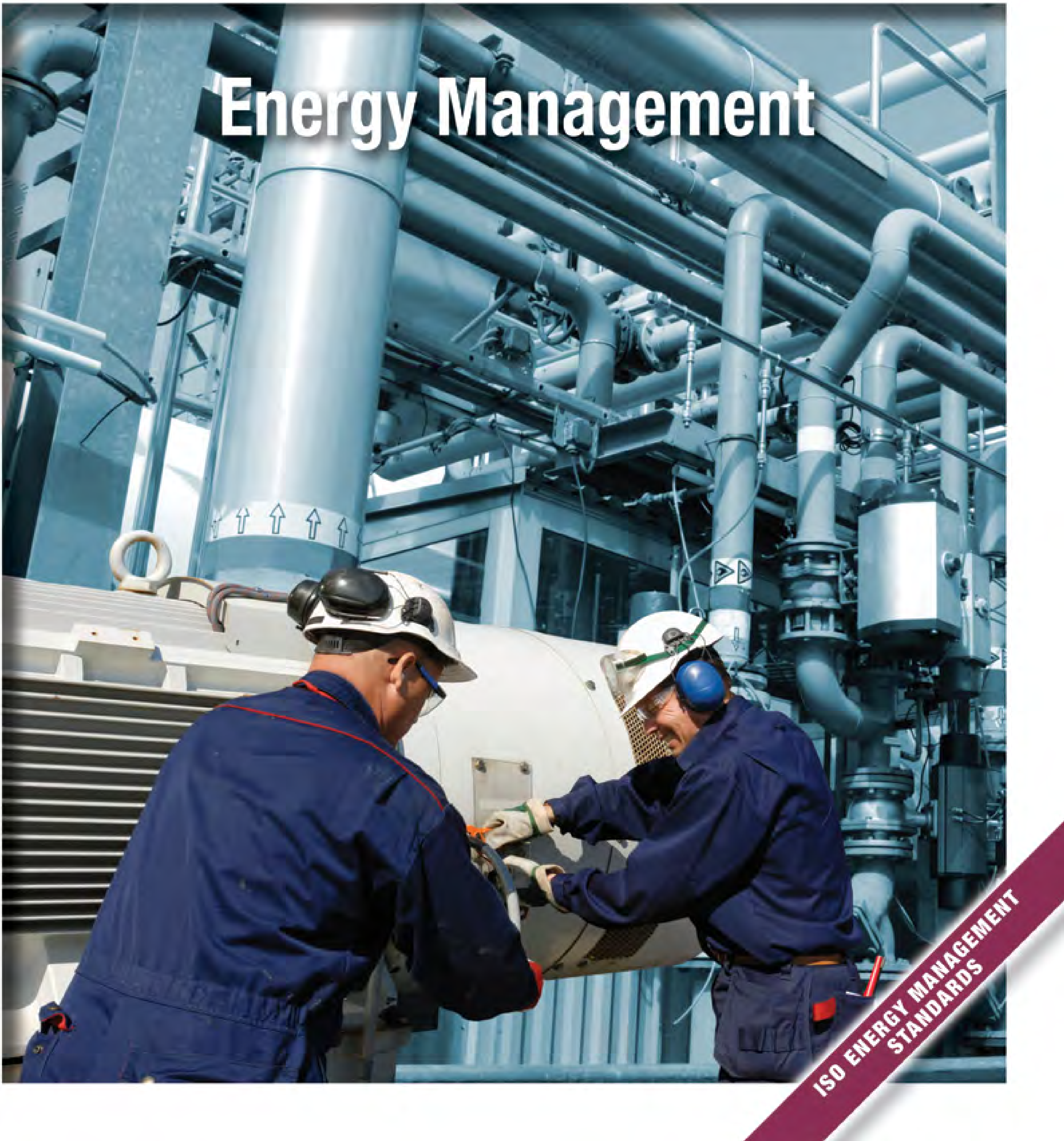
Audit of Steel Cord Producer | Electroplater Assessment | HVAC Optimization

March 2009

COMPRESSED AIR BEST PRACTICES®



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- ✔Energy savings from variable speed drive technology.
- ✔The air quality guarantee with reference to oil content.
- ✔Air cooled or water cooled machines.
- ✔Extended warranty and service packages available.
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- ✔Which machines really offer production enhancements and other cost reductions?

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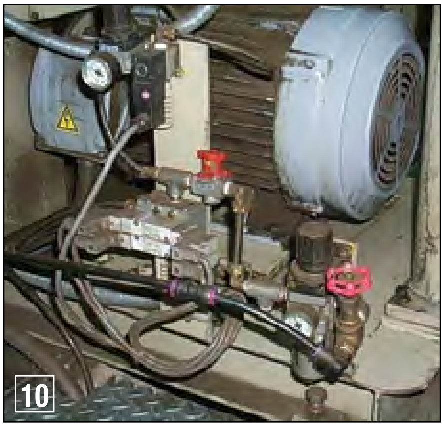
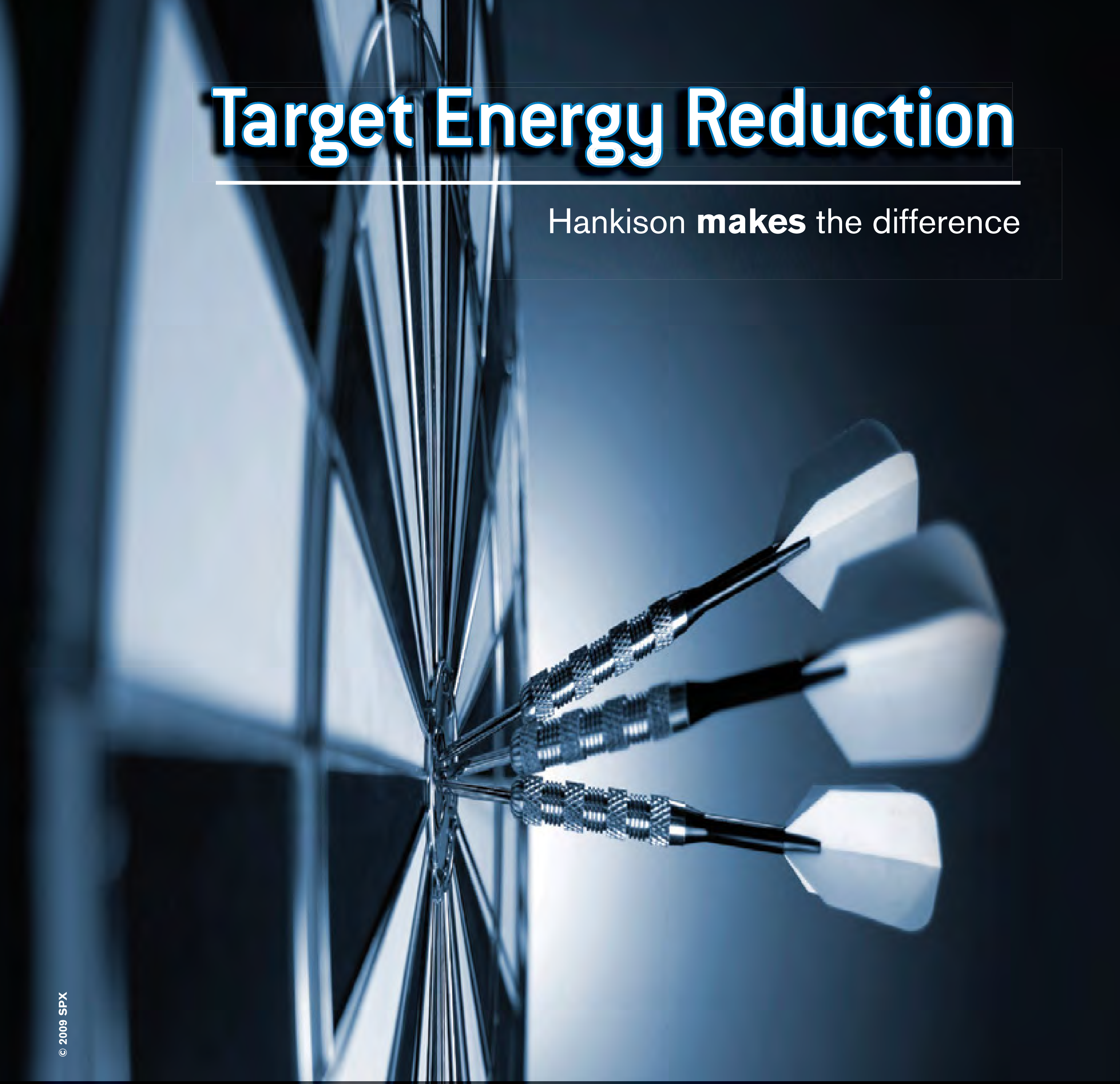


COLUMNS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FROM THE EDITOR

Energy Management

In this edition, we have published four different system assessment reports done in industrial facilities. The first is supplied by Mr. Don Wirth of Tencarva Machinery, and it explores the actions taken to solve pressure problems in a facility. The second is about an electroplating company, which was able to save 1,631,000 kW/h and $153,000 per year due to a compressed air system assessment done by the engineers at Scales Industrial Technologies.

In the third, Mr. Thomas Mort continues his enlightening series of articles with "HVAC Optimization," one of the larger opportunities for energy savings in most facilities. The article reviews how to reduce costs and energy for heating and air conditioning by improved control of exhaust air.

The electroplating company saved $153,000 and 1,631,000 kW/h per year in energy costs.

The appropriate sizing of point-of-use pneumatics, air preparation, piping and storage is one of the less understood topics out there. It is very common to find that these components are creating pressure drops and causing plants to operate at higher compressed air pressures. Worse, pressure losses cause production machinery to operate at less than optimal conditions. In the fourth system assessment report, Mr. Frank Moskowitz shares with us valuable techniques to calculate the sizing of these components to prevent pressure losses at production equipment.

Finally, Mr. Wayne Perry shares interesting information on what ISO is doing with Energy Management Standards through an interview with ISO Secretary-General Rob Steele.

We hope you enjoy this edition and thank you again for your support and for investing in industrial energy efficiency.

ROD SMITH
Editor
rod@airbestpractices.com

UTILITY-AIR NEWS

Kaeser Announces ENERGY STAR Partnership

Kaeser Compressors proudly announces its recent partnership with the Environmental Protection Agency's ENERGY STAR program. This partnership reflects Kaeser's belief in providing customers with the highest quality, most efficient compressed air products and optimized, energy-saving systems.

With the help of ENERGY STAR, Americans saved about $16 billion on their 2007 energy bills while reducing greenhouse gas emissions equivalent to those of 27 million vehicles. Kaeser intends to leverage its partnership with ENERGY STAR to communicate the importance of energy management to the industrial marketplace — and increase the national statistics for energy savings in the coming years.

Kaeser prides itself on its long-standing commitment to the environment and energy management. An Allied Partner with the Department of Energy and an ISO 14001 Environmental certified company, Kaeser partnered with ENERGY STAR to further promote the importance of saving energy.

"Kaeser is helping improve our nation's energy and environmental outlook."

— EPA Administrator Stephen L. Johnson

"Our commitment to energy management extends beyond our products and services," said General Manager and Executive Vice President Frank Mueller. "The design for our headquarters expansion includes many energy-saving elements, and our employees actively participate in energy and waste reduction programs."

The Kaeser headquarters expansion now underway in Fredericksburg, Virginia will include a Thermoplastic Olefin (TPO) roof to reflect sunlight rather than absorbing it like other types of roofs. The design also includes an efficient under-floor air distribution system and daylighting resulting in less energy required to heat, cool and illuminate the building. Current recycling and conservation programs are in place for batteries, cellular phones, computer equipment, electricity and more.

"Environmental responsibility is everyone's responsibility — and today I'm pleased Kaeser Compressors is taking this motto to heart," said EPA Administrator Stephen L. Johnson. "By making smart energy choices, Kaeser Compressors is helping improve our nation's energy and environmental outlook."

For more information on Kaeser's commitment to energy management, please call 800-777-7873 or visit us at www.kaeser.com.

UTILITY-AIR NEWS

"We are honored to be listed as one of the 100 most sustainable corporations in the world."

— Paul Hense, President, Atlas Copco Compressors

ASCO Numatics Announces the 2009 Industrial Automation Engineering Scholarship

FLORHAM PARK, NEW JERSEY — (Marketwire, Feb. 3, 2009) — ASCO Numatics, the world's leading manufacturer of comprehensive fluid automation solutions, flow control and pneumatics, today announced the beginning of the 2009/2010 academic year application period for two $5,000 scholarships available to U.S. engineering students pursuing careers in industrial automation-related disciplines. ASCO Numatics will also give $1,000 grants to the engineering departments of the colleges where the winners are enrolled.

"ASCO Numatics started the scholarship program to help identify and encourage the next generation of leaders in the engineering industry," said Robert W. Kemple, Jr., Executive Vice President, Sales and Marketing — Americas, ASCO Numatics. "We were very impressed by the quality and enthusiasm of last year's applicant pool. We are excited to continue this program throughout 2009 and expect the same high-quality applicants and talented winners."

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 an engineering, instrumentation, systems, electrical, mechanical or automation discipline at an accredited U.S. educational institution for the 2009/2010 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.

ASCO Numatics will present the scholarship awards at the 2009 ISA Expo, October 6–8, 2009 at the Reliant Center in Houston. The ASCO Numatics award presentation will be part of the annual ISA Young Automation Professionals Festival (YAPFEST). ISA hosts YAPFEST for automation professionals between ages 18 and 30.

Complete application details and forms are available at www.asconumatics.com/scholarship.

Atlas Copco Among World's 100 Most Sustainable Corporations

Atlas Copco was named on the list of the Global 100 Most Sustainable Corporations in the World for the fourth consecutive year at the World Economic Forum in Davos, Switzerland, on January 28, 2009.

"In 2008 Atlas Copco took further steps in the corporate responsibility area, including the launch of new energy efficient products and solutions, while increasing the number of employees who are working in a unit with an environmental management system," said Annika Berglund, Senior Vice President of Corporate Communications, Atlas Copco. "We are pleased to see that our consistent and hard work is recognized in external evaluations and that our people take pride in our continuing efforts to increase our sustainability."

The Global 100 includes companies from 15 countries encompassing all sectors of the economy. The companies were evaluated according to how effectively they manage environmental, social and governance risks and opportunities, relative to their industry peers. This year the Global 100 traced the roots of all listed companies to determine their years of origin. In total, 46 of the 100 companies have been in business for at least 100 years. Atlas Copco was established on February 21, 1873 and turns 136 this year.

"As a member of the global community, we are honored to be listed as one of the 100 most sustainable corporations in the world," said Paul Hense, President of Atlas Copco Compressors LLC, with North American headquarters in Rock Hill, South Carolina. "Our dedication to sustainable business practices extends across our ability to provide customers with reliable compressed air solutions that save energy and increase production efficiency."

The Global 100 Most Sustainable Corporations in the World is a project initiated by Corporate Knights, Inc. (www.corporateknights.ca), with Innovest Strategic Value Advisors, Inc. (www.innovestgroup.com). Launched in 2005, the annual Global 100 is announced each year at the World Economic Forum in Davos, Switzerland. Learn more about the Global 100 at http://www.global100.org.

Learn more at www.atlascopco.com.

Compressed Air Audit of the Month

A Steel Cord Producer Manages Pressure

By Don Wirth, Tencarva Machinery Company

March Audit of the Month

Where:	Southeast U.S.
Industry:	Steel Cord Production
Issues:	Unstable Pressure and Pressure Drop
Audit Type:	Supply and Demand Side

System Before Audit

Operating Hours	8,760 hours
Power Cost kW/h	$0.04545
Avg. Air Flow	586 cfm
Avg. Air Flow, %Cs.	39.6%
Peak Demand, kW	148.9 kW
Load Factor %	45.3%
Annual Energy, kWh	1,251,292 kWh
Annual Energy Cost	$56,871

System After Audit

Operating Hours	8,760 hours
Power Cost kW/h	$0.04545
Avg. Air Flow	536 cfm
Avg. Air Flow, %Cs.	36.2%
Peak Demand, kW	101.4 kW
Load Factor %	30.3%
Annual Energy, kWh	835,544 kWh
Annual Energy Cost	$37,975

Audit Savings

Reduction in Energy Use	415,784 kWh
Reduction in CO_2 Emissions	296.5 metric tons
Equivalent CO_2 for Homes	39.3 homes
Equivalent CO_2 for Vehicles	54.3 vehicles
Total $ Savings	$18,896

Managing Pressure Fluctuation and Pressure Drop

System Overview

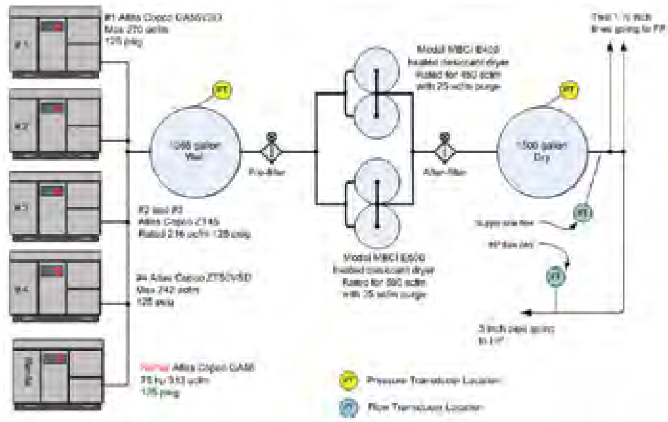
The facility produces "steel cord" and is a division of a large corporation. The following information was produced from a compressed air system analysis done over seven days in 2008.

The compressed air system is an essential utility required for all aspects of operation. Clean, dry compressed air is delivered to two production areas known as HP (half product) and FP (final product). The compressor room is situated between these two production areas. HP receives air through a single 3-inch header, and FP receives air through a 1-inch diameter loop and a 1½ inch diameter loop. Piping is copper throughout. Point-of-use piping is fed from troughs on the floor to each individual machine.

There is a 1,065-gallon wet compressed air storage tank, two heated desiccant dryers in parallel and a 1,500-gallon dry compressed air storage tank. There are five compressors on the supply side. They are as follows:

- #1 Atlas Copco model GA55VSD lubricant-injected compressor rated 270 acfm which was online
- #2 and #3 are Atlas Copco ZT45 oil-free compressors each rated for 216 acfm, only #2 was online
- #4 Atlas Copco model ZT50 VSD oil-free compressor rated for a max flow of 242 acfm and online
- #5 is a rental, an Atlas Copco model GA55 lubricant-injected, fixed speed compressor rated 312 acfm and online

During the assessment, the fixed-speed rental GA55 ran fully loaded along with #1 GA55VSD trimming and #4 ZT50VSD trimming. The compressor #3 ZT45 was online but never loaded into the mix. Average flow varied between 500 and 600 scfm. Wet receiver pressure (discharge pressure) averaged 111 psig with a 6-psig loss through filters and dryers. The dry receiver pressure was, therefore, 106 psig. The HP side fed with a 3-inch header had no pressure gradient from supply to demand. The FP side, because of the undersized header system, lost an additional 8 psig from dry tank to end use.



Measurement Methodology

Measurements creating a baseline of the compressed air system are required to gain a basic understanding of the dynamics occurring in the plant. This compressed air analysis consisted of three days of on-site study and seven days of data collection. The running compressor power was recorded and supply-side pressures were recorded at the common discharge of the compressor (wet receiver) and after the cleanup equipment (dry receiver). Demand-side pressures were recorded in four areas: at a remote receiver on the HP side, at wastewater treatment, at a remote receiver on the FP side and on column F53 in FP.

With this data we were able to create a pressure profile and identify where the pressure drops or draw-downs were taking place. We needed to identify whether or not the main header was at fault (possibly undersized for the flow) or if the reported pressure drops were at the end-users local piping or from the diaphragm pumps that run each day. Two thermal mass-type flow meters were installed: one at the discharge of the dry receiver for total flow and one in HP for that area only.

The data collection lasted for seven days and sample intervals were at three seconds with an average of every seven samples. This equates to a 21-second interval. A total of 28,801 readings were taken at each test point with the 45-second averaged interval.

AirMaster+ Software was used to analyze the data collected in this system. AirMaster+ is a Windows-based software tool used to analyze industrial compressed air systems. AirMaster+ is intended to enable auditors to model existing and future improved system operations and evaluate savings from energy efficiency measures with relatively short payback periods. More information on AirMaster+ Software can be found at www.compressedairchallenge.org.

Annual Electricity Costs

The data was tabulated within the AirMaster+ Software tool. A weighted average of $0.04545/kWh was used. Using the seven days of data, we have extrapolated them to provide a profile of one year of energy costs. These costs do not include maintenance fees, labor or water/sewage use.

COMPRESSOR	AVG. AIR FLOW, ACFM	AVG. AIR FLOW, %CS.	PEAK DEMAND, kW	LOAD FACTOR, %	ANNUAL ENERGY, kWh	ANNUAL ENERGY COST, $
#1 GA55VSD	211	78.1	55.9	78.2	438,213	19,917
#2 ZT45	0	0.1	18.1	32.8	156,667	7,121
#4 ZT50VSD	75	30.8	20.4	30.9	174,871	7,948
Rental GA55	300	100	55.2	101.8	481,541	21,886
Total	**586**	**39.6**	**148.9**	**45.3**	**1,251,292**	**56,871**

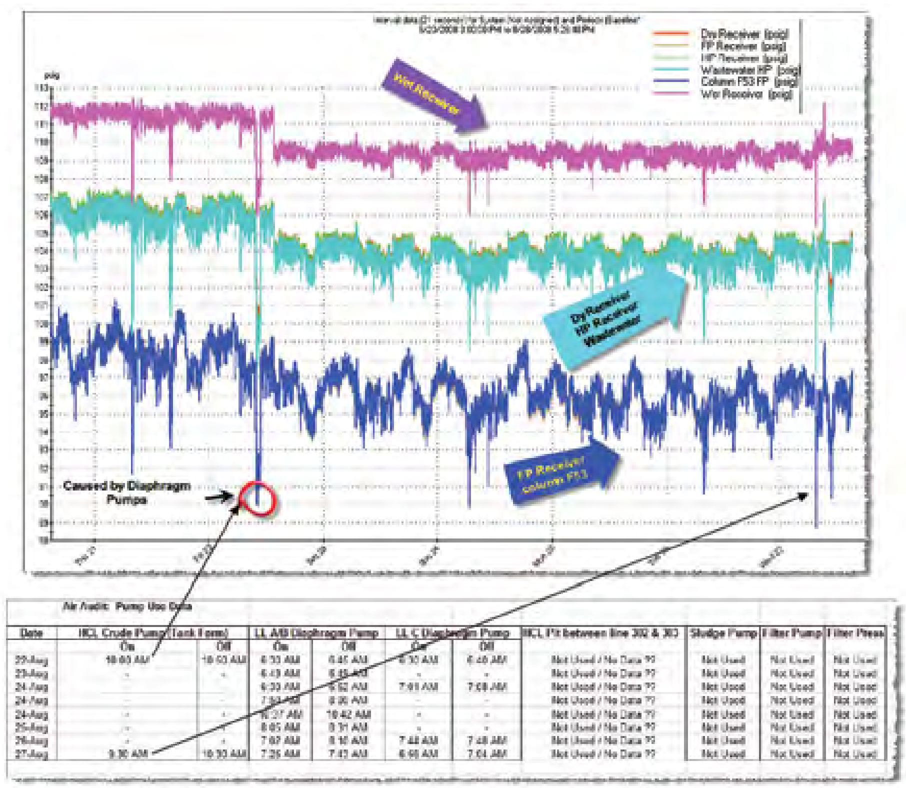
COMPRESSED AIR AUDIT OF THE MONTH

A Steel Cord Producer Manages Pressure

> "The audit of this facility has discovered the source of the pressure fluctuations and recommends examining alternatives to the pumps being used that cause these demand events."

Pressure Profile

The pressure profile chart shows the pressure gradients that exist from supply to demand. The occasional pressure drops correspond to the HCL or LL pumps coming online. Later we will see that these pressure drops are due to the compressors not responding to the demand. Pressure in the FP area of the plant is consistently 7–8 psig less than the dry receiver pressure in supply. This is due to the flow traveling in undersized piping. The two loops, comprised of 1-inch and 1½-inch diameter piping, are not capable of the flows required in FP.



Date	HCL Crude Pump (Tank Form)		LL A/B Diaphragm Pump		LL C Diaphragm Pump		HCL Pit between line 302 & 303	Sludge Pump	Filter Pump	Filter Press
	On	Off	On	Off	On	Off				
22-Aug	10:00 AM	10:50 AM	6:33 AM	6:45 AM	6:30 AM	6:46 AM	Not Used / No Data ??	Not Used	Not Used	Not Used
23-Aug	-	-	6:43 AM	6:45 AM	-	-	Not Used / No Data ??	Not Used	Not Used	Not Used
24-Aug			6:33 AM	6:52 AM	7:01 AM	7:08 AM	Not Used / No Data ??	Not Used	Not Used	Not Used
24-Aug	-	-	7:50 AM	8:36 AM	-	-	Not Used / No Data ??	Not Used	Not Used	Not Used
24-Aug	-	-	10:27 AM	10:42 AM	-	-	Not Used / No Data ??	Not Used	Not Used	Not Used
25-Aug	-	-	8:05 AM	8:31 AM	-	-	Not Used / No Data ??	Not Used	Not Used	Not Used
26-Aug	-	-	7:07 AM	8:10 AM	7:44 AM	7:48 AM	Not Used / No Data ??	Not Used	Not Used	Not Used
27-Aug	9:30 AM	10:30 AM	7:26 AM	7:43 AM	6:58 AM	7:04 AM	Not Used / No Data ??	Not Used	Not Used	Not Used

HP, which is fed with a 3-inch diameter header, is quite capable of handling all the flow requirements during all aspects of production. This would include all the diaphragm pumps that are used since they are all fed off the 3-inch from HP. Looking back at the chart, you will notice how the pressure gradient from dry receiver to end-of-line at the HP receiver, and even wastewater treatment, are all identical. Pressure draw-downs are felt plant-wide and not isolated to any area.

The drawing and plating machines in HP are all lower pressure applications. Pictured to the right is a typical regulator that is installed on most HP end-use equipment. It is scaled in MPa (megapascals). A .4 to .5 MPa setting equates to 58–72 psig. Barring a major supply-side failure, HP area will never be impacted or have issues relating to pressure. Even the diaphragm pumps can operate at lower pressures.

FP is the area of production where low pressure could cause an occasional disruption. Due to the undersized pipe, the given flow to FP creates a 7–8 psig gradient (from dry receiver to end users). The chart shows an average pressure of 93 psig in FP. When diaphragm pumps come online, such as the trash pumps, LL (liquid lubricant) or HCL pumps, we see the pressure draw-down very easily. The draw-down lasts as long as the pump is online and then the pressure recovers. A key finding here is that given a different combination of compressors, the pressure drop was not that extreme. This would lead us to believe that the pressure drops can be cured with the right mix of compressors online. Piping issues still are a threat to stabilizing pressure, but the supply side is still the bigger impact.

FP's pressure concern is in the rewinding area. We measured pressure at the furthest machine, which was FGW-10. The regulator at each rewinder is set for .5 MPa, which is 68 psig. High-speed data logging proved this. This is at least 20 psig lower than the lowest pressure recorded during the seven days of logging. Only a compressor failure could cause the pressure in FP to drop and impact this area. Additionally, the safety switch is set at 58 psig or .4 MPa and this pressure will probably never be reached.

COMPRESSED AIR AUDIT OF THE MONTH

A Steel Cord Producer Manages Pressure

Increase Pipe Size to Reduce Pressure Drop

Distribution piping should be sized so that the air velocity within the pipe does not exceed 20 ft/sec. Higher velocities may cause condensate to be blown across a condensate drop leg and cause larger pressure excursions to occur. The following equation explains the sizing process:

$$1.)\quad a = \frac{144 \times Q \times Pa}{V \times 60 \times (Pd + Pa)}$$

Where:

a = Cross-sectional area of the pipe bore, in^2
Q = Flow rate, ft^3/min free air
Pa = Prevailing atmospheric absolute pressure, psia
Pd = Compressor discharge gauge pressure (or line pressure), psig
V = Design pipe velocity, ft/sec (we will use 20)

$$2.)\quad a = \frac{\pi \times d^2}{4} \quad \text{or} \quad d = \sqrt{\frac{a \times 4}{\Pi}}$$

Where:

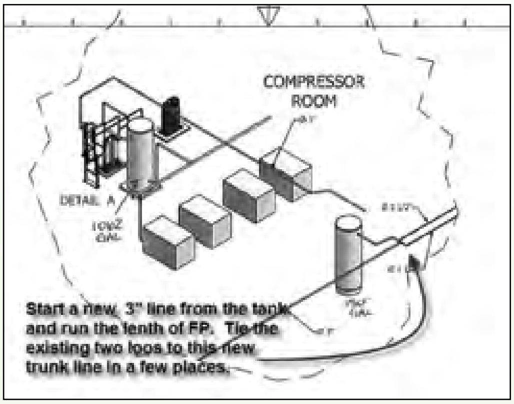
a = Cross-sectional area of pipe bore, in^2
d = Pipe bore diameter, in

Here is the equation for sizing a pipe for the 450 scfm of air and keeping the velocity at 20 ft per second:

$$a = \frac{144 \times 450 \text{ cfm} \times 14.5}{20 \times 60 \times (90 + 14.5)} = 7.492 \text{ sq. inches}$$

$$d = \sqrt{\frac{7.492 \times 4}{\Pi}}$$

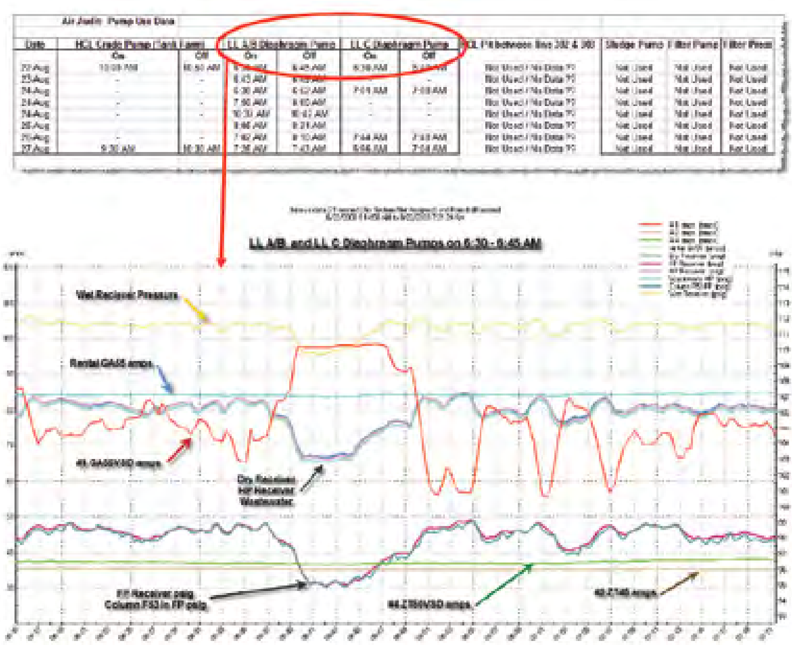
Answer is: d = 3.08 inches



Examining the Pressure Draw-Down

The pressure profile chart has a red circle around the first big pressure draw-down. The chart below is a close-up look at this event. It was caused by the HCL pump coming on from 10:00 A.M. to 10:50 A.M. Here we can see how the compressors reacted to this event. Flow readings on the HP flow meter went from an average of 150 scfm to 300 scfm, an increase of 150. Online were compressors #1 GA55VSD, #2 ZT45, #4 ZT50VSD and the rental GA55. The rental at 85 amps was always fully loaded while #2 ZT45 at 35 amps was unloaded during the entire seven days.

That leaves the two VSD's to handle any increase in flow above what the GA55 can supply. The red line is the #1 GA55VSD, and you can see how it responded immediately and went full rpm. The problem is the green line, which is the #4 ZT50 VSD. It did not offer its full output and therefore you can see the pressure throughout the entire plant was in draw-down. This means the demand flow exceeded the supply flow. When the pump shuts down, the pressure returns to its average values. Looking back at the demand-side piping, we see that the tank farm and wastewater treatment are off the 3-inch line. Yet the entire plant experiences the draw-down of pressure due to the inability of the supply side to react to the new load.



Demand-Side Recommendations

Demand Side — Air Leaks

A leak survey was not performed, however. We were told that during maintenance with no production running, one ZT45 rated at 215 acfm can just about hold header pressure to 100 psig. We would consider this the gross leakage rate. This equates to about 35% leakage.

Leakage could be occurring under the troughs that feed all production machines. Pictured here (in green circle) is poly flow tubing that comes up to feed each machine. Push-to-connect or ferrules could be leaking. Since they are inaccessible, the leaks never get fixed. If the company eliminates only 50 scfm of air leaks, it would amount to an additional savings of $4,700 per year.

Demand Side — Diaphragm Pumps

The flow increase from our charting shows an approximate 150-scfm increase when a diaphragm pump is running. With the minimal piping diameters and less than desirable response from the compressors, we need to either change the pumps to electrical type or repair all piping/volume and compressor control response. To reduce energy and optimize the system, we need to use less compressed air. To do so means finding other methods besides compressed air to perform the functions occurring now. One way is to replace the culprit diaphragm pumps with an electrical equivalent.

Centrifugal pumps are commonly used in place of diaphragm pumps when the viscosity of the fluid is not an issue. Where viscosity is an issue, there are electrically driven "peristalic hose pumps." They are capable of the same pumping characteristics as the pneumatically driven diaphragm pumps. Although this report does not endorse any particular product, I recommend that the firm investigate this type of pump along with any others that can replace the air-intensive diaphragm pumps presently in use.

Distribution Header Pressure Drop

The existing 1-inch and 1½-inch diameter piping that makes up the FP loops are undersized for the flows that are required to support production. Now remember that leakage is a real flow and is taking up some valuable real estate in the pipes. If leakage was reduced by 50%, there is a good chance that the flows would be okay in the existing piping scheme, but for now let's look at what size piping can handle the flows required to FP. If we use 600 scfm minus the 150 going to HP or 450 scfm as a maximum peak flow, we can calculate what size pipe is needed. The more flow you try to put through a pipe the greater the pressure drop will be. Pressure drop in a pipe increases with the square of the increase in flow. This means if you double the flow, the pressure drop will increase four times what is was!

COMPRESSED AIR AUDIT OF THE MONTH

A Steel Cord Producer Manages Pressure

Supply-Side Recommendations

The compressed air supply, utilizing sufficient storage and proper distribution, must meet the compressed air demand. If supply, storage and distribution are not in tune or aligned, excessive pressure fluctuations will occur resulting in increased operating costs. Most compressors' ability to load or unload is controlled by line pressure. Typically, a drop in pressure indicates an increase in demand. This then causes a compressor to come on-line or load and thus handle the increase in flow. In this system, this takes place on a regular basis as pressure rises and falls; however, the compressors cannot see the true production floor pressure and are only reacting to the pressure in the wet receiver. The wet receiver, as we have seen from our data, could be 10–15 psig higher than actual point-of-use pressures.

There is no automation in place to orchestrate the compressors starting or stopping. Because it is very difficult to successfully cascade more than two compressors, there are times when the system is running with too much horsepower, all sharing the load and they simply cannot react to demand events in time. With no automation, compressors maintained a higher than normal power usage regardless of production requirements. This occurs because as the pressure increases, so does the demand for air in all unregulated uses such as leaks, open blowing and users with the regulators cranked all the way open. This phenomenon is called "artificial demand" and it prevents the compressors from being able to equalize the pressure throughout the header.

New Compressor

If we were to install a 100-hp air compressor, such as a GA75 lubricant-injected fixed speed, we can accomplish what the rental and the ZT45 are currently doing but with less power. A single 100-hp compressor would require about 82kW fully loaded and output 460–480 cfm. Now we only need to trim with the GA55VSD. This puts all lubricant-injected rotaries online, which have a greater cfm per bhp than oil-free. **This equates to a $14,184 savings over the existing baseline.**

Electric-Timed Drains

Electric-timed condensate drains are used on each compressor and on each receiver tank. A ¼-inch timed drain operating for 10 seconds and open every 30 minutes (at $0.05kWh) can cost $700 in compressed air loss per year. The system has six in operation, which potentially is costing over $4,000 in compressed air. Ask your vendor for zero air-loss type drains, and replace the existing drains.

Conclusion

The audit of this facility has discovered the source of the pressure fluctuations and recommends examining alternatives to the pumps being used that cause these demand events. We also recommend the installation of a new 3-inch header down through FP starting at the dry receiver. This header should be tied into the existing loops.

Purchase a fixed-speed compressor rated at 100hp that will enable a reduced energy profile to operate under the current and future demand environment. Finally, perform a thorough leak check, especially on the under floor trough piping and replace timed condensate drains with zero air loss type condensate drains. BP

COMPRESSOR	AVG. AIR FLOW, ACFM	AVG. AIR FLOW, %CS.	PEAK DEMAND kW	LOAD FACTOR, %	ANNUAL ENERGY, kWh	ANNUAL ENERGY COST, $
System Baseline	586	39.6	148.9	45.3	1,251,292	56,871
New System Total	536	36.2	101.4	30.3	835,544	37,975

For more information please contact Donald Wirth, Tencarva Machinery Co., tel: 615-742-3101, email: dwirth@tencarva.com, www.tencarva.com

AIR STANDARDS

Energy Management Standards

BY WAYNE PERRY, TECHNICAL DIRECTOR, KAESER COMPRESSORS

Most readers of this magazine are familiar with the ISO 9000 and 14000 families of standards. The 9000 family pertains to quality management systems and the 14000 family deals with environmental management. These are probably the best-known management standards in the world. Late next year, there will be another international management standard that is expected to be more widely adopted than either of the two standards above. That new standard will be ISO 50001.

In late 2007, the national standards organizations for the United States (American National Standards Institute — ANSI) and Brazil (Associação Brasileira de Normas Técnicas — ABNT) proposed a new field of technical activity for ISO. This new field will add energy management to the ISO stable of standards. The proposed scope states:

> Standardization in the field of energy management, including: energy supply, procurement practices for energy-using equipment and systems, energy use and any use-related disposal issues. The standard will also address measurement of current energy usage and implementation of a measurement system to document, report and validate continuous improvement in the area of energy management.

I recently had a chance to speak with Rob Steele, the new Secretary-General of ISO, about energy management standards.

AIR STANDARDS

Mr. Rob Steele, ISO Secretary-General

Rob Steele took up the post of ISO Secretary-General on January 1 2009. Rob Steele was the Chief Executive Officer of Standards New Zealand (SNZ) until 2007. He is a Chartered Accountant, a member of the New Zealand Institute of Directors and a Fellow of the New Zealand Institute of Management. Since leaving SNZ, Rob Steele has provided advice to organizations both in New Zealand and overseas on strategic business and standards issues, assisted regulators and standards organizations in several countries to develop strategies in public policy and standardization and worked with a United Nations specialized agency in three countries on energy efficiency systems and an international standard for industry. Rob Steele was Secretary of the Pacific Area Standards Congress (PASC) from 2002 to April 2007. During his tenure as CEO of the New Zealand standards body, he represented SNZ on ISO's governance bodies where he was involved in developing policies on the global relevance of International Standards and led an ad hoc group to develop recommendations on ISO's strategy on management system standards.

When and how did ISO become interested in an energy management standard?

Rob Steele: For some time, the United Nations Industrial Development Organization (UNIDO) had recognized industry's need to mount an effective response to climate change and to the proliferation of national energy management standards.

In March 2007, UNIDO hosted a meeting of experts, including representatives from the ISO Central Secretariat and nations that have adopted energy management standards. That meeting led to submission of a UNIDO communication to the ISO Central Secretariat requesting that ISO consider undertaking work on an international energy management standard.

ISO's US member, the American National Standards Institute (ANSI) made a formal proposal for ISO to establish a committee on this subject. In February 2008, the ISO Technical Management Board (TMB) approved the establishment of a new project committee, ISO/PC 242, Energy Management, to develop the future ISO 50001 management system standard for energy.

Prior to joining ISO, I actually worked with the UNIDO team as a standards expert. I was privileged to work with Bob Williams and Marco Matteini of UNIDO, Aimee McKane of Lawrence Berkeley National Laboratory and of course Wayne Perry from Kaeser Compressors, and to participate in workshops in Thailand, China and Brazil. So I have more than a little interest in the development of this standard as well.

Why is another standard needed? Can't energy be managed with an existing standard such as ISO 14000 or other existing national standards?

Rob Steele: ISO's current portfolio of more than 17,800 International Standards includes over 100 related to specific energies. Benefit was seen in developing a new global approach to systematically addressing energy performance in organizations of all types — pragmatically addressing energy efficiency and related climate change impacts. This approach has been well proven in the environmental area. ISO has more than 350 standards addressing specific environmental issues, such as standardized sampling, testing and analytical methods for the monitoring of the quality of air, water and the soil. However, the development of the ISO 14001 standard for environmental management systems offers a holistic framework for controlling and reducing the environmental impact of any type of organization and for improving its environmental performance. ISO 50001 will follow the management system approach, which has proved so successful with ISO 14001 for environmental management and ISO 9001 for quality management.

The benefit of developing an ISO International Standard is that it distills worldwide experience and expertise. In addition, based on international consensus, it will be developed for global relevance and will provide an internationally harmonized, understood and accepted approach to energy management. National standards may not benefit from such broad input and, with their differing requirements, may pose technical barriers to trade.

How broad is the interest in this standard?

Rob Steele: Currently, 34 ISO national members bodies from all regions of the world are participating in the development of ISO 50001, with another six as observers, while UNIDO and the World Energy Council have liaison status.

How does the standard development process work?

Rob Steele: ISO standards are developed within technical committees or subcommittees dedicated to a specific technology or industry sector by national delegations of experts from countries interested in the work. When consensus is reached on the content of the standard, it is circulated to ISO's worldwide membership for balloting and comment, first as a draft, then a final draft, before publication as an International Standards.

Tell me a little about PC 242. What is the purpose of the PC? Who chairs the group? Where and when do they meet?

Rob Steele: "PC" stands for "Project Committee" which works like a technical committee but is established to focus on a single standard and disbanded once its work is finished. PC 242, Energy Management, was specifically set up to develop ISO 50001. It has a twinned secretariat from a developed country and a developing country provided by, namely, the American National Standards Institute (ANSI) and ISO's national member for Brazil, Associação Brasileira de Normas Técnicas (ABNT). The Chair is Edwin Pinero (U.S.A.).

The first meeting of PC 242 was held on September 8–10, 2008 in Washington, DC. As part of the proceedings, delegates described various national or organizational initiatives in detail. For example, a presentation was given by UNIDO on the preparatory work the organization has carried out to support the ISO process by researching energy management needs in developing countries.

This gave PC 242 an insight into the different policies and situations around the world, which need to be taken into account in the development of a globally relevant International Standard for energy management.

Excellent progress was made in the technical discussions and a first working draft has already been created. Publication of ISO 50001 is targeted by the end of 2010.

AIR STANDARDS

"ISO 50001 is expected to similarly achieve major, long-term increases in energy efficiency — 20 % or more in industrial facilities."

— Rob Steele, ISO Secretary-General

Is the standard going to be based on any existing standards? Will companies who already implement ISO 9001 or ISO 14001 be able to easily implement this new standard?

Rob Steele: PC 242 has already taken the key decision to base the standard on the common elements found in all of ISO's management system standards. This will ensure maximum compatibility with key standards such as ISO 9001 and ISO 14001.

It is anticipated that the standard will be based on the same management system principles such as continual improvement, and use the Plan-Do-Check-Act cycle employed in these standards.

How does ISO see the importance of ISO 50001 in relationship to other ISO standards?

Rob Steele: The vast majority of ISO standards are specific to a product, service, material, process, technology or practice. In combination with these, standards like ISO 9001 and ISO 14001 provide a systematic, holistic framework for managing the organizational processes related to these products and services in order to address challenges faced by any organization, regardless of its activity, such as quality and environmental management.

ISO has identified energy management as one of the top five fields meriting the development and promotion of International Standards. Effective energy management is a priority focus because of the significant potential to save energy and reduce greenhouse gas (GHG) emissions worldwide.

Existing ISO standards for quality management systems and environmental management systems have successfully stimulated substantial, continual efficiency improvements within organizations around the globe. ISO 50001 is expected to similarly achieve major, long-term increases in energy efficiency — 20 % or more in industrial facilities. BP

I would like to thank Rob Steele for taking time out of what has to be a very busy schedule to comment on ISO 50001. If you would like more information about this standard, you can contact:

ISO Central Secretariat, Trevor Vyze, vyze@iso.org
ISO/PC 242 Secretary, Jason Knopes of ANSI, JKnopes@ansi.org
Co-Secretary Felipe Viera of ABNT, Felipe.Vieira@abnt.org.br

For more information, please contact Wayne Perry at email: wayne.perry@kaeser.com or visit www.kaeser.com

Assessment Improves Electroplater Production and Saves Energy

BY PAUL SHAW, SCALES INDUSTRIAL TECHNOLOGIES

Faced with rising energy costs, a large electroplating company sought to improve the efficiency and reliability of its compressed air system. After getting a quote from their vendor on a new 300-hp compressor to replace an existing unit, the company sought a comparison quote due to the significant investment the new compressor represented. Based on a recommendation from one of their customers, they turned to Scales Industrial Technologies.

Rather than simply providing a quote for a new compressor, Scales recommended a compressed air system assessment. This impressed the company enough to give Scales the green light to assess the system. Scales' engineers found that by modifying some production equipment, the firm could reduce its compressed air demand by 80%. This would allow the company to operate just as effectively with a much smaller compressor and achieve significant energy and maintenance savings.

ASSESSMENT IMPROVES ELECTROPLATER PRODUCTION AND SAVES ENERGY

The Project

The primary demand for compressed air in the plant was from a series of compressed air-driven nozzles that atomized water to rinse away chemicals used during the plating process. Working with a nozzle manufacturer, Scales designed a process change that enabled the strip washing nozzles to use water alone instead of in conjunction with compressed air. Eliminating the air-driven strip washing sharply reduced the plant's compressed air requirements.

The assessment also found that a filter press was being fed an unneeded, constant supply of compressed air. Scales' engineers worked with the plant employees to install high-pressure, off-line air storage supplied by a 5-hp reciprocating compressor to accommodate the high-volume, intermittent demand of the filter press. This further reduced the load on the main compressor. Finally, a leak detection and repair campaign led to additional compressed air energy savings. The combination of all these measures reduced the plant's air demand to where it could be met with a smaller compressor. The plant was able to replace their 300-hp compressor with a 75-hp variable displacement compressor and a new, energy-efficient dryer.

Project

- Replaced 300-hp centrifugal unit with 75-hp rotary screw compressor
- Added 5-hp reciprocating compressor package with compressed air storage
- Added 75-hp compressor for back-up
- Converted compressed air-driven strip washing nozzles to water-driven nozzles
- Identified and repaired leaks
- Costs after utility rebate: $72,500

Benefits

- Annual energy savings of $153,000 and 1,631,000 kWh
- Production benefits of $50,000 annually
- Other annual savings of $49,000
- Simple payback of less than 4 months

Results

Not only did Scales' recommended project improve energy efficiency and yield significant energy savings, it also improved production and yielded important non-energy benefits. Compressed air energy use was reduced by more than 80%, saving 1,631,000 kWh and $153,000 per year. The project also resulted in annual savings of $49,000 from lower water and water treatment costs, lower cooling tower loads and lower maintenance costs. Additionally, production became more reliable, leading to $50,000 in annual avoided product loss. Because the company qualified for an incentive of $217,500 from its electric utility, total implementation costs were $72,500, resulting in a simple payback of just over 4 months. This project's success has encouraged this electroplating corporation to become more proactive about energy efficiency. BP

For more information please contact Paul Shaw, Scales Industrial Technologies, tel: 1-800-627-9578, email: info@scalesair.com, www.scalesindtech.com

> **"Scales worked with our operators to retrofit our rinse lines utilizing state-of-the-art technology. Involving our operators in this retrofit process was the key to gaining their commitment and enthusiasm. In addition to the anticipated energy savings, we are enjoying a higher-quality surface finish along with enhanced process consistency and capability."**
>
> **— Operations V.P., Electroplating Client**

Demand-Side System Optimization:

Point-of-Use Air Cylinders, Valves, Distribution and Storage

BY FRANK MOSKOWITZ, DRAW PROFESSIONAL SERVICES

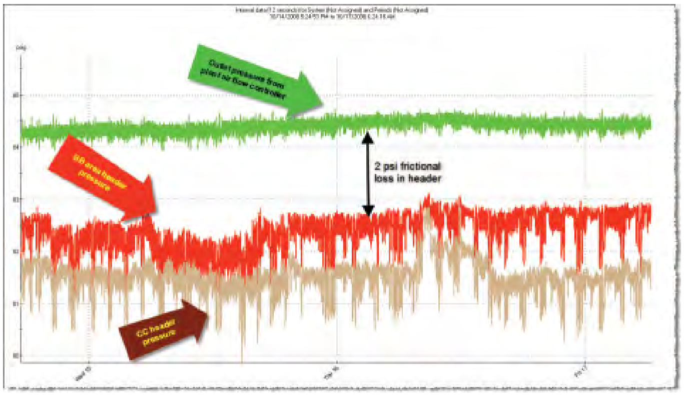
Introduction

In many (if not most) industrial facilities, the highest priority is a reliable compressed air system that supports manufacturing equipment and processes. Energy saving modifications that represent risk to the production process are not acceptable. Simply put, if the system experiences an event which causes a production curtailment, scrap or outage, the energy efficient operating scenario will be quickly abandoned in favor of the (former) less efficient, but more reliable, operating methodology. If an energy cost reduction initiative totaling $34,000 in savings per year leads to excessive scrap rates due to pressure problems, and this costs the factory $500,000 per year in lost revenue, it's clear why reliability takes priority.

When an operator cannot produce his/her final product to meet quality controls guidelines, then he or she will make modifications (usually pressure related) to fix the issue. The 85 psig setpoint from the plant air flow controller is frequently raised to 90 or 95 psig during certain jobs that run. This is to insure that the products are meeting spec.

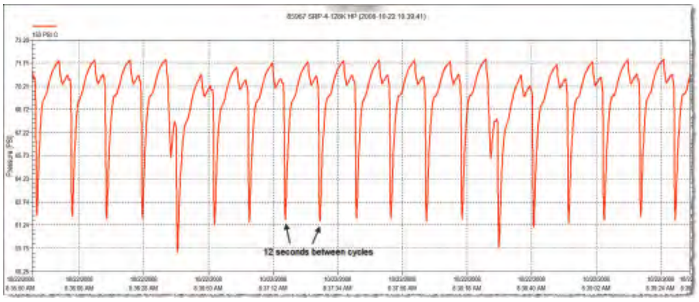
The first and foremost complaint from an operator or production area is "I don't have enough pressure." Low pressure in certain areas of the plant is caused by many reasons. It is actually restricted flow that causes the low pressure. At many facilities, it is from very definite issues. The nature of some production machines is that they require large volumes of air to actuate large fast-acting cylinders. The more air cylinders on a machine all working in tandem will create peak flows that most point-of-use piping and valves cannot handle.

The chart below shows the header pressure in the areas of an example plant that experience lower than desired pressure. As the data shows, we only have 81.5 psig average pressure at the end of CC section of the plant. The plant air pressure is also impacted by a pneumatic transfer that occurs a few times per hour. This is easily seen by the frequent pressure dips in the red and brown lines below. The transfer only impacts the header by approximately 1 psig and although this seems insignificant, when you are asking for more pressure to run your product, every single psi counts!



A critical production line has been configured to operate at 80 psig and produce the desired end product as needed. That's fine if the 80 or 81 psig available in the header can get to the cylinders and valves at the machine. From the header to the working cylinders and valves in the machine are more piping, filters, lubricators, control valves and other components that serve only to starve the flow of air needed to maintain that 80 psig requirement.

Below is a chart of pressure that was recorded at a 1/10 second sample rate. It was attached at the base of the drop where the pipe attached to the machine. Each cycle is 12 seconds. The flow required was so great that pressure couldn't even recover back to the 81 psig of the header.



DEMAND-SIDE SYSTEM OPTIMIZATION: POINT-OF-USE AIR CYLINDERS, VALVES, DISTRIBUTION AND STORAGE

The chart below is from another production machine and this time the cycles aren't as fast as the previous ones so the pressure does come back to the header pressure after each cycle. But all point-of-use piping and fittings are undersized and not allowing the required volume of air per actuation to occur. The results are quite clear in the pressure drops of 20 psig.

If we could allow the flow that is required to enter the machine as needed, there would be minimal pressure drop. But the problem lies in the fact that when cylinders actuate, there is a very large peak flow of air required to move them through their respective stroke lengths at the desired pressure. When peak flows exceed the flow rating of valves and piping, pressure drop occurs. The fix is usually a modification of the local piping/FRL's or added point-of-use storage to compensate for undersized components. Let's take a look at how to calculate the flow into a cylinder as it actuates.

FLOW RATE INTO A CYLINDER AND FLOW COEFFICIENT

The flow rate into a cylinder is based upon the amount of air needed to move the piston load and to force out exhaust air from the other side of the cylinder at a specified speed. Because it will require a specific mass of air to perform the required work, the flow rate must be stated in scfm (standard cubic feet per minute) which is the only compressed air term that states airflow in mass flow rate. A standard cubic foot of air is defined as air at a barometric pressure of 29.92 inches of mercury (we will use 14.5 psia) with a temperature of 68°F and a relative humidity of 0% and a weight of 0.0750 lbs.

The standard flow rate can be calculated by first determining the volume of the cylinder:

$$V\,(in^3) = A\,(\text{area}) \times S\,(\text{stroke})$$

Next we calculate the standard compression ratio:

$$\frac{\text{Pressure at cylinder (psig)} + \text{absolute pressure (psia)}}{\text{Absolute pressure at site (psia)}}$$

We can calculate the standard flow rate using the following formula:

$$SCFM = \frac{V_{in^3}\,(\text{standard compression ratio})}{(\text{time to fill cylinder}_{sec})28.8}$$

An example of a typical air cylinder found on a machine would be 8-inch diameter by 8-foot stroke. Let's say it strokes in three seconds and the pressure is 80 psig. What is the actual flow into the cylinder?

$$V_{in^3} = A_{in^2} S_{in} \qquad V_{in^3} = 50.24x96 \qquad V_{in^3} = 4823.04$$

$$A = \frac{\Pi d^2}{4} \qquad A = \frac{\Pi 8^2}{4} \qquad A = 50.24$$

Compression Ratio at 80 psig = 80+14.5/14.5 = 6.51

$$SCFM = \frac{(4823.04)(6.51)}{(3)28.8} \qquad SCFM = 363.4$$

This one cylinder would require a flow of 363 scfm! What size piping is needed here?

The 363.4 is the actual *standard flow rate* during the actuation. This should be the value used to size the proper valves, hoses, filters and regulator for this particular cylinder. Note that other cylinders might be actuating at the same time on a piece of equipment and their flows must be considered when sizing the branch piping to feed this machine. The manufacturer might average the flow over a minute and therefore the published flow would be lower. **Average flow should not be the guideline for sizing components.**

FLOW COEFFICIENT OR CV

When selecting valves for air cylinders, an important consideration is their ability to pass the required volume of air at an acceptable pressure drop. This is referred to as the flow rating. A common method of rating flow is by CV factor.

The CV factor is derived from an expression which gives the number of gallons of water per minute that will pass through the valve with a 1 psi differential between the valves inlet and outlet.

In many valve designs, the variation in capacity between different flow paths may vary up to 50%. One manufacturer's ½-inch port valve may actually pass less flow then another ¼-inch port valve.

The National Fluid Power Association is currently using the following formula for obtaining the capacity coefficient or Cv:

$$C_v = \frac{Q}{22.48}\sqrt{\frac{T_1 x G}{\Delta P x (P_2 + P_a)}}$$

Where:

C_v = Capacity coefficient
Q = Flow in scfm (14.5 psia, 0% RH, 68 °F)
G = Specific gravity of the fluid (G = 1 for air)
T_1 = Absolute temperature °R (460 + degrees F)
ΔP = Allowable pressure drop
P_2 = Final outlet pressure
P_1 = Inlet pressure (ΔP = P2 – P1)
P_a = Atmospheric pressure in psia

1. The effects of relative humidity (RH) on "G" for air is 0.6% over the range of 0 to 100% RH, and therefore can be ignored.

2. This equation is valid for subsonic flow only. To insure subsonic flow (flow velocities below the speed of sound [1100 ft/sec]), limit pressure drop so that:

$$\frac{P_2 + P_a}{P_1 + P_a} \text{ is between .85 and 1.0}$$

The following reference table is an easy resolve from the above equation:

Inlet pressure (psig)	Compression Ratio (14.5)	"A" constants for various pressure drops 2 psi ΔP	5 psi ΔP	10 psi ΔP
10	1.6	.155	.102	
20	2.3	.129	.083	.066
30	3.0	.113	.072	.055
40	3.7	.097	.064	.048
50	4.4	.091	.059	.043
60	5.1	.084	.054	.040
70	5.7	.079	.050	.037
80	6.4	.075	.048	.035
90	7.1	.071	.045	.033
100	7.8	.068	.043	.031
110	8.5	.065	.041	.030
120	9.2	.062	.039	.029
130	9.9	.060	.038	.028
140	10.6	.058	.037	.027

Using the "A" constant for the above table, the formula becomes:

C_v = Flow rate (scfm) x A

Our 8-inch cylinder example with a 2 psig pressure drop would become: C_v = 363 x .075 = 27

SIZING PIPE FOR A GIVEN FLOW

The more flow you try to put through a pipe the greater the pressure drop will be. Pressure drop in a pipe increases with the square of the increase in flow. Which means if you double the flow, the pressure drop will increase four times what is was!

Distribution piping should be sized so that the air velocity within the pipe does not exceed 30 ft/sec. Higher velocities may cause condensate to be blown across a condensate drop leg, and cause lager pressure excursion to occur. The following equation explains the sizing process:

$$a = \frac{144QP_a}{V\,60(P_d + P_a)}$$

Where:

a = Cross-sectional area of the pipe bore, in^2
Q = Flow rate, ft^3/min free air
P_a = Prevailing atmospheric absolute pressure, psia
P_d = Compressor discharge gauge pressure (or line pressure), psig
V = Design pipe velocity, ft/sec (we will use 30)

$$a = \frac{\pi d^2}{4} \quad \text{or} \quad d = \sqrt{\frac{a4}{\pi}}$$

Where:

a = Cross-sectional area of pipe bore, in^2
d = Pipe bore diameter, in.

Let's use our 363 scfm flow from the 8-inch cylinder.

Here is the equation for sizing a pipe for the 363 scfm of air and keeping the velocity at 30 ft per second.

$$a = \frac{144QP_a}{V\,60(P_d + P_a)} \qquad a = \frac{144(363)(14.5)}{(30)60(80+14.5)}$$

$$a = 4.455873in^2$$

$$a = \frac{\pi d^2}{4} \quad \text{or} \quad d = \sqrt{\frac{a4}{\pi}}$$

$$d = \sqrt{\frac{4.455873(4)}{\pi}} \qquad d = 2.38in$$

(Continued on pg. 34)

SEVEN SUSTAINABILITY PROJECTS FOR INDUSTRIAL ENERGY SAVINGS

Project #3: HVAC Optimization

BY THOMAS MORT, CEM

Overview

Reducing energy costs and pollution emissions involves many areas within an industrial facility. My studies have found seven (7) key (or common) areas where low-cost, practical projects can be implemented. Combined, these projects provide savings exceeding 10% of the annual energy spend with an average payback of less than one year.

Seven Key Sustainability Projects

1. Lighting
2. Demand Control
3. HVAC Optimization
4. Compressed Air
5. Metering
6. Heat Recovery
7. Project Implementation and Funding

This month's article will focus on the heating, ventilation and air conditioning (HVAC) component of energy management. As you read this article, many of you may just be exiting this year's long, cold winter season. It may still be fresh in your mind just how much extra energy costs are because of winter heating. Though I will focus on the subject of winter heating, these concepts also apply to air-conditioned manufacturing facilities.

HVAC Optimization Project Objectives

We can describe our HVAC Optimization project as an effort to reduce costs and energy for heating and air conditioning by improved control of exhaust air. The symptoms to help identify the opportunities for this project include:

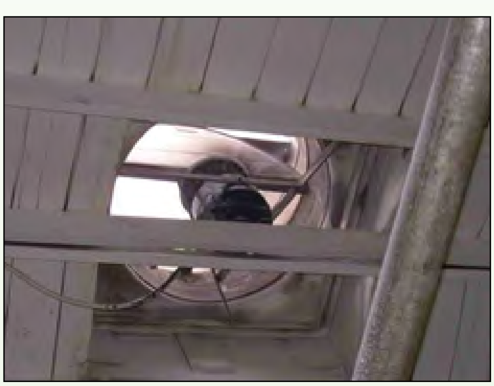
1. The facility has a large amount of air exchange (air changes per hour)
2. The facility requires heating during the winter months
3. The existing ventilation system does not have optimization controls

Take a look around your facility. Do any of these photos look familiar?

Filtration systems, sometimes called, "Bag Houses", act like vacuum cleaners sucking the air out of the factory.

Inside the factory, you can see many different types of exhaust hoods. Many times, exhaust hoods are sucking the air out of an area even when there is no production at the machine.

Ceiling or wall mounted exhausts are a major source of negative pressure in a factory. Large volumes of air can be exhausted even with small horsepower motors.



SEVEN SUSTAINABILITY PROJECTS FOR INDUSTRIAL ENERGY SAVINGS

"Reducing the exhaust air by 30,000 cfm at $1.00/cfm will save $30,000 per year."

Step #1: Calculate Gas Costs for Winter Heating

To begin this project you will need some basic information about the costs related to winter heat and the amount of air exchange happening on the manufacturing floor. A quick check for winter heating costs is to take the monthly gas bills and make a table of the amount of gas used each month as in the table below.

Does the amount of gas used increase during the winter months? If so, estimate the amount of gas used during a typical non-heating month such as August. Multiply this amount by 12 months to get an estimate of the amount of gas used for production that is not related to the weather. Now add the total amount of gas used for the year and subtract the amount used for production. This will give you an average amount of gas that is related to the cold weather.

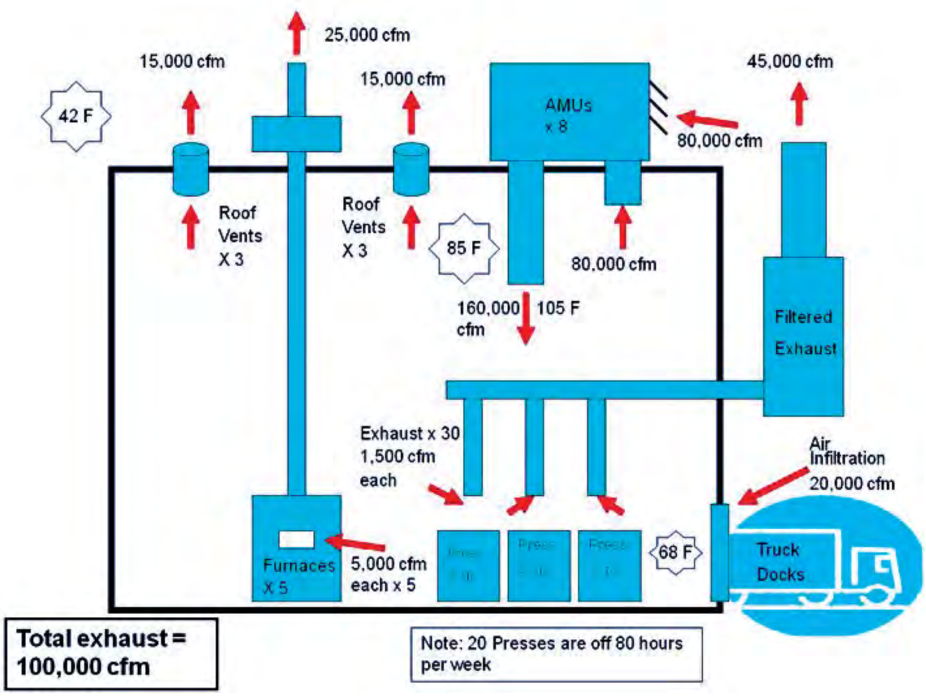
1. 4,657 mmbtus (gas used in August) x 12 months = 55,884 mmbtu (gas for production)
2. Total gas used in 1 year = 67,632 mmbtus
3. 67,632 (total gas used) – 55,884 (gas used for production) = 11,748 mmbtus (gas used for winter heat)
4. At an average cost for gas of $9.80/mmbtu the cost for winter heating is $115,130 per year.

The next step is to estimate the approximate number of hours winter heat is required per year. Adding up the hours during the winter months from November through March provides a rough estimate. A more accurate number can be derived by adding up all the days where the average temperature is < 56 °F. This number can be found by using the free data available on the website: www.weatherunderground.com/history. Enter your zip code and choose the selection "history." From this data you can also determine what the average temperature was during the heating season. In our sample factory from central Ohio, we found there were 3,960 hours per year that the temperature was below 56 °F, and the average temperature was 42 °F. The differential temperature is 56 °F – 42 °F = 14 °F.

	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Natural Gas	mmbtu	7200	7340	7301	5660	4961	4561	2129	4657	4661	5878	6148	7136	67632
Natural Gas	$/mmbtu	9.80	9.80	9.80	9.80	9.80	9.80	9.80	9.80	9.80	9.80	9.80	9.80	9.80
Natural Gas	$	70562	71932	71552	55464	48614	44698	20864	45639	45676	57600	60253	69937	662791
Weather														
Heating	HDD	1048	1167	1043	594	388	147	40	73	310	637	738	996	7181
Cooling	CDD	0	0	0	0	18	21	105	65	0	0	0	0	209

Step #2: Calculate Amount of Exhaust Air

Another important piece of data to know is the amount of exhaust air that is being removed from the factory by dust collectors, furnace exhausts, roof and wall exhausts, etc. Sometimes you can find this data in the environmental survey reports. Another way is to measure the airflow using a Velometer. System nameplate data can be used but is often far different from the actual exhaust flow. HVAC service personnel often have a small probe meter than can be inserted into a duct and determine the flow rate. In my sample factory, the volume of exhaust air is 100,000 cubic feet per minute (cfm).



With this data we can roughly calculate the cost of heating the make-up air and then rejecting it back into the countryside. The formula is:

differential temperature x flow rate (cfm) x heating hours/yr x cost of gas x 0.00000182 = annual cost

1. 14 degrees x 100,000 cfm x 3,960 hours x $9.80/mmbtu x 0.00000182 = $98,000 per year.

Think about this: Every 1,000 cfm of air that is being exhausted costs $1,000 per year or $1.00 per cfm. A small squirrel cage fan of 1 horsepower can eject 3,000 cfm or $3,000 of heated air.

SEVEN SUSTAINABILITY PROJECTS FOR INDUSTRIAL ENERGY SAVINGS

Step #3: Opportunities to Reduce Cost

What are some of the opportunities to reduce cost in this sample model?

Reduce the roof exhaust air by reversing the flow of the roof exhaust units and distributing the air into the roof area of the factory using flexible distribution ducting as shown in the photo below. Our model factory was under negative pressure and drawing in cold air from the truck bays and other doors, windows and cracks. This caused the need for local heaters while hot air was going out the roof. Reducing the exhaust air by 30,000 cfm at $1.00/cfm will save $30,000 per year. A plant in central Ohio recently applied these principals, and even though the 2008/2009 winter has been extra cold, they have not run the large steam boiler system yet this year to heat the manufacturing areas.

Shutting down excess exhaust hoods during periods of reduced production can also help reduce the heating costs. Twenty (20) exhausters could be shut down for 80 hours per week (50% of the time):

20 exhausters x 1,500 cfm/exhauster x $1.00/cfm x 50% of the time = $15,000 of savings per year

Look for any areas where the exhaust flow can be reduced during periods of reduced production.

Fresh air make-up tubes and fans can be used to distribute the cold air from outside and mix it with the warm ceiling air. These systems help reduce negative pressure problems and can significantly reduce the winter heating costs.

Conclusion:

Exhausting air is expensive. Every cubic foot of air that is exhausted means an equal cubic foot of air must be returned. If it is cold outside and you have to heat this return air, the costs could be tremendous. Challenge everyone in your facility to look for excess exhaust air, opportunities to supply fresh air to hot areas and to find ways to shut down or slow down roof exhausts during winter months. BP

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DEMAND-SIDE SYSTEM OPTIMIZATION: POINT-OF-USE AIR CYLINDERS, VALVES, DISTRIBUTION AND STORAGE

(Continued from pg. 27)

This size pipe does not exist in any branch lines that feed the end use machines. Some do however have 2-inch rubber hose as a connection but when you factor in the end hose barbs and pipe fittings, there still is a reduction in flow and thus an increase in pressure drop. Pictured right is a classic example of using rubber hose to feed a machine that requires in excess of 600 scfm in peak flows. Rubber hose has a greater pressure drop than equivalent sized pipe. End hose barbs further restrict the flow.

All of our calculations shown above are based on the velocity calculation shown below. Remember it is desirable to keep the velocity in distribution piping down to 30 fps. This will provide minimal flow restrictions.

$$V_{fps} = \frac{cfm(14.5)}{60a(P_2+14.5)} \qquad a = \frac{\pi d^2}{4 \text{ x } 144} \qquad a = \frac{144QP_a}{V\,60(P_d+P_a)}$$

Where:

V = Velocity in ft/sec

cfm = Air flow, free air, in ft^3/min

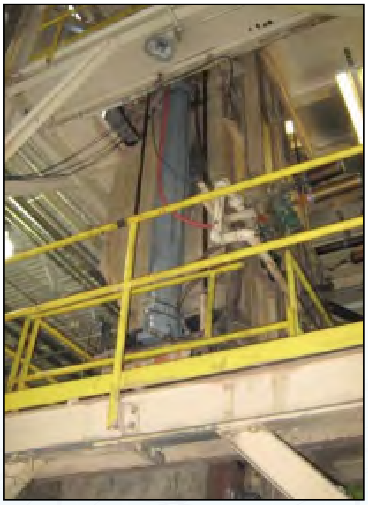
a = Cross sectional area of the pipe bore in ft^2

d = Pipe bore diameter in inches

P_2 = Gauge pressure in header or pipe

With a known flow, pressure and pipe cross sectional area (a), you can calculate V in feet per second.

Pictured right is a machine with a very large air cylinder. The 8-inch diameter by 8-foot stroke cylinder used as an example previously is not unique at most plants. We came up with 363 scfm flow if the cylinder actuated in three seconds. That's just the push stroke. What about the retract portion of the stroke? What happens if one or two more cylinders are actuating at the same time as this big one? The answer is very clear. As shown by the high speed data, the pressure drops can be upwards of 20 psig or more, simply because we cannot pass the large flows required through the existing branch piping. In a previous example, the restrictions were so severe that the 12-second cycles weren't allowing enough time for the pressure to even recover back to the 81 psig of the header.



So how do we supply these large volumes of air required by most cylinders during their actuation? The answer is point-of-use storage.

STORAGE SIZING FOR A HIGH VOLUME INTERMITTENT USE

Note: point-of-use storage works if there is a time delay between events or actuations. When the repetitive speed of the event is very fast, one must use the *correct diameter piping* to allow the flow unrestricted into the end use.

The following is an example of how storage can be utilized in lieu of modifying distribution, branch lines size or undersized filters, regulators or lubricators.

Let's say our 363 scfm cylinder actuates one way in three seconds. The pressure starts at 80 psig and we do not want the pressure to vary by 5 psig. The receiver volume required to support this event is calculated as:

$$V_{cf} = \frac{T_{\min} Q(14.5)}{\Delta P}$$

$$V_{cf} = \frac{\frac{3}{60}(363)(14.5)}{5} \text{ x 7.48 Gal/CuFt}$$

$$Gallons = 393$$

Where:

T_{min} = 3/60 minutes (event time)

Q = 363 cfm

P_a = 14.5 psia (atmospheric pressure)

P_1 = 80 psig header pressure into receiver

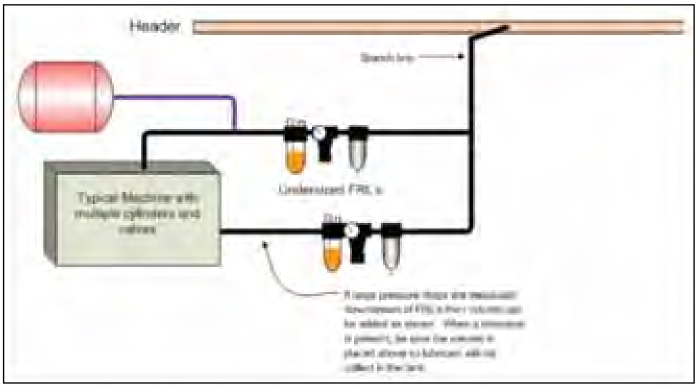
P_1-P_2 = ΔP

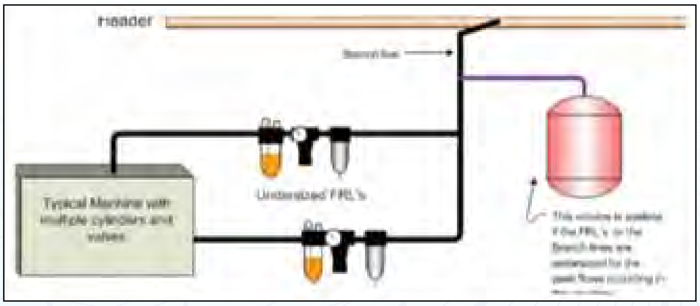
P_2 = 75 psig (lowest allowable pressure)

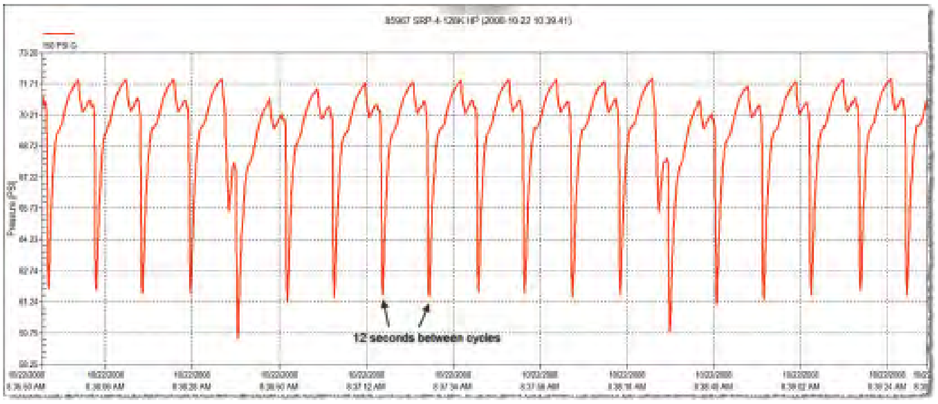
This is a simplified calculation and does not take into account the flow into the tank during the event. This gives conservative sizing.

DEMAND-SIDE SYSTEM OPTIMIZATION: POINT-OF-USE AIR CYLINDERS, VALVES, DISTRIBUTION AND STORAGE

There are many options available when it comes to adding point-of-use storage. One must first establish the root cause of the pressure drop, and then place the volume where it will benefit. In most cases the pressure drop is cause by undersized FRL's (filter regulator lubricator). As shown previously, cylinders actuate quickly and demand peak flows of air far greater than most point-of-use components can handle. Using calculations on the previous pages, you can size a receiver for the high-volume intermittent flow required for a particular cylinder. Sometimes the pressure drop is caused by only one culprit component. Once that is identified you need only to add the volume for that circuit. Pictured here are classic installations that served to alleviate the pressure drop caused by undersized components. If storage is placed in the branch line feeding the end use, there is a likelihood that the pressure drop will still exist. The reason is that the FRL was causing the pressure drop and the volume was on the wrong side of the FRL so it couldn't be utilized. Below pictures show placement of the receiver above the piping and downstream of the lubricator. If the volume was placed below the pipe, the lubricant would tend to collect in the tank and maybe not get to the end use components as desired.







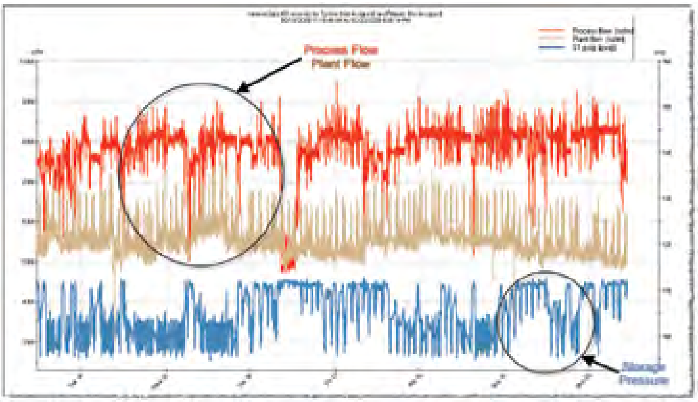
With reference to the above data tracing, the pressure drop **was not from an undersized FRL,** but from an **undersized branch line** that feeds the process. The header in that area is only 1½ inches and the branch line drop is ¾ of an inch. With the flows required, you simply cannot get the air through the piping to support the machine. The result is shown above. If the machine were to stop, you would see the pressure quickly return to the 81 psig of the header. The only resolve here is to increase the size of the local header and increase the size of the drop feeding the machine. The header in this area of the plant should be three inches and the drop should be two inches.

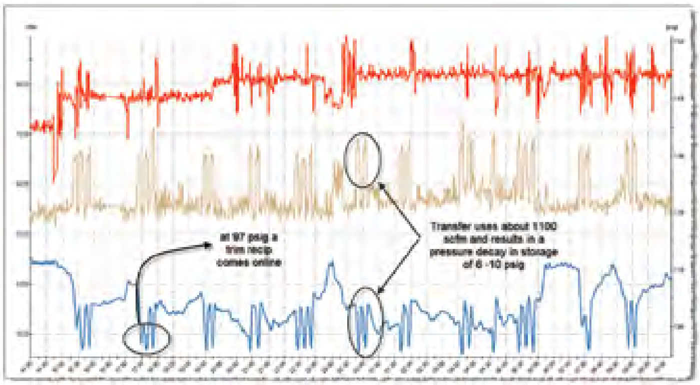
Lubricators need to be adjusted to allow proper oil mist to reach all downstream valves and cylinders. When the oil is dripping out of exhaust mufflers, it indicates an over-abundance of lubricant. The adjustments on the lubricators need to be examined.

> "Since transfer only requires 36 psig, it might be cost effective to purchase a single-stage, oil-free rotary screw compressor."

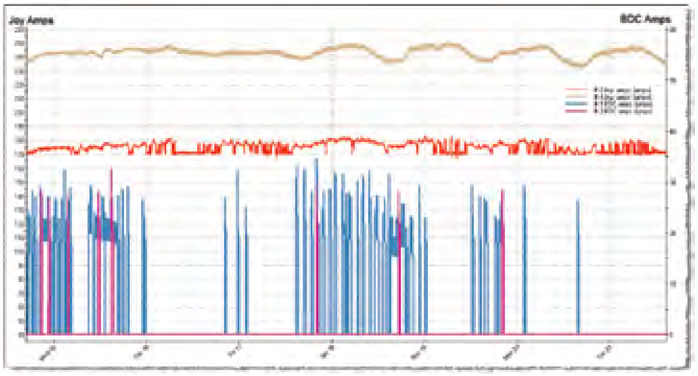
DEMAND-SIDE SYSTEM OPTIMIZATION: POINT-OF-USE AIR CYLINDERS, VALVES, DISTRIBUTION AND STORAGE

The chart below shows process air flow, plant air flow and storage pressure. As previously mentioned, the average flow to process is about 8000 scfm with peaks to 9000 scfm. Plant air averages about 5500 scfm with peaks to 6700 scfm. Plant air peaks are from pneumatic transfer. Bottom chart is a closer look showing how the pneumatic transfer effects the plant flow and storage pressure.





Dense phase transfer is the single largest event that occurs in this plant (barring a compressor failure). One line uses pneumatic transfer while the other line uses a mechanical transfer method. Hopefully there will never be an overlap of the two. An overlap would cause a very large draw-down in storage that would dip below the setpoint of the flow controller to plant air and impact production. With the present transport flow, the pressure in the storage tanks does go below the 97 psig setpoint where the automation will start a recip. The chart below shows just how often a recip starts and stops.



The data above shows the two recips contribution to the electrical cost. Each time the transport is on, the pressure drops and a recip starts. The total for one year would be $19,634. We assume that the 7 days of data collection are typical of the whole year. An alternative might be to dedicate a low pressure compressor to the transfer. Since transfer only requires 36 psig, it might be cost effective to purchase a single-stage, oil-free rotary screw compressor. Most will go to 45 psig. The 1000 to 1500 scfm required for transfer will not impact the plant pressure any longer. The savings would be the energy costs from above, plus reduced maintenance and cooling water costs required to keep the recips ready. BP

For more information contact Frank Moskowitz, Draw Professional Services, tel: 480-563-0107, email: fmoskowitz@drawproservices.com

PERSONAL PRODUCTIVITY

Harnessing "Personality Style" for Peak Performance, Productivity and Efficiency

BY PAT JOHNS

We may all be created equal — but we are certainly not all the same.

By harnessing a very basic working knowledge of the concept of personality style, we will start to develop the tools that can enhance the way we communicate in almost every interpersonal interaction we encounter! There is little escaping our personality style type, so we might as well respect and celebrate this fascinating aspect of behavioral diversity. After all, some of these well-accepted principles were first identified over 4,000 years ago and have been packaged, repackaged and presented for a very long time.

My first exposure to the concept of personality style, which is now one of the cornerstones of my corporate training program, came during "boot camp" for my inaugural job with the Xerox Corporation. The system back then was called Professional Sales Skills Training, and to learn this highly sought after, cutting edge concept required several weeks at the newly constructed Xerox Training Center near Washington D.C.

The portion of the program that dealt with this insightful concept was called "Needs Satisfaction Selling". It was high-tech stuff 30-plus years ago, and it wasn't just about selling.

Simply stated, by learning to rapidly identify a potential prospect's personality and communication style, we can immediately customize our approach and direct our efforts to specifically satisfying the priorities, or the needs, of that individual. In doing this, we become more effective at achieving the desired outcome. Thus the name "Needs Satisfaction".

Like so many core competencies we pick up along the way, these communications lessons learned back at Xerox would stay with me. Often having little or nothing to do with sales, these skills would bubble to the surface in a variety of ways. Long after I would leave the copier business for a new career in compressed air, this knowledge would remain and serve as the foundation for many a win-win experience!

Personality Styles

Most of us are already familiar with the concept that the human brain is divided into two distinct hemispheres, each controlling different functions. The right half of our brain operates in the creative realm and the left deals with the more analytical processes. Just as we are either right or left handed, we also demonstrate tendencies that suggest us to be either right or left brain dominant. This physiological reality offers a good starting point, but is only just a part of the story. Here is the rest of the story:

- Initially, it is important that we begin by disarming our initial skepticism and simply acknowledge that there are, indeed, some basic brain wiring differences among us.
- Then, it is necessary that we accept the simplicity that with a brief vocabulary of just a few basic "Personality Style" terms, these differences can simply and easily be described and understood.
- Finally, we must trust that intuitively and instinctively we can be confident in our ability to understand the dynamics of this concept.

Even without any significant training of Personality Style, if we simply open our eyes the applications become obvious and we will see that the dynamics of this phenomenon are factoring in all around us. After all, these concepts set the tone and offer the foundation for what makes good drama and good comedy. For many, validation of this principle is to look no further than our spouse, as we tend to initially be attracted to the opposite style and therefore often choose partners who demonstrate complementary Personality Style traits and skills. The Amiable Personality often pairs with the Driver Personality, and the Expressive Personality often pairs with the Analytical Personality.

It is from these four types that we can build a simple vocabulary to understand the nature and Personality Style of one another's basic communication tendencies.

We can all be described as predominantly one of the following:

- **The Driver** — determined, efficient, decisive and practical.
- **The Expressive** — ambitious, stimulating, enthusiastic and dramatic.
- **The Analytical** — serious, industrious, persistent and exacting.
- **The Amiable** — supportive, dependable, agreeable and willing.

Awareness of these four descriptions quite often is all that it takes. By simply respecting and accepting our different natures, we can immediately relieve many of the frustrating bottlenecks and inefficiencies we run up against while communicating with the world around us.

However, taking the real working application of this to the next level requires one more critical step and one more very important word — "Versatility." It is when we choose behaviors that reflect Versatility that we can relieve much of the communications resistance that is created within interpersonal systems.

Versatility can best be described as "one's ability and willingness to be what other people need us to be in order to more effectively achieve our objectives together".

Versatility is a choice!

When dealing with the Driver, provide facts, be clear and specific, to the point and stick to business.

When dealing with the Expressive, offer personal experiences, take time to relate, be warm, outgoing and talkative.

When dealing with the Analytical, provide information and gain professional respect by establishing task-related competence.

When dealing with the Amiable, show warmth and sincere interest in them as people and don't be all business.

PERSONAL PRODUCTIVITY

> "Respecting and celebrating personality differences is just another way that interpersonal Best Practices can be achieved."
>
> — Pat Johns

Points to remember:

- Success does NOT depend on our Personality Style
- Success depends on our ability and willingness to be Versatile
- Simplicity is the key to utilizing Personality Style
- Acknowledge that just because a personality is different does not mean it is wrong
- Realize that often times the reaction we receive is not personal, it is just natural for the Personality Style of the other person
- Find humor in personality diversity, not frustration
- Show a willingness to laugh at yourself
- Make a conscious choice every day to utilize Versatility

By managing our expectations in the following ways, we will less often be disappointed and frustrated and more often find ourselves pleased and satisfied.

- Expect, celebrate and respect that the Driver personality will push towards the bottom line
- Expect, celebrate and respect that the Expressive personality will sell, sell, sell and fill the air with words
- Expect, celebrate and respect that the Analytical personality is willing to collect and utilize exacting data
- Expect, celebrate and respect that the Amiable personality will be there to support with warm relationships and customer service

Conclusion

Either we can consciously choose to communicate by using the Personality Style language of the other person, or we can continue to insist that others speak our language and then only hope that we have been understood. When in doubt, yield on behalf of the other person's personality and you will never be wrong! Respecting and celebrating personality differences is just another way that interpersonal Best Practices can be achieved.

Pat Johns will take your organization to the top! An expert motivator, Pat works with organizations that want to fast-forward their performance, productivity and profits. An expert athlete, Pat has competed in over 60 ultra-marathons and marathons worldwide. His sport: "endurance trail running." Upon completing the 2005 Himalayan 100, Pat became the only person to finish the high-altitude, 100-mile running race on the India-Nepal borders four times. However, Pat's story is not just about running; it's about how we change when we embrace any challenging events!

For more information contact PFJ Communications, tel: 214-695-0028, http://www.pat-johns.com/

RESOURCES FOR ENERGY ENGINEERS

TRAINING CALENDAR

TITLE	SPONSOR(S)	LOCATION	DATE	INFORMATION
Compressed Air Challenge® Fundamentals of Compressed Air	Southern California Edison, California Energy Commission, DOE EERE	Irwindale, CA	3/3/09	Adriana Chavez tel: 626-812-7563 Adriana.chavez@sce.com www.compressedairchallenge.org
Compressed Air Challenge® AIRMaster+	PG&E, California Energy Commission, DOE EERE	San Francisco, CA	3/10/09	Cheryl Boswell Barnes tel: 209-932-2500 cjb9@pge.com www.compressedairchallenge.org
Energy Management	Atlas Copco	Chicago, IL	3/11/09	tel: 847-981-8995 x200 (Giuliana)
Compressed Air Challenge® Fundamentals of Compressed Air	Hughes Machinery Omaha Public Power District, Atlas Copco, DOE EERE	Omaha, NE	3/24/09	Dennis Tribble tel: 402-571-5004 dtribble@netexpress.net www.compressedairchallenge.org
Compressed Air Challenge® Advanced Mgmt. of Compressed Air	Hughes Machinery Omaha Public Power District, Atlas Copco, DOE EERE	Omaha, NE	3/25/09	Dennis Tribble tel: 402-571-5004 dtribble@netexpress.net www.compressedairchallenge.org
Compressed Air Challenge® Fundamentals of Compressed Air	Sacramento Municipal Utility District, California Energy Commission, DOE EERE	Sacramento, CA	4/7/09	Nancy Kenney tel: 417-455-5402 Kenny-n@mssu.edu www.compressedairchallenge.org
Compressed Air Challenge® Fundamentals of Compressed Air	Hughes Machinery, Alliance for Bus. Education Missouri Southern State Univ. Atlas Copco, DOE EERE	Joplin, MO	4/15/09	Nancy Kenney tel: 417-455-5402 Kenny-n@mssu.edu www.compressedairchallenge.org
Compressed Air Challenge® Fundamentals of Compressed Air	PNM, DOE EERE	Albuquerque, NM	9/10/09	Carmen Chico tel: 505-241-4404 Carmen.Chico@pnm.com www.compressedairchallenge.org
Energy Management	Atlas Copco	Seattle, WA	5/20/09	tel: 206-244-3818 (Rawleigh)

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.

RESOURCES FOR ENERGY ENGINEERS

PRODUCT PICKS

New Direct Drive Rotary Screw Compressor

Quincy Compressor has introduced a new line of 20–50 horsepower direct drive rotary screw compressors. The units are quiet at 67 db(A) when packaged with a modular enclosure and 74 db(A) without the enclosure. A Siemens PLC-based microprocessor control provides efficient inlet valve modulation control and the ability to network up to six air compressors. A basic gauge control package is also available. All units feature a 10-year Royal Blue Warranty.®

The direct drive air-end uses no gears or belts. With a C-face mounted motor, power is efficiently transmitted directly where it's needed, ensuring smooth operation with no alignment issues. Easy maintenance is a key feature due to a unique horizontal separator tank and multi-service block allowing for optimized oil separation. This design enables the use of a spin-on filter, making separator maintenance quick and easy.

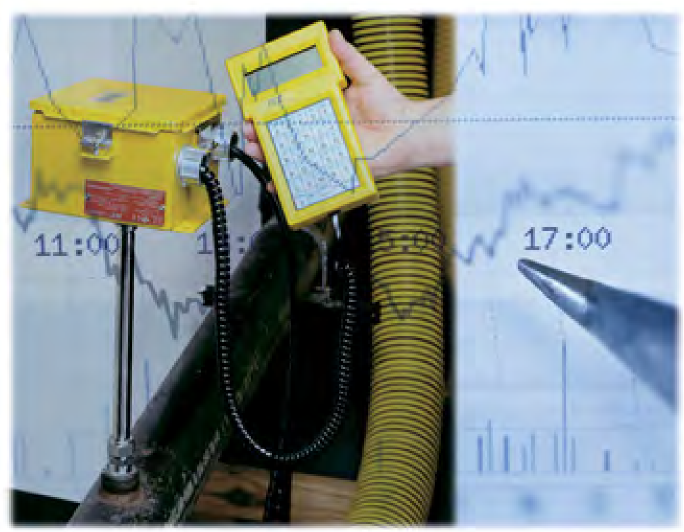
Quincy Compressor
www.truequincy.com

New Air Demand Analysis Program

Kaeser Compressors has announced a new comprehensive Air Demand Analysis program. This complete compressed air system audit uses state-of-the-art data loggers and precision sensors to create a detailed air usage profile for your individual facility.

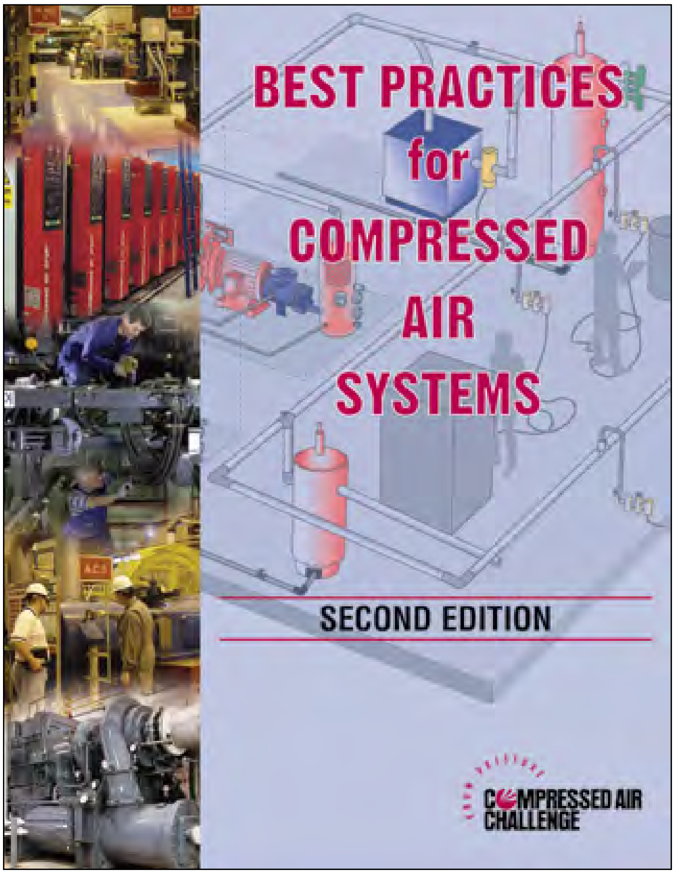
Kaeser's Air Demand Analysis monitors and charts air-flow, power consumption and system pressures during normal operating hours over a period of 10 days. Available for systems large and small, this exceptional tool creates a complete picture of air requirements including the relationship between peak and base load compressors and each compressor's duty cycle!

Kaeser Compressors
tel: 800-777-7873
www.kaeser.com/ada



LITERATURE PICKS

New Edition of "Best Practices for Compressed Air Systems®" from the Compressed Air Challenge®



The Compressed Air Challenge® has released the Second Edition of their authoritative "Best Practices for Compressed Air Systems®." The Best Practices manual provides tools needed to reduce operating costs associated with compressed air and to improve the reliability of the entire system. The 325-page manual addresses the improvement opportunities from air entering the compressor inlet filter, through the compressor and to storage, treatment, distribution and end uses, both appropriate and potentially inappropriate. Numerous examples of how to efficiently control existing and new multiple compressor systems are provided in one of the many appendices.

The Best Practices manual created by the Compressed Air Challenge® begins with the considerations for analyzing existing systems or designing new ones. The reader can determine how to use measurements to audit their own system, how to calculate the cost of compressed air and even how to interpret electric utility bills. Best practice recommendations for selection, installation, maintenance and operation of all the equipment are included in each section.

The Best Practices for Compressed Air Systems® manual is a product of the Compressed Air Challenge®, co-authored by Bill Scales and David McCulloch and is not associated with Compressed Air Best Practices® Magazine.

Compressed Air Challenge®
www.compressedairchallenge.org

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 in this column was gathered on February 9, 2009.

FEBRUARY 9, 2009 PRICE PERFORMANCE	SYMBOL	LAST PRICE	1 MONTH	6 MONTHS	12 MONTHS
Parker-Hannifin	PH	$41.91	-0.9%	-33.6%	-36.3%
Ingersoll Rand	IR	$16.93	-17.9%	-58.3%	-57.5%
Gardner Denver	GDI	$23.08	-5.2%	-50.1%	-29.3%
United Technologies	UTX	$49.60	-7.0%	-26.7%	-31.8%
Donaldson	DCI	$32.68	-0.9%	-29.1%	-21.6%
EnPro Industries	NPO	$20.83	-2.3%	-47.9%	-34.0%
SPX Corp	SPW	$49.78	12.3%	-58.0%	-52.1%

January 20, 2009 — Parker Hannifin Corp. (NYSE: PH) reported results for its fiscal 2009 second quarter ending December 31, 2008. Fiscal 2009 second quarter sales were $2.7 billion, a decline of 5% from $2.8 billion in the same quarter a year ago. Net income declined 26.7% to $155.4 million from $211.9 million in the second quarter of fiscal 2008. Earnings per diluted share declined 22% to $0.96 compared with $1.23 in last year's second quarter. Cash flow from operations for the first six months of fiscal 2009 was $444.5 million, or 7.7% of sales.

"Current quarter results reflect the fact that the global recession has deepened and widened in recent months and creates some uncertainty for the remainder of our fiscal year and throughout calendar 2009," said Chairman, CEO and President Don Washkewicz. "Although we are positioned to fare much better in this recession than in the past, current market conditions are unprecedented and have required us to lower our expectations for the year and reduce costs across our operations. As a direct result of the actions we have taken under the Win Strategy during the past seven years, including our ability to adjust and manage inventory on a real-time basis, Parker is better prepared to adapt to changing market circumstances and weather the challenges ahead."

In the Industrial North America segment, second-quarter sales increased slightly to $993 million, and operating income declined 24% to $107.6 million compared with the same period a year ago. In the Industrial International segment, second-quarter sales declined 11.5% to $1 billion, and operating income declined 34.3% to $115.1 million compared with the same period a year ago.

In addition to financial results, Parker also reported a decline of 20% in total orders for the quarter ending December 31, 2008 compared with the same quarter a year ago. Parker reported the following orders by operating segment: 18% decline in the Industrial North America segment compared with the same quarter a year ago, 28% decline in the Industrial International segment compared with the same quarter a year ago, 2% increase in the Aerospace segment on a rolling 12-month average basis and a 28% decline in the Climate and Industrial Controls segment compared with the same quarter a year ago.

For fiscal 2009, the company revised guidance for earnings from continuing operations to the range of $3.85 to $4.25 per diluted share. Previous guidance for earnings from continuing operations was $5.35 to $5.75 per diluted share.

"While the outlook holds many challenges, Parker has a seasoned management team that has experience managing through a downturn," added Washkewicz. "Workforce and expense reductions have been implemented throughout the company and contingency plans are in place should further actions become necessary. In short, we are prepared to adjust our costs appropriately to reflect changing demand levels. At the same time, we will stay vigilantly focused on long-term growth and are confident that we will emerge in an even stronger position as demand in our end markets improves."

WALL STREET WATCH

CHARLOTTE, NC — January 21, 2009 — SPX Corporation (NYSE:SPW) today announced its 2009 annual financial guidance. "We believe the company is well-positioned to meet the challenges ahead, including the uncertain economic environment," said Chris Kearney, President, Chairman and CEO of SPX. "In response to the current state of the global economy, we are initiating a number of restructuring actions for 2009 totaling as much as $65 million. We believe this positions us well given current conditions and continues our strategy of simplifying our business structure for the future."

Kearney said the company is committed to its long-term strategy of focusing on the three global end markets of global infrastructure, tools and diagnostics and process equipment. He also emphasized SPX's strong financial position. "Our available liquidity of over one billion dollars will provide us flexibility in making strategic capital allocation decisions. Our disciplined approach to capital allocation continues to generate positive returns as our recent share repurchases and the integration of the APV acquisition are helping to mitigate the economic and currency translation headwinds we face in 2009," he added.

The 2009 annual financial guidance for SPX includes:

Revenues are expected to decline between 7% and 12% to approximately $5.3 to $5.6 billion. Organic revenues are expected to be flat, down 5% from 2008, while divestitures and the impact of currency fluctuations are expected to reduce reported revenues by approximately 2% and 5%, respectively.

Earnings from continuing operations are expected to be $5.40 to $5.80 per share, down 10% to 16% from 2008. The company expects to incur $65 million, or approximately $0.85 per share, in restructuring charges in 2009. These charges are primarily focused on cost reductions in response to the slowing global economy.

Operating cash flow from continuing operations is expected to be in the range of $330 million to $370 million, while capital expenditures are targeted at $100 million. The resulting free cash flow target (cash flow from continuing operations less capital expenditures) is expected to be in the range of $230 million to $270 million. This performance represents 85% to 95% conversion of expected net income.

HARTFORD, CT — January 21, 2009 — United Technologies Corp. (NYSE:UTX) today reported fourth quarter 2008 earnings per share of $1.23 and net income of $1.1 billion, up 14% and 8%, respectively. Consolidated revenues for the quarter at $14.5 billion were lower than last year by 1%, with 3 points of organic growth more than offset by 5 points of adverse foreign exchange translation. Cash flow from operations was $2 billion and, after capital expenditures of $406 million, substantially exceeded fourth quarter net income.

"We remain confident that UTC's strong global franchises and experienced management team will continue to outperform even in this environment."

— Louis Chenevert, UTC President and CEO

Full year earnings per share of $4.90 and net income of $4.7 billion increased 15 and 11 %, respectively, from 2007 results. Revenues increased 7% to $58.7 billion, including 5 points of organic growth, 1 point foreign exchange, and 1 point net acquisitions. Full year cash flow from operations was $6.2 billion and capital expenditures were $1.2 billion.

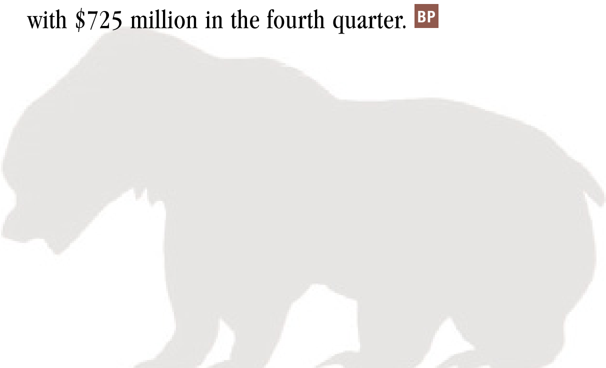
"UTC had a solid close to 2008 in spite of deteriorating end markets and currency headwinds. Solid margin expansion at the aerospace units and at UTC Fire & Security offset the impact of a sharp decline at Carrier," said UTC President and CEO Louis Chênevert. "Balance works at UTC. While Carrier saw organic revenue decline 7% in the quarter, all other units reported organic growth with Sikorsky at an exceptional 25%. New equipment orders at Otis declined 14% in the quarter, including 6 points from the stronger dollar. On a similar basis, Carrier's Commercial HVAC new equipment orders were down 7% (foreign exchange 3 points). Commercial aerospace spares orders in the quarter were just below sales at Pratt & Whitney and just above sales at Hamilton Sundstrand.

"We saw the impact of difficult economic conditions on our order rates and expect tough compares during the first half of 2009," Chênevert added. "We aggressively continue to reduce our costs and restructure our businesses in line with new market conditions. In the fourth quarter, restructure costs were $136 million and reached $357 million for the full year. We also expect to accelerate 2009 restructuring and launch approximately $150 million of actions in the first quarter.

"We remain confident that UTC's strong global franchises and experienced management team will continue to outperform even in this environment," Chênevert continued. "Accordingly, UTC confirms its prior expectation for 2009 earnings per share of $4.65 to $5.15."

Chênevert added, "Cash flow from operations less capital expenditures reached 105% of net income in 2008 with strong fourth quarter execution on collections and seasonal inventory reduction. We anticipate being at our usual standard of cash flow from operations less capital expenditures equal to or exceeding net income again in 2009."

Share repurchase in the quarter was $690 million and totaled $3.2 billion for the year. Acquisition spending, including debt assumed, was $1.4 billion for the year with $725 million in the fourth quarter. BP



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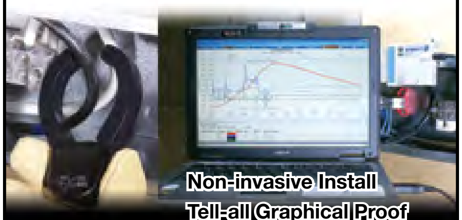

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