Automotive Assembly Audit Centrifugal Compressors

May 2008

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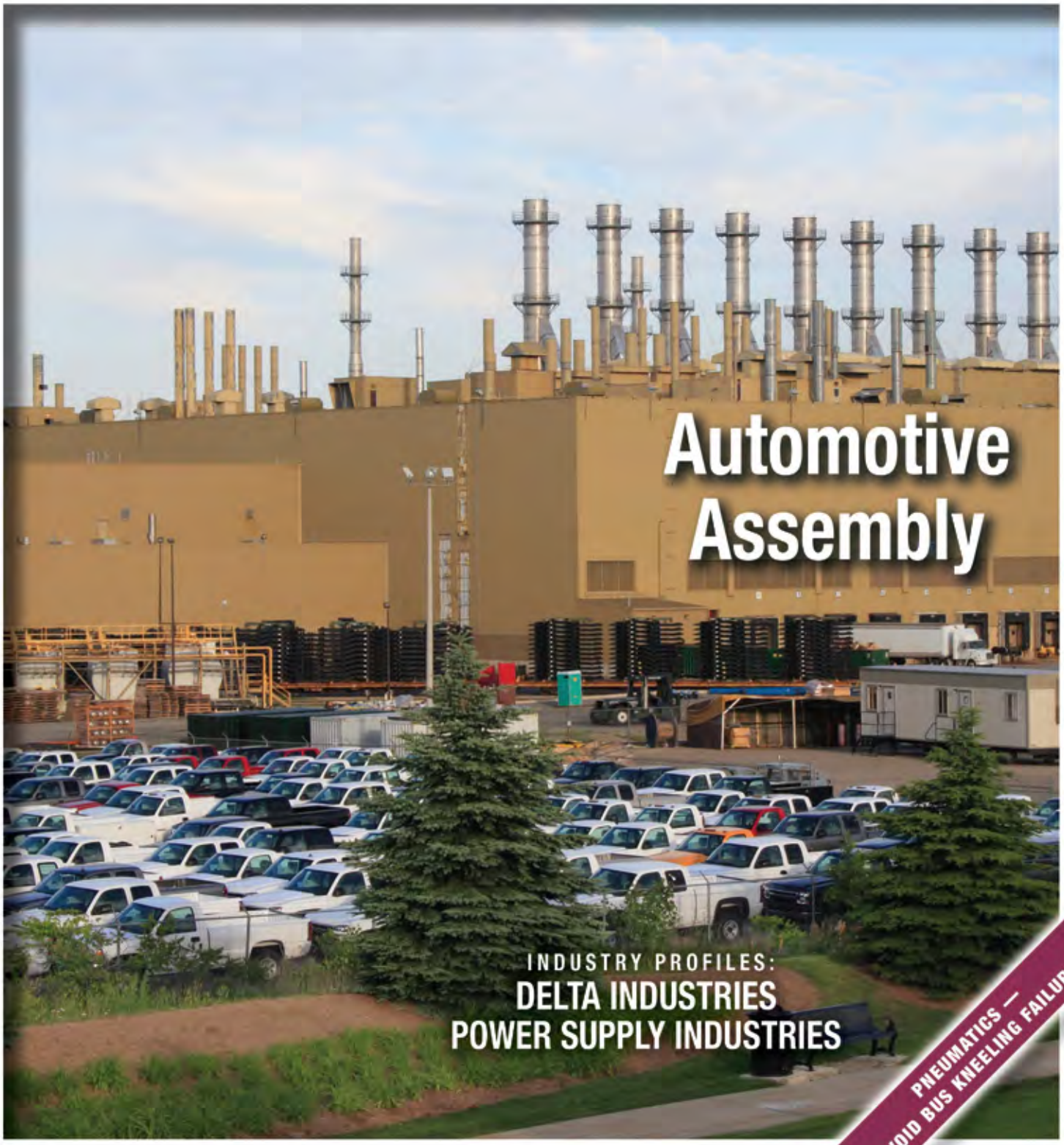

Automotive Assembly

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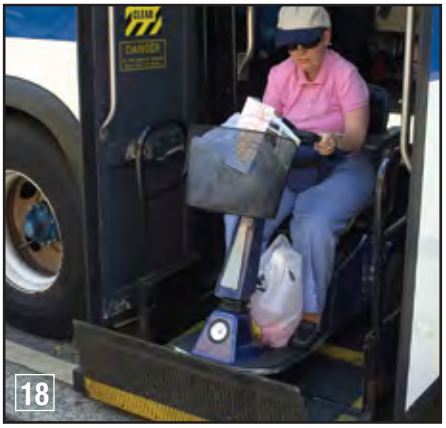

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FROM THE EDITOR

Automotive Assembly

Lean manufacturing has swept across the U.S. and nowhere has it been more necessary than in vehicle manufacturing. The ever-changing circumstances and production volumes in U.S. plants has made evaluating legacy compressed air systems more important than ever. This industry is ripe for energy-saving opportunities in their compressed air systems.

In our May Audit of the Month, Jim Timmersman shares with us a three-phase audit he is involved in with a automotive assembly plant. The energy savings opportunities identified sum close to $1 million per year. He outlines how he is working together with this firm to address this opportunity in three phases. The Phase 1 audit saves over $250,000 per year with a 10-month payback and 72% internal rate of return.

New technology in bus/coach kneeling modules are bringing opportunities to pneumatic system experts like Paxton Augustine of Parker Hannifin. His article in this month's edition examines ways to avoid making mistakes and having failures in these systems.

Starting air compressors for centrifugals is something that has been a problem for Big 3 automotive plants in the past. Every now and then, plants find that their starting air isn't up to the challenge and they experience down time. Hank Van Ormer provides us with a "Best Practice" article based upon his experience in Michigan solving these problems.

Finally, we profile two compressor distributorships with a great deal of experience with automotive assembly factories. Power Supply Industries and Delta Industries share with us some of their techniques and experience in optimizing compressed air systems.

A common thread I am observing, is the great need to better measure what is going on with compressed air systems. Measuring flow, dew point, amperage and pressure is necessary to understand your compressed air system. Measurement strategies then illuminate where all the energy saving opportunities are. It's actually not rocket science — compressed air is just a relatively unmonitored process in most factories.

In closing, I'd like to encourage the automotive assembly industry to continue addressing their compressed air systems and capitalize on the energy-saving opportunity they represent.

ROD SMITH


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UTILITY-AIR NEWS

Atlas Copco Inaugurates New Facility in China

Atlas Copco announced in March 2008 that it has inaugurated a new compressor manufacturing plant in Shanghai, China. The new plant is a part of Shanghai Bolaite Compressor Co., Ltd. and will strengthen the company's offer on the Chinese market.

Based in Jiading District Shanghai, the new production facility will manufacture piston compressors and oil-injected screw compressors below 450 kW. The new facility will not only include production capabilities, but will also include a customer center and a product development facility, employing a total of 265 people. "We believe our new state-of-the-art facility signals the start of a new phase for the development of the Bolaite brand and will allow us to better service the needs of our clients, and enhance our position in the fast growing Chinese market," says Ronnie Leten, President of Atlas Copco's business area Compressor Technique.

The new facility has been built in accordance with Atlas Copco's standard criteria, which include a concept for the basic factory layout and principles for marketing and after-sales services. Atlas Copco also requires environmental certification in compliance with ISO14000 and the new factory is therefore, amongst other things, equipped with an advanced sewage treatment system. Bolaite was established in 1999 and acquired by Atlas Copco in 2006. Over the years, Bolaite has built up solid sales and service structure, and has an extensive distribution network in China. The company is a part of Atlas Copco Compressor Technique's Industrial Air and Oil-free Division.

For more information visit www.atlascopco.com

EPA Energy Star 2008 Award Winners

The EPA announced in April their 2008 Energy Star award winners. Lowe's Cos. Inc., PepsiCo, Food Lion, LLC, Toyota Motor Engineering & Manufacturing North America Inc., Marriott International Inc., and 3M, are among those showcased in a report released by EPA for reducing greenhouse gas emissions through energy efficiency. The report, "Profiles in Leadership, 2008 Energy Star Award Winners," highlights 74 award-winning organizations across many sectors of the U.S. economy, including schools, hospitals, real estate, manufacturing, chemicals and home building. "EPA applauds these organizations for preserving our environment and our energy resources," said EPA Administrator Stephen L. Johnson. "Whether you are running a business or a school, these energy all-stars prove a brighter future starts with each of us." The award winners were selected from over 12,000 organizations that partner in the Energy Star program. Through their pioneering efforts, the winners have made substantial reductions in greenhouse gas emissions by means of energy efficiency and awareness. They include large and small organizations and those with long track records of success as well as those that are quickly excelling in their partnership. In 2007, Americans, with the help of Energy Star, saved $16 billion on their energy bills and avoided greenhouse gas emissions equivalent to those of 27 million vehicles.

For more information about Energy Star, visit: http://www.energystar.gov/awards

Pneu-Logic Partners with Ecos Air

Pneu-Logic Corporation, a compressed air energy efficiency company, has announced in March the formation of a strategic alliance with Portland, OR-based Ecos Air, an energy-consulting firm who provides electrical utility program assistance for Pacific Gas & Electric (PG&E) and San Diego Gas & Electric (SDG&E). Under the new partnership, Pneu-Logic will be providing system assessment and consulting services on behalf of Ecos Air, enabling them to serve a much higher number of industrial utility customers who have asked for assistance with their compressed air system from the utilities that serve them, as well as helping the customers reduce their carbon footprint. "This partnership will enable Pneu-Logic to enhance the already strong position Ecos Air holds with the various utilities they are already providing services for," says Bryan E. Anderson, Director of North American sales for Pneu-Logic. "Pneu-Logic's world-class engineering team will be able to provide Ecos with a level of service and quality that is unmatched in the compressed air industry today. We are excited to partner with such a reputable, well respected and professional organization in the field of energy savings."

Pneu-Logic Corporation, based in Portland, OR, provides comprehensive and expert compressed air assessment and consulting services for customers in all industries. Pneu-Logic has designed, patented and provides its customers with the most advanced compressed air management and control systems available today in the world, typically saving customers between 15% and 30% on their total annual compressed air electricity costs. Pneu-Logic and its authorized resellers have sales offices and operations located in the UK, South Africa, Italy, Germany, Taiwan and the United States.

For more information visit www.pneu-logic-corp.com

ASCO and Numatics Merge

ASCO and Numatics, business units of Emerson Industrial Automation, have merged operations in North America to form ASCO Numatics — a unified company that offers comprehensive flow control and pneumatics solutions for a wide range of industry-focused applications.

"The synergies from combining these two great businesses in North America will accelerate their growth in high-potential markets such as life sciences, pharmaceuticals, power generation and biofuels," said John Meek, President, Americas, ASCO Numatics. "We are the first company to combine a broad portfolio of highly reliable fluid power and control solutions with focused process expertise to generate lower cost of ownership, greater asset availability and improved productivity."

The ASCO Numatics product line in North America consists of more than 50,000 valves, an extensive selection of air preparation equipment and a comprehensive set of position indicators. ASCO products include solenoid pilot valves, angle body piston valves, linear and rotary indicators, valve monitoring systems, redundant control systems and pressure sensors. The Numatics line covers valve manifolds, filters, regulators, lubricators and dryers.

With the largest presence of any fluid power and control supplier, ASCO Numatics can deliver consistent local service and technical support anywhere in the Americas.

"Our designers, engineers and technicians are renowned for their expertise in solving the challenges of air and fluid flow," said Meek. "When these capabilities are combined with the exceptional quality and reliability of our products, customers benefit from faster installation, smoother system integration, reduced maintenance and a single point of accountability."

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

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Compressed Air Audit of the Month

Saving Energy in Automotive Assembly

By Jim Timmersman

May Audit of the Month

Where:	Midwest U.S.
Industry:	Automotive Assembly
Issues:	Flow and Pressure Fluctuation
Audit Type:	Supply and Demand Side

Financials

Investment:	$206,325
Energy Cost Before Investment:	$1,662,557
Energy Cost After Investment:	$1,400,024
Energy Savings/Year:	$206,325
Input kW Before Investment:	4,591 kW
Input kW After Investment:	3,866 kW
Input kW Reduction:	725 kW
Power Cost/kWh:	$0.04134
Operating Hours/Year:	8760
Project Life (years):	10
Power Cost Escalation (per year):	2%

10-Year Summary

Energy Savings Before Tax:	$2,668,557
Payback Period Before Tax (years):	0.79
Energy Savings After Tax:	$1,387,650
Internal Rate of Return After Tax:	72%

A. Introduction

This Midwestern automotive assembly factory has two major production areas called the "East" and "West" facilities. The objective of the engineering staff at this company is to optimize the compressed air energy costs as they relate to the number of vehicles manufactured per day. The task at hand is to continue to ensure the reliable supply of compressed air to all processes, while reducing the energy costs.

This article will describe the actions taken to reduce the energy costs. We are not at liberty to disclose the numbers pertaining to the numbers of cars manufactured. The facility operates "24/7" so we have 8,760 operational hours per year. The average electrical rate at this facility is $0.04134 kW/h. The energy formula used is:

kW = bhp *.746 * (1/Motor Efficiency)

Due to the size of the compressed air installations, we have broken the audit into three phases based upon our initial observations. *This article details the system configuration, measurements and recommendations of our Phase 1 audit* whose objective it is to reduce air consumption while stabilizing air pressure and capture the energy saving benefits of doing so.

Phase 1: Reduce Air Consumption While Stabilizing Air Pressure
Phase 2: Optimizing the Air Treatment System
Phase 3: Managing Air Leaks

B. Air System Configuration Review

The powerhouse supplies compressed air to both the East and West Facilities. There is a mix of centrifugal and reciprocating air compressors. The 600 hp (horsepower) recips are older and we observe a significant consumption of lubricant. The cycling refrigerated air dryers are rated for 20,000 cfm each. The air goes into a 12" header, which takes the air to the different facilities. The quality of the air leaving the powerhouse is an issue that will be part of our "Phase 2" audit looking at air quality. The powerhouse has the following air compressors and air dryers installed:

1. Powerhouse Air Compressors
   a. Five (5) 600 hp reciprocating compressors. They are water-cooled, oil-injected, twin-horizontal piston compressors. Each unit is capable of producing 2,500 cfm for a total of 12,500 cfm
   b. Five (5) centrifugal compressors producing a total of 27,184
   c. Total plant air capability for the West Facility is 39,684 cfm
2. Powerhouse Air Dryers
   a. Two (2) thermal mass, cycling refrigerated air dryers rated for 20,000 cfm each
   b. One (1) heatless regenerative air dryer rated for 165 cfm
   c. One (1) refrigerated air dryer rated for 100 cfm
   d. Total powerhouse drying capability for 40,265 cfm

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COMPRESSED AIR AUDIT OF THE MONTH

Saving Energy in Automotive Assembly

The East and West Facilities have been receiving compressed air loaded with moisture and oil for many years. Each department, therefore, has built their own protective installations of point-of-use air dryers to provide -40 °F pressure dew points. The dryers are all packaged with coalescing filters to provide filtration of oil aerosols and solid particulates. They are used to protect the processes in the body shop and painting areas (clear coat and base coat). The West Facility also has breathing air systems installed for the painting personnel. We see significant levels of purge air waste and again this will be detailed in Phase 2 of the audit.

The facility does have condensate drains of different types installed on the air dryers and on the receivers of the air compressors. There are no condensate oil/water separators installed in the facility. The following air dryers and breathing air systems are installed:

1. East Facility Point-of-Use Air Dryers
    a. Five (5) heatless regenerative air dryers capable of drying a total of 7,300 cfm
    b. Three (3) heated regenerative air dryers capable of drying a total of 5,200 cfm
    c. Total point-of-use air drying capability in the East Facility is 10,500 cfm

2. West Facility Point-of-Use Air Dryers

    a. Three (3) heatless regenerative air dryers capable of drying a total of 12,300 cfm

    b. Two (2) heated regenerative air dryers capable of drying a total of 4,200 cfm

    c. Two (2) heatless regenerative catalyst breathing air purifiers/dryers capable of drying and purifying 1,350 cfm

    d. Total point of use air drying capability in the West Facility is 17,850 cfm

The East and West Facilities have very limited air storage capabilities. When there are surges in plant air flow demand, there are no buffers. This causes the air compressors to constantly turn on (or just keep running) to meet demand. This is a key part of our findings as the air storage is incapable of meeting changes in air demand.

1. East & West Facility Air Storage Receivers

    a. Two (2) 2,500 gallon vertical receivers capable of storing a total of 668 cfm

    b. Five (5) 1,500 gallon vertical receivers capable of storing a total of 1,000 cfm

    c. One (1) 620 gallon horizontal receiver capable of storing a total of 83 cfm

    d. Total air storage capability in both the East and West Facilities is 1,751 cfm

C. Measuring Flow and Pressure

Flow Measurement

Measurements were taken "24/7" during a two-week period. Flow and pressure were measured at thirteen locations including the 12" header coming from the powerhouse, the 6" sub-headers and throughout the facility. Flow and pressure were measured during all three production shifts.

A first step to understanding your air system is to create a detailed list and block drawings of all the compressed air equipment in the system.

COMPRESSED AIR AUDIT OF THE MONTH

Saving Energy in Automotive Assembly

Peaks and valleys in air demand can be managed efficiently by air storage and flow controllers.

The flow measuring equipment used in this survey was an Insertion Mass Flow Meter calibrated for the corresponding pipe size transmitting a -5 to +5 VDC signal. The signal was transformed into meaningful data and a data sample was recorded every 0.5 seconds. Data was then transferred onto computers and analyzed with printout data summaries and data details.

The audit has reviewed the approximate surge flows at various distribution points to identify possible problems with pressure drop. The information gathered in this study indicates the plants ability to run at substantially lower pressure than the compressor rating of 110 psig.

We used pressure transducers and calibrated gauges to test the facility's compressed air system for static and dynamic air pressure. This test provides insight into the actual air pressure being delivered to the points of use, typically less than thought or shown on air regulator gauges, or other pressure gauges located throughout the compressed air system. This facility has very good main header distribution lines with some major problems in sub-headers with static versus dynamic pressure.

The second objective in the test is to determine the compressed air system's potential for an energy-saving flow controller application. Throughout our time walking through the facility, we asked different personnel what they thought the minimum acceptable air pressure required for their application was. The acceptable range was from a high of 90 psig to a low of 85 psig.

The probe locations and measurements were as follows:

	CFM			PSI		
PROBE LOCATIONS	**HIGH**	**LOW**	**AVG**	**HIGH**	**LOW**	**AVG**
Main 12" Line	23,551	5,714	13,540	99	92	96
Base Coat Dryer # 1	1,853	1,389	1,702	94	93	93
Base Coat Dryer #2	1,116	937	1,009	94	93	94
Base Coat Dryer #3	842	486	755	94	93	94
Clear Coat Dryer #1	1,304	695	904	92	89	91
Clear Coat Dryer #2	1,017	614	648	93	90	92
Powder Coat Dryer	1,986	365	1,397	94	84	92
Body Shop #1	700	408	609	95	94	94
Body Shop #2	1,497	978	1,336	95	93	94
Body Shop #3	907	636	793	95	87	95
Old Filter Location	2,248	1,336	1,874	95	93	95
6" Paint Feed Line #1	2,572	1,414	2,086	95	93	94
6" Paint Feed Line #2	2,703	1,814	2,407	94	93	94

The readings indicate significant changes in air flow demand during the day. The powerhouse air compressors are averaging 96 psi, but at times are producing 99 psi. This is well above the requirements of the facility. The flow demands are the biggest issue as we see tremendous peaks and valleys in flow production in the powerhouse.

The Base Coat area has a relatively stable demand situation while the powder coat area has some very large demand events. This is causing big swings in the 6" paint feed lines in each facility. The body shops #1 and #2 are also showing significant peaks and valleys in air demand.

EXISTING CONDITIONS	
Average Flow	22,221 cfm (6,107 (East) + 16,204 (West))
Horsepower On-Line	5,662 bhp
Pressure Range	87-108 psig
Avg. kW Usage	4,591 kWh
Compressor Energy Costs*	$1,662,577

POTENTIAL SAVINGS	
cfm Savings	1,112 cfm
bhp Savings	894 bhp
kW Savings	725 kWh
Operational Hours	8760/Year
*Cost Per kW	$0.04134
Total First Year Savings	**$262,553**

PROPOSED AIR SYSTEM	
Average Flow	21,109 cfm
Horsepower On-Line	4,786 bhp
Stable Pressure	95 psig
Avg. kW Usage	3,866 kWh
Compressor Energy Costs*	$1,400,027

EQUIPMENT REQUIRED:	
25,000 gallons additional storage for the East Facility	
25,000 gallons additional storage for the West Facility	
Two (2) flow controllers — one for each Facility	
Investment:	**$ 206,325**
ROI Estimate:	**10 months**

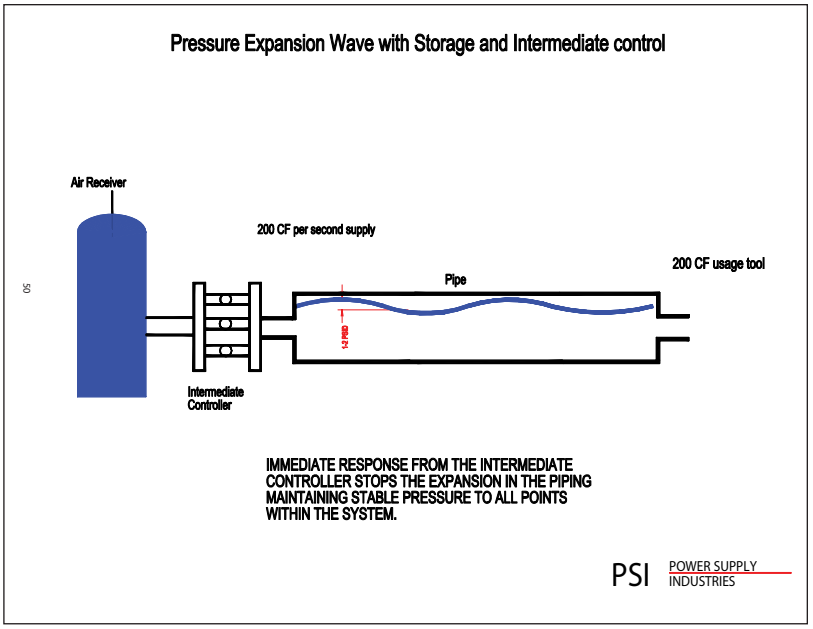
D. Recommended Actions

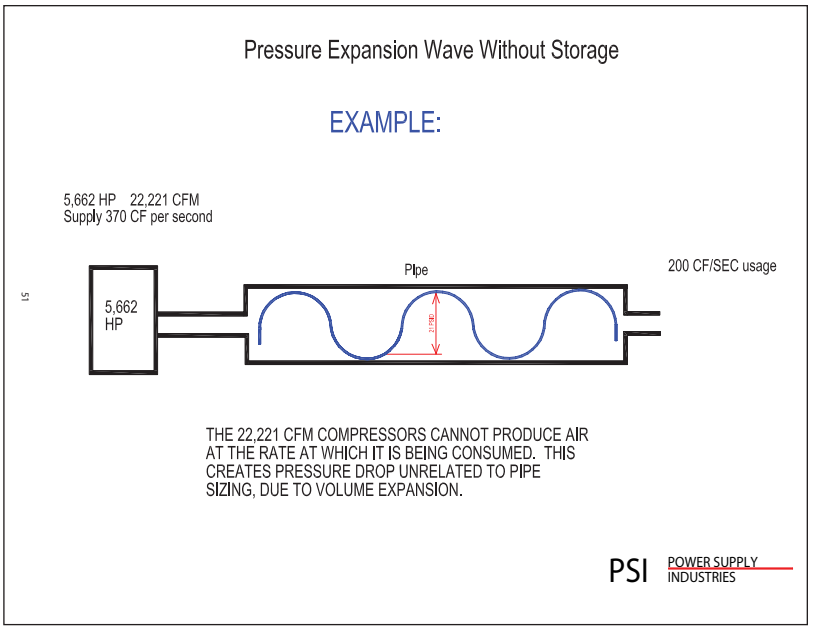
We can reduce the artificial demand of the air system through the use of storage and a flow controller to maximize horsepower on-line. Please note, the facility's rotary screw air compressors are set to run at 110 psig, yet we are operating equipment from 87–108 psig in the main distribution system. Artificial demand is demand created by increasing the pressure above the point actually necessary to run the plant.

We recommend that each facility (East and West) have a 25, 000 gallon receiver tank installed with a flow controller. The receiver tank will provide the air system with air during the frequent demand swings and protect the air compressors. The air compressors will be set to simply maintain a 95 psi pressure level in the receiver tanks.

COMPRESSED AIR AUDIT OF THE MONTH

Saving Energy in Automotive Assembly





This recommendation will convert the plant air system from a "REACTIVE" system to a "MANAGED" system. The combination of proper storage and an intermediate controller will result in energy savings and eliminate excess horsepower on-line while ensuring system integrity. Receiver capacity is needed to absorb the cfm demand spikes and to keep the input source(s) sensing average demand rather than peak demand. Without a controlled pressure differential on both sides of the receiver, there is no useful storage. Without storage, the system must allow system pressure to decay in order to use it.

Without proper storage, the system must operate at a higher-pressure with enough input generation on-line to adequately support any change or event which may occur in the system. No system can afford the financial and operational consequences of not having enough storage (capacity) to adequately satisfy the largest event without requiring additional horsepower.

These actions will allow the facility to reduce air consumption by 1,112 cfm, which translates into an air compressor average kW usage reduction of 725 kW/h. The estimated total savings will be $262,553 per year.

E. Conclusion

This automotive assembly facility has tremendous peaks and valleys in compressed air demand. Our audit, using flow meters and pressure transducers with calibrated gauges, has proven this. Our Phase 1 audit recommends the use of storage tanks and flow meters to reduce air consumption while stabilizing pressure. Implementing the recommendations in Phase 1 will provide estimated annual savings of $262,553 with an estimated payback of 10 months and an internal rate of return of 72%.

Once completed with Phase 1, we can embark upon Phases 2 and 3 of the audit (not outlined in this article). The Phase 2 audit will examine ways to reduce the significant purge air of the heatless desiccant air dryers (estimated annual energy cost of $312,380). The Phase 3 audit will examine ways to eliminate the significant levels of compressed air leaks in the West Facility (estimated annual energy cost of $487,076).

The Phase 1 audit and the preliminary findings for Phases 2 and 3 demonstrate that this automotive assembly facility can significantly reduce the energy costs related to the compressed air system per vehicle manufactured. BP

For more information, please contact Jim Timmersman, Power Supply Industries, tel: 314-277-1777, email: jim.timmersman@psiind.com, www.psiind.com

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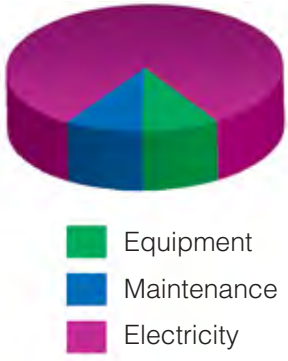

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How to AVOID the Most Common Bus/Coach Kneeling FAILURES

By Paxton Augustine, Product Marketing Manager, Parker Hannifin Corporation, Pneumatic Division

Overview

Kneeling modules are quickly becoming the centerpiece of accessible vehicle equipment. This trend began with passage of the Americans with Disabilities Act (ADA) in 1991. Prior to the ADA, about 40% of all transportation vehicles were accessible to persons with disabilities. Today, over 50% of a fleet owner's vehicles (e.g., public transit authorities and school districts) must be compliant with Title II of the Act, which explains the extent to which public transportation services are affected and how the Department of Transportation (DOT) will regulate requirements. By 2012, 100% of the vehicles in these provider's fleets must be accessible to persons with disabilities (except providers that meet the small business definition). For this reason, bus OEMs require that these modules are durable, compact and lightweight while withstanding harsh elements. Functionally, the modules must be able to deflate air bags on demand and lower the bus quickly to ease passenger entry. Conversely, the module must then inflate the air bags at a similar pace, enabling the bus to resume its scheduled route. Kneeling modules are designed for OEM installation on new vehicles and to retrofit older model vehicles.

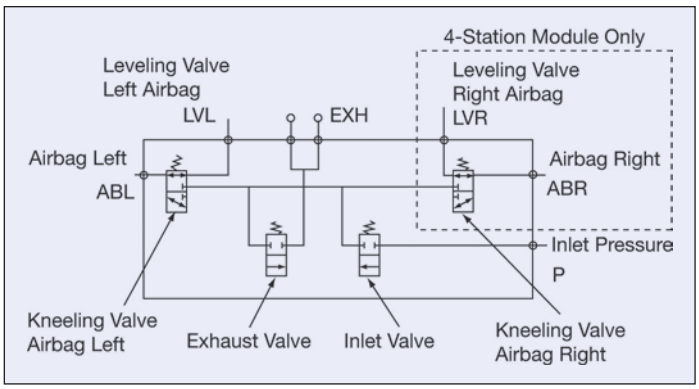

Figure 1: Pneumatic Circuit for a Kneeling Module – *Integrated valves in a singular kneeling module provide a compact unit with less tubing and fittings.*

Extensive testing must be performed to ensure that kneeling modules are reliable and durable enough to meet the demands of the Bus & Coach Industry. A typical bus kneeling application could see a module mounted to the exposed underside of a NYC transit bus where hundreds of stops are made per day in wintry conditions with temperatures reaching extreme negative degrees. If the kneeling module fails to perform as required, needless time delays result and passengers endure unnecessary difficulties in entering/exiting the bus. If the circumstances are severe enough, passengers may be denied entry on the bus due to their physical limitations that require the kneeling. This white paper addresses the **most common types of failure modes** regarding bus kneeling, along with the **causes for these failures,** and therefore what **design considerations** need to be incorporated into a kneeling module to prevent these failures from occurring. Extensive testing illustrates how these design criteria ensure optimum performance in a variety of harsh conditions while maintaining the durability and reliability of the module by minimizing component failure.

Failure Modes and Causes

What is a failure? If a product or system does not meet or exceed a customer's expectations in regard to performance, service, and/or quality, then a product failure results. The two most common failure modes for kneeling modules are life cycle failures and leakage failures. A **Life Cycle Failure** is when the product does not perform as promised. This is the most extreme failure mode. Many transit authorities and fleets will disable the vehicle's kneeling function as a result of continual inconsistent performance. This failure mode can occur for various reasons, from solenoid failure, to poppet or spool valves not shifting, to spring breakage. In the case of **Leakage Failures,** the product continues to perform, but excess air is wasted because of system leakage. This is considered a secondary failure

mode due to the lack of severity. Leakage failures can result in excessive noise either at the point of the leak, or quite often from the air compressor operating at a higher than normal cycle rate to maintain air system pressure. Not only is the noise pollution an issue for the driver and passengers, but more importantly, the wasted energy results in increased operating costs for the bus owner through more frequent maintenance and downtime from excessive operation. It should be noted that leakage failures that continue for an extended period of time can often escalate to more severe life cycle failures.

The three most common causes of kneeling module failures — whether life cycle or leakage — are **Temperature, Contamination and Vibration.** The following section details these three major causes of failure, along with summary highlights from a series of tests conducted to simulate these real-world applications with side-by-side comparison of multiple modules.

Failures Caused by Temperature

The most critical kneeling module performance requirement for bus OEMs and end-users (e.g., fleet owners) alike is to function properly in a wide range of temperatures. Both high and low temperatures cause failures. High temperatures can induce life cycle failures by causing seals to soften and wear too quickly. Solenoids failures can also occur due to overheating if the module sees temperatures in excess of 100 °C. Low temperatures, however, are by far the most common cause of both leakage and life cycle failures and, therefore, a more critical element around which to design a module.

Kneeling systems must be able to meet the industry standard requirement of performance at -40 °F (-40 °C). When temperatures reach extreme negative degrees, seals will begin to harden and stick causing a "no shift" failure mode to occur. When seals harden they are also more susceptible to becoming cut as the valve operates,

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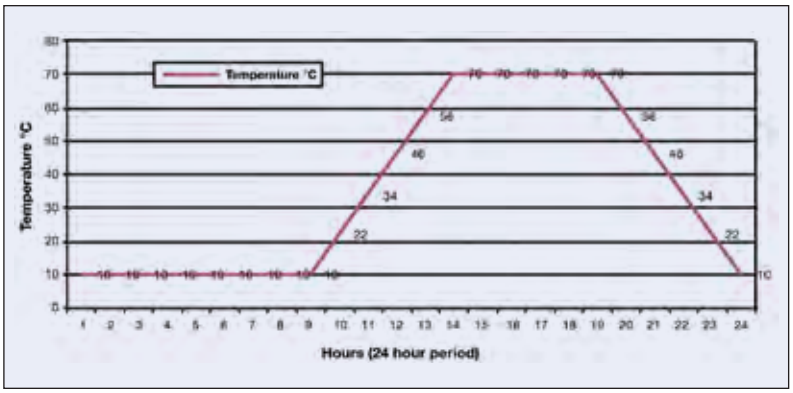
Figure 2: *Temperature test set-up*

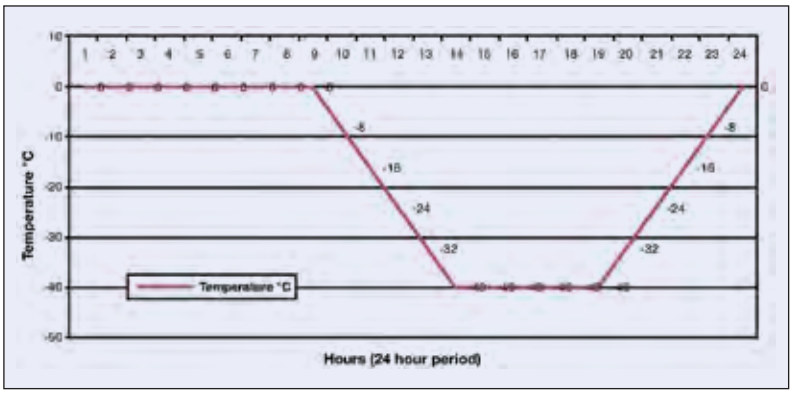
thus causing a leakage failure. Eventually the damage will be so great that a life cycle failure will result. Seal shrinkage due to extreme cold can also cause the valve to not seal properly, thus resulting in a leakage failure.

Dryers not installed and maintained properly in the air system that operates the kneeling module can also cause life cycle failures. Water in the air lines freezes when the temperature falls below 32°F (0°C) and causes the internal components of the module to no longer function because they have frozen together. Regardless of a kneeling module's ability to operate in extreme temperatures, an effective system must be provided (and maintained) to dry the system's compressed air. Unless moisture is removed from compressed air, it will condense as liquid water in the lines and cause line and component damage when it freezes. Even if freezing doesn't occur, water in the compressed air stream can wash away needed lubricants in cylinders and valves causing equipment malfunctions and premature component failure.

Many kneeling system manufacturers claim that their product will perform in extreme temperatures, specifically -40 °F. The question is how well? The only way to know for sure is by conducting a series of low/high temperature endurance tests that best simulate the real world conditions the module will be exposed to during operation. This test was performed on 10 kneeling modules.



This extreme hot temperature cycle simulates summer operation.



This extreme cold temperature cycle simulates winter operation.

Testing Method — Using 10 kneeling module,24 temperature tests were conducted. Six 3-station 24VDC and four 4-station 24VDC units were used for this test. With 100-psi air to each module's supply port, 6.5 cubic inch volume chambers connected to the right airbag and leveling valve ports, and 3 cubic inch chambers to the left airbag and leveling valve ports, the tests measured for leaks under the following conditions:

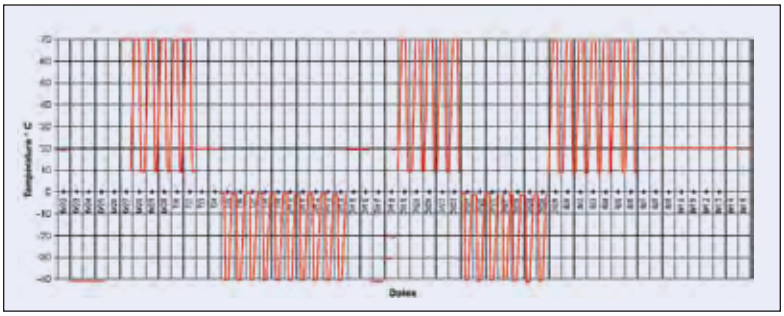
- Room temperature
- Low temperature and high temperature profiles; with and without a dryer
- Six- to eight-day duration cycling tests at different temperature profiles
- Sticking tests at different temperature profiles

As noted, the hot temperature profile shown in Figure 3 was used to simulate summer operation. The cold temperature profile shown in Figure 4 was used simulate winter operation over a 24-hour period. The temperatures ranged from -40 °F (-40 °C) to 158 °F (70 °C). All supply ports for each module were connected to a distribution manifold to allow total leakage to be checked individually by a flow meter. A Programmable Logic Controller (PLC) was used to time the exhaust from the modules to minimize air pressure spikes inside the chamber.

The PLCs were programmed to both automatically cycle the modules during normal testing or provide for manual control so that individual solenoids could be activated for leakage checks.

The cycle rate used for testing was 34 cycles per minute and the test duration equated to 20 years of intensive operation: 2,102,400 cycles calculated; assuming one (1) complete kneeling cycle every five (5) minutes for a non-stop duration of 20 years. Shown below in Figure 5 is the profile for the cycle testing as the modules were continuously exposed to either the summer or winter profile. Both seasonal profiles were alternated weekly throughout the entirety of the life cycle testing.

Endurance Test Time Line (Figure 5)



This extreme hot temperature cycle simulates summer operation.

An operational cycle for a 4-station unit:

- Supply, left and right airbag solenoids all on
- Supply, left and right airbag solenoids all off
- Exhaust, left and right airbag solenoids all on
- Exhaust, left and right airbag solenoids all off

An operational cycle for a 3-station unit:

- Supply, left airbag solenoids both on
- Supply, left solenoids both off
- Exhaust, left airbag solenoids both on
- Exhaust, left solenoids both off

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Figure 6: *Over-molded poppet removed from kneeling module after 2 million cycles*

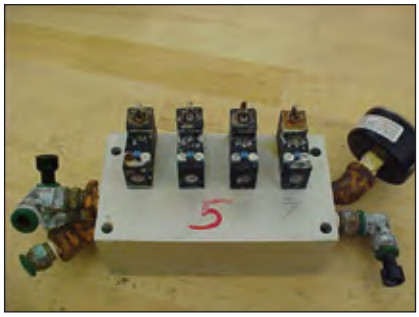

Figure 7: *Kneeling module after Salt Spray Testing*

Figure 8: *Salt Spray Testing performed on pilot operator and coil*

Test Results — At room temperature, all of the modules tested were leak free when solenoids were de-energized — normal ride mode for the bus. When filling airbags, all modules were also leak free. During the airbag exhausting phase, one 4-station module had excessive leakage due to an o-ring failure at the 800,000 cycle point (approx. 8 years). Upon completion of the cold and hot sticking tests, with the restoration of warmer temperature, all modules were leak free. All modules continued functioning during low temperature testing, but developed excessive leaks. As the test progressed, most of the low temperature leakage stopped when temperatures rose. Wear on the over-molded poppet (Figure 6), along with the poppet o-rings was minimal. Upon further examination after the completion of the test, it was discovered that the failed o-ring was due to a molding defect in the product and not as a result of the cycle testing.

Failures Caused by Contamination

While not as severe a factor as temperature, contamination is also a leading cause of failures of kneeling systems on busses and coaches. Contamination from weather and environmental conditions causes damage and potential failure to both the external and internal components of a kneeling module. External contamination to the module can eventually lead to leakage failures. Dirt and dust, water, salt, rocks and other debris can cause extensive damage to a kneeling module. For this reason, it is absolutely critical to design a system that will protect the module against these harsh elements. Internal corrosion is usually caused by contamination from water and/or oil from the compressor. This type of contamination can often lead to more severe life cycle failures. As mentioned above, if the system does not use a dryer to control moisture build up in module components and air lines, it can cause damage if the water either freezes or washes away lubricants needed to ensure that the module functions properly. Oil from other components of the air system can also cause damage to the module. This occurs when the oil has a reaction with different internal components. Seals suffer the most significant damage. A chemical reaction can damage seals significantly, thus reducing the life of the kneeling module.

Testing Method — For this series of tests, four kneeling modules were used to measure the module's performance in environments that cause contamination and corrosion — both externally and internally. The specific tests performed on these modules were **Salt Spray Testing** and **Oil & Moisture Injection Tests.**

During the **Salt Spray Test,** four kneeling modules were placed in a salt fog chamber. The chamber was filled with a 5% salt and water solution. Humidity and heat were added throughout the test. The modules were soaked in the salt mixture for 200 hours and, following completion of the test, were function tested one final time. A second salt spray test was also performed under the same test conditions, but specifically on the kneeling module solenoid. In order to isolate the solenoid from the rest of the module during the testing, the second test used transportation-rated inline solenoid valves that utilize the same solenoid technology.

To perform the **Oil & Moisture Injection Test,** four kneeling modules were connected downstream from a lubricator. An oil/moisture mixture was injected into each module at a rate of 3 cc per hour. The modules were then cycled at 18 cycles per minute continuously for 48 hours. Following the initial 48 hours, the modules were then tested for full function capability, as well as, all potential full system leaks using an upstream flow meter.

Test Results — All four kneeling modules functioned properly following the first 200-hour Salt Spray Test. Each unit showed some oxidation around the solenoid valves and steel pipe fittings; but there was no oxidation on aluminum parts or internal components (See Figure 7). Results of the second test showed that both solenoid and solenoid pilot operators were still operational after 500 hours of salt spray testing. The solenoid mounting screws were heavily oxidized at the completion of the soak test. See Figure 8 below.

The Oil & Moisture Injection Test proved to be more demanding than the Salt Spray Tests. Two of the four kneeling modules functioned properly throughout the entire test, but the remaining two units stopped functioning after 14 hours of cycle time. At the end of the cycling, however, all four units functioned properly and did not leak. A cause for the two units failing to cycle the entire test could not be determined.

Failures Caused by Vibration

Vibration is the third major cause for leakage and lifecycle failures in kneeling modules. If not designed properly into a product, fasteners, springs, connectors, fittings and other components have the potential to vibrate loose, break or general component failure can result due to shock G vibration force.

Testing Method — Four 4-station modules were mounted on a vertical axis. Four bolts were used to attach the module to a fixture; 120 in-lbs of torque was applied. A five (5) minute resonance sweep was performed to determine peak frequency (10-2500Hz at 2Gs) and then a durability test for 100,000 cycles was performed at that frequency. These procedures were then repeated for both horizontal and lateral axes. See Table 1 below.

Vibration Test — (extracted from test report provided by Intertek)

TABLE 1 – DURABILITY TEST FREQUENCY

BLOCK	VERTICAL AXIS	HORIZONTAL AXIS	LATERAL AXIS
2	242 Hz	246 Hz	387 Hz
3	250 Hz	275 Hz	424 Hz
4	229 Hz	260 Hz	200 Hz
6	293 Hz	301 Hz	427 Hz

Shock Test: 22G, 11ms pulses

10 positive pulses and 10 negative pulses

Random Vibration: 10 – 1000Hz

15 GRMS

1-hour duration

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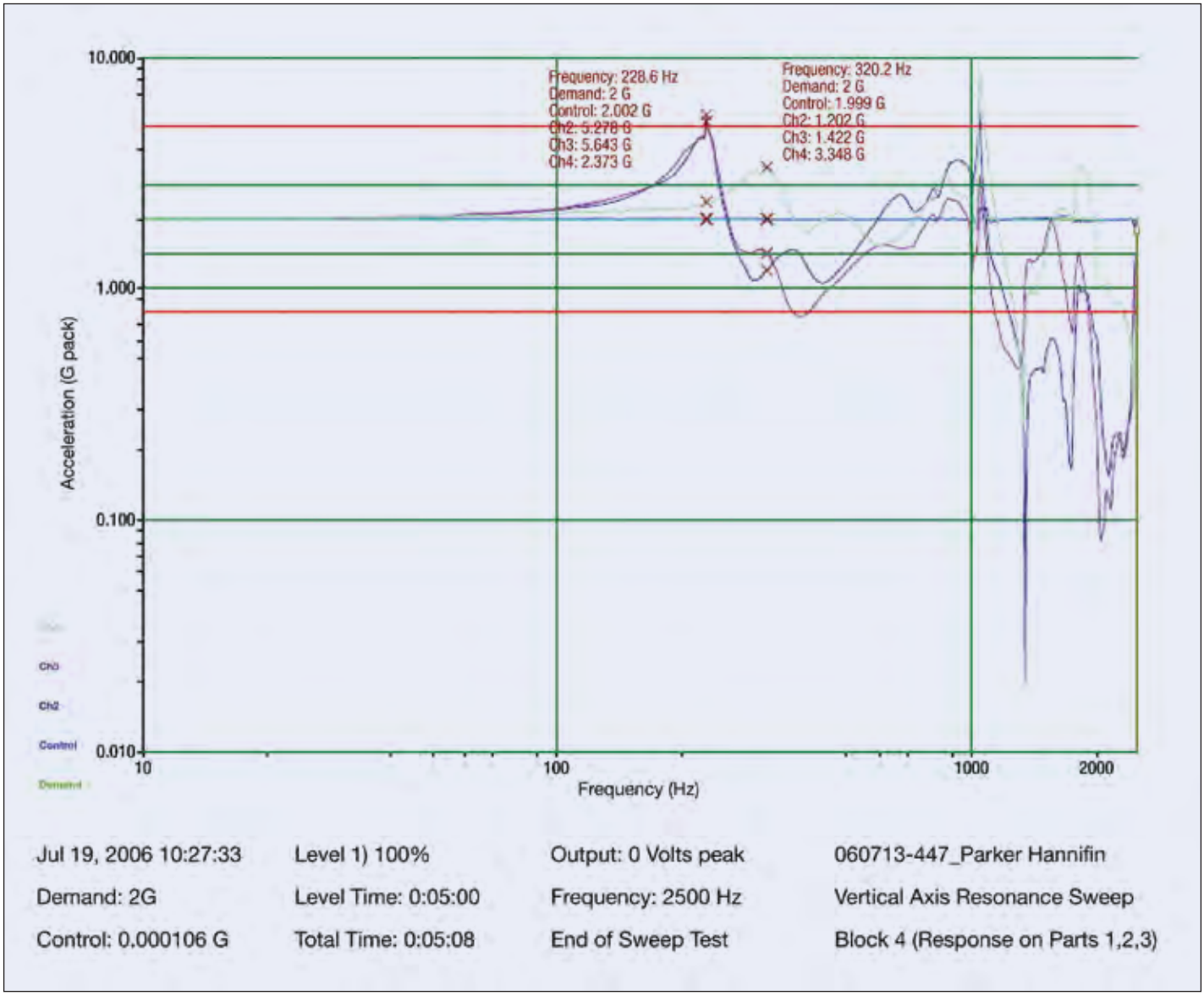

Figure 9: Lateral axis set-up

Test Results — All four modules tested and all of the solenoids were fully functional after each test. Additionally, module number four was subjected to additional shock and random vibration in each axis. Following each profile the solenoids were checked for functionality.The test proceeded axis by axis in the following sequence: resonance sweep, durability, function check, shock test, function check, random vibration and a final function check. The block worked properly after each step. Functional checks were performed by using shop air (nominal 90 psi). The solenoids were cycled manually to permit audible detection of any malfunction (Figures 9 and 10). The supply valve on the module was opened, the left valve checked, followed by the right valve. The exhaust valve was then opened to release trapped air.

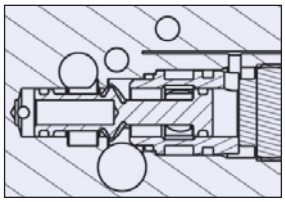

Figure 11: *Cross-sectional view of an over-molded poppet assembly*

A Kneeling Module Designed for Reliability and Durability

After careful examination of all modules used for each series of test, the following is a list of the key design considerations identified that directly contributed to the successful results discussed in the previous section.

Single-Piece Anodized Body — This critical component of the module is the core to the entire design. The kneeling module's anodized body, along with other internal aluminum components, allows it to withstand harsh environments. Much of the success of the modules tested was directly influenced by the anodizing process these modules underwent during fabrication. **Other Observations —** Precision machined internal parts, as well as, the stainless steel return spring, designed specifically for the transportation industry, also contributed to the testing success, and ultimately ensuring a long operating life in the field. A single body design allowed for the flexibility to build three or four station modules from one component. A one block design for both versions also resulted in the same bolt hole pattern and connections for test setup. As a result, labor costs for assembly can be reduced in the field due to fewer components, connections and tubing. Fewer connections equate to fewer leak paths than with multiple valve assemblies and fewer components to purchase. The module size was also an added benefit as it is easily able to fit in tight spaces. Also, the module was designed so that components can be easily replaced if necessary.

Over-Molded Poppet Valve Design — Although listed second, this key design point is certainly just as important as the first, if not more. The life and performance of the kneeling module rests almost entirely on the performance of this component. The quality of design and manufacturing of the poppet valve can both influence the life cycle failure mode, as well as, the leakage. The poppet assembly was also the most affected by all three failure mode causes identified (temperature, contamination and vibration) and, as a result, was the most affected component during all the various tests conducted. **Observations —** This low-temperature compound, precision ground poppet design, versus a spool design, was much better suited for harsh environments. A special over-molded rubber was used on the valve, which is suitable for both low and high temperature applications, ranging from -40 °F to +158 °F. Since the valve was designed with fewer components, there were less possible failure modes as a result. Performance wise, the valve's higher flow rate allows the bus to raise and lower at a faster pace compared to other modules observed.

Low-Temperature Dynamic O-Rings — These seals, used in conjunction with low temperature grease, allow the module to operate at optimum levels in harsh transportation environments. As stated previously, the two dynamic o-rings along with the precision ground poppet are the most critical internal components that ensure the module will be able to withstand the temperature extremes and corrosive environments.

Exhaust Protectors — These devices act similar to a check valve as they permit unrestricted airflow during system exhausting, but also prevent air and, more importantly, external contaminants such as dust, dirt, salt, water and snow to make their way back into the valve.

Transportation-Grade Solenoid & Pilot Operator — As mentioned in the salt spray testing section, this same pilot operator and mobile solenoids (22-mm grommet with 18" flying leads) are used on both this module and another transportation rated inline valve. The solenoid and pilot operator are both temperature rated to -40 °F to +158 °F (-40 °C to +70 °C) along with voltage characteristics of +/- 30% of rated voltages. Additionally, the ruggedness of the pilot operators can be witnessed by their maximum pressure rating of 232 psig (16 bar).

Conclusion

While no controlled environment test will ever replace real-world application testing, the severity of the above series of tests shows that as the transportation industry continues to grow, the performance level of the products being supplied to OEMs needs to improve at a similar pace. For this reason, OEM bus companies and fleet owners are looking to companies that specialize in motion control systems, specific to the transportation industry, to develop **better products with superior performance** that will also simplify installation, reduce maintenance requirements and parts inventory, as well as, employ designs that consider space limitations. BP

For more information regarding the products referenced in this white paper, please visit www.parker.com/pneu/kneeling

Real World Best Practices

by Hank Van Ormer

GUIDELINES FOR STARTING AIR FOR CENTRIFUGAL COMPRESSORS

I. Introduction:

Centrifugal compressors, when shut off, often need a source of "instrument" quality compressed air volume (scfm) and pressure (psig) in order to restart. If the machine is off but the system is "pressured up" with other compressors on, this is not a problem and the "starting air" is available from the main air system supply.

On such occasions when the total air system is off and at no pressure — such as during a power failure — a separate source of the proper volume and proper pressure must be available to start most centrifugal compressors.

Sometimes this can come from other non-centrifugal compressors (positive displacement), which are part of the air supply, but other times only centrifugals are available in a powerhouse.

What size compressors at what pressure is needed? What dictates this requirement in most commercial centrifugal air compressors? How is the best way to supply the air so it will be of proper quality and volume, "always available", when needed? The economic cost of not being able to start the air system in a major plant (centrifugals are often the compressor of choice — 1,000 hp and up) can generate very significant dollars very quickly. Centrifugals are usually on larger air systems — i.e. plants with high fixed costs — unscheduled loss of production is to be avoided.

II. Various methods and equipment used for centrifugal start up air — *basis 1,000 hp compressor, nominal 5,000 scfm @ 100 psig*

Different sized air compressor packages from 10 hp to 75 hp or more. Packages installed with air receivers, dryers, filters, etc., to deliver instrument quality air.

Different types of air compressors: lubricated, oil free, and non-lubricated have all been used somewhere.

- **Lubricated compressors:** oil is in the compression chamber and must be removed.
- **Oil-free –** no oil in the compression chamber but there is oil in the drive train. The most common type would be a reciprocating single or double acting cross head design with "distance piece" to stop the oil from migrating up the piston rod into the compression area.
- **Non-lubricated —** there is no oil in the compression chamber or anywhere else in the unit.

Obviously, when the presence of oil is to be avoided, the *non-lubricated* type would inherently be the most reliable from an "oil carryover" standpoint. This design has historically been a smaller reciprocating compressor (25 hp and smaller), usually air cooled with very limited duty cycle, often 1,000–1,500 hours between overhauls.

Centrifugal compressors are "oil-free type" usually with a lubricated "bull gear type" drive.

The preferred source of starting air is non-lubricated since oil getting into the centrifugal compressor is not only an inconvenience, but unchecked can lead to premature failure. In reality, the starting air is not often run to the compressor.

Stored bottles of nitrogen can be a proper supply of inert, clean, dry gas used to supply starting air. It can be stored at very high pressure and regulated to lower pressure flow which will allow the proper volume of air to be stored in a smaller area — that is, if you know the volume. Nitrogen as a start up gas has several drawbacks:

- Relatively expensive
- Often is "borrowed" for another use
- Small leaks may be undetected — during the long time between uses they may not have sufficient volume to do the job
- Undersized for the job either initially or because of a change in situation — i.e., leaks on valves, control lines, seals, etc.

III. Common problems with a centrifugal compressor starting air system:

- Used for another process — not available when needed. The average centrifugal in a multi-unit installation probably only needs starting air once every three years, or less, but at that time it is very critical.

  Often during the long unused periods of time, other users "temporarily" tap into this starting air supply "because it's there!" When starting air is called for these other users will also be on, not leaving enough to start the compressor.

- Air is needed — the start up compressor is not in condition to run
  - Used for various other services — not maintained
  - Sits for 3 years or more — becomes somewhat forgotten
- Starting air compressor runs OK — can't handle the load
  - How much (cfm) did you size for?
  - Did it used to do the job when new?
  - What has happened? Can the air requirement change?

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GUIDELINES FOR STARTING AIR FOR CENTRIFUGAL COMPRESSORS

IV. Identifying the starting air compressed air demand

Identifying this demand is very complex — it varies by manufacturer and basic design. It varies by accessory selection. It varies by the units overall condition and what type of maintenance it receives.

To develop this section we reviewed the training material, operating/installation manuals and other published data from the four major centrifugal manufacturers used in North America.

We also went back to models from the 1970s, 1980s, 1990s and current units. We interviewed manufacturer field service personnel, user operating personnel and other knowledgeable people.

Buffer seal air: Of the four leading manufacturers supplying centrifugals in North America, two of them use similar versions of double labyrinth seals. These seals require air injection or "buffer air" between the two sets of seals to assure no oil migration from the shaft lubricating oil to the compression area.

Reviewing various installation manuals, we found a 10 to 20 cfm demand for instrument air. Instrument air has been defined as refrigerated dryers with 5 micron filtration to .01 micron particulate filtration.

> "In the field, we have observed centrifugals with more than 100 cfm of leaks in the flanges and valving."

Realizing that the larger the compressors and the seal itself, the more buffer air may be required. We have also found a more specific reference to seal air estimated flow volume. This data was confirmed by engineering and service personnel of several manufacturers.

Typical flow values for buffer air:

- New — 1% of total flow
- Worn — 3% of total flow

What else may affect the actual value of "seal buffer air":

- Adjustment and condition of seal air regulator — normal setting at 6 psig
- Adjustment of bleed off valve if used

These are estimated values. For any specific compressor, check with the OEM.

Let's see what this means: At a 10–20 cfm demand, we are in the 5 to 10 hp aircooled, single acting, reciprocating class with a 120 gallon air receiver or larger at 150–175 psig. The maximum flow available with a typical industrial 10 hp compressor would be about 30 cfm at 175 psig — regulated to* 10 psig (or lower) with an estimated regulator droop of 20 psig. We would have about 140–160 cfm of stored air that could be bled out of the tank to augment the compressor flow if the demand was to exceed its capacity.

A typical 1,000 hp compressor delivers 5,000 cfm — 1% buffer air when new is *50 cfm demand*. At this level, the 10 hp unit would be able to stay on about 2–3 minutes supplying buffer air. If the seal wears to the full 3%, this demand will go to 150 cfm — the run will last just a little over 1 minute.

Of course, this is only the buffer air — demand does not include the air required for the various controls.

Summary: An older centrifugal with buffer air and "worn seal" will use up to 150 cfm per 1,000 hp of instrument air at about 10 psig unless otherwise stated. If there is an adjustable bleed, there may be an additional 15–25 cfm demand.

* Normal buffer air is 5–7 psig with the auto cutoff usually about 2–3 psig. The higher the pressure, the higher the flow.

Two of the four centrifugal manufacturers *do not need buffer* air for their *single labyrinth seal design*. They may employ an air driven venturi vacuum generator or ejector. This uses about 16 cfm at 30 psig but **is not required for start up**. The venturi vacuum generator or ejectors are used to pull a vacuum on the oil sump to eliminate oil migration and optimize oil flow. These air operated ejectors can be replaced with an electric driven model by at least one manufacturer.

Control Air: If identifying the probable buffer air is somewhat complex, so too is identifying the control air. All centrifugal compressors will require this in some manner to start with some exceptions.

Most of the units in the field have pneumatic operated control valves for the inlet guide vanes or an inlet butterfly valve and the blow off valve. There may be some other standard operating pneumatic operated control valves on some models.

The air flow required to operate these is very low when in new operating condition; i.e., no leaks — no blown seals — no ruptured diaphragms — etc. One manufacturer sets this minimum volume at 10–25 cfm and this is probably very accurate. Depending on the design, the pressure requirement can vary from 40 to 80 psig. If all the valves are in the closed position, the start up can possibly occur at much less flow and pressure. However, good sizing would allow for higher pressure to activate the valves and enough air to handle a few leaks and worn valves — i.e. 25 cfm @ 80 psig. New units can all be ordered with electric operated valves if desired. Pneumatic valves can also be changed to electric operated in the field, but all things considered, this may not be very practical. Many operators perceive pneumatic valves more reliable than electric and feel pneumatic Venturi valves are much less prone to sudden failure.

Other compressed air demand that may also exist on the unit being started:

Cabinet cooling — Many factory packages (particularly in older units with hard wiring and/or solid state controls) will come with an air operated vortex type refrigerated cabinet cooler installed on the control cabinet.

These will generally use 15 to 30 cfm of air at pressures from 50 to 80 psig. Applied correctly, they should use the highest pressure with

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the lowest flow generator. This will develop the most temperature drop, 70–80 °F and when equipped with a proper temperature control to shut off the air when not needed, they will only use the actual required air.

In the real world, most of these are installed *without* this shut off and should be modified. This air has to be considered in the total instrument air.

Recommendation: A cabinet cooler is not required to start the compressor, and if one is in place, it should, at a minimum, be connected to the compressor starter. When the unit starts, it should activate a timer to **open the air to the cabinet cooler 15 minutes after start up** so it won't expand the control air start up flow demand. Investigation may reveal that cabinet cooling is not required particularly if the electrics have been updated.

Other constant bleeds:

There are other constant bleeds that may or may not be part of the main air supply which, *if not removed* at time of start up, will have to be considered. Many of these, like the cabinet coolers, *will not* be required for start up and can be bypassed during start up as described with the cabinet coolers. To be sure, always check with the OEM's service and/or engineering group before taking any specific action.

Some of these are:

- Balancing control regulators with a small constant bleed
- Seal air bleed off if used
- Control valves with constant bleeds
- Venturi vacuum generators to evacuate certain areas such as control cabinets, oil sumps, etc. This can range from a constant bleed of 10 cfm to 25 cfm with a probable average of 15–20 cfm.
- Condensate drains kept open all the time by plant personnel or a "vee notch" ball valve designed and applied not to completely close. There will be a minimum of one per intercooler and aftercooler, plus potentially any "wet air" risers. This demand is usually around 20–25 cfm; however, it can be much higher.

And the most obvious — **LEAKS.** In real life there will always be leaks. The volume or magnitude of these in the compressed air supply package is very dependent on the quality and level of maintenance.

Some of the obvious leak locations are:

- Small to medium size (2–10 cfm): Hose/pipe connections; unions; cylinder/valve connections; push/pull connections; quick disconnects; regulators; filters, etc.
- Large to extra large (15–30 cfm or larger): Leaking or misadjusted blow off valves; flange connections between stages; discharge air to aftercooler; worn control valve bodies/cylinders; etc.

In the field, we have observed centrifugals with more than 100 cfm of leaks in the flanges and valving.

V. Establishing general packaged system specifications for optimum centrifugal starting air by type and size of the compressors

General specifications and action guidelines:

- Main air supply should be from a non-lubricated or oil-free compressor or properly filtered lubricated unit
- Package to be aircooled for flexibility and portability
- Package dedicated *only* to centrifugal start up air
  - Run 30 minutes once a month to be sure of availability
- Pre-selection work: Working with professional service support, identify any constant bleeds and isolate the demand from the start up as required
- Determine the need for (or no need for) seal air
- List all the control valve, leaks, open bleeds, etc., that can be identified.
- All distribution tubing/piping should be sized to the maximum potential flow and should be of non-corrosive material to avoid self generating contamination.
- The air delivered to the compressor should be clean and dry — defined as "instrument air" — in reality, we have three choices of types of dryers: **refrigerated, desiccant or membrane.**

Refrigerated dryers have been generally satisfactory in the past, but the +40 ºF or more pressure dew point can be high enough to have some liquid water in the compressed air — particularly the control air.

REAL WORLD BEST PRACTICES

GUIDELINES FOR STARTING AIR FOR CENTRIFUGAL COMPRESSORS

Refrigerated dryers do not do well in a "start up" situation. They have to come on and "cool down" before they can handle a load of air to dry. This can be up to one hour of operation depending on the size and model; otherwise, they will deliver "wet air" to the system. This limitation really makes them unacceptable as a source of dry air for starting air. It is interesting to note that we have observed many field starting air systems with refrigerated dryers. However, when the starting and pressurization sequence takes less than 30 minutes to 1 hour, the refrigerated dryer will probably not meet the specification.

Desiccant dryers offer a -40 ºF pressure dew point or lower. They do have several drawbacks:

- The bed can become saturated over time if the valves are not shut or leak. If this occurs, the initial start up air may be wet.
- Desiccant dust can be a significant problem when a new dryer is received and/or a new bed of desiccant is installed. The after filter is designed to handle this but it would be very critical if the dust got into the starting air system.

Heatless desiccant dryers also use about 15% of the *rated flow* for pure air — this too must be considered when selecting the air supply. In reality, on a short run, a well maintained heatless desiccant dryer will usually perform well.

Membrane dryers — the membrane dryer also uses purge or sweep air *but only* proportional to the *"actual flow demand"* — not always the full "rated" flow. Membrane dryers offer a very solid +35 ºF pressure dew point with the ability to sometimes reach +10 of pressure dew point. They need no warm up time and there is no dust generated to worry about.

Producing and drying the air at 120 psig to a 35 ºF pressure dew point will remove about 89% of the water vapor. A 35 ºF PDP and 120 psig, the membrane dryer will offer the following operational system pressure dew points:

Buffer air: 7 psig = @ -10 ºF PDP
Control air: 80 psig = @ +25 ºF PDP

Both of these operational pressure dew points should be very effective.

This will require very stringent filtration (.01 micron particulate) to protect the membrane which will also deliver "clean air" to the buffer and control air.

The membrane dryer has the best initial cost after a refrigerated dryer.

Drying the air at a higher pressure and then using it at a lower pressure will have the effect of "Lowering the System Pressure Dew Point".

Summary: We believe the membrane dryer with proper filtration will perform as required for this application. Considering the initial price, flexibility, predictability, performance and ease of installation, this would be *our dryer of choice*, particularly with an internally cooled rotary screw. The next dryer of choice would be an appropriately sized heatless type.

VI. Start up compressed air sizing recommendations by type and size of centrifugal compressors

Selecting and sizing a "standard" unit for this application is made very complex because of the leakage factor that could exist. The other variables are very identifiable and a clear predictable maximum demand can be established, if required, which is both unit and site specific.

To set up the following matrix for volume (cfm), we are assigning 50 cfm of leaks including condensate drains and 25 cfm of other open bleeds as a maximum demand. Installations that have such leaks and drains that would exceed this on this unit to be started should address the correction of them or at least take control steps to block them off at start up.

Condensate drains can be modified (if approved by maintenance) to level activated, electric actuated such as the capacitance tube moisture sensing drain which should not be open during start up.

AIR USAGE — MAXIMUM CFM EXPECTED	500 HP		1000 HP		1500 HP		2000 HP	
	DOUBLE SEAL	SINGLE SEAL	DOUBLE SEAL	SINGLE SEAL	DOUBLE SEAL	SINGLE SEAL	DOUBLE SEAL	SINGLE SEAL
Normal flow	2500	2500	5000	5000	7500	7500	10,000	10,000
Buffer air 5–7 psig	75	0	150	0	225	0	300	0
Control air								
Standard pneumatic controls	25	25	25	25	25	25	25	25
Miscellaneous bleeds	25	25	25	25	25	25	25	25
Leaks	50	50	50	50	50	50	50	50
Dryer purge air*	30	15	37	15	48	15	60	15
Total value required cfm	205	115	288	115	373	115	460	115
Required pressure/psig seal control valves	10 / 85	10 / 85	10 / 85	10 / 85	10 / 85	10 / 85	10 / 85	10 / 85

* Dryer purge air desiccant number is somewhat fixed – membrane 15-20% will be proportional to actual flow and probably average less.

The table at left points out:

Sizing buffer air for units that have the double labyrinth seals worn to the full estimated 3%, will require 280 to 300 cfm/1000 hp of total air under these conditions including 150 cfm of buffer air.

Those that don't require seal buffer air really only need control air plus any bleeds, leaks, etc. Programmed bleeds can be isolated and the valves and vacuum pumps can be converted to electric and thus requires *no start up* air. There can be great difference of opinion as to the performance between electric and pneumatic valves. In general, the 100 cfm estimate for starting air requirement without buffer air seems somewhat oversized with a normal well maintained compressor. Not all compressors have a normal, well maintained life.

The dryer purge air is directly proportional to the rated air demand with a desiccant regenerative heatless dryer and to the actual flow demand with a membrane dryer.

Selecting the appropriate compressed air supply:

With the normal operating hours of this start up air system, probably less than 10–15 hours per year (30 minutes once a month), energy efficiency is not a high priority. The driving criteria is reliability — ability to deliver the required quality of air and ease of maintenance and inspection.

In our basic sizing model, we have estimated 100 cfm as enough control air to handle a normal, well maintained centrifugal not needing seal buffer air regardless of size or brand. This 100 cfm is needed at a nominal 85 psig to serve the highest rated required pressure (80 psig). This need may vary with compressor brand model and type and make of valve. If the air can be used at a lower regulated pressure, it will extend the effective flow time of the storage. With 15 cfm or purge air included for the dryer purge air, the total becomes 115 cfm at 85 psig.

The presence of significant leaks and worn out valves and cylinders can dramatically affect this value.

For the low pressure buffer seal air (10 psig regulated to 5 or 7 psig), we have used the highest wear estimate as the double labyrinth seals — 3% of full load flow.

This puts the buffer air from 500 hp to 2,000 hp in 50 hp including the appropriate volume of dryer purge air.

When discussing the best possible size with several very experienced compressor manufacture personnel, they all agreed a 60 to 75 hp class unit should always work (250–325 cfm) for a 1,000 hp class unit unless it is a truly poor conditioned unit. BP

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Doing What is Right for Customers

Compressed Air Best Practices™ spoke with John Reinert (President) of Delta Industries.

John Reinert of Delta Industries

Good morning. How did Delta Industries get started?

I had worked in sales for 7½ years for a compressor distributor in Chicago and wanted to start a business so I could control my own destiny and bring higher quality levels of service to my customers. I left my employer with just this idea and without having anything lined up. My original plan was to be an independent sales representative.

I began speaking with Mr. Reiner Mueller and Mr. Roy Stuhlman at Kaeser Compressors and it coincided with the fact that they were looking to build distribution in the Chicago area as well. I was impressed by the products and the people of Kaeser and could not resist when offered the opportunity of working together.

I started Delta Industries in 1987, as a Kaeser distributor working out of rented office space. I was a one-man operation with some rented space at a shipping company down the street that received and shipped the compressors I sold. I kept an inventory of spare parts for each compressor sold. I did the start-ups myself and contracted out installation and service work as required.

My customers really appreciated the quality of Kaeser compressors and by June of 1988, I had enough business that I hired a secretary, a service technician and our first sales person, Bradley Fresh who is still with us today.

What is the scope and size of Delta Industries today?

Today we employ 45 people and have facilities in Downers Grove, Grant Park, Peoria and Decatur, Illinois. Six years ago we expanded into Iowa and operate out of Cedar Rapids and Des Moines.

We have a very experienced company. I have been in the compressor business for more than 25 years now. We have many employees with 20+ years of service and sales experience. Delta Industries offers 24-hour service capabilities and has a fully stocked parts department and an extensive inventory of compressors. Our sales, service and parts people are all factory-trained and benefit from Kaeser Compressors' very strong training programs. We emphasize that Delta is able and willing to help with compressed air system designs, and provide point-to-point drawings and flow diagrams. Our application people know what tools to use to better gain an understanding of what's going on in a system. We make recommendations to our customers regarding their needs for back-up, the control of multiple compressors, proper air treatment, proper installation, including ventilation, serviceability, storage and distribution piping. Delta helps educate clients to understand the fact that the cost of operating an air system typically far exceeds the price of the equipment and installation. Delta Industries provides service before and after the sale that helps customers produce compressed air at the lowest overall cost per cfm.

Does Delta have any specific "company philosophy?"

What we try to live by is to do what is right for the customer. Our clients typically are not compressed air experts. They are occupied running their own businesses and rely on us to keep them running effectively and efficiently. Sometimes it's our job to educate our customers on another way of doing things, if it's in their best interest.

A very common scenario is that a customer thinks they need another air compressor because they require more air pressure. We had a tire retreader call us asking for a 125 hp air compressor. They had a 75 hp compressor that they felt was not getting the job done because during certain hours of the day, they didn't have enough air pressure.

This customer had a large air demand event that occurred several times a day. We analyzed this demand and were able to recommend a new system with a 40 hp compressor combined with large storage tanks for the intermittent air events. This system now takes care of all their air needs with significantly lower energy costs. The customer has enough air pressure at all times, and they spent less money on equipment than they would have on the system that they had asked for.

As the owner, what is your management style?

I am very hands-on. I continue to work with a handful of accounts myself on the sales side. I call on a few factories and engineering firms and make calls with our twelve outside sales people. This helps me stay current with the applications, questions and concerns of our customers. In this way, I can maintain a working knowledge of how we and our vendors are performing for our customers. While this takes some time away from managing the overall business, I feel the time spent is worthwhile.

What one recommendation do you have regarding air audits?

There are many things to say here but what comes to mind is that we see a lot of amp testers being used to calculate air demand in a facility and feel that this can unintentionally mislead a customer. Customers should understand that flow meters and pressure transducers should be included for a complete evaluation of their air system.

We called an automotive parts manufacturing facility that had a 50 hp compressor that didn't always keep up with required air pressure. A competitor visited them and used amp testers to determine demand. The amp readings told them that the 50 hp, at times, was running flat out and could not produce any more air. They then recommended that the facility purchase a 75 hp air compressor.

Delta visited the installation and recommended an air demand analysis (ADA) that included a flow meter. We determined that the discharge air flow was below what a 50 hp should deliver. We examined the compressor and found that the existing 50 hp had a leak that was not detected by the other company. This is an example of why it is better to actually measure air flow.

Delta Industries Staff: (back row l-r) Paula Karmia, Don Whitledge, Glen Mack, John Reinert, Jennifer Kurt, Rich deCaneva (front row l-r) Sal Graziano, Barbara Shuman, Tiffany Visco

Delta Industries Application Engineering: Paula Karmia, Julie Ratcliff, Chris Vasey, Rich deCaneva, Sal Graziano (l-r)

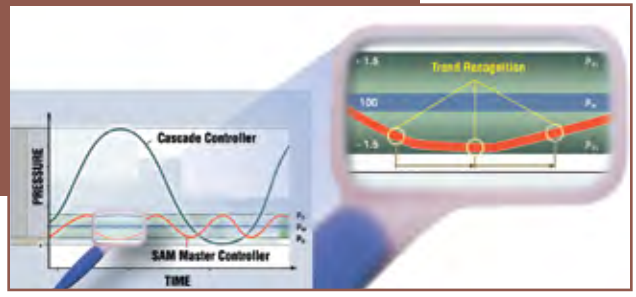
DOING WHAT IS RIGHT FOR CUSTOMERS

A conventional sequencer with cascade controllers operates on the "wet" side with a much wider pressure band in order to accommodate systems with multiple compressors, and account for clean air treatment equipment with the anticipated pressure drop, as well as ensure the required system pressure.

System controllers, like Sigma Air Manager, monitor the actual system pressure with a single precision sensor while taking into account the clean air treatment equipment and the actual pressure drop, effectively managing and maintaining the required system pressure from the "dry" side.

In a four compressor system (e.g. 25 to 50 hp each) that requires 100 psi operating pressure, a cascade controller would allow a 100 psi to 120 psi pressure band. A master system controller like SAM would only require a 100–103 psi band.

At $0.08 per kW hour, and 8–12 hours per day, that would result in annual savings of $2,000 to $15,000.



What changes have you seen in Chicago's industrial market?

The market has changed quite a bit over these past twenty years. The big steel mills and manufacturing facilities have left the city and the suburban to more rural areas, or even out of the country. We still have a solid food industry and warehousing industry. Transportation is a significant industry be it railroads, airports or automotive. We have a lot of cars here of course, so the automotive aftermarket business is strong.

How has the automotive aftermarket changed?

Car dealerships, auto repair and collision centers have all gotten larger and more sophisticated. They used to all be small "mom and pop" stores and now they tend to be larger companies. Allstate Insurance now owns a series of body shops, for example. Now, instead of talking to an owner, we may be talking to a manager of multiple facilities making decisions for standardized systems.

The requirements and expectations for air quality and reliability are higher from collision repair businesses these days. They cannot afford down-time due to a compressor breaking down nor the extra work involved dealing with the effects of paint fisheyes caused by poor air quality. Management understands that investing in high quality compressed air systems makes financial sense. The costs of not doing so are too high.

A shift has occurred from piston compressors to rotary screw compressors. We used to have to explain the differences, but now most buyers understand the benefits. Rotary screw packages are quiet and vibration free. As the quality requirements go up, more and more people in the automotive repair business have opened their eyes to these packages. We've been selling rotary systems in this market for twenty years now. We had to do a lot more educating in the beginning. Now the benefits of rotary screw compressors are more obvious and well known.

We also work with equipment suppliers that sell automotive aftermarket products. These people sell other related products into that market and it is an efficient way to reach a lot of facilities. We then supply the technical service support.

What are the trends with automotive manufacturing?

An automotive plant here in the Chicago area has centrifugals and rotaries. They have been moving towards smaller rotary screw compressors to assure steady air pressure and air quality for labs and small assembly areas. They attempt to optimize the overall air system by supplying lower pressure (80 psi) to conserve energy for their general air use. They install point-of-use rotary screw compressors from 5 to 300 hp to handle higher pressure and air quality needs in specific areas. These departments are isolated from the main utility and can count on stable system pressure (100 psi or higher) in this way.

What kind of air treatment are the car manufacturers using?

We normally see refrigerated air dryers for the overall utility air system. Desiccant air dryers are used in the powder coating areas. We normally recommend the heated desiccant air dryers in these situations with purge-saving controls. We see breathing air purifiers in the paint areas as well. Breathing air purifiers include a carbon monoxide catalyst that converts

carbon monoxide, if present, into carbon dioxide. Sometimes, simply a carbon filter is used. Either way, a downstream carbon monoxide monitor with an alarm is required.

Use flow meters (vs. just compressor amp meters) to understand air usage

What are the trends with energy costs?

Awareness of energy costs is going up. We've been doing energy awareness seminars for many years together with Kaeser Compressors. Customers are made more aware of the benefits and consequences resulting from decisions made regarding their air systems when we discuss sizing, installation, maintenance and how they operate the equipment they purchase.

Energy costs in the Midwest are not as high as they are on the east and west coasts. This makes energy saving investments more difficult to justify here, but we certainly have many applications where significant energy-savings can be achieved.

One example is at a railroad yard installation where the hump yard uses a desiccant air dryer during the winter months when it is cold outside. The compressed air passing through the external piping requires a lower dew point to stay dry during the winter months. So then during warmer weather, for about six months a year, they do not need this lower dew point, which comes at a higher energy costs. We installed a system with bypass piping which allows them to use a refrigerated air dryer six months of the year and the desiccant air dryers during the colder months. This also provides them with a back-up for their warm weather air drying.

Do the utility companies provide compressed air rebates in Illinois and Iowa?

We don't see rebate programs in Illinois for compressed air. This is most likely related to the relatively low electric rates here. We have been involved in some meetings discussing this and I believe that there are programs under consideration. The power company in Northern Illinois is ComEd. The utility near Peoria is Ameren CILCO. We believe this is an area of opportunity.

There have been rebate programs from power companies in Iowa, like with Alliant Energy and Mid-American Energy. They have worked with us on energy surveys and fund projects or provide rebates based upon the savings. Energy audits are performed before and sometimes after projects to verify that the savings have happened.

Please comment on one major opportunity you see with compressed air systems?

Improving a compressors control systems is a major opportunity. Most facilities have multiple air compressors all running with their own localized controls. The opportunity lies in using one master controller, which understands the needs of the compressed air system and then decides intelligently which of the air compressors should be operating. This information also becomes available to the company's building management control system so that compressed air can be monitored and managed.

Advances in compressor control technology have made this possible. We are implementing the Kaeser Sigma Air Manager (SAM) system with our customers who have multiple air compressors running with cascading pressure set points. The SAM system is a PC as opposed to a PLC. We can program the SAM to record and graph out all system parameters and performance trends. The SAM will do a continuing self-audit to see if your system is performing as it should and not wasting energy.

You can also take external measurements, like those from a flow meter or a pressure transducer, and input that information into the SAM where the data is recorded and available for viewing.

How can the SAM save on energy costs?

The SAM selects the correct number and size of machines to operate based on the demand in the system. The SAM also provides a very tight pressure band control, within +/- 1.5 psi, with multiple machines. We used to have to cascade machines at different pressure set points in order to maintain system pressure. This technique causes facilities to operate air compressors at higher pressures than required. This is where the significant savings in energy costs lie. SAM allows the customer to pick a target pressure, effectively controlling up to 16 compressors. Compressors can be installed in various places in the plant and connected to a centralized control system via communication cables. BP

Thank you, Delta, for your insights.

For more information, please contact John Reinert, Delta Industries, tel: 630-960-3900, email: jreinert@deltaind.net, or visit www.deltaind.com

BEYOND THE "CUSTOMER-CENTRIC" BUZZWORD:

Six Truths You Need to Know about Really Putting the Customer First

BY DAVID GIANNETTO AND ANTHONY ZECCA

Who does your company exist to please? In your daily business operations, who ultimately determines whether you and your people get paychecks or pink slips? Who does the mission and vision statements place at the center of your employees' universe? If your answer to all three questions is "the customer," you're not alone. Most leaders wake up each morning hoping to live up to their company's promise to maximize customer value and deliver the best possible customer experience. Unfortunately, good intentions don't always translate to success. Despite its new buzzword status, "customer-centric" is an ideal that most companies fail to uphold.

"Creating a customer-centric company is a classic case of easier said than done," says Giannetto, coauthor along with Anthony Zecca of The Performance Power Grid: The Proven Method to Create and Sustain Superior Organizational Performance (Wiley, 2006, ISBN: 0-470-05144-2, $27.95). "It's a concept that every business leader at any level wants to think he has a grasp onto, but more times than not, he doesn't."

"And here's a sobering reality check," he adds. "Tough economic times are coming, and if you aren't giving your customers the most for their money right now, they won't think twice about dropping you when times get tough. And that will be when you need them most."

No wonder "customer-centric" is thrown about so freely at most executive planning sessions. (Giannetto says it's replaced "innovative" as the new, mandatory strategic language). It describes a way of doing business that is no longer optional — and most leaders are finding that living up to the phrase requires more than changing a few words around in the company's vision statement.

"Becoming a customer-centric organization requires a departure from years of tradition, a clear look at who and what your organization is and a deeper understanding of what motivates your customers to buy from you, or from your competitor, than you may be used to having," says Giannetto. "Fortunately, the cost to make this change is surprisingly low, while the benefits and the returns are shockingly high. And that's why I think every company should make an effort to make the switch."

If you've realized that staying viable requires you to become truly customer-centric, here are a few truths you need to understand up-front:

TRUTH #1: Right now your company is product-centric.

Most companies still base their operations on the value chain that was popularized by Michael Porter in the mid-80s. The value chain is a string of critical processes that begins with raw materials, or inputs, and ends with a product or service delivered to a happy customer. Thinking this way makes sense because it is easy to place the customer at the end of the process. But this mind-set doesn't just affect an organization's structure; it weaves its way into every aspect of how the organization manages itself and how managers make decisions.

In short, it creates a situation in which employees throughout the organization are focused upon delivering the product or service for which they are responsible. Engineers are working to design new products that will keep them one step ahead of their competition. Manufacturing is producing goods to meet customer orders or demand projections. The sales department courts potential buyers so that they become actual customers. Once they do, salespeople then return to identifying new targets and trying to transition those. Manufacturing works to refill shelves. Engineering continues developing products. The cycle continues.

"Employees are trained to think in terms of product development, delivery and value," says Giannetto. "Even if it doesn't know it or intend to do so, the organization becomes product-centric, not customer-centric. Management is comfortable with this view of the world; after all, how can a mainstream management theory like the value chain approach be wrong? But then, when they do try to focus on the customer, they do not know how."

TRUTH #2: Your employees may not understand the customer.

To put the value chain concept in perspective, consider how a power utility works, says Giannetto. Power is generated by a complex and often dangerous power plant. It is delivered to the customer via a complicated and often dangerous network. The customer then consumes this power and must pay for it, creating the need for back office operations such as accounting, finance and customer service. The rest of the company's employees consist of highly educated engineers, highly trained and specialized workers and a management team that is also highly educated and experienced in their field. Together they make up 75% of the organization.

"But have you ever stopped to consider that an organization designed this way — and believe me, the power industry has plenty of company — has a lot of people focused on consistency in design, execution and production, but little focus on the customers and what they want?" says Giannetto. "That's 75 percent of an organization that has little understanding of the customer's true needs. It just goes to show what a challenge becoming customer-centric can be for most companies. But it is possible; you simply need to know where to start."

TRUTH #3: Your company's money isn't allocated with the customer in mind.

When trying to transition to a more customer-centric organization, employees who have power within the organization are reluctant to yield it to those who understand the customer better. And their unwillingness to relinquish power results in a reluctance to shift funding from traditional areas to those that most affect the customer.

"To get an idea of what this kind of transition looks like for a company, let's go back to the power utility example," says Giannetto. "For a power utility, this means that engineers, who have often dedicated their entire lives to the study of their work, must be considered equal to project managers and customer service agents, most of whom do not hold any academic degree. Money, resources and staffing must focus on project management and call center technology, not just on million- or billion-dollar assets. There must be financial recognition that these things equally affect the customer — and when large sums of money are involved, change tends to happen slowly."

BEYOND THE "CUSTOMER-CENTRIC" BUZZWORD:

SIX TRUTHS YOU NEED TO KNOW ABOUT REALLY PUTTING THE CUSTOMER FIRST

TRUTH #4: To stay viable in today's business world, you must cut the value chain and hop on the "customer-critical path."

As you might have guessed, your customers are your partners on this path. And they must start their journey before they even become your customers — while they are still prospects, in other words. It isn't always easy for a company to think along these new lines, but consider what a new client would need if they approached your organization for the first time. Ask yourself questions such as: What do they really need? Why did they choose to approach us and not our competitor? Are they approaching just us, or everyone in the market, and what will set us apart?

Once the customer perspective becomes clear, natural customer groupings will emerge. It is your job to strive to see things from the perspective of these natural customer market segments. From this initial entry point, the organization can methodically walk along the customer-critical path through each major step that these new customer segments must go through in order to become happy, paying customers.

"This is the true value chain of the organization — a string of processes that become critical because they directly affect the customer, regardless of the product, service, organizational chart, academic degree or bias," says Giannetto. "Find the customer-critical path and you can guide your customer through your organization in the way that is most meaningful, and profitable, to both them and you."

TRUTH #5: The customer-critical path offers more options for your customers.

Any business leader knows that not every customer's needs are the same. This remains true even within an industry that has only one real product, like a power utility. The customer-critical path may start in several places in its efforts to meet the needs of several different types of customers — from household customers that simply need power turned on to major projects that require significant project management and preplanning.

"Eventually these starting paths merge," says Giannetto. "It will occur at the point at which all customers are happy. From there they may take a different path. That is the great thing about being customer-centric. There isn't one narrowly focused value chain confining your customers. The customer-critical path allows you to easily adapt to your customers' needs so that your company can be useful to them long-term."

TRUTH #6: Adopting the customer-critical path can transform every aspect of your company.

The customer-critical path approach offers a significant value for organizations that adopt it, says Giannetto. It allows them to better understand their customers, so that they can be segmented and targeted by products or services with more effective value propositions. This drives the bottom line in several ways. A stronger value proposition increases appeal, driving revenue. Better service and customer interaction improve the customer experience and increase customer loyalty, driving customer lifetime value.

"The customer-critical path also becomes a vital decision-making tool for management," says Giannetto. "It provides a clear and unbiased perspective on where resources should, and should not, be spent. It defines the relative worth of projects, assets and expenditures, painting a clear picture of what results will be if the customer-critical path is not properly maintained."

"If your mission and vision statements say you are customer-centric, follow the words up with real action," says Giannetto. "You'll make your strategic plan actionable, setting your organization on a path towards true differentiation and market leadership. Properly crafted, the customer-critical path becomes a pleasant stroll through the park for your customers, and also happens to be the most profitable path for your organization." BP

About the Authors:

David F. Giannetto *is considered one of the most experienced practitioners and a true thought leader in the Enterprise and Business Performance Management arena. He is the director of Cohn Consulting Group's Enterprise Performance Management Practice, and has been with J.H. Cohn LLP since 1999. He is responsible for helping client organizations improve operation efficiency, management effectiveness, customer satisfaction and systems integration through the implementation of the latest performance management methodologies. Prior to this, he was an operations manager and quality auditor for Airborne Express Freight Corporation (currently DHL) at locations throughout northern New Jersey and New York City.*

Anthony Zecca *is the partner-in-charge of Cohn Consulting Group, a division of J.H. Cohn LLP, one of the country's largest accounting and consulting firms. Tony is an expert in driving corporate performance, developing business intelligence systems, and creating highly functional management teams. He has worked with top management to assess overall organizational effectiveness and strategic alignment, and to improve management effectiveness, profitability and cash flow. Tony is an accomplished financial and management professional and a seasoned strategist focused on helping clients develop and implement growth and profit strategies that obtain breakthrough results within varying economic and market environments. He has served as the chief operating officer (COO) for several companies on the strategies and concepts consultants talk about, but rarely implement.*

About the Book:

"The Performance Power Grid: The Proven Method to Create and Sustain Superior Organizational Performance" (Wiley, 2006, ISBN: 0-470-05144-2, $27.95) is available at bookstores nationwide, major online booksellers or direct from the publisher by calling 800-225-5945. In Canada, call 800-567-4797.

For more information, please visit performancepowergrid.com.

COMPRESSED AIR

BEST PRACTICES

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2008 FOCUS INDUSTRIES!

Energy Management, Bulk Handling, Food Processing, Plastics & Blow-Molding, Automotive Manufacturing, Pharmaceutical & Laboratory, Energy Audits, Food Packaging, Automotive Transit, Steel & Metals

Working Together for Compressed Air Best Practices

Compressed Air Best Practices is a technical magazine dedicated to discovering **Energy Savings** and **Productivity Improvement Opportunities** in Compressed Air Systems for specific **Focus Industries**. Each edition outlines "Best Practices" for compressed air users — particularly those involved in **managing energy costs in multi-factory organizations**.

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

- **Compressed Air Users — Focus Industry**
  - A. Energy & Utility Managers share air requirements & specifications
  - B. Audit case studies and "Best Practice" recommendations
- **Utility Providers & Air Auditors**
  - A. Utility Company Rebate Programs
  - B. Case Studies by Expert Compressed Air Auditors
- **Compressed Air Industry**
  - A. Profiles of Manufacturers and Distributors
  - B. Product Technologies Best Suited for the Focus Industries
  - C. Industry News

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International pricing for print edition — $65 in Canada and $95 for other countries.

A Passion for Saving Energy

Compressed Air Best Practices™ spoke with Jack Bertelsmeyer (President) and with Curt Hertel (Vice President) of Power Supply Industries (PSI).

Congratulations on PSI's 25th Anniversary!

Thank you. We started Power Supply Industries (PSI) during a recession in 1983 here in Saint Louis, with five employees including Jack and I (Curt Hertel). We had an inside sales person, a service technician, a secretary and we were the sales team. We had to do a little of everything and even painted desks in the warehouse at night. When we started making sales calls, it was slim-pickings. Over time and on a tight budget, we were able to build the business. We've represented Gardner Denver compressors since the beginning and have seen steady growth.

Our philosophy has always been to supply our customers with the best possible service. We feel that the best way to accomplish this is to make our customers compressed air systems as efficient and reliable as possible. This is why we have always strived to stay on the leading edge of industry innovation and automation. Our audit department has helped save our customers over $18 million dollars in energy savings over the last eleven years.

What is the size and scope of PSI today?

In Saint Louis we employ twenty-eight people. We have eight graduate engineers in sales engineering, technical service and air system auditing positions. We have three DOE Airmaster-Certified auditors on staff. We have 23,500 square feet here and a full-blown rebuild shop for all types of reciprocating, rotary screw and centrifugal compressors. We employ one full time technician for electronic panel rebuilds, wiring diagrams and sequencers. We also have four refrigeration technicians and can service all types of refrigerated and desiccant air dryers. We have a professional engineer, Ed Ball, heading up our blower and vacuum division as well.

In Illinois, our Decatur facility has 12,000 square feet dedicated to warehousing and a full-service compressor rebuild and repair shop. We opened this facility in 1985 and it has done very well for us. Peoria was opened in 2003. We employ 11 people between Decatur and Peoria. PSI today covers eastern Missouri and southern/central Illinois.

PSI is also a licensed mechanical contractor in the Saint Louis area. We offer and provide turnkey installations. Our customers like being able to bring the whole project to us. We will design the installation, lay it out, audit the facility and do the installation. We have the certified welders on staff to do all the plumbing.


PSI POWER SUPPLY INDUSTRIES

"Award Winning Results"

Illinois Governor's 2004 Pollution Prevention Award Winner

Maytag Herrin Laundry Products

Sponsored by: Waste Management & Research Center

A Division of the Illinois Department of Natural Resources

What industries do you serve?

We benefit from having a very broad diversity of industries in our region. This helps stabilize the economy here. If one industry is down, there are a lot of other industries that may be on a positive business cycle. The food industry is probably the most consistent industry for us. Here is a list to give you a feel of the industrial diversity in our area.

- Coal mines in southern Illinois
- First and second tier automotive suppliers
- Automotive assembly
- Aerospace: suppliers to Boeing
- Food processing and packaging
- Plastic blow molding
- Power generation
- Cement industry along the Mississippi River
- Steel mills and foundries
- Pharmaceuticals
- Printing
- Metalworking and fabrication
- Oil refineries
- Chemical plants

What makes PSI unique?

PSI is the only company in Saint Louis that focuses exclusively on compressed air. Most firms are also into air tools, pumps, pneumatics, boilers and hydraulics. We try to be the compressed air experts in this area and feel that this requires 100% of our resources and focus.

The other thing that makes us unique is our passion for saving energy. When we audit compressed air systems, our objective is to shut off air compressors. We work to find the best ways for our customers to achieve these objectives. We work with the local power companies and conduct seminars with them. We have even trained some of their personnel. Educating and training people on how to save energy has become an important part of what we do. Over the past fifteen years, we have been conducting six to eight energy management seminars per year at our facility here in Saint Louis. They are extremely well attended by factory personnel in this region.

What is the local utility company doing with rebates?

The local utility saw what we were doing fifteen years ago with audits. They saw us turn off a 200 horsepower compressor at a customer as a result of an audit and wanted to learn more. They send people to our seminars and we still work together. They have, however, stopped offering rebates. We are not sure why.

Please describe your auditing philosophy.

We've been doing compressed air system auditing for fifteen years now and it is ingrained in what we do. We have a true systems approach. If a customer calls and asks for a 100 hp compressor, we will ask them why he believes that is the correct size for his needs. We take great pains to provide the customer with what he needs — rather than with what he thinks he needs. Our customers appreciate this expertise.

Jim Timmersman of PSI conducts an energy management seminar

We focus on the compressed air system header piping and what needs to be done on the factory floor to optimize the header pressure. We educate our customers on system reliability and on having a system design that can automatically bring other compressors on line (for redundancy) in the most energy efficient manner.

Customers can monitor the dynamic efficiency of their compressed air system from their desktop PC.

To do this requires our expertise in compressor sequencing and using master controllers for multiple air compressors. We also focus on providing HMI (Human Machine Interface) capabilities with the sequencers and integrating this information into the customers building management system. In this manner, our customers can monitor the dynamic efficiency of the compressed air systems from their desktop personal computers.

Please describe your Level 1 to Level 3 auditing process.

We offer three levels of audits to our customers. The Level 1 Audit involves a walkthrough of the customers' facility. We inspect and document the equipment and interview plant personnel. We have a several-page worksheet, which we will fill in. We then will come back to the customer and provide an estimate potential energy savings.

The Level 2 Audit focuses on the supply-side of the system. We measure dew point (air quality), flow and pressure for a week. We will also take the readings on compressor amperage. We think it is important to nail the numbers. The numbers have to be right (and representative of normal working conditions). We have some corporate auditing agreements where our

A PASSION FOR SAVING ENERGY

Power Supply Industries Headquarters in Fenton, Missouri

process in "nailing the numbers" has really been refined. We have gone to this focus in the last couple of years. We used to just measure flow and pressure. The people who just measure amperage can provide misleading information. On a modulating control rotary screw compressor, amperage can read nearly the same — no matter what the load is. Measuring amperage also relies on accurate horsepower ratings (and flow outputs) from manufacturers. Amps can also mislead you if something is wrong with the compressor like a malfunctioning inlet valve.

The Level 3 Audit examines the demand-side (as well as the supply-side) of the compressed air system. It involves static dynamic testing. What is the actual delivered pressure at the point of use? Sometimes there are choke points where pipes are restricting flows. The Audit examines storage, air leaks and inappropriate uses (like opening boxes with open blowing).

The Level 2 and Level 3 Audits provide the customer with a CEO/CFO level document which outlines the energy saving opportunity, the capital required and the actions required. We work nationwide for some large corporations and our emphasis is on getting the numbers right!

"Our emphasis is on getting the numbers right!"

What observations do you have on auditing practices out there?

We think it is great that "energy management" has become popular. We are, however, concerned that some "auditors" may unwittingly provide customers with inaccurate information on their systems. The main problem out there is a lack of knowledge on how to measure and how to interpret the data.

Flow should be measured with a hot wire anemometer flow meters. We've used many types of flow meters over the years and we like these. They can be faulty if you have moisture in the air. Droplets of water will increase the flow measurement artificially. You can cross-check that with amperage readings. The flow meters measure how quickly the flow of air strips heat from the probe. If liquid water hits it, the evaporative cooling distorts the reading.

Pressure measurement is done with 0–150 psig, pressure transducers with 4–20 milliamp outputs. We recommend measuring dew point and ppm with devices using chilled mirror technology.

A full-blown audit needs to involve more than just measuring flow or just measuring amperage. Otherwise, the audit is just a sales tool for those trying to sell a new air compressor. We have seen audits where only pressure was measured and a VSD compressor was purchased. The solution should have been to fix the intermittent demand with storage.

What are some other new trends you are seeing?

We installed an unmanned compressor station two years ago. The customer asked us to take over their compressed air system. We were to supply their process air to ensure 99% uptime. We have 2 x 200 hp compressors with two desiccant dryers and two boosters to go to 650 psi. If there is a system glitch, the system dials a cell phone and we can dial back in and see what is going on with the system. We can remote monitor the system and see what the alarms were or view when the routine maintenance needs to be done. Slowly but surely, we see a growth trend here.

Thank you, PSI, for your insights.

For more information please contact Jack Bertelsmeyer, Power Supply Industries, tel: 636-343-5252, email: powersupply@psiind.com, www.psiind.com

RESOURCES FOR ENERGY ENGINEERS

TRAINING CALENDAR

TITLE	SPONSOR	LOCATION	DATE	INFORMATION
Fundamentals of Compressed Air	Compressed Air Challenge®	Omaha, NE	5/6/2008	www.compressedairchallenge.org
Advanced Management of Compressed Air	Compressed Air Challenge®	Omaha, NE	5/7/2008	www.compressedairchallenge.org
Humidity Measurement Training Seminar	Vaisala	Detroit, MI	5/14–15/2008	www.vaisala.com/seminar
Advanced Turboshaft Gas Turbine & Centrifugal Compressor 2008	UNI Strategic	Bur Dubai Kuala Lumpar, Malaysia	5/12–13/2008 5/15–16/2008	www.unistrategic.com
Humidity Measurement Training Seminar	Vaisala	Baltimore, MD Dallas, TX	6/11–12/2008 8/13/2008	www.vaisala.com/seminar
Compressed Air Management	Power Supply Industries	Fenton, MO	8/19/2008	www.psiind.com
Humidity Measurement Training Seminar	Vaisala	Boston, MA	9/8–11/2008	www.vaisala.com/seminar
Best Practices in Compressed Air	World Energy Engineering Conf.	Washington D.C.	10/2/2008	www.energycongress.com
Humidity Measurement Training Seminar	Vaisala	Toronto, ON	10/8/2008	www.vaisala.com/seminar
Compressed Air Management	Power Supply Industries	Fenton, MO	11/4/2008	www.psiind.com
Humidity Measurement Training Seminar	Vaisala	Chicago, IL	11/5–6/2008	www.vaisala.com/seminar

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

PRODUCT PICKS

New Oil-Injected Compressors

Atlas Copco announced a new range of GA oil-injected rotary screw compressors. Energy efficiency is achieved through patented asymmetric rotor profiles, which reduce volumetric losses. Other design features to further reduce energy consumption include, radial fans with VSD regulation, high-efficiency motors and no-loss drains. Energy-saving options include an integrated energy recovery system and/or VSD for the main motor. Air quality is provided by an integrated refrigerant dryer and oil coalescing filter. The refrigerant dryer features an energy saving feature called "Saver Cycle Control."

Atlas Copco
(800) 232-3234
compressors.vsd@us.atlascopco.com
www.atlascopco.com

RESOURCES FOR ENERGY ENGINEERS

PRODUCT PICKS

FRL Air Prep Units

Parker Hannifin Corporation General Line FRL Air Preparation Units protect pneumatic equipment and extend operating life, as well as reduce energy waste and safety hazards in pneumatic systems. General Line Parker filters, regulators and lubricators provide clean and precise air control for demanding applications. F602 standard filters from Parker deliver excellent water removal efficiency in heavy-duty applications with minimum pressure drop requirement. A unique deflector plate that creates swirling of the air ensures maximum water and dirt separation. A 40-micron filter element is standard and a 5-micron filter is available. Port sizes range from ¾" to 2 ½" with flow rates from 390 standard cubic feet per minute (scfm) to 1,500 scfm.

The F602's large filter element surface guarantees low-pressure drop and increased element life. A large bowl capacity with a sight gauge is standard. A twist drain is standard with an optional auto drain available if the application requires removing large volumes of liquid and/or particulate matter from the air stream. F602 filter kits and accessories include bowls, drains, filter elements and repair packages.

Parker also offers a complete line of high-flow and coalescing filters. F701 coalescing filters catch sub-micron particles that standard filters will not catch. Grade 6 filters (1 micron) and Grade 10 filters (.5 micron) are the two grade elements available. F701 filters are available with a standard differential pressure pop-up indicator or an optional differential pressure gauge. Parker's R119 standard regulators offer high-flow performance and a rugged design for the most demanding applications.

Parker Hannifin
(269) 629-5000
www.parker.com

Optical Hygrometer

Kahn Instruments has introduced the new Optisure Optical Hygrometer. The Optisure is a high-performance, precision hygrometer that utilizes Kahn's improved optical measurement technology to provide a fundamental, highly accurate and reliable method of continuously measuring the dew point temperature of a gas sample.

Available in both vertical and horizontal bench mount configurations, the Optisure with its internal sensor has a measurement range of -76 to +104 °F dew point and accuracy of ±0.18 °F for both dew point and temperature measurement.

Key features include a hinged sensor housing that allows easy access to the sensor mirror, a high resolution, backlit LCD screen, MODBUS communications capability and a built-in SD card drive for data logging. An innovative frost assurance system eliminates any ambiguity in determining ice versus super-cooled water on the sensor mirror, resulting in improved measurement capability, faster response time and more confidence in measurements. To compensate for the presence of undesirable contaminants on the mirror, Optisure includes an enhanced Dynamic Contamination Correction (DCC) system that automatically eliminates any measurement error that may be caused by mirror particulate contamination.

Kahn Instruments
(860) 529-8643
hygros@kahn.com
www.kahn.com

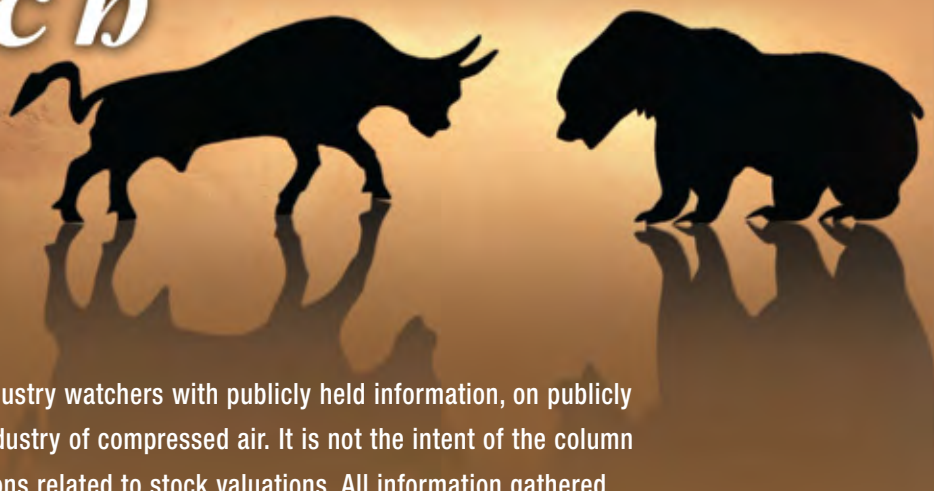
New Air Prep Equipment

Bimba Manufacturing announced its new line of Air Preparation Equipment featuring three sizes of Filters, Regulators and Lubricators (FRLs). The Miniature Series (10) is available in ⅛" and ¼" NPT and offers the standard Compressed Air Filter, Pressure Regulator, Air Line Lubricator, Filter/Regulator Combination Unit and Oil Removal Filter. Series 10 also offers a variety of FRL assembled combinations. The Compact Series (20), available in ¼", ⅜" and ½" NPT, comes in the same standard FRLs as the Miniature Series and also includes a Vapor Removal Filter and multiple assembled combinations. The Large Series (70) is available in 1" and 1½" NPT and offers the standard Filter, Regulator, Lubricator, Combination Unit and Oil Removal Filter as both the Miniature and Compact series. In addition to the standard FRLs, each of the three series offer optional accessories, including, porting blocks, shut-off valves, gauges, soft start/quick-dump valves and other useful additions. These units can be ordered as individually stocked components to ship the same day or assembled to custom specifications and shipped within two days.

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

Wall Street Watch

BY COMPRESSED AIR BEST PRACTICES



The intent of this column is to provide industry watchers with publicly held information, on publicly held companies, involved with the sub-industry of compressed air. It is not the intent of the column to provide any opinions or recommendations related to stock valuations. All information gathered, in this column, was on April 3, 2008.

Charlotte, NC, February 27, 2008 — SPX Corporation (NYSE: SPW) today reported results for the year ended December 31, 2007:

Full Year 2007 Highlights:

Revenues increased 15.7% to $4.82 billion from $4.17 billion in 2006. Organic revenue growth was 9.8%, while completed acquisitions and the impact of currency fluctuations increased reported revenues by 3.2% and 2.7%, respectively.

Segment income and margins were $622.4 million and 12.9%, compared with $502.7 million and 12.1% in 2006.

Diluted net income per share from continuing operations was $5.33, compared with $3.74 in 2006. The primary drivers of the increase were the improvement in segment income, a reduced number of common shares outstanding and a lower effective tax rate in 2007.

Adjusted net income per share from continuing operations was $4.85 in 2007, as compared to the company's guidance of $4.70 to $4.80. This figure is adjusted to exclude the following items:

- Miscellaneous tax benefits totaling $0.59 per share as compared to the company's expected 32.0% tax rate
- 2007 charges of $5.0 million, or $0.06 per share, related to legacy legal matters recorded in corporate expense
- 2007 non-cash charge of $4.0 million, or $0.05 per share, for impairment of intangible assets

Net cash from continuing operations was $404.2 million, compared with $48.6 million in 2006. The primary drivers of the increase were improved working capital performance and 2006 interest and tax payments totaling $175.2 million relating to the retirement of the company's convertible debt in the first quarter of 2006.

Free cash flow from continuing operations was $313.3 million, compared with a cash use of $7.1 million in 2006. The increase was due to the items noted above, partially offset by increased capital expenditures in 2007 to support continued growth of the company.

WALL STREET WATCH

Chris Kearney, Chairman, President and CEO said, "In 2007 SPX continued to grow and deliver strong financial results. Revenues for 2007 were $4.82 billion, an increase of 15.7% over 2006. Organic revenue growth was almost 10%, driven by strong demand in our infrastructure and energy markets. "Our strategy of aligning the company around our three strategic growth markets of global infrastructure, process equipment and diagnostic tools are working. We have strong momentum and are well positioned for continued growth in 2008," Kearney concluded.

Flow Technology Revenues for the fourth quarter of 2007 were $323.1 million compared to $244.1 million in the fourth quarter of 2006, an increase of $79.0 million, or 32.4%. The increase was due primarily to organic revenue growth of 18.0% and the acquisition of Johnson Pump. The organic revenue growth related primarily to strong demand in the power, oil and gas, chemical, sanitary and dehydration markets, as well as pricing improvements and new product introductions. The impact of currency fluctuations increased revenues by 3.1% from the year-ago quarter.

Segment income was $49.9 million, or 15.4% of revenues, in the fourth quarter of 2007 compared to $37.1 million, or 15.2% of revenues, in the fourth quarter of 2006. The increase in segment income and margins was due primarily to the strong level of organic growth and manufacturing efficiencies achieved from continuous improvement initiatives, offset partially by the acquisition of Johnson Pump, which performed at lower margins than the segment.

Minneapolis, MN, February 25, 2008 — Donaldson Company, Inc. (NYSE: DCI) announced second quarter-diluted earnings per share ("EPS") of $0.42, an 11% increase from $0.38 last year. Net income was $34.1 million, up from $31.3 million last year. Sales were $511.8 million, a 10% increase from $463.7 million in the second quarter of 2007.

For the six-month period, EPS was $0.95, an increase of 17 % from $0.81 last year. Net income increased 15% to $77.4 million versus $67.3 million last year. Sales were $1.037 billion, up 14% from $910.2 million in fiscal 2007.

"Our globally-diversified portfolio of filtration businesses provided the foundation to deliver another record quarter of sales and earnings," said Bill Cook, Chairman, President and CEO. "Strength in our Engine Products businesses internationally plus continued growth in our international Industrial Products businesses, including Industrial Filtration Solutions and Special Applications Products, helped offset some of our weaker NAFTA markets."

"Overall, we are on track with our business plan for the balance of fiscal 2008. We see sufficient strength across our Engine Products and Industrial Products businesses to increase our sales forecast for both segments and anticipate achieving our first $2 billion revenue year. In addition, we remain confident that we will deliver our 19th consecutive year of record earnings."

Financial Statement Discussion

The impact of foreign currency translation increased reported sales by $27.1 million in the quarter and $47.7 million year-to-date. The impact of foreign currency translation increased reported net earnings by $3.5 million in the quarter and $6.8 million year-to-date.

Gross margins of 31.9% for the quarter and 32.4% year-to-date compare to prior year margins of 30.5% and 31.3% for the same periods. During the quarter, the implementation of our new warehouse management system in our main U.S. distribution center caused delays in processing Customer orders. This resulted in approximately $2.1 million of unplanned higher distribution and operating costs and delayed sales of $5.5 million. We are making progress and anticipate catching up on these delayed shipments in our third quarter.

Operating expenses for the quarter were 22.0% of sales, up from 21.2% last year. Our second quarter included $3.0 million for the majority of our annual stock option expense, compared to $2.5 million last year. Year-to-date operating expenses were 21.4% of sales, up from 20.7% last year.

The effective tax rates of 30.0% for the quarter and 28.4% year-to-date compare to 25.6% and 28.7% for the same periods last year. Last year's second quarter rate included a $2 million benefit, primarily from the Research and Experimentation Tax Credit reinstatement.

As part of our ongoing share repurchase program, we repurchased 1,151,000 shares during the quarter for $46.5 million. Year-to-date, we have repurchased 1,203,700 shares for $48.6 million.

Fiscal 2008 Outlook

Engine Products: We increased our outlook and now expect 10 to 12% full year sales growth.

- We expect our NAFTA Transportation Products sales to decrease slightly in the third quarter before growth returns in our fourth quarter
- We expect the NAFTA residential construction market to remain weak. However, production of new agriculture equipment by our customers is projected to remain strong globally.

- Our Aftermarket sales are expected to continue growing due to strong equipment utilization internationally. We expect to continue benefiting from the increasing amount of equipment in the field with our PowerCore™ filtration systems

Industrial Products: We increased our outlook and now expect 14 to 16% full year sales growth.

- Full year Industrial Filtration Solution sales are projected to grow 10 to 15% due to continued strong global manufacturing investment and production utilization conditions
- We now expect our Gas Turbine Products sales to increase 20 to 30% for the full year. Continued strength is expected from both the international power generation and the oil and gas markets
- Special Applications Products sales are now expected to grow 10 to 15% for the full year BP

MARCH 3, 2008 PRICE PERFORMANCE	SYMBOL	LAST PRICE	1 MONTH	6 MONTHS	12 MONTHS
Parker-Hannifin	PH	$71.37	12.0%	1.4%	26.0%
Ingersoll Rand	IR	$45.66	6.9%	-14.0%	4.2%
Gardner Denver	GDI	$39.87	3.0%	0.5%	10.2%
United Technologies	UTX	$70.76	2.1%	-10.7%	10.0%
Donaldson	DCI	$40.72	-3.3%	0.0%	14.3%
EnPro Industries	NPO	$34.23	9.6%	-12.8%	-5.9%
SPX Corp	SPW	$108.14	1.8%	17.7%	53.6%

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JOB MARKET

Job Openings in the Compressed Air Industry

TECHNICAL SALESMAN

GRS FLUID HANDLING

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

Background Required

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

Why you would want this job?

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

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

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

SERVICE TECH

TAMPA BAY, FLORIDA

Service tech needed at Air Compressor Company in Tampa Bay, Florida. Full Benefits and Good Compensation

Send resume to: mguzman@ibacinc.com

COMPRESSED AIR SYSTEMS SPECIALISTS

PNEU-LOGIC CORPORATION

Pneu-Logic designs the world's most advanced compressed air management systems. Pneu-Logic is looking for experienced System Assessment and Project Engineers to:

Perform compressed air system assessments.

- Develop instrumentation plans.
- Perform baseline analysis and 'what if' scenario simulations.
- Summarize findings in a written engineering report.

Design and implement control systems.

- Develop, review and approve production drawings.
- Work with customers to coordinate project schedules and deadlines.
- Perform onsite systems testing and start-ups.

Pneu-Logic offers excellent benefits, a chance for advancement and a path toward equity in the company. For immediate and confidential consideration, **please send your resume to:**

dusty.smith@pneu-logic-corp.com.
www.pneu-logic-corp.com

You're invited to participate in the

26th West Coast EMC Energy Management Congress

May 14-15, 2008
Seattle, Washington
Washington State Convention & Trade Center

Presented by

aee® The Association of Energy Engineers

Hosted by

PSE PUGET SOUND ENERGY
The Energy To Do Great Things

Industry Conference, Expo & Networking Event...

The **West Coast Energy Management Congress** (EMC) is the largest energy conference and technology expo held on the U.S. West Coast specifically for business, industrial and institutional energy users. It brings together the top experts in all areas of the field to help you set a clear, optimum path to both energy cost control and energy supply security.

You can explore promising new technologies, compare energy and facility management products and services, alternative energy options, and learn about innovative project implementation strategies. The multi-track conference covers a variety of topics, many specific to the region.

The full **EMC 2008** agenda includes a two-day conference and expo, as well as several optional intensive seminars, workshops and tours.

The conference is designed to provide hands-on, up-to-the-minute information you can use right away to improve your energy management program, including distributed energy opportunities, renewables, power quality issues, thermal distribution systems, new tools for maintenance and overall facility management, and creative project financing options. Case studies will detail successful application of new technologies and other innovative cost management strategies. You'll also hear insightful commentary from leading experts on what the future holds and how best to prepare for it.

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Snohomish County PUD Public Utility District No. 1

www.energyevent.com • 770-447-5083 • info@aeecenter.org

Kaeser SFC compressors:
The product of a better idea.

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