AIR AND MINE EQUIPMENT INSTITUTE OF AUSTRALIA

EFFICIENT COMPRESSED AIR SYSTEMS

HOW TO SAVE ENERGY, REDUCE COSTS AND HELP THE ENVIRONMENT

OVERVIEW

SUMMARY

In Australia, about 10% of all industrial electricity consumption is used in powering compressed air systems.

Most manufacturing plants need an air compressor to drive tools such as high-speed drills, pneumatic hammers, riveting guns, etc. Its use lies at the heart of all compressed air supply systems.

Compressed air systems are safe, reliable and versatile. They are often taken for granted workhorses that plod through the day without much worry, for a cost you don't think about. However, taking a good look at your system's performance can produce surprising economies. A properly designed and maintained compressed air system that is energy efficient could save your company thousands of dollars each year.

TYPES OF COMPRESSORS

Compressors commonly used in industry are outlined in the table below.

Compressor Type	Characteristics	
Reciprocating	Low energy consumption Suitable for high pressures Easily adjustable	Oscillating forces High end temperatures High maintenance Noisy Relatively expensive
Vane	Simple construction Quiet	Limited capacity range Oil residues in the air
Screw	Quiet and simple operation Lower end temperatures Simple to use for heat recovery Compact	Oil residues in the air
Centrifugal	Low energy user for large capacities Quiet Controllable capacity	Sensitive to dirt in air Relatively high cost Energy efficient

WHAT SORT OF COMPRESSED AIR SYSTEM WOULD SUIT YOU BEST?

Which system is a decision controlled by the type of work you expect it to do.

Reciprocating compressors are by far the best choice for small volumes in situations where operation is short-term or intermittent, and load is fluctuating. For example, a tyre shop where demand varies.

They can be used alongside screw compressor systems to provide smaller amounts of air that may be required on weekends or nights.

Screw compressors are best used where you need a relatively constant 'base load' air supply. For example, a production line where operation is continuous.

The sizing of a screw compressor is imperative in order to reduce the idling time. When a screw compressor is in off-load mode the inlet valve closes and the power consumption drops down to 25% of the on-load power.

For heavily intermittent compressed air usage systems, larger volume, variable output controlled, frequency controlled or switched reluctance speed regulated screw compressors can provide the answer for energy efficiency.

The diagrams below highlight the load situations which best suit screw or reciprocating compressors.

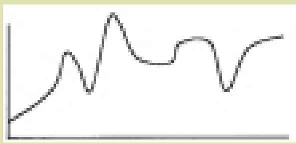


Figure 1: *Reciprocating compressors are typically used in smaller applications where there is intermittent demand, as in a tyre shop*

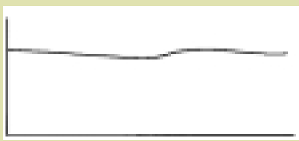


Figure 2: *Screw compressors are best where the demand for compressed air is relatively constant, as in a production line situation*

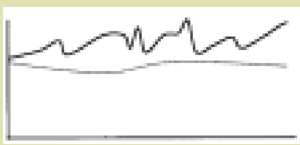


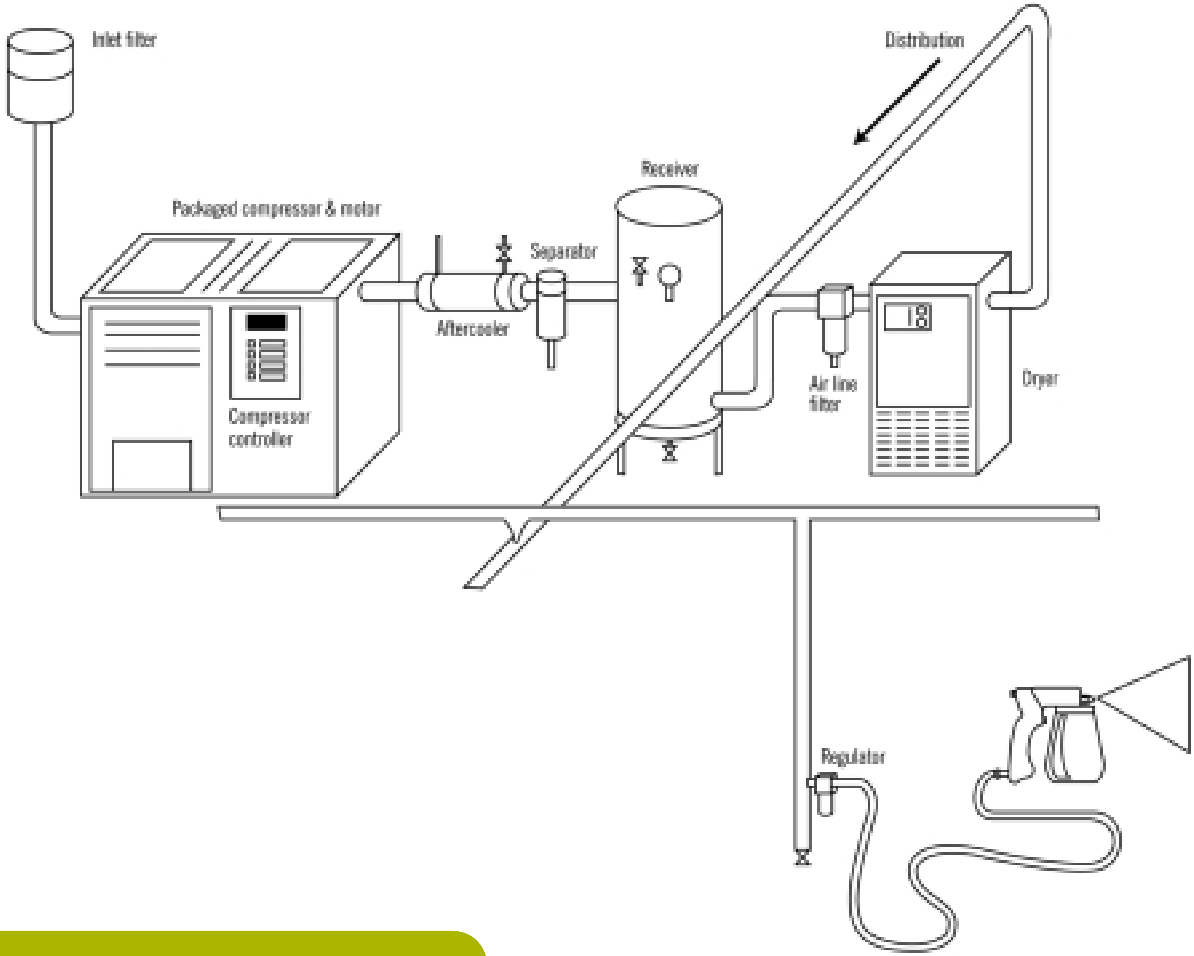
Figure 3: *In situations where there is a constant load, with occasional fluctuations in demand, it may be best to use a screw compressor system for base load, with a stand-by unit to meet extra demands as they arise*

HOW THE COMPRESSED AIR SYSTEM WORKS

Each component in a typical system helps to deliver clean, dry, compressed air that's free of pressure fluctuations at its point of use. If any component is working inefficiently, the system's performance suffers and operating costs rise.

Like any high-pressure system, they are prone to leaks or other failures that can result in lower performance.

Figure 1: Typical compressed air system layout



COMPONENTS OF THE SYSTEM

Inlet filter:	Removes particles from the air entering the compressor.
Compressor:	Compresses air to a small volume, increasing the pressure.
Motor:	Drives the compressor.
Compressor Controller:	Directs the compressor's output. It may be microprocessor, electromechanical or pneumatically based. Advanced controllers include machine protection and information management.
Aftercooler:	Compression leaves the air hot and wet. The aftercooler lowers the temperature of the air leaving the compressor and removes water that condenses as the air cools.
Separator:	Removes liquids from the compressed air.
Receiver:	Stores a large reserve of compressed air to maintain a smooth flow to the plant.
Air line Filter:	Removes solids and liquids from the compressed air stream. Can be placed throughout the system.
Dryer:	Helps to eliminate any remaining moisture in the compressed air by using either a refrigerated condenser or a desiccant. Refrigerated condensers cool the air to condense water vapours into a liquid that is then drained from the system. Desiccants are powders or gels that remove water by absorbing it.
Condensate Trap:	Collects and discharges liquid that condenses out of the air stream. Integral part of aftercoolers, dryers and separators.
Distribution Piping:	Links the components. It distributes the air from a main header to branch lines and subheaders to drop points connected to individual tools.
Pressure regulator:	Controls air pressure and flow at individual points of use.

THE MAIN DRAINS ON EFFICIENCY

The majority of the energy in an air compressor is converted into heat. Wasted heat need not be a lost resource. It is usually possible to recover generated heat and use it elsewhere in a plant. For instance, the hot exhaust air from the air compressor can be ducted into other spaces to provide heating in the winter, or to heat water. Some 15% of the energy input can be wasted through leakages. Energy audits have regularly highlighted system leakage exceeding 20% and in some cases, more than 50% of the total air compression output. This wastage can be easily fixed.

A system management program can help a plant minimise its energy losses. The ideal time to think about your compressed air system is before it is installed.

WHEN INSTALLING NEW PLANT

Whether you are building new facilities from scratch, or modifying existing facilities, it is usually possible to design a large system so that it is modular, with isolation points allowing parts of the system to be operated independently of the rest.

You might be able to site compressors in different areas, instead of housing several in one shed. (This could be important in minimising air temperatures at the compressor intake - the higher this is, the less efficient the performance.)

SELECT SIZE TO MEET NEEDS

Select the size of the compressor so that it runs as closely as possible to full load.

Choose suitably sized receivers to act as a buffer between output and demand.

Importantly, do not install an oversized compressor to meet anticipated future demand. It is usually more economical and more efficient to install an additional, appropriately sized compressor when needed later.

CONSIDER USING MULTI-STAGE COMPRESSORS

These provide additional efficiencies, for example, the air can be cooled between the compression stages.

CONSIDER ENERGY EFFICIENT ACCESSORIES AND SYSTEMS

The industry offers a number of options to minimise the energy losses in compressed air systems such as internal and external controllers, compressors with variable output and variable speed, high efficiency electric motors.

HOW TO GAIN BIG EFFICIENCIES IN YOUR PRESENT SYSTEM

ESTABLISH A REGULAR MAINTENANCE PROGRAM

Take advantage of the routines that equipment manufacturers have recommended. Adopt as your company policy, their advice on inspection intervals, and maintenance and service procedures for each system component.

HUNT FOR AIR LEAKS

Leaks may be costing much more than you think. Table 1 lists the estimated amount of air leaking from a system operating at a pressure of 700 kPa, for 2000 hours per year, the energy wasted and its cost for an electricity tariff of 10 c/kWh.

Analysing one result as an example, if the sum of all leaks is equivalent to a hole of only 6.4 mm diameter, 51.2 litres/second of air is lost, wasting 34,040 kWh of energy each year at a cost of $3,404.

WHAT CAN YOU DO TO STOP THIS ENERGY WASTE?

System operators are usually the first to know if a problem such as a leak has developed. Educate your plant staff, emphasising the importance of monitoring the line.

Regularly (monthly) check for leaks in all piping, joints, drains, relief valves, drain valves, flexible hoses, quick release hose fittings and filter/lubricator units. If a leak is found, instant repairs or replacement of the part are necessary.

A common method of leak detection involves spraying pipes with soapy water and looking for bubbles. Another method involves the use of ultrasonic detectors. A good time to check for leaks is after hours when the factory equipment is quiet.

CHECK SYSTEM OPERATING PRESSURE

It is important to ensure that the air pressure at the compressor is the minimum required to do the job.

Air must be delivered to the point of use at the desired pressure and in the right condition. Too low a pressure will impair tool efficiencies and affect process time. Too high a pressure may damage equipment, and will promote leaks and increase operating costs. It's a balancing act, but getting it 'just right' delivers good savings for you.

As a general rule, for every 100 kPa reduction in operating pressure results in about 8% energy and cost savings[1].

Table 1. Air leakage, wasted energy and cost for equivalent hole diameter

EQUIVALENT HOLE DIAMETER (mm)	QUANTITY OF AIR LOST IN LEAKS (l/s)	ANNUAL ENERGY WASTE (kWh)	ANNUAL COST OF LEAKS ($-AUD)
1.6	3.2	2,128	$213
3.2	12.8	8,512	$851
6.4	51.2	34,040	$3,404
12.7	204.8	136,192	$13,619

Energy Savings (kWh) = 8% x kW rating x pressure reduction (in kPa) /100 x operating hours	
EXAMPLE 1:	Reducing the system pressure on a 75 kW air compressor from 800 kPa to 700 kPa operating for 2000 hours per year
Energy Savings	= 0.08 x 75 kW x 100 kPa/100 x 2000
	= 12 000 kWh per year
	= $1 200 @ 10c/kWh tariff

CHECK TEMPERATURE REDUCTION AT THE COMPRESSOR INTAKE

Investigate the possibility of providing cooler air to the compressor intake. Experience shows that using cooler outside air rather than hot compressor room air can save up to 6% of compressor power[1].

A very cheap way to save on compressed air costs is to duct outside air directly into the compressor inlet.

If air is drawn from a cool, dry source, rather than from a hot compressor house, the system will operate more efficiently.

Energy Savings (kWh) = 1% X kW rating X reduced temperature (°C) / 3 X operating hours	
EXAMPLE 1:	Reducing the inlet temperature on a 110 kW air compressor from 24 to 18 °C operating for 2000 hours per year
Energy Savings	= 0.01 x 110 kW x 6 °C /3 x 2000
	= 4 400 kWh per year
	= $440 @ 10c/kWh tariff

CHECK ALL BELT DRIVES

If the compressor is belt driven, check that the belts are correctly tensioned. If they are slack, energy loss will occur due to belt slippage. If they are too tight, the belts will be subject to excessive stress and the compressor and motor bearings will be placed under extra load.

CHECK OR INSTALL SHUT-OFF TIMERS

Make sure that the compressor and any associated refrigerated air drying equipment is switched off when you don't need it. Automatic time switching can do this for you.

If a few pieces of equipment need air during off-hours, look at supplying these from a small compressor. As well as saving electricity costs, switching off equipment when not required will also cut back on servicing costs.

CONTROL YOUR AIR COMPRESSOR USAGE

If your system has more than one compressor, fit a timer to control the compressor sequencing, so that the most appropriate compressor is the lead machine. In this way, the largest machine(s) will operate during periods of high air consumption, the smaller machine(s) operating at other times, such as night shift or to supply essential equipment on weekends and holiday periods.

It may be possible to reduce system pressure by more than 50% when you fit a controller, while maintaining as much air as you really need. The savings are impressive.

Another approach to saving wasted power and money is by installing a smaller, low-pressure system for use during slack periods.

[1] *SEDA, Energy Savings Manual, 2000*

PREVENT CARELESS USE

Often, compressed air availability is treated much the same way we treated water in the past, as an unlimited resource that costs us virtually nothing.

Using a system as a drying aid for machinery or parts is a common example of the disregard shown for the real value of compressed air. It's like using a truck to haul a box of matches - a simple fan would usually do the same job for a fraction of the cost.

THE RIGHT SELECTION

Prior to the purchase of a new system all available options of compressed air systems should be considered.

A power cost calculation or a compressed air audit will suggest the right system. In most cases, these additional costs are a fraction of those that are lost in energy, if a wrong decision is made.

WHAT TO DO NEXT

Follow this checklist to make your air compressor system more energy efficient.

- Check for leaks and pressure losses throughout the system regularly (monthly)
- Ensure the entire system is monitored by good housekeeping practices
- Ensure condensation can be removed swiftly from the distribution network, or does not occur
- Reduce pressure settings to the minimum where possible
- Use high efficiency filters and dryers where required
- Reduce the compressor intake air temperature by ducting outside air into the compressor inlet
- Check that receivers are sized to store air for short heavy demands
- Check that the size of your compressor meets current demands only

REVIEW

It is very easy to save energy and operating costs on your compressed air system. The simple measures outlined above can be introduced almost immediately, with instant benefits.

If your system is to be managed successfully, the size of the compressor should be selected carefully to match your needs, and the size of the distribution network should be optimised.

Finally, the quality of the compressed air should be carefully assessed.

If you would like more information or detailed guides, contact:

Air and Mine Equipment Institute of Australia
www.amei.com.au
email: info@amei.com.au

For up-to-date telephone details please check the AMEI website.

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