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Achieving the Best Response During Abnormal Conditions

EMERSON

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Executive Summary

Abnormal conditions (process disturbances or operations that deviate from optimal performance) in plant environments that are not resolved quickly can definitively lead to incidents resulting in economic loss along with safety and environmental issues. According to an Abnormal Situation Management Consortium® survey of the US petrochemical industry, incidents are frequent and typically incur costs ranging from $100,000 to more than $1,000,000 per year. For example, one plant surveyed had 240 shutdowns per year totaling a cost of more than $8,000,000.

It was also found that refineries, on average, experience a major incident once every three years costing on average $80,000,000. One insurance company's statistics showed that the industry was claiming on average over $2.2 billion per year due to equipment damage. Furthermore, it is likely that actual total losses to the companies are significantly higher than what was claimable. The most distressing, however, is that many of these shutdowns were preventable.[1]

Decision support systems have been developed and deployed to assist with these problems but have been found to be difficult to integrate and update across the enterprise. Therefore, a modern framework with advanced integration capabilities is required for proactive discovery and correction of abnormal conditions before a costly incident occurs.

Emerson, through its new Plantweb Optics Analytics solution, has developed an intelligent framework along with easy-to-use tools to empower plant operations to achieve the best response during abnormal conditions. Plantweb Optics Analytics automates root cause analysis based on key events, symptoms, process behavior and other variables, and presents resolutions to correct problems. It also aggregates events from dispersed systems and recognizes them based on combinations from multiple sensors. As well, it can avoid nuisance alarming by combining information from all areas to determine true root causes.

Plantweb Optics Analytics' extensive toolkit of methods for event detection and reasoning includes a number of Smart Equipment add-on modules, a process equipment library that provides knowledge **out-of-the-box**, and root **cause analysis** models represented by cause and effect fault trees. Using all the available data in multiple plant systems and multiple sensors, Plantweb Optics Analytics can generate a message indicating root cause problems and quickly recommend corrective actions.

Plantweb Optics Analytics translates alarms, events and data into a single page for the operator's summarizing, key operational issues that can potentially impact production, quality, safety, and any potential environmental issues. Without Plantweb Optics Analytics, the operator would be required to navigate through many pages of alarms, DCS displays, and trending analysis before determining corrective actions, and thereby loosing valuable time resulting in production losses and, at times, safety issues (which may lead to a plant shutdown). Therefore, the utilization of Emerson's Plantweb Optics Analytics modules is the best way to empower operations to artfully maximize normal conditions and to achieve the best response during abnormal conditions, in the quickest amount of time.

Plant Incidents Rising Along With Costs

Many plant shutdowns are actually preventable

Abnormal conditions (process disturbances or events that deviate from optimal performance) in a plant environment that are not resolved quickly can definitively lead to incidents resulting in economic loss along with safety and environmental issues.

Symptoms of an **abnormal condition** appear on operator control room screens in the form of alarms. Studies have shown that power and chemical plant operations experience approximately one alarm every two minutes throughout a shift.2 When the alarms arrive in large quantities, operators may become overwhelmed and unable to determine the root cause in time to avert an incident. Many companies have attempted to reduce the number of alarms by using filtering techniques and rationalization, but have not yet found how to identify the problem early enough for timely correction.

Decision support systems have been developed and deployed to assist with these problems, but they have often been found to be difficult to integrate and update across the enterprise. Therefore, a modern framework for integration is required for proactive discovery and correction of abnormal conditions before a costly incident occurs. Let's take a look at alarm systems, decision support systems, and how to achieve the best responses by deploying Emerson's Plantweb Optics Analytics intelligent architecture and modules.

Alarm Management Systems vs Truly Managing Abnormal Conditions

Alarms do not detect deviations from optimum operations, nor from best practices

Alarms, usually put in place for safety reasons, are a limited set of conclusions on very few individual variables with thresholds set to detect extreme conditions. Their thresholds must be set far from normal operations to avoid nuisance alarms. Alarms do not detect deviations from optimum operations, or deviations from best practices, so they are not useful for improving operations near normal conditions.

Alarms also miss many minor problems that become major only after their effects propagate over time. By the time alarms occur, in particular alarms on temperature or pressure, significant time has passed from the time of the initial failure. In effect, alarms look backwards in time.

Many variables (most do not have alarms) must be reviewed to perform proper analysis of alarm causes and to recommend the best response. A view of the larger picture, with all sensors monitored, is required to efficiently respond. Operators should not be alerted for every minor deviation as a standard alarm system demands. Instead, an operator should be notified only when key events, symptoms, process behavior and other variables indicate a particular problem. This would drastically reduce the number of false alarms.

Alarm management systems allow users to periodically generate historical reports and graphs to review the alarm history and pinpoint repetitive alarms. Historical analysis has supported an alarm reduction process, which is a useful activity that prevents operators from being distracted by meaningless nuisance alarms. However, a historical analysis of alarm management systems alone does not directly help operators with current operational decision-making.

One approach to managing the volume of alarms is called alarm filtering, which simply groups the alarms together, hiding them under another alarm unless a detail display is opened. Filtering can be dangerous because information is hidden and the model cannot be guaranteed to cover all cases, leading the operator to miss information contained in important alarms.

In addition, alarm filtering does not directly address the problem of providing the right diagnostic information to identify and take the appropriate corrective action. Better analysis and presentation could be provided if alarm management systems were associated with events and equipment. Links associating alarms with equipment in the plant map would allow superior recognition of clusters of alarms and diagnosis, as well as easier searching. In addition, a graphical user interface could be developed with color animation to indicate problems directly related to equipment and units, not just tags.

Finally, alarm management systems focus on DCS/SCADA alarms without including higher-level business events. Integration with business systems was not in the initial development plans of alarm management systems vendors. Overall, alarm management systems do provide a useful role but are limited in their applications. The best approach is to integrate an alarm management system via an intelligent architecture that enables a decision support system to make the best use of the broader range of data, information, and knowledge available in the plant.

Traditional Diagnostic or Decision Support Systems

Many decision support systems lack the necessary integration within the enterprise

Diagnostic or decision support systems rely upon a rules-based engine to solve problems. The rules based engine is dependent upon data and information received from other sources within the plant environment along with applied human knowledge. Most decision support systems have been developed with the intent to solve problems related to a particular situation or event. They often do not span the enterprise and have limited access to all of the real-time data, information, and plant changes required to be effective.

Some real-time decision support systems have achieved success in the process industry by focusing on diagnosis and alarm filtering. However, many are difficult to update to reflect plant changes, integrate with plant control systems and enterprise computing systems, or the inevitable recognition of incomplete or incorrect models. Another main problem with decision support systems has been that they require extensive customization work.

Therefore, a modern intelligent framework with root cause analysis technique needed for industry decision support system applications. “Generic” models for diagnosis must be developed to ensure that once updates are made to the process schematic, diagnostic reasoning can automatically account for changes.

Achieving the Best Response with Plantweb Optics Analytics Intelligent Architecture

Plantweb Optics Analytics is action-oriented, providing automated diagnosis and suggestions to prevent, mitigate, and correct problems

Plantweb Optics Analytics naturally complements alarm management systems. Plantweb Optics Analytics is action-oriented. It offers automated diagnosis (based on more than just alarms), and suggests actions to mitigate and correct problems. It also integrates events from disparate systems, and recognizes events based on combinations of multiple sensors, not just “alarms” from a DCS. Plantweb Optics Analytics also has a much wider toolkit of techniques for event detection and reasoning, such as monitoring standard deviations from frozen or excessively noisy sensors, SPC techniques, detecting changes from recent history, and so on. It can avoid irritating alarms by combining information from key events, symptoms, process behavior and other variables to determine true problem events.

While some recurring alarms are a nuisance due to bad alarm thresholds, others do indicate recurring process problems. After the majority of the obvious nuisance alarms are eliminated, the remaining recurring problems are more likely to indicate operations problems. These systems store a long history of alarm events which are useful input to diagnose problems detected by deviations from KPI targets over long time periods.

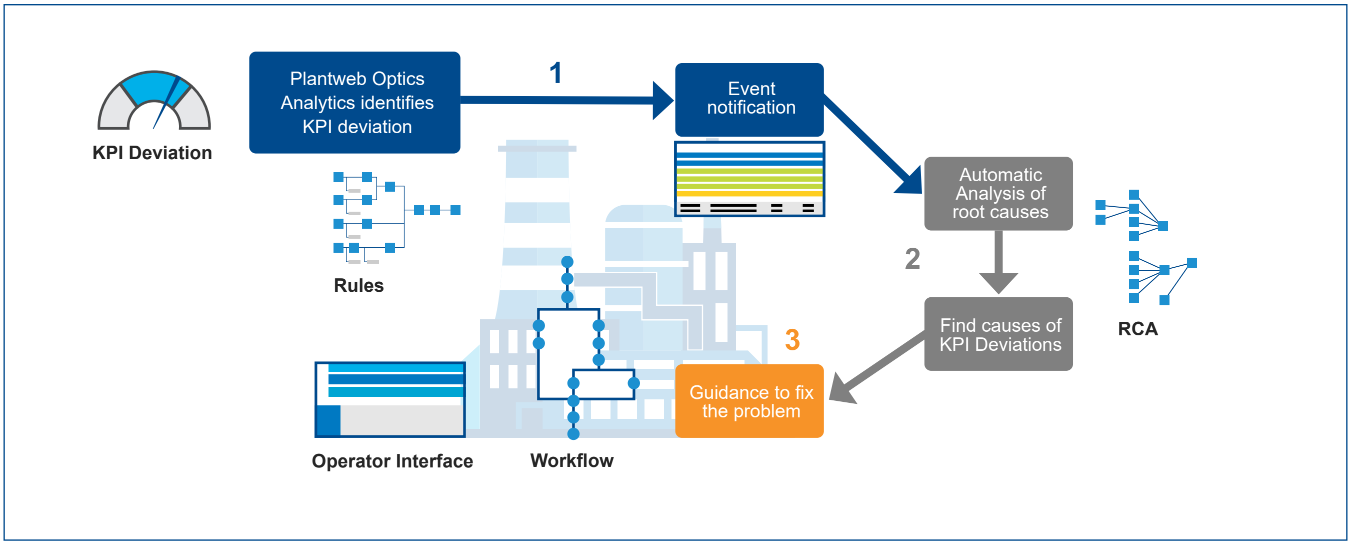

Figure 1: Plantweb Optics Analytics' three-step decision-making process.

Utilizing Plantweb Optics Analytics' Rules technology and related three-step decision-making process, (Figure 1), a real solution is available. Symptoms of abnormal conditions are detected and transmitted to the RCA module for root cause diagnosis. Events and messages can be specified as requiring acknowledgement or not, assuming the correct user privileges. An application can be configured to map event or message priority to colors. At run time, these background colors indicate the priorities of alarms and messages. The highest priority among the outstanding messages and alarms is also used to set the background colors of domain objects on schematic displays so that users can easily see the current health of the process. Alarm panels and messages also provide immediate navigation to schematics containing their associated domain object. Similarly, from a schematic display, users can navigate to the alarms or messages.

Additionally, Plantweb Optics Analytics enables operators to fix problems by providing corrective actions in line with best practices through the operator interface messages or Plantweb Optics Analytics Workflow engine.

Knowledge Out-of-the-Box

Knowledge out-of-the box provides expert knowledge of process operations

Knowledge out-of-the-box provides expert knowledge of process operations that does not require any additional modification or customization from the user. This is accomplished through the Plantweb Optics Analytics Rules engine that was developed by domain experts and engineers equipped with years of experience in the process industries. As a result, utilizing this knowledge-out-of-the-box reduces the engineering, configuration, and development cycle. Let's take a look at how Rules provides data validation for measured variables or alarms.

Rules maintains data validation in a number of ways. The following are all examples of data validation that can be done for individual (continuous) variables:

- Spike rejection
- Limit checks
- Normal noise filtering
- Zero standard deviation to detect stuck sensors

- Sudden shifts in the normal amount of noise
- Sudden shifts in the normal amount of noise detection (based on typical standard deviation)
- Filtering to minimize the effects of noise over a period of time can be done with the exponential filter, moving average, least squares line or curve fit, or nonlinear exponential filter.

More sophisticated data validation in Rules involves multiple measurements. When there are multiple sensors that measure the same variable, the statistically best estimator for the variable is to calculate a weighted average with weighting based on the variances (square of the standard deviation). The variances can be estimated using a Rules block. For validation, the deviations of each measurement from the average are calculated to determine if at least one of the measurements is suspect.

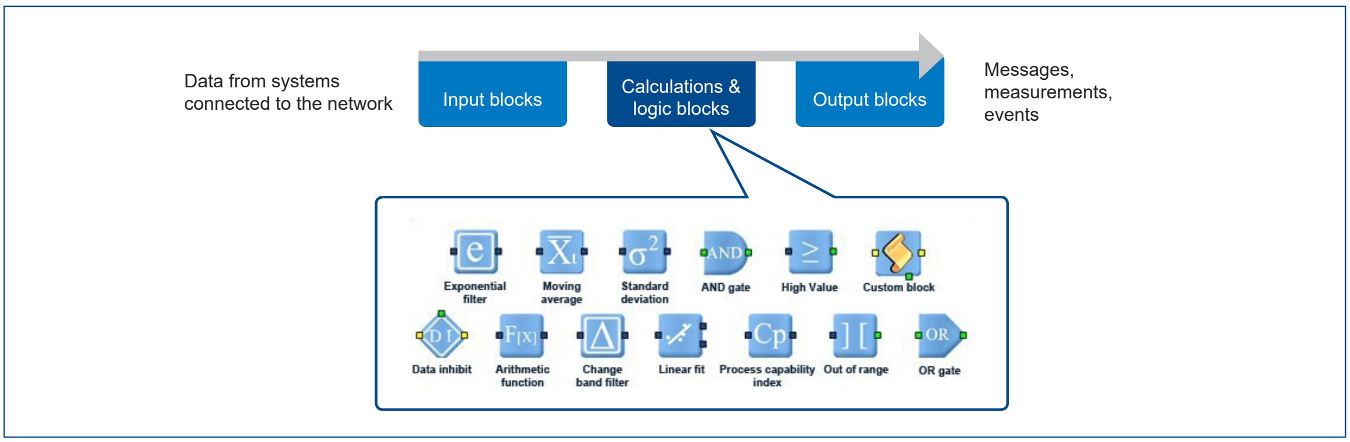

Figure 2: Data validation using Rules Figure 2: Data validation using Rules.

If models are available that allow prediction of a variable, then that prediction can be used in place of an actual sensor in the estimation and validation techniques mentioned above. As an example, using the “rate of change algorithm” on the Claus catalytic reactor outlet temperature allows the prediction of catalyst deactivation due to sulfur and carbon deposits. This deviation launches the diagnosis engine based on the automated root cause analysis technique in order to isolate the root cause. Besides, Plantweb Optics Analytics provides operators with corrective actions in line with best practices to prevent the loss of catalyst. There are also ad-hoc forms of validation that are easy to implement in Rules, but most importantly for this discussion, an alarm can be validated.

It is understood that alarm validation usually means comparing the alarm to expectations based on other measurements. The simplest case is when a field alarm is generated with an independent sensor from the sensor in the DCS. The sensor in the DCS is compared to the alarm threshold set in the field. Therefore, if the DCS sensor value would not result in an alarm, then the alarm is deemed questionable.

But, if the alarm is generated by the DCS based on a sensor reading, the approach for validating the continuous variables would be utilized. In general, all of the above techniques apply – obtain the best estimate of the measured variable and determine if it would generate an alarm. The ad-hoc approaches translate as well. If a high pressure alarm in a distillation tower is activated, one should expect to see higher temperatures than usual in the tower, or recent increases in temperature. In Rules, the variable values or changes over time can be viewed.

Therefore, using knowledge and all the available data in multiple plant systems and multiple sensors, Plantweb Optics Analytics can validate an alarm, determine root cause problems, and recommend corrective actions. Conversely, a false alarm based on a bad sensor can be successfully diagnosed. In addition, Plantweb Optics Analytics identifies and addresses the scenarios of multiple alarms associated with a single root cause failure.

With Plantweb Optics Analytics in place, operations can maximize normal run time while predicting conditions to prevent abnormal conditions. In those cases when an abnormal condition occurs, Plantweb Optics Analytics is able to quickly respond with a diagnosis so that operators can determine the best response and take the corrective action. Therefore, the utilization of Plantweb Optics Analytics is the best way to empower operations to artfully maximize normal conditions and to achieve the best response during abnormal conditions.

Keywords

A

abnormal conditions – situations occurring within a process that deviates from planned courses of production that could have significant impact on the enterprise's safety, cost, and efficiency.

alarm filtering – applied to reduce the number of alarms and to prioritize them, where the goal is to produce fewer alarms and to help identify the most critical ones.

applications services – represents the services offered to communicate with the business layer.

automated root case analysis – the ability of an application to directly investigate the original sources of plant and process interruptions before they can have potentially critical consequences on the enterprise without requiring operator interference.

C

client layer – represents the presentation layer. This layer stands for the top-most level of the application and is used to translate tasks and results to something the user can understand.

corrective action – the resolution to be taken in order to correct an abnormal condition such that the process once again aligns with planned actions.

D

data service – represents the services offered for data collection from data sources.

data sources – represents several systems from which real-time, historical, or transactional data can be gathered.

data sources layer – represents the data access layer, it includes several systems from which real-time, historical, or transactional data can be gathered. The data is passed to the logic tier for processing, and eventually to the user.

decision support – information and knowledge provided by intelligent solutions to aid the resolution-making process.

decision support systems – intelligent solutions that gather information and knowledge from throughout the enterprise in order to aid the resolution-making process in the case of an abnormal condition.

E

effective operations management – Operations management typically represents the supervision of the bulk of a business' assets. Effective operations management helps companies reach their business and performance targets as well as develop capabilities that will keep them ahead of their competitors into the future, often by (but not limited to) reducing costs, increasing the safety of operations, reducing the risk of operational failure, and providing the basis for future innovation.

F

false alarms – inaccurate or mistaken notifications of threats or problems.

fault propagation model – a technique used to analyze an undesired event and all associated causes in order to identify the root causes of the event.

K

knowledge capture – the act by which intelligent solutions preserve and archive valuable user experiences for future use.

Plantweb Optics Analytics – Emerson's intelligent application that seeks to proactively detect and diagnose operation issues before they impact production and safety, reduce the problem-to-resolution cycle time, and aggregate and transform data into valuable knowledge and information.

knowledge out-of-the-box – a ready-made technology that meets a need that would otherwise require a special development effort.

O

operational intelligence – the goal of reaching optimized business efficiency by using real time monitoring of processes to detect and respond to situations involving interruptions, opportunities, and bottlenecks.

P

problem-to-resolution cycle time – the entire period during which a process problem starts, manifests, and is conclusively repaired.

R

root cause – the original sources of plant and process interruptions.

root cause analysis – investigation of the original sources of plant and process interruptions before they can potentially have critical consequences on the enterprise.

S

server layer – represents the business logic layer. It coordinates the application, processes commands, makes logical decisions and evaluations, and performs calculations. It also moves and processes data between the two surrounding layers (data sources and client layers).

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