Effective maintenance

Asset monitoring for a low-voltage Integrated Motor Control System (IMCS): a case study

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When it comes to plant operation, no operator likes surprises. But in the fast-paced, round-the-clock world of manufacturing, how can one avoid encounters with the unexpected?

Keeping the health of plant equipment in check is fast becoming the key to avoiding these surprises, and thus the secret to a company's success. Substantial cost savings and productivity gains can be made by adopting a maintenance practice that is both predictive and proactive – in other words, condition-based.

A successful implementation of ABB's MNS *i*S system with asset monitoring technology was completed at a chemical company in Finland, helping improve its maintenance practices and achieve welcomed cost savings.

OMG Kokkola in Finland is the world's leading producer of cobalt-based specialty chemicals used primarily in batteries and hard metal cutting tools. Because of these extremely sensitive applications, the company's cobalt powders must meet very high-quality standards. Imagine the resulting disaster if a laptop battery exploded in an airplane!

To keep its systems current, OMG upgraded the automation system for its cobalt chemical line in 2006. One important part of this upgrade was the modernization of its low-voltage Motor Control Center (MCC). To enable full exploration of the maintenance improvement possibilities, the company chose ABB's MNS *i*S, an Integrated Motor Control System. Equipped with smart sensor measurement, MNS *i*S can measure current, voltage and temperature and provides a wealth of information. Most significantly, it enables the use of information for comprehensive condition-based maintenance practice.

At OMG, the use of sophisticated smart instruments and intelligent MCCs was quite common. There was a lot of information already available; however, it was not resulting in maintenance improvement as anticipated. The distinctive constraints were as follows:

- *Routing of information*. The information available through the smart equipment was routed through the distributed control system (DCS) controller – regardless of its relevance – thereby degrading the controller's performance and negatively impacting critical plant control applications. The role of the DCS controller needed to be focused on process control (rather than on information management).
- *Information relevance*. Information not related to process operation was being directed primarily to the process operators, who had little use for it.
- *Information utilization*. Site operators were lacking specific instructions about what actions to take and could not independently interpret the information for necessary corrective measures.

Information can only be meaningful when it is directed where it is valued, understood and utilized. A single unified environment that could present the right information to the right operator at the right time would be essential for the practical use of information at the site.

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OMG maintenance practice

The maintenance practice at OMG could be broadly classified into two categories: preventive and corrective.

Preventive maintenance

Preventive maintenance consists of regularly scheduled maintenance inspections during which a complete overhaul of all equipment is made, regardless of its true need. It is the most common maintenance for field instruments, motors, valves, pumps, etc, and serves as an insurance against potentially costly breakdowns during operation. The prevailing rationale for employing this inefficient maintenance method is the lack of factual data that quantifies the actual need for repair or maintenance of plant machinery, equipment and systems. Maintenance scheduling at OMG was often based on previous experience or on actual equipment failures. The most disturbing fact: Although maintenance occurred regularly, there was still no guarantee that the equipment would not break down between inspections.

Corrective maintenance

Corrective (or reactive) maintenance is performed only after a failure has occurred. It is normal in process dynamics that production may be interrupted by trips or overloading – while undesirable, these issues can be resolved. The challenge however is when the equipment itself breaks down and replacement parts are not immediately available.

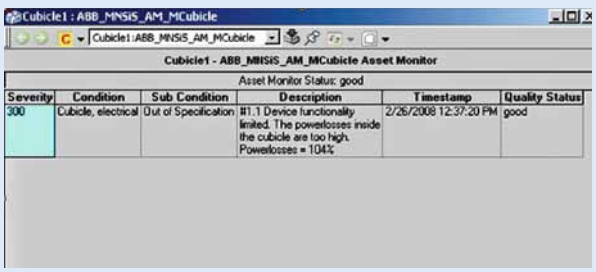
Asset monitoring for IMCS maintenance

Traditionally, LV constant-speed motors were not thought to greatly impact the overall plant availability; however, most of the plant shutdowns can be attributed to them. A trip on any such motor or a fault in the operating motor starter in the MCC was enough to halt a process. ABB's asset monitoring technology for MNS *i*S was deployed at OMG to explore the maintenance effectiveness possibilities in the area of low-voltage (LV) Integrated Motor Control Systems (IMCS).

Asset Monitor is a software component that gathers data from various sources, brings it into the context of the asset and evaluates the information 1. Conditions are assessed, possible degradation detected and remedies proposed. A fault report is subsequently delivered to personnel equipped to act upon the information.

1 Asset Monitor interface a and evaluation with possible cause of fault and suggested action b

a



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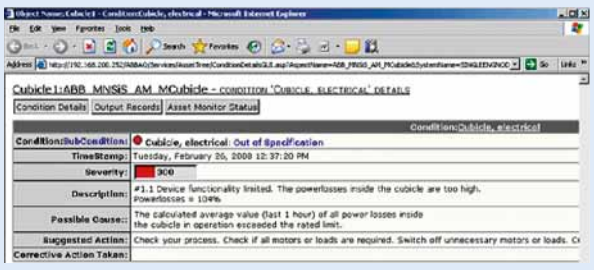


Asset Monitor runs directly on the DCS platform, ABB's System 800xA, which is already available in the plant. The information collection and presentation is depicted in 2.

MNS *i*S provides a fieldbus interface for process-oriented data exchange and control to the DCS controller. All other electrical and maintenance-specific information is directly routed via an OPC[1] server, installed directly on the DCS operator station PC server. The asset monitoring workstation provides an exclusive workplace for maintenance purposes: Maintenance personnel can log in based on their specific roles (eg, technician) and view the pertinent information.

Inside the workplace there are four different structures through which to navigate. All structures serve as aids and their usage depends upon the operator's needs.

- Control structure: All IMCS in various electrical substations are shown and navigated through based on the communication structure.
- Location structure: This depicts the locations of all the IMCS in the plant.
- Asset structure: Here, the IMCS structure is divided into IMCS name followed by the grouping of motor starters based on the control schematics (eg, DOL, RDOL).
- Documentation structure: All the relevant IMCS documentation can be accessed through this structure.

Within these different navigation structures, there are several maintenance-oriented faceplates and display structures for all IMCS motor starters. These displays are accessible from all four navigation structures and are described in Factbox1.

ABB's asset monitoring technology for MNS *i*S was deployed at OMG to explore the maintenance effectiveness possibilities in the area of low-voltage Integrated Motor Control Systems.

IMCS motor-starter Asset Monitor

The motor-starter Asset Monitor gathers the actual usage data on motors, contactors and motor-starter contacts for condition-based monitoring, which are used to predict the necessary maintenance. The Asset Monitor distinguishes among equipment that is:

- Under continuous operation without switching
- Rarely operated or not used within a specified time
- Under capacity or over capacity for pertinent maintenance

The Asset Monitor also continuously evaluates all events, alarms and trips for specific maintenance and essential working issues. It groups these conditions into electrical, mechanical, operating and process-related categories. This categorization makes it possible to identify and direct the information to the appropriate maintenance operator, who can take the necessary action. These conditions are further categorized into subconditions with severity levels showing the degradation of asset performance for quick identification and operator action. The conditions, subconditions and severity levels are depicted in 3.

A right click on the conditions in Asset Monitor opens a new window with the fully analyzed problem or condition, and answers the following questions:

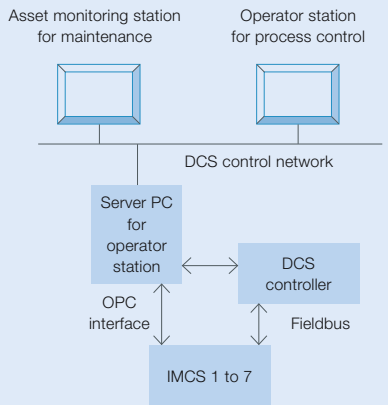
- What/where is the problem?
- What is the type and severity of the problem?
- How was the problem caused?
- Who is the appropriate operator to initiate action (ie, Is the issue operation- or maintenance-related)?
- What specific actions are needed to solve the problem?

If an emailing or SMS service is enabled, the fault report is directed to the right operator to initiate resolution of the problem.

Motor-starter maintenance faceplate

To support the electrical operator, a motor-starter faceplate depicting a single-line diagram of the motor starter is provided 4. The faceplate also contains all measured values and status information for online monitoring. In addition, it enables the resetting of

2 Information collection and presentation with Asset Monitor



Factbox 1 Maintenance-oriented faceplates and display structures for IMCS motor starters

- Event and alarm lists: displays a chronological list of all alarms and events
- Trend display for operation: shows logging of all three-phase currents, voltages and contact temperatures in all outgoing contacts in trend form
- Trend display for diagnostics: captures trip currents, thermal image tracking, "time to trip" should a motor run under overload conditions, and calculation of "time to reset," which is the cool-down time typical motors need after a thermal overload trip
- History logs: all logged values as stored data; these can be retrieved for data analysis at a later date
- Motor-starter Asset Monitor: evaluates all events, alarms and trips for specific maintenance and essential working issues, and is the most important functionality aspect of asset monitoring
- Motor-starter maintenance faceplate: a single-line representation of a motor starter in graphic form; provides a dynamic view of any fault within the motor starter; is well suited for electricians
- Asset viewer: provides an at-a-glance status of all motor starters in tree form

special maintenance-oriented fault conditions. These are:

- Too many thermal overload (TOL) alarms
- Too many TOL trips
- Too many start limitation alarms
- Too many start limitation trips
- Insertion cycles

Furthermore, Asset Monitor also supports national languages, and the asset monitoring software package uses the colors, symbols, nomenclature and layout specified by NAMUR[2] guidelines.

Asset-monitoring-based maintenance

The MNS *i*S IMCS provides a great amount of information and maintenance data. Asset monitoring software then puts this data into context for the maintenance operator. The IMCS, for example, is based on withdrawable motor-starter technology where the number of insertion cycles of motor starters does matter. When the number of insertions on a particular module reaches a set number of cycles, electrical contact maintenance is required. This ensures an optimum electrical contact connection and contact pressure for optimum motor-starter operation during the life cycle.

A similar condition-based monitoring is performed by continuously measuring the contact temperature for quality deterioration of the cable connection. Asset Monitor also performs operation supervision and identifies motors or equipment that have been in continuous operation to raise specific maintenance issues. It also checks that the motor starters are placed in a designated compartment after maintenance. Additionally, it performs a continuous check on all internal components, their consumption and lifetime calculation, and informs the operator about their health status, maintenance or replacement planning. All such conditions are constantly monitored and evaluated by Asset Monitor. The maintenance issues are categorized as electrical, mechanical, process and operation related, and are then directed to the appropriate maintenance team.

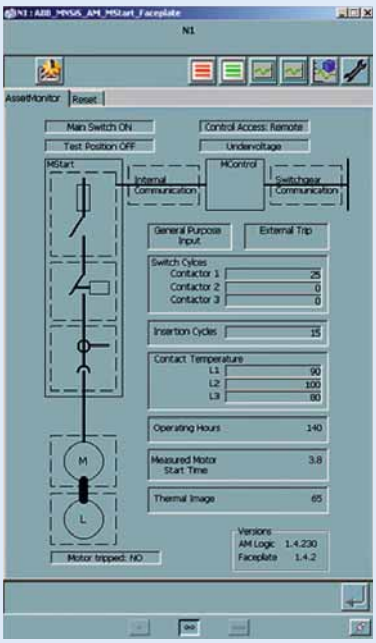
Asset Monitor is a software component that gathers data from various sources, brings it into the context of the asset and evaluates the information.

Just as operators are notified when maintenance is necessary, so are they warned when the conditions require proactive response. The warning criteria, the time delay before the trip occurs and the trip severity are all

3 Asset Monitor conditions and subconditions

Severity (condition)	Subcondition	Description
1 (Normal)	Normal	Motor is available; status is normal; asset functionality is fully available; no maintenance is required
2 (User-defined)	Failure	General-purpose input: the severity and the condition details “description,” “possible cause” and “suggested action” are customer-defined; the icon depends on selected severity
100 (Low)	Maintenance required (soon)	Motor is available; status is maintenance required (soon); asset functionality fully available but maintenance required soon to avoid functional restrictions
250 (High)	Maintenance required (now)	Motor is available; status is maintenance required (now); asset functionality available but maintenance required now to avoid functional restrictions
400 (Outside IMCS)	Out of specification	Motor is still available; status is out of specification; asset functionality available but decreased due to operating conditions outside the specified limits
500 (Inside IMCS)	Out of specification	Motor is still available; status is out of specification; asset functionality available but decreased due to internal problems
750 (High; outside IMCS)	Function check	Motor has been stopped; operation is not possible; status is function check; asset functionality may be temporarily restricted due to ongoing work on the asset (eg, as local operation or maintenance)
900 (High; outside IMCS)	Failure	Motor has been stopped; status is failure; asset functionality lost due to malfunction of its peripherals or to operating conditions
1000 (High; inside IMCS)	Failure	Motor has been stopped; status is failure; asset functionality lost due to malfunction in the asset itself

4 Asset Monitor faceplate



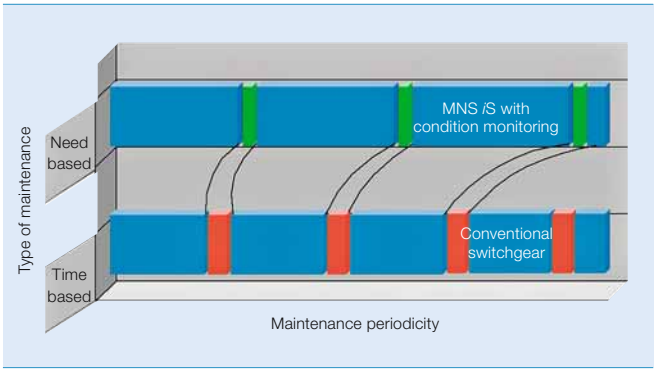
Footnotes

[1] OPC: OLE for Process Control, where OLE is Object Linking and Embedding

[2] NAMUR is an international association of automation technology users in the process industry.

configurable on every fault, safety or motor-protection function. Most importantly, the thermal capacity is continuously tracked for all motors. If a motor is operating under overload conditions, then Asset Monitor dynamically calculates a precise time at which the motor may trip, notifying the monitoring operator and initiating a corrective action. When the trip is imminent, all measured values (including the trip current) are logged for post-analysis, and a detailed report is generated for faultfinding. These online working or maintenance issues are calculated on the basis of current, voltage and temperature measurements by the IMCS.

5 Depiction of Asset Monitor's ability to complement but not replace traditional maintenance methods



The motor-starter Asset Monitor gathers the actual usage data on motors, contactors and motor-starter contacts for condition-based monitoring, which are used to predict the necessary maintenance.

The IMCS also tracks general conditions that can be defined by the user. For example, when monitoring external conditions related to motors or process interlocks, the condition details, cause, severity level and suggested actions are user-defined.

OMG expectations and assessment

Asset monitoring provided an opportunity to improve the prevailing maintenance situation at OMG. The goals and results of the implementation follow.

Additions, modifications and usage

The main consideration in establishing the asset-monitoring program was maintaining the existing DCS structure and process control task. There was to be no additional programming in the DCS controller, and the process-control operation was to be undisturbed – ie, the system should not require modifications in order to work. The asset-monitoring program should be easy to acquire, easy to operate and accessible from day one.

This expectation was met. The information gathering from MNS *i*S was performed in real time and the data was directly routed to the operator without passing through the DCS process controller.

User-friendly system

OMG expected the maintenance information generated by Asset Monitor to be clear and user-friendly – working with the system should not require specific expertise.

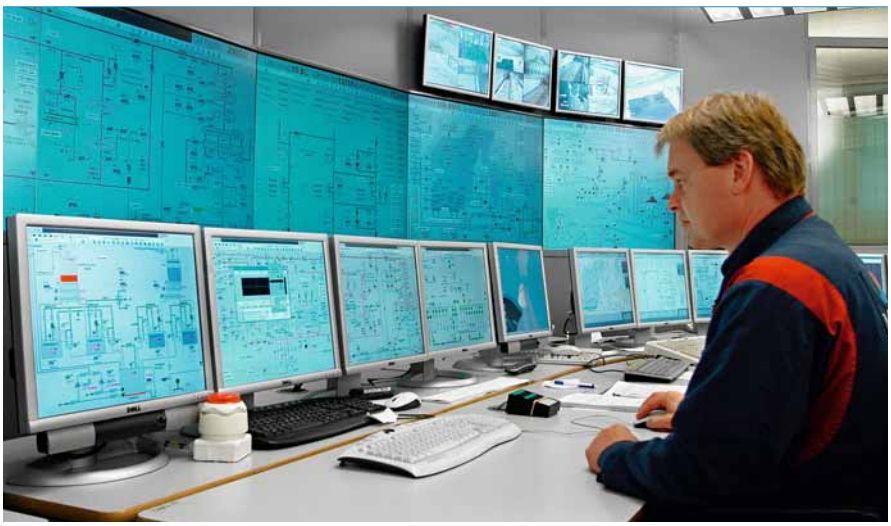
To become familiar with, adopt and utilize the system, training was necessary for the maintenance technicians. OMG found the system to be technician friendly.

Plant-wide maintenance workplace

OMG required that all maintenance activities for connected switchgears be performed on the same platform, with no switching of applications. The same platform was also to be extendable as a unified platform for plant-wide maintenance at a later date.

All MNS *i*S switchgears at the OMG site were connected to the asset monitoring platform. All other ABB-supplied plant equipment and process instruments can be connected to the same platform in the future. ABB offers generic Asset Monitors for third-party equipment but it would be necessary for OMG site personnel to configure them.

ABB's System 800xA in practice



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Maintenance practice improvement

The most important objective was that the asset-monitoring program should substantially reduce maintenance requirements and improve the IMCS performance. Asset monitoring cannot be interpreted as a substitute for the traditional preventive or reactive maintenance management methods at

Factbox Implementing Asset Monitor

The knowledge gained through the OMG implementation will well serve other companies looking to improve their maintenance efforts. Efficient utilization of the program requires a carefully constructed strategy and execution plan prior to its implementation.

1) Define objectives and execution plan. What is the desired outcome of the asset monitoring program? How should Asset Monitor solve the current plant maintenance issues? An execution plan detailing the resources, personnel and work model should be set. The identified team should have a stake in the program, and their training needs must be clearly identified and met.

2) Upper management involvement and support. Initial capital investment and resources are required to successfully launch the asset monitoring program. Upper management must fully support the implementation and commit the necessary resources, personnel and training.

3) Willing and prepared team. Existing maintenance practices and work cultures may need to be modified to adapt to the new way of working. The team should be willing to acquire new skills to make effective use of the program.

OMG. It can, however, be a valuable addition to a comprehensive, total plant maintenance program. 5 shows how asset monitoring can complement traditional maintenance practices.

Preventive maintenance is time based and is performed at regular intervals. Predictive maintenance must also be performed regularly, but the intervals are need based; ie, they can be shorter or longer. The duration of maintenance time differs, however – with preventive maintenance this can be comparatively longer as maintenance is performed on all equipment; with predictive maintenance this can be shorter as maintenance is performed only as needed. Most importantly, preventive maintenance is precautionary and is performed regularly, and yet it cannot always prevent a catastrophic shutdown when maintenance is required between two scheduled intervals. This is precisely where the online condition monitoring in Asset Monitor comes in, since the visualization of key plant information and asset performance are continuously under the radar of maintenance personnel.

Asset monitoring cannot eliminate reactive or fix-on-failure corrective maintenance. It can, however, effectively aid in warning operators of developing conditions so that corrective actions can be initiated before a breakdown occurs. When a trip or fault happens, Asset Monitor can help in quick identification of the problem, directing any technician through the fault-resolution process. Though it would not eliminate tripping or faults completely, asset monitoring would greatly reduce the mean time to repair (MTTR) in reactive maintenance.

A good predictor

The premise of ABB's Asset Monitor technology is that continuous monitoring of an asset's actual condition will ensure an accurate prediction of maintenance interval, thereby reducing the probability of asset failure between maintenance intervals, improving the availability and health of the asset, and increasing the overall availability of operating plants – all while reducing maintenance costs. It enables, in a sense, a condition-driven preventive maintenance program.

Asset monitoring can be a valuable addition to a comprehensive, total plant maintenance program.

Additionally, Asset Monitor helps reduce spare parts inventory by providing ample time to order replacement parts. Prevention of unplanned failures and early detection of incipient asset problems can only increase the useful operating life of plant equipment. As the asset's consumption is also monitored, the tool can aid in deciding whether replacement of the asset is more viable than repairing it.

The DCS controllers are provided with only process-related data for process control and interlocking, making the process-control communication fast and pertinent. The controller can utilize this data for more effective and critical execution of process-control loops. And the different operators can access the information of interest and act on it directly. This setup also reduces the latent time between process and maintenance operators.

A well-implemented and exercised condition monitoring maintenance practice should enable a reduction in unnecessary maintenance and downtime, higher performance and lower maintenance costs. Most importantly, it should optimize all aspects of an asset's performance.

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