Intelligent detection and monitoring

Condition-based maintenance in gas analysis

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Sensors are the eyes and ears of process control. A modern manufacturing plant is alive with sensors observing every aspect of its activity. The tightening of standards and the drive for greater asset effectiveness are further increasing the dependency on such devices. To prevent the waste or fines that can result from a faulty sensor, the sensors themselves increasingly need to be observed. But watching alone is not enough – operators and maintenance planners must have advance warning that a sensor may soon cause trouble.

ABB's AO2000 (Advance Optima) gas analyzers record the output of sensors and process it into statistics and trends. The remaining lifetime of devices can be accurately predicted, permitting replacement to be better synchronized with planned plant downtime. Good maintenance planning is no longer a matter of luck.

Modern analyzer systems 1 are used in industrial and municipal facilities for the monitoring and control of diverse processes – in chemical and cement plants, power stations and other industries where continuous concentration measurements of gases and liquids are imperative.

Nevertheless, many industrial plants still do not even pursue a preventive maintenance strategy. Equipment runs until it fails. This trend is, however, on its way out as new and stringent regulations command compliance with quality standards or, in its absence, closure of the unit.

ABB's AO2000 gas analysers offer state-of-the-art technology for operational reliability. The design's unique communication network facilitates easy overview of the complete system. Standard interfaces allow simple integration into higher-ranking PC, measurement and control, or distributed control systems. These make it possible to centrally monitor decentralized systems.

Structure of a modern process gas analysis system

What is condition-based maintenance?

Maintenance is a strategy for the preservation or restoration of the operative readiness of plants, machinery, etc. Maintenance strategies can range from **reactive** (maintenance after damage/failure); **preventive** (prophylactic, regular/periodic) to **condition-based** (oriented towards predicting actual wear and tear).

To understand how effective condition-based maintenance can be, it is necessary to pose two crucial questions: how long is the interval from the first possible detection of an incipient failure until functional failure occurs? Is there sufficient time for counter-measures?

This can be illustrated by considering the air-filter of a car. In a preventive maintenance scenario, this filter is changed after a specified mileage, regardless of whether or not it needs to be changed just then. A condition-based approach would use the measurement of the pressure drop across the filter. There would be a limit value that, when surpassed, would generate the "Change Filter" message. Additional recording of the pressure differences over time would create a trend-curve on the basis of which the optimum time for changing the filter would be predicted. Precisely such data are of immeasurable value in the environment of industrial maintenance, as only in this way can equipment availability be maximized and the costs of maintenance minimized.

> The sensitivity of a gas analyser drifts slowly from the day of manufacture.

When does condition-based maintenance make sense?

The air filter example makes it clear that problems and failures can be prevented with the provision of an adequate number of sensors in combination with data collection and analysis. Greater integration of data sources (such as process control data and condition-based monitoring data) is possible through the use of interfacing systems.

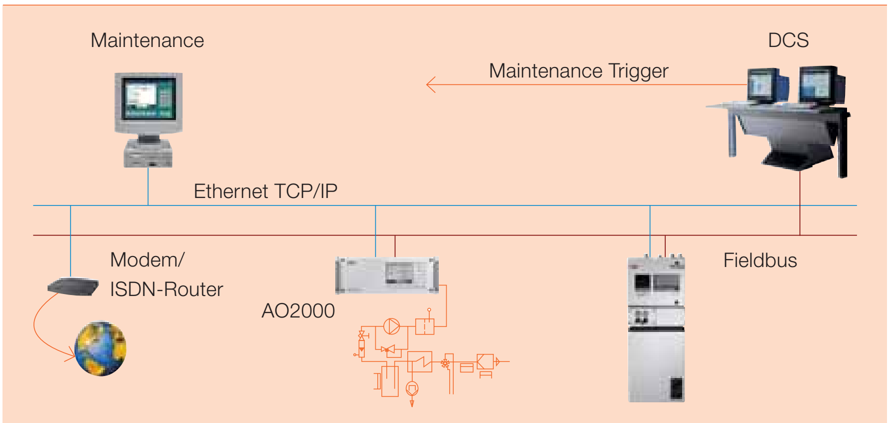
Whether condition-based monitoring is appropriate, necessary and affordable depends on the individual case. Condition-based maintenance is imperative when critical components are concerned and their failure has sustained negative effects (on safety, environment, production, etc.) and/or when wear and aging are involved.

Aging and wear are inevitable and can be irrelevant, provided they do not adversely affect the functioning of the overall system. Thus, the sensitivity of a gas-filled detector in a gas analyser drifts slowly from the day of manufacture. This is unavoidable and the effect is compensated for by regular calibration. At some time or other, however, the measured values will become unreliable. Can this moment be predicted? Yes, it can! The right data and information can be acquired and analyzed (permitting diagnosis), and the "residual lifetime" can be determined.

Enabling compliance with environmental Standard EN 14181, QAL3 requirement

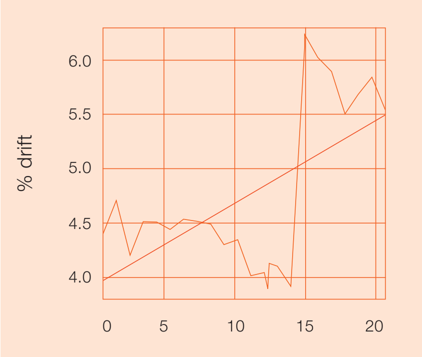
Strict environmental regulations are an on-going challenge for continuous gas analysis (CGA). The European Standard EN 14181 "Stationary source emissions – Quality assurance of automated measuring systems" was promulgated in September 2004. It ensures that automated measuring systems for continuous emission measurement comply with specified requirements for the reliability of measured values. The quality assurance levels QAL1/2/3 were introduced for this purpose. These quality assurance levels comprise the suitability of a CGA for the measuring task (QAL1), validation after installation (QAL2) and monitoring during operation (QAL3). With the introduction and implementation of EU Directives 2001/80/EC and 2000/76/EC, emission monitoring is subject to this quality system. Besides using performance-tested instruments, plant operator

1 Schematic representation of analyzer including gas conditioning and remote coupling structure of a modern process gas analysis system

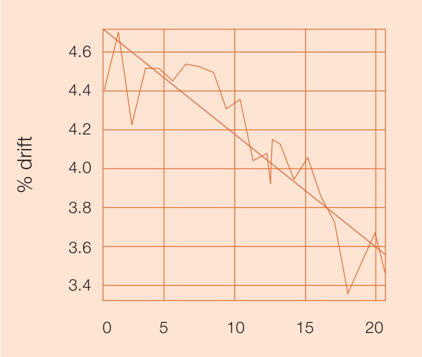


2 Condition-based maintenance based on intelligent data preparation

a Drift data includes an outlier: the extrapolation results



b The remaining service life can be calculated from the cleaned-up drift data



must comply with QAL3 requirements. Failure to do so can result in heavy fines.

What are the challenges of compliance?
Intensive use of modern communication technology is necessary for specialized service technicians to be able to monitor the operation of the CGAs. The measuring capability of the CGAs and their availability can be continuously evaluated via remote access (phone line, intranet). Each analyzer reports its health status when the system detects irregularities. As a result, statutory requirements with respect to the quality of the measuring results and their availability can be centrally met despite the distributed nature of the system.

Service experts are, at any time, able to carry out remote diagnoses and, perform remote trouble-shooting.

What does Analyze IT offer?
The Analyze IT Explorer is a software tool that helps operate the installed process analysis technology more effectively. ABB's gas analyzers are equipped with an Ethernet port that allows continuous access to data from the connected instruments **1**. Data from all sub-systems can be logged – from gas sampling to gas conditioning and gas analysis. Signals such as flows, temperatures, pressures, status signals and also the measured data from different types of analyzers can be integrated in the AO2000 gas analyzers either directly via the internal system bus or via additional I/O-cards.

The Analyze IT Explorer processes all data in such a way that the status of an analyzer system can be provided at a glance. This includes graphical representation and the storage of data. An event signaling system sends detailed error messages and maintenance requests to the service team. Such messages can be sent by SMS directly to a mobile phone.

Thus, ABB analyzers form the intelligent nodes in this process, permitting the Analyze IT Explorer to access the data of the measuring chain. The operator can use this setup for central monitoring and data transmission. The operator can also gain systematic support by allowing ABB after-sales service staff remote access to the analyzer.

Global service – global expertise
Despite regular inspection and maintenance of the analyzer system, the operator is often unable to identify or prevent errors and failures through lack of the necessary expert knowledge of the system.

In consequence, ABB offers operators a series of service products assuring optimum support and safeguarding the measuring process – so achieving improved availability of the measured value.

Remote service technology plays a central role here. Service experts are, at any time, able to carry out remote diagnoses and, perform remote troubleshooting. During such sessions, all status messages, conditioning components and statuses of calibration and detectors are evaluated, and, if required, compared with historical data.

In this way, a complete overview of the system can be obtained without recourse to field service. Malfunctions and unreliable data are recognized in good time as are the effects of aging. This transforms field service from an on-demand to a systematic activity. A costly spare part inventory at the operator's premises, can, in many cases, be dispensed with. Remote service technology contributes to high system availability, cost optimization and optimal planning of service activities.

How are higher alarms generated?
Since mid-2004, ABB has been examining new methods of statistical data evaluation in a project, in conjunction with the most advanced coking plant in the world in Schwelgern near Duisburg (KBS GmbH). One finding of the pilot project with KBS GmbH was, that problems that arise through human intervention in the system should not be underestimated. If a technician briefly switches off an instrument, the subsequent data evaluation is affected

by a malfunction. Therefore the preprocessing of data, such as denoising, detrending, detection of outliers and cleansing are indispensable. 2a shows the raw drift data of an AO2000 at the coking factory. A shift – provoked by human intervention – is conspicuous in the data record. Data preprocessing filters out the shift 2b and the remaining service life of the detector can then be predicted from the cleaned-up data.

In addition to the alarms generated by simple infringement of the threshold limits, Higher alarms were generated in this project through statistical data analysis. Principal Components Analysis (PCA), for example, can combine several signals to form a new "virtual" signal, which can then be accessed as if it were the single signal of a threshold evaluation. The advantage of such a process is that critical system statuses, which cannot be read in single signals, are also detected.

The changes in the performance of a device can also be analyzed over time and extrapolated. The simplest form of extrapolation is linear. Unfortunately, a large number of mechanical and chemical aging effects are not adequately described by linear behavior. Higher dimensional extrapolation models must be used. This opens up a wealth of possibilities. A suitable alarm can be generated before a possible failure occurs. Prognosis horizons of several months are already being achieved, reliably predicting failure. Consequently, any pending plant downtimes can be used to combine maintenance tasks into a single equipment shutdown.

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Gas analyzer systems in the future

The expert obtains requisite data from the data history. He thereby has a view to the past and knows the history of the instrument. Automatic evaluations help to solve the problems that arise effectively. More importantly, they enable predictions to be made about when which problems will occur, and with what probability.

Condition-based maintenance relies on the knowledge of how component statuses change and deteriorate over time. Future equipment for continuous gas analysis will have more and more intelligence and use a variety of data that was not used in the previous generation of gas analysers. The systems will learn to make predictions from the data history about aging, ie, the loss of useful life contingency. The following types of diagnosis will play an important role:

- Signal-based (eg, alarm value infringement)
- Data-based (statistical evaluation, data mining)
- Model-based (comparison of the actual data with the data supplied by a model)

The possibilities of remote diagnosis and remote maintenance will ease the burden of the end user. Critical changes in the mechanical system, optical system and electronics will be detected early on so that necessary measures can be taken. Experts will be able to mobilize at any time.

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