NGV Fueling Stations New CAGI Initiatives

September 2007

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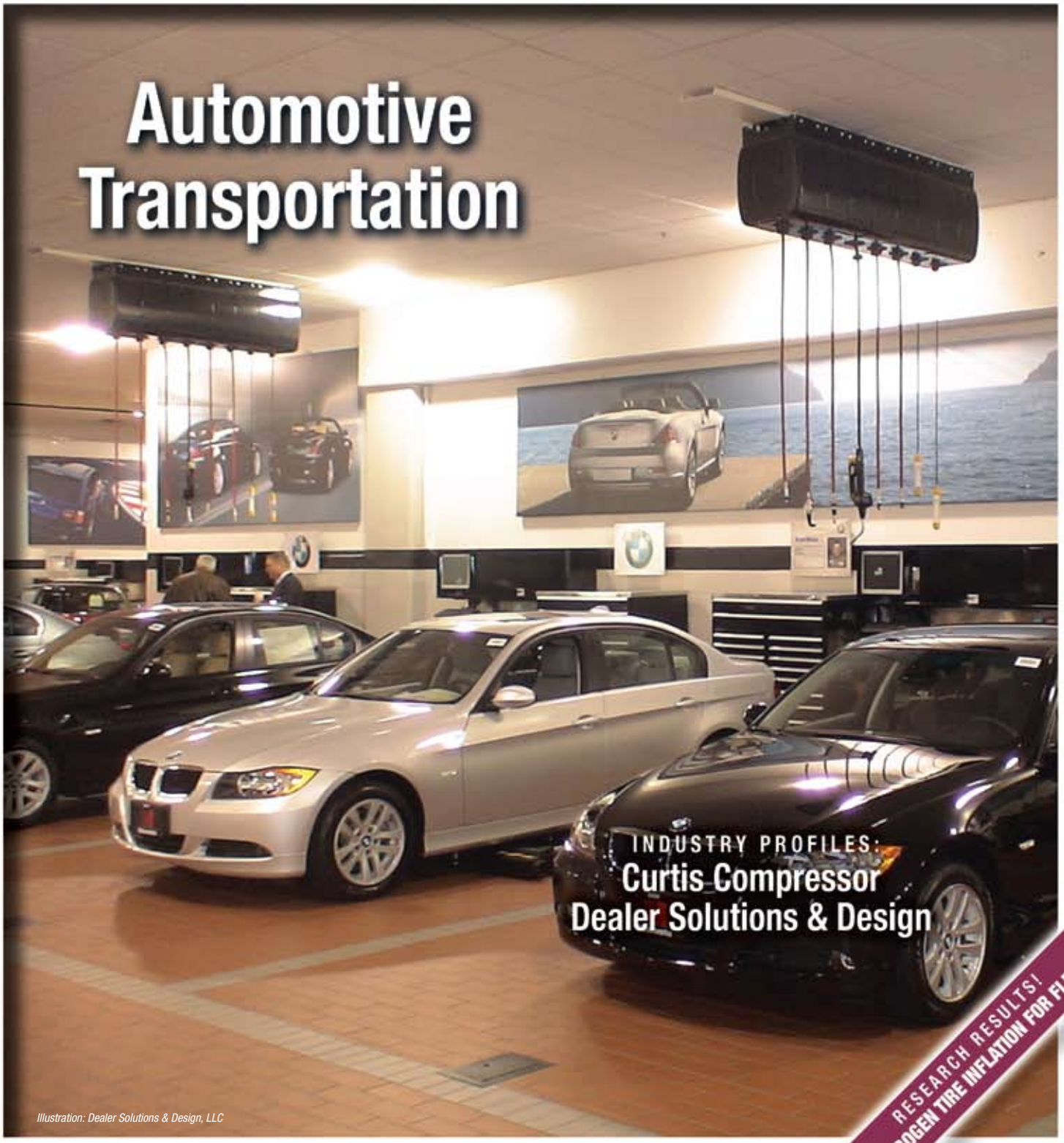

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FOCUS INDUSTRY FEATURES

FROM THE EDITOR

Opportunities for Compressed Gases in Automotive Transportation

The automotive transportation industry is in the national spotlight due to high gasoline prices and concerns over the oil supply and global warming. Alternative fuels are all the rage, with ethanol, hydrogen, fuel-cell and electric vehicles dominating the headlines as potential solutions to these issues. This edition of Compressed Air Best Practices highlights compressed gas alternatives, which can contribute solutions to the high emissions and relatively poor fuel efficiency of today's automotive transportation industry.

Nitrogen tire inflation is highlighted in this edition due to the completion of what, in my opinion, is a landmark research study completed by **Konrad Mech**. Mr. Mech's research, with the support of Transport Canada, examines the effects of nitrogen tire inflation on fuel efficiency and tread wear on a fleet of long-haul trucks in Canada. The trial was conducted in a fleet consisting of 70 long haul tractors and 117 trailers. Data was collected from 6.1 million tractor miles and 110 million tread miles over a nine-month period. The results showed 4–6% better fuel economy and 86% longer tread wear. The opportunity is here for the installation of nitrogen generators to enable fleets to capitalize on these benefits. **Jay Hedges** of **Curtis Compressor** and **John Lucidi** of **Parker Hannifin** share with us photos and information on new nitrogen generator technologies their companies are launching this quarter.

Natural gas vehicles (NGV) for short-haul fleets command a 20–25% market share, according to **Stephe Yborra** of **NGV America**. The fuel-economy and emission benefits versus diesel are proven. Municipal fleets of school buses, city buses, street cleaners and refuse haulers are among the primary clients. Building the infrastructure of NGV fueling stations has been the focus of **GreenField Compression** for many years. In this edition, we outline the opportunities and challenges facing companies like GreenField, who supply the turnkey natural gas compressors, dryers and fuel dispensers. An opportunity seems to exist in creating closer coordination between utility companies, fleets and the sales channel to come up with implementable rebate programs to assist with the capital requirements of these projects.

The Compressed Air and Gas Institute (CAGI) announces three new initiatives in this edition. The first is performance verification testing for 50–200 hp lubricated rotary screw air compressors and for 200–1,000 scfm refrigerated air dryers. The second initiative is the launch of an online e-learning center called the SmartSite. Last but not least, CAGI announces the first Innovation Awards. Aimed to promote awareness and education, it is a contest for engineering undergraduates at five universities to come up with innovative uses of compressed air. Congratulations to CAGI Officers **Dave Prator**, **Rob Haseley**, **Rick Stasyshan** and **John Addington**.

I hope you enjoy reading this edition as much as I did putting it together. I salute the entrepreneurs in the compressed gas business who are creating opportunities and efficiencies for the automotive transportation industry.

ROD SMITH

COMPRESSED AIR INDUSTRY ARTICLES

COMPRESSED AIR BEST PRACTICES MAGAZINE
www.airbestpractices.com

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A Publication of: Smith Onandia Communications L.L.C.
217 Deer Meadow Drive
Pittsburgh, PA 15241

Compressed Air Best Practices is published monthly by Smith Onandia Communications LLC., 217 Deer Meadow Drive, Pittsburgh, PA 15241. Phone 251-510-2598, Fax 251-929-0424, email patricia@airbestpractices.com. Publisher cannot be held liable for non-delivery due to circumstances beyond its control. No refunds. Standard postage is paid at 233 Jefferson Street, Greenfield, Ohio 45123. Canadian and international distribution: IMEX International Mail Express, 1842 Brummel Drive, Elk Grove Village, IL 60007. POSTMASTER: Send address changes to Compressed Air Best Practices, 217 Deer Meadow Drive, Pittsburgh, PA 15241. SUBSCRIPTIONS: Qualified reader subscriptions are accepted from plant managers, plant engineers, service and maintenance managers, operations managers, auditors, and energy engineers in manufacturing plants and engineering/consulting firms in the U.S. and Canada. To apply for qualified reader subscriptions, please fill in the reader response cards herein and mail or fax or go to www.airbestpractices.com. To non-qualified subscribers subscriptions are $55 in the U.S., $65 in Canada, and $95 for International. When available, extra copies of back issues are $4 plus shipping. Contact Patricia Smith for subscription information at tel: (251) 510-2598 or email: patricia@airbestpractices.com. REPRINTS: Reprints are available on a custom basis, contact Patricia Smith for a price quotation at tel: (251) 510-2598 or email: patricia@airbestpractices.com.

RESULTS

OF A TRIAL OF NITROGEN TIRE INFLATION IN A LONG-HAUL TRUCKING FLEET

BY KONRAD MECH, P. ENG., MBA

Abstract

Drexan Corporation conducted an experimental trial in 2006 to determine the fuel economy and tread wear benefits of nitrogen tire inflation to the long-haul trucking industry. In 2005, Drexan received a contribution agreement for this trial from Transport Canada in round 7 of the Freight Sustainability Demonstration Program. The trial was conducted in a fleet consisting of 70 long-haul tractors and 117 trailers of different configuration (Super B, tridems and tandems). Data was collected for 1,988 wheel positions. The trial covered more than 6.1 million tractor miles and 110 million tread miles over a 9-month period. Two methods were used to determine fuel savings to this fleet: comparison of trial results against two historical baselines, and comparison of electronically monitored engine performance data with a control within the trial itself. Tread wear was monitored by wheel position by equipment using an electronic data collection system called Snapshot[1]. The experiment was designed to control for all variables impacting tread wear and fuel economy. Results were evaluated using statistical analysis software and were determined to be statistically significant.

Mr. Konrad Mech of Drexan Corporation

The results are as follows.

- When compared against historical data, nitrogen tire inflation provides 6.1% better fuel economy than a fleet with air inflation and no tire pressure maintenance program.
- When compared against both historical data and the in-trial control, nitrogen tire inflation provides approximately 4% better fuel economy than a fleet with air inflation and a tire pressure maintenance program.
- When compared to the in-trial air-inflated control, nitrogen tire inflation provides an average of 86% longer tread wear over air-inflated tires with a tire pressure maintenance program. No historical data was available within the trial fleet to compare historical tread wear with the trial period.

The study proves that nitrogen improves fuel efficiency and tread wear for long haul fleets. The study infers that nitrogen extends casing life and reduces failures.

1 Snapshot is a product of International Marketing Inc., Professional Arts Building, Suite C, P.O. Box B, Chambersburg, PA 17201, toll-free 800-233-7086, fax 717-264-5483.

RESULTS OF A TRIAL OF NITROGEN TIRE INFLATION IN A LONG-HAUL TRUCKING FLEET

Parker Tire$aver Portable Nitrogen Tire Autoinflator

Background

Lawrence Sperberg wrote a paper in 1985 titled, *Million Mile Truck Tires — Available Today*. Sperberg's paper analyzes and re-presents data from a trial that was conducted in the early '70s. In his trial, 98 tires comprised the data set: 54 new and 44 retreaded drive tires. The construction of these tires was bias ply, and the study covered approximately 7.5 million tread miles.

The key focus of Sperberg's study was the effect of nitrogen on tire casing life and tread wear. Sperberg concluded that new tires inflated with nitrogen had 26% more tread wear on average than air-inflated tires. Further, Sperberg showed that retreaded tires had 54% longer tread wear on average than air-inflated tires. Sperberg noted that the retreaded casings were in fact oxygen-aged, i.e. they had not been inflated with nitrogen prior to being retreaded.

Sperberg also discussed the results of chemical analysis of the tire rubber using electron beam microscopy. He determined that oxidation of the tire casing rubber and tread rubber was the cause of accelerated tread wear in the air-inflated tires, and that it was the elimination of oxygen that arrested or eliminated this aging.

Oxidation of tire rubber has been previously addressed by others, notably John Baldwin of Ford in his paper, *Effects of Nitrogen Inflation on Tire Aging and Performance*, presented to the Rubber Division, American Chemical Society in May 2004, and Guy Walenga of Bridgestone Firestone in his presentation, *Nitrogen Inflation for Truck Tires*, presented at the Clemson University Tire Industry Conference in March 2004.

While Sperberg's findings are very promising for the industry, fleet owners and fleet maintenance managers would not accept his findings for today's realities. Their reasons were:

- Tire construction has changed.
- Tire compounds have changed.
- It had a very small sample size.
- It tested only one tire position: drive tires.
- It did not provide any data on potential fuel savings.

Yet fleet owners and managers face economic challenges due to rising fuel costs and tire prices. A list of impacts on fleet operating costs and the underlying cost driver would include:

- Fuel costs (underinflation)
- Tread wear (underinflation and oxidation)
- Sidewall damage (oxidation)
- Retreadability (oxidation)

When proposing nitrogen tire inflation to this segment, we found that fleet owners and maintenance managers consistently asked us these questions:

1. Where is the hard data on the benefits of nitrogen — in the context of how I operate my fleet?
2. What will nitrogen cost me to deploy?
3. What is the cost to maintain nitrogen inflation in my fleet operations — not only in my own facilities, but on the road along my routes — even across the continent?
4. What is the tangible benefit, net of capital investment, subcontract costs and direct and indirect labor? What will nitrogen inflation actually do for my fleet?

Fleets needed these answers with a hard return on investment before they would commit capital and resources to adopt this technology.

The Experimental Trial and Transport Canada's Freight Sustainability Demonstration Program

We realized we had to redo Sperberg's trial to update his findings for today's factors. We also realized we had to address the particular needs of fleet operators. For instance, most fleet operators do not wish to scrap their complete tire asset base in a wholesale upgrade to a new tire technology. They generally wish to get the full service life out of existing assets. So our methodology had to respect this significant need.

Luckily, Sperberg's and Baldwin's work led us to conclude that for a fleet, converting to nitrogen provides benefits to fleet managers and operators regardless of where a tire is in its life cycle. Sperberg's data on retreaded casings indicates significant benefits for oxygen-aged casings.

Realizing that as a small company we required assistance to produce this data, we approached Transport Canada under a program called the Freight Sustainability Demonstration Program. After rigorous examination and significant due diligence by their in-house technical team, our submittal was funded on the merits of the proposal and Drexan received a contribution agreement from the Crown in 2006.

RESULTS OF A TRIAL OF NITROGEN TIRE INFLATION IN A LONG-HAUL TRUCKING FLEET

The objectives of our study were the following:

- Quantify the mean increase in fuel efficiency by using nitrogen as the tire inflation gas instead of compressed air.
- Quantify the mean increase in tire tread wear by using nitrogen as the tire inflation gas instead of compressed air.
- Monitor failure rates of tires during the study.
- Conduct the study with a statistically significant sample size and over a long enough period to reduce or eliminate experimental noise due to variance.
- Finally, and most critically for the target audience for this study: Conduct this study with the minimum impact possible on fleet operations, while gathering real-world data on the costs of fleet conversion and fleet maintenance.

Description of the Participants

The trial fleet was Harris Transport based in Winnipeg, Manitoba. The trial fleet had excellent characteristics that met the requirements of our experimental design:

- The fleet has a very stable history with virtually no fluctuation in tractor or trailer numbers. This meant we could compare current performance to past history.
- The fleet gave us 1,988 wheel positions. This gave us a statistically significant sample size with high confidence level, as compared to Sperberg's sample of 98 tires.
- The fleet uses owner operators, so the same driver runs the same rig. Also, in this fleet, tractors are generally mated with trailers.
- The fleet hauls on consistent long-haul routes, running from Manitoba west to British Columbia and from Manitoba south to San Diego. This meant our data would incorporate seasonal effects of ambient temperature change and altitude change over the route.

For the control group, 35% of the fleet was run with air inflation. Air-inflated tractors were paired with air-inflated trailers, and nitrogen tractors with nitrogen trailers. Any potential blend of air tractors with nitrogen trailers or vice versa would serve to make the results more conservative (i.e. shorter tread wear, lower fuel economy).

The fleet has excellent historical records used for filing for fuel tax credits. But in addition to these paper records, the fleet also incorporated SensorTracs[2] into each tractor, so we were able to capture data electronically for each tractor in the trial. Hubometers installed on each piece of equipment served as a check on the Sensortracs data.

To make the study even more interesting, in 2004 and prior, the fleet did not have a good tire pressure maintenance program. But in 2005, Harris Transport incorporated a tire pressure maintenance program using a third-party outside tire service company. So the results are able to compare three fleet maintenance scenarios: lax tire pressure monitoring, aggressive tire pressure monitoring and nitrogen tire inflation.

The third-party tire service company, West End Tire, was well suited to perform the labor for the experiment. West End Tire was the Canadian beta test partner for Parker Hannifin's cold weather trials of Mobile Tire$aver Nitrogen tire inflation systems, so we had a good working relationship and, therefore, could confirm proper conduct of the experiment using this customer and proven service provider.

In addition, West End Tire entered into a service contract with Harris in 2005 and was already fully immersed in Harris' fleet maintenance protocols. Not only were the results of West End's work already incorporated into Harris' historical results for 2005, but we could be assured that West End's presence onsite would not taint the experiment. The only changes to the maintenance work flow would be the inflation gas and the tread wear measurements. West End Tire is also Harris's retreaded tire supplier, supplying Hawkinson and Marangoni Ringtread products.

Design of Experiments

Equipment was converted to nitrogen on a random, FIFO system — what was in the yard was converted — on a stagger-start basis from February to April 2006. West End Tire converted tractors and trailers from air inflation to nitrogen inflation using a Parker Hannifin MTS12 or MTS06 Mobile Nitrogen Tire Inflation System. Tires were purged to atmospheric pressure and then inflated to setpoint pressure using the generators. Purity of the gas in the casing was verified using a hand held oxygen analyzer, and minimum purity in the casing was 95%. Four tread depth readings were taken per tire using a hand-held data collection system called Snapshot. This tread wear data was tracked by tire by equipment. Tread wear data was recorded during the course of the trial as equipment cycled through the work yard. Equipment had closing readings taken after 6 months elapsed time, so closing data was taken between September and November 2006.

The drivers did not know which vehicles had nitrogen and which had air. The conversion was done by West End Tire as part of normal tire maintenance at Harris's Winnipeg depot. Because the fleet conducted maintenance in a business-as-usual mode, we controlled for any maintenance impact. The fact that West End was noting tread wear meant that Harris employees would not taint the experiment through changed behavior due to knowledge of experimental results.

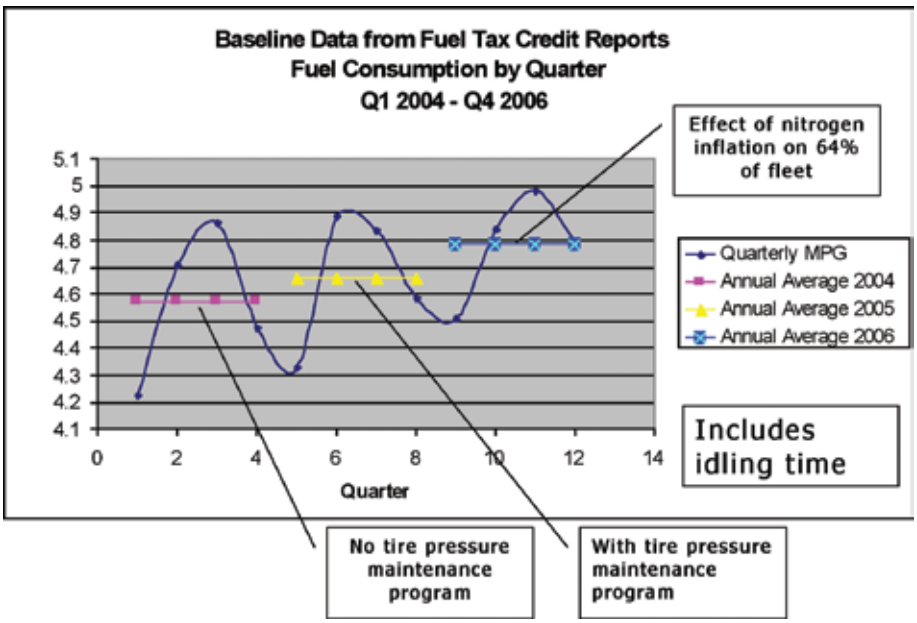
2 SensorTracs is a product of QUALCOMM Wireless Business Solutions, 5775 Morehouse Drive, San Diego, CA 92121-1714.

RESULTS OF A TRIAL OF NITROGEN TIRE INFLATION IN A LONG-HAUL TRUCKING FLEET

Because drivers always drove the same equipment, we eliminated individual driving behavior as a factor, and because the routes were consistent, we eliminated route variances as a factor.

The trial started in February, statistically the coldest month of the year in Canada, and incorporated July, statistically the hottest month of the year in Canada, so the data set incorporates climactic changes during the course of the trial as well as during the course of individual hauls. We captured a minimum of 6 months' data per piece of equipment. Because we ran the trials over 9 months spanning winter through fall, we accounted for climactic events.

Fig. 1: Comparison against Historical Data



Because we converted equipment at random, without regard to tire age, new or retread, tread depth, tire brand or retread technology, we were able to assure ourselves that any change in the mean could be due only to the inflation gas and nothing else.

Results: Fuel Efficiency

When we submitted our proposal to Transport Canada, we told them that based on existing sources, we expected to see fuel savings in the range of 2% obtained through optimized rolling resistance.

Our data set of 2 years of history and 9 months of fleet usage during the trial period encompasses more than 22 million tractor miles.

Figure 1 is produced from the fuel tax credit reports during the trial period and from historical records. It is important to note that this data includes idling, which is why the mileage is so low in winter months. The sine wave shape shows the period from winter (cold, therefore more idling, therefore lower fuel efficiency) to summer (hot, therefore less idling, therefore higher fuel efficiency) and back to winter.

The first sine wave shows 2004 data — before a tire pressure maintenance program. The average for this period is shown in the purple line — about 4.58 mpg.

The second sine wave shows 2005 data. It shows the positive impact of the tire pressure maintenance program on the fleet. The average fuel efficiency increases to 4.67 mpg — including idling.

The third sine wave is very interesting. This shows the impact of nitrogen tire inflation on the fleet average fuel economy, which becomes almost 4.8 mpg. But nitrogen was used in only 64% of the tractors in the fleet. So if the entire fleet had been converted, the increase would have been greater still.

Overall, while the seasonal sine wave is consistent year-on-year, the trend for efficiency is up and to the right based on the introduction of each measure — pressure maintenance and then nitrogen inflation.

Figure 2 uses a second methodology to demonstrate significant fuel savings.

While Figure 1 compared fleet fuel efficiency year-on-year, Figure 2 compares fuel efficiency within the experiment itself. This data is derived from electronic data capture using Sensortracs, and it excludes idling. It is important to note that this trial covers more than 6.1 million tractor miles and represents fuel usage during actual driving (including standing idling at stop lights).

The lower curve shows fuel consumption for the air-inflated control group. The upper curve shows the fuel consumption for the nitrogen-inflated test group. We see clearly that the nitrogen-inflated vehicles were 2/10ths of a mile per gallon more efficient than the air-inflated control. We also see that the lines are essentially parallel over the entire test period.

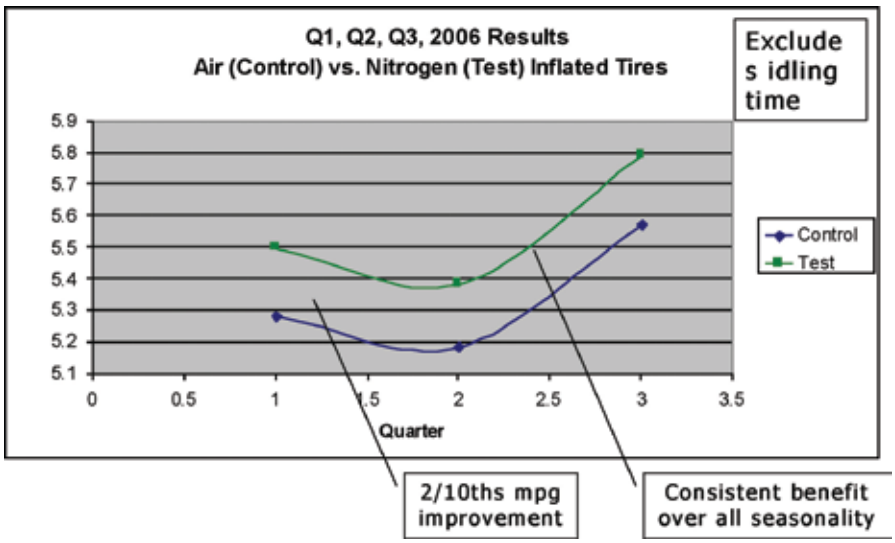
Results: Tread Wear

Prior to this trial, we had very promising anecdotal evidence of increased tread life from existing Tire$aver customers. We had customers on small trials telling us about obtaining tread wear between 45,000 to 50,000 km per 32nd.

Figure 3 is a graph prepared from this anecdotal evidence. While the data used to prepare this graph is statistically insignificant due to small sample size, it explains why a nitrogen-inflated tire gets more tread miles than an air-inflated tire. The purple (lower) line shows a new trailer tire with approximately 250,000 km of tread wear. Our customer base says this is typical tread wear for new, air-inflated trailer tires. However, these same customers said that they were seeing 45,000 to 60,000 km tread wear per 32nd on nitrogen-inflated tires. Extrapolating this as a straight line yields the blue line.

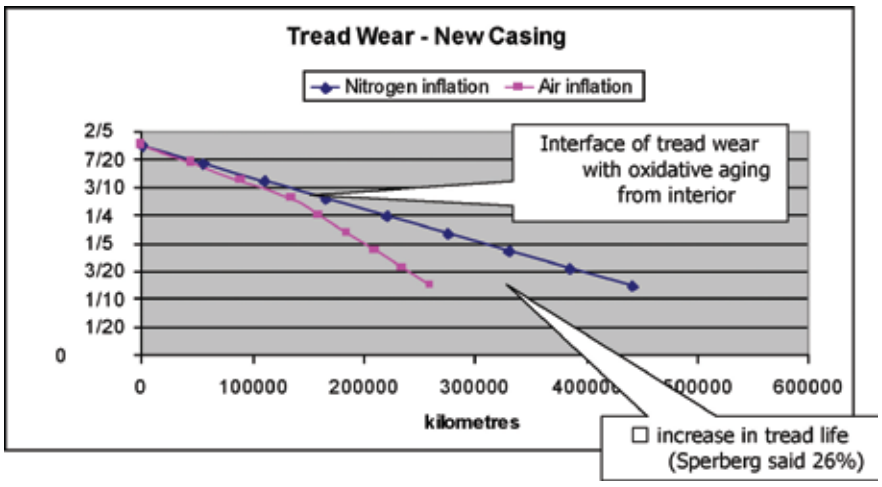
Harkening back to Sperberg, he explained the mechanism for increased tread wear over the entire tread life shown in Figure 3. Sperberg's experiment showed that for new tires, nitrogen provided 26% longer tread life. He concluded that the increase was due to the

Fig. 2: Comparison of Test vs. Control within the Experimental Trial



elimination of oxidative aging of the tire rubber that occurs in air-inflated tires right through to the tread face itself. The interface between the tire road surface with the oxidated tread rubber is represented at the inflection point of the purple line in this graph where it curves downward. At this point, the aged tire rubber has shorter polymers. Oxygen has broken down unsaturated bonds in the tire rubber. Shorter polymers mean weaker polymers, a softening durometer hardness of the tread rubber and accelerated wear of the tread rubber due to road contact. And this is indeed what fleet owners and operators report as their experience in the field.

Figure 3: Expected Tread Wear — New Casings



(Continued on page 48.)

COMPRESSED AIR TECHNOLOGY (CAT) VEHICLES

BY ROD SMITH

A Compressed Air Technology (CAT) Vehicle

A French inventor named Guy Negre has been toiling in his engineering laboratory for 14 years to develop a compressed air car. Having recently signed an agreement with Tata Motors, a $5.5 billion car manufacturer in India, he has taken a firm step toward turning his compressed air technology (CAT) concept vehicles into reality.

Background

In 1991, armed with a background in aeronautics and Formula 1 engine development, Mr. Negre invented a dual-energy engine that ran on gasoline and compressed air. The concept attracted enough investors for him to create Moteur Developpment International (MDI). The following years were dedicated to further development of the engine until 1998, when the TOP (Taxi with O Pollution) was doing test runs in the streets of Brignolles, France. At this time, MDI's concept began attracting the attention of European media and industry experts.

As is the case with many technological breakthroughs, most investors don't want to invest until the concept is proven. MDI, while receiving many technical accolades, experienced a number of years in which the major automotive companies investigated the technology but would not commit to it. MDI's web site (www.theaircar.com) states that one of the reasons may have been that the necessity of compressed air storage tanks would have required completely new frame designs for the car manufacturers. This led MDI to turn to individual entrepreneurs and create a turnkey factory business plan, offering manufacturing licenses for specific geographic markets.

To date, MDI claims to have sold 50 manufacturing licenses around the world in countries including Mexico, Peru, Spain and many others. The head of MDI's international manufacturing licensing division, Mr. Miguel Celades, says, "This is a historic opportunity for investors, one that some of the world's most successful entrepreneurs have already taken advantage of."

Single-Energy and Dual-Energy Cars

Mr. Negre has developed two systems. His single-energy car runs solely on compressed air, while the dual-energy model uses compressed air at speeds below 50 km/hour and then switches to gasoline at higher speeds on the highway. The dual-energy engine can use most types of gasoline.

Compressed Air System

Limited information is available on the compressed air system. Drawings on the web site show a high-pressure compressed air tank with air stored at 300 bar. The tanks are the same ones used for natural gas vehicles and are made of carbon fiber by Airbus Industries. The air is expanded to 30 bar to drive the pistons in the engine. Engines have 2, 4 and 6 cylinders. Single-energy cars can be equipped with an on-board air compressor, which will refuel the car when stopped.

Air treatment is mentioned as a "condensation evacuation system," but no details are given. The expansion of the air lowers its temperature, and the exhaust air is at temperatures between 9 ºF and 32 ºF. Exhaust air can be reclaimed for the air conditioning system, eliminating the need for a separate refrigeration system and increasing mileage efficiency. A pneumatic braking system also recovers 13% of the energy.

Emissions

Since there is no combustion in the engine, there is virtually no air contamination. According to the MDI web site, major cities like London may eventually prohibit the use of gasoline engines. London is cited as a city where gasoline-powered vehicles must pay a fee to enter the city. Another benefit of no combustion is that oil (vegetable oil) changes are necessary only every 50,000 kilometers.

Refueling Challenges

Refueling can be accomplished in 3–4 hours with the optional on-board air compressor. The cars can also be refueled at a station equipped with 300 bar compressed air, but currently there aren't many of those around. Because of this infrastructure issue, it appears that the initial target market will be short-haul fleets with their own maintenance and refueling facilities. Fleets with small urban automobiles like taxis appear to be the first candidates. The other alternative is urban residents who drive short distances each day and can recharge the car at night. A concern may be the kW cost of home-charging a high-pressure air compressor.

Conclusion

The concept is proven, yet as with all true innovations, challenges remain. I hope the technology finds a niche due to the zero-emission levels. What is crystal clear is that no one technology will be adopted any time soon for all automobiles. The recent agreement between MDI and Tata Motors is good news for the concept. Perhaps CAT vehicles will be the future choice for city transport.

For more information, visit www.theaircar.com or contact Rod Smith at rod@airbestpractices.com.

Natural Gas Compressor FOR NGV FUELING

BY ROD SMITH

The North American automobile and truck industry is faced with a highly publicized — and long overdue — challenge to reduce its level of harmful emissions. Politicians are also challenged to reduce reliance on oil, especially imported oil from dangerous regions of the world. Natural gas vehicles (NGVs) represent an under-publicized and under-utilized opportunity to address these issues. Natural gas is an abundant, domestically produced fuel that provides significant environmental and economic benefits. The primary challenge to more widespread adoption of NGVs is the lack of fueling infrastructure to support them.

Primary NGV Fuel Station Customers

NGV Fuel Station Locations

Mr. Stephe Yborra of NGVAmerica estimates that there are around 1,100 active natural gas refueling stations in the U.S. Almost 35% of these are in California, due to the state's progressive policies and grant programs to reduce emissions and promote alternative fuel use. Massachusetts, Texas, New York and Michigan are other states with concentrations of fueling stations, although stations exist in nearly every state. Compressed natural gas (CNG) fueling facilities may be located on-site at a fleet's maintenance center or yard, at a stand-alone CNG station or at a traditional retail petroleum station.

Centrally-based high-fuel-use accounts like transit, garbage, airports, schools, municipal and short-haul fleets are the primary NGV customers and best targets to pursue. NGVs are available in a wide range of vehicle models, including sedans, pick-ups and vans, buses (shuttles, school and transit) and heavy-duty work chasses like garbage trucks, street sweepers and delivery trucks.

These fleets not only save money (because natural gas is far less expensive than gas or diesel fuel), they also enjoy the "green publicity" NGVs generate within their communities.

Systems STATIONS

NGV Fueling Station Fundamentals

Basically, an NGV fueling station consists of a natural gas supply (usually from the local utility), a compressor package and dispensing system. Depending upon the utility, natural gas arrives at different pressures. **Dave Pearce**, general manager at **GreenField Compression** (Richardson, Texas) says, "We see intake pressures range from 5 psi in the Northeast to 400 psi in some locations in Southern California." Moisture is removed from the gas before entering the compressor through the use of desiccant dryers and filters. An engine- or motor-driven compressor boosts the gas to pressures ranging from 4000 psi to 4500 psi in North America. CNG then goes either directly into the vehicle or into storage tanks for later dispensing.

About Natural Gas Vehicles

- There are about 100,000 NGVs on U.S. roads today and over 5 million worldwide.
- There are more than 1,100 NGV fueling stations in the U.S. — many of which are available for public use.
- Natural gas costs, on average, one-third less than conventional gasoline at the pump.
- More than 30 different manufacturers produce about 100 models of light, medium and heavy-duty natural gas vehicles and engines.
- Roughly 22% of all new transit bus orders are for natural gas.
- Natural gas is sold in GGEs or gasoline-gallon-equivalents. A GGE has the same energy content (124,800 BTUs) as a gallon of gasoline.

Data Courtesy of NGVAmerica (www.ngvamerica.org)

NATURAL GAS COMPRESSOR SYSTEMS FOR NGV FUELING STATIONS

> "Natural gas supply is domestically produced, and the technology is available today."

Fast-Fill and Time-Fill NGV Fueling Stations

There are two types of NGV fueling systems: fast-fill and time-fill. Fast-fill systems allow customers to refuel as quickly as they do with gasoline or diesel fuel. They require compressor systems coupled with a cascade of high-pressure storage tanks capable of supplying great amounts of natural gas in short time periods. **Hank McElvery**, a regional sales manager at **Greenfield Compression**, comments, "Fast-fill stations can cost nearly double that of a time-fill installation of similar capacity. Many fleets request quotes for fast-fill because it is how they are used to refueling with diesel. Time-fill systems use smaller compressor and mini-buffer-storage systems and can take 6–9 hours to refuel a vehicle."

The refueling process is very simple. The CNG dispenser has a hose with a nozzle, which forms a perfect seal with the vehicle's CNG cylinder receptacle. Gas then flows into the cylinder until it's full. Labor is minimal and simply consists of the quick initial hook-up.

THE BENEFITS OF NGVS

BY NGVAMERICA

NGV Benefits — Petroleum Displacement

Making America less dependent on foreign oil is a national priority. While in 2005 the U.S. imported over 65% of the oil it used, 97% of the natural gas used in the U.S. was produced in North America (85% from the U.S. and 12% from Canada). Every gallon equivalent of natural gas used in vehicles is one less gallon of petroleum that has to be imported.

NGV Benefits — Urban Emissions

Exhaust emissions from a typical NGV are much lower than those from gasoline- or diesel-powered vehicles. For example, the natural gas-powered Honda Civic GX is recognized by the U.S. EPA as the cleanest commercially available, internal-combustion vehicle on earth. In addition, dedicated NGVs produce little or no evaporative emissions during fueling and use. In gasoline vehicles, evaporative and fueling emissions account for at least 50% of a vehicle's total hydrocarbon emissions.

Typical dedicated NGVs can reduce exhaust emissions, compared to gasoline vehicles, by:

- Carbon monoxide (CO) by 70%
- Non-methane organic gas (NMOG) by 87%
- Nitrogen oxides (NOx) by 87%
- Carbon dioxide (CO_2) by almost 20%

Natural gas vehicles also produce far less emissions than diesel vehicles. For example, under stringent 2007 EPA heavy-duty engine emission standards now in effect, NGVs produce only one-sixth the NOx of comparable diesel engines.

Natural Gas Compressors

Natural gas compressors are reciprocating trunk-piston type compressors with six cylinders. Compression capacity is based on intake gas pressure, flow requirements of the fleet and how much redundancy is requested. Time-fill versus fast-fill systems and the number of vehicles to be refueled simultaneously are key factors that determine the capacity and number of natural gas compressors and storage cylinders required. **McElvery** states, "It comes down to how many gallons per minute we have to produce from the CNG system. A fleet manager may have 100 buses needing 50 gallons per bus and 10 hours to fuel them."

A variety of manufacturers offer different CNG compressor packages to meet the need from as little as 4 cfm to as much as 5300 cfm. GreenField offers three packages that accommodate the required flow capacities, suction pressures, discharge pressures, and drive-type requirements. Their smallest model provides flows to 120 cfm at 4500 psig, while the largest can supply 1000 cfm at 4500 psig.

NGV fuel dispensing system

NGV Benefits — Greenhouse Gases

Per unit of energy, natural gas contains less carbon than any other fossil fuel and thus produces lower carbon dioxide (CO_2) emissions per vehicle mile traveled. While NGVs do emit methane, another principle greenhouse gas, any increase in methane emissions is more than offset by a substantial reduction in CO_2 emissions compared to other fuels. Tests have shown that NGVs produce up to 20% less greenhouse gas emissions than comparable gasoline vehicles and up to 15% less than comparable diesel vehicles.

NGVs also emit very low levels of carbon monoxide (approximately 70% lower than a comparable gasoline vehicle) and volatile organic compounds. Although these two pollutants are not themselves greenhouse gases, they play an important role in helping to break down methane and other greenhouse gases in the atmosphere and thus increase the global rate of methane decomposition. This more rapid breakdown could more than offset the small increase in direct methane emissions from NGVs.

NGV Benefits — Safety

CNG, unlike gasoline, dissipates into the atmosphere in the event of an accident. Gasoline, on the other hand, pools on the ground, creating a fire hazard. The fuel storage cylinders used in NGVs are much stronger than gasoline fuel tanks. The design of NGV cylinders is subject to a number of federally required "severe abuse" tests, such as heat and pressure extremes, gunfire, collisions and fires. NGV fuel systems are "sealed," which prevents any spills or evaporative losses. Even if a leak were to occur in an NGV fuel system, the natural gas would dissipate up into the air, because it is lighter than air. Natural gas has a high ignition temperature, about 1,200 ºF, compared with about 600 ºF for gasoline. It also has a narrow range of flammability; that is, in concentrations in air below about 5% and above about 15%, natural gas will not burn. The high ignition temperature and limited flammability range make accidental ignition or combustion of natural gas unlikely. Natural gas is not toxic or corrosive and will not contaminate ground water.

For more information, visit www.ngvamerica.org.

NATURAL GAS COMPRESSOR SYSTEMS FOR NGV FUELING STATIONS

Turnkey Systems

The gas compressor, while the heart of the system, is just one of many components, which include flow meters, valves, control panels and desiccant dryers. Parker, Xebec and SPX Pneumatic Products offer desiccant units, which range from dual-tower designs that regenerate automatically to single-tower and manual-purge designs.

Companies like GreenField Compression offer complete pre-piped compressor/dryer/storage tank systems and also the dispensing unit. GreenField has an agreement with Gilbarco, a leading supplier of gasoline gas dispensers, to modify their dispensers for natural gas.

Challenges

Finding capital is the primary obstacle facing fleet managers who want to install an NGV fueling station. Stations can run from as little as $60,000 to as much as several million dollars. Dave Pearce says, "Although our sales (of NGV fueling systems) are growing 50% a year, a new installation can cost between $800,000 and $3 million, and this is difficult for many fleets to come up with." This cost is the total project cost for a fleet.

The good news is federal and state grants may be available, and there are new tax credits for NGVs, station equipment and fuel, which lower the initial outlay and generate attractive life-cycle economics. In addition, a number of utility companies offer incentive programs. The federal government allows a tax credit of 30% of the cost of fueling equipment (up to $30,000) and also provides a motor fuels excise tax credit of $.50 per GGE. These credits are even available to tax-exempt organizations. More information about vehicles, stations and these credits is available on NGVAmerica's web site, www.ngvamerica.org. Check with your local utility, too. The new economics of NGVs are prompting many that suspended their NGV market development programs during deregulation in the 1990s to rethink their position.

This presents our industry with an opportunity. Many air compressor sales engineers already work with utility company "Business Services" field sales staffs to identify energy-saving compressed air projects at industrial plants air (80–175 psig). In many cases, the utilities even provide rebate funds to help improve project ROI economics.

Conclusion

The benefits and advantages of NGVs over gas- and diesel-powered vehicles are proven. The establishment of NGV fueling stations is the key factor for the success of their widespread use, especially in fleet applications. Natural gas supply is domestically produced, and the technology is available today. The challenge lies in educating fleet managers about NGV and fuel station technologies and the available funding that make ROIs compelling. If compressed air businesses were to develop the type of close coordination on NGV station projects with utility companies and customers like they have with industrial compressed air applications, the results could be better air quality, reduced reliance on foreign oil, a more convenient NGV fueling network and a better bottom line for fleet managers.

For more information, please contact Rod Smith, Compressed Air Best Practices, telephone 251-680-9154, e-mail rod@airbestpractices.com.

DISCOVER CURTIS

Compressed Air Best Practices spoke with Jay Hedges, Vice President, Sales & Marketing, Curtis Compressor.

Curtis Compressor has a long history, doesn't it?

Absolutely. Curtis was founded in 1853, and we are celebrating the 154th anniversary this year. The company has a long history as a manufacturer of industrial reciprocating air compressors. The culture of this company has always been centered on strong customer service and high quality products. We are always inviting new customers to "discover" the high levels of delivery reliability and customer service they can experience with us.

We started our serious involvement with rotary screw compressors 12 years ago with the acquisition of Redmax, now an assembly and custom-engineered packaging facility in Buffalo, New York. The Curtis RS Rotary Series has proven to be a successful industrial product line, and with the addition three years ago of the KS Series, we currently offer rotary screw products from 5 to 300 horsepower. Today Curtis Compressor offers a very thorough product line of lubricated and oil-free reciprocating and rotary screw compressors and vacuum units.

Can you review the acquisition of Curtis by Fu Sheng and then by Oaktree Capital Management?

For most of its history, Curtis was a privately held company based in St. Louis. Two years ago, Curtis was acquired by the Fu Sheng Industrial Company. Based in Taiwan, Fu Sheng is a major player in the Asian compressor industry. The company has three operating divisions.

1. The Machinery Division is dedicated to air compressors and also offers scroll, rotary screw and centrifugal refrigeration compressors. This division acquired the Plant Air Package division of Elliott Turbomachinery (based near Pittsburgh) three years ago to establish, together with Curtis, a significant presence in the U.S. and has plans to establish a presence in Europe, as well as Central and South America.

2. The Sporting Goods Division has a 30% global market share in golf club manufacturing. We do contract manufacturing for most of the major consumer brands in the world.

3. The Electronics Division manufactures components for the semiconductor industry.

Last week, Oaktree Capital Management received regulatory approval for the acquisition of Fu Sheng for an estimated $859 million. Including the assumption of debt, the deal is valued at $1 billion. Oaktree is a U.S. based capital management firm with assets worth $46 billion. They have purchased a 47% stake in the business. The majority share of the business is now held by the family of the Founder and Chairman of Fu Sheng, Mr. Lee Hou Teng, and by Fu Sheng management. The Company is now being de-listed from the Taiwanese stock exchange and returns to being a privately held firm.

CURTIS® AIR COMPRESSORS

DISCOVER CURTIS

Mr. Hannu Heinonen and Mr. Karl-Heinz Gilfert (left to right)

What is the global reach of Fu Sheng?

Fu Sheng is the number-one compressor manufacturer in China. It has three factories in China building rotary screw and reciprocating compressors. They are located in Shanghai, Beijing, and the heavily industrialized region in southern China. We also have compressor factories in Vietnam and Taiwan. We believe that the modern manufacturing technology in these facilities, coupled with the relatively low labor cost structures in Asia, gives us a strategic advantage in the global market.

Europe is home to our German subsidiary, FS Europe, which has become our global engineering and technology center for rotary screw compressors. Mr. Hannu Heinonen, who is actually based with us here in St. Louis, is the global rotary product manager. He is working together with the staff of Mr. Karl-Heinz Gilfert, at FS Europe Gmbh, to develop our future global rotary screw product lines. Mr. Gilfert comes with more than 30 years of experience at GHH and leads a highly technical rotary screw engineering team in Germany for Fu Sheng. At the Hannover Fair in May, we already launched two new global rotary screw compressor product lines. We will be seeing these products in the U.S. in 2008.

Top management at Fu Sheng is taking a long-term strategic approach to becoming a global player in the compressor business. Acquisitions are an important part of the process, as is new product development. In North America, the acquisitions of the Elliott PAP division and Curtis have established the platform from which we will grow.

What is the strategy for growth in North America for Curtis?

We are forecasting growth of 20–25% per year over the next five years. This is in a market we expect to see grow by 3–5% per year. Obviously, this means we expect to gain market share. We are already well underway with this strategy and are meeting our objectives. We plan to do this with new technology initiatives, aggressive marketing strategies and new sales channel development. This is an exciting period for us as we attract talented new employees and sales channels, who are discovering many advantages to working for and with Curtis and Fu Sheng.

Please describe the new oil-less rotary screw technology.

The Curtis ZW Series oil-less rotary screw compressor.

Curtis has a long history of supplying oil-less reciprocating compressors. We have continued this tradition with the introduction of the new ZW Series oil-less rotary screw compressor. We already have more than 500 installed units worldwide, and our clients are very pleased with the air quality, energy efficiency and durability of the design. We currently offer 20–50 hp models and will expand to 100 hp by year end and then to 150 hp in early 2008. For applications above 150 hp, we refer our clients to the FS Elliott oil-free centrifugal compressors.

As an oil-less rotary screw, the system contains absolutely no oil — unlike a "dry" or "oil-free" rotary screw compressor. Water is used to cool, seal and lubricate the compressor. A few of the advantages of using water are:

- Lower initial investment
- No power loss from gears or belts
- Nearly ideal isothermic compression improves efficiency
- No oil-related service costs
- Reduced high-cost air-end rebuilds

Another advantage with water is the low air discharge temperature. Water absorbs the heat from the air and provides discharge temperatures of 115–120 ºF over ambient. A dry screw, by comparison, has discharge air before the after-cooler of 500–600 ºF above ambient temperatures. The low discharge temperatures eliminate the need for an after-cooler and separator and reduce the system pressure drop compared to other designs.

An innovation to the technology is how we purify the water used to cool, seal and lubricate the compressor. In the past, other companies have introduced some designs that have not effectively purified the water. This can allow impurities to build up inside the air-end itself, attaching themselves, and cause the air-end to go out of balance. Impurities sometimes present in water, like calcium, lime and rust, are removed by our innovative reverse-osmosis .001 micron water filtration system. It removes dissolvable solids and creates "flat water" — the same water used for surgery in hospitals. The system has a storage tank to make sure water levels are maintained. It also does an automatic system flush every 100 running hours to eliminate any potential accumulation of impurities being drawn in from the ambient air. This is an optional system, which is not necessary if an end user verifies that the water supply contains less than 50 ppm of dissolvable solids and that water pressure is between 40–60 psig.

DISCOVER CURTIS

The Curtis portable nitrogen tire inflation solution.

What other new products are you introducing?

We have expanded our offering of packages which are popular in the automotive service market. This includes 5–50 hp rotary screw compressors, which are tank mounted with optional refrigerated air dryers. This reduces both the overall footprint of a compressed air system and installation time. We have also introduced duplex packages into our ML Series reciprocating compressor product line. The ML Series is our heaviest-duty pump, which has excelled over the years in oil-field and other rugged industrial applications. We have found, however, that the automotive service industry is also interested in this premium product, so we developed the duplex packages they want for their intermittent demand profiles. Product development is also introducing new 20–30 hp models of the CA Series reciprocating compressor line. This is our biggest seller into automotive service applications, representing an ideal quality and value balance. The new models are being snapped up as we expand our marketing initiatives into the automotive service market.

I hear Curtis is also preparing a new nitrogen tire inflation product.

Correct! We are excited to be launching a brand-new technology in nitrogen tire inflation on August 1, 2007. The systems use innovative membrane technologies, which separate nitrogen from compressed air very efficiently. There are three models, with the smallest being an 8 cfm portable unit. There are also three stationary models, which can provide nitrogen flows to 24 cfm. They are all equipped with auto-inflators, allowing the service bay to inflate all four tires simultaneously in just seven minutes. The auto-inflators automatically double-purge the tires and provide nitrogen purities of 97–99% in the tires, an above-average nitrogen purity level. We see increasing demand for this technology and believe our automotive sales channels will be effective with it.

Please describe your new initiatives into the automotive service market.

We began by restructuring our sales organization. Before, we had five territory managers calling on industrial distributors with one national sales manager. Today, we have three regional sales managers and 51 sales reps who work for 12 different sales representation companies. We have been able to attract some of the best salespeople for our own team (and are still adding to it) and also some of the highest quality rep organizations in the U.S. Many have switched lines after discovering what's happening at Curtis and are strong companies, some of whom have sold air compressors for over 60 years.

The automotive service industry has been dominated by two air compressor suppliers over the past 30 years. We have found that the market is very interested in having another supplier who understands how this market works and how to service it. We have already entered into agreements with some national accounts, like Sherwin Williams, SPX, DES and Ford

Rotunda, and are working on other national reseller agreements with firms like Car Quest and Meyers Tire. Many more deals are in the works. Automotive distributors are supported by the rep organizations that have been providing them with air compressors, lifts, air tools and other service-bay items for years. Our reps can supply an automotive service company with 50–75% of all the equipment they need; product they want to buy. We expect this market segment to become 20% of our revenue over the next few years.

How about your industrial sales efforts?

The success of our oil-less rotary screw product line, the current range of rotary screw products and the global designs coming in 2008 have us anticipating that this will be the fastest growing part of our business. We have some joint distributorship agreements already, where an industrial distributor receives both the Curtis and the Elliott centrifugal product lines. This provides an industrial distributor with products ranging from 3 hp recips and 5 hp rotaries to 5000 hp centrifugals! We have a clear strategy to have the broadest product offering on the market.

> "We have a clear strategy to have the broadest product offering on the market."

We sell our industrial products primarily through industrial distributors. They are our preferred path to market. Many industrial distributors have sold our reciprocating compressors for years and sold the rotary screw products of another supplier. In 2008, we will begin to convert many customers to our new global-designed rotary screw technologies that offer many technical advantages, such as the ZW Series.

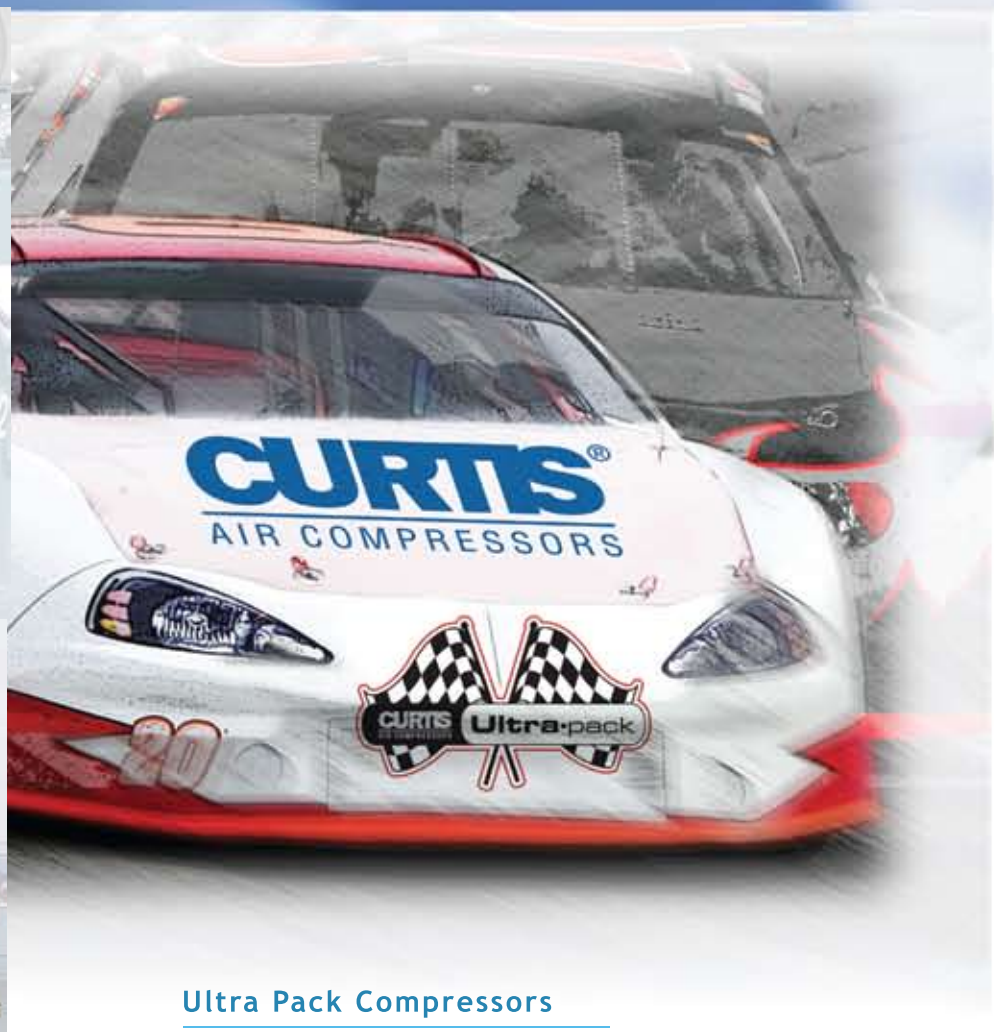
When we are not able to establish quality distribution in key markets, we have developed the capability to sell and service end users through four company stores in the U.S. We run two company stores in San Diego and have just established a new one in Los Angeles. We also operate a store out of our rotary assembly facility in Buffalo, New York. The San Diego market has seen astounding growth over the past seven years, led by Mr. Joe Vanderbilt.

This experience, while by itself proving to be very successful, is also strategically beneficial to Curtis in helping us to understand how successful industrial distributors run their companies. Mr. Vanderbilt will soon lead a team of sales consultants who will assist industrial distributors with business planning and best practices advice, such as which computer systems to use and the ratio of service personnel to inside and field sales personnel, and even provide growth capital, in an effort to help aggressive distributors grow their businesses. This new consultative approach to working with industrial distributors will bring us into a close working partnership with them and accelerate their transition to our new rotary screw technologies.

Thank you, Curtis Compressor, for your insights.

For more information, please contact Jay Hedges, Curtis Compressor, telephone 314-383-1300 ext. 227, e-mail jayhedges@curtistoledo.com, www.curtiscompressor.com.

Curtis Gives You an Easily



Ultra Pack Compressors

5vt8up - simplex tank mounted electric two-stage 145-175 psi packaged with optional equipment

- Air-Cooled Aftercooler
- Magnetic Motor Starter
- Dual Control
- Low Oil Level Shutdown
- Automatic Tank Drain
- Tank Isolator Pads

SIMPLEX UNITS - single stage (5-15hp)

DUPLEX UNITS - two stage (5-15hp)

CURTIS AIR COMPRESSORS Ultra·pack

ULTRA PACK Compressors

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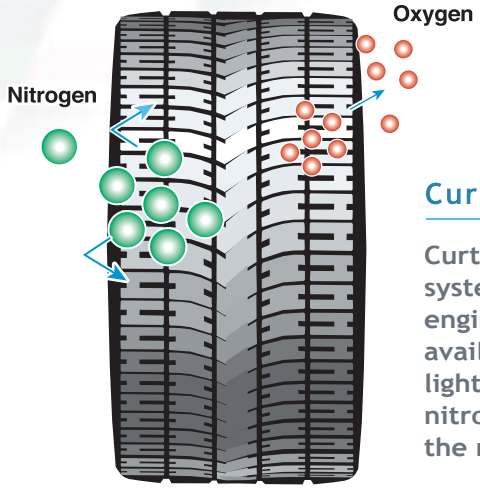
NTF Series Nitrogen Fill

CURTIS AIR COMPRESSORS NTF•series

Increase your profit margin with Curtis Nitrogen



You're an expert on tire service and you constantly strive to offer the best to your customers. Take a leap ahead of your competition now, increase your sales, and improve your bottom line at the same time with Curtis Nitrogen.

Curtis Nitrogen Tire Inflation Systems

Curtis provides both a portable and a stationary dry nitrogen tire inflation system, giving you choices for delivering nitrogen with some of the best engineered, most versatile nitrogen inflation systems and accessories available. Our units include CFM ranges designed for automotive applications, light truck or heavy utility vehicles. Our NTF series is built to deliver DRY nitrogen as a much safer alternative for tire inflation. Give your customers the nitrogen advantage.

Compressed air slowly passes through the rubber walls and tread of the tire. Tires filled with compressed air can lose as much as 12 PSI over 6 months, which decreases fuel mileage and increases tire wear.

Portable Unit: NTF600 S-P

Specifications:

- Nitrogen Purity Control
- High Efficiency coalescing and activated carbon filtration package with differential pressure gauge and automatic condensate drain
- Fabricated steel base
- All components necessary for fully automatic operation pre-piped & wired
- Entire package powder coated for appearance and durability

CURTIS® AIR COMPRESSORS

Curtis *The Symbol of Quality & Excellence Since 1854*

IMPROVE, INSTRUCT, INSPIRE:

BY JOHN ADDINGTON

Compressed air continues to occupy a significant foothold as a source of energy alongside electricity, gas and water. Many are calling it "the fourth utility," and with good reason. Compressed air has long been the primary source of power in a wide variety of manufacturing processes, including chemical processing, electronics, automotive and PET blow molding. And with recent efficiency improvements, it has even found its way into some nontraditional areas such as amusement parks, woodworking and dry cleaning.

"As these markets have grown, the use of compressed air and gas has evolved and branched out, allowing industry associations, such as the Compressed Air & Gas Institute (CAGI), to raise the bar, incorporate new technologies and forge new ground on behalf of its members…and the industry as a whole," stated Dave Prator, president of CAGI. "CAGI's proactive initiatives are another example of the institute's important role in strengthening the interface between the manufacturer and the customer."

But compressors are intricate pieces of equipment with very different responses depending on the operating parameters of the system into which they are integrated. Compressed air systems can be an extremely inefficient energy source if improperly operated and maintained. In fact, more than 85% of the cost of owning an air compressor results from its operation and maintenance, not the actual purchase price. This has been a driving force in the new initiatives recently undertaken by CAGI.

Raising the Bar

The typical first step any end user takes when seeking out a new compressor is to "shop around" to get a general idea of the capabilities and performance characteristics available. Most times, they find disparate data from manufacturers, making it hard to compare one system against another. For compressed air to be truly used and accepted as an effective energy source, it's imperative that the equipment be properly matched to the application at hand. To address the need for information that will help users properly match equipment and applications, CAGI developed standardized data sheets. The sheets are completed by member companies and contain key performance data. To assure that the stated performance on the sheets is actually delivered, CAGI went one step further and developed a means of verifying information contained on the sheets. A universal validation method run by an independent third party seemed a good way to help ensure this.

An industry-wide performance verification program (www.cagi.org/verification.htm), complete with behind-the-scenes testing and verification, has been in development by CAGI and its industry partners for quite some time. The voluntary program, slated for official launch this month, is open to all manufacturers, regardless of whether they are a CAGI member or not. It specifically targets airflow capacities and efficiencies in lubricated rotary screw compressors from 50–200 hp, as well as in stand-alone refrigerated compressed air dryers from 200–1,000 scfm.

On a regular and random basis, the program administrator appointed by CAGI will select and test samples of the manufacturer's equipment to verify that the samples meet the manufacturer's published performance ratings. (Per CAGI datasheets, including tolerances i.e. flow KW input, etc.) Units, selected at random by the administrator from available stock, will be tested annually. If a tested unit does not pass, the manufacturer has the option to have a second unit tested of the same type that was previously chosen by the administrator. If this unit also fails, the manufacturer must re-rate the unit based on the test results within 30 days or withdraw from the program.

New Innovations for the Compressed Air and Gas Industry

The program's Verification Seal for compressors (a) and dryers (b) ensures that equipment has met the specifications put forth by the manufacturer.

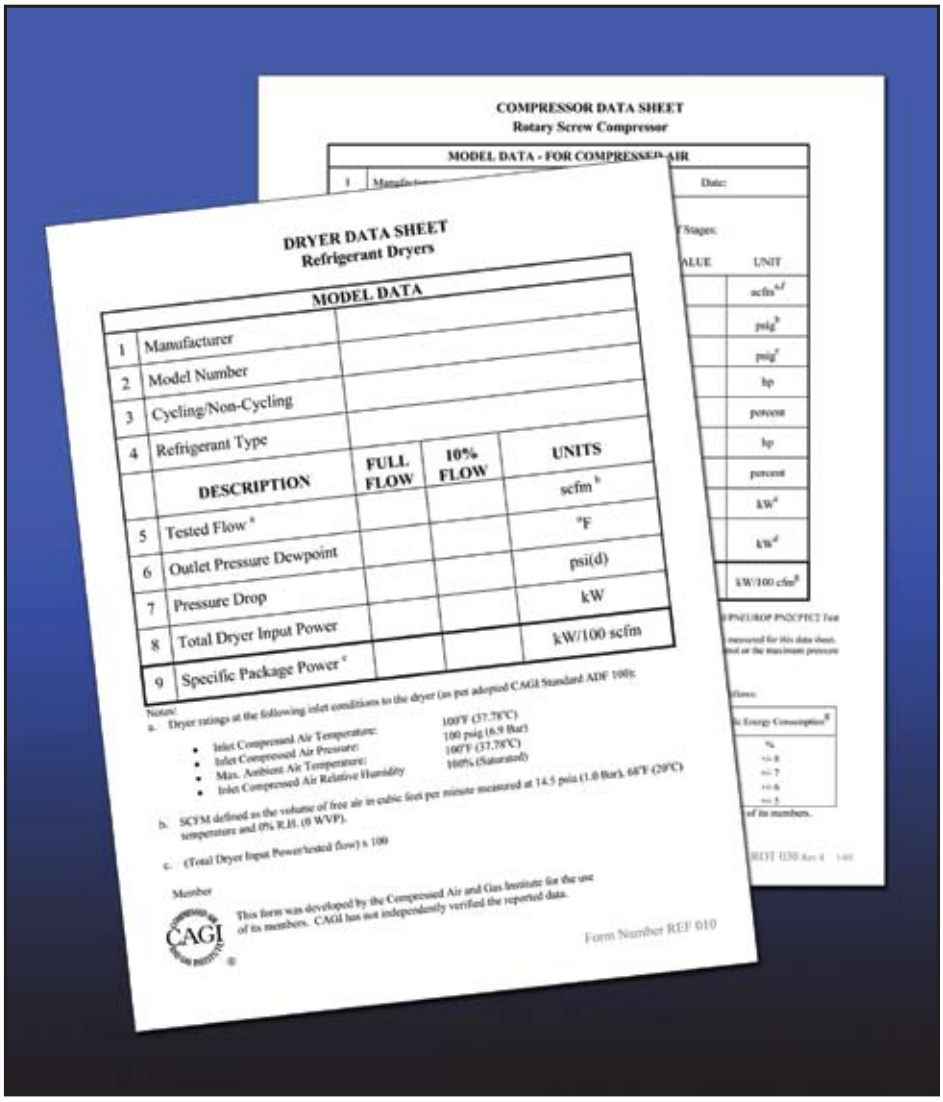
The manufacturer would then display the official CAGI Program Verification Seal (see figures 1a and 1b) on the models' specification sheets and in all product literature, which includes the standard CAGI data sheets published on participants' web sites. These data sheets define operational and performance information used during the specification and application decision-making process.

Rob Haseley, chair of CAGI's Verification Program subcommittee, noted, "We have heard from our customers that having to sift through the data sheets of various compressors had become a very time-consuming process, and in the end, they weren't really sure they were making a fair comparison. Our established CAGI data sheets, combined with a standardized testing program such as this one, is going to be a tremendous help to make sure that what you're getting is going to be the most useful piece of equipment for your application. Otherwise, productivity will be down, maintenance costs will be up and no one will be happy.

"Since compressed air and gas is essential to the manufacturing process, we needed a system in place that enables end users to effectively evaluate equipment and system performance," continued Haseley.

For compressors, the method used to verify the equipment is the CAGI/PNEUROP PN2CPTC2, Acceptance Test Code for Electrically Driven Packaged Displacement Air Compressors (Annex C to ISO 1217). For air dryers, it's the CAGI ADF100, Refrigerated Compressed Air Dryers; Methods of Testing and Rating. Each of these standards has been employed for a number of years and is well accepted throughout the compressed air and gas community.

IMPROVE, INSTRUCT, INSPIRE: NEW INNOVATIONS FOR THE COMPRESSED AIR AND GAS INDUSTRY



The data collected for Performance Verification enables end users to objectively compare equipment specifications.

Incorporating New Technologies

The Internet has made available a wealth of static information, but even more important is the interactive opportunities it provides. The second wind of change that CAGI is riding is the advent of an online e-learning center, SmartSite (www.cagi.org/smart_site.htm), which provides training on important aspects of compressed air systems and is designed to help users maximize air system efficiency.

The main attraction of the site is the innovative e-learning courseware, Introduction to Compressed Air Systems, which consists of seven modules. Enrollees begin their educational instruction with a compressed air basics module and then focus on modules instructing them on the different types of compressors, capacity controls and distribution systems. The courseware's final three modules concentrate on waste control air treatment, as well as compressor installation and air system maintenance.

The Educational & Promotional/Marketing Committee has worked hard on the content for the site, and the CAGI board expressed a continuing commitment to fostering education at all levels within the industry.

Rick Stasyshan, chair of the Educational & Promotional/Marketing Committee, said, "Education is a vital aspect of raising compressed air and gas to a level where it not only competes with the other three power sources, but jockeys for first position. We all know how efficient it can be when employed properly, and associations like CAGI are taking the steps needed to make the larger industrial population aware of these benefits as well."

The courseware is available 24/7, allowing participants to complete each module at their own pace at home, on the road or in the office. This saves both time and money, while increasing the technical knowledge and career advancement opportunities for those within the compressed air and gas community. In some cases, employers will apply these courses toward continued education units (CEUs).

In addition to learning the do's and don'ts of compressed air systems, users are provided with maintenance tips as well as ways to maximize an air system's efficiency, all of which fosters better system performance, longer system operation and decreased operating costs. The goal is to continually strengthen the use and validity of compressed air and gas as an efficient energy source.

The more educated a technician, the more the industry will benefit; therefore, other SmartSite tools and learning aids are available, including technical papers, videos, CDs, an educational poster and CAGI's widely used Compressed Air and Gas Handbook.

Forging New Ground

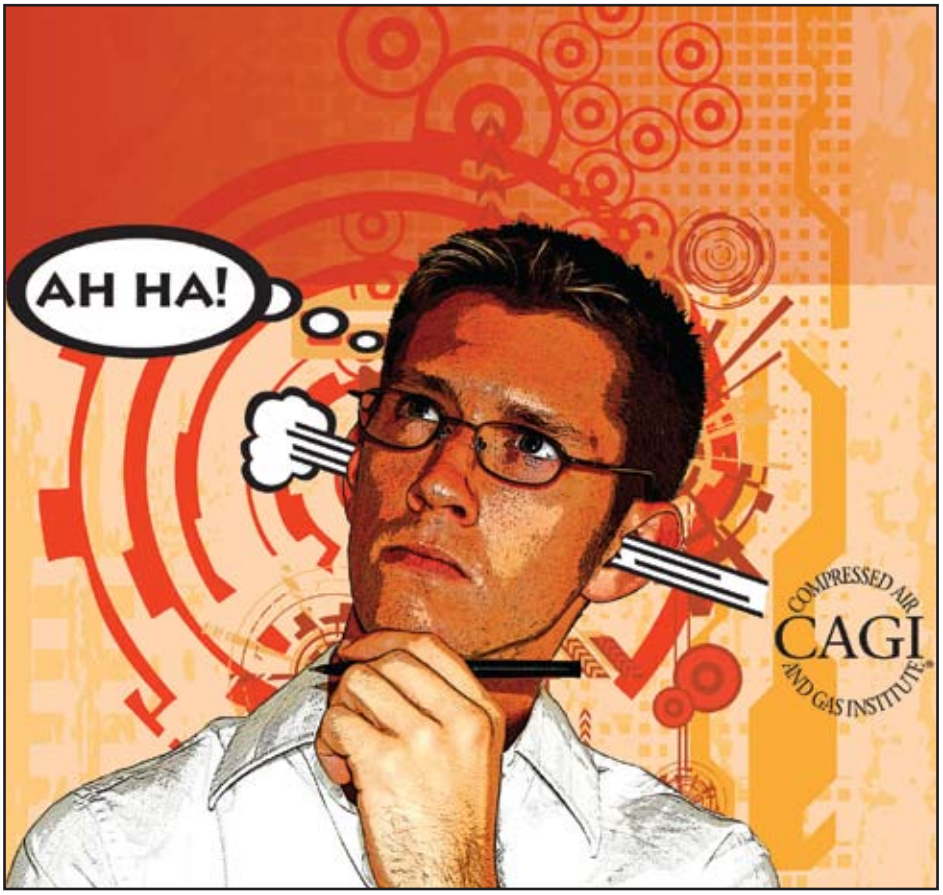
The SmartSite education process is an excellent way to help those in the industry expand their knowledge of compressed air and gas, but what about the "up and comers" who may not have embarked on a career within the industry…yet?

This September marks CAGI's first Innovation Awards (www.cagi.org/awards.htm), a contest that promotes the increased awareness and use of compressed air and gas as a power source. Engineering undergraduates will design a system and compete to have their design honored as an innovative use of compressed air.

The universities slated to participate in the inaugural year include Iowa State University, Milwaukee School of Engineering, Purdue University, University of Minnesota and Virginia Tech University, all of which offer well-established ASME chapters, enabling CAGI to collaborate with representatives from this organization to advance the success of the contest. Students from these institutions will submit air-powered designs within one of four categories: machine tool application, motion control device, consumer product or other.

Working with CAGI member volunteer mentors, the student teams will have more than four months to incept and design an innovative compressed air application. Another set of CAGI member volunteers will evaluate each design submission based on innovation, marketability and presentation, with winners announced in April 2008.

During initial planning, CAGI spoke with faculty and ASME members at the participating schools. From an educational perspective, the thinking was the same amongst those interviewed. Schools are continually looking for new and interesting ways to expand their students' range of knowledge. This contest will enable students to think outside the box and obtain hands-on experience in the engineering field before they head out into the working world. The industry needs this type of a public forum to showcase the talents of emerging engineers.



Innovative and fresh thinking will pave the way for new uses of compressed air and gas.

The Innovation Awards affords CAGI with a host of opportunities to help generate excitement and interest among some of the freshest engineering talent, which will ultimately benefit the users and manufacturers of compressed air and gas systems. The entrants also receive access to the innovative SmartSite courseware, and a guest speaker program has been developed in conjunction with the contest, enabling CAGI representatives to visit participating schools and provide real-world, practical knowledge of the uses of compressed air and gas.

One of the more long-term objectives includes incorporating the contest into the curriculum of the engineering program at each school, again, elevating the awareness of this powerful energy source.

When talking about good things to come, three seems to be the magic number, and the developments underway within the compressed air and gas industry, specifically at CAGI, seem to support that philosophy. CAGI is committed to providing the consumer a simplified means of evaluating compressed air components by providing verified and easy-to-understand data. The association is also interested in furthering consumer education to increase efficiency and understanding of compressed air systems not only for those currently within the industry, but for the future users and specifiers as well.

For more information, contact John Addington, Managing Director, Compressed Air & Gas Institute. Phone (216) 241-7333 or visit www.cagi.org

DESIGNING A CAR DEALERSHIP

Compressed Air Best Practices spoke with Bob Stewart, president, and Micheal Bolden, vice president, of Dealer Solutions & Design.

Good afternoon! What business does your company focus on?

Good afternoon. Dealer Solutions & Design is based in the Atlanta area and provides a "concept-to-completion" approach to the design, development, specification and construction of automotive dealership fixed operations, which encompasses the vehicle maintenance, parts and collision repair facilities. Our services provide clients with the most productive and profitable facility possible. We accomplish this by utilizing a streamlined process, which saves time and money, and the overall objective is to build a facility which will maximize the facility owners' return on investment.

Our company focuses on providing the very best fixed operations solutions to the automotive industry. With a seasoned team of fixed operations specialists with over 180 years of combined experience and involvement in more than 1500 automotive facilities, DSD has the knowledge and talent to make an automotive dealership or facility the very best it can be.

Bob, can you provide us with examples of who some of your clients are?

Sure. Dealer Solutions & Design is fortunate to be endorsed nationally by BMW of North America and Southeast Toyota Distributors. We have completed over 40 Land Rover and Jaguar facilities across the country and have done facilities for virtually every manufacturer in the U.S. in almost every state. We do the facilities for the Hendrick Automotive Group (over 41 projects to date), Sonic Automotive Group (over 52 projects to date), Premier Automotive Group and Prestige Automotive Group (six projects each), just to name a few of our valued long-term clients.

Dealer Solutions & Design is endorsed nationally by BMW North America.

Our industry has seen a tremendous amount of growth and consolidation. Dealer groups are getting larger, and we have both private and public companies who own multiple dealerships. The facilities are also much larger now. The normal car dealership we design today averages 40 service bays — the norm used to be 20! Many dealerships now operate facilities in excess of 120,000 square feet. All of these factors have created strong demand for our services.

Does your firm also renovate facilities?

Yes. Our projects are approximately 85% new construction and 15% renovations. Older dealerships typically need to move out of the downtown areas to higher traffic areas. Demographic changes and the need for larger facilities often forces that. In some areas like the Northeast, however, renovations or conversions are more frequent due to lack of available "green field" property. We need to be innovative and creative at times and have created state-of-the-art dealerships out of restaurants, museums and warehouses!

Additionally, in our new facility designs and renovations we brought some innovation to the industry by carrying the manufacturer's corporate identity into the service and parts departments. We started this around 12 years ago, when we were able to start ground-up with Land Rover's national expansion. In the prototypical design we created, the "Land Rover green" color was used for lifts, work benches, parts bins, etc., carrying the corporate identity into the fixed operations. This trend is a standard now.

Micheal Bolden (VP), Buz Psathas (Sr.Facility Specialist) and Ron Hall (VP) of Dealer Solutions and Service (left to right).

What are some of the specific benefits you offer your clients?

Automotive facilities have historically had significant amounts of wasted space and insufficient thought given to building designs, which hampers workflow and production throughput. A *properly designed facility* optimizes productivity, profitability and return on investment. A *properly constructed facility* minimizes change orders, speeds up the construction process and increases the accuracy of construction. A *properly equipped facility* enhances individual and company operational efficiencies and maximizes production and employee satisfaction. Our process has four facets:

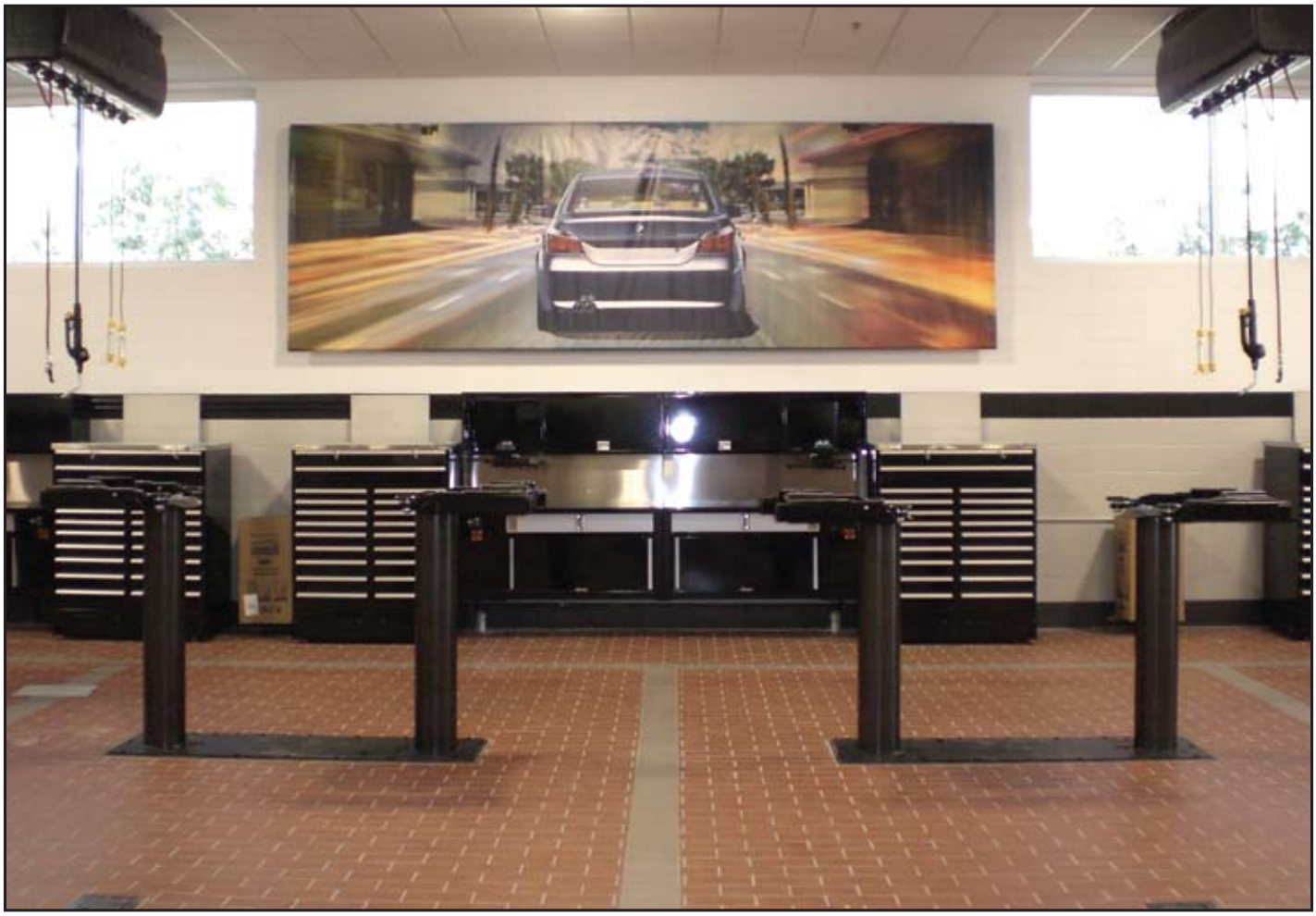
1. Expert Design Development — Our industry-specific facility specialists are highly trained in operational flow, dimensional and proximity requirements and employee productivity and profitability optimization for the fixed operations areas.

2. Comprehensive Operational Maximization — By understanding paper flow, work and production processes, as well as all the systems to aid or improve these areas, we can uniquely help to bring more net profit to the bottom line of any automotive facility.

3. Leading Edge Facility Specification — Our team is also versed on all the latest systems and equipment solutions available to help enhance and improve quality and production.

4. Industry Renowned Project Managers — Our team understands your business, your people, your processes and how to help properly build your facility. They know how to deal with the complex construction- and design-related issues with fixed operations, as well as coordinate construction, delivery and installation issues and logistics.

DESIGNING A CAR DEALERSHIP



Automotive service bay with compressed air drops.

Micheal, so your firm also specifies compressed air systems, right?

Yes. They are a part of our total facility solution. Our ability to combine the above benefits, along with providing and installing all systems and equipment for an automotive service department, parts department, collision center, car wash and quick lube, saves our clients time and money in the design, construction and acquisition processes.

What types of air compressors do you recommend?

There are two primary types; reciprocating and rotary screw compressors. Reciprocating air compressors are more prevalent. Most shops require air compressors between 10 and 50 hp in size. Most clients are simply looking for reliable and high-quality equipment, and we always recommend tandem motors and compressors. Reciprocating tandem configurations are important in that they allow capacity for peak demand periods without over-sizing the air compressor, in addition to providing back-up during servicing. Screw compressors are often requested due to their quieter operation and their reduced space requirements. Noise can be a consideration when a dealership is located near a residential area. Rotary screws are also seen more often in a body shop environment, where they require a higher volume of low pressure, cleaner quality air.

What are the operating requirements?

Each facility goes through an interview process to review their air applications and to establish demand flows and pressure requirements. Demand is tied to the number of service bays and the amount of throughput the client wants to plan for. Pressure requirements range from 175 psig for service bays to 110–120 psig for body shops. Tire changers, tire balancers and the air-operated safety locks for lifts require 90–120 psig. Some pneumatic hand tools require pressures above 120 psig.

Can you describe how you assess a car dealership's demand?

Sure. We look at several factors, beginning with the number of service bays they have. We then determine the cfm requirement per bay. The most cfm used in a service bay is for the ½-inch impact wrench, which consumes approximately 5 cfm. We then look at the number of detail bays. Here we may find safety blow nozzles which consume 8 cfm. Automotive service facilities have big shifts in demand, while body shop demand profiles are more consistent. For automotive service bays, we use a 50% service factor because the tools are used intermittently. Finally, we apply an 80% productivity factor since the technicians are not working in the bay all day, every day. We then add up the numbers and come up with demand in cfm.

What type of compressed air treatment do you recommend?

We recommend "Body Shop Quality Air" for all of our customers. In our industry, this means that the air is clean enough for the painting process. Every system we recommend has an air-cooled after-cooler, receiver tank, refrigerated air dryer and an oil-coalescing after-filter. This provides our customers with reliable 38 ºF pressure dewpoints and oil removal to 0.01 ppm.

Please review your installation recommendations.

Air compressors are typically located in a tool room or a storage room far away from any customer areas. When doing renovations or reviewing client's drawings, we often see improper air circulation and ventilation. We also see a lack of a drain for water run-off. In our new facilities, we typically design the compressor room to be at the end of the facility with good access to fresh ambient air or add a "bump out" or partially enclosed shed.

We always put a continuous-loop piping system in the ceiling to try to equalize the flow. We use a matrix for pipe sizing based upon the linear feet of piping and the flow of air in cfm. The most common piping materials used are galvanized iron pipe and copper. Galvanized is the most popular, because it is very strong and can support a lot of air drops.

Copper is also used in our applications. It provides better air flows, but its price can be a little volatile. Extruded aluminum is sometimes requested, but most automotive facilities don't need to change their drop locations, so the flexibility this pipe offers is not usually needed.

Please describe your drops for the service bays.

We take the air drops off the top side of the main header as a precaution against moisture. The air drops also have 6-inch to 2-foot (extreme) drip legs with a quarter-turn ball valve. Service drops can come from an air/utility box, which is used with above-ground lifts in many instances. This gives you two air outlets and two plugs for 110 volt service. You bring compressed air and power down from the ceiling, with a ½-inch drop, to the utility box. Reels can be overhead or on the wall. Some air reels are mounted in the wall-mounted workbenches. Roger Penske with the United Auto Group started this trend with his car dealerships. We find the installation cost is about 30% more, and you have hoses coming across the work area, which people can trip on. We prefer mounting the reels on the ceiling or on the lifts (if above-ground lifts are used).

Thank you, Dealer Solutions & Design, for your insights.

For more information, contact Bob Stewart, Dealer Solutions & Design, telephone 770-274-3500, e-mail bob@dsdteam.com, www.dsdteam.com.

THE ART OF USING STORAGE

BY HANK VAN ORMER

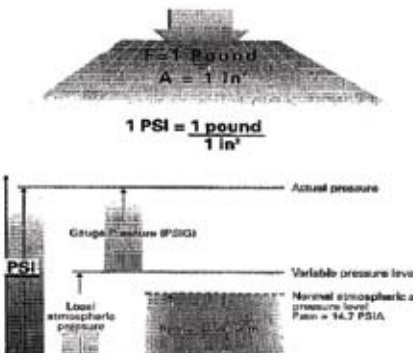
Over the years, a great deal of information and misinformation has been published on the use of stored air volume (or air receivers) in compressed air systems.

Ask people what to do with the air receiver, and you will receive many contradictory answers, including:

- It goes before the system entry and after the air supply — or
- It does better when installed at the end of the air system — or
- It goes after the dryer — or
- It goes before the dryer — or
- Every air system needs one — or
- Rotary compressors not using step controls don't need one if there is enough system piping — or
- A two-step control compressor needs only 1 gallon of storage per cfm to operate correctly — or
- The proper storage for two-step (and other) compressors is 20% of rated flow — (500 cfm x .20 = 100 cu. ft. or about 750 gallons) — or
- To be effective, any demand-side control system should be sized 2 to 4 gallons per cu. ft.

The list could go on and on, considering that a compressed air system is dynamic with ever-changing demand uses, weight of inlet air compressed, pressure float, and other factors. What are the real best practices?

Before reviewing these, let's review what actually happens in an air receiver as taught in "Compressed Air 101."



Unlike water, compressed air (and gas) is a compressible liquid and, as such, follows some very fixed rules, which are logarithmic in nature. Most actions can be predicted and calculated using simple algebra.

- Pressure has two basic designations:

  PSIA — local atmospheric pressure, which varies with altitude and weather.

  PSIG — reads the amount of pressure (pounds per square inch) above PSIA.
- Flow is in ACFM or FAD — How much air is going to or from the storage in cubic feet per minute, taken into the compressor at ambient conditions.
- With these thoughts in mind —
  - How long will it take an air compressor to fill a 400 cu. ft. air receiver from 0 psig to about 100 psig with an ambient pressure of 14.5 psia with a compressor that delivers 100 ACFM?
  - How long for the same scenario in Flagstaff, Arizona, with a normal ambient pressure of 11 psia?

14.5 PSIA	11 PSIA
0 psig (14.5psia) = 400 acfm	0 psig (11 psia) = 400 acfm.
14.5 psig (29.0 psia) = 800 acfm	11 psig (22 psia) = 800 acfm
29.0 psig (43.5 psia) = 1200 acfm	22 psig (33 psia) = 1200 acfm
43.5 psig (58.0 psia) = 1600 acfm	33 psig (44 psia) = 1600 acfm
58.0 psig (72.5 psia) = 2000 acfm	44 psig (55 psia) = 2000 acfm
72.5 psig (87.0 psia) = 2400 acfm	55 psig (66 psia) = 2400 acfm
87.0 psig (101.5 psia) = 2800 acfm	66 psig (77 psia) = 2800 acfm
101.5 psig (116 psia) = 3200 acfm	77 psig (88 psia) = 3200 acfm
	88 psig (99 psia) = 3600 acfm
	99 psig (110 psia) = 4000 acfm

This is an accurate representation (the numbers are rounded off) of what happens in any storage volume. Each time the vessel is filled, the pressure rises "1 Atmosphere" or (1) whatever the local ambient psia reading is at the time.

To accurately estimate the time to accomplish the pump-up, you can see it takes 3200 acfm with 14.5 psia and 4000 acfm with 11 psia. Allowing for the first 400 cu. ft. that is in the receiver before the compressor starts pumping, it will take approximately 28 minutes with a 14.5 psia or 36 minutes with an 11 psia. (By the way, it's not 4 minutes.)

There are other factors that can and do modify this answer somewhat, such as temperature, water vapor and more. However, for estimating the storage effect the receiver is going to have on the system, this is very accurate.

EFFECTIVELY

The Math behind the Answer

This is the only formula you need to accurately predict or calculate what will happen with regard to time, pressure and net flow for any storage volume.

Pump-Up Formula:

$$T = \frac{V \times (P2 - P1)}{C \times Pa}$$

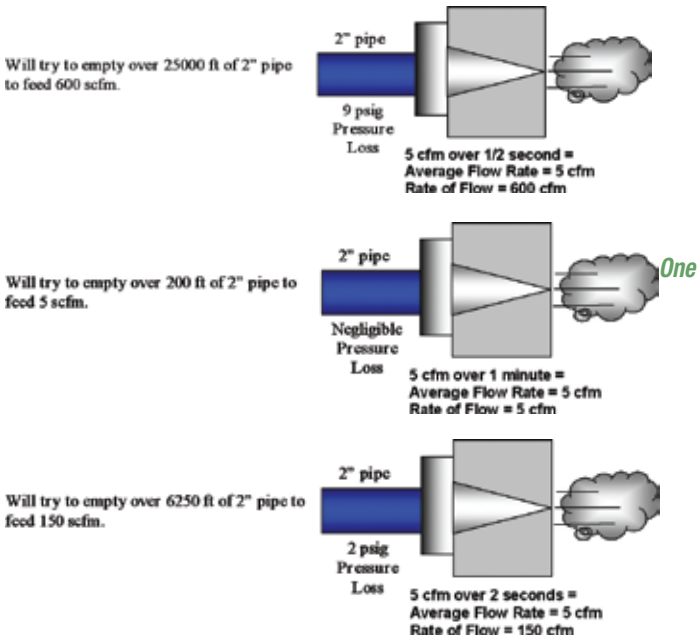
- T = Time in Minutes
- V = Receiver capacity in cubic feet
- P2 = Final receiver pressure – psig
- P1 = Initial receiver pressure – psig
- C = Net Flow in or out (Rate of Flow)
- Pa = Atmospheric Pressure

Most of the above definitions are self explanatory; however net flow in/out in rate of flow may require some explanation:

- When the air is leaving the receiver at a higher rate of flow than it is coming in, you will be calculating *pressure decay time* in minutes.
- When the air is entering the receiver at a greater rate of flow than leaving, you will be calculating the *pump-up time* in minutes.

Average Flow / Rate of Flow

This flow rate versus rate of flow does not normally come into play on main air system storage, but in a process that may have a short burst of (5 scfm) over a very short time (½ second), such as a dust collector/pig blowing.



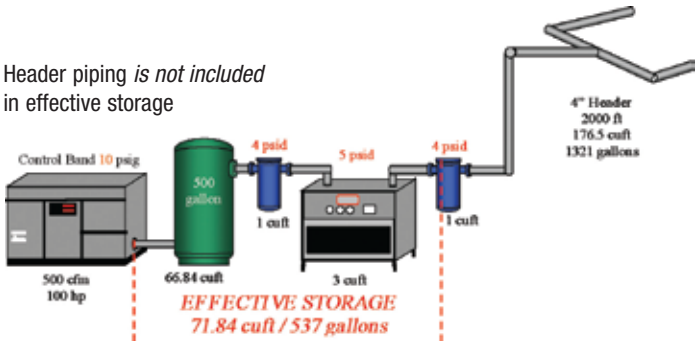
One

More Definition — "Effective Storage"

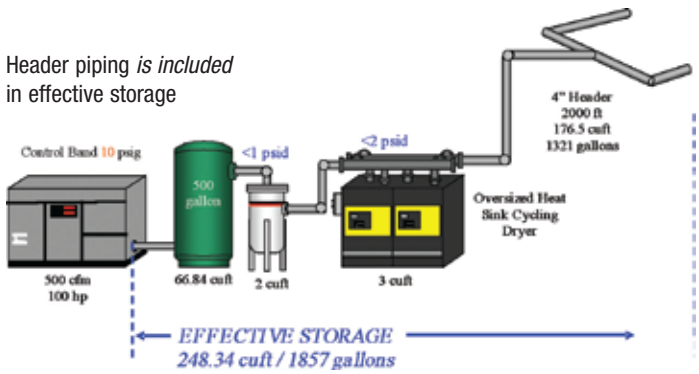
Effective storage — The storage volume in piping, receivers and air treatment equipment ending where the capacity control *operating band* or *dead band* runs out due to pressure loss. Normally, this would be 10 psig (i.e. 100 psig full load — 110 psig unload)

Establishing Effective Storage by Eliminating Interconnecting Pressure Loss

Header piping *is not included* in effective storage

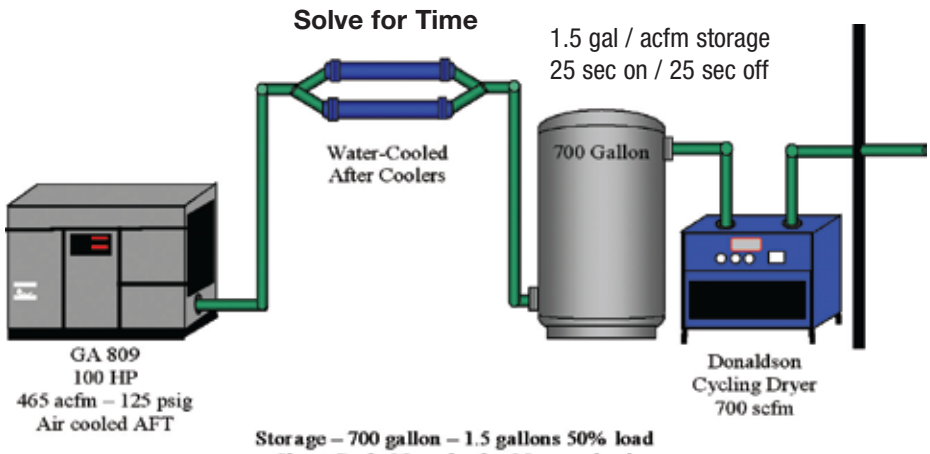


Header piping *is included* in effective storage



- Replace conventional coalescing/particulate filter with long life (5–10 years) loose-packed deep-bed type, low pressure loss (<1psid). Use oversized heat sink type cycling dryer, low pressure loss (<2 psid), energy efficient, no freeze-up problems.
- Same system has increased effective storage three and a half times. From 1.07 gallons per acfm to 3.7 gallons per acfm. We are now utilizing the system header!
- Poorly configured or too small interconnecting piping is a very common cause of a loss of effective storage due to excessive pressure loss.

THE ART OF USING STORAGE EFFECTIVELY



Storage – 700 gallon – 1.5 gallons 50% load
Short Cycle 25 sec load – 25 sec unload

Full Load -	78 kW
Unload (10 sec) -	77 kW
Blow down (25 seconds) -	37 kW (Average 57 kW – BD)
Average Operating kW per cycle	66.75 kW
Annual electrical cost -	$23,790/yr
Full blow down time of compressor	60 seconds
Full blow down kW at idle	21 kW

Compressor does not stay off long enough to reach full idle.

6.45 gal / acfm storage
101 sec on / 101 sec off

Storage – 3000 gallon (nominal) - 50% load
Cycle 101 sec load – 101 sec unload

Annual electrical cost -	$19,017/yr
Annual electrical savings -	$ 4,773/yr
Full load kW -	78 kW
Average kW blow down -	36.6 kW
Average operating kW per cycle -	53.3 kW

8.6 gal / acfm storage
120 sec on / 120 sec off

Storage – 4000 gallon (nominal) - 50% load
Cycle 120 sec load – 120 sec unload

Annual electrical cost -	$18,765/yr
Additional annual electrical savings -	$ 252/yr
(Extra savings for 2000 gallons more storage)	
Full load kW -	78 kW
Average kW blow down -	36.6 kW
Average operating kW per cycle -	52.65 kW

The extra 1000 gallons has very little economic effect on the specific economics after we have established basic acceptable effective storage.

What Size Receiver to Fix Short Cycling?

Short cycling is to be avoided because it is very hard on the equipment, often leading to premature failure of switches, motors, coolers and more. In the case of lubricant-cooled rotary screw compressors, it can preclude reaching proper energy savings.

Required Storage for Proper Step-Type Capacity Control Operations

What happens with 1.5 gallon of effective storage using the preceding formula? Here is an actual application from one of our air system reviews:

We have just reviewed one of the classic purposes for an air receiver — to work with a control system to achieve:

- **Pressure Stabilization:** Use storage to handle short-term demand spikes rather than turn on another compressor or go to a higher compressor load. The air receiver, when the compressed air flows through it, will experience much slower pressure rise and fall than the pipe and thus smooths out the control band.
- **Pulsation Dampening:** Air receivers eliminate heavy pulsations and negate their effect on other system components.
- **Separation:** Since the air slows down dramatically when it enters an air receiver, most liquids and solid contaminants fall out of the air stream and to the bottom of the receiver, where they can be removed.

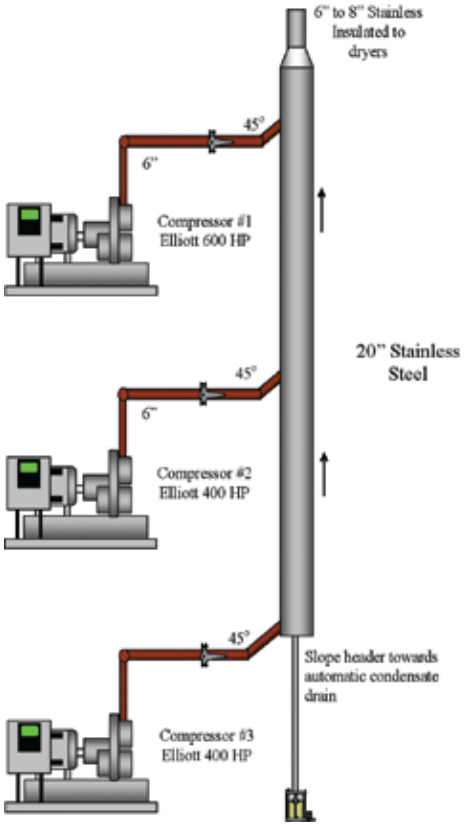
Various types of compressor control systems will react differently with proper effective storage, but since efficiency is based on a timely response to the need or lack of need for air on the production floor, a well applied and sized air receiver and or proper effective storage is a MUST for ALL air systems. Additional storage could also be in the form of an oversized collection header tying multiple compressors and dryers together.

We almost always recommend the primary stored air should be dry and held to a steady pressure to meter out to the production area as required.

Other Best Practices Uses

Before looking at some of the more common best practices uses for storage other than control air, keep several facts in mind:

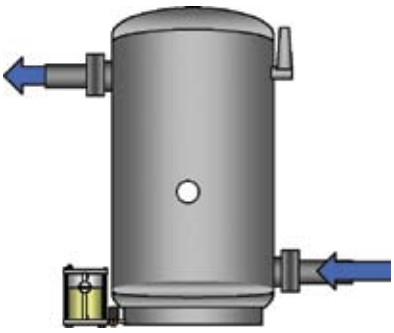
- Proper efficiency depends on:
  - The compressors or air supply responds only to the real system demand — not to any signals generated in the interconnecting piping and equipment.
  - The compressors or air supply responds in time to create full support and not cause other problems. For example: If the air arrives late, it overdrives the pressure. Many processes today operate with fast-acting electronic control valves with operation measured in microseconds. Controls with diaphragms and springs will operate in multiple seconds. This time delay or permissive action must also be considered along with signal-time delay. Proper storage can handle this, but it must be carefully applied and designed by knowledgeable personnel.



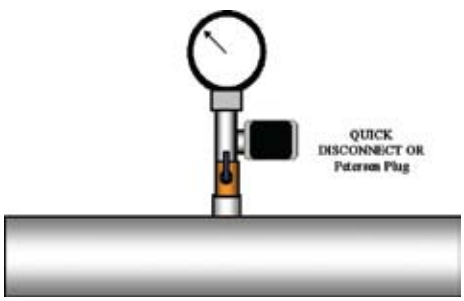
Bear in mind, compressed air is not "nothingness." It has weight, and the higher the volume and pressure, the more it weighs. Since it has weight, it also has inertia, or a tendency to continue to move in the direction it is currently moving. The smaller the pipe, the higher the velocity at the same volume and pressure.

When compressed air is moving in one direction in a pipe, it cannot instantly turn around and flow in the other direction during normal operation. This will take some amount of time and perhaps some back pressure forcing it back, which becomes a counter flow.

General Guidelines



- Always enter the receiver in the lower half and exit at the top. This will allow separated material to fall to the bottom and be removed. Entering at the top and exiting at the bottom will allow much of the separated material to continue on with the air stream.
- Always install a no-air-loss automatic condensate drain on an air receiver with a bypass line.
- Always slope header piping and risers, etc., towards the air receiver.
- A safety relief valve should be on every receiver with a volume rating equal to or more than the maximum available or applied air compressor supply in scfm. The maximum pressure setting of the valve should not exceed the maximum working pressure rating on the tank.
- We always recommend a high quality pressure gauge be installed on each receiver with a valve and a port to install a test gauge.



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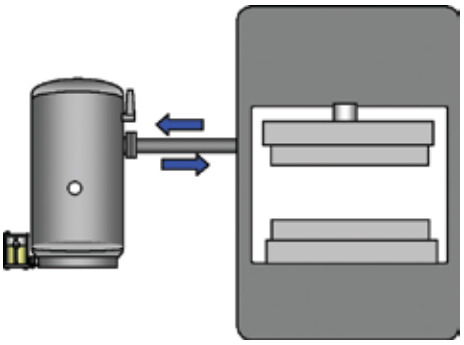
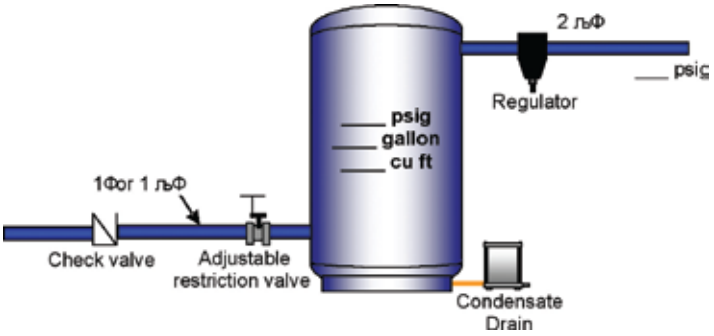


Air Receiver as a "Bladder Tank"

It is comon for many people to install an air receiver as support storage, or bladder tank, to handle a short-term demand. Often, this receiver is only connected to the system with *one line in and out*.

This works when the receiver is located at or very near the process, such as a safety volume for air brakes on a press. It then supplies the surge demand, mitigating the draw-down effect on surrounding operations. Generally, though, piping in this manner has many downsides, while the only upside is saving the cost of some extra pipe.



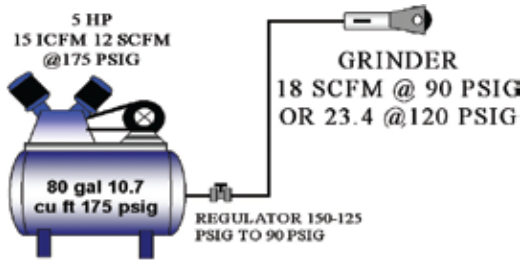
We almost always recommend piping through the receiver from the air system, and in this case of a local surge demand, size the receiver to handle the indentified load with acceptable pressure drop. This, combined with a restriction refill valve, will insulate the surrounding processes and ensure a solid air supply to the process.

For example: Install an appropriate sized receiver near the process entry. Store air at line pressure; regulate the flow out at required inlet psig to the process. Size the regulator to handle maximum rate of flow (scfm) to lowest rate of flow rate (scfm) with steady pressure of the lowest expected psig. Install check valve and adjustable restriction valve on inlet line to air receiver.

What is Demand-Side Control?

Demand-side control is an often-used form of high storage volume used in the bladder-tank style. An oversized receiver holds air at system pressure and feeds to the system through electronically operated valves or pressure regulators designed to hold the exit pressure at some minimum range (±2 psig, for example).

Any time you feed a regulator/flow controller, it should come from an appropriate sized receiver or storage.



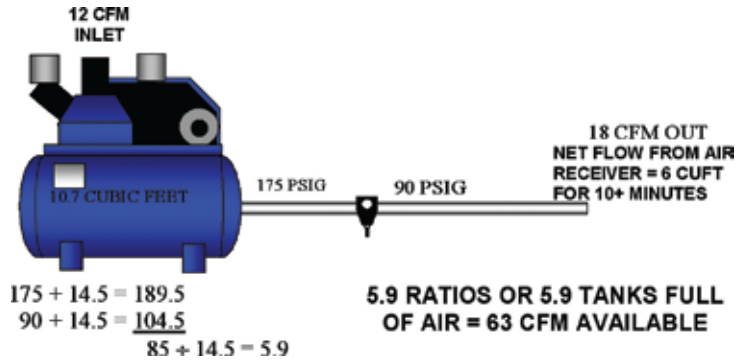
The receiver size (and the proper in and out piping) should be designed to handle the maximum expected rate of flow and allow a predetermined maximum pressure loss.

Holding the system header pressure steady will eliminate system overdrive or pressure rise and minimize artificial demand (extra flow caused by excessive pressure).

A properly applied electronic-control air management control system can also hold a steady header pressure but not develop extra storage if required. Often the designer will elect to install the storage at the process rather than on the total system. Demand-side control is another version of storage used to convert a short duration, high rate of flow to a low average rate of flow.

The following 5hp tank-mounted air-cooled compressor operation as applied in a typical body shop is an excellent example of demand-side control. In their case, the stored air runs an 18 scfm demand with a 12 scfm compressor, but there are limitations.

Storage buys time — it does not create volume.



Total demand 18 scfm.

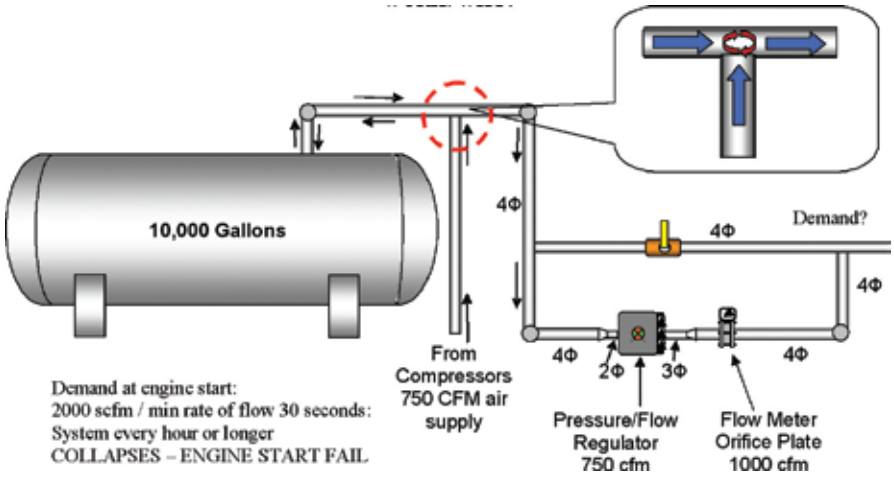
- The compressor delivers 12 scfm.
- The tank delivers 6 scfm to equal 18 scfm.
- The tank can fall 5.9 atmospheres before it reaches 90 psig (from 125 psig) = 63 cfm available.
- The tank buys 10 minutes of run before falling too low.

Note: Storing air at high pressure and using it at low pressure DOES NOT create more air volume as sometimes misconstrued. It only buys time!

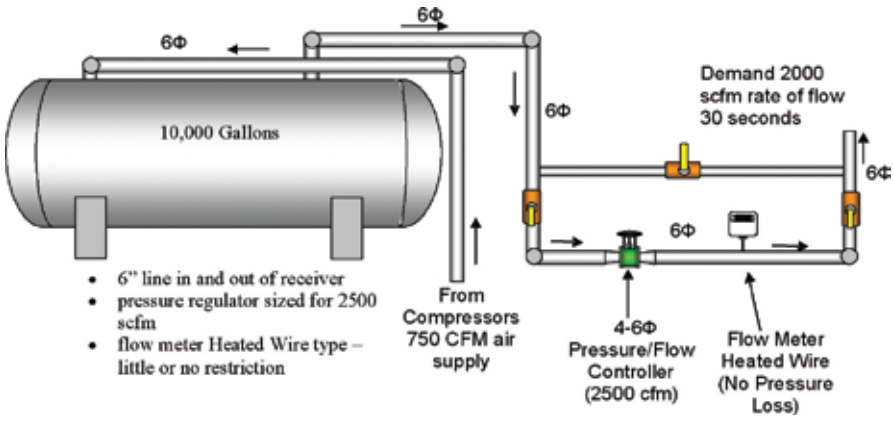
There is no limit to using storage to affect surge demand, but you must be very careful how you size, select and install. Local plant personnel must understand the concept in case conditions change.

Some Demand-Side Storage Applications that Did Not Work as Installed and Why:

1. Proper rate of flow was not identified.
2. Single in/out piping could not respond fast enough to hold the system.



Correction to Piping and Equipment Changes:



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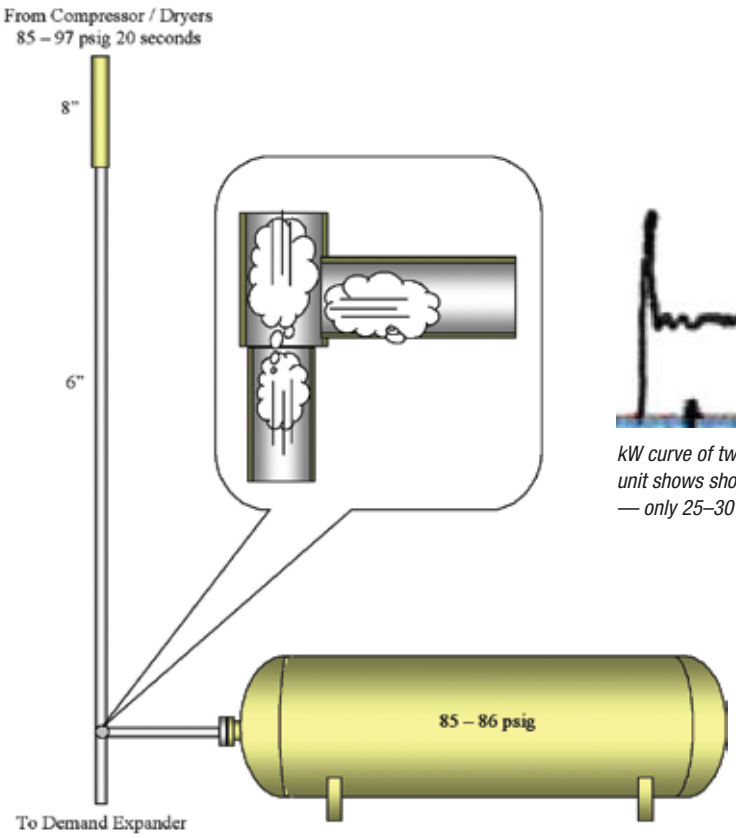


kW curve of two-step controller trim unit shows short cycle all the time — only 25–30 seconds loaded.

What is happening?

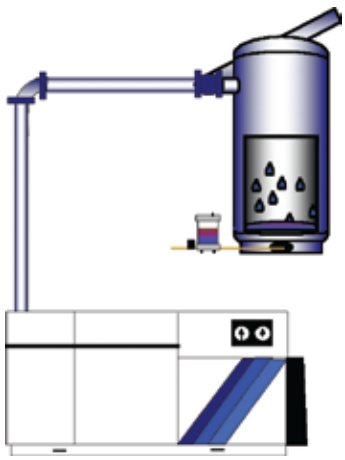
The storage tank continues to feed the demand expander/flow controller to augment the air supplied by the base load centrifugal. When the discharge line pressure falls to 85 psig, the two-stage oil-free rotary screw loads in for trim. Within 25 to 30 seconds, the line pressure goes from 85 psig to 95 psig. The rotary screw is being controlled with an operating band of 3.5 psig with pressure taken at the tank, unload point 88.5 psig. The local capacity control on the compressor is set to unload at 95 psig sensed at the discharge line.

Prior to the trim machine loading, the air is traveling from the receiver to the main discharge air line. As soon as the trim unit loads in, the discharge pipeline pressure rises. The air cannot go into the receiver, because it is blocked by the compressed air and its inertia to flow out.

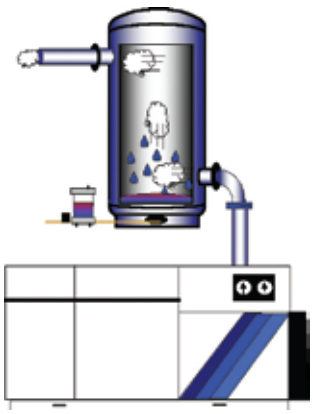
After 25 seconds, the discharge pipe pressure has raised 10 psig and the compressor shuts off. The tank pressure only increased 1 psig or less.

This piping arrangement has virtually eliminated the effective storage of 20,000 gallons for control air. The proper way to integrate this very large storage vessel is to run two separate lines, one in and one out.

Here is a flow profile of two identical units side by side servicing the same demand at separate times along with the chart recorder showing their corresponding flow profiles.

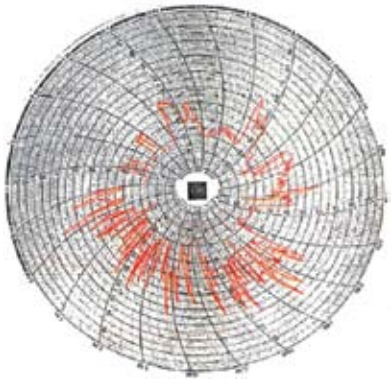


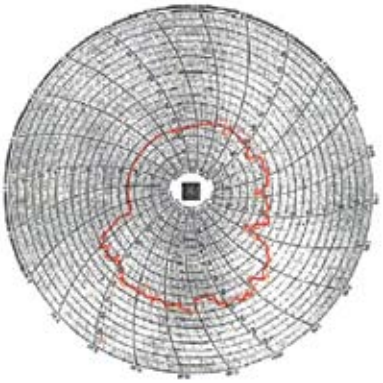
A 660-gallon receiver *installed with common inlet/outlet* connection



A 660-gallon receiver *installed inline*

The single-entry/-exit system caused high turbulence and restricted flow. Compressed air tends to overdrive the system pressure. Most installations should always go through the air receiver, entering at the bottom and exiting at the top.



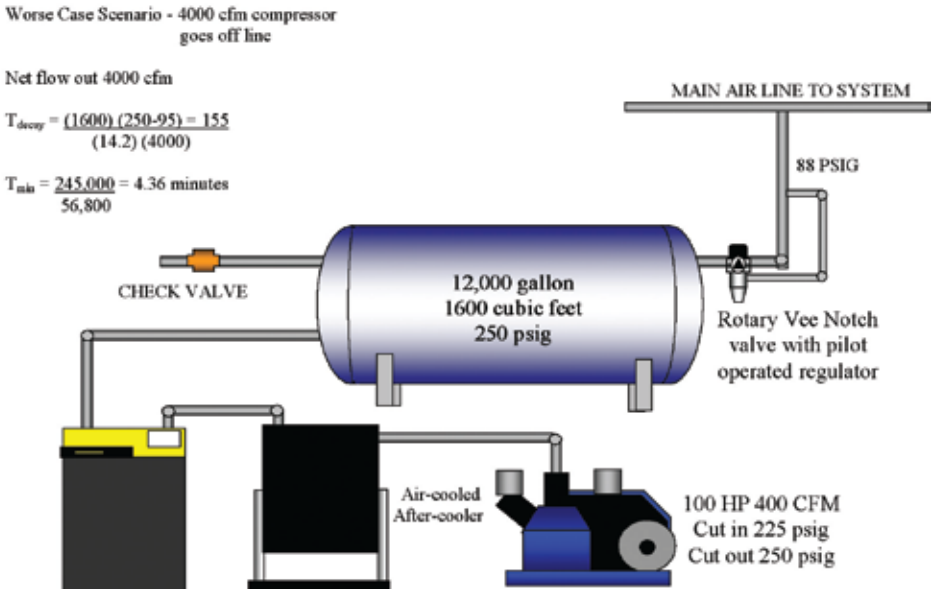


Off-Line Storage to Handle Identified Peak Loads Provides Longer Duration and Higher Load

Storage capacity can be increased with bigger tanks and/or higher pressures. For certain cases such as this (4000 scfm for 4+ minutes), both are applicable. The auxiliary 100hp air compressor will not run much, but the air will always be there when needed.

Installing an air receiver off-line with appropriate air supply and regulated flow will:

- Maintain system minimum pressure during auxiliary compressor start-up.
- Eliminate compressor loading or start-up and/or keeping an idle compressor on-line continuously.



When the 4000 cfm compressor goes off-line due to a malfunction, the receiver will carry the system for 4+ minutes, giving the stopped auto-hot-start units time to receive the signal and start. Nominal permissive start-time requirement for this would be 1 to 2 minutes.

The cost effectiveness of this type of project is helped by incorporating receivers that are often available in the used equipment market, some of which may be used propane tanks taken out of service. However, such units must be properly purged with nitrogen.

WHEN COMPRESSED AIR IS CRUCIAL

Air compressors are the heart of the automotive repair shop. Without the optimum air compressor technology, these shops face costly rework, high maintenance and replacement costs, exorbitant downtime — and very unhappy customers.

BY ED SULLIVAN

Given the technological age in which we live, the preferences for a specific air compressor design might seem a bit argumentative. Yet, for businesses that are highly dependent on compressed air, especially those with demanding applications, choosing the right compressor technology may be crucial.

In the automotive collision repair business, for example, the continuous availability of unfaltering, high-volume compressed air is vital to support various tools as well as the filtered breathing air system.

"When the air goes down, we're dead in the water," says Sandy Muir, vice president of facility management at Caliber Collision Centers, a chain of 65 shops throughout Southern California and Texas, specializing in automotive structural, mechanical body and refinish work. "Until we got the right compressor technology, I would get a call that one or two shops were down every day, waiting for service technicians to get them back up and running."

With first-class operations running 24/7, having air compressor problems was unacceptable for Caliber. Ultimately, it was also unacceptable to customers, including car owners and insurance companies. Both wanted high quality but timely repairs to get the cars restored to OEM standards and avoid the expense and inconvenience of rental cars. Since collision work is a continuous flow, air system downtime often delayed deliveries of a whole chain of technicians, processes and cars.

"This situation was intensified by our need for clean air, including providing a pure supply to our paint systems and tools as well as the breathing system that delivers fresh air via masks to our paint spray technicians," explains Muir.

Choosing the right technology

Over the years, Caliber had used or evaluated several types of air compressor systems, including piston-driven models and rotary screw designs.

"Everybody is familiar with the old piston-style compressor," says Muir, "It's a fairly simple concept, a piston running up and down and turning a crankshaft. But of course that motor also relies on intake and exhaust valves, which tend to wear and then leak. Once that happens, oil and sometimes fuel can get into the air system. That is definitely a drawback to the purity of the system and causes maintenance headaches."

WHEN COMPRESSED AIR IS CRUCIAL

Caliber has also used rotary screw compressors but was disappointed with the inherent volumetric and efficiency problems due to the "blow hole" and air leakage (back to the intake) of those compressors. Moreover, in order to make up for inefficiencies and keep up air volume, designers of rotary screw compressors incorporate higher speed, which is detrimental to service life.

"Also, the pressure build-up at the end of the screws is so high and so hot, it burns out the bearings," says Muir. "Plus, they could never keep the back end of the screws together because of the axial thrust, so they just kept adding more and bigger bearings. We've had screw compressors blow up because of the extreme pressure point at the end of the screws."

Most recently, Caliber changed over to rotary vane compressors, a more sophisticated technology with only one major moving part. The rotary vane design is far more efficient and cleaner than piston or rotary screw technologies. Also, the vanes (or blades) are held outwardly by centrifugal force. A film of oil between the blades and the stator (housing) wall forms a practically perfect seal. Importantly, the performance of a rotary vane compressor does not degrade over time, because the vanes slide on an oil film during rotation, preventing direct contact with the internal surface of the stator. This means there is virtually no wear on the vanes.

Caliber purchased their rotary vane compressors from Lans Company (Glendora, CA), a major distributor of compressed air systems. While Lans provides a selection of compressor technologies, brands and accessories, when it comes to rotary vane compressors, the firm recommends the Mattei line.

"One problem with rotary vane compressors was the use of Bakelite vanes," explains Lans Co. President Stuart Silverman. "But the Mattei models are cast iron, and because of the oil system, there is virtually no wear. I would say they last three times longer than the rotary screw models. Also, the Mattei rotary vane compressors use no bearings, but instead use a bushing, so they last much longer than other models."

Silverman adds that the volumetric efficiency of these compressors is approximately 90%, supplying a reliable continuous volume of air while also providing a substantial savings in energy, wear-life and maintenance costs.

Wide-ranging improvements

Since installing the rotary vane compressors at every location, Caliber has experienced very few problems. "I may get a call once a month," says Muir, "which is music to my ears, compared with the two calls I used to get on the average day."

He adds that the new compressors not only meet the reliability requirement, but also reduce cycle time, which is an important advantage from both an operational and a competitive standpoint.

Having continuously available and consistently clean compressed air provides other advantages to those in the auto body repair business.

"Customers are driving more expensive cars with more expensive finishes in recent years," Muir explains. "For that reason our industry receives continuous scrutiny from customers, as well as stringent guidelines from agencies such as insurance organizations and California's Bureau of Automotive Repair. The whole industry has become very high tech; every car has to have electronic read-outs, and we use electronic measuring systems for our frame-alignment equipment. Paints have become very exotic and expensive. You don't want to have to paint a car twice because of an air pressure problem. Not only will it cost the time to remove and redo the paint, but the material itself is now very expensive."

Muir adds that his firm is currently converting to water-based paints to comply with California state safety requirements. That means a whole new paint system for Caliber's 30+ California shops in 2007. Muir feels that the advanced compressor system will help protect that major investment.

Simplifying service

Rotary vane compressors such as the Mattei are easier to maintain and service, requiring fewer repairs and longer intervals than their piston or rotary screw counterparts. The compressor can be assembled and dismantled quickly with standard tools. Easy dismantling of the machine into subassemblies also makes fault diagnosis easy.

"We don't normally perform any service on these compressors," Muir says. "We have Lans handle all service throughout the air system, including air dryers and our breathing system. We know air is the heart of our business. When we call and say we have an air problem, we need quick response and knowledgeable service."

Muir says he's learned that his firm requires a partner when it comes to air systems. He says it is utterly frustrating to deal with multiple vendors on multiple systems that are integrated. "They can give you a runaround," he explains. "Like when we might have an air dryer down and the air dryer technician points to the air compressor and says that's where the problem is. We don't want anybody passing the buck like that. So we want a partner who is an air specialist to take care of it all. And having that kind of relationship has really paid off."

Plus savings

While the cost of electric power needed to drive compressors is not a major issue with some users, excessive use of power may be a significant cost that is often swept under the rug. For example, older models of compressors often cause a spike in the electric power load during peak usage periods, resulting in a demand profile that could cost many thousands of dollars per year.

"In some businesses, such as body shops, the air compressor is the biggest piece of equipment," says Silverman. "Relatively speaking, it can cause a lot of expense. With the Mattei compressors, which are very efficient to begin with, we install a 'part winding start' at no extra charge. That allows the motor to ramp up to speed, which lowers the usage spike during peak periods. By making the peak smaller, we can lower a sizable electric bill. And the savings will be more than enough to justify the cost of a high-efficiency air compressor. Shops that are running 60-horsepower compressor motors could save as much as $1,000 per month."

> "Having continuously available and consistently clean compressed air provides other advantages to those in the auto body repair business."

For more information, contact Lans Company, 438 W. Carter Drive, Glendora, CA 91740; toll-free 888-596-5267, phone 626-963-9457, fax 626-963-5267, e-mail mail@lanscompany.com; or visit www.lanscompany.com

About the Author
Ed Sullivan is a technology writer based in Hermosa Beach, California.

RESULTS OF A TRIAL OF NITROGEN TIRE INFLATION IN A LONG-HAUL TRUCKING FLEET

(Continued from page 13.)

Figure 4: Expected Tread Wear — Retreaded Casings

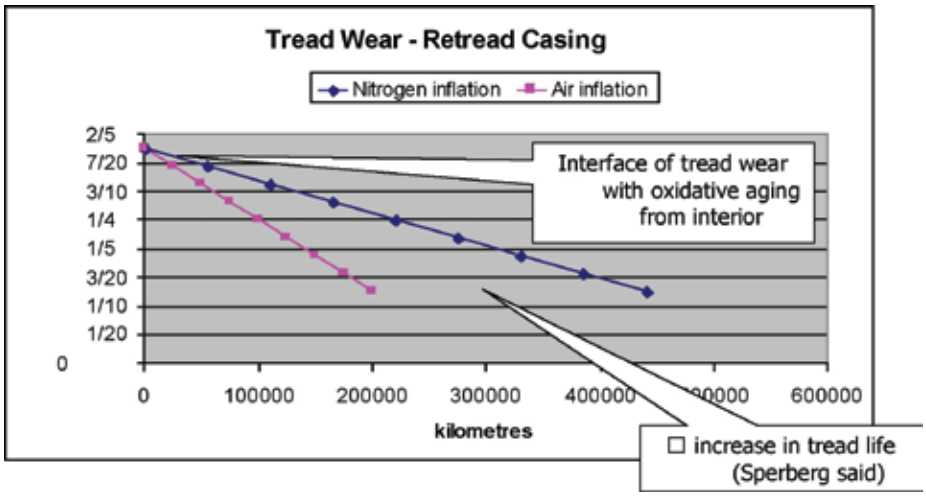


Figure 4 shows a similar treatment for retreads, but with even shorter life for the retreaded tire. Recall that Sperberg said nitrogen-inflated retreads lasted 54% longer than air-inflated retreads. This occurs not because the nitrogen-inflated tires last longer — that would be impossible. This occurs because the air-inflated tire rubber breaks down faster. Because the oxygen in air has no more bonds to attack in the casing, the oxygen molecules start to break down the tread rubber faster than in a new casing.

In our proposal to Transport Canada, we told them we expected to see an improvement in tread wear due to the elimination of oxidative aging in the casings. Please note that during the trial, since we were doing business-as-usual maintenance, if a tire needed to be replaced, it was. The replacement tire was inflated with the same gas as before — air with air, or nitrogen with nitrogen. So during the trial, old oxidative-aged casings were replaced with new rubber — either new casings or newly retreaded tires.

We obtained more than 110 million miles of tread wear data from the actual trial, and our sample size included 1,988 tire positions. We have extremely high confidence in the results.

This bubble chart compares the air-inflated control to the nitrogen-inflated test group.

Lawrence Sperberg's study was conducted over 7.5 million tread miles with only 98 tire positions, all on drive tires, with an obsolete tire construction. Our study encompasses more than 110 million tread miles of data for 1,988 tire positions, with today's widely used steel-belt radial tire construction. We also have more than 22 million tractor miles of fuel efficiency data.

The left balloon shows the air-inflated control with 452 tire positions. This control group obtained 5.38 mpg average fuel consumption and average tread wear of 26,623 km per 32nd.

The right balloon shows the nitrogen-inflated test group with 836 tire positions. The nitrogen group achieved average fuel consumption of 5.56 mpg and average tread wear of 49,748 km per 32nd.

These results show a 3.3% increase in mean fuel efficiency for nitrogen-inflated tires over compressed air. These results show an 86% increase in mean tread life for nitrogen-inflated tires over compressed air. However, both these metrics are obtained in a fleet that already has a tire pressure maintenance program in place. The increase in fuel efficiency for this fleet, when compared to historical data prior to a tire pressure maintenance program, is truly impressive — it is 6.1%.

Results — Casing Failures

The results for casing failure were inconclusive due to the small number of failures (eight total for the life of the trial). Seven failed casings were nitrogen-inflated, while one was air-inflated. The tires that did fail were all extremely high mileage, multiple-retread casings.

Discussion of Economic and Public Policy Implications

Guy Walenga is engineering manager, North American Commercial Products, Bridgestone/Firestone North American Tire LLC. During his presentation, *Nitrogen Inflation for Truck Tires*, at Clemson University's Tire Industry Conference in 2004, he stated, "So far, we have verified many advantages of nitrogen inflation with no negative performance attributes. The only negative we see is the added cost. Can the added cost be justified by improved performance, such as:

- Fewer road failures and less downtime
- Additional retreads
- Better wear life and fuel economy from better inflation retention?

In reply to Mr. Walenga's question, "Can the added cost be justified?" our answer is a resounding yes. The economics are compelling. In fact, fleet maintenance managers and fleet operators ignore these findings at their economic peril.

Harris spent $8,500 to convert 65% of their fleet to nitrogen. They saved more than 110,000 gallons of diesel during the trial period. That is roughly $285,000 in fuel-cost savings alone. But the average increase in tread life not only decreases the cost per km dramatically, it also defers actual cash flow for fleets. In a tight-margin business, a dollar saved is better than 10 dollars earned in the top line, because there are no cost of sales associated with the savings.

Further, because the fuel efficiency can be quantified so tightly, the reduction in greenhouse gases can be calculated, claimed through the appropriate program and sold for incremental revenue on carbon trading sites. This incremental revenue alone may be enough to cover the cost of the entire nitrogen program.

Assuming that at some stage the owners would like to sell this company, the true value of nitrogen tire inflation is not just the cost savings. It is the savings that drop to the bottom line of the business as earnings, multiplied by the appropriate business multiplier.

For this particular business, the enterprise value of converting to nitrogen tire inflation is worth more than $710,000 for the period of the trial, excluding tire savings. Annualized savings would be greater, because nitrogen inflation maintenance is less expensive than fleet conversion.

For a very large fleet that is publicly traded, the shareholder value is determined by taking the earnings per share (EPS) from the latest stock tables. EPS for FedEx and UPS are around 3.

There are also public policy implications to this technology. In the last State of the Union address to the American people on January 23, 2007, President Bush set a target of 20% fuel reduction by 2017 to reduce dependence on foreign oil. Our data shows that nitrogen tire inflation has the potential to deliver nearly one-quarter of that savings immediately.

Further, the United States and Canada have both stated they will support carbon trading. This technology directly benefits the long-haul trucking industry by enabling the quantification of fuel savings and, therefore, the monetization of carbon credits. Extended tire life and extended casing life also mitigate waste disposal issues. Lastly, this would be perceived by the general public as the right thing to do.

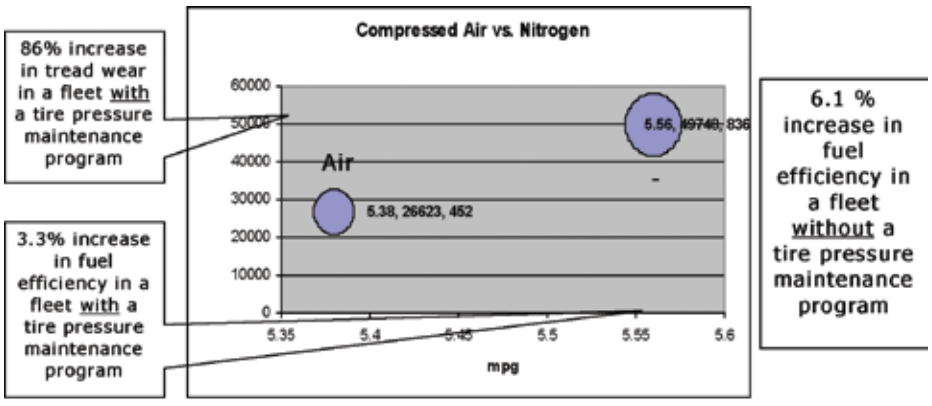
Conclusion

Nitrogen tire inflation significantly improves fuel efficiency and, therefore, reduces greenhouse gases. Nitrogen tire inflation also significantly increases tread life. The return on investment for fleets is substantial.

The results of this study and other related research also indicate that nitrogen inflation enables more retreads per casing (since the casing would appear to retain its mechanical and elastomeric properties), fewer failures for the same reason, and the resultant secondary benefits:

- Fewer roadside service calls
- Fewer lost service hours due to breakdown
- Reduced liability for accident or tread damage
- Safer highways
- Fewer tire disposal issues.

Figure 5: Tread Wear and Fuel Efficiency — Air vs. Nitrogen Inflation



Sperberg study (1985): 7.5 million tread miles, 98 drive tires, bias-ply tire construction
Mech and Mech study (2006): Over 110 million tread miles, 1,988 drive & trailer tires, steel- belt radial tire construction

Author's Acknowledgements
I would like to thank Dave Connaughton from Parker, Harvey Brodsky from TRIB, Transport Canada, Andre Mech of Mech and Associates and the good people from Harris Transport and West End Tire for their assistance in research and development of this paper. For more information, contact Mr. Konrad Mech, P. Eng., MBA, Vice President, Drexan Corporation, Burnaby, BC, Canada, e-mail KMech@drexan.com, toll-free 800-663-6873.

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