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HYDROCARBON PROCESSING®

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Case history: Quantifying the benefits of alarm management

The role of the process console operator has evolved. These operators are responsible for more equipment (assets), instrumentation, control loops and alarms. The process console operator role has become more complex with the advancement of the distributed control system (DCS).

Alarm management (AM) improvement processes and solutions encompass practices and software designed to prevent alarm floods and "chatter," and to reduce the information overload to the console operator. The result is minimizing the potential damage caused by a process operator missing a critical alarm. By using timely alarms that lead an operator to corrective actions, the goal is to improve plant safety, to increase efficiency and to reduce environmental constraint limit violations.

Best-practice initiatives. An AM initiative focuses on implementing best practices into the company culture. A series of routine AM tasks scheduled on a daily, weekly, monthly and yearly basis that assign accountability across all levels of the corporate structure can promote a successful program.

Many processing plant executives want to know the financial benefits and justifications for implementing and maintaining AM processes and software. Here are several possible benefits resulting from an AM improvement process.

What is an AM improvement process? First-class AM includes a combination of work processes and software technology. A life cycle approach should be used, with respect to AM. More importantly, AM is a continuous process, not a single project. TABLE 1 summarizes the five phases (work processes) involved in developing and implementing a first-class AM improvement process:

FIG. 1 illustrates the phases of the AM life cycle. A first-class AM improvement process solution includes software designed to facilitate many of these steps. The AM software functionality includes:

- Software for alarm analysis to automatically generate Web-based, key performance indicator (KPI) reports for an accurate snapshot of the present alarm system performance. FIG. 2 and TABLE 2 show some of these KPIs in an example benchmark report.
- Software to manage the alarm configuration that allows the import and collection of alarm configuration data from the DCS and other control systems. This software facilitates the management of change (MOC) of the alarm configuration and limits data; and it should also contain some audit reporting capability.
- Software to ensure that the right users are notified of key events. Automatic notifications are delivered to improve operator visibility and to prevent abnormal events. Unconfirmed events are escalated to the correct personnel.
- Software to document operating boundaries (or the operating "envelope") based upon "real" operating limits.

Benefits from the AM improvement process. From FIGS. 3 and 4, a comparison of the number, percentage and type of alarms before and after the implementing an AM improvement process is listed. Many clients of AM report a reduction in the total alarm rate of 50% or more, and some report a 75% reduction.[2] In addition, FIG. 5 shows the typical reduction in percentage of alarms as the AM process proceeds.

The best and most rigorous method for determining the actual benefits resulting from the AM improvement process would be to:

- **Step 1.** Estimate the cost of various events/alarm types and levels.

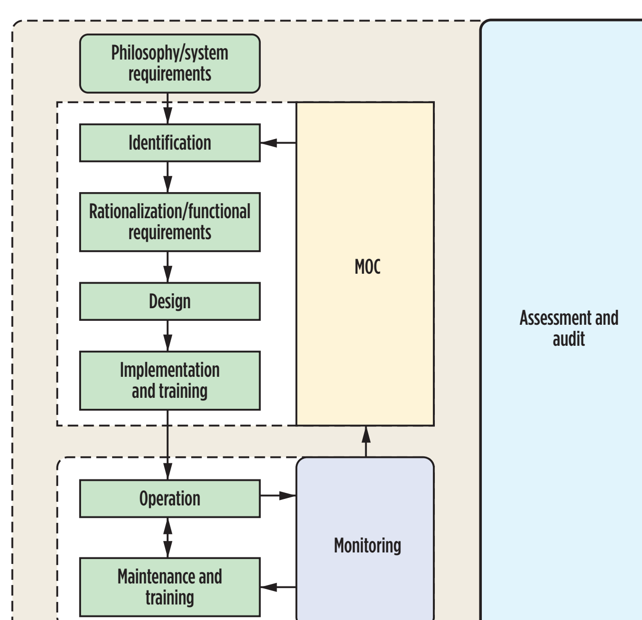

FIG. 1. The AM improvement process life cycle. Source: ISA 18.2.[3]

o **Example 1**—If a compressor seal exceeds a high-temperature limit five times, the seal will fail and result in a compressor shutdown.

o **Example 2**—If a pressure exceeds a high limit and a pressure-relief valve opens, it may not reseat, resulting in a unit shutdown.

TABLE 1. The work processes or phases needed to implement AM

Phase 1—Awareness
Benchmarking
Commitment and ownership
Development of an alarm philosophy, including a corporate document that should outline:
Objectives of the alarms
Procedures for defining alarms
How to assign priorities
Expected operator responses
MOC process
Assignment of ownership and accountability
Phase 2—Assessment
Analysis
Work plan
Phase 3—Alarm redesign
Procedures
Documentation
Rationalization
Housekeeping
Phase 4—Implementation
DCS configuration
Training
Implementation of a MOC system
Phase 5—Benefits
Performance monitoring
Ongoing audit and enforcement
Upset investigation

o **Example 3**—If a pipe's temperature exceeds a particular limit, stress-corrosion cracking increases and facilitates early pipe failure with little or no loss of metal.

- **Step 2.** Estimate the frequency of the events.
- **Step 3.** Calculate an annual total cost associated with missed alarms that were exceeded by multiplying the cost of each event by the frequency for the events.
- **Step 4.** Estimate how much the plant throughput could increase if alarms were better managed and the plant was run closer to the actual "operating envelope" as opposed to running with large "safety factors" built into the alarm limits.
- **Step 5.** Implement the AM improvement process and run it for six months.
- **Step 6.** Document the actual reductions in frequency of events over six months with the AM process.

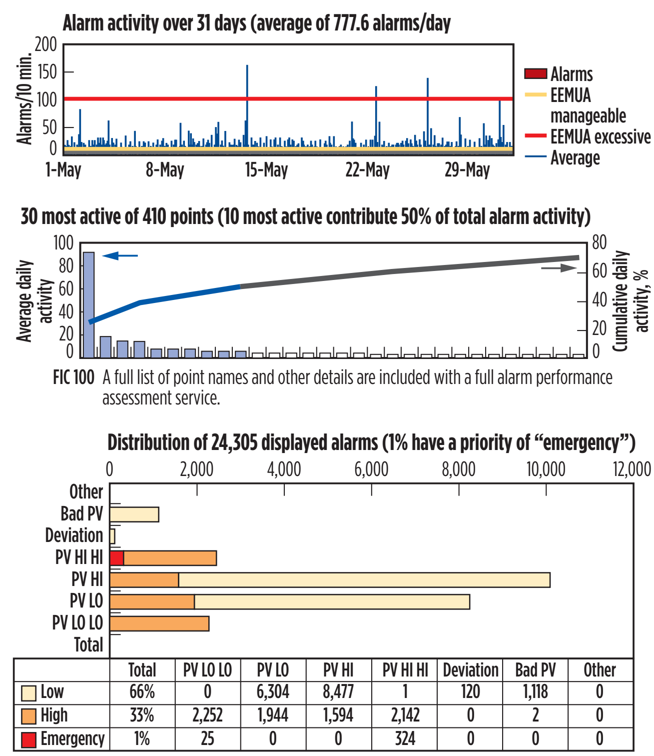

FIG. 2. An example of a benchmark report.

TABLE 2. An example of a benchmark report

	Alarm activity metrics	Console OP#3	EEMUA (steady state)	Q1 median	Overall median	Q4 median
			Benchmarks			
Time at risk level (steady state) 4th quartile	Manageable level (≤ 1 alarms per 10 min)	33% (10 days, 8 hr)	–	90%	74%	56%
	Over-demanding level (2 to 10 alarms per 10 min)	52% (16 days, 5 hr)	–	7%	23%	32%
	Excessive level (> 10 alarms per 10 min)	14% (4 days, 11 hr)	–	3%	3%	12%
Alarms/10 min	Average	5.4	< 1	1.97	2.06	7.34
	Maximum	162	< 10	N/A	N/A	N/A
Hourly average	Alarms	32	< 6	11.8	12.4	44
	Interventions	11.4		7.72	17.3	11.8
	Intervention-to-alarm ratio	01:02.9		01:01.5	1.4:1	01:03.7
Alarms per day	Average	777.6	< 288	283.7	296.6	1,057

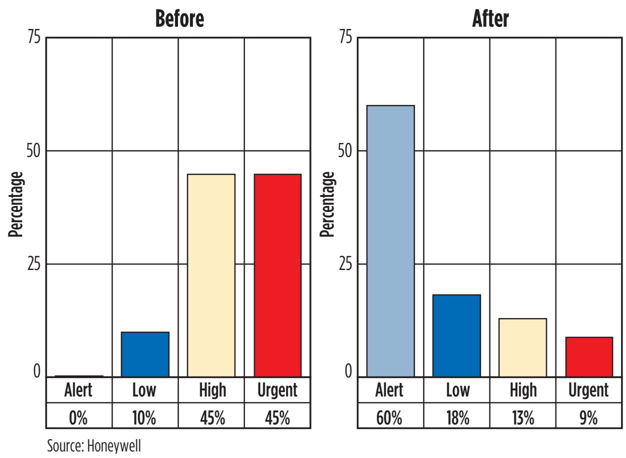

FIG. 3. Before and after alarm distributions.

• **Step 7.** Document actual increases in plant throughput or product production increases.

• **Step 8.** Estimate the increased profits associated with Steps 6 and 7.

Companies that have implemented the AM improvement process at a first plant, have performed this rigorous analysis (post-audit). They have verified that the AM satisfied the corporate investment criteria (investment hurdle rate) to proceed with a company-wide rollout of the AM improvement process. They have documented results, including:

- Reductions in unplanned shutdowns
- Increases in plant throughput
- Reductions in emergency alarm frequency.

Another option for determining benefits is reviewing the past year of incident reports, identifying the ones that are alarm associated and then totaling the resulting losses from the events.

Case history. For example, consider how to estimate the benefits that would result in an AM improvement process for a 100,000-bpd refinery. In this example, heuristics, experience, simple financial models and engineering judgment are used to calculate these benefits. The main economic benefits estimated are divided into several categories:

- Fewer abnormal situations
- Increase in throughput from opening alarm limits by operating the complex closer to actual physical limits but not exceeding them
- Reduction in avoidable maintenance
- Decrease in capital expenses for equipment and repairs.

Some additional benefits are smaller or may be more difficult to quantify. These result from safety improvements, fewer environmental incidents, energy savings and compliance with government rulings. These additional benefits can be significant, but will not be estimated in this article. The total annualized benefits from an AM improvement process for a 100,000-bpd refinery are estimated and summarized in **TABLE 3.**

Fewer abnormal situations. After AM has been implemented, the reduction in frequency of alarms is well documented. Fewer abnormal situations resulting from AM has been reported. Using a cracked spread of $24/bbl and a charge rate of 100,000 bpd results in a calculated profit of $2.4 million/

TABLE 3. Estimated annual benefit of an AM improvement process for a typical 100,000-bpd refinery, $ million

Category	Annual benefit, $
Reduction in abnormal situations	2.88
Increase in plant throughput	1.68
Reduction in avoidable maintenance	1.11
Reduction in capital equipment for repairs	0.22
TOTAL	**5.89**

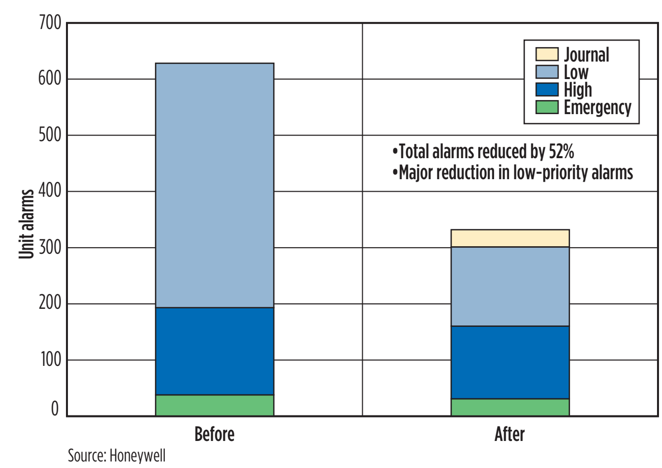

FIG. 4. Before and after alarm numbers.

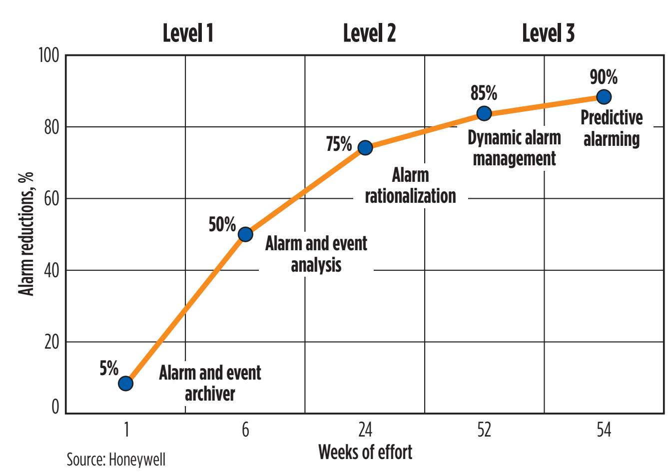

FIG. 5. Reduction in alarms as AM progresses during lifecycle.

day. With a basis of four days per year of unplanned downtime, a 30% reduction in unplanned downtime yields a conservative AM annual benefit of $2.88 million.

Increase in plant throughput. After AM has been implemented, some clients have reported plant throughput increases. With AM, the operators were more confident to run the unit closer to actual physical constraints due to having proper, just-in-time alarming systems. Using the previously calculated daily profit of $2.4 million/day, an increase of only 0.2% in throughput yields a conservative AM annual benefit of $1.68 million.

Reduction in avoidable maintenance costs. When human-error-caused abnormal incidents occur, unplanned maintenance work is required. This estimate attempts to quantify those preventable costs. The benefit is calculated by a 0.25% reduction in a plant maintenance budget of $44 million annually.

Decrease in capital equipment for repairs. When human-error-caused abnormal incidents occur, equipment and materials are required for repairs or additional wear-out resulting from the event. This estimate attempts to quantify those preventable costs. The benefit is calculated by a reduction in plant capital budget of 1% in total material costs of a $22 million annual budget. The estimated benefit is conservative when compared to benefits described in the referenced AM user success story, which describes a 3% increase in throughput and a three-month payout time.[4]

Lessons learned. There are measureable benefits in applying AM improvements. These benefits will entail using experience, simple financial models, good engineering judgment and financial calculations. Using very conservative estimation methods, the estimated benefits for an AM improvement program for a 100,000-bpd refinery show an ROI certain to surpass the typical corporate investment hurdle rate. HP

ACKNOWLEDGMENT

Much of the AM improvement process technology was developed in the Abnormal Situation Management (ASM) Consortium that was founded in 1994 by Honeywell and many processing companies.

LITERATURE CITED

Complete literature cited available at HydrocarbonProcessing.com.

Root cause involving alarms

One of the root causes of the 1979 Three Mile Island nuclear plant accident was described recently:[1]

During the first few minutes of the accident at Three Mile Island, more than 100 alarms went off, and no system was in place to filter out the important signals from the insignificant ones, according to the 1979 Kemeny report. "Overall, little attention had been paid to the interaction between human beings and machines under the rapidly changing and confusing circumstances of an accident," the commissioners wrote.

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