How to apply ISA-18.2 Alarm Management Techniques to SCADA Systems

Common workarounds for applying alarm management to systems that were never designed for it

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Highlights from the 2015 ISA Water / Wastewater and Automatic Controls Symposium – August 4-6, 2015 – Orlando, Florida, USA
About the Speaker

Graham Nasby, P.Eng., PMP, CAP, FS.Eng. (TUV)

- Senior I&C Engineer, Eramosa Engineering
- ISA18 “Alarm Management” Standards Committee – Voting Member
- ISA18 Working Group 7 “packaged systems” – committee co-chair
- IEC committee responsible for IEC-62682 – named Canadian expert
- Director, ISA Water/Wastewater Division (2013-2015)
- Past Chair of the 2012 & 2013 ISA Water/Wastewater and Automatic Control Symposium
- Has published over 30 papers and articles on automation topics
- Recipient of 2013 ISA awards for Volunteer Leader, Division Leader & Division Excellence
- 2011 ISA “Keith Otto” award for best article of year in InTech “SCADA Standardization”
- Background in various industry sectors including municipal water/wastewater

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Presentation Outline

- What is Alarm Management
- Overview of ISA-18.2
- Key SCADA Software Features Required
- Master Alarm Database
- Alarms vs. Notifications vs. Logged Events
- Alarm Summary Display
- Alarm Priorities
- Alarm Shelving and Alarm Out-of-Service
- Standardizing Alarm Design: Using Alarm Function Blocks
- On-Delay, Off-Delay, and Deadband
- Change Control, User Permissions, and Change Logging
- Final Words
The SCADA Alarms Challenge

- Old Days: a few dozen alarms
  - A few dozen Alarm Lights

- Modern SCADA Systems
  - Can easily add hundreds of alarms with a few keystrokes
  - Many, many, many software configuration options
  - How do we decide how to configure and use alarms?
  - How do we avoid alarm overload?
  - Do we really need all these alarms?
Typical Before / After for applying 18.2


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

Methodology for identifying, rationalizing and designing alarms to be a powerful tool for operations, and eliminating non-useful alarms

![Alarms Per Day Graph](image)

Typical example of results of 18.2 being implemented (showing before/after)
ISA 18.2 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
Key SCADA Software Features 1 of 2

- Master Alarm Database
- Ability to create non-alarm messages and logged events
- Support for Alerts, Prompts, and Maintenance Messages
- HMI Alarm Summary Display Screen
- Alarm Sorting, Filtering, Routing
- Alarm Areas/Grouping
- Alarm Priorities
- Alarm Classes
Key SCADA Software Features 2 of 2

- Standardizing Alarm Features with Function Blocks
- On-Delay, Off-Delay, Deadband
- Conditional Alarming: base condition plus additional logic
- Alarm Shelving Method with Authorization / Logging
- Alarm Out of Service
- Change Control – Permissions, Setpoints, Configuration
- Configuration Change Logging
- Alarm Setpoint/Attribute verification & enforcement
Master Alarm Database (MADB)

- Master Alarm Database
  - Central repository of approved alarms and their configuration

<table>
<thead>
<tr>
<th>Tag</th>
<th>Priority</th>
<th>Desc.</th>
<th>Condition</th>
<th>Consequence If Ignored</th>
<th>Consequence Severity</th>
<th>Expected Operator Response</th>
<th>Time to Respond</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1-380-LAH-201</td>
<td>LOW</td>
<td>Aeration 1 High Level</td>
<td>High Level Switch Activated for 10sec</td>
<td>Overflows in Secondary clarifiers.</td>
<td>MINOR</td>
<td>Check Level Controller</td>
<td>2 hours</td>
</tr>
<tr>
<td>P1-380-AAL-102</td>
<td>MED</td>
<td>Aeration 1 Low DO</td>
<td>DO below 3ppm for 30min</td>
<td>Loss of Biological Action, Risk of Damage to Biological Mass</td>
<td>MAJOR</td>
<td>Investigate and turn on additional blowers</td>
<td>1 hour</td>
</tr>
<tr>
<td>P1-380-PALL-456A</td>
<td>LOW</td>
<td>Aeration 1 Air Pres. Low Low</td>
<td>Less than 15psi for 5min</td>
<td>Loss of Energy if Air Leak, Poor Aeration (Note: there is a low DO alarm)</td>
<td>MINOR</td>
<td>Check pressures in air distribution system via HMI, check valves in field</td>
<td>4 hrs</td>
</tr>
</tbody>
</table>
MADB Contents

- **Alarm Tag**
- **Alarm Description** (full description & what is shown on HMI)
- **Identification**: Trigger Condition, Purpose
- **Rationalization**:
  - Consequence & Severity if Ignored
  - Expected Operator Response, Time to Respond
  - Alarm Priority & Alarm Class
- **Design**: Trigger Condition, On/Off Delays, Additional Filtering Logic, Setpoints, Routing/grouping information for the HMI
- **Operation**: When put into service, If Periodic Testing is required
MADB Implementation

- **Common Approaches**
  - Built-in MADB in SCADA package (nice to have, but rare)
  - Excel Spreadsheet (often used)
  - Customized Microsoft Access Database
  - 3rd Party Application

- **Tips**
  - Keep it simple – not too many columns
  - Capture Setpoints, and document why those setpoints were selected
  - Periodically check against what is actually programmed in PLC/RTU
  - Have a “last updated” date for each alarm
  - Keep it up to date
HMI: Alarms, Events and Notifications

• SCADA Systems can have multiple types of notifications

<table>
<thead>
<tr>
<th>Operator notification types</th>
<th>Operator is expected to take an action</th>
<th>Operator might need to be aware but is not required to take action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arises from an abnormal process or equipment situation</td>
<td>Alarm</td>
<td>Alert</td>
</tr>
<tr>
<td>Arises from a normal situation</td>
<td>Prompt</td>
<td>Status</td>
</tr>
</tbody>
</table>

Figure 6 – Sample criteria for notification types from an alarm philosophy

• SCADA systems should have support for:
  – Alarms
  – Other notifications: alerts, prompts, maintenance messages
  – Event messages
  – Logged-only events
### HMI: Alarm Summary Display Screen

- Dedicated screen for displaying alarms – only alarms
- Ideally on its own dedicated monitor in multi-monitor setup

![Image of alarm summary display screen]
HMI: Alarm Summary Display Columns

- Recommended Minimum Columns
  - Alarm Priority
  - Full Alarm Tag
  - Alarm Description
  - Current Status of Alarm: Active, RTN, Ack/Non-Ack
  - Date/Time of Trigger
  - Date/Time of RTN (return to normal)
  - Date/Time of Ack
- Others
  - Alarm Area/Group (in large systems)
  - Alarm Class (e.g., identify EPA alarms)
  - Operator Response Information
HMI: Alarm Sorting, Filtering, Routing

• Alarm Summary Display
  – Sort alarms by date/time, priority, area
  – Enough columns to see alarm context and information
  – Ability to show second filtered alarm display – to investigate an issue
  – Nice to Have – Click on alarm, user goes to relevant process screen

• Large Systems
  – Route alarms to the specific operator for that area
  – Ability to change routing of alarms depending who is on shift
  – Automatic alarm routing based on time of day: day vs. night.
  – Additional filtered alarm displays to show alarms specific to an area
HMI: Alarm Priorities

- Alarm priorities help operators prioritize when multiple alarms are active.

- Commonly Used Alarm Priority Schemes:
  - Low, Medium, High
  - Low, Medium, High, Critical
  - Info, Low, Medium, High, Critical

- Do not include non-urgent messages in the alarm display (e.g. maintenance alerts, operator prompts, logged events, etc.)

- ISA-18.2 suggests an alarm distribution of:
  - LOW 80%, MEDIUM 15%, HIGH 5%, CRITICAL <1%
**HMI: Alarm Shelving & Alarm Out of Service**

- **Alarm Shelving**
  - Core feature of ISA-18.2 alarm management
  - Controlled way for an Operator to temporarily disable an alarm
  - Temporary means alarm will auto-re-enable after delay (e.g., 8 hrs)
  - Should be software support for doing this with user permissions
  - For “Highly Managed Alarms” you may want to disallow shelving

- Historically SCADA support for alarm shelving is very poor to nonexistent. You will often have to write custom code to do this.

- Use “Out of Service” for long-term disabling of alarms
- Make sure all Alarm Shelving and Out of Service actions are logged!
PLC: Standardized Alarm Blocks

- Use a standardized function block in your PLC for all alarms
- Key Features:
  - Raw Status vs. Alarm Bit
  - Condition Inversion
  - Logic-Based Suppression
  - ON-Delay
  - OFF-Delay
  - Shelving / Out of Service support (if required at PLC-level)
- Additional Features for Analog/Value Alarms
  - Deadband
  - Alarm Masking if Signal is Bad
  - Masking of Lesser Alarms (L vs. LL)
  - Rate of Change
PLC: ON-Delay and OFF-Delay

• **ON-Delay**
  – Time that “condition” must be true before alarm triggers
  – Alarm Condition vs. Alarm Triggering
  – Example
    – High level in a wet well where a pump will come on to pump it out
    – On high level, only alarm if high level is sustained for 60 seconds
    – Don’t alarm if high level true for 30 seconds and then resolves itself

• **OFF-Delay**
  – Time that “alarm stays active” before it returns to normal
  – Think: minimum time alarm bit stays active
  – Helps avoid “flicker alarms” that trigger too fast to see
  – Useful for alarm dialers so dialer will detect the alarm
PLC: Deadband for Analog Value Alarms

- Also called “Hysteresis”
- Deadband prevents chatter with analog alarms
- Defined as % of associated instrument range
- Example
  - On a 0 – 10m level transmitter
  - Configure HIGH ALARM of 8.0 m with 10% deadband
  - Means: Alarm triggers at > 8.0 m, and alarm returns to normal at < 7.9 m
- When combined with ON-Delay and OFF-delay can be powerful tool!
PLC & HMI: Change Control & Permissions

- SCADA Systems must have user accounts and permissions
- Do not run a system where all users have configuration access

- Recommended minimum levels:
  - Engineer – configuration/programming access
  - Administrator – can add/delete accounts
  - Supervisor – can change setpoints
  - Operator – only operate, not change setpoints
  - Guest – view only, default access

- Any changes to the SCADA system should be logged
Final Words

- Alarm Management offer significant operational improvements
- Deploying Alarm Management in SCADA systems can be challenging
- Key software features are often missing in SCADA systems

- Carefully look at which functionality is important to your needs
- Document what you need, and then put in a plan to implement it
- When considering customization, consider the effort to maintain it
- Focus on implementing what will deliver maximum operational benefit

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