

Compressed Air Systems

work

Energy Smart.

Many businesses use compressed air in their day to day activities for production line equipment, pneumatic tools or pneumatic control systems.

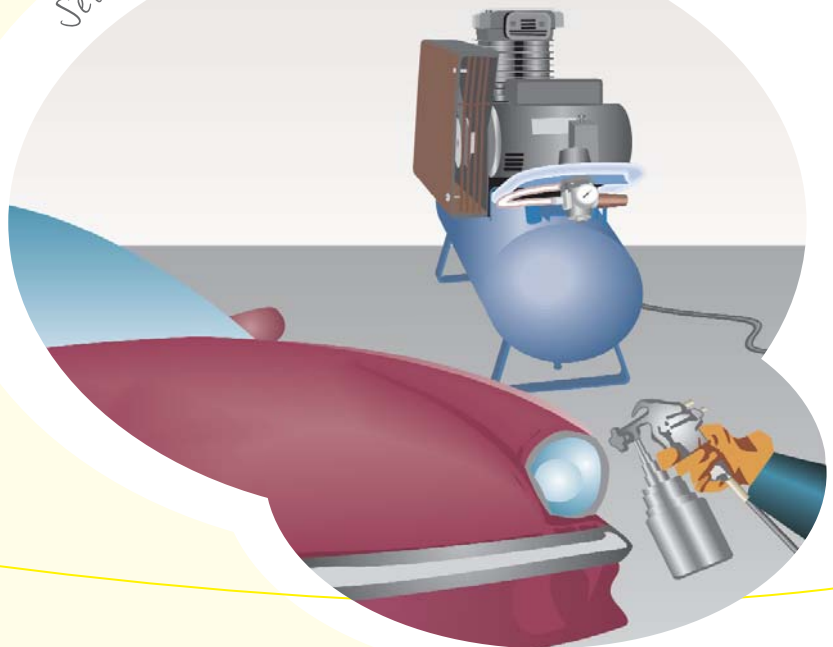
Compressed air is often viewed as 'free' energy, but the generation of compressed air can make up a large part of total energy use. In addition, leaks, mismatched supply/demand and inappropriate uses will result in unreliability, wasted energy, reduced productivity and higher operating costs.

By paying attention to your compressed air system you can improve efficiency, reduce costs and increase productivity and reliability. This can lead to improved competitiveness, less downtime and greater return on your investments.

Facts and Figures

- Up to 90% of the energy used to compress air is wasted and is discharged as heat.
- Around 10% of all industrial electrical consumption in Australia is used to produce compressed air.
- At a nominal pressure of 700kPa, every 50kPa increase in compressed air pressure increases energy use by approximately 4%.
- Leaks in compressed air systems waste energy and can account for up to 30% of a compressor's output. This will cost you money and will reduce the operating life of your system.
- Energy used for compressed air can cost 7 to 10 times more than electrical energy when used for mechanical or process related work.
- Most energy savings opportunities are quite simple and do not require significant capital outlay.

Set pressure to minimum required for the task



Types of Compressors

There are 4 main types of air compressors:

Reciprocating compressors - operate in a similar way to a car engine - air is drawn into a cylinder through the action of a piston. Pressure can be developed on one or both sides of the piston. They are the most energy efficient, both at full and part loads.

Rotary vane compressors - a rotor with sliding vanes is used. As the 'non-centred' rotor rotates, the sliding vanes form spaces, which expand and contract through one complete turn, so air is drawn in, compressed and let out when an exhaust port is exposed. They are moderately efficient at low loads, although their efficiency decreases with size.

Rotary screw compressors - two meshing helical rotors rotate in opposite directions. The free space between the rotors decreases axially, which compresses the air trapped between the rotors. For large industrial uses, these compressors usually cost the least to purchase and install but can be expensive to run. They rapidly lose efficiency at part load, unless variable speed drives are used.

Centrifugal compressors - air is accelerated by high speed rotating impellers. To reach the required operating pressures, several impeller stages may be required. They have low installation costs but are expensive to purchase. They are relatively efficient down to about 60% of their design output.

Air compressor efficiencies

Standards exist for testing the performance of a compressor but they have not always been applied consistently and performance test results and efficiency ratings are not always published in standard formats. The result is that purchasers can find it difficult to compare air compressor performance.

When comparing the performance of different compressor models it is important to ensure that the systems have been tested using the same standard methodology and that the information provided is consistent. Comparing systems that have been tested using different 'standard' conditions (pressure, temperature and humidity), system losses and motor

ratings can impact on the overall estimation of system efficiency by 5% or more.

Each compressor type has its advantages and each should be considered.

Comparison of different compressors.

Item	Reciprocating	Rotary Vane	Rotary Screw	Centrifugal
<i>Efficiency at full load</i>	High	Medium - high	High	High
<i>Efficiency at part load</i>	High due to staging	Poor: below 60% of full load	Poor: below 60% of full load	Poor: below 60% of full load
<i>Efficiency at no load (power as % of full load)</i>	High (10% - 25%)	Medium (30% - 40%)	High-Poor (25% - 60%)	High-Medium (20% - 30%)
<i>Noise level</i>	Noisy	Quiet	Quiet-if enclosed	Quiet
<i>Size</i>	Large	Compact	Compact	Compact
<i>Oil carry over</i>	Moderate	Low-medium	Low	Low
<i>Vibration</i>	High	Almost none	Almost none	Almost none
<i>Maintenance</i>	Many wearing parts	Few wearing parts	Very few wearing parts	Sensitive to dust in air
<i>Capacity</i>	Low - high	Low - medium	Low - high	Medium - high
<i>Pressure</i>	Medium - very high	Low - medium	Medium - high	Medium - high

Matching systems with your business

The type of compressor system you choose for your business should be based on what it will be used for.

Reciprocating compressors are the most commonly used. They are best used where operations are short-term or intermittent and where the load fluctuates, such as panel and paint shop businesses. These compressors can also serve as a backup to screw compressor systems where the daily air profile is fairly constant but weekends or nights have smaller more variable air requirements.

Rotary screw compressors are best used in production line situations where operation is continual and you need a relatively constant 'base load' air supply. Under these conditions, they are very efficient, however, under low or no load conditions they control their output by reducing their inlet volume, reducing efficiency dramatically. Essentially the system uses the same amount of electricity at all times, regardless of its output due to the constant operation of the compressor

The following table compares different types of compressors.

motor. This wastage can be moderated by the use of variable speed drives.

Centrifugal compressors are used in a wide range of applications, but are best suited to operations that require very large quantities of compressed air such as in textile mills.

Rotary vane compressors are used in a wide variety of applications. They are best suited to applications when used at full load.

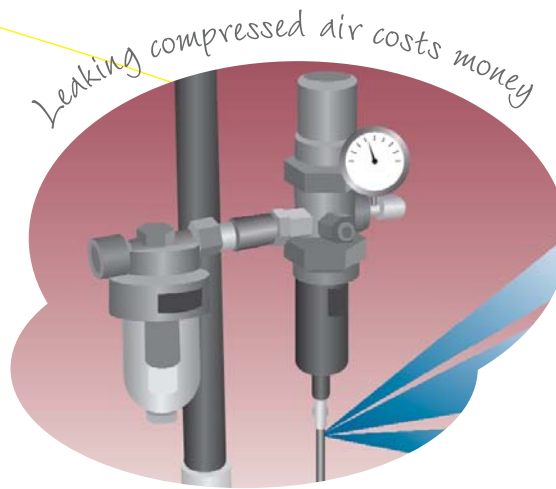
Life Cycle Costs

The lifetime cost of a compressed air system generally follows the 80/20 rule. Maintenance and energy accounts for 80% of the total costs and the purchase cost is about 20% of the lifetime costs (over a 15 year life).

For example, a typical standard 7.5 kW compressor costs approximately \$6,500 to purchase and will incur operating costs of approximately \$24,500 over its 15 year life (at 3,100 hours/year, \$0.10/kWh, 0.7 load factor).

Strategies for improving the efficiency of your system

Check for leaks regularly - simply walking around your plant during shutdowns and listening can identify many leaks. Other methods include spraying joints or suspect areas with soapy water and looking for bubbles or using ultrasonic detection equipment. The following table shows the estimated costs for leaks of various sizes.



Costs of leaking pipes.

Hole size (mm)	Volume of air lost (litres per second)	Approximate annual energy use (kWh)	Approximate annual cost of leak (\$)
0.4	0.2	130	13
0.8	0.8	530	53
1.6	3.2	2,100	210
3.2	12.8	8,500	850
6.4	51.2	34,000	3,400
12.8	204.8	136,200	13,620

Assumptions: operating pressure of 700kPa, 2,000 hours per year, electricity tariff of 10 c/kWh.

Reducing air pressure at the compressor - make sure the air is delivered at the right pressure and in the right quality. Every 50kPa increase in pressure raises energy consumption by approximately 4%. Setting the system pressure to the minimum level required to do the job will significantly reduce energy use and wear and tear on the equipment.

Minimise pressure drop - consider the efficiency of the components in your system, including air treatment equipment such as filters, dryers and coolers. Other factors that can reduce pressure drop include:

- reducing the distance the air travels through the system by locating the compressor as close as possible to the point of use
- making your distribution lines as straight as possible - the less bends in the system the better the airflow
- ensuring piping is adequately sized.

Design your system correctly - it is possible to design a compressed air system so that the system is modular, comprising of a number of smaller systems that can be operated independently or as part of the complete system. This will allow sections to be added or removed as required. You should try to:

- match the compressor capacity as closely as possible to demand
- size receivers (storage tanks) to cater for short heavy demand
- use only high quality (clean and dry) air - filters and dryers accentuate pressure drop
- install variable speed drives where feasible to allow power consumption to react to system demand
- where practical, use multi-stage compressors
- install pipes that allow condensate to drain away.

Cool intake air - the cooler the intake air, the more efficiently your compressor will work (cool air is denser). Using cooler air rather than warm air can reduce energy use by up to 6%. Try to shade your compressor or, if it is located inside, duct in cool air from outside.

Pressure Drop

Pressure drop is the reduction in air pressure from the output of the compressor to the actual point of use. Pressure drop occurs as the compressed air travels through the treatment and distribution system. A pressure loss of less than 10% of the compressor's discharge pressure, measured from the receiver tank output to the point of use, is considered typical of an efficient system.

The outcomes of a poorly designed system, with excessive pressure drop, are poor system performance and excessive energy use. Restrictions in airflow will result in higher operating pressures than are needed and consequently higher energy consumption.

There are a number of factors that can contribute to a reduced operating pressure at the point of use. Before increasing the capacity or the system pressure, which will result in a significant increase in energy consumption, try reducing the pressure drops in the system. This may ease the problem.

Causes of Pressure Drop

Any type of obstruction that interferes with flow will result in pressure drop. Selecting the right pipe size is critical. Small pipes result in high air velocities, with the resulting friction inside the pipes causing excessive pressure drop.

Restrictions, such as bends in pipe work or roughness on the inside of the pipe, all act to restrict flow and cause a drop in pressure. Deadlegs (pipe work servicing unused equipment) in delivery systems will also have a detrimental impact on the performance of the system and should be removed.

Generally, pressure drop is greatest at the point of use, through flexible or undersized and leaking hoses, tubes, filters, regulators and lubricators.

At the supply side of systems, air/lubricant separators, after-coolers, moisture separators, dryers and filters are significant factors impacting on pressure drop.

Efficient operation of your system - ensure the compressor and other equipment (refrigeration, air dryers etc) are turned off when not being used. This can be done manually or by installing automated controls.

Reduce operating hours - if your plant requires reduced amounts of air outside normal hours, consider using either a dedicated system or a smaller compressor.

Optimise compressor sequencing - where there is more than one compressor, consider automating sequencing so the appropriate unit meets different levels of demand.

Eliminate inappropriate use - many tasks that use compressed air can be carried out more efficiently using an alternative technology. Things to avoid include:

- creating a venturi vacuum system by passing high-pressure air past an orifice. Install dedicated vacuum technology instead
- using compressed air instead of blowers (fans) for cooling, agitating, mixing and to inflate packaging
- cleaning or dusting with compressed air. Brushes, blowers or vacuum systems are better suited to these tasks and use less energy
- using compressed air to drive motors where electrical drives can be utilised. It is important to be aware, however, of other system requirements, such as system control, reliability and safety, which may mean that compressed air systems are preferable
- using compressed air instead of low pressure air for blow guns, air lances or agitation
- supplying air to any decommissioned equipment or to un-regulated end users. 'Dead-legs' should be disconnected from the system as far back in the network as possible to reduce system pressure drop.

Regular maintenance - following the manufacturer's recommended maintenance schedule will ensure your system is operating in an efficient manner. You should always:

- keep the air filters clean. Dirty or damaged air filters will increase pressure drop and make your compressor work harder
- ensure condensate drain traps are operating correctly to minimise condensate build up and air wastage from open drains.

Recover waste heat - recovering heat (e.g. from the compressor cooling fins) rejected during the compression process can reduce the energy used in other processes. The amount of savings will depend on the type of fuel being replaced. Possible applications include:

- pre-heating boiler feedwater (i.e. up to 60°C)
- warm water for industrial cleaning processes.

Air Pressure and Volume

Although air requirements can vary between processes, the most common operating compressed air pressure is around 700 kPa.

A very common misunderstanding is that the air pressure should be increased if more airflow is required. However, the reverse is often true. When pressure is increased the flow rate is reduced as the following equation shows.

$$\text{Volume of compressed air} = \frac{\text{Free air volume} \times \text{Initial pressure}}{\text{Final pressure}}$$

Where; pressure is in absolute units

In addition, airflow from leaks, open blowing and production applications without regulators, will increase as system pressure is raised. This 'artificial demand' substantially increases energy consumption and reduces system life.

A more efficient alternative to increasing the compressor discharge pressure or adding additional compressors should be considered. You should look into the following:

- the potential to reduce system pressure drop
- adding or increasing storage capacity
- demand/intermediate controls
- equipment should be specified and operated at the lowest efficient operating pressure.

It is also important to ensure that the compressor discharge air pressure is set at the minimum required to meet the maximum end user air pressure requirement. Too high a pressure can increase equipment maintenance requirements, exacerbate leaks, and increase operating costs.

On the other hand, too low a pressure will reduce tool efficiencies and may impact on overall production times. A simple method for finding the lowest possible pressure is to establish which piece of equipment has the greatest pressure requirements. Then gradually turn down the compressor pressure until the low pressure has a detrimental effect on the equipment operation.

Alternatively, if there is one piece of equipment that requires air at a pressure substantially higher or different to the rest of the system, consider providing a dedicated compressor for the job. This will allow you to reduce the pressure of the larger system.

More Information

If you would like more information regarding compressed air systems you should contact a consultant or engineer. Further energy saving advice for business is also available from SEDO's **Energy Smart Line**. Simply call **1300 658 158** or alternatively visit SEDO's website at www.sedo.energy.wa.gov.au

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