Diagnosis management
for maximum process reliability

Acting instead of reacting

Diagnosis management for maximum process reliability and productivity

Diagnosis and condition monitoring have a very promising future in automation. And with good reason: Unscheduled downtime is expensive – in some cases, one minute can cost up to 10,000 euros!

Active diagnosis management

The trend: To actively and significantly increase process reliability and the productivity of equipment by treating diagnosis as asset management. Innovative diagnostic strategies, including products with diagnostics capability and numerous Festo services can help here, reducing equipment lifecycle costs and providing a more rapid return on investment (ROI) with increased competitiveness.

Individual diagnostic strategies use an individual mix of different types and levels of diagnosis. Additional reliability is provided by strategies such as regularly recording the overall equipment effectiveness (OEE) or total productive maintenance (TPM).

The aim: A diagnosis portfolio based on clear industry standards, which is open, can be integrated, and is fit for the future. Moreover, scalable diagnostic strategies that guarantee near 100% machine availability by the OEM.

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Reliable productivity thanks to diagnosis

Increased productivity – or modern, cost-saving service strategies? Depending on the perspective from which you consider diagnosis and condition monitoring, there are various different motivations and reasons for the increasing integration of diagnostic strategies and tools in automation systems. Overall, however, there are numerous interfaces and common interests.

For the people who operate the systems, whether they are company owners, managing directors or even shift supervisors in production companies, the focal aspect of diagnosis and condition monitoring is unquestionably increased equipment productivity, and therefore a long-term improvement in competitiveness.

Planners, design engineers and manufacturers of machines and equipment set great store by aspects that make life easier: their first priority is to reduce costs for expensive service visits, service contracts or productivity guarantees. They may also be tasked with looking at new business and operating models such as machine leasing or pay-per-use plans.

Diagnosis management: A new era in maintenance

Due to the complexity of systems, machinery and equipment, diagnosis and condition monitoring are already an indispensable factor in factory and process automation. Their importance is set to grow dramatically over the next few years.

Against a background of increasingly tough global competition, sophisticated individual diagnostic strategies offer a decisive competitive edge by significantly increasing the overall efficiency of expensive equipment. Since any chain can only be as strong as its weakest link, the principle of consistency also applies to diagnosis strategies. Good strategies integrate even small machine and equipment parts from the word go, and provide for a consistent diagnostics capability.

The challenge: A conscious business decision in favour of strategic diagnosis and asset management, in order to increase productivity. This is the only way in which optimum overall equipment effectiveness (OEE) can be achieved. This value is the result of three factors: availability, performance rate and quality rate.

All-round diagnostics: The portfolio from Festo

Festo has for some time now been aware of the strategic importance of diagnosis and condition monitoring – and has acted accordingly.

Analysis has shown that four areas are of major significance for the most efficient individual diagnostic strategies:

1) A portfolio with extensive diagnostics capability across the entire control sequence – suitable for industrial communications from actuator to factory level. For products themselves as well as at a cross-product level, by means of information technology (IT) and industrial services.

2) Cheaper diagnosis – for example through technological advances that enable more cost-effective diagnosis with a rapid return on investment. The key words here include reduced programming costs, function integration for components, and clever networking.

3) From condition diagnosis to process diagnosis: It must be possible to mix different diagnostic procedures and levels in a way that results in an ideal individually tailored solution. This may include, for example, preventive maintenance, optimisation via fault lists, fault analysis, visualising potential sources of faults, regular recording of overall equipment effectiveness (OEE) and integration into a TPM (total productive maintenance) system.

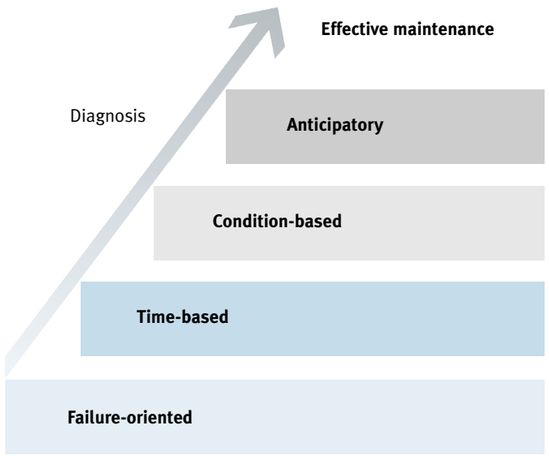
4) Lean & service management – for comprehensive diagnosis without in-house expertise, and a focus on core competencies with lean resources.

Wanted: The right point in time

Diagnosis and condition monitoring
Diagnosis at various levels or condition monitoring: Both of these serve to identify or swiftly rectify any faults or impermissible conditions that may arise in systems or components, and ideally even to prevent these from occurring in the first place.

It is therefore the aim of innovative maintenance strategies to use secure data to identify a time window for maintaining equipment or exchanging components that is system and usage-dependant and is ideal from a business point of view. If maintenance takes place too soon, overall costs are increased unnecessarily; if the warning systems malfunction, downtime also costs money.

Current strategies therefore consist of a mix of four levels. Discounting the failure-based fire brigade strategy, which involves the full risk of waiting for damage to occur, three other maintenance strategies of varying levels are available.



Anticipatory: Condition monitoring

Interval-driven: Preventive, time-dependent maintenance
Simple condition monitoring for increased reliability and ease of planning: In the case of preventive maintenance, staff exchange various wear-intensive or other susceptible components in line with fixed time intervals that are usually recommended by the manufacturer. This is frequently based on the experiences of the operating/maintenance personnel, the operating time of drive units, switching cycle rates or stroke rates, and also sensors such as flow sensors that monitor and analyse the condition of pneumatic equipment.

From counters to symptoms: Condition-based maintenance
Condition-based maintenance defines the ideal time window considerably more individually and precisely: Regular monitoring and the creation of diagnostic data enable maintenance to be better controlled.

Vision and supreme discipline: Anticipatory maintenance
Anticipatory maintenance is essentially a refined version of preventive maintenance, but with the subtle difference that modern methods and trend analyses are used to determine the time at which components need to be exchanged, in an operationally-dependent and dynamic manner.

The drivers here are new technologies such as miniaturised sensors, wireless transmission, high-performance controllers and intelligent, model-based methods. The further development of methods oriented towards anticipatory maintenance is yet another challenge for the supplier. However, the focal point of anticipatory maintenance is and always will be the interpretation and evaluation of the data collected.

The decisive advantage is that, for example, the effects of changing environmental conditions can be better recorded than in a rigid interval scheme. This makes anticipatory maintenance interesting for machine manufacturers as well, not only because recourse claims can be modified or verified, but also because it makes specific optimisation and full-service packages possible.

The future of condition monitoring
All in all, condition monitoring is an innovative, multi-faceted topic in which, in the field of pneumatics, it is the lifecycle management of machinery and equipment rather than wear and tear that plays a leading role. It touches on subjects such as process diagnosis and the monitoring of operational costs whilst at the same time forming the basis for new service and business models.

Failure as an emergency: Diagnostic strategies

Stage 1: Discovering the fault – monitoring
Monitoring is an ongoing technical activity aimed at detecting faults or failures, generally by using a single sensor signal or derived characteristic value. This involves monitoring a characteristic value, e.g. the flow rate, and constantly comparing actual and setpoint values for any limit violations. Any impermissible conditions are thus identified by maintenance personnel. In pneumatics, the basis for monitoring is sensors, e.g. pressure sensors, flow sensors, limit switches or position sensors. This form of monitoring can also be found in condition monitoring. In electrical equipment, monitoring takes place e.g. by checking current characteristics for short circuits or overloading, checking voltage levels for tolerance deviations, or checking the limit values for analogue signals.

Stage 2: Locating the fault
Diagnosis uses characteristics and symptoms to identify the existence of actual or impending faults – and locate them. It analyses directly measurable signals using cause and effect mechanisms. Diagnosis may alternatively be model-based, enabling the number of sensors and the costs to be significantly reduced.
In order to localise faults in pneumatic systems, personnel rely on existing data from drive units and valves as well as additional key sensors such as pressure and flow, analysing this data using controllers and software solutions. Malfunctions here may include inadmissible leakage due to tubing damage. The maintenance staff are guided to the location of the problem. In electrical equipment, a wiring-based diagnosis indicates to the sensor or consumer exactly which cable is faulty.

Stage 3: Identifying the fault
If safety-critical or quality-critical drive units are involved, it is a good idea to carry out an in-depth diagnosis to additionally identify the type of fault. For example, the CPX electrical terminal can already provide a detailed description of faults in electrical peripherals. For individual process-relevant drive units, an additional pressure, flow or position sensor can aid in identifying the fault. Maintenance staff are therefore guided to the machine, and are equipped with the correct spare part. Likewise in electrical equipment, CPX can indicate faults such as broken wires or undervoltage.

An additional area: Process diagnosis
In process diagnosis, the focus is on identifying the causes of faults within the process. For example, high-speed cameras such as the SBOC/SBOI compact camera system might relay peripheral signals from the production process to the user control program. By linking in with the process, even process faults in pneumatic components that are functionally relevant to the process can be included. For example, a jammed component may change the movement of a cylinder – in the machine diagnostic system, the actuator thus becomes a process diagnosis sensor.

The future of system diagnosis
In the future, system-oriented diagnostic strategies will take on increasing importance, because they can be used to reduce the number of sensors and therefore the costs, and greater customer benefits can be generated due to their proximity to the system function. These functions already exist for electrical equipment. For pneumatics, Festo is working on a component that will enable system diagnosis to be carried out. Festo Energy Monitoring is an early component of this type.

One extremely important factor in the success of top-level machine diagnostic systems is the creation of neutral machine interfaces, preferably of a standardised nature. In this field, Festo is collaborating intensively in VDMA work groups and with the Profibus user organisation.

Figures, figures and more figures

Cost pressure as a result of increased globalisation is now affecting the majority of companies in almost every industry. The demand for higher productivity whilst reducing costs and increasing the reliability of processes and equipment is leading to costs being viewed in a new light, and also to new collaboration models between machinery manufacturers, suppliers of (sub)systems and equipment operators.

New perspectives: Lifecycle cost management
In the quest for potential savings that will provide all three partners with a win-win situation, corporate financial managers are analysing the overall costs of capital goods, from planning, operating and maintenance costs right through to disposal. In the field of mechanical engineering, total costs are therefore increasingly being viewed in the form of the total cost of ownership.

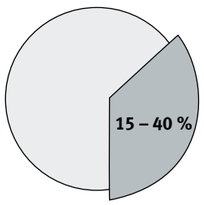
This has given rise to some interesting figures: At 15%, procurement costs represent one of the smallest cost groupings within the lifecycle of machinery or systems.

Maintenance and servicing
In contrast to this, however, studies carried out by Rockwell Automation show that 15 – 40% of the indirect costs of manufacturing companies are the result of maintenance and servicing, with 50% of these costs being considered avoidable. Strategically oriented diagnosis and condition monitoring are the best ways of reducing these costs.

At 70% of expenditure, repairs represent the largest item of indirect costs – as unplanned consequential costs, these amount to between 10% and 28% of overall lifecycle costs. Moreover, according to the trade magazine “Produktion”, these consequential costs should be increased by a factor of 4 or 5! This is due to machine downtime, quality deficiencies, inability to deliver and loss of image.

Modern maintenance strategies are using new parameters and indices such as OEE (overall equipment effectiveness) and TEEP (total effective equipment productivity) from these findings to calculate plant downtime, production losses and organisational losses. These figures are then fed into integrated management strategies such as TPM (total productive maintenance) in order to improve the effectiveness of production installations.

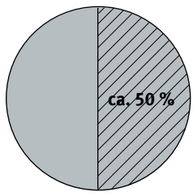
Indirect costs of a manufacturing company



Costs for maintenance/servicing

Additional indirect costs

Maintenance and servicing



Costs for maintenance/servicing

Potential savings due to diagnosis and condition monitoring

Reducing costs: Diagnosis and condition monitoring
Even though it might seem like a paradox at first sight, the somewhat higher costs for diagnosis, condition monitoring and service packages for the strategic optimisation of maintenance and servicing are relatively low and pay for themselves – usually over a very short period of time.

Recent investigations show that around 35% of all damage can be anticipated in advance – particularly where mechanical equipment is concerned. Condition monitoring is to be recommended in these cases.

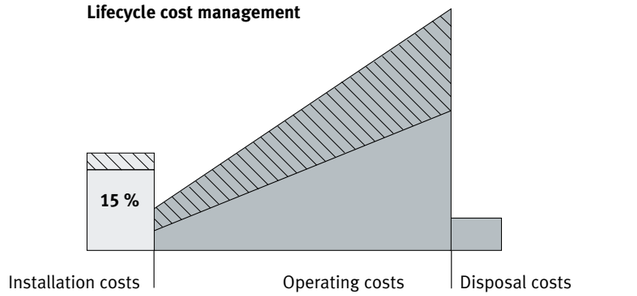
Diagnosis as a damage-limiting discipline helps in the remaining 65% or so of cases, in which components or systems fail in an unforeseen manner. Electrical or electronic equipment is involved in almost 35% of these failures.

Responsibility for operating costs
Machine manufacturers and component suppliers are assuming increasing responsibility for the operating costs of their products and systems – either as a result of legal regulations or on their own initiative. Keyword: Energy certificate.

This expansion of core competencies is of strategic importance at Festo: In addition to a complete portfolio of products with integrated diagnosis functions, it has led to a varied service offer covering operating costs, maintenance and the lifecycle of components and subsystems. Practical examples show that the cost of compressed air in production plants can be reduced by 28% thanks to clear analysis and a targeted exchange of causal components.

Festo is also developing a multi-stage diagnostic strategy for systems and components, which will also serve as a basis for this new type of collaboration – at a reduced cost.

Lifecycle cost management



Slightly higher costs for diagnosis

Long-term potential for savings thanks to diagnosis

Automating more intelligently …

… with products for optimum diagnosis management
Behind the challenge of more intelligent automation, Festo has the specific goal of reducing time and costs within our customers' value creation chain – whilst simultaneously increasing productivity and process reliability, as part of asset management.

What matters: The operation phase
If you look specifically at the operating phase of machinery, intelligent systems from Festo such as status monitoring, machine diagnosis and condition monitoring solutions play a decisive role in reducing maintenance and servicing costs and maximising productivity. These intelligent systems usually consist of actuators, sensors, software, controllers and visualisation technology, and they react to the causes of malfunctions listed to the right.

Decisive: Advanced thinking about the operations phase
Planning properly in advance means you can work without worrying later on… because the potential savings resulting from condition monitoring and diagnosis don't appear until the operations phase – but these need to be considered in advance.

As a partner for more intelligent automation, Festo has therefore developed a portfolio strategy across the entire control sequence that systematically integrates a diagnostic capability – whilst keeping costs low, for example by integrating diagnostic functions into products. This results in more rapid engineering as well as simpler procurement and easier installation. Commissioning can be carried out via a teach-in or parameterisation – with no need for time-consuming programming.

Classifying the causes of malfunctions
The following types of error are considered:
Communications errors
- Fieldbus interrupted
- Defective communications

Energy supply
- Power supply unstable or switched off
- Compressed air supply unstable or switched off

Device faults
- Defective module
- Faulty internal connections

Peripheral errors
- Defective connections
- Faulty sensors and actua tors

Process errors
- Runtime errors
- Context errors (temperature, pressure, missing/jammed part…)
- Media error (particles, water, oil)

Special configurations such as sporadic faults or configuration errors in modular products and equipment should also be borne in mind.

Automating more intelligently …

… with strategies for open communications and service guarantees
Festo solutions compress diagnostic information and deliver it via standard interfaces for higher-level process or machine diagnosis. This is also of interest to OEMs in the context of runtime guarantees, full service contracts, and to protect against unfounded recourse claims.

Diagnostic levels and diagnostic depth in the automation pyramid

6 Remote maintenance, remote diagnostics

5 Master process control system and visualisation
Compressed I/O
and diagnostics data
Process visualisation

4 PLC level
Communication, status and diagnostic data from several thousand I/Os

4.1 Visualisation
through programming

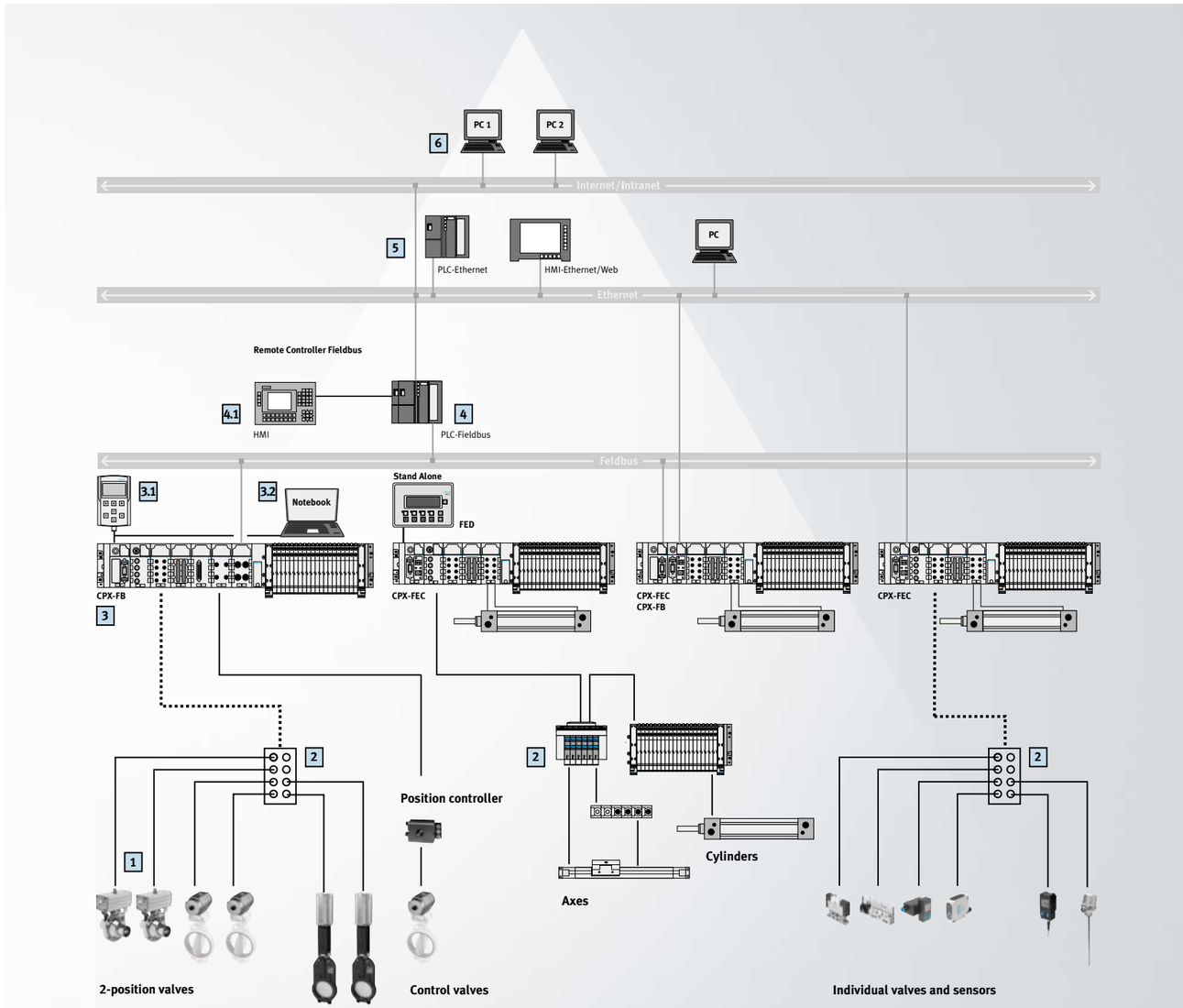
3 Field device level
64 to 512 I/Os per device

3.1 Handheld operator unit
Diagnostics in plain text, without programming

3.2 CPX maintenance tool
Local diagnosis and parameterisation via Ethernet

2 Module level
Digital: 4, 8, 16 channels, analogue: 2, 4 channels

1 Sensor/actuator level
1 sensor = 1 channel,
1 valve/actuator = 1 channel



Double the savings: Total diagnosis with CPX

The modular electrical terminal CPX has become the central product for diagnosis. Outstanding as a stand-alone remote I/O for diagnosis, the diagnosis features of the CPX combined with Festo valve terminals such as the MPA and VTSA are virtually limitless. For example, in the case of integrated valve diagnosis: The combined electrical and pneumatic diagnostic data taps new and valuable additional information that results in added synergy and diagnosis potential.

Distributed intelligence: The CPX-FEC

The front-end controller CPX-FEC in IP65 facilitates customer-specific programming for diagnosis and/or stand-alone operation of the electrical terminal – for any type of fieldbus. Automatic visualisation via the integrated Web server comes as standard.

This integrated valve diagnostics design from Festo is consequently unique. Keywords include:

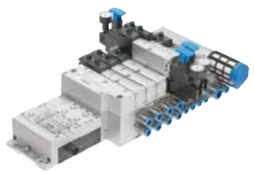
- Intelligent pre-processing for less effort by the PLC;
- Channel-oriented I/O and valve diagnosis for rapidly discovering the source of errors;
- Integrated condition monitoring

One terminal for many valve terminals

CPX can be used in conjunction with:

- VTSA – the new ISO 15407-2 and ISO 5599-2 standard – pneumatic diversity and functionality included
- MPA – The ultimate in valve terminals: flat, serial linking, up to 128 valves
- Midi/Maxi – tried and tested, with high flow rates
- CPI – distributed installation system for applications where space is tight and cycle times need to be optimised

The electrical diagnostic data of the CPX system is always available, and can be seamlessly integrated into existing diagnosis and visualisation systems. The CPX Web monitor also makes remote diagnosis and maintenance possible.



Simple to integrate: The electrical peripherals

Regardless of whether they are based on Ethernet, Internet or fieldbus: the electrical peripherals at sensor/actuator level are scalable, can be used selectively, parameterised and integrated into any control design – precisely customised from a functional and diagnostic point of view.

And twice the savings: Because the CPX design incorporates fundamental diagnostic functionality at no added cost. So rapid commissioning comes as standard – with considerably reduced time consuming programming, which can amount to 30% of programming costs.
The result: significantly increased productivity plus reduced total costs for machine manufacturers and operators.

Reliable pneumatics: Diagnosis at the valve

The serial linking of the MPA valve terminal makes it a specialist when it comes to pre-processing and channel-oriented diagnosis/condition monitoring. Pressure regulation and integrated pressure measurement ensure a constant process quality. Using a fieldbus connection, you can even change the pressure parameters. For maximum system reliability, MPA monitors the actual numerical pressure values with statistical process controls 24 hours a day. Furthermore, valve pilot control monitoring provides a new quality of information at the connected valve.

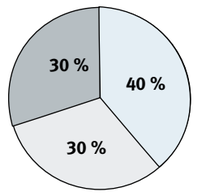
The future today: Proportional technology and MPA

The VPPM-MPA proportional pressure regulator with fieldbus is a globally unique combination of modules for recording and regulating pressure. VMPA-FB-PS and VPPM on one CPX/MPA can remotely control and monitor all values including upper and lower limits. Measuring and controlling pressure via a fieldbus is made possible thanks to the internal serial bus system of the MPA valve terminal. Together with the digital and analogue I/O modules, this significantly improves the production process – thanks to the latest communications and system integration.

Safety and reliability with elegance

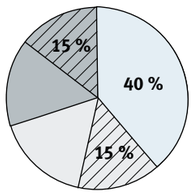
- Constant pressure and status information: top quality manufacturing
- Comprehensive documentation
- Total productive maintenance
- Extremely secure and reliable data transmission for maximum performance
- Remote diagnosis

Distribution of programming effort



Process programming
Diagnosis programming
Visualisation programming

Savings potential with CPX/MPA



Savings potential thanks to integral diagnosis and visualisation

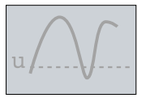
CPX Web monitor as an integrated IT service

Three error modes for simple detection

Current errors – LED-supported diagnosis provides rapid, immediate assistance. A CPX-MMI reports locally in normal text. Fieldbus or Ethernet transmits details at channel level for process visualisation.

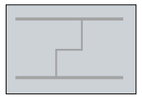
Future errors – these will hopefully not even occur, thanks to automatic condition monitoring for preventive maintenance. Numerical data and warning messages – at channel level, e.g. for up to 128 solenoid coils.

Random errors/history – more rapidly analysed and detected thanks to a diagnostic trace which automatically stores the 40 most recent errors. No need for time-consuming investigations, even for intermittent errors!

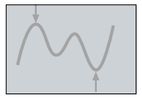


Undervoltage per module
- Electronics -25 %
- Load -10 % / Valves -25 %
- Emergency off ≤10V

Wire break can be selected
- per channel
- per module
- per valve

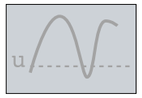


Short circuit can be selected
- per channel
- per module
- per valve

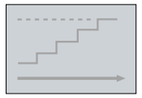


Upper/lower limit value
- per analogue channel
- voltage
- current
- temperature
- pressure

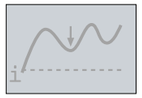
Error memory
- last 40 messages
- with a time stamp
- recognises intermittent errors



Undervoltage per valve manifold
- auxiliary power supply to valves monitored separately
- load/valves -25 %



Condition monitoring
- setpoint values defined per valve
- monitoring of downstream mechanics/processes
- preventive diagnosis/maintenance



Monitoring of valve pilot control
- pull current
- jammed solenoid
- manual override not reset

Overview of diagnostic options in the Festo valve terminal range

U = Voltage
I = Current input
T = Temperature
DE = Digital input
DA = Digital output
AE = Analogue input
AA = Analogue output

	CPX-4DE	CPX-8DE	CPX-8DE-D	CPX-4DA	CPX-8DA	CPX-8DE-8DA	CPX-16DE	CPX-16DE-D	CPX-2AE-U-I	CPX-4AE-I	CPX-4AE-T	CPX-2AA-U-I	CPA	Midi	VTSA	MPA standard	MPA diagnosis	MPA pressure sensor
	Digital I/O								Analogue I/O				Pneumatic components					
Undervoltage				■	■	■						■	■	■	■	■	■	
Short circuit – signal				▒	▒	▒					▒	U	▒		▒		▒	
Short circuit – supply	■	■	▒				■	▒	■	■	■	■	▒		▒		▒	
Wire break									I	I	▒	▒	▒		▒		▒	
Lower limit value									▒	▒	▒	▒						▒
Upper limit value									▒	▒	▒	▒						▒
Parameterisation errors									▒	▒	▒	▒						▒
Condition monitoring																	▒	
Pilot control monitoring																	▒	

□ No diagnosis
■ Module-oriented diagnosis
▒ Module/channel-oriented diagnosis

New approaches in industrial communications: The role of IT in automation

Conventional or innovative? Fieldbus or Ethernet?
IT services for industrial communications are becoming ever more important and dominant for reliable production processes. Their status is constantly growing, perhaps due to the increasingly complex, frequently highly networked and exceedingly finely timed nature of the production process. In such an environment, it pays to keep track of things – via fieldbus or Ethernet.

It's your decision which approach is best for you. Festo has comprehensive communications strategies for both situations – including appropriate products and technology-independent consultancy.

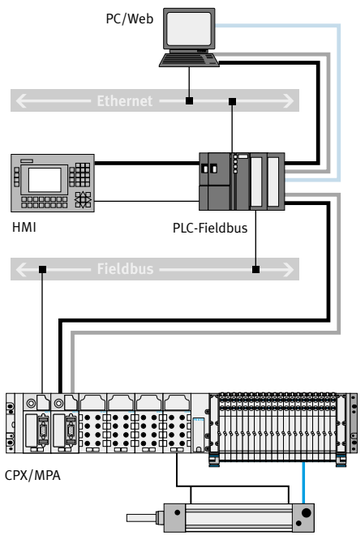
One path: The conventional fieldbus
The conventional fieldbus: The central formatting of information with one protocol for controlling, status and diagnosis, and a host controller for the basic formatting and distribution of data in bits and bytes.

Status and diagnostic information is displayed via a visualisation system, and separately formatted for the higher-level system.

One disadvantage here is the amount of information and its time-consuming channelling, which takes up to 30% of the programming effort for diagnosis and visualisation alike.

Moreover, a Web-enabled industrial communications system extending to factory level can usually only be achieved via an Ethernet-enabled protocol. Fieldbus systems are therefore not suitable for all diagnosis scenarios.

Fieldbus:
All communications link centrally via PLCs



Communications links
- Visualisation
- Diagnosis
- Program/process control

Many paths: Innovation via Ethernet
New industrial communications via Ethernet: Control, status and diagnosis are sometimes located in separate applications, with different links being set up for data access.

This data can be made available either as bits and bytes or as standard text and images. It is displayed via a browser – and therefore via a host – meaning the user can be located anywhere. So this approach is ideal for remote diagnosis and maintenance via the intranet and Internet, because communications via Ethernet generate Web-enabled representation.

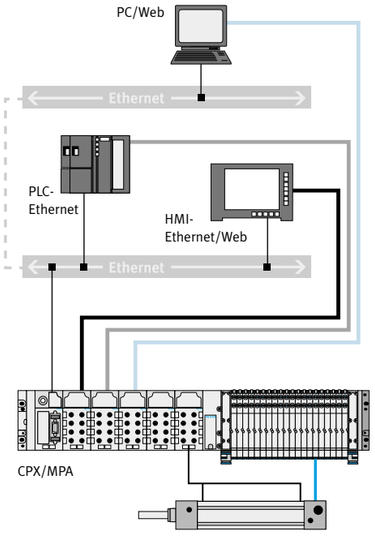
The disadvantage here is that a grasp of complex information technology is required even for the automation aspects, and it needs to be reliable, secure, robust – and in real time.

Products for Ethernet
- CPX terminal online – the visualisation solution for reduced engineering, programming and Festo plug and work®.
- CPX terminal – Ethernet nodes CPX-FB32/33/34/35; strategically optimised for maximum flexibility and minimum effort.
- CPX-FMT – the new diagnosis maintenance tool directly on your PC. Integrates IT services and valve terminals, saving up to 30% of programming costs.
- CPX-FEC – integral preprocessing. For customer-specific programmable valve terminals with optimum PLC performance in IP65/IP67:
  - Web server
  - E-mail as a status/reporting function
  - DDE access for monitoring in Excel
  - Standardised OPC interface
  - Remote maintenance via public networks
  - Integral miniature control system

Diagnostic data à la carte: Control for motion
Compressing, editing, displaying and visualising diagnostic data – the controller development system CoDeSys dramatically simplifies communications with heterogeneous hardware such as pneumatic and electric drive units, valve terminals and compact camera systems – by using five IEC 61131-3-standard programming languages.

The conclusion: Diagnostic data always freshly displayed on screen, exactly as the user wants it – even for extremely complex processes such as production lines.

Industrial Ethernet:
Direct communications links between distributed stations



Communications links
- Visualisation
- Diagnosis
- Program/process control

All eyes on safety – Sensor technology and vision systems

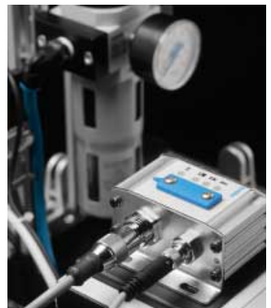
Sensor technology as safety
This analogy applies more than ever before in automation.
Is the machine working? Could problems occur? Are processes running correctly and are products free from defects? Sensors and vision systems are industrial sensory organs that ensure improved performance in automation.

A complete portfolio
Just like nature's sensory organs, the individual types of sensor also have different tasks. Often, optimum performance can only be obtained from equipment or best quality from the products when all the components are interacting correctly.

The Festo selection of components therefore ranges from conventional proximity sensors to vision systems with intelligent compact cameras.

Sensor expertise from Festo: Many sensors represent the ultimate in technically feasible and practical solutions. From the world's smallest inductive sensor to factor 1 technology and from colour sensors to monitoring smooth running.

Sensors – an overview
- Proximity switches and position transmitters
- Pressure switches, pressure and vacuum sensors
- Flow sensors
- Inductive proximity switches and sensors – from recognition to the distance measurement of metal objects
- Optical sensors – for a wide variety of optical tasks ranging from recognising colours and tiny parts through to laser distance sensors
- Evaluation units and connection technology – ensuring that everything fits, matches and functions smoothly: The NEBU modular cable system.



Fluid sensors in detail

1. Pressure and vacuum sensors
Efficient and reliable pressure and vacuum monitoring and regulation round off the protection of functionality in pneumatics automation. They expand the spectrum of application of equipment, providing more security and offering the option of remote maintenance and monitoring.

Pressure and vacuum sensors SDE1
Highly functional: All pressure values are continuously under control with the SDE1 modular system for pressure measurement, monitoring and sensing.

Pressure and vacuum sensors SDE3
Space-saving: Pressure sensors SDE3. Designed for sensing relative pressures and differences in pressure – optionally with two independent pressure switches plus LCD display in a single device.

Pressure and vacuum switch SDE5
For low-cost, simple and rapid detection of compressed air, regulators and vacuums, and object detection via back pressure.

2. Flow sensors
Flow monitoring provides a simplified diagnosis and condition monitoring processes:
A change in the flow rate is often an indication that problems are likely to occur.

Flow sensors SFE1
For leak detection, leak testing of end products and flow monitoring for parts feeding – including diagnosis.

Flow sensors and transmitters SFE3/SFET
Suitable for applications in the electronics, light assembly, optical and pharmaceutical industries.

Flow sensor MS6-SFE
This high flow rate sensor can be operated either as a standalone unit or ideally combined with MS series service units.

Innovative solutions ...

... Position transmitter SMAT
Sensor technology suitable for all pneumatic cylinders: Proximity sensors for the binary feedback of piston position and integral displacement encoders for determining the position of the entire piston stroke have until now been the standard.

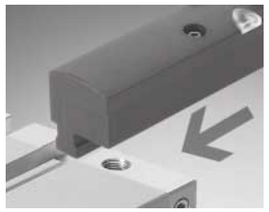
These are now being supplemented by an additional innovative sensing solution: The position transmitter SMAT. This continuously detects the position of the cylinder piston within a range of 50 mm, and generates a displacement-proportional analogue output signal.
As a space and cost-saving alternative, SMAT replaces customised solutions such as potentiometers and inductive sensors that have to be mounted externally on piston rods or drive units. Measurement is contact-free, and position sensing therefore generates no wear and tear.

In focus: Objects and processes
With reproducibility of 0.1mm, SMAT is the safe, reliable solution for detecting objects and monitoring processes. Objects are detected reliably during press-fitting, clamping, position sensing, the quality sorting of parts and during workpiece replacement. The position transmitter SMAT also ensures reliable processes during the handling and production of sheet metal, when monitoring for wear and tear and when checking quality, as well as in laser and welding systems.

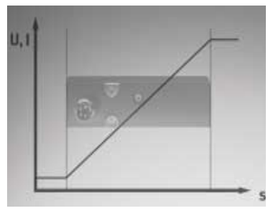
It connects directly to the analogue input modules of Festo PLCs, IPCs and valve terminals, saving time during installation and commissioning.

Space and cost-saving alternative: The Festo position transmitter SMAT, mounted here on a compact cylinder ADNGF, performs much better than customised solutions such as potentiometers or inductive sensing.

Wide range of use



Easy installation



Reliable: Position is known to 100%

... Vision systems – with inbuilt profitability
Industrial vision systems are the innovative driving force in production automation. And no wonder, because intelligent cameras such as the SBO.. -M and SBO..-Q compact camera systems help to significantly improve productivity and flexibility through process diagnosis and to eliminate downtime – each in its own different way.

For example, the compact camera system SBO..-Q is suitable for a wide range of applications – even those involving stationary parts. Whether it's used for checking the orientation of small parts, measuring turned parts, precisely positioning drive units or localising objects in order to control handling equipment – this camera system's reliable inspection results speak for themselves – 100% quality inspection guaranteed.

High speed for processes
The SBO..-M variant represents an innovative and attractively priced alternative to conventional high-speed cameras. With 185 to 2000 images per second, this camera can be used during commissioning and maintenance to diagnose and optimise high-speed automation processes that cannot be seen clearly by the human eye. It can also be used to monitor functions that involve rapid movements.

The Checkbox is responsible for the type identification, position checking and quality inspection of moving parts via backlighting. The Checkbox Compact, Identbox, Countbox and Sortbox are easy to set up and operate thanks to clear interfaces and teach-in functions. When used in conjunction with handling components and feed technology, they enable automation tasks and process diagnosis to be carried out reliably and optimally.

Combating downtime – Intelligent compressed air preparation

Everything under control
Just like high compression internal combustion engines, state-of-the-art pneumatic systems place certain demands on the quality of their “fuel” – compressed air – in order to run smoothly: they need to be virtually free of particles, residual moisture and compressor oil if they are to avoid unplanned machine downtime due to:

- The failure of oiled-up valves
- Leakage due to worn seals
- Reduced performance due to corroded components
- Back pressure due to contaminated silencers.

Reliable production processes – right from the start
Where pneumatic systems are concerned, reliable production processes have their origins upfront through an optimum supply of compressed air. Latest-generation intelligent service units such as the highly modular MS range provide ideal compressed air for every requirement.

For example, for highly sensitive production processes in the food industry or in biotechnology/ pharmaceuticals: compressed air quality in accordance with ISO 8573-1:

1. The quality class for solid con taminants
2. The quality class for water content
3. The quality class for total oil content

A clean supply of compressed air prevents contamination and incrustations, known as fouling, thus maintaining the value of pneumatic equipment. A positive side-effect: The service life of components usually increases.

Diagnostic functions carried out via integrated sensor technology and remote control add security and provide new solutions for increased productivity. The process-oriented status information together with the constant monitoring of compressed air parameters further reduce process costs via condition monitoring.

These functions are also of interest to OEMs, for example because it is possible to log operating conditions when machinery is handed over, and consumption profiles can be checked.

Integrated diagnosis in detail

Pressure monitoring: Integrated pressure sensors MS6-...-AD1

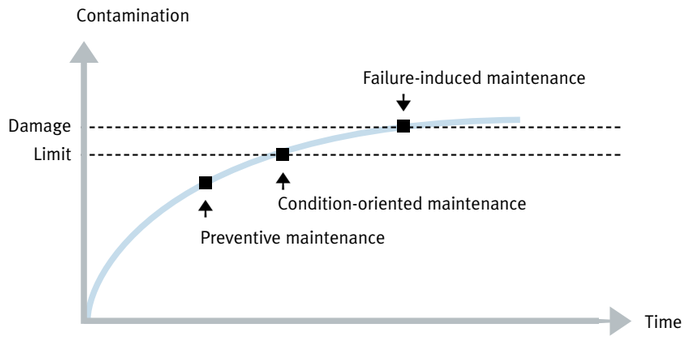
- Pressure sensors as an alternative to pressure gauges for regulators, filter regulators, valves and branching modules
- Full functionality of the pressure sensor SDE1
- Straightforward electrical connection via M8/M12 plugs
- Avoidance of pressure fluctuations or drops thanks to reliable pressure monitoring, measurement and sensing

Everything under control: Flow sensor MS6-SFE

- Unidirectional flow sensor with display
- Save energy: Simple leak testing by measuring consumption and flow rate without additional peripherals
- Process reliability: Rapid error detection due to threshold monitoring and analogue output

Filter status always available: Filter contamination indicator MS4/MS6-LFM-...-DP

- Maintenance intervals can be planned via a percentage display of the contamination level
- Safe and reliable production processes thanks to programmable threshold values for filter change signal



An illustration of maintenance strategies in relation to increasing contamination

Systematically tracking down leakages – Festo Energy Monitoring

Brand new: Compressed air energy monitoring GFDM. An essential part of the comprehensive diagnosis solution from Festo, which links a rapid return on investment with an increased service life of equipment.

Compressed air is a valuable commodity
Systematically tracking down leakages – Festo Energy Monitoring makes sense particularly in the case of larger or older systems with leakages of over 200 l/min. An efficient maintenance plan ensures maximum process reliability, since the consumption and flow rate of compressed air in supply lines to system units are constantly being monitored. The status of the system in comparison to a reference status is indicated via status displays of
“green” (normal operation),
“yellow” (warning),
“orange” (maintenance advisable) and
“red” (alarm).

At the same time, compressed air monitoring enables the air consumption element of process costs to be evaluated, thereby helping to determine the proportional product costs for individual parts of the system.

Stand-alone system – easy to retrofit
The GFDM components – sensors, diagnostic controller and visualisation – constitute a stand-alone system that has no influence on the existing process. The exchange of key process data, such as the operating mode and triggering signals for determining air consumption, takes place via a digital interface. This means that GFDM can be retrofitted onto existing processes simply and easily – via FED directly on the system or using VipWin visualisation software for the monitoring of parameters from a console or office.

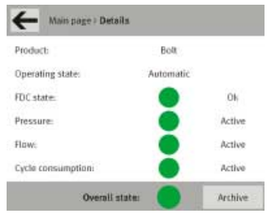
What the GFDM system has to offer
Application-specific limit values can be set for early preventive intervention, with GFDM promptly detecting undesirable deviations.

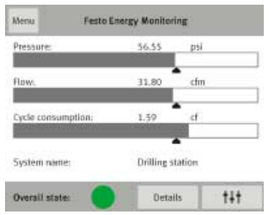
Different operating states, such as automatic operation and stop mode, can be monitored separately. In particular, the air consumption in stop mode is an indication of system leakages; wasted resources that can be reduced if they are detected promptly.

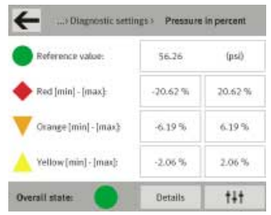
Energy Monitoring can separately monitor up to 16 different products or process conditions within a single installation. When products are changed, the associated reference data record is automatically loaded, enabling monitoring to continue uninterrupted.

Trend visualisation and stored flow and air consumption data are fed into process documentation and provide valuable input data for additional analysis in the customer application.

Complete: Integrated services
To supplement the GFDM system, Festo is offering new services that round off this recently introduced hardware and software to form a complete solutions package including energy monitoring functionality. The services contained in this modular solutions package can be selected individually, and assist customers in the design, commissioning and support of the energy monitoring system.







Additional tailored diagnostic services

Additional services provide valuable assistance in achieving or significantly improving on diagnosis and condition monitoring objectives. Festo has therefore integrated numerous services into its offering, in order to provide concrete support for OEMs and end users.

Particularly in pneumatics, these services benefit from the outstanding expertise of Festo specialists, and also from custom-made technical equipment.

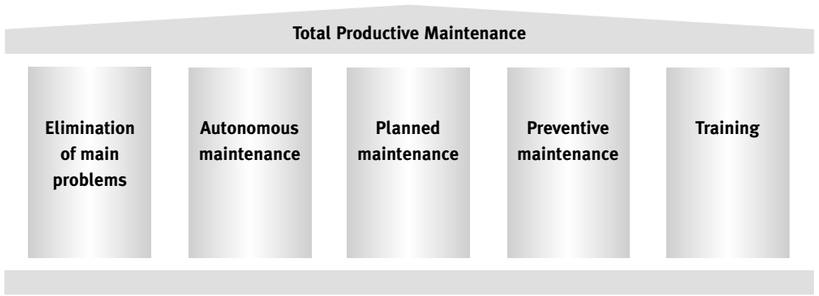
The primary objective of operational services is to increase productivity and system availability. Customers themselves decide on the breadth and depth of these services.

Combining several services

Condition monitoring support
The service relating to the energy monitoring system GFDM.
A combination of:
- Compressed air quality analysis
- Compressed air consumption analysis in conjunction with the energy saving service
- Installation recommendations
- Commissioning support and
- Requirements-oriented service contracts

ensure maximum efficiency of the energy monitoring system, high levels of process reliability and system availability, reduced operating costs and increased system service life.

Total Productive Maintenance
A variety of pre-determined measures for improving maintenance strategy help to achieve increased system availability. Central to TPM are its five pillars (see illustration).



Individual services

The classic: Festo energy saving service
Cut down on compressed air consumption and reduce energy costs – on average, the strategic maintenance and optimised design of pneumatic systems can reduce compressed air usage by up to 35%, or in extreme cases even up to 60%. The latest measuring technology is available for globally standardised measurement results.
- Leakage/consumption measurement at machine level
- Machine inspection/leakage location
- Leakage rectification
- Efficiency checking/accounting.

The OEM equivalent: The Festo compressed air consumption analysis
For optimal compressed air provision, reliable cost planning and reliable processes: for the first time, OEMs and end users can discover how much compressed air their equipment and automatic assembly machines required – all documented.

Measurements at machine level:
- Average compressed air consumption (downtime/operation)
- Maximum compressed air consumption
- Compressed air consumption per machine cycle
- Compressed air consumption per time interval
- Pressure curve

For optimum “fuel”: The Festo compressed air quality analysis
Modern pneumatics place certain demands on the quality of compressed air, in order that they can function smoothly for long periods of time.

Contents:
- Measurement of compressed air quality
- Identification of weak points
- Suggestions for improvement

Modular and machine-related: The Festo service contract
Precisely those services that you need for maximum process reliability: Inspection, maintenance and minor repairs. Compressed air quality and energy efficiency checks are included.

Further options:
- Guaranteed availability
- Defined lead and response times
- Spare parts management

A top-level overview – integration into machine designs

Successful condition monitoring requires machines and systems to be considered as a whole. Fluid engineering and electrical drives units, connected mechanics, sensors and distributed control units. Precisely how these components interact constitutes the expertise of the machine manufacturer. However, it is only with a knowledge of the processes, procedures and production steps of the producing company that the manufacturer can adjust the CM system optimally to meet this company's needs.

Wanted: End-to-end strategies
We know that pneumatics is only one part of the whole. By delivering its technology components and expertise in the field of diagnosis, Festo is making a contribution to the machine diagnostic strategy. With the clear objective of having this contribution flow into a common, higher-level strategy.

Festo components and solutions are therefore designed in such a way that they can be integrated into higher-level control systems and software, and can feed a wide range of standard interfaces. The motto: No individual solutions! To this end, component suppliers, machine manufacturers and end users need to collaborate more closely in the future.

Partnership generates an overall perspective
For this reason, Festo is working with partners at various different levels. One example is the VDMA condition monitoring working committee. Another is the research project entitled "Condition-oriented maintenance of packaging machines" (www.zupack.de), in which the manufacturers of packaging machines, control systems and components are developing a tailor-made condition monitoring system for the packaging in dustry.

Packaging machine at the Optima Packaging Group

Two typical applications

1. Local maintenance – with excellent support
An assembly system consisting of 5 cells and approx. 80 pneumatic axes for assembling and checking valves requires monitoring. Trend monitoring is intended to report deviations in the pneumatic axes and, in the event of a malfunction, indicate the defective actuator. Emphasis is placed on the monitoring of compressed air.

The following data is recorded: Air consumption, operating pressure, flow rate, positioning times, valve switching cycles and the double strokes of the actuators. Actual and setpoint values are constantly compared. The CPX diagnosis can detect numerous types of electrical fault.
An additional pressure sensor is installed for safety-related axes. The system provides detailed information about the causes of faults. References to the briefest error analyses and component exchanges are automatically recorded during commissioning, with results being made available in SAP via the local intranet.

The project was implemented using existing Festo components.

2. External service provider – inbuilt reliability
Over and above the functionality of the above application, diagnostic data is to be provided for remote servicing by the packaging machine manufacturer of a flow-wrapping machine with a cycle time of approx. 100 bags/ min.

Fault rectification and additional troubleshooting are now to be carried out via a Web browser and secure Internet connection using pneumatic diagnostic data in the same way that data from the electric drive units is currently processed.
The interpreted pneumatic diagnostic data, which is held in a structured format in the CPX-FEC, is to be stored in the higher-level Siemens S7 controller – and from there, it will be transmitted to a data server that can be accessed by machine manufacturers and other external service providers. They have exclusive access to this server, and can use the CPX data for their remote servicing.

Here, Festo has implemented a design that can be transferred to other applications, and that provides data for higher-level controllers.

Route planner – diagnosis in the future

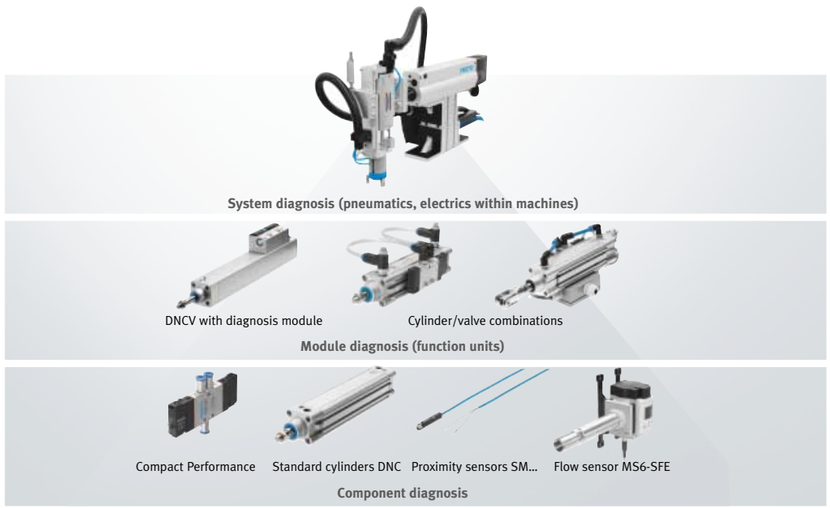
The trend towards increased availability and low lifecycle costs is set to increase over the next few years. Diagnosis will be seen as part of asset management. As a response to this, machine operators and mechanical engineers will intensify the development of intelligent machine diagnostic systems, but will also be investing in the implementation of new maintenance strategies and collaborative business models.
Throughout these developments, Festo in its role as technological leader will be supporting all areas of drive technology – through leading-edge technological developments and a newly established portfolio of services.

The technological route: Diagnostic toolkits
Technological developments at Festo are characterised by the further expansion of its toolkit of diagnostic components and systems plus associated controllers and software. In the future, increasingly intelligent components with added diagnostic capabilities will not only permit the diagnosis of drive systems, but also the monitoring of associated processes.

The declared objective of Festo is to generate more benefits for maintenance and servicing. It is implementing this aim by providing Festo modules for system diagnosis.

Considerable effort is required in order to develop diagnosis methods further. The strategy: from preventive methods to anticipatory diagnosis.

All technical developments are characterised by the fact that drive systems are a part of complete machines and systems. It is therefore an essential prerequisite that standardised interfaces be used and integrated. In addition, cost-effective machine diagnosis systems are characterised by value-creating collaboration between different suppliers of intelligent components and sub-systems.



The aim: Simple and user-friendly
For this reason, we should not be cluttering up machines and systems with increasingly complex technology and more sensors. The aim of all these developments is to create simple, user-friendly systems for distributed use with a high cost-benefit ratio and as few added sensors as possible.

The service offering route: Taking responsibility for support
Central to the developments of the Festo service offering are three main pillars. The first pillar: supporting modern maintenance strategies such as integration into the TPM philosophy. The second pillar: Internet-based service platforms, which are rapidly growing in importance, as well as collaborative business models involving machine operators, machine suppliers and external service providers. This will additionally enable Festo drive systems to be monitored "remotely", with guidance and support being provided for local servicing as part of preventive maintenance.
The third pillar: our long-term goal – taking responsibility for key performance indicators relating to drive systems, such as availability, OEE and energy costs.
This must involve seamlessly integrating the processes of the operator (the maintenance process), the machine supplier and the processes within the Festo service offering. Lifecycle costs can only be reduced if everyone involved contributes their core competencies.

20..? Perspectives
Festo plans to build up a complete technology and service offering for the condition monitoring and diagnosis of drive technology – tailored and integrated into intelligent machine designs and modern maintenance philosophies. Of prime importance here are reducing lifecycle costs, increasing availability and optimising maintenance and servicing effort.

Regardless of whether you focus on factory or process automation – or whether your company is involved in both areas: Manage your diagnosis processes actively – acting instead of reacting!

We would be delighted to discuss an appropriate diagnostic strategy with you.

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