APROL ConMon
Predict the unpredictable with Condition Monitoring

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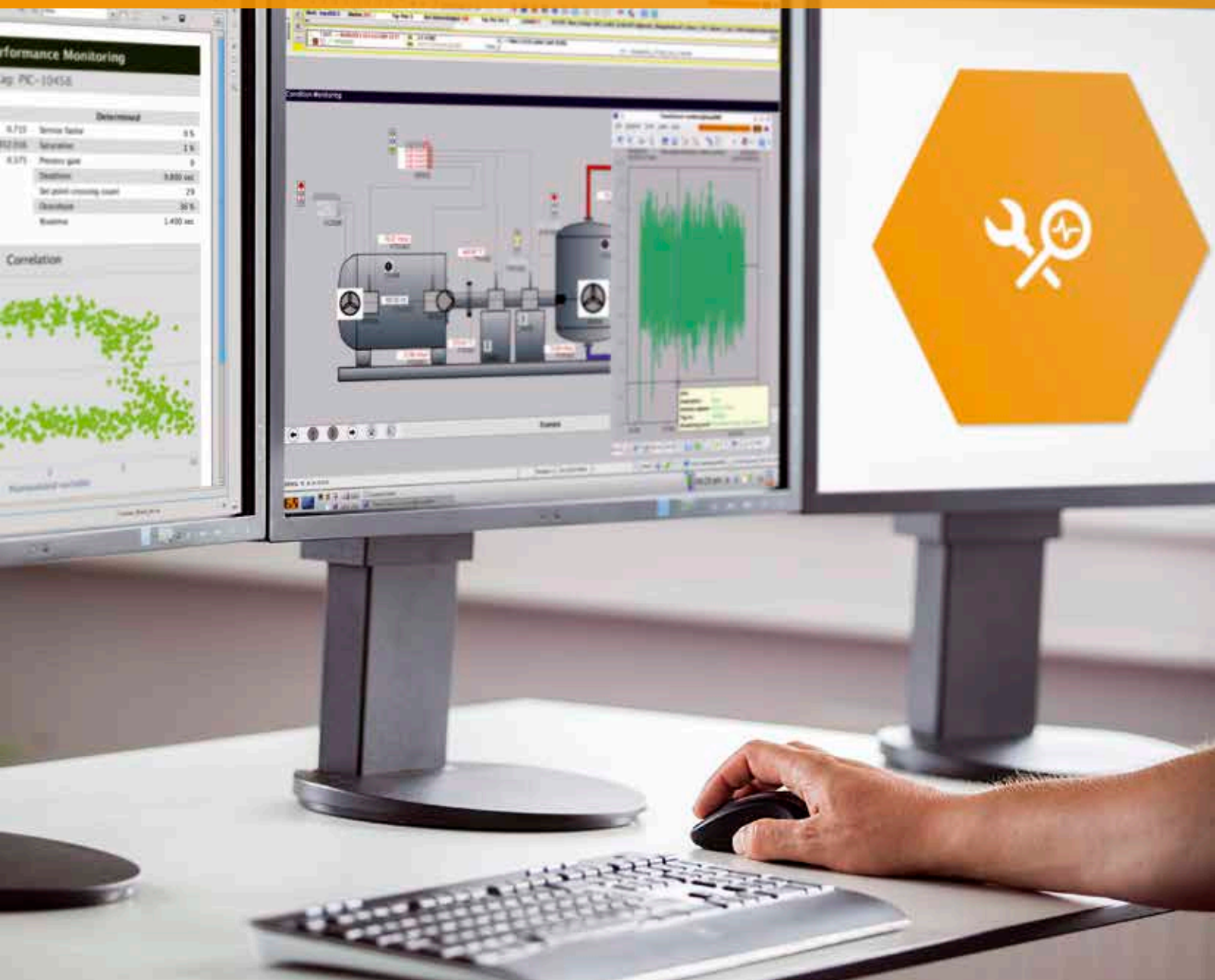


Maximize product quality while reducing maintenance costs.

Contents

APROL ConMon

Higher product quality – Lower maintenance costs

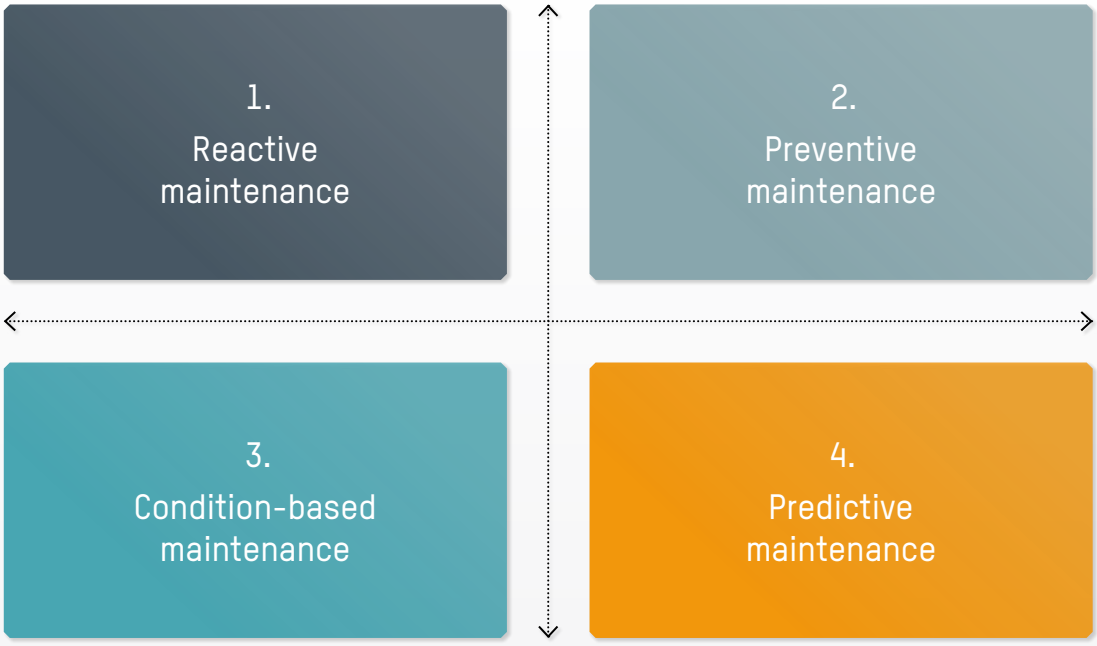
Operators of production equipment are all too familiar with the dilemma: How do you improve product quality and increase system availability while at the same time cutting back on maintenance costs?

Reactive/Preventive strategies dominate
So far most companies have taken a reactive or preventive approach. Yet these strategies fail to provide a real solution to the maintenance dilemma.

More quality and availability – Less maintenance
The solution lies in making informed maintenance decisions based on the actual condition of your equipment wherever possible. Still, there is no one-size-fits-all strategy, and each unit within a plant needs to be taken individually under consideration of legal requirements and what makes the most sense technically and economically.

According to various studies, cost and complexity are the main deterrents preventing companies from pursuing a more advanced condition-based approach. These days, however, intelligent sensors make these solutions much more affordable and easier to use. With APROL ConMon, B&R offers a pre-installed and pre-configured package that makes implementing condition-based maintenance more straightforward than ever.

Maintenance strategies

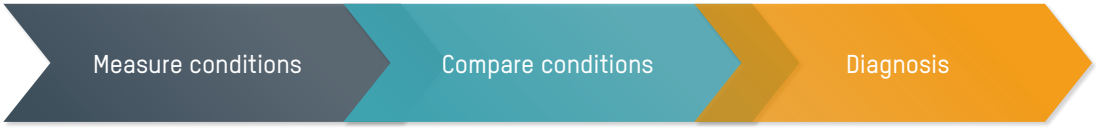


1. Reactive maintenance
One approach that is still frequently used is reactive maintenance, where machines or plants are only repaired in the event of failure or defect.

2. Preventive maintenance
With preventive maintenance, machines or plants are shut down at defined intervals to check and, if necessary, replace used components. Parts are inspected for wear in order to increase the lifespan and availability of the machine. This type of maintenance often results in fully functional components being replaced before their full service life has been utilized. The cost of preventive maintenance eats into a considerable share of profits at many companies.

3. Condition-based maintenance
The goal of condition-based maintenance is to utilize information about the condition of production equipment in order to optimize the scheduling of maintenance work, ultimately resulting in maximized production quality and minimized maintenance costs.

Precise and continuous measurement
Modern instrumentation makes it possible to record, determine and assess the condition of machines and systems continuously and with a high degree of precision. This information helps identify potential sources of malfunction and damage in advance so that corrective action can be scheduled for a time when it is convenient instead of an emergency situation.



Exploit full useful life
You can get value out of components for nearly their entire useful life – while eliminating the majority of primary (and therefore also secondary) damage.

Simple and affordable solutions prevent failure
Early detection of damage, through vibration analysis for example, helps to prevent total system failure.

VDI 2888 provides guidelines for users
VDI Guideline No. 2888 provides potential users with a manual on how a company can introduce condition-based maintenance.

Condition monitoring defined in VDI/VDE 2651 (Plant Asset Management (PAM) in the process industry)
VDI/VDE Guideline No. 2651 (Plant Asset Management (PAM) in the process industry) defines condition monitoring as involving the measurement and analysis of an asset's condition. Condition monitoring has established itself predominantly in the field of rotating equipment.

In order to avoid misunderstandings, it is important to define the assets or asset categories to which condition monitoring applies.

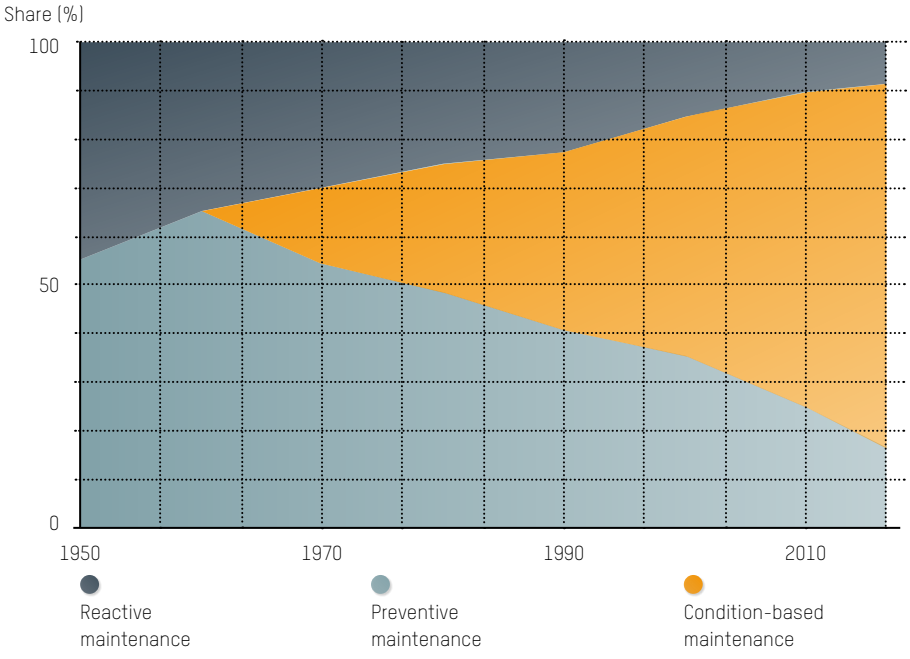
"An ounce of prevention"
Those who follow the adage "an ounce of prevention is worth a pound of cure" will be well prepared to face the constantly increasing demands for more safety, availability and efficiency.

4. Predictive maintenance
Intelligent maintenance that begins long before a machine or system malfunctions is called predictive maintenance.

Advanced technology and analytical models allow operators to detect complex patterns and predict unplanned events. In order to be effective, predictive maintenance techniques must be based on large volumes of heterogeneous data.

Data aggregation and data mining
Hundreds of detailed parameters from a variety of sources are aggregated and analyzed. Data mining techniques are used to examine historical data to uncover previously unrecognized – and often very complex – causal relationships. In combination with production data and information from sensors, the probability of malfunctions becomes predictable. This knowledge can be used to make more informed maintenance decisions, such as deferring tasks of lower importance to allow for prompt replacement of components where failure is imminent. It also allows for proactive identification of systematic error patterns and their root causes.

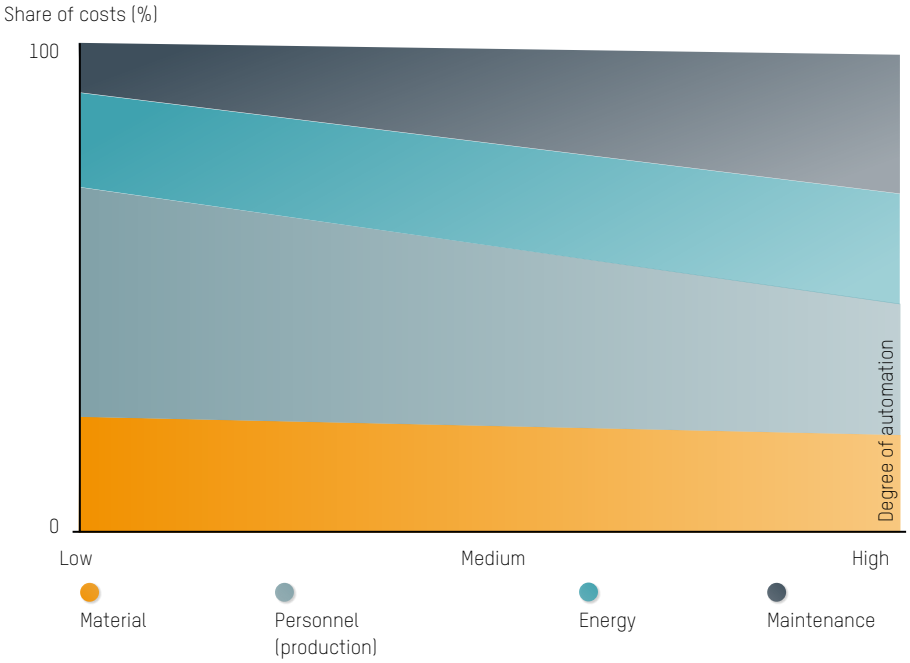
Maintenance strategy trends



Reactive/Preventive maintenance on the decline
The prevalence of reactive maintenance (unplanned downtime, secondary damage) and preventive maintenance (useful life not exploited) is declining in favor of condition-based and predictive maintenance.

Stark differences between industries
In some areas, reliance on reactive and preventive maintenance has been fading for decades, while in others progress stagnated many years ago.

Degree of automation vs. maintenance costs

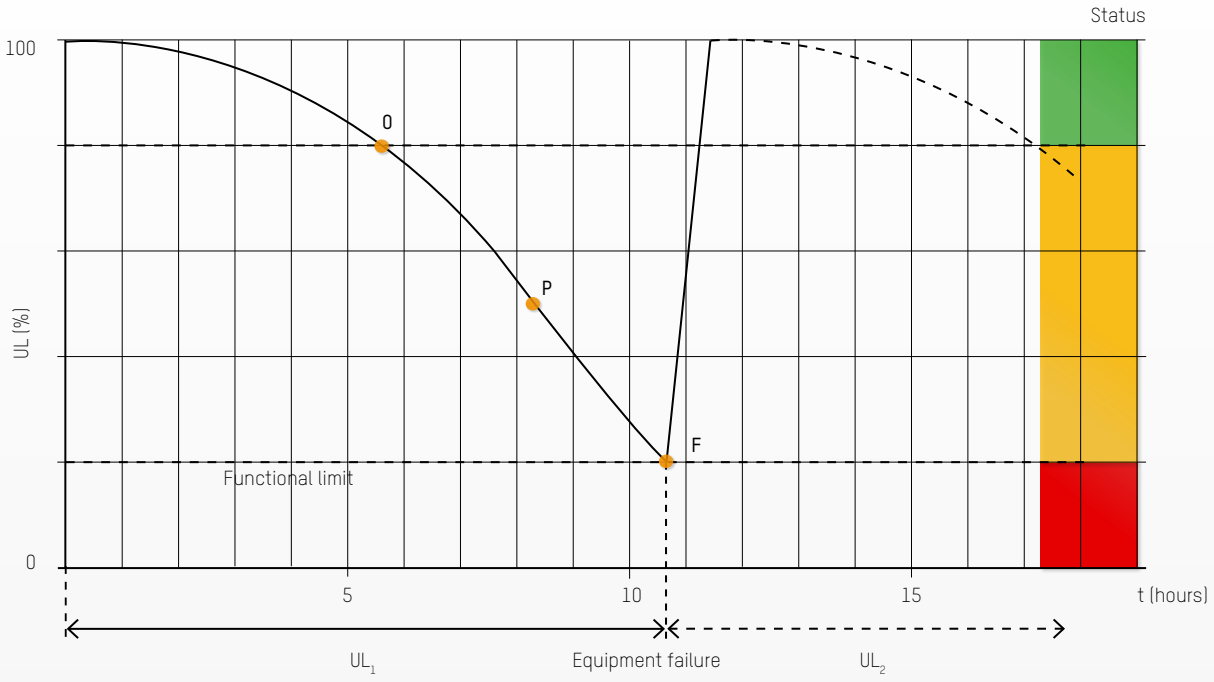


Shift in relative costs
Looking at relative costs, the clear trend is that personnel costs (maintenance personnel excluded) sink as the degree of automation increases.

Maintenance costs rise
At the same time, we see that the more complex the system, the higher the maintenance costs (maintenance, inspection and repairs). The additional expenses for maintenance, however, are more than compensated by the reduction in personnel costs.

Significance of maintenance rises with degree of automation
The inescapable conclusion is that the importance of maintenance, which is already quite significant, will continue to grow as a company increases the degree of automation used in its equipment.

Useful life

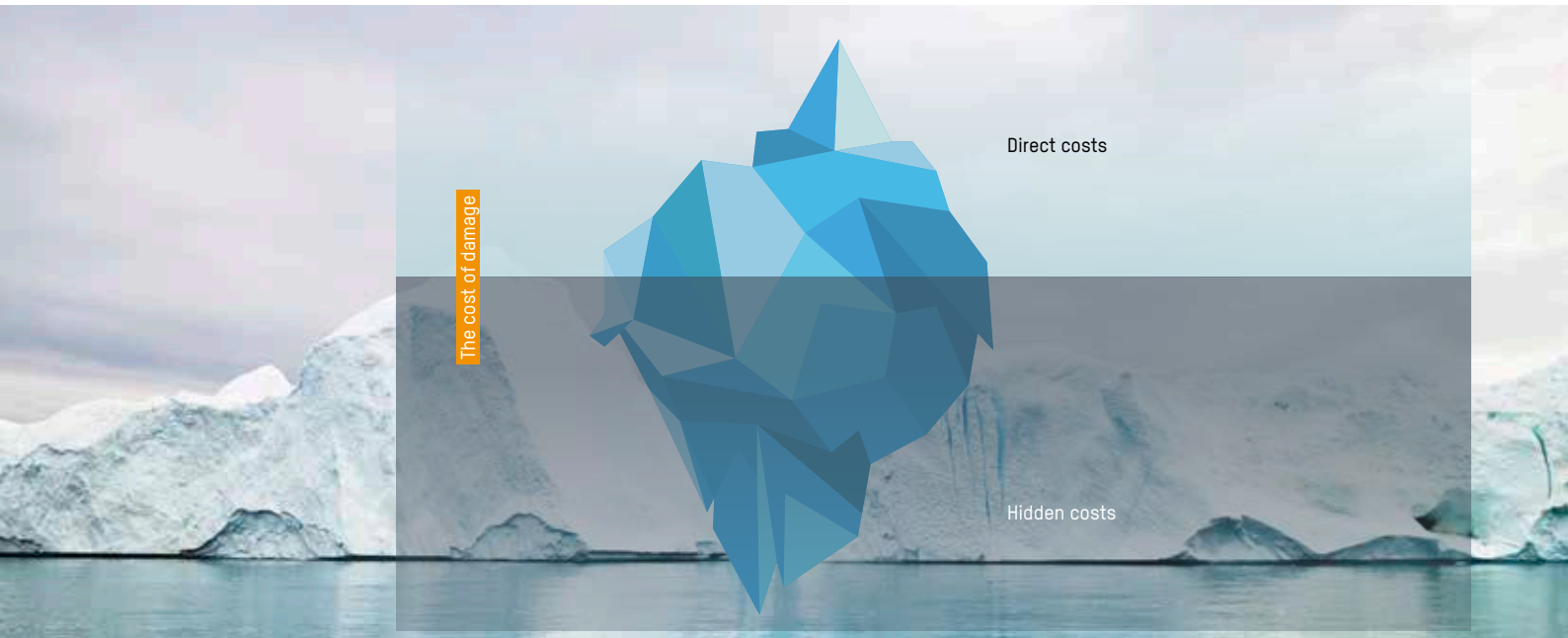


UL Useful life **O** Onset of potential malfunction (undetected) **P** Potential malfunction (detected) **F** Malfunction results in equipment failure

Potential malfunctions remain undetected
The graph above shows the progression of a component's useful life (UL), starting with a new component (UL_1). After a certain time in the field, a point is reached where the potential for malfunctions becomes significant (O). The onset of this phase generally goes unnoticed until the potential reaches a higher level (P).

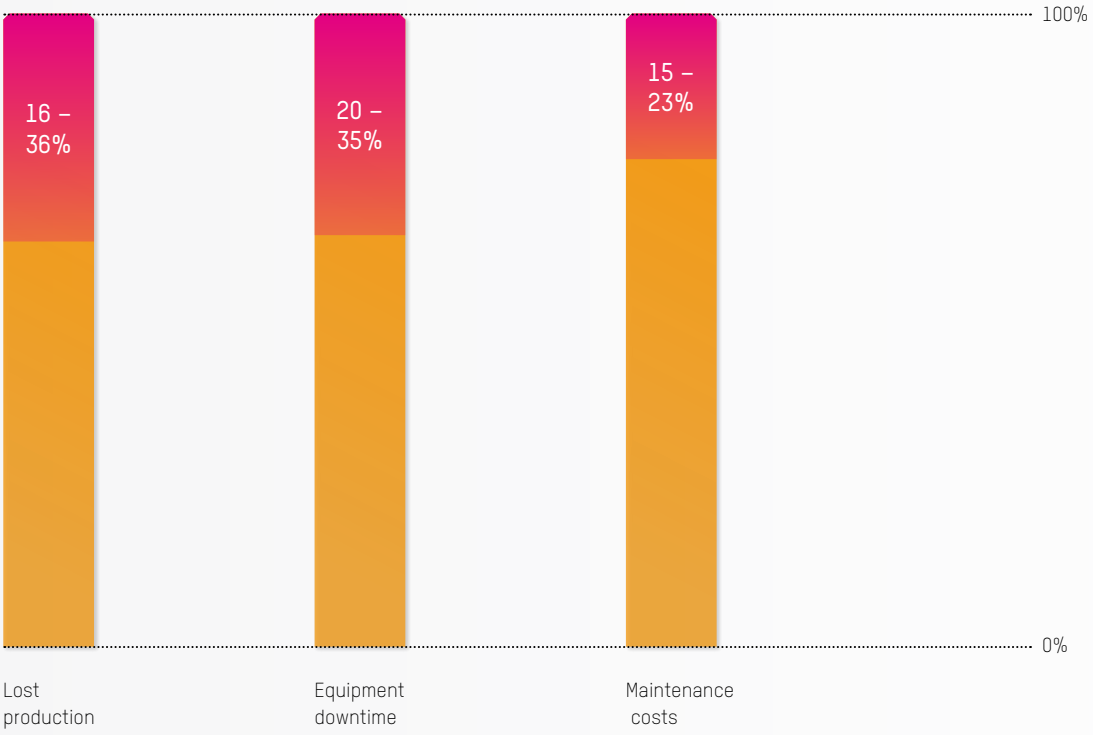
Malfunction causes equipment failure
At this point in time, the malfunction must be corrected before it results in equipment failure (F).

Advantages of condition-based maintenance



- Timely detection of primary damage helps prevent secondary damage
- "Built-in safety" helps protect human operators and the environment
- Knowing the current state of the system helps more accurately predict achievable product quality and production quantities
- Components provide value for more of their useful life
- The mean time between maintenance is increased
- The majority of needless repair work is prevented
- Spare parts inventory can be streamlined
- More advanced notice of repairs allows for more convenient downtime planning
- Knowledge of wear levels improves operational safety
- "Built-in" safety allows operators to focus on core responsibilities

Cost savings through condition-based maintenance



Highlights

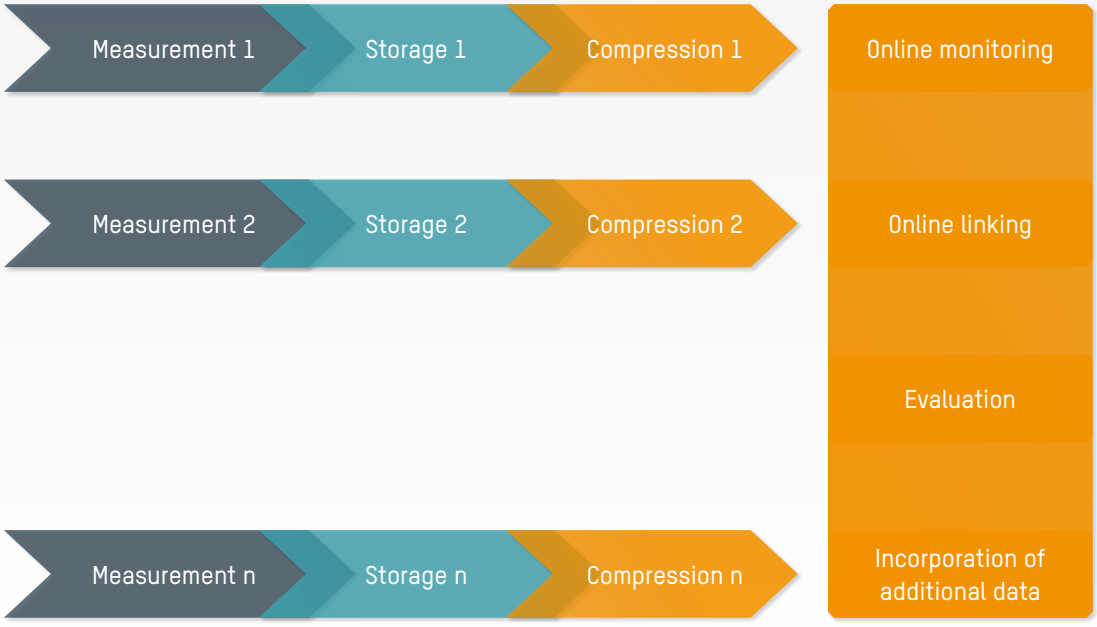
- → 16-36% reduction of production losses
- → 20-35% less downtime
- → 15- 23% lower maintenance costs

Condition monitoring systems

Condition Monitoring Systems (CMS) are described as systems that monitor the condition of machines and systems.

The primary goal of a CMS is to gather and relay the current condition of a system as well as to provide advanced detection or prediction of damage. In order to achieve these goals, the system must provide the following functionality:

- → Measurement, storage and compression of condition parameters
- → Online monitoring of parameters
- → Online linking of parameters
- → Evaluation of measurement data
- → Incorporation and processing of additional data



A CMS measures dynamic condition parameters such as torque and vibration

Unlike a standard monitoring system, a CMS measures, stores and compresses not only quasistatic parameters such as temperature, pressure, motor current, power and speed, but also dynamic parameters like torque and vibration. These dynamic parameters can provide insight into the

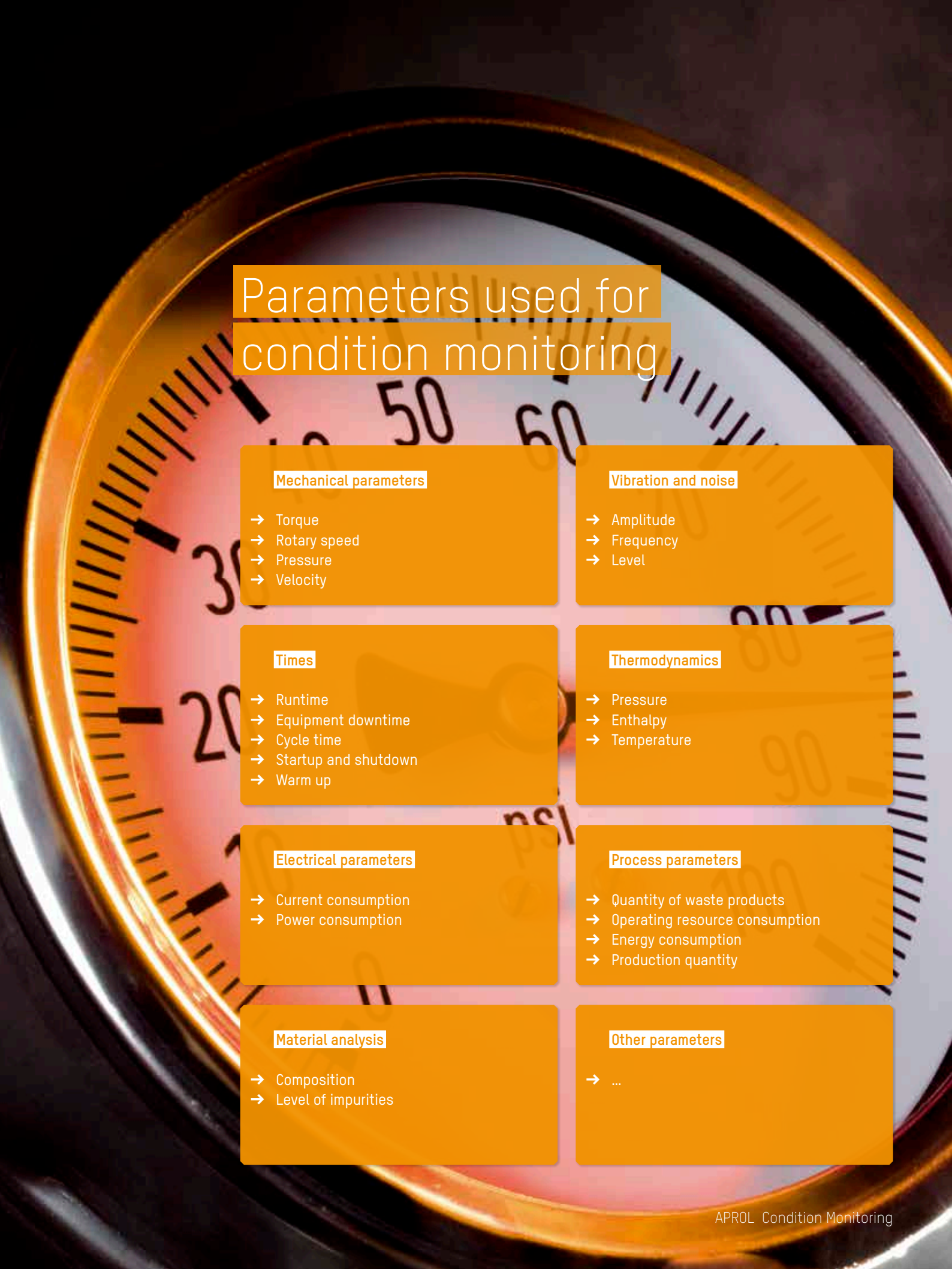
progression of wear and tear as well as the load on the machine or system.

The data gathered by the CMS represents a valuable source of information for maintenance planning.

Condition monitoring systems are primarily used in the areas of vibration monitoring (oscillations, structure-borne sound), current consumption, pressurized air consumption, torque measurement, thermal imaging and oil analysis.

Increased vibration usually caused by imbalances
Vibration analysis is based on the principle that all mechanical processes involve the transmission of forces that are ultimately conducted to the surface of the structure. Frequently, an increase in the vibrations produced by machines with rotating masses is an indication of a mechanical imbalance. Such an imbalance can result in increased wear and eventually damage to bearings, rotating parts, the frame of the machine or even the building itself.
In ventilation systems, imbalances may be caused by deterioration or build-up on the rotor blades. Parts that are loose, misaligned, come into contact with other parts or don't fit properly also cause increased vibrations.

Fast Fourier transform for identifying characteristic frequencies
After the vibration signal is recorded, a fast Fourier transform is used to break it down into its components, whose values are then analyzed. Doing so allows characteristic frequencies to be identified that would not occur in optimal conditions. The calculated RMS value of the component signals serves as a reference for determining the existing degree of damage. If the kinematic properties of the machine are known (number of teeth on gears, type of roller bearings, speed, etc.), then it is also possible to identify the damaged components.



Parameters used for condition monitoring

Mechanical parameters

- Torque
- Rotary speed
- Pressure
- Velocity

Vibration and noise

- Amplitude
- Frequency
- Level

Times

- Runtime
- Equipment downtime
- Cycle time
- Startup and shutdown
- Warm up

Thermodynamics

- Pressure
- Enthalpy
- Temperature

Electrical parameters

- Current consumption
- Power consumption

Process parameters

- Quantity of waste products
- Operating resource consumption
- Energy consumption
- Production quantity

Material analysis

- Composition
- Level of impurities

Other parameters

- ...

Plant Asset Management (PAM)

VDI/VDE Guideline No. 2651 "Plant Asset Management (PAM) in the process industry" divides the main tasks of PAM into three categories:

- Monitoring, diagnosis, prognosis and therapy
- Provision and storage of information
- Analysis, presentation and dissemination

Main tasks involved in Plant Asset Management (PAM) in the process industry in accordance with VDI/VDE Guideline No. 2651.

Monitoring, diagnosis, prognosis & therapy

- **Performance monitoring** of production plants, sub-plants and plant components by means of indicators. This includes control performance monitoring of feedback control loops and associated assets.
- **Asset indications** with user-dependent display and administration as well as monitoring of process alarms (number of alarms, number of alarms/unit of time, priorities, etc.).
- **Condition monitoring (CM)** serves the purpose of monitoring the condition of an asset (CM for pressure gauge sensors, CM for centrifugal pumps, etc.).
- **Signal monitoring** deals with the recording and processing of signals and subsequent analysis of attributes.
- **Functional testing** includes initiation and execution of inspections to ensure the functional reliability of assets (e.g. partial stroke test for safety valves).
- **Condition diagnosis** is the evaluation of symptoms to make a diagnosis.
- **Maintenance requirements** are formulated based on diagnosis and prognosis functions. Includes documenting maintenance requirements and making them available.
- **Prognosis of performance** is the predicted development of an asset's condition based on the latest condition diagnosis.
- **Determination of wear tolerance** refers to the deduction of the remaining useful life of an asset based on past and present asset information.
- **Suggestion of therapy** involves the deduction of suitable measures to establish the required function of the asset.
- **Performance optimization** includes initiation of measures to optimize the performance efficiency of an asset.

Provision & storage of information

- **Master data** – Fundamental database used to identify an asset and allocate its data (asset history). This database can be compiled in another system and applied or copied from there.
- **Document management** – Provision of all asset-related documents utilizing asset-specific information such as version and serial number.
- **Asset history** – Chronological and systematic storage of asset-related data (e.g. for life cycle management).
- **Version management** – Administration of the version history (e.g. software, hardware, firmware, application parameters) over the asset's life cycle, citing any relevant modifications. Version management is also part of the asset history.

Analysis, presentation & dissemination

- **Administration of operator interventions** – Logging and analysis of all asset-related operator actions (Audit Trail)
- **Calibration and gauging** – Checking and setting the required precision for the respective asset.
- **Configuration and parameterization** – Selection and adaptation of modules and components for the task assigned to the asset (in the course of commissioning and maintenance).
- **Asset alarms and indications** – Deduction of asset alarms and indications as a function of monitoring and diagnosis. User-dependent presentation of asset alarms and indications (asset alarm management).
- **Proven-in-use** – Technical qualification of assets for certain areas of application based on a statistical analysis of the assets' history.
- **Economic parameters** – Economic assessment of assets for specific areas of application based on a statistical analysis of the assets' history (OEE, TCO, ROI).

Standalone solution for measurement and monitoring in all industries

APROL ConMon is B&R's solution for measuring, recording and evaluating all relevant condition parameters to provide optimal support for the continual improvement process.

- → Measurement, storage and compression of condition parameters
- → Online monitoring of parameters
- → Online linking of parameters
- → Evaluation of measurement data
- → Incorporation and processing of additional data

Flexible integration into existing automation solutions
APROL ConMon can be used as a standalone solution – independent of any existing building control systems, SCADA systems, process control systems and PLC solutions – or it can be integrated into an existing APROL process control system.

APROL ConMon – An optimal solution for all industries
APROL ConMon can be customized to monitor a single machine, an entire factory, a building, a process or a plant.

→ **Machine automation**
When a new series-produced machine is developed, highly effective equipment is needed in order to measure, record and evaluate all of the relevant parameters. APROL ConMon provides optimal support in this task.

→ **"Black box" for machine builders**
Another interesting application of the standalone version of APROL ConMon is as a "black box" for an OEM to reliably and seamlessly monitor whether the user operates the machine in accordance with specifications during the warranty period.

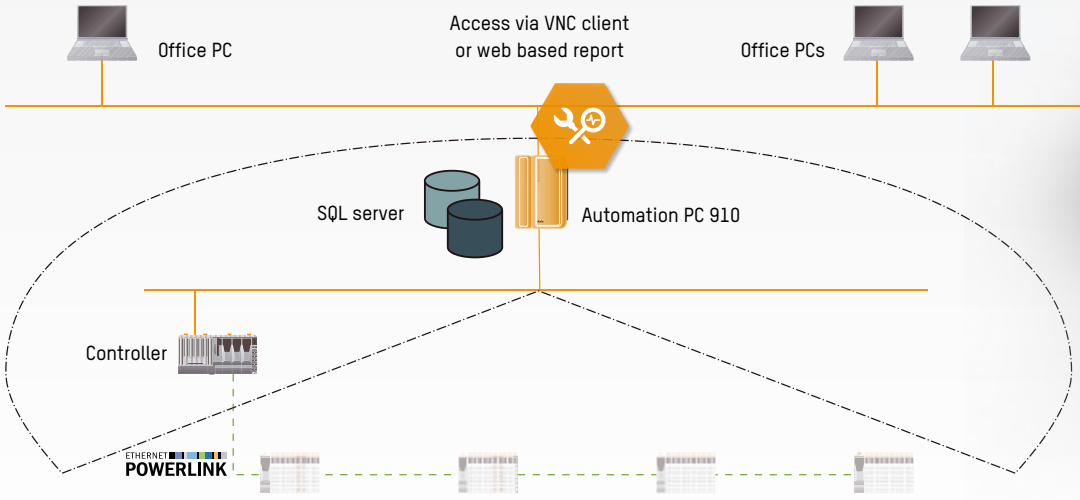
→ **Plant automation**
The typical plant automation application is a mid-sized plant with multiple controllers. Since condition monitoring is generally also used to protect the individual components as well, the optimum solution in this case is integration into the overall APROL system.

→ **Process automation**
When an APROL process control system is already in use, integrating ConMon has the added benefit that all system functions have full access to the condition monitoring data.

With an existing third-party process control system, condition monitoring is generally implemented via separate systems of sensors and evaluation electronics. These systems can be connected via interfaces to display their data in the third-party process control system. Detailed analysis of vibration measurements can be performed directly in the standalone version of APROL ConMon.

→ **Factory automation**
Factory automation often requires collection of additional condition monitoring data for individual machines. These measurements are obtained from additional remote I/O modules and then processed in a separate APROL ConMon system.

Condition Monitoring – Ready to use



Automation PC 910:
Robust solution for
control cabinet installations

The ready-to-use APROL ConMon solution is based on the APROL process control system to ensure maximum flexibility with very little engineering. It also makes the implementation of Condition Monitoring Systems (CMS) and Plant Asset Management (PAM) tasks considerably easier. With APROL as the platform, it is also possible to implement solutions that go far beyond conventional condition monitoring tasks. Because of its outstanding scalability, the system can grow to meet new demands, ensuring exceptional long-term investment protection.

System topology

An APROL ConMon system consists of an Automation PC 910 situated in a control cabinet. It includes the complete system with all necessary software preinstalled. In addition to the engineering and operator software, the system also includes a high-performance database with an SQL interface. It is based on the extremely stable SUSE Linux Enterprise Server operating system. All required data is archived.

Usually installed in the control cabinet without a monitor, the APC910 can be accessed over the network from workstation computers using a web browser or VNC client. There is no need to install additional software.

A controller is required in order to read the condition monitoring data from the I/O modules and to preprocess these values. Depending on the number of I/O points, it is possible to add many more controllers.

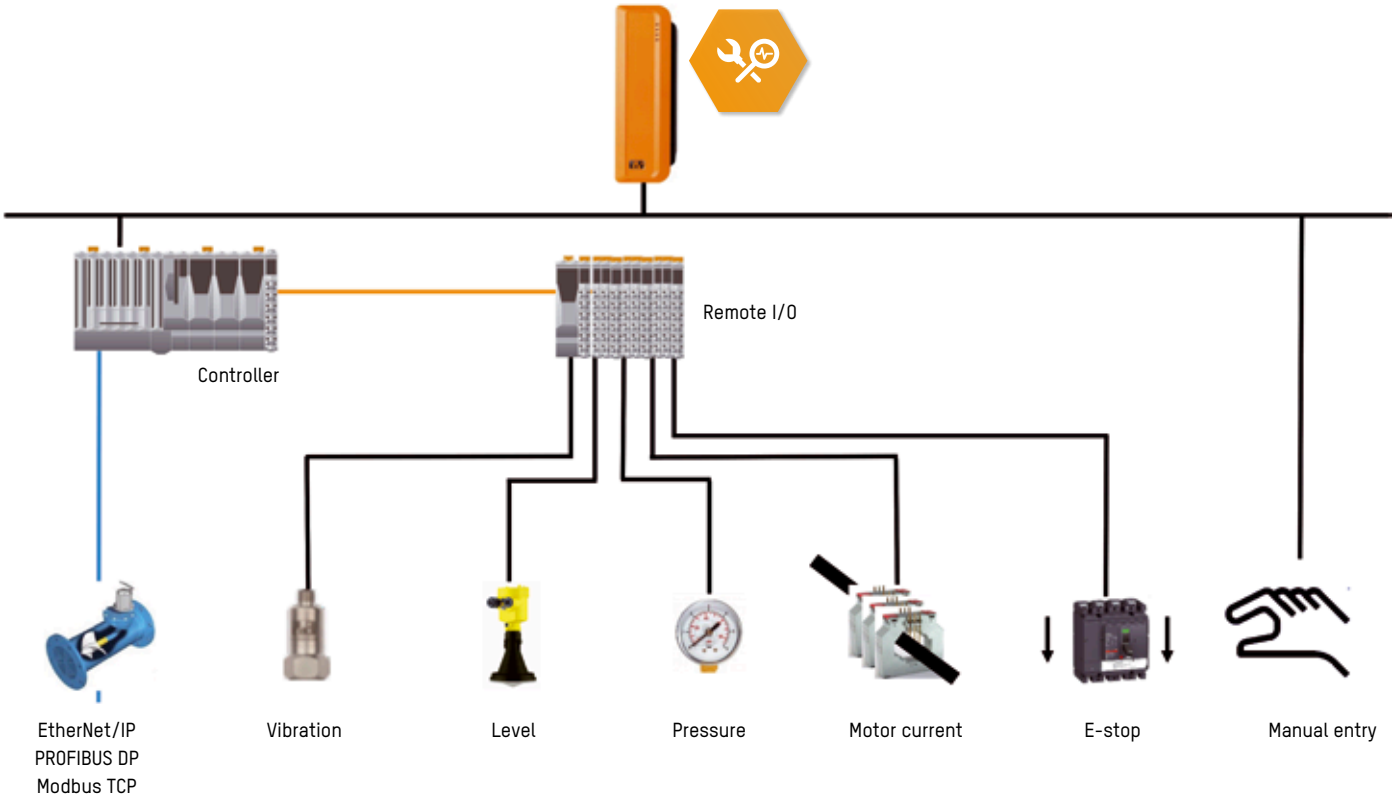
The controllers and I/O modules communicate via POWERLINK. When using existing bus cabling, Modbus TCP or PROFIBUS DP are also possible alternatives.

Measuring condition parameters

Condition parameters are measured using extremely compact X20 I/O modules.
The following modules are available:

- **Vibration metering and analysis**
  X20CM metering module for condition monitoring tasks with 4 IEPE analog inputs, 51.5625 kHz sampling frequency and 24-bit converter resolution
- **Electrical power metering**
  X20AP energy metering module for active, reactive and apparent power; records phase sequences, individual phases and cumulative values; current over neutral line; records frequency and harmonics (up to the 31st harmonic)
- **Binary signals for runtimes/states**
  X20DI digital input module for runtime, downtime, etc.
- **Analog signal for pressure, flow rate, etc.**
  X20AI analog input module for analog measurement signals
- **Analog signal for temperature**
  X20AT analog input module for PT100, PT1000, thermocouples
- **Count pulses for speed, quantity, etc.**
  X20DC digital counter module for digital measurement pulses
- **Counters for volume/mass flow rate**
  X20CS interface module with integrated M-Bus master for connecting up to 250 M-Bus slaves (e.g. counters for gas meters, electricity meters, heat meters, pulse counters)
- **Counters for volume/mass flow rate, energy**
  X20IF interface module for connecting Modbus RTU, ModbusTCP, PROFIBUS DP, EtherNet/IP (e.g. counters for existing measurement points)
- **Switching loads / E-stop**
  X20DO digital output module or X20IF interface module for connecting or disconnecting loads either manually or via logic
- **Manual entry of time intervals, maximum runtimes, etc.**
  Manual entry of various maintenance parameters or manual reading of measured values (lab measurements, etc.) via faceplate
- **Operating data from ACOPOS drives**
  All relevant data read via fieldbus interface

APROL ConMon system structure



Broad range of products for measuring condition parameters

- Vibration metering and analysis using metering module for condition monitoring
- Electrical power using metering module for electrical power
- Runtime, downtime, etc. using binary input module
- Pressure, flow rate, etc. using analog input module
- Temperature (PT100, PT1000, thermocouples) using analog input module
- Speed, quantity, etc. using counter module
- Counter states for volume/mass flow rate using M-Bus master
- Counter states for volume/mass flow rate and energy by connecting field devices via Modbus RTU, ModbusTCP, PROFIBUS DP and EtherNet/IP
- Switching loads / E-stop using digital output module, either manually or via logic
- Relevant operating data from ACOPOS drives via fieldbus interface
- Manual entry of maintenance parameters (time intervals, maximum runtime, etc.) or reading measured values (lab measurements, etc.) using faceplate

Control modules

The user can select from a comprehensive library of powerful control modules.

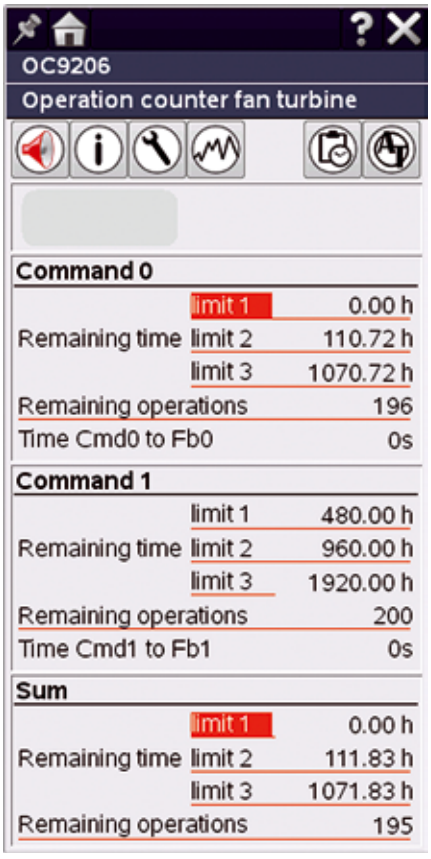
Control modules for APROL ConMon

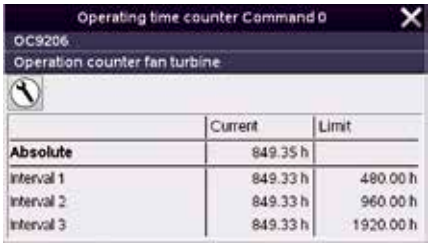
1. Reading binary states

A control module for reading binary states is used primarily to create and log messages and alarms.

Configurable switch-on delays, switch-off delays and a latch allow this module to be adapted to specific applications.

The signal state of the input and output is automatically plotted as a trend curve.

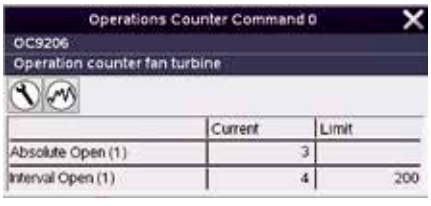


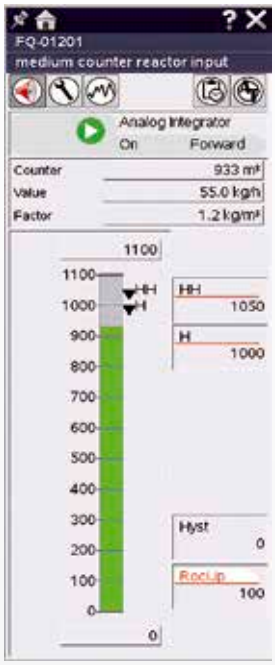


Control modules for APROL ConMon

2. Time, operating hours and operating cycle counter

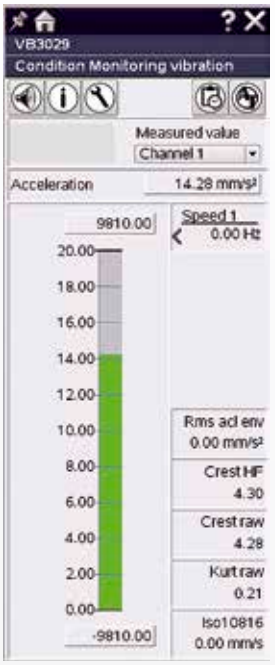
A control module is available for reading startup and shutdown times, runtimes, downtimes, cycle times, warm up times, etc., and for generating alarms and messages. Additionally, the time between the output of a command and the receipt of feedback is measured and recorded. The control module records data in two logical directions (open/closed, right/left, etc.) as well as calculating their sum total.





Analog integrator for resource consumption

Reading process parameters



Vibration measurement

Control modules for APROL ConMon

3. Monitoring quantity (analog interface / pulse counter)

The "Totalizer 01" control module is used to measure process parameters such as use of operating resources, energy consumption, production quantities, waste quantities and more. It provides precise integration of analog measurements (such as flow rate) as well as pulse counting (forward, backward). Leakage suppression and monitoring rate of change (up/down) can also be configured.

The signal state for the forward counter, backward counter, and the resulting sum counter are automatically plotted as a trend curve.

Control modules for APROL ConMon

4. Monitoring process parameters

The "Analog Monitor" control module is used to measure process parameters (mechanical, thermodynamic, analytical, etc.) such as torque, rotary speed, pressure, velocity, temperature, composition and impurities. It supports monitoring of up to 6 limits for analog values (e.g. temperature) as well as monitoring of rate of change (up/down). A configurable filter is also integrated.

The signal state of the input (raw value) and the effective value are automatically plotted as a trend curve.

Control modules for APROL ConMon

5. Monitoring of vibrations

The "CondMon" control module is available in addition to the module for vibration metering and analysis (amplitude and frequency). The 4-channel structure of the metering module is mirrored in the faceplate.

Five statistical parameters can be displayed

For a selected channel, up to five statistical parameters and the velocity assigned to the channel can be displayed in addition to the measurement signal itself (velocity or acceleration).

Velocity and acceleration for the configured frequency domain are recorded on the metering module and output as primary measurement values.

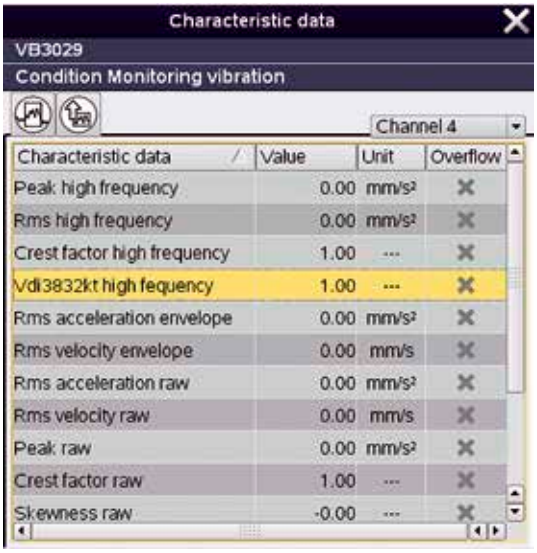
Parameters for direct condition evaluation
In addition, statistical parameters are calculated, such as vibration severity in accordance with ISO 10816. It is often possible to draw conclusions about the condition of the machine based on these parameters alone, without any further analysis of frequency characteristics, and display the results in the form of a traffic light symbol.

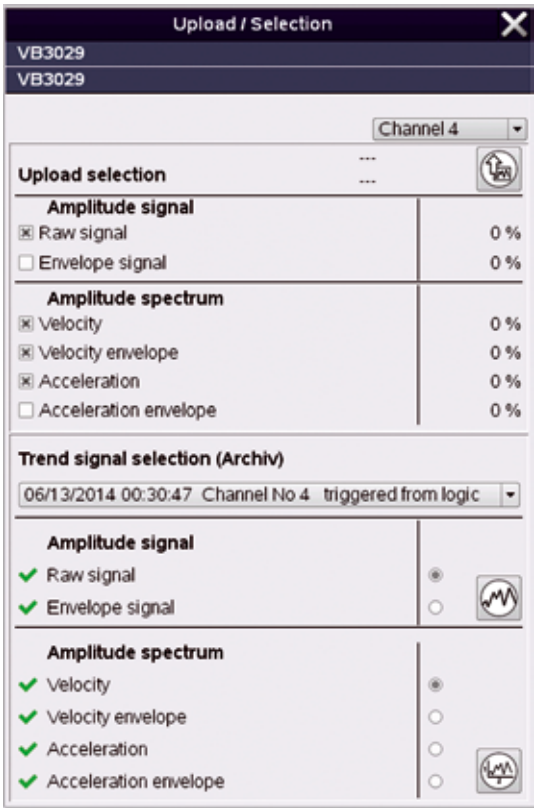
Preprocessing in the metering module
In standard applications, the raw signal is completely preprocessed within the metering module, with velocity, acceleration and statistical parameters output via the I/O channels.

Amplitude signal
For more detailed analysis, the "ConMon" control module can be used to access the amplitude signal (change in amplitude of acceleration over the course of the measuring period) as either a raw value or an envelope. Data is read sequentially from the module and stored in the trend archive.

Amplitude spectra
Like the amplitude signal, it is possible to access the amplitude spectra produced via FFT in the metering module as either a raw value or envelope.

Trigger manually or via logic
Saving amplitude signals and amplitude spectra in the trend archive can be triggered manually or by logic.





Amplitude signal
A curve showing the change in acceleration amplitude over the course of a measurement period (either as a raw value or envelope) allows for a detailed analysis to identify the source of the vibration.

TrendViewer supports diagnostics

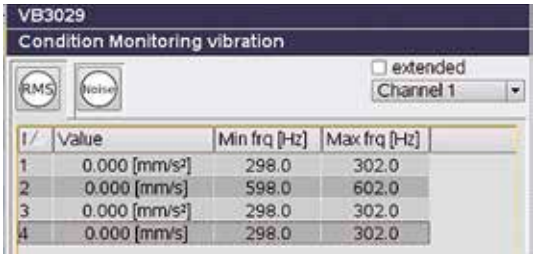
→ The many powerful TrendViewer features can be used to display and analyze condition parameters and identify correlations with other process parameters.

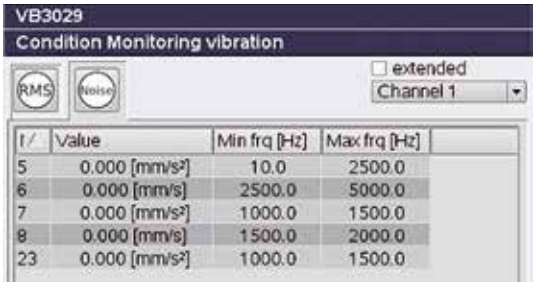
Display amplitude spectra
The display of amplitude spectra makes it easy to identify individual disturbance frequencies and accurately attribute them to potential sources.

Identification of monitored frequency bands

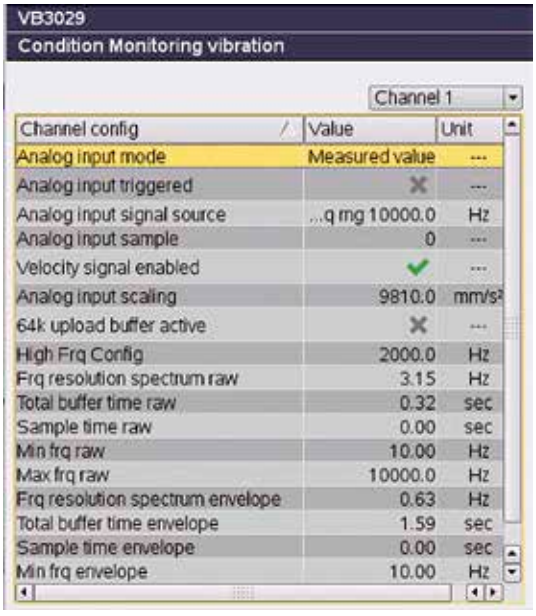
→ Any of the 32 frequency bands can be assigned to the 4 channels in the module configuration. These frequency bands are identified by lines in the amplitude spectra.

Monitoring with 32 frequency bands
The 32 frequency bands can assigned to the 4 channels as needed.

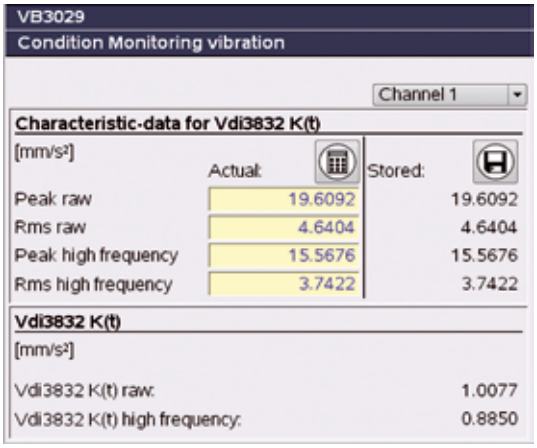




Configuration overview
All essential configuration information is grouped by channel on the faceplate.



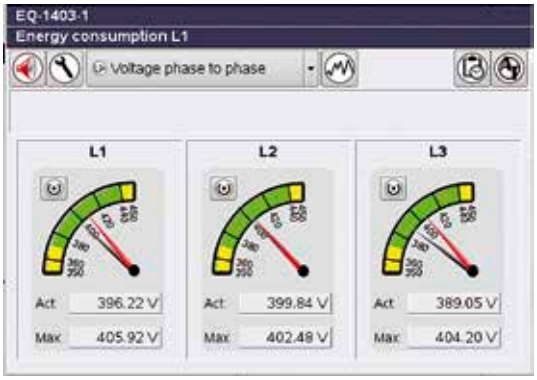
Reference values for performance monitoring
Once a machine or system has been commissioned and its optimal operating state established, a number of baseline statistical values can be stored directly on the module and compared against current vibration data over the course of the machine or system's life cycle.



Control modules for APROL ConMon

6. Monitoring electrical values with the X20AP energy metering module

The "EngyMon01" control module can be used in addition to the metering module for electrical power in order to read energy consumption process parameters.



Including the harmonics
Unplanned outages of machines, systems or individual consumers can result not only from in-

creased energy consumption, but for other reasons as well. Due to the use of countless inverters in every possible area nowadays – not least in order to save energy costs – the resulting harmonics play a large role in diminishing power quality in electrical grids. These harmonics must be taken into consideration when measuring energy in order to achieve sufficient precision. Because of this, they are covered up to the 31st harmonic.

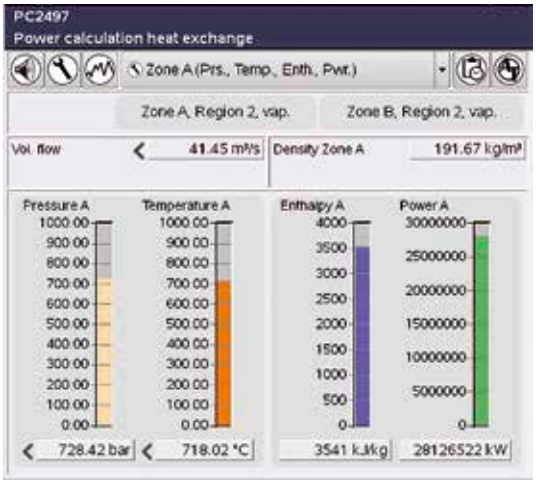
Monitoring the mains frequency
Unexpected failure of electrical components, especially in isolated operation, can also be prevented by measuring the mains frequency with a precision of 0.01 Hz.

Detecting imbalances
Measuring current via the neutral line can help detect imbalances on the consumer brought about by short-circuited coils, for example, which makes it possible to avert resulting malfunctions by carrying out targeted measures in a timely fashion.

Detection of reactive load on the consumer
Preventing reactive current reduces energy consumption and decreases the load on the mains power supply. Targeted measurement of reactive and apparent power helps identify the cause right at the source.

Identifying sluggishness through reference curves
Measuring motor current is a simple and reliable way to monitor the sluggishness of an electric motor. Changes in current consumption point to increased sluggishness. Baseline current measurements of a reference movement during commissioning (reference curve) can help visualize the change in sluggishness over time in a trend curve.

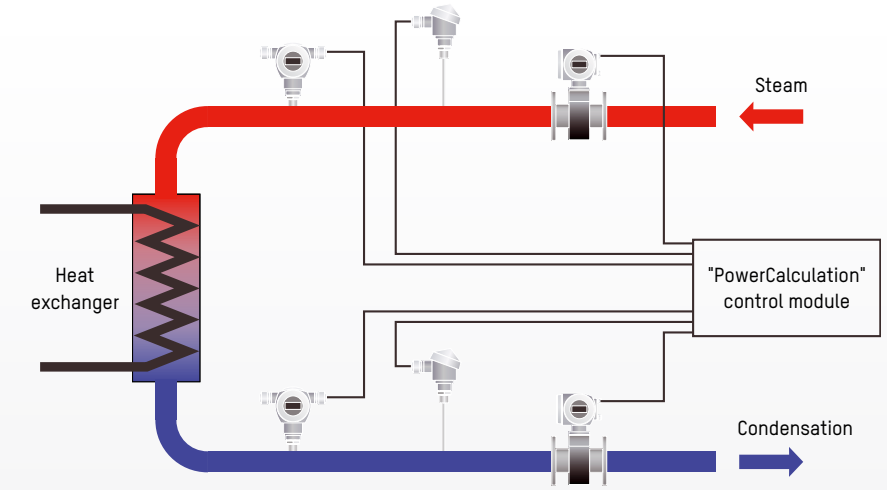
Control modules for APROL ConMon
7. Energy and flow calculation for water and steam in accordance with IAPWS-IF97
APROL ConMon also includes the "PowerCalculation" control module for thermodynamics (enthalpy) to directly calculate the thermal power/energy of water, saturated steam and superheated steam in accordance with IAPWS-IF97. It records incoming and outgoing energy currents of water, saturated steam and superheated steam, and their differences. This control module eliminates the need to have expensive computers dedicated to energy unless absolutely required for calibration certification.



"PowerCalculation" control module

This module is used to calculate thermal power/energy from one or two meter runs in accordance with IAPWS-IF97.

The incoming and outgoing energy currents of water, saturated steam and superheated steam, as well as the heat exchanged with the outside environment, are calculated and displayed by the "PowerCalculation" control module.



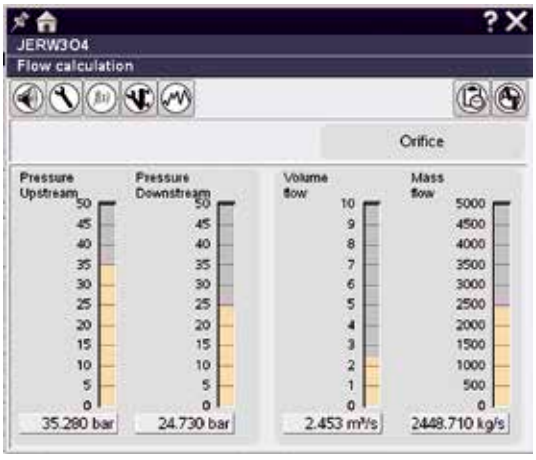
"PowerCalculation" control module for calculating the thermal power/energy from 1 or 2 meter runs in accordance with IAPWS-IF97.

Control modules for APROL ConMon

8. Flow measurement in accordance with EN ISO 5167 (-2,-3,-4)

The "FlowCalculation" control module calculates the rate of flow in pipes with a circular cross section in accordance with ISO 5167-2 (orifice plates), ISO 5167-3 (nozzles and Venturi nozzles) and ISO 5167-4 (Venturi tubes).

A high degree of precision is achieved by calculating the mass flow rate using Newton's method and taking the flow speed and Reynolds number into consideration.

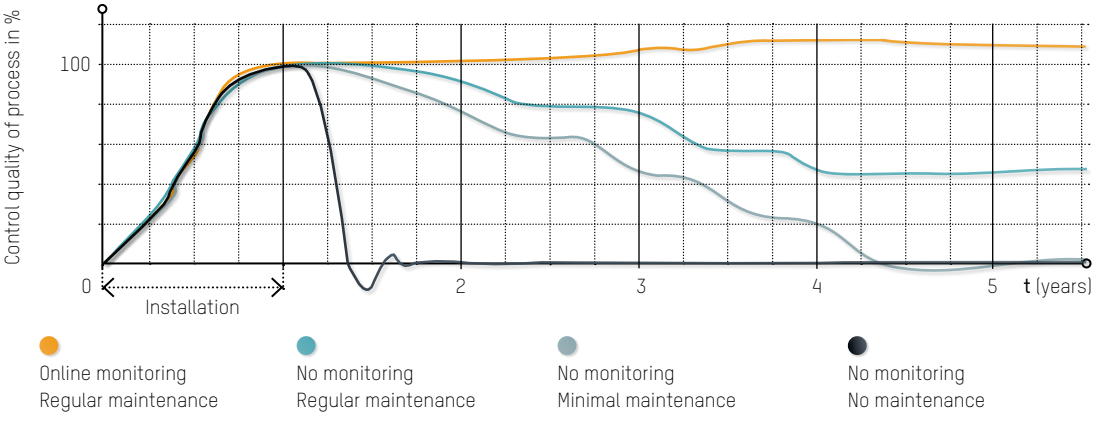


Control performance monitoring for control loops

Manual mode ensures stable operation
It is a well-known fact that PID controllers are generally not configured optimally and must therefore be operated manually at least some of the time. Plant operators are also not able to monitor the control loops allocated to them 100% of the time. This can only be achieved with integrated process control system functionality.

Creeping degradation
Monitoring control quality helps automatically detect creeping degradations of control loop performance so that appropriate maintenance measures can be taken or control parameters optimized.

Statistical parameters identify tendencies
The "CPM01" control module provides various statistical parameters that can be used to assess the quality of control loops. These parameters are crucial for achieving maximum process control efficiency. Even APROL APC (Advanced Process Control) solutions are fundamentally dependent on the quality of lower-level automation. The basic idea is to provide and display data that is relevant to the control loop. The calculated parameters must be interpreted by the user. The minimum variance index is thus determined by comparing the variance of the controlled variable of the controller being used with the variance which would occur through the use of a minimum variance controller.



The graph shows a possible curve of the control performance of control loops or involved assets over the life cycle of the system.

A CPM block provides numerous parameters for continuously monitoring and assessing the quality of control performance.

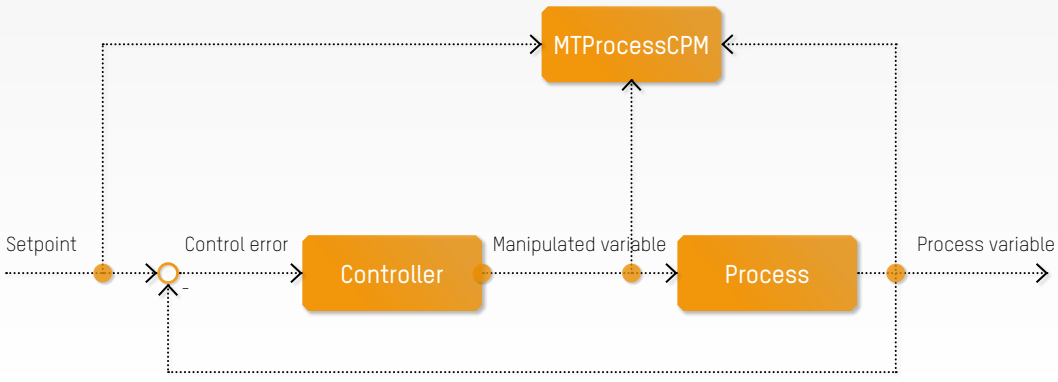
A drift in the MV index over a given period of time can indicate a change in control performance. In other words, it is not the absolute value which is relevant for an evaluation, but rather the relative value or tendency.

CPM01 control module
This module calculates the various statistics needed to assess the performance of control loops.

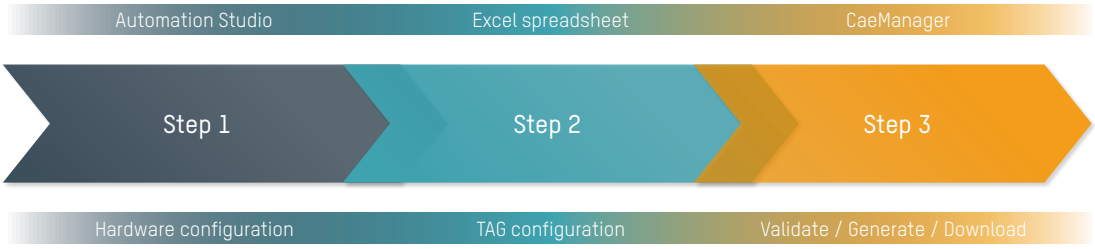
Input data for control performance monitoring
The setpoint (W), manipulated variable (Y), controlled variable (X) and operating mode (manual/auto) must be provided in order to allow the non-invasive calculation of continuous and condition-based parameters.

Continuously calculated parameters
These include parameters such as integral absolute error, integral squared error, standard deviation of the setpoint and control error, average value of the manipulated variable, standard deviation of the manipulated variable and the controlled variable, number of controlled variable setpoint crossings and display of the process limit (manipulated variable saturation).

Parameters calculated based on condition
These include parameters such as the percentage of time the controller has been operated in automatic mode ("ServiceFactor"), the system's dead time, the minimum variance index and control performance indexes (difference between optimal and current evaluation criteria).



APROL ConMon configuration



APROL ConMon configuration in a few easy steps
Since APROL ConMon is designed as a ready-to-use condition monitoring solution and comes preinstalled, there is no added time or cost of installing the APROL system software. The entire hardware configuration is also included; all the user has to do is adjust the network settings as needed (IP addresses, hostnames, etc.).

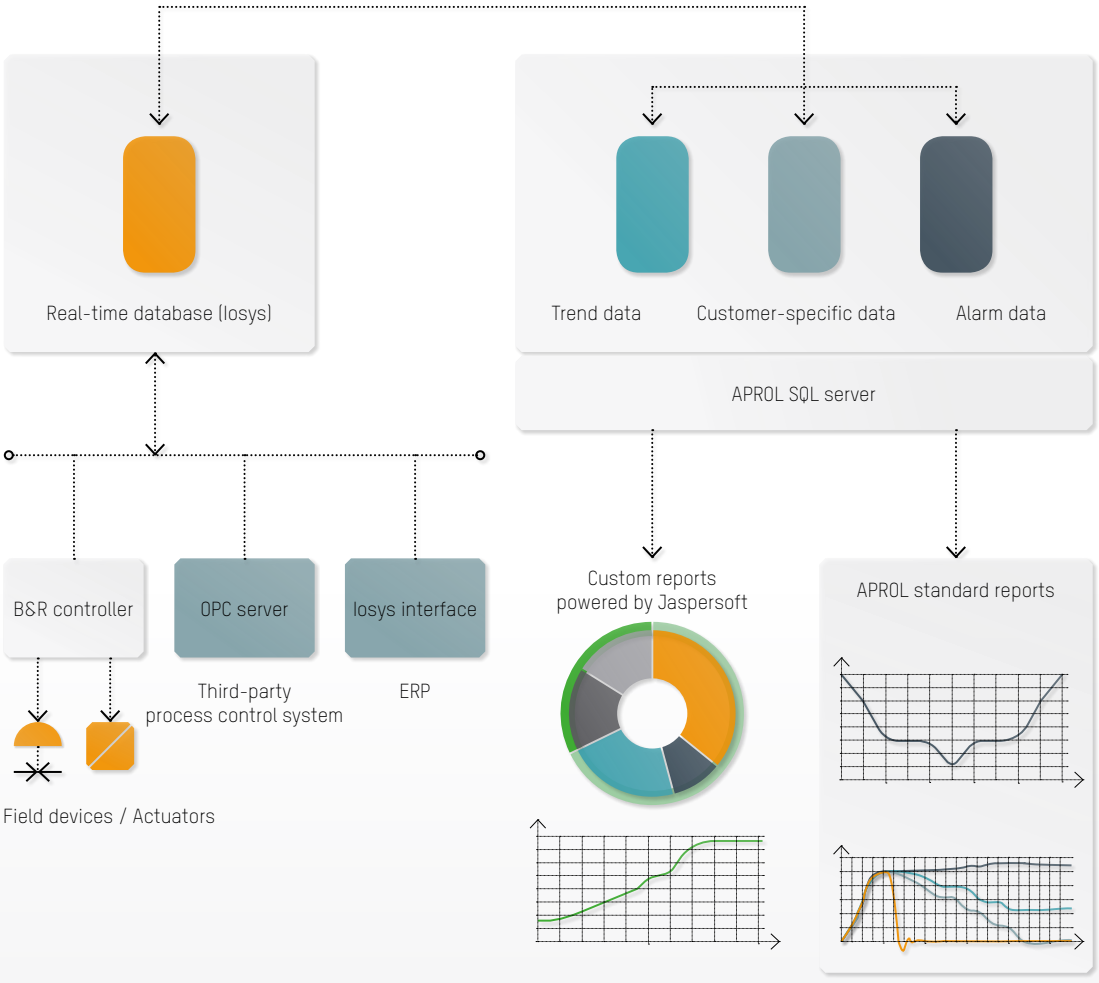
Hardware topology in Automation Studio
A controller for recording relevant measured values is a standard component in every APROL ConMon system. The hardware topology depends on customer requirements and is the first thing to be configured in the integrated Automation Studio project.

Define the measurement points in a spreadsheet
The second step involves defining the measurement points and associated parameters, as well as assigning the necessary templates to the sensors. This data is subsequently used to automatically generate all of the programs used to record, process and archive measurement data. Depending on the I/O and control modules used, the generated programs may require some parameter adjustments.

Configure, validate and download
The third step comprises the automatic validation and any error output from all of the project elements (user software) before downloading to the APROL ConMon system (controller and control computer).

APROL ConMon operator station
APROL ConMon provides the user with an intuitive user interface. In addition to the operator station, a web-based reporting environment with a dashboard landing page is available. In addition to this interface, APROL ConMon also provides a powerful environment for system diagnostics and operation for special tasks usually handled by measurement and control engineers (e.g. commissioning, maintenance).

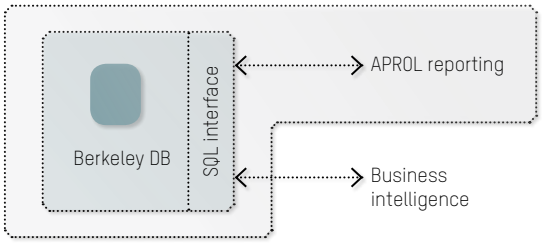
Asset history



Alarm and trend systems

With APROL ConMon, the Alarm and Trend systems are available without restrictions. This means that alarm and trend data points defined in the templates are monitored and recorded automatically in the respective archive when a relevant event occurs. All of this data can be accessed freely in web-based standard reports.

APROL ConMon database



APROL reports powered by Jaspersoft

In addition to a wide range of prepackaged APROL reports, an integrated business intelligence suite from Jaspersoft is also available. The integrated Jaspersoft BI Enterprise Edition includes a BI server and offers dashboard interfaces as well as self-service reports. Users without any previous technical knowledge can use these web-based tools to create their own reports and display interactive dashboards.

Reporting software

Report design tool
A user-friendly report design tool makes it easy to create, format and distribute reports for a standard browser or mobile devices with drag-and-drop functionality.

Reports can be generated with data from many different sources, including MySQL, JDBC, XML and CSV. A metadata layer with data visualization functions for accessing multiple data sources ensures data security, while at the same time simplifying the underlying structure for users without previous technical knowledge.

Interactive reports
Interactive reports with perfectly reproduced diagrams and tables can be created for print or online display in no time flat. A browser-based, interactive display tool can be used for filtering and sorting as well as changing column formats and saving data to the report repository.

Highlights

→ Publishing (export) in PDF, XLS, XLSX, XML, HTML, XHTML, CSV, DOC or ODT format for easy processing down the line

Dashboard software

Dashboard software makes it possible for users to combine data and graphic indicators to summarize important information. Multi-report dashboards can also be created using both internal and external data.

Web-based dashboard design tool
An intuitive, web-based design tool allows users to drag-and-drop components into place to create a custom dashboard. The ability to select parameters facilitates even more interactive workflow and gives users the flexibility to display and analyze data in the shortest possible time.

Mobile access

Interactive reports and dashboards can be displayed in native iPhone and Android apps. The touch-capable browser can also be used to create reports and analyze data on tablet devices.

Highlights

→ The necessary security for mobile and tablet devices is guaranteed by server-side authentication.

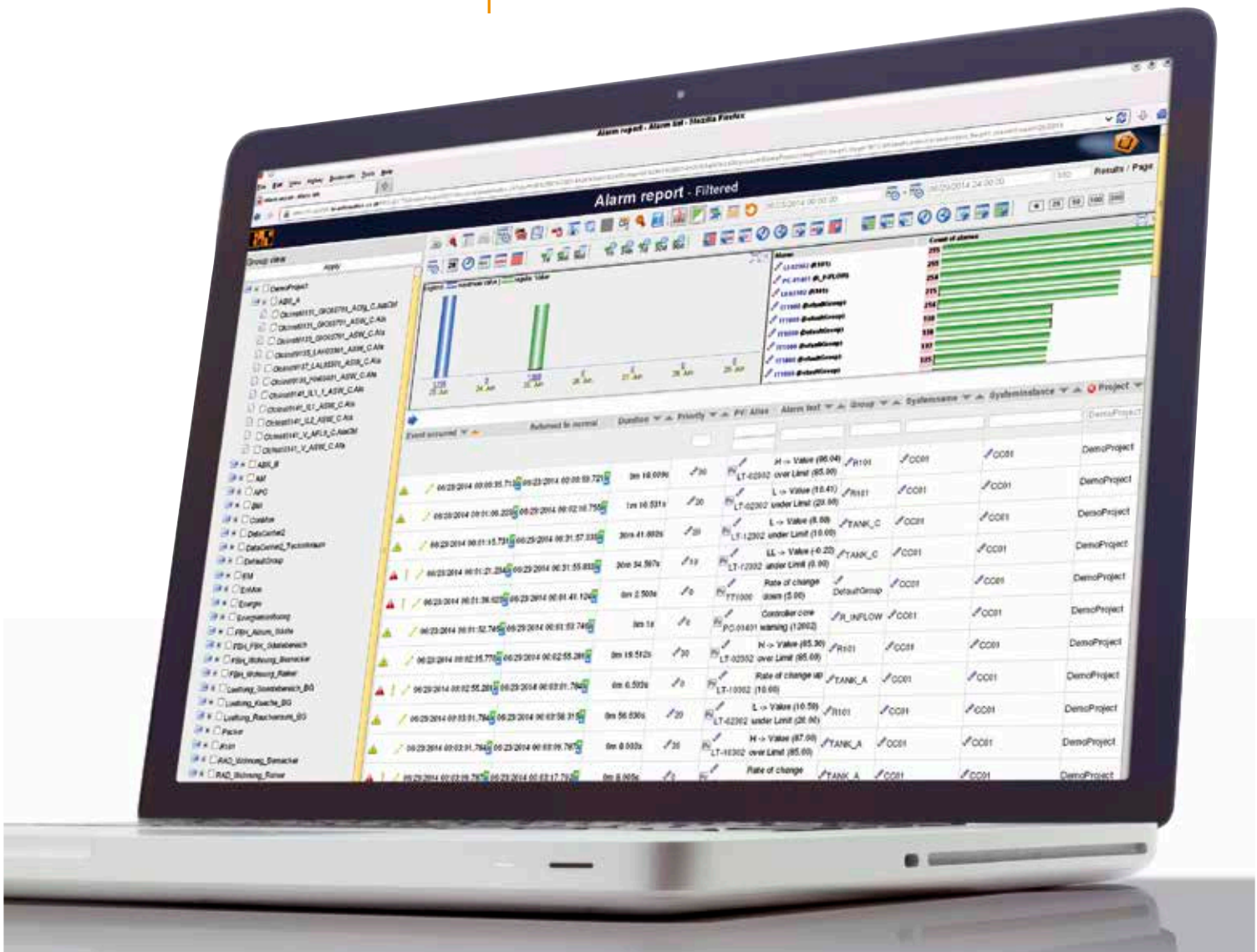
Analysis software

Self-service analytical solutions allow data to be queried easily and interactively to provide the valuable information necessary to make the right decisions.

Data integration software (separate license required)

The data integration software performs extraction, transformation and loading (ETL) of data from various relational and non-relational databases into a data warehouse, where it can be accessed for reports and analyses. This ETL functionality currently offers over 450 data connectors and native integration with ERP and CRM applications like SAP and SugarCRM.

APROL Alarm Report

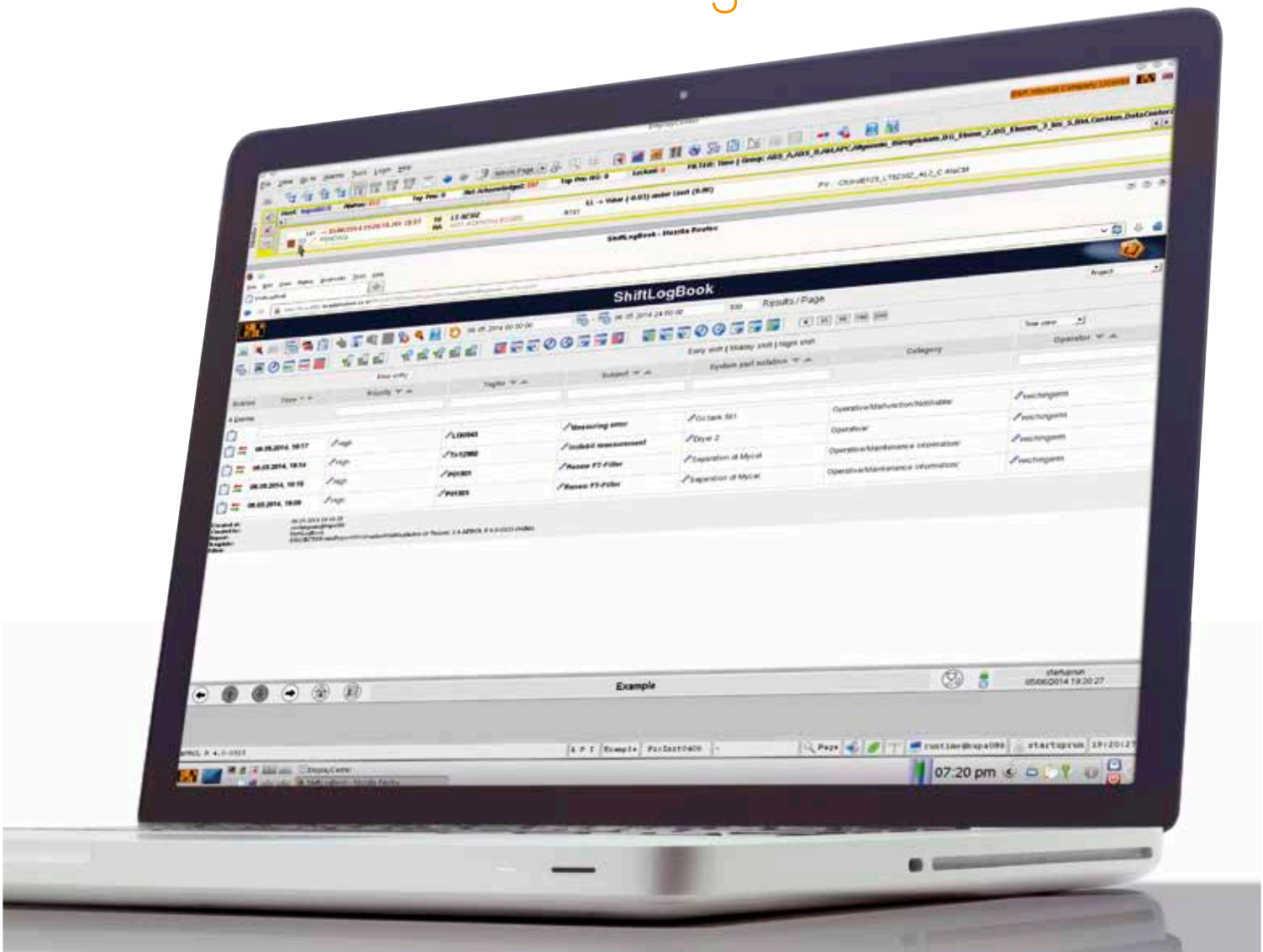


Alarm Report

The Alarm Report provides detailed information about process alarms, including the number of alarms, alarms per unit of time, priority, beginning/end of event, etc.

Of the many detailed reports available, the Alarm Report is the primary tool for getting an overview of any alarms triggered for the values currently being monitored. All historical as well as any currently pending alarms can be viewed in chronological order. Extensive options for filtering and displaying the results (e.g. frequency distribution, hit lists, runtime analysis, etc.) provide optimal support for analyzing the causes of errors.

APROL Shift Logbook

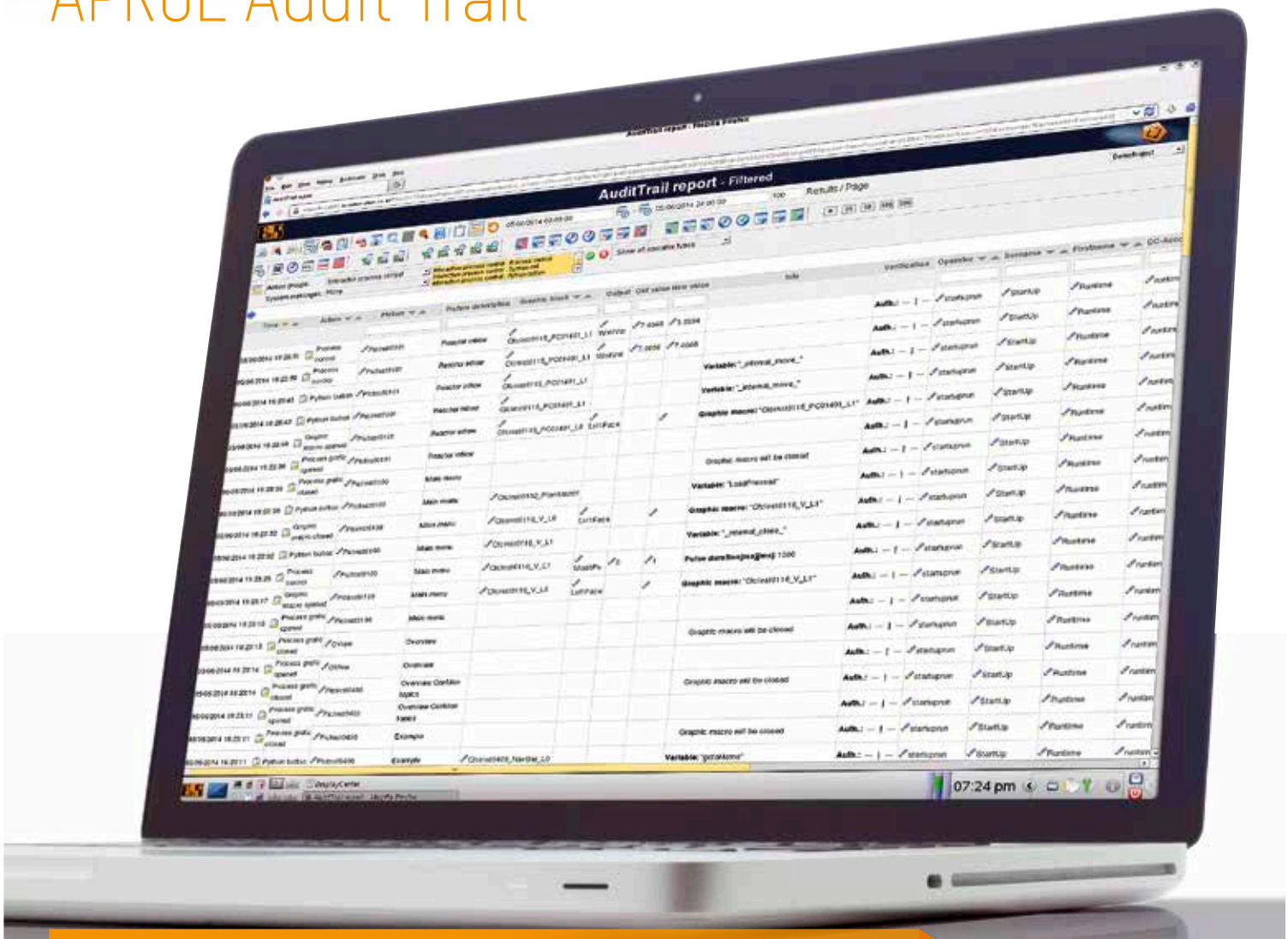


Shift Logbook

The Shift Logbook ensures a seamless flow of communication in companies with multiple-shift operation. The handoff between shifts is generally rushed, yet smooth production relies on each new shift being fully informed of issues that were faced by the previous shift.
The Shift Logbook provides an exceptionally simple and efficient electronic transition.

With the logbook, events and issues are fully documented and grouped in categories for easy evaluation. Even maintenance requirements can be entered in the logbook for further processing.

APROL Audit Trail



Audit Trail

→ The Audit Trail report lists all actions taken by the operator.

Version management

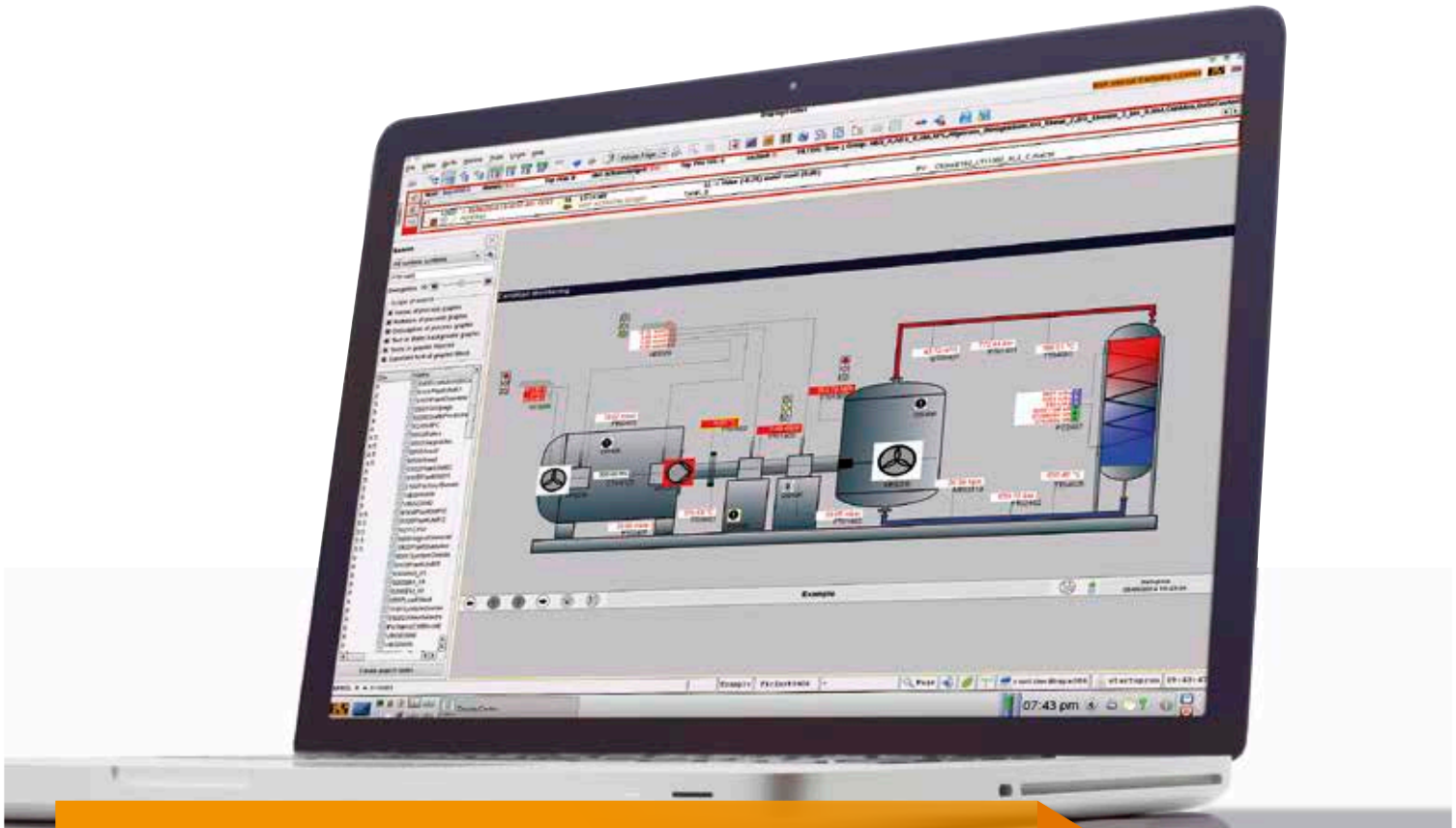
→ The version management feature in CaeManager maintains the version history (e.g. software, hardware, firmware, application parameters) over the asset's life cycle, noting any relevant modifications in the project database.

TrendViewer for analyzing signal curves and dependencies

The TrendViewer allows continuous process data (in 20 slots) as well as event data (alarms, notifications, switching operations, comments, etc.) to be plotted in one graph. This overview allows the operator to clearly identify correlations such as increased vibrations that result from the peak electrical loads that occur when large consumers or conveyor systems are connected.

Process diagrams bring clarity to complex systems

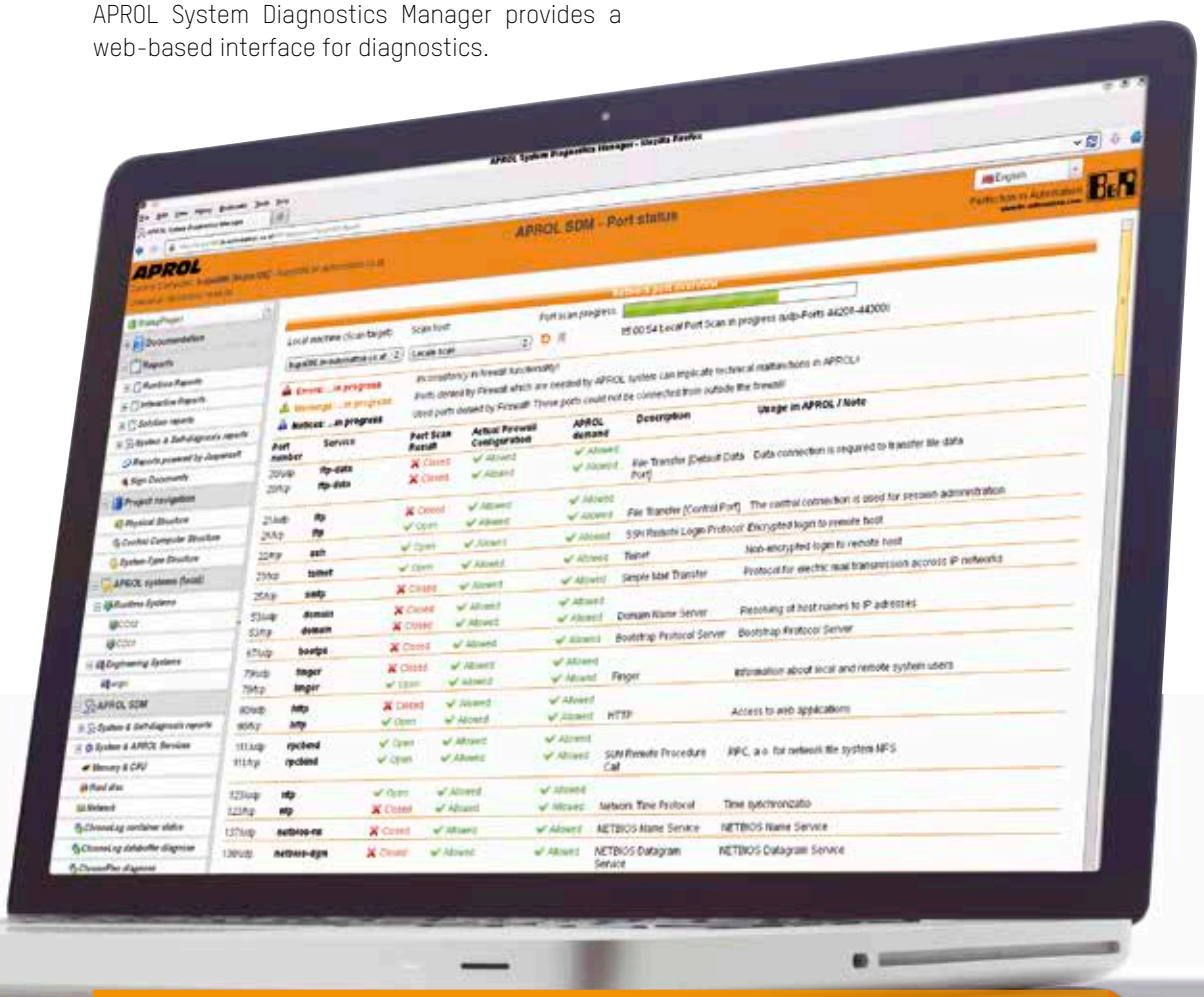
APROL ConMon can be used to create convenient overviews of entire plants, subsystems, machines and other groups of assets.



- → Dynamic graphic macros can be placed via drag-and-drop.
- → Clicking on graphic macros opens up the associated faceplate showing details of all available values from that particular measurement point.
- → Clicking again opens related trend curves and alarms.
- → An image tree makes it possible to build hierarchies as needed.

System and self-diagnostics

APROL System Diagnostics Manager provides a web-based interface for diagnostics.



- → This type of web-based interface also provides access to the controller, which means that I/O modules and channels can be displayed and diagnosed in full detail.
- → All relevant data from the condition monitoring system is easily accessible to the operator.
- → System and self-diagnostics run in the background and automatically detect any problems that occur (fan failure, loss of connection, insufficient memory, CPU load, etc). APROL System Diagnostics Manager also generates alarms and records signal curves.

Seminars

Training for APROL solutions (ConMon, EnMon, etc.) is provided in two seminars: Basic and Advanced.

SEM820.3 APROL Solutions Training – Basic

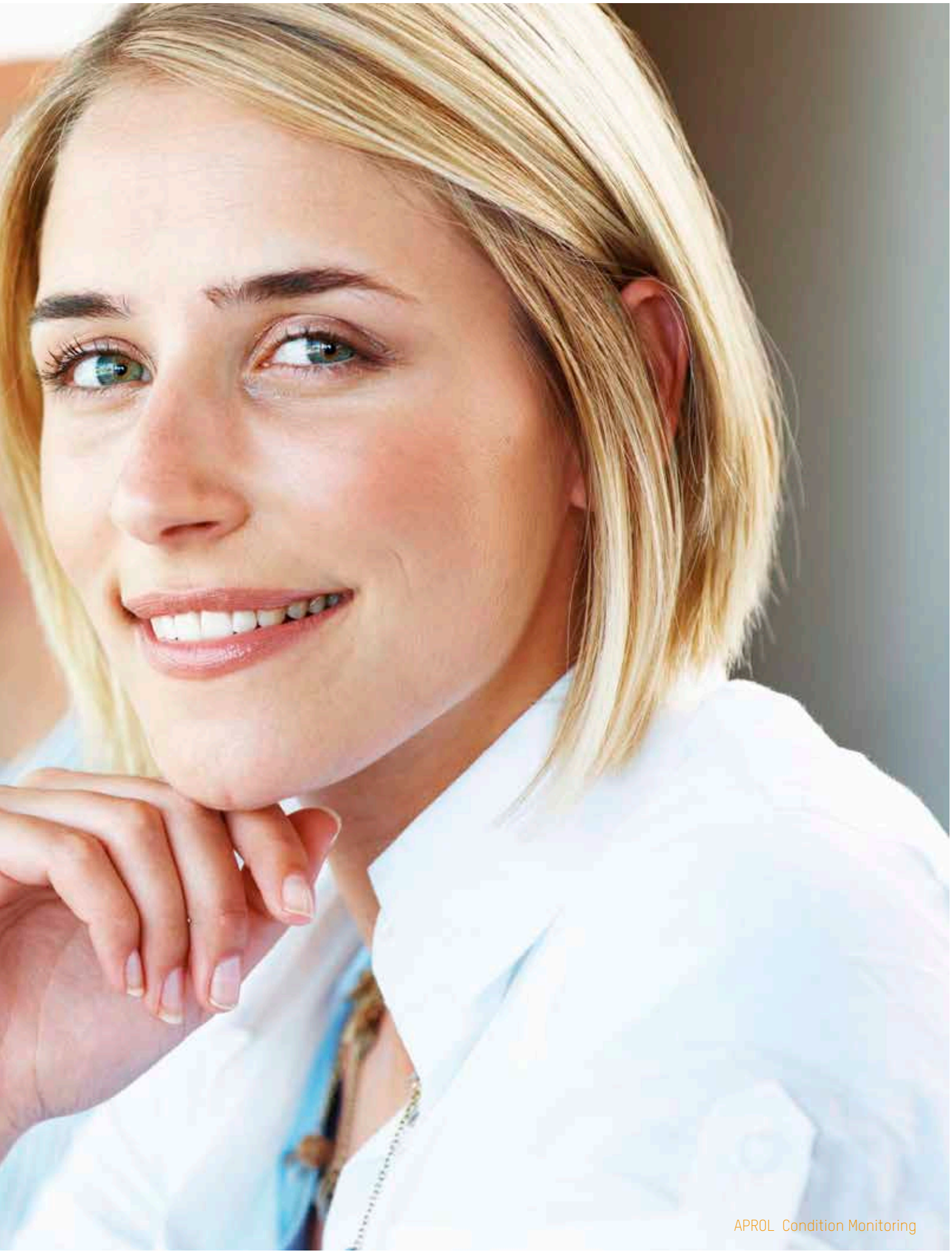
- Provides the basic knowledge necessary for getting started
- Length of training: 3 days

- Configuring the entire topology (I/O modules, fieldbus systems) using Automation Studio
- Structure and contents of templates for input signals and transducers
- Defining measurement points using an Excel-based tool
- Generating, validating and downloading all of the necessary programs in the ConMon system using CaeManager
- Using web-based ConMon reports including the Alarm Report
- Backup and restore

SEM821.2 APROL Solutions Training – Advanced

- Incorporates more advanced knowledge
- Length of training: 2 days

- Trend system including the TrendViewer evaluation tool
- Creating simple process graphics (single-line graphs)
- Using the DisplayCenter
- Using additional web-based standard reports
- Fieldbus technology (Profibus DP, Modbus TCP, etc.)
- Basic functions of control modules (PAL)



Scalability / Licensing of APROL ConMon

In order for a solution to be cost effective, licensing must be tailored to individual requirements. The APROL ConMon Standard Package therefore includes the following system software (licenses):

AP:OEM-ROEX-ConMon APROL ConMon Stand-Alone Solution

Contains preinstalled system software (as listed under "Scalability/Licensing of APROL ConMon") and hardware (Automation PC 910 with accessories and controller and no I/O modules) as well as all required license keys (operating system, APROL, etc.).

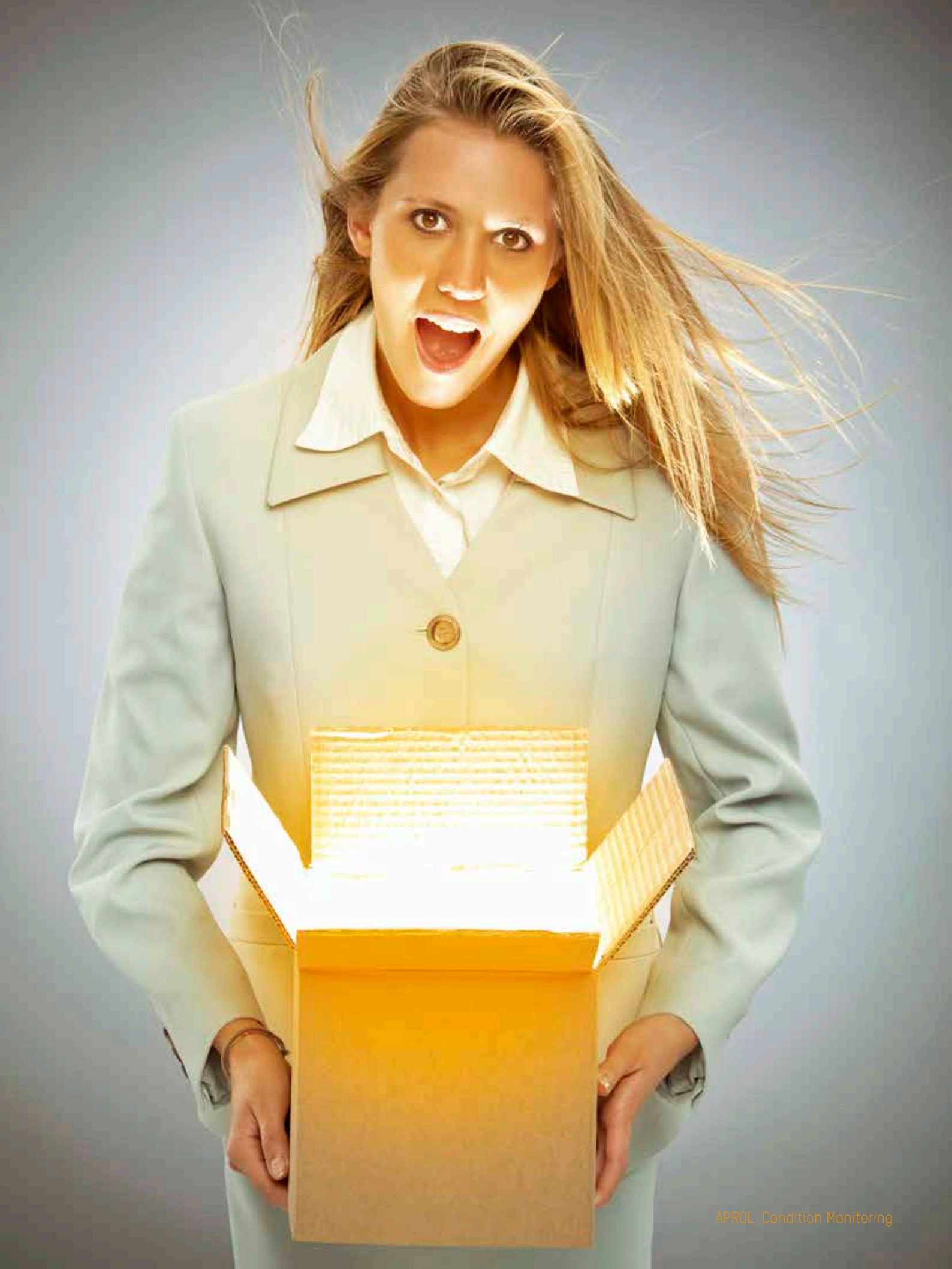
- **1x "APROL ConMon Stand-Alone Solution" licensing package**
  As listed under "Scalability/Licensing of APROL ConMon"
- **1x Automation PC with preinstalled APROL ConMon system software** System unit with 2 slots (1x PCI / 1x PCIx 4-slot), Intel Core i7 2.3 GHz, 16 GB RAM, SSD hard drive, USB mouse, USB keyboard with English layout
- **1x X20CP3586 controller**
  - X20 CPU ATOM, 1.6 GHz, POWERLINK V1/V2, 3x IF, 1024 MB CompactFlash

Additional licenses for extending the AP:OEM-ROEX-ConMon package

- **1x AP.LIB-APC-CNT-NEW PAL Edition ConMon (PAL-ConMon)/CNTRL**
  Required if an additional controller is to be used
- **1x AP.SW1-XXXXIO-NEW** ***APROL I/O Runtime License (XXXX= 0050... 20000 I/O points)***
  Required if more than 50 I/O signals from I/O modules are needed in a project
- **1x AP.SW1-XXXXGV-NEW** ***APROL NEW GV Runtime License (XXXX= 0050... 20000 GVs)***
  Required if more than 50 fieldbus-based I/O signals are needed in a project

Condition monitoring made easy with ready-to-use APROL ConMon

- **Reduced administrative work for asset management**
  Monitoring, measurement and evaluation of an asset's condition are automated by extensive system functions and fully documented.
- **Increased system availability**
  Reduce maintenance costs while increasing the availability of your system.
- **Improved product quality**
  In addition to increasing system availability, condition monitoring also leads to better product quality.
- **Standalone solution with no risk**
  The standalone solution ensures no-risk installation of a self-sufficient condition monitoring system parallel to an existing automation solution.
- **I/O modules to handle any measurement signal**
  A wide variety of I/O modules ensures that data from any measuring instrument can be fed into the system.
- **Minimum engineering costs**
  As a ready-to-use solution for condition monitoring, APROL ConMon reduces engineering costs to a minimum. Tedious programming is replaced by convenient parameter configuration.
- **Maximum flexibility**
  The APROL process control platform integrates process control functionality to ensure maximum flexibility.
- **100% investment protection**
  The APROL process control system provides full investment protection by growing along with your requirements and ensuring long-term availability.



Integrated automation
Global presence
Solid partnership

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