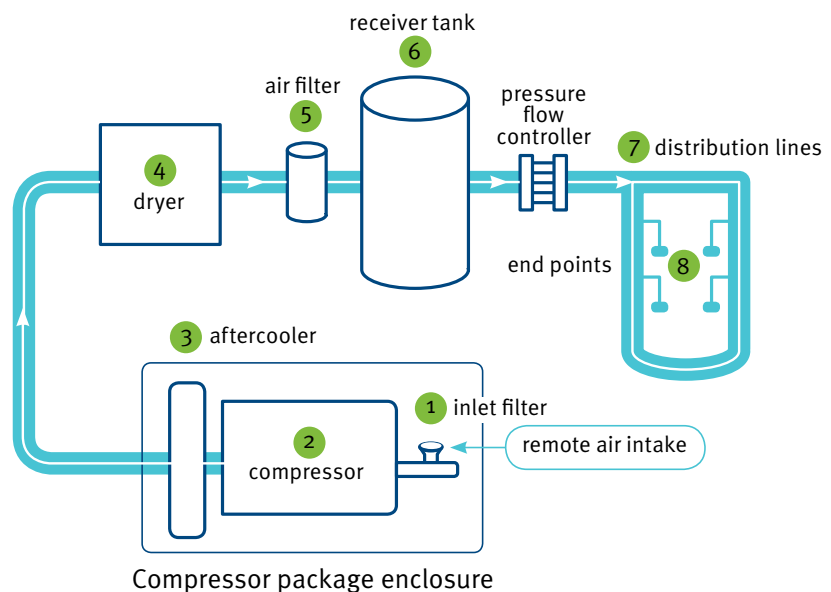


COMPRESSED AIR EFFICIENCY – F₄

Energy eco-efficiency opportunities in Queensland Foundries

Compress your costs

Compressed air is used widely in foundries for a variety of tasks including blowing sand into or off moulds, pneumatic transport, spray coating and cleaning. It is very inefficient with around 80 per cent of electricity input lost as waste heat. As air compressors usually consume their purchase price in electricity every year it is wise to design systems carefully and optimise their operation and maintenance.



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 increases the pressure on the air, 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.



INSTALLATION OF AN EFFICIENT COMPRESSOR SAVES ENERGY.

The replacement of ageing screw compressors at Bradken Foundry in Ipswich will reduce the site's annual electricity consumption by more than 106.7 MWh. That's a saving of over \$10,000 every year!¹

As the typical demand for compressed air fluctuates greatly Bradken was careful to correctly size the new compressors to more accurately meet the site's load requirement. The compressor also uses variable speed drives so the motor speed is continually adjusted to meet the load.

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.

Table 1 - Cost of compressed air leaks²

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

Visible pipework makes it easier to detect leaks. Leaks can often be identified by simply shutting off all other equipment and listening. The compressor will cease running when the required pressure is reached if there are no leaks. Leaks can also be detected by applying soapy water to joints or connections and looking for bubbles. Leaks should be tagged and repaired immediately.

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.



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

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

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.

LEAK AUDIT SAVES MONEY

After noticing a spike in the site's energy consumption over a weekend when the foundry was not operating Bradken in Ipswich undertook a leaks audit of their compressed air system and identified 10 leaks. Left unchecked these leaks would have cost the site 294.6MWh in electricity every year, or approximately \$30,000.³ These were all fixed immediately and Bradken now has a regular maintenance program onsite which includes regularly checking, recording and repairing leak audits.

¹ Based on an electricity cost of 10c per kWh.

² SEDA (Sustainable Energy Authority Victoria), 2000, Energy Smart Compressed Air Calculator, Sustainable Energy Development Authority, Sydney, www.energysmart.com.au/wes/displaypage.asp?flash=-1&t=2007324&PageID=53

³ Based on an electricity cost of 10c per kWh.

Reducing pressure set points

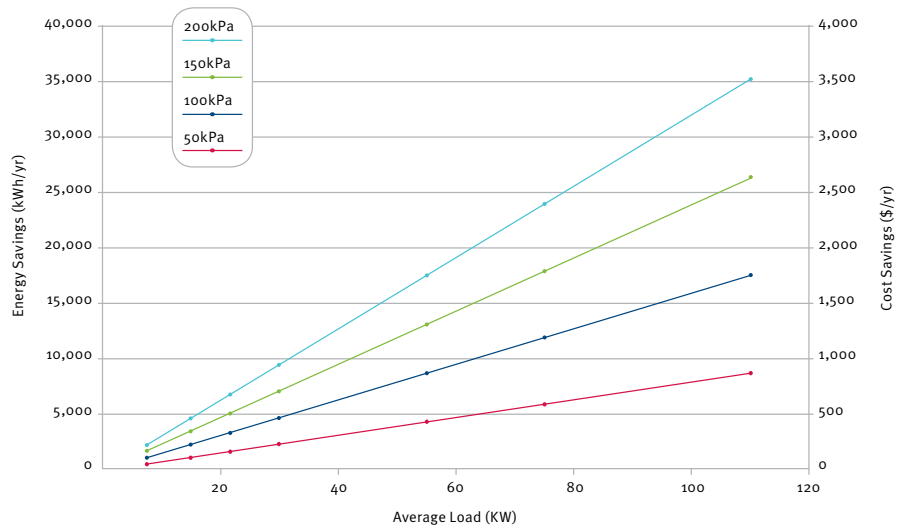
Air pressure should be the minimum required for the end use application. This can be determined by investigating the pressure required by equipment and tools.

In some cases, isolated pieces of equipment may 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.

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.

Figure 1 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.⁴

Figure 1 – Potential costs and energy savings made by reducing air pressure



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.carbontrust.co.uk/Publications/publicationdetail.htm?productid=GPG385&metaNoCache=1

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.⁵

Dirty filters can typically cause an increase in power consumption of three per cent.⁶

⁴ SEDA, 2002, Energy and Greenhouse Management Toolkit, www.sustainability.vic.gov.au/resources/documents/Module5.pdf

⁵ Compressed Air Association of Australasia, 2005, Efficient Compressed Air Systems – 2 Compressed Air – Efficient Utilisation www1.eere.energy.gov/industry/bestpractices/software_motormaster.html

⁶ US Department of Energy, 2004, Energy Tips – Compressed Air Tip Sheet #14, www.eere.energy.gov/industry/bestpractices/pdfs/compressed_air14.pdf



Air compressor filters should be kept clean to reduce pressure drops.

Opportunities to reduce pressure drops

Actions that can reduce pressure drops include:

- 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.
- Using automatic condensate traps, which open when water is present, 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.⁷ 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.
- Keeping the distance of piping as short as possible and minimise bends to reduce losses.
- Making sure pipe joints allow smooth air feed to reduce turbulence.
- Sizing piping according to peak flow rate and pipe length.

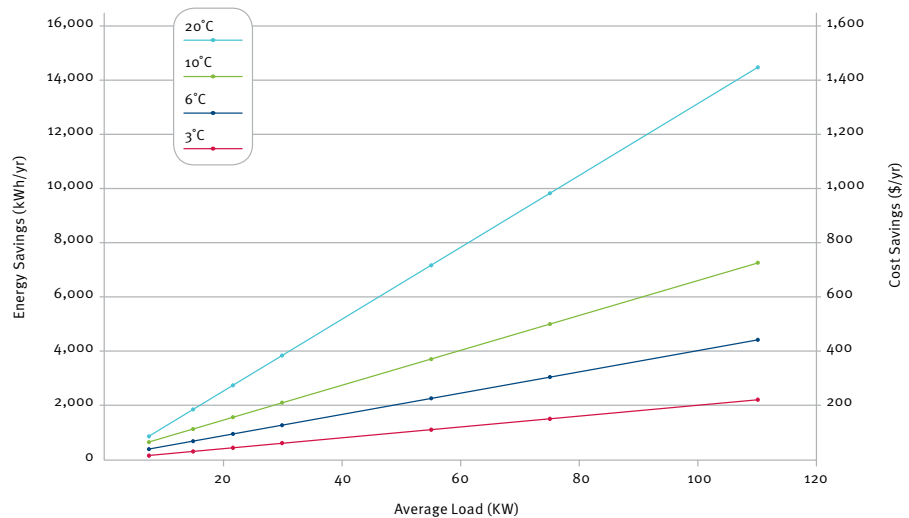
Reduce the temperature of the compressor's inlet air

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 a 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.⁸

Figure 2 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 2000 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.⁹

Figure 2 – Potential costs and energy savings by reducing inlet air temperature



The Energy Smart Air Calculator is a free internet based calculator that determines the potential savings that can be 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

⁷ Compressed Air Association of Australasia, 2005, Efficient Compressed Air Systems.

⁸ SEDA, 2002, Energy and Greenhouse Management Toolkit.

⁹ SEDA, 2002, Energy and Greenhouse Management Toolkit.



Air receiving tank can be installed to meet peak demand.

Match supply with demand

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.

Use 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.

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 outlines potential benefits of heat recovery from a compressor.

Table 2 - Sample calculation of heat recovery potential

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

High efficiency motors

The new MEPS2 standards have placed Australia in the forefront of high efficiency motors. While the initial purchase cost of the high efficiency motors will increase the payback period will be fairly short due to reduced power consumption. The MEPS2-rating of imported motors and motors enclosed in compressor casing can be checked by obtaining the relevant MEPS documentation from the supplier. A full list of motors regulated and registered for MEPS can be found at: www.energyrating.gov.au. For more information on motors, view the Motor, pump and fan efficiency (F5) fact sheet in this series.

This series of fact sheets provides examples and suggestions to the modern foundry operator 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.



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

The eco-efficiency for the Queensland manufacturers project is an initiative of the Department of Employment, Economic Development and Innovation and the Department of Environment and Resource Management with technical information provided by UniQuest through the Working Group for Cleaner Production. For further information visit the project website www.ecoefficiency.com.au