Safety Information — Human Factors

Prepared by WG-16 Worker Safety Safety Info HF 08/18

Task

Alarm Management

Alarm systems alert operators to plant conditions, such as deviation from normal operating limits and to abnormal events, which require timely action or assessment. Alarms are key sources of information to guide operator actions to maintain safety.

Alarm: a signal or message to an operator (usually with a sound, blinking screen alert and/or a flashing light) indicating a problem requiring the operator's attention and action.

Alarm management is an issue for any site or process where there is reliance on human response to an alarm to prevent or control incidents, as well as major accident hazards. Alarm management is relevant to:

- simple sites as well as complex operating facilities;
- sites with a small number of alarms, for example simple storage sites or cylinder filling site;
- sites with a single control room with a DCS (distributed control system) such as an acetylene plant or stand-alone Air Separation plant;
- Remote Operating Centres (ROC) from which multiple distant facilities are controlled.

Photo: An example of a ROC controlling a variety of up to 50 operating plants – sometimes in different countries.

Principles of alarm management are the same in all types of sites – to raise operator awareness of the situation and to assure the correct and timely human response to alarms through:

- providing sufficient response time;

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- good interface and system design, including well defined alarm priorities to aid fast and accurate
    - understanding and diagnosis,
    - Decision making, by providing explanations for alarm causes,
    - Action taking, through well-defined corrective actions and procedures;
- monitoring and review,
- training and competence arrangements.

Poorly designed alarm systems may hinder rather than help the operator and may result in failure to identify a need to act, or failure to select an effective course of action, especially in emergency situations. Poor alarm management can also desensitise operators, for example from too many nuisance alarms or false alarms.

However, alarm systems can be improved by establishing and implementing a clear philosophy to reduce and prioritise alarms. Operator response can also be facilitated by clear procedures and training.

Companies should consider any changes which improve responses to alarms and therefore improve safety.

Learning more about alarm handling.

If the answer to any of the questions below is 'yes', then you need to take action

1.	Do operators sometimes not know what to do about a particular alarm (for example proper documentation displayed, causes and corrective actions to be taken, priority, limits, time delays, dead bands)?	☐
2.	Is the wording of some important alarm messages unclear?	☐
3.	Do operators just accept alarms without reading the message?	☐
4.	Is it often not clear what caused an alarm?	☐
5.	Are some alarms too quiet compared to the background noise?	☐
6.	Are some alarms so loud that they startle operators and make it hard for them to think or to hear what anyone else is saying?	☐
7.	Do operators turn off the sounder because it is sounding too often or is too loud?	☐
8.	Are too many alarms activated during a typical shift, even if there isn't a major problem?	☐
9.	When there is a problem, do lots of alarms activate?	☐
10.	Does one alarm seem to set off others until there are just too many to deal with?	☐
11.	Are many alarms always on display or valid?	☐
12.	Are some alarms false alarms?	☐
13.	Although alarms can be reset, do they just keep coming back?	☐
14.	Do alarm messages disappear from screens before anyone has a chance to read them?	☐
15.	Is it hard for operators to decide which alarm to deal with first when many appear at once?	☐
16.	Are alarm lists mixed in with other information?	☐
17.	Is alarm overload a particular problem during start up or shut down (or other normal changes of process)?	☐
18.	Do alarms require frequent or difficult operator action that could have been automated?	☐
19.	Do operators prefer to work with graphical trends rather than relying on alarm lists for some parameters?	☐

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If the answer to any of the questions below is 'no', then you need to take action

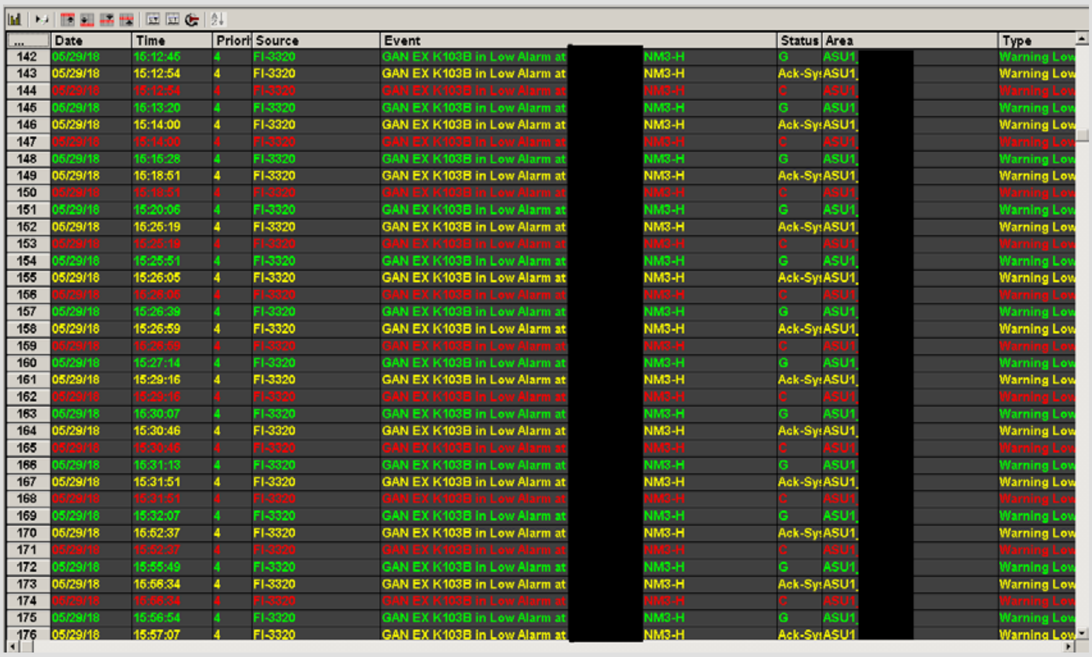
20. Are alarm lists arranged in an obvious logical order? ☐

21. Can operators clearly distinguish a single alarm on the interface? ☐

22. Are different alarm priorities distinguished on screen e.g. by colour/sound? (see examples below) ☐

***Poor**: shows multiple alarms over very short space of time - Alarm flood condition - due to incorrectly set up alarm bands as the process value is going through its alarm bands multiple times in a short space of time.*

This alarm will "mask" an audible alarm from another alarm event due to the flood overload.



***Better**: Alarms come through when a process problem occurs – no alarm flood conditions present when a plant trips.*

You can see the vibration alarms when a high vibration event occurs is activated, prompting the operator to investigate.

23. Do operators find alarm prioritisation appropriate? (safety-critical, high, medium and low priority) ☐

24. Are safety-critical alarms clearly distinguished and separately displayed? ☐

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25.	Are the occurrence rates of safety-critical and high priority alarms in accordance with industry guidelines (See **Useful Reference Information** references [6] and [7])?	☐
26.	Is there a clear process overview (plant detail mimic) with adequate information including alarm details?	☐
27.	Is the alarm list clear (font type and size that can also be read standing back from screen to allow conferring with supervisor)?	☐
28.	Can the alarm list be filtered for example by priority or plant area or time period?	☐
29.	Can alarms be silenced before being studied or accepted? (an essential feature)	☐
30.	Is resetting of alarms only possible if they have **cleared** (i.e. have returned to normal) and have been **acknowledged** by the operator?	☐
31.	Are alarms suppressed when equipment is off-line or being maintained?	☐
32.	Do you have a strategy or philosophy for alarm system design and handling?	☐
33.	Is there a process or a standard for alarm system review and modification?	☐
34.	Does the alarm system recognise normal/upset/emergency situations?	☐
35.	Are there competence requirements for of all those involved in design and use of alarm systems?	☐
36.	Are key performance measures for the system (alarm rates) recorded and tracked?	☐
37.	Is there an adequate alarm log / history? (What information is recorded? How is the information used?)	☐
38.	Is information about the safety, environmental or financial consequences of each alarm situation readily available to the operator?	☐
39.	Is there a process to actively collect operator feedback and suggestions for improvement?	☐
41.	Is there a process in place for continuous improvement of alarm system design and management?	☐
42.	Is there a clear communication strategy between ROC and workers at remote sites?	☐
43.	Is the information in alarm lists presented in a way that operators can respond effectively and efficiently to the alarms?	☐
44.	Is there a company or site policy that identifies operators access rights to change alarm settings?	☐

What should my company do about it?

What can managers do about it?

Understanding alarms:

Management should ensure that anyone who needs to take action in response to an alarm will:

- Be able to see and hear the alarm under all conditions.
- Quickly understand what caused the alarm and how serious it is.
- Know from training or instructions what to do next and in what order.
- Have enough time to take action.
- Realise when the situation has returned to normal.

Avoiding operator overload:

Management should ensure that operators are not:

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- Overloaded by lots of irrelevant alarms that come up quickly. It is worth noting that people facing as few as 10 alarms a minute in an emergency will quickly abandon the alarm list to reduce stress.
- Experiencing certain alarms activated permanently or coming up very frequently
- Startled by the alarm or unable to hear/concentrate because of it.

If the operators are overloaded, they will find a way to solve the problem without using the information provided by the alarm system. If alarms are ignored, they might as well not be there and could result in incorrect actions compromising the safety of the plant. Staffing levels should be assessed to ensure that alarms can be managed during plant disturbances

A system or software to measure alarm performance will help detect the above situation and provide data for benchmarking against industry guidance (See **Useful Reference Information** references [5] and [6]).

Alarm system lifecycle:

Design, installation, training, testing, operation, monitoring, maintaining, audit etc are part of the lifecycle of an alarm system, described in industry standards such as IEC 62682: *Management of alarm systems for the process industries* [6] and ANSI/ISA-18.2: *Management of Alarm Systems for the Process Industries* [7].

There should be regular process to review alarm KPIs with a multi-disciplined team (for example addressing the “top 10” alarms to reduce the total number of alarms). Reviews should include learnings from any incidents, accidents and management of change.

Alarm system design:

Alarm management is primarily a design issue, trying to correct problems is much more difficult. Your company should make sure that alarms are designed to modern guidelines such as that published by EEMUA, *Alarm systems, a guide to design, management and procurement*. EEMUA Publication No 191 [5], and IEC [6]. The aim of this guidance is to help engineers develop alarm systems that are more usable and which result in safer and more cost-effective operation.

Improving alarm systems makes it easier for operators to interpret alarms and take correct and timely action and reduce both their stress and the likelihood of error. This allows better control of processes and helps avoid incidents and major accidents.

Alarm system installation and training:

Alarm systems must be properly installed, commissioned and tested to ensure they will work under all required conditions. Employees must be fully informed in the meaning of alarms and practiced in the actions to be taken.

Alarm system testing:

The whole alarm system from detector/initiator, including any trip actors (for example shut-off valves) and the alarm sounder must be maintained and tested regularly to ensure that all elements operate correctly. Frequency should be determined based on criticality of the alarm.

Guidance on solving alarm handling problems

Problems with alarm handling are of two types: problems with the design of the alarm system, and problems with the procedures for handling alarms. The table below is based on modern alarm guidance. It will help you to identify some of the main alarm handling problems you may have in your workplace and suggest what to do about them.

DESIGN

PROBLEM	POSSIBLE SOLUTIONS
Alarm sound is not heard above typical noise levels.	Raise alarm volume to 10dB(A) above other workplace noises. Consider re-locating alarm sounder.
Alarm drowns out communications.	Allow operators to lower the volume of alarms once they've sounded.
Lighting levels cannot be seen above typical lighting levels.	Make alarm bright enough for all expected conditions; use colour to highlight the alarm; accompany visual alarm with a sound.
Difficult to tell one alarm apart from another – sounds or lights are very similar.	Use 'coding' (e.g. different sounds; different colours;) to show importance of alarms and group by the safety function to which they relate, highlight differently on the alarm log /history (screen or printout).
Nuisance alarms - false alarms, 'fleeting' (disappear quickly) or persistent standing alarms.	Fix process equipment and/or repair faulty instrumentation. Change set points, hysteresis or dead bands, in accordance with company change management procedures, to make the system less sensitive to short duration unimportant fluctuations. When alarms are expected (e.g. during testing and maintenance) and these cannot be overridden, use tags to indicate they are being tested. Resolve identified issues in a timely manner. Implement a system to track and review the number of co-incident alarms, alarm throughput, frequent or nuisance alarms and empower operators to re-prioritise, remove or suppress alarms in accordance with company change management procedures. Resolve "Top 10" most frequent alarms (until their proportion is less than 5% of total number of alarms). Note that IEC 62682 [6] gives suggestions for KPIs for fleeting, chattering and standing alarms.

DESIGN	
PROBLEM	**POSSIBLE SOLUTIONS**
Flooding – many alarms are presented together and/or disappear too quickly, so that it is difficult for operator(s) to respond correctly.	Design systems to minimise alarms and to present alarms in priority order. Provide operators with clear procedures and training on how to prioritise their actions. Implement a system to track and address nuisance alarms as described above. Implement proper alarm suppression during plant trip (logic or software solution). Implement plans to continually reduce alarm flooding during process upset towards industry best practices [6][8].
Operators do not have enough time after the alarm commences to take the right action.	Make the alarm levels show the progress of an alarm situation e.g. a tank overfill alarm sounds at 'high' level then again at 'high high' level. The setpoint of the "high" level has to provide time for operator to respond and avoid "high high" alarm setpoint. Provide clear instructions and opportunities to practice in real time. Prioritisation of alarms can help direct the operator as to how quickly he/she should respond.
Alarms are missed because the area where they appear is not constantly manned	Install 'repeater' alarms in several places; enforce manning of key operating areas or redirect alarm to portable device/smartphone/radio when operator is away from control desk. Control system shall not reset an alarm if it has not been accepted by an operator
Operators experience other problems with alarms such as irrelevant and unimportant information being given or poor alarm names being used	Invite operators to make suggestions about alarm problems and to propose solutions; check solutions against recommended guidance [6]. Good practice would be to engage a rationalisation team to review all plant alarms and determine whether they are truly an alarm (i.e. require operator response) or just provide information. Ideally information should not be displayed in the same colour as alarms, should not flash and should not appear in alarm logs or lists.
The importance or priority of alarms is not obvious.	Process risk assessment should identify which plant conditions should generate a critical alarm. Critical alarms should only be connected to events that have potential consequences for personal safety,

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DESIGN	
PROBLEM	**POSSIBLE SOLUTIONS**
	process safety or the environment.
Alarms are in place because it's too difficult to automate the process – puts the responsibility on the operator to act.	Design alarms according to good practice principles (See **Useful Reference Information** references [6] and [7]) – but beware not to overload the operator.

Solving alarm problems will require persistence and patience. You will need to collect information on what the problem is – by asking people.

Then you will need to persuade management to make improvements. You can change some things easily – others may take a long time and require investment.

Useful Reference Information

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