Alarm Management Bootcamp

Bill Hollifield
PAS Principal Alarm Management & HMI Consultant
About Bill Hollifield

- BSME, MBA
- Industry veteran of 35+ years
- Global experience in
  - Alarm Management
  - High Performance Operator HMI
  - Process Control
- Co-author and committee member for:
  
  - Voting Committee Member: ISA 101 Human-Machine Interface
  - ISA 18.2 Alarm Mgt. Standard
  - EPRI Alarm Management Guidelines (Co-author)
  - EEMUA 191
  - RP-1167 Alarm Mgt for Pipeline Systems
  - Committee member
About PAS

• Founded in 1993
  • Operations Effectiveness
    • Control Loop Performance
    • Alarm Management
    • High-Performance HMI
  • Automation Effectiveness
    • Automation Systems Integrity
    • Disaster Recovery
    • Knowledge Retention/Collaboration

• Industry Organizations & Strategic Partners
  • Voting Member of the ISA18 committee
  • EPRI, ISA, API, AICHE, NPRA, EEMUA

Worldwide Customer Base
Human vs. Mechanical Reliability

Equivalent Forced Outage Rate

True in general for the process industries:

Mechanical Reliability & Automation Improvements have leveled off.

Human Performance Improvements have not really begun!
Human Error is a Prime Factor in Most Accidents
You Never See This:

Hundreds die from SIL-2 System being used instead of SIL-3!

Engineers Sentenced to Execution

<table>
<thead>
<tr>
<th>“Mistakes were made”</th>
<th>SIL</th>
<th>PFD</th>
<th>PFD (power)</th>
<th>RRF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1 - 0.01</td>
<td>$10^{-1} - 10^{-2}$</td>
<td>10 - 100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.01 - 0.001</td>
<td>$10^{-2} - 10^{-3}$</td>
<td>100 - 1000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.001 - 0.0001</td>
<td>$10^{-3} - 10^{-4}$</td>
<td>1000 - 10,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0001 - 0.00001</td>
<td>$10^{-4} - 10^{-5}$</td>
<td>10,000 - 100,000</td>
<td></td>
</tr>
</tbody>
</table>
Operator Effectiveness: Three Support Factors

• Operation Effectiveness - Effective controls, systems, tools, and training to enable operators to effectively detect and successfully handle abnormal situations.

• The Three Components
  – Effective Alarm Management
  – Control Loop Performance
  – High Performance HMI

• Effective Abnormal Situation Management requires all three

The War of the Worlds
H.G. Wells
Overview

• The Basics of the Alarm Management Problem
• Approaches for New Systems and Existing Systems
• Proven Solutions in Alarm Management
• Project Justification
• The ISA-18.2 Standard
Poor Alarm Systems Encourage Poor Operating Practices

“Operating By Alarm”

The typical result of an overloaded alarm system and an HMI with no Hierarchy

Poor alarm systems contribute to upsets, incidents, and accidents
“Operating By Alarm” Can Compensate (Poorly) for Poor HMIs
The Alarm Problem in a Nutshell

• Improperly configured alarm systems are widespread!
• They Generate Thousands of Alarm Events That Cannot be Evaluated By The Operator!
  – Which alarms are safe to be ignored by the operator?
## Alarm Summary -- Hammer Unit

<table>
<thead>
<tr>
<th>Point</th>
<th>Description</th>
<th>Alarm</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure</td>
<td>This alarm is probably not important</td>
<td>PVHI</td>
<td>2</td>
</tr>
<tr>
<td>Temp</td>
<td>This alarm is definitelly not important</td>
<td>PVLO</td>
<td>1</td>
</tr>
<tr>
<td>Level</td>
<td>This alarm is a fluff alarm</td>
<td>PVHH</td>
<td>1</td>
</tr>
<tr>
<td>Flow</td>
<td>This alarm does not matter</td>
<td>PVLL</td>
<td>2</td>
</tr>
<tr>
<td>Differential pressure</td>
<td>This alarm does not require action</td>
<td>PVL</td>
<td>2</td>
</tr>
<tr>
<td>Pressure</td>
<td>This alarm is not even an alarm</td>
<td>PVHI</td>
<td>2</td>
</tr>
<tr>
<td>Temp</td>
<td>This alarm can be ignored</td>
<td>PVHI</td>
<td>1</td>
</tr>
<tr>
<td>Level</td>
<td>This alarm should not exist</td>
<td>PVLO</td>
<td>1</td>
</tr>
<tr>
<td>Flow</td>
<td>This alarm violates all best practices</td>
<td>PVHH</td>
<td>2</td>
</tr>
<tr>
<td>Differential pressure</td>
<td>This alarm is really an alert not an alarm</td>
<td>PVLL</td>
<td>1</td>
</tr>
<tr>
<td>Pressure</td>
<td>This alarm is just to make sure you are reading</td>
<td>PVL</td>
<td>1</td>
</tr>
<tr>
<td>Temp</td>
<td>This alarm can be fixed at the end of shift</td>
<td>PVHI</td>
<td>1</td>
</tr>
<tr>
<td>Level</td>
<td>This alarm was left in here by the previous shift</td>
<td>PVHI</td>
<td>1</td>
</tr>
<tr>
<td>Flow</td>
<td>This alarm should have been shelved</td>
<td>PVLO</td>
<td>1</td>
</tr>
<tr>
<td>Differential pressure</td>
<td>This alarm is worthless</td>
<td>PVHH</td>
<td>1</td>
</tr>
<tr>
<td>Pressure</td>
<td>This alarm is to wake you up</td>
<td>PVLL</td>
<td>2</td>
</tr>
<tr>
<td>Temp</td>
<td>This alarm is to verify the previous alarm worked</td>
<td>PVL</td>
<td>1</td>
</tr>
<tr>
<td>Level</td>
<td>This alarm is needed by Hector from pas only</td>
<td>PVHI</td>
<td>2</td>
</tr>
<tr>
<td>Flow</td>
<td>This alarm is for the dcs engineer only</td>
<td>PVHI</td>
<td>1</td>
</tr>
<tr>
<td>Differential pressure</td>
<td>This alarm is the pre alarm of the pre alarm</td>
<td>PVLO</td>
<td>1</td>
</tr>
<tr>
<td>Pressure</td>
<td>This alarm is to make noise in the room</td>
<td>PVHH</td>
<td>2</td>
</tr>
<tr>
<td>Temp</td>
<td>This alarm should be recorded not annunciated</td>
<td>PVLL</td>
<td>1</td>
</tr>
<tr>
<td>Level</td>
<td>This alarm is was free so why not?</td>
<td>PVL</td>
<td>1</td>
</tr>
</tbody>
</table>

Who failed? The operator? Or the alarm system?
How Did This Come About?

Analog Panel Board
- A single, fixed and contiguous board
- At-a-glance view of the entire process
- Early pattern recognition of process upsets
- Direct and quick access to controls
- 50-to-150 alarms per board
- Every alarm important

CRT-Based Console
- 4-6 screens and 50-100 displays
- “Key-hole” view of the process
- Post event recognition of process upsets
- Multiple keystrokes to access controls
- 2,000-to-4,000 alarms per console
- Alarms misconfigured
A Proven Approach: The PAS Seven Steps

• Step 1: Develop, Adopt and Maintain an Alarm Philosophy
• Step 2: Collect Data And Benchmark Your Systems
• Step 3: Perform “Bad Actor” Alarm Resolution
• Step 4: Perform Alarm Documentation and Rationalization
• Step 5: Implement Alarm Audit and Enforcement Technology
• Step 6: Implement Real Time Alarm Management
• Step 7: Control and Maintain Your Improved System

The “What” AND the “How”
A concise approach to optimizing alarm systems.
The EPRI Alarm Management Guideline

- Co-written by PAS
- A combination of knowledge from several sources:


**What went into The Alarm Management Handbook and the EPRI Guideline:**

Over 20 years of experience & over 120 person-years of effort

Comprehensive compilation of best practices

Lessons learned from hundreds of successful projects

Practical, field-proven strategies and techniques
Step 1: The Alarm Philosophy Document

An Alarm Philosophy is:

a comprehensive document on “how to do alarms right!”

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“We don’t need no stinkin’ rules!”
<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 Alarm Philosophy Introduction</td>
<td>8.0 Specific Alarm Design Considerations</td>
</tr>
<tr>
<td>2.0 Purpose and Use of an Alarm Philosophy</td>
<td>8.1 Handling of Alarms from Instrument Malfunctions</td>
</tr>
<tr>
<td>3.0 Alarm Definition and Criteria</td>
<td>8.2 Alarms for Redundant Sensors and Voting Systems</td>
</tr>
<tr>
<td>4.0 Alarm Annunciation and Response</td>
<td>8.3 External Device Health and Status Alarms</td>
</tr>
<tr>
<td>4.1 Operator Roles and Responsibilities for Alarms</td>
<td>8.4 ESD Systems</td>
</tr>
<tr>
<td>4.2 Alarms Routed to Multiple Operators/Locations</td>
<td>8.5 ESD Bypasses</td>
</tr>
<tr>
<td>4.3 Alarm Summary Display Characteristics and Usage</td>
<td>8.6 Duplicate Alarms</td>
</tr>
<tr>
<td>4.4 Proper Alarm Indication on Graphics</td>
<td>8.7 Consequential Alarms</td>
</tr>
<tr>
<td>4.5 Annunciated Alarm Priority</td>
<td>8.8 Pre-Alarms</td>
</tr>
<tr>
<td>4.6 Navigation and Alarm Response</td>
<td>8.9 Alarms That Prevent Harm to Personnel</td>
</tr>
<tr>
<td>4.7 Use of External Lightbox Annunciators</td>
<td>8.10 Flammable and Toxic Gas Detectors</td>
</tr>
<tr>
<td>4.8 Hardwired Switches</td>
<td>8.11 Safety Shower and Eyebath Activation Alarms</td>
</tr>
<tr>
<td>5.0 Alarm System Performance</td>
<td>8.12 Building-Related Alarms</td>
</tr>
<tr>
<td>5.1 Alarm System Roles and Responsibilities</td>
<td>8.13 Alarm Handling for Programs</td>
</tr>
<tr>
<td>5.2 Alarm System KPIs and Analyses</td>
<td>8.14 Alarms to Initiate Manual Tasks</td>
</tr>
<tr>
<td>5.3 Alarm Performance Reports</td>
<td>8.15 Control System Status Alarms</td>
</tr>
<tr>
<td>5.4 Alarm Record /History Retention</td>
<td>8.16 Point, Interlock, and Program References to Alarms</td>
</tr>
<tr>
<td>6.0 Alarm Handling Methods</td>
<td>9.0 Management of Change</td>
</tr>
<tr>
<td>6.1 Nuisance Alarm Handling</td>
<td>9.1 MOC Applicability</td>
</tr>
<tr>
<td>6.2 Advanced Alarm Handling Methodologies</td>
<td>9.2 MOC Methodology</td>
</tr>
<tr>
<td>6.3 Alarm Shelving</td>
<td>9.3 MOC Requirements</td>
</tr>
<tr>
<td>6.4 State-Based or State-Dependent Alarms</td>
<td>10.0 Training</td>
</tr>
<tr>
<td>6.5 Alarm Flood Suppression</td>
<td>11.0 Alarm Maintenance and Improvement Process</td>
</tr>
<tr>
<td>6.6 Operator Messaging and Alert Systems</td>
<td>11.1 Problem Detection and Resolution</td>
</tr>
<tr>
<td>7.0 Documentation and Rationalization (D&amp;R)</td>
<td>11.2 Alarm System Maintenance</td>
</tr>
<tr>
<td>7.1 Alarm Determination</td>
<td>11.3 Alarm Testing</td>
</tr>
<tr>
<td>7.2 Alarm Priority Determination</td>
<td>11.4 Alarm Philosophy Updates</td>
</tr>
<tr>
<td>7.3 Areas of Impact and Severity of Consequences</td>
<td>12.0 Appendices</td>
</tr>
<tr>
<td>7.4 Maximum Time for Response and Correction</td>
<td>12.1 Definitions</td>
</tr>
<tr>
<td>7.5 Severity of Consequences /Time to Respond Matrix</td>
<td>12.2 References</td>
</tr>
<tr>
<td>7.6 Alarm Setpoint Selection</td>
<td>12.3 Related Industry Standards and Codes</td>
</tr>
<tr>
<td>7.7 Alarm Documentation</td>
<td>12.4 Internal Company Standards and Codes</td>
</tr>
<tr>
<td>7.8 Alarm Classification</td>
<td>12.5 Control System-Specific Appendices</td>
</tr>
<tr>
<td>7.9 Alarm System and Other Site Procedures</td>
<td></td>
</tr>
<tr>
<td>7.10 Implementation, Commissioning, and Checkout</td>
<td></td>
</tr>
</tbody>
</table>
What is an Alarm?

An audible and/or visible means of indicating to the operator an equipment **malfunction**, process **deviation**, or **abnormal condition** requiring a **response**.

- **Operator Action Is:**
  - Manipulation of the control system to effect process change
  - Directing others to make changes or take actions
  - Changing operating mode
  - Manual changes
  - Begin troubleshooting / analysis of a situation
  - Contacting other people or groups regarding a situation
  - Logging conditions for later examination, maintenance, or repair

- **Operator Action is Not:**
  - Writing something down in a logbook
  - Thinking “OK, That’s nice to know.”
  - Thinking “OK, The next shift can deal with that tomorrow.”
  - Thinking “OK, the system is working normally.”

Alarm Systems are RESERVED for items that meet this definition!
Proper Alarming

Alarms Must Require Operator Action!

– The alarm system is RESERVED for such things.
– Events not requiring operator action should not produce alarms
– Place alarms on the best indicator of the situation’s root cause.
– Produced upon abnormal situations only.
– Alarms should be clear and informative.

– These principle are commonly violated
New Alarm Systems – Initial Configuration

• A new system is a BLANK SLATE
• Only the Alarm Philosophy determines any “default” alarm settings.
  – Example: All analog inputs will have a priority 4 Bad Value alarm configured.
• “Rules of thumb” for alarm selection are not used!
  – Example of a poor rule of thumb: “Every analog input will have Lo-Lo, Low, High, and HIHI alarms set at 10%, 20%, 80% and 90%)
• Alarms are individually determined through the process of Rationalization.
• Every alarm must meet the selection criteria and definition.
• Alarm Priorities are determined through a best-practices, consistent approach.
Existing Alarm Systems – REVISE Configuration

• Existing systems are often a mess
• Originally configured without an alarm philosophy
• Poor alarm selection
• Poor alarm prioritization
• Improper alarm setpoints
• Years of poor to non-existent management of change after original commissioning
• Uncontrolled alarm suppression
• Solution: Requires review and reconfiguration after a proper Alarm Philosophy is adopted
Step 2: Alarm System Analysis

Alarm Analysis - Specific Problem Identification

Top 10 Most Frequent Annunciated Alarms

Annunciated Alarms per 10 Minutes

- 42 Days -

Highest 10-minute Rate = 852
Alarm Flood = 10+ in 10 minutes
Peak Exceed 700

Automated Analysis with Automated Reporting
### Alarm System Performance Targets (From ISA-18.2)

<table>
<thead>
<tr>
<th>Metric</th>
<th>Target Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annunciated Alarms per Time:</strong></td>
<td><strong>Target Value:</strong> Very Likely to be Acceptable</td>
</tr>
<tr>
<td><strong>Target Value:</strong> Maximum Manageable</td>
<td></td>
</tr>
<tr>
<td><strong>Annunciated Alarms Per Day per Operator Position</strong></td>
<td>~150 alarms per day</td>
</tr>
<tr>
<td><strong>Annunciated Alarms Per Hour per Operator Position</strong></td>
<td>~6 (average)</td>
</tr>
<tr>
<td><strong>Annunciated Alarms Per 10 Minutes per Operator Position</strong></td>
<td>~1 (average)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Metric</th>
<th>Target Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Percentage of hours containing &gt; 30 alarms</strong></td>
<td>~ &lt;1%</td>
</tr>
<tr>
<td><strong>Percentage of 10-minute periods containing &gt;5 alarms</strong></td>
<td>~ &lt;1%</td>
</tr>
<tr>
<td><strong>Maximum number of alarms in a 10 minute period</strong></td>
<td>10 or less</td>
</tr>
<tr>
<td><strong>Percentage of time alarm system is in a flood condition</strong></td>
<td>~ &lt;1%</td>
</tr>
<tr>
<td><strong>Percentage contribution of the top 10 most frequent alarms to the overall alarm load</strong></td>
<td>~&lt;1% to 5% maximum, with action plans to address deficiencies.</td>
</tr>
<tr>
<td><strong>Quantity of chattering and fleeting alarms</strong></td>
<td>Zero, action plans to correct any that occur.</td>
</tr>
<tr>
<td><strong>Stale Alarms</strong></td>
<td>Less than 5 present on any day, with action plans to address</td>
</tr>
<tr>
<td><strong>Annunciated or Configured Priority Distribution</strong></td>
<td>3 priorities: ~80% P3, ~15% P2, ~5% P1 or 4 priorities: ~80% P3, ~15% P2, ~5% P1, ~&lt;1% “Priority Critical.” Other special-purpose priorities are excluded from the calculations</td>
</tr>
<tr>
<td><strong>Unauthorized Alarm Suppression</strong></td>
<td>Zero alarms suppressed outside of controlled or approved methodologies</td>
</tr>
<tr>
<td><strong>Improper Alarm Attribute Change</strong></td>
<td>Zero alarm attribute changes outside of approved methodologies or MOC</td>
</tr>
</tbody>
</table>
Automated Alarm & Event Analysis
Step 2: Alarm System Analysis

Automatic Weekly and Monthly Reports – PDF, WORD, or WEB

JANUARY 2009

Examine Alarm Data
Step 3: Fix Your “Bad Actor” Alarms!

• The “top 10” alarms usually make up 20% to 80% of the entire alarm system load
• Many different types of bad actor alarms
• All can be corrected.
“Bad Actor” Alarms: Expected Gain

• Average system load improvement is ~60% from resolving Bad Actor alarms

<table>
<thead>
<tr>
<th>PAS Bad Actor Alarm Work Process Results</th>
<th>Baseline Alarms</th>
<th>Reduction from PAS Bad Actor Recommendations</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>System 1</td>
<td>339,521</td>
<td>325,423</td>
<td>95.8%</td>
</tr>
<tr>
<td>System 2</td>
<td>225,668</td>
<td>133,307</td>
<td>59.1%</td>
</tr>
<tr>
<td>System 3</td>
<td>414,887</td>
<td>333,395</td>
<td>80.4%</td>
</tr>
<tr>
<td>System 4</td>
<td>64,695</td>
<td>46,749</td>
<td>72.3%</td>
</tr>
<tr>
<td>System 5</td>
<td>93,848</td>
<td>71,372</td>
<td>76.1%</td>
</tr>
<tr>
<td>System 6</td>
<td>79,434</td>
<td>72,935</td>
<td>91.8%</td>
</tr>
<tr>
<td>System 7</td>
<td>482,375</td>
<td>413,094</td>
<td>85.6%</td>
</tr>
<tr>
<td>System 8</td>
<td>644,487</td>
<td>593,904</td>
<td>92.2%</td>
</tr>
<tr>
<td>System 9</td>
<td>183,312</td>
<td>77,417</td>
<td>42.2%</td>
</tr>
<tr>
<td>System 10</td>
<td>106,212</td>
<td>38,566</td>
<td>36.3%</td>
</tr>
<tr>
<td>System 11</td>
<td>91,686</td>
<td>29,188</td>
<td>31.8%</td>
</tr>
<tr>
<td>System 12</td>
<td>39,305</td>
<td>8,625</td>
<td>21.9%</td>
</tr>
<tr>
<td>System 13</td>
<td>33,115</td>
<td>22,646</td>
<td>68.4%</td>
</tr>
<tr>
<td>System 14</td>
<td>44,527</td>
<td>24,882</td>
<td>55.9%</td>
</tr>
<tr>
<td>System 15</td>
<td>58,049</td>
<td>51,782</td>
<td>89.2%</td>
</tr>
<tr>
<td>System 16</td>
<td>13598</td>
<td>4138</td>
<td>30.4%</td>
</tr>
<tr>
<td>System 17</td>
<td>21071</td>
<td>8516</td>
<td>40.4%</td>
</tr>
<tr>
<td>System 18</td>
<td>20739</td>
<td>13152</td>
<td>63.4%</td>
</tr>
<tr>
<td>System 19</td>
<td>5567</td>
<td>2247</td>
<td>40.4%</td>
</tr>
<tr>
<td>System 20</td>
<td>1271</td>
<td>868</td>
<td>68.3%</td>
</tr>
</tbody>
</table>
Step 3: Bad Actor Alarms – Varieties

Chattering alarms
Fleeting alarms
Stale alarms
Duplicate alarms (configured)
Duplicate alarms (dynamic)
Nuisance diagnostic alarms (such as bad measurement)
Alarms that do not represent events requiring operator action

The methods for solving these are available and proven.
Step 4: Documentation and Rationalization

- Ensures your actual alarms comply with your alarm philosophy (operator actions, priorities, time to respond, etc.)
- Documents your alarms (Set Points, Causes, Consequences, Corrective Actions), creating a Master Alarm Database.

Fix problems while they are small
# Alarm Priority Determination

A simple, grid-based process:

<table>
<thead>
<tr>
<th>Impact Category</th>
<th>Severity NONE</th>
<th>Severity: MINOR</th>
<th>Severity: MAJOR</th>
<th>Severity: SEVERE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personnel Safety</strong></td>
<td>No injury or health effect</td>
<td>Any alarm for which Operator Action is the primary method by which harm to a person is avoided shall be configured at the highest DCS priority level.</td>
<td>Operating permit levels (e.g. NO$_x$, SO$_x$, stack opacity, particulates) or other mandates not exceeded. Local environmental effect not crossing fence line, no community complaints. Contained release with little, if any, clean up and negligible financial consequences. Internal or routine reporting requirements only.</td>
<td>Operating permit levels (e.g. NO$_x$, SO$_x$, stack opacity, particulates) or other mandates exceeded to a degree involving a reportable but not high-ranking incident. Single minor exceedance of statutory or prescribed limit. Contamination causes some non-permanent damage. Single or very few community complaints expected.</td>
</tr>
<tr>
<td><strong>Public or Environmental</strong></td>
<td>No effect</td>
<td>Operating permit levels (e.g. NO$_x$, SO$_x$, stack opacity, particulates) or other mandates not exceeded. Local environmental effect not crossing fence line, no community complaints. Contained release with little, if any, clean up and negligible financial consequences. Internal or routine reporting requirements only.</td>
<td>Operating permit levels (e.g. NO$_x$, SO$_x$, stack opacity, particulates) or other mandates exceeded to a degree involving a reportable but not high-ranking incident. Single minor exceedance of statutory or prescribed limit. Contamination causes some non-permanent damage. Single or very few community complaints expected.</td>
<td>Operating permit levels (e.g. NO$_x$, SO$_x$, stack opacity, particulates) or other mandates exceeded to a degree involving significant provincial reporting. Reporting characterized as an ATCO high ranking incident. Limited or extensive toxic release, crosses fence line. Impact involving the community, multiple complaints expected. Repeated exceedances of limits. Uncontained release of hazardous materials with environmental and 3rd party impact. Extensive cleanup measures or financial consequences.</td>
</tr>
<tr>
<td><strong>Generation Loss</strong></td>
<td>No effect</td>
<td>Unit derate of &lt;XX MW for &lt; YY HR</td>
<td>Unit derate of &gt;XX MW but less than a full generator</td>
<td>Unit outage of 1 or more generators for any length of time</td>
</tr>
<tr>
<td><strong>Generation Impact on Electrical Grid</strong></td>
<td>No effect</td>
<td>Generation loss or dip that is automatically compensated for by computerized grid load adjustment</td>
<td>Generation loss involving significant adjustment of grid resources, requiring human response in planning and intervention</td>
<td>Generation loss that is likely to produce brownout or cascade to blackout conditions</td>
</tr>
<tr>
<td><strong>Cost / Financial Loss / Down-time</strong></td>
<td>No loss</td>
<td>Event costing &lt;$10,000. Reporting required only at the department level</td>
<td>Event costing $10,000 to $100,000 Reporting required at the plant level</td>
<td>Event costing &gt;$100,000 Reporting required above the plant level</td>
</tr>
</tbody>
</table>
Alarm Priority Determination

Steps 2 and 3

From the Severity of Consequence Grid: NONE, MINOR, MAJOR, SEVERE, plus:

- How much **time** does the operator have to successfully respond and avoid the consequence?

<table>
<thead>
<tr>
<th>Time Available to Respond</th>
<th>Maximum Time To Respond</th>
<th>Consequence Severity: MINOR</th>
<th>Consequence Severity: MAJOR</th>
<th>Consequence Severity: SEVERE</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 30 Minutes</td>
<td>More than 30 Minutes</td>
<td>If possible, re-engineer the alarm so it has the characteristic of urgency.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 - 30 Minutes</td>
<td>10 to 30 minutes</td>
<td>Priority 3 (P3)</td>
<td>P3</td>
<td>P2</td>
</tr>
<tr>
<td>3 - 10 Minutes</td>
<td>3 to 10 minutes</td>
<td>P3</td>
<td>P2</td>
<td>P2</td>
</tr>
<tr>
<td>&lt;3 Minutes</td>
<td>Less than 3 minutes</td>
<td>P2</td>
<td>P1</td>
<td>P1</td>
</tr>
</tbody>
</table>

Determines Alarm Priority
The right tools save time and money

- **Document Alarms**
  - Causes
  - Consequences
  - Corrective Actions
  - Classification
- **Classify Alarms**
  - Process Performance
  - Equipment safety
  - Your Classification System
- **Rationalize Priorities**
  - Impact / Severity / Maximum Response Time
  - Priority and Trip Point for each process state
- **Template based work process**
  - Create templates from any alarm
  - Apply templates to any alarm
Step 5: Audit / Enforce Proper Alarm Settings

- Alarm Configuration security is often ineffective.
- “Alarm Creep” will occur after D&R unless positive steps are taken.
- Best Practice: Automatically audit alarm settings to ensure they are not improperly changed.

### Summary of Changes in Alarms Needing Management of Change (MOC)

<table>
<thead>
<tr>
<th>Type of Change</th>
<th>Quantity During Analysis Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm Enable State</td>
<td>79</td>
</tr>
<tr>
<td>Alarm Trip Points</td>
<td>181</td>
</tr>
<tr>
<td>Alarm Priority</td>
<td>92</td>
</tr>
<tr>
<td>Tag Range</td>
<td>121</td>
</tr>
<tr>
<td>Tag Execution Status</td>
<td>175</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>648</strong></td>
</tr>
<tr>
<td><strong>Average Per Day</strong></td>
<td><strong>5.6</strong></td>
</tr>
</tbody>
</table>
Alarm Audit and Enforce

Master Alarm Database

Periodically audit alarm values from DCS, compare to Master Alarm database

Automatically Generate Regular Exception Reports

Optional and with Control: Enforce proper alarm settings to DCS

Server
Step 6: Implement Real Time Alarm Management

• Real-time, dynamic Alarm Management techniques are used to reduce inappropriate alarms caused by changing operating conditions. These techniques include:

  – **Advanced Alarm Shelving** (Temporarily suppress alarms safely, with proper tracking and control)
  – **State-Based Alarming** (Sets of multiple alarm settings that are optimum and correct for all your operating conditions. HIGHLY EFFECTIVE for BATCH PROCESSES)
  – **Alarm Flood Suppression**
    (Minimize these hazardous conditions!)
  – **Operator Alert Systems**
    (A toolset for notification of things that should not be alarms.)
Step 7: Control and Maintain Your Improved System

• **CONTROL** - Insure that gains are not lost over time. Transition responsibilities. Continue to analyze.

• Ensure Proper Management of Change

On-Going KPIs
Justifying Alarm Management

• In the past:
  • Site analyses proved that operators had to ignore hundreds to thousands of alarms
  • Seen as a risk mitigation effort
  • ROI is speculative, measured in “avoided incidents” or “reduced severity of incidents,” which are difficult justification concepts.
  • Many major, industry-leading companies perceived the value of and were early adopters, as far back as the mid-1990s.
  • Some claims of significant loss avoidance
  • Later 1990s and 2000s, alarm management became a widespread area of industry concern – a hot topic – many more companies began improvement programs.

• 2009: The ISA-18.2 Standard is issued – a game changer
The ANSI/ISA 18.2 Alarm Management Standard

- Management of Alarm Systems for the Process Industries
- A vital and essential next step for alarm management
- Began in 2003
- Released June 2009
- It includes only **"the WHAT"**:
  - A framework of alarm management life cycle steps and activities
  - Mandatory and recommended practices
  - Additional content will be published in follow-up “Technical Reports”
- It **does not have** **"the HOW"**
  - Detailed or specific “How to” guidance
  - Work practice examples
  - Specific method recommendations or details

Email bhollifield@pas.com for a white paper on understanding and applying ISA-18.2
ISA-18.2 Application

• Does ISA-18.2 Apply to You?
  – YES – if you have a DCS, SCADA systems, PLCs, or Safety Systems, or anything where an operator responds to alarms!
  – Petrochemical, Chemical, Refining, Platform, Pipelines, Power Plants, Pharmaceuticals, Mining & Metals. Also for continuous, batch, semi-batch, or discrete processes.

• Grandfathering
  – 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.”
ISA-18.2 Regulatory Impact

• ISA-18.2 is a “recognized and generally accepted good engineering practice” (RAGAGEP)

• OSHA and other agencies have “general duty” clauses
  – “The employer shall document that equipment complies with recognized and generally accepted good engineering practices”

• Regulatory agencies ARE TAKING NOTICE of ISA-18.2

• A regulated industry can be expected to either comply or show they are doing something “just as good or better”

• The OSHA Regional PSM Coordinators and the CSB (Chemical Safety Board) now have approval to internally distribute ISA-18.2 to their inspectors - to cite it in investigations and for enforcement reasons.

Standards become de facto regulations.
ISA-18.2 Regulatory Impact

• The IEC officially adopted ISA-18.2 as a combination international IEC/ISA standard (IEC 62682 Ed. 1.0) in late 2014.
• PHMSA is aware of ISA-18.2, and the API-1167 Recommended Practice for Pipeline Alarm Systems (December 2010) is in close alignment with ISA-18.2.
• From an OSHA Presentation, October 2009 at the ISA Expo
ISA-18.2 Regulatory Impact Examples

More examples:

OSHA takes RAGAGEP seriously!
ISA-18.2 Regulatory Impact

• September 30, 2009: OSHA fines BP Texas City an additional $87 Million from the 2005 explosion

• PDF documents are available at www.galvestondailynews.com

• The OSHA documents reference RAGAGEP
  – specifically citing failure to follow ISA Standards and ASME codes as the basis for the fines
ISA 18.2 – High Level

• The definition of an alarm is:
  – An audible and/or visible means of indicating to the operator an equipment malfunction, process deviation, or abnormal condition requiring a response

• Alarm systems should be reserved for items meeting this definition

• There is often confusion in alarm terminology
  – ISA 18.2 contains excellent definitions of terms to provide a common language for discussion of alarm system arcana

If it doesn’t call for an operator response, then it isn’t an alarm!
ISA 18.02: Seven simple steps? Not exactly...

We engineers love complicated diagrams!
ISA 18.2 Life Cycle Stages

- Philosophy
- Identification
- Rationalization
- Detailed Design
- Implementation
- Operation
- Maintenance
- Monitoring / Assessment
- Management of Change
- Audit

This is a “requirements and document structure.” It is **NOT** an efficient step-by-step project plan – particularly for existing systems!
ISA 18.2 – Mandatory “Shall” Elements

• **Alarm Philosophy** with defined responsibilities, criteria for determining and classifying alarms, the basis for alarm prioritization, and other elements

• **Practical Compliance:** Step-by-step instructions for creating a *comprehensive alarm philosophy document* are contained here.

• **Alarm System Performance Monitoring** with defined targets and monitoring for unauthorized change

• **Practical Solution:** Automated software monitoring and reporting of KPIs, such as PlantStateSuite – with web-based one-click reports

<table>
<thead>
<tr>
<th>Metric</th>
<th>Target Value</th>
<th>Target Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Announced Alarms per Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Announced Alarms Per Day per Controller Position</td>
<td>~50 alarms per day</td>
<td>~300 alarms per day</td>
</tr>
<tr>
<td>Announced Alarms Per Hour per Controller Position</td>
<td>~6 (average)</td>
<td>~12 (average)</td>
</tr>
<tr>
<td>Announced Alarms Per 10 Minutes per Controller Position</td>
<td>~1 (average)</td>
<td>~2 (average)</td>
</tr>
<tr>
<td>Percentage of hours containing &gt;30 alarms</td>
<td>~&lt;1%</td>
<td></td>
</tr>
<tr>
<td>Percentage of 10-minute periods containing &gt;5 alarms</td>
<td>~&lt;1%</td>
<td></td>
</tr>
<tr>
<td>Maximum number of alarms in a 10 minute period</td>
<td>~10 or less</td>
<td></td>
</tr>
<tr>
<td>Percentage contribution of the top 10 most frequent alarms to the overall alarm load</td>
<td>~&lt;5% to 5% maximum, with action plans to address deficiencies.</td>
<td></td>
</tr>
<tr>
<td>Quantity of chattering and fleeting alarms</td>
<td>Zero, action plans to correct any that occur.</td>
<td></td>
</tr>
</tbody>
</table>

**State Alarms**

- Less than 5 present on any day, with action plans to address.

**Announced or Configured Priority Distribution**

- 3 priorities: -80% P3, -15% P2, -5% P1
- 4 priorities: -80% P3, -15% P2, -5% P1, -5% P1 (Priority Critical). Other special-purpose priorities are excluded from the calculations.

**Unauthorized Alarm Suppression**

- Zero alarms suppressed outside of controlled or approved methodologies.

**Improper Alarm Attribute Change**

- Zero alarm attribute changes outside of approved methodologies or NOC.
ISA 18.2 – Mandatory “Shall” Elements

- **Alarm Rationalization** shall be used to determine:
  - Alarm type and priority
  - Alarm setpoint or logical condition
  - Documentation requirements
  - Classification

- Creation of an up-to-date *Master Alarm Database* is required

- **Practical Solution**: Perform rationalization in accordance with documented and efficient best practices, and have an online, up-to-date Master Alarm Database with multiple capabilities created by the *PlantState Suite Alarm Rationalization Module*
ISA 18.2 – Mandatory “Shall” Elements

• Training For Operators:
  – Initial training with documentation
  – Training for alarm modifications
  – Alarm response procedures

• Practical Compliance:
  – Easily provide operators with access to all of the alarm documentation in the Master Alarm Database via web access or embedding into the control system HMI.

---

**Alarm: PVHI**
**Class:** Minor Financial
**Priority:** 3
**Setting:** 320 deg F
**Response Time:** <15 min

**Alarm Consequences:**
- Off spec Production
- Lowered efficiency

**Alarm Causes:**
- Excess steam
- Pressure excursion
- Insufficient reflux
- Feed composition variance

**Corrective Actions:**
- Adjust base steam rate
- Check pressure and feed parameters vs. SOP 468-1
- Adjust reflux per computation; check controller for cascade mode
- Check feed composition
ISA 18.2 – Mandatory “Shall” Elements

• Alarm system testing requirements

• The HMI Interface has a variety of requirements about alarm depiction, including
  – Mandatory control of alarm suppression
  – Provision of alarm shelving
  – Provision of specific information about shelved and out of service alarms.

• **Practical Compliance:** PlantState Suite Alarm Shelving Module (and look into *High Performance HMI*)

• An MOC Process for alarms is required
  – **Practical solution:** documentation supported by automated change monitoring In PlantStateSuite
New Concept: Alarm Classification

- **Alarm Classification** is to track administrative requirements. Examples:
  - Some alarms may require periodic refresher training and others may not
  - The same could be true for testing, maintenance, reporting, HMI, etc
- Alarm **classes** are defined and used to keep track of administrative requirements
- Alarm classification is **NOT** alarm priority or alarm type
- There are **no specific classes** required and **no minimum number** of class definitions specified in ISA-18.2
- We recommend the “**keep it simple**” approach and to have a very simple class structure with minimum variations
- **Practical Compliance:** The PSS Rationalization Module has built-in capabilities for adding a custom field for “Classification” and easily replicating the appropriate classification to the correct alarms

![Alarm Classification Diagram](image)
New Concept: Highly Managed Alarms

• ISA-18.2 specifically defines only one class of alarms, namely “Highly Managed Alarms.”

• There is no requirement to have any alarms of this class.

• If you designate that you do have some, then you must perform 17 different explicitly identified ISA 18.2 administrative requirements!

• There is no benefit from using this specific ISA-18.2 classification!

• Practical Compliance: Instead, if you have a few very important alarms for which you have several administrative requirements, make your own class for them and document your own specific practices for them.
Obtain the document from ISA.org!

RESISTANCE IS FUTILE

SCHOOL STARTS SEP 4 RESISTANCE IS FUTILE

RESISTANCE IS FUTILE

ALARM MANAGEMENT IS NO LONGER OPTIONAL!

TIME TO GET STARTED
Avoid getting to know...

...your regulatory inspectors really well

They just want to help you
And Don’t Forget the Window to Alarms

Let’s do something about these very poor operator HMI’s!

But that’s another topic and entirely... on how to do an HMI right!
Summary

• Poorly performing alarm systems are contributing factors to major accidents and poor operating performance

• Proper Alarm System Management and Alarm System Performance is essential to maximum-efficiency operations

• Effective operator HMIs are a key factor in incident mitigation

• The solutions to the problems are well known and fully documented

• Don’t re-invent the wheel! These methods are proven in hundreds of successful projects.

ANSI/ISA 18.2
Management of Alarm Systems for the Process Industries

“WHAT” to do...

“The Alarm Management Handbook
A Comprehensive Guide
Second Edition

Practical and proven methods to optimize the performance of alarm management systems

By Bill Hollifield & Eddie Habibi
Pampered by Jim Pinkel
PAS Can Help

• Private, company-specific workshops are available, focusing on your own data and systems
• Alarm Management and HMI Services
  – Alarm Philosophy Development
  – Alarm System Analysis, Reporting, & Benchmarking
  – Bad Actor Resolution
  – Alarm Documentation and Rationalization
  – Advanced Alarm Software
  – High Performance HMI Philosophy and Style Guide Development
  – Assessment and benchmarking of existing HMIs
  – Design and creation of a HIGH PERFORMANCE HMI
• Proper Alarm System Configuration
• Alarm Management and HMI go together
• Books are available at pas.com and Amazon.com
Questions

Any Questions?

Email Bill for white papers on both:

*Understanding and Applying ISA-18.2: Alarm Management*

*and*

*High Performance HMI*

- Bill Hollifield (Bhollifield@pas.com)
- www.pas.com