Best Practice Compressed Air

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Introduction

Compressed air is a very useful and valuable utility. Although it is being used for most of the plants, compressed air is often ignored until something goes wrong with it, or the compressors fail to keep up with rising air demand. Compressed air systems generally include compressor(s), filters, dryers, piping, valves and connected process equipment. This Best Practices is developed to provide you energy saving measures to reduce the operating costs associated with the use of compressed air and improve the reliability of the entire system. The energy efficiency of a typical compressed air system can be improved 20% or more.

Source: AkzoNobel

General Recommendations

Saving can be achieved in the compressed air system by applying energy saving measures listed below;

- Avoid leakage
- Reduce set pressure
- Reduce pressure drop
- Reduce intake air temperature
- Check Air quantity
- Check Air quality
- Do not use compressed air when it is not necessary
- Isolate areas or equipment
- Maintain the compressed air system
- Select efficient compressor
- Review the compressor control systems
- Peak shaving
- Use multi-stage compressors
- Combine compressed air systems

For a plant with an average air consumption of 1000 m^3/hr throughout the year, energy costs is approximately 120000 Euro/year. For instance,
24000 Euro can be saved when 20% saving is achieved in the energy usage when above listed methods are applied.

Note: Calculations in this document are based on compressed air cost 0.02 Euro/m^3 or 0.09 Euro/kWh (approximate value for Europe). Annual operating time is taken as 6000 hr to calculate the savings.

Overview

Overview of the energy saving measures with respect to saving opportunity, and their applicability to the compressed air system (new, revamp or existing installations) is indicated in Table 1. Saving opportunity is percentage energy reduction in the compressed air system. Potential saving can vary from site to site, approximate saving potential is given in the table. Energy saving opportunity is ranked as Low ← Medium ← High. For example, 10% reduction is considered as high.

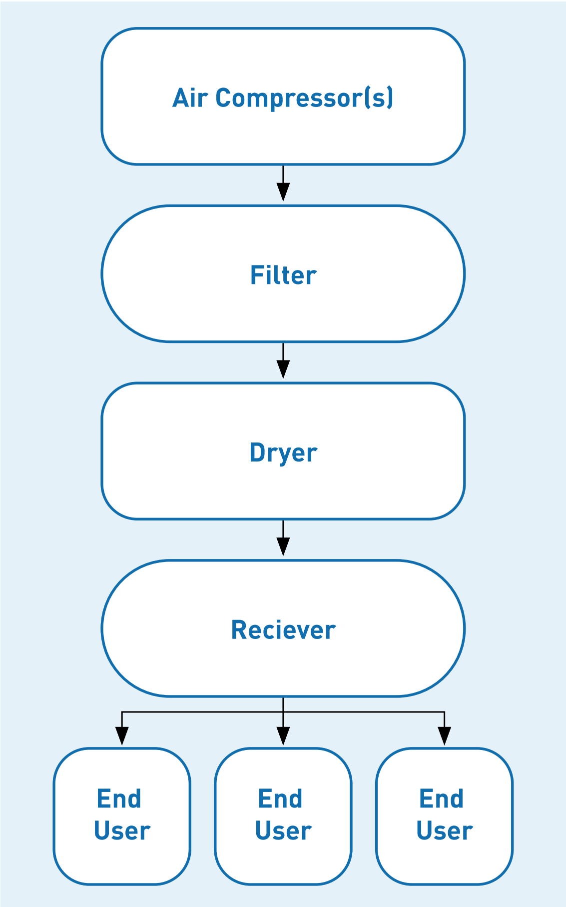
Tabel 1: Overview of the saving measures

Energy Saving Measure	Saving Opportunity	Applicability of the measure to the compressed air system		
		Existing	Revamp	New
Avoid leakage	High	✔	✔	
Reduce set pressure	High	✔	✔	
Reduce pressure drop	Low		✔	✔
Reduce intake air temperature	Medium		✔	✔
Check Air quantity	Low	✔	✔	✔
Check Air quantity	Medium		✔	✔
Do not use compressed air when it is not necessary	Medium	✔	✔	
Isolate areas or equipment	Medium	✔	✔	✔
Maintain the compressed air systems	Medium	✔		✔
Select efficient compressor	High		✔	✔
Review the compressor control systems	High		✔	✔
Peak shaving	Low			✔
Use multi-stage compressors	Medium		✔	✔
Combine compressed air systems	Low			✔

Compressed Air System

Typical compressed air system block diagram is given in Figure 1.

Figure 1: Compressed air system block diagram



Compressed air systems consist generally of the following main parts.

- **Compressor**
  - Compresses air to a small volume by increasing the pressure. Main compressor types are reciprocating compressors, screw (rotary) compressors, vane compressors and centrifugal compressors.
- **Filter**
  - Removes solids and liquids from the compressed air. Filter can be placed throughout the system.
- **Dryer**
  - Condenses and extracts water vapor from the compressed air. Three types of dryers are available: membrane, refrigerant, and desiccant.
- **Receiver**
  - Stores compressed air in order to meet rapid increases in demand. In this way, air compressors can be turned off for certain periods or run at a lower load.
- **Distribution piping:**
  - Links the components. It distributes the air from a main header to branch lines and sub headers to drop points connected to individual tools.

A brief description of other components is given below;

- Inlet filter: removes particles from the air entering the compressor. It is usually part of the compressor package.
- Motor: drives the compressor – also known as prime mover.
- Compressor controller: directs the compressor's output. It may be microprocessor, electromechanical or pneumatically based.
- After cooler: 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.
- Condensate trap: collects and discharges liquid that condenses out of the air stream. It is an integral part of after coolers, dryers and separators.
- Pressure regulator: controls air pressure and flow at individual points of use.

Energy saving measures

4.1 Avoid leakage

Leaks are a significant source of energy waste in a compressed air system. Leaks can waste up to 50% of the compressed air produced by the compressor. Reducing leakage is a key measure that can be used to improve energy efficiency.

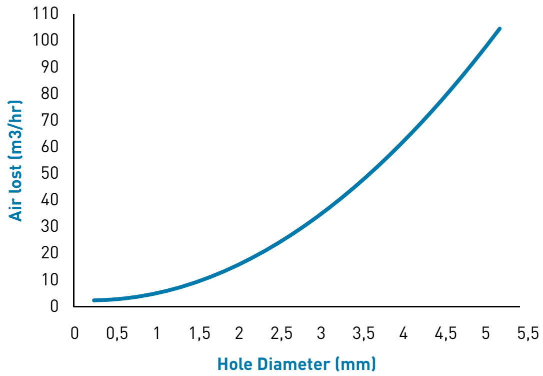
Although leaks can occur in any part of the system, the most common problem areas are pipe joints, pressure regulators, filters, lubricator, valves left open, flanges, equipment left running or not isolated hoses, condensate traps, couplings, and threaded fittings. There are three key ways to find compressed air leaks.

- The simplest way is to listen to the leakages. However, it must be noted that listening for leaks is unreliable especially in a noisy environment,
- Another method is to brush soapy water over areas suspected of leaking and look for bubbling. This method is cheap and simple, but it is a very time-consuming process.
- The third is ultrasonic leak detection. Ultrasonic detectors can pinpoint leaks very accurately and quickly by detecting the signature ultrasound signals of highpressure leaks.

Some compressed air service providers can perform ultrasonic leak detection programs if the resources from the site are not available.

Leakage rates are function of the supply pressure in an uncontrolled system and increase with higher system pressures. Leakage rates identified in m^3/hr are also proportional to the square of the hole diameter. Indication of air leakage based on the hole diameter is given in Figure 2.

Figure 2: Indication of air leakage based on the hole diameter (at 6barg)

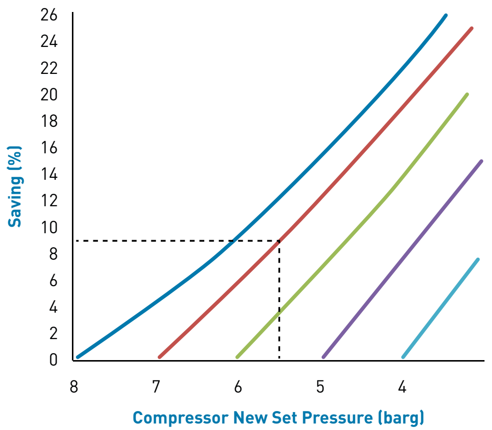


For instance, 4mm leakage costs approx. 11500 Euro/year.
Making staff aware of the cost to the business from leaks and encouraging them to actively report leaks is an important step, as they are always present on the shop floor and are best placed to notice any changes.
Fixing leaks often involves tightening or replacing connections, fixing holes in pipes or repairing damaged equipment such as pressure regulators. Often, simply cleaning and applying thread sealant to fittings will help. Replacing equipment will be necessary in some situations. Once leaks are regularly being repaired, the system is regularly to be checked and maintained. Minimizing compressed air leaks can also contribute to problems with system operations e.g. fluctuating system pressure due to partly removal of the base load, excess compressor capacity due to less air consumption.

4.2 Reduce the set pressure

At most plants, several air pressures required for different processes. Often the pressure set-point of the compressor(s) is set higher than necessary for practical reasons. By determining the actual required pressure (often control/safety valves) the set point can be reduced. Note that the required set point can be different during day and night. Also during weekends and holidays a reduced set point might be possible. Figure 3 illustrates the effect of the set pressure reduction on the energy saving.

Figure 3: Effect of the set pressure reduction on the energy saving



For example, energy consumption can be reduced by 9%, when air set pressure is reduced from 7 barg to 5.5 barg. It means 5000 Euro can be saved annually for 100 kW power compressor.

4.3 Reduce pressure drop

Pressure drop is another major cause of inefficiency in compressed air systems. Pressure drop is the decrease in pressure between the compressor and the user. Excessive pressure drop will result in a poor system performance and excessive energy consumption. A certain amount of loss is inevitable from some components such as filters, dryers and separators.

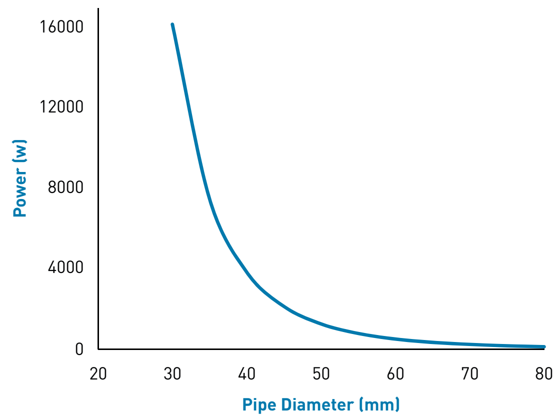
However, there are ways to ensure a minimal pressure drop in the system.

A good performed compressed air system should have a pressure drop of less than 10% between the compressor outlet and the user.
Pressure drop (thereby the energy consumption) can be reduced by focusing on the following units;

- Filters, dryers and separators
- Regulators
- Valves
- Piping layout, The more bends, elbows etc. in piping network, the higher the pressure drop will be.
- Pipe diameter

Pipe diameter has a large impact on the pressure drop of the system. The smaller the pipe, the more energy is lost by the system (see Figure 4 for power loss for a given diameter pipe). It should be kept in mind that while the pipe diameter may have been large enough for the capacity required at the time of installation, if demand has since increased; the pipe diameter may now be too small for the system's requirements.

Figure 4: Power loss for a given diameter pipe (for air flow 50 m³/hr and 100m pipeline at 7 barg)

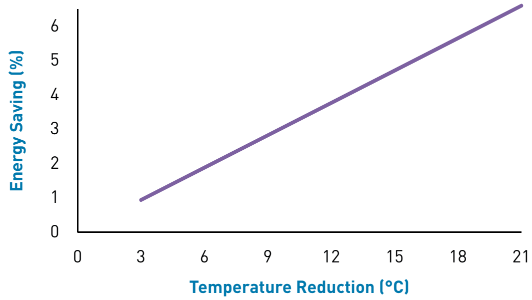


4.4 Reduce Intake air temperature

The air compressor often sucks air from the ompressor room itself. The efficiency of the compressor can be greatly improved by providing cooler air at its intake. This can be as simple as sucking air from outside the compressor house or another location on-site.

Another important consideration is where the waste heat from the compressor is discharged to. Is it exhausted into the compressor house or into the atmosphere? Figure 5 shows energy savings in the air compressor by the air inlet temperature.

Figure 5: Energy saving in the air compressor by the air inlet temperature reduction



Especially with air-cooled compressors, the cooling air within that compressor room can get 15°C higher than the outside temperature. For example 2550 Euro energy saving can be achieved annually from 100 kW capacity air compressor when the inlet air temperature is reduced by 15°C.

4.5 Check Air quantity

The required compressed air system volume can be determined by summing a plant's compressed air requirements and the duration of such volumes (system load profile). Total air requirement is not the sum of the maximum requirements for each tool and process, but the sum of the average air consumption of each. Try to avoid peak consumption coincide. Oversizing leads to additional energy loss due to lower yields at partial load. Plants with wide variations in air demand need a system that operates efficiently under partload. In such a case, multiple compressors with equencing controls may provide more economical operation. Plants with a flatter load profile can use simpler control strategies.

4.6 Check Air quality

High quality air is more expensive to produce. Knowing the proper air quality level required for successful production is an important factor in containing compressed air energy and other operating costs. Air quality is determined by the air dryness and contaminant level required by end users. Separators, filters, dryers and condensate drains are used to improve compressed air quality. Over treating air beyond the required dryness and allowable contaminant level wastes money and energy.

Equipment maintenance is also important for sustaining the desired air quality levels. Poor air quality can have a negative effect on production equipment and can increase energy consumption and maintenance needs.

4.7 Do not use compressed air when it is not necessary

Because of its availability and another alternative would require higher capital cost, compressed air is often preferred. However, its running costs is often more expensive than the alternatives. To reduce compressed air energy costs, alternative methods of supplying low-pressure users should be considered before using compressed air in such applications (see list below for the alternative methods).

- Air motors and air pumps
  - Mechanical (electrical driven) pumps are more efficient than air driven diaphragm pumps.
- Open blowing, mixing
  - Open-blowing applications waste compressed air. For existing open-blowing applications, a blower or a fan or high efficiency nozzles can be considered.
- Parts cleaning, sparging, aspirating, atomizing Low-pressure blowers, electric fans, brooms, and high-efficiency nozzles are more efficient than compressed air.
- Idle, and not used equipment
  - Put an air-stop valve at the compressed air inlet. Disconnect air supply to equipment.

Before deciding to replace a low-pressure end user with an alternative source, it is important to determine the minimum practical pressure level required for the application.

If most of your equipment uses low-quality air while a few pieces of equipment require highquality, consider moving that equipment on to a point of use system with a much smaller compressor and dryer. This will save on energy costs, as it will use less energy in treating the air for the entire system.

4.8 Isolate areas or equipment

Sometimes areas or equipment are used only short periods of time (batch or campaign production). During non-production hours compressed air is still used and leakages are still present. By isolating and shutting down the compressed air system, all air consumption is eliminated in this part of the plant.

4.9 Maintain the compressed air system

4.9.1 Maintain the compressor

Ensuring regular maintenance is carried out on the compressor will also reduce energy costs. Ensure the inlet filter is not blocked and keep coolers clean and properly lubricated.

4.9.2 Maintain separators, filters, dryers and valves

Filters

Regularly check and replace filters. Blocked filters can cause a significant pressure drop and waste energy. Gauges can be installed that measure the pressure drop across the filter and indicate when a new filter is required. Because some end users may require a higher level of air quality than others, it may not be necessary to have the entire airflow filtered to the highest level of air quality.

Dryers

Dryers should be sized for the maximum anticipated rate of flow and must be matched to the air quality requirements. Overdrying wastes energy.

Drain valves

The longer drains remain open, even partly open, the more compressed air is lost from the system. Replace manual, disc and timed drains with new electronic level sensing drains to reduce the amount of waste.

Condensate Traps

Traps should allow removal of condensate, but not compressed air, and should not be left open. Regular check on condensate traps is advised to see they functions good or not.

Receiver

When a receiver is too small (e.g due to the capacity expansion) for air demand needs, the compressor will start and stop more frequently. Each start/stop gives additional losses. By improving the ability of storage to meet demand, start/stop frequency can be minimized. In an existing system, there are two things that can be done to improve air storage:

- Install a larger main receiver for the entire system.
- Install secondary receivers near equipment that will rapidly increase its demand for compressed air.

4.9.3 Leakage Survey

Leaks can be checked and maintained by conduction a leakage survey regularly.

4.10 Select efficient compressor

Optimizing and upgrading the compressor should also be considered when looking at improving the efficiency of the compressed air system. In Table 2 comparison of compressor types with respect to energy saving is represented.

Tabel 2: Overview of the saving measures

Compressor	Reciprocating	Screw	Vane	Centrifugal
Efficiency (kW/m³/min)	7.8 - 8.5	6.4 - 7.8		5.8 - 7
Advantage	• Also suitable fo high pressures (→13 bar) • Can be relatively small size an d weight • Smaller initial cost • Simple maintenance procedures • Efficient multi-stage compression available	• Simple operation • Lower temperatures • Low maintenance 7 investment costs • Quiet and compact • Vibration free • Commercially available • Variable speed units with relatively good turndown	• Simple operation Lower temperatures • Quiet • Low maintenance	• Energy efficient • Large Capacity • Quiet High air quality
Disadvantage	• High noise levels • High maintenance cost • Suitable for smaller systems • Requires strong foundation • High oil carry over when won	• High energy use • Low air quality • Lose efficiency rapidly at partial load	• Only suitable for low pressure • Low air quality	• High initial cost • Inefficient at low capacity Specialize maintenance • Only water-cooled models available

4.11 Review the Compressor Control System

There are different types of control systems available for compressors. The existing control may not be the most efficient method, or the compressor may have no control system at all.

Start/Stop

This method of control will start the compressor once the pressure drops below a certain level and stop it once the desired pressure has been reached. This method is not preferred when there is a frequent increase in demand.

Load/No load

Using this method, the compressor will charge the system to the desired pressure, then the compressor motor will continue to run at constant speed while the compressor action is disengaged. At constant speed the motor can use between 20 and 35% of full load power.

Throttling

This method is only energy effective with screw or vane compressors that run at 70% load or above.

Variable-speed screw compressors

Variable-speed screw compressors control the motor speed whilst keeping the slide valve to the compressor fully open to meet fluctuating air demand.

Other energy efficient control ways are; slide vale (internal air circulation), piston cylinders for reciprocating compressors, and inlet guide vanes for centrifugal compressors. Depending on the load profile, the addition of variable speed drives and/or another (differently sized) compressor can be considered to save considerable amounts of energy. Variable speed drives can be fitted to the motors of screw and vane compressors, and most suppliers are now offering factory-fitted, variable-speed units. These allow the motor to be run at the rate required in order to fulfill demand at that time. However, variable speed drives should only be fitted in cases where air demand varies. Using a variable-speed drive for a compressor that runs at full load constantly will consume more energy. Alternative is to install one variable speed unit, with two or more base load units to save on capital cost.

4.12 Peak Shaving

Peak shaving has to be considered together with the compressor control strategy and compressor sizes. When a compressor is running at no-load operation it still consumes 20-35% of the energy. One of the possibilities to prevent no-load operation is peak-shaving. This can be done by scheduling production or installing a buffer.

4.13 Use multi-stage compressors

Multiple stages can be used to improve the efficiency of screw and centrifugal compressors. Additional cooling can be placed between the stages to further increase the efficiency of the second stage.

4.14 Combine compressed air systems

Sometime multiple compressed air systems exist on site. Combining systems can have various benefits such as peak shaving, more optimal use of compressors, better control etc.
However it also can turn out to be unfavorable for example when multiple pressure levels are used and after the change all the air has to be produced at the highest.

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Source: AkzoNobel