The Magazine for ENERGY EFFICIENCY in Compressed Air, Pneumatics, Blower and Vacuum Systems

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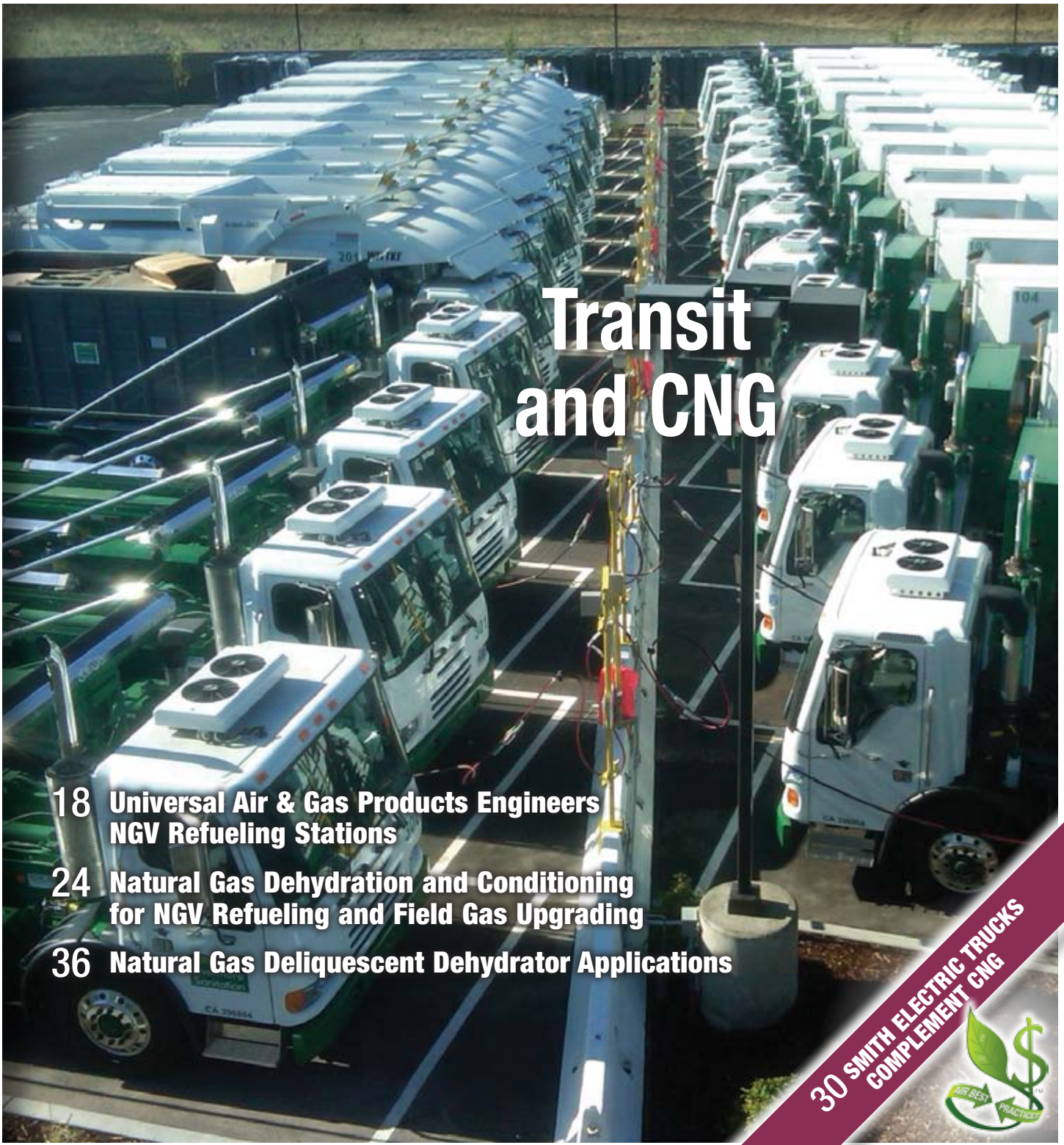
June 2013



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HITACHI
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SUSTAINABLE MANUFACTURING FEATURES


18

24

COLUMNS


30

FROM THE EDITOR

CNG and Alternative Fuel Vehicles

According to NGV America, an association supporting the use of natural gas vehicles, the U.S. imported 11 million barrels of foreign oil a day in 2008. This import number has fallen to a 2013 average of 8.4 million. The U.S. imports 47% of the oil it uses, while 98% of natural gas consumption is produced in North America. Making the U.S. less dependent upon foreign oil has become a national priority and for this trend to continue, demand for Alternative Fuel Vehicles-including those using compressed natural gas (CNG), must increase. In 2011, industry data shows that U.S. vehicular natural gas displaced the use of 360 million gasoline gallon equivalents (GGE). The number of natural gas vehicles (NGVs) on U.S. roads has reached 120,000. Fleets are leading the recent growth and now almost 40% of trash trucks are natural gas powered. Transit buses are the largest user of natural gas as nearly 20 percent of all transit buses, in 2011, ran on CNG or liquid natural gas (LNG).

Most estimates say that natural gas currently costs $1.50 less per GGE at the pump. NGVs also meet the strictest emission standards, including California's AT-PZEV Standard. The U.S. EPA has also issued reports confirming significantly reduced exhaust emissions vs. older gasoline-fueled vehicles.

Given all these benefits, why is it the U.S. ranks 17th in the world with less than 1% of the global natural gas vehicle fleet? That question is worth looking at but the good news is that "big business" and the U.S. federal and state governments are finally putting some muscle behind NGVs. Proof of this is the gaggle of forecasters pegging the number of U.S. NGV refueling stations to grow from 1,200 today to approximately 10,000 by 2018.

The compressed air and gas industry has a tremendous opportunity to participate in the supply side (on site drilling) and demand side (NGV refueling stations) of this growth. Our gas compression and dehydration technology and engineering capabilities are on display this month with articles on Xebec Adsorption, Universal Air & Gas Products and Van Air & Gas Systems. We added another article, on another petroleum-displacing Alternative Fuel Vehicle, covering the electric trucks manufactured by Smith Electric.

I hope you enjoy this issue as much as I did putting it together. We all have an exciting reduced-petroleum transit future. Thank you for your support and for investing in ***Compressed Air Best Practices***®. BP

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* Statistics on this page were sourced from NGV America at www.ngvc.org

COMPRESSED AIR, PNEUMATICS, VACUUM & BLOWER INDUSTRY NEWS

Giant Eagle Opens First Two Compressed Natural Gas Fueling Stations

Building on its long-standing commitment to environmental sustainability, multi-format food and fuel retailer Giant Eagle, Inc. unveiled its first two compressed natural gas (CNG) fueling stations in the Pittsburgh area. Giant Eagle officials demonstrated the new CNG technology by fueling one of the company's brand new custom-equipped delivery trucks, as well as passenger vehicles at the area's first publicly accessible CNG fueling station.

"We are dedicated to doing business in the most sustainable manner possible across all of our business operations," said Giant Eagle Executive Vice President and Chief Operating Officer John Lucot. "Our efforts have been greatly advanced with the help of others, and we give thanks to the local and state officials here today as well as to our allies at Volvo and EQT who partnered with us to make these facilities possible." Lucot added, "This project delivers improved air quality for the region through emissions reductions, reduces dependence on traditional fuels, and serves as a regional catalyst for southwestern Pennsylvania in adopting and understanding alternative fuels and clean transportation technology."

According to data from the International Association for Natural Gas Vehicles, CNG typically is priced one-third below the cost of gasoline and diesel. In addition to cost savings, CNG reduces particulate matter emissions by 94 percent, carbon monoxide emissions by 75 percent, nitrogen oxide emissions by up to 49 percent, and carbon dioxide emissions by 25 percent.

In addition to the environmental benefits, commercial CNG vehicles run 50 percent quieter than diesel trucks. Giant Eagle's 10 new CNG fleet vehicles will displace more than 100,000 gallons of diesel fuel during the fleet station's first year of operation alone.

"Until now, there have been no viable alternative fuel options for heavy-duty delivery trucks with the necessary level of power required to navigate the region's hilly and mountainous terrain," said Giant Eagle Vice President of Logistics Bill Parry. "To continue evolving our environmentally friendly fleet, Giant Eagle worked closely with Volvo to design the 10 new CNG vehicles here today with an 8.9 liter Cummins engine as the first of their kind in the commercial transportation industry."

Pennsylvania State officials hope the launch will help kick start greater commercial and consumer adoption of fuel technology that will benefit the environment and support Pennsylvania's in-state natural gas industry. "Pennsylvania should be a leader in CNG expansion, and CNG-powered vehicles can become a big part of Pennsylvania's clean air strategy," Pennsylvania Department of Environmental Protection Secretary Mike Krancer said. "Public-private partnerships like this one are helpful and can become a part of this effort, especially at this early stage. We should all look for opportunities for Pennsylvania to become a leader in the CNG fueling sector."

CNG is sold in gasoline gallon equivalents (GGEs), with each GGE having the same energy content as a gallon of gasoline. Vehicles using CNG typically have similar fuel economy ratings to standard gasoline or diesel vehicles. Based on current market pricing, Giant Eagle will likely

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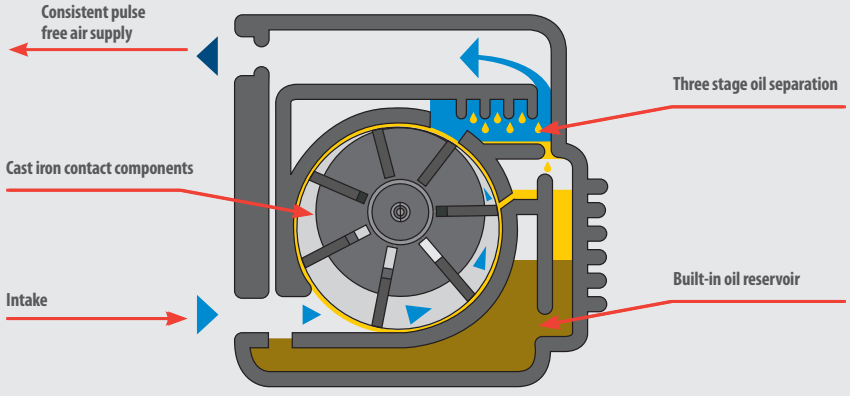

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introduce the fuel for sale to consumers between $1.90 and $2.00 per GGE. The self-service station for passenger vehicles will be open 24/7 and will accept major credit cards. First time users of CNG can watch a video of how to properly fuel their CNG powered vehicle right at the station.

About Giant Eagle
Giant Eagle Inc., is one of the nation's largest food retailers and food distributors with approximately $8.6 billion in annual sales. Founded in 1931, Giant Eagle, Inc. has grown to be the number one supermarket retailer in the region with 170 corporate and 58 independently owned and operated supermarkets in addition to 162 fuel and convenience stores throughout western Pennsylvania, Ohio, north central West Virginia and Maryland.

www.gianteagle.com

Waste Management Leads Fleet Conversions to CNG

Waste Management is leading the charge in fleet conversions. Compressed Air Best Practices® Magazine salutes the commitment being made by this company and we wanted to publish excerpts from an open letter titled "Natural Gas Trucks Help Waste Management Meet Clean Air Goals", written in January 2013, by their President and CEO, David Steiner.

"Waste Management has the nation's largest fleet of heavy-duty trucks that run on clean-burning natural gas. We have 2,000-plus such trucks working across North American cities today, and we're on a path to convert our 18,000 collection vehicle fleet to natural gas. This conversion makes good business sense for our company and our shareholders because of the significant maintenance and diesel fuel costs savings. It's much cleaner for the environment, and our CNG trucks are much quieter than diesel powered ones.

With political instability in oil-producing regions around the world and approximately 80 percent of conventional oil reserves controlled by the OPEC cartel, it seems obvious that our country must end its dependence on a single fuel source for our transportation sector. If we increasingly focus on developing our own resources — like natural gas — we will, at once, help grow the economy, and shrink prices at the pump.

I'm proud of Waste Management's leadership role in greening our fleet. That includes our investments in fueling infrastructure, and supporting government efforts to accelerate the same for compressed natural gas (CNG) for use by the public in their vehicles. As a major consumer of diesel fuel, we gladly lend our support to policies that foster a less oil-dependent transportation system.

Today, at WM, we have 40 natural gas-fueling stations across North America — 15 of which are publicly accessible, and another seven with pre-approved third-party access. We own the stations, purchase their fuel, and finance their construction. We are planning 13 more for early 2013, with more to follow.

Another pride point for me is our award-winning plant in California that converts landfill gas to liquefied natural gas (LNG), which in turn powers 300 of our trucks every day. This LNG is the lowest carbon intensity fuel of any commercial scale transportation fuel currently produced in California. These trucks service our customers in Oakland, San Diego and several cities in Los Angeles and Orange Counties. Indeed, I'm very pleased that we have created an "environmental closed loop" for the City of Oakland, where some of their waste is disposed at our landfill and the resulting landfill gas powers the WM trucks that collect their waste and bring it to our recycling centers and other post-collection facilities.

Waste Management's fleet professionals have spent several years of experimentation and they — our driving force so to speak — are convinced that converting our collection vehicles to natural gas is our best option today. I agree.

Doing so improves energy and operational efficiencies and reduces greenhouse gas emissions. As of 2012, we already have reduced our carbon dioxide emissions by 20 percent — beating our 2020 goal of 15 percent eight years ahead of schedule. By 2020, our commitment will pay off as a reduction of 350 million gallons of fuel, about 3.5 million metric tons of CO_2 emissions and $1 billion of operational costs."

www.wastemanagement.com

Quincy Compressor Acquires Four National Pump & Compressor Midwest Branches

Quincy Compressor has acquired the assets of four National Pump & Compressor's (NPC) branches in the state of Illinois. Formerly operating as Cochrane Compressor and acquired by NPC in 2009, the acquired company has been a Quincy distributor for more than 60 years.

"Our manufacturing business began in Quincy, Illinois nearly 100 years ago in 1920. This acquisition allows us to focus on sales and service in the Midwest," said John Thompson, President Quincy Compressor. "We have established strong customer relationships in the region and intend to strengthen our market presence, building upon the solid customer base established by NPC's Chicago-based team."

Forty-three employees in a variety of sales and service roles joined Quincy Compressor from NPC. The acquired branches now form

Quincy's direct sales and service center in Illinois, which ranks as the United States' fifth largest economy. As a key industrial and manufacturing hub of the American economy, it serves a broad range of manufacturing sectors including chemical, electronics, food and general industry.

www.quincycompressor.com

Clean Energy and Mansfield Partner to Provide Fully Integrated Natural Gas Fueling Solution

Clean Energy Fuels Corp. and Mansfield Energy Corp. announced a strategic partnership to offer customers the most comprehensive solution in the compressed natural gas (CNG) fuel industry. Sales teams from both companies will offer Clean Energy's natural gas fueling station construction and operational services to current and potential customers. These services will be supported by Mansfield's large-scale fuel supply capabilities, and Gas-2-Gallons fuel management system creating a superior solution for the growing number of fleets making the switch to cleaner, cheaper natural gas.

"This agreement joins two leaders of fleet fueling into strategic partners that will provide the highest level of service and best value for customers in the rapidly-growing natural gas fuel market," said Andrew J. Littlefair, president and CEO of Clean Energy. "No other company offers fuel customers the benefit of scale and expertise that Mansfield provides. Clean Energy has built and operated more CNG stations and fueled more

COMPRESSED AIR, PNEUMATICS, VACUUM & BLOWER INDUSTRY NEWS

natural gas vehicles than any company in the U.S. Together, we will be the best solution in the marketplace."

"We want our customers to have the best solution possible for fueling with natural gas," said Michael Mansfield, CEO of Mansfield. "We bring scale in commodity supply, risk management, and transaction processing. Clean Energy has scale in design, engineering and operations. Bringing these strengths together for our customers provides the benefits of proven technology coupled with large scale operating efficiencies to provide the best value and simplest path to natural gas adoption in the market today."

Mansfield Gas Equipment Systems has ongoing CNG service and operations contracts with 43 locations as well as 20 new CNG sites currently under development in the waste, transit, and municipal fleet sectors. This portfolio will be combined with the 348 CNG and liquefied natural gas (LNG) fueling stations Clean Energy currently owns, operates or supplies, further solidifying Clean Energy's position as the largest provider of natural gas infrastructure for transportation in North America. Clean Energy's total strategic partnerships to-date represent over 11 billion gallons of gasoline and diesel delivered annually.

The company also will become the Western distributor of Mansfield Gas Equipment Systems' FuelMaker, a small scale business and home re-fueling system.

Natural gas fuel costs up to $1.50 less per gallon than gasoline or diesel, depending on local market conditions. The use of natural gas fuel not only reduces operating costs for vehicles, but also reduces greenhouse gas emissions up to 30% in light-duty vehicles and 23% in medium to heavy-duty vehicles.

www.cleanenergyfuels.com

Plug-and-Play Compressed Air Containers from BOGE

BOGE Anlagenbau, based in Bielefeld, Germany, offers base frames and container solutions. There are many reasons why customers all over the world opt for a container compressed air station, ranging from lack of space to flexibility of installation location. "Customers choose a compressed air container if they do not want the compressors on the shop floor, their compressor room is too small or they simply forgot to plan for a compressed air system," explained Stefan Klare, Head of Operations, BOGE Anlagenbau. A container station can also be used for short-term solutions; for example for installing on building sites.

Tailored to compressed air requirements and geared to maximum energy efficiency, the experts at BOGE Anlagenbau deliver customized plug-and-play solutions: "We do all the cabling, pipework and ducting inside the container — all that remains to be done is to lay the electricity cable and the compressed air line," said Stefan Klare. All containers are fitted with features like fire extinguishers, access door with panic lock, emergency exit light, lighting and working socket. BOGE is going to manufacture its own container for lease this year, so customers can avail of BOGE air during compressed air shortages as well.

BOGE Anlagenbau is currently completing a large container project in Saint Petersburg. An oil-free SO 220-series compressor with adsorption dryer is being installed inside a 40 ft container (12 m), with a cooling water re-cooler on top. The project includes a 15-ft container, which houses a pump station for water circulation. Both containers are all set for winter with 100 mm of insulation and several 2 kW space heaters. A ventilation system inside the container supplies cool air in the summer months.

www.boge.com/us

Atlas Copco Compressors Creates Central Technical Support Competency Group

Atlas Copco Compressors has created a new central Technical Support Competency Group to provide support for in-depth technical inquiries from customers, distributors and employees across the United States. The new group is headquartered in Rock Hill, S.C.

The creation of the Technical Support Competency Group is at the center of Atlas Copco's strategy to align technical support with product competencies as opposed to geographic regions. While dedicated technical support liaisons will continue to assist with regional-focused customer activities such as site visits, the new group will expand the current customer service model to include high-level technical support and product knowledge available to customers across the U.S.

"We are constantly striving to improve when it comes to first-class customer service," said John Brookshire, president, Atlas Copco Compressors LLC. "The new technical support group possesses high-level expertise in technology-based support that will enhance our regional support centers and take our customer service offerings to a new level."

In addition to developing specific technology-based competencies, Atlas Copco is also opening a Remote Monitoring Center, which will act as the central hub for monitoring compressor systems at customers' sites. The Technical Support Competency Group will maintain this service offering and will work with the local regional liaisons or distribution partners to address customer needs as they develop.

The new group will be based in Rock Hill, S.C., at the new Business Services Center, conveniently located near the product management team. The location will be custom-fitted to ensure optimum working space, including multiple video conferencing points and the latest VOIP telephone technology. The team will provide coverage across all U.S. time zones and can be reached by calling one dedicated number — 866-865-7995.

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THE SYSTEM ASSESSMENT

Optimize a Compressed Air System with Highly Fluctuating Air Demand

By Dr. Ing. Nicola Piccardo; Product Manager Centrifugal Compressors, Ingersoll Rand; Europe, Middle East and Africa

➤ Abstract

When an air system requires large quantities of air (ca. >100 m³/min) and air demand highly fluctuates during the day, it is common belief among end-users that large variable speed screw compressors can deliver significant savings opportunities by precisely matching the compressed airflow to the system's demand.

Consider the case depicted in Fig. 1 as an example. Where the daily flow demand has a variability of up to 90% of the maximum air demand, the study compares the energy consumption of six alternative solutions in terms of number of installed compressors, compressor sizes and types of compression technologies (i.e., oil free centrifugal and oil free rotary).

The influence of an air compressor's control system and its different control logics is also taken into consideration in the analysis.

The energy consumption of the same six solutions are then compared with different air demand patterns to simulate the behavior of the six systems in the case of varying production needs (i.e., other four daily air demand patterns with different variability are also consider ed).

Selecting the Right Compressed Air Solution

There are different compression technologies and each one can have its own advantages and disadvantages, depending on the particular application, operating range, power, capacity and other aspects.

Nevertheless, when an air system requires large quantities of air and air demand highly fluctuates during the day, it is a common belief among end-users that only the use of large, variable speed screw compressors can deliver great saving opportunities by exactly matching the flow of the compressed air delivered to a system's demand.

The purpose of this study is to compare and evaluate six different compressed air solutions when air demand is highly fluctuating. The study considered five variable flow profiles, as depicted in Fig. 1 to 5, to define some guidelines to help end-users select the best system for their application.

Related Case Studies

In **Case No. 1 (Fig. 1-2),** the air demand highly fluctuates between night and day shifts, from approximately 30 m³/min to 220 m³/min, which represents a variability of 90 percent of the flow.

Fig. 2 further defines the flow profile in Case No. 1. The y-axis represents the request flow as an absolute figure on the left, and as a percentage of the maximum requested system flow on the right. The x-axis shows the time as a percentage of the total observation period. Given this data, the researcher can deduct that the plant represented in Case No. 1 operates below the average flow almost 50% of the time. This flow spectrum is typical of a production site with two six-hour night shifts with low air demand and two six-hour day shifts with high air demand.

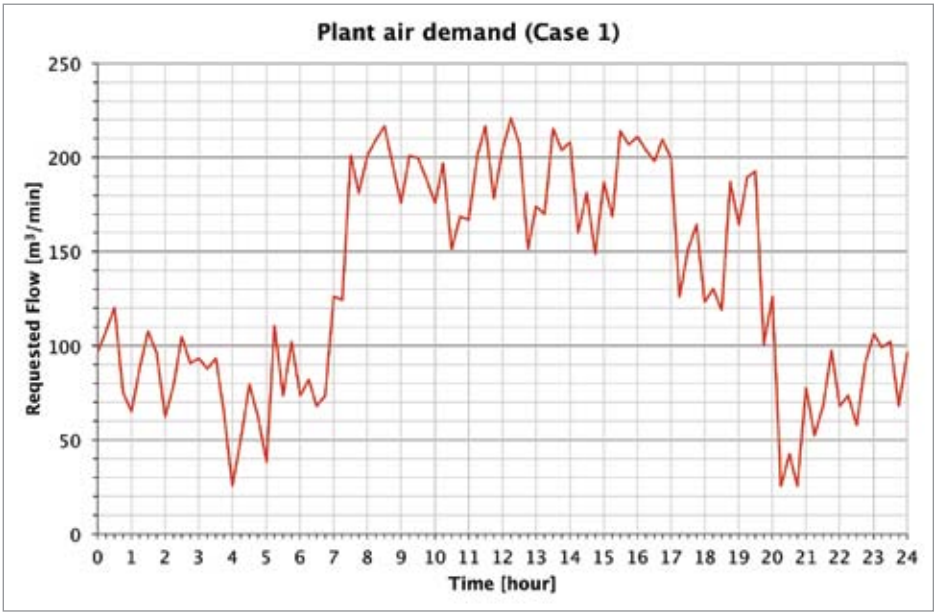


Fig. 1: High variability (90 percent) flow profile for a 24-hour time period.

The other four cases analyzed are depicted in Figures 3 to 6 and are representative of:

Case No. 2 (Fig. 3): Another highly variable spectrum with 90% of variability but compared to Case No. 1, less than the average flow is requested for only 30 percent of the time. This spectrum is typical of a production with one eight-hour night shift with low air demand and two eight-hour day shifts with high air demand.

Case No. 3 (Fig. 4): Similar to Cases No. 1 and No. 2 but with lower variability than before (ca. 65 percent of maximum flow instead of 90 percent). To differentiate it from the previous

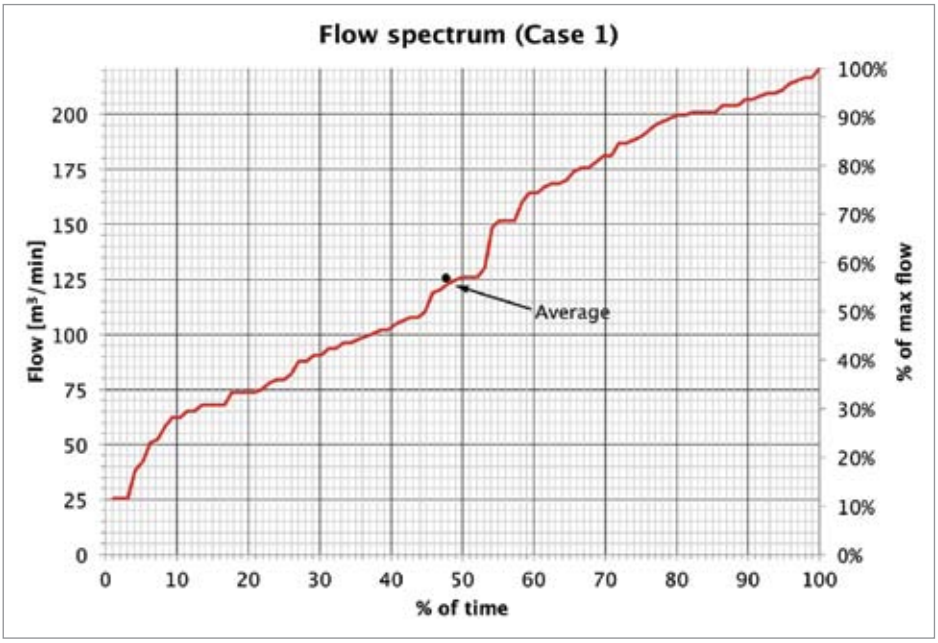


Fig. 2: High variability (90 percent) flow spectrum.

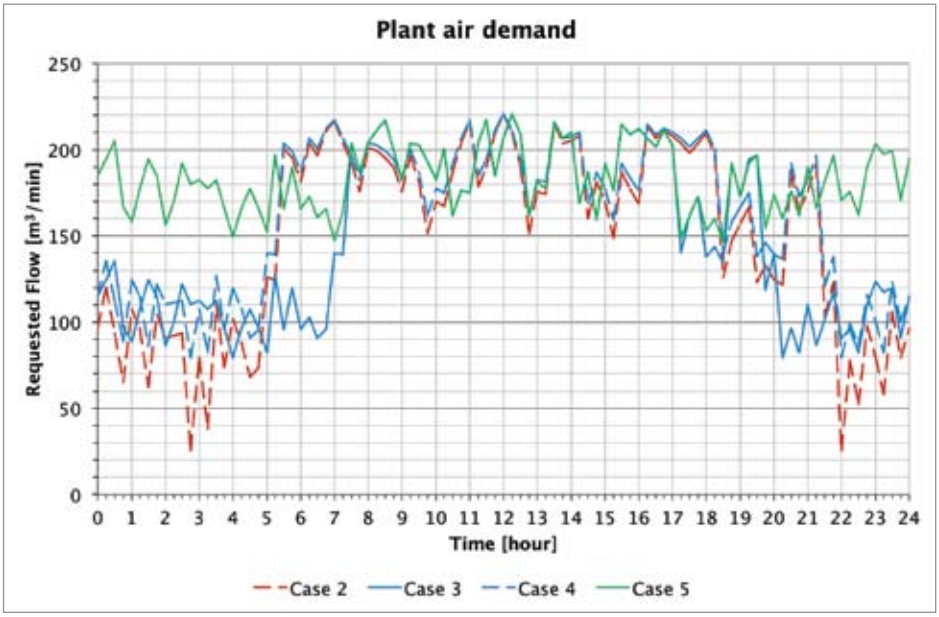


Fig. 3: High variability (90 percent) flow profile for medium time.

THE SYSTEM ASSESSMENT |

Optimize a Compressed Air System with Highly Fluctuating Air Demand

two cases, we call this a case with medium variability. As for Case No. 1, this variability occurs for a long time, as less than the average flow is requested for approximately 50 percent of the time.

Case No. 4 (Fig. 5): A medium variability flow pattern (ca. 65 percent of maximum flow, like Case No. 3); compared to Case No. 3, less than the average flow is requested only 30 percent of the time.

Case No. 5 (Fig. 6): A low variability flow pattern with a variability of only approximately 30 percent of the maximum flow all day long, representative of 24 hours per day — almost constant production.

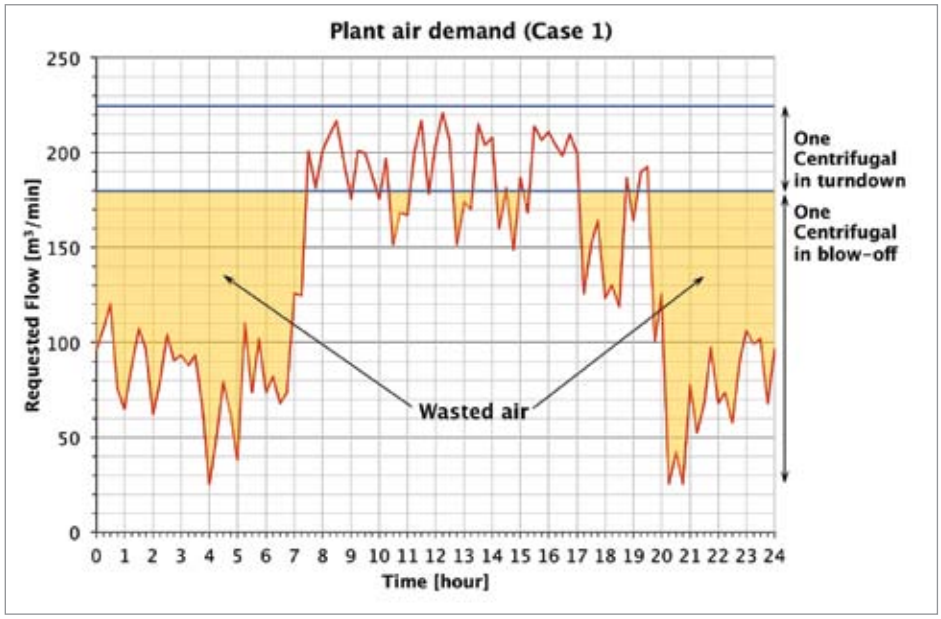


Fig. 4: Air blow-off with only one 220 m3/min centrifugal compressor.

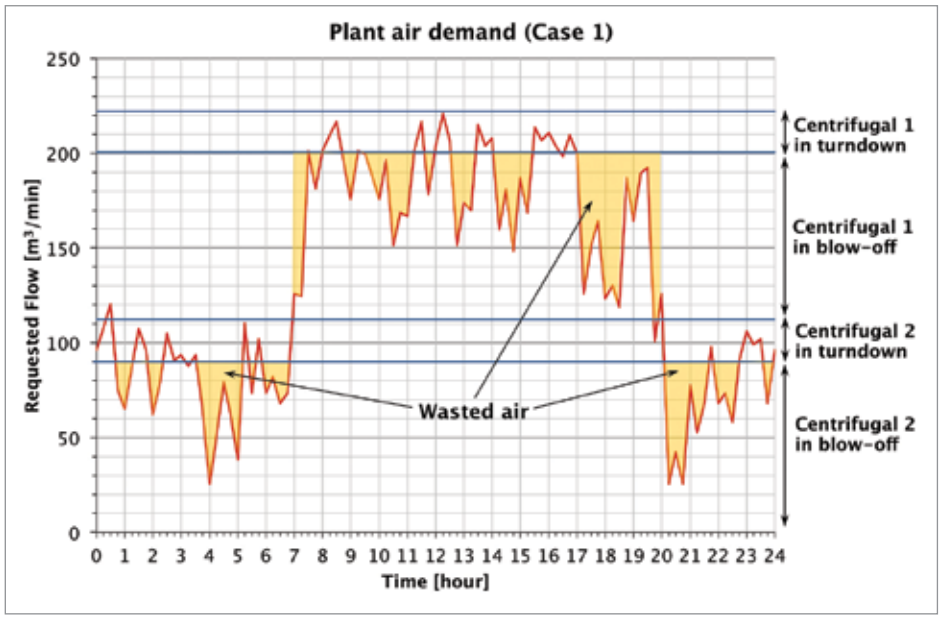


Fig. 5: Air blow-off with two 110 m3/min centrifugal compressors without load-sharing control.

Energy-Saving Compressor Solutions

From the energy consumption point of view, there are six alternative compressor solutions for the situations described in Cases 1-5:

- **Solution A** considers one centrifugal compressor and one large (700 kW) variable speed screw compressor whose maximum flow is half of the system's maximum flow demand.
- **Solution B** uses two centrifugal compressors whose maximum flow is half of the maximum system's flow demand. It is known that centrifugal compressors can be designed for best efficiency with a smaller regulation range or a wide regulation range, also called turndown, with lower design efficiency. In this second solution, compressors are designed for peak efficiency and have the latest and most efficient load-sharing control.
- **Solution C** utilizes two centrifugal compressors designed with wide regulation range. Also in this solution, like for all the following solutions with multiple centrifugal compressors, the centrifugal compressors have a load-sharing control since this control system always allows reduction in the blow-off of the centrifugal compressors by extending the system's regulation range.
- **Solution D** considers three centrifugal compressors whose maximum flow is one-third of the system's maximum flow demand. It is designed for wide turndown and load-sharing control.

THE SYSTEM ASSESSMENT | Optimize a Compressed Air System with Highly Fluctuating Air Demand

- **Solution E** considers mixed technologies, but in this case there are two centrifugal compressors with load-sharing control and one small (160 kW) variable speed screw compressor. In this scenario, the compressors are not controlled by a scheduler. This means that the small variable speed screw compressor is used only to cover peak air demands.
- **Solution F** utilizes the same compressors as in E, but in this case the three compressors are controlled by a scheduler. The scheduler allows the system to operate — for example, to load, unload or switch-off — each compressor according to a predefined schedule in order to optimize the system from various points of view; in this case, from the energy consumption point of view.

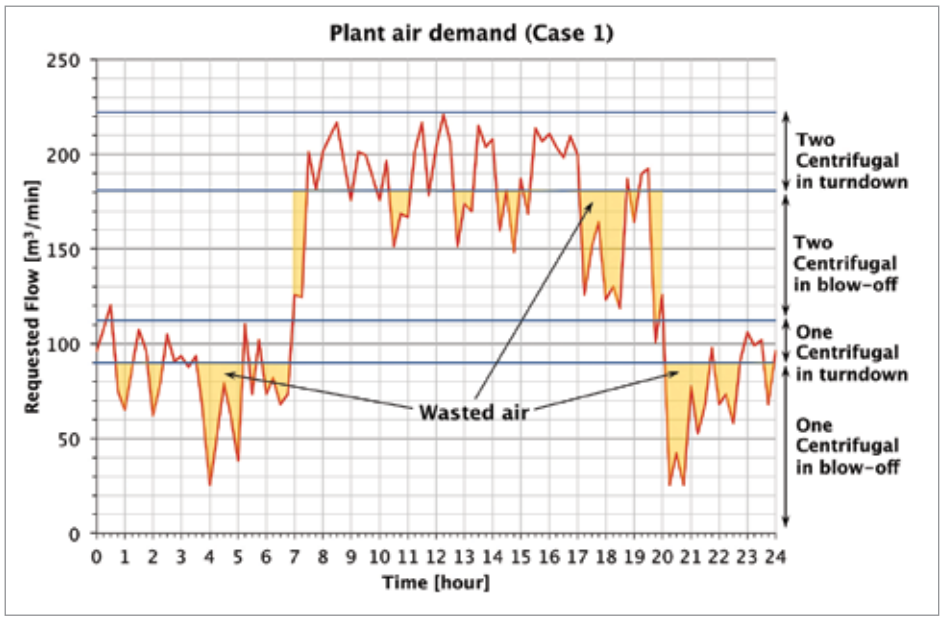


Fig. 6: Air blow-off with two 110 m³/min centrifugal compressors with load-sharing control.

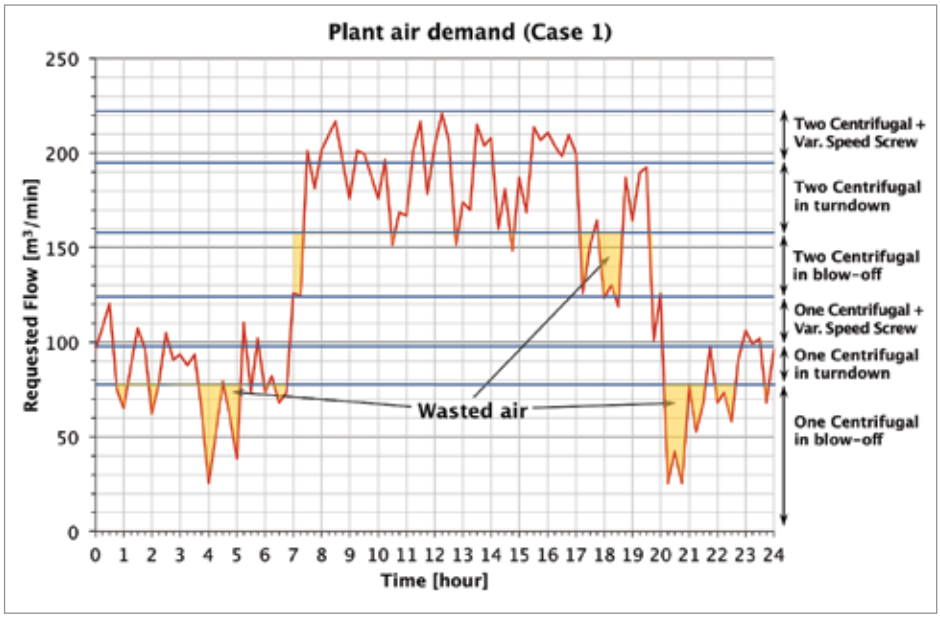


Fig. 7: In Solution F, air blow-off with two 100 m³/min centrifugal compressors designed for peak efficiency with load-sharing control plus one 25 m³/min (160 kW) variable speed screw compressor with scheduler.

Coming back to our original flow profile in Fig. 1, Solution A — with one centrifugal compressor and one large variable speed rotary compressor — can exactly match the flow requested by the system. For this reason, it is an unbeatable combination as there is no wasted air. Nevertheless, what we have to establish is whether it is also the most efficient solution from an energy consumption point of view. The use of one single centrifugal compressor with a maximum flow equal to the maximum system demand is not a viable solution due to the large amount of wasted air, as shown in Fig. 4. For this reason, this configuration was not listed among the previously discussed solutions.

When multiple centrifugal compressors are installed in a system, it is possible to reduce the blow-off of the centrifugal compressors with the installation of a load-sharing control system. Figs. 5 and 6 show the difference, in terms of regulation range of two identical compressors, whose maximum flow is half of the system's maximum air demand, without and with a load-sharing control system.

In the case of variable flow demand beyond the natural regulation range — also called "turn-down" — of a centrifugal compressor, the use of a state-of-the-art load-sharing control system is always beneficial when two or more centrifugal compressors are used in a system, since air blow-off is reduced.

Each of the solutions described in Solutions B to F allows the system to have a different amount of wasted air. In some cases, like

Solution F (Fig. 7), the air blow-off is minimal. It is very close to the zero blow-off in Solution A, using one centrifugal compressor and one large variable speed screw compressor. Nevertheless, it is not the minimization of the air blow-off that determines the best systems but the minimization of energy consumption.

Considering the performances at a pressure of 8 barg for each of the compressors used in Solutions A to F, Fig. 8 shows the comparison of the daily energy consumption for the flow pattern of Case No. 1 with high variability for a long time. It also shows the relative efficiency between Solution A — the unbeatable solution — and the other five solutions. The efficiency of Solution A is taken as a reference and equals 100.

Solution A is not the unbeatable solution, but Solution F — composed of two centrifugal compressors with load-sharing and one small 160 kW variable speed screw compressor with a scheduler — is the best solution in terms of energy conservation. Solution F allows the user to save almost 3% compared to Solution A.

Solution C — configured with two centrifugal compressors designed with wide regulation range and load-sharing control — despite some air blow-off, is only 0.3 percent lower efficiency than Solution A; therefore, it is a preferable option from an operating point of view. In fact, if we consider 300 operating days per year and an average energy cost of 0.10 €/kWh ($0.13/kWh), Solution A allows operators to save only 1500 € ($19,500) per year versus Solution C. These savings do not justify this system's operating disadvantages: Solution A utilizes two compressors with completely different spare parts, and if a backup compressor is needed, only one can be chosen, which does not guarantee the same operating efficiency. Solution C, using two identical centrifugal compressors, eliminates both of these problems.

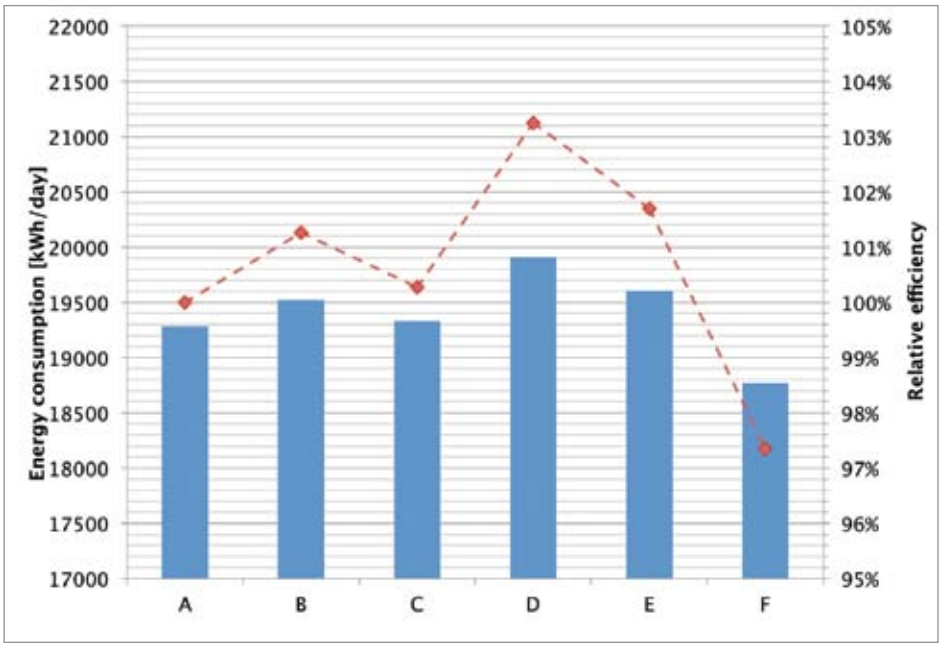
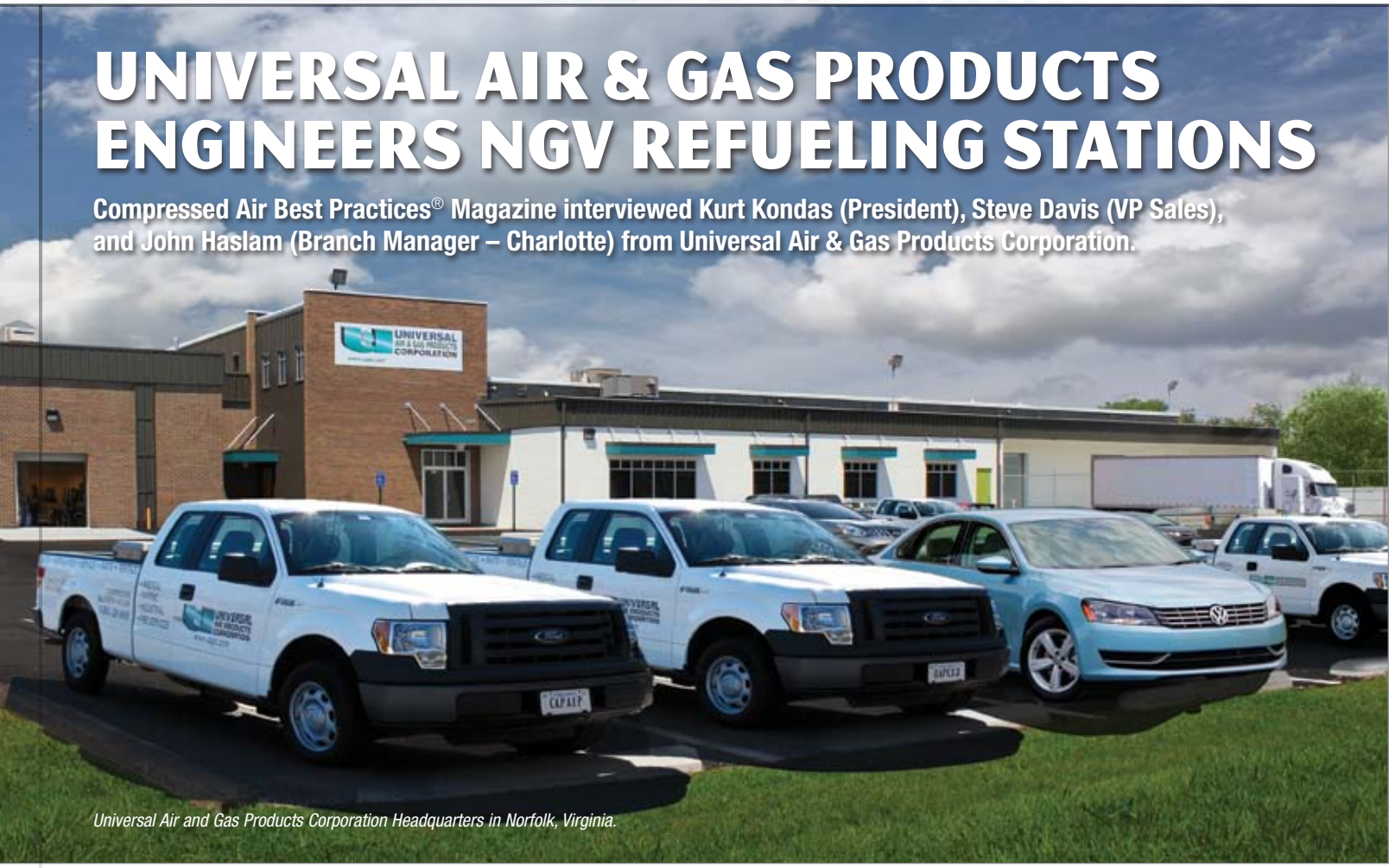


Fig. 8: Systems comparison, daily energy consumption.

Continued on page 41.

UNIVERSAL AIR & GAS PRODUCTS ENGINEERS NGV REFUELING STATIONS

Compressed Air Best Practices® Magazine interviewed Kurt Kondas (President), Steve Davis (VP Sales), and John Haslam (Branch Manager – Charlotte) from Universal Air & Gas Products Corporation.



Universal Air and Gas Products Corporation Headquarters in Norfolk, Virginia.

➤ **CABP:** Good morning. Thank you for taking the time to discuss natural gas fuel systems.

UAPC: Glad to do it. Universal Air & Gas Products Corporation (UAPC) has decades of experience in gas compression, storage, dispensing, regulation and controls for natural gas fuel systems. We have been designing and manufacturing natural gas fuel systems through the many "roller-coaster" market cycles related to natural gas fuel systems.

CABP: Your firm certainly isn't a typical "air house". Please describe UAPC's focus on designing and manufacturing gas packages.

UAPC: Since 1962, UAPC has worked with air or gas compression, filtration, drying and precipitation systems. These custom-engineered systems range from 0.002 Torr vacuum to 6000 psig. This is truly a "knowledge market" where clients value (often with their lives) our years of experience designing and building systems.

An example of this is breathing air systems. We supply SCBA refilling stations for fire departments and also support many SCUBA applications at 3000 to 6000 psig for OSHA Grade E breathing air. We also provide OSHA Grade D low-pressure breathing air systems ranging from 60 to 200 psig. Each situation is unique and demands customized engineering and high-quality fabrication.

Located in Norfolk, we have long supported our military with a wide range of projects. Most are custom projects to support a unique application. We have a rental fleet of air compressors, for example, customized for the military. When a submarine docks for maintenance, the Navy requires a high-pressure, dockside, pier-power air compressor ready to be used in an explosion-proof environment. We have technicians working on military ships and submarines worldwide. For this, both UAPC and some of our technicians have been prequalified and have different secrecy clearances depending upon the project. In addition to our rental air compressors, we also have a fleet of CNG compressors available for long-term rent for the CNG refueling market.

This history led us naturally into other custom-engineering markets like medical compressed air, vacuum and blower systems complying with NFPA-99 standards. The alternate fuel compression systems market has also gotten us heavily involved with biogas, digesters, hydrogen, landfill gas, syngas, and wastewater applications.

CABP: The stories you could tell (but sometimes can't)! Please describe UAPC's overhead commitment required to support

so many market segments requiring custom engineering.

UAPC: Sure. We've been called a "design and build" engineering firm. We've also been called a "Boutique Engineering" firm. We have seven engineers on staff. Many of us have strong backgrounds in chemistry and metallurgy. We work with our team of 3D CAD designers to meet customer needs in these unique packages. Once the client signs off, this software output goes to the production floor.

UAPC has a significant investment in manufacturing; we build everything in-house except for the ASME pressure vessels. We do all the fabrication in-house in our 51,000 square foot warehousing and manufacturing plant located in Norfolk, Virginia. Here we can cut, bend, weld and paint all the custom components engineered for each job. Our assembly area then puts all the components together as a complete package. Our engineers also program and build the PLCs and controls for each unit. If our customer needs a HMI panel with certain information displayed, we design it here in-house. Our systems are supported with SCADA with remote adjustment capability as an option.

A lot of companies subcontract this kind of work. It's unique to UAPC that we do all this work under one roof. There is an advantage to having a "gas guy" designing the controls and building a PLC — specifically for a gas package.

CABP: Let's talk about natural gas.

UAPC: Where do you want to start? We design 30 psi high-volume applications feeding co-gen engines, 600 to 1200 psig packages for shale gas, landfill gas, individual plant systems like a 275 psig system at a steam plant. In addition, we have many decades of experience designing and building natural gas vehicle refueling stations with pressures ranging from 3000 to 6000 psig.

Compression, storage and drying equipment supplying CNG fuel for a public access station.

UNIVERSAL AIR & GAS PRODUCTS ENGINEERS NGV REFUELING STATIONS

CABP: OK. Let's start with the macro situation. How do you view the future of the Natural Gas Vehicle (NGV) market?

UAPC: We've been involved with the compressed natural gas (CNG) market roller coaster ride for twenty years now. Historically, this market has been driven by government grants, causing the market to surge and then fade away. For UAPC, we've always had a certain volume of CNG business, but this is our third such surge in CNG activity.

This time, however, we believe is different. Now, we are seeing the vehicle and truck OEMs make great strides in vehicle reliability. They are also investing unprecedented amounts in NGV vehicle and truck design and manufacturing lines. This is in response to the extraordinary demand for energy independence in the U.S. This has contributed to a new (and we believe permanent) commitment to compressed natural gas by gas producers, infrastructure developers, vehicle OEMs, and consumers. We still have a long way to go, but we think NGVs are here to stay.

Beyond energy independence, CNG is a win/win for air quality, job creation, and business finances. For example, Waste Management recently announced they are converting their entire fleet of garbage disposal trucks to CNG. They say a typical garbage truck is saving $200 per day on fuel — that's a huge financial impact for a company of this scale — and there are greatly reduced emissions. It's a bonus for everyone.

CABP: What topics are on the minds of your customers investing in the NGV infrastructure build-out?

UAPC: To provide the anticipated build-out of NGV refueling station infrastructure, industry experts are projecting a remarkable growth rate of forty percent per year for the next five years.

We work with two very distinct buyer groups — municipalities and private investors. Municipalities operate fleets of school buses and garbage trucks. Private investors are building convenience-store or stand-alone NGV refueling stations. They have different motivations and challenges.

Twin 125 horsepower compressor packages with inlet desiccant dryer for large time-fill NGV Refueling System for Refueling Transit Buses.

Municipalities operating school buses and garbage trucks have a defined demand for fuel that is easy to forecast. Here we deal with a municipal-fleet manager who remembers seeing his fuel budget disappear when diesel and gasoline prices spike. Many municipal-fleet managers we speak to talk about 2009 when their yearly fuel budget had been depleted by the month of May. They want to reduce fuel costs but even more importantly, they want a stable fuel cost. They believe the advancements and expansion of natural gas exploration — in the U.S. — will provide them with a long-term, low-cost, stable fuel supply situation they can budget for.

The second distinct buyer is the private investor building NGV refueling stations into existing convenience stores or building stand-alone NGV stations. This is where the ROI scenario is important. If you are a fuel retailer, natural gas is attractive to sell due to higher profits per gallon. These guys are used to making a nickel ($0.05) profit per gallon sold. With natural gas, profits are said to average $0.75 cents per gallon equivalent. This provides the motivation to invest.

A big challenge and risk area for these investors, however, is to forecast demand. You hope to have anchor fleets using your station, but this isn't guaranteed. In a convenience store, how many NGVs will pull in to refuel? This is a tough question for forecasting. UAPC works with investors on their forecast models, and then we help them design the "supply-side" NGV station that best match this forecast. This is a highly consultative process, often requiring several years.

CABP: Please describe the time-filled NGV refueling stations you design.

UAPC: Our philosophy is to help customers design NGV refueling systems able to satisfy their current demand — but that are modular so that when demand grows they can easily

add capacity to their system. This is often the most efficient use of their capital. Many times we talk to clients who have been told by others to design for maximum future demand. Our position is that until these larger stations reach full utilization, their ROIs will fall short of investor expectations.

There are two fundamental types of NGV refueling systems. One is a time-filled system, and the other is a fast-fill system.

Time-filled (also known as "slow-fill") systems use a simple fill-post and are for anchor-based fleets. A municipality or private-fleet operator with garbage trucks may have twelve hours available to refuel overnight. That's simple to do, as they have a defined demand and refueling time period. We do help these fleet operators answer questions such as, "What are the conversion (to CNG) costs for the trucks? How much fuel does each vehicle hold? How much does each truck consume per day? How much fuel will be required during refueling per truck? How much time is available for refueling?" These questions will drive system characteristics including inlet gas pressure, discharge pressure, gas storage and throughput required.

CABP: What are fast-fill NGV refueling systems, and what are some of the design considerations?

UAPC: A normal gas station or convenience store will use a fast-fill NGV refueling station. Cars and trucks pull in to refuel and are on their way. Time is of the essence for these customers, so we have to focus on delivering sufficient flow and pressure of natural gas-on demand. A fast-fill system, allowing customers to fill their tanks in three or four minutes, uses a low, medium and high-bank storage system feeding into the dispenser. The gas dispenser looks just like a regular dispenser, except it's a "smart" dispenser that knows which storage bank to pull gas from. As the vehicle fills, the dispenser knows to change supply pressures by switching supply banks. The target pressure is normally 3600 psig. When gas flows slow, and we are below our target pressure of 3600 PSIG, the dispenser switches to the higher-pressure storage bank to reach our target pressure in a timely manner.

An important factor here is storage. You can install smaller compressors (and spend less capital) if you have space for storage. Many convenience stores, however, do not have space, so they need a larger flow compressor to maintain the required fill time.

As an added service, UAPC offers our customers a fully enclosed compressor. This option provides gas stations and convenience stores a way to protect their equipment against hot summers and cold winters. We design

Public access NGV fast-fill refueling station.

enclosures with both ventilation and freeze protection. Other important reasons to consider enclosures are noise suppression, increased safety and protection against vandalism (with locked access doors). Most of our customers choose enclosures that are design-neutral, while others have developed special designs to highlight their CNG service. Better than half the systems we design are fully enclosed.

UNIVERSAL AIR & GAS PRODUCTS ENGINEERS NGV REFUELING STATIONS

CABP: Please discuss temperature compensation and sequencing controls in NGV fueling stations.

UAPC: Two primary NGV fueling system control components are temperature compensation and sequencing controls. Gas will expand or contract depending upon the ambient temperatures. Fast-fill stations are subject to tremendous temperature swings during the fall and spring each year. UAPC controls imbed programming, which is constantly reading ambient temperatures and calculating what variations in pressure need to occur. The software will calculate, at a given temperature, what our fill-pressures should be.

Sequencing controls determine which bank is filled first, second and third. Natural gas station storage tanks are generally rated for 5500 psig. Our systems provide for a 1000 psig buffer because we can easily see a 500-600 psi swing in pressure due to changes in ambient temperature. The last thing we want to do is to over pressurize the storage vessels. Nobody wants to see (or hear) a relief valve actuate at these high pressures!

CABP: Motor drives and controls — what are the design drivers with NGV fueling systems?

UAPC: Some clients want electric drives while others want natural gas engines. Most use electric drives if they have available power. A key thing to remember here is that this unit will most likely be, by far, the biggest power consumer on site. A convenience store has some refrigeration compressors and a municipal warehouse may have an HVAC system with fan motors. However, these don't compare to larger horsepower motors on the CNG compressors! In eighty percent of the cases we see, the natural gas compressors are the biggest energy consumer — by far.

One of our main design objectives, therefore, is to minimize the peaks in power demand when the compressors start. Peak demand on two 50 hp motors, for example, can total 350 amps — similar to what is seen in small manufacturing plants. This kind of in-rush spike can really impact a facility's energy bill. We have a customer in South Carolina who owns a landfill and operates a fleet of 17 CNG trucks. He has a time-fill system. They plug in at the end of day, and in the morning they are full and ready to go. The owner called saying his local electric utility was about to implement a change, making his peak demand period between 3 and 8 p.m. This meant his demand charge was going to occur exactly when his consumption was the highest. Our solution was to modify the PLC controlling the compressors so they wouldn't turn on and begin the refueling process until after 8 p.m.

On fast-fill systems, you want the compressor to give all you can — as fast as you can get it. Case specific, our designers will use Wye delta starters and/or variable speed drives to avoid the demand peaks when you start the motor.

Another thing we do to control power consumption is to use a modular approach. Other suppliers will put in one large motor with one large compressor. We break it up into smaller modular systems using, for example, twin 50 hp compressors with staggered starts to reduce the inlet rush (using Wye delta starters) instead of one large 100 hp compressor. Most suppliers will size the gas compressors based upon a theoretical peak demand level and put in one unit able to satisfy the demand, disregarding peak energy consumption concerns.

CABP: How do you control moisture levels in natural gas?

UAPC: Gas quality is an important factor when designing a system. Depending upon the age of the pipeline, gas can be a lot wetter in some areas of the country than others. Saturated (laden with water) natural gas on the suction (inlet) side of a gas compressor can cause breakdowns and problems with the vehicle's

Twin-hose fill-posts for overnight refueling of a gas utilities' NGV service fleet.

fuel delivery system. Dry gas is a must for a reliable NGV refueling station.

As noted, the moisture content of inlet gas will vary. Because gas moisture content can change, gas dryers are required to ensure a predictable high quality gas to the vehicle. Typically, you can get the gas company to give you a gas analysis to size a gas dryer properly. The specification for municipal gas is seven lbs. of water per million cubic foot. That's pretty dry. In ninety percent of cases, the dryer isn't doing much work. The gas quality is pretty good — normally.

On lower flow machines (75 cfm and below) we often use cartridge type dryers using molecular sieve adsorbents. These cartridge-type dryers are installed on the high-pressure discharge of the compressor. On larger systems, we typically use suction side low-pressure dryers that are placed just after the gas meter coming into our system. The gas is then dried before coming into the compressor.

CABP: What are some challenges facing the NGV Industry?

UAPC: The lack of predictability and long-term visibility with federal regulations and government tax incentives. For example, the automotive industry looks long-term at things like the 2015 Emissions Standard, which is the current standard. However, if you are Ford, and are thinking of new CNG vehicles and production lines, you want to know what the Emissions Standard will be in 2025.

The 3800 series of federal tax incentives were set to be discontinued — but then on the last day of the year, they were continued. We lost a whole year because they didn't reinstate the tax incentive until December 31st, and investors decided to hold off until they knew what the future looked like.

Another challenge facing private investors interested in investing in NGV infrastructure is the competition from natural gas companies. Some of these companies have installed their own refueling stations and are selling natural gas at very low prices so that they can secure gas-supply contracts. Selling gas at $1.18 (an equivalent gallon) is not something on which a private investor can make a decent ROI, and this is impacting investment in some geographies. There are a couple of gas companies that have gotten into the dispensing business. They will finance the whole site construction, with a "take-or-pay" contract, which can be a high risk for the investor.

Despite the challenges, the future is clear. Our country's thirst for energy independence, which supports job creation, a strong economy and our national security, has never been higher. Universal Air and Gas is at the forefront of this critical change to an abundant, low-cost alternative fuel.

CABP: Thank you for your insights. BP

For more information please contact Universal Air & Gas Products Corporation at tel: 800-326-8406, email: info@uapc.com, www.uapc.com

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Natural Gas Dehydration and Conditioning for NGV Refueling and Field Gas Upgrading

By Kurt Sorschak (President and CEO) and Guy Couturier (Applications Manager) from Xebec Adsorption, Inc.

Compressed Natural Gas (CNG) is an alternative fuel source (to diesel and gasoline) with far-reaching benefits to North America. Strategically important benefits include energy independence, improved air quality, job creation, and lower and more stable fuel prices. This paper discusses natural gas desiccant dryer requirements in Natural Gas Vehicle (NGV) refueling stations, compares deliquescent to desiccant dryers and reviews two on-site field gas upgrading examples in displacing diesel fuel

Section I: Natural Gas Dryers for NGV Fueling Stations

Xebec Adsorption has been supplying Natural Gas Dryers for CNG (Compressed Natural Gas) fueling stations worldwide for over twenty-five (25) years. It has been only in recent years, however, that more and more countries have been turning to natural gas as an alternative fuel source for transportation. This growing demand is due to a few reasons: natural gas is much less expensive than diesel or gasoline, it is a much cleaner fuel and it can also mean energy independence. In the U.S. alone, it is predicted that 6,000 to 15,000 new NGV refuelling stations will be built by 2023.

The Importance of Low *Pressure* Dew Points

The dryer on a CNG station is an important component. If the gas is not dry when entering the compressor on the fueling station, it can lead to freeze up problems at the dispenser and in the tank of the vehicle. This is obviously disastrous as it can result in the closing down of the station. So why would a station builder not install a dryer? The most common reason for not installing dryers in NGV refueling stations is the belief that the gas is already dry. However, it should be taken into consideration that although the gas dew point may be as low as -40°C in the pipeline at pipe pressure, the effects of compression will affect the dew point of the gas (Joule-Thomson effect).

Physical laws dictate that the dew point of a gas increases as its pressure increases. Therefore, although the dew point of the gas in a given pipeline may be very low when it reaches the compressor, it will be significantly higher when the gas leaves the compressor. This is why natural gas desiccant dryers are required in the majority of NGV stations in order to conform to the ISO 15403:2000(E) Standard, specifically in areas where lower temperatures are encountered during the colder winter months.

"The single most important safety requirement of compressed natural gas (CNG) fuel is a very low water dew point temperature to preclude the formation of liquid water at any time. Liquid water is the precursor to the formation of corrosive compounds through combination with components in natural gas, namely carbon dioxide and hydrogen sulphide. The combination of corrosive agents, and the pressure cycling, caused by fuel consumption and subsequent refilling of the fuel storage container, can result in crack growth in metals and ultimately damage and failure. Also liquid water itself can be detrimental as it may cause blockages, both liquid and solid, in the fuel system." — Source: ISO 15403:2000 (E) Standard, paragraph 5.1

A Regenerable Twin-Tower Natural Gas Desiccant Dryer.

A Regenerable Heat Reactivated Twin-Tower Natural Gas Desiccant Dryer.

A Regenerable Single-Tower Natural Gas Desiccant Dryer.

What can happen, at a NGV Refueling Station, without the appropriate natural gas desiccant dryer systems?

1. First Step: Natural gas (at pipeline pressure dew point) enters the gas compressor. The gas is compressed, significantly increasing gas pressure, temperature and moisture concentration.
2. Second Step: Gas enters storage banks and expands. This causes significant decreases in gas temperature and the condensation of moisture. Liquid is now present and we have a problem.
3. Third Step: High-pressure gas containing moisture travels to the dispenser, enters the vehicle cylinder and expands once again. The NGV tank is now carrying water along with natural gas!

Monitoring and Measuring *Pressure* Dew Point

In order to continually measure the moisture level of the gas before it is compressed, every desiccant dryer should feature a pressure dew point probe. It is essential that the probe is recalibrated annually in order to ensure an accurate reading. A new dew point probe can be very costly, so in order to support its customers and ensure safety on the station, Xebec offers a recalibration program where a recalibrated probe is provided in exchange for a used probe. Continuous measuring and monitoring of pressure dew point with dew point probes, ensures the continuous operation of the gas dryer and the NGV refueling station.

Section II: Differences Between Desiccant and Deliquescent Natural Gas Dryers

There are important differences between regenerative "desiccant" type dryers, using molecular sieve as the drying media, and "deliquescent" type dryers. Although they both can reduce the gas dew point, there are important and considerable differences in the dew point performance characteristics between the two.

Deliquescent dryers operate on the principle of dew point suppression, which is entirely dependent on the inlet temperature of the gas to the dryer. Dew point suppression

NATURAL GAS DEHYDRATION AND CONDITIONING FOR NGV REFUELING AND

Compressed Air Best Practices® Magazine interviewed Kurt Sorschak, President and CEO, of Xebec Adsorption Inc.

Kurt Sorschak, President and CEO of Xebec Adsorption, Inc.

CABP: Good morning. Please describe Xebec Adsorption.

XEBEC: Xebec Adsorption has sold over 8,000 adsorption dryers to over 1,300 customers worldwide. Our head office is in Blainville, Quebec where we have a 41,753 square foot manufacturing facility and 70 employees. The company also operates a 20,451 square foot facility in Shanghai, China with 34 employees. Xebec was acquired from Parker Hannifin and has an exclusive focus on gas purification. This acquisition was done in a management buyout in June 2007.

CABP: What is Xebec's market share and what are the growth prospects of NGV refuelling stations?

XEBEC: This is an exciting time in North America (and across the world) as we re-evaluate our energy sources, infrastructures, and consumers. The installed base of NGV refuelling stations has stabilized at roughly 1,200 refuelling stations in North America. This number hasn't changed much over the past five years. We have seen roughly 100 new stations per year offset a loss of 100 stations each year. Xebec has a desiccant dryers in eighty (80%) percent of these refuelling stations.

The forecast now is that over next three to seven years, North America will experience a build-out of anywhere from 6 to 15,000 new NGV refuelling stations. There is no real consensus on this broad range, but the good news is that the most conservative number being used is 6,000 new stations. Most people talk in the range of 10-15,000 new stations. Either way, thousands of new stations are coming on line and it's a great opportunity.

There are about 200,000 gasoline refuelling stations in North America. A study examined how many stations would need diesel fuel and they came up with 30,000 stations. When they looked at natural gas refuelling station numbers, they came up with a lower number to serve Class 5 to Class 8 truck engines for trucks-this is how they came up with the 6 to 15,000 station number. Once people start talking about serving the needs of NGV prototype cars, the numbers go through the roof. Chrysler just introduced, for example, a NGV version of the 300 Series pickup.

CABP: Who is driving the infrastructure investments and why?

XEBEC: There is a change in the CNG industry. All along the supply chain it used to be all niche players like Xebec. Now, major companies like General Electric and Atlas Copco are in the game. Gas utilities and U.S. oil companies have said they will build out the infrastructure. General Electric wants to build 100 stations this year and then 200 stations each year thereafter. Waste Management has a fleet of 19,000 trucks and has announced they will convert the entire fleet to CNG!

Aside from the strategic benefits, like energy independence and air quality, what is really driving this industry is increased profits for all steps in the food chain. Natural gas is estimated to be fifty percent (50%) less expensive to bring to the NGV refuelling station than diesel. From there, we still see different pricing strategies out there. Stations owned by Clean Energy normally price CNG at roughly 10-15% below diesel. Looking at the cost differential, they clearly have higher gross margins per gallon with CNG than with diesel. Fleet operators realize the 10-15% cost reduction to drive the demand.

CABP: What are the opportunities you see with field gas upgrading?

XEBEC: There are approximately 2,300 rigs operating in North America. A drilling rig consumes between 600 and 3,000 gallons per day of diesel fuel. The diesel fuel cost is $5.00 per gallon after transportation and a rig normally has a 50-65% utilization rate in a calendar year. Rig operators realize a significant cost savings using on-site field gas and often this also allows them to maintain desired product levels.

By purifying the natural gas, drillers can displace 60% of their diesel requirements by running a mixture of diesel and natural gas. The trend has already begun and, in our opinion, most drillers will be modifying their engines to bi-fuel capabilities.

CABP: How can air compressor distributors get involved with the natural gas industry?

XEBEC: Up until now, compressed natural gas was a special niche serviced by the compressed gas guys. We would, for example, send our own technicians out to job sites or use the service groups of packagers. With the installed base growing as it is forecasted to do, we believe on-site technical service will become an issue and that the compressed air industry is perfectly qualified to serve this need.

The future NGV refuelling stations and drilling rigs will all have gas compressors, desiccant dryers, and filters requiring maintenance and service. It's not a big step from compressed air to natural gas — from an equipment standpoint. The service teams presently employed by air compressor distributors can be trained to handle CNG installations. We are currently working to get compressed air distributors trained to do the field service and maintenance of our gas purification products.

We expect a particularly good opportunity on NGV station side. Many packagers don't have capacity to do service nationwide for these installations. They don't have a national service network. As the numbers increase, this is an opportunity for the compressed air guys.

CABP: Thank you for your insights.

FIELD GAS UPGRADING

performance, with these dryers, is typically in the range of 10 to 30 ˚F at best. A dew point suppression of 20 ˚F means that if the inlet temperature of the gas to the dryer is 100 ˚F, the pressure dew point of the gas exiting the dryer will be 80 ˚F. This situation can be quite common since this type of dryer is installed at the discharge of the gas compressor. Gas compressor after-coolers can have approach temperatures of 20 ˚F or more.

Deliquescent dryers consist of a vessel filled with a mixture of water-soluble salts or organic compounds, or both, in the form of tablets or beads. As the wet gas passes through the drying media, a percentage of the water vapor is absorbed by the tablets. During this absorption process the tablets gradually dissolve, and droplets of dissolved media and water collect in the bottom of the vessel drain area in the form of a "slurry" which will need to be regularly drained as part of normal operation.

Regenerative Natural Gas Desiccant Dryers

Regenerative gas desiccant dryers, using a molecular sieve desiccant as the drying media, work on a different principle of adsorption.

As the gas passes through the desiccant bed, the water vapor is adsorbed by the molecular sieve desiccant. The desiccant is not dissolved in this process. The molecular sieve continues to remove the moisture from the gas stream until it is exhausted and subsequently regenerated. The time to initiate the automatic regeneration cycle is typically detected by a precision dew point monitor installed at the outlet of the dryer system.

Desiccant dryers use a closed-loop heat reactivated regeneration system which circulates an electrically heated gas flow through the desiccant bed thus removing the moisture from it, then subsequently cooling the gas, and separating the liquid water to drop out into a collection receiver.

Desiccant dryers use a special molecular sieve for natural gas service and the closed loop heat-reactivation regeneration is extremely efficient and will continuously produce dew point levels which exceed worldwide codes that govern the dew point of the gas used in CNG vehicles. The most common codes for CNG gas quality in North America are SAE J1616 and CARB (for

NATURAL GAS DEHYDRATION AND CONDITIONING FOR NGV REFUELING AND

California). Both of these codes state that the dew point of the compressed gas at vehicle fuel storage container pressure vessel must be at least 10 ˚F below the 99% winter design condition of the location of installation of the CNG station. As an example, if the 99% coldest winter temperature in San Jose is 35 ˚F, then the dew point of the gas in the storage vessels must be 25 ˚F or less at all times.

Regenerative type molecular sieve dryers can easily exceed such dew points. They are able to reach well below –100 ˚F pressure dew points. Sub 32 ˚F pressure dew points can only be achieved with desiccant dryers. This is why they are commonly used in North American NGV refueling stations. Natural gas desiccant dryers are capable of handling inlet operating pressures from 5-1200 psig and flows up to 25,000 SCFM. These dryers can also be sized for pipeline quality gas applications as well as saturated gas applications.

Xebec's compact M-3100, fast cycle PSA unit was used on an off-shore platform off the California coast.

The Xebec compact M-3100 fast-cycle PSA system was the perfect solution to dehydrate field gas at a Southern California oil field.

Section III: Field Gas Upgrading and On-Site Utilization

Oil exploration and production (E&P) operators around the world are facing significant and growing concern over their business models, driven by rising diesel fuel costs and detrimental environmental impact assessments. These challenges present a tremendous opportunity for the natural gas industry.

There are enormous economic and environmental benefits in powering diesel-fueled rigs with natural gas. Conversions have already been proven by a number of early adopters, using both bi-fuel and dedicated natural gas engines. Different sources of natural gas like field gas and liquefied natural gas (LNG) have also been tested. With each technology and fuel type, operators and technology companies are now addressing some operational challenges and looking to increase efficiencies. There is no doubt, however, that the viability of powering rig operations with natural gas is a new reality and can make a major impact on overall fuel consumption on a global level.

Natural Gas Use Benefits to Oil Rig Operations

Extensive use of natural gas in the energy grid builds additional domestic energy security and has implications for rail, mining, military, construction services, freight transportation, airport and port authorities, and more. In oil rig operations, the cost savings and positive environmental impacts that early adopters are experiencing are already significant. There are documented results such as dedicated natural gas engines saving in excess of 1,000 gallons of diesel fuel a day, reducing CO_2 and NOx emissions up to 20 percent, and reducing operating costs from a range of $500 to more than $2,000 a day in some locations.

FIELD GAS UPGRADING

- Oil & gas drillers and frac pump operators can displace up to 60% of their diesel fuel usage with field gas.
- Environmental performance is improved with a significant reduction in carbon dioxide, particulate matter (PM) and nitrogen oxide (NOx) emissions. Plus, natural gas engines run quieter than diesel counterparts and their emissions are odorless.
- There is reduced flaring and improved productivity as extraction does not need to be turned down because of flaring quotas.

Two Projects Displacing Diesel with On-Site Field Gas

Xebec provides a proven, cost-efficient, flexible, containerized solution to displace diesel fuel with on-site field gas. The system addresses the needs of a significant customer base of E&P operators — particularly those in unconventional sources like shale oil and shale gas.

The operating system, called AGX, separates well gas into a natural gas stream and produces an exhaust stream rich in Natural Gas Liquids (NGLs). Two field gas conditioning systems were deployed in 2006 and are currently experiencing excellent results.

1. One of the largest independent oil and natural gas companies in California purchased Xebec's purification technology to purify natural gas to meet strict quality specifications for natural gas in California. Our M-3100 unit is installed on a platform off the coast of California. It upgrades the platform's stranded gas that would otherwise have to be re-injected into sales gas. The successful results comes from not only the superior gas recovery and product purity, but also in respecting the strict space limitations imposed by the offshore platform operator.
2. An oil producer, located in Southern California, was struggling to meet California's new and more stringent sales gas specifications for ethane and heavier hydrocarbons. Oil production had to be decreased due to the limited capacity of their LTS unit, used to dehydrate and de-rich the field gas from the oil wells to produce sales gas. Gas production in an oil field is a necessary function of oil production. Therefore, a limitation in gas throughput automatically drives a decrease in oil production, resulting in revenue loss. The Xebec AGX system cost less than one-third of a new LTS unit and, by reusing the existing LTS to improve methane recovery, the gas throughput capacity doubled

The market is growing for NGV refuelling stations and on-site gas upgrading. Gas drying is an important part of the process and understanding how to achieve, measure, and manage pressure dew point is important to the success of these installations. Natural gas desiccant dryers will play an important role in the build-out of this new infrastructure in North America. BP

For more information contact Kurt Sorschak, President and CEO, Xebec Adsorption, email: ksorschak@xebecinc.com, tel: 450-979-8701, www.xebecinc.com

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Smith Electric Trucks Complement CNG

Compressed Air Best Practices® Magazine interviewed Bryan Hansel (CEO), and Edward Anculle, (Associate Mechanical Engineer – R&D) of Smith Electric Vehicles.

Major Fleet Operators Are Adopting Electric Trucks.

➤ **CABP:** Good afternoon. Please describe the history of Smith Electric Vehicles.

Smith: Good afternoon. Smith was originally founded in Newcastle, England. They started out by building an electric home milk-delivery truck. It was a true boutique business focused on a niche. A good friend of mine bought the company, in 2004, with the plan to broaden the scope of the business. Smith Electric Vehicles was launched in 2007, in the U.K., and incorporated here in the United States in 2009.

Smith is one of the world's leading manufacturers of all-electric commercial vehicles, which are zero-emission and less expensive to own and operate when compared with traditional diesel trucks. The company produces trucks for multiple industries, including food & beverage, utility, telecommunications, retail, grocery, parcel and postal delivery, school transportation, military and government. Smith's customers include many of the world's largest fleet operators, including PepsiCo's Frito-Lay division, FedEx, Staples, TNT, Sainsbury's, Coca-Cola, DHL, and the U.S. Military.

Our two primary plants are in Newcastle (U.K.) and in Kansas City. We have committed to a new production facility, located in the Bronx area of New York City. We are currently researching the possibility of our next plant opening in Chicago.

CABP: How do EPA and local emission standards impact demand?

Smith: We now have just under 1,000 zero-emission electric trucks on the road. Fleet operators are recognizing a strong ROI without any government incentives. When "Air Quality Dollars" are available, however, the ROI just gets better.

Cities are prioritizing air quality and EPA standards on emissions are expected to keep going up in the new laws coming in 2014 and 2017.

Air quality dollars are being placed in markets like California, Chicago, New York — who all have incentives in place. Taking a diesel truck off the road for ten years, scores 10 times better (to qualify for federal incentives) than any other federally-funded projects.

The Chicago Department of Transportation (CDOT), under the Mayor Emanuel's leadership, has announced a comprehensive, $15 million incentive program that will encourage companies and individuals to modernize their fleets and convert to electric vehicles. The first of its kind in the US, this plan rewards fleets on an increasing scale for replacing their most diesel-consuming vehicles.

The program's initial $15M is funded by resources from the federal Congestion Mitigation Air Quality (CMAQ) program and will provide vouchers to assist companies in reducing the costs of converting their vehicles to electric. The City is also considering additional incentives such as preferential loading zones and decreased registration costs to complement the voucher program. Fleets can stack the State of Illinois' Alternative Fuel Vehicle and EV Charging Station Rebates on top of the City's incentive.

Through similar federally funded incentive programs, the City has helped deploy 404 cleaner vehicles, including 159 compressed natural gas (CNG) livery/taxi vehicles and 223 alternative fuel stations, including 17 CNG and 202 electric vehicle-charging stations — the densest network of any major city. These vehicles and stations have displaced 200,000 barrels of oil and reduced greenhouse gas emissions by 2,850 tons.

Smith electric vehicles have zero tailpipe emissions — in fact, there is no tailpipe. This means no harmful air pollution — no particulate matter, no nitrous oxides, no carbon monoxide and of course no CO_2. Even when charged with conventional grid electricity, our vehicles still deliver a substantial CO_2 saving over the equivalent diesel vehicles. From a well to wheel perspective our greenhouse gas impact is thirty percent (30%) of a diesel equivalent vehicle. Charge them with renewable energy and you have a genuinely carbon-free transport solution.

CABP: How do fleet managers choose between CNG and Electric?

Smith: Electric trucks are a complement to CNG. There will be a number of technologies making up an effective fleet of the future. CNG technology is focusing on longer-length routes of up to 500 miles. A typical CNG application, in the private sector, is for trucks doing a standard route from a factory to the distribution center. Public transportation, doing a fixed route of up to 300 miles per day, is the other early adopter of CNG. With longer routes, you consume enough fuel to justify the CNG infrastructure investments required (for even the first truck). CNG ROI's work well when there are a large number of trucks doing many miles on a fixed route.

CABP: What does the electric truck ROI look like vs. diesel trucks?

Smith: Electric trucks have physics are on their side. We are comparing a ninety percent (90%) efficient electric motor vs. a combustion energy that is thirty percent (30%) efficient. It's like what one sees with LED lights — you get the same amount of work done for a fraction of the energy cost. Smith Electric trucks are approximately eighty percent (80%) less expensive per mile driven when comparing kWh to diesel costs. Major companies making asset decisions are aware of this. The typical Smith MPG equivalent is well over 30 MPGe as opposed to 8-10 MPG for an equivalent diesel.

The Cab & Chassis in the Testing Area.

The Mattei Rotary Vane Air Compressor System.

SMITH ELECTRIC TRUCKS COMPLEMENT CNG

The ROI math, for electric trucks, works on route distances of less than 100 miles. Depot-based logistic companies, making local deliveries, are our market niche. Any local delivery is our niche. The average FedEx truck averages 70 miles per day. The average Frito Lay urban delivery truck averages 50 miles per day.

Reduced maintenance costs also help the ROI calculation. There are over 1,000 moving parts in an internal combustion engine and only four in an electric motor. With very few moving parts, the annual service and maintenance expense is much lower, and the practical operating life is longer than conventional diesel trucks. The Smith vehicle maintenance regime is simple; two daily fluid level checks on the electric motor and cab heater, plus an annual check on the batteries. The vehicle's standard service schedule applies for everything else — running gear, brakes, suspension & steering components.

Aside from ROI, customers get much hire driver satisfaction. Electric trucks are "whisper-quiet" and there are no fumes. It's like driving a completely normal truck — except it's so silent and you don't have to go to the gas station. Drivers like it!

CABP: Can you comment on the individual adoption phases by some customers?

Smith: For the most part, our client base has a multi-year commitment to Sustainability and fleets are a big part of this. Fleet managers are introducing the next generation of non-diesel fuels to support corporate sustainability plans while increasing the ROI of their fleets. We can estimate our impact on this plan. We can help map the impact electric trucks will have on all elements of the business.

Smith Electric Vehicles field personnel do a feasibility study to evaluate the duty cycle of a vehicle and a fleet. We come in and do driver assessment and training. If a client is looking for a broader strategy, this does require an assessment. It's more about choosing a strategy. Electrification is worth studying and we have the knowledge to assess whether this is viable. Let's lay out a plan to get it done — it's not just about buying trucks.

Fleets want to trial a new technology in the adoption process. Our large strategic relationships have a replacement cycle — each year a certain percentage of the fleet is replaced. Some fleets have set their goal at fifty percent (50%) of their fleet going electric over a period of years . The Smith Electric truck has delivered reliability and financial viability. We are past 3 million miles in the marketplace. The concept is now validated. We are now at the tipping point to go to scale.

The Newton Box Truck by Smith Electric.

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SMITH ELECTRIC TRUCKS COMPLEMENT CNG

CABP: Any company-specific success stories?

Smith: Sure. Frito Lay is moving towards electric trucks for local store deliveries and CNG for longer-run trucks running hundreds of miles from factories to distribution centers. Frito-Lay deploys North America's largest fleet of all-electric trucks. Frito-Lay has invested in 176 Smith Newton trucks, which it operates in the U.S. cities of New York; Columbus, Ohio; and Ft Worth, Texas. The company, which is part of PepsiCo, has also deployed Newton trucks in Canada.

FedEx Express has also initiated the deployment of 100 Smith vehicles in the U.S., adding to the electric vehicles already in service throughout the company's global fleet.

Based on current fuel prices, Smith trucks offer fuel costs that are as much as seventy-five percent (75%) lower than diesel, along with virtually silent operations, eliminating noise and pollution. The Newton all-electric truck delivers a top speed of 60 mph (97km/h), offers a range of up to 150 miles (65-190km) on a single charge and a payload of over 16,000 pounds (7,250kg). Flexibility in battery configurations allows customers to customize vehicle range based on duty cycles of their routes. The Newton operates at peak effectiveness in urban applications that demand heavy 'stop-and-go' driving. A single overnight charge provides more than enough range for most urban delivery routes.

CABP: Please describe the re-charging process.

Smith: Ninety-nine percent (99%) of our clients are single shift operations. This means the energy consumption from battery re-charging occurs during off-peak hours. Overnight charging is ideal as it occurs when the grid demand is down and has excess capacity.

A short-term challenge can be to bring more load to one parking lot. If a depot charges 20 trucks, in phase 1 of their electric-vehicle adoption program, it's usually a simple installation. When they expand electrification to 150 vehicles, at that address, they might not have enough load. They now have to look at how to bring in more electric power to the site.

The Newton Refrigerated/Cold Plate Truck by Smith Electric.

Recharging is simple. A standard recharge from 0% — 100% takes 6 to 8 hours on the Smith Newton and the Smith Edison truck models. A fast charge system is available on the Smith Edison panel van and minibus, completely refilling the battery in about 4 hours.

Smith vehicles come equipped with a fully integrated on-board charging system that optimizes charging efficiency and monitors re-charge state to maximize battery performance and longevity. The Smith on-board charger is a fully automatic, 208-240 volt, single or three phase, line to line, 60 Amp, 12/18kW charger, utilizing a standard J-1772 connection in the US and a standard 32A single or three phase socket in Europe and Asia.

CABP: Please describe the battery technology.

Smith: Smith vehicles feature the latest in lithium ion battery cell technology, power management and direct drive trains. A cornerstone of our strategy is to look at the battery as a commodity. We have flexibility to source batteries as it makes the most sense. In just the past three years, we have seen a fifty percent reduction in battery costs.

Our battery management system works on bricks of 20 kWh. We have 40, 60, 80, and 120 kWh trucks. Most clients seem to prefer the 80 kWh truck. We size the battery to the route. The sizing is roughly one kWh per mile-plus or minus. A thirty-mile route would use a 40 kWh pack. We have sizing software that takes into account route specifics. We will analyze average temperatures, hills, and highway use to calculate the battery size.

CABP: Why did you choose rotary vane air compressors for your trucks?

Smith: Our core technology is in power management and in the direct-drive train. We manage all the energy (coming in and going out). We are innovating around the electrification of the vehicle. The Smith Drive is our proprietary vehicle drive and control system, which features a configurable drive controller with integrated inverters for the management of auxiliary systems-like the Mattei rotary vane air compressor.

The air compressor is supporting our air brake system. We followed the SAE1455 Standard to test automotive commercial components. We tested the rotary vane air compressor in a chamber for vibration, temperature and humidity variances — all at the same time while it was running under brakes pressure loads. The testing discovered some small packaging issues which were resolved. The overall unit passed our tests.

The temperature specification, for our trucks, is for -30 ˚C to 55 ˚C ambient temperatures. The air compressor has to run in this temperature range as well. A main challenge was in a high humid ambient, we can see condensation occur around 10 ˚C in the air compressor. This condition caused some failures, on our previous compressor, and found a large amount of water in the oil.

Working with Mattei, we modified the thermostat of the compressor so it can heat up faster than most and was able to achieve the nominal temperature within the vehicle drivecycle operation. The compressor now warms up the oil very quickly so it can operate in quick vehicle starts stops and under these low temperatures with high ambient humidity.

After testing, we found the rotary vane to be a very quiet and durable air compressor for this application. Since our electric truck is very quiet, we wanted to keep sound down. The main thing a driver hears is the radiator fans in our trucks. We also appreciate how durable the rotary vane compressor is and it's wide range of operating temperatures.

CABP: Can you describe your air brake system?

Smith: Absolutely. We have a regenerative air brake system. An electric motor receives power from the battery and driven by the SMITH drive. The electric motor then powers the air-cooled rotary vane air compressor. The air compressor is located between the rails in the middle of the truck. We use one air compressor size for all the air brake trucks. Mattei supplies an inlet air filter. There is an air dryer — the Wabco vertical air dryer system. The air compressor delivers to 120 psig compressed air to cylinders where you store the air that is provided to the brakes. A Wabco regulator system maintains 120 psig pressure. The air compressor has unloads at 130 psig.

This electric vehicle compression concept is more efficient than the traditional diesel engine-coupled air compressor. The regular diesel air compressor would consume up to 4.0 kW depending on the speed of the engine. Our system consumes a maximum power of 1.5 kW at the end of the compression cycle with a constant speed independent of the driveline speed. We are able to achieve all FMVSS regulations. By the way, the air brake system also supports our comfortable air-cushioned driver seats!

CABP: Thank you for your insights. BP

For more information contact Smith Electric Vehicles, tel: 816-464-0508, email: Sales_NorthAmerica@smithelectric.com, www.smithelectric.com

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Natural Gas Deliquescent Dehydrator Applications

Compressed Air Best Practices® Magazine interviewed Tyler Currie, Vice President Business Development, Van Air Systems and Van Gas Technologies.

Dual 20" diameter deliquescent gas dryers condition field gas that is being used to fuel a series of small gas turbines. The turbines produce electricity at a remote location without access to grid power. The first vessel is filled with GasDry Prime desiccant. The second vessel is filled with GasDry Max desiccant.

➤ **CABP:** Good morning. What are some natural gas applications where deliquescent dehydrators are used?

Van Gas: Good morning. When natural gas emerges from the ground, it bears little resemblance to the clean-burning natural gas used in our factories and homes. At the well site, natural gas is saturated with water, contains heavy liquid hydrocarbons, oil and even rocks and sand! Sophisticated treatment systems, of different types, purify natural gas before it can enter a utility transmission line and then enter a business or home.

Most of this gas treatment takes place in centralized processing plants. Triethylene glycol (TEG) dehydrators are the most prevalent technology for removing water vapor from natural gas . Molecular sieve dryers are also quite common in gas processing plants. Molecular sieve units have operating processes similar to industrial heat-regenerated compressed air dryers. Natural gas, however, often needs to be purified at the wellhead before reaching the processing plant. Deliquescent dehydrators are normally used, in remote locations where no power supply exists, to dry small gas volumes located between the wellhead and these main treatment plants. The most common applications are instrument gas, fuel gas, sales gas, and emissions mitigation.

CABP: Please describe Instrument Gas dehydration.

Van Gas: Instrument Gas is a term used for the gas required to support the surface equipment using pneumatic-actuated valves for flow control and drainage. This surface equipment is located at the wellhead and other sites before the processing plant. All of this equipment is remote-located in a field, desert or mountainside — where there is no power supply. In remote areas, you don't have any electric power supply to support an electric-motor driven air compressor able to support the pneumatic controls. Therefore, natural gas operators use their own product — pressurized gas — to operate these pneumatic control systems. Thus the term instrument gas.

This instrument gas is saturated with moisture and as there is no electric power source, operators need a simple, power-less means to dry the gas. This is where deliquescent dehydrators come in. Small deliquescent dryers are typically attached to the side of a production separator tank. Three-phase production separators, at the wellhead, represent the first step in splitting apart gas, liquids, and oil. The separators use automated valves connected by small tubing runs which must be kept clean and dry. Small deliquescent dehydrators dry these very small volumes of instrument gas to keep actuators from freezing. A frozen instrument gas line, on a production separator, will potentially shut down a well.

CABP: What are the Fuel Gas applications?

Van Gas: Fuel gas applications, for deliquescent dryers, are again located at the well head or somewhere before the first processing plant. These outdoor sites do not have any electric power supply and a robust dryer is needed able to withstand wind, rain, snow and whatever Mother Nature throws at us! Natural gas operators often need dry natural gas to support heating, rotating equipment, and flares.

Heating requirements in the field can include space-heating a building. Small buildings are often erected, in remote sites where it gets very cold, for shelter for personnel and equipment. Another heating application is heaters for oil tanks. It's hard to burn wet gas so small deliquescent dryers are used to dry the fuel.

When gas compression is required near the wellhead, natural gas compressors are used. The gasends are often driven by reciprocating natural gas-fired engines. These engines need the humidity level in their fuel reduced as burning saturated gas can cause problems.

Many well pads will use a flare to destroy waste vapors coming off tanks (for example). A flare has a pilot light that needs to be ready to go at a moment's notice. If that fuel is coming from an untreated source, it has to be dried. You can't have the pilot light area freezing up due to moisture present in the gas stream. Located in a little 1/8" stainless steel tube, if that pilot light freezes up, it won't ignite.

CABP: I see Van Air Systems / Van Gas products as I drive around here in Western Pennsylvania.

Van Gas: Yes, the deliquescent dryers you see on country roads are what we refer to as "Sales Gas" applications. "Farmer Jones" has a small well (referred to as a Farm Tap) and is selling gas into a local natural gas pipeline. In order to sell the gas, before it's inserted into the line, he needs a simple way to extract humidity from his gas. Van Gas Technologies has supplied thousands of deliquescent gas dryers installed in the legacy, shallow wells of the Appalachian basin located in Western Pennsylvania, Ohio, New York, and West Virginia.

Van Gas Technologies produces three grades of deliquescent desiccant: GasDry Prime, GasDry Peak, and GasDry Max. The grade selection depends on operating conditions and the required outlet dew point.

Sales gas refers to the product the operator is selling. The customer is usually another gas company. There are usually moisture and purity specifications that have to be met to complete a sale. There are many transactions along the supply chain. There are many, many cases where operators want to sell gas to a certain specification but they don't have access to a treatment plant and they need to get some drying done to complete a sale. This is where deliquescent dryers are often used right at the custody transfer point between gas operators.

Instrument gas dryers, with 1 Micron Particulate Prefilters, protect valves on production separators.

CABP: Please discuss emission mitigation and how deliquescent desiccants fit in.

Van Gas: Newer plays, like in the Marcellus Shale, have large-scale infrastructures with centralized treatment plants. As mentioned before, far and away the most

NATURAL GAS DELIQUESCENT DEHYDRATOR APPLICATIONS

An 8" diameter deliquescent gas dryer is filled with GasDry Max desiccant at a farm tap in West Virginia. The owner of the well must dry the gas in order to meet a sales gas moisture specification.

prevalent way to dry natural gas is to use Triethylene Glycol (TEG) Dehydrators. This process, however, produces emissions for which each operator is allotted permission to emit to a certain level. Once they reach their emissions limit, they have to cut back production.

Gas dryers using deliquescent desiccant do not create any emissions and there are situations where they have been used in lieu of a TEG system. We work with a gas producer in southern California operating some wells on some artificial islands just off the coast of Long Beach. They could not get a TEG system permitted due to emissions. Instead they now operate several large deliquescent dryers since our process doesn't vent any gas.

CABP: Please describe the deliquescent tablets.

Van Gas: Deliquescent desiccants have been used to dehydrate natural gas, by the oil and gas industry, for over 70 years. Desiccants are made up of hygroscopic salts, such as calcium chloride, lithium chloride and potassium chloride. Desiccants attract and absorb water vapor, which gradually dissolves the desiccants into brine. This process is called 'deliquescing'. The amount of moisture removed from the gas depends on the type of desiccant. Calcium chloride, the most common and least expensive desiccant, removes approximately 67% of the water vapor in natural gas. Lithium chloride based desiccants, which are more expensive, remove approximately 87% of the water vapor in natural gas. Our desiccants come in a pressed tablet form. They're ultimately packed into a bed within a vertical pressure vessel. The vessel is called the dryer or dehydrator.

CABP: Can you provide a drying process description?

Van Gas: Sure. Deliquescent drying is a very simple process; it has no moving parts and needs no external power so that it can be used in offshore or remote sites. Wet natural gas enters the dehydrator vessel below the desiccant support grid and flows up through the desiccant bed. The support grid prevents the desiccant tablets from dropping into the brine sump. The wet gas flows upward through the support plate and the drying bed, where it contacts the desiccant tablets. The moisture from the gas is absorbed by the tablets and accumulates on the surface of the tablets. Gradually the moisture dissolves the desiccants into brine droplets, which trickle down into the claim area that is connected to a brine storage tank. When the desiccants reach equilibrium or the maximum amount of moisture they can adsorb, the 'dry' gas exits on the top of the vessel to the main gas line.

CABP: How is the liquid removed from the tank and how is the desiccant "regenerated"?

Van Gas: Smaller units, used for minimal flows, are usually manually drained. They see so little flow that a couple of teaspoons of condensate is gathered in buckets during the weekly maintenance procedures.

In larger dehydrators, draining is done automatically with a pneumatically-controlled float drain inserted into the sump area of the vessel. Larger units with pressure vessel diameters ranging from 12" to 48" inches these will produce several gallons per day of this brine (a salty liquid). This brine is then sent to the wastewater tank located at the site. Almost all wellheads have large wastewater tanks to capture the liquids coming off the production separator. The volume of liquid coming from the dryer is a small percentage of the wastewater being accumulated in these tanks.

The tablets are not regenerated. They're a consumable product. New tablets are normally added to the vessel on a 45-60 day cycle by the operator. The tablets are packed in 25-50 lbs. bags and are manually poured through ports in the top of the pressure vessel.

CABP: Thank you for sharing this information. BP

For more information contact Tyler Currie, Vice President Business Development, Van Air Systems and Van Gas Technologies, tel: 303-444-2869, email: tyler.currie@vanairinc.com, www.vanairsystems.com

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– Gregory Rhames, Asset Reliability Manager/Site Energy Manager, Verallia Glass, Jan/Feb 2012 Edition of Compressed Air Best Practices®

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Continued from page 17.

Fig. 9 shows the annual pure energy costs comparison[1] of the six compressor solutions in case of an airflow pattern, as per Case No. 1. Another important consideration is to evaluate the behavior of the six solutions in case future production changes affect daily air consumption.

The flow patterns in Cases No. 2 to 5 represent different variable airflow profiles under various production conditions, which cover almost all the solutions — from the most variable to the least variable — as depicted in Fig. 3.

Table 1 summarizes the relative efficiencies between Solution A and the other five solutions with variable flow profiles, as in Cases No. 1 to 5.

Consider again compressor performances at a pressure of 8 barg, 300 operating days per year, and an average energy cost of 0.10 €/kWh ($0.13/kWh). Solution F allows operators to save 15000 € ($19,500) per year in Case No. 1 and approximately 40000 € ($52,000) per year in Case No. 5, compared to Solution A. Solution C has slightly higher energy costs, about 1500 € ($1,950) per year in Case No. 1, but in Case No. 5 it allows approximately 25000 € ($32,500) per year in savings compared to Solution A. Evaluating Case No. 1, a person may wonder how Solution A — which is able to deliver exactly the airflow requested by the system without any air blow-off — has almost the same efficiency as Solution C. The answer is revealed in Figs. 10 and 11.

Fig. 10 compares the specific power at 8 barg of different centrifugal models with large variable speed screw compressors.[2] A 75 m³/min centrifugal compressor working at the design point is 19% more efficient than a 500 kW variable speed screw compressor; a 115 m³/min centrifugal compressor is 14% more efficient than a 700 kW variable speed screw compressor; and a 140 m³/min centrifugal compressor is 19% more efficient than a 900 kW variable speed screw compressor.

The energy saved against the variable speed screw compressor when the centrifugal compressor works near its design point, or in general in its full regulation range, compensates for the energy that is wasted

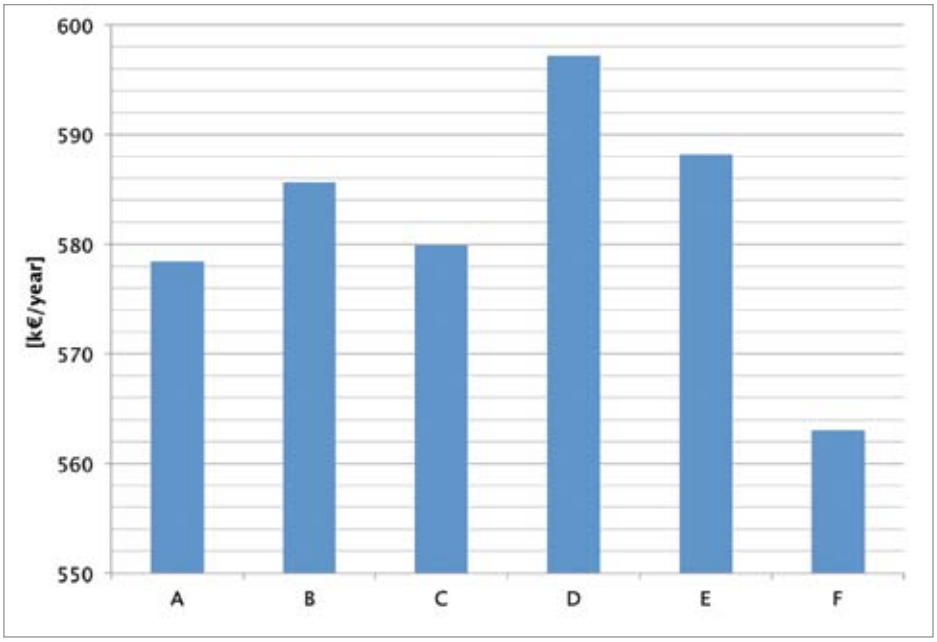

Fig. 9: Yearly energy costs comparison in Case No. 1.

		Compressors solution					
		A	B	C	D	E	F
Flow profile	#1	0%	+1.3%	+0.3%	+3.3%	+1.7%	-2.7%
	#2	0%	-1.0%	-1.3%	+1.8%	-1.6%	-3.6%
	#3	0%	+0.1%	-0.9%	+0.6%	+4.0%	-4.9%
	#4	0%	-1.2%	-2.3%	-0.3%	+1.6%	-4.2%
	#5	0%	-3.5%	-3.1%	-0.4%	-5.1%	-5.1%
		4th	3rd	2nd	6th	5th	1st

Table 1: Energy efficiency comparison: The efficiency of Solution A is used as a reference. Negative red or orange percentages indicate that the system is less efficient than Solution A, and positive and green figures indicate that the system is more efficient than Solution A. Yellow means the two systems are more or less equal. The last row shows the ranking of the six solutions considering the system's efficiency (or yearly energy costs), flexibility and ease of operation, i.e., common spare parts and an equally efficient backup compressor.

1 Energy cost comparison is based on the performances of new compressors only, i.e., it does not take into consideration the effect of rotor wear on the screw compressors, which significantly deteriorates compressor performances. Such deterioration does not occur on centrifugal compressors, as they are intrinsically wear-free.

2 Note that each square for centrifugal represents the specific power of one single machine at its design flow only; it is not a curve over all the regulation range, as for variable speed rotary.

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from centrifugal compressor blow-off. In fact, if we plot the specific package power of the 115 m³/min centrifugal compressor used in Solution C, both in its regulation range and also when blowing-off (Fig. 11), we see that the specific power remains better for a range even wider than just the regulation range.

Considerations for Centrifugal Compressors

In summary, only the knowledge of the real weight or balance, in terms of percentage of time or variable operating conditions, allows operators to determine if the large variable speed screw air compressor is right for the system. This is an important concept that is often neglected or misunderstood. We will use another real case to clarify this concept.

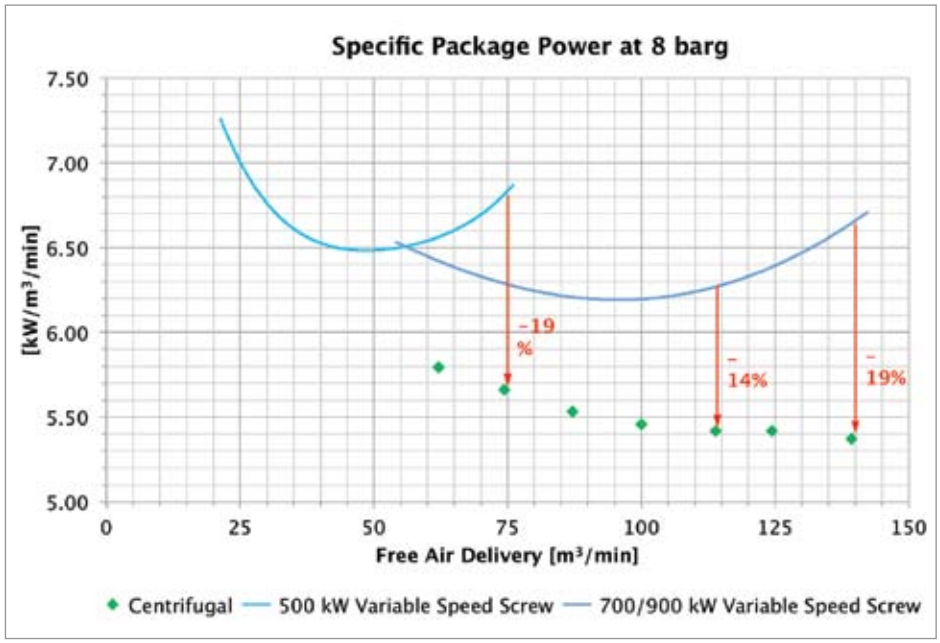

Fig. 10: Specific package power comparison at 8 barg.

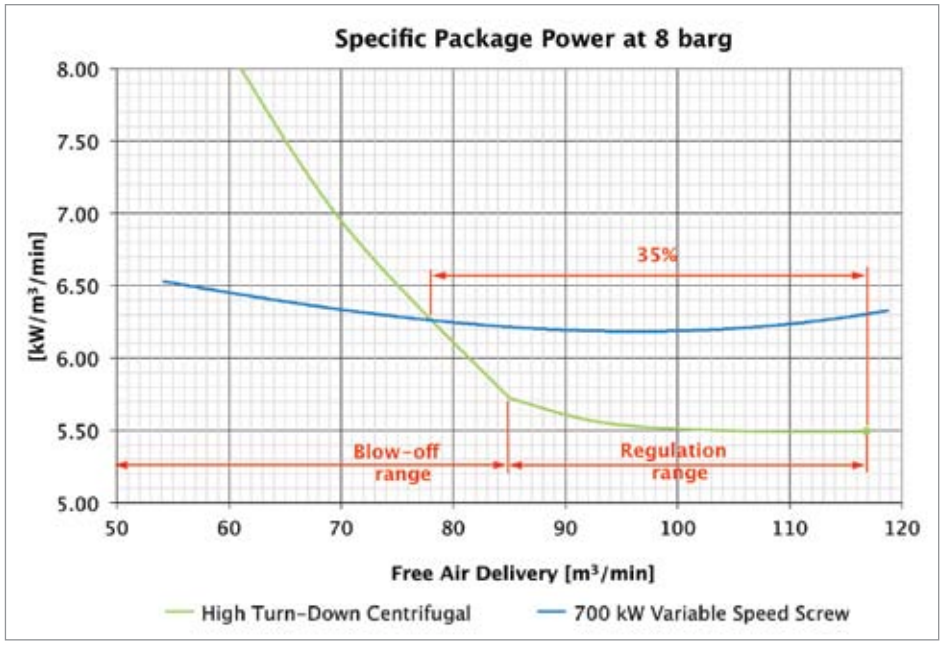

Fig. 11: Specific package power comparison at 8 barg over the full operating range.

There was a customer with five old 4 barg centrifugal compressors of various sizes ranging from 70 m³/min to 120 m³/min. Last year, he decided to update the compressor room to reduce operating costs. He said an audit was performed and the first step was to improve their system's efficiency. To accomplish this, he decided to replace one centrifugal compressor with a 500 kW variable speed screw air compressor.

After further investigation, they determined that some mornings between 8-10 a.m., the manufacturer had to shut down one production line to prepare for the type of glass to be produced the following day. During these two hours, they had an excess of air of 60 m³/min. Since the old centrifugal compressor was able to regulate only 20 m³/min, the centrifugal compressor was blowing off 40 m³/min of air. By replacing this compressor with a 500 kW variable speed screw compressor, he said they would have been able to avoid any blow off, improving the system's efficiency and reducing the operating costs.

Unfortunately, this was an incorrect and misleading approach. It is true that a 500 kW variable speed screw compressor would avoid blow-off during the plant's downtime, but the customer did not consider a real performance comparison as shown in Fig. 12. The customer should have conducted an energy cost comparison between a new, two-stage centrifugal compressor and the desired two-stage 500 kW variable speed screw compressor.

It can be deducted from the compressor's data sheets that at an operating pressure of 4 barg, a 500 kW variable speed screw compressor is 43% less efficient than an equivalent centrifugal compressor. Even if the centrifugal compressor

is blowing off 13 m³/min, it is more efficient than the variable speed screw compressor.

To determine the best machine for the application, the customer should have evaluated the cost of blowing-off 40 m³/min for two hours per day and calculated the extra cost of using a compressor that is 43% less efficient the remaining 22 hours of the day.

The calculations reveal:

Cost of blow-off:
40 m³/min × 4.3 kW/m³/min × 2 h/d × 350 d/y × 0.10 € ($0.13)/kWh ≈ **12.000** € ($15,600)/year [3]

Extra cost for compressing 80 m³/min for 22 hours/day with a 43% less efficient compressor:
80 m³/min × (6.0 - 4.2) kW/m³/min × 22 h/d × 350 d/y × 0.10 € ($0.13)/kWh ≈ **110.000** € ($144,000)/year

To avoid wasting 12.000 € ($15,600)/year due to the blow-off during scheduled down time, the customer would have spent 110.000 € ($144,000)/year more, running a 43% less efficient compressor for the rest of the day. Even if we consider that 22 hours/day the variable speed screw compressor does not always work at full load, the difference is so large that it would be hard to affirm that the customer would have saved energy and money by buying a 500 kW variable speed screw compressor instead of a new centrifugal compressor.

Conclusions

The cases analyzed in this article show that when an air system requires large quantities of air (ca. >100 m³/min) and air demand highly fluctuates during the day, the use of large variable speed screw compressors (300-400 kW and above) rarely represents the magic solution that is often claimed by some compressor manufacturers. Alternative technologies or solutions, like the centrifugal compressor with load-sharing control, often allow operators to realize much greater energy savings, despite the system air blow off.

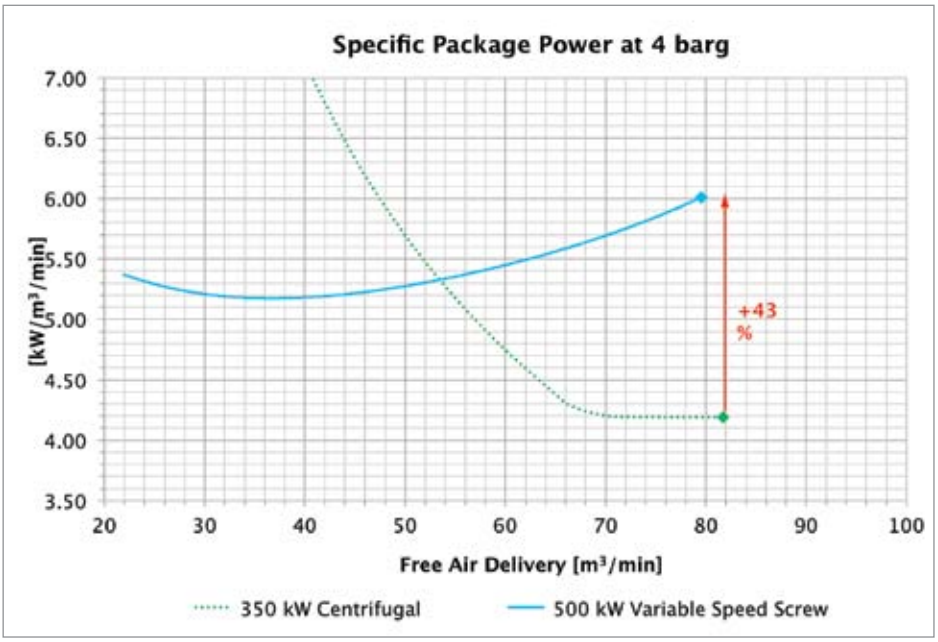

Fig. 12: Specific package power comparison in regulation range at 4 barg.

In fact, centrifugal compressors can be more efficient than large, variable speed screw compressors even if they blow off 10-15% of their design capacity. Rather than evaluating if one compressor technology reduces compressed air blow off, it is recommended that operators evaluate the compressor's efficiency over its operating range, i.e., at full load and partial loads.

First, it is important to know the system's exact flow profile and flow spectrum to determine how much time the compressor will operate in one condition versus another, e.g., blowing-off some air vs. operating near its design capacity. For this reason, it is important to conduct an air assessment before starting any evaluation. The results must be read and interpreted correctly — and not exploited to justify the sale of a compressor!

Nevertheless, each case is customer-specific and several aspects that could influence the final choice should be considered: installation requirements, floor space, need for backup units and/or spare parts stock, system's flexibility in case of different future production needs and initial capital investment. The initial capital investment was intentionally excluded from this study because the scope was to evaluate the systems from the energy consumption point of view only. The initial capital investment and payback period would drive the final decision. Without entering into pricing discussions or details, Solutions B and C are likely to have the lowest initial capital investments. BP

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3 12000 € ($15,600) per year is the worst case, because in reality not all the days the customer has to change the production lines. Also, two hours continuous blow-off could be avoided if a load-sharing system with anti-blow-off was installed, reducing the 12000 € ($15,600) per year to a few hundred Euro (Dollars).

RESOURCES FOR ENERGY ENGINEERS

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SKF Launches New High-Speed Permanent Magnet Motor Solution for Aeration Blowers

SKF announced the launch of an energy efficient high speed permanent magnet motor solution for aeration blowers in wastewater facilities, which can reduce energy consumption by up to 40 percent. In wastewater facilities, the aeration blower system can demand as much as 80 percent of the plant's total energy consumption, so the SKF solution offers the potential to make huge energy savings. When used in a 350 kW blower it may result in annual savings of 500,000 kWh, which equals a 375-ton reduction in CO_2 emissions. The SKF solution for aeration blower systems is included in the SKF BeyondZero* portfolio.

"SKF has developed a new, innovative and sustainable solution that targets the market challenges faced by the water and wastewater industry. The SKF solution for aeration blower systems meets the demand for energy efficiency and the need for reduction of maintenance and service costs, as well as the requirement to comply with air quality and safety standards. Compared with a traditional blower, the SKF solution in a 350 kW centrifugal air blower offers payback on investments in one year from energy savings alone",says Vincent Megret, Managing Director, SKF Magnetic Systems.

The SKF solution for aeration blower systems comprises a high-speed permanent magnet motor (PMM) that can deliver between 75 kW-350 kW, active magnetic bearings (AMB) and integrated AMB control system. This range of oil-free motor solutions has a number of features that enhance performance; for example, unlike traditional induction motors, the PMM maintains efficiency at half-load and half-speed operation. The SKF solution for aeration blower systems also uses less mechanical parts than traditional drive systems, which means reduced maintenance, while powerful built-in monitoring and diagnostic capabilities maintain high performance and reliability.

The new SKF permanent magnet motor on display at the 2013 Hannover Messe. Pictured are Alexandre Moureaud and Rainer Deuerling (left to right) from SKF Magnetic Systems.

*The SKF BeyondZero product portfolio contains products that offer enhanced environmental performance characteristics. To be included in the SKF BeyondZero portfolio, SKF products, services and solutions must deliver significant environmental benefits.

Visit www.skf.com

Atlas Copco Introduces SmartLink Data Monitoring for Compressors

Atlas Copco has introduced a new compressed air monitoring program, SmartLink, which will increase connectivity between Atlas Copco and its customers with advanced, 24/7 data monitoring. When integrated with the Elektronikon controller, SmartLink gives customers and Atlas Copco access to a web-based monitoring dashboard that alerts for the need of proactive prevention before equipment failures and gives professionals the information they need to make recommendations that can save a facility energy costs.

"The new SmartLink program alerts customers and service technicians in real-time to compressed air performance changes, allowing a service technician to address a maintenance issue before it could result in any downtime," said Alfredo Piccolo, vice president of Service Marketing in the United States. "This new program features three levels of service monitoring starting with free service with the option to add uptime and energy monitoring at a low monthly cost."

SmartLink is easy to install and the monitoring dashboard is user-friendly and customizable. Data is gathered, compared and analyzed — providing customers with both a quick snapshot and a complete in-depth analysis of their air supply — and is fully customizable to fit a customer's data monitoring needs. When necessary, warning messages are sent to customers via text message and email.

"Smart Link adds value to all customer types, whether you have a maintenance team of 15, or you don't have a dedicated team on-site,"

TECHNOLOGY PICKS

said Piccolo. "SmartLink will streamline service requests and ensure that customers receive proactive service. Eliminating any possibility of downtime has always been our goal, which will lead to increased productivity, energy efficiency and cost savings for the customer."

Atlas Copco plans to integrate SmartLink into compressed air installations worldwide and the program will start to come as standard on most oil-injected rotary screw compressors throughout 2013.

As part of their investment in the SmartLink program, Atlas Copco Compressors in the United States will centralize remote monitoring capabilities into a hub for monitoring compressor systems at customers' sites. The center, which plans to open in May 2013, will be operated by a central Technical Support Competency Group. This group will provide support for in-depth technical enquiries from customers, distributors and employees across the United States, as well as proactive monitoring and outreach for energy savings. The group will be headquartered in Rock Hill, S.C.

Visit www.atlascopco.us

Teseo Introduces the New AP68 Aluminum Piping Profile

TESEO srl, specializing in the design, production and sale of aluminum piping and fittings for the construction of distribution plants for compressed air, vacuum, nitrogen and other fluids under pressure, is introducing the **new AP68 profile,** with a diameter for the new AP range designed to handle air distribution for compressors up to 140 kW. The new profile, **corresponding to 2¾ inches,** is 20% lighter than the equivalent HBS piping, but stronger with its thicker walls.

With its unique design and a wide range of accessories, AP speeds up installation and plant modifications, also on complete installations. It can be installed using standard tooling, with few easy and safe operations, without any threading, welding or painting. All four profile faces can carry outlet plates or anchors. The new-generation joints have also been enhanced with a **reduction of locking screws,** which translates into significant **installation time reduction:** 3 screws only for L-joints instead of 8 in the previous version, and 4 instead of 16 for straight joints.

Many parts are interchangeable to streamline modifications and upgrades to the modular system. The new **AP68 diameter is also available in 45° and 90° curves, or with special bends and shapes upon request.** A new set of mounting brackets provides for quick, convenient and intuitive mounting. The DT drilling tool can be used to create new connection points, drilling the line under pressure easily and safely.

With the renovation and expansion of the AP range, conventional naming has been adopted. Now, the product name matches the outer diameter, so that customers are facilitated in selection and can compare TESEO's systems to other aluminum or traditional piping, easily and intuitively.

With the same nominal diameter, the AP system offers higher flow rate and lower pressure drop, delivering high performance with no energy waste.

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New Leakshooter LKS 1000 Ultrasonic Leak Detecting Camera

The Leakshooter LKS 1000 is the first camera to detect, measure and photograph air and vacuum leaks. It provides the dual possibility of ultrasonic leak detection with a visible image. This enables users, for the first time, to see on a large LCD color screen the precise location of air and vacuum leaks. Near a leak, a dynamic target will appear, and change in size and color from yellow to red depending on the severity of the problem. At the bottom of the screen, the continuous measurement of dB RMS and MAX is displayed on a color bar graph.

Once facing a leak it is then possible to take a picture of the precise leak location. The Leakshooter LKS 1000 can store up to 1000 pictures in JPEG format. All pictures show date, time, dB level and can be numbered manually. The pictures can be transferred to a PC with the LEAKWIEVER software.

While operating the camera, the possibility to listen to the leak noise with the headphones is still possible. The operator is then for the first time able to see what he's listening to. The Leakshooter LKS 1000 detects a leak of 0.1 mm with 3 bars pressure at 20 meters. Adjustable gain from 50 db to 110 db for use in any kind of surroundings.

Leakshooter LKS 1000 is an invention of SYNERGYS TECHNOLOGIES. Looking for Distributors in the Americas.

Visit www.leakshooters.com

New CEJN High-Performance eSAFE Coupling

eSafe is an innovative and patented safety coupling offering the highest flow combined with a low pressure drop. In addition eSafe has a low connecting force, compact and easy to grip design making it the natural choice when choosing a safety product with top of the line features. Safety has been our top priority for many years and our constant strive to develop safe and high performing products finally led us to eSafe. As our customer you no longer have to choose between performance and safety. eSafe is a one hand operated, compact, high flow coupling that vents before disconnection eliminating the risk of hose-whip keeping the operator from harm.

The top of the line features offered in our eSafe range require real craftsmanship and is the only coupling that allows you to get maximum capacity out of your tool. The job is done quicker using less energy and the result is higher productivity, cheaper energy bills and lower environmental impact. Can you afford not to change? eSafe is a new generation of premium coupling for premium performance.

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Michell Condumax II Hydrocarbon Dew Point Analyzer

Michell Instruments has one of its top performing analyzers, the Condumax II, working its magic at a natural gas storage facility in Europe. The storage operator had lost confidence in his existing analyzers as the hydrocarbon dew point readings were erratic and the water dew point readings were unresponsive. The Condumax II Hydrocarbon Dew-Point Analyzer was installed at the facility and a side-by-side test showed the Michell analyzer provided faster measurements that were more accurate than the existing analyzers.

Fast response is critical to natural gas storage operators as they must provide emergency gas supply to satisfy peak demand on the transmission network, particularly during winter months. The storage operator rented a Condumax II Hydrocarbon and Water Dew-Point analyzer to provide measurements in parallel with the operator's current analyzers. This allowed them to check the accuracy and responsiveness of their equipment against a different

TECHNOLOGY PICKS

analyzer at minimum capital expense, however because of the positive results, the Michell Condumax II was permanently installed.

During the test period, the Condumax II provided consistent hydrocarbon dew-point readings, and showed better levels of response at lower dew points than the previously installed analyzers. The Condumax water dew-point readings taken during the test period responded significantly faster to changes in the process than the analyzers under review.

At the end of the test, the company was satisfied that its concerns about the reliability of the readings of the current analyzers were justified. As the engineer explained: "The [previous analyzer] drifts to higher hydrocarbon dew point levels over time in direct comparison to the consistent and repeatable CONDUMAX II hydrocarbon dew-point readings over several days. This drift behavior and direction is a problem, because it brings the reading nearer to the agreed [maximum] contract value for hydrocarbon dew point with [the customer] ... in [some] cases they were close to breaking the contract value." Because the customer needed to have complete confidence in the levels of hydrocarbon and water dew point in the process, they chose to permanently install the Condumax II.

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