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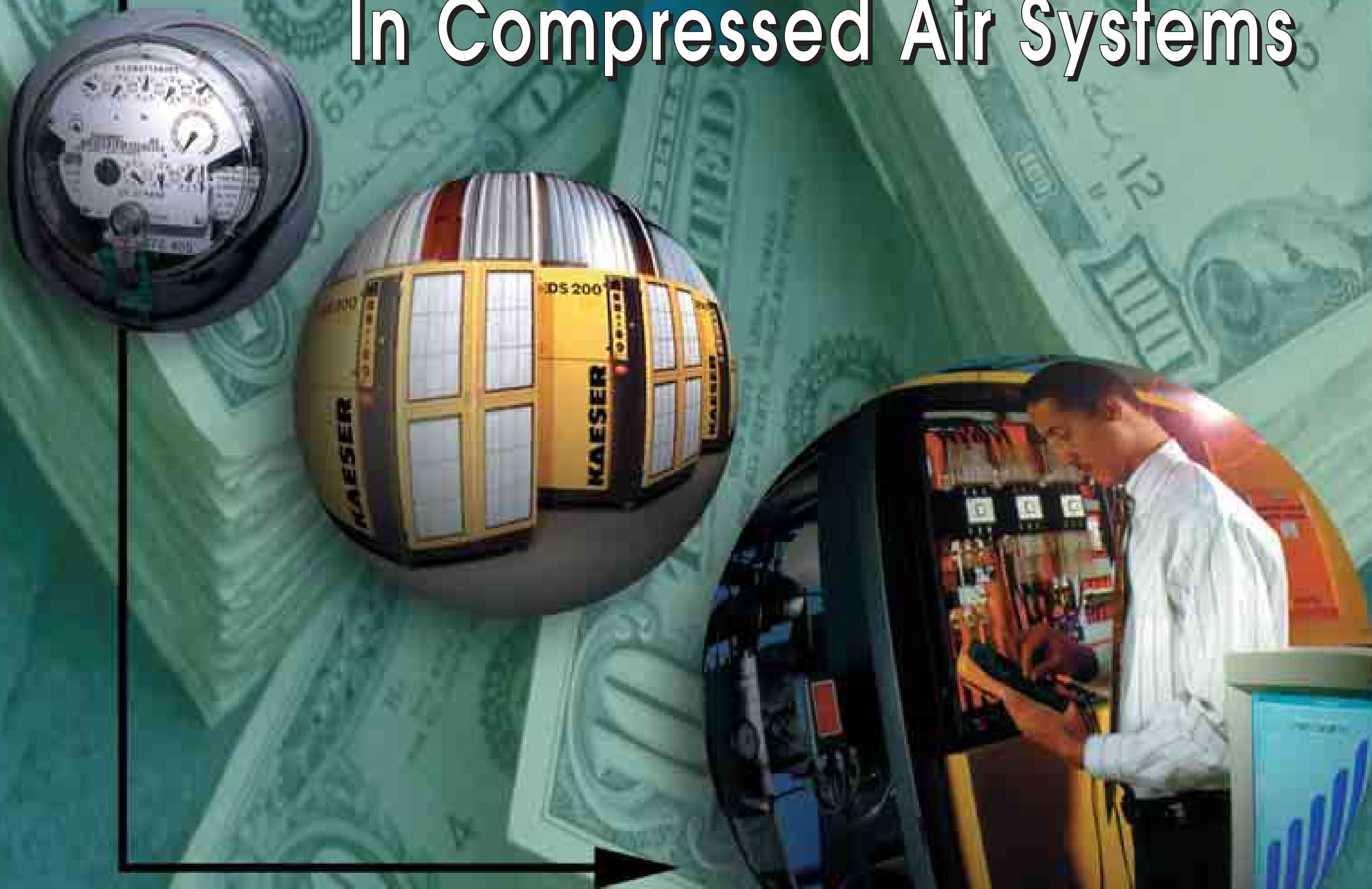
Energy SAVINGS In Compressed Air Systems



- Evaluating Compressor Efficiency
- Cost-Justifying More Efficient Compressors
- Waste Heat Recovery
- Find and Reduce Leaks
- 6 Steps to Energy Savings

Achieve Significant Savings Through Improved Energy Management

Provided as a service by Kaeser Compressors, Inc.

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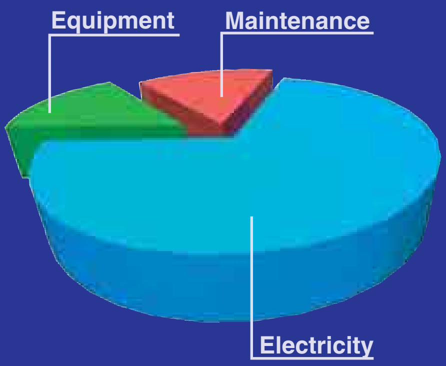
70% of Your Long-Term Compressor Cost is Electricity

Analyze the total cost of a compressed air system and you'll realize that power cost is significant. In just one year it could exceed the cost of the compressor itself. Over a period of ten years, this could consume 70% of your overall costs.

That's why it is important to investigate energy efficiency when considering a new compressor.

Kaeser's proprietary Sigma Profile compresses air efficiently. It delivers up to 20% more cfm per horsepower than other airend designs.



Evaluate your compressed air costs and potential savings

Compressed air is your most expensive utility

This is a fact that has been documented time and time again. It takes 7 to 8 hp of electricity to produce 1 hp worth of air force. Yet this high energy cost quite often is overlooked. Here are some questions you should ask yourself:

Do you know your compressed air costs?

Do you know how much compressed air is really required for your plant?

Do you select compressed air equipment with energy costs in mind?

Do you monitor the use of compressed air like your other utilities?

This brochure gives you the information you need to answer these questions, save energy and improve your compressed air system operation.

Why evaluate energy costs?

Depending on plant location and local power costs, the annual cost of electrical power can be equal to–or as much as two times greater than–the initial cost of the air compressor. Over a 10-year operating period, a 100 hp compressed air system that you bought for $40,000 will accumulate up to $800,000 in electrical power costs. Following a few simple steps can significantly reduce energy costs as much as 35%.

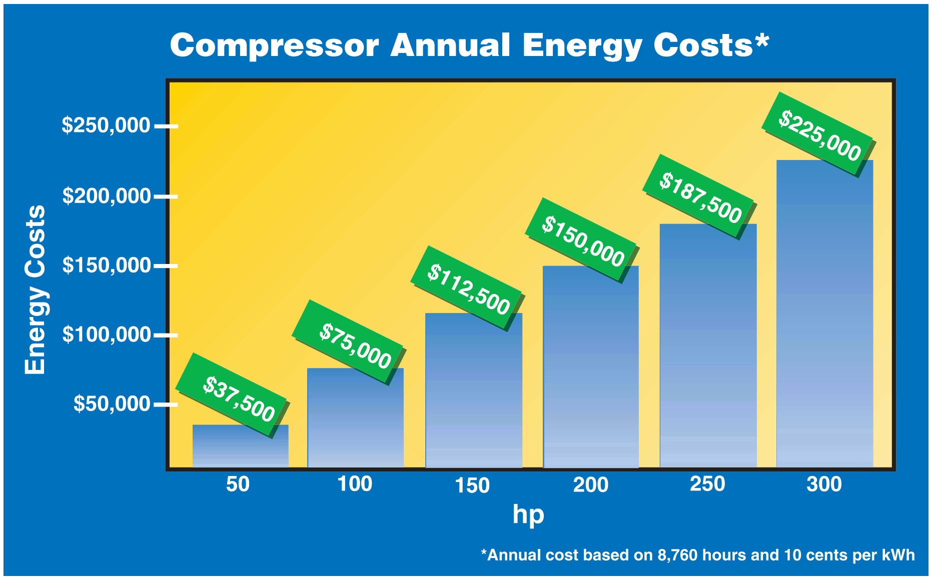


Chart 1

Identifying the electrical cost of compressed air

To judge the magnitude of the opportunities that exist to save electrical power costs in your compressed air system, it is important to identify the electrical cost of compressed air. Chart 1 shows the relationship between compressor hp and energy cost. In addition, consider the following:

Direct cost of pressure

Every 10 psig increase of pressure in a plant system requires about 5% more power to produce.

For example: A 520 cfm compressor, delivering air at 110 psig, requires about 100 hp. However, at 100 psig, only 95 hp is required. Potential power cost savings (at 10 cents per kWh; 8760* hours) is $7025 per year.

Indirect cost of pressure

System pressure affects air consumption on the use or demand side. The air system will automatically use more air at higher pressures. If there is no resulting increase in productivity, air is wasted. Increased air consumption caused by higher than needed pressure is called artificial demand.

An unregulated system using 520 cfm at 110 psig system pressure will consume only 400 cfm at 80 psig. The potential power cost savings (520 cfm - 400 cfm = 120 cfm = 24 hp, at 10 cents/kWh; 8760 hrs.) is $16,864/year.

Also remember that the leakage rate is significantly reduced at lower pressures.

The cost of wasted air volume

Each cfm of air volume wasted can be translated into extra compressor hp and is an identifiable cost. As show by Chart 1, if this waste is recovered, the result will be about $750/hp per year in lower energy costs.

Select the most efficient control

The magnitude of the above is solely dependent on the ability of the compressor control to translate reduced air flow into lower electrical power consumption.

Chart 2 shows the relationship between the full-load power required for a compressor at various air demands and common control types. It becomes apparent that the on line—off line control (dual control) is superior to other controls in translating savings in air consumption into real power savings. Looking at our example of reducing air consumption from 520 cfm to 400 cfm (77%), the compressor operating on dual control requires 83% of full-load power. That is 12% less energy than when operated on modulation control. If the air consumption drops to 50%, the difference (dual vs. modulation) in energy consumption is increased even further, to 24%.

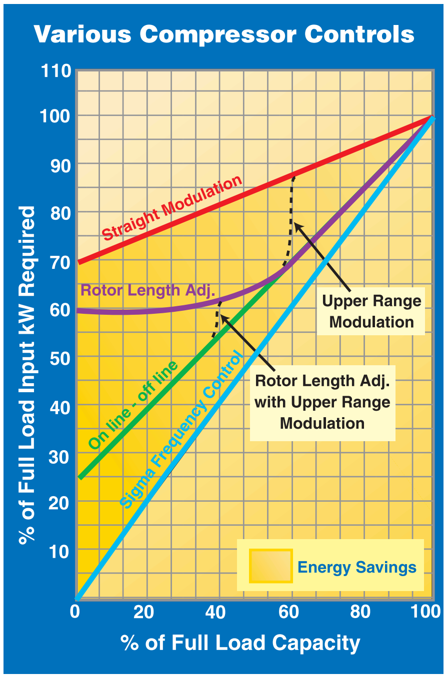


Chart 2

Reliable Controls

Developed by Kaeser in conjunction with Siemens AG, this patented compressor control features an industrial based PC with an Intel® microprocessor inside. Five different compressor control configurations are available to precisely match compressor performance to air demand and increase energy savings.

With Sigma Control, compressor systems can be monitored and adjusted from any location worldwide. Sigma Control also features extensive capabilities for maintenance trending and air demand tracking.

**8760 hours is based on operating 24 hours/day, 7 days/week, 52 weeks/year.*

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Sigma Profile Airend

Airend performance is critical to the compressor's overall efficiency and thus the compressor's energy consumption and operating costs. The Sigma Profile airend, developed by Kaeser Compressors, can save up to 20% in energy consumption. The Sigma Profile is standard on Kaeser rotary screw compressors. Units are available from 5 to 3000 cfm with discharge pressures up to 217 psig. Rotary screw compressors produce virtually pulsation-free air.

Justify a more energy-efficient compressed air system

Look beyond the purchase price

As noted earlier, the electrical power costs of a compressed air system impact the bottom line far more than initial price and maintenance. How can we evaluate the true impact each element of the compressed air system has on the electrical power costs?

The air compressor package

The air compressor package has a very significant impact on overall operating power costs. There are other pieces of equipment in a compressed air system that support the air compressor. These also impact on power costs, both directly and indirectly, but the core of it all is the air compressor package. Energy wasted at the air compressor site can never be recovered.

What are the components of an air energy-efficient compressor?

Compressor element (airend) - performance can vary up to 20% depending on what airend size and style is used.

Drive motor efficiency - at the 100 hp size, there is a maximum efficiency difference of no more than 2% between EPAct and premium efficiencies. Referring to the previous example, a 100 hp compressor would save $1500 annually.

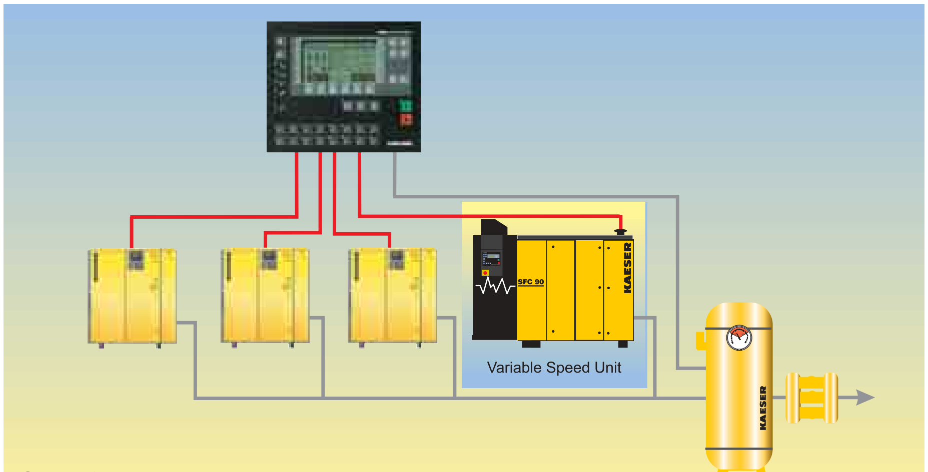
Compressor controls - are an important part of the air compressor package, matching compressor supply to demand. As outlined previously, the right control type (dual control) is essential for efficient operation. Maximum savings of 45% are possible (refer to Chart 2). Any reduction of air usage in a system accomplished by good demand-side management (adequate storage and flow controller) can be translated into real power cost savings by the control system, and none does this better than dual control.

Important Formulas

$$\text{Power cost} = \frac{(\text{hp})\ (0.7457)\ (\text{power rate})\ (\text{hours})}{\text{motor efficiency}}$$

$$\text{Horsepower (3 ph)} = \frac{(\text{volts})\ (\text{amps})\ (1.732)\ (\text{motor eff.})\ (\text{power factor})}{746}$$

$$\text{Horsepower (1 ph)} = \frac{(\text{volts})\ (\text{amps})\ (\text{motor eff.})\ (\text{power factor})}{746}$$



State-of-the-art control systems generate large savings.

System master controls

A microprocessor-integrated controller allows the system to maintain a stable system pressure and ensures that only needed compressor units are operating at their most efficient level.

User-friendly, PLC-based controllers can mix and match compressor supply to demand, including automatically shutting off units not needed, and bring on backup units as required.

Advanced controllers not only sequence and select units as required, but also ensure that no more than one unit in a multiple-unit installation will be operating at inefficient part load. All other units will be operating efficiently at full load.

Electrical power savings result from operating fewer compressors at a lower pressure than with conventionally controlled compressors.

Reduce pressure drop in system components

When buying or replacing equipment, make sure it maintains low pressure drop over its entire service life. Also, ensure that filters and dryer are sized and maintained properly. The total pressure drop across all compressed air system components, including piping, should not exceed 15 psi.

Remote Monitoring

Sigma Air Manager combines the benefits of modern industrial PC technology with Internet technology to provide unparalleled compressor control, monitoring and reports. Optional software provides enhanced reporting and enables end users to control air system operation from any location.

Efficiency Rules of Thumb

- Air compressors normally deliver 4 to 5 cfm per horsepower at 100 psig discharge pressure.
- Total pressure drop across all compressed air system components, including piping, should not exceed 15 psi.
- Compensating for pressure drop consumes about 1% more power for every 2 psi adjustment at the compressor.
- Power cost for each 1 horsepower operating constantly for one year at 10 cents per kwh is about $750.
- Leak costs add up quickly. Just one 1/16” leak at 100 psig consumes 6.5 cfm (approx. 1.5 hp).
- Size air storage tanks and pipes based on your demand profile. Many systems lack adequate storage. Larger tanks are often an inexpensive way to improve system performance.
- A 50 hp compressor rejects heat at approximately 126,000 Btu per hour. Approximately 119,600 Btu/hr of this is recoverable.

Add to your savings with waste heat recovery, flow controller, and leak reduction

Top exhaust compressors facilitate energy-saving heat recovery without adding to system footprint.

Intermediate flow controls reduce leak losses and artificial demand while maintaining optimum pressure and flow.

Waste heat recovered from compressors can be used for heating

The heat generated by air compressors can be used effectively within a plant for space heating and/or process water heating. Considerable energy savings result in short payback periods.

Process heating: Heated water is available from units equipped with water-cooled oil coolers and aftercoolers. Generally, these units can effectively discharge the water at temperatures between 130°F and 160°F.

Space heating is essentially accomplished by ducting the heated cooling air from the compressor package to an area that requires heating. If ductwork is used, be careful not to exceed the manufacturer's maximum back-pressure allowance. When space heating is used in the winter, arrangements should be made in the ductwork to return some of the heated air to the compressor room in order to maintain a 60°F room temperature. This ensures that the air discharged is at comfortable levels.

Waste heat recovery is particularly effective when the primary air compressor package is an oil-cooled rotary screw type.

Estimating the real energy savings in dollars must include identifying the actual cost of the current source of energy (natural gas, electric, propane, etc.). (See Energy Savings Through Heat Recovery.)

Use of flow controllers

Most compressed air systems operate at artificially high pressures to compensate for flow fluctuations, leaks and downstream pressure drops caused by lack of "real" storage and improperly designed piping systems. Even if additional compressor capacity is available, the time delay caused by bringing the necessary compressor(s) on-line would cause unacceptable pressure drop.

Operating at these artificially high pressures requires up to 25% more compressor capacity than actually needed. This 25% in wasted operating cost can be eliminated by reduced leakage and elimination of artificial demand.

A flow controller separates the supply side (compressors, dryers, and filters) from the demand side (distribution system). It creates "real" storage within the receiver tank(s) by accumulating compressed air without delivering it downstream. The air

Energy Savings Through Heat Recovery

$$\text{Btu savings/yr.} = 0.95^{*} \times \text{compressor hp} \times 2545\ \text{Btu/hp} \times \text{hrs operation/yr.}$$

$$\text{\$ savings/yr.} = \frac{\text{Btu savings/yr.}}{\text{Btu/unit of alternate fuel}} \times \text{\$ fuel cost/unit of alternate fuel}$$

**air cooled*

Btu/unit of alternate fuels:

Electricity	=	3413 Btu/kWh	Gasoline	=	125,000 Btu/gal
Firewood	=	20,960,000 Btu/cord	Kerosene	=	135,000 Btu/gal
Natural gas	=	1000 Btu/cu ft	Propane	=	91,500 Btu/gal
#2 oil	=	138,500 Btu/gal			

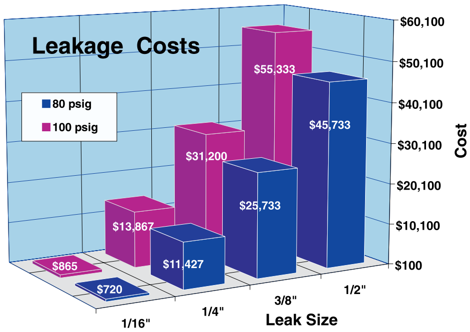
pressure only increases upstream of the air receiver, while the flow controller delivers the needed flow downstream at a constant, lower system pressure. This reduces the actual flow demand by substantially reducing leakage and artificial demand.

Find and reduce leaks

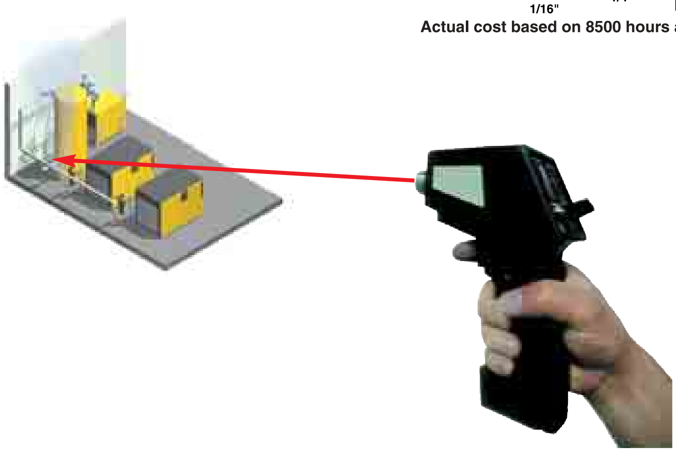
Leaks are expensive. Statistics show that the average system wastes between 25 and 35% to leaks. Routine leak monitoring and repair is essential to control costs. Equip maintenance personnel with proper leak detection equipment, and train them in how to use it. Establish a routine for regular leak inspections. Involve both maintenance and production personnel.

As a start, measure the leak rate during non-operating hours. Pump the system up to operating pressure, turn off the compressor and measure how long it takes for the pressure to drop from operating pressure to another chosen level. From this you can calculate the leak rate.

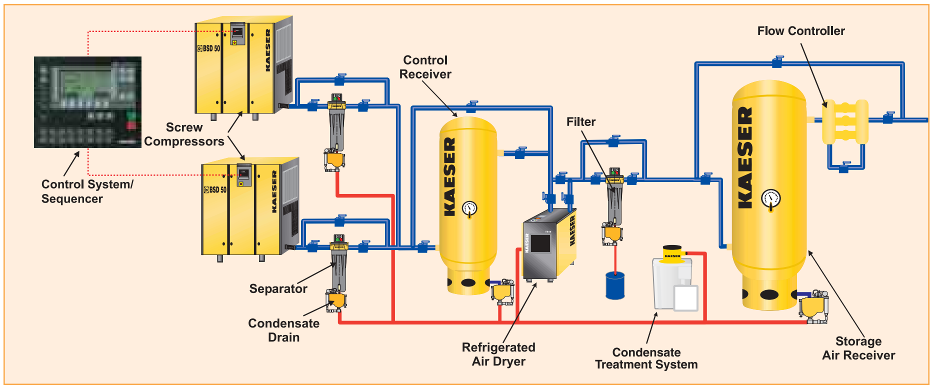
A 3/8" leak at 100 psig, for example, may cost $30,000 per year (see chart below). The higher the system pressure, the more air lost through leaks.



Actual cost based on 8500 hours and 8 cents/kWh



Ultrasonic leak detector



Optimized Compressed Air System

This diagram depicts multiple compressors controlled by a system controller, followed by clean air treatment and a storage air receiver with a flow controller. This setup ensures optimal use of energy.

Comprehensive leak detection device

A comprehensive leak detection device is used for compressed air and vacuum systems, valve seats, drain traps, tanks, and pipe lines. This device can also be used for mechanical checks on bearings and gear boxes.

Easy to Maintain

Kaeser compressors are designed for easy maintenance and serviceability. The air filter, fluid filter, and fluid separator are all easy to reach, check, and replace. Special inlet filter mats are readily accessible. To facilitate fluid changes, each rotary screw compressor is fitted with a fluid change pressurization valve and drain hose. The doors and lid on the compressor cabinet allow immediate access to all maintenance points.

Mission Statement

We strive to earn our customers' trust by supplying high quality Kaeser air compressors, related compressed air equipment and premium blower systems. Our products are designed for long-term reliability, easy maintenance, and energy efficiency. Prompt and dependable customer service, quality assurance, ongoing training, and engineering support contribute to the value our customers have come to expect from Kaeser. Our employees are committed to implementing and maintaining the highest standards of quality to merit customer satisfaction. We aim for excellence in everything we do.

Our engineers continue to refine manufacturing techniques and take full advantage of the newest machining innovations. Extensive commitment to research and development keeps our products on the leading edge of technology to benefit our customers.

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Member of Compressed Air and Gas Institute CAGI www.cagi.org

Take 6 steps to energy savings

STEP	HOW TO DO IT	POTENTIAL SAVINGS Percent	$/Year**
Step 1: ❑ Evaluate your compressed air costs.	✓ Add up all compressor capacity (in cfm). ✓ Determine average air demand (in cfm).* ✓ Use Chart 2 to determine % of full load power (dual or modulation control). Chart 1 gives you energy costs/year (correct for kWh cost if other than 10 cents/kWh).		
Step 2: ❑ Identify wasted air volume.	✓ Check leakage rate during off periods. ✓ Determine what pressure is really needed at point of use. ✓ Calculate wasted air through "over" pressurization. (Artificial demand, increased leakage)** See page 2 and 3.	**10 - 35%**	**$7500 - $26,250**
Step 3: ❑ Calculate specific performance	✓ Conduct power cost analysis to compare specific performance, using CAGI data sheets when available.	**20%**	**$15,000**
❑ Select most efficient compressor control.	✓ Properly sized compressors running in dual control mode frequently offer best efficiency.	**0 - 45%**	**$0 - $33,7500**
Step 4: ❑ Reduce pressure drop in your compressed air system.	✓ Measure pressure drop at maximum flow across all system components (piping, dryers, and filters). ✓ Equip filters with differential pressure gauges and routinely replace filter elements ✓ Periodically calculate pressure losses due to pipe friction and upgrade piping as needed.	**0 - 10%**	**$0 - $7500**
Step 5: ❑ Stabilize and/or reduce system pressure.	✓ Install a Flow Controller in conjunction with appropriate storage volume.* ✓ Install master controllers in multiple compressor installations.*	**10 - 25%**	**$7500 - $18,750**
Step 6: ❑ Evaluate potential for heat recovery.	✓ Identify applications which require heating (i.e. space heating and water or other liquids). ✓ Analyze existing costs for these applications. See page 6. ✓ Implement compressor duct system or liquid/oil heat exchanger(s).	**0 - 90%**	**$67,500**

*We recommend that you contact your compressed air specialist for additional support.

**Potential savings are based on 100 hp compressor installation operating 8760 hrs/year @ 10 cents/kWh.

NOTE: Potential savings are not necessarily cumulative.