Intelligent alarming

Effective alarm management improves safety, fault diagnosis and quality control

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Courtesy Chilten Air Support Unit, England

As industrial plants become larger and more complex, an increasingly sophisticated alarm system is required to inform operators of potential malfunctions. With hundreds of different processes running at once, operators can be hard pushed to keep up with alarms, even under normal conditions. Without careful management, alarms can be ignored by even the most diligent of operators. Persistently active alarms may even be disabled, leading to potentially disastrous consequences.

To ease the problem of operator overload, ABB offers a number of alarm management tools. Its Power Generation Information Management (PGIM) system incorporates alarm and event management functions, and the alarm hiding functions of System 800xA allow certain alarms to be hidden under certain conditions, thereby avoiding unnecessary distraction of operators. ABB Engineering Services, together with local ABB project groups, also provide alarm management consulting services.

With modern digital control systems (DCS), it has become very easy to configure large numbers of isolated alarms. This often results in systems that generate many alarms (more than 2000 alarms per day and operator are typical for many industrial processing plants) during normal operation, and even more during process upsets. It is unreasonable to expect an operator to respond to alarms arriving at this rate.

In the oil and gas industry, alarm management is a well-established practice and, in many cases, a legal requirement. Other industries, such as power generation, pulp and paper, and the chemicals industry, are following suit. In 1999, the Engineering Equipment and Materials Users Association (EEMUA) published a guide to the design, management and procurement of alarm systems, known as EEMUA 191 [1]. The document has since become the worldwide de facto standard for alarm management. Among its key messages are that every alarm should be useful and relevant to the operator, and that operators can be realistically expected to deal with a long therm average alarm rate in steady operation of around one alarm every 10 minutes. It also states that all alarms should have predefined operator responses.

The basic recommendations [2] for alarm management are to:

- Measure alarm rates, and other alarm key performance indicators, and compare them with recommendations from EEMUA 191, or with values from reference plants.
- Identify low hanging fruits – it is often possible to improve an alarm system significantly with very little effort.
- Eliminate nuisance alarms. This might include tuning control loops, replacing faulty sensors and changing the status of some indicators from alarms to events.
- Measure the alarm performance indicators regularly to ensure they stay in the desired target area.

These cost-effective steps relate to normal operating conditions. Once they are well under control, the next step is to reduce alarm floods during process upsets.

Current situation

In the control rooms of many existing plants, one can easily find symptoms of bad alarm management. These include:

- Display screens persistently covered with alarms
- Frequent alarms during normal operation, and even more during plant upsets
- Alarms standing for long periods (days or weeks)
- Bulk acknowledgement of alarms without investigation ("blind" acknowledgment)
- Operators failing to value alarms as a support system
- Audible alarms being disabled to avoid constant noise pollution

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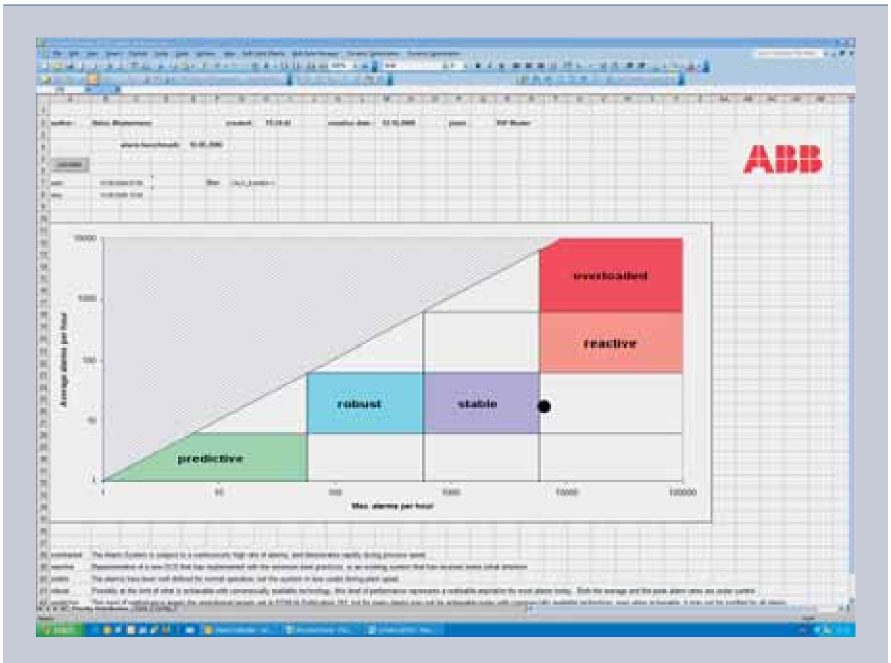
In extreme cases, the alarm system is completely ignored by the operators and the plant would run more efficiently if the DCS had no configured alarms at all!

In large safety-critical plants such as refineries or offshore platforms, alarm management is often required by law. A thorough analysis of accidents like the Texaco Refinery explosion at Milford Haven (1994) has clearly shown that bad alarm management contributes to accidents: In Milford Haven, the operators (a team of two) received 275 different alarms in the 11 minutes before the explosion. This is why a number of authorities, including the UK's Health and Safety Executive and the Norwegian Petroleum Directorate [3], require safety-critical plants to implement systematic alarm management.

If critical situations can be stabilized and emergency shutdowns avoided, this not only increases the safety of a plant, but also offers substantial economic benefits – unplanned shutdowns are very expensive and better alarm management enhances process efficiency.

EEMUA 191 is a set of guidelines for alarm management, but its recommendations are not mandatory. However, the document does describe best practice and is used by a number of regulatory bodies. Standards such as Namur NA102 "Alarm Management" [4] and ISA RP18.2 "Management of Alarm Systems for the Process Indus-

1 Alarm management benchmark, first proposed by Campbell Brown of British Petroleum



Operational profitability

tries" [7] are based on the ideas in EEMUA 191. The guidelines focus on the properties of the operator's information processing capabilities and emphasize the usability of alarm systems from the operator's perspective. The old way of thinking was to blame malfunctions on human error if an operator had overlooked an important alarm. However, EEMUA 191 makes it clear that if the plant's management has failed to reduce alarm rates to a reasonable level, then the operator cannot be held accountable.

EEMUA 191 specifies several measurable performance indicators that can be used to assess the performance of a plant's alarm system:

- The long term average alarm rate in steady operation should be less than one alarm in 10 minutes.
- The number of alarms during the first 10 minutes of a major plant upset should be less than ten.
- The recommended alarm priority distribution is high (5 percent), medium (15 percent), and low (80 percent).
- The average number of standing alarms should be less than ten.

EEMUA 191 offers an affordable methodology to compare practices in individual plants with industry best practice.

Alarm management basics

An important first step in alarm management is to record all A&E (alarms and events) messages in an electronic database for further analysis. Alarm printers are still used in some plants, but they are expensive to maintain and can result in valuable information being buried in archives that nobody reads. Alarm management tools, like Power Generation Information Management (PGIM), can connect to all kinds of different DCSs, for example with help of the OPC[1)] A&E standard, or by using a printer port. PGIM allows A&E messages that are stored in SQL[2)] server databases to be searched and filtered.

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The following steps are typical of an alarm management project (see eg [6] for a detailed description):

Benchmark

Once a significant quantity of data has been collected from a plant, it can be compared with reference plant data eg, as provided in EEMUA 191. Subsequent strategies can be devised according to certain key performance indicators 1.

Alarm philosophy development

It is very important to have a single written document that describes a consistent, plant-wide, alarm philosophy. This document must define the methodology and rules for setting alarms, eg how alarms should be prioritized. It must describe operators' roles and responsibilities and how changes in current practice should be managed. Such a document may already exist as part of the plant's engineering strategy. If not, it must be created as part of the alarm management project.

Nuisance alarm removal

Nuisance alarms are alarms that serve no justifiable purpose, ie they are of no value to the operator. Such alarms exist in many plants and their removal can reduce the alarm rate significantly with very little effort. A very useful tool for the identification of nuisance alarms is the PGIM hit list, which sorts alarms by activation frequency. Many alarm management projects have shown that a small number of alarms often make a highly disproportionate contribution to the overall alarm rate.

Typical nuisance alarms are:

- Chattering alarms, caused by badly adjusted equipment, faulty sensors or process noise
- Alarms that require no operator action, and should therefore be reconfigured as events

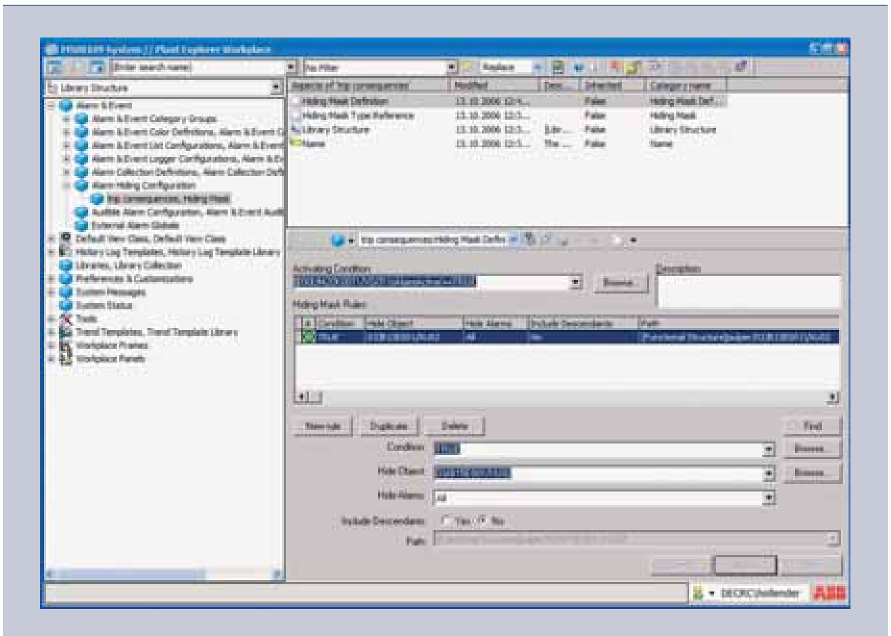
Alarm rationalization

This is the process of reviewing alarms in the light of the plant's alarm philosophy. It includes the determination (and documentation) of each alarm's rationale and design requirements. The basis for the alarm setting, the consequence of deviation, and corrective action that can be taken by the operator may also be included, along with each alarm's priority status. Priority is often based on the consequences of the alarm or on its allowable response time.

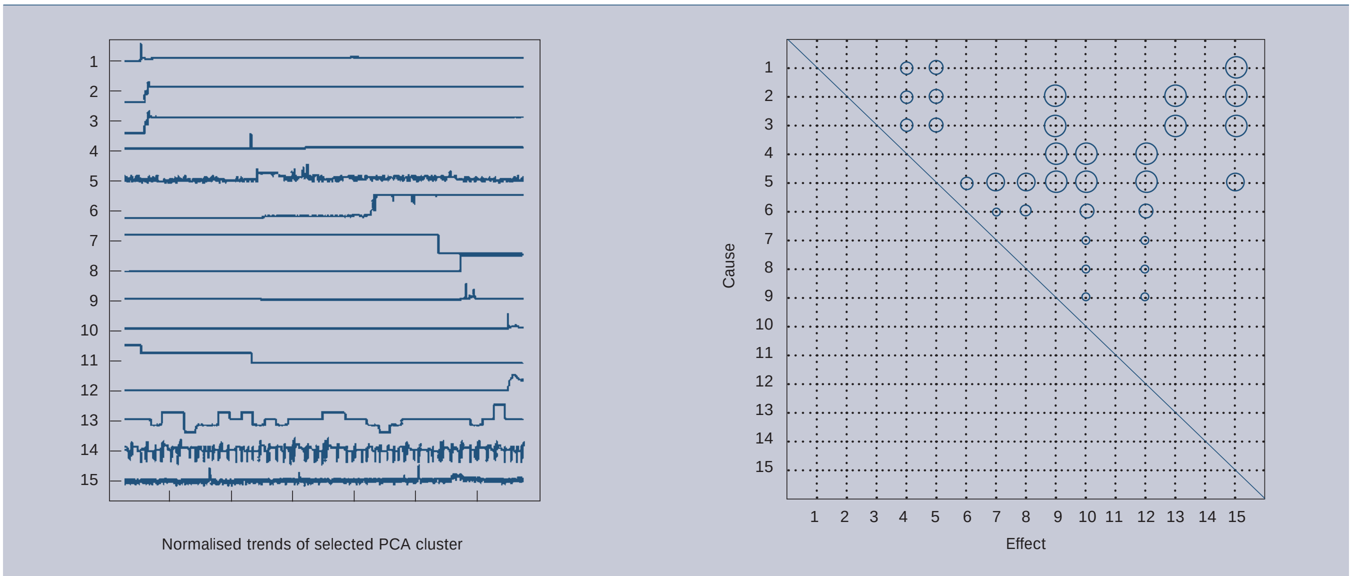
Continuous improvement

As the plant changes over time, it is important to establish alarm manage-

2 System 800xA hiding mask



3 Mapping causal relations between process variables. The process variable 15 has a strong causal relation with process variables 1, 2 and 3. This can be used as a proposal for a process engineer to specify an alarm hiding rule.



ment as a routine part of the plant's procedures. (In the US, alarm management is often seen in the context of "six sigma" programs that target process variations that lead to subsequent breakdowns or failure of the process).

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Hiding consequential alarms

Accidents like the one in Milford Haven show that operators can be overwhelmed by floods of alarms, especially in extreme situations. This is because a single root cause can have many different consequences, each of which triggers additional alarms. Basic alarm management, as described here, is not particularly helpful in such situations. In order to achieve EEMUA's target of no more than 10 alarms during the first 10 minutes of a process upset, a more rigorous approach must be taken. ABB's 800xA control system offers an alarm-hiding feature. This allows certain alarms (depending on process state or other active alarms) to be hidden from the standard alarm lists, but easily accessed when required 2.

It is a demanding task to identify all the causal relations between alarms that are required for the configuration of alarm hiding rules. Some commercially available Alarm Management tools can compute correlation coefficients between alarms. This analysis can be used as a basis for the configuration of alarm hiding rules. It is very important to note that those tools use binary data only (alarm on/off) and not the full richness of the original process data. It is obvious that by using historical process data more precise information about causal relations can be found.

To better understand the potential of this approach several days of historical data from two different plants was analyzed with Process Disturbance Analysis methods [6]. Some interesting causal relations have been identified which are currently being accessed together with process experts from the plants and shown in 3.

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[2] Tanner, R., Gould J., Turner, R. and Atkinson T. (2005), Keeping the peace (and quiet). ISA InTech September 2005.
[3] Norwegian Petroleum Directorate YA-711: Principles for alarm system design, 2001 (http://www.ptil.no/regelverk/R2002/ALARM_SYSTEM_DESIGN_E.HTM)
[4] Namur NA102: Alarm Management. 2005
[5] Hollifield, E. Habibi, The Alarm Management Handbook. 2006
[6] Horch, A., Peak performance, ABB Review 1/2007 pp24–29
[7] ISA RP18.2 Management of Alarm Systems for the Process Industries (draft)

Footnotes

1) OPC: formerly OLE (Object Linking and Embedding) for Process Control
2) SQL: Structured Query Language