Setting the Standard for Automation™

Alarm System Performance Metrics

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Presenter

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Presentation Abstract

This presentation centers on the primary metrics commonly used to quantify alarm system performance; how they are constructed, benchmark performance targets, and typical causes for under-performance.

The foundation of the presentation is Technical Report ISA-TR18.2.5-2012 Alarm System Monitoring, Assessment, and Auditing, supplemented by speaker insights gained from reviewing hundreds of performance reports received from process plants worldwide in multiple industries.

Reference Material

TECHNICAL REPORT

ISA-TR18.2.5-2012

Alarm System Monitoring, Assessment, and Auditing

Approved 26 October 2012

Performance Metrics

Performance metrics are usually targeted toward operations management. These metrics are broad indicators of alarm system performance, which should be assessed by comparison to performance goals stated in the alarm philosophy. These metrics may not identify specific problems.

- Average alarm rate
- Percent of time the system is in a flood condition
- Quantity and listing of out-of-service-alarms
- Alarm priority or type distribution

Diagnostic Metrics

Diagnostic metrics are usually targeted toward the alarm system owner and personnel responsible to take action. These metrics identify specific problems with specific alarms.

- Listing and quantity of the most frequent alarms
- Listing and quantity of chattering alarms
- Listing of stale alarms
- Listing of shelved alarms with shelving duration
- Listing of out-of-service alarms with durations
- Listing of alarms shown by analysis to be potentially redundant

Deployment Metrics

Deployment metrics are usually targeted toward alarm system owners and responsible personnel to measure progress on implementing alarm management practices.

- Percent of alarms rationalized
- Percent of alarms monitored
- Priority distribution of rationalized alarms.

Scaling Metrics

Scaling metrics are measurements used to determine other metrics. This includes such items as:

- Number of configured alarms for a particular system
- Number of alarm occurrences for a particular system or group of systems.

Scaling metrics are not directly used or reported, but are used in reporting other metrics.

Audit Metrics

Audit metrics include the data on alarm systems that have been audited. These metrics include:

- Number and nature of unauthorized alarm changes;
- Number and nature of unauthorized alarm suppression.

Audit metrics are usually targeted toward alarm system owners and operations personnel. These metrics can be used to measure execution of alarm management procedures stated in the alarm philosophy, e.g., management of change.

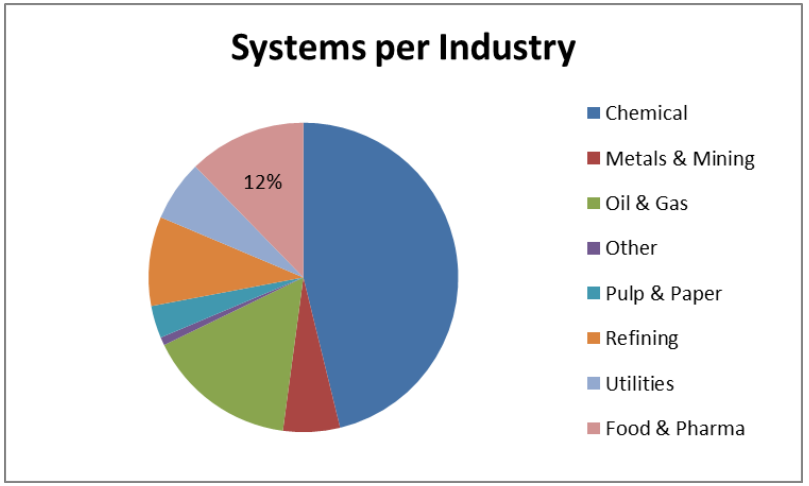
ISA-18.2 Suggested Target Values

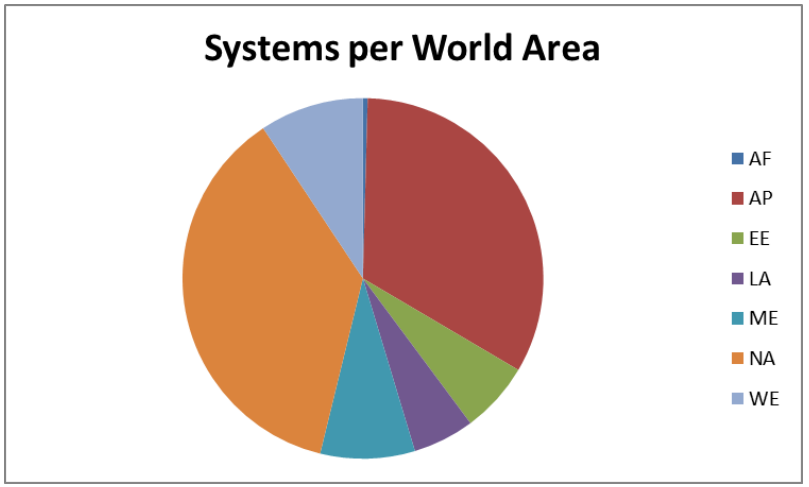
Metric	Target
Annunciated Alarms Per Day Per Operating Position	150 – 300
Annunciated Alarm Per Hour Per Operating Position	6 – 12
Annunciated Alarms Per 10 Minutes Per Operator Position	1 – 2
Percent of 10 minute periods containing > 10 alarms	< 1%
Maximum number of alarms in a 10 minute period	<=10
Percent of time the system is in flood	< 1%
Annunciated Priority Distribution (Low Priority)	~80%
Annunciated Priority Distribution (Med Priority)	~15%
Annunciated Priority Distribution (High Priority)	~5%
Percent contribution of top 10 most frequent alarms	< 1% to ~5%
Quantity of Chattering and Fleeting Alarms	0
Stale Alarms (Active for more than >24 hours)	< 5 on any day

Alarm performance based upon at least 30 days of data.

Sample Data Sets

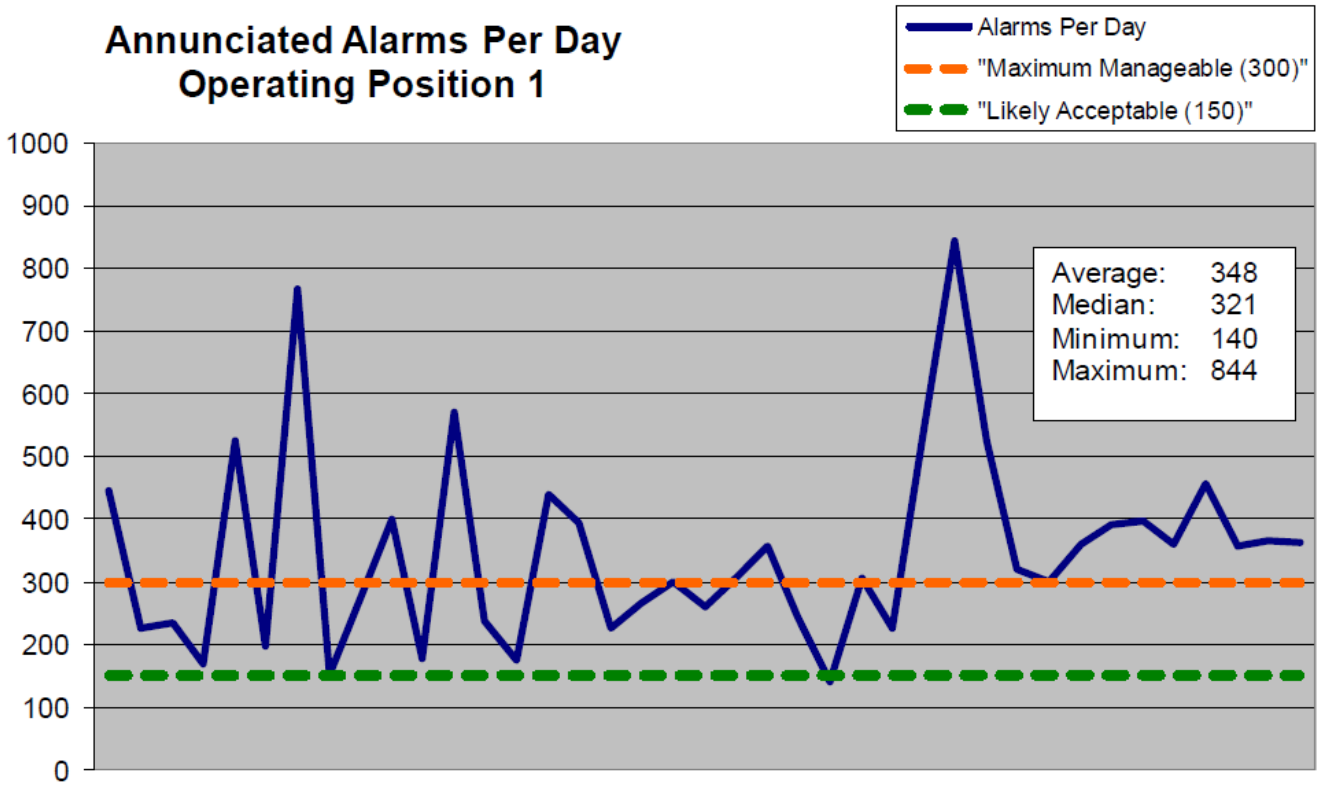
- Performance and diagnostic metrics from 236 systems collected in in 2014-2015
- Most are starting-point metrics, prior to nuisance alarm elimination and rationalization
- These were whole-system reports, nominalized by system IO count and number of operator positions for this presentation.





Average Alarm Rate

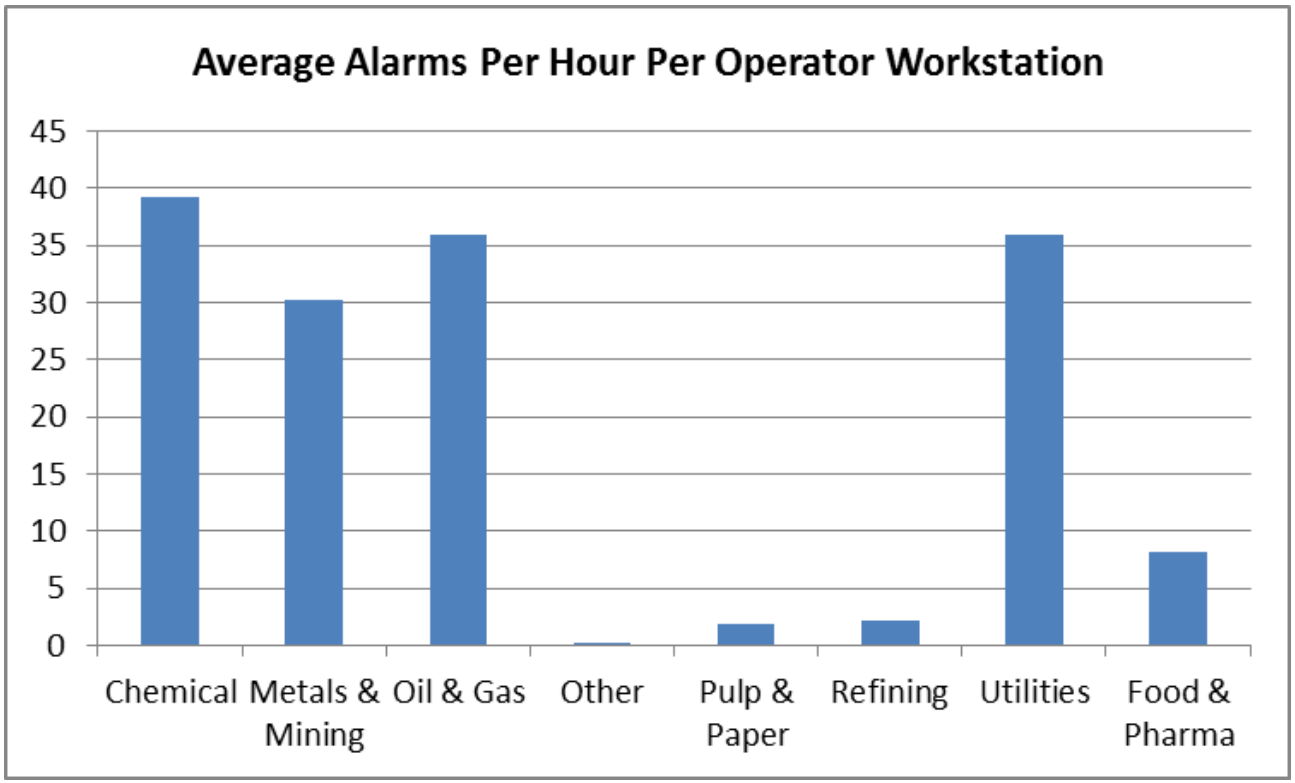
A useful initial measure of the overall performance of the alarm system. The average alarm rate is the most common alarm system performance metric. Periods of unusually high alarm activity are easily identified in trend charts.



Average Alarm Rate Per Hour Per Operator Workstation

- 29.0 alarms/hr. for all industries
- 8.1 alarm/hr. For Food & Pharma

Alarm Rate	Per 1 Hour
Acceptable	~ 6 Alarms
Manageable	~12 Alarms
Demanding	~ 30 Alarms
Unacceptable	> Alarms

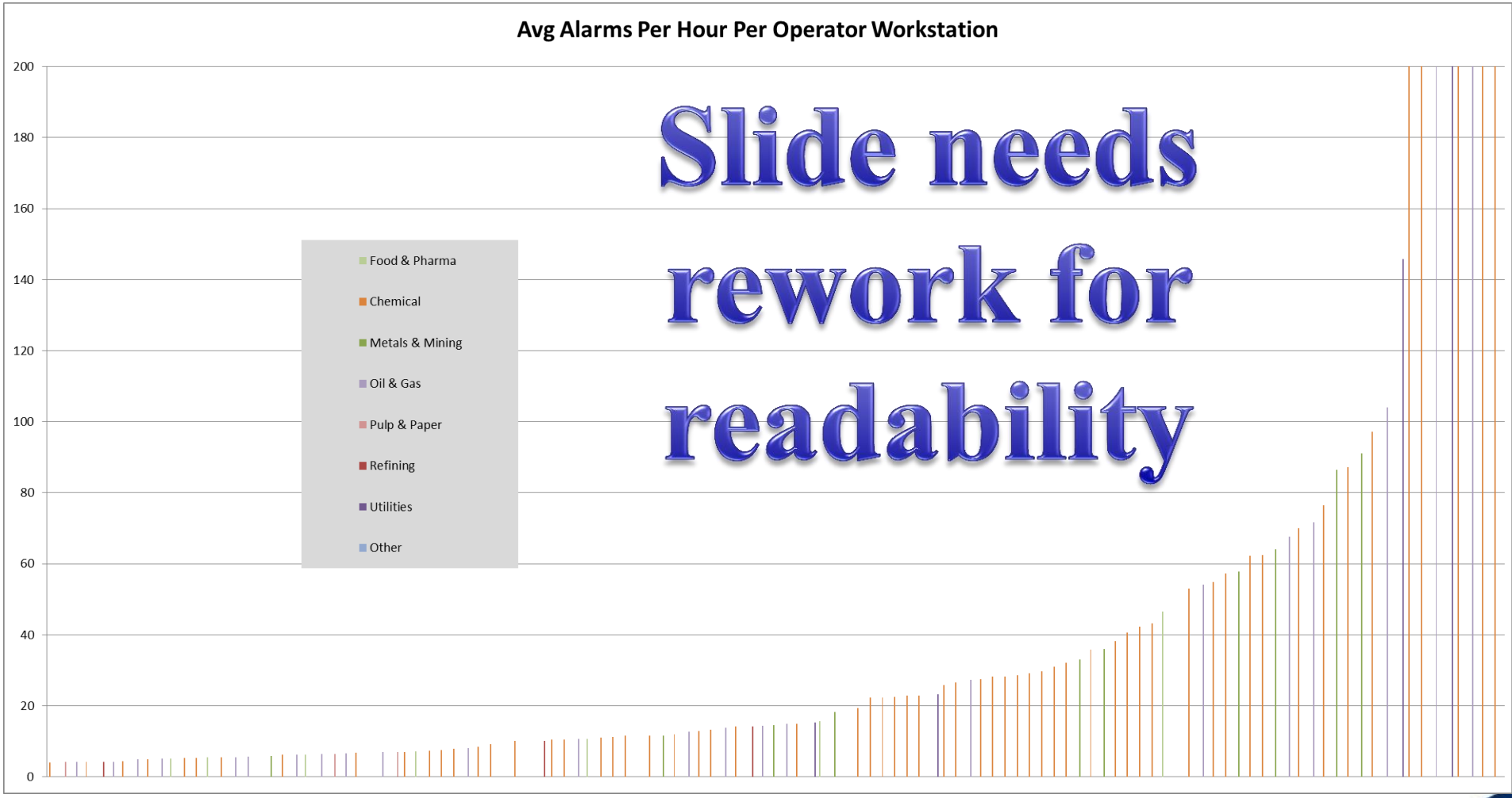


What can we learn from average alarm rates?

- If very low. Then probably good.
- If very high. Need to know more.

Alarm Rate By System
Per Hour Per Operator Workstation

Per individual system it varied from near zero to 1063 alarms / hour!



Averages and Alarm Floods

- Averages can be misleading, providing no sense of peaks in the alarm rate, making it difficult to distinguish “alarm floods” vs. steady-state “normal” operation.
- An alarm flood can be defined as beginning when the alarm rate exceeds 10 or more alarms occurring in 10 minutes, and ending when the rate drops below 5 alarms in 10 minutes (a short-term manageable rate).

Pictorial representation of the alarm flood definition

Percent of Time In Alarm Flood

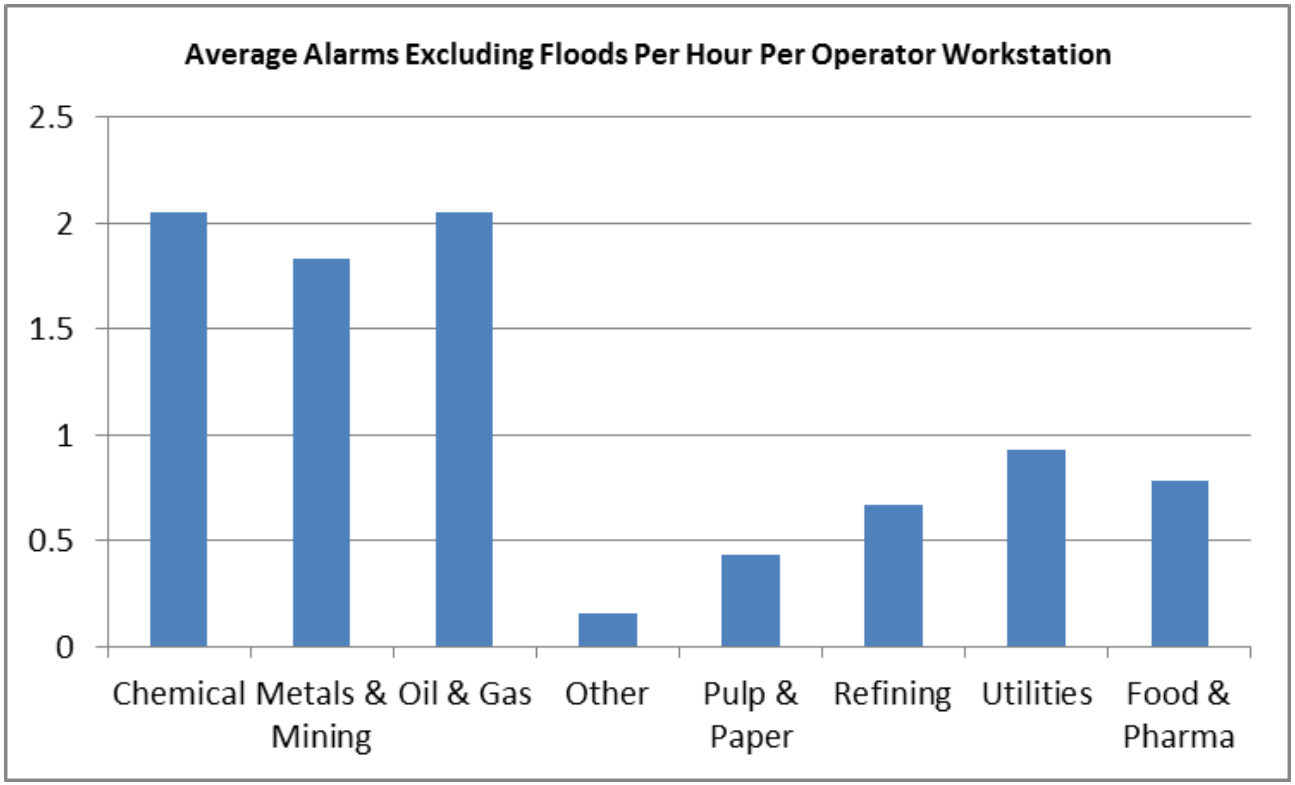
- XX

Slide under construction.

Average Alarm Rates Per Operator Position Excluding Alarm Floods

- 1.6 alarms/hr. for all industries
- 0.8 alarm/hr. For Food & Pharma

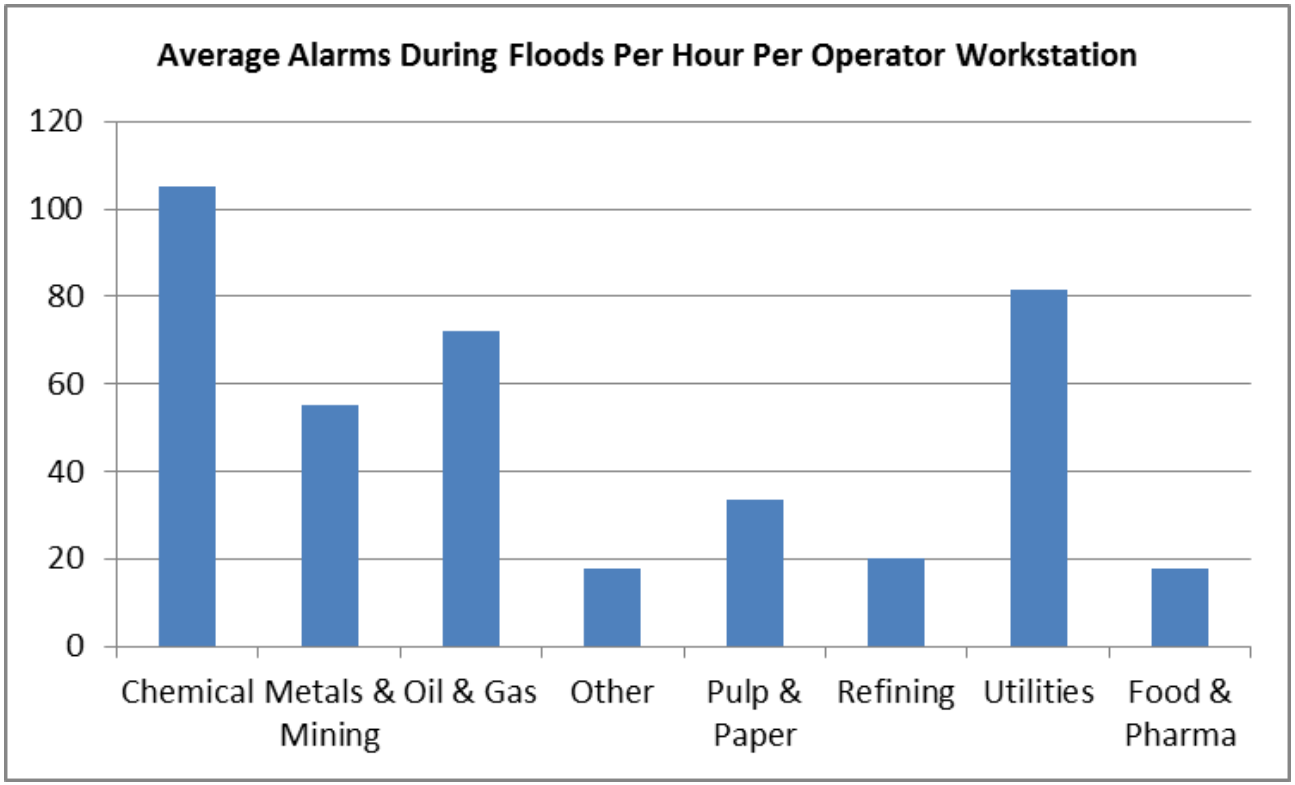
Alarm Rate	Per 1 Hour
Acceptable	~ 6 Alarms
Manageable	~12 Alarms
Demanding	~ 30 Alarms
Unacceptable	> Alarms



Average Alarm Rates Per Operator Position During Alarm Floods

- 73.8 alarms/hr. for all industries
- 18.0 alarm/hr. For Food & Pharma

Alarm Rate	Per 1 Hour
Acceptable	~ 6 Alarms
Manageable	~12 Alarms
Demanding	~ 30 Alarms
Unacceptable	> Alarms



Typical Problems Associated With A High Alarm Rate Excluding Floods

- Chattering alarms
- System and device maintenance alarms
- Non-alarm notifications
  - Messages
  - Prompts
  - Alerts
- Metric calculations?

Typical Problems Associated With A High Alarm Rate During Floods

- Redundant Alarms
- Cascading Alarms
- Process state transitions where the alarm system is not designed to “follow the process”

Alarm Flood Severity

- Flood severity based on the most alarms received in a single ten minute period:
  - 10 to 20 alarms — minor flood
  - 20 to 30 alarms — moderate flood
  - > 30 alarms — severe alarm flood
- In a severe flood, the alarm system can become a hindrance or distraction, rather than acting as a useful tool to assist the operator. During such periods, alarms are likely to be missed.

Most extreme alarm floods, Max. count of alarms in a 10 minute period

XX

Alarm Priority Distribution

Prioritization of alarms provides a mechanism for placing a qualitative value on the importance of the alarm. The priority of an alarm determines its significance and how quickly the operator should respond to an alarm. Proper guidelines for a recommended three-priority system distribution are widely known and reflected in ISA-18.2, namely:

- ~80% Low Priority
- ~15% Medium Priority
- ~5% High Priority

All System PIE Chart

“High Priority” alarm percentages

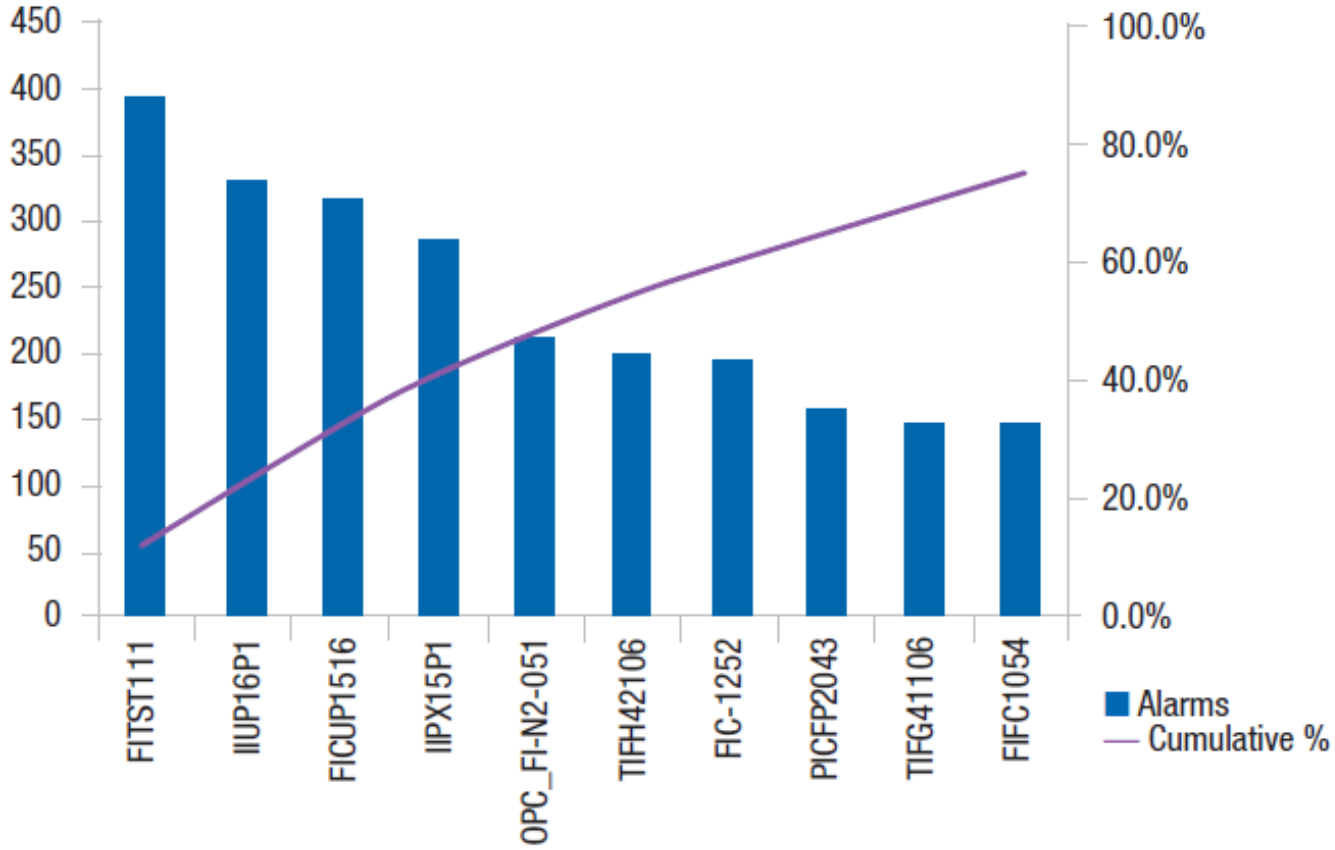
Average “High Priority” Alarm Percent of Total Alarms:

Typical Problems Associated With A High Percent of High Priority Alarms

- Alarms based on ultimate (unmitigated) consequences rather than direct (proximate) consequences
- Priority used to classify alarms for reasons other than guiding operator on order of actions
- Chattering high priority alarms, often system and device alarms
- Priorities left at vendor default settings

Top 10 Source Contribution To Total Alarm Count

Relatively few alarms often produce large percentages of the total system alarm load. Substantial performance improvement can be made by addressing the most frequent alarms.



Top 10 Alarm Source Contribution By Industry and World Area

Average Top 10 Alarm Percentage Per System:

Typical Problems Associated With A High Top 10 Percentage

- Nuisance alarms — alarms that operators have come to expect, and in most cases, ignore or consider to be informational
- The alarm system is being misused to (frequently) generate operator prompts based on routine changes in process conditions or operating states

Stale Alarms

- Alarms which remain in the alarm state continuously for a substantial time period. (24 hours is a recommended value for analysis) They often last for days, weeks, or months.
- Following their initial appearance, such alarms provide little valuable information to the operators. They clutter the alarm displays and interfere with the operator's ability to detect and respond to new and meaningful alarms.

Stale Alarm Quantification

Snapshot Method: Number present at a certain time of day.

- Takes into account any local operator alarm filtering which can be difficult or impossible to discern in the event history, providing the truest indication of actual operator experience
- Allows Direct comparison to ISA benchmark.

Tally Method: A count of the number of alarms annunciations that reached an old age (e.g. 24 hours) during a fixed time period (typically a week or month)

- Can be applied uniformly to the ubiquitous OPC accessible event data available from multiple process control, safety and other systems
- Can generate ordered lists of the longest standing alarms for continuous improvement efforts

Stale Alarm Tallies By Industry and World Area

Stale Alarm Tally Per 30 Days Per Operator Position:

Typical Problems Associated With Stale Alarms

- Not following one of the basic principles of alarm management, that alarms should be produced only upon abnormal conditions. For example, standby or other equipment that is intentionally shut down should not produce alarms simply because they are off.
- Alarms that persist beyond the called-for operator action, waiting for maintenance action.
- Alarms that are essentially latched due to excessive application of hysteresis.

Key Ideas and Thoughts

- Identify and resolve nuisance alarms, to get a more realistic picture when reviewing subsequent alarm rate metrics.
- A substantial reduction in configured alarms is the usual result of alarm rationalization, along with a resulting alarm priority distribution close to recommended values.
- Stale alarms are usually addressed by examination of the cause and application of logic or state-based techniques.
- Alarm floods are more difficult to address, often involving a dynamic alarm management solution.
- ISA-TR18.2.5-2012 is an excellent resource for interpreting alarm metrics and common causes.

Discussion