Advanced Alarming Techniques

This whitepaper provides information to assist with implementation of Emerson’s AgileOps™ suite of alarm management modules and several native advanced alarming module templates available for the DeltaV™ Distributed Control System.

Dynamic alarm suppression can help eliminate alarm floods for a more effective operator response to process disruptions and equipment failure.
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Introduction

This document describes Emerson’s AgileOps™ software, along with several native control module templates and associated displays available for use with the DeltaV™ distributed control system, to accomplish dynamic alarming, advanced alarm shelving and to collect alarm count statistics. The modules and displays described in this document pertain to a DeltaV v14 system, but with minor modification they may also be applied in DeltaV system versions v10, v11, v12 and v13.

This document is technical in nature, intended for use by a skilled DeltaV control engineer.

The DeltaV module templates and human machine interface (HMI) displays described in this document are included with a standard DeltaV system at no extra cost. The modules are based on standard DeltaV system function blocks available since v10 for use in any system regardless of any customer-specific or standardized control library. The modules are intended to run in a DeltaV controller for maximum reliability and speed, and for application to operational systems where existing active control modules may not be modified. To request these module templates and displays, contact your local Emerson or Emerson business partner.

The AgileOps™ software described in this report is a standard add-on for the DeltaV system, with separate licensing and installation.

Dynamic Alarming

Dynamic alarming describes various techniques for modifying alarm attributes based on plant operating state. The primary benefits are providing optimum alarm configuration in any the plant state and eliminating alarm floods. The benefits are realized through automatic modification or suppression of multiple alarms resulting from an equipment malfunction or process abnormality, or from a controlled shutdown or process transition. State-based alarming is the most powerful technique. First-out alarming, conditional alarming and dynamic flood suppression are also available. The dynamic alarming modules can be used to accomplish the following:

- Change alarm configuration when a change in operating state is detected (AgileOps™)
- Suppress alarms when multiple alarms occur for a single process event (first-out alarming)
- Suppress excessive or irrelevant alarms which are generated when the process or equipment state changes unexpectedly (AgileOps™, alarm flood suppression)
- Modify alarm attributes (priority, suppression state, alarm limit) when the process or equipment state changes unexpectedly (AgileOps™)
- Determine the initiating alarm or trip (first-out alarming and alarm flood suppression)
Capturing Actual Alarm Counts

Most alarm system performance data can be obtained through analysis of system alarm and event records. Emerson’s products for doing this are AgileOps EventKPI and DeltaV Analyze. The DeltaV Alarm Statistics module samples the actual counts of current active, acknowledged and stale (alarms active over 24 hours) alarms at an operator workstation twice a day and at the end of each month calculates their average.

AgileOps™ Alarm Management Software

The AgileOps software application suite is Emerson’s premier product for alarm management. AgileOps is compatible with multiple control systems including Emerson DeltaV®, Honeywell Experion® and TDC®, Siemens PCS7® and Invensys Foxboro®, thus delivering a complete alarm management system for an entire site with one or multiple control system manufacturers. It can be used for the following tasks:

- Rationalize the alarms from the control system
- Document the results in a master alarm database
- Provide help information directly to the operator from the alarm display or control module faceplate
- Define alarm dynamics by system operating cases and programmed alarm shelving by grouped lists to prevent alarm flooding scenarios
- Update alarm configuration via bulk edit

While the native modules are a good fit for small systems with simple logic and a few alarms to manage, AgileOps is the recommended solution for:

- Plant-wide dynamic (state-based) alarming and control
- Advanced shelving capabilities including automatic shelving of stale alarms and alarm shelving by plant state
- Alarm rationalization, documentation and master alarm database
- On-line alarm attribute verification against approved master alarm database values with optional enforcement (scheduled and on demand)
- Flexible alarm metrics reporting and custom reports

AgileOps displays are designed for easy view and configuration of rationalization results, operator help information, dynamic alarming settings, logic that determines operating state (case), and shelving criteria. Another distinct advantage of AgileOps lies in alarm auditing. The audit report will not flag as exceptions any alarm attribute modification that is done by AgileOps dynamic alarming or shelving.

AgileOps is modularized for ease of navigation and to separate functionality. That said, the modules are designed to work together, with effective cross-communication. A short description of the AgileOps modules follows.

Master Control System Database (MCSD)

The Master Control System Database (MCSD) module provides a central source for pre-approved, approved and historical control system parameter settings including alarm system design (rationalization) results. This is the Master Alarm Database (MAD) that is required by the ISA 18.2 standard. MCSD is used to configure other modules of AgileOps: Dynamic Management (DM) and List Management (LM) modules.
MCSD also includes other features:

- **AutoDiscovery**: automatically browses the control system and brings all of the necessary alarm information into AgileOps. After the initial sync with the control system, AutoDiscovery can be set to run on a periodic basis in order to verify if any alarms have been added or modified. If it finds any changes, it will flag the exception – the user can then decide to update the AgileOps database to match what is on the control system if the change was legitimate. Unauthorized changes can be enforced back to the online database. This greatly cuts down on user errors when transferring all of the points on the control system to AgileOps.

- **Boundaries**: MCSD supports effective boundary management. While configuring each tag, a user can also define its respective boundaries (operating limits or constraints). An equipment engineer may input a maximum pump safety limit, while the process engineer would input a maximum operating flow. MCSD would catalogue all of these inputted boundary layers and display them in an intuitive format for alarm rationalization members to understand. Once all the boundaries are in place, determining alarm set points, priorities and corrective responses becomes easier to understand and implement.

### Dynamic Management (DM)

The Dynamic Management (DM) module provides the capability to manage alarms through the states and state transitions of the unit according to pre-configured logic. Plant processes are dynamic by nature; DM allows the alarm configuration to change appropriately as the operating state changes. Therefore, it can effectively eliminate alarm floods during process transitions and upset conditions; operators can focus on controlling the transition or stabilizing the plant rather than responding to unnecessary alarms. DM also includes transition management to unsuppress or enable alarms only as needed during a process mode change. Alarm configuration changes available include priority and alarm limit modification, suppression and disabling. Without dynamic alarm management, a facility will usually not be able to meet the ISA 18.2 target metrics of peak alarm rate and % of time in flood.
List Management (LM)

The List Management (LM) module is an advanced alarm shelving tool that provides features not available in standard shelving modules included in DeltaV or any other control system. It not only allows operators to shelve nuisance alarms, but also can shelve stale, standing alarms automatically. LM features:

- Exclusion list (restricts which alarms an operator is able to shelve)
- Simple right-click entry from operator graphics
- Entry validation – verifies roles and restricts multiple entries
- Easy list configuration and management
- Automatic shelving to remove stale alarms from the alarm summary
- Automatic unshelving based on an alarm being inactive or using a fixed un-shelve timer
- State-based shelving, in conjunction with DM
EventKPI (EKPI)

EventKPI (EKPI) allows the measurement, tracking and reporting of key performance indicators for events occurring in a facility. EKPI reports alarm metrics as a result of data analysis which it collects automatically from one or more control systems. Metrics can be analyzed by the minute, hourly, daily, weekly, monthly or on a yearly basis. EKPI is designed as an enterprise application that provides the necessary detailed information from local unit personnel up through complex-wide and cross facility views for the enterprise.

In addition to the standard dashboards and reports, Users can create ad-hoc reports, generate new reports and publish them. Users can trigger reports to be run automatically and emailed if certain criteria are met or on a preset schedule. EKPI provides the necessary information to document and support improvements in a facility’s Alarm Management program.
First-Out Alarming Module

First-out alarming can be useful in cases where the shutdown of equipment causes a cascade of alarms that overload the operator making it difficult for them to determine the initiating cause and take appropriate corrective action.

First-out alarming permits the first occurring alarm in a related group of alarms to annunciate and suppresses the rest. A typical application would be the alarms associated with a burner management system. In this example table for the boiler pictured below, a first out alarm group is configured to determine which condition activated the Master Fuel Trip interlock:

<table>
<thead>
<tr>
<th>Tag</th>
<th>Description</th>
<th>Alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT200</td>
<td>High Fuel Supply Pressure</td>
<td>High Alarm</td>
</tr>
<tr>
<td>PT200</td>
<td>Low Fuel Supply Pressure</td>
<td>Low Alarm</td>
</tr>
<tr>
<td>XD201</td>
<td>Loss of Combustion Air</td>
<td>Discrete Alarm</td>
</tr>
<tr>
<td>XD202</td>
<td>Loss-of-Flame</td>
<td>Discrete Alarm</td>
</tr>
<tr>
<td>XD203</td>
<td>Loss of Actuating Energy</td>
<td>Discrete Alarm</td>
</tr>
</tbody>
</table>
The module template FO_ALM_SUP is designed to implement first-out alarming. Key features include:

- Up to 16 participating alarms in a first-out group, where each alarm can be configured for suppression and/or priority change
- First-out alarm indication
- Supervisor, operator, and logic enablement
- An alarm can be configured as a trigger only, without being suppressed by other first-out triggers

*Some alarms in the alarm group may only be intended as first-out trigger sources.*

First-out Alarming State Diagram
Alarm Flood Suppression Module

Alarm systems can be difficult to manage following a major event (such as the trip of a compressor) as operators may be subjected to more alarms than they can respond to. Such disturbances are particularly stressful and can be considered as relatively hazardous periods of operation. During an alarm flood, the operator’s effectiveness is diminished, which could lead to an undetected unsafe plant environment due to critical alarms being missed. In order to minimize the number of alarms following the trip or event, alarm flood (dynamic) suppression may be required.

Dynamic flood suppression logic monitors process conditions to detect a significant equipment failure or process disturbance. When detected, a single ‘common’ alarm is presented to the operator, with related alarm help, and all of the expected consequential alarms associated with the event are suppressed. A typical application would be to eliminate an alarm flood associated with a compressor trip.

The module templates ALM_FLOOD_SUP and ALM_FLOOD_SUP_32 are designed to implement first-out alarming. Key features include:
- Up to 32 participating alarms, extensible in blocks of 16, that can be configured for suppression and/or priority change
- Zero to eight confirming (required) process conditions
- Zero to eight triggering (voting) conditions with user-defined number of votes needed to initiate activation
- First out indication for the triggering condition(s)
- Supervisor and operator enablement
- A ‘common alarm’ with a configurable message, for use in situations where the initiating event doesn’t have its own alarm
- Configurable post trigger ‘time-out’ behavior, to either (a) leave all participating alarms suppressed, (b) remove suppression from all participating alarms or (c) remove suppression from all participating alarms except those that are still in an active condition.

Alarm Flood Suppression Module state transition diagram.
Conditional Alarming

Conditional alarming is a useful technique to eliminate stale alarms and is easily accomplished via simple configuration. A typical application would be preventing a low-pressure alarm from activating until an upstream pump has been on for sufficient time to generate the expected pressure, and to prevent the low-pressure alarm from activating each time the pump stops.

Other problems such as chattering and fleeting alarms can be eliminated through application of tuning parameters such as hysteresis, on-delay and off-delay. These are also easy to configure in the same box as the conditional alarming parameters.
Alarm Statistics Module

The intended use for this module, ALM_STATISTICS, is to collect monthly averages for active, shelved, acknowledged and stale alarms at an operator position based on twice daily actual alarm counts, which can then be configured for history collection and subsequent use in alarm summary reports.

These alarm statistics are useful to evaluate the overall effectiveness of the alarm system. Relevant target metrics are defined in the ISA-18.2 standard shown below.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Target Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annunciated Alarms per Time</td>
<td>Very Likely to be Acceptable</td>
</tr>
<tr>
<td>Annunciated Alarms per Hour per</td>
<td>Maximum Manageable</td>
</tr>
<tr>
<td>Operating Position</td>
<td></td>
</tr>
<tr>
<td>Annunciated Alarms per 10 Minutes</td>
<td>~6 (average)</td>
</tr>
<tr>
<td></td>
<td>~12 (average)</td>
</tr>
<tr>
<td>Operating Position</td>
<td></td>
</tr>
<tr>
<td>Stale Alarms</td>
<td>Less than 5 present on any day, with action plans to address</td>
</tr>
<tr>
<td>Unauthorized Alarm Suppression</td>
<td>Zero alarms suppressed outside of controlled or approved methodologies</td>
</tr>
</tbody>
</table>

Selected Alarm Performance Metrics from ISA-18.2

The key features of this module include:

- Actual counts of alarm are taken twice daily, at 1:00AM and 1:00PM, to account for the operator's true span of process areas coverage over the course of the month.
- A scheduled task is provided, ALM_STATS_CALC.evs, to update the alarm counts in the ALM_STATISTICS module based on the current operator's actual area assignments and workstation area filtering settings.
- A faceplate is provided for this module, ALM_STATISTICS_fp.grf.
- The module keeps track of the actual number of samples taken during the month to automatically correct for any missing samples when calculating average monthly quantities.
- OPTIONAL: Priority thresholds can be applied to filter alarm counts as desired.
- OPTIONAL: The definition of a stale alarm can be modified as desired. The default criterion for a stale alarm is that it has been active for over 24 hours.
- OPTIONAL: The number of daily samples and sampling times can be configured as desired.

General Notes:

- This module is distributed with the DeltaV v14 system.
- Documentation is provided in DeltaV Books Online under the title ALM_STATISTICS module template.
Alarm Shelving and Out of Service

ISA 18.2 defines shelving as temporary alarm suppression initiated by the operator for a limited period of time. It provides the operator with a mechanism to deal with the occasional nuisance alarm or alarms that are temporarily invalid for a short period of time. Operators are accountable for the alarms they shelve, and all shelved alarms should be reviewed and justified during the shift transition. Each alarm can be pre-assigned its own maximum shelving time (including 0 mins), ensuring that appropriate controls are provided for which alarms can be shelved and which cannot.

Out-of-service is another form of suppression defined in ISA 18.2. Alarms that are out-of-service are considered to be in a maintenance mode. Operators should be aware of out-of-service alarms, but generally speaking someone else is accountable for the alarm’s maintenance action and eventual restoration to active service. Un-suppression of out-of-service alarms is not automatic.

The DeltaV system distinguishes alarm shelving, where the operator is accountable for restoration to service, from out-of-service and logic-suppressed alarms where they are not. Alarms can be unshelved by the operator individually or in mass, completely independent of their out-of-service condition or suppression by logic. In addition, the DeltaV system allows the selection of a reason for suppression, where the available reasons can be modified via user-editable name set. To support suppression by logic, suppression reasons can be marked for use only by logic. User permissions for shelving and out-of-service suppression are also independent, such that only authorized personnel (or logic) are able to remove alarms from service.

Shelving state changes, out-of-service state changes and suppression reason are captured in the event history and included in alarm setting audit reports. Electronic signature policies can also be applied to them, for the highest level of accountability and tracking.
Context menus reflect user permissions. In this example the user has authority to unshelve one or all visible shelved alarms, update the suppression reason and remove the alarm from service.

User suppression actions are captured in the event journal.
Considerations and Best Practices for Definition of Trigger Conditions

Creating well-thought out trigger conditions is an important step to ensure that suppression is activated only when it is necessary and appropriate expected. The following recommendations adapted from ISA-TR18.2.4-2012 are provided to guide the definition of effective suppression conditions.

- Use input from multiple sensors with at least 2 (3 is preferred) positive indications of state (2 of 2 or 2 of 3 voting).
- Avoid related measurements with a high probability of common cause failure.
- Avoid unreliable measurements.
- Use deadband with analog values to prevent mode cycling.
- Include error-handling capabilities incorporated into the voting scheme so that accurate state detection is still available when a sensor fails.
- Don’t require operator confirmation of detected state; the dynamic alarming application is designed to alleviate alarm flooding, but this practice allows the floods to occur because of delayed response and unnecessary delays in alarm suppression.
- HMI should clearly indicate status of the trigger conditions and the state of the suppression group.
- Utilize delay timers and intelligent enabling to avoid potential alarm floods when multiple alarms are to be removed from suppression upon a state change.
- Test trigger conditions and logic on a test system and verify correct values are read on the live system before enabling the logic to suppress alarms.

Considerations And Best Practices For Determining Whether An Alarm Can Be Suppressed

Each alarm to be suppressed should be evaluated to ensure that it is acceptable to be suppressed in the proposed scenario. Safety alarms / safety related alarms may need to remain unsuppressed if potential hazards are still present. The following recommendations adapted from EEMUA 191 are provided to help guide the review of alarms to be suppressed.

- Agree on the alarm's basic purpose / intent.
- Is it referenced in HAZOPs or other Safety documentation? If so, verify that the hazard documented is no longer present in the condition proposed for suppression.
- Is the loss of the alarm function in the proposed operating condition likely to create a hazard or lead to an operational difficulty?
- Is the alarm used to infer a problem elsewhere? Will this other problem exist in the process condition that suppresses the alarm in question?
- Is there another alarm which will provide similar information (pump stopped / discharge low flow)? If so, the alarm in question may not be needed at all. Does this other alarm also need to be suppressed?
Final Considerations

In addition to state-of-the-art alarm management software and native DeltaV advanced alarming components, Emerson provides industry leading engineering services to assist users in all aspects of the alarm management program. Services include developing alarm management philosophy, front to back alarm rationalization, dynamic alarm design, software configuration and installation, metrics reporting and evaluation, recommendations for improvement, and periodic program auditing. Emerson engineering services are conducted by engineer personnel who are recognized subject matter experts. Emerson maintains voting membership on the ISA 18 committee and actively participates in other industry groups such as the Center for Operator Performance.