White Paper

F-US Energy Monitoring Package (GFDM)

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F-US Energy Monitoring Package Publication

Compressed air is one of the most expensive sources of energy on the plant floor of a modern manufacturing facility. Surprisingly, this is generally not a well-known or accepted fact among manufacturers. However, there are certain steps that can be taken by manufacturers to significantly increase the efficiency and economy of their facilities. If compressed air usage is closely monitored, this could not only result in substantial cost savings but could also reduce machine downtime and improve the life expectancy of the machinery.

Manufacturing of compressed air is expensive; 79% of the manufacturing costs are caused by the cost of electrical energy, while 15% and 6% are the costs for capital investment and maintenance respectively. The US Department of Energy uses 18-30 cents per 1000 cubic feet of compressed air as an economic estimate. An internal survey at Festo revealed that 70% of users of compressed air were not even aware of how air is consumed in their facility. 80% said that they had not implemented air consumption reduction programs. With these statistics, it is clear why air consumption reduction is of prime importance.

The Problem

However state-of-the-art a pneumatic system may be, undesired increases in air consumption cannot be ruled out. In addition to this, daily wear-and-tear contributes to leakages, which could amount to huge losses in terms of money and performance. When these conditions become apparent, users tend to increase system pressure to combat the increased requirement on the system caused by this artificial demand. By adding more compressor capacity, leaks will continue to draw more air, leading to increasingly more energy being wasted.

Besides contributing to energy waste, pressure drops because of significant leakage could lead to pneumatic components performing below par, and consequently reducing their life expectancy. When pneumatic components start to slow down, users will increase system pressure in order to meet application requirements. This short-term fix inevitably leads to more serious problems with the components, eventually leading to failure.

It is apparent that as a result of these issues, system air consumption monitoring should be an on-going process. Many users continue to run pneumatic systems until a catastrophic failure occurs, typically because it is quite challenging to isolate which process and/or component is contributing to the increasing air consumption. A one-time leak reduction program is one way to detect leakages; however, a continuous life-time monitoring will result in cost-effective operation and prolonged continuance of the pneumatic equipment.

The Solution

There do exist limited monitoring and/or diagnosis audits for specific industry segments, but there is no generic tool which will provide overall system monitoring and diagnosis resulting in a comprehensive cost reduction. As a solution to tackle this problem, Festo Corporation has developed a tool to monitor system flow and air consumption in conjunction with smart sensors, a diagnostic controller and a user friendly graphical display. This product is available as a complete package, which will be easy to configure and provide data in a real-time setting. In addition to real-time data, it can provide in-depth data analysis for system flow and air consumption.

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Festo Energy Monitoring
The Energy Monitoring Package essentially consists of a flow sensor, a pressure sensor, a diagnostic controller and different solutions to visualize the diagnostic information about the air consumption of a machine cycle. Visual display is available in the form of a graphical display unit known as the FED (Front End Display). The package can be combined in conjunction with an external SCADA system, wherein the data evaluation can be done off-site. For processes to be clearly identified (identification of process start and stop triggers), an interface (digital output) is required from the machine/process PLC to the FDC (digital input). In case the customer does not require process identification the GFDM package is totally self-sufficient and needs no external interface besides a power supply. The sensor range is selected for the customer's machine requirements. The Energy Monitoring Package is delivered pre-configured, thereby eliminating the chance of configuration difficulties by the user. It is ideal for evaluation of the air consumption for different operation modes of a machine, to evaluate the health status of the pneumatic system, find the optimal point of operation of a machine, preventive maintenance, and central or decentralized monitoring of air consumption. Minimal training is required to get started with the Energy Monitoring Package contents. The software to configure the sensors comes pre-configured as part of the package and is very intuitive.

The intelligence of the Energy Monitoring Package is embedded in the controller. This modular device includes the controller, analog input modules for flow sensors and digital input modules for communication with the machine.

Once commissioned, the Energy Monitoring Package will continuously monitor the air consumption of the machine resulting in constant updates about system performance. An increase in system air consumption is quickly indicated. This helps to reduce downtime and keeps the equipment in good working order, in addition to ensuring a cost-effective production schedule and delivering a quality product. Data obtained from different projects shows that cost recovery for implementing the energy monitoring package would be well within 1 year.

The customization of the display for the customer is straightforward. The basic essence of customization is to configure the tolerance settings for the monitored parameters; namely flow and air consumption for the current release. The parameters have to be configured individually. Once the configuration is applied, the teach-in process can be started. The teach-in process is performed by averaging the data over a number of cycles.

When it comes to the point of archiving or doing off-line number crunching, the Energy Monitoring Package has quite a few possibilities to offer. The recorded data can be exported into spreadsheet format (.csv format), allowing easy post-processing using spreadsheet processing software. It also provides archiving of data, which can be later invoked for review or post-processing. Referencing can be done to capture a "good" condition of the system. This data can then be used to monitor the life condition of the system and can be invoked on-demand for troubleshooting of the system in case of any problems. A graphical display is provided for real-time analysis of the flow rates and the system air consumption. In addition to waveform analysis, bar charting is also provided as an additional means of data analysis.

Automatic scaling of units is enabled for real-time display of the flow rates and system air consumption. This graphical display can be rearranged to select an appropriate area for graphical visualization. Alarm functionality indicates when user-defined thresholds are violated. Failure display can be evoked for up to four user-defined thresholds. Green indicates normal operation; yellow corresponds to a warning; orange indicates that maintenance is recommended; and red corresponds to alarm. Thresholds and trends make it possible for deviations to be recognized in a timely manner. Visualization is available for industrial conditions on the machine level. This makes it possible for machine operators to analyze machine conditions and make the necessary adjustments to avoid the substandard operation of the machine.

Figure 1: Available package configurations

Components		Available GFDM configurations					
		1	2	3	4	5	6
Controller							
CECX		X	X	X	X		
Pressure Sensor							
SDE1		X	X	X	X	X	
Flow Sensors							
SFE1		X		X		X	
MS6			X		X		X
Visualization							
SCADA › PC*		X	X				
SCADA › FED				X	X	X	X

* - PC to be arranged by customer

Figure 2: As seen from the screen-shot of the graphical display unit above, the horizontal bars represent the current values of the parameters being monitored for every machine cycle. The vertical arrow heads represent the reference values that are used to assess the parameter status.

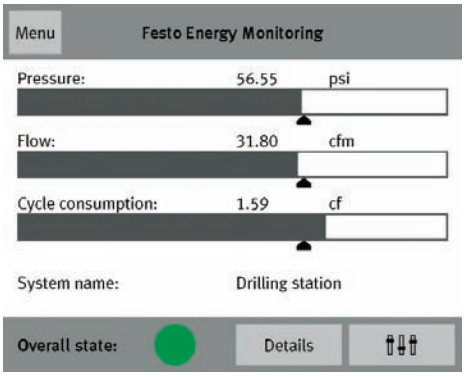
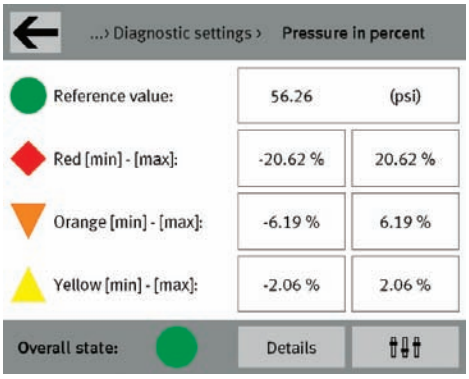
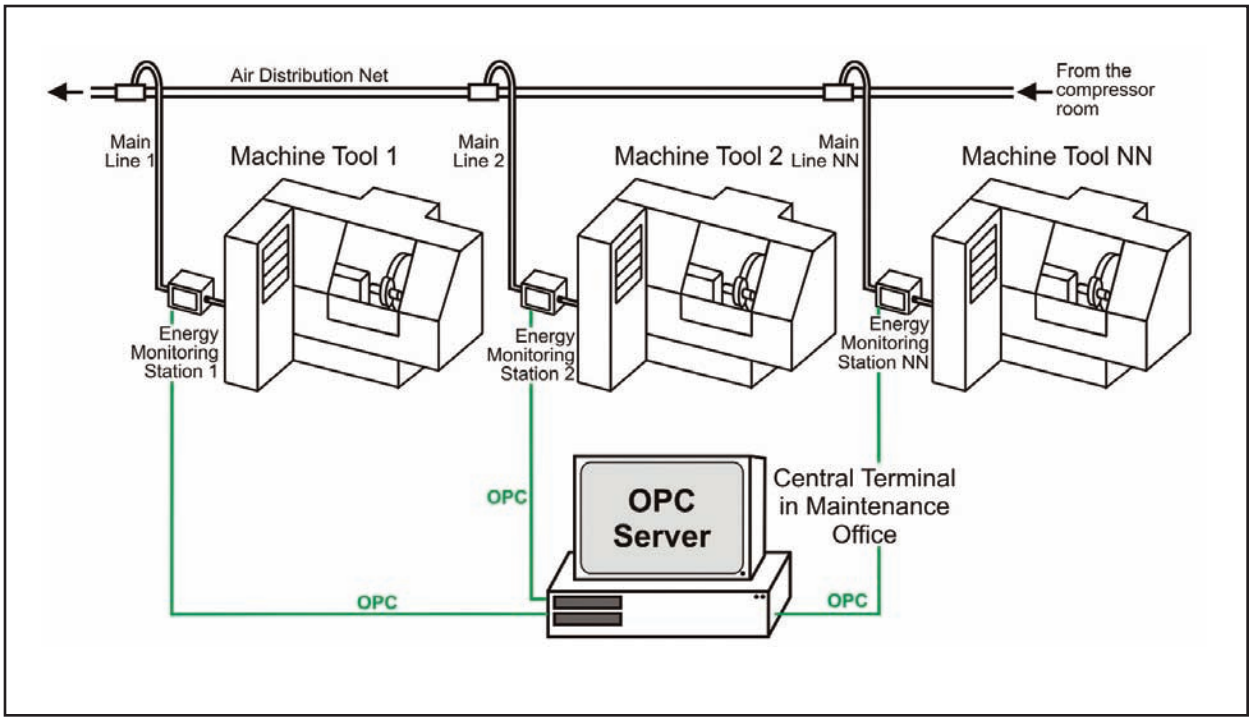


Figure 3: Screen shot of the graphical user display with the diagnostic settings



The Energy Monitoring Package also allows the user to configure the package for up to 16 different processes. These could be configurations for batch operations and can be totally independent from each other. If there are many different variations in batches, a new teach-in is not necessary. Previously generated data is available and is uploaded automatically. This allows for different operating batches at different clock hours allowing for 24/7 operations; if necessary, using one monitoring package.

Figure 4: The above drawing represents a typical application with the Energy Monitoring Package. Each package can be installed on a machine to monitor up to 16 separate processes. Further, the data of each package can be independently visualized at a centralized terminal on a users OPC server which is facilitated with the SCADA software.



Cost Savings Example

Every customer has one essential question: how much do I save if I use this package in my production? An example to calculate the cost savings is given below. However, this example concentrates only on energy costs and does not take into consideration that leakage and pressure losses usually slow down the production speed of machines. Also, downtimes caused by catastrophic failures which could have been prevented by early leak detection are not taken into account.

The following table gives an overview about the amount of compressed air which exhausts into the ambience dependent on pressure and diameter of the leak.

Table 1: Losses of compressed air in [l/min] and [scfm] dependent on pressure and leakage diameter. Flow values in [l/min] are given in gray columns, flow values in [scfm] are given in white columns.

Pressure		Leakage diameter in [mm] and [inch] / Flow in [l/min] and [scfm]											
[bar]	[psi]	[mm]	[inch]	[mm]	[inch]	[mm]	[inch]	[mm]	[inch]	[mm]	[inch]	[mm]	[inch]
		0.5	**0.019**	**1**	**0.039**	**1.5**	**0.059**	**2**	**0.078**	**2.5**	**0.098**	**3**	**0.118**
4	58	9.34	0.33	37.39	1.32	84.12	2.97	149.6	5.28	233.7	8.253	336.5	11.88
5	72.5	11.68	0.41	46.73	1.65	105.1	3.71	186.9	6.6	292.1	10.31	420.6	14.85
6	87	14.02	0.49	56.08	1.98	126.2	4.45	224.3	7.92	350.5	12.37	504.7	17.82
7	101.5	16.35	0.58	65.42	2.31	147.2	5.19	261.7	9.24	408.9	14.44	588.8	20.79
8	116	18.69	0.66	74.78	2.64	168.2	5.94	299.1	10.56	467.3	16.5	672.9	23.76
											[scfm]		[l/min]

Let us assume in a plant, there are 20 leaks of the size 0.5 mm [0.019 inch] at 6 bar [87 psi], 20 leaks of the size 1 mm [0.039] at 6 bar [87 psi] and 10 leaks of the size 2 mm [0.078 inch] at 7 bar [101.5 psi]. In reality, the scenario could be and usually is much worse and the customer is generally not aware of this futile expenditure.

If the plant runs for an annual aggregate of 6000 hours with an electric rate of $0.07/kWh and compressed air generation requirement of approximately 18 kW/100 cfm, then, the following formula can be used to calculate the potential cost savings:

Potential Cost Savings = # of leaks x flow rate [scfm] x kW/[scfm] x operating hours/year x $/kWh

Cost savings from 0.019 inch leaks = 20 x 0.49 x 0.18 x 6000 x 0.07 = $740
Cost savings from 0.039 inch leaks = 20 x 1.98 x 0.18 x 6000 x 0.07 = $2,993
Cost savings from 0.078 inch leaks = 10 x 9.24 x 0.18 x 6000 x 0.07 = $6,985

Thus total cost savings per year from eliminating these leaks = $10,718

Summary

The Energy Monitoring Package is a diagnostic tool to monitor air consumption and flow rate in conjunction with smart sensors, a diagnostic controller and a user friendly graphical visualization, realizing the savings potential for more efficient use of compressed air. The Energy Monitoring Package is a stand-alone system; therefore no impact on the automation process is caused, making it easy to integrate into an existing machine. The system will help the user optimize the use of compressed air at the point of consumption, and develop an efficient maintenance plan which will ensure a considerable return on investment, along with extended machine usage. Combining the Energy Monitoring Package with minimal-leakage products and state-of-the-art pneumatic products from Festo would provide extremely cost-effective solutions.

Product Range and Company Overview

A Complete Suite of Automation Services

Our experienced engineers provide complete support at every stage of your development process, including: conceptualization, analysis, engineering, design, assembly, documentation, validation, and production.

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Complete custom engineered solutions

Custom Control Cabinets
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Complete Systems
Shipment, stocking and storage services

The Broadest Range of Automation Components

With a comprehensive line of more than 30,000 automation components, Festo is capable of solving the most complex automation requirements.

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Pneumatics
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PLCs and I/O Devices
PLC's, operator interfaces, sensors and I/O devices

Supporting Advanced Automation... As No One Else Can!
Festo is a leading global manufacturer of pneumatic and electromechanical systems, components and controls for industrial automation, with more than 12,000 employees in 56 national headquarters serving more than 180 countries. For more than 80 years, Festo has continuously elevated the state of manufacturing with innovations and optimized motion control solutions that deliver higher performing, more profitable automated manufacturing and processing equipment. Our dedication to the advancement of automation extends beyond technology to the education and development of current and future automation and robotics designers with simulation tools, teaching programs, and on-site services.

Quality Assurance, ISO 9001 and ISO 14001 Certifications

Festo Corporation is committed to supply all Festo products and services that will meet or exceed our customers' requirements in product quality, delivery, customer service and satisfaction.

To meet this commitment, we strive to ensure a consistent, integrated, and systematic approach to management that will meet or exceed the requirements of the ISO 9001 standard for Quality Management and the ISO 14001 standard for Environmental Management.

9001: CERTCC5-16248-2006-AQ-ESN-TGA
ISO 9001
ISO 14001
DNV
Certified Company
14001: CERTCC5-16248A-2006-AQ-ESN-TGA

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