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White Paper

Why is Alarm Management Required in Modern Plants?

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Why is Alarm Management Required in Modern Plants?

1. Introduction

All modern process control systems provide alarm systems to assist process operators in managing abnormal situations. Nevertheless, the integrity and effectiveness of alarm systems can either provide assistance or be a hindrance to the process operators in responding to these situations. Through the efforts of the Abnormal Situation Management Consortium, EEMUA, and other professional groups, a large amount of best practice information exists to aid the control system engineer in designing effective alarm systems. However, due to various reasons, most existing control systems must be redesigned/re-engineered in order to take advantage of these newer system capabilities and best practices. The re-design/re-engineering of alarm systems in these control systems is a responsible first step in responding to the increasing frequency of industrial incidents and to begin to address the billions of dollars that these incidents cost manufacturers annually. By any comparison, the re-design/re-engineering efforts are well worth the investment. This white paper presents a new alarm philosophy and approach to achieve these objectives.

2. Alarm Problems in DCS

Indeed, all DCSs have a sophisticated alarm and HMI system for operators to monitor and control plant status. These are powerful platforms for users to design and configure effective alarm systems. The DCS alarm system can be a vital, productive tool for managing industrial process control plants, and can be configured to identify and notify personnel of a wide variety of abnormal conditions in a manufacturing process. Alarm systems should alert the operator to a possible problem, provide warning early enough to allow remediation, guide the operator to the problem, its cause and corrective action, and confirm or deny the effectiveness of the operators' efforts. However, a large number of existing alarm systems do not perform well.

First, before the plant is operating, it is difficult to make a good or optimal design and configuration of the alarm system. For example, too many alarms are configured; unreasonable alarm limits or dead bands are set; improper alarm orders are arranged; too many unimportant alarms during startup/shutdown are triggered, etc. This is because the plant status is not well known or there is a shortage of more powerful alarm functions. Second, the plant characteristics may change with time, possibly resulting in an improper configuration . Third, demands on operators are increasing through:

1. The need for process operation close to maximum efficiency
2. Higher costs of process interruptions
3. More complex processes
4. Lower safety margins (which give less opportunity to recover from upsets)
5. Environmental regulations (which may prohibit venting to atmosphere, direct discharge to waterways or landfills)
6. Fewer operators
7. Higher staff turnover (resulting in less experienced operators)

For example, increasing sophistication of control systems and processes means that systems are being operated in multiple modes by complex computer control, with the mental model held by the operator, and this model changes significantly over time. If human factors are not considered during design, then these starkly different operator roles ensure a continuation of overload situations and further incidents. It is becoming increasingly difficult for any one operator to understand both the complete process and the actions of the computer control system. In fact, the potential for problems is increasing in modern plants. Finally, industrial plants are constantly seeking to improve operations to achieve better economic results. As a result, the alarm system in particular is a significant obstacle to further improvement.

Nevertheless, the importance and necessity of improvement is often questioned by asking "Is our existing Alarm System sufficient?" The answer is usually, "No," based on the following questions:

1. Are all alarms necessary, requiring operator action?
2. How many alarms occur during normal operation?
3. How many occur during a plant upset?
4. How many standing alarms are there?
5. Is there ever an overwhelming event accompanied by alarm 'floods'?
6. Are there nuisance alarms, are large numbers of alarms acknowledged in quick succession or are audible alarms regularly turned off?
7. Is alarm prioritization reasonable?

8. Do operators know what to do with each alarm?
9. Have there been any critical incidents or near misses where operators missed alarms or made the wrong response?
10. Is there a written policy/strategy on alarms?

Plants may make significant investments to improve their overall operations by 2-3% for the year only to lose two years' profits to one unscheduled shutdown. In fact, a typical plant loses more than 5% of its total capacity every year due to slow downs and an approximately equal amount due to off-spec product, quality giveaway and other lost opportunities, not to mention any unscheduled unit outages the plant may incur. These costs are often underestimated. Individual plants typically compute lost opportunities only as a function of production targets and margins. For example, if a typical plant were to recover the 5% productivity loss cited above, the increase in profit would not be 5% but nearly 50-60%. Given that most fixed and variable costs have already been covered, nearly all of the additional revenue would be profit!

Furthermore, accidents like the following example underline the need to do something for alarm systems:

The 1994 explosion and fires at the Texaco Milford Haven refinery injured twenty-six people and caused damage of around £48 million and significant production loss. Key factors that emerged from the Health and Safety Executive's (HSEs) investigation were:

1. There were too many alarms and they were poorly prioritized
2. The control room displays did not help the operators to understand what was happening
3. There had been inadequate training for dealing with a stressful and sustained plant upset

In the last 11 minutes before the explosion the two operators had to recognize, acknowledge and act on 275 alarms!

3. Alarm Management

Alarm Management is imperative to assessing, improving and optimizing plant alarms, thereby increasing the effectiveness of plant operators by only notifying them of a need for their intervention.

3.1 What is an Alarm Management System?

Most plant personnel equate alarm management with reducing alarms; however, this is only one piece of the puzzle. The whole puzzle involves providing operators with enough information to prevent abnormal situations and to prevent the escalation of those abnormal situations that cannot be prevented.

A poor alarm system results in billions of dollars lost every year to accidents, equipment damage, unplanned plant or unit outages, off-spec production, regulatory fines and huge intangible costs related to environmental and safety infractions. Alarm Management is about safety, the environment, optimizing operations and increasing corporate profits.

One important philosophy is that the operator must have some action for any specific alarm. If the action is not required, the alarm should be removed. Further, reducing or eliminating alarm floods liberates an operator to respond to plant demands, enabling them to avoid shutdowns and keep the plant running at optimal performance. In addition, the advanced alarming -- like alarm shelving -- can dramatically reduce alarms temporarily during a specific period so the operators can focus on important alarms and reduce startup/shutdown time.

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The relationship between a DCS alarm system and an Alarm Management System is shown in Figure 1.

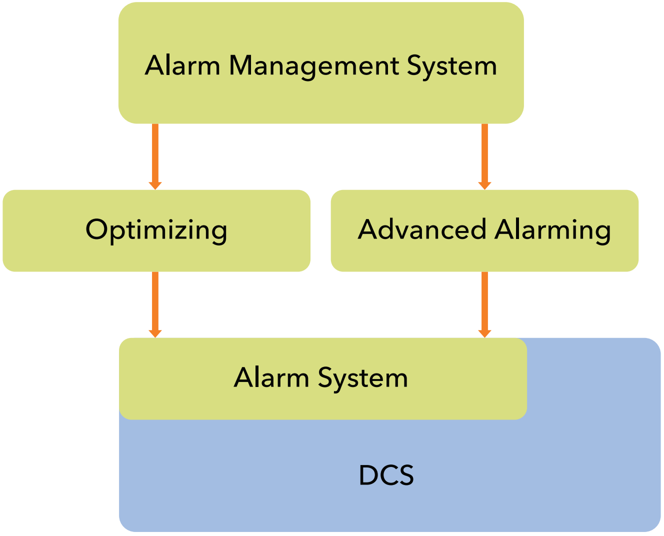

Figure 1. DCS alarm system and Alarm Management System

The alarm system of the DCS is the executer of all alarm functions. However, the Alarm Management System is the monitor and optimizer for the DCS alarm system, which is used to reduce nuisance alarms, rationalize related alarms, avoid alarm floods and so on. In addition, some advanced alarm functions like alarm shelving and alarm suppression can be added to existing the DCS alarm system to make it more effective.

As a result, it is possible to reduce unscheduled plant shutdowns, improve performance and mitigate the risk of incidents and excursions and hence to enhance reliability and profitability by improving the performance of the existing alarm system.

3.2 How does an Alarm Management System work?

The DCS alarm system can be optimized and enhanced by an Alarm Management System. An Alarm Management System and service attempt to identify unnecessary alarms, improper alarm set values and where improvements can be made to the current procedures for dealing with alarms, which can be demonstrated in Figure 2.

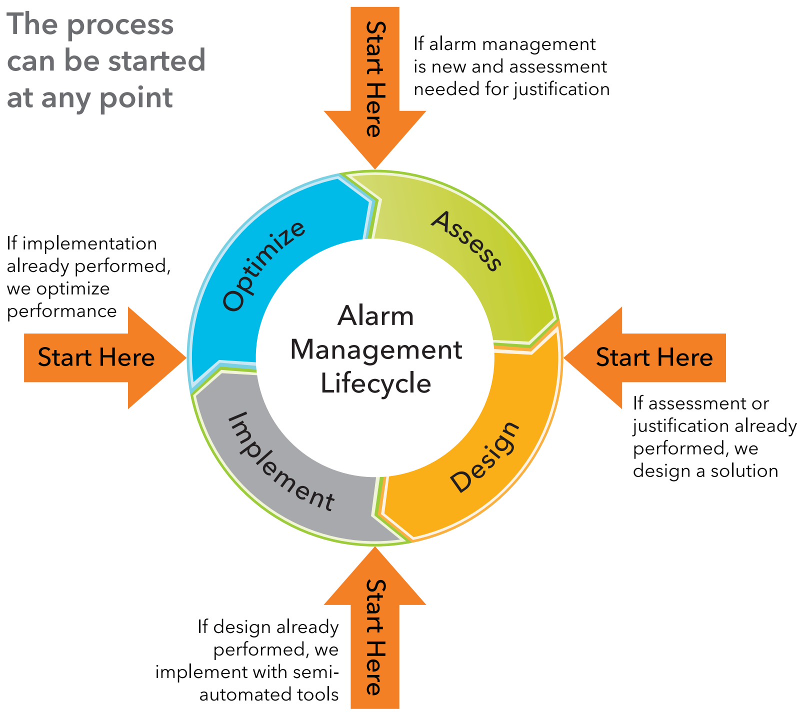

Figure 2. Alarm Management System

As shown, Alarm Management System and service is not a one-time project; it is a redesign/re-engineering and a life-long process. Therefore the performance of the alarm system is continuously being improved and optimized. The key functions and services are summarized as follows:

Alarm Philosophy Development

The Modern Alarm Philosophy is introduced to plant operations. The alarm philosophy is the collection of guiding principles and targets by which users configure alarms and measure alarm performance. Most philosophies cover the following criteria at a minimum:

1. What is an alarm?
2. How are priorities set based on criticality and time to respond?
3. General alarm considerations, e.g., how to deal with BAD I/O alarms?
4. Alarm performance criteria and resolution activities?

Most plants do not have a robust Alarm Philosophy. All alarms are defined on an ad hoc basis. This is the root cause of most alarm problems. An effective Alarm Philosophy outlines key concepts and governing rules for alarm strategy, e.g., what constitutes an alarm and what risk categories pertain to your site operations. It outlines roles and responsibilities, change management procedures and project goals, such as target alarm rates.

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Alarm Analysis
The Alarm Analysis module identifies potential areas for alarm system performance improvement. This module automatically collects configuration data, alarm messages and the operator action journal from the DCS. The data can be automatically captured and imported without any manual intervention. Main Analysis includes:

1. Alarm System Performance (Alarms per Time Period, Frequent Alarms, Chattering Alarms, Priority Distribution, Alarm Summary, etc.)
2. Alarm System Settings (Alarms Set by Priority, Disabled/Inhibited Alarms, etc.)
3. Process Changes (Alarm Enable States, Alarm Priorities, etc.)

The results of the analysis reports can be used to improve and monitor alarm system performance.

Performance Metrics Manager
This module enables business personnel at all levels to make informed and timely decisions by providing timely and accurate access to Key Performance Indicators (KPIs).

The Performance Metrics Manager provides comparable metrics through benchmarking and normalization for alarms and operator interactions independent of control systems and database formats.

Report Manager
This module is a report mechanism. Report sections may be created from specific components and then included in a report that may be scheduled for automatic execution and publishing. In addition, each report execution may trigger an e-mail notification that can be customized to any number of e-mail recipients.

Real-Time Alarm Viewer
This module provides real-time viewing of alarm messages from the alarm system on any authorized client PC connected to the Alarm Management Server. For Foxboro I/A Series systems, the alarms are collected from one or more printer ports on a Foxboro I/A workstation. A serial to Ethernet converter is used to send the alarm messages on a LAN to the Alarm Management Server. This is the same LAN used for transferring data for statistical analysis.

The alarm messages can be sorted and filtered in any column to facilitate analysis and make the elimination of alarm printers possible.

Advanced Alarm Management
This module provides more enhanced alarm functions for the DCS alarm system to reduce Alarm Floods:

1. Alarm Shelving
2. Grouped Alarms
3. Alarm Priority Reduction
4. Alarm Load Shedding
5. Pattern Recognition
6. Alarm Suppression (Redundant Voted Alarms, Eclipsing Alarms, etc.)

Alarm Suppression provides significant benefits in removing standing alarms when a plant unit is shut down, provided that the meaning of 'shut down' is clearly understood. If inventory has been removed as part of the shutdown process and the equipment is fully isolated, then suppression of all the alarms is likely to be appropriate.

However, if the plant may restart on short notice, with key inventories in place, then there will be a number of alarms that should not be suppressed during a plant shut down. In addition, in batch industries like pharmaceutical plants, alarm setpoints or whether an alarm is configured typically change depending on the batch phase. If it is not part of the automation, it may generate alarm floods. Similarly, alarm conditions may change during different recipes, which may also result in alarm floods. State-based alarm techniques are used in these situations to suppress those alarm floods.

4. Case Study-Salt River Project

Salt River Project (SRP) is the 3rd largest US public power utility with 6,500 MW generated and supplied to 900,000 customers with annual revenue of $2.5B USD. It was named "Utility of the Year" in 2004 by Electric, Light & Power. Invensys performed Alarm Management at two SRP power generation plants:

1. Santan – 9 gas fired combined cycle units with 1,100 MW
2. Navajo – 1 of 3 coal fired once through supercritical units with 800 MW each

The existing situation is characterized by the following comment:

"We were getting alarm horns all the time; at startup, shutdown and day to day operation. In one 18 hour period, operators were confronted with 5000 alarms, every one of which required intervention of some sort and 98 percent were designated top priority. The plant had to designate an operator just for alarm management," said Ron Bewsey, SRP I&E Supervisor and I/A Administrator.

Therefore, in the first phase the main tasks are to increase operator available time to improve plant performance and reduce the alarm rate and the chance of missing important alarms. The project scope is:

1. Initial Alarm System Performance Assessment
2. Alarm Philosophy Workshop
3. Alarm Philosophy and Design Functional Spec
4. Alarm Rationalization
5. Alarm Rationalization Implementation
6. Advanced Alarming – Future
7. Alarm rationalization service team

The achievements in Santan are:

a) Startup time and effort is reduced from 2 operators up to 4 hours to 1 operator less than 2 hours

b) 40% of configured alarms and resulting nuisance alarms were picked out and deleted.

The achievements in Navajo are:

a) Initial priority distribution (Priority 1: 98%, Priorities 2 through 4: 2%) is updated to a final priority distribution (Priority 1: 11%, Priority 2: 14%, Priority 3: 75%, Priority 4: Information Only, Priority 5: Non-critical bad I/O)

b) 44% of the configured alarms and resulting nuisance alarms were picked out and deleted

5. Conclusion

Unreasonably and improperly configured alarm systems contribute to accidents at a non-trivial rate. Although alarm systems are intended to minimize incidents, too often they amplify the consequences of these incidents. Nuisance alarms, alarm floods and improperly prioritized alarms all contribute to operator confusion, and thus increase accident frequency. DCS Alarm systems can be improved and optimized through the Alarm Management System and service. This re-design/re-engineering procedure restores the alarm system to a healthy and helpful state by eliminating nuisance alarms, reducing alarm floods, and ensuring that the necessary alarms are properly prioritized and documented. This white paper states the necessity of introducing an Alarm Management System and Service to existing DCS alarm systems.

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