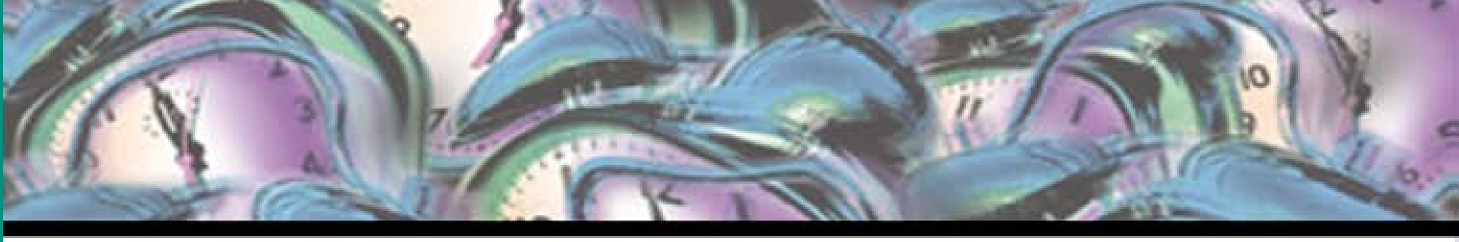


Alarm Management

Operators at a regional wastewater treatment plant develop a process to reduce nuisance alarms

Michael D. Johnson and William Hendrix Jr.

The 165-mgd (624,500-m^3/d) Sacramento (Calif.) Regional Wastewater Treatment Plant is one of the few treatment facilities designed during the 1970s that incorporates fully automatic control. In June 2001, the Sacramento Regional County Sanitation District (RCSD), the facility's owner, completed installation of a process computer control system that provides extensive alarm capabilities. With more than 37,000 database points, the system enables operators to monitor nearly every aspect of the plant, its processes, and the performance and condition of its equipment. The system displays all alarms from plant processes and the computer system on operator alarm screens. However, this new alarm capability generated far more alarms than the system and operators could manage.

Besides the sheer number of alarms, other factors indicated that RCSD had a problem managing alarms at the facility. For example, no plantwide philosophy existed for managing alarms, nor did design guidelines or procedures for adding new alarms. Similarly, no standard procedures were in place for removing existing alarms.

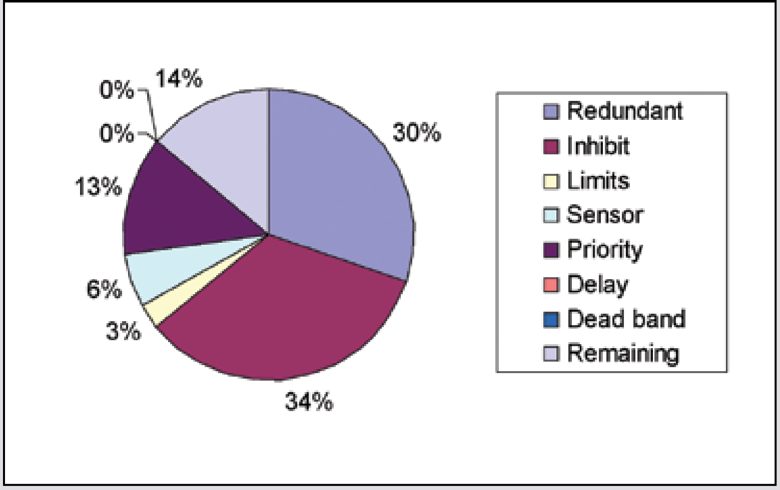
Nuisance alarms prevailed, because alarms were set to occur even when no operator action was needed. Many alarms were active even when nothing was wrong. At times, operators were not always sure how to respond when alarms activated. Some alarms were active for weeks or months.

Another problem involved alarm "storms" that would occur when routine operations occasionally produced a large number of alarms, or minor operating upsets generated significant numbers of alarms. Major operating upsets would result in an unmanageable number of alarms.

Auditing the Alarms

In April 2003, RCSD and EMA Inc. (Minneapolis), a consulting engineering company, audited the alarm system and found more than 700 active alarms, most of which were characterized as nuisance alarms. An analysis of active alarms classified the sources of the nuisance alarms into

Figure 1. Audit Alarm Results



seven categories:

- Redundant alarms repeated or indicated the same root cause as other alarms.
- Inhibit alarms resulted from normal operations, such as when equipment is designated as being out of service or on standby; these alarms were so named because they could be inhibited by indicating to the control system that a normal operation had occurred.
- Alarm-limit alarms resulted from limits being set too close to normal operating parameters.
- Sensor-range alarms resulted from sensor ranges being set too close for calibration tolerances.
- Priority alarms are alarms that could be reassigned to a lower priority.
- Delay alarms are transient alarms that could be reduced in number by system functions, such as initial delay or cutout delay, that decrease the system's sensitivity to detecting transient alarms.
- Deadband alarms are "chattering" alarms that could be reduced by changing an alarm's deadband, the small range around an alarm value within which an alarm's status does not change.

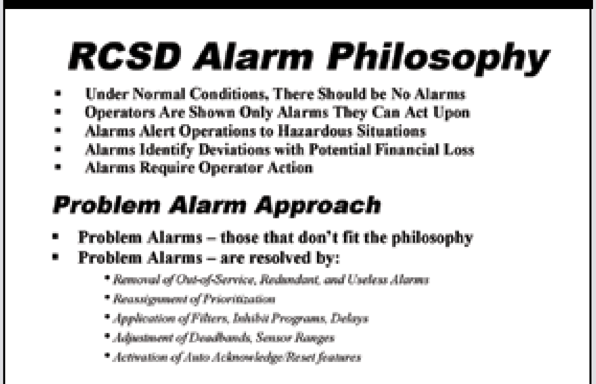
Redundant and inhibit alarms comprised 64% of the nuisance alarms (see Figure 1, left). Almost 10% were caused by alarm limits being set too close to acceptable operating limits or calibration tolerances. Another 13% were considered to be a lower priority than assigned. This audit provided an initial description of the issues related to alarm management facing the operators.

The audit also found points in the process computer control system configured as alarms to record test data. Conducting tests is a normal activity in many treatment facilities, one that typically does not require operator action. Therefore, these points should be displayed only to the persons conducting the test, rather than to all operators. To support the efforts of those who have to record test data, the process computer control system's data-acquisition utility is configured to display test point alarms only to the person or persons conducting the test.

Following a Four-Step Method

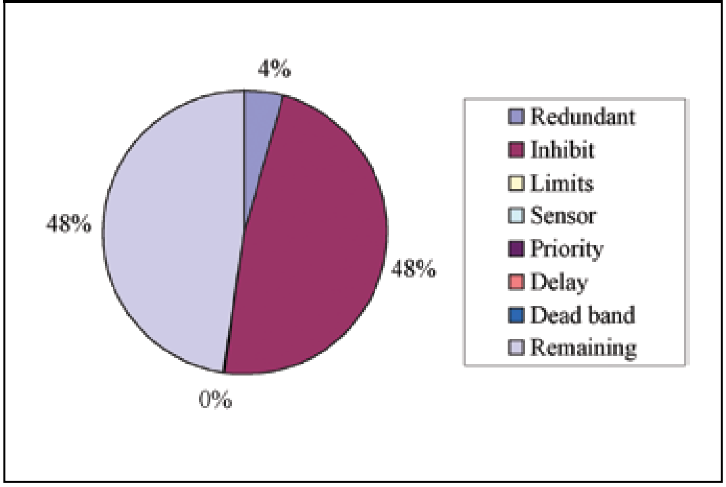
To resolve the problems with managing alarms at the facility, EMA and RCSD applied an approach consisting of four steps: assessing, designing, implementing, and optimizing. The first step — assessing — involved auditing the active alarms, analyzing the results for root causes, and developing a philosophy for managing alarms. The second step — designing — entailed documenting design guidelines for determining what constitutes an alarm, and developing procedures for adding and removing alarms. The third step — implementing — involved reconfiguring alarm priorities, limits, and deadbands, as well as modifying operating procedures and training to support the new alarm philosophy. The fourth step — optimizing — used analytical tools to investigate causes of specific alarms and identified a graphic alarm presentation to aid operators in interpreting and responding to process and equipment upsets.

Figure 2. Alarm Philosophy Employed by the Sacramento (Calif.) Regional County Sanitation District (RCSD)



EMA and RCSD began the process of improving the alarm system by developing a philosophy for managing alarms. By holding workshops with senior operators, RCSD was able to develop a philosophy based on a shared understanding that incorporated certain key tenets. First, participants agreed that the purpose of alarms is to maintain plant performance within normal limits, recognize and avoid hazardous situations, identify deviations that could lead to financial loss, and improve understanding of complex processes. Second, alarms were defined as a warning that a process variable has passed a defined limit and is approaching a value that is undesirable, unsafe, or both; a problem annunciated via an audible sound, a visual indication, a message, or a combination of these indicators; and, most importantly, something that requires operator action.

Figure 3. 2004 Alarm Audit Results



This philosophy implies the use of automatic alarm acknowledgement and automatic alarm resets to reduce response requirements for operators. To this end, the following features on the process computer control system were used:

- Auto Akn, which automatically acknowledges alarms when they appear on the display (an operator need only reset the alarm); and
- Auto Reset, which automatically resets an alarm after an operator acknowledges it.

This shared understanding developed by RCSD and its operators is embodied in the RCSD Alarm Philosophy (see Figure 2, p. 67).

Design guidelines were developed to document when and how to add and remove alarms. The approach to managing alarms was designed to resolve the largest sources of problem alarms. The following actions were taken:

- Obsolete alarms were removed.
- Deadbands were increased to reduce alarm "chatter."
- Alarm delays were applied to eliminate alarms that simply note transient conditions.
- Priorities were changed to separate warning conditions from actual alarm conditions.
- Alarm-inhibit functions were introduced to reduce alarm "flooding" resulting from normal operating conditions that generate alarms.

By implementing this approach, RCSD and EMA reduced the sources of nuisance alarms.

Figure 4. Alarm Occurrences Within a 7-Day Period (by Frequency)

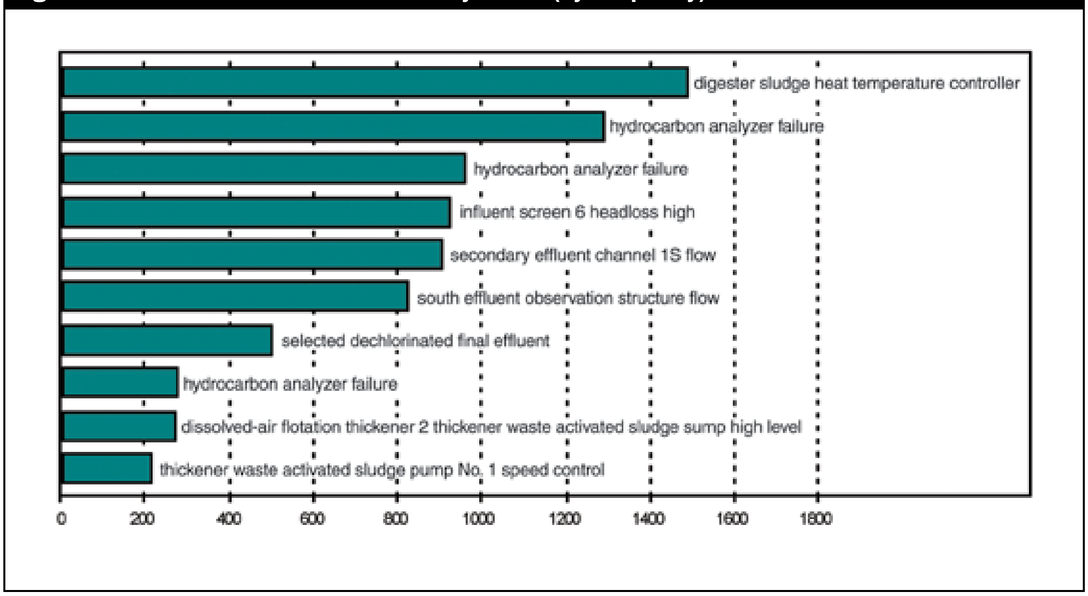


Figure 5: Sample Screen From Iconic Alarm System

A second audit was conducted in April 2004 to measure the progress and results associated with this approach to managing alarms.

A comparison of the 2004 alarm audit to the original 2003 audit confirms that the approach used to remove alarms was effective in reducing the largest sources of nuisance alarms (see Figure 3, p. 68). However, the total number of nuisance alarms did not decline significantly. Ninety-six percent of the nuisance alarm sources either were difficult to implement, requiring program modifications to inhibit alarms on a case-by-case basis, or hard to identify, requiring individual analysis of the alarm cause. This audit demonstrated the need for more comprehensive tools for analyzing alarms.

Implementing Analytical and Maintenance Procedures

EMA and RCSD recognized the need to procure an alarm-analysis tool that could collect and analyze significant amounts of "hard" data about alarm frequency and occurrences. Because previous analysis was based only on snapshots of alarm screens, it could not provide clear insight into specific alarm deficiencies. The analytical tool had to be able to capture and analyze alarm activations, acknowledgements, actions taken, and system status events, all of which had to be time-stamped to support statistical analysis.

Because the process computer control system typically generated more than 1000 alarm events per day, or an alarm every 90 seconds, a 3-month history of alarm events easily could include more than 200,000 events.

Using LogMate, an alarm-analysis tool offered by TiPS Inc. (Georgetown, Texas), RCSD analyzed the top 10 most frequently occurring alarms in a single week. This analysis revealed that a controller alarm monitoring the temperature of digester sludge activated 1484 times, or about once every 7 minutes (see Figure 4, p. 68). Three alarms used to warn of hydrocarbon analyzer failure were found to have activated 2519 times. The four alarms contributed to more than 39% of the total alarm activations during the week in question. Assuming that the three alarms monitoring hydrocarbon analyzer failure share a similar cause, resolving only two alarm causes would have reduced the number of active alarms during the week by almost 40%.

Such an analysis helps those who manage the alarm system to identify and prioritize methods quickly to resolve problem alarms, in this case, alarms that do not fit within the RCSD Alarm Philosophy.

When the philosophy has been applied consistently, icons will be used in new alarm screens to optimize further alarm presentation and operator response. Figure 5 (above) illustrates an example of an iconic alarm screen.

Decisions made as part of the operation of large, complex facilities often produce unintended consequences. When RCSD installed new process control capability, it provided tremendous capacity to display alarms related to an enormous number of computerized plant processes. However, this new capacity for displaying alarms quickly revealed a problem with the way the district managed alarms.

By applying the approach of assessing, designing, implementing, and optimizing, RCSD resolved these alarm management issues. As a result, the district has reduced the treatment plant's total number of alarms by at least 50%, virtually eliminated nuisance alarms, maintained the number of unacknowledged alarms at zero, and significantly improved early detection and prevention of discharge violations.

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