Alarm management – update to EEMUA 191

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The first edition of the EEMUA 191 guide was published in 1999. Despite advancements, alarm management remains a challenge, with poor performance still cited in accident investigations. The latest fourth edition, published in November 2024, has been restructured to better reflect how users approach alarm management. It includes more diagrammatic representations, expanded human factors considerations, and revised terms and definitions to align with relevant standards, including IEC 62682, IEC 61511, and IEC 61508. The guide also addresses technological changes, such as the increased use of remote management.

This paper summarises alarm management in general and the main updates made in the latest edition of the guide.

The role of alarms in broader safety management has been clarified. Most alarms are handled by a Basic Process Control System (BPCS), which has low integrity and is not formally credited in safety studies. However, alarms still contribute to overall risk management. The fourth edition adopts the term 'Highly Managed Alarm' (HMA) to identify alarms that require greater reliance on human operator response. If used as part of a safety function, these alarms can be credited in safety studies, provided they meet defined requirements. HMAs may also be used for other critical purposes, such as environmental protection, asset protection, and quality control.

A common issue in alarm management is the misclassification of events as alarms when they should not be. The guide now provides clearer guidance on using alerts and operator prompts instead. This will help reduce the number of configured alarms while ensuring that operators still receive the information needed for situational awareness.

Previous guidance recommended that audible alarm signals should be a minimum of 10 decibels above background noise. However, this is no longer suitable for most modern control rooms. The revised guide suggests 3 to 4 decibels above, instead. It also states that up to four different alarm sounds can be used for different classes and priorities, and that audible indications are not typically required for alerts.

The role of alarm prioritisation has been clarified. It makes it clear that no alarm should ever be ignored because its priority only gives an indication of which to respond to first if several occur at the same time. Organisations need to develop their own prioritisation methods but the guide gives some high level advice.

An alarm rationalisation study should be conducted as part of any major project and repeated throughout operations based on system performance. One of the key objectives, often overlooked, is to eliminate unnecessary alarms. A formal rationalisation report should document the review process, confirming operator response expectations, alarm settings, and priority levels. The guide now includes an example alarm rationalisation procedure to aid implementation.

This updated guidance in EEMUA 191 aims to drive safer, more effective alarm management, helping organisations reduce alarm overload, enhance operator performance, and align with evolving industry standards. It will be of great interest to anyone working in hazardous industries.

Key Words: Alarm management, human factors, situational awareness, control room design, functional safety, EEMUA 191.

Introduction

Alarm systems form an essential part of the operator interfaces to most modern facilities. They provide vital support to the operators by warning them of situations that need their attention and intervention. However, when alarm systems are poorly designed or managed they can become a liability, overwhelming operators with irrelevant or excessive information, delaying critical actions, and contributing to accidents.

Accident investigations continue to highlight alarm system failures. For example, the 2022 accident at the BP-Husky refinery [CSB 2024]. Two brothers, who were employees at the site were fatally injured whilst draining liquid from a vessel that had accumulated because of a process upset that occurred two days before. Alarm flood was identified as one of the contributing factors. In 12 hours a total of 3,712 alarms were recorded (over 300 per hour). The workload created by the alarm flood contributed to delays and errors in responding to critical alarms and in shift-to-shift communications.

This paper outlines the key principles of alarm management and summarises the major changes introduced in the latest edition of EEMUA 191. The aim is to help organisations to implement good practices to reduce alarm overload, improve operator performance and reduce risk.

History of EEMUA 191

EEMUA 191 is a guide and not a standard. Its aim has always been to assist organisations to implement alarm management systems that satisfy the requirements of relevant standards and regulations. It presents good practices that will support efficient and profitable system performance.

The first edition of EEMUA 191 was published in 1999 following research carried out by Great Britain's Health and Safety Executive (HSE) [HSE 1997]. This research had been prompted by several process industry accidents including an explosion and fire at the Milford Haven refinery in 1994 [HSE 1998]. A survey identified many problems with alarm systems and cases where inadequacies in alarm system performance had led to financial loss or to equipment or environmental damage.

EEMUA 191 was written to provide comprehensive, practical guidance on alarm systems, from design and procurement to ongoing management and improvement. It filled a significant gap at the time and went on to be recognised as a definitive guide for implementing effective alarm management. Second and third editions were published in 2007 and 2013.

The latest, fourth edition of EEMUA 191 was published in November 2024 [EEMUA 2024]. One of the drivers of this was publication of the international standard IEC 62682:2022 Management of alarm systems for the process industries [IEC 2022], which updated some principles and terminology. The opportunity was taken to restructure the way some information was presented, including more use of diagrams. Some themes, including the importance of understanding user requirements and human factors, were given more weight. Although many of the principles expressed in previous editions were not changed, much of the accompanying explanatory text was improved. Some updates were made to reflect changes in technology and align the guide more closely with functional safety standards IEC 61508 [IEC 2010], and IEC 61511 [IEC 2016].

Restructuring the guide reduced its overall size by 50 pages (although it is still over 200 pages long). Some of the content was converted from basic guidance into templates that organisations can copy and adapt for use, including:

- Human Factors Integration Plan (HFIP) for alarms.
- Prioritisation methods.
- Example alarm philosophy.
- Alarm rationalisation procedure.
- Alarm review checklists.

Role of alarms

Having a clear definition is the first step in understanding the role of alarms. EEMUA 191 uses the following definition, consistent with IEC 62682.

An alarm is an audible and/or visible means of indicating to the operator an equipment malfunction, process deviation, or abnormal condition requiring a timely response.

Whilst the technical means of annunciating an alarm is important, the much more fundamental aspects of this definition relate to how they are used in practice.

The definition makes it clear that alarms present information to operators. Anyone else who may have an interest in an alarm should be viewed as secondary. If their requirements can be met without detriment to the operator, that is fine. If not, the operator's requirements should take precedence.

The definition also makes it clear that an alarm should require a response. Generally, the response to an alarm should be a process action (e.g. altering a control set point, changing over to a standby pump). The operator receiving the alarm may not perform the action themselves and so their response is to instruct someone else to act. However, if the operator's involvement is only to relay the occurrence of the alarm (sometimes known as a 'catch and pass alarm'), an alternative solution should be considered that does not involve the operator.

The definition also makes it clear that an alarm should require a timely response. What this means in practice will depend on the nature of the operation. For a continuous process plant with a permanently manned control room it may be appropriate to set a limit of two hours. In other cases a longer time may be more appropriate. However, extending it from several hours to a day or more is unlikely to be appropriate.

The key message here is that an alarm system cannot be managed if there is not a common understanding of the role of alarms. Organisations should have a clear definition and a comprehensive alarm philosophy. Examples of both are provided in the fourth edition of EEMUA 191, but organisations can (and should) amend them to satisfy their requirements.

These basic issues regarding use of alarms have not changed in the fourth edition of EEMUA191. However, defining the role of alarms as part of a broader safety management context, was clarified due to self-evident confusion about how alarms contribute to safety.

Most process alarms are handled by a Basic Process Control System (BPCS), which has low integrity and is not an independent risk control. Similarly, the operator responding to an alarm may have been the initiator of the condition that caused the alarm. This is often interpreted as meaning no credit can be taken for alarms handled by the BPCS. However, this may lead to overly pessimistic assessments. It is likely to result in greater reliance on higher integrity engineered layers of protection, including Safety Instrumented Systems (SIS) and relief valves, that are expensive to install and maintain. Engineered controls can introduce risks due to behavioural changes that result in operators over relying on them so that the risk reduction is less than expected. Also, they can cause problems with spurious activation and the need (perceived or actual) for frequent inhibits or overrides.

Whether credit is given for alarms or not, well designed alarm systems will contribute to controlling risks. They enable operators to deal with situations before a hazardous condition has occurred. The contribution that most alarms make is to reduce the demand on engineered layers of protection. No control is ever 100% reliable, but the cumulative effect of each layer, including response to alarms, is what makes the overall system safe enough to allow its operation.

There are some circumstances where credit may be taken for an alarm as an independent layer of protection. Confusingly, these have often been referred to as 'safety' or 'safety related' alarms, and often just described as 'critical'. Following extended discussions it was decided to adopt the alternative term used in IEC 62682 of Highly Managed Alarm (HMA).

HMAs create a higher reliance on operator response to avoid an undesirable outcome (e.g. major accident, significant asset damage). Their contribution to risk reduction may go beyond simply reducing a demand on engineered layers of protection, sometimes because there is none, or those in place are not effective enough to achieve the risk reduction required. This means operator response may be the last line of defence.

HMA can be used for all types of critical concern, not just safety. The fourth edition of EEMUA 191 proposes identifying subcategories such as HMA-S (safety), HMA-E (environment), and HMA-A (asset). While an organisation may share information about HMA-S with its safety regulator, it can apply the same approach to other business-critical issues without being required to disclose them externally.

IEC 62682 [IEC 2022] makes it clear that HMA require more administration and documentation than most 'normal' alarms. For each there should be:

- An alarm response procedure (more detailed than for most alarms).
- A competence standard for operators who may have to respond.
- A defined proof test method, and
- A defined test frequency.

The general aim should be to minimise use wherever possible by adopting systems that are inherently safer and more robust, and engineered solutions that are less reliant on human action. An organisation is free to use the terminology that suits its requirements, but it should make a clear distinction in its alarm philosophy between normal alarms and those creating a higher reliance on operator response.

Non-alarm notifications

A common issue in alarm management is alarms being configured that do not require an operator response or the response is not required in a timely manner. These unnecessary alarms distract the operator and add workload. They are one of the main causes of poor alarm system performance.

Some unnecessary alarms are configured on systems for spurious reasons. A typical explanation being 'we always have an alarm for that.' Others are well motivated, often because they represent an event that may be interesting or useful for the operator, and people are worried that if an alarm is not provided it may be missed. Using other types of notification can overcome this problem. The fourth edition of EEMUA 191 provides guidelines for use of 'alerts' and 'prompts' to reduce the challenges with alarm management.

Alerts give information to an operator that may be useful for their situational awareness. The key point is that the operator does not need to respond, but can if they are able to. Alerts can help the operator to run the process more efficiently. During upsets, many alerts might be generated but can be ignored until all alarms have been dealt with.

Some alerts may be useful to other people and handled by other reporting methods. For example, information about equipment condition may trigger an alert that appears in a daily report for the maintenance team.

A prompt is a trigger for an operator to act that is not time critical and failure to act does not have any safety implications. Usually the process is held in a safe hold position. The typical uses are for batch processes and automated sequences such as compressor start-up. One thing that has caused confusion in the past is that similar audible notifications have been provided for prompts and alarms.

EEMUA 191 also refers to 'events' as a record of any change in process, plant or equipment condition. (e.g. a pump starting or stopping, a valve opening or closing). Alarms and alerts are also events. Most events should not create an alarm because a response from the operator is not required. Events are most useful as an offline diagnostic tool, typically via a data historian.

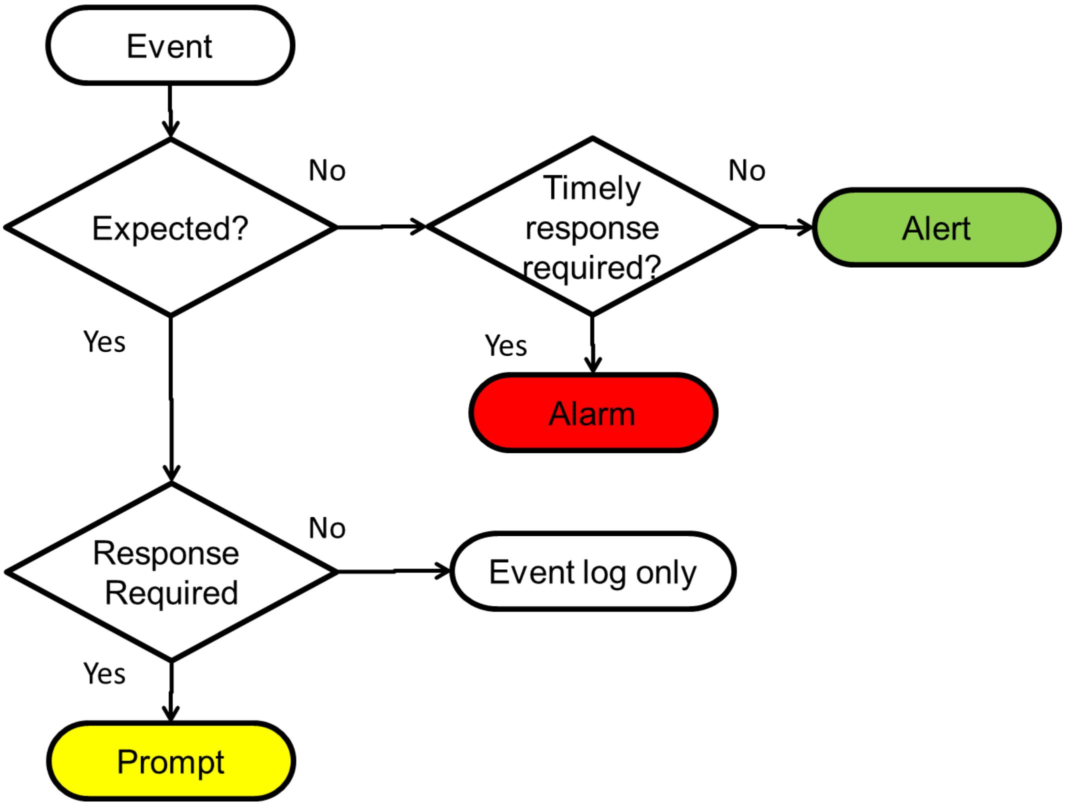

Figure 1 Flowchart guiding selection of alarm and non-alarm notifications.

Optimising alarm detection

The first task for a new alarm is to get noticed. Operators have other duties and it is unrealistic to expect them to be always scanning a console for new alarms or to be permanently in close proximity. An audible signal is usually used to show that an alarm has been activated.

Previous guidance recommended that audible alarm signals should be a minimum of 10 decibels above background noise. For modern control rooms, that are often very quiet, this sound level may startle operators and interfere with verbal communication. The revised guide suggests 3 to 4 decibels is more appropriate.

Different audible signals can provide additional information about alarms. For example, using sounds to indicate different alarm priorities. The fourth edition of EEMUA 191 suggests a maximum of four different sounds are used that are easy to distinguish. Whilst this may seem quite limited, the most important aspect is what is useful to the operator. A well-managed system will create alarms relatively infrequently and the operator will be expected to respond to every alarm immediately. This means they only need to detect that an alarm has occurred and so there is little requirement to use different sounds.

For non-alarms, the fourth edition of EEMUA 191 has clarified that alerts and prompts should not normally be provided with an audible signal. If one is used, it should be much less prominent than the sounds used for alarms.

Prioritisation

The underlying principles of prioritisation have not changed since previous editions of EEMUA 191. However, some of the guidance has been amended to make sure the key messages are understood.

The purpose of prioritisation is to help the operator to decide which alarm to respond to when more than one occurs at the same time. In this situation the response to a low priority alarm may be delayed. However, if only one alarm is active the operator should always respond immediately, no matter its priority. Giving an alarm a low priority does not mean it can be ignored or receive a delayed response.

One reason for confusion is that alarm priorities are often determined by time available to respond. An initial screening may differentiate based on consequence. Time to respond is the second consideration. However, the time to respond is not an indication that response can be delayed.

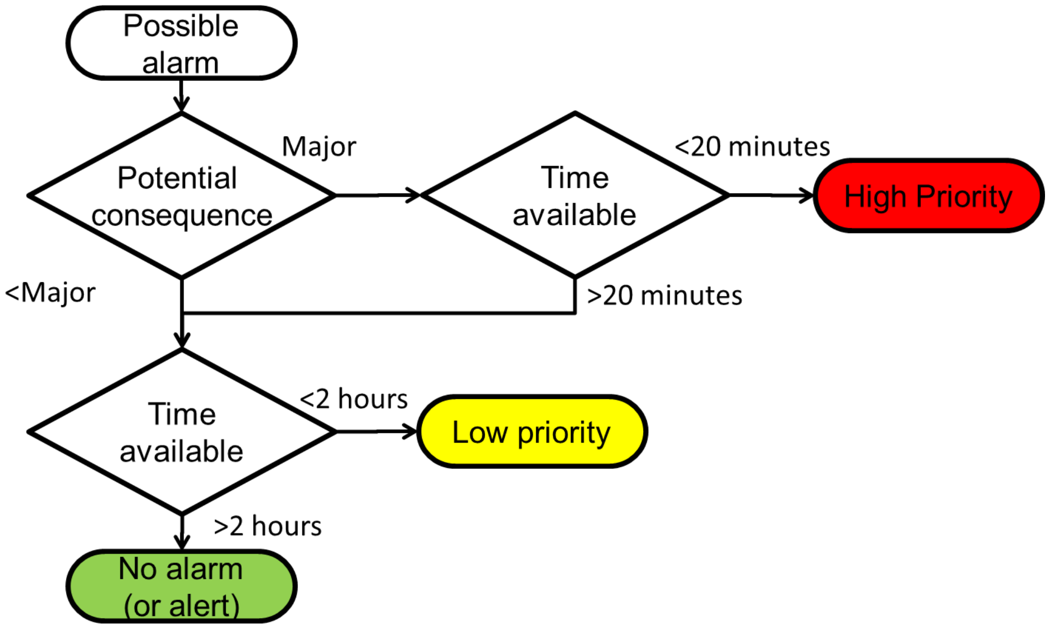

Figure 2 Flowchart guiding alarm prioritisation.

The fourth edition of EEMUA 191 provides some guidance about how to prioritise alarms but this is one area where each organisation should develop its own methods. In many cases it may be necessary to adapt the approach to specific facilities or plants. The approach should be fully documented in the alarm philosophy. It should be applied consistently to every alarm an operator receives, which can be challenging if they receive alarms from more than one system.

Rationalisation

Alarm rationalisation is a formal study that looks at how the system is arranged. It is not just about prioritising existing alarms. Identifying and deleting unnecessary alarms, or changing them to alerts or prompts, should be a key consideration. Rationalisation studies should be conducted as part of any major project and repeated throughout a facility's life, depending on system performance. Unfortunately, there are no short cuts to alarm rationalisation. It requires a detailed assessment of every alarm on the system.

A principle of alarm management is that every alarm is justified. The most compelling justification is that an alarm can reduce the risk of a major accident. Whenever alarms are considered for other types of risk the potential benefit should be balanced against the negative impact, including the potential to overload and distract the operator. The table below may be used to guide this justification. However, arguably the most important question is whether an operator has to respond, because if the answer is 'no' it is an unnecessary alarm.

Table 1 Checklist for evaluating an alarm

Characteristic	Questions
Is the alarm relevant?	Does the operator need to know this?
Unique?	Is there another alarm with the same duty?
Timely?	Will the operator have time to respond?
Prioritised?	Does the alarm indicate its importance?
	Does the alarm need special action above others?
Understandable?	Will the message be understood by the operator?
Diagnostic?	Does the message identify the problem that has occurred?
	Can the operator quickly get to more detailed information?
Advisory?	Does it indicate the action to be taken?
	If not, where can this information be found?
Focusing?	Does the alarm draw the operator's attention to the most important issues?

A formal rationalisation report should document the review process, confirming operator response expectations, alarm settings, and priority levels. The fourth edition of EEMUA 191 includes an example alarm rationalisation procedure.

Hierarchy of risk control

Alarms should not be used to compensate for poorly engineered systems. The hierarchy of risk control is recognised as an effective way of managing risks and highlights that alarms are a relatively unreliable solution because they rely on human actions. However, they have a role in managing residual risks after other, more reliable controls, have been implemented.

System design should always aim to apply risk controls as follows

- Inherent safety – eliminate or minimise hazards so that there is no chance of a hazard occurring. Alarms are not required for inherently safe systems.
- Passive engineering – design and build plant to withstand the maximum possible range of operating conditions. Process excursions will not create a hazard and alarms are not required (provided the plant is properly maintained).
- Active engineering – install devices that will automatically transfer a process to a safe state when activated by an excursion. Examples include SIS and pressure relief valves that operate without any human intervention. Alarms are not part of their operation but have a key role in reducing demand on the safety systems because the operator can intervene before the activation point is reached.
- Administrative controls – competent people working to defined procedures avoid problems and know how to respond if things go wrong, which may be indicated by an alarm.
- Mitigation – arrangements to reduce the consequences of an event. Process alarms are ineffective at this stage because the hazard has already occurred but protective system alarms (e.g. fire and gas detection) may have a role in triggering a response that mitigates the risk (e.g. evacuate the area, active firefighting).

Overall, the question is whether arrangements for alarm management are achieving risk levels that are As Low As Reasonably Practicable (ALARP). This is a judgement made by demonstrating all options to reduce risk have been identified and that an optimum combination of controls has been implemented.

Human limitations and capabilities

There can be reluctance to take credit for alarms and other administrative controls because people are fallible. They can be imprecise in their actions, they forget things, misinterpret data and lose attention. They can miss alarms that occur and make the wrong response. Also, even if they do notice an alarm they may choose not to respond.

On the other hand, people have remarkable capabilities that have proven difficult to replicate with even the most sophisticated technology. They are particularly good at recognising visual patterns and noticing very minor changes. They can take account of information from many different sources to support situational awareness, allowing them to understand what is happening, even if it is something that they have never encountered before or been trained to handle. When an operator notices an alarm they look for data to help them understand what is happening. Some will come from control system displays. However, they may also consider information given at shift handover, e-mails and reports received (possibly months previously), direct observations (sounds, vibrations and smells), environmental conditions (weather, time of day). These other sources of information are clearly outside of the scope of alarm system design but understanding human factors can help develop a system that supports the operator to act reliably.

Conclusion

Since its launch in 1999, thousands of copies of the EEMUA 191 Guide have been sold worldwide to process operating companies, suppliers, engineering contractors, training organisations, regulators, inspection bodies, and individual engineers. Over time, it has become the de facto reference for good practice in alarm management, with many organisations reporting significant performance improvements when they invest the necessary time and resources to achieve true operational ownership of their alarm systems.

The fourth edition aims to further enhance safety and effectiveness, helping organisations reduce alarm overload, improve operator performance, and keep pace with evolving industry standards. It is relevant to anyone in hazardous industries, whether upgrading an existing system or introducing a new one.

Lasting success depends on a clear understanding of the role of alarms and the risks of tolerating a poor system. Compliance with regulations, standards, and local policies is essential, but it is the development of a robust, facility-specific alarm philosophy that will drive sustained performance. Alarm management involves many areas where no single ‘right’ answer exists, and informed judgement is often needed to reach the optimum solution. There is no quick fix: systems must be actively maintained, supported by adequate resources, and managed by people with the right competencies.

Developing effective alarm systems, and improving existing ones requires:

- A good definition of alarm.
- A documented alarm philosophy.
- Focus on operator requirements, based on a sound understanding of human factors.

- Well-engineered systems that have applied inherent safety and the hierarchy of risk control.
- A full database of all alarms received by the operator.
- Rationalisation and prioritisation, removing unnecessary alarms, using alerts and prompts where appropriate, and support for the operator to respond correctly to every alarm they receive.
- Clear leadership, sustained management commitment to provide necessary resources and a consistent approach.

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