Alarm Management Standards and Best Practices

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PlantPAx System Core

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Alarm Management Introduction

- An alarm management system is crucial to safe and productive operations:
  - Reduced unplanned downtime
  - Increased safety
  - Improved operator effectiveness
  - Better process performance/yields

- The goal of this session is to discuss these Alarm Management standards and learn about design and implementation best practices to ensure an effective alarm management system.
The Good Old Days...
Misapplication of Modern Technology
Emergence of Industry Standards

Ineffective Alarm Management
- Excessive number of alarms
- Alarm meaning to operator ambiguous
- Alarms and notifications often disabled

Understanding the Costs of Poor Alarming Management
- Major accidents and losses
- Lost production (up to 3-5%)
- Operator burnout

Establishment of Good Engineering Practice
- Insurance industry and HSE concerns adopting ISA S18.02 as a basis for examining overall process safety and sustainability

Emergence of Standards and Regulations
- ISA S18.02
- 49 CFR 195.446

1994
Abnormal situation Management (ASM) Consortium formed

1999
EEMUA 191 1st Edition

2003
ASM Alarm Management Guidelines 1st Edition
NAMUR 102 on Alarm Management

2007
EEMUA 191 2nd Edition

2009
Emergence of Industry Standards

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Desired State of Alarm Management

- All alarms require an operator response or there is a consequence
  - Do “information-only” alarms add value or help develop bad habits?
- An engineering process must be followed to ensure alarms are defined, prioritized, and presented properly
- Alarms must be presented at a rate that the operator can respond
  - How long does it take for an operator to take action on an alarm?
- It must be clear when the alarm system is not performing as intended
  - What alarms have been suppressed and why?
Alarm Management Lifecycle

Identify, Rationalize, and Design
- What should alarm? When?
- To whom should it alarm? How are they notified?
- How is the operator to respond?
- How should the alarm be configured?

Monitor and Assess
- Alarm system configuration as intended
- All alarms in-service or have action plans for repair
- Most frequent alarms/systemic issues addressed
- Rate of alarms appropriate for operator

Operate and Maintain
- Potential Cause:
  - Chemical Leak
  - Scrubber/Filter Breakthrough
  - Failed Instrument
- Verify:
  - Area
  - Scrubber Operation
  - Manual readings
- Response:
  - Isolate Chemical Source
  - Initiate repair of scrubber/instrument
- Potential Consequence:
  - Personnel Safety
  - Environmental Violation

Philosophy

Implement

Audit and Management of Change
Alarm Management Lifecycle

A Philosophy

B Identification

C Rationalization

D Detailed Design

E Implementation

F Operation

G Maintenance

H Monitoring & Assessment

I Management of Change

J Audit

ALARM PHILOSOPHY
Alarm Philosophy Document

- What is an alarm?
- Roles and requirements
- Rationalization requirements
- Alarm class definitions, design, requirements
- Alarm priorities, definitions, etc.
- Alarm shelving / suppression rules
- Alarm system monitoring requirements
- Management of change
- Training

Recommend securing agreement on philosophy from Senior Management
1. Form a committee of stakeholders, involve an alarm management expert if possible
2. Get educated - learn the fundamentals of alarm management, common mistakes, performance metrics, what defines well performing systems, etc.
3. Study the current state of the alarm system (if existing), compare & contrast against industry best practices (sadly not industry norms)
4. Leverage the experts, and make use of the recommendations & standards
5. Draft, review, edit, review, repeat as necessary
6. Once approved, review the alarm philosophy periodically for any necessary changes
Alarm Management Standards and Best Practices

ALARM RATIONALIZATION
Alarm Rationalization Process

• For every event suspected to possibly be an alarm:
  - Determine if the event is an alarm
    • What is the required corrective action to be performed by the operator?
    • What is the immediate consequence if action is not taken?
  - Events which are NOT alarms:
    • Nothing for the operator to do to correct the condition
    • Event is not an indication of a problem
    • No consequences if no response is taken
    • Same problem indicated elsewhere (i.e. more than one alarm for one root cause)
Alarm Rationalization
(“Wow, this is a lot of work”)

• For every alarm, document:
  - The alarm type
  - The alarm class
  - The alarm priority (based on rules in the alarm philosophy)
  - Alarm limit or condition
  - Required operator action
  - Consequences of not carrying out operator action in a timely manner

• Then verify:
  - Alarm priorities align with consequences of operator inaction
  - Alarm limits or conditions allow time for operator action
  - Reasonable and observable operator action is identified
Detailed Design Phase

• Understand the capabilities and limitations of the process control system(s)

• Document how the results of the alarm rationalization effort will be implemented

• This step often involves more complex configuration steps than you may have done before implementing alarm management
  – To make it easier, develop standard treatments to advanced alarming scenarios, for example:
    • How do you handle multiple alarms that occur as a result of a trip condition?
    • How do you handle alarms on equipment not-in-use?
  – Create logic as standard and apply it in every applicable situation
Some “Managed Alarm” Techniques

- **Roll-up / Group–Based Suppression**
  - Diagram showing connections and nodes labeled with alarm states and symbols.

- **Time-limited Suppression (Shelving)**
  - Diagram showing a shelving mechanism with parameters like 'EnableShelving', 'Time_until_UnSuppress', and 'ShelfTime'.

- **Counter-based Suppression**
  - Diagram illustrating a counter with parameters such as 'Alarm_Time', 'CounterSuppressReq', and 'Floating_Count'.

- **Matrix / State-based Alarming**
  - Diagram depicting a matrix with states and interconnections, labeled with nodes like 'State', 'InputBit', and 'OutputBit'.

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Above all else, avoid the common mistake of configuring unnecessary alarms

Detailed Design - Logic

- Define & document, for every alarm:
  - Alarm limits
  - Alarm deadbands
  - Alarm debounce timer (delay timers)
  - Programmatic changes to alarm settings (i.e. process state driven changes)
Detailed Design - HMI

• How to effectively indicate:
  – Points in alarm
  – Alarm states, priorities, types, messages, etc.

• Allow the operator to:
  – Acknowledge alarms
  – Silence audible alarms
  – Determine the proper response & perform it

• Additional considerations:
  – Color conventions, iconic representations, etc.
  – Rules for acknowledgement, suppression, etc.
  – Mechanisms for sorting, filtering, etc.
  – Representation in the alarm banner, summary, etc. as well as area overviews, unit displays, detail pages, faceplates, etc.

Arguably the most critical issue, as this is the part of the system with which the operator interacts directly
Alarm Management Standards and Best Practices

IMPLEMENTATION
Alarm System Implementation

Alarms configured and maintained in the controller

OR

Alarms configured and maintained in the alarm server

OR

Both methods are used in combination

The optimum solution is often a combination based on user requirements and system architecture
### Rockwell Automation Options for Alarm Implementation

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HMI Classic Alarming</strong></td>
<td>Alarms as a property of a HMI tag in the FactoryTalk View HMI Server</td>
<td>• Only architecture supported for FactoryTalk View ME</td>
<td>• Limited visualization objects</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Support for a high number of alarms (40,000 per HMI Server, of which 10,000 can be analog)</td>
<td>• Limited alarm logging functionality</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Logs alarm in local time (as configured in HMI server)</td>
</tr>
<tr>
<td><strong>FactoryTalk Alarm &amp; Events (FT A &amp; E)</strong></td>
<td>Alarms configured in the controller or FactoryTalk View A&amp;E server. Device-based alarms (ALMA, ALMD) are subscribed to by the RSLinx Enterprise Server when the alarm option is enabled. Server-based alarms (Digital, Level, or Deviation) are configured in Tag Alarm and Event Server in FactoryTalk View SE.</td>
<td><strong>Advantages</strong></td>
<td><strong>Disadvantages</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Includes complete set of visualization components</td>
<td>• No support for PanelView Plus platform (FTView ME)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Native ability to log Alarm History to SQL database</td>
<td>• Lower number of supported alarms (20,000 alarms) and clients (20) per system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Logs alarm in UTC time</td>
<td></td>
</tr>
</tbody>
</table>
Alarm Option Recommendations

• Only use HMI Classic Alarms if your application doesn't support the use of FactoryTalk Alarms and Events (FT A&E)
  – Topology limits (>20 clients/application)
  – Platform limits (PanelView Plus)
  – Capacity limits (>20,000 alarms per system, >2000 alarms per controller)

• For mixed architectures (FactoryTalk ME and FactoryTalk SE)
  – Use HMI Classic Alarming for your FactoryTalk View ME application(s) and FactoryTalk Alarm & Events Alarming for your FactoryTalk View SE application which can both talk to the same controller.
PlantPAx Alarm Recommendations

- PlantPAx recommends FTA&E server-based alarms (detection in controller, notification handled by server)
- Advantages of this approach for PlantPAx:
  - Integration of alarm configuration and display into library (AOI’s, global objects, and faceplates) for ease of engineering/deployment
  - Solution supported by both FTA&E and Classic alarming so can be used regardless of topology/platform/capacity
  - Difficult to estimate load of FTA&E device-based alarms, especially in redundancy
  - More flexibility to applying alarm management techniques in P_ALARM or controller detection in general

- PlantPAx Process Library (KB 62682) uses a dedicated AOI (P_ALARM) for each configurable alarm. Documentation is provided for connecting HMI Classic Alarms or FTA&E Server-Based Alarms for mixed architectures.
Controller-based Alarm Configuration

![Diagram of ALMD Properties - FADH1101A101 (Sheet 1, E2)](image)

- **Condition:** Input = 1
- **Severity:** 500
- **Minimum Duration:** 0 ms
- **Message:** High Deviation Alarm /s5:0 %AlarmName*/ Value: */N:3 %Tag1 NOFILL DP:

<table>
<thead>
<tr>
<th>Associated Tags</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FIC1101A101.PV</td>
<td>REAL</td>
<td>Transfer Flow Controller</td>
</tr>
<tr>
<td>2</td>
<td>FIC1101A101.DevHLimit</td>
<td>REAL</td>
<td>Transfer Flow Controller</td>
</tr>
</tbody>
</table>

**Alarm Class:**

**FactoryTalk View Command:**

**Status:** OK

- **Alarm:** Normal
- **Acknowledged**
- **Execution Order Number:** (routine not verified)

**Delivery:**

- **Never display description in a routine**
Server-based Alarm Configuration
Alarm Management Standards and Best Practices

OPERATION
Operations
(i.e. Run Time Components)

FTA&E includes a Full Complement of Run-Time Components
Alarm “Breadcrumbs” Guide the Operator

1. Filtered alarm banner notifies operator of a problem. Double-click to go right to the appropriate display.

2. Area button indicates an alarm in the area; Drop-down shows which units have alarms.

3. Display clearly shows alarm and other problems.

5. Alarm tab shows more detail, complete with diagnostic information where available.
Alarm Banner

- Up to 5 most current, highest priority alarms
- New FactoryTalk View docking feature allows it to be stationed as a permanent fixture on the HMI client.
- Launch Summary directly from bottom of Banner for more details

Docked in Client window to always appear at top or bottom of any graphic screen
**Alarm Summary**

- Provides all the details
- No HMI effort required, configuration only

### Alarm Summary Table

<table>
<thead>
<tr>
<th>Alarm State</th>
<th>Condition</th>
<th>Message</th>
<th>Event Time</th>
<th>Alarm Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal, Unack'd</td>
<td>HI</td>
<td>Tank 1 Level</td>
<td>10/8/2006 4:42:35 PM</td>
<td>Tank FarmA</td>
</tr>
<tr>
<td>Normal, Unack'd</td>
<td>TRIP</td>
<td>Motor Contactor Weld, - Line 1 · Contactor 17</td>
<td>10/8/2006 4:42:36 PM</td>
<td>NorthBuilding Cab12</td>
</tr>
<tr>
<td>Normal, Unack'd</td>
<td>HI</td>
<td>Tank 1 Pressure</td>
<td>10/8/2006 4:42:42 PM</td>
<td>Tank FarmA</td>
</tr>
<tr>
<td>Normal, Unack'd</td>
<td>LOLO</td>
<td>Tank 1 Level</td>
<td>10/8/2006 4:42:44 PM</td>
<td>Tank FarmA</td>
</tr>
<tr>
<td>Normal, Unack'd</td>
<td>LO</td>
<td>Tank 1 Level</td>
<td>10/8/2006 4:42:45 PM</td>
<td>Tank FarmA</td>
</tr>
<tr>
<td>In Alarm</td>
<td></td>
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<td></td>
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<tr>
<td>In Alarm</td>
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<td>Normal, L</td>
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<tr>
<td>Normal, L</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### Filter Options
- Select Filter
- Print
- Run View Command
- Ack
- Ack Comment
- Ack Page
- Suppress
- Alarm Status
- Normal / Unack
- Faults / Display List

### Additional Features
- Number of Events
- In Alarm / UnAck
- In Alarm / Ack
- Normal / Unack
- Faults / Display List

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Alarm Status Explorer

- Use to manage all alarm subscriptions on this server
- Identify which alarms are suppressed or disabled
- Sort by alarm condition and status
- Launch from the Summary
Alarm Log Viewer Object

- Alarm Server points to any SQL data base for alarm history
  - Microsoft SQL Express installation included
- Multiple Alarm Servers can point to the same data base.
- Log Viewer Object allows display of historical alarm data in FactoryTalk View
  - Or, write your own SQL query to access the database directly
  - 4 different “Views” are pre-configured
- Simple to use powerful filtering and sorting options with controller driven time stamp allow easy recreation of SOE trail (Sequence of Events)
Alarm Management Standards and Best Practices

MONITORING & ASSESSMENT
Alarm System KPIs

1. Average Alarm Rate
2. Maximum Alarm Rate (High Water Mark)
3. % of Time Alarm Rate is Outside of Limit

... and Some Recommended Benchmarks

![Graph showing different alarm rates and their corresponding performance levels. The graph is divided into four quadrants based on the percentage of time the alarm rate is outside of the limit and the maximum alarm rate.]

- **Overload** (50% of time outside limit, high maximum rate)
- **Reactive** (25% of time outside limit, moderate maximum rate)
- **Robust** (5% of time outside limit, low maximum rate)
- **Predictive** (1% of time outside limit, very low maximum rate)

- Maximum Alarm Rate (alarms / 10 minutes)
  - 10
  - 100
  - 1000

- Average Alarm Rate (alarms / 10 minutes)
  - 1
  - 10
  - 100

- % of Time Alarm Rate is Outside of Limit
  - 1%
  - 5%
  - 25%
  - 50%
### Other Useful Alarm System KPIs...

<table>
<thead>
<tr>
<th>Top 10 most frequently occurring alarms</th>
<th>Number of alarm peaks per time period (alarm floods)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of long standing / stale alarms</td>
<td>Priority distribution of alarms</td>
</tr>
<tr>
<td>Unauthorized alarm property changes</td>
<td>Number of alarms per operating position</td>
</tr>
<tr>
<td>Chattering alarms</td>
<td>Suppressed alarms outside of approved methodologies</td>
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... and Some Recommended Benchmarks

- Unauthorized alarm property changes
- Number of long standing / stale alarms
- Top 10 most frequently occurring alarms
- Number of alarm peaks per time period (alarm floods)
- Priority distribution of alarms
- Number of alarms per operating position
- Chattering alarms
- Suppressed alarms outside of approved methodologies

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of alarms</td>
<td>&lt; 5% of Total (over 30 days)</td>
</tr>
<tr>
<td>Number of alarms with plans to address</td>
<td>&lt; 5</td>
</tr>
<tr>
<td>Number of unsuppressed alarms</td>
<td>0</td>
</tr>
<tr>
<td>Number of suppressed alarms</td>
<td>0</td>
</tr>
<tr>
<td>10 minute time interval alarms</td>
<td>(10 alarms / 10 min) &lt; 1%</td>
</tr>
<tr>
<td>Priority distribution</td>
<td>80% Low, 15% Medium, 5% High</td>
</tr>
<tr>
<td>Number of alarms per hour</td>
<td>~6-12 Alarms / hour</td>
</tr>
<tr>
<td>Suppressed alarms</td>
<td>0</td>
</tr>
</tbody>
</table>

Excel-based query direct to alarm history

Alarm “Grid” view in controller configuration environment
Pre-Built Alarm Reporting Tools

FactoryTalk VantagePoint and Alarms & Events Reports are Available Through KnowledgeBase AID 68296
Audit and Management of Change

1. Verify alarm configuration settings against your design on a periodic basis*

2. Control Alarm Setpoint and Priority Changes
   - Follow MOC procedures, update alarm rationalization and design documents, identify any other alarms or functions effected

3. Return unapproved changes to their approved configuration state

4. Monitor Alarm Shelving and Suppression
   - List of suppressed alarms
   - Logged comments associated with suppressed alarms
   - Accumulated time each alarm was suppressed
   - Number of times each alarm was suppressed

* Be sure to distinguish permanent changes with those made automatically

Protect your investment to keep an effective alarm system!
Management of Change

- **Features / Functions**
  - **Authentication**
    - Prevent unauthorized changes
  - **Audit**
    - Track authorized user changes
  - **Archive**
    - Centralized, versioned, secure configuration storage
  - **Disaster Recovery**
    - Automated backup and change detection
PlantPAx Alarm Management Overview

CONCLUSION
Why is the ISA Standard important?

• Regulatory agencies have general duty clauses and interpretations for example:
  – OSHA has issued a interpretation letter stating that a National Consensus Standard (such as ANSI/ISA-18.2) is a RAGAGEP
  – In 2009, OSHA issued an additional $87M in fines stemming from the 2005 Texas City explosion, specifically citing failure to remediate using ASME codes and ISA standards

• ISA 18.2 states
  “The practices and procedures of this standard shall be applied to existing systems in a reasonable time as determined by the owner/operator”
DOT 49 CFR 195.446 (Transportation of Hazardous Liquids by Pipeline) states:

(e) Each operator* using a SCADA system must have a **written alarm management plan** to provide for effective controller* response to alarms. An operator’s* plan must include provisions to:

1. Review SCADA safety-related alarm operations using a process that ensures **alarms are accurate** and support safe pipeline operations;
2. **Identify** at least once each calendar month points affecting safety that have been taken off scan in the SCADA host, have had **alarms inhibited**, generated **false alarms**, or that have had **forced or manual values** for periods of time exceeding that required for associated maintenance or operating activities;
3. **Verify** the correct safety-related **alarm set-point values and alarm descriptions** when associated field instruments are calibrated or changed and at least once each calendar year, but at intervals not to exceed 15 months;
4. Review the alarm management plan required by this paragraph at least once each calendar year, but at intervals not exceeding 15 months, to determine the effectiveness of the plan;
5. **Monitor the content and volume of general activity** being directed to and required of each controller* at least once each calendar year, but at intervals not exceeding 15 months, that will assure controllers* have sufficient time to analyze and react to incoming alarms; and
6. Address deficiencies identified through the implementation of paragraphs (e)(1) through (e)(5) of this section.

*In regulation terminology, operator = end user company, controller = control system operator
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Where to start?

A. Philosophy
B. Identification
C. Rationalization
D. Detailed Design
E. Implementation
F. Operation
G. Maintenance
H. Monitoring & Assessment
I. Management of Change
J. Audit

Benefits of Alarm Management

• Possibility to regain what studies have shown as 3 - 8% production losses due to abnormal situations*
  - Reduction in yield or unplanned downtime

• Regulatory compliance
  - With the creation of standards, Alarm management has become “good engineering practice” increasing liability of a non-managed system

• Identification of process problems
  - Excessive variability / tuning problems
  - Valve / equipment problems

• Incident prevention
  - The potential cost of a single incident may justify investment

• Improved productivity - both equipment & personnel
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Questions?