Alarm Management – An Introduction
1. The Old and the New
2. Importance of Alarm Management & Historical Context
3. Guides, Standards and Regulations
4. Benefits & Design of Alarm Management
5. Alarm Issues
The Old...

- Simple and clear alarms
- Alarm annunciators
- Hard wired alarms
The Scope of the Problem

- Operators typically monitor more than 5,000 devices.
- Each device typically has 4 to 5 alarms configured on it.
- Devices x alarms results in Operators having to manage 20,000 to 25,000 alarms.
- The average Operator gets 1,200 alarms per day, approximately 1 per minute!
- Engineering Equipment & Materials Users’ Association (EEMUA) recommends no more than 6 alarms per hour.
The Causes of the Problem

• Historically, alarms were expensive and difficult to add resulting in careful review before implementation
  – Each had to be hardwired
  – Limited space in control panels

• Today, hardware and software advances have made it possible to alarm most devices at minimal cost
  – Large increase in the quantity of alarms
  – Less review resulting in reduced quality
Fundamental ASM Problem

The Paradox of Automation...

- Better automation leads to more sophisticated processes
- More sophisticated processes leads to more opportunities for error
- We “fix” the increasing errors with still more automation

When things go wrong, people have difficulty intervening to correct the problem!

Poor User Centered Automation
Why Grey Scale Graphics

• Directing operator’s attention to the most critical information with the least possibility for confusion, slow response, or errors in detection or interpretation.

• addressing concerns with respect to individuals that might have color vision deficiencies

• reducing glare so ambient light levels are high enough to support both visual acuity for non-display tasks (e.g., reading paper copy) and also biological clock adjustments for the appropriate day or night shift.
Basic principles of human sensation and perception...

- To enhance situation awareness, techniques to enhance the salience of the associated display elements.
- An object is more salient than another object if it ‘stands out’ or grabs one’s attention.
- Important to emphasize abnormal states, off-normal conditions and dynamic data. If red means critical alarm state then it should not also mean a pump is off.
- The background display color in combination with the ambient light level of the control room can impact the probability of eye strain and fatigue as well as visual acuity.
Sources of Abnormal Events

People:
- Fail to detect problems in reams of data
- Are required to make hasty interventions
- May be unable to make consistent responses
- May be unable to communicate well

Established in literature; confirmed by 18 plant studies - US, Canada, & Europe
Human Limitations

- If we look at the causes of the events themselves, 90% are preventable,
  - Majority are due to the actions or inactions of people
  - People will always be a part of the decision-making process in plant operations
- People aren’t inept. People do have limitations.
  - We are not good at detecting problems in large bodies of data
  - Don’t have enough time to think through consequences
  - Not as consistent as automation, given the same inputs
  - Communication can be an problem
- All of these human limitations are exacerbated by stressful situations
  - Design the system with human strengths and limitations
ASM Grey Scale

Many bright, saturated colors fail to draw attention to critical states

Selective use of color draws attention to abnormal and off-normal states.

Normal Color Vision

Approximate Perceptual Experience for Deuteranopia and Protanopia Color Deficiency
HMI – Individual Graphic Migration

- Initial Process Graphic
  - Enabling Scope Execution
  - Workpack Execution
  - (Note: More than one Workpack will be required to complete dynamic element migration when elements from more than 1 Process System are present)

- Migrated Statics Graphic
  - Current MB300 dynamic elements
  - Stage 1
  - Stage 2
  - Stage N

- Partially Migrated Dynamics Graphic

- Migrated Process Graphic
The Causes of the Problem

• Alarms are continuously added
  – Often after incident reviews

• Changes in process
  – After de-bottlenecking projects

• Equipment changes and degrades
  – Different vendors with different normal operating conditions
  – Wear resulting in reduced efficiency

• Seasonal changes to process
Common Problem Alarm Types

- **Standing**
  - No dynamic process logic
- **Nuisance Alarms**
- **Frequent**
  - Poor Set value/s
  - Possible control problem
- **Redundant**
  - Equipment out of service
  - Alarms still functional
- **Improperly Prioritised**
  - EEMUA recommends process alarm priorities of: 80% low, 15% medium and 5% high
..and the New

- DCS systems installed
- Numerous free alarms
- Everything is turned on
**Alarm:** An audible and/or visible means of indicating to the operator an equipment malfunction, process deviation, or abnormal condition requiring a response.

Figure 2 – Definition of alarm from ISA18.2

One of the most important principles of alarm management is that an alarm requires a response. This means if the operator does not need to respond to an alarm (because unacceptable consequences do not occur), then the point should not include an alarm. Following this cardinal rule will help eliminate many potential alarm management issues. The recommendations in the standard provide the “blueprint” for eliminating and preventing the most common alarm management problems, such as those shown in Table 1.

<table>
<thead>
<tr>
<th>Alarm Management Problem</th>
<th>Cause(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarms are generated which are ignored by the operator.</td>
<td>“Nuisance” alarms (chattering alarms and fleeting alarms), faulty hardware, redundant alarms, cascading alarms, incorrect alarm settings, alarms have not been rationalized.</td>
</tr>
<tr>
<td>When alarms occur, operators do not know how to respond.</td>
<td>Lack of training and insufficient alarm response procedures</td>
</tr>
<tr>
<td>Minor plant upsets generate a large number of alarms.</td>
<td>Average alarm load is too high. Redundant alarms, cascading alarms, alarms have not been rationalized.</td>
</tr>
<tr>
<td>The alarm display is full of alarms, even when there is nothing wrong.</td>
<td>“Nuisance” alarms (chattering alarms and fleeting alarms), faulty hardware, redundant alarms, cascading alarms, incorrect alarm settings, alarms have not been rationalized.</td>
</tr>
<tr>
<td>Some alarms are present on the alarm display continuously for long periods of time (&gt;24 hours).</td>
<td>Corrective action is ineffective, equipment is broken or out of service, change in plant conditions.</td>
</tr>
<tr>
<td>During an upset, operators are flooded with so many alarms that they do not know which ones are the most important.</td>
<td>Incorrect prioritization of alarms. Not using advanced alarm techniques (e.g. state-based alarming).</td>
</tr>
<tr>
<td>Alarm settings are changed from one operator to the next.</td>
<td>Lack of management of change procedures</td>
</tr>
</tbody>
</table>
Alarm Timeline

Normal (A)  Unack Alarm (B)  Ack & Response (C)  Return to Normal (D)

process response without operator action

consequence threshold

measurement

process response to operator action

operator takes action

ack delay  operator response delay  process deadtime  alarm deadband  process response delay

alarm setpoint

deadband delay

Process Variable

Time
Why is Alarm Management Important?

Accident investigations have identified that:

inadequate alarm system performance contributed to a significant number of industrial accidents...

- Three Mile Island - 1979
- Piper Alpha - 1988
- Milford Haven Refinery - 1994
- Buncefield Oil Storage - 2005
Three Mile Island - 1979

A series of failures and operational errors occurred that resulted in the release of a measurable amount of radioactive material into the air.

- Alarms are not applied properly
- The use of alarms is not fully understood
- Alarm systems can avoid these incidents
Piper Alpha Oil Rig - 1988

An accumulation of errors and questionable decisions caused a catastrophic fire on the offshore platform causing 167 deaths and billions of dollars worth of damage.

- Inadequate shift handovers
- Issues with false alarms
A severe electrical storm caused plant disturbances.

An explosion that occurred five hours later was a combination of failures in management, equipment and control systems during the plant upset.

**Twenty-six** people were injured and damage of **£48 million** was caused.

- Too many alarms that were poorly prioritised
- Control room displays did not help the operators to understand what was happening
- During the last 11 minutes before the explosion, the two operators had to recognise, acknowledge and act on 275 alarms
In December 2005, a number of explosions occurred. A large fire engulfed a high proportion of the site. Over 40 people were injured; fortunately there were no fatalities.

• Alarms were not tested regularly

- Not a standard or regulation
- Globally accepted as the benchmark for best practice
- Guidance on designing, managing and procuring alarm systems
Management of Alarm Systems for the Process Industries

- Based upon the EEMUA 191 recommendations
- To address development, design, installation and management
- Aims to improve safety within process industries.
Alarm management is a process, not a product.

- Analyze your system and understand your problems
- Determine key performance metrics
  - Operator workload
  - Problem alarms
  - Compare facility performance
- Gap analysis (you cannot improve what you cannot measure)

PTP-Global
Alarm Management Lifecycle

- Corporate document that specifies
  - Objectives of alarms
  - Assign roles & responsibilities
  - Procedures for defining alarms
  - How to assign priorities
  - Expected Operator responses
  - Management of change

- Benchmarking & Assessment
- Alarm Philosophy
- Alarm Rationalization
- Implementation & Execution
- Maintenance
- Continuous Improvement
Alarm Management Lifecycle

- Benchmarking & Assessment
- Alarm Philosophy
- Alarm Rationalization

- Systematic review and documentation of each configured/engineered alarmable tag in the DCS
- Store information in Alarm Database
- Objective is to optimize alarm quantity and quality
  - Ongoing process, target 50 to 100 worst alarmable tag per day

PTP-Global
Alarm Management Lifecycle

- Implement alarm strategy on DCS
- Implement advanced alarming strategies
  - Alarm shelving
    - Temporary disabling of alarms depending on process state
  - Dynamic alarming
    - Change alarm limits depending on process state
  - Alarm grouping
    - Use top level alarm to summarize multiple ones (with drill-down capability)
  - Alarm eclipsing
    - Disable an H alarm if the HH alarm limit is reached
Alarm Management Lifecycle

- Integrate into work practices and embed into company culture
- Prevent unauthorized changes
- Track changes made
- Monitor performance
Alarm Management Lifecycle

- Benchmarking & Assessment
- Alarm Philosophy
- Alarm Rationalization
- Implementation & Execution
- Maintenance
- Continuous Improvement

- Analyze alarm floods during upsets
- Frequent intervention analysis
  - Identify opportunities for additional process automation (supervisory control)
Benefits of Alarm Management

- Compliance with best practice
- Improved safety measures
- Reduced maintenance costs and better plant operation
- Improves production and Human performance
- Reduces operator workload
- Improved shift handovers
- Reduced insurance rates
Well Designed Alarm Management

“The purpose of an alarm system is to direct the operator’s attention towards plant conditions requiring timely assessment or action”

• Alert, inform and guide the operators
• Prevent unnecessary shutdown
• Only present the operator with useful and relevant alarms
• Use prioritisation to highlight critical alarms
• Have a detailed response to each alarm
• Allow enough time for the operator to respond
Common sense suggests that, in general, the more alarms installed per operator, the greater the likelihood of problems with spurious alarms, high alarm rates, etc. On the other hand, a small number of alarms should not be viewed as necessarily desirable as this may mean that the operator will be unaware of important events. A balance has to be struck, and it is inevitable that on a large complex plant a large number of alarms will be required.

Number of Alarms

<table>
<thead>
<tr>
<th>Number of Installed Alarms per operator</th>
<th>Number Configured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 1000</td>
<td>A major alarm system, which will require significant investment throughout its life cycle and which needs to be developed and maintained to the best practices available within industry if it is to work well.</td>
</tr>
</tbody>
</table>
## Average Alarm Findings

<table>
<thead>
<tr>
<th></th>
<th>EMMUA</th>
<th>Oil &amp; Gas</th>
<th>PetroChem</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 10 Minutes</strong></td>
<td>10</td>
<td>220</td>
<td>180</td>
<td>350</td>
<td>180</td>
</tr>
<tr>
<td><strong>Average Alarms/10 Minute Interval</strong></td>
<td>1</td>
<td>6</td>
<td>9</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td><strong>Distribution % (Low/Med/High)</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>
# Alarm Issues – Priority (1)

<table>
<thead>
<tr>
<th>Priority of Alarm</th>
<th>Number Configured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical (emergency)</td>
<td>20 (Total)</td>
</tr>
<tr>
<td>High</td>
<td>5%</td>
</tr>
<tr>
<td>Medium</td>
<td>15%</td>
</tr>
<tr>
<td>Low</td>
<td>80%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EMMUA</th>
<th>Oil &amp; Gas</th>
<th>PetroChem</th>
<th>Power</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution % (Low/Med/High)</td>
<td>80/15/5</td>
<td>25/40/35</td>
<td>25/40/35</td>
<td>25/40/35</td>
</tr>
</tbody>
</table>
Alarm Issues – Flooding

Alarm activations occur so fast that the operator becomes “flooded” by them and is unable to distinguish useful information, which can cause:

• The operator may work on a less important alarm, or
• Attempt to struggle with all of the alarms, or
• Give up completely on the alarm system
More Alarm Issues

<table>
<thead>
<tr>
<th>Issue</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chattering Alarms</td>
<td>Comes in and clears at least three times in one minute</td>
</tr>
<tr>
<td>Nuisance Alarms</td>
<td>Where a few number of alarms cause significant amount of alarm activations.</td>
</tr>
<tr>
<td>&quot;bad actors&quot;</td>
<td></td>
</tr>
<tr>
<td>Masking</td>
<td>Where an alarm sound cannot be heard above typical noise levels</td>
</tr>
</tbody>
</table>
What Companies are Currently Providing

Very limited analysing alarm log on DCS

Data being stored in Printer replacement products

Extracting data to Excel and performing frequency

Collection of data can be manual; going to the data source
If data logs, data has to be conditioned very complex
Very time consuming, can take several hours
What is an Analyser

- Displays Real-time Key Performance Indicators (KPI)
- KPI display for Systems, Area’s and Connectors
- Seamless integration between displays
- Handover End of Shift Reports
- Improved Performance for Frequency Analysis
- Pre-formatted Reports
- Simple to use
We take in information through our senses.

We might misread something, we might miss something important, we might choose to focus on certain things rather than others.

We process the information and make decisions …

We might make the wrong connections, we may not have all of the facts, we might make the wrong assumptions.

We act accordingly in line with the decision made.

We might select the wrong response, we might set out to act in one way but get “clumsy.”
Conclusion

• Understanding ASM. Focus on issues that provide a better understanding of ASM, insight into reducing future incidents and prepare ops teams to handle abnormal situations as they do occur.

• Training and skill development. Focus on anticipating and coping with abnormal situations.

• Communications. Critical to communicate issues to plant personnel using technology during normal, abnormal and ER situations.

• Procedural Operations. Focus on procedures to accomplish important tasks particularly during start-up and shut-down.

• Process Monitoring and control. Focus on automation technologies for effective operations.