Products and functions for efficient maintenance in the process automation

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Increase in productivity through intelligent maintenance

How can the productivity of a plant with a high level of automation be increased even further? Surveys have indicated that plant operators in all sectors consider increased availability and shorter downtimes to be the most effective lever toward increasing productivity. Investigations have shown that downtimes are frequently the result of insufficient maintenance – despite the fact that maintenance is already a significant portion of the lifecycle costs.

Intelligent maintenance strategies can make a significant contribution toward increasing productivity:

• Failures can be prevented by monitoring the current plant condition.
• Maintenance can then be planned. It does not wait until a fault has occurred, but implements appropriate measures in advance for avoiding faults. The timing of maintenance can be planned such that the existing resources can be used optimally.
• Innovative maintenance strategies pay for themselves twice: planning security and the specific application of methods reduces the direct maintenance costs.
• Plant availability is increased at the same time. This means that consequential costs resulting from failures, such as quality deficiencies or loss of image, are reduced.

Totally Integrated Automation supports intelligent maintenance strategies. The SIMATIC Maintenance Station is of significant importance, and presents the information relevant to maintenance from all automation components in a uniform and clear manner, thus providing the maintenance engineer with valuable support for making decisions.

Maintenance strategies

There are two maintenance strategies: response to failures or taking preventive measures. In the case of failure-oriented corrective maintenance, measures are only initiated when a fault has occurred, i.e. failures are acceptable in this case and may be minimized by a redundant plant design.

The objective of preventive strategies is to carry out maintenance measures before faults even occur, in order to avoid possible downtimes. This strategy can be satisfied using time-dependent and load-dependent measures. Regular maintenance work is an example of time-dependent measures. The load state is determined from the number of switching operations, operating hours or load peaks.

Benefits of intelligent maintenance

- Continuous plant monitoring
  - Reduces the risk of failures, and increases the availability
  - Enables maintenance to be planned

- Optimized use of maintenance resources
  - Increases maintenance quality
  - Achieves cost savings

The potential for savings arises:

- During maintenance itself and
- By avoiding consequential costs

Condition Monitoring, that is to say status monitoring, aims to detect imminent faults at an early stage. It provides information on the remaining duration of use. In the case of condition-based maintenance, the maintenance measures are only initiated when the period of use has expired.

It has been shown in practice that optimum results can be achieved through intelligent combination of the different strategies.

Higher operating expenses for condition-based maintenance will be worthwhile for devices that play a central role for the availability of a plant and have high replacement costs. But mostly there are also devices where failures can be faced without endangering the availability and productivity of the plant.

Maintenance strategies
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Introduction

Plant asset management as a maintenance task

General information

Various tasks have to be handled during the operating phase of a plant, for which different groups of persons are responsible.

The production personnel operate and monitor the plant, and make sure that the desired products are produced with the appropriate quality, in the defined quantity, at a specified time, and with minimum resources with respect to personnel, raw materials, energy, costs, etc.

Maintenance staff must

- ensure a high availability of the plant,
- ensure this availability in the long term by implementing optimization measures, and
- carry out maintenance measures with minimum use of personnel, material, energy, costs, etc.

As a result of their different tasks, these two groups of persons have different information requirements.

Information on the measured process tags is available for the plant operator. Apart from the measured value itself and its status, this may, for example, be the information on whether the measured value is still valid.

The focus of interest for the maintenance engineer is the status of the production equipment that is reflected in the states of the devices and components used (i.e. particularly in the states of the field devices). Typical states in this respect include "Component OK", "Maintenance required", "Failure" or "Function check".

SIMATIC PCS 7 allows a clear classification of the information for the user groups Plant Operators and Maintenance Engineers.

Different demand for information at the plant:

Plant operator
Information on the process such as:
- Recipe parameters
- Temperature characteristic
- Pressure values
- Raw material stocks
- Output

Maintenance personnel
Information on the state of the production equipment such as:
- Components OK
- Maintenance required
- Failure
- Functional check
Asset management in production

The term “asset management” comes from the world of finance and economics and refers to the manner in which a company deals with its long-term and current assets. These include the production equipment with its plant components such as apparatus, machines, pipelines etc. and the equipment and devices for their automation. All these are referred to as assets. In association with production, asset management covers all activities and measures which serve toward retaining or increasing the value of a plant. This is called plant asset management.

Benefits of plant asset management

Plant asset management allows the maintenance engineer

• to unambiguously identify and evaluate the assets, this means the production equipment and its components,
• to carry out the appropriate measures in the case of deviations from the desired or expected state.

As a result of monitoring, i.e. the recording and evaluation of status variables, the condition of a component or device can be determined.

It can be recognized, for example, that no signal is received from the sensor, resulting in the diagnosis "Open circuit". This result triggers a maintenance request, and maintenance must then be carried out to eliminate the open circuit.

This measure – replacement of a faulty line in this example – ensures that the component is returned to the desired condition and closes the maintenance cycle. This means that plant asset management is the basis for increased productivity.
Intelligent maintenance in process engineering

Despite the different tasks of operators and maintenance staff, it is meaningful and necessary to map the information of both staff groups within one process control system and not to use different systems.

There are various reasons for this:

• Uniform visualization for all components and devices.
• No limitation to selection of field devices.
• The same information sources (field devices) are relevant to both automation and maintenance.
• There is a close link between automation and asset management functions because, for example, the current control strategy of the plant plays an important role for the assessment of a component status.
• Engineering data for automation can also be used for maintenance.
• Simplified handling of the system, since users need only be acquainted with the engineering, operator control and monitoring tools of a single system.

The process control special interest group of the pharmaceuticals industry (NAMUR) has formulated essential requirements (NE 91) from the user’s viewpoint. This attaches special significance to the integration of the Plant Asset Management into the process control system.

• Plant Asset Management is a part of the process control system.
• Recording and assessing the status of the assets.
• Inclusion of all assets (process control devices and plant components).
• Separation of maintenance-relevant information and process data.
• Uniform visualization for all assets.
• No limitation to selection of field devices.

In addition, there is a requirement (NE 107) that all field devices must provide standardized status messages about their status as follows:

• Good
  no known restriction of function
• Uncertain
  Operation outside the specified range
• Device failure
  Need for maintenance
• Maintenance required
  Function check (process value manipulated)
• Function check, local operation
  Failure (process value invalid)

Processing plants, whose open and closed loop control is performed with SIMATIC PCS 7 and components of Totally Integrated Automation, satisfy the user requirements formulated by NAMUR.

The resulting information is divided up to prevent the plant operators and maintenance staff from being flooded with information. To achieve this, a maintenance station (MS) is introduced in addition to the operator station (OS). Maintenance-relevant information is kept away from the operator station. This information is collected and presented on the maintenance station. The same HMI tools are used for the operator station and the maintenance station and the HMI philosophy is identical.

Plant Asset Management with SIMATIC PCS 7

- Process engineering plants with SIMATIC PCS 7 and components of Totally Integrated Automation meet the requirements of NAMUR.
- Automation and plant asset management run on the same system.
- The information for plant operators maintenance staff is divided between the operator station and the maintenance station.
- Shared configuration and uniform user interfaces minimize the expense of an effective Plant Asset Management.
Integrated plant and cross-system maintenance

Plant asset management is only truly productive if maintenance staff can view diagnostic information relating to the entire process chain at a glance. In practice, this means that: Inbound and outbound processes such as logistics, bottling and packaging plants must be capable of support by the same maintenance team that is responsible for the actual process, without a great deal of additional expertise having to be built up. If the process control system and the controllers of the upstream and downstream systems originate from the same vendors, different alarm systems can cause considerable additional expense.

If a plant is automated with SIMATIC PCS 7, therefore it is worthwhile for the plant operators to select machines and systems that are automated with SIMATIC and visualized with SIMATIC WinCC for their inbound and outbound processes, as then they can exploit all the advantages of Totally Integrated Automation.

If machines or systems for inbound or outbound processes are operated and monitored by means of SIMATIC WinCC, then the SIMATIC Maintenance Station presents itself as an option to the SIMATIC WinCC SCADA system for the display of maintenance-relevant information.

The integrated functionality of Totally Integrated Automation also makes it possible, using the SIMATIC PCS 7 Maintenance Station, to monitor the packaging or bottling line by means of a client. In other words: the maintenance information from the process control system and SCADA system can be merged on a central Maintenance Station. Display, logic, and message management are identical. The uniform look and feel saves on overhead and generates a high degree of acceptance within the maintenance team. The SIMATIC Maintenance Station for SIMATIC PCS 7 and SIMATIC WinCC makes a significant contribution to increasing maintenance productivity and thus to increasing the availability of the overall plant.

Optimizing instead of repairing

The task of maintenance is not only to avoid unscheduled production downtimes, but also to optimize the running of the plant. Optimization must be based on analysis of traceable processes. The maintenance station offers the basic data set for integrated analysis of all weak points. This is not unusual in a process control system. However, in inbound and outbound processes diagnostics are often restricted to signaling a fault and then forgetting about it as soon as it has been repaired. With Totally Integrated Automation, the maintenance station becomes the basis for Total Productive Maintenance.
Visualization of information for maintenance

In order to recognize the conditions of individual devices or components unequivocally, a uniform symbol representation has been implemented.

There are symbols for the device status itself and also for the importance of a maintenance request. In addition, the status of a maintenance measure is displayed. The conditions of all devices and equipment of the automation technology and of the plant components are indicated by these standardized symbols.

Uniform symbols for the conditions of components and devices

Besides the uniform display of symbols, a significant detail for the overview is a hierarchical structuring of information in which the maintenance engineer also has access to all required details of the components and devices, based on an overview display (plant view).

The overview display uses the standardized symbols to visualize the condition of a component itself and also provides collective information on the conditions of all devices in the subordinate hierarchies.

The collective condition message shows the OK condition or the seriousness of a possible problem in red, yellow, or green, as per a traffic light. A button can be used to access all subordinate hierarchy levels step-by-step down to the bottom device level.

Further views of the maintenance information are available in addition so that the maintenance engineer has a complete overview of all current information of the asset relevant to maintenance. This permits assessment of the plant status at a glance.

The information is consistently structured and hierarchically organized. The quantity of information displayed on each individual screen always remains manageable for the maintenance engineer, who nevertheless has easy access at any time to the complete information.
Maintenance Station – User interface for maintenance

The SIMATIC PCS 7 Maintenance Station software package is available as an alternative to SIMATIC PCS 7 for implementing plant asset management. You can use this software package to expand an Operator Station to a Maintenance Station.

The maintenance engineer can process the diagnostics messages and maintenance requests of the assets on the maintenance station. Via the maintenance station the engineer can access:

- components of the process control system: intelligent field devices and I/O modules, field bus, controller, network components and plant bus as well as servers and clients of the operator systems.
- assets that do not belong directly to the process control system, such as pumps, motors, centrifuges, heat exchangers or control loops (passive or indirect assets). These are represented by proxy objects in which the diagnostics rules are stored.

Standard diagnostics functions

In order to obtain information on the diagnostics status of individual plant areas or components, maintenance engineers can change from the overview display to the respective diagnostics display of the subordinate hardware level. If a fault is signaled in the overview display, the "loop in alarm" function permits rapid switching to the diagnostics faceplate of the associated component. The information is filtered according to the area of responsibility of the user.

The following information can be offered:

- Display of diagnostics status determined by the system
- Information on the component, such as process tag name, manufacturer or serial number
- Display of diagnostics messages of a component
- Visualization of type and current state of initiated maintenance measure

Information on passive or indirect assets

For passive or indirect assets without self-diagnostics (pumps, motors, control loops etc.), inadmissible operating states can be derived from various measured values and their deviations from a defined normal status using the programmable logic block AssetMon.

These are displayed as a maintenance alarm on the maintenance station. With the aid of the AssetMon, individual diagnostics structures, project-specific diagnostics rules and condition monitoring functions can be implemented.

Construction of a maintenance station

The SIMATIC PCS 7 Maintenance Station is of modular design. In small plants it is possible to install the operator station and the maintenance station on the same PC. Just like the operator system, the maintenance station can be expanded into a client/server application with multi-client operation.

The signals and messages from the components and devices which are relevant to maintenance are collected and saved on the server of a client/server application. They are displayed on the client.

The SIMATIC PCS 7 Maintenance Station is based on standard SIMATIC products:

- SIMATIC PCS 7 ES / OS for configuration and HMI functions,
- SIMATIC PDM for connecting the field devices and
- SIMATIC SNMP OPC Server for interfacing network components
Maintenance Station – User interface for maintenance

Configuring a maintenance station

When setting up a Maintenance Station, the user only has to assign the corresponding attribute once during the configuration. This automatically generates a technological hierarchy for diagnostics displays. The diagnostics displays can be subsequently expanded by project-specific contents.

Visualization in the maintenance station

In the operating state, the maintenance station's client requests cyclic data from the associated server. The client can additionally access hardware components and field devices directly by means of an on-line connection, so that the maintenance engineer has the relevant information available at all times. Various components with highly different diagnostics capabilities are used for SIMATIC PCS 7. However, from the viewpoint of maintenance, all components are displayed in the same manner. Therefore the maintenance and diagnostics conditions of the components are represented by standardized symbols.

The symbols indicate the maintenance status

- of a component (maintenance state display)
- of subordinate devices (maintenance group display)
- and, if applicable, the status of maintenance work (operator state display).

Symbol displays and component faceplates

The conditions of the components or also of subordinate components are visualized using standardized symbol displays in the diagnostics displays. The symbol displays of the components contain:

- Bitmap of component
- Tag designation of component
- Maintenance state display
- Group display for maintenance messages from subordinate components

Clicking an element in the symbol display either opens the subordinate hierarchy level or a component faceplate. This faceplate contains various views of the respective component in which further device-specific information can be output. There are three standard views:

Identification:
Depending on the component, the identification view displays all information available from the hardware configuration or via SIMATIC PDM in the device description, of the Electronic Device Description (EDD). In addition, the maintenance status is displayed and, if available, the status of a redundant component.

Messages:
The Messages view displays diagnostics error messages, operator inputs and maintenance requests.
Maintenance:
The maintenance view is used for the response of the operator to a maintenance request of a component. Maintenance work can be requested. The status of the work can also be specified. This is recorded, and signaled in the symbols. A work instruction number and a comment can still be entered for each work request. The instruction number has no effect within the Maintenance Station and is only included in the report. This can be used for transfer to maintenance planning.

![Faceplate for maintenance view](image1)

**Process Device Management**

Depending on the diagnostics capability of a device, there are additional views. For example, in the component operating display for intelligent field devices (DP, PA, HART), additional information is output that the Process Device Management (PDM) makes available. Changes in the parameterization are managed in a change logbook and can be called up from the Maintenance Station. In this case, the time and name of the responsible operator are output.

Configuration changes can also be output. The diagnostic information of intelligent field devices is determined with the PDM on the basis of the EDD of a field device. In the EDD, the device manufacturer also specifies, for example, the supplementary information to be provided in the event of faults. This can also display the cause, a trend statement and instructions for clearing the fault. In addition, PDM can be called directly from the faceplate. This call makes all vendor-specific information and documents incorporated by the vendor available for intelligent field devices.

![Faceplate, detail view of a component](image2)
Add-ons as options for the SIMATIC PCS 7 Maintenance Station

Alarm Control Center alarm management system

The WinCC Alarm Control Center (ACC) alarm management system transmits alarms from visualization and control systems to mobile receivers such as cellphones or pagers.

The messages are automatically sent to the responsible person or group of people. If no response is received within a programmable period of time from a notified person (such as a text message), other people are notified. In conjunction with the escalation system, alarm scenarios can be implemented for a wide range of requirements.

Even the basic package incorporates a shift management facility, enabling personnel to be assigned depending on the time and the day of the week.

Text messages are sent via ISDN, analog modem or GSM modem. For additional requirements, transmission channels are available for systems including VOIP, voice and PABX systems. Configuration and user control is web-based, via LAN or Wireless LAN.

Further options allows the Alarm Control Center to be adapted to individual requirements. The Replication option enables high-availability, redundant systems to be configured. The Dialog module permits active contacting of stations, such as to log off a station by remote configuration or to query process values. Advanced call archive analysis enables detailed logs to be generated, and supports other quality assurance measures.

Further information:
www.siemens.com/alarmcc

PM-MAINT intelligent maintenance management

The PM-MAINT add-on supplements the SIMATIC Maintenance Station with the following functions:

Maintenance planning
PM-MAINT can be used for planning, based on performance data or calendar intervals, so as to define clearly when maintenance tasks are to be carried out. Damage reports and repair jobs from the SIMATIC Maintenance Station also enable unforeseen maintenance work to be scheduled.

Management of supplementary information
Data essential to effective maintenance can be entered relating to the maintained plant and machinery. In addition to component, manufacturer and sourcing data, electronic documents can also be linked to the items and related maintenance jobs. This provides maintenance staff with direct access to aids such as repair instructions, circuit diagrams, photos, manuals and the like.

Archiving of maintenance data
All maintenance activities are logged in an archive. Analysis of the archive enables maintenance operations to be assessed in detail, providing for continuous improvement.

Further information:
www.siemens.com/pm-maint
SIMATIC IPCs are rugged industrial PCs for professional automation solutions in 24-h operation. Because of their high system availability, in PCS 7 systems they are often used, for example, as operator or maintenance station or also as engineering station or OPC server.

The SIMATIC PC DiagMonitor monitoring and signaling software recognizes possible hardware and software faults at an early point in time, and provides corresponding messages for the Maintenance Station. In connection with several SIMATIC IPCs, client/server network architectures can be set up via LAN and can centrally monitor all SIMATIC IPCs in plant facilities using DiagMonitor. The integrated webservice lets you view and manage data via an internet browser. Efficient service structures can be established by integrating automated communication paths, e.g. by means of Ethernet, e-mail, or text messages (phone).

DiagMonitor supplements the operating data of the monitored PCs with text messages, transmits them via the SNMP OPC server and outputs them in the associated asset management view.

- The "Monitoring 1" view indicates the number of operating hours of the SIMATIC IPC and the interior unit temperature at different measurement points in the device, e.g. at the processor and at the motherboard.
- In two additional views the speeds of the fans are output or diagnostic data and information on the status of the drives is displayed. It is then possible, for example, for the user to replace hard disks as a preventive measure before a loss of data occurs (preventive maintenance).

In addition, the user is warned in good time of fan or hard disk failures (preventive maintenance). In the event of an alarm, the DiagMonitor can also start autonomous programs such as special PC tools or user-specific applications for individual response to alarms.

Prevention of potential failures

- Diagnostics and signaling functions for PC temperature, fan, hard disks (SMART), system status (watchdog)
- Operating hours counter for preventive maintenance
- Recording and evaluation of operating data
- Integral log function, comprehensive text messages and online help in German and English

Possibilities for minimizing PC downtimes:

- Product Equipment Data: Online service tool for simple and quick information about the equipment configuration in the delivery condition. The information also supports the procurement of spare parts (www.siemens.com/ped).
- The after-sales information system for SIMATIC IPC/PG offers product and contact information on the Internet in one central location (www.siemens.com/asis).
Monitoring and diagnosis of networks

SIMATIC PCS 7 communicates with the subordinate components of Totally Integrated Automation via Industrial Ethernet and PROFIBUS and uses the network components and communications processors (CPs) of SIMATIC NET. In addition to reliable communications, these also offer the facility for network diagnostics during runtime.

Monitoring of PROFINET/Industrial Ethernet

Network components

Network components are SCALANCE X (Industrial Ethernet switches), SCALANCE W (Industrial WLAN), and SCALANCE S (Industrial Security).

SCALANCE X-200 managed
Unversally applicable, from machine-level applications to networked plant sections. Configuration and remote diagnostics are integrated in the STEP 7 engineering tool. This increases plant availability. Devices with a high degree of protection permit a cabinet-free construction. Appropriate switches (SCALANCE X-200IRT) are also available for use in plant section networks with hard real-time demands and maximum availability.

SCALANCE X-300 managed
Networking of subsystems/plant sections, as well as for connecting to the enterprise network. The SCALANCE X-300 managed product line combines the firmware functionality of SCALANCE X-400 with the compact design of SCALANCE X-200. The SCALANCE X-300 switches thus offer expanded management features and firmware functionality in comparison with the SCALANCE X-200 switches. Moreover, electrical and optical Gigabit Ethernet ports are available, as well the XR-300 Rack Switches as versions in 19-inch design.

SCALANCE X-400 managed (Layer 3)
For use in high-performance plant networks (e.g. with high-speed redundancy). Due to the modular design, the switches can be adapted to the task at hand. Due to the support of IT standards (e.g. VLAN, IGMP, RSTP), the seamless integration of automation networks into existing office networks is possible. Routing functions on Layer 3 support communication between different IP subnets.

SCALANCE W
Thanks to wireless communication, an even higher level of plant flexibility can be achieved, maintenance work is simplified, and service times and downtimes are reduced. The IWLAN solution from Siemens Industry makes these advantages available through a coordinated portfolio of WLAN equipment for industrial use, even for fail-safe communication in the context of operator and machine safety. This includes IWLAN access points and client modules (SCALANCE W), wireless connections for PROFIBUS and distributed I/Os, mobile operator panels, planning software, and extensive accessories.

SCALANCE S
The SCALANCE S security modules enable logging of access data in one log file (syslog protocol). These data show how, when, and by whom the network has been accessed. Attack attempts can be detected early and appropriate preventive measures taken.

Network management

The integrated network management with the standard SNMP (Simple Network Management Protocol) in SCALANCE X and W provides information for the diagnosis of devices.

The network management products SINEMA E (SIMATIC Network Manager Engineering), SINEMA Server (Management), and the SNMP OPC server provide support in the planning and simulation or monitoring and diagnosis of wireless and wired networks in the industrial environment. SINEMA Server is specifically used in larger networks and for extensive network management. The SNMP OPC server is used exclusively for the processing of SNMP message frames and their transfer to be represented in other systems.

SINEMA Server network management
The SINEMA Server (Simaic Network Manager) network management software diagnoses and visualizes Ethernet networks. It continuously logs network activities using various protocols such as SNMP, DCP, and LLDP and makes them available to users and other systems on the network, e.g. HMI software such as WinCC, for evaluation and further processing. Devices, their properties and their topology are recognized, and network statistics are compiled by means of autodiscovery.
These can be displayed graphically and if desired also supplemented using individual diagnostics screens. In addition, at runtime cyclical data from Ethernet participants is queried and network alarms are reported. Websites are used to present and pass on the information. Furthermore, the software offers an e-mail client function and OPC server in order to forward network data and alarms to other systems. SINEMA Server can be easily integrated in HMI (Human Machine Interface) and visualization systems such as SIMATIC WinCC. Changes in the network are also accordingly logged and archived in a database. For the analysis of past network failures or as evidence of network availability, the database information can be prepared and documented as reports for any configurable period of time. The SINEMA user interface and its available features are accessible via the browser from any computers on the network.

The following components can be diagnosed:

- SCALANCE X and W network components
- SIMATIC NET Industrial Ethernet CPs
- SIMATIC S7 with integrated PROFINET interface
- PROFINET IO devices, e.g. ET 200
- Other Ethernet devices

SNMP OPC server
The SNMP OPC Server enables diagnostic and configuration data to be read from any Ethernet devices and displayed on the Maintenance Station. Alongside standard maintenance data, simple plant network problems such as failure of a line can be quickly and easily detected by means of this software.

Device configuration is integrated into STEP 7. Ethernet devices can be read from a STEP 7 project or, using the auto-discovery function, directly from the live network. The user can easily add all devices detected there to the device list for monitoring on the OPC Server. Then this configuration data is exported into the Maintenance Station, where tags, alarms and faceplates are automatically created for the devices concerned.

Monitoring of PROFIBUS

Online diagnostics with diagnostic repeater
Particularly in the case of exceptional stress, e.g. trailing cables or strong vibrations, frequent inspection of the cables is recommended to reduce failures to a minimum. The diagnostic repeater is available for this purpose. It is integrated as an RS 485 repeater in the PROFIBUS network and also has powerful features for the diagnosis of cable faults.

The diagnostic repeater determines the topology of the bus system. If there is a fault, a standard diagnostic message is automatically transmitted to the master.

This means that even sporadic cable faults can be detected and signaled. Even maintenance engineers without PROFIBUS expertise can also quickly and reliably locate and fix bus cable faults.

Diagnosis of optical PROFIBUS links with OLM
To set up optical PROFIBUS connections, optical link modules (OLMs) are used. They offer the following diagnostic options:

- Function monitoring by means of signaling contact
- Signaling of the fiber-optic cable quality with LEDs for channel monitoring
- Analog value signaling of the fiber optic line quality; evaluation with voltmeter via measurement terminal or reading to the PLC via analog module

Benefits of network monitoring and diagnosis

- High network availability through targeted and rapid localization of faults
- Documentation of network activities for analysis and verification of network availability
- Monitoring and improving network utilization
- Automatic detection of new or faulty participants
- Integration of diagnostics data in automation and visualization systems
- Detailed and clear graphical network representation
Monitoring and diagnostics for process sensors and analysis

Standardized and meaningful diagnostics alarms are a part of the electrical device description (EDD). SIMATIC PCS 7 utilizes the EDD and forwards the relevant message automatically to the Maintenance Station. The user receives information not only about which problem is involved, but also on how to resolve it.

The PROFIBUS profile specification 3.01 supplies an upgrade of the status byte, now designated "Condensed Status". The purpose of the "Condensed Status" is to reduce the number of alarms and make them more user-friendly. In addition, users have the opportunity of changing the priority level for each diagnostic alarm and thus define what is relevant to their own process.

Numerous EDDs are currently being upgraded to Extended EDDs (EEDDs). They have the following advantages:

- new standardized look & feel for all Siemens devices
- Quick start wizards for faster commissioning
- improved graphics for advanced diagnostic functions

For most Siemens devices, the manual is part of the EDD.

When using PROFIBUS, Asset Management functions can be used to greatest effect if the devices used conform to the PROFIBUS "Identification and Maintenance" specification as well as profile specification Version 3.01. Siemens devices conform to these standards. According to the "Identification and Maintenance" specification, the information to be made available should include the following:

- Manufacturer
- Order Nos.
- Description
- Installation date
- Serial number
- Hardware and software changes

As the information is also available in the device, it can be read from the configuration software and permanently stored in the software memory.

Temperature measurement

SITRANS T are the temperature measuring instruments for process engineering plants. By means of intelligent technology, these devices provide optimum support for the commissioning and maintenance. Due to various designs such as complete measuring points, head-mounted transmitters, or rail-mounted or field devices, the user has a great deal of freedom. For preventive maintenance, for example, the following functions are available in all devices:

- Universal connection of resistance thermometers, thermocouples, resistance-type transmitters and DC voltage signals.
- Monitoring of the measuring point for short circuit and open circuit.
- Min/max pointer for monitoring the electronics and sensor temperature.

The following devices are available as head-mounted transmitters or integrated into a complete measuring point:

**SITRANS TH300 – the HART device:**

The operating hours counter evaluates the temperature values of the sensor and electronics, edits them and displays them in eight temperature classes. The measured values can be archived. It is possible to derive a strategy for prognostic maintenance from the sensor temperature loading – if aging processes are known.

The output current is monitored cyclically, simulated as a fixed value or ramp function.

- Memory function of RAM, ROM, EEPROM according to checksum method
- Program sequence due to targeted approach to checkpoints (watchdog)

**SITRANS TH400 for PROFIBUS PA**

With the possibility of connecting two sensors in redundant mode. The profile 3.0 device ensures easy interchangeability.

With FISCO certification, use in potentially explosive areas is uncomplicated.

**SITRANS TH 400**

For installation on mounting rail with integrated power supply, SITRANS TW is a universal 4-wire temperature transmitter for mounting in control cabinets:

- Monitoring of limit values and output via HART or signaling relay
- Runtime meter for electronics

**SITRANS TW for rail mounting**

For installation on mounting rail with integrated power supply, SITRANS TW is a universal 4-wire temperature transmitter for mounting in control cabinets:
Pressure, absolute pressure, differential pressure, flow and hydrostatic level measurement

SITRANS P is a family of pressure measuring instruments. The SITRANS P DS III and P-300 digital transmitters are suitable as universal transmitters for measuring gauge pressure, absolute pressure, and differential pressure, and also for flow and hydrostatic level measurement.

They have a series of integrated diagnostic and simulation functions that allow the user to assess the specific state of the device or of the whole measurement point during commissioning, servicing and maintenance operations.

The preventive maintenance is supported by functions such as

- Operating hours counter for measuring cell and electronics.
- Event counter for upper and lower limit violation
- Min/max pointer for pressure, sensor temperature and electronics temperature
- two freely parameterizable timers that can set off a warning or an alarm on reaching a preset threshold.

As part of the corrective maintenance the device diagnostics effectively support the clearance of faults. For this, the following are cyclically monitored:

- Memory integrity of RAM, ROM and EEPROM by means of checksum method
- Correct program sequence in microcontroller due to targeted approach to checkpoints (watchdog)
- Sensors for breakage and function of the linearization calculation.

In addition, simulation functions are available for checking the configuration of the transmitter and of the connected control system input. These also contribute to fast and definitive troubleshooting and thus to greater efficiency in the maintenance operations.

From the combination of the stated functions, measures can be derived that contribute to the prognostic maintenance and thus increase plant availability even further and help to raise productivity.
Monitoring and diagnostics for process sensors and analysis

Flow measurement

For flow measurement, Siemens offers various contactless measurement procedures:

- SITRANS F M MAGFLO magnetic-inductive flow meters
- SITRANS F C MASSFLO Coriolis mass flow meters

The devices are flexible in their application and can be positioned at any point in the installation.

MAGFLO and MASSFLO flow meters provide excellent, correct and predictable information about the HART or PROFIBUS Profil 3.0 interfaces. The latest MASSFLO version "SIMATIC Siflow FC070 Coriolis transmitter" can be directly integrated into the SIMATIC system via the backplane of the SIMATIC module. SIMATIC Siflow FC070 has a SIMATIC S7-300 environment. The SIMATIC Siflow FC070 permits seamless integration into the automation system.

MAGFLO flow meters are used for applications with conductive liquids and MASSFLO flow meters, for example, for non-conductive liquids, high precision requirements or in processes in which the process parameters are subject to severe fluctuations.

MAGFLO flow meters are not sensitive to fluctuations in pressure, temperature, viscosity or electrical conductivity (min. 5 µS/cm guaranteed).

The device is equipped with a host of diagnostic functions that are displayed in plain text and stored in a logbook. In this way, sporadically occurring faults can also be located. These faults are automatically sent to the system in accordance with the standards of the diagnosed requirements of Namur NE 107.

The measuring transducer, including outputs, is monitored. The pickups are continuously checked and empty pipe detection is performed. In addition, MAGFLO flow meters offer the option of checking the entire measurement system with an external verifier.

MASSFLO flow meters are not sensitive to fluctuations in pressure, temperature, density, electrical conductivity or viscosity. An ASIC guarantees improved reaction to discontinuities. The devices are practically unaffected by external noise – an essential requirement for raising the dynamic range.

MASS 6000 monitors both application-dependent faults and those device settings selected by the user:

- too much air in the measuring tube
- Empty tube detection
- Unstable flow signal
- Zero point error
- Density of fluid and temperature limits
- Measuring range limits

The user-specific settings are compared with the actual values to determine an optimal setting. Faults, caused by mechanical vibrations, cavitation or pump noises can affect the measurements.

Extended diagnostic functions in the MASS 6000 transmitter by means of intrinsic sensor resonance frequency, pick-up amplitudes and signal-phase can identify these influences.

As NAMUR NE 107 is supported, extensive diagnostic functions are available in the Maintenance Station. This enables the maintenance personnel to adopt the necessary measures. From this standardized information (type and frequency of the alarms), the user can draw conclusions that indicate imminent failure or predictive maintenance. This enables step to be performed to improve the measurement quality or prevent a loss of production.
Level measurement

Three different measurement procedures are available for level measurement: Radar technology, capacitive level measurement and ultrasonic technology.

Level measurement with contactless radar technology:

- SITRANS LR400/LR460 with FMCW radar (Frequency Modulated Continuous Wave)
- SITRANS LR200, Pulse Radar
- SITRANS LR300, Pulse Radar
- SITRANS Probe LR, Pulse Radar

Level measurement with contactless ultrasonic technology:

- SITRANS Probe LU with ultrasonic compact echo sounder

Capacitive level measurement with limit recording:

- POINTEK CLS 200/300/500
- SITRANS LC 300/500

Siemens level meters have a series of internal and external monitoring functions. For example, the Pointek CLS 200/300/500 limit switches offer the opportunity of detecting external influences such as deposits or pollution and deriving maintenance requirements from them.

The device diagnosis includes not only the typical electrical and electronic components, but also the assessment of the signal for its measurement quality with regard to its trustworthiness and strength. The Maintenance Station reports the maintenance requirements on reaching a limit value.

SITRANS LR400/LR460 cumulates the operating data and calculates from it the remaining life in terms of the preventive maintenance.

POINTEK CLS200/300 recognizes the degree of encrustation. The current status of the device in each case is the basis for the predictions of remaining life. This makes prognostic maintenance possible. Maintenance measures can be planned to maximum effect. The result of maintenance work already carried out is also fed into the trend calculation.

Due to their design and the patented Active Shield Technology, SITRANS LC300/LC500 are suitable for difficult applications, in which reliable measurement and high accuracy are important, virtually unaffected by material deposits or pollution. They have a greater fault-tolerance than comparable devices. The need for maintenance is reduced to a minimum.

Adjustable limit values for the various warning levels allow optimum adaptation to the physical circumstances.
Monitoring and diagnostics for process sensors and analysis

Pump diagnosis for monitoring oscillating displacement pumps

SITRANS DA400 is a diagnostic device for continuous status monitoring of oscillating displacement pumps. The device detects even the tiniest leakages at the valves in oscillating displacement pumps. No additional troubleshooting is necessary.

The principle is based on the measurement of the acoustic emission caused by the creation of cavitation in the case of leakages. In addition, there is an option for monitoring additional variables such as pressure or temperature at the pumps. On achieving certain limits, these are signaled to higher level systems by means of digital outputs or via PROFIBUS PA. Apart from adjusting the device on site, parameterization by means of PROFIBUS is also possible.

SITRANS DA 400 increases plant availability by means of
• significantly shorter downtimes
• extended maintenance intervals, as pumps only require maintenance work when their condition demands it.
• avoiding consequential damage due to failure, because defective parts are replaced long before the entire component fails. In addition, the early detection of leakages permits optimum forward planning of the maintenance measures. The operational method of a plant can also be adapted, thereby improving availability.

The status-oriented maintenance also contributes to energy saving: A premature drop in performance is detected at an early stage and can be rectified by replacement or repair of the affected parts.

SITRANS DA400 thus makes a considerable contribution toward reducing the total cost of ownership and raising the productivity.

Large amplitudes, caused by leakage in the intake valve, indicate the defect.
Gas analyzers

Siemens offers a wide range of gas analyzers.

- **CALOMAT 6/62**
  thermal conductivity gas analyzers for determining the quantity of hydrogen or helium in binary gas mixtures
- **FIDAMAT 6**
  Cumulative measurement of hydrocarbons according to the flame ionization principle
- **OXYMAT 6/61**
  Gas analyzers for measuring oxygen according to the paramagnetic principle
- **OXYMAT 64**
  Gas analyzers for measuring trace oxygen by means of ZrO₂ sensors
- **ULTRAMAT 6**
  One- and two-channel gas analyzers for highly selective measurement of infrared-active components
- **ULTRAMAT/OXYMAT 6**
  Combination of OXYMAT 6 and ULTRAMAT 6 in one device
- **ULTRAMAT 23**
  Gas analyzers for measurement of up to three infrared-active components and oxygen.
- **LDS6**
  In-situ gas analyzers for the measurement of O₂ (temperature), NH₃, HCl, HF, H₂O, CO, CO₂ and special applications in flue gas before and after purification. Further applications are possible in the chemical and petrochemical industries, steel production and cement and paper mills.

The gas analyzers have extensive functions for device diagnostics and thus for corrective maintenance. In addition, they are capable of detecting functional irregularities. These appear as a maintenance requirement or as a failure alarm in the display of the Maintenance Station or at the signal output, or they are signaled via PROFIBUS PA/DP to higher level systems. The messages are recorded in a logbook.

Possible causes for maintenance requirements include:

- Calibration tolerance exceeded due to pollution of measurement chamber, drift or change of the calibration gas
- Zero or comparison gas contains too much oxygen (OXYMAT 6)
- Use of incorrect test or comparison gas
- Detector defective or comparison gas failed
- Maximum measurement chamber or measurement probe temperature exceeded (OXYMAT 6) or heating defective
- Combustion gas failure or flame extinguished (FIDAMAT 6).

In addition, maintenance requirements may result from:

- Monitoring of the chopper motor (ULTRAMAT 6)
- Monitoring of the magnetic field (OXYMAT 6)
- Monitoring of external fault signals (sample preparation)
- Flow monitoring (ULTRAMAT 23)
- Monitoring of external fault signals (sample preparation)
- Low transmission due to loss of calibration of the transmitter or receiver unit (LDS6)

With these monitoring functions, the gas analyzers ensure reliable operation and support an effective and corrective maintenance.
SIPART PS2 is an electropneumatic positioner for control valves. The device is suitable for high-precision control of valves and flaps in the widest variety of applications.

Apart from extensive basic functions for self-monitoring, the controllers are characterized by the following on-line diagnostics functions that are in direct relation to the current demand for maintenance:

- Slow movement of a valve
- Pneumatic leakages (e.g. torn membrane)
- Blockage of a pipe or breakage of valve cone
- Wear and tear of the valve seat or cone
- Deposits or caking on the valve seat or cone
- Adhesion of the stuffing box
- Partial stroke test for open/close control valves (e.g. safety valves)
- Partial stroke test for control valves

These faults are signaled according to their degree of seriousness and thus the urgency of maintenance according to a three-stage scale of assessment (spanner symbols, see page 8).

These faults are also shown on the on-site display in their different stages. This enables faults to be detected at an early stage, long before it comes to equipment failures or a plant standstill.

Moreover, in view of preventive maintenance measures, the following values are also monitored, where in part a gradual notification (see above) can be made:

- Operating hours (also differentiated by temperature ranges and setting ranges)
- Operating temperature, current and min. / max.
- Stroke counter (stroke integral)
- Number of changes in direction

The use of predictive maintenance is based on the fact that the life of the corresponding components can be fully used without the risk of failure or damage. The level of loading can therefore generate instructions that can be used for optimizing the mode of operating the plant and thus raising the availability.
Monitoring and diagnosis for protection, switching, and drive components

Selective protection of load feeders

In the process industry, automation components are generally powered with 24 V DC. With the SITOP PSE200U selectivity module, any 24 V load is reliably monitored for overload and short circuit and in the event of faults it is switched off.

A selectivity module monitors up to 4 load feeders which can also be connected in sequence following defined periods in order to offload the power supply. Monitoring currents are adjustable between 0.5 to 3 A and 3 to 10 A. The electronic system allows short current spikes such as making current switching spikes, but longer-lasting overloads or short circuits are switched off.

If one of the four outputs is switched off, a sum signaling contact is activated and can be evaluated by the higher-level automation system. The service technician recognizes on site which 24-V feeder is concerned, since each output has a multi-color LED to indicate the current operating status. Besides fast error detection and localization, this leads to a reduction of downtimes.

Contactor with remaining life time (RLT) signaling

Contactor main contacts are parts subject to wear, and must be replaced before they reach the end of their service life. The erosion of the contact material, and therefore the electric service life (= number of switching operations) is larger or smaller depending on the load, category of use, operating mode etc.

Routine checks/visible inspections by the maintenance personnel provide information on the status of the main contacts. The remaining life time message function of the SIRIUS contactors with RLT handles this task and makes on-site visual inspections unnecessary. It not only counts the switching operations – which do not provide information on the contact wear – but, more importantly, the actual advancement of the erosion of each of the three main contacts is electronically recorded, evaluated, saved, and signaled when defined limits are reached. These saved data are not lost even if the control supply voltage fails.

State-oriented maintenance permits optimum utilization of the contact material. This results in a reduction in operating costs with a simultaneous increase in plant availability.

The message is sent via relay contact or AS-Interface when a residual life time of 20% is reached. Via, for example, a SIMO-CODE pro digital input and thus via PROFIBUS, the messages are forwarded to the SIMATIC PCS 7 Maintenance Station.
SIRIUS SIMOCODE pro motor management system

SIMOCODE pro is a flexible, modular motor management system for motors with constant speeds in the low-voltage performance range. It optimizes the connection between control system and motor feeder and increases the plant availability. SIMOCODE pro is specially designed for use in motor control centers (MCC) of the process industry and power plant technology, where it is used for the protection and control of motors/pumps, etc., for example in hazardous areas, in areas with heavy starting (paper, cement, and metal industry), and in fault-tolerant systems.

Special features:
- Multifunctional, electronic full motor protection which is independent of the automation system
- Flexible software instead of hardware for the motor control
- Detailed operational, service and diagnostics data
- Energy management capability
- Communication via PROFIBUS DP

In order to be able to offer the ideal system for every application, SIMOCODE pro flexible can be expanded with the following function modules: Digital, analog, ground fault and temperature modules. The PCS 7 function block library permits the display of diagnostic data on the Maintenance Station. This prevents faults or, if necessary, allows them to be quickly located and cleared. The diagnostic alarm here is not signaled in great detail via PROFIBUS, but via the faceplate with display directly on the cabinet as well. This enables measured values, status information and fault messages to be displayed in plain text directly on the display with switchable languages.

If a device or a whole cabinet drawer in motor control centers (MCC) has to be replaced, the addressing plug enables the new PROFIBUS address to be assigned quickly and without complication to the replacement unit. Also by using a memory module, the parameterization of the unit to be replaced can be transferred directly to the new SIMOCODE pro – simply by plugging it into the system interface.

One essential feature of SIMOCODE pro is the autonomous execution of all protection and control functions, even when communications with the control system are interrupted. Even on failure of the bus system or of the automation system, the full functionality of the branch is guaranteed. A defined behavior may be parameterized for failure incidents such as targeted disabling of the branch or execution of certain parameterized control mechanisms (e.g. reversing the direction of rotation).

Operating and statistics data that facilitate status-oriented maintenance:
- Motor operating hours, motor standstill times, device operating hours
- Number of motor starts and overload trips
- Internal comments stored in the device

Diagnostic data for corrective maintenance:
- Numerous detailed early-warning and fault alarms for processing in device or in control system
- Device-internal fault logging
- Time-stamping of selected status, warning and fault messages for precise time recording of process signals
- Value of the last tripping current
- Acknowledgement errors (e.g. no current flow in the main circuit after a switch-on control command), etc.
Diagnosis of drives

Hardly any other group of products influences plant availability as much as drive engineering: Production stops if these products fail. Such unplanned plant downtimes are associated with expensive production outages, unplanned repairs, and frequently consequential damage.

Therefore all drive systems and frequency converters of the SINAMICS, MASTERDRIVES and MICROMASTER ranges with their associated motors are integrated into the SIMATIC PCS 7 Maintenance Station. This results in the common, uniform presentation of maintenance-relevant information which permits preventive and prognostic maintenance strategies.

The components report autonomously that maintenance is required. One example are the medium-voltage converters such as SINAMICS GM150. For instance, by means of a differential pressure procedure the degree of contamination of the dust filters is determined.

In the water-cooled version, the analog conductivity measurement continuously monitors operation of the ion exchanger and outputs an early-warning message when the exchange capacity decreases. The operating fans for air cooling and the pumps for water cooling are equipped with operating hour counters that recommend checking of components on reaching a certain number of operating hours.

The CM 240NE chemistry module can be used in connection with the SINAMICS G120 Control Unit CU 240S DP-F. The chemistry module includes a terminal strip that meets the NAMUR specifications and thus the essential requirements of the chemical industry. An ATEX-certified PTC thermistor analysis function for thermal motor protection via PTC thermistors built into the motor is integrated.

The drive systems are incorporated into the maintenance station using the DriveES PCS 7, an add-on package for SIMATIC PCS 7. DriveES PCS 7 allows Siemens drives to be controlled via SIMATIC PCS 7 using standard function blocks and operated and controlled in the operator station by means of faceplates.

Status assessment of high-voltage machines

An established procedure for assessing the condition of high-voltage machines is partial-discharge diagnostics (PD) which is carried out as an offline or online measurement depending on the application. This is an important measure within reliability-based maintenance strategies for large drives.

In order to measure the PD signals, as an option the patented “SIEMENS Insulator Integrated Coupling Units” can be installed in high-voltage motors at the factory. The post insulators in the terminal box are simply replaced by the Insulator Integrated Coupling Units. This results in decisive benefits:

- Simple, low-cost installation
- No change in terminal box necessary
- Rugged mechanical design
- Highest and tested safety of the insulation distances
- Direct interface to condition diagnostics
Monitoring and diagnosis for protection, switching, and drive components

Using the example of a mixer drive, the maintenance with Drive ES PCS 7 is represented: In time, the material to be mixed starts setting in the agitator. Until now, the agitator was cleaned at planned, regular intervals to guarantee its availability. With the aid of new functions in the Maintenance Station, the cleaning can in future be performed as and when required.

The frequency converter offers the option of load torque monitoring and the type of reaction when the limit is exceeded. Within the load limits, the mixer works without any problem. With regard to the mixer, it is known that the degree of pollution has an indirect effect on the torque characteristics of the frequency converter. On exceeding the limit, an alarm is reported to the controller.

From this alarm of the converter, Drive ES PCS 7 generates a corresponding maintenance display for the Maintenance Station. Now the cleaning of the mixer can be performed on the basis of need.

Additionally it is possible to record the frequency of cleaning demands and to deduce process optimizations or anticipatory maintenance scenarios.

Thus, maintenance can as well be optimized for moving devices and availability and efficiency of the plant can be increased.
Benefits

- Plant-wide and uniform display of diagnostics and maintenance states throughout the plant
- Integrated support of condition-based maintenance
- Optimization of complete workflow from diagnostics up to termination of maintenance measure
- Maintenance functionality integrated in the system – no additional engineering overhead

For further information on this subject please visit:
www.siemens.com/automation/maintenance

SIMATIC HMI:
www.siemens.com/simatic-hmi

SIMATIC PC DiagMonitor:
www.siemens.com/diag-monitor

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