Compressed Air

Compressed air systems are widely used in industry, accounting for some 10% of all industrial electrical power consumption. There are many reasons why compressed air as a source of power is preferred over other forms of energy. It is clean to use, can be stored, and does not pose a health or fire hazard. Compressed air is a versatile, safe and the most common utility found in industry today. Compressed air is used as an energy source, a cleaning fluid, a source of conveying and even as a source for cooling.

Its versatility, simplicity and availability, has led to the common mis-conception that compressed air is a cheap utility and mismanagement of it can result in significant energy waste. The factors most commonly responsible for this energy loss are air leaks, unnecessary use of compressed air for cleaning, and improper system layout. A properly designed and maintained compressed air system can contribute significantly to improving the energy efficiency of an operation.

Compressed Air

The theoretical power or ideal compression power is the power required to compress air, assuming 100% efficiency (i.e. no losses). The ideal compression power can be determined by the following equation:

$$W_t = 0.00433 \times P_i \times Q_{fa} \times N \times \left[\left(\frac{P_d}{P_i} \right)^{\frac{0.231}{N}} - 1 \right]$$

where:

W = ideal compression power (kW)
P_i = inlet pressure (kPa) in absolute
Q = equivalent free air flow rate (L/s)
N = number of compression stages
P_d = discharge pressure (kPa absolute)

"0.00433", "0.231" and "1" are equation constants taking into account the specific heat of air and unit conversions and the actual power absorbed will be greater than the power above given the same inlet and outlet conditions.

Type of air compressors and their efficiencies

The type of compressor most likely to be used for an industrial compressed air system depends largely on size, cost, and reliability requirements:

- Rotary screw compressors in sizes up to 500-600 kW are very popular because of their high reliability and low maintenance requirements.
- Centrifugal compressors are often used in sizes ranging from about 150 kW up to over 10,000 kW. The larger size models are relatively low in cost and small in physical size compared to reciprocating compressors.
- Reciprocating compressors are one of the oldest air compressor technologies, but are commonly used today only in sizes up to 25kW. These compressors are often used for light-duty applications or in start-up industrial enterprises because they are reliable and low cost.
- Rotary vane compressors are not commonly used as they tend to be energy inefficient and require higher maintenance than other compressor designs.

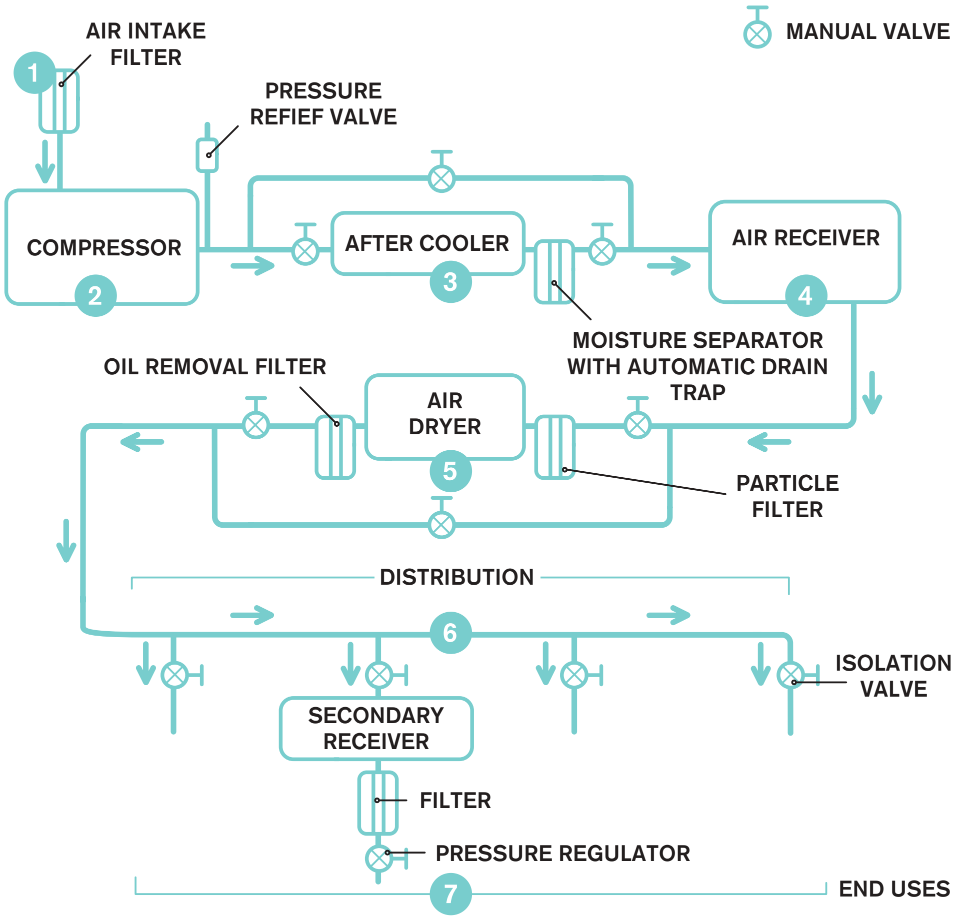
Dryers

Application criteria for dryers include the air intake climate, the degree of air dryness needed, cost and reliability:

- For facilities where there is no concern about freezing, refrigerated air drying is often used. If freezing is a concern, regenerative desiccant dryers will be used.
- If air must be very dry, regenerative dryers will be used.
- If cost is a primary concern, as in the case of a start-up company or a light-duty industrial process, the deliquescent dryer is more common. This type is less common in moderate or heavy-duty industry because of a perception that its performance is less reliable than other types under varying conditions.

Compressed Air Schematic

A typical compressed air system consists of compression, cooling, storage, and distribution equipment is shown below.



- Intake Filtering (1): Incoming air must be filtered to remove dust and other contaminants.
- Compression (2): The filtered air is compressed (typically to 80 to 110 psi) with motor-driven screw, centrifugal, or reciprocating compressors.
- Cooling (3): Compressing air raises its temperature dramatically, so cooling is required. Much of the energy "lost" in making compressed air is in the form of removed heat. Cooling is also important in the process of drying air. Much of the water vapour condenses as the air is cooled, making it easy to drain away.
- Air Storage (4): A tank called an air receiver typically is placed downstream of the cooler to provide surge capacity for the system. Some systems provide additional receiver tanks in the process area to accommodate variable demand.
- Drying (5): Cooled, pressurised air still carries a significant amount of moisture and lubricants from the compression process, virtually all of which must be removed before the air can be used. Drying compressed air can be very energy intensive.
- Distribution (6): A system of distribution pipes and regulators convey compressed air from the central compressor plant to process areas. This system includes various isolation valves, fluid traps, intermediate storage vessels, and even heat trace on pipes to prevent condensation or freezing in lines exposed to the outdoors. Pressure losses in distribution typically are compensated for by higher pressure at the compressor discharge.
- Point of Use (7): At the intended point of use, a feeder pipe with a final isolation valve, filter, and regulator carries the compressed air to hoses that supply processes or pneumatic tools.

Energy Savings in Compressed Air Systems

- Cost. Compressed air is by far the most expensive energy source. If 100 units of electricity enter the motor of an air compressor only 10 to 20% of these units do useful work – an efficiency of only 10% to 20%. This means that the cost of compressed air is 5-10 times more expensive than electricity and alternatives to compressed air should always be taken seriously at the design stage and in operation.
- Compressed Air for Conveyancing. As a source of conveyance it is expensive. Check out alternatives such as blowers or mechanical conveyors.
- Fix Air Leaks. Air Leaks account for up to 40% of compressed air usage and should be identified and fixed.
- Mis-use of Compressed Air. It should not be used as a cleaning medium, a duster or a brush.
- Use Air Nozzles and Amplifiers. Air nozzles and amplifiers utilise ambient air using venturi effect and can save up to 70% of air used in open ended pipes.
- Use Valves. Use automatic shut off valves to isolate air from machines that are not in use or require maintenance.
- Avail of Free Cooling. Reduce temperature of air intake to air compressor by using outside air piped into intake of air compressors.
- Re-use Waste Heat. Duct hot waste air to heat stores or other suitable areas and recover heat in cooling water used for interstage cooling of two-stage air compressors.
- Two-stage Compression. Use a good two-stage air compressor to feed base air demand and if the air profile is peaky then use a variable speed drive compressor to satisfy peaky air demands. Two-stage air compressors are more efficient than single stage air compressors and should always be considered when purchasing a new compressor. Ensure that the interstage air pressure is optimised and that the interstage cooling is sufficient. If not check for fouling and lack of cooling water.
- Use Desiccant Air Dryers. Desiccant air dryers can use 20% of air generated for regeneration of the desiccants. These are sometimes controlled on a timer basis. Dew point control will also provide good savings.
- Drying. Only dry air that is needed should be dried.
- Drains Valves. Use automatic drains on air receivers. They waste less air then manual purging.
- Air Speed. Ensure that pipe air velocities are less then 6 m/s to ensure pressure losses are kept to a minimum.
- Determine Efficiency. Install an air flow meter on the receiver outlet and measure all electrical energy into the compressors so that efficiencies can be determined.
- Lower the Outlet Pressure. Lower the outlet pressure to a minimum that satisfies production requirements. Each bar of extra outlet pressure increases energy usage by 14%.
- Receivers and Amplifiers. Use local air receivers for high air demand applications. Use air amplifiers for the process that requires a higher pressure.
- Air as Motive Force. Don't buy machines that use air as a motive force when direct electrical driven machines will do.

Typical savings that can be achieved

Efficiency Measure	Average Savings	Max Savings	Average Payback (yrs)*
Reduce air leaks	26%	59%	0.9
Reduce system pressure	2%	11%	1.3
Install/adjust uploading controls	10%	34%	0.8
Sequence compressors	8%	34%	2.7
Reduce run time	33%	16%	<0.1
Total savings (per plant)	44%	65%	0.8

It can be seen that the average savings are greater than 40% with average time to recoup investments of less than one year.

ESB Independent Energy has considerable expertise in the efficient utilisation of Compressed Air Systems. If you require further information please contact your Customer Relationship Manager or ESBIE Head Office at 00 353 1 8628300.