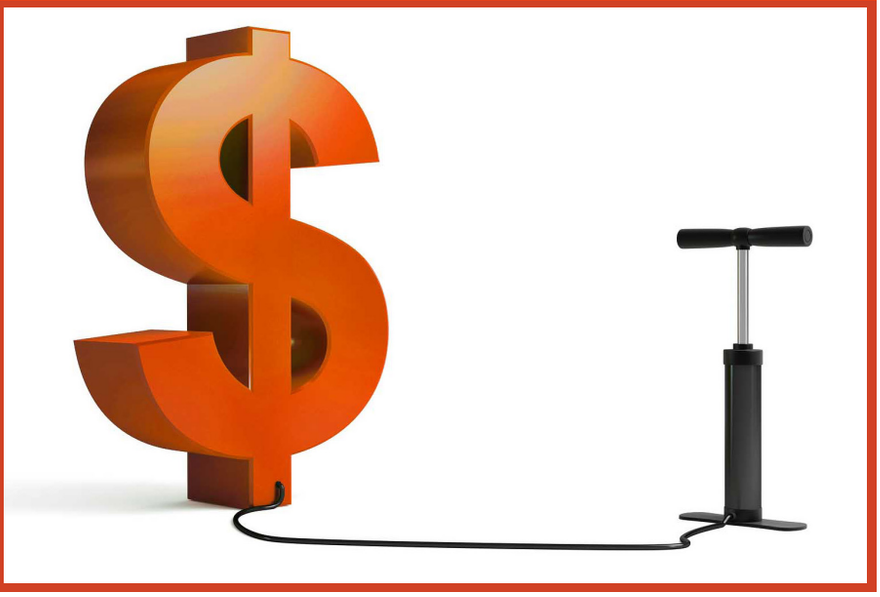
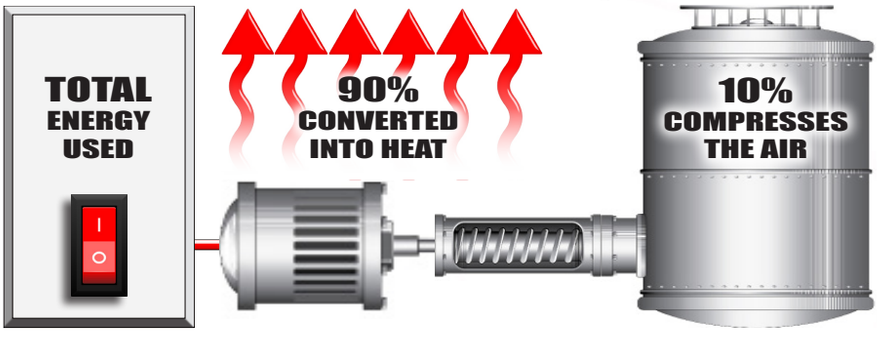
Are your compressed air costs inflating your overheads?

Wiley's Martin Bevis shares his experience on the most efficient and reliable operation of industrial screw type air compressors and compressed air systems



Most industrial manufacturers use compressed air as part of their process. Whilst the cost of providing this service is not as high profile as refrigeration or the raising of steam, it represents yet another overhead to the business and if not managed correctly is probably the most inefficient use of electrical power on your site.

Consider this. Of the electrical power consumed by the air compressor motor; only 10% (approx.) of that energy is used to compress the air itself, the remaining 90% is converted directly into heat.



There is nothing that can be done about the physics that leads to this situation; however most of this heat can be recovered. Whilst you would not have chosen to use electrical power to provide the equivalent heat energy, it represents the only sensible option to recover some of the dollars you have spent on the electrical power to generate that heat in the first place.

Consider further then, that of the 10% of the energy that is usefully converted into compressed air, how much of this air is now wasted through leaks in the distribution system?

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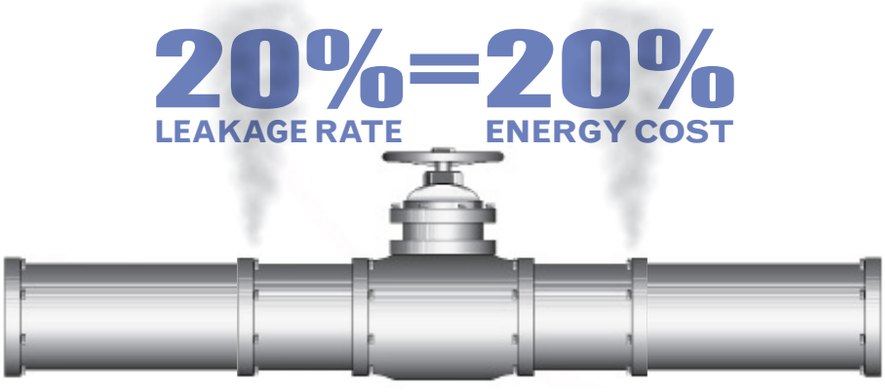
A leakage rate of 20% is not uncommon in industrial plants that have not been audited or don't have a regular maintenance regime. Therefore at this rate of leakage, only 8% of the original electrical power input to the air compressor system has been converted to usable compressed air.

This situation can quickly swing even further out of balance if you are not considering each of the following areas in your general utilities audit.

1. **Air Leaks**
2. **Heat Recovery**
3. **Location of Air Compressors**
4. **Air Drying**
5. **Variable Frequency Drive (VFD) Control**
6. **System Operating Pressure**
7. **Compressed AirPipework**
8. **Incorrect Applications for Compressed Air Usage**
9. **System Controls**

1. Air Leaks

A leak reduction program is the most cost effective means of reducing compressed air costs. A 20% leakage rate means an additional 20% electrical energy is being consumed unnecessarily.



INDICATIVE ANNUAL COSTS FOR AIR LEAKS

Estimated diameter of leak in mm	Estimated leakage at 7 bar system pressure (l/sec)	Est. cost per KWH of electricity in $	Annual running hours of compressed air system	Annual cost of leak in $
0.5	0.2	0.15	8000	100
1.5	1.8	0.15	8000	900
3	7.1	0.15	8000	3550
6	28	0.15	8000	14000

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An easy starting point to establish if there is an air leak problem is to carry out the following check:

1) Switch on an air compressor when the site is unoccupied i.e. there should be no legitimate air consumption on the plant.

2) Assuming the compressor is the onload/offload control type, when the system has reached normal operating pressure, record the time the compressor is actually onload over a period of 15 minutes (approx.).

3) From this calculate the compressor onload percentage by comparing the onload time with the offload time. You then multiply this figure by the capacity of the compressor that is running. This is the volume of compressed air that is being constantly wasted due to leaks.

Note: This does not tell you where you are losing the air; just that you have a problem.

Determining where the leaks are would require the engagement of a specialist company such as www.airaudit.com.au to survey the complete compressed air system, or the hire of an ultrasonic leak detector to carry out the leak audit in-house. From the leak audit an action plan should be put together to fix the problem.

Examples of areas for attention include:

- Filter bowls, where the drains may be stuck open
- Auto drains, stuck open
- Pneumatic quick fit connectors
- Flexible PVC air lines
- “Temporary” air lines which have become permanent
- Incorrect fittings used so hoses held fast with hose clips
- Compressed air used to cool motors or to provide control cabinet pressurisation etc

Recommendation.
Prior to purchasing additional compressors based on the underperformance of your existing compressed air plant, it is recommended that you carry out an air leak audit and action a repair programme. You may find that you don’t need that new air compressor after all.

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2. Heat Recovery

Before any heat recovery project is justified the true air demand of the plant must be established i.e. all air leaks fixed. If this is not done beforehand then the project will be flawed due to the incorrect power consumption of the air compressor giving inflated heat recovery figures at the expense of wasted electrical power.

With air compressors there are two main options – utilise the hot air directly from the machine or install additional heat exchange equipment and recover the heat from the compressor oil. If the hot air can be used all year round such as in a process application, or as preheated air into a boiler burner air intake, this ensures that the heat is fully utilised and will give the best payback.

Factory space heating is another use but cannot generally be used all year round and in the summer months the hot air would have to be ducted to the outside. This still offers a payback but not the best.

NOTE: if you intend ducting hot air from a compressor an additional duct mounted fan may be required as the compressor fan is only sized to transport the hot air a short distance away.

Recovery of heat from the hot oil heat exchanger is likely to offer more options as it can be used to generate a hot water stream that can be used in many applications e.g. domestic washing water, process hot water, or as boiler hot well make up.

The purpose of the air compressor is to produce compressed air efficiently and at the lowest cost. The installation of a heat recovery system attached to the compressor should not compromise this primary objective.

Where the recovered heat can be fully utilised then payback times of less than two years can be achieved.

If you are about to replace or upgrade your compressed air plant, ensure your chosen supplier offers heat recovery options that may also be available as a retrofit to any plant that you will retain. There are plenty of manufacturers who are switched on to heat recovery. Don't settle for less.

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3. Location of Air Compressors

Air compressors should be located in the coolest and cleanest area available. This is because the cooler the intake air is, the more efficient the compression. A drop in temperature of the intake air by 4 degrees Celsius will reduce the power consumption by 1%. The clean air input ensures the minimum of pressure drop across the intake air filter before it is changed under the service regime and therefore assists with the overall efficiency of the machine.

4. Air Drying

The air should always be dried after compression and before delivery to the plant. The purpose of this is to remove the many litres of acidic water and oil that would end up in the compressed air system and ultimately into the pneumatic systems of the shopfloor equipment. Not only will this moisture corrode and damage the machinery pneumatics, but where there is venting of compressed air within machinery control panels the moisture in the air will condense and potentially damage any electrical equipment sharing the same panel.

After the compressor the air should always be fed into an air receiver with the in feed near to the bottom of the receiver and the out feed near to the top. The receiver provides two functions, firstly it provides a reservoir of air to smooth out demand peaks but it also provides primary moisture removal prior to the air dryer itself.

The receiver should be fitted with an auto drain to regularly and consistently remove the accumulated moisture. The airline out of the receiver should be fitted with a coarse type auto drained filter before the air reaches the dryer.

The two common choices for air drying are fridge drying or desiccant drying. A fridge dryer will dry the compressed air to a dewpoint of approx. 3-4 degrees Celsius. If the environment that the air is to be used in is colder than this, then a desiccant type dryer is recommended as moisture will condense in the compressed air stream if it cools below the 3-4 degrees Celsius.

The desiccant type is more expensive to purchase and run so unless the superior drying effect is actually required then the fridge dryer is the best option. Typically a fridge dryer will add 3% to system running costs, and a desiccant dryer between 8 and 15% dependant on the type.

Due to the costs associated with desiccant drying it would be wise to consider whether or not locally installed desiccant dryers can be used at low temperature points of use rather than for the complete site, where the fridge drying standard may suffice for most applications.

After the dryer a fine type auto drained filter should be installed in the airline to provide a final clean up for the compressed air delivered to site.

5. Variable Frequency Drive (VFD) control

More machines are now being offered with VFD control as a means of controlling the speed of the screw and hence matching the output accurately to the factory demand. These machines cost more but are a worthwhile investment as the air pressure control is superior to an onload/offload control machine which can have benefits to shopfloor processes, and they are more energy efficient at part loadings.

The motor fitted to an onload/offload machine can still typically consume 20-25% of full load power when it is in offload mode or 'running light'—so these machines are not energy efficient when run at low loads.

If it is likely that the machine will always run at 100% then the extra cost of the VFD control will provide little benefit and the onload/offload type will be the best choice as it will always be running at maximum load and therefore maximum efficiency.

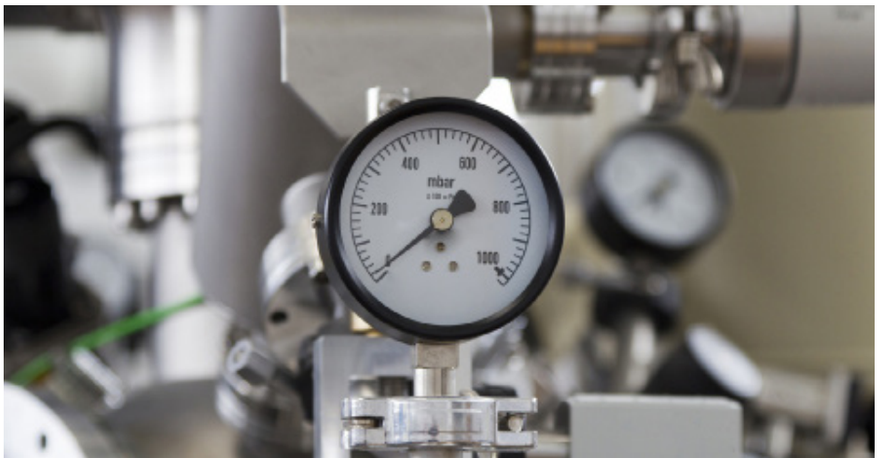
A combination of onload/offload machines for the base loading and a VFD machine for the topping up of the compressed air volume is not uncommon where there are multi-compressor installations.

6. System Operating Pressure

It is important to establish the lowest pressure that your compressed air system requires, as running it at an excessive pressure will increase your energy costs.

A reduction in the generated pressure by just 100 kPa will reduce the power costs by 7%.

The excessive pressure settings may be required due to under sizing of the distribution system and a lack of attention to major pressure drops. In the case of the latter, the system design should be reviewed and modified so the energy savings from the reduced system pressure can be realised.



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7. Compressed Air Pipework

The compressed air distribution system should be designed to minimise air pressure losses. If this is not the case then the compressors may have to be run at an elevated pressure to combat these losses.

See below the table giving **maximum** recommended airflow rates in a steel pipe distribution system at a range of system pressures and pipe bores. Exceeding these indicated volumes will cause undue pressure losses.

System air pressure	Pipe Bores					
	15mm	20mm	25mm	40mm	50mm	65mm
400 KPa	15.4 litres per second	23	44	135	260	410
630 KPa	23.4 litres per second	35	65	200	390	620
800 KPa	29.3 litres per second	44	83	255	490	780

The ease of installation and lower costs of a plastic pipework air distribution system compared to a metal pipe system are an attractive proposition. However, there are some safety points to be considered first with plastic pipework.

WARNING: Never use PVC pipework or fittings on a compressed air service, regardless of whether the pressure rating is suitable. PVC is too brittle to be safe for this high pressure service and people have been injured by high velocity shards of shattered PVC when the line or fitting fails under the compressed air pressure.

When choosing a plastic piping system check with the manufacturer that it is compatible with the type of oil being used in the air compressors on site. There is a history of synthetic compressor oils degrading plastic pipework systems, ultimately leading to failure. Not all plastic pipework systems are suitable.

8. Incorrect Applications for Compressed Air Usage

There are applications on the shopfloor where compressed air is used as part of the process rather than to operate pneumatic valves or cylinders on production machinery. Such applications may include product cooling, product drying or air knives to remove water from product. In these cases the use of high pressure air reduced in pressure to suit the process requirements is wasteful. These processes, if significant, should be reviewed to see if a low pressure blower might provide a more economical solution to the air requirements than using compressed air.

9. System Controls

Compressed air is the 'invisible' service. Too often air compressors are left running over weekends or public holidays because it is no one's responsibility to turn them off, and so air is being produced completely unnecessarily for long periods of time which wastes electricity and burns up the working life of the compressor.

If you cannot link the air compressors to your Building Management System (BMS) then install a digital 24 hour, 7 day timer to the compressors so they are shut off when not required. Air compressors are easy for an operative to start when the air is required again and distribution systems charge up quickly if adequate capacity is installed. Your compressor supplier may even offer a dedicated equipment controller to achieve the same goal automatically.

If the air demand profile is significantly lower but still required at different times of the week e.g. night times or weekends, when base demand may be much lower when there are only a few people working. A small compressor devoted to this low demand duty is worth consideration.

The installation of a flow meter linked to the BMS or a chart recorder will provide the information required to determine the low demand profile, and more importantly the extent of that demand, so the cost and benefits of an off peak machine can be calculated.

Conclusion

Compressed air is the invisible piped service. You can't see it, nor can you smell it. On a busy factory floor you would be hard pressed to even hear it. But if your compressed air system is not correctly managed you will most certainly feel it.

It is a vital service to most plants and is expensive to generate. Careful design and regular attention to the system will ensure that your operating costs do not blow out.

My top three objectives for your work list next week are:

1. Carry out a leaks audit on your compressed air system
2. Ensure there is a procedure/method for switching the compressors off when not required
3. Ensure the compressor room is well ventilated and check if the air generation pressure is excessive. Can it be turned down without consequence?

About the author
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