

How to utilise variable speed drives with air compressors

Most air compressors become less energy efficient as air demand is reduced. In extreme cases, up to 65% of the rated electrical power is still used even when there is no demand for air.

By purchasing a variable speed drive (VSD) compressor or retrofitting a VSD to an existing compressor companies can save energy and money.

The usual way of regulating compressor capacity relies on controlling inlet or exhaust valves, to restrict the output of the compressor while it continues to run at full speed.

With positive displacement compressor a better solution can be to regulate output by varying the speed. In this way, when demand for air reduces, so does power consumption.

The business case

Many businesses gain significant financial benefits from installing variable speed compressors or retrofitting VSDs to existing machines. In many companies, the costs can be recouped in less than four years.

What do VSDs cost?

The cost of VSDs depends on the size of the unit. Use the table below as a guide to the cost of buying a new variable speed compressor, or of retrofitting a VSD.

Table 1 VSD by motor size

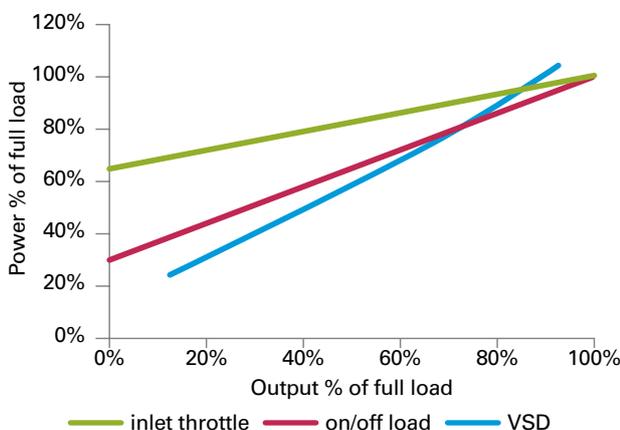
Motor size (kW)	Maximum output (m ³ /min)	Maximum output (cfm)	Cost of new compressor (£)	Cost of retrofitting VSD (£)
22	3.5	124	12,500	3,500
30	5.0	173	14,500	4,000
45	6.2	219	20,500	6,000
55	8.2	290	23,000	7,000
75	9.9	350	27,000	8,500
90	13.3	470	31,500	10,000

The technology

The advantages of variable speed drives are:

- efficiency over fixed speed machines is improved at part load conditions under 75%.
- pressure fluctuations are eliminated, which often reduces system generation pressure by up to 0.5 bar, giving extra energy savings.
- variable speed controls provide 'soft starting' eliminating high inrush currents.
- when more than one compressor is used on a single system. Giving one compressor a variable speed drive allows the other fixed speed compressor(s) to run at optimum efficiency on base load with the VSD compressor varying its output so the compressor installation precisely matches the actual demand. In these cases, fitting electronic compressor sequence controls maximises savings.

Figure 1 Benefit of VSDs against other types of air compressor controls



Specification checklist

Variable speed technology can be applied to most air compressors and they are available as new machines from 5kW to over 500 kW.

Although VSDs do save money under most load conditions, the extra cost is only justified when the average load on the compressor is less than 75%.

You can estimate the load on a compressor by:

- timing the on-load and off-load periods – you can usually hear the change between the two states. It is not possible to determine the load with modulating

control by this method so these compressors may need switching to on/off load to determine the average load.

- asking a compressed air equipment supplier or independent firm to install monitoring equipment on the system. This will measure energy consumption and variations in airflow and pressure. You may have to pay for the service, but it is the most reliable method of identifying actual air demand and costs.

Because your air demands may vary throughout the day, you need to check at a range of times to estimate the average load. Monitoring equipment will do this automatically. To estimate the potential savings from using a VSD, you need to know:

- the present compressor type and method of capacity control.
- the average electricity price (p/kWh).
- the compressor's full load (kW) – if you need to estimate this, then work with a figure of 100% of the motor rating.
- annual compressor operating hours.

Once the average load is known an assessment can be made of the likely savings and whether an existing compressor is a suitable size to be retrofitted or whether a new compressor with built in VSD is the better option.

New compressors with built in VSD have been designed and tested to operate over a wide speed range and often have special features that would not be part of a retrofit e.g. direct coupled motors eliminating gearbox or belt drive losses. Purpose built VSD compressors will normally have a wider control band than retrofitted units giving better efficiency across a range of demands and will also be backed by the manufacturer's warranty.

Retrofit of existing machines can give good benefits at lower cost than buying new but great care must be taken when retrofitting VSDs on rotary screw and piston machines to ensure that correct levels of lubrication are maintained, vibration problems are avoided and cooling is not compromised. This is particularly true on two stage oil free compressors, where manufacturers generally advise against retrofit. Any retrofit should only be carried out by specialist installers who can set the operating parameters to avoid these problems or fit ancillary units to overcome the problems. A retrofit by a third party will also invalidate any manufacturer's warranty.

VSD retrofit should not be considered on centrifugal machines as they usually run above the first critical speed and serious damage can occur if the speed is changed.

Commissioning checklist

Setting up the VSD is crucial to a smooth-running, energy saving system. It's a job for specialist installers who will ensure you maximise savings and avoid any damage to the compressor. Table 2 sets out the basic commissioning procedure.

Table 2 Commissioning procedure

Action	Comments
Decide on the compressed air pressure parameters	The operating gauge pressure for most compressed air systems is 7 bar, but you should check this against equipment requirements.
Input the parameters into the variable speed controller	On retrofit units, you may need to feed these parameters directly into the VSD controller. New compressors fitted with VSDs have integrated control circuits, so you only need to enter the parameters into the main compressor control panel.
Start the compressor, monitor the speed and air pressure	This ensures the VSD is operating within the set parameters.

Common problems

Always consider the following if you are thinking about installing VSDs:

- Location of the air pressure sensor** – This is critical, especially on systems with long pipe runs. If the sensor is in the wrong position, the equipment at the end of the distribution system may not receive enough pressure.
- Control systems** – Most older control systems are only designed for on/off load compressors that control between two set pressures. VSD machines operate at a fixed setpoint. Care should be taken on commissioning to ensure the VSD compressor control and fixed speed machines stay on base load at all demands. To achieve this it may be necessary to run a VSD outside the control system or to upgrade the control system to a more modern system that has been designed to control VSD units.
- Electromagnetic interference** – Inverter VSDs may produce electromagnetic interference that can affect radio and telecoms equipment. Most manufacturers incorporate special filters, but you should take care with the layout keeping the length of wiring to a minimum and ensuring all motor-side cables have earth screens. Specialist advice can help you to avoid problems later on.
- Harmonics** – The use of VSDs can create harmonic distortion in the power supply. When the VSD load size is small and the available power is large, the effects generally go unnoticed. However, when either a large number of low-current VSDs, or just a few very large-load VSDs are used, they can have a negative impact on the electrical system which can effect other equipment. Specialist advice can help you to avoid problems later on.
- Suitability of the compressor and its motor** – When operating at lower speeds, the oil pump and cooling fan on the compressor motor will also run more slowly. This needs to be taken into account at the specification stage on retrofits to avoid the compressor and motor overheating.
- Overheating** – Retrofitted VSD controllers need to be installed in an environment that is within a defined temperature range and has a good supply of cooling air.

Finding a supplier

You may already know of a good contractor. If not, the British Compressed Air Society may be able to help.

They give technical advice and have a list of companies that offer inspection and maintenance services.

You can contact the British Compressed Air Society by phoning 020 7935 2464 or learn more about their services by visiting their website, www.bcas.org.uk