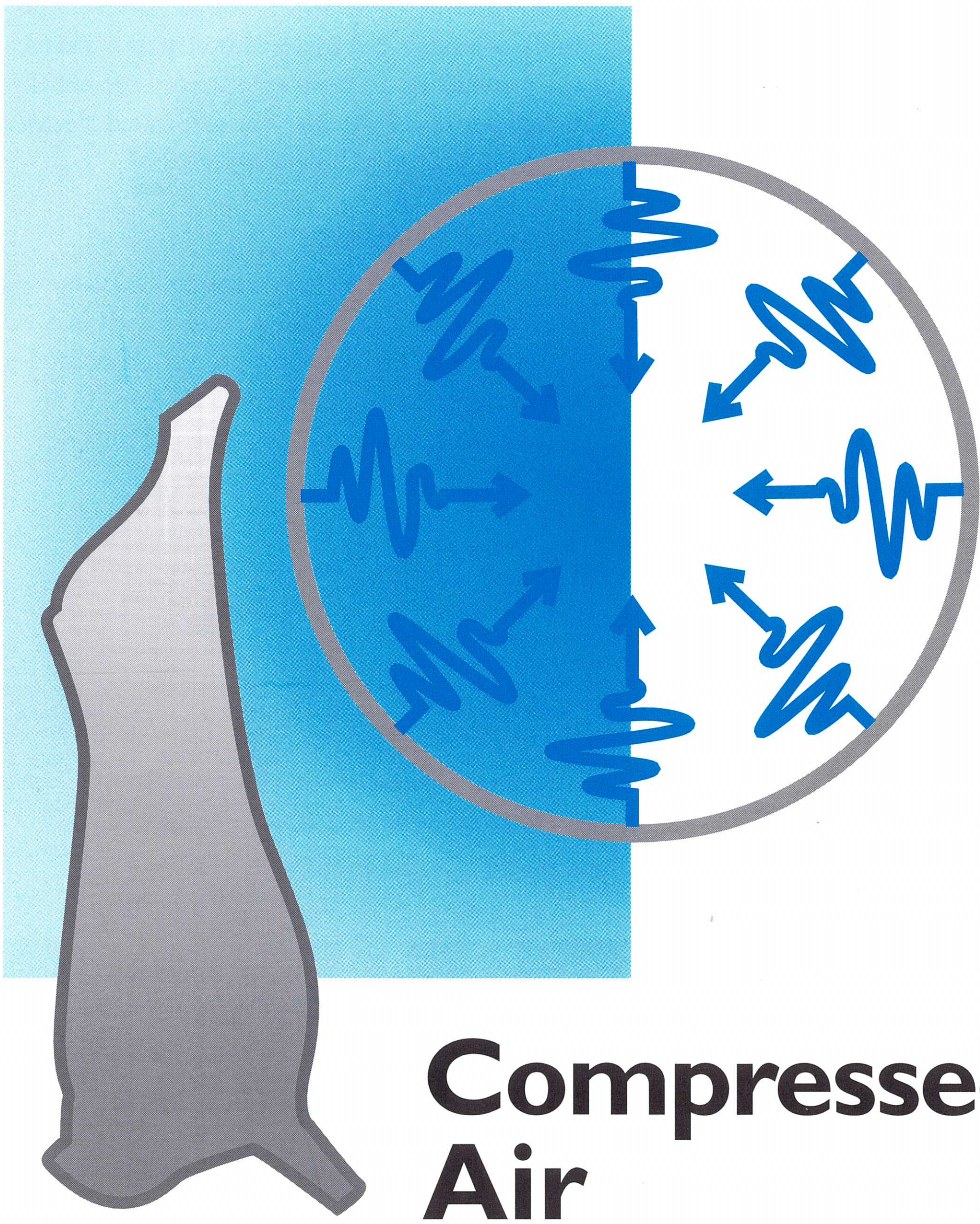

Compressed Air

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Compressed air is a convenient source of power, widely used in the meat industry to operate hand tools and actuators and to transfer waste material. Compressed air has the advantages of convenience and safety, with the main disadvantage being the need for electrical power to compress the air.

Air Compressors

Compressed air in the meat industry is generally generated at a pressure of around 700kPa. Single stage, reciprocating or screw compressors are most commonly used.

Screw compressors are becoming more common due to their advantages of simplicity of construction, ease of maintenance, compactness and hence, suitability for location in a sound-proof enclosure. Figure 1 shows a typical arrangement of a screw compressor.

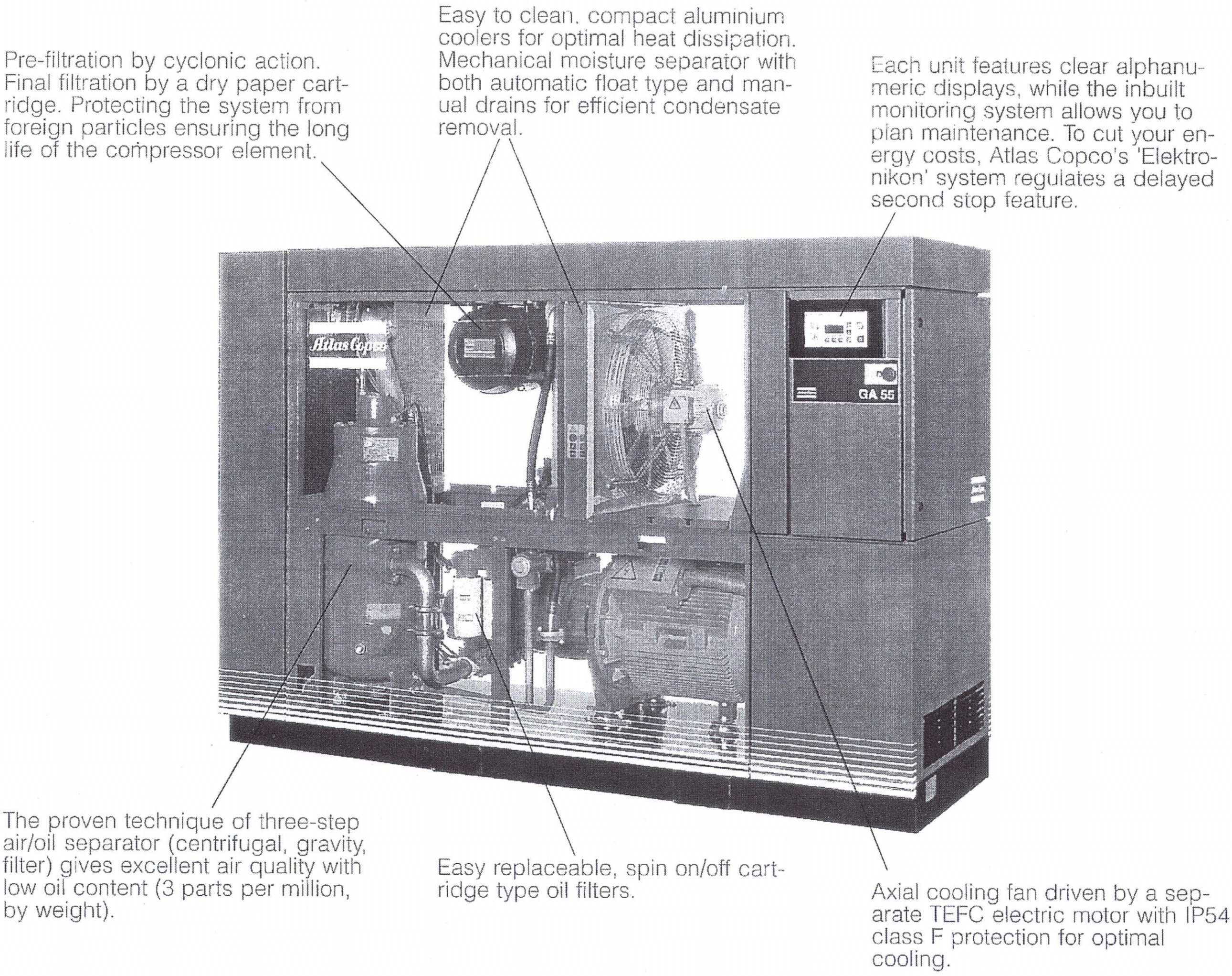
The latest air compressor control systems can be relatively sophisticated computer-based systems, arranged to monitor all operations, control on-off cycle times and maintain high levels of compressor operational efficiency. However, irrespective of the control system used, the overall efficiency of any compressed air system is ultimately determined by the equipment making up the entire system.

In a typical large abattoir using air-driven hand tools, actuators and material transport systems, the installed air compressor capacity can exceed $0.5m^3$ per sec of free air. The associated electrical power input would be around 170kW.

Air-using Equipment

Compressed air is a convenient and safe source of power for hand tools and actuators used in a wet environment. The drive for greater efficiencies in the meat processing industry is reflected in an increased use of equipment, much of it using compressed air as a power source.

FIGURE 1 Typical arrangement of screw compressor



Examples of equipment types and their free air usages are :

	l/sec
hide skinning knives	6.0 to 7.5
fat and bone trimmers	4.0
circular breaking saw	13.0
large reciprocating breaking saw	25.0
small reciprocating breaking saw	13.0
small scribing saws	8.5 to 11.0
large horn saw	19.0
	l/cycle
cattle hock cutter	0.5
smallstock hock cutter	0.1
sheep brisket scissor	9.0

In abattoir operations the greatest demand for compressed air is usually associated with the blow transfer of waste materials. The air used per blow cycle is determined by the total volume of the blow tank(s), blow line diameter and length, and frequency of use. In a typical single $1m^3$ blow tank system using a 150mm diameter blow line, over a 100m distance, the volume of air used is over $2.8m^3$ of free air per cycle.

Compressed Air Distribution Systems

After adequate compressor capacity the most important requirements of any compressed air distribution system are adequate compressed air storage capacity and pipeline sizing.

Compressor capacity and equipment use are generally given on a free air basis, i.e. the air volume given is that at atmospheric pressure. However, after the compressor, all equipment is handling air at a pressure above atmospheric, which reduces the volume of air being handled. In considering storage capacities and pipeline sizes, the air volume must be corrected to allow for the effect of compression.

Storage Capacity

Adequate air storage (receiver) capacity is essential for a number of reasons:

One is to ensure that the number of start and stop operations of the compressor per hour does not exceed the manufacturer's recommendations; failure to comply with the recommendations will result in possible damage to the compressor and a reduced compressor life. Another is to ensure that sufficient air volume is available to meet variations in demand without a significant drop in air pressure, which could affect equipment operations.

There are no fixed rules relating air storage capacity to compressor capacity, since this will vary from installation to installation, depending on the equipment and processes being served. However, a generally accepted rule-of-thumb is that the storage volume should not be less than the volume of air supplied by the compressor in one minute. In the example quoted earlier, a compressor operating at 700kPa and having a capacity of 500 l/sec would require a minimum receiver capacity of:

$$\frac{0.5\ (\text{m}^3/\text{sec of free air}) \times 60\ (\text{min})}{7.91\ (\text{ratio of compression})} = 3.8\text{m}^3$$

Pipeline Sizing

Adequate pipeline sizes are essential in all parts of the system. Pipelines which are too small result in higher air velocities in the pipelines which, in turn, result in higher pressure drops and entrainment of moisture.

A high pressure drop in the air distribution system means that the compressor has to operate at a higher pressure, requiring greater electrical power inputs; or, the air-using equipment has to operate at a lower pressure, which may make it less efficient. A compressor operated at 800kPa rather than 700kPa requires an additional power input of at least 10%.

The ratios of compression for a range of pressures are:

Compressed air gauge pressure (kPa)	4	5	6	7	8	9	10
Ratio of compression (vol. free air/vol. compressed air)	4.95	5.94	6.92	7.91	8.9	9.89	10.87

Air delivered from a compressor has a high moisture content. Some of this is removed at the compressor discharge, some in the air receiver; but some settles out in the pipeline. In a properly designed pipeline system this moisture is arranged to gravitate to drainage points for removal. If the air velocity is high, then this moisture is difficult to remove and it can be picked up and carried forward, damaging equipment. Compressed air velocities in the range 6 to 9m/s are considered to be reasonable for pipelines.

The volumes (l/s) of compressed air at a pressure of 700kPa, passing through a range of diameters of steel pipes to AS1074 at various velocities, are:

Velocity (m/s)	Pipe diameter (mm) 20	25	32	40	50	65	80	100
5.0	1.8	2.8	5.0	6.8	10.8	18.2	25.1	42.8
6.0	2.1	3.4	6.0	8.1	13.0	21.8	30.1	51.3
7.0	2.5	4.0	7.0	9.5	15.1	25.5	35.1	59.9
8.0	2.8	4.5	8.0	10.8	17.3	29.1	40.1	68.5
9.0	3.2	5.1	9.0	12.2	19.5	32.8	45.1	77.1

Treatment of Compressed Air

Clean, dry, compressed air must be supplied to air-driven equipment to ensure trouble-free operation. Air introduced into the system by the compressor will be at ambient temperature and will contain moisture, the quantity of which will determined by the ambient humidity. When the air volume is reduced by compression, the air temperature is increased, and the quantity of moisture in excess of that contained in the saturated air at the higher temperature will be rejected in the form of free water.

Following compression, it is usual to cool the air in a radiator-type arrangement to release the water and any oil picked up in the compressor so that they can be must be arranged to ensure that the water and oil are removed from the system as they appear. In some instances a water-cooled after-cooler and integral moisture trap may be required.

In addition to providing storage capacity, an air receiver can act as a rough air cleaner. Being generally uninsulated it allows the air to cool further, releasing more water and oil from the compressed air. To take advantage of the air-cleaning capacity of the air receiver it is usual to provide it with a liquid trap, as indicated in Figure 2.

The pipeline distribution system also provides additional cooling, resulting in additional water and oil being rejected from the air. To ensure that both the water and oil are removed, all pipelines should be arranged to slope in the direction of the air flow towards a trapped and drained collection point. A suitable arrangement is indicated in Figure 3.

FIGURE 2 General arrangement of air receiver

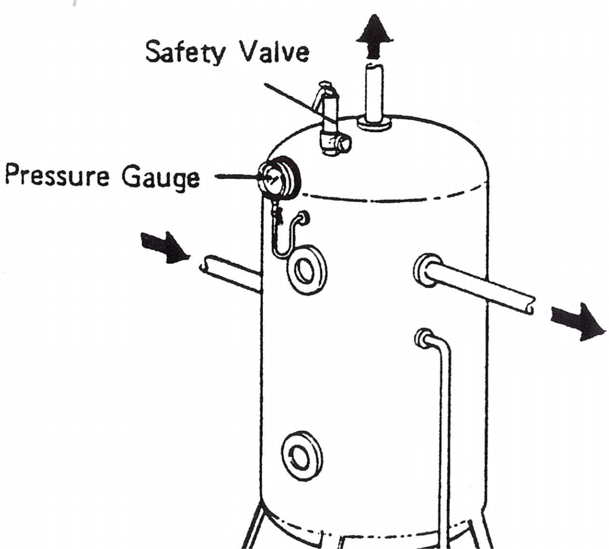
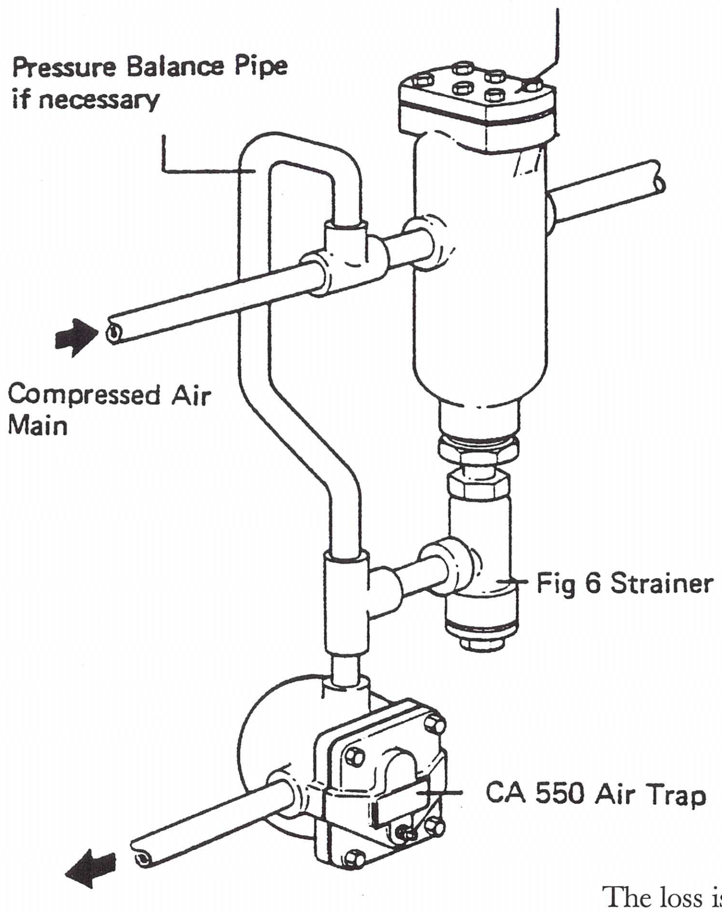


FIGURE 3 General arrangement of separator and trap on main air line



In some situations where very clean, dry compressed air is required – such as instrument air – it may be necessary to use a refrigerated air dryer to achieve the quality of air demanded.

System Efficiencies

The production and use of compressed air is a relatively inefficient operation, requiring the use of electrical power to compress air which is finally discharged back to the atmosphere. However, the limited use of compressed air can often be justified on the grounds of reduced capital cost, convenience and increased standards of safety and hygiene.

The blow transfer of waste materials is a good example of the advantages of improved hygiene, convenience and lower capital cost, when compared to a mechanical conveyor transfer system, easily justifying its use.

Once in place, the greatest loss in efficiency of a compressed air system is generally associated with the unplanned loss of air from the system. The nature of air means that losses are not readily obvious in a noisy environment. This is often compounded by the fact that air losses at the point-of-use are often accepted as part of the system. Preventative measures should include periodic auditing of the reticulation system after-hours. Even small leaks can be heard above low background noise.

The cumulative loss from a number of apparently small leaks can be substantial. For example, at a pressure of 700kPa, a 5mm hole will pass in excess of 30 l/s of free air.

The volume of air loss can be estimated by monitoring the compressor on-load cycle time when the plant is not operating. The loss is calculated as follows:

leakage rate = compressor-rated capacity x % on-load cycle time.

For example, a 0.1m^3/s capacity compressor running 10% of the time on-load has a 10l/s loss.

A common cause of air loss is the practice of leaving equipment switched on during breaks in production. A conveniently located isolating valve or the fitting of time-controlled solenoid valves will assist in the reduction of losses.

Additional Information

More detailed information on this subject is provided in the following:

'Compressed Air – How to Make the Most of Your System from Compressor to Point-of-use', Spirax Sarco Ltd Practical Study PS 12. 1978, and Information Book IB 12. 1976.

Additional information

Additional help and advice are available from Food Science Australia, Meat Industry Services Section:

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