Intelligent Alarm Management

Agenda

- Understanding Alarm Issues
  - History
  - Top 7 alarm problems
  - Consequences of poorly implemented alarm system
- Improving Operator and Alarm Effectiveness
  - Standards
  - Continuous Improvement Model for Alarm Management
  - Benefits of an Alarm Improvement Project
- Proficy Technology for Alarm Management
  - HMI Situational Awareness
- Q&A
“Alarm management is one of the most undervalued and underutilized aspects of process automation today. In most cases, alarm systems do not receive the attention and resources that are warranted. This is understandable, because alarming appears to be a deceptively simple activity. Many plants still use the alarm management philosophy developed by the engineering firm when the plant was built.

As alarm systems become less effective, they diminish the effectiveness of all automation.”

Larry O'Brien, Dave Woll – ARC, Alarm Management Strategies
Why are modern alarming systems ineffective?

- Outdated alarm management philosophy
- SCADA/HMI Systems make over- alarming all too easy
  - No discipline required
- Problem = too much information for operators
- Poorly designed alarm system results in negative:
  - Plant operations
  - Performance
  - Profitability
  - Safety
- Problem compounded by lack of leadership and ownership
Control Panels to Control Systems

- DCS/SCADA has replaced panel control rooms
- Number of tags has increased 100x
- Space to display process information has decreased
- Area of responsibility for operators has increased

Decreasing display area per operator
Increasing point count per operator
Too Many Alarms

- Panel alarms were limited and expensive to add
- DCS/SCADA alarms are built into tag with many alarms per tag
- Many alarms are enabled because they are “free”
Symptoms

- Alarm activations occur w/o need for operator action
- There is no plant-wide philosophy for the alarm system
- There are no clear guidelines for when to add an alarm and how to do it
- There are no controls for removing existing alarms
- Operating procedures are not tied to alarm activations
- When alarms activate, the operator is not always sure what to do about them
- Seemingly routine operations produce alarms that serve no useful purpose
- Minor operating upsets produce a significant number of alarm activations
- Significant operating upsets produce an unmanageable # of alarm activations
- Some alarms remain active for long periods of time
- When nothing is wrong, there are active alarms
- Alarms often occur at a rate that operators cannot keep up with
- Too many alarms with a high priority
- Lots of alarms switch in and out quickly and provide no value to the operator
- Important alarms are missed during incidents
- Records of why alarms were designed the way they are poor or missing
- Alarm testing procedures or records are poor or missing
Top 7 Alarm Problems
Nuisance Alarms
Top 7 Alarm Problems

1. Nuisance alarms
   - Alarms that trigger when no abnormal condition exists or when no operator action is required.
   - Desensitize the operator.
   - Reduce the response to real alarms.
   - Often caused by maintenance issues or improper limits.
Standing Alarms
Top 7 Alarm Problems

2. Standing alarms
   - Tags that remain in alarm for extended periods.
     - Ack’d but not cleared for between 8 & 12 hours (one shift)
     - Ack’d but not cleared for 24 or more hours
   - No operator action is required.
   - Do not clear after operator action has been taken.
   - Clutter the alarm system
Top 7 Alarm Problems

3. Alarm Floods
   - Multiple alarms in a short time, usually triggered by a single event
     - 10 consecutive time periods of $\geq 10$ alarms within 10m
     - $\geq 100$ alarms within 10m regardless of how often
     - $\geq 10$ alarms occurring within any 10m time period until rate drops below 5 alarms in 10m period
   - Dangerous problem with alarm systems.
   - Most complex alarm problem to solve.
   - Potential to overwhelm the operator.
Alarms With No Response

IGNORE THIS SIGN.
Top 7 Alarm Problems

4. Alarms without response
   - Cause and/or response not documented for the operator
   - Alarms that are intended as alerts
   - Pre-alarm alarms (e.g., HI alarm to indicate that a HIHI alarm may activate)
Alarms With Wrong Priority
Top 7 Alarm Problems

5. Alarms with the wrong priority
   – Priority not used consistently
   – Too many alarms with a high priority
Top 7 Alarm Problems

6. Out of Service Alarms
   - Equipment that is not running which still produces alarms
   - Alarms taken out of service with authorization
   - Alarms that have been shelved/suppressed but which have not been revisited for unshelving.
REDUNDANCY

The Same Thing Over and Over Again

REDUNDANCY

The Same Thing Over and Over Again

REDUNDANCY

The Same Thing Over and Over Again

REDUNDANCY

The Same Thing Over and Over Again

REDUNDANCY

The Same Thing Over and Over Again
Top 7 Alarm Problems

7. Redundant Alarms
   - Multiple alarms to indicate the same action
Top 7 Alarm Problems

1. Nuisance Alarms
2. Standing Alarms
3. Alarm Floods
4. Alarms Without Response
5. Alarms With The Wrong Priority
6. Out-of-Service Alarms
7. Redundant Alarms
1. No plantwide philosophy or design exists
2. Operator training inadequate
3. Operator displays poorly designed
4. Inadequate attention paid to plant practices and procedures
5. Alarm limits and priorities rarely re-visited for validity
6. Controls platforms contribute to overuse and overly complex alarm system designs
7. Alarms are constantly added (e.g., HazOps, etc.) but rarely deleted
Consequences of Ineffective Alarm Mgmt

http://www.youtube.com/watch?v=c9JY3eT4cdM
# Consequences of Ineffective Alarm Mgmt

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deviation Alarms in Regulated Industries</td>
<td>$2 to $6K Per Alarm</td>
</tr>
<tr>
<td>US Petrochemical Industry Losses:</td>
<td>$10-$20 Billion</td>
</tr>
<tr>
<td>Annual Automation Industry Equipment Damage:</td>
<td>Over $2 Billion</td>
</tr>
<tr>
<td>Typical Cost of Unplanned Incident:</td>
<td>$100K to $1 Million</td>
</tr>
<tr>
<td>Major Incidents in Refining Industry Average Cost:</td>
<td>$80 Million</td>
</tr>
</tbody>
</table>
Break
ALARM DEFINITION
What is an alarm?

Four Guiding Principles:

• Requires Operator Action
• Provides enough time for success
• Provides information
• Alarm only important things
Operator Action

• Primary Action examples:
  – Putting controller in manual
  – Starting a pump
  – Shutting a valve
  – Reducing a controller setpoint
  – Breaking a cascade loop
  – Waiting longer to initiate a task or initiating a task earlier

• Secondary Action examples:
  – Communicating with others
  – Scheduling something contemporaneously
  – Taking a note of an event
  – Thinking about something
Time and Dynamics
Time and Dynamics

We really don’t want to be very far into this region.

We’d like to stay in this region.

We’d like to stay in this region.

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An Event

- Normal
- More Normal
- Abnormal

1. Normal
2. Abnormal (no alarms)
3. Abnormal (alarms)
4. Cause Identified
5. Solution Decided
6. Solution Implemented
7. Plant Responds

Time

Consequence Line
Timeline of an event

Failure Occurrence in the Process or in the Safeguarding system

Failure is detected

System internal Diagnostic time

Time for Corrective action

Time for reaction of process on the corrective action

Safe status of the process is assured

Fault not managed

Cushion

See
Understand
Decide
Act

Fault tolerance time

Process safety time

Time to manage fault
STANDARDS AND METHODOLOGY FOR IMPROVEMENT
How to Improve

“ARC believes that a truly effective alarm management strategy must be approached in the context of a Six-Sigma DMAIC process, incorporating a definition of the alarm management scheme desired, measurement, and auditing of the existing alarm management philosophy. This is followed by an analysis of the findings and a path toward improvement that is augmented by a constant reevaluation and continuous improvement process.”

Tom Fiske, ARC Advisory Group
## Classical vs. 6σ Quality

### The Classical View of Quality

**“99% Good” (3.8σ)**

- 20,000 lost articles of mail per hour
- ~15 minutes each **day** of unsafe drinking water
- 5,000 incorrect surgical operations per week
- 2 short or long landings at most major airports **daily**
- 200,000 wrong drug prescriptions each year
- 7 hours without electricity each **month**

### The Six Sigma View of Quality

**“99.99966% Good” (6σ)**

- 7 lost articles of mail per hour
- 1 minute every **7 months** of unsafe drinking water
- 1.7 incorrect surgical operations per week
- 1 short or long landing at most major airports every **5 years**
- 68 wrong drug prescriptions each year
- 1 hour without electricity every **34 years**
ALARM PROBLEMS ARE PROCESS DEFECTS!

1. Nuisance Alarms
2. Stale Alarms
3. Alarm Floods
4. Alarms Without Response
5. Alarms With The Wrong Priority
6. Out-of-Service Alarms
7. Redundant Alarms
Six Sigma - DMAIC

- **Define** relates to philosophy development and rationalization
- **Measure** relates to determining alarm behavior and alarm effectiveness
- **Analyze** relates to root cause analysis and performance benchmarking
- **Improve** relates to the remedial action necessary to align the prevailing implementation with the alarm philosophy
- **Control** relates to alarm execution
Standards and Best Practices

EEMUA 191
ISA 18.2
ISA 18.2 Alarm System Management Lifecycle

Philosophy

Identification

Rationalization

Detailed Design

Implementation

Operation

Maintenance

Management of Change

Monitoring & Assessment

Audit
ISA 18.2 Alarm System Management Lifecycle

- Philosophy
  - Identification
  - Rationalization
  - Detailed Design
  - Implementation
  - Operation
  - Maintenance

- Management of Change
- Monitoring & Assessment
- Audit

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Alarm Management and Philosophy Development

• Framework to establish the criteria, definitions & principles for all alarm lifecycle stages

• Alarm philosophy ensures that facilities can achieve:
  – Consistency across process equipment
  – Consistency with risk management goals & objectives
  – Agreement with good engineering practices
  – Design & management of the alarm system that supports an effective operator response
Alarm Philosophy

- **Philosophy defines and clarifies:**
  - **Operator-centric items**
    - Responsible operator
    - Qualified operator
    - Operator ownership
    - Alarms mean action
    - Activations provide sufficient time
    - Priority guides
    - Alarm response information
    - Appropriate design

- **Plant-centric items**
  - Alarm system not for design or maintenance inadequacies, poor procedures, unduly stressful operations, operation outside of proper design conditions, etc.
  - Broken and missing equipment
  - Unusual Plant Operation
  - Unusual Plant Situations
  - Recognition of limitations of alarm system operation
## Elements in Philosophy

<table>
<thead>
<tr>
<th>Alarm Philosophy Contents</th>
<th>Required</th>
<th>Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose of alarm system</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Definitions</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>References</td>
<td></td>
<td>X</td>
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<tr>
<td>Roles and responsibilities for alarm management</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Alarm design principles</td>
<td>X</td>
<td></td>
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<tr>
<td>Rationalization</td>
<td>X</td>
<td></td>
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<tr>
<td>Alarm class definition</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Highly managed alarms</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>HMI design guidance</td>
<td>X</td>
<td></td>
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<tr>
<td>Alarm setpoint determination</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Prioritization method</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
## Elements in Philosophy (con’t)

<table>
<thead>
<tr>
<th>Alarm Philosophy Contents</th>
<th>Required</th>
<th>Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm system performance monitoring</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Alarm system maintenance</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Testing of alarms</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Approved advanced alarm management techniques</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Alarm documentation</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Implementation guidance</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Management of change</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Training</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Alarm history preservation</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Related site procedures</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Special Alarm Design Considerations</td>
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<td>X</td>
</tr>
</tbody>
</table>
Break
Stage 2 - Identification
ISA 18.2 Alarm System Management Lifecycle

- Philosophy
- Identification
  - Rationalization
  - Detailed Design
  - Implementation
  - Operation
  - Maintenance
- Management of Change
- Monitoring & Assessment
- Audit
A Good Alarm

- **Relevant.** They are not spurious or of low operational value
- **Unique.** They do not duplicate another alarm
- **Timely.** They do not actuate too early before a response is required, nor too late for the operator to properly respond
- **Prioritized.** They indicate the importance to the operator for successfully managing the underlying problem
- **Understandable.** They have a message that is clear and easily recognized
- **Guiding.** They facilitate the solution
Stage 3 - Rationalization
ISA 18.2 Alarm System Management Lifecycle

- Philosophy
- Identification
- Rationalization
- Detailed Design
- Implementation
- Operation
- Maintenance
- Management of Change
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Stage 3 - Alarm Rationalization

• Alarm Rationalization
  – **Optimizes** the alarm database for safe and effective operation
  – **Results** in reduction of # of alarms, prioritization, alarm organization, # alarms assigned to operators and alarm presentation
## Alarm Rationalization (example 1)

<table>
<thead>
<tr>
<th>Severity Consequence</th>
<th>None</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>Critical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>0</td>
<td>25</td>
<td>75</td>
<td>100</td>
<td>300</td>
</tr>
<tr>
<td>Environmental</td>
<td>0</td>
<td>75</td>
<td>100</td>
<td>150</td>
<td>250</td>
</tr>
<tr>
<td>Financial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Time Available (in minutes for effective action)

- **≤ 3**: Emergency
- **> 3 but ≤ 10**: High
- **> 10 but ≤ 30**: Medium
- **> 30**: Low

### Priority (urgency-only priority assignment)

<table>
<thead>
<tr>
<th>Priority</th>
<th>Breakpoint Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>From 500 and above</td>
</tr>
<tr>
<td>High</td>
<td>From 350 up to 499</td>
</tr>
<tr>
<td>Medium</td>
<td>From 250 up to 349</td>
</tr>
<tr>
<td>Low</td>
<td>From 100 up to 249</td>
</tr>
<tr>
<td>[Might not be an alarm?]</td>
<td>0 up to 99</td>
</tr>
</tbody>
</table>

### Multiplier (multiplies consequence-severity values)

<table>
<thead>
<tr>
<th>Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4</td>
</tr>
<tr>
<td>1.2</td>
</tr>
<tr>
<td>1.0</td>
</tr>
<tr>
<td>0.9</td>
</tr>
</tbody>
</table>

**Consequence X Time = Priority**
Alarm Rationalization (example 2)

1. Start
   - If the operator does not respond effectively to this potential alarm, what is the probability of:
     - Very serious outcome (death or serious injury)
       - High
         - How quickly must operator respond?
           - Rapid (< 5 min)
       - Medium
         - How quickly must operator respond?
           - Medium (5-30 min)
           - Long (> 30 min)
     - Sorous outcome (serious equipment or environmental damage)
       - Low
         - How quickly must operator respond?
           - Rapid (< 5 min)
       - High
         - How quickly must operator respond?
           - Medium (5-30 min)
           - Long (> 30 min)
     - Relatively moderate outcome (significant impact on products)
       - Low
         - How quickly must operator respond?
           - Rapid (< 5 min)
       - High
         - How quickly must operator respond?
           - Medium (5-30 min)
           - Long (> 30 min)
         - Medium
           - How quickly must operator respond?
             - Medium (5-30 min)
             - Long (> 30 min)
         - Low
           - How quickly must operator respond?
             - Rapid (< 5 min)
             - Medium (5-30 min)
             - Long (> 30 min)
2. No particular outcome (or no operator action required)
3. Could this information be useful for post event analysis?
   - Yes
     - JOURNAL
   - No
     - NO ACTION
Example Alarm Redesign Results

Start with 154 alarms
- 62 (of the 154) deleted outright. They were unnecessary.
- 59 (of remaining 92) had documentation errors that were corrected
- 52 (45 from 92 remaining, 7 from 62 deleted) changed to alerts
- 50 (of the 47 remaining, some more than one each) had configuration corrections
- 26 (of the 47 remaining) had their priority changed
- 19 (of the 47 remaining) were reduced to 7 alarms
- 7 (of the 35 remaining) were reduced to a single alert
- 3 (of the 28 remaining) had the alarm settings changed
- 2 new alarms were added (making a total of 30 alarms)
- 1 new alert was added
- 14 (of the 30 alarms) were “toggled” on or off based on plant state

Results:
- 30 configured alarms
- 53 alerts

80% REDUCTION
Top 10 Reasons to Rationalize

1. To make sure operators get the information they need; formatted so they can recognize what’s happening, its importance, and the appropriate action.

2. To reduce the total number of alarms to the minimum necessary to operate the plant safely and efficiently.

3. To prioritize alarms by importance or significance in terms of risk (safety, environmental, operational, and cost) and in relationship to other alarms.

4. To improve presentation, organization and availability of alarms for safe and efficient operation of the facility and for effective troubleshooting.

5. To reduce the number of alarms occurring during abnormal situations to the minimum required to diagnose, identify and understand the indicated condition.
Top 10 Reasons to Rationalize (con’t)

6. To approach the “black screen” concept: Bring the number of alarms during normal operation to near zero by reducing standing, chattering, nuisance, and transient alarms; optimizing alerts; managing pre-alarms; improving field instruments; identifying process issues; etc.

7. To validate all alarm parameters including action, setpoint, deadband, test frequency, etc.

8. To verify alarm performance parameters including detection time, required action, appropriateness of action, required time to perform action, training, procedures, help screens or manuals, etc.

9. To identify process design issues and faulty field instrumentation.

10. To document the alarm system for internal use and regulatory compliance.
Stage 4 – Detailed Design
Stage 5 – Implementation
ISA 18.2 Alarm System Management Lifecycle

- Philosophy
- Identification
- Rationalization
- Detailed Design
  - Implementation
  - Operation
  - Maintenance

Management of Change

Monitoring & Assessment

Audit

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## Implementation – Key Concepts

<table>
<thead>
<tr>
<th><strong>Scope</strong></th>
<th>Must implement a complete operator area at the same time.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Timing</strong></td>
<td>Implementation can be timed for plant shutdown or done “on the fly”.</td>
</tr>
<tr>
<td><strong>Use your simulator</strong></td>
<td>Plants with reasonably good simulators have the ability to both test the alarm system performance <em>and</em> train operators on the new alarm system itself.</td>
</tr>
<tr>
<td><strong>Implementation is more than changing alarms</strong></td>
<td>All of the plant infrastructure that changes to support the new alarm system is included. The short list includes graphics (i.e., HMI), procedures, and training.</td>
</tr>
</tbody>
</table>
Implementation Steps

- Obtain all of the management of change (MOC) authority to proceed
- Translate the design for the alarms to the proper PCS (primary control system) configuration code ready for download
- Prepare the enhanced alarm capabilities
- Prepare additions and modifications to the process graphics
- Prepare and review training materials
- Train operators and other personnel
- Update all plant documentation
- Update and put into practice all other complementary plant infrastructure changes such as maintenance, incident investigations, and so on
Implementation Steps (cont'd)

- Download and activate the new configuration and graphics changes
- Replace old procedures and guidelines with the new ones
- Download and activate all remaining changes
- Verify all of the changes
- Review the operability to ensure things are working as designed and that your “as-designed” fulfills the enterprise requirements for good and safe operation
- Obtain all MOC approvals to put new design into service
Cutover and Testing (liftoff!)
Stage 6 – Operation
ISA 18.2 Alarm System Management Lifecycle

- Philosophy
- Identification
- Rationalization
- Detailed Design
- Implementation
- Operation
- Maintenance
- Monitoring & Assessment
- Management of Change
- Audit
Stage 7 – Maintenance
ISA 18.2 Alarm System Management Lifecycle

1. Philosophy
2. Identification
3. Rationalization
4. Detailed Design
5. Implementation
6. Operation
7. Maintenance
8. Monitoring & Assessment
9. Management of Change
10. Audit

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Stage 8 – Monitoring and Assessment
ISA 18.2 Alarm System Management Lifecycle

- Philosophy
- Identification
- Rationalization
- Detailed Design
- Implementation
- Operation
- Maintenance
- Monitoring & Assessment
- Management of Change
- Audit
Stage 9 – Management of Change
ISA 18.2 Alarm System Management Lifecycle

- Philosophy
- Identification
- Rationalization
- Detailed Design
- Implementation
- Operation
- Maintenance
- Management of Change
- Monitoring & Assessment
- Audit
Stage 10 – Audit
ISA 18.2 Alarm System Management Lifecycle

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

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Alarm Management Lifecycle Loops

- Philosophy
  - Identification
    - Rationalization
    - Detailed Design
    - Implementation
      - Operation
        - Maintenance
  - Management of Change
    - Monitoring & Assessment
      - Audit
# Alarm Mgmt Lifecycle Stage Inputs and Outputs

<table>
<thead>
<tr>
<th>Alarm Mgmt Lifecycle Stage</th>
<th>Activities</th>
<th>Clause #</th>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Philosophy</td>
<td>Define processes for alarm management and ASRS.</td>
<td>6, 7</td>
<td>Objectives and standards.</td>
</tr>
<tr>
<td>B</td>
<td>Identification</td>
<td>Determine potential alarms.</td>
<td>8</td>
<td>PHA report, SRS, P&amp;IDs, operating procedures, etc...</td>
</tr>
<tr>
<td>C</td>
<td>Rationalization</td>
<td>Rationalization, classification, prioritization, and documentation.</td>
<td>9</td>
<td>Alarm philosophy, and list of potential alarms.</td>
</tr>
<tr>
<td>D</td>
<td>Detailed Design</td>
<td>Basic alarm design, HMI design, and advanced alarming design</td>
<td>10, 11, 12</td>
<td>Master alarm database, alarm design requirements.</td>
</tr>
<tr>
<td>E</td>
<td>Implementation</td>
<td>Install alarms, initial testing, and initial training.</td>
<td>13</td>
<td>Completed alarm design and master alarm database.</td>
</tr>
<tr>
<td>F</td>
<td>Operation</td>
<td>Operator responds to alarms, refresher training.</td>
<td>14</td>
<td>Operational alarms, alarm response procedures.</td>
</tr>
<tr>
<td>G</td>
<td>Maintenance</td>
<td>Maintenance repair and replacement, periodic testing</td>
<td>15</td>
<td>Alarm monitoring reports and alarm philosophy.</td>
</tr>
<tr>
<td>H</td>
<td>Monitoring &amp; Assessment</td>
<td>Monitoring alarm data and report performance</td>
<td>16</td>
<td>Alarm data and alarm philosophy.</td>
</tr>
<tr>
<td>I</td>
<td>Management of Change</td>
<td>Process to authorize additions, modifications, and deletions of alarms.</td>
<td>17</td>
<td>Alarm philosophy, proposed changes.</td>
</tr>
<tr>
<td>J</td>
<td>Audit</td>
<td>Periodic audit of alarm management processes.</td>
<td>18</td>
<td>Standards, alarm philosophy and audit protocol.</td>
</tr>
</tbody>
</table>
Lifecycle Entry Points
Alarm Lifecycle Entry Points

Philosophy

Identification

Rationalization

Detailed Design

Implementation

Operation

Maintenance

Management of Change

Monitoring & Assessment

Audit
ALARM SYSTEM METRICS
## Alarm Configuration Metrics

<table>
<thead>
<tr>
<th>Number of installed alarms per operator</th>
<th>Number Configured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 100</td>
<td>Simple technology OK. Places a large SAFETY load on operator.</td>
</tr>
<tr>
<td>100 – 300</td>
<td>Mixed annunciator and computer alarms can be effective. Need other tools for basic problems.</td>
</tr>
<tr>
<td>300 – 1000</td>
<td>Need sophisticated tools with powerful logical tools. Philosophy is very important.</td>
</tr>
<tr>
<td>Over 1000</td>
<td>Major system. Requires significant investment and industry best practices throughout.</td>
</tr>
</tbody>
</table>
## EEMUA 191 Recommended Priority Allocation

<table>
<thead>
<tr>
<th>Priority of Alarm</th>
<th>Number Configured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical (emergency)</td>
<td>Approx. 20 (total)</td>
</tr>
<tr>
<td>High</td>
<td>5% of total configured</td>
</tr>
<tr>
<td>Medium</td>
<td>15% of total configured</td>
</tr>
<tr>
<td>Low</td>
<td>80% of total configured</td>
</tr>
</tbody>
</table>
### Alarm Benchmarks

<table>
<thead>
<tr>
<th></th>
<th>EEMUA</th>
<th>Oil &amp; Gas</th>
<th>Petro Chem</th>
<th>Power</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Alarms per Day</strong></td>
<td>144</td>
<td>1200</td>
<td>1500</td>
<td>2000</td>
<td>900</td>
</tr>
<tr>
<td><strong>Average Standing Alarms</strong></td>
<td>9</td>
<td>50</td>
<td>100</td>
<td>65</td>
<td>35</td>
</tr>
<tr>
<td><strong>Peak Alarms per 10m</strong></td>
<td>10</td>
<td>220</td>
<td>180</td>
<td>350</td>
<td>180</td>
</tr>
<tr>
<td><strong>Average Alarms 10m Interval</strong></td>
<td>1</td>
<td>6</td>
<td>9</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td><strong>Distribution % (L/M/H)</strong></td>
<td>80/15/5</td>
<td>25/40/35</td>
<td>25/40/35</td>
<td>25/40/35</td>
<td>25/40/35</td>
</tr>
</tbody>
</table>
### EEMUA 191 Maximum Activation Rates by Priority

<table>
<thead>
<tr>
<th>Priority</th>
<th>Target Maximum Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>VERY infrequently</td>
</tr>
<tr>
<td>High</td>
<td>&lt; 5 per shift period</td>
</tr>
<tr>
<td>Medium</td>
<td>&lt; 2 per hour</td>
</tr>
<tr>
<td>Low</td>
<td>&lt; 10 per hour</td>
</tr>
</tbody>
</table>
**EEMUA 191 Criteria relating to plant upset conditions**

<table>
<thead>
<tr>
<th>Number of alarms displayed in 10 minutes following a major plant upset</th>
<th>Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than 100</td>
<td>Definitely excessive and very likely to lead to the operator abandoning use of the system</td>
</tr>
<tr>
<td>20-100</td>
<td>Hard to cope with</td>
</tr>
<tr>
<td>Under 10</td>
<td>Should be manageable – but may be difficult if several of the alarms require a complex operator response</td>
</tr>
</tbody>
</table>
## EEMUA 191 Alarm Activation Rates Benchmark

<table>
<thead>
<tr>
<th>Long-term average rate</th>
<th>How acceptable is it?</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 1 per minute</td>
<td>Not acceptable</td>
</tr>
<tr>
<td>1 every 2 minutes</td>
<td>Over demanding</td>
</tr>
<tr>
<td>1 every 5 minutes</td>
<td>Manageable</td>
</tr>
<tr>
<td>&lt; 1 every 10 minutes</td>
<td>Acceptable</td>
</tr>
</tbody>
</table>
A range of alarm system performance

% time alarm rates outside target (5 per 10 minute period)

Level 1
Overloaded

Level 2
Reactive

Level 4
Robust

Level 3
Stable

Level 5
Predictive

Maximum alarm rate (expressed as number of alarms in a 10 minute period)
### Additional Alarm Activation Metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Benchmark</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acknowledgement ratio</td>
<td>99.5%</td>
<td>The % of time alarm activates AND operator ack’s it before it clears</td>
</tr>
<tr>
<td>Alarm flood (serious)</td>
<td>No standard; think 0</td>
<td>10 consecutive time periods of 10 or more alarms within 10m; 100 or more alarms within 10m regardless of how often</td>
</tr>
<tr>
<td>Alarm flood (short term)</td>
<td>No standard; think 0</td>
<td>10 or more alarms occurring within any 10m time period until rate drops below 5 alarms in 10m period</td>
</tr>
<tr>
<td>Chattering</td>
<td>No standard; think 0</td>
<td>10 or more within 1 minute</td>
</tr>
<tr>
<td>Consequential alarms</td>
<td>No standard; think 0</td>
<td>1+ alarms that follow the first w/in 5 min 90% or more of the time</td>
</tr>
<tr>
<td>Related</td>
<td>No standard; think 0</td>
<td>2 or more alarms that occur simultaneously, w/o regard to activation order, within 5 min 90% or more of the time</td>
</tr>
<tr>
<td>Repeating</td>
<td>No standard; think 0</td>
<td>10 or more w/in 15 minutes (used for analog bad-actors)</td>
</tr>
<tr>
<td>Stale</td>
<td>5 or less</td>
<td>Ack’d but not cleared for between 8 &amp; 12 hours (one shift)</td>
</tr>
<tr>
<td>Standing</td>
<td>No standard; think 0</td>
<td>Ack’d but not cleared for 24 or more hours, (but none after a month)</td>
</tr>
<tr>
<td>Time to acknowledge</td>
<td>Emergency: &lt; 30s High: &lt; 1m Medium: &lt; 3m Low: &lt; 10m</td>
<td>Should meet this standard over 95% of the time. Horn may be silenced at any time without effect</td>
</tr>
<tr>
<td>Time to clear</td>
<td>No standard</td>
<td>Useful to track general operability difficulty</td>
</tr>
</tbody>
</table>
Phase 1 - Alarm Management and Philosophy Development

• Framework to establish the criteria, definitions & principles for all alarm lifecycle stages

• Alarm philosophy ensures that facilities can achieve:
  – Consistency across process equipment
  – Consistency with risk management goals & objectives
  – Agreement with good engineering practices
  – Design & management of the alarm system that supports an effective operator response
Phase 2 - Determining Alarm Behavior & Effectiveness

• What is working
• What is NOT working
• Audit of alarm history
  - “bad actors”
  - Duration of states = variability
  - Standing alarms
  - Which alarms/events trigger floods
Phase 3 - Analyze Root Causes and Provide Benchmarking

- Root cause analysis
- Benchmarking, tracking
- Analysis:
  - Control system operation
  - Effect of alarms on operators
  - Causes of operational problems
Phase 4 - Improvement through Remedial Action

• Remedial action examples
  – implementing conformance to the alarm philosophy
  – elimination of nuisance alarms
  – tune alarm priorities
  – elimination of alarms with the same root cause
  – recalibration or elimination of standing alarms
ALARM SYSTEM MANAGEMENT BENEFITS
Key Benefits of Alarm Management
Key Benefits of Alarm Management

• Reduced Maintenance Costs
  - GENERAL RESULTS: within 6 months after alarm improvement work is commissioned and smoothly operating, plants see a 5% - 15% sustained reduction in unplanned maintenance costs.

• Lower Insurance Costs
  - GENERAL RESULTS: European manufacturers are seeing a 20-30% reduction in their risk operations insurance due to the implementation of EEMUA-compliant alarm improvement.
Improved Production Through Better Process Management

Plant Operating Target
Planning Constraints
Operational Constraints
Optimization Efforts
Plant Capacity Limit

Days Per Year

< 60%
95%
100%
Improved Production Through Better Process Management

Focused efforts can Result in recovery of 3 – 8% of capacity

- Higher Plant Operating Target
- Fewer Planning Constraints
- Fewer Operational Constraints

Plant Capacity Limit

< 60%

95%

100%
Capture Workforce Knowledge!
Other Benefits of Alarm Management

<table>
<thead>
<tr>
<th>AREA</th>
<th>BENEFITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Reduced risk of human injury and incidents.</td>
</tr>
<tr>
<td>Unplanned downtime</td>
<td>Avoid plant shutdown, lost product, and associated costs.</td>
</tr>
<tr>
<td>Information management</td>
<td>Avoid nuisance alarms, improved fault tracing.</td>
</tr>
<tr>
<td>Role of the operator</td>
<td>Give operator more time to focus on the process, creating knowledge workforce.</td>
</tr>
</tbody>
</table>
RESOURCES

• BOOKS

• Standards and Publications
  – ISA 18.2 Standard
  – EEMUA 191 Publication

• Web Sites & Articles
  – Wikipedia - Alarm Management
  – *ASM - Achieving Effective Alarm System Performance*
  – Control Global
  – ARC Advisory Group
  – Chemical Processing.com

ASM = Abnormal Situation Management Consortium
Questions?