Introduction to Alarm Management

Author: *Emanuel Oliveira*

1 INTRODUCTION

This document describes the basic functionalities associated with how the alarms are managed on an Alarm System. At the time of writing, most of the active and recent projects were in the marine and offshore environment. For that reason, the information presented in this note is influenced by the standards applied in such environments.

2 DEFINITIONS

Table 1 lists the terms used in this document and the respective definitions according to [1].

Table 1: Terms and definitions

acknowledge	Operator action that confirms recognition of an alarm.
active	Alarm in a state in which the alarm condition is true.
alarm	Audible and/or visible means of indicating to the operator an equipment malfunction, process deviation, or abnormal condition requiring a timely response.
alarm group	Set of alarms with common association (e.g., process unit, process area, equipment set, or service).
alarm message	Text string displayed with the alarm indication that provides additional information to the operator (e.g., operator action).
alarm off-delay	Time a process measurement remains in the normal state before the alarm becomes inactive.
alarm on-delay	Time a process measurement remains in the alarm state before the alarm is annunciated.
alarm priority	Relative importance assigned to an alarm within the alarm system to indicate the urgency of response (e.g., seriousness of consequences and allowable response time).
alarm setpoint	Threshold value of a process variable or discrete state that triggers the alarm indication.
alarm system	Operator support system for generating and handling alarms for managing abnormal situations.
first-out alarm[1]	Alarm determined (i.e., by first-out logic) to be the first in a multiple-alarm scenario.
latching alarm	Alarm that remains in alarm state after the process condition has returned to normal and requires an operator reset before the alarm returns to normal.
reset	Operator action that unlatches a latched alarm.
silence	Operator action that terminates the audible alarm indication.
suppress	Prevent the annunciation of the alarm to the operator when the alarm is active.
unacknowledged	Alarm state in which the operator has not yet confirmed recognition of an alarm indication.

Legacy alarm systems, particularly those lacking the alarm acknowledgement functionality, use the term **alarm accept**. However, this term is not mentioned in the IEC standard [1] nor any marine classification society rules listed in the References section. Therefore, the term **alarm accept** will be omitted in this document.

[1] Also referred to as **first-up alarm**.

The **reset** functionality will also be left out of the scope of this document. Except for latching alarms, the reset functionality is associated with the process[2], not alarm management. A **latching alarm** remains in the active state (see Alarm States section) even after the condition that triggered it returns to normal. Only the operator reset will transition the alarm state to normal. Note that a latching alarm is not a common functionality.

The terms **Acknowledge** and **Silence** often cause confusion. Due to the importance of these terms in an Alarm System and their consequence in the control of a process, these functionalities will be detailed below. First, however, an understanding of the alarm states is important.

3 ALARM STATES

Figure 1 presents a diagram showing the alarm state transition. The diagram shows the four main alarm states and omits the following states, usually implemented in more complex alarm systems:

- Shelved
  Temporarily suppress an alarm initiated by the operator, with engineering controls to *unsuppress* the alarm.
- Suppress by design[3]
  Alarm annunciation to the operator is prevented based on plant state or other conditions[4].
- Out of Service
  Alarm indication is suppressed, typically manually, for reasons such as maintenance.

Each alarm state has two characteristics: the *active state*, which is directly related to the state of the process, and the *acknowledge state*. These two characteristics are completely independent; one is associated with the state of a process, the other is associated with an operator action.

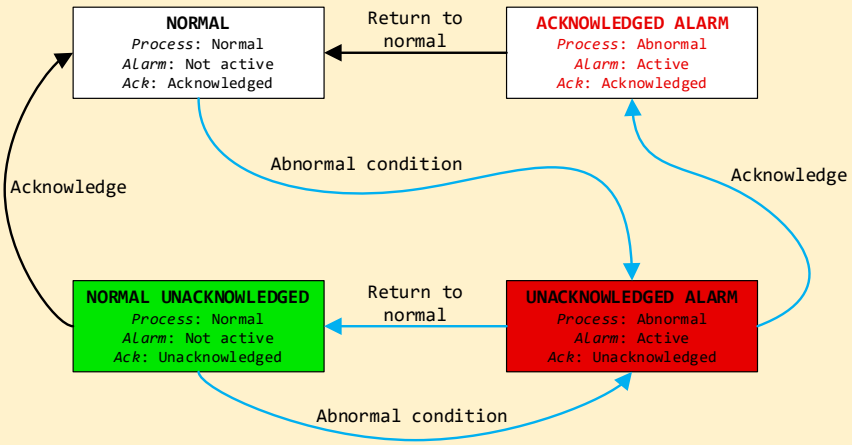

Figure 1: Alarm states and transitions

An Alarm System reacts to those transitions, also called **events**. An alarm list displays or changes the information to the operator whenever one of those transitions, or events, occur. Each event has a timestamp associated, and that is the timestamp shown to the user on any alarm list.

3.1 Active State

As mentioned, the alarm state is directly related to the state of the process, i.e., to the condition (e.g., temperature, pressure, contact state, etc.) that activates the alarm. Therefore, the alarm will be active only when the process condition is abnormal.

[2] Process unit, process area, equipment set, or service.
[3] Commonly referred to as **supressed** or **blocked**.
[4] For example, first-out alarms.

An exception to the above is the latched alarm. As the Definitions section mentions, a latched alarm becomes active when the process becomes abnormal but only returns to the not active state after an operator reset.

3.2 Acknowledge State

The acknowledge state of an alarm is purely dependent on the operator. The acknowledge can be seen as a notification from the operator to the Alarm System that a specific alarm was seen. Therefore, the alarm system must allow the operator to acknowledge only the alarms presented to the operator. DNV Rules [1] explicitly state in paragraph 1.5.6 that "*only visible alarms may be acknowledged*."

Note that some alarms might be deemed not required to be acknowledged due to their lower severity. In that case, the alarm will become NORMAL as soon as the process condition is no longer abnormal.

4 ACKNOWLEDGE AND SILENCE

The functionalities associated with Acknowledge and Silence are different. However, these functions can be performed simultaneously in specific circumstances, as described in the following sections.

4.1 Acknowledge

The acknowledge functionality was already presented in the Acknowledge State section above.

The requirement that the acknowledge functionality must only acknowledge the alarms presented to the operator is simpler to comply with if the acknowledge function is performed where the alarms are presented, i.e., the computer or graphical console. Having a physical button to acknowledge the alarms usually implies an alarm list (typically an alarm banner[5]) to be permanently presented to the operator, and only the alarms visible on that list or the top one will be acknowledged.

After the alarm is acknowledged, it must be still presented to the operator whilst the associated alarm condition is active.

The acknowledge function might also silence the audible signal.

4.2 Silence

The only purpose of the silence functionality is to silence the audible signals.

When sounders or buzzers are installed in multiple locations, usually a silence button exists on each location. The scope of the silence functionality associated with each location, i.e., if it only silences the audible signal on that location or in all locations, will depend on the Client requirements or how far those locations are from each other. However, in paragraph 2.3.8 of [4], Lloyd's Register states "*Acknowledgement of alarms at positions outside a machinery space is not to silence the audible signal or extinguish the visual indication in that machinery space.*"

Visual alarm indications must not be affected by the silence functionality.

5 ALARM DISPLAY

The alarms are usually presented to the operator using two separate lists: pending alarms[6] and alarm historic.

The term 'pending' is associated with all the states other than NORMAL presented in Figure 1. If the alarm state is not NORMAL, it implies that it is pending on the process to become normal or on the operator to acknowledge it. The pending alarms list shows the last of the blue transitions shown in Figure 1. Once the alarm state is NORMAL, it is no longer shown in the pending alarms list.

The alarm historic[7] shows all transitions shown in Figure 1.

[5] Alarm list with a limited number and most recent alarms.
[6] Also referred to active alarms for simplicity.
[7] Also referred to as Alarm Log; according to [1], an Alarm Log is short term repository for alarm records, and an Alarm Historian is long term repository for alarm records.

So that the operator can distinguish between the different alarm states, each state must be presented differently. Marine classification societies have this as a requirement for Alarm systems, and Lloyd's Register even goes a step further by stating in paragraph 2.3.9 of [4] "*Unacknowledged alarms on monitors are to be distinguished by either flashing text or a flashing marker adjacent to the text. A change of colour will not in itself be sufficient to distinguish between acknowledged and unacknowledged alarms.*"

Below is show a suggestion of implementation for alarm lists. None of the references listed in the References section specify how alarms must be displayed.

Unacknowledged alarm	Red background; black/white text
Acknowledged alarm	White background; red text
Normal unacknowledged	Green background, black/white text
Normal acknowledged	Black text, white background

6 ALARM PRIORITIES

The alarm priority is an indication of the importance of an alarm and its consequence on the process.

When multiple alarms are presented simultaneously to the operator, the alarm priority allows the operator to select which ones to address based on the respective severity.

IMO [2] specifies priorities the four alarm priorities listed in Table 2.

Table 2: IMO alarm priorities

Priority	Definition
Emergency alarm	Immediate danger to human life or to the ship and its machinery exists and that immediate action should be taken.
Alarm	Condition requiring immediate attention and action, to maintain the safe navigation and operation of the ship.
Warning	Condition requiring no immediate attention or action. Warnings are presented for precautionary reasons to bring awareness of changed conditions which are not immediately hazardous, but may become so if no action is taken.
Caution	Awareness of a condition which does not warrant an alarm or warning condition, but still requires attention out of the ordinary consideration of the situation or of given information.

Graphical Consoles or software packages used to implement Alarm Systems usually have a numerical value associated with the alarm priority. However, no standard or rules specify how the numerical value is related to the alarm severity. Table 3 presents an implementation suggestion.

Table 3: Numerical alarm priorities

Priority	Definition
1	Loss of functionality; 'Low Low' or 'High High' limit reached.
2	Eminent loss of functionality; 'Low' or 'High' limit reached.
3	No immediate effect on functionality.
4	Information only[8].

7 REFERENCES

[1] Management of alarms systems for the process industries, IEC 62682

[2] Codes on Alerts and Indications, International Maritime Organization, December 2009

[3] Rules for Classification – Ships, Part 4. Chapter 9, Section 3, DNV, January 2018

[4] Rules and Regulations for the Classification of Ships, Lloyd's Register, July 2021

[8] Acknowledge might not be required.

NOTES: