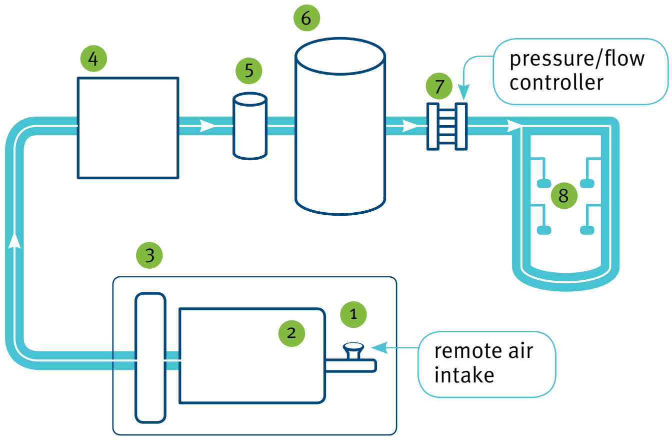
COMPRESSED AIR EFFICIENCY – U4

Eco-efficiency resources for the food processing industry

Compress your costs

Compressed air is used widely by the food processing industry for a variety of tasks including vacuum packing, cleaning, spray coating, conveying and bottling. These processes are very inefficient with around 80 per cent of electricity input lost in waste heat. As air compressors usually consume their purchase price in electricity every year it is essential to design systems carefully and optimise their operation and maintenance.



Compressor package enclosure

The diagram above is a typical compressed air system. The inlet filter **1** removes any particles from the outside air before it enters the compressor. The compressor **2** then compresses the air, increasing its pressure and making it hot and wet. The aftercooler **3** helps to cool the air and remove moisture before it travels to a dryer **4** that will eliminate any remaining water. An air filter **5** removes any remaining solids before the compressed air is stored in a receiver tank **6.** When the compressed air is needed it travels from the tank along distribution lines **7** to individual tools or end points **8.** Any moisture that condenses out in the air lines is caught and removed by condensate traps.

Reduce leakage losses

Leakage is usually the largest source of energy waste associated with compressed air usage. Table 1 provides an indication of the cost of leaks. Visible pipework also makes it easier to detect leaks.

Smaller leaks can also be detected by applying soapy water to joints or connections and looking for bubbles. Leaks should be tagged and repaired immediately.

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Larger leaks can sometimes be identified by shutting off all other equipment and simply listening. The compressor will cease running when the required pressure is reached if there are no leaks.

When equipment shutdown is not feasible an ultrasonic leak detector can be used. These detectors are simple to use and can detect leaks inaudible to the human ear.

Leaks not only waste energy but also cause pressure drops that adversely affect the operation of air-using equipment and tools, which reduces production efficiency.

Table 1: Cost of compressed air leaks[1]

Equivalent hole diameter (sum of all leaks)	Quantity of air lost per leak (m^3/year)	Cost of leak ($/year)
Less than 1 mm	6,362	95
From 1 to 3 mm	32,208	483
From 3 to 5 mm	117,633	1,764
Greater than 5 mm	311,738	4,675

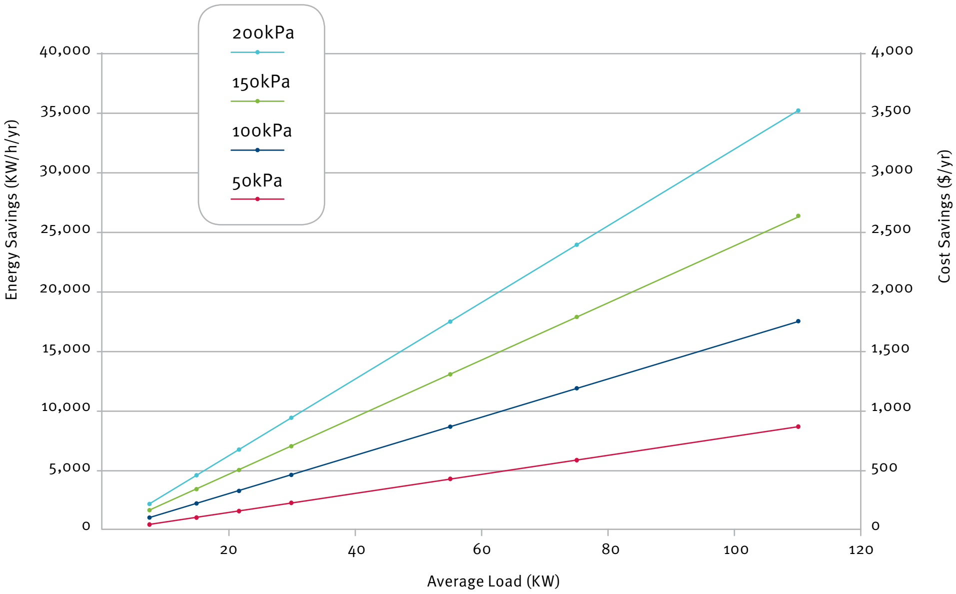
Assumption: 700 kPa system, operating 2000 hrs/year, electricity costs 10 cents/kWh

Reduce the air pressure of the system

Many systems are operated at higher pressures than necessary to compensate for possible leaks and pressure drops. This actually promotes leaks and may also damage equipment. Lowering pressure set points or pressure drops throughout the system can reduce the operating pressure needed.

Figure 1 below provides an indication of savings (in energy and costs) that could be made by reducing the pressure in 50 kPa increments for 700 kPa system operating 2000 hrs/year. The savings are given at loads varying from 7.5 kW to 110 kW. Calculations are based on an electricity cost of 10 cents/kWh.

Figure 1: Potential costs and energy savings that can be made by reducing air pressure[22]



Compressor system consisting of (left to right) a nitrogen generator used for food packaging, four air filters, a receiver tank and two compressors.

Reducing pressure set points

Air pressure should be the minimum required for the end use application. This can be determined by investigating the pressure required by equipment and tools.

In some cases, isolated pieces of equipment require significantly higher pressure. Redesigning individual items or installing a second compressor to service these items may be more cost effective. Some sites are divided into high and low-pressure networks.

1 SEDA (Sustainable Energy Authority Victoria), 2000, Energy Smart Compressed Air Calculator, Sustainable Energy Development Authority, Sydney, www.energysmart.com.au/wes/displayPage.asp?PageID=53&t=20068429

2 SEDA, 2002, Energy and Greenhouse Management Toolkit, www.sustainability.vic.gov.au/resources/documents/Modules.pdf

If it is not possible to separate items that require lower air pressure than the main supply, pressure regulators can be fitted to prevent over supplying the end use.

For larger systems with numerous take-off points, a ring main is the preferred layout. Ring mains supply air to equipment from two directions halving the velocity and reducing the pressure drop. Ring mains also allow isolation valves to be incorporated for servicing without interrupting other equipment.

For simple systems where the point of use and supply are relatively close together, single lines are more suitable.

The *Good practice guide on energy efficient compressed air systems* from the Carbon Trust provides more information www.bcas.org.uk/pdf/carbontrust/GPG385.pdf

Reduce pressure drops throughout the system

Pressure drops typically occur as air travels through obstructions such as dryers or filters, or restrictions that resist air flow, such as piping, bends or roughness. In a properly designed system, pressure drops should be kept below 10 per cent of the compressor discharge pressure.[3]

Dirty filters can typically cause an increase in power consumption of three per cent. [4]

Possible opportunities to reduce pressure drops

- Selecting, sizing and maintaining air treatment components such as dryers and filters with the lowest possible pressure drop whilst providing complete protection. Filters should be cleaned and replaced as per the manufacturer's instructions.
- Optimising the design of air treatment equipment to reduce the surface area of the pipe. This will reduce water condensation in the lines and potential corrosion.
- Automatic condensate traps, which only open when water is present, can be used instead of manual condensate traps if the traps are often left open. Reliable and low maintenance electronic condensate drain traps are also available that ensure no air is lost when water is discharged.[5] Strainers fitted prior to the trap improve the trap's efficiency as they protect the trap from fouling. If this is an ongoing problem, traps with a blast action discharge should be considered. Ensure drains are located correctly.
- Keeping the distance of piping as short as possible and minimize bends to reduce losses.
- Making sure pipe joins allow smooth air feed to reduce turbulence.
- Sizing piping based on peak flow rate and pipe length.

Air compressor filters

Reduce the temperature of the compressor's inlet air

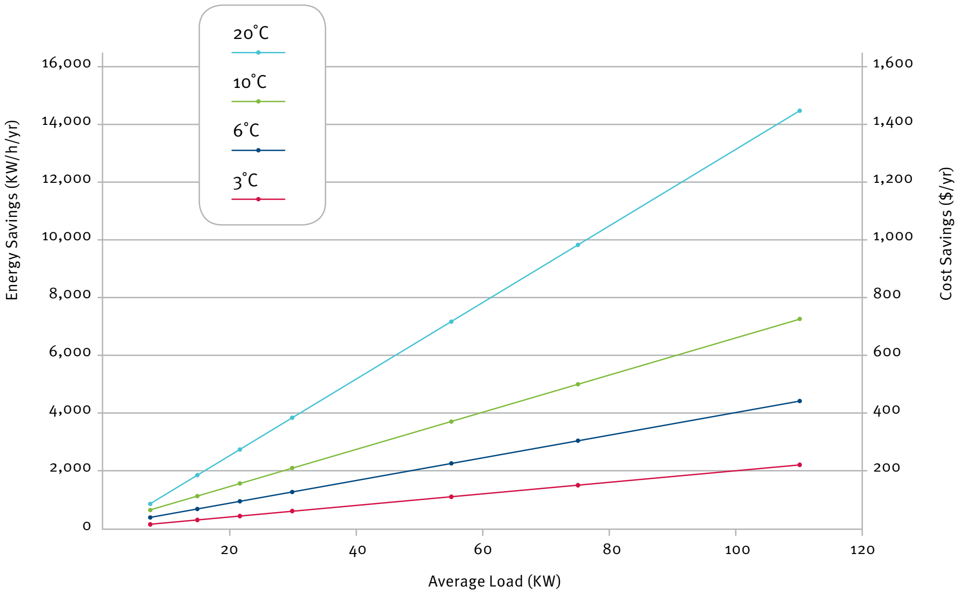
Up to six per cent of a compressor's power can be saved by using cool inlet air that requires less energy to compress. If inlet air is currently taken from a hot compressor house, consider ducting cool air from a shady outside area. Situate compressors in well-ventilated area with hot compressor air ducted away from the inlet feed.

For every 3°C reduction in inlet temperature there is a one per cent reduction in energy usage.[6]

Figure 2 following provides an indication of savings (in energy and costs) that could be made by reducing the temperature of the inlet air by 3°C through to 20°C for a 700 kPa air compressor system operating 2,000 hours per year. The savings are given at loads varying from 7.5 kW to 110 kW. Calculations are based on an electricity cost of 10 cents/kWh.

3 Compressed Air Association of Australasia, 2005, Efficient Compressed Air Systems – 2 Compressed Air – Efficient Utilisation www.amei.com.au/downloads/guide_2.pdf
4 US Department of Energy, 2004, Energy Tips — Compressed Air Tip Sheet #14, www.eere.energy.gov/industry/bestpractices/pdfs/compressed_air14.pdf
5 Compressed Air Association of Australasia, 2005, Efficient Compressed Air Systems
6 SEDA, 2002.

Figure 2: Potential costs and energy savingsby reducing inlet air temperature[7]



The Energy Smart Air Calculator provides a free calculator to determine the potential savings made by checking and repairing leaks, reducing air pressure or lowering the inlet air temperature. For more information visit www.energysmart.com.au/sedatoolbox/compressedAir.asp

Match supply with demand

Air receiving tank

Air compressor systems should be selected to suit the load requirements. Installing an oversized system to allow for future expansion should be avoided as systems operate most efficiently at full load.

Systems should be selected depending on how much air is needed and when it is required. Some compressors, such as centrifugal compressors, while relatively costly, are quite efficient even when down to about 60 per cent of their design output. Screw compressors, on the other hand, are less costly to purchase but lose efficiency rapidly when operated at part loads.

A correctly-sized compressor will operate efficiently for constant loads.

Fluctuating loads may be better served using a combination of compressors. Electronic control systems (sequencers) can match supply with demand and are suitable for large multi-compressor systems.

Air receiver tanks can be added to compressed air systems to cope with occasional demand spikes instead of running a secondary compressor.

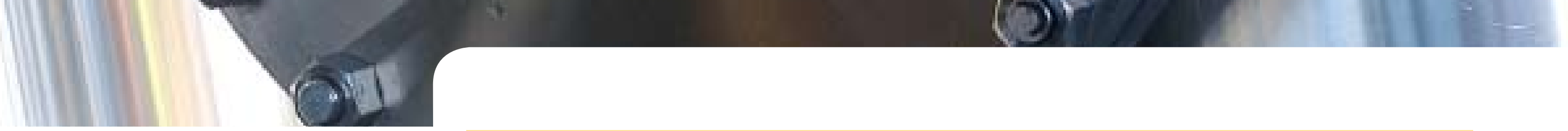
CASTLEMAINE PERKINS REPLACES AN OVERSIZED AIR COMPRESSOR TO OPTIMISE THE LOAD AND SAVES[8]

Castlemaine Perkins is Queensland's largest and oldest brewing company. Through the use of 'energy management system' software, the company identified opportunities to improve the efficiency of its compressed air production.

The plant had two large centrifugal compressors. The first ran fully loaded the majority of the time and was therefore quite efficient. The second compressor however, only ran when demand exceeded the capacity of the first, generally operating at part load, and was thus largely inefficient.

The site also had two small standby reciprocating air compressors that could run at various loads. However, because of their poor mechanical condition they were also operating inefficiently.

7 SEDA, 2002
8 Australian Greenhouse Office, Castlemaine Perkins, Compressed Air Efficiency, www.greenhouse.gov.au/challenge/members/castlemaine_perkins.html



The plant decided to shut down one of the large centrifugal compressors and to refurbish the two reciprocating compressors. Now normal demand is met by one centrifugal and one reciprocating compressor, with the second reciprocating compressor used to supplement during peaks in demand. In periods of low demand, such as weekends, the load is managed wholly by the two reciprocating compressors.

The plant now saves an estimated 1,300 MWh of electricity and 1,300 tonnes of CO_2 per year or around $78,000. The payback period was just one year.

Use compressors only when necessary and not for applications where low pressure air from a blower or fan would suffice. Remember to shut off air supply to equipment not in use.

Air compressors will usually consume their purchase price in electricity every year. Design the system carefully and optimise its operation and maintenance.

Heat recovery

Heat recovery of rejected heat from compressors can provide economic benefits. The practicality of recovering heat is most commonly limited by the distance between the heat source and the potential application.

Table 2: Sample calculation of heat recovery potential[9]

Equipment	Energy input (MJ/day)	Percentage waste heat	Theoretical recoverable heat (MJ/day)	Heat recovery efficiency	Actual recoverable heat (MJ/day)	Potential savings* ($/day)
Air compressor	2,250	80%	1,800	75%	1,450	17

*Assumption: Potential savings per day based on $0.012/MJ gas

This series of fact sheets provides examples and suggestions to the modern food processor on how to achieve both economic and environmental benefits from eco-efficiency. Visit the project website www.ecoefficiency.com.au for more ideas and case studies.

9 Australian Greenhouse, 2003, Motor Solutions Online, Selecting the Best Motor and Equipment retrieved 22/05/2007 from www.greenhouse.gov.au/motors/reference/s2.html

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