White Paper

Air Services reduce operational costs of pneumatic systems

FESTO

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In the past few years, oil prices have continually skyrocketed upwards. Consequently, saving energy and optimizing throughput has become more crucial. Successfully decreasing energy usage while increasing output depends on paying the greatest attention to the small details in the way we design and operate manufacturing equipment and processes. Compressed air specialists help both the machine builder and the end user first understand and then improve energy consumption at the individual machine level.

The importance of compressed air

Second only to electricity, compressed air is the most important energy carrier in manufacturing. However, a recent study done by the U.S. Department of Energy showed that approximately 10% of the electricity consumed by a typical industrial facility is for generating compressed air. For some facilities, compressed air generation can account for even 30% or more. Yet there is hardly a factory that can function without compressed air. For many industrial applications, pneumatics is the preferred drive technology. Pneumatic technology is often selected due to its advantageous characteristics including overload resistance, extraordinary service life, ease of assembly, reliability, economical cost factors and safety aspects. All these advantages might suggest that pneumatic applications wouldn't require any monitoring technology for operation. However, after looking at Figure 1, it may be suggested that this statement be reconsidered. In view of the fact that 88% of the costs for compressed air are for electrical energy and maintenance, it becomes apparent that the cost of pneumatics is not the investment but the operation. Therefore, it makes sense to pay special attention to the proper usage of compressed air. Assuming that the compressors, the distribution system, and the pneumatic drives are all properly sized, steps must be taken to avoid the inefficient use of compressed air and/or air losses caused by leaks.

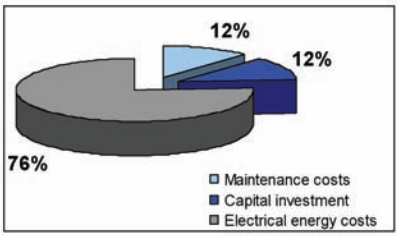


Figure 1:
Operating costs for compressed air systems
source: U.S. Dept. of Energy

Wasted Air

Wasting compressed air is usually seen as harmless. A little air lost here and there doesn't seem like a big deal. This may be the reason why air leaks are often not taken seriously. The fact is compressed air is the most expensive energy medium available in a production facility. Consequently, air leaks are an underestimated waste of energy and money. In existing installations, leaks are the primary cause of excessive compressed air consumption, as high as even 30% of the total air used. In today's highly competitive markets, manufacturing companies and machine builders may be surprised to learn that costs for compressed air can range up to $ 0.30 per 1000 scf. Wasted compressed air may be harmless to the environment, but it is not harmless to the bottom line. When cost is an issue, it is absolutely essential to recognize when compressed air is exhausting into the atmosphere.

Compressed air: the most expensive energy in a production facility

Another factor regarding leaks is something referred to as artificial demand. The higher your supply pressure, the more air your leaks will consume, creating a greater demand on your compressor. By reducing the supply pressure, you can greatly reduce the amount of air that is required to be produced by your compressor. For example, a 1/4" orifice at a 110 psi supply pressure will generate a leak rate of 72 cfm. The same 1/4" orifice, with the supply pressure reduced to 60 psi, will generate a leak rate of 43.6 cfm; a reduction of nearly 40%. Taken another step further, the financial gain by keeping the system pressure lower, just seen at this one leak, is as follows:

60 psi supply
43.6 cfm x 525,600 min/yr x .00024 ¢ per cf (1) = $5499.88 per year

110 psi supply
72.0 cfm x 525,600 min/yr x .00024 ¢ per cf (1) = $9082.37 per year

By simply reducing the main pressure the artificial demand created by this leak at 110 psi is reduced and a customer can save $3582 per year for this one orifice alone.

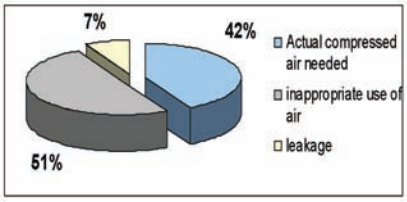


Figure 2:
Results of a customer survey by Festo

In addition to leaks, the inappropriate use of air accounts for a large percentage of wasted compressed air. In many factories, hand held blowers, pneumatic vacuum generators and coolers all contribute to this. Figure 2 represents actual recorded data from an air audit performed by Festo. Although the customer was vigilant about keeping air leaks to a minimum, their inappropriate uses of air consumed over half of the compressed air. By replacing these commonly used apparatus with low pressure devices, machine builders can dramatically reduce the requirement for compressed air. Additionally, restricting the flow of air to inactive or inoperative equipment will also greatly contribute to energy savings.

There are many companies offering audits for compressor rooms and leakage elimination for the distribution systems. However, once the piping enters a machine most of these services stop. Compressor technology and pneumatics, even though both deal with compressed air, are two very different fields. Compressors represent the supply side, whereas pneumatics the demand side. These two types of audits are rarely offered together, since the two fields of expertise are rarely found together.

If the agenda is to save energy by optimizing the air usage, what service would make most sense? The answer is simple, both! The supply side can be optimized to fulfill the demand in a more efficient manner, but unless the demand is optimized the compressors will still supply more energy then actually needed. The demand side can be optimized by reducing air usage, but besides an increase in throughput and stable pressure levels not much energy is saved due to continued running of the compressor.

Servicing the demand side ensures the lowest possible demand with maximum throughput followed by a supply side service/adjustment to compensate for less demand and inefficiencies. Now the energy savings are even higher than having done both services independently. The important thing to remember is that supply side services do not compete with demand side services, but rather add value to each other. With optimized demand side, one can expect to save up 35% in energy savings. Combined with a compressor audit, the savings can be over 50%.

(1) Per the Dept. of Energy, the average cost of compressed air is between .00018 and .00030 ¢ per cf.
For this example, we will use the average value of .00024 ¢ per cf.

Machine level audits compared to compressor audits

Everyone wins; the compressor company, the pneumatics company, the environment, and most importantly, the customer. The goal is to ensure that compressed air consumption is kept at the optimum level; the proper level required for reliable system operation. Ideally, the analysis would be performed when the system is first installed. In this way, the pneumatic components within the system and the compressed air distribution network back to the point of initial generation can be adjusted to the ideal settings. The pressure and wear behavior of compressed air generation and distribution systems is a common situation, and a thorough maintenance overhaul will often pay huge dividends in improved cost efficiency

Benefits for End Users
For the end user, reliable and cost effective pneumatic systems are a key element in the production process; the issues are clear, and the savings can be impressive. Experience shows that by identifying and eliminating leaks, by optimizing the compressed air generation and distribution layout, plant operators can expect to save up to 50% of energy costs. With savings of that order, a full optimization and maintenance program will pay for itself within two years – often considerably quicker.

Festo Energy Saving Service helps End-Users

Better operating efficiency
- Fewer operating losses
- Line improvement opportunities
- Accurate input for TPM program

More reliable processes
- Improved asset care
- Optimized maintenance of pneumatic components
- Reduced shock load on pneumatic frames
- Reduced noise generation

Greater profitability
- Reduced compressed air costs
- Reduced Energy Levy Taxation

Benefits for Machine Builders
For the machine builder, the implications of high energy prices are creating a more energy conscious and discerning marketplace. Energy consumption is now a real differentiator, and this, alongside the requirement to test and provide valid compressed air consumption figures, is a major incentive to analyze and improve performance. What has hampered many companies is the lack of appropriate technologies and techniques for the accurate measurement of compressed air consumption and, more importantly, the expertise to analyze the data and provide effective action plans.

The first step in working with machine builders is to improve the accuracy of sizing components to define the optimal compressed air system for a specific machine. That information is then used to generate documentation that will give the customer evidence for standards compliance and support an effective total preventive maintenance (TPM) program.

Festo's Compressed Air Consumption Analysis can help machine builders create a more cost-effective, competitive product

Accurate documentation
- Assists in making energy reduction plans and clearer goals
- Makes it easy for the user to demonstrate ISO 14001 compliance

More competitive pricing
- Lower shock loads enable fabrication cost reduction
- Component sizing – and therefore costs – can be optimized

Improved machine operating efficiency
- Less downtime and better machine performance for the end user

Festo Innovations
In response to the higher cost of energy for compressed air and to better assist our customers with cost savings and machine operation efficiency, Festo has developed three services to meet these needs. These services are the Festo Air Quality Service, Festo Air Consumption Analysis, and Festo Energy Saving Service.

Festo Air Quality Service

Machine builders need to provide efficient production within a limited budget. Pneumatic components do eventually fail, and the point in time at which this failure occurs is directly related to amount of usage, the application, and the quality of air. Realizing that poor air quality often prevents customers from achieving maximum performance and life span from pneumatic devices, Festo Air Quality Service was developed to ensure ideal working conditions for pneumatics.

Evaluation of compressed air quality

- **Particle content – the cleaner the better**
  Risk: Dust from the surroundings and rust particles from the air distribution system drastically increases the wear of moving parts and may cause clogs.
- **Oil content – the less the better**
  Risk: The factory lubrication lasts for life unless oils wash the "good" lubrication out. In addition, oils containing esters attack the seals of pneumatics and can cause leakages and the jamming of valves.
- **Water content – the dryer the better**
  Risk: Due to missing or under-dimensioned air drying units, water in the pneumatic system washes out the lubrication of the components.

Procedure
The Festo Air Quality Service measures the oil and water content at one point in the air distribution system. Taking into consideration what pneumatic components are present, an air quality improvement plan is developed to ensure the best working conditions for pneumatics. It is recommended to apply this service on the machine level to insure that correct air quality is present at every point in the system. Festo Air Quality Service includes:

- Inspection of air preparation units on demand side
- Inspection of filters
- Oil content measurement according to ISO 8573
- Water dew drop point measurement according to ISO 8573
- Development of an improvement plan

Festo Air Consumption Analysis

Festo Air Consumption Analysis was primarily developed for OEMs. Realizing the cost of energy, air consumption figures have become an important sales argument for companies that sell machines. Festo Air Consumption Analysis enables machine builders to understand and document precise consumption figures for new and existing machines. The Festo Air Consumption Analysis provides an "industrial window sticker" which summarizes the air consumption, the pressure, and compressed air temperature levels that the machine requires to run at an optimum level. This allows the customer of the OEM to determine the compressor loads beforehand by clarifying compressed air demands. Knowing the figures for the production modes of the machine also helps when creating a cost analysis.

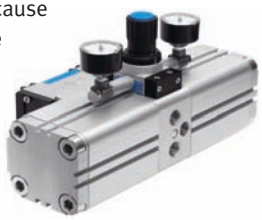
Procedures and Analysis

Procedure
Measuring equipment is inserted into the main supply line and the machine is run in all available modes (standby, off, running, part A, part B, etc...). Consumption figures for each mode are compiled into a document that acts just like a window sticker on a car. Afterwards, the machine is evaluated on a component-by-component basis. The results are discussed and explained in detail. This service can be the last step in a commissioning/quality control process.

Festo Air Consumption Analysis includes the following phases performed by pneumatic specialists using state-of-the-art measuring equipment and advanced analysis software:

- Flow and pressure measurement at the machine level to gather data on compressed air consumption and pressure
- Illustrative presentation of results, with supporting documentation of values
- Recommendations for improvements, by technical consultants

During a recent Festo Air Consumption Analysis, it was noticed that a factory's total air consumption was exceedingly high because the total system pressure was excessive in order to power a single cylinder that required a much higher pressure than rest. Based on a Dept. of Energy study, every 2 psi decrease of system pressure translates to nearly a 1% energy savings. As a result of the Festo Air Consumption Analysis, it was recommended to use a Festo DPA pressure booster for this one cylinder in order to reduce the overall system pressure.



Festo Energy Saving Service

Realizing a potential cost savings of up to 35%, Festo developed a service that would help customers save money through improved energy management.Festo Energy Saving Service is a machine-level evaluation. Air leakages are located and eliminated on a piece by piece in-depth evaluation of all pneumatic devices. This complete evaluation covers all components of the system from fittings and quick- connects to valve terminals and actuators. Every leak located is documented, and recommendations for improvement are included in a final comprehensive report.

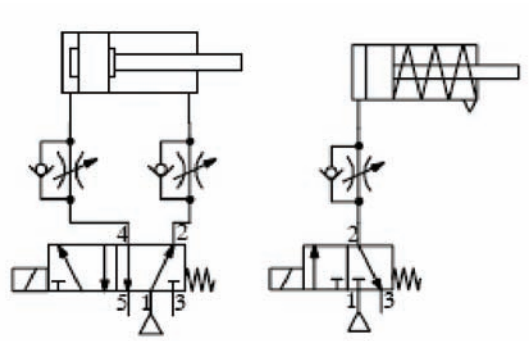
Procedure
The first step is the installation of the measuring equipment into the main air line, followed by consumption measurements of the machine in running and standby mode. Leakages are identified with ultrasonic sound equipment. Every leak located is inspected and methods for the future prevention of leaks in this specific location are noted. However, even a system with zero leaks can be optimized to increase energy savings. In order to accomplish this, every pneumatic component is checked for correct sizing and application. After the improvements have been implemented, a second measurement is done for the purpose of a cost savings analysis. Festo Energy Saving Service includes the following phases, performed by specialists:

- Consumption measurement to detect leaks and consumption during machine operation
- Inspection to identify any points and leaks within piping, tubing, and fittings
- Measured-value analysis summarizing the results in terms of characteristic values and costs
- Generation of measured values for static leakage and consumption
- Preparation of cost/benefit analysis and documentation
- Optional repairs to eliminate leaks and replace any defective components.

Energy Saving Service

After the service is completed, a comprehensive report is created summarizing all located leakages and points of improvement; energy cost per year for running the machine and cost savings achievable through the Festo Energy Saving Service.

A suitable example of saving energy through ideally sizing pneumatic components to optimally perform the function required was one discovered during a recent Festo Energy Saving Service. The recommendation offered was to replace the double acting cylinders with single acting, spring return cylinders. As a result, the 5/3 way valve was replaced with a lower cost 3/2 way valve, and one flow control valve was eliminated. This brought the total number of connections from 9 to 5. The total air consumption was reduced by nearly 50%, and the potential sources of leaks were reduced by 44%.



But, there are disadvantages to this solution which have to be taken into account:

- Need to use a larger bore cylinder than the double acting cylinder to overcome spring force.
- Unable to increase spring return time
- Lower retracting force
- Shorter stroke only

ESNU
single acting cylinder

Another interesting potential solution that would overcome all these disadvantages would be to use a fluidic muscle instead of the single acting cylinder. A major advantage of using the muscle is its axial force to bore size ratio. The average muscle generates approximately 10 times the force compared to a cylinder with the equivalent bore. Therefore, while still reducing the air consumption by only needing air for a single motion, by using the fluidic muscle one can use a much smaller bore size to generate the equivalent force. The challenge here is that a completely different design approach must be taken.

MAS
fluidic muscle

Summary

In order to combat rising energy costs, manufacturers and end users alike need to scrutinize the efficiency of their machines and optimize systems that use pneumatic drive technology. Eliminating wasted energy, such as leaks, combined with correctly sized components to reliably perform the job can save up to 35% in total energy savings. Festo provides three different air services in order to meet these customer needs.

For more information, please visit www.festo.com/us/airservices

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