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

COMPRESSED AIR BEST PRACTICES

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June 2012

System Assessments

Clear the way for quality air

Hi, I'm Michelle and I have been working with our customers across the United States for the last 10 years. Products that optimize quality in your air supply are not just accessories we offer; they are a way of life for us at Atlas Copco. That's why we produce such a wide variety of dryers, aftercoolers, filters and oil-mist eliminators just to name a few.

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Our mission is to continue to bring sustainable productivity through safer, cleaner, more energy-efficient, and cost-effective compressed air technology. Simply log onto **www.atlascopco.us/michelleusa** or call **866-688-9611** to learn more about us, our products, and how we have earned and will continue to earn our reputation.

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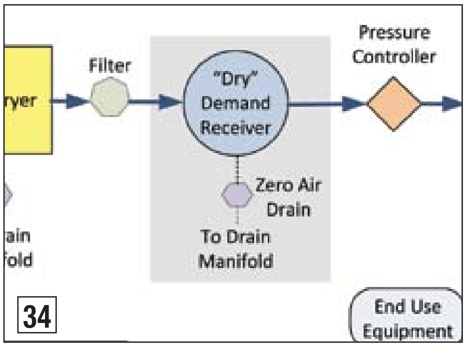

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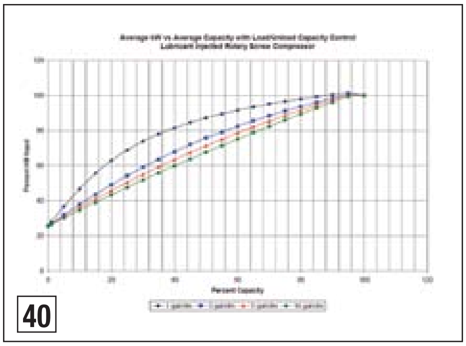

FROM THE EDITOR | System Assessments

Compressed air system assessments come in two categories; supply and demand-side assessments. End users need to be equally aware of both types. Both types are necessary. Supply-side system assessments represent the vast majority of proposed system assessments — simply because it's less time consuming. In this issue, we provide examples of both types of system assessments.

Production equipment uses pneumatic components and represent the biggest challenge in demand-side system assessments. Pam Ohlemiller, from SMC, provides us with a very interesting example of how to modify an existing pneumatic cylinder so that it can operate at lower pressure. An example is given of an Assembly Machine that had ten pneumatic cylinders retrofitted with special valves that resulted in lower associated compressed air energy costs.

Paul Edwards, from Compressed Air Consultants, provides us with "Part 2" of his supply and demand side system assessment case study at a petrochemical plant. This sequel covers the demand side work his firm did to significantly reduce compressed air demand at this huge facility.

Piping and storage systems represent another significant opportunity in demand side assessments. This topic is explored by Hank van Ormer, from Air Power USA, with his article, "Designing Compressed Air Piping Systems" and by Ron Nordby, from John Henry Foster, with his article on "Demand (Dry) Storage."

We have one important supply-side assessment article provided to us by Ron Marshall, on behalf of the Compressed Air Challenge®. The article is titled, "Optimizing the Specific Power of Part-Loaded Compressed Air Systems." I can't emphasize enough that although demand-side assessments are critically important (the most popular being the leak audit), energy savings will not occur unless the air compressors have the appropriate controls.

Our mission is to distribute educational and motivational content on the **positive work** being done every day by people, like you, who get their hands dirty and get the job done with profitable energy efficiency projects. We thank the authors above for sharing their knowledge and thank you for your support and for investing in *Compressed Air Best Practices®*. BP

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COMPRESSED AIR, PNEUMATICS, VACUUM & BLOWER INDUSTRY NEWS

Atlas Copco Product Company Houston Inaugurated

Atlas Copco Compressor Technique officially inaugurated a new product company in Houston, Texas on May 4, 2012. Located just minutes from the George Bush International Airport, the 96,000 square foot (8,900 sqm) facility employs 150 people. It is expected to fill a minimum of 15 additional positions and is designed to expand as the need arises. Stephan Kuhn, Business Area President Compressor Technique commented, "The U.S. market is very important to Atlas Copco and this is one more step in strengthening our footprint in the USA. This investment allows us to better serve our customers for engineered compressor packages and air and gas treatment products in the Americas."

The facility will support four organizations within Atlas Copco; the Southern Region Customer Center, Pneumatech air treatment product production, Atlas Copco Systems Houston, and Greenfield Compression. Chris Lybaert, Oil-free Air Division President said, "This facility marks only the beginning of our expanded capabilities to provide customized solutions for specific applications. This includes industry-specific certifications, like API and ATEX, and engineered compressor and dryer systems for a multitude of gases, pressures, and voltages."

A wide range of custom-engineered skid-mounted packages are built in this facility. "This facility creates engineered compressor and dryer packages using the entire portfolio of Atlas Copco products," says Horst Wasel, Quality Air Division President. "On the air dryer side, heatless, heated purge, and blower purge desiccant dryers are built here as stand-alone products or integrated into the skid packages." Centrifugal, oil-free and lubricated rotary screw, and reciprocating air compressors are packaged here according to customer requirements.

"Pipeline and exploration companies, operating all over the world, require custom engineering and testing capabilities for voltages and pressures," says Dave Prator, Southern Region Customer Center President. "Our team of application engineers takes projects from on-line global customer meetings, to CAD Drawings, to final testing of up to 3600 psig and 3500 horsepower." www.atlascopco.com

Atlas Copco

CAGI Launches Enhanced New Website

The Compressed Air and Gas Institute, a leading source of manufacturer and product-neutral support for compressed air professionals for more than 90 years, has launched www.cagi.org to provide continually updated content and coverage of timely topics relevant to today's workforce.

A CAGI subcommittee, comprised of individuals representing the major compressed air and gas manufacturers, launched the site as a means to provide credible, unbiased, non-commercial information for a broad industry audience that ranges from plant engineers to students. The site includes energy efficiency tips, trending topics and educational materials, maintenance advice, application and usage tips, and a member resource directory.

"With so much noise coming from a variety of sources, we felt it was critical to establish a credible, non-commercial resource for compressed air professionals of all levels of expertise and training," said Mike Stone, chairman of the CAGI promotional subcommittee. "This new website does exactly that, cutting through the clatter and providing a comprehensive resource that allows compressed air professionals to educate themselves and make unbiased decisions about how to optimize their system so that it efficiently meets their needs."

The website features three distinctive features to help compressed air professionals: *SmartSite* selection guides, and CAGI data sheets. *SmartSite*, established in 2005, is a 24/7 online learning center that provides training, resources and technical information for individuals interested in learning about the fundamentals of compressed air.

By accessing the CAGI selection guides, consumers can input data collected from their current compressed air systems and access non-branded equipment selection guides to gain a better understanding of what products are best suited for their system. The CAGI data sheets, one of the more popular CAGI

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resources, define operational and performance information used during the specification and application decision-making process. The information contained in the manufacturer's data sheets is verified by independent third-party testing.

For more information about Compressed Air and Gas Institute, go to http://www.cagi.org/. In addition to the e-learning coursework on the *SmartSite*, selection guides and data sheets there are additional resources, including technical papers, videos and CDs, and the *Compressed Air & Gas Handbook* available through CAGI. www.cagi.org

Ingersoll Rand Campbellsville, KY Plant Wins Governor's Safety Award

Nearly 150 Ingersoll Rand employees of the Campbellsville, Kentucky plant enjoyed a celebration of safety this week — 12 years of no lost time incidents! That's 5 million hours! At the event, Ingersoll Rand employees were able to speak about their experiences with the company. These employees really set the tone of dedication as they looked forward to passing on the plant's tradition to the next generation.

Employees were treated to a catered lunch, branded jackets, which noted the special occasion, and a visit from our Ingersoll Rand Racing hauler. DJ Copp, former NASCAR tire-changer, ran a 16 person bracket-style competition for two pairs of NASCAR pit passes as well.

After lunch, several high-level members of Kentucky's government, along with senior Ingersoll Rand leaders, addressed the employees. Sen. Jimmy Higdon and Rep. Jim "Bam" Carney congratulated the plant for the accomplishment. Secretary of the Kentucky Labor Cabinet, Mark Brown, also addressed the crowd and presented the Governor's Safety Award. Joe Wolfsberger, Ingersoll Rand's vice president for environmental health and safety, presented a plaque to Dale Judd, the plant's material manager, who has worked there for almost 42 years.

The Campbellsville, KY facility produces reciprocating air compressors and small rotary air compressors. www.irco.com

Chicago Pneumatic Distributor Meeting

More than 100 Chicago Pneumatic (CP) distributors and staff gathered in Charlotte, N.C., from March 27–29 to learn more about exciting new products, new financing offers and new sales and marketing support CP is rolling out.

Entitled "Rev-Up Revenue," the event's race car theme captured all of the momentum the CP team has been building in 2012, offering the company's distribution partners a front-row seat to a variety of new initiatives designed to engage new leads and drive revenue in the upcoming year.

"Hosting a distributor event has been a priority for our team," said Ellen Steck, President of Chicago Pneumatic. "There is so much to be proud of, from our new product offerings to our sales team and our enhanced marketing and sales support materials. Our top priority remains making it easier for our distributors to do business with CP, helping our partners bring our industry-leading product line to their customers."

Rob Little, from Chicago Pneumatic, describes the features of a new air compressor (pictured on the left).

The event featured presentations by Alain Lefranc, Vice President of Multibrand Marketing, Atlas Copco, and noted business speaker Carl Henry. Distributors also enjoyed sessions detailing finance options, marketing support and public relations, a celebration dinner at Charlotte's NASCAR Hall of Fame, and tours of both the National Distribution Center and CP's production and manufacturing facility in Rock Hill, S.C.

The highlight of "Rev-Up Revenue" was distributors meeting with CP experts to check out the compressors first-hand, ask questions and learn more about the products' features, advantages and benefits.

"Events like this are crucial to our success as a company," said Steck. "We are thrilled to share our road map for success with our distribution partners, and the key to that success is information. We're committed to working together to best meet their customers' needs, because at the end of the day, we want their next compressor sale to be made with a CP compressor." www.cp.com

Parker Acquires Olaer

Parker Hannifin Corporation announced that it has signed an agreement to acquire the Olaer Group headquartered in Deeside, United Kingdom. Olaer is a leading manufacturer of a broad range of advanced hydraulic accumulator and cooling technologies to provide solutions for energy, mobile and industrial markets.

Olaer has annual sales of approximately 150 million Euros ($200 million) and employs 550 people. The company has manufacturing and sales facilities in the United Kingdom, France, Sweden and China and sales companies in 14 countries. Upon completion of the transaction, the acquired company will be integrated into Parker's Hydraulics Group as part of the Industrial Segment. Approximately 88% of the sales will be reported as Industrial International and 12% reported as Industrial North America.

"This acquisition, once completed, will allow us to strengthen our position in key growth areas both geographically and by end market," said Jeff Cullman, President of Parker's Hydraulics Group. "Olaer has built a strong position in Europe and a growing presence in Asia. Importantly, Olaer has a solid reputation in our target growth markets such as oil and gas, power generation and renewable energy. The acquisition would also expand our product offering with the addition of cooling technologies and deepens our expertise in bladder accumulator technology. We look forward to the closing of this acquisition when we can welcome the Olaer employees to Parker."

"Joining Parker is absolutely the right move for Olaer now," said Mike Blenkinsop, Chief Executive Officer, Olaer Group. "This transaction will secure Olaer's continued development, with the added dimension of being an integral part of one of the world's leading manufacturing companies." www.parker.com

Parker

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THE SYSTEM ASSESSMENT

Open-Minded System Assessments Part 2

Petrochemical Plant

By Paul Edwards and Mike Lenti, Compressed Air Consultants

June 2012 System Assessment of the Month

Where:	North America
Industry:	Petrochemical Industry
Audit Type:	Supply and Demand Side

System Assessment Win/Win Results*

Energy Savings per year:	$267,771
Rental/Maintenance Savings:	$742,592
Project Investment:	$1,150,000
Simple ROI:	19 months
Reduction in Energy Use:	9,237,000 kWh
Equivalent CO_2 Emissions:	6,632 metric tons*
Equivalent CO_2 for homes:	861 homes
Equivalent CO_2 for vehicles:	1,268 vehicles

*Source: CO_2 Calculator on www.airbestpractices.com

The Facility

This large petrochemical facility employs 400 employees and contractors. The site covers an area of almost 900 acres. Natural gas liquids are used as a feedstock at the plant to manufacture ethylene, the world's most widely used petrochemical. Over the past year, the company had experienced thirty (30) "close-scrapes" with having entire sections of the plant shut down to pressure losses in the instrument air system. The experience we had, during this assessment, reaffirmed our belief that every system must be approached with an open mind. There is no single, cookie-cutter, system assessment approach that works for all facilities.

This petrochemical facility was spending $1,110,000 annually to operate their compressed air system. The blended rate for electricity at this site was $0.03 per kWh. Electrical energy costs were $471,000 and compressor rental/maintenance costs were $639,000 per year. The system assessment identified yearly savings opportunity totaling $743,000 per year could be found with an investment of $1.15 million. The simple ROI on the project is 19 months.

This system assessment exhaustively examined the supply and demand-sides of the compressed air system. Part 1 of this article detailed the improvements made to the supply-side. Part 2 of this article covers the demand-side projects. Due to article length space constraints, we can only describe in detail a few of the areas of improvement.

Cost reduction of compressed air systems can be counterintuitive. In this particular audit, the value of an open mind is demonstrated as this system was one where replacing compressed air with nitrogen actually makes economic sense.

Demand-Side System Overview

The purpose of the audit was to improve reliability throughout the facility. Reliability on the demand side can be defined by having adequate air pressure and air quality at all times throughout the facility. This outcome is a function of both the operation of the supply side and the operation of the demand side. If a demand problem occurs, such as a dust collector pulsejet failure, it can reduce the air pressure in a local sector. If a compressor fails and the backup compressor takes too long to start, the pressure would drop in this circumstance too.

Actions that can be taken in demand to improve system reliability primarily fall along the lines of reductions in demand or smoothing out their impact. Reductions in demand affect the system in three different areas: demand, distribution, and supply.

By reducing demand, there are fewer competitors for air in a particular sector. An upset in one location will have less of an impact on the other applications in the area. Any extra flow that might be required for that upset, would therefore be more easily met by both the supply and distribution system.

Application	Current Inst Air	Current Plant	Future Inst	Future Plant	Overall CFM Reduction
Cabinet Coolers - Plant	203		150		53
Peepers, Fireyes, Iris	154		120		34
Dust Collectors	0	166		28	138
Potable Water	110			0	110
Cabinet Purge	109		81		28
Air Movers	0	105		60	45
Leaks	200	200	100	100	200
Decoking		72		72	0
Cabinet Coolers - Compressor	0	65	0	32.5	33
Reactor Valves on 2.5 min cycle	64		64		0
Open Blowing - Aeration		44		0	44
Gear Spray, Oil Atom Flame Control	0	10		10	0
POU Desiccant Dryers and Auto Drains	4		4		0
Artificial Demand					0
Base Reduction	641	661	369	302	631
Assumed Nitrogen Replacement					100
Projected Overall Reduction					**731**

A reduction in demand also has an impact on the distribution system. The lower air consumption means that the piping system has less demand to carry, reducing the pressure drop between the compressor room and the applications. This lower pressure drop means that either more air is ultimately stored in the system if the pressure is kept at the higher-level or the pressure setting to the plant can be lowered. Lowering the pressure the plant in a system with a flow controller means there's more storage in the air system to meet peak loads. Lowering the pressure in the system without a flow controller reduces the operational pressure of the compressors resulting in lower operating temperatures.

Lowering the system pressure whether flow controller is there or not, results in a lower demand overall in the majority of systems. This reduced demand reduces the duty cycle of the compressors which in most cases improves the reliability. In many cases this reduction in demand allows for fewer compressors to be online at any one time. These additional compressors are now in the backup mode and if the controls are properly configured, then they can now be set up to come online quickly in the event of a major demand events or a failure of another compressor.

THE SYSTEM ASSESSMENT

Petrochemical Plant: Part 2

Furthermore, reductions in demand ease the load on the dryers and the filters. The reduced load can improve air quality in cases where the clean up equipment is running near its full capacity. This also reduces the pressure drop across the clean up equipment.

In some cases the reduction in demand also enhances the reliability of the application itself. For example, decreasing the number of pulses for a dust collector or increasing the air quality to the dust collector ultimately results in longer bag element life.

Therefore, demand reduction, is actually quite important to a reliability improvement. At the same time it helps create financial return thereby increasing the value of the project financially to the organization. As the following chart shows, we believe there is a minimum of 731 cfm of demand reduction available and could likely go even higher with an aggressive program.

Dust Collectors

Dust Collector Controls — of the 10 dust collectors observed, seven were timer-based controls and three were pulse on demand or clean on demand controls. The challenge the timer-based control systems is that they pulse regardless of whether the bag is clean or dirty, if they are not interlocked to the fan controls. Of the seven units observed, six were running despite the fact that the differential across them was zero or close to 0 inches of water column. Adding clean on demand controls and setting them to pulse between three and 5 inches or four and 5 inches of water column will significantly reduce the demand on all of these units for minimal cost. Adding clean on demand generally cost between $600 and $1600 per bag filter depending upon the age of the existing control system. This cost is for NEMA 1 type controls. It is not known whether the dust collector controls need to be rated for NEMA 7 duty. The project assumes that at least five dust collectors will be retrofitted with clean on-demand controls.

Three of the units that were equipped with clean on demand controls were effectively set up by timer based controls. These units were in the railcar loading and railcar/truck load areas. They were effectively set up as clean on demand because their cut in pressure was 0 psig and their cut out pressure was 2.5 and 4 inches of water column. An example of this is shown to the right. By setting this up to clean at 0", the effectively made it a timer based control system negating any potential air reduction.

There is an additional benefit to operating on clean on-demand and that is bag life. The fewer pulses the bag sees, the longer the element lasts. It is very conceivable to double and triple bag life thereby increasing the reliability dust collectors as well as reducing their operational cost by adding this type of control system

There are two additional actions that the plant can undertake which will improve the operation of the dust collectors. The first action is to meter the recovery of the manifold. What that means is throttle the feed air to the manifold so that air pressure recovers to its max right before the next pulse occurs. While this does not change the actual demand (that is the number of molecules of gas used) it does however reduce the flow going to the application. Rather than supplying a single large pulse of air, this method provides a trickle charge to the dust collector minimizing its impact on its neighbors. It also has the additional benefit of limiting the amount of flow lost to a failed pulsejet.

The second action the plant should consider undertaking is the addition of a pressure gauge reading the actual pressure in the manifold that is easily accessible to an operator. If a pulsejet fails, it will suck down the entire contents of a particular manifold and possibly cause low air pressure to its local sector. If the pressure gauge is nonexistent or inaccessible, it is far less likely for local operator to note the actual pressure. The existence of this pressure gauge will allow operators going about their normal day-to-day operation to note a pulsejet failure earlier. It will also speed up the process troubleshooting low air pressure problems in the plant as the dust collectors can be scrutinized in 5 to 10 seconds rather than 30 to 60 seconds.

1. Open Blowing and Aeration

There were several areas in the plant where hoses with the straight valves and no safety nozzles were found. These were found in railcar loading, on the top assist polymer unit storage silo and the polymer unit pellet scalperator. We observed in operator using a three-quarter inch hose with a valve in the rail loadout and were told that the separator screen cleaning occurred on a very regular basis.

We believe the plant can get very acceptable results in all these applications with minimal effort and cost.

In the case of the rail loadout, the plant and attempted to use the Silvent 707 C nozzle. Operators no longer use the nozzle and this is likely because it did a poor job. The specifications for this nozzle are shown in the attachments section. An analysis of the nozzle shows a potential explanation for the problem. The graph to the right was created using the data from that table. It shows the velocity of the air as a function of distance from the nozzle tip and it is easy to see a very quick drop-off. The particular gun that we saw did not have an extension on it and would look close this to the gun on the far left below.

This would mean that the operator would hold it in his hand and the distance between the nozzle and the plastic being blown could be 5 to 10 feet and possibly more.

We believe that if an extension were added to the gun, the velocity would be higher where it counts most at the plastic bead. It is also likely that a nozzle that uses less air could be used as long as it had an extension. If you've ever worked with even small safety guns, your experience would probably tell you that even these guns if the air was applied closer to the beads, the blowing force would be more than sufficient to clean the top of the railcar.

In the case of the pellet scalperator, we found two 3/8 inch hoses and a 1/2 inch hose, all of which were off. These hoses likely use between 50 and 200 cfm each when in operation. We had not observed the cleaning of the screen so it is not possible for us to say with any certainty whether or not blower air could do the job.

It is recommended that the plant test multiple blowguns with extensions for rail loadout and separator cleaning. Involving the end-users with the testing program increases the likelihood

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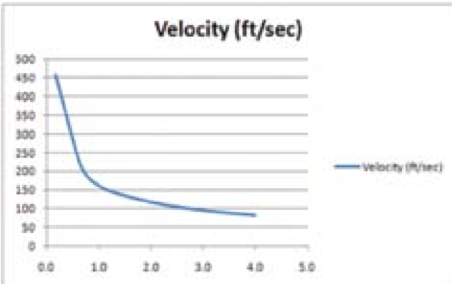


of success. Suppliers that could be included are Guardair, Silvent, Exair, Wondergun and/or ITW/Vortec. The purpose of the testing would be to find the nozzle or air gun with the lowest flow that cleans acceptably well. It may turn out that different nozzles are required for the different applications. The project assumes that 10 guns are purchased for use throughout the facility. While no savings are projected, the use of these engineered nozzles will meet OSHA's requirements while reducing the impact an open line can have on its immediate neighbors.

Compressed air was also used in the wastewater area for sparging of a tank. A flowmeter was installed and the demand was measured at 44 cfm. This application can be seen to the right. Discussions with the plant indicate that it is probable that air from the Lamson blower could be used as an alternate. Blower air typically costs 1/3 to 1/10 of the cost of compressed air and hence replacement would have a positive effect on the overall cost of operation. It would also take a significant demand off the pipe feeding the wastewater area.

Please note that the single biggest error plants make when installing blower air, is under sizing the feed pipe. If blower air is to be used, the piping needs to be sized for the flow and will likely be in the 1.5–2" size.

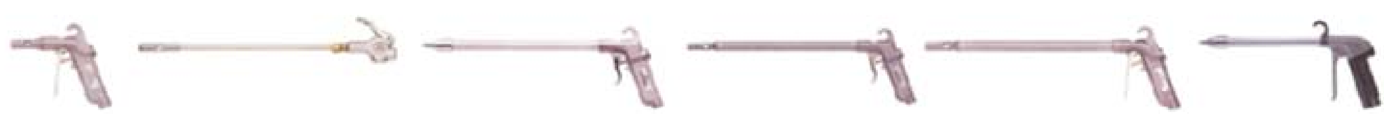
Leaks

At the time of the write up of the demand side, the full leak study had not been completed. It is inevitable that during the course of an audit, leaks are found. While this survey is far from exhaustive, it is a start as it will often catch a substantial portion of the larger leaks in a facility. An additional ultrasonic leak study is being conducted and that work has not been completed as of the writing of this report. Therefore, the potential savings projected in this report is likely to be lower than the actual projections from the leak study. In general, the leak load is fairly low of what we see in most plants of this size. The table below shows what was found.

One leak that was found illustrates the need for operator awareness and training. This was on a hose used for tire filling in the wastewater area. This can be seen to the right.

This black hose had to air leaks consuming roughly 10 to 15 cfm and would cost the plant $1800 year-round.

Rather than turn the air off to the hose or repair the hose or replace the hose it was just left on. This makes perfect sense if there is not an awareness that compressed air costs as much is a really does. We saw multiple occasions of conscientious behavior and would think that compressed air would be no different if the operators had a clear and precise understanding of



Location	Eqpt	Application	Size	Comments
Mixer	Dense Phase	Filter Bowl	6	Could be N2 but likely air
Blend Silos	Diverter Valve	FRL	5	
Train Loading	Attic	Solenoid Valve	30	"Been there a month" "Thirteen weeks for work order" New E&I may shorten
Train Loading	Bin	Slide Gate Tube	3	
Water Treatment	Filter Press	Multiple	10	
Polymers	Pellet Feed	Cut Tubing	2	
Blend silos				Significant Leak Noise on west side, bottom floor
Classifier Screens	Two leaks	Hose Connection	11	
Utility Area	Panel	Cut Tubing	4	
Utility Area	Dryer	Solenoid Valve	10	
Wastewater	Glycol Panel	C fitting	4	
Wastewater	Sanitary Unit	Regulator		Unknown
Wastewater	Southernmost building	Bad Valve	2	On drop
Wastewater	Air hose for Bicycle Tires	Split hose	9	Two leaks
		Total	96	

the cost of compressed air. We suspect that if the operators realized that this hose leak was worth $1800 per year, they would do something about it. Therefore operator training is recommended on an annual basis.

Reducing demand is a key component and a critical strategy in the overall plan to improve reliability. In sustaining these improvements, leak detection and repair needs to be an ongoing activity for the facility. Please note that both the detection and repair need to be done on a timely basis.

From a detection perspective, the plant should have an ultrasonic survey done once every six months. The survey, leaks are identified, tagged and quantified in scfm. Wherever possible, the cost to repair the leaks should also be documented too. Without this information, the plant is not able to make a sound business decision whether to fix a leak or not.

Detecting where the leaks are with the human ear while the plant is in production is very difficult. Ultrasonic detection devices exist that would allow an operator to listen for leaks by tuning in to a specific frequency that is unique to compressed air, and makes detection much

easier during production. These devices are expensive, especially when intrinsically safe, but they are valuable.

Leak repair also needs to be done on a timely basis and it sounds as if this is the primary challenge facing this facility when it comes to a sound program. In talking to the operators at rail loading, we discovered that a repair work order had been in for four weeks.

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We were then told that it takes roughly 14 weeks for the repair. The cost of this leak is roughly $450 per month and would only cost $200 to $300 to fix. So the plant wastes $1600 of air for a $200 fix.

What may make sense is to develop a program where the leaks can be categorized as small, medium, and large, and have maintenance evaluate any medium to large leaks found by production personnel. They could then assess the cost of repairing the leak versus the costs of the leak. This would then allow them to make a decision as to how quickly the leak should be repaired and if internal resources were not available, then outsource the repair.

It is assumed that 100 scfm of leaks can be eliminated and kept off line.

Compressed Air Replacement by Nitrogen

In most plants, auditors often look to replace nitrogen with compressed air. The cost of nitrogen is usually much greater than compressed air. This plant is in a unique situation where the nitrogen demand has dropped off enough that the nitrogen plant is blowing off excess nitrogen. It's been estimated that there is 1300 cfm of blowoff which ultimately could be used to replace of compressed.

This turns common sense on its head and suggests there is an opportunity to reduce cost by reducing the air consumption using nitrogen as the replacement gas.

There are great many applications where the air could easily be replaced by nitrogen. There is obvious concern with applications involving human respiration in the immediate area. In the evaluation of applications, consideration should be given to the actual cfm used by the process any area does in as there may be some applications such as outdoor panel purge where the concern may not be that large. For instance, our best estimate at the moment for panel purge is a few cfm. We would be surprised if a panel located in an outdoor location can have enough cfm flow to asphyxiate a worker on it given the open conditions. We would involve the safety director in making this determination.

Other applications that would seem to be likely candidates include instruments such as the fire eyes peepers and irises, valves, and possibly the cabinet coolers. More information is required to determine if the decokers would be a viable candidate, but if it was, then the replacement of compressed air with nitrogen could have a significant impact on the overall operation of the ethylene side of the plant.

While the audit currently assumes only 100 cfm of replacement, there is 1300 ft.^{3} per minute of nitrogen potentially available which could have a massive impact on system reliability.

Over the long haul, it does make sense to measure nitrogen blowoff if it is not being done at this point in time. It is possible that the nitrogen applications would need to be shifted back to air the process requirements for nitrogen increase.

Air Movers

Air movers are a flexible, light (as in weight) source which are easy to move and position in response to a need for cooling. This convenience comes at a cost.

For example, look at the performance of one manufacturer's air mover, the ASI-1200. Looking at the performance at 70 psig, you'll see that the fan produces 1429 scfm of cooling air consuming 53 scfm of air. That is roughly the equivalent of 12 hp at 4.5 scfm per hp.

Electric motor driven fans, while a bit bulkier are far more efficient and can provide far more cooling air flow for less power. One brand's

	50 PSIG	70 PSIG	90 PSIG
Model	**Cooling Air CFM**		
ASI-1000	935	1274	1422
ASI-1200	1211	1429	1580
ASI-2900	2770	3304	3752
ASI-4100	3785	4562	5041
Model	**Compressed Air Consumption**		
ASI-1000	38	53	64
ASI-1200	38	53	64
ASI-2900	76	99	127
ASI-4100	117	152	197

1 hp vane axial fan with 10' of duct produces 2940 cfm of cooling air.

Four air movers were observed throughout the facility. The first unit observed was a Coppus RF 20 was on top of a polymer unit blender roof and was used for silo venting. This model consumes 160 cfm when in operation.

The second was a Texas pneumatic unit and is likely the model TX6. This was being used in another polymer area for work being performed on one of the large motors. This also was an explosion-proof area the expected demand is roughly 60 cfm.

The third unit was a Jectair model eight and was in the air compressor room and was used strictly in the summer on a compressor oil cooler to provide additional external cooling. Its nickname is the Arkansas cooler. This unit at 60 PSI would consume 178 cfm. If in operation for three months of the year straight, then the annual cost is $7900 per year and it would be consuming air only when the compressors are taxed the most due to the lower density that occurs in the summer months.

A fourth unit was found on a furnace deck and this particular unit consumes 132 cfm when in operation.

One consideration in replacing air movers at this facility is the local environment where the air mover is being installed. One of the challenges in applying these air movers is where and how the fan motor is connected into the facility's electrical grid. We think this could be a permitting problem for many of the explosion-proof areas.

The project assumes that the only air mover that can be changed out easily is the cooler serving the air compressor room. Assuming that this still needs to be an explosion-proof application that is permanently installed, then a replacement air mover would cost under $4000.

From a budgetary perspective, a 2000 cfm explosion-proof air mover would cost roughly $2200 and consume 0.75 hp. A 3,000 cfm explosion-proof air mover would consume 1 hp and costs roughly $3300. A 5000 cfm air mover costs $3800.

Replacing the other pneumatic air movers can be replaced with electric motor driven units is treated as an option.

Conclusion

Keeping an open mind is critical in all system assessments. Each client has different priorities and circumstances. In this case, the plant had a significant volume of compressed air that could be eliminated without negatively impacting plant productivity. In taking the approach of detailed demand side analysis, the potential for system improvement in terms of reliability and operational cost was increased substantially. By taking an even wider viewpoint and considering the counterintuitive, additional opportunities such as compressed air replacement by nitrogen, were added to the potential list of actions to be taken.

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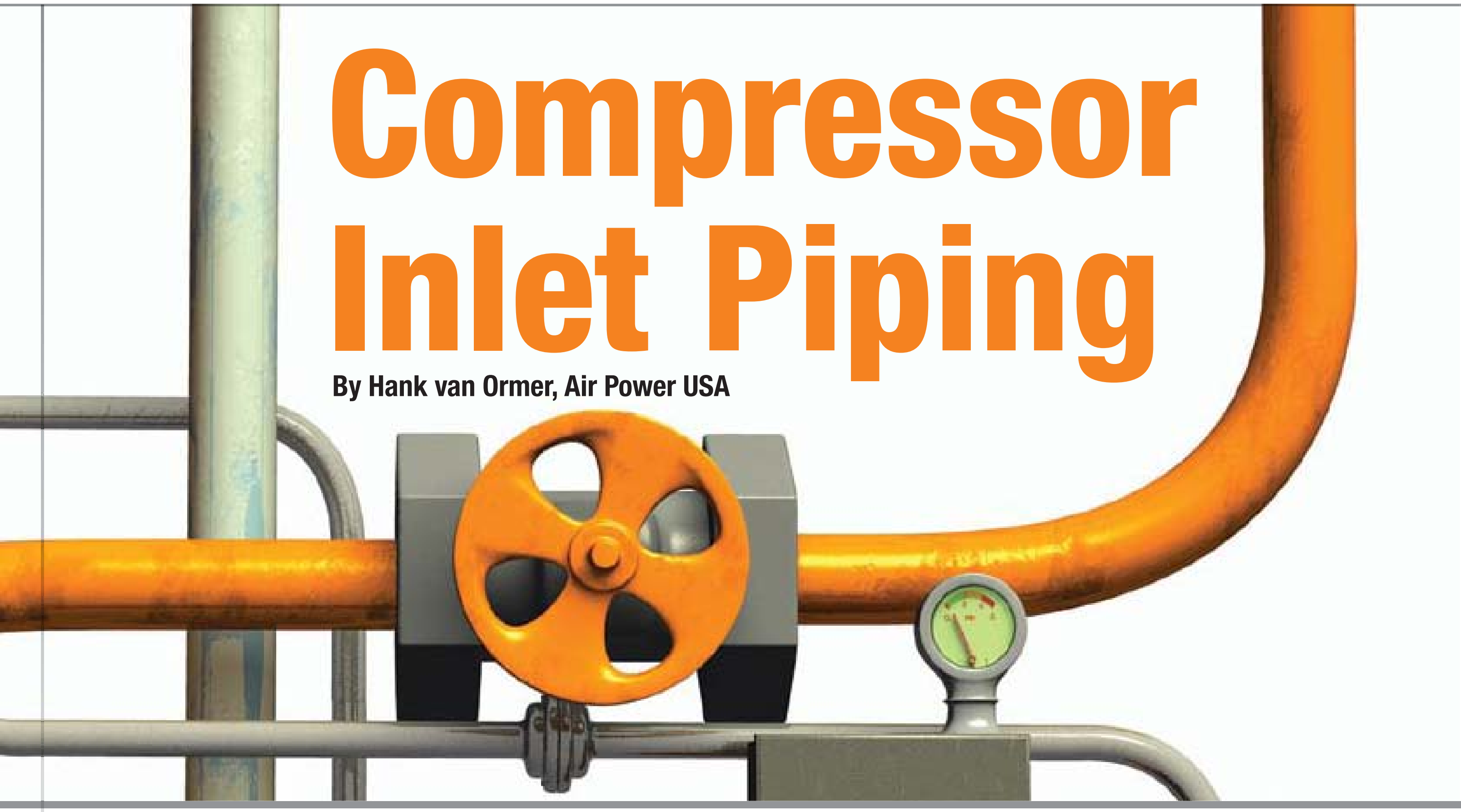


Compressor Inlet Piping

By Hank van Ormer, Air Power USA

The subject of compressed air piping has probably had more pages written about it than any other topic, even storage. Like many other topics in "practical" compressed air technology, a significant portion of this is controversial and often directly opposed.

These guidelines are not designed to replace the appropriate correct volumes of information and are not designed to answer all questions regarding a specific installation. They are designed to arm you with basic principles that always apply and, when followed, will end up with a well performing system. As with all our guidelines, they are based on performance and measured critical data in the field molded with theoretical performance. We have developed and used these guidelines over the last twenty years and find them very accurate.

Types of Piping Offered for Compressed Air

Consult federal, state and local codes before deciding on the type of piping to be used. The usual standard to be applied is the ANSI B31.1. For health care facilities, consult the current Standard NFPA 99 of the National Fire Protection Association.

The compressed air piping materials can be divided into two basic types: Metal and Non-metal.

Non-Metal Pipe — commonly called "plastic" pipe has been offered for many years as compressed air piping because:

- It is lighter than most metal and easier to handle
- It can be installed with no special tools such as welders, threaders, etc.
- It is generally non-corrosive
- Installation with the appropriate gluing material is fast
- The labor (which can also be unskilled) is much lower in cost than most metals (copper, stainless, black iron), and the total job may often be less expensive installed

What has held back this materials acceptance by many compressed air people and organizations?

Early on, PVC was used for compressed air piping, and it was not long before the fact became evident that it sometimes "shattered" when it failed sending sharp pieces throughout the area. New products were introduced that utilized material that did not shatter. However, this material and all others offered to date have significant limitations:

- Most of these are limited to an operating temperature of 140 ˚F to 200 ˚F. The failure in an aftercooler can easily reach or exceed these numbers. PVC, for instance, is limited to about 160 ˚F at 125 psig, but it actually starts to weaken at 70 ˚F

- Most of these materials are not compatible with compressor oils in general and particularly many synthetics
- Although pipeline fires are rare today, when there is one in plastic pipe, there is a good chance that it will melt through the plastic pipe and migrate into the plant

Typical Pressure Temperature Ratings for Thermoplastic Piping

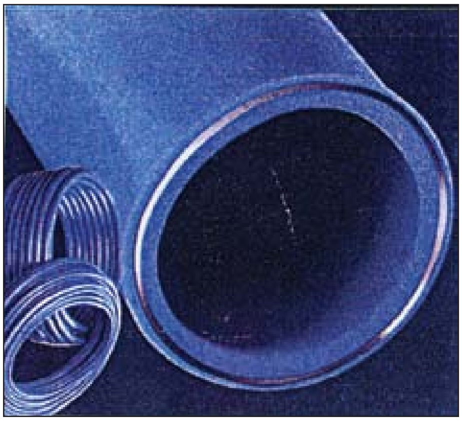
As with all other thermoplastic piping components, the maximum non-shock operating pressure is a function of temperature. The heat of compression should be fully dissipated so that the maximum temperature rating (140 ˚F for 1/2", 120 ˚F for 3/4") is not exceeded in the pipe system.

The pressure ratings for typical thermoplastic piping and fittings are about a constant 185 psi for all sizes in the temperature range -20 ˚F to 100 ˚F, and are gradually reduced above 100 ˚F, as shown in the table.

Overall, the compressed air industry has not accepted any type of plastic pipe as appropriate and safe for downstream compressed air. As a consultant, we would agree with this given today's material, data and available alternatives.

Metal Pipe can be black iron, stainless steel, copper, aluminum, etc. with proper thermal and pressure characteristics.

Black Iron or Steel Pipe in compressed air systems will corrode when exposed to condensate (H_2O) and thus become a major source of contamination to the whole system. This pipe is usually



Even this HDPE plastic pipe with an aluminum centerpiece is still rated at 73 ˚F and 140 ˚F. It does not have published testing above 140˚. Resistance to common oils and solvents is not published.

COMPRESSOR INLET PIPING

Aluminum air system piping with connections that require no special tools or pipe threading. — Courtesy Transair

a threaded connected 3" diameter and smaller and welded with larger diameters. Compared to copper and aluminum, it is much heavier and harder to work with, but less expensive. The internal corrosion issue is much more significant with oil free air than with lubricated compressors.

Stainless Steel is often a good selection particularly when exposed to oil-free wet air and its extremely high acid level condensate (before the dryers). Stainless steel is often lighter for the same pressure temperature rating and installs well when welded. Threaded stainless steel often tends to leak. Ring seals such as those used in grooved connections will work well with stainless steel. As piping material, however, the potential lower installation cost and faster welding (use of grooved fittings) may well make it the most overall economical.

Copper Pipe is a common selection for sensitive air systems and when selected correctly and connected correctly is very rugged. The working pressure of copper piping is 250 psi for Type "M" hard, Type "L" hard, and Type "K" soft, and 400 psi for Type "K" hard. Further, since 50/50 solder melts at 421 ˚F, it will be more resistant to high temperatures. Even if it does fail, it will do so in a predictable manner. The pipe ends will separate. The working temperature limit of copper piping is about 400 ˚F. (Data from Piping Handbook, 6th edition).

- Never join pipes or fittings by soldering. Lead-tin solders have a low ultimate strength, a low creep limit, and, depending on the alloy, start melting at 361 ˚F. Silver soldering and hard soldering are forms of brazing and should not be confused with lead-tin soldering. Silver soldering and hard soldering is brazing with a silver alloy type of filler material which melts in the range of 1145 ˚F to 1800 ˚F.

Aluminum compressed air pipe as applied today has become very popular. This has been developed not only to provide a smooth (low pressure loss due to friction) inner surface, and eliminate self contaminating, but also offer enhanced flexibility to meet the ever changing compressed air distribution needs. This is particularly desirable in the automotive support industry with changing assembly and subassembly areas.

Most of the aluminum pipe manufacturers rate their material at +4 ˚F to 140 ˚F or 176 ˚F. The piping material usually has a melting point of over 1,100 ˚F.

Material and Optimal Coatings for Inlet Air Piping and Discharge Air Piping

The question of galvanized piping comes up often in compressed air system piping instead of schedule 40 black iron for the nominal 100 psig air systems. To help evaluate this, let's look at inlet and discharge piping separately.

Guidelines for Inlet Piping

The proper inlet pipe brings the air from the filter to the compressor with no pressure loss and should not create operational problems with any type of self-contamination on the inside. It is important to realize that the ambient inlet air condition may well dictate the selection of one type of pipe over another.

Galvanized inlet piping has the advantage of resisting corrosion better than standard iron pipe. However, over time when the corrosion does set in, the galvanizing material then peels off. The inlet pipe is now a producer of potentially very damaging, solid contaminants between the filter and the compressor. This would be particularly dangerous to the mechanical integrity of a centrifugal compressor. We do not recommend this.

During high-humidity weather it is quite conceivable that condensation will form in the inlet pipe. Therefore, the OEM installation manual usually recommends a drain valve be installed on the pipe before the inlet. Condensation in the pipe will obviously accelerate the time frame before the coating breaks down. This time frame is dependent upon where the thinnest portion of the coating is applied.

Stainless steel inlet pipe is an excellent material for such large-diameter, low-pressure inlet air, as long as it is installed properly and the inside is properly cleaned.

There are also many grades of *thermoplastic material* suitable for inlet air piping.

Air Power USA recommends either stainless steel or proper thermoplastic-type material for inlet piping and **does not** recommend galvanized piping. Extruded aluminum will work well, but, depending on circumstances, may or may not be the economical choice.

Extruded Aluminum Alloy

Aluminum tubing that can be easily assembled with normal hand tools can bring a great deal of flexibility to an operating air system or sub-system. These are particularly effective for specific work areas, which may have to change on a routine basis.

Discharge and Distribution Piping

Here we have more complex considerations:

The discharge air from the compressors can be at 250 ˚F to 350 ˚F (for centrifugal, oil-free rotary screw and reciprocating types), or from 200 ˚F to 220 ˚F (for lubricant-cooled rotary screw compressors), so the pipe must be able to withstand those temperatures.

Even if there is an aftercooler that drops the temperature to 100 ˚F, consideration must be given as to the consequences if the aftercooler were to fail.

COMPRESSOR INLET PIPING

Compressed air generated condensate tends to be acidic. In oil-free compressors (such as centrifugals and oil-free rotary screws), it is usually very aggressive.

The basic objective of the interconnecting piping is to deliver the air to the filters and dryers and then to the production air system with little or no pressure loss, and certainly with little or no self-contamination.

Galvanized piping will have the same problems once it begins to peel, as we described on the inlet application. In all probability, due to the aggressive acidic characteristics of the condensate, the galvanized coating life may be much shorter.

Regardless of the thermoplastic pipe manufacturer's claim, we never recommend any plastic type material for interconnecting piping and rarely for distribution header piping. Most of these materials carry cautions not to be exposed to temperatures over 200 °F and to avoid any types of oil or lubricants.

Here again stainless steel or coated aluminum is our number one recommendation for the interconnecting piping from the compressor to the filter and dryers when the compressed air is oil free. It will obviously resist corrosion much better than standard schedule 40 black iron. Some other considerations:

- Most areas will allow schedule 10 stainless steel in lieu of schedule 40 black iron
- For the same diameter pipe, stainless steel will be much lighter and easier to handle usually lowering the labor cost
- For welded connections, stainless steel usually requires just one bead, while black iron pipe usually requires three beads (weld, fill and cover). This should also lower the labor cost
- Stainless steel does not usually seal well when threaded. It will do much better with grooved type connections when welding is not practical

Summary

The following comparison chart summarizes some of the pros and cons of each type of piping material. This information has come from discussions with piping manufacturers, mechanical contractors, and plant personnel along with years of system analysis by field personnel.

Distribution Headers and Drops

The objective for the main header is to transport the maximum anticipated flow to the production area and provide an acceptable supply volume for drops or feeder lines. Again, modern designs consider an acceptable header pressure loss to be 0 psi.

The objective for the drops and feeder lines is to deliver the maximum anticipated flow to the work station or process with minimum or no pressure loss. The line size should be sized for near-zero loss. Of course the controls, regulators, actuators and air motors at the work station or process have requirements for minimum inlet pressure to be able to perform their functions.

Specific Guidelines on Piping — By Type of Compressor

These tips are general in nature. For a specific unit consult the manual and/or manufacturer.

Inlet Air Piping

Rotary compressors:

1. Use dry filters or pressure aspirated oil wetted if unit has modulation control
2. For remote filter installation, remove filter from package to be installed:
   - No valves or obstructions in the inlet interconnecting pipe
   - Can use supported flex/rubber hose to pipe outside enclosure to connect to inlet pipe
   - If inlet is outside, be sure to install a bird deflector
   - Support inlet piping, do not hang on the unit

> "The compressor discharge pressure was reduced to 98 psig, which represents a power savings of 6%, equivalent to about $9,585 annually."
>
> — Hank van Ormer, Air Power USA

- Be sure pipe is free of dust, rust, weld beads, scale, chips, etc. before starting the compressor
- If running over 50 feet (confirm with manufacturer), increase pipe size at least one size or greater over the filter housing connection size

Reciprocating compressors:

1. Always try to increase inlet air piping one or two sizes above compressor connection size. Never reduce inlet pipe size from connection size on the unit
2. Brace/clamp pipe at regular intervals — DO NOT have pipe weight on compressor connection
3. Be sure pipe is clean and free from rust, scale, etc., before starting the compressor
4. Be sure you are not in "critical length" and if you are, consult manufacturers data for proper corrective action
5. Use inlet pulsation bottles when possible on larger units. Be sure bottle is clean before starting the unit
6. Can use dry or oil bath filter. When in doubt, consult manual or manufacturer
7. Avoid critical lengths

Centrifugal:

1. If a remote inlet filter is to be used, it is necessary to work closely with the supplier/manufacturer to size the inlet pipe. Because the centrifugal compressor is a "mass flow" type compressor, its overall performance is very dependent on identifiable and predictable inlet air pressure
2. Install drain leg on inlet line before the air enters the compressor

Discharge Piping

Rotary:

1. Pipe size should always be larger than unit connection size. Determine correct pipe size based on system flow, length of pipe, number of bends/valves, acceptable pressure drop, etc.
2. Pipe so condensate from air line cannot run back into unit
3. Support pipe so there is no strain at or on the compressor connection

Reciprocating:

1. Pipe size should be one or two sizes larger than compressor connection size. Never reduce discharge pipe size from connection size of unit. Check the pipe size for velocity and calculate pressure loss
2. Brace/Clamp pipe at regular intervals. DO NOT have pipe strain on compressor connection

COMPRESSOR INLET PIPING

3. Be sure you are not in "critical length" and, if you are, consult manual or manufacturer for proper corrective action
4. Use discharge pulsation bottles when possible on larger units

Centrifugal:

1. Refer to the manual/manufacture for detailed location of check valves, back valves, safety valves, etc
2. Discharge piping should be larger than the compressor connection and should have a smooth run directly away from the unit. It should not be too large, which can possibly create a "stonewall" type effect at the discharge
3. All turns should be "long sweep ells" to allow a minimum of backpressure. This is always recommended in any air system but it is much more critical in a mass flow centrifugal
4. All piping should slope away from the compressor. All risers should have drain legs. Install a drain leg immediately after the compressor in the discharge line

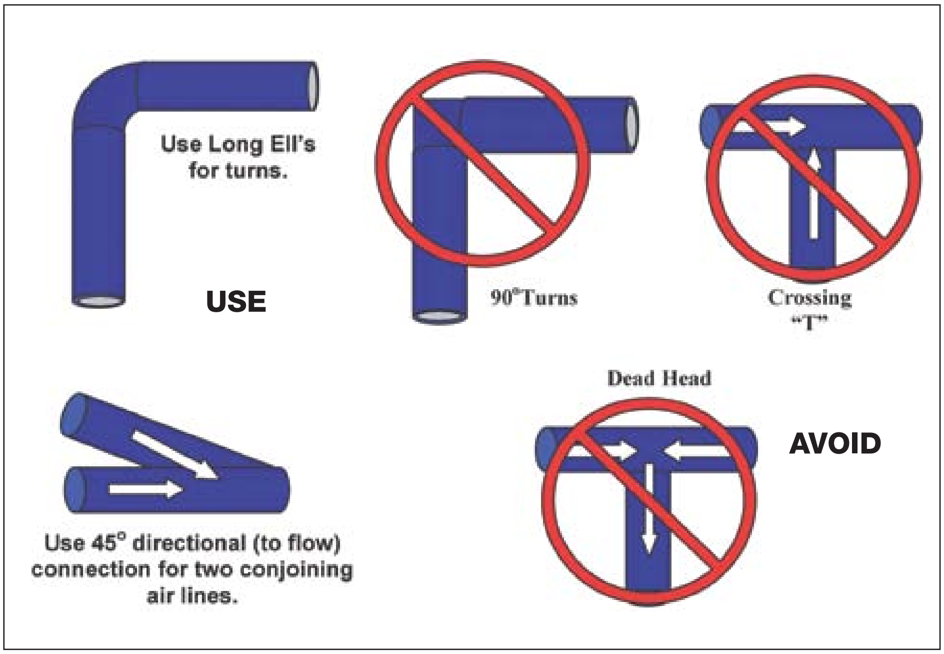
Interconnecting Piping with Multiple Units

Interconnecting Piping Configuration is between the compressor discharge through the air treatment equipment and storage before entering the production area.

Over the years we have found very few plants where the interconnecting piping does not cause control problems with multiple units, particularly rotary screw units with modulating controls. This usually leads to multiple units at part load and, consequently, poor basic efficiency. Step controlled units with extreme short cycling may experience poor efficiency and lead to premature failure of operating components.

The objective in sizing interconnecting piping is to transport the maximum expected air flow from the compressor discharge through the dryers, filters and receivers to the main distribution header with minimum pressure drop. Contemporary designs that consider the true cost of compressed air target a total pressure drop of less than 3 psi.

Avoiding such things as high turbulence and its resistance to flow with resultant pressure spikes and loss, the interconnecting piping should be sized with regard to velocity rather than friction loss only. Design configuration has significant impact on this also. All pipeline velocities are to be 20 fps or less at pipeline psig. At these velocities, even some poor piping configuration practices will have much less negative impact, if any.



General Guidelines for All Piping

All air inlet and discharge pipes to and from the inlet and discharge connection of the air compressor must take into account vibration, pulsations, temperature exposure, maximum pressure exposed to, corrosion and chemical resistance, etc. In addition, lubricated compressors will always discharge some oil into the air stream, and compatibility of the discharge piping and other accessories (such as O-rings, seals, etc.) with both petroleum and/or synthetic lubricants is critical.

General Rules for Sizing Pipe in a Compressed Air Distribution System

1. Pressure drop between the compressor and point of use is irrecoverable
2. Pipe size should be large enough that pressure drop is held to a minimum or even nonexistent. There is no reason to tolerate any pressure loss during normal operation in the header distribution

3. Arrange piping to avoid the following types of strains:

    A. Strains due to dead weight of the pipe itself

    B. Strains due to expansion or contraction of the piping with temperature change

    C. Strains due to internal pressure within the piping

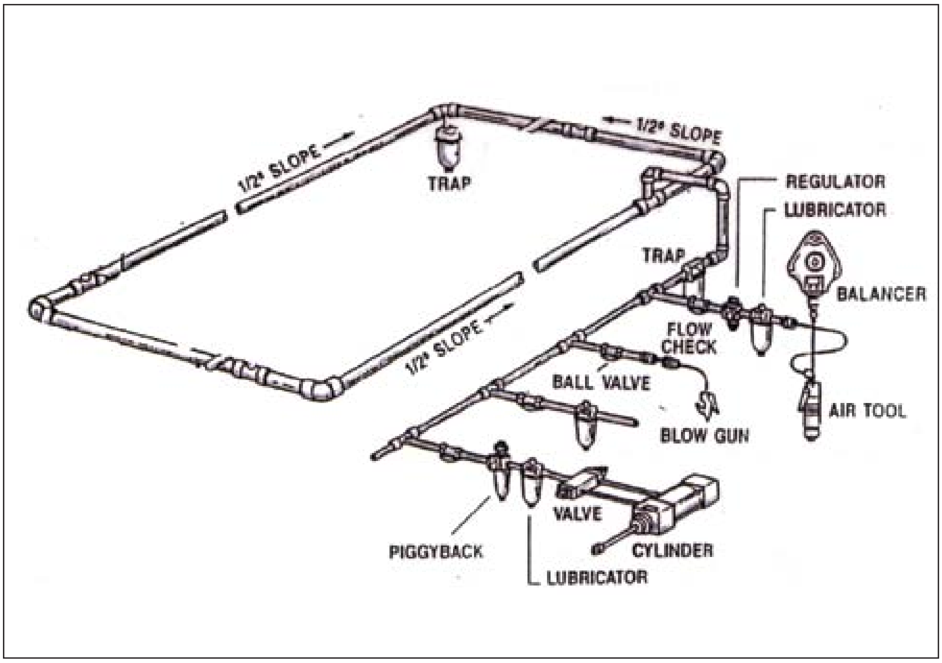
4. Design inlet and discharge piping for smooth flow with uniform translateral velocity over the entire area of the piping

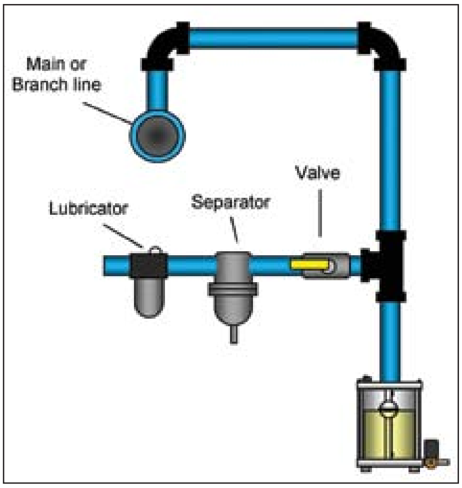
5. Install a safety valve between the compressor and shut-off valve at 5 to 10 psi above compressor operating pressure. Never exceed the working pressure rating of any ASME vessel in the system

6. Plan for future emergencies and establish a tie in point to install a temporary compressor with power and aftercooler (if required)

7. Consider bypass lines or valves on all items that may require future maintenance

8. Use a loop design system if possible, both around the plant and within each production zone





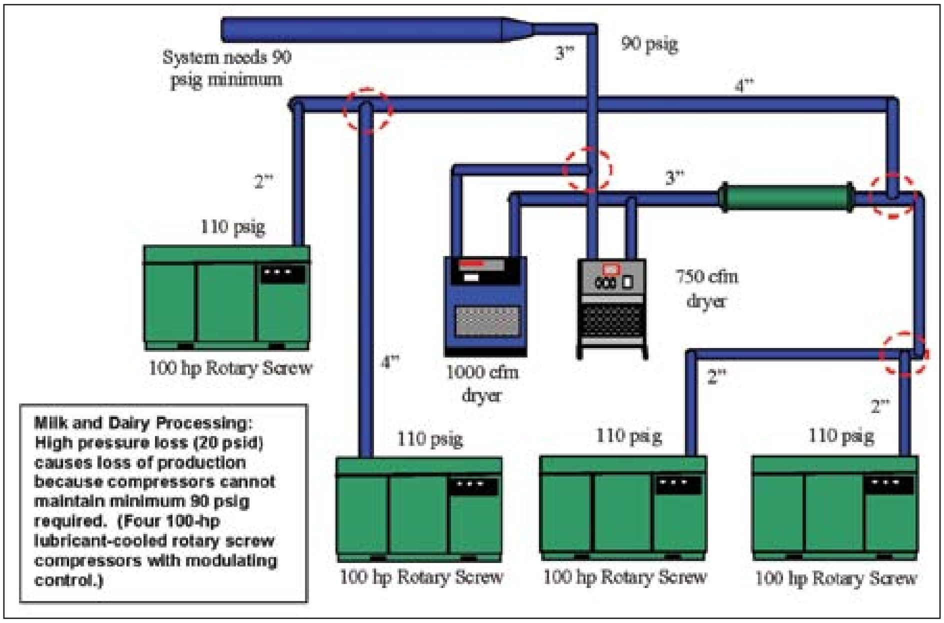
COMPRESSOR INLET PIPING

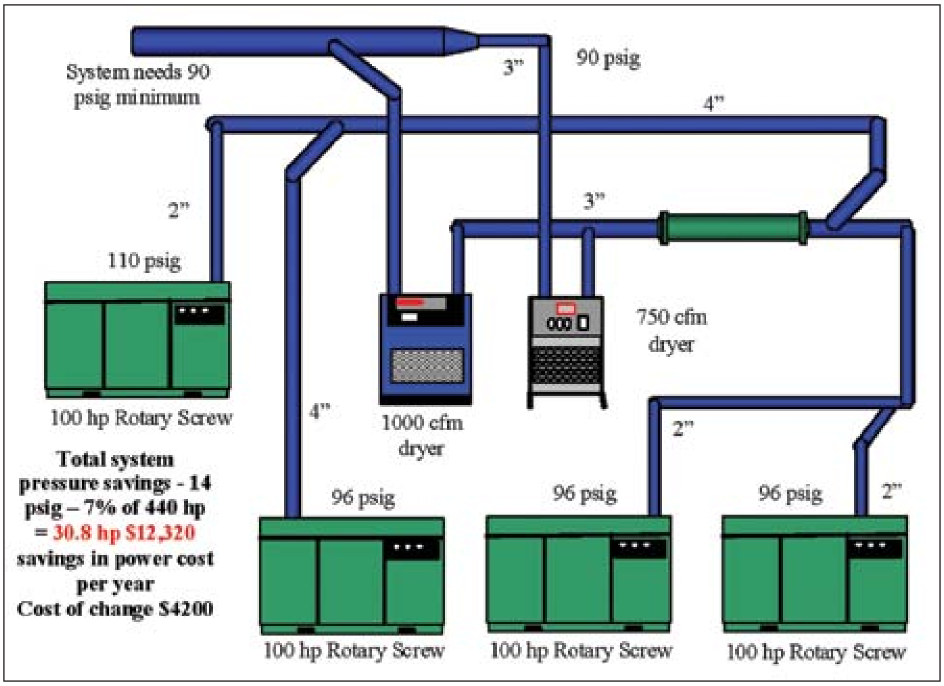
9. Consider a second air receiver at end of the line or loop only if you have peak demands for air near that point

10. Locate outlets from the main header as close as possible to point of application. This helps limit large pressure drops through hose

11. Outlets should always be taken from the top of the pipeline to alleviate carryover of condensed moisture to tools

12. All piping should be sloped so that it drains toward a drop leg moisture trap or receiver away from the compressor and/or process





Flexible connections should be used to reduce or absorb vibration and mitigate the effect of thermal expansion. *They should not be used to correct misalignments.* Any flex connection used should be investigated to be sure its specification fits the operating parameters of the system.

It is important to note that improper or incorrectly applied piping and material in an air system can result in mechanical failure, damage, and serious injury or death.

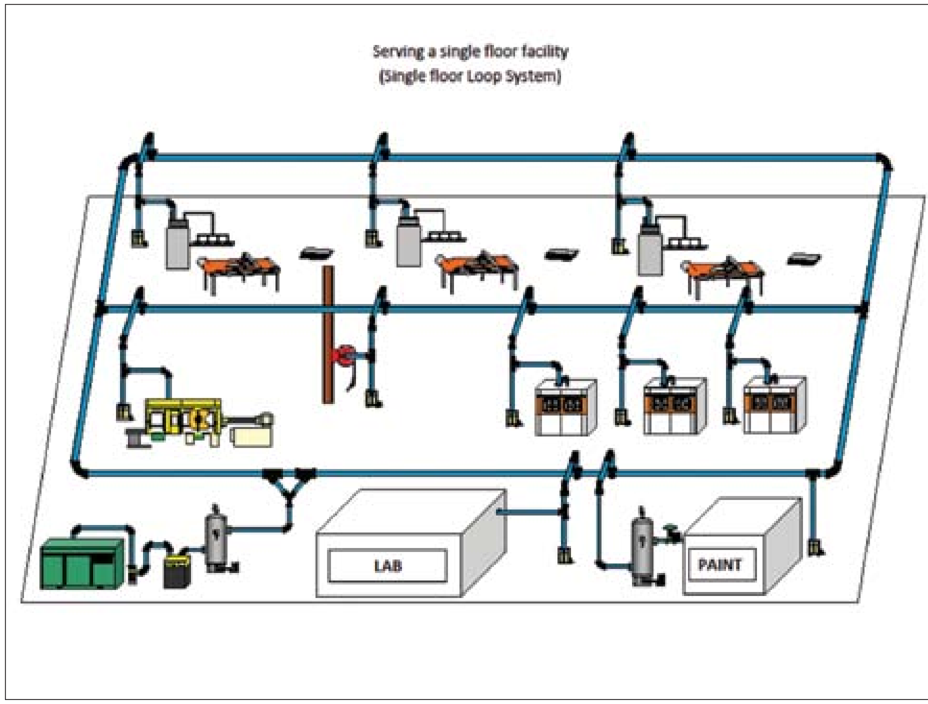
Summary

1. If proper copper piping is used, be sure the copper and solder used has the proper characteristics to handle the anticipated temperatures at full load

2. Use of plastic piping. There are many negatives that have accumulated over the years around the use of plastic piping
   - Lack of resistance to failure due to fatigue caused by vibration
   - Lack of resistance to softening crazing, cracking and from lubricants, particularly diester synthetics
   - Susceptibility to a catastrophic failure results from something like and aftercooler failure
   - Potential catastrophic failure caused by an outside fire
   - Potential catastrophic failure from a pipeline fire or detonation
   - Potential to be attacked from outside or within from airborne chemicals and condensate (inside)
   - A failure in plastic or PVC pipe under pressure may explode or shatter, endangering personnel in the area

3. There have been new product introductions of plastic piping systems which claim to have solved most of the negative problems including the shattering characteristics. New plastic pipes are based on *specially modified formulation or acrylonitrile butadiene styrene (ABS) resin*

4. Many people feel that any type of non-metallic (i.e. plastic) piping is a high risk because in any air system (particularly lubricated) the potential for a pipeline fire always exists. Even though it may be a most unlikely occurrence, plant safety is certainly enhanced if the pipeline fire stays in the pipe and does not burn through the wall



COMPRESSOR INLET PIPING

Poor Piping Configuration in Action

The plant was running four 100 hp lubricant-cooled rotary screw compressors under modulating control. It was losing productive capacity because a 20 psi pressure drop made it impossible to maintain the required minimum 90 psig in the header. This piping schematic shows the original piping. Four 100 hp, 490 cfm oil-cooled rotary screw compressors delivered air to a 6" main header. The velocity in the 4" interconnecting piping was as follows:

- 13.2 fps @ 490 cfm
- 26.4 fps @ 980 cfm
- 39.6 fps @ 1,470 cfm
- 47.4 fps @ 1,760 cfm

Four crossing tees added turbulence at these velocities. The total pressure loss with all machines at full load was 20 psig. When demand increased, the pressure in the main fell below 90 psig, shutting down production. Two changes solved the problem. First, the 4" crossing tees were changed to directional angle entry. The pressure drop fell to 6 psi and the main system now receives 104 psig that is easily regulated to a steady 90 psig. The connections were prefabricated and installed during a one-day maintenance shutdown at a cost of $4,200. This eliminated the production interruptions that had occurred for twenty years. Second, the compressor discharge pressure was reduced to 98 psig, which represents a power savings of 6%, equivalent to about $9,585 annually. BP

For more detailed piping guidelines, consider purchasing the Air Power USA, Piping Guide.

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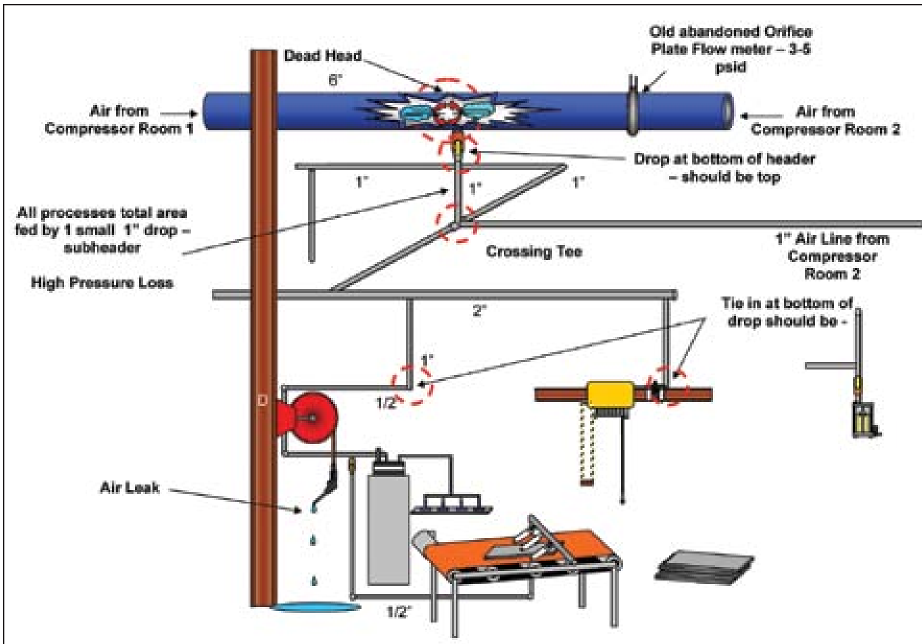
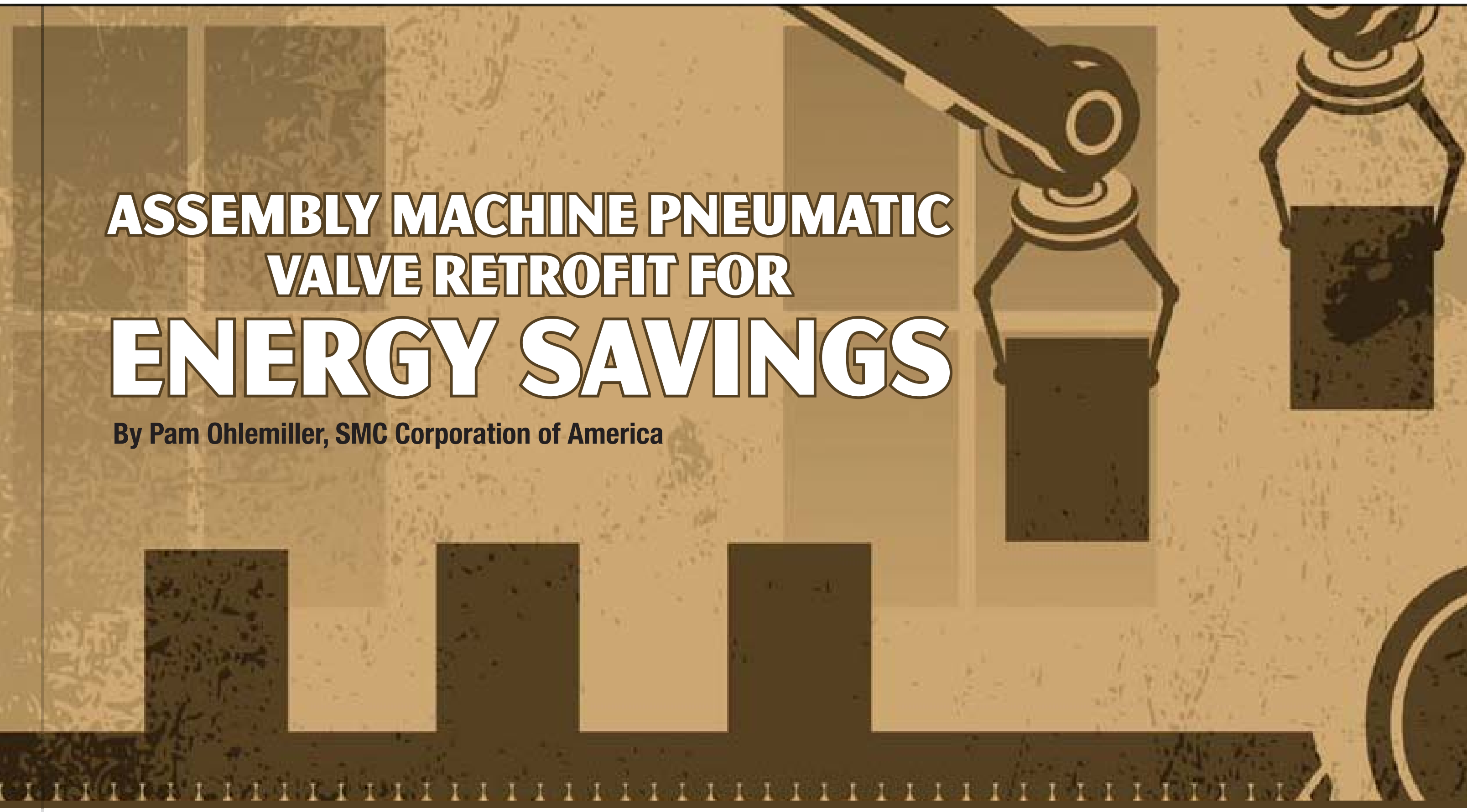


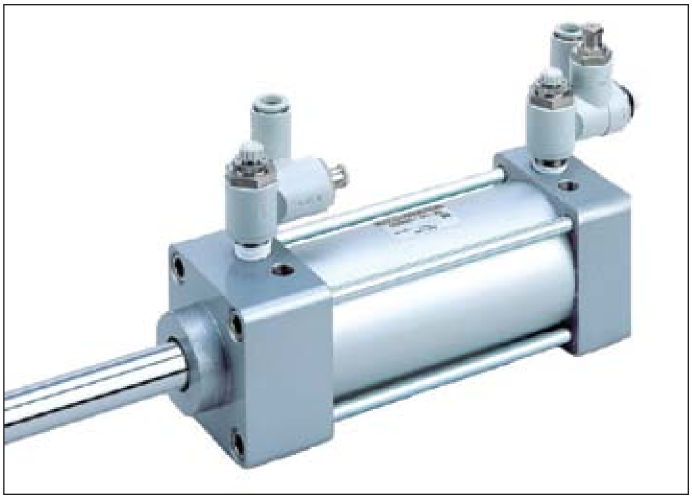
Common Compressed Air Distribution Piping Mistakes



ASSEMBLY MACHINE PNEUMATIC VALVE RETROFIT FOR ENERGY SAVINGS

By Pam Ohlemiller, SMC Corporation of America

Responsible companies are looking at ways to not only reduce their energy consumption, but to make their production more efficient. This is a great general business practice, but how can you be sure that what you are doing has positively impacted the bottom line? More specifically, what can you implement that is repeatable as a best practice to save energy, and better yet, what can you implement that can be used to retrofit various machines across your floor? One solution is found in upgrading to modern pneumatic valves capable of saving energy by reducing compressed air consumption.



The ASR/ASQ valve components reduce the pressure requirement on the non-working side of a pneumatic cylinder.

The following is a case study that looks at a specific small component assembler and evaluates how the addition of one component, a new pneumatic valve, can decrease the energy consumption of this assembly cell.

Application Example: A Small-Component Assembly Machine

The purpose of this small-component assembly machine is to mechanically fit spacers onto spools. The machine uses a total of ten (10) pneumatic cylinders, working as part of a system to assemble 1,908 finished units per day. The pneumatic cylinders are of various types (rotary, grippers, guided, etc). The machine's functionality is generally summarized in five steps.

- **Step 1:** Spacers are placed within a manually filled hopper. The hopper is jolted periodically by a cylinder, moving the spacers to the bottom of the hopper
- **Step 2:** The spacers fall into a vibrating bowl feeder where the vibration of the bowl moves the parts to the outside of the feeder channel
- **Step 3:** The spacers then fall onto a conveying system where they are mechanically aligned by another series of cylinders
- **Step 4:** Finally, the spacers are picked up by a gripper and are positioned for the final phase of the process
- **Step 5:** A final system of pneumatic cylinders and valves work together to force the spacer onto the spool

A pneumatic cylinder jolts the hopper periodically, moving the spacers to the bottom of the hopper

The spacers fall onto a conveying system where they are mechanically aligned by another series of pneumatic cylinders. Meanwhile, a similar process is taking place with the spools. These spools will be what eventually hold the spacers

The final product, spacer on spool, is then ejected into a holding bin where they are now ready for collection

ASSEMBLY MACHINE PNEUMATIC VALVE RETROFIT FOR ENERGY SAVINGS

The Pneumatic Valve Retrofit

The objective of installing the ASR/ASQ components is to reduce the pressure on the non-working side of a cylinder, and thus reduce the energy consumed annually.

SMC Series ASR/ASQ pneumatic valves were installed on each of the ten (10) cylinders where standard push-to-connect fittings had previously existed. Specifically, one ASR valve was installed on each of the ten cylinder's non-working side and an ASQ valve was installed on the working side.

The Cylinder's Low-Pressure/ Non-Working Side

The valves cut air consumption by operating the non-working actuator stroke at a reduced pressure. These valves have the potential to reduce air consumption by up to 40%. Here is how it works; in conventional installations the working and nonworking stroke operate at the same pressure. The ASR pneumatic valve is installed on the low pressure/ non-working side of the cylinder. It contains a regulator, check valve and speed controller providing the low, regulated pressure on the return stroke. Essentially, the ASR is a regulator, check valve, and speed controller all in one.

The Cylinder's High-Pressure/Working Side

On the working/high pressure side, the ASQ is installed. The ASQ contains an exhaust valve with a speed controller. The ASQ exhausts the supply pressure on the return stroke.

The quick exhaust cuts air consumption by reducing the pressure on the non-working stroke. The inclusion of the speed controllers make the movement more smooth — and the inclusion of the quick

Lab Test on Reduced Flow Requirements

To determine the exact savings, a test environment was created in the SMC lab to quantify the exact savings. Environment 1 was first connected to a 6.4 gallon tank of compressed air at a pressure of 85 psig. There was six feet of tubing to a regulator set at 45 psi. Once the cylinder was connected and the compressed air tank was filled, the air compressor was turned off. This provided a measurable quantity of air. The actuator was then supplied the air and thus, began to actuate. In this environment, 47 strokes depleted the static air supply. The process was repeated three times to ensure consistency, and consistently 47 strokes depleted the supply.

Environment 2 was then connected to the same system. The only variable in the environment was the introduction of the energy saving valves to the cylinder. The standard push-to-connect fittings were removed from both sides of the cylinder and the ASR/ASQ valves were added in their place. Under the same conditions, 54 strokes depleted the static air supply. This is an increase of 7 strokes from Environment 1. The addition of the energy saving valves showed a 19% increase in the number of strokes, or quantity of work, possible from the static supply of air, and thus a 19% decrease in air consumption. The added plus is that in environment 2, the pressure was set at 45psi. In short, the ASQ is a pilot valve and 2-way flow control valve all in one.

Environment 1 without ASR/ASQ Energy Saving Valves

Environment 2 with ASR/ASQ Energy Saving Valves

The ASR contains a regulator, check valve and speed controller and is installed on the low pressure/non-working side of the cylinder.

The ASQ contains an exhaust valve with a speed controller and is installed on the cylinder's high-pressure/working side.

exhaust make the response time faster. If just a flow control is used, then the pressure rise is delayed, slowing the response time — meaning a longer stop time.

Return-on-Investment

The small-component assembly machine potentially saw a 19% decrease in air consumption after the energy saving valves were installed on all ten cylinders. Plans are in place to confirm these numbers with compressed air flow data-logging.

The estimated annual compressed air cost per cylinder in the system was $1,177 per year. With ten like cylinders, the total annual cost to run the machine was $11,776. After installation of the series ASR/ASQ valves, the operating cost of these ten cylinders could fall below $9,539 — a decrease in energy costs of 19%. Considering the list price of each of the valves is approximately $27, the return on investment is clear.

Note: all compressed air savings calculations assume that the compressor controls are dynamic and the power consumption ratio to operating capacity ratio is a 1:1. If using a compressor without dynamic controls, the compressor will need to be adjusted to benefit from the full energy savings expressed in this example. BP

For more information contact Pam Ohlemiller, Product Manager, SMC Corporation of America, tel: 317-688-0273, email: pohlemiller@smcusa.com

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DEMAND (DRY) STORAGE

PART II: *Application and Use in an Efficient Compressed Air System*

By Ron Nordby, Vice President Sales and Marketing, John Henry Foster

In continuation of our series examining the application of storage in a compressed air system, this article will focus on another type of supply side storage concept: demand (dry) storage. Before discussing the definition, application and use of demand storage, I would like to reiterate that contrary to current thought, consideration should be given to control (wet) and demand (dry) storage being separate storage solutions based on their primary purpose.

When applying control storage in a compressed air system, the main objective should be improving the functionality and efficiency of the air compressor controls. Other issues such as moisture removal or supplementing demand storage should be considered ancillary benefits, not a rationalization for its application. Moisture removal, while desirable, is more effectively achieved by a properly engineered separation and condensate drain system. Utilizing control storage as a supplement to demand storage may seem logical however, it must be noted that control storage due to its location in the system is unfiltered and wet. This raises the possibility that intermittent flow levels, in response to demand events in the system, could exceed the capacity of air preparation equipment resulting in unfiltered and wet air being delivered to the distribution system.

Definition Of Demand Storage

The definition of demand storage for the purpose of this article is a pre-conditioned volume of compressed air located on the supply side of the system, which is generated by the intentional creation of a pressure differential at a level above system pressure.

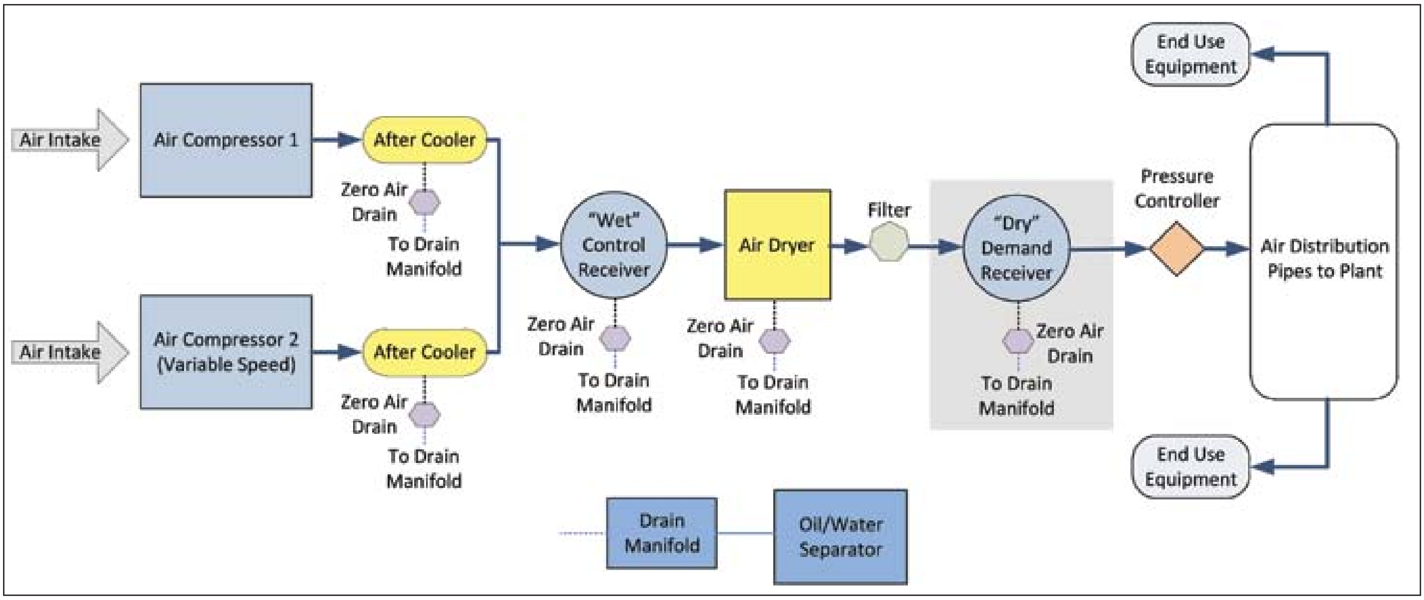

Diagram provided by CEA Technologies Inc. Compressed Air Energy Efficiency Reference Guide. John Henry Foster modified.

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DEMAND (DRY) STORAGE PART II

Application and Use in an Efficient Compressed Air System

Should You Consider Demand Storage?

It is not a question of will a compressed air system function without demand storage, it is a question of how well. If reliability, productivity and efficiency are not a priority then a compressed air system can operate without demand storage. Many examples of systems operating without demand storage in industrial plants today are easily identifiable because they usually exhibit one or more of the following conditions:

1. Operating at a higher system pressure than necessary
2. Increased system air demand
3. More on-line compressor horsepower than required
4. Excessive fluctuation in system pressure levels
5. High maintenance costs

The negative impact caused by the lack of adequate demand storage on the compressed air system can be attributed to the original intent of compressor controls and system dynamics. Compressor manufacturers design compressor controls to first and foremost protect the compressor, then to satisfy the discharge pressure setting and in some cases provide for limited part load efficiency and networking capability. Without demand storage, the controls of an air compressor are required to support all demand events in the time frame which they occur within the compressed air system. This was not the original intent of compressor controls. It does not matter what type of compressor or compressor control is involved, the expectation of reacting effectively and efficiently to the changes that may occur in a compressed air system is impractical. With the proper amount of demand storage applied to the air system the benefits should include:

- Lower and consistent system pressure
- Reduction in system air demand levels
- Reduction in on-line horsepower
- Improvement in overall system efficiency
- Consistent quality of compressed air
- Reduction in maintenance costs

What Role Does Demand Regulation (Flow Controller) Play In The Creation Of Demand Storage?

One of the critical factors in the creation of demand storage is the intentional creation of a significant pressure differential. If we rely solely on naturally occurring pressure drop, very little if any, demand storage will be generated. For example, a 1000 gallon receiver with a 2 psid will produce only 18 cf of demand storage. Point of use regulation could be utilized as an alternative to demand regulation in the creation of demand storage if each point of use was properly regulated at its lowest effective pressure level. Statistics and experience have shown however, that less than 50% of point of use applications have regulators installed and many of those are adjusted incorrectly.

Without the installation of demand regulation (flow controller) in combination with a storage receiver, demand storage cannot be created effectively or efficiently. The application of a flow controller allows the system designer to not only establish a pressure differential but also a separation between the supply and demand sides of the compressed air system. No longer is it the responsibility of the compressor controls to react to each demand event in the system, its concern is simply to maintain demand storage. Supporting demand events now becomes the responsibility of the flow controller in conjunction with demand storage. This allows the system designer to more effectively control the rate of change and reaction time within the compressed air system by controlling the expansion of air across the flow controller. More importantly, he is able to achieve this at a greater speed and capacity level than on-line horsepower alone.

> "If reliability, productivity and efficiency are not a priority, then a compressed air system can operate without demand storage."
>
> — Ron Nordby, John Henry Foster

DEMAND (DRY) STORAGE PART II

Application and Use in an Efficient Compressed Air System

Determining the amount of demand storage required varies greatly due to system dynamics and constraints, as well as ancillary requirements of the system i.e. supporting a failure of an online compressor. System considerations might also dictate the utilization of other storage concepts i.e. general, point of use or off-line storage in conjunction with demand storage. It is extremely important that sound engineering principles be involved in the design and application of demand storage. Without a thorough audit of the complete system the results might not meet expectations. It serves no useful purpose to either over or under create demand storage. If performed properly, you should be able to identify from the audit results the optimum amount of demand storage required to produce the results you expect.

The information needed to determine the amount of demand storage required would include some or all of the following:

1. Minimum System Pressure Required

A properly performed audit should include the demand as well as the supply side of the compressed air system with each compressed air user individually evaluated for the minimum required system pressure. It is very common that the perceived pressure requirement is higher within 10 ft. of the compressed air user. It is critical that these issues are addressed in order to determine the true minimum pressure requirement.

2. Pressure Limitations Of The Air Compressors

Confirm the design pressure range of each compressor in the system. If it is a load/no load control, what are the cut in and cut out pressures? If you are utilizing a type of compressor network control system, identify the lowest pressure level expected within the parameters of the control system.*

3. Size And Duration Of Demand Side Events

What is the magnitude, cycle time and duration of the demand event? The longer the event duration, the shorter the recovery time and the greater the magnitude of the event, the more problematic it becomes to utilize only demand storage.

4. Time Required For Trim Machines To Start And Load

If there is a multi-compressor installation where one or more compressors will be considered for trim, it is critical to know how long it will take a compressor to reload or come on line. This is especially critical for larger horsepower compressors such as centrifugal, where the time needed to go from an off position to a loaded position could exceed one minute. Other considerations would be a control permissive that would delay start-up or reloading sequences.

5. Supply Side Pressure Drop

The capacity to create demand storage is determined by the available useful differential between the storage vessel, flow controller and the volume of the storage receiver itself. Once the pressure capability at the discharge of the compressor is identified, two factors must be considered:

- Virtually all compressed air systems have purification equipment (i.e. filters, valves, and air dryers) installed between the compressor discharge and the storage vessel. Purification equipment is a source of pressure drop that could range from 5 to 15 psi. It is critical that this pressure drop be minimized as much as possible for it will reduce the differential that is required in the creation of demand storage
- A 3–5 psig differential should be maintained between supply pressure and the system pressure setting on the demand regulator. If the upstream pressure and the system pressure at the demand regulator equalize, the compressed air system goes dynamic with the supply side tracking the demand side and system pressure control is lost

The goal of this article is to provide basic information on the definition, purpose and advantages of demand storage. The limitations of available space dictate the amount of information which can be provided and my hope is that the information contained in this article gives you a base of information to start the process. That being said, I cannot stress enough the importance of working with qualified individuals and companies who can provide you with the data you will need to make informed decisions. If you would like additional information please feel free to contact me. BP

For questions concerning control storage or any other types of storage and related applications, please contact Ron Nordby, John Henry Foster, tel: 651.681.5724, email: ron.nordby@jhfoster.com or visit www.jhfoster.com.

* VSD compressors have an advantage of being able to increase the system pressure, but be aware that raising this pressure level above the design point will reduce the capacity of the compressor.

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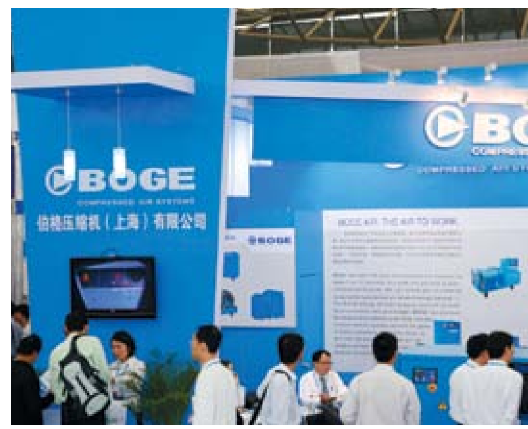

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OPTIMIZING THE SPECIFIC POWER OF PART LOADED COMPRESSED AIR SYSTEMS

By Ron Marshall for the Compressed Air Challenge®

Compressed air is expensive to produce but when one realizes the actual cost of using compressed air to produce mechanical work it can be mind boggling. Various inefficiencies between the compressor and the ultimate end use can act like a tax, robbing a portion of this valuable energy source before it is used and making the ultimate cost of using compressed air for power far more than you know. Fortunately there are some things that can be done to reduce these costs and improve efficiency.

Cost of Compressed Air

So let's first explore the cost of compressed air. The Compressed Air and Gas Institute or CAGI have developed a very useful way of rating air compressors, using specific power, sort of like a gas mileage rating for compressors (Figure 1). These are results from testing under some standard conditions and show how much power a specific compressor consumes for a given output. Specific Power is stated in kW per 100 cfm.

The specific power show for this compressor means if you are paying 10 cents per kWh for your power and you have a 5 day a week two shift operation running about 4,200 hours per year it should cost you about $8,500 per year to produce each 100 cfm of compressed air, about as much air as a 25 hp compressor can produce.

For a 24 hour 7 day a week operation the cost to supply 100 cfm of air would more than double to about $18,700 per year. These costs assume the compressor is running fully loaded which is its most efficient point.

Low Equivalent Mechanical Output

But what does that 100 cfm of air get you in direct mechanical output at the other end of your system? The Compressed Air Challenge has calculated an example for us as presented in our Fundamentals of Compressed Air Systems seminar. If your compressed air drives an air motor, for example, like one that you might have inside an air operated drill or grinder or impact wrench, it would take about

> "A good way to easily improve your system efficiency and get back part of the leak tax is to find and fix your air leaks, targeting a best practices 10% leakage rate or lower."
>
> — Ron Marshall, Manitoba Hydro

Fundamentals of Compressed Air Systems WE (web-edition)

Learn more about condensate drains and other consumers of compressed air in our *Fundamentals of Compressed Air Systems WE* (web-edition) coming in September or one of our many in person seminars being held in the coming months. Please visit www.compressedairchallenge.org for more information about the training.

If you have additional questions about the new web-based training or other CAC® training opportunities, please contact the CAC® at **info@compressedairchallenge.org.**

30 cfm of compressed air input at the tool to get one horsepower of mechanical shaft power output. Based on the CAGI sheet this 30 cfm would be equivalent to over 6 kW of compressor electrical power input, but would produce less than one kW of mechanical power or one horsepower of output.

2	Model Number: 100 [X] Air-cooled [ ] Water-cooled [X] Oil-injected [ ] Oil-free	# of Stages: 1 VALUE	UNIT
3	Rated Capacity at Full Load Operating Pressure [a, f]	434	acfm [a,f]
4	Full Load Operating Pressure [b]	125	psig [b]
5	Maximum Full Flow Operating Pressure [c]	128	psig [c]
6	Drive Motor Nameplate Rating	100	hp
11	Total Package Input Power at Rated Capacity and Full Load Operating Pressure [d]	92.6	kW [d]
12	Specific Package Input Power at Rated Capacity and Full Load Operating Pressure [g]	21.3	kW/100 cfm [g]

Figure 1: Excerpt of a typical CAGI Sheet for a fixed speed compressor

Compared to a direct drive electric tool the CAC concludes that a compressed air powered tool costs you seven times as much to operate, or in this case about 150 kW for every 100 cfm of air motor load.

Leak Tax

But this assumes that all the compressed air you produce actually makes it to the tool. Unfortunately no compressed air system is completely tight, they leak, and the leaks make the system less efficient. The typical system leak level in a busy plant ranges between 15% of the average flow for a very tight system, to 50% for a poorly maintained system. In rare cases, usually involving systems with lots of capacity to spare, the percentage of leaks can reach as high as 80%.

Let's assume your system is average and has a 30% leak rate. This means that you have to produce 40 cubic feet for every 30 cubic feet of compressed air you use. Because of this the air powered tool is now costing an equivalent to 10 times that of a direct drive electric tool or about 213 kW per 100 cfm.

Efficiency Ratings at Part Load

But there is another issue that should concern you, the efficiency characteristics of lubricated

OPTIMIZING THE SPECIFIC POWER OF PART LOADED COMPRESSED AIR SYSTEMS

rotary screw compressors at part load. You may have been surprised to learn that compressed air power can cost you ten times more than direct electric power but the news gets worse under certain conditions. When we consider the poor efficiency of some modes of compressor operation at part load the costs go up even more. Modes of compressor operation are explained in CAC's training seminars or in Fact Sheet 6 - Compressed Air System Controls in our website library.

In Figure 1 we saw an excerpt of a CAGI data sheet for a typical 100 hp 125 psi rated compressor. Examining and comparing sheets like this are a great way to compare

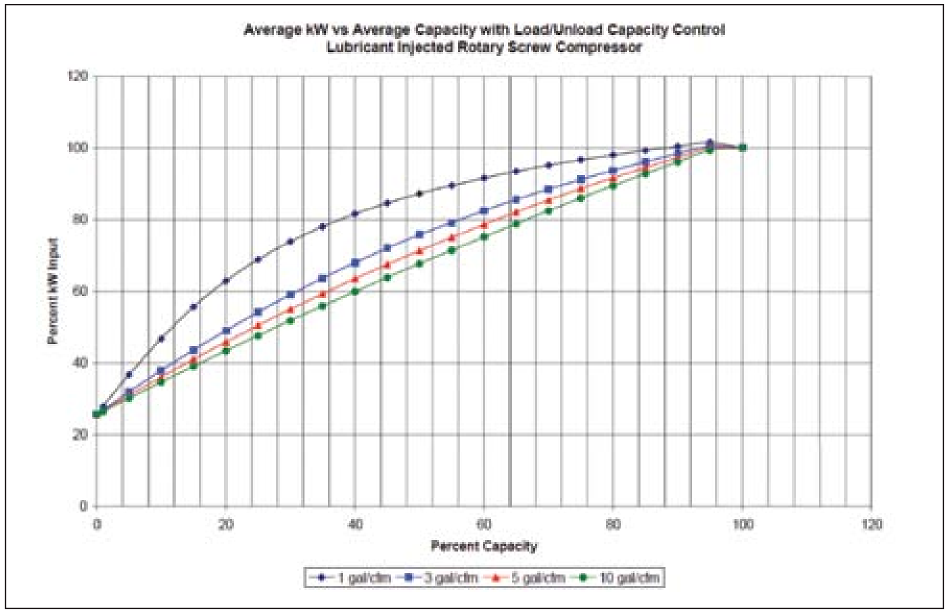

Figure 3: This CAC table can be used to estimate load/unload efficiency at part loads

compressor efficiencies between brands and models. This particular compressor has a specific power of 21.3 kW per 100 cfm as we can see at the bottom of its data sheet. **The key point in looking at this data is to realize that the rating is only valid at full load.**

It is important to realize the CAGI data sheets for fixed speed compressors do not show this efficiency degradation as the compressor is part loaded AND that the efficiency reduction may be dependent on some other system characteristics like the amount of effective storage capacity (Figure 3).

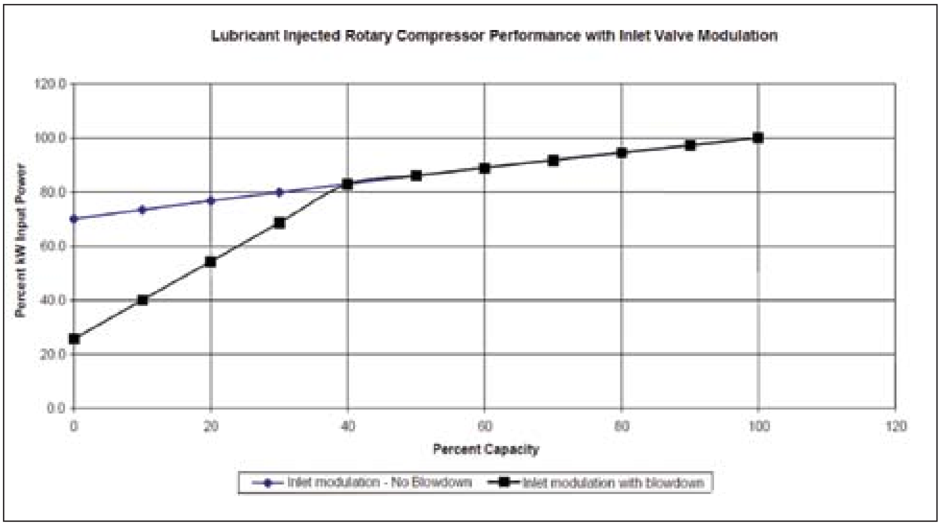

Figure 4: Part load curve for Modulation Source: CAC

OPTIMIZING THE SPECIFIC POWER OF PART LOADED COMPRESSED AIR SYSTEMS

CAC® Qualified Instructor Profile

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KNOW PRESSURE COMPRESSED AIR CHALLENGE

Ron Marshall C.E.T, C.E.M, has been employed with Manitoba Hydro, the crown owned electricity and gas utility in Manitoba, Canada since 1977. He is a Certified Engineering Technologist and has received certification as an Energy Manager, Demand Side Management and Measurement and Verification Professional through the Association of Energy Engineers.

Ron was the first Canadian participant to qualify as a DOE AIRMaster+ specialist. Ron has worked in the industrial compressed air field since 1995 as an Industrial Systems Officer for Manitoba Hydro's Customer Engineering Services Department. Ron is Manitoba Hydro's industrial compressed air systems expert and his efforts contribute to the utility's Power Smart Performance Optimization program, a utility incentive program that supports industrial customer energy audits and electrical and gas efficiency projects.

Ron is a member of Compressed Air Challenge's Project Development Committee and Chair of CAC's Marketing working group. Ron is a frequent contributor to various CAC related magazine articles.

Qualified For:
Fundamentals of Compressed Air Systems

Part Load and Control Mode Tax

If the actual average loading on a system compressor is only about 40% of full load we can see for two common modes of compressor control, Modulation and Load/Unload, the specific power increases significantly. For the compressor shown in Figure 1 the specific power would rise by a factor of almost double to about 44 kW per 100 cfm for modulation mode and for load/unload systems with 1 gallon per cfm storage capacity. Like in the game of golf a higher specific power number means you are doing worse. This new specific power would make the compressed air motor more than 20 times more costly than a direct drive tool.

Studies Reveal Most Systems Run Part Loaded

We've found by studying the Manitoba Hydro service territory that the average air compressor loading ranges between 25 and 40% for single compressor systems. In a typical system the average loading is usually quite a bit lower than the total installed capacity once design for peak loading, safety factors, and production variations due to downtime, personnel breaks, evening shifts, weekends and holidays and such are considered.

If you have an average system with a lubricated screw compressor installed, chances are you are operating inefficiently and compressed air is costing you a bundle. Fortunately there are things you can do about it to improve the numbers.

	Input Power (kW)		Capacity (acfm)[a,d]	Specific Power (kW/100 acfm)[d]
8*	92.6	Max	457.0	20.27
	79.5		391.3	20.31
	66.9		325.7	20.54
	54.9		260.0	21.12
	43.5		194.4	22.40
	32.7	Min	128.7	25.44
9*	Total Package Input Power at Zero Flow[c, d]		0.0	kW
10				

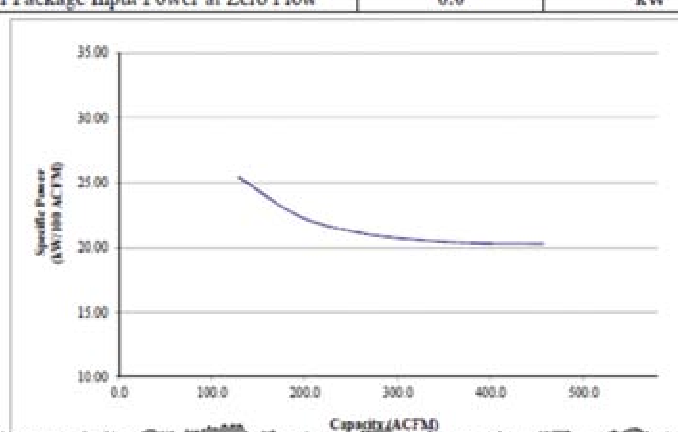

Figure 5: Selected VSD CAGI curve at 125 psi

Adding Storage

So let's take another look at the flow vs. power curves for various compressor control modes. We can see that by adding storage capacity by a factor of 10 and running the compressor in load/unload mode we can realize an efficiency gain.

Let's look at the effect of applying load/unload mode control to the same screw compressor as we compared earlier. If the compressor had 10 gallons of storage capacity, rather than 1 gallon the specific power at 40% loading, the specific power would fall to about 32 kW/100 cfm a savings of 27%, however, this would require a pretty massive storage tank, in this case over 4,000 gallons, about 6 feet round and 20 feet high.

VSD Operation

Table 5 shows a selected CAGI curve for a VSD controlled compressor. These curves can vary depending on the manufacturer and type of compressor and pressure. We can see that by applying a new VSD compressor to an average load of 40% of the original compressor our compressor specific power will reduce to about 23 kW per 100 cfm produced. The VSD mode of operation in this case would achieve savings of around 48% over modulation and load/unload operation with 1 gallon per cfm, and reduce need a storage tank to only about one fifth the size.

What does this mean? The previous discussion shows that if your compressed air system is part loaded applying storage or VSD control mode to your compressed air system can optimize the specific power making it less costly to produce your compressed air.

Additional Savings Measures

- **Elimination of the end uses —** Obviously if it costs 10 to 20 times more to produce the same shaft output we recommend looking at alternate methods of producing the mechanical power. Some specific end uses in your plant could be what CAC classes as "inappropriate". Investigation is required
- **Leakage reduction —** A good way to easily improve your system efficiency and get back part of the leak tax is to find and fix your air leaks, targeting a best practices 10% leakage rate or lower
- **Discharge pressure reduction —** Improving pressure differentials by maintaining and properly sizing filters, air dryers, piping, regulators, connectors and hoses could allow you to reduce the discharge pressure setting of your compressor and save power. For example if the VSD compressor mentioned above was operated at 100 psi it would consume only 18.7 kW per 100 cfm at the 40% loading for a savings of about 20% (based on actual CAGI Data)
- **Right sizing —** The use of a large compressor for a load that is only 40% of its capacity may not be the most economical solution. It may be possible to right size the compressor to a smaller size making the new compressor operate more efficiently closer to full load

Do you want to know more about compressed air optimization? There's help a mouse click away. I would recommend going to the Compressed Air Challenge website and having a look around. There you will find links to training seminars, knowledge resources, tools and links that will help you better understand your compressed air system problems and what to do about them. Website: www.compressedairchallenge.org BP

To read more System Assessment articles, visit www.airbestpractices.com/system-assessments/compressor-controls

"The use of a large compressor for a load that is only 40% of its capacity may not be the most economical solution. It may be possible to right size the compressor to a smaller size making the new compressor operate more efficiently closer to full load."

— Ron Marshall, Manitoba Hydro

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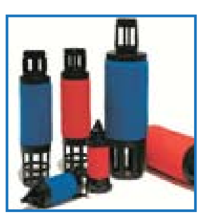

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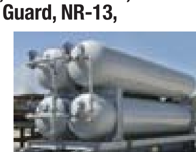

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