations:

- Backpressure from small piping, high turbulent fittings and connecting small filters, etc., must be minimized to allow enough effective storage to avoid "short cycling"
- When installed in the same system with modulating controls, such as a centrifugal compressor or variable speed drive rotary screw, the load in point of the two-step control must be above the set point of either type unit because the modulating and VSD controls react immediately to any pressure above their set point and back down into part load
- Variable speed drive is available on two-stage oil-free rotary screws and in addition to enhancing efficiency compared to fixed speed over **part** of its load band, it also creates a smooth modulating flow rather than full load/no load

Centrifugal Compressors — Inlet Butterfly Valve (IBV) (and Bypass/Unloading Valve):

When the IBV closes with constant pressure regulation in reaction to a sensed rise in system pressure over the full-load set point (indicating an oversupply), the pressure on the downstream side of the throttle valve falls. This is the actual pressure entering the impeller/diffuser. As the pressure drop across the IBV increases, the density of the entering air decreases, resulting in a lower "mass flow" in relation to icfm (inlet/ambient cubic feet per minute). There is a resultant decrease in power as the mass flow falls — but not in the same proportion. The specific power — scfm of compressed air produced per kW (input kW) — deteriorates.

Additionally, as the butterfly valve reaches the end of its closure, it will cause some increased turbulence further reducing the effective flow into the impeller.

At "full idle", all manufacturers close or partially close, the inlet butterfly valve and open the "inlet bypass valve" or "unloader valve". The compressor is now theoretically flowing just enough air through the stages for cooling and to avoid vacuum and minimize the power draw on the unit.

Regardless of the type of butterfly valve and bypass or unloader valve, the inlet butterfly valve is used in several distinct types of controls:

Constant pressure or base load: This is designed to control the discharge at a constant point and matches the compressor output to the demand. As the pressure rises, the bypass valve opens, venting excess air to atmosphere. *There is no reduction in power.* This is a base load control only and basically obsolete today in industrial applications if they are to experience any varying load.

Inlet throttle or modulation control: The inlet butterfly is controlled to permit the compressor to operate on its characteristic curve when the demand for air is less than the compressor's rated capacity. As the inlet valve closes and the rising pressure approaches surge point, the bypass valve begins to open slowly, bleeding off excess air to match demand. Once the bypass valve is fully open there is no further reduction in power.

Full unload or auto dual control: At a predetermined discharge pressure (before the surge point), the compressor is unloaded by:

1. Closing the inlet valve
2. Opening the bypass or unloading valve

At full unload; the power draw will usually be from 25–35% for a "nominal" 20%.

INLET GUIDE VANES (IGV):

Inlet guide vanes are usually mounted on the inlet to the first stage in industrial air compressors but may be installed on each stage in larger process units.

The volume flow can be *increased* or *decreased* within specific limits at a constant pressure. Inlet guide vanes vary the flow and produce a swirl in the inlet airflow usually in the direction of the impeller rotation. At signals from the controller, the vanes rotate to any position from parallel to the air stream to fully closed as these vanes produce the swirl, which induces rotation of the air in the same direction as the impeller. The effect is to reduce the work required to produce the same air discharge condition. The net result is lowering input power requirements and improving specific power (cfm/kW) at lower flow conditions. IGV's can also increase the flow up to 20% when in the "over throttle" position (flow against rotation) at the same pressure compared to an inlet butterfly valve. This increased flow will require a commensurate amount of additional horsepower.

REAL WORLD BEST PRACTICES

EVALUATION GUIDELINES FOR TWO-STAGE, LUBRICANT-FREE ROTARY SCREW AND MULTI-STAGE (3) CENTRIFUGAL AIR COMPRESSORS

Performance of Inlet guide vanes:

There is no question that inlet guide vanes lower the power required to produce a lower-than design flow at the same pressures compared to an inlet butterfly valve. Simply put, they are a more efficient "turn down" control than the IBV — usually about 4–6%.

Typical three-stage 2,200-scfm centrifugal performance data full to turndown (70%) and same on comparable sized two-stage lubricant free, rotary screw, two-step control, fixed speed.

Typical Part Load Performance Comparison

TYPE	CENTRIFUGAL		2-STAGE ROTARY SCREW	
Control	IGV		OL/OL	
SCFM full load	2,200 scfm		216 scfm (2218 scfm*)	
Turndown Flow	1,550 scfm		N/A	
FL Pressure	110 psig		110 psig	
kW @ 110 psig full load	386 kW		383.5 kW (estimated) (466 bhp)	
Cfm/kW/100 psig	5.71 cfm/kW		5.64 cfm/kW	
kW @ 90% load	344 kW	1980 scfm 5.75 cfm/kW	352.82 kW	1947 scfm 5.52 cfm/kW
kW @ 80% load	317 kW	1760 scfm 5.65 cfm/kW	322 kW	1731 scfm 5.37 cfm/kW
kW @ 70% load	288 kW	1550 scfm 5.38 cfm/kW	287.6 kW	1515 scfm 5.27 cfm/kW
kW @ 60% load	↑ End of turndown Constant 288 kW at lower flows to production ↓		256.9 kW	1298 scfm 5.05 cfm/kW
kW @ 50% load			230.01 kW	1082 scfm 4.7 cfm/kW
kW @ 40% load			199.4 kW	8.56 scfm 4.34 cfm/kW
kW @ 30% load			168.7 kW	649 scfm 3.85 cfm/kW
kW @ 20% load			134.2 kW	433 scfm 3.23 cfm/kW
Annual Electrical Cost $/cfm full load	$61.36 cfm/year		$62.10 cfm/year	
Total Estimated Annual Electrical Cost @ full load	$135,254/year		$134,378/year	

For more information contact Hank Van Ormer, tel: 740-862-4112, email: hankvanormer@aol.com, www.airpowerusainc.com BP

RESOURCES FOR ENERGY ENGINEERS

TRAINING CALENDAR

TITLE	SPONSOR	LOCATION	DATE	INFORMATION
Fundamentals of Compressed Air	Compressed Air Challenge®	Cleveland, OH	6/24/2008	www.compressedairchallenge.org
Advanced Management of Compressed Air	Compressed Air Challenge®	Irwindale, CA	6/24/2008	www.compressedairchallenge.org
Fundamentals of Compressed Air	Compressed Air Challenge®	Downey, CA	7/23/2008	www.compressedairchallenge.org
Humidity Measurement Training Seminar	Vaisala	Baltimore, MD Dallas, TX	6/11–12/2008 8/13/2008	www.vaisala.com/seminar
Compressed Air Management	Power Supply Industries	Fenton, MO	8/19/2008	www.psiind.com
Humidity Measurement Training Seminar	Vaisala	Boston, MA	9/8–11/2008	www.vaisala.com/seminar
Best Practices in Compressed Air	World Energy Engineering Conf.	Washington D.C.	10/2/2008	www.energycongress.com
Humidity Measurement Training Seminar	Vaisala	Toronto, ON	10/8/2008	www.vaisala.com/seminar
Compressed Air Management	Power Supply Industries	Fenton, MO	11/4/2008	www.psiind.com
Humidity Measurement Training Seminar	Vaisala	Chicago, IL	11/5–6/2008	www.vaisala.com/seminar

Editor's Note: If you conduct compressed air system training and would like to post it in this area, please email your information to rod@airbestpractices.com

PRODUCT PICKS

New Blower

Tuthill announced the Qube, featuring the new Qx blower. It is the perfect quiet, low-cost, quick delivery solution for pneumatic conveying. Benefits include high efficiency with low noise (< 75 dBA); up to 18 psi; a compact footprint; and a powder coated steel enclosure (24 dBA attenuation). Additional features include integral check valve, discharge from back and discharge flexible connector.

Tuthill Vacuum & Blower Systems
Howard DeCelis
Tuthill Vacuum & Blower Systems
1-800-825-6937
hdeCelis@tuthill.com
http://vacuum.tuthill.com

RESOURCES FOR ENERGY ENGINEERS

PRODUCT PICKS

New Dew Point Sensor to -112° F

The Vaisala DRYCAP® Dew Point Transmitter DMT152 utilizes a new, ground-breaking polymer sensor technology that combines the proven stability and durability of the Vaisala's existing thin-film polymer DRYCAP® sensor with an expanded range down to -112° F dew points. Before the launch of this new technology, polymer sensors could only measure dew point temperatures as low as -76° F, which precluded their use in very dry gasses found in Class I compressed air systems or in some plastics drying systems. Polymer sensors are well known for their ability to withstand condensation and to recover from liquid water exposure. Until the launch of the DRYCAP® DMT152 technology, these benefits were unattainable in the very dry measurement ranges.

The DMT152 dew point transmitter utilizes the latest generation of Vaisala DRYCAP® sensor technology which relies on the patented, auto-calibration feature providing end users both dry end accuracy and durability. The auto-calibration function also significantly improves wet to dry response time to just minutes instead of hours or days. Additionally, the DMT152 mechanics have been designed to withstand harsh environments that require protection against dust, dirt and splashed water.

Typical industries and applications where this technology can be applied include desiccant air dryers, glove boxes and other dry chamber applications, SF6 gas in high-voltage switchgears and any inert gases where measuring very low water vapor content is required. The Vaisala DRYCAP® DMT152 comes with NIST traceable calibration certificate and can be delivered in less than a week.

Vaisala
(888)-VAISALA
instruments@vaisala.com
www.vaisala.com/DMT152

Free Air System Training CD

Kaeser is offering a FREE interactive Air System Maintenance CD. This training tool details common maintenance functions for rotary screw compressors, refrigerated and desiccant dryers, filters and drains.

This CD is for both the end users and service technicians alike. Its interactive nature is designed to be user-friendly and easy to navigate. Using instructional video, voice over and graphics, it illustrates the steps necessary for routine maintenance and keeping air systems in top operating condition. Our Air System Maintenance CD is also enhanced by helpful Web site links for many accessory products and a copy of Kaeser's popular Compressed Air System Installation Guide.

This CD is available free of charge in English or Spanish.

Kaeser
(800) 777-7873
www.kaeser.com

OIL CONTROL Monitoring System

The BEKO oil monitoring system allows permanent oil-content monitoring of compressed air. The quality of compressed air can be monitored online for the very first time by measuring the residual oil content. Measurement is carried out by means of an ion-exchange method. The sensitivity of the sensor guarantees early detection of an increasing oil content, resulting, for example, from defective filters. This helps to successfully avoid consequential damage to machines and products.

Beko
(704) 663-6621
beko@bekousa.com
www.bekousa.com

New Pneumatic Cylinders

Bimba Manufacturing announced the addition of the EFP MultiPosition and EFQ MultiForce cylinders to the EF product line.

The EFP Extruded Flat MultiPosition cylinder is a double–acting, single-end rod cylinder that provides three positions in one cylinder package. This unit is designed to help simplify machine changeovers and save costs. By utilizing the existing EF footprint, this two-piston design saves space and eliminates the need for an additional cylinder.

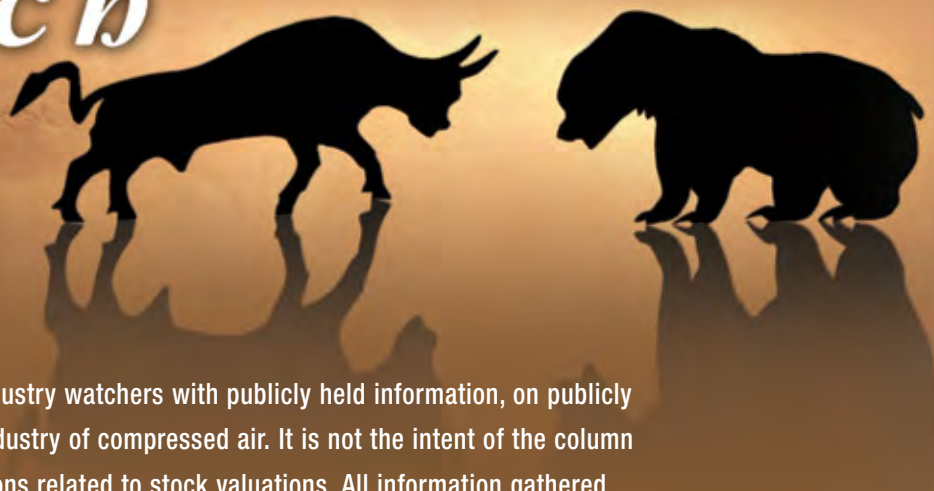
The EFQ Extruded Flat MultiForce cylinder is a double-acting, single-end rod cylinder that doubles the resultant force on extension. This cylinder features a two-piston design that eliminates the need for higher-pressure systems or unique configurations. And, to save air volume and operating costs, only one piston lis pressurized on the return stroke.

Both cylinders share the same popular benefits of the EF product line, including PTFE impregnated hard anodized body for superior wear resistance and seal life. The EFP and EFQ are both easily interchangeable to other compact extruded cylinders of the same bore size and can easily connect and operate to an application's pneumatic logic.

Bimba
(800) 323-5095
www.bimba.com

Wall Street Watch

BY COMPRESSED AIR BEST PRACTICES



The intent of this column is to provide industry watchers with publicly held information, on publicly held companies, involved with the sub-industry of compressed air. It is not the intent of the column to provide any opinions or recommendations related to stock valuations. All information gathered in this column was on May 16, 2008.

Hoffman Estates, IL, April 22, 2008 — Bosch Rexroth AG, parent company of Bosch Rexroth Corporation in North America — (www.boschrexroth-us.com), announces $7.4 billion (5.4 billion Euros) in sales for 2007 — up 8.8% from the previous year. During the last fiscal year, the drive and control company invested $517 million (377 million Euros) and increased the number of employees around the world by approximately 3,100, bringing the total number to nearly 33,000. The company is also expecting continued strong growth in the mobile applications, industrial automation and renewable energy sectors in 2008.

Despite the uncertain economic situation, 2007 sales in the Americas region grew by 3.1% in dollars. Unfortunately, because of the changing currency rate, the company recorded a 5.5% decline in Euros.

"The sales department wanted to celebrate because we recorded an increase in dollar sales," said Berend Bracht, president and CEO of Bosch Rexroth Corporation. "But the board in Germany was looking at a decline in sales because of the exchange rates."

The U.S. will continue to be an important automation technology market for Bosch Rexroth, a supplier to practically every branch of the plant automation and machinery OEM business. The strong sales, Bracht said, can be attributed in particular to industrial hydraulics and large gear systems for wind farms.

Globally, Bracht noted, "One of the key drivers of our growth comes from the extremely positive economic development in Central and Eastern Europe." Sales for Europe were on a growth track during 2007. Excluding Germany, sales were up by more than 14%. In Germany, Bosch Rexroth expanded sales by 8.3% in 2007. It also achieved double-digit sales increases in China and India. "We're seeing strong development in India, resembling the growth from China a few years ago — the potential is similar," said Bracht, highlighting the importance of this growth region.

3,100 New Jobs Worldwide

The high demand also had a positive effect on the number of jobs created. In 2007, Bosch Rexroth's global workforce grew by 3,150 employees, with jobs added in Germany, the Americas, Central and Eastern Europe, as well as in Asia.

WALL STREET WATCH

Investments in Additional Capacities

With investments in the range of $517 million (377 million Euros), Bosch Rexroth has significantly increased its worldwide production capacity. Investment for 2007 stood at 7% of sales, and the company raised the investment rate once more. Between 2002 and 2006, the investment rate averaged just fewer than 5% of sales, which was already above average for the industry. Bracht also indicated more capacity expansion is planned for 2008. In addition to establishing and expanding its production facilities in Central and Eastern Europe, Bosch Rexroth is also bolstering its capacities in Germany and the U.S.

Strong Growth in Renewable Energies

With production capacity increases for large gear systems, Bosch Rexroth, the automation partner for wind energy plant manufacturers, is preparing to meet the fast-growing demand for renewable energies coming especially from the U.S. and Asia. In its latest study, the Global Wind Energy Council, an association of worldwide wind energy organizations, predicts annual growth rates of more than 20% for the next few years.

Bosch Rexroth's 2007 sales also grew in the solar technology sector, where the company offers innovative installation and automation solutions for more cost-efficient series production of solar cells.

Innovations for Increasing Energy Efficiency

"As a complete drive and control technologies supplier, Bosch Rexroth has the unique application and engineering expertise for optimizing cross-technology systems," said Bracht. The company is combining its latest advancements in electrical drives and controls, hydraulics, pneumatics and mechatronics with sustainable energy-efficient system solutions.

He presented a positive outlook. "Order volumes appear healthy and we are expanding our capacities. Therefore, we are looking ahead to a double-digit percentage increase in sales for 2008," concluded Bracht.

Hamilton, Bermuda, April 30, 2008 — Ingersoll-Rand Company Limited (NYSE:IR), announced that total revenues increased by 9.5% and operating income increased by 18% for the first quarter of 2008 compared with the 2007 first quarter.

The company reported net earnings of $181.6 million, or diluted earnings per share (EPS) of $0.66, for the first quarter of 2008. First-quarter net earnings included $211.7 million, or EPS of $0.77 from continuing operations, as well as $30.1 million of cost, equal to EPS of $0.11, from discontinued operations. Discontinued operations represents the net earnings and retained costs of divested businesses and included $24.8 million of after-tax costs related to the sale of the compact equipment business in 2007 and $6.5 million of after-tax cost related to an adverse verdict in a product liability lawsuit in the first quarter of 2008.

Net earnings for the 2007 first quarter of $217.5 million, or EPS of $0.70, included EPS of $0.50 from continuing operations and EPS of $0.20 for discontinued operations.

"Our first-quarter 2008 performance continued to demonstrate the benefits of our transformed business portfolio, which is characterized by significantly improved product, market and geographic diversity, compared with our previous reliance on capital-intense, heavy machinery businesses," said Herbert L. Henkel, Chairman, President and Chief Executive Officer. "We are managing our businesses to offset downturns in the domestic market with strong revenue growth from international operations and recurring revenues. As we expected when we began our transformation in 2000, we are better positioned to withstand isolated market downturns, and our continuing focus on innovation, accelerated productivity gains and cost and expense reductions will sustain our ability to grow and deliver consistent financial results."

Additional Highlights for the 2008 First Quarter

Revenues: The company's revenues increased by 9.5% to $2,163.3 million compared with revenues of $1,976.2 million for the 2007 first quarter. Currency had a 4% favorable impact on year-over-year revenue gains. First-quarter U.S. revenues increased slightly, while revenues from international operations increased by approximately 21%.

Total recurring revenues, which include revenues from parts, service, rental and used equipment, increased by 13% compared with the first quarter of 2007, and accounted for 19% of total revenues.

Operating Income and Margin: Operating income increased by 18% to $247.0 million for the first quarter of 2008 compared with $208.6 million the first quarter of 2007. First-quarter operating margin also increased to 11.4% compared with 10.6% last year. Leverage on revenue growth, expense reduction, productivity actions and price increases were partially offset by unfavorable business and product mix and higher commodity costs.

First-quarter Business Review: The company classifies its businesses into three reportable segments based on industry and market focus: Climate Control Technologies, Industrial Technologies and Security Technologies.

Industrial Technologies is focused on providing solutions to enhance customers' industrial and energy efficiency and provides equipment and services for compressed air systems, tools, fluid power production and energy generation systems. Total revenues in the first quarter increased by approximately 11% to $743 million. Strength in industrial and process markets outside of North America and revenues from the aftermarket business continued to benefit the Air and Productivity Solutions business. Revenues in the Americas increased by about 4%, primarily due to strong recurring revenues. Air and Productivity Solutions revenues in Europe, Asia and India grew by approximately 30% compared with 2007.

2008 Outlook — Ingersoll-Rand Stand Alone "Many of Ingersoll Rand's major end markets continued to experience solid overall demand in the first quarter as weaker activity in North America was offset by strong performance overseas. Orders increased by approximately 6% compared with last year. Our backlog increased in all business segments and grew by 10% overall compared with the first quarter of 2007," said Henkel. "Based on our recent order pattern and a review of customer and channel activity, we continue to expect mid-single digit growth for the balance of 2008. Going forward, we expect flat performance in North America, moderating growth in Western Europe and continued brisk growth in the developing economies of Eastern Europe, Asia and Latin America. Consistent with this environment, we anticipate revenue growth of approximately 5% to 6% for full year 2008, including 2% related to currency. Operating margins are expected to increase in the range of 1.0 to 1.5 percentage points in 2008, based on higher volumes and improved cost productivity, to offset material cost inflation."

2008 Outlook-Second Quarter "We expect overall further softening of U.S. end market activity in the second quarter of 2008. As a result, we expect Ingersoll Rand's stand-alone second-quarter 2008 revenue growth of 5% to 6% compared with 2007." BP

MAY 16, 2008 PRICE PERFORMANCE	SYMBOL	LAST PRICE	1 MONTH	6 MONTHS	12 MONTHS
Parker-Hannifin	PH	$85.00	11.4%	8.5%	33.6%
Ingersoll Rand	IR	$45.85	-0.1%	-6.0%	-6.4%
Gardner Denver	GDI	$51.46	27.5%	60.0%	30.8%
United Technologies	UTX	$73.96	2.0%	-0.5%	8.0%
Donaldson	DCI	$46.53	11.7%	15.8%	26.2%
EnPro Industries	NPO	$38.57	4.4%	18.2%	-5.5%
SPX Corp	SPW	$126.74	13.0%	25.5%	58.3%

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JOB MARKET

Job Openings in the Compressed Air Industry

SALES POSITION

LAS VEGAS, NEVADA

As an authorized Master Distributor for Ingersoll-Rand Industrial Technologies products, Cate Industrial prides itself on finding and hiring the best talent there is to represent the products it offers. Currently we are seeking an experienced air system consultant for our southern Nevada and southern Utah area. This position is based out of our Las Vegas office. The prospective candidate will have a minimum of five (5) years successful outside sales experience with similar compressed air equipment. An energetic self-starter who can manage and organize his/her time effectively to produce the most results possible out of the area is a must. Computer skills, including Microsoft Office program proficiency, are required to be considered for this fast-paced opportunity.

The company will provide the following:

- Competitive commission-based compensation
- Company car
- Continuing job-related training

These items are available through the company:

- Health and dental insurance
- Life insurance
- 401k

To be considered for this position, please email your current resume, work history and references to: tmcbride@cateequipment.com.

Our company website is www.cateindustrial.com.

TECHNICAL SALESMAN

GRS Fluid Handling is working with a client who is a top manufacturer of compressed air products and equipment to search for a top technical salesman. This position will oversee sales for a Western Regional territory and be responsible for the total sales performance of their blower line.

Background Required

- Successful track record of selling blowers; Preferably positive displacement blowers
- A four-year degree, preferably a technical degree
- Ability to work autonomously, based in a home office
- Ability to travel a west coast territory as required

Why you would want this job?

- Company offers security
- Ability to work for a growing division of a well-established global manufacturer
- Future advancement and growth opportunities throughout the organization
- Very visible position, where someone's hard work will not go unnoticed

This position offers a chance to move into a highly visible role with distinct responsibilities and challenges. It offers the chance to work autonomously and grow a business segment. Our client is well respected with a great product and talented support staff.

For more information, please contact Joe Bertolami, GRS, tel. 440-684-6150 *3007, e-mail jbertolami@grsrecruiting.com; www.grsrecruiting.com

REGIONAL SALES MANAGERS

AIR COMPRESSORS 5-300HP

Industrial Compressor manufacturer is in process of expanding nationwide sales coverage and is now recruiting for qualified candidates to fill two new positions within the following geographic areas:

Opportunities

- In Southwest Region
- In Upper Midwest Region

Requirements

- Experience within the compressed air industry
- Travel a 4–5 state sales territory
- Ability to build and support industrial distributor network
- Ability to assist distributors with compressor applications
- Ability to sales train distributors on complete product line

Benefits

- Opportunity to work with a fast-growing company
- Several new product lines being launched in 2008
- Benefit package, 401K
- Company car, expense account
- Future advancement and growth opportunities

These positions also offer an opportunity to work within the framework of a leading world-class global compressor company and utilize available resources. New production equipment and ERP systems have been recently implemented to meet our rapid growth rate.

For immediate and confidential consideration, please send your resume to: humanresources@curtistoledo.com

World Energy Engineering Congress returns to nation's capital in 2008!

WORLD ENERGY ENGINEERING CONGRESS
WEEC 2008

Presented by: The Association of Energy Engineers
Hosted by: SAIC From Science to Solutions
Featuring: Green Street EXPO at NESC, Sponsored By ENERGY STAR

The key opportunity of the year for end users and decision-makers from business, industry, and government sectors to learn about the newest technologies, hear industry's leading experts, and network

The Association of Energy Engineers (AEE) is very pleased to bring the **WORLD ENERGY ENGINEERING CONGRESS (WEEC)** to Washington, DC for 2008—and to an extraordinary new venue—the Gaylord National Convention Center on the Potomac. Now in its 31st year, the **WEEC** is well-recognized as the most important energy event of national scope for end users and energy professionals in all areas of the energy field. It is the one truly comprehensive forum where you can fully assess the "big picture" – and see exactly how the economic and market forces, new technologies, regulatory developments and industry trends all merge to shape your critical decisions on your organization's energy and economic future.

The **WEEC** conference and expo target the complete spectrum of technologies and services of greatest importance to our delegates in attendance, including, but not limited to:

energy management • combined heat & power / cogeneration / distributed generation • lighting efficiency thermal storage and load management • integrated building automation • industrial energy strategies boilers and combustion controls • green & sustainable initiatives • geoexchange technologies renewable and alternative energy energy management • HVAC systems and controls energy services and project financing • solar and fuel cell technologies applications specific to federal energy management programs

WEEC's highly acclaimed **GreenStreet expo showcase**, introduced in 2007 and co-presented by the U.S. EPA's ENERGY STAR®, will again be a prominent part of the WEEC for 2008. Here you can examine firsthand the latest green / sustainable / environmentally friendly energy technologies now available for both new design and retrofit projects.

Government Energy Leaders

Department of Defense

GAO Accountability • Integrity • Reliability

NTIS U.S. Department of Commerce National Technical Information Services

Red Star Energy Leaders

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www.energycongress.com

Kaeser SFC compressors:
The product of a better idea.

In the drive to save energy costs by precisely matching *air production* to *air demand*, Kaeser's Sigma Frequency Control compressors are the most energy-efficient variable speed, single-stage compressors you can find. The competition simply can't compare in performance *or* quality.

Kaeser SFC compressors offer a wider range of operation, from 20% partial load to 100% full load. Plus, our oversized *Sigma Profile*™ airend rotates at lower speeds for greater output while consuming less energy.

With near-unity power factory, built-in phase protection, and superior pressure control, our SFCs are built for a lifetime! And, since we offer them in the widest range of sizes – most with integral dryer options – we have just the right model for your needs. Of course, the best way to appreciate the superior engineering of Kaeser SFC compressors is to see them in operation, so call **866-516-6888** to find one near you.

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