AMERICAN NATIONAL STANDARD

ANSI/ISA-18.2-2016

Management of Alarm Systems for the Process Industries

Approved 17 March 2016

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ANSI/ISA-18.2-2016
Management of Alarm Systems for the Process Industries

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Introduction

Purpose

This standard addresses the development, design, installation, and management of alarm systems in the process industries. Alarm management includes multiple work processes throughout the alarm management lifecycle. This standard defines the terminology and models to develop an alarm system, and it defines the work processes recommended to effectively maintain the alarm system throughout the lifecycle.

This standard was written as an extension of existing ISA standards with due consideration of other guidance documents that have been developed throughout industry. Ineffective alarm systems have often been cited as contributing factors in the investigation reports following major process incidents. This standard is intended to provide a methodology that will result in the improved safety, quality, and operation in the process industries.

This standard is not the first effort to define terminology and practices for effective alarm systems. In 1955 ISA formed a survey committee titled Instrument Alarms and Interlocks. The committee evolved to Standard & Practices Committee 18. In 1965 the committee completed ISA-RP18.1, *Specifications and Guides for the Use of General Purpose Annunciators*. In 1979 ISA released, as a product of the ISA18 and ISA67 committees, ISA-18.1-1979 (R2004), *Annunciator Sequences and Specifications*. In 1994 Amoco, Applied Training Resources, BP, Exxon, Gensym, Honeywell, Mobil, Novacor, Texaco, Shell, and others formed the Abnormal Situation Management Consortium (ASM) to develop a vision for better response to process incidents, with additional support in 1994 from the U.S. National Institute of Standards and Technology (NIST). In 1999 the Engineering Equipment and Materials Users' Association (EEMUA) issued Publication 191, *Alarm Systems: A Guide to Design, Management and Procurement*, which was updated in 2007, and again in 2013. In 2003 the User Association of Process Control Technology in Chemical and Pharmaceutical Industries (NAMUR) issued recommendation NA 102, *Alarm Management*. This ISA standard was originally issued in 2009, and International Electrotechnical Commission (IEC) developed IEC 62682 from that version and issued it in 2014.

During the development and maintenance of this standard every effort was made to keep terminology and practices consistent with the previous work of these respected organizations and committees.

This document provides requirements for alarm management and alarm systems. It is intended for those individuals and organizations that

a) manufacture or implement embedded alarm systems,

b) manufacture or implement third-party alarm system software,

c) design or implement alarm systems,

d) operate and maintain alarm systems, and

e) audit or assess alarm system performance.

Organization

This standard is organized in two parts. The first part is introductory in nature, (Clauses 1 to 5). The main body of the standard follows (Clauses 6 to 18), which presents mandatory requirements and non-mandatory recommendations as noted.

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1 Scope

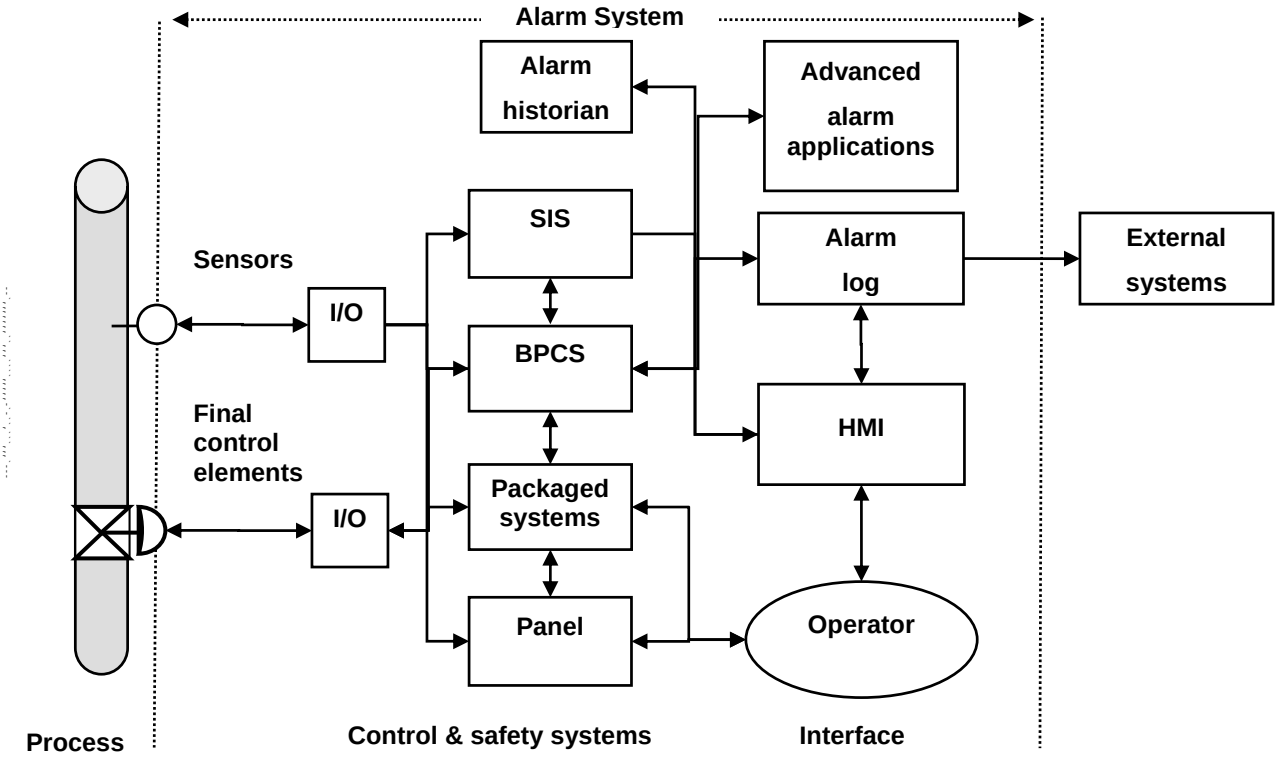
1.1 General applicability

This standard specifies general principles and processes for the lifecycle management of alarm systems based on programmable electronic controller and computer-based human-machine interface (HMI) technology for facilities in the process industries. It covers all alarms presented to the operator through the control system, which includes alarms from basic process control systems, annunciator panels, packaged systems (e.g., fire and gas systems, and emergency response systems), and safety instrumented systems.

The practices in this standard are applicable to continuous, batch, and discrete processes. There can be differences in implementation to meet the specific needs based on process type.

In jurisdictions where the governing authorities (e.g., national, federal, state, province, county, city) have established process safety design, process safety management, or other requirements, in addition to the requirements of this standard, these should be taken into consideration.

The primary function within the alarm system is to notify operators of abnormal process conditions or equipment malfunctions and support the response. The alarm systems can include both the basic process control system (BPCS) and the safety instrumented system (SIS), each of which uses measurements of process conditions and logic to generate alarms. Figure 1 illustrates the concepts of alarm and response dataflow through the alarm system. The alarm system also includes a mechanism for communicating the alarm information to the operator via an HMI, usually a computer screen or an annunciator panel. Additional functions of the alarm system are an alarm and event log, an alarm historian, and the generation of performance metrics for the alarm system. There are external systems that can use the data from the alarm system.



NOTE Other packaged systems (i.e., fire and gas systems) can be included in the control system.

Figure 1 – Alarm system dataflow

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1.2 Exclusions and inclusions

1.2.1 Operators

The functions of the operator receiving and responding to alarms are included in the scope of this standard. Management of operators is excluded from the scope of this standard.

1.2.2 Process sensors and final control elements

The alarms from sensors and final control elements are included in the scope of this standard. Process sensors and final control elements are shown in Figure 1 to indicate alarms can be implemented in these devices. The design and management of process sensors and final control elements are excluded from the scope of this standard.

1.2.3 Annunciator panels

The integration of independent alarm annunciator panels into an alarm system is included in the scope of this standard. The specification and design of annunciator panels is excluded from the scope of this standard. ISA-18.1-1979 (R2004), *Annunciator Sequences and Specifications*, provides information on alarm annunciator functions.

1.2.4 Human machine interface

The appearance of alarms in the HMI and functions of alarm related displays are included in the scope of this standard. The design and maintenance of the HMI are excluded from this standard. ANSI/ISA-101.01-2015, *Human Machine Interfaces for Process Automation Systems,* provides information on HMI.

1.2.5 Safety instrumented systems

The alarms from safety instrumented systems are included in the scope of this standard. The safety instrumented system (SIS) is shown in Figure 1 to indicate alarms can be implemented in these devices. The design and management of safety instrumented systems are excluded from this standard. ISA-84.00.01*, Functional Safety: Safety Instrumented Systems for the Process Industry Sector – Part 1: Framework, Definitions, System, Hardware and Software Requirements,* provides information on safety instrumented systems.

1.2.6 Fire detection and protective systems and security systems

The alarms and diagnostics from fire detection and protective systems or security systems that are presented to the operator through the control system are included in the scope of this standard. The design and management of fire detection and protective systems and security systems are excluded from the scope of this standard.

1.2.7 Event data

The indication and processing of analog, discrete, and event data other than alarm indications are excluded from the scope of this standard. The analysis techniques using both alarm and event data are excluded from the scope of this standard.

1.2.8 Alarm identification methods

Required methods of alarm identification are not specified in this standard. Examples of alarm identification methods are listed.

1.2.9 Management of change

A specific management of change (MOC) procedure is not included in this standard. Some requirements and recommendations for a MOC procedure are included.

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1.2.10 Purchase specification

This standard is not intended to be used as an alarm system purchase specification. It does not eliminate the need for sound engineering judgment. No particular technology is mandated.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISA-84.00.01-2004 (IEC 61511 Mod) Part 1*, Functional Safety: Safety Instrumented Systems for the Process Industry Sector – Part 1: Framework, Definitions, System, Hardware and Software Requirements*

ANSI/ISA-101.01-2015, *Human Machine Interfaces for Process Automation Systems*

3 Terms, definitions, and acronyms

For the purposes of this document, the following definitions apply.

3.1 Terms and definitions

3.1.1

absolute alarm

alarm generated when the alarm setpoint is exceeded (e.g., high-high, high, low, low-low)

3.1.2

acknowledge

operator action that confirms recognition of an alarm

3.1.3

active

an alarm in a state in which the alarm condition is true

Note 1 to entry: Functions such as deadband, on or off delays and latching can allow the alarm to be active when the alarm condition is false or the alarm to not be active when the alarm condition is true.

3.1.4

adaptive alarm
alarm for which the setpoint is changed by an algorithm (e.g., calculated based on production rate)

3.1.5

adjustable alarm

operator-set alarm

alarm for which the setpoint can be changed manually by the operator

3.1.6

advanced alarming

collection of techniques that can help manage annunciations during specific situations

EXAMPLE: state-based alarming

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3.1.7

alarm

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

3.1.8

(alarm) annunciation

function of the alarm system to call the attention of the operator to an alarm

3.1.9

alarm attribute
setting for an alarm within the process control system

EXAMPLE: alarm priority

3.1.10

alarm class

group of alarms with common set of alarm management requirements (e.g., testing, training, monitoring, and audit requirements)

EXAMPLE: safety related alarm class

3.1.11

alarm deadband

change in signal from the alarm setpoint necessary for the alarm to return to normal

3.1.12

(alarm) filtering

function which selects alarm records to be displayed according to a given element or elements of the alarm record

3.1.13

alarm flood
condition during which the alarm rate is greater than the operator can effectively manage (e.g., more than 10 alarms per 10 minutes)

3.1.14

alarm group

set of alarms with common association (e.g., process unit, process area, equipment set, or service)

3.1.15

alarm historian

long term repository for alarm records

3.1.16

alarm log

short term repository for alarm records

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3.1.17

alarm management

alarm system management

collection of processes and practices for determining, documenting, designing, operating, monitoring, and maintaining alarm systems

3.1.18

alarm message

text string displayed with the alarm indication that provides additional information to the operator (e.g., operator action)

3.1.19

alarm off-delay

debounce

time an alarm remains active after the process measurement has returned within the alarm setpoint

3.1.20

alarm on-delay

time before an alarm becomes active after the process measurement has exceeded the alarm setpoint

3.1.21

alarm philosophy

document that establishes the basic definitions, principles, and processes to design, implement, and maintain an alarm system

3.1.22

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)

3.1.23

alarm rate

number of annunciated alarms, per operator, in a specific time interval

3.1.24

(**alarm) record**

set of information which documents an alarm state change

3.1.25

alarm response procedure

guidance for response to an alarm (e.g., operator action, probable cause)

Note 1 to entry: The guidance can be in many forms and not only in the form of a procedure document.

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3.1.26

alarm setpoint

alarm limit

alarm trip point

threshold value of a process variable or discrete state that is used to determine if the alarm is active

3.1.27

(alarm) sorting

function which orders alarm records to be displayed according to a given element of alarm record

3.1.28

alarm summary

alarm list

display that lists annunciated alarms with selected information (e.g., date, time, priority, and alarm type).

Note 1 to entry: Return to normal indications can also appear on the alarm summary.

3.1.29

alarm system

collection of hardware and software that detects an alarm state, communicates the indication of that state to the operator, and records changes in the alarm state

Note 1 to entry: the operator is included in the alarm system. See Figure 1.

3.1.30

alarm system requirements specification

document which describes the functionality of the alarm system

3.1.31

alarm type

alarm attribute which gives a distinction of the alarm condition

EXAMPLE: low process variable alarm, high process variable alarm, or discrepancy alarm

3.1.32

alert

audible and/or visible means of indicating to the operator an equipment or process condition that requires awareness and which does not meet the criteria for an alarm

3.1.33

allowable response time

maximum time between the annunciation of the alarm and when the operator must take corrective action to avoid the consequence

3.1.34

annunciator

device or group of devices that call attention to changes in process conditions

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3.1.35

assessment

comparison of information from monitoring and additional qualitative (subjective) measurements, against stated goals and defined performance metrics

3.1.36

audit

comprehensive assessment that includes the evaluation of alarm system performance and of the work practices used to administer the alarm system

3.1.37

bad-measurement alarm

alarm generated when the signal for a process measurement is outside the expected range (e.g., 3.8mA for a 4 to 20mA signal)

3.1.38

benchmark

an initial audit of an alarm system designed to specifically identify problem areas for the purpose of formulating improvement plans

3.1.39

bit-pattern alarm

alarm that is generated when a pattern of digital signals matches a predetermined pattern

3.1.40

calculated alarm

alarm generated from a calculated value instead of a direct process measurement

3.1.41

call-out alarm

alarm that notifies and informs an operator by means other than, or in addition to, a console display (e.g., pager or telephone)

3.1.42

chattering alarm

alarm that repeatedly transitions between active state and not active state in a short period of time

3.1.43

classification

process of separating alarms into alarm classes based on common requirements (e.g., testing, training, monitoring, and auditing requirements)

3.1.44

control system

system that responds to input signals from the equipment under control and/or from an operator and generates output signals that cause the equipment under control to operate in the desired manner

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Note 1 to entry: The control system can include one or more basic process control systems (BPCS), safety instrumented systems (SIS), or packaged systems.

3.1.45

controller-output alarm

alarm generated from the output signal of a control algorithm (e.g., PID controller) instead of a direct process measurement

3.1.46

decommission

process to remove an alarm from the alarm system

3.1.47

deviation alarm

alarm generated when the difference between two values exceeds an alarm setpoint (e.g., deviation between primary and redundant instruments or a deviation between process variable and controller setpoint)

3.1.48

discrepancy alarm

mismatch alarm

alarm generated by the difference between the expected plant or device state to its actual state (e.g., when a motor fails to start after it is commanded to the on state)

3.1.49

display
visual representation of information used by the operator for monitoring and control

3.1.50

dynamic alarming

automatic modification of alarm attributes based on process state or conditions

3.1.51

enforcement

enhanced alarming technique that can verify and restore alarm attributes in the control system to the values in the master alarm database

3.1.52

event

representation of a solicited or unsolicited fact indicating a state change

Note 1 to entry: For example, mode changes or device state changes.

[SOURCE IEC 62264-2:2013, modified – a note has been added.]

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3.1.53

first-out alarm

first-up alarm

alarm determined (i.e., by first-out logic) to be the first, in a multiple-alarm scenario

3.1.54

fleeting alarm

alarm that transitions between an active alarm state and a not active alarm state in a short period of time without rapidly repeating

3.1.55

highly managed alarm (HMA)

alarm belonging to a class with additional requirements (e.g., regulatory requirements) above general alarms

EXAMPLE: safety alarm

3.1.56

human machine interface (HMI)

collection of hardware and software used by the operator to monitor and interact with the control system and with the process via the control system

3.1.57

implementation

transition stage between design and operation during which the alarm is put into service

Note 1 to entry: Implementation includes activities such as commissioning and training.

3.1.58

instrument diagnostic alarm

alarm to indicate a field device or signal fault

EXAMPLE: out-of-range alarm

3.1.59

interim alarm

alarm used on a temporary basis to replace an out-of-service alarm

3.1.60

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

3.1.61

master alarm database

authorized list of rationalized alarms and associated attributes

Note 1 to entry: The list can be in many forms and not only in the form of a database.

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3.1.62

monitoring

the measurement and reporting of quantitative (objective) aspects of alarm system performance

3.1.63

nuisance alarm

alarm that annunciates excessively, unnecessarily, or does not return to normal after the operator action is taken

EXAMPLE: chattering alarm, fleeting alarm, or stale alarm

3.1.64

operator

controller

person who monitors and makes changes to the process

3.1.65

(operator) console
interface for an operator to monitor and/or control the process, which may include multiple displays or annunciators, and defines the boundaries of the operator's span of control

3.1.66

operator station

human-machine interface within the operator console

Note 1 to entry: Operator station can include multiple screens.

3.1.67

out-of-service

state of an alarm during which the alarm indication is indefinitely suppressed, typically manually, for reasons such as maintenance

3.1.68

packaged system

self-contained combination of hardware and software that can provide alarm, HMI, and control functionality for a specific process function that is part of a facility

3.1.69

plant state

plant mode

defined set of operational conditions for a process plant

EXAMPLE: shutdown, normal operation

3.1.70

prioritization

process of assigning a level of operational importance to an alarm

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3.1.71

process area

physical, geographical or logical grouping of resources determined by the site

[SOURCE: IEC 62264-1:2013, 3.1]

3.1.72

rate-of-change alarm

alarm generated when the change in process variable per unit time (d*PV*/d*t*) exceeds a defined setpoint

3.1.73

rationalization

process to review potential alarms using the principles of the alarm philosophy, to select alarms for design, and to document the rationale for each alarm

3.1.74

re-alarming alarm

re-triggering alarm
alarm that is automatically re-annunciated to the operator under certain conditions

3.1.75

recipe-driven alarm

alarm with setpoints that depend on the recipe that is currently being executed

3.1.76

remote alarm

alarm from a remotely operated facility or directed to a remote interface

3.1.77

reset

operator action that unlatches a latched alarm

3.1.78

return to normal

clear

alarm transition from an active alarm state to a not active alarm state

3.1.79

safety alarm

safety related alarm

an alarm that is classified as critical to process safety for the protection of human life or the environment

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3.1.80

safety instrumented system (SIS)

instrumented system used to implement one or more safety instrumented functions. A SIS is composed of any combination of sensor(s), logic solver(s), and final elements(s)

[SOURCE: IEC 61511]

Note 1 to entry: This can include either safety instrumented control functions or safety instrumented protection functions or both.

3.1.81

shelve

temporarily suppress an alarm, initiated by the operator, with engineering controls (e.g., time-limited) that unsuppress the alarm

3.1.82

silence

operator action that terminates the audible alarm indication

3.1.83

stale alarm

alarm that remains annunciated for an extended period of time (e.g., 24 hours)

3.1.84

state-based alarm

mode-based alarms

alarm that has attributes modified or is suppressed based on operating states or process conditions

3.1.85

statistical alarm

alarm generated based on statistical processing of a process variable or variables

3.1.86

suppress

prevent the annunciation of the alarm to the operator when the alarm is active

EXAMPLE: shelve, suppress by design, remove from service

3.1.87

suppressed by design

alarm annunciation to the operator prevented based on plant state or other conditions

3.1.88

system diagnostic alarm

alarm generated by the control system to indicate a fault within the system hardware, software or components

EXAMPLE: communication error

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3.1.89

tag

point

unique identifier assigned to a process measurement, calculation, or device within the control system

3.1.90

unacknowledged

alarm state in which the operator has not yet confirmed recognition of an alarm indication

3.2 Abbreviations

ACKED	Acknowledged
ASRS	Alarm system requirements specification
BPCS	Basic process control system
cGMP	current good manufacturing practice
DSUPR	Designed suppression
ERP	Enterprise resource planning
FMEA	Failure mode and effects analysis
HAZOP	Hazard and operability study
HMA	Highly managed alarms
HMI	Human machine interface
I/O	Input / output
LOPA	Layer of protection analysis
MES	Manufacturing execution system
MOC	Management of change
NORM	Normal
OOSRV	Out of service
P&ID	Piping (or Process) and instrumentation diagram
PHA	Process hazards analysis
RTNUN	Return to normal unacknowledged
SHLVD	Shelved
SIS	Safety instrumented system
UNACK	Unacknowledged

4 Conformance to this standard

4.1 Conformance guidance

To conform to this standard, it shall be shown that each of the mandatory requirements has been satisfied.

4.2 Existing systems

For existing alarm systems designed and constructed in accordance with codes, standards, or practices prior to the issue of this standard, the owner/operator shall determine that the equipment is designed, maintained, inspected, tested, and operated in a safe manner. The

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practices and procedures of this standard shall be applied to existing systems in a reasonable time as determined by the owner/operator.

4.3 Use of required functionalities

This standard requires certain control system functionalities (e.g., shelving) to support the alarm system. A functionality is not required where the alarm philosophy states the functionality is not used.

4.4 Responsibility

Conformance to this standard is the responsibility of the owner/operator.

5 Alarm system models

5.1 Alarm systems

Alarm systems are used to communicate indications of abnormal process conditions or equipment malfunctions to the operators, the personnel monitoring and operating the process, and support the response. Effective alarm systems are well designed, implemented, operated, and maintained. Alarm management is the set of practices and processes that ensures an effective alarm system.

A foundational part of alarm management is the definition of an alarm; an audible and/or visible means of indicating to the operator an equipment malfunction, process deviation, or abnormal condition requiring a timely response. An essential element of this definition is the response to the alarm. This definition is reinforced in the alarm management processes described in this standard.

5.2 Alarm management lifecycle

5.2.1 Alarm management lifecycle model

Figure 2 illustrates the relationship between the stages of the alarm management lifecycle described in this standard. The alarm management lifecycle covers alarm system specification, design, implementation, operation, monitoring, maintenance, and management of change activities from initial conception through decommissioning.

The lifecycle model is useful in organizing the requirements and responsibilities for implementing an alarm management system. The lifecycle is applicable for the installation of new alarm systems or managing an existing system.

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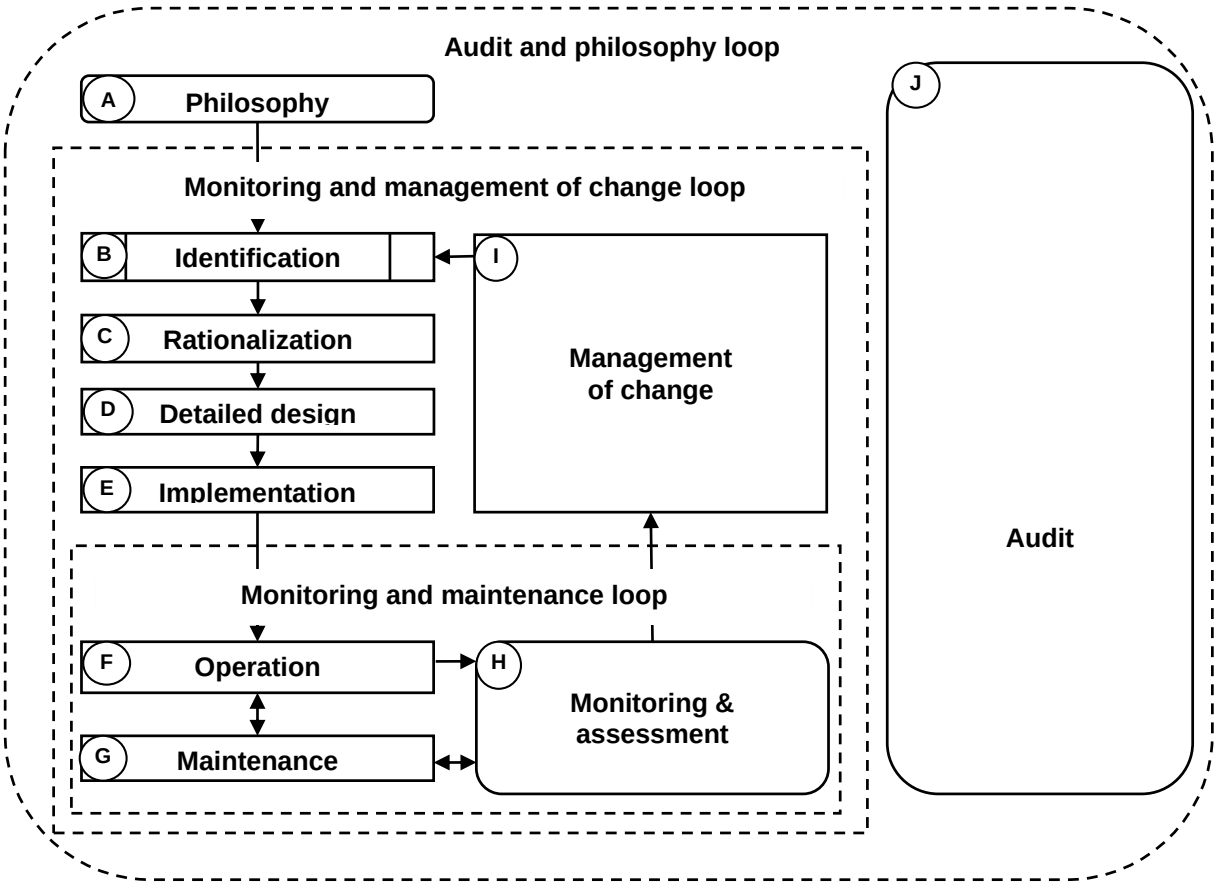

NOTE 1 The box used for stage B represents a process defined outside of this standard per 5.2.2.3.
NOTE 2 The independent stage J represents a process that connects to all other stages per 5.2.2.11
NOTE 3 The rounded shapes of stages A, H, and J represent entry points to the lifecycle per 5.2.3.
NOTE 4 The dotted lines represent the loops in the lifecycle per 5.2.5.

Figure 2 – Alarm management lifecycle

5.2.2 Alarm management lifecycle stages

5.2.2.1 General

The alarm management lifecycle stages shown in Figure 2 are briefly described in the following sub-clauses. The letter label is an identifier used in the text. The requirements and recommendations for each stage are described in Clauses 6-18 of this standard.

5.2.2.2 Alarm philosophy (A)

Basic planning is necessary prior to designing a new alarm system or modifying an existing system. Generally, the first step is the development of an alarm philosophy that documents the objectives of the alarm system and the processes to meet those objectives. The alarm philosophy reflects the operations and maintenance work processes, and can reference those processes in other documents. For new systems the alarm philosophy serves as the basis for the alarm system requirements specification (ASRS) document.

The philosophy starts with the basic definitions and extends them to operational definitions. The criteria for alarm prioritization and the definition of alarm classes, performance metrics, performance limits and reporting requirements are based on the objectives and principles for alarm systems. The schemes for presentation of alarm indications in the HMI, including use of

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priorities, are also set in the alarm philosophy, which should be consistent with the overall HMI design. The philosophy specifies the processes used for each of the alarm management lifecycle stages, such as the threshold for the MOC process and the specific requirements for change. The philosophy is maintained to ensure consistent alarm management throughout the lifecycle of the alarm system.

The development of the ASRS is included in the philosophy stage of the lifecycle. The specification can be plant specific, providing details on restrictions or options, and can be the basis for selecting new or modifying existing control systems. The specification typically goes into more detail than the alarm philosophy and can provide specific guidance for system design.

5.2.2.3 Identification (B)

The identification stage is a collection point for potential alarms proposed by one of the methods for determining if an alarm might be necessary. These methods are defined outside of this standard so the identification stage is represented as a predefined process in the lifecycle. The methods can be formal such as process hazards analysis, safety requirements specifications, recommendations from an incident investigation, good manufacturing practice, environmental permits, P&ID development or operating procedure reviews. Information from identification (e.g., alarm setpoint, consequence) should be captured for rationalization. Process modifications and operating tests can also generate the need for alarms or modifications. Some alarm changes will be identified from the routine monitoring of alarm system performance. At this stage the need for a new alarm or modifications to an existing alarm has been identified and the alarm is ready to be rationalized.

5.2.2.4 Rationalization (C)

The rationalization stage reconciles the identified need for an alarm or alarm system change with the principles and definitions in the alarm philosophy. The steps can be completed in one process or sequentially. The output of rationalization is documentation of the alarm, including any advanced alarm techniques, which can be used to complete the design.

Rationalization is the process of applying the requirements for an alarm and generating the supporting documentation such as the alarm setpoint, the consequence, and corrective action that can be taken by the operator.

Rationalization includes the prioritization of an alarm based on the method defined in the alarm philosophy. Often priority is based on the consequences of the alarm and the allowable response time.

Rationalization also includes the activity of classification during which an alarm is assigned to one or more classes to designate requirements (e.g., design, testing, training, or reporting requirements). The type of consequences of a rationalized alarm, or other criteria, can be used to separate the alarms into classes as defined in the alarm philosophy.

The rationalization results are documented, typically in the master alarm database (i.e., an approved document or file), which is maintained for the life of the alarm system.

5.2.2.5 Detailed design (D)

In the design stage, additional alarm attributes are specified and designed based on the requirements determined by rationalization. There are three areas of design: basic alarm design, HMI design, and design of advanced alarming techniques.

The basic design for each alarm follows guidance based on the type of alarm and the specific control system.

The HMI design includes display and annunciation for the alarms, including the indications of alarm state and alarm priority.

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Advanced alarming techniques are additional functions that improve the effectiveness of the alarm system beyond the basic alarm and HMI design (e.g., state-based alarming).

5.2.2.6 Implementation (E)

In the implementation stage, the activities necessary to install an alarm or alarm system and bring it to operational status are completed. Implementation of a new alarm or a new alarm system includes the physical and logical installation and functional verification of the system.

Since operators are an essential part of the alarm system, operator training is an important activity during implementation. Testing of new alarms is often an implementation requirement. The documentation for training, testing, and commissioning can vary with classification as defined in the alarm philosophy.

5.2.2.7 Operation (F)

In the operation stage, the alarm or alarm system is in service and it performs its intended function. Refresher training on both the alarm philosophy and the purpose of each alarm is included in this stage.

5.2.2.8 Maintenance (G)

In the maintenance stage, the alarm or alarm system is not operational but is being tested or repaired. Periodic maintenance (e.g., testing of instruments) is necessary to ensure the alarm system functions as designed.

5.2.2.9 Monitoring and assessment (H)

In the monitoring and assessment stage, the overall performance of the alarm system and individual alarms are continuously monitored against the performance goals stated in the alarm philosophy. Monitoring and assessment of the data from the operation stage may trigger maintenance work or identify the need for changes to the alarm system or operating procedures. Without monitoring, the performance of an alarm system is likely to degrade over time.

5.2.2.10 Management of change (I)

In the management of change stage, modifications to the alarm system are proposed and approved. The change process should follow each of the alarm management lifecycle stages from identification to implementation.

5.2.2.11 Audit (J)

In the audit stage, periodic reviews are conducted to evaluate the effectiveness of the alarm management process and maintain the integrity of the alarm system. Audits of system performance can reveal gaps not apparent from routine monitoring. Execution against the alarm philosophy is audited to identify system improvements, such as modifications to the alarm philosophy. Audits can also identify the need to increase the discipline of the organization to follow the alarm philosophy.

5.2.3 Alarm lifecycle entry points

5.2.3.1 General

Depending on the selected approach, there are three points of entry to the alarm management lifecycle

a) alarm philosophy,

b) monitoring and assessment, and

c) audit.

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These entry points are represented by rounded boxes in Figure 2. As entry points these lifecycle stages are only the initial step in managing an alarm system. All stages of the lifecycle are necessary for a complete alarm management system.

5.2.3.2 Start with alarm philosophy (A)

The first possible starting point is the development of an alarm philosophy which establishes the objectives of the alarm system and may be used as the basis for the alarm system requirements specification. This is the lifecycle entry point for new systems.

5.2.3.3 Start with monitoring and assessment (H)

The second possible starting point is to begin monitoring an existing alarm system and benchmark the performance. Problem alarms can be identified and addressed through maintenance or management of change. The monitoring data can be used in a benchmark assessment prior to the development of the alarm philosophy.

5.2.3.4 Start with audit (J)

The third possible starting point is an initial audit, or benchmark, of all aspects of alarm management against a set of documented practices, such as those listed in this standard. The results of the initial audit can be used in the development of a philosophy.

5.2.4 Simultaneous and encompassing stages

The lifecycle diagram (Figure 2) is drawn to represent sequential stages. There are several simultaneous stages which are represented in the lifecycle. Some stages encompass the activities of other stages.

The monitoring and assessment stage (H) is simultaneous to the operation and maintenance stages.

The management of change stage (I) represents the initiation of the change process through which all appropriate stages of the lifecycle are authorized and completed.

The audit stage (J) is an overarching activity that can occur at any point in the lifecycle and includes a review of the activities of the other stages.

5.2.5 Alarm management lifecycle loops

5.2.5.1 General

In addition to the alarm management lifecycle stages, there are three loops in the lifecycle. Each loop performs a function during the cycle.

5.2.5.2 Monitoring and maintenance loop

The monitoring and maintenance loop is the routine monitoring that identifies problem alarms for maintenance. Repaired alarms are returned to operation.

5.2.5.3 Monitoring and management of change loop

The monitoring and management of change loop is triggered when routine monitoring indicates the design of an alarm is not compatible with the alarm philosophy. The design might need to be modified or an advanced alarm technique might need to be applied. The alarm could remain in operation while the MOC process is initiated and the stages of the lifecycle are repeated.

5.2.5.4 Audit and philosophy loop

The audit-philosophy loop is the lifecycle itself and the process of continuous improvement of the alarm system. Audit identifies processes in the lifecycle to strengthen.

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5.2.6 Alarm management lifecycle stage inputs and outputs

The alarm management lifecycle stages are connected as the outputs of one stage are often the inputs to another stage. The connections are not fully represented in the lifecycle diagram (Figure 2). Table 1 provides more information on the relationships between the inputs and outputs of the lifecycle stages.

Table 1 - Alarm management lifecycle stage inputs and outputs

Alarm management lifecycle stage		Activities	Clause number	Inputs	Outputs
Stage	Title				
A	Philosophy	Document the objectives, guidelines and work processes for alarm management, and ASRS.	6,7	Objectives and standards, audit recommendations	Alarm philosophy and ASRS.
B	Identification	Determine potential alarms.	8	PHA report, P&IDs, operating procedures, etc.	List of potential alarms.
C	Rationalization	Rationalization, classification, prioritization, and documentation.	9	Alarm philosophy, and list of potential alarms.	Master alarm database and alarm design requirements.
D	Detailed design	Basic alarm design, HMI design, and advanced alarming design.	10,11,12	Master alarm database and alarm design requirements.	Completed alarm design.
E	Implementation	Install alarms, implementation testing, and implementation training.	13	Completed alarm design and master alarm database, ASRS.	Operational alarms and alarm response procedures.
F	Operation	Operator responds to alarms, and refresher training.	14	Operational alarms and alarm response procedures.	Alarm data.
G	Maintenance	Maintenance repair and replacement, and periodic testing.	15	Alarm monitoring reports and alarm philosophy.	Alarm data.
H	Monitoring & assessment	Monitoring alarm data and report performance.	16	Alarm data and alarm philosophy.	Alarm monitoring reports and proposed changes.
I	Management of change	Process to authorize additions, modifications, and deletions of alarms.	17	Alarm philosophy and proposed changes.	Authorized alarm changes.
J	Audit	Periodic audit of alarm management processes.	18	Standards, alarm philosophy, and audit protocol.	Recommendations for improvement.

5.3 Alarm states

5.3.1 Alarm state transition diagram

The alarm state transition diagram shown in Figure 3 represents the states and transitions for typical alarms. While there are exceptions, this diagram describes the majority of alarms and serves as a useful reference for the development of alarm system principles and HMI functions.

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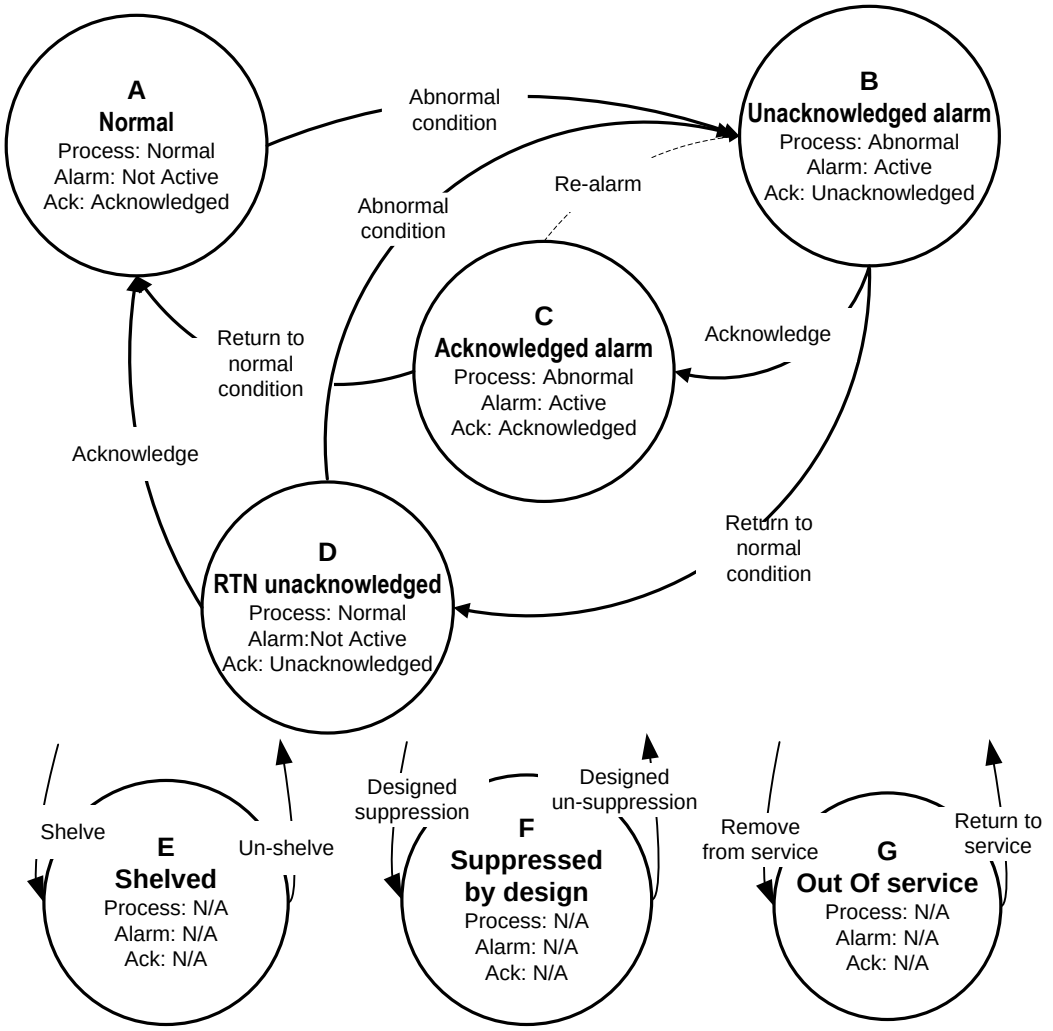

NOTE 1 States E, F, and G can connect to any alarm state in the diagram.
NOTE 2 The dotted line indicates an infrequently implemented option.
NOTE 3 N/A indicates not applicable or that the condition is not relevant in the alarm state.

Figure 3 - Alarm state transition diagram

5.3.2 Alarm states

5.3.2.1 General

The circles in the Figure 3 represent the states of an alarm. The letter label is an identifier. The second line is a state name, often abbreviated. The third line describes process conditions, the fourth and fifth lines list the alarm status and its acknowledgement status, respectively. The possible states of alarm suppression are shown on the lower part of the diagram.

5.3.2.2 Normal state (A)

The normal (NORM) alarm state is defined as the state in which the process is operating within normal specifications, the alarm is not active and previous alarm occurrences have been acknowledged.

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5.3.2.3 Unacknowledged state (B)

The unacknowledged alarm (UNACK) state is the initial state of an alarm becoming active due to abnormal conditions. In this state the alarm is unacknowledged. Previously acknowledged alarms can be designed to re-alarm, causing a return to this state.

5.3.2.4 Acknowledged state (C)

The acknowledged (ACKED) alarm state is the state in which the alarm is active and the operator has acknowledged the alarm.

5.3.2.5 Return to normal unacknowledged state (D)

In the returned to normal unacknowledged (RTNUN) alarm state, the process is within normal limits and the alarm becomes not active before an operator has acknowledged the alarm condition.

5.3.2.6 Shelved state (E)

In the shelved (SHLVD) alarm state, an alarm is temporarily suppressed using a controlled methodology, and not annunciated. An alarm in the shelved state is under the control of the operator. The shelving function can automatically unshelve alarms.

5.3.2.7 Suppressed-by-design state (F)

In the suppressed–by-design (DSUPR) alarm state, an alarm is suppressed based on operating conditions or plant states, and not annunciated. An alarm in the suppressed-by-design state is under the control of logic that determines the relevance of the alarm.

5.3.2.8 Out-of-service state (G)

In the out-of-service (OOSRV) alarm state an alarm is manually suppressed (e.g., control system functionality to remove alarm from service) when it is removed from service and not annunciated, typically for maintenance. An alarm in the out-of-service state is under the control of maintenance.

NOTE An alarm in the out-of-service state is not the same as out of service for a unit or piece of equipment. Equipment can be out of service while the associated alarms are not out of service.

5.3.2.9 Alarm status by state

The alarm status of different alarm states is summarized in Table 2.

Table 2 - Alarm states

ID	Mnemonic	State name	Process condition	Alarm status	Annunciate status	Acknowledge status
A	NORM	Normal alarm state	Normal	Not active	Not annunciated	Acknowledged
B	UNACK	Unacknowledged alarm state	Abnormal	Active	Annunciated	Unacknowledged
C	ACKED	Acknowledged alarm state	Abnormal	Active	Annunciated	Acknowledged
D	RTNUN	Returned to normal unacknowledged alarm state	Normal	Not active	Annunciated	Unacknowledged
E	SHLVD	Shelved state	Normal or abnormal	Not active or active	Suppressed	Not Applicable
F	DSUPR	Suppressed-by-	Normal or	Not	Suppressed	Not Applicable

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ID	Mnemonic	State name	Process condition	Alarm status	Annunciate status	Acknowledge status
		design state	abnormal	active or active		
G	OOSRV	Out-of-service alarm state	Normal or abnormal	Not active or active	Suppressed	Not Applicable

5.3.3 Alarm state transition paths

5.3.3.1 General

The arrows in Figure 3 represent transitions between states. The diagram does not directly illustrate effects of alarm deadband and on-delay or off-delay, which are included in the evaluation of alarm status (i.e., active or not active)

5.3.3.2 Transition from normal to unacknowledged (A→B)

The transition from normal to unacknowledged occurs when the process has gone out of the normal range beyond the alarm setpoint and has remained in this state long enough to make the alarm active.

5.3.3.3 Transition from unacknowledged to acknowledged (B→C)

The transition from unacknowledged to acknowledged occurs when an operator acknowledges an alarm that is active before the process returns to normal and the alarm becomes not active.

5.3.3.4 Transition from acknowledged to unacknowledged (C→B)

The transition from acknowledged to unacknowledged is the infrequently used option that periodically generates repetitive alarm indications for a single alarm while the alarm remains active.

5.3.3.5 Transition from acknowledged to normal (C→A)

The transition from acknowledged to normal is part of a normal sequence for an alarm. The alarm moves from the acknowledged state to normal and becomes not active.

5.3.3.6 Transition from unacknowledged to return-to-normal unacknowledged (B→D)

The transition from unacknowledged to return-to-normal unacknowledged occurs when the process returns to normal and the alarm becomes not active before an operator has acknowledged the alarm.

5.3.3.7 Transition from return-to-normal unacknowledged to normal (D→A)

The transition from return-to-normal unacknowledged to normal occurs when an alarm has returned to normal and becomes not active. This transition can require operator acknowledgment, or can be acknowledged automatically.

5.3.3.8 Transition to shelved (any state → E)

The transition to shelved occurs when an operator shelves an alarm to avoid clutter in the active alarm displays. Shelving is a manual operation.

5.3.3.9 Transition from shelved to normal or unacknowledged (E → A or B)

The transition from shelved to normal or unacknowledged occurs when an alarm is un-shelved, manually or automatically. If the alarm is active, the transition should be to the unacknowledged state. If the alarm is not active, the transition should be to the normal state.

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5.3.3.10 Transition to suppressed-by-design (any state → F)

The transition to suppressed-by-design occurs when process conditions or states are used to suppress alarms by design. Designed suppression is typically an automatic operation.

5.3.3.11 Transitions from suppressed-by-design to normal or unacknowledged (F → A or B)

The transition from suppressed-by-design to normal or unacknowledged occurs when process conditions or states are used to un-suppress alarms when appropriate. Designed un-suppression is typically an automatic operation. If the alarm is active, the transition should be to the unacknowledged state. If the alarm is not active, the transition should be to the normal state.

5.3.3.12 Transition to out-of-service state (any state → G)

The transition to out-of-service state occurs when an alarm is removed from service for maintenance or other reasons. Remove from service is typically a manual operation.

5.3.3.13 Transition from out-of-service to normal or unacknowledged (G → A or B)

The transition from out-of-service to normal or unacknowledged occurs when an alarm is returned to service when it is available after maintenance. Return to service is typically a manual operation. If the alarm is active, the transition should be to the unacknowledged state. If the alarm is not active, the transition should be to the normal state.

5.4 Alarm response timeline

5.4.1 General

Figure 4 represents a process measurement that increases from a normal condition to an abnormal condition and the two possible scenarios based on whether the operator takes the corrective action or not. It is possible to map some alarm states from Figure 3 to the timeline shown in Figure 4, to clarify the definition of terms related to time.

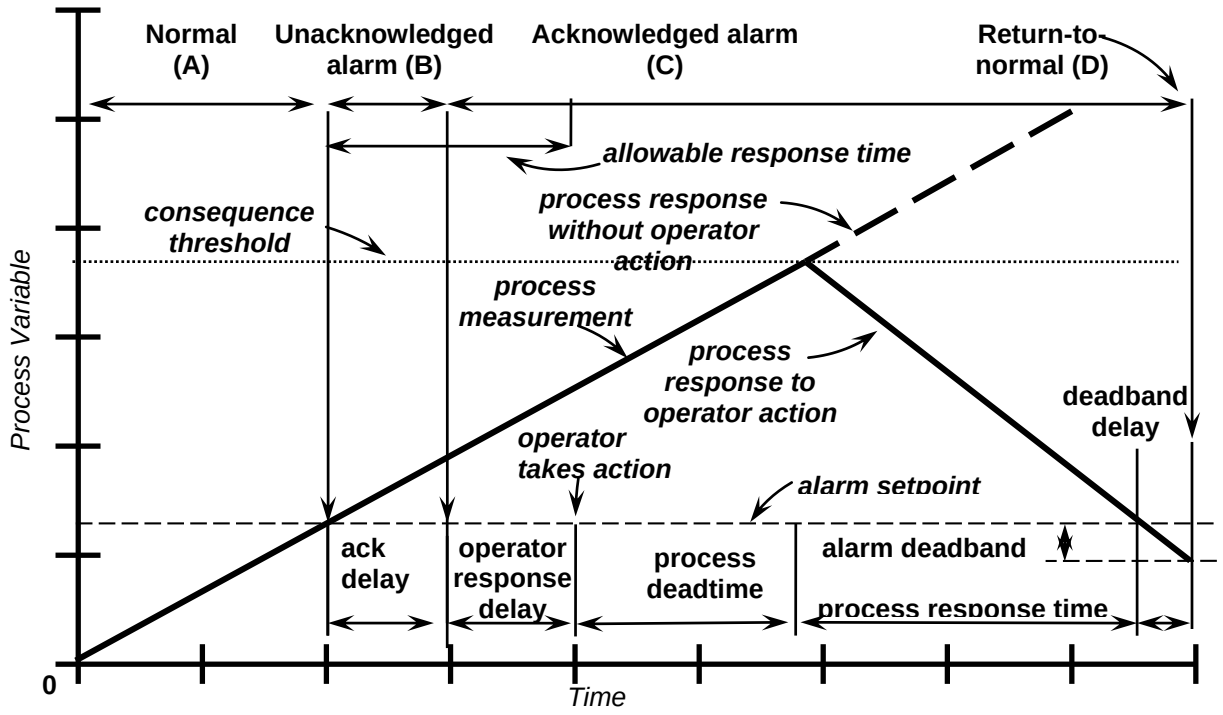

Figure 4 - Alarm response timeline

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5.4.2 Normal (A)

The normal alarm state is defined as the state in which the process is operating within normal specifications, the alarm is not active and previous occurrences of the alarm have been acknowledged.

5.4.3 Unacknowledged (B)

The unacknowledged alarm state results when the measurement crosses the alarm setpoint. There are several factors that affect the alarm annunciation such as

a) measurement accuracy,

b) sampling interval, and

c) alarm on-delay.

The alarm is not always immediately acknowledged by the operator.

5.4.4 Acknowledged (C) and response

The acknowledged alarm state is reached when an operator acknowledges the alarm condition, after the acknowledge delay. The operator can take action before or after acknowledging the alarm. In this state the alarm is active. There are several factors that affect the operator response time such as

a) system processing speed,

b) HMI design and clarity,

c) operator awareness and training,

d) operator workload,

e) complexity of determining the operator action, and

f) complexity of the operator action.

The actual response time for the alarm is the time beginning when the alarm is annunciated and ending when the operator takes the corrective action. It includes the detection of the alarm, the diagnosis of the situation and determination of the operator action in response, and the execution of that response. The upper limit of the response time is the allowable response time, the point beyond which the consequence will occur even if action is taken.

5.4.5 Return-to-normal (D)

The return-to-normal alarm state should result from the correct operator action within the allowable response time. There are several factors that affect the time until the alarm returns to normal. These include the following:

a) the operator response delay,

b) the degree of corrective action taken,

c) the process deadtime in response to the corrective action,

d) the process response time to the corrective action,

e) the accuracy of the process measurement,

f) the deadband of the alarm setpoint, and

g) the operational speed of the alarm system.

5.4.6 Allowable response time

The allowable response time is estimated from the process deadtime, the rate of change of the process variable and the separation between the alarm setpoint and the consequence threshold. In Figure 4, the operator response delay is shown within the allowable response time.

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5.4.7 Alarm setpoint

The alarm setpoint can be adjusted to increase or decrease the allowable response time. The process for evaluating the alarm setpoint is alarm setpoint determination.

5.4.8 Consequence threshold

The consequence threshold is the value of the process measurement at which the consequence begins to occur. The consequence results when no operator action is taken, incorrect or insufficient action is taken or the action is not completed within the allowable response time.

5.4.9 Alarm deadband

The deadband delay shown in Figure 4 illustrates that the alarm does not return to normal immediately after crossing the alarm setpoint.

5.5 Feedback model of operator – process interaction

5.5.1 General

A model of operator-process interaction is shown in Figure 5. In response to a disturbance or malfunction, the process or system undergoes some change. If that change deviates significantly from the reference or objective for the process, the operator takes action to bring the process back to the reference. The following three stages of activity occur in the operator sub-system leading to action:

a) the indication of deviation from desired normal operation (i.e., an alarm) is detected,

b) the situation is diagnosed and the corrective action determined, and

c) the corrective action is implemented to compensate for the disturbance.

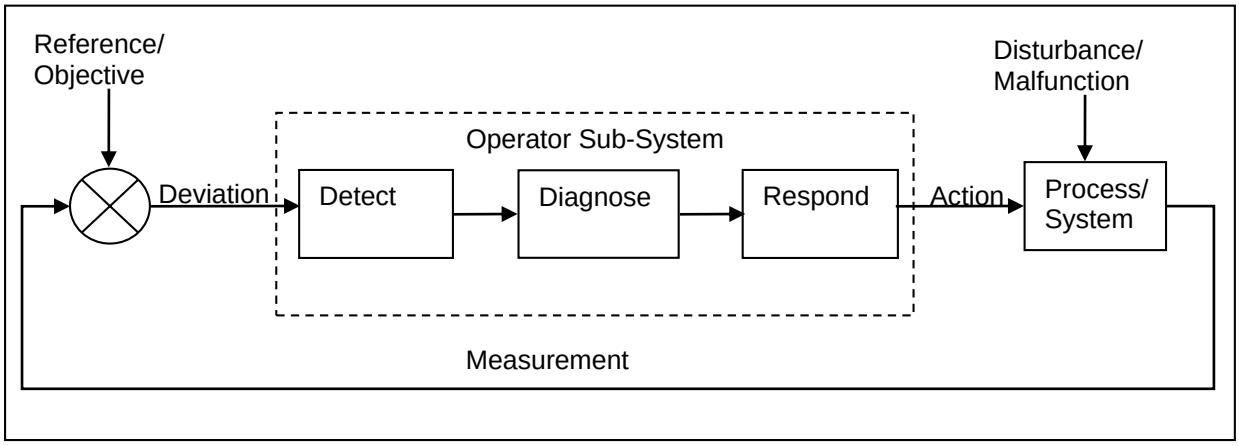

Figure 5 - Feedback model of operator process interaction

5.5.2 Detect

The operator becomes aware of the deviation from the desired condition by an alarm caused by a disturbance. The design of the alarm system and the operator interface facilitates the detection of deviation.

5.5.3 Diagnose

The operator uses knowledge and skills to interpret the information, diagnose the situation, and determine the corrective action to take in response to the deviation. The alarm response procedures aid the operator's diagnosis.

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5.5.4 Respond

The operator takes corrective action in response to the deviation and monitors the process to determine if the deviation is corrected.

5.5.5 Performance shaping factors

The ability of the operator to carry out the sub-system functions is affected by a variety of variables, including:

a) workload,

b) operator console ergonomics,

c) short term or working memory limitations,

d) fatigue,

e) training, and

f) motivation.

6 Alarm philosophy

6.1 Purpose

The alarm philosophy serves as the framework to establish the criteria, definitions, principles, and responsibilities for all of the alarm management lifecycle stages. This is achieved by specifying items including the methods for alarm identification, rationalization, monitoring, management of change and audit to be followed. An alarm philosophy document facilitates:

a) consistency across the alarm system,

b) consistency with risk management goals and objectives,

c) agreement with good engineering practices, and

d) design and management of the alarm system that supports an effective operator response.

6.2 Alarm philosophy contents

6.2.1 General

Due to the wide variety of equipment used within the process industry, the detailed content of the alarm philosophy can vary between industries and from one location to another. The required and recommended contents of the alarm philosophy are listed in Table 3.

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Table 3 - Required and recommended alarm philosophy content

Alarm philosophy contents	Required / recommended	Sub-clause
Purpose of alarm system	Required	6.2.2
Definitions	Required	6.2.3
References	Recommended	6.2.4
Roles and responsibilities for alarm management	Required	6.2.5
Alarm design principles	Required	6.2.6
Alarm setpoint determination	Recommended	6.2.7
Prioritization method	Required	6.2.8
Alarm class definition	Required	6.2.9
Highly managed alarms (or site equivalent)	Recommended	6.2.10
Rationalization	Required	6.2.11
Alarm documentation	Required	6.2.12
Alarm design guidance	Required	6.2.13
Specific alarm design considerations	Recommended	6.2.14
HMI design principles	Required	6.2.15
Approved enhanced and advanced alarming techniques	Recommended	6.2.16
Implementation guidance	Required	6.2.17
Alarm response procedures	Required	6.2.18
Training	Required	6.2.19
Alarm shelving	Recommended	6.2.20
Alarm system maintenance	Required	6.2.21
Testing of alarms	Required	6.2.22
Alarm system performance monitoring	Required	6.2.23
Alarm history preservation	Recommended	6.2.24
Management of change	Required	6.2.25
Alarm Management Audit	Required	6.2.26
Related site procedures	Recommended	6.2.27

For alarm systems designed for new plants, the alarm philosophy should be drafted as part of the project planning and development, and be fully defined and approved before alarm rationalization.

For existing alarm systems which are being remediated, and no philosophy exists, the alarm philosophy should be one of the first stages of the remediation effort.

The required contents of the alarm philosophy can exist in other site procedures. These procedures should be referenced in the alarm philosophy.

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6.2.2 Purpose of alarm system

The alarm philosophy shall include the purpose and objectives of a process plant alarm system. Having the purpose and objectives clearly defined supports the alarm management lifecycle activities. This definition can facilitate the design, implementation, and maintenance of an effective alarm system.

6.2.3 Definitions

The alarm philosophy shall include definitions of terms that will be encountered in the course of design and improvement of an alarm system, to ensure that all participants share a common understanding. The definition of an alarm shall be documented in the alarm philosophy.

6.2.4 References

The alarm philosophy should include a list of appropriate references. References may be internal company documents (e.g., MOC procedure), external standards, or published material.

6.2.5 Roles and responsibilities for alarm management

The alarm philosophy shall establish responsibility for the activities of the alarm management lifecycle. Specific aspects should include the following:

a) the owner of the alarm system, the philosophy, and related documents;

b) the role responsible for management and regular maintenance of the alarm system;

c) the role responsible for technical support to resolve problems with the alarm system;

d) the role responsible to ensure that the requirements listed in the alarm philosophy are followed.

6.2.6 Alarm design principles

The alarm philosophy shall address the criteria for selection and principles for design of alarms, consistent with the definition of an alarm.

The criteria and principles should address:

a) the role of the alarm system in identifying approaches to unsafe or abnormal operation, warning of malfunctions, and prompting the operator of actionable changes in the process;

b) the methods to be used for alarm identification;

c) the alarm states (e.g., normal, acknowledged, shelved, etc.) that the facility will use.

6.2.7 Alarm setpoint determination

The alarm philosophy should provide guidance on the methods used for determination of alarm setpoints. Alarm setpoint determination can use several inputs (e.g., consequence thresholds or complexity of the operator response).

6.2.8 Prioritization method

Consistent priorities aid the operator in deciding the order of response during a period with a high alarm rate. The alarm philosophy shall address the prioritization, including the following:

a) the basis for alarm prioritization (e.g., severity of consequence, time to respond, etc.);

b) the metrics for alarm design (e.g., priority distribution);

c) the impact of classification on prioritization, if any.

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6.2.9 Alarm class definition

Alarm classes are used to set common requirements for managing alarms. An alarm may belong to more than one class. The alarm philosophy shall include the definition of the alarm classes. It should include the following class requirements:

a) alarm prioritization considerations,

b) alarm documentation,

c) HMI design,

d) operating procedures associated with these alarms,

e) operator training and training documentation,

f) alarm maintenance,

g) alarm testing,

h) alarm monitoring and assessment,

i) alarm MOC,

j) alarm history retention, and

k) alarm audit.

6.2.10 Highly managed alarms

Highly managed alarm (HMA) classes are classes of alarms that require more administration and documentation than others. If HMA classes are used, the alarm philosophy shall define the criteria for assigning alarms to HMA classes. The designation of alarm classes as highly managed should be based upon one or more of the following:

a) alarms critical to process safety for the protection of human life (e.g., safety alarms),

b) alarms for personnel safety or protection,

c) alarms for environmental protection,

d) alarms for current good manufacturing practice,

e) alarms for commercial loss,

f) alarms for product quality,

g) alarms for process licensor requirements, and

h) alarms for company policy.

6.2.11 Rationalization

This alarm philosophy shall list the criteria to assess alarms and the information to be captured during rationalization. Guidance on the knowledge and experience of the rationalization team should include:

a) operations,

b) process,

c) control system, and

d) alarm philosophy.

6.2.12 Alarm documentation

The alarm philosophy shall specify the documentation for alarms. This should include the following:

a) rationalization information (e.g., a master alarm database), and

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b) specifications for advanced alarm management techniques (e.g., designed suppression).

Other documentation may be identified by the requirements of the different alarm classes.

Appropriate documentation ensures that advanced techniques are implemented consistently, providing expected behaviors to the operator across all modes of operation.

6.2.13 Alarm design guidance

The alarm philosophy shall provide guidance on the design practices. This guidance should address:

a) alarm deadband,

b) alarm on-delay,

c) alarm off-delay

d) alarm types, and

e) composition of alarm messages.

6.2.14 Specific alarm design considerations

The alarm philosophy should specify rules and methods for the design of alarms covering specific circumstances where consistency is important (e.g., bypass alarms, alarms from redundant sensors, alarms from packaged systems, batch process related alarms). Alarm classes may be the source of such specific design considerations.

6.2.15 HMI design principles

The alarm philosophy shall specify the alarm presentation method to establish principles for consistent display and annunciation.

Specific elements that should be covered in this section include the following:

a) the alarm presentation method (e.g., color, symbol, and alpha-numeric);

b) the mechanism used (e.g., panel, BPCS console screens, etc.) to communicate the alarms to the operator;

c) recommendations for the indications on the HMI of the alarm states (e.g., normal, acknowledged, shelved, etc.) that will be used at the facility;

d) the types of displays that will be used (e.g., alarm summary, first-out, etc.);

e) the functions that will be available in the HMI, including shelving, suppression and enhanced and advanced alarm techniques.

6.2.16 Approved enhanced and advanced alarming techniques

If enhanced and advanced alarming techniques are used, this section of the alarm philosophy shall be used to identify the approved techniques and related responsibilities and work processes. Identification of approved enhanced and advanced alarming techniques supports the training of personnel on these techniques. Not all sites will use the enhanced and advanced alarming techniques.

6.2.17 Implementation guidance

The alarm philosophy shall specify the methods for initial training, commissioning, and checkout of the alarm system.

6.2.18 Alarm response procedures

The alarm philosophy shall address alarm response procedures. Available alarm response procedures can reduce the time it takes the operator to diagnose the problem and determine the

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appropriate corrective action, as well as promote consistency between operators. The philosophy may include the following:

a) the alarms that need alarm response procedure (e.g., based on priority or class),

b) the information included in the alarm response procedures (e.g., cause, consequence, corrective action), and

c) the method to access the alarm response procedures (e.g., via the operator interface).

6.2.19 Training

The alarm philosophy shall address how plant personnel are to be trained on the use, management, and design of the alarm system, including the training documentation requirements.

Specific aspects of training that shall be covered in the alarm philosophy or other equivalent documentation for each of the alarm classes include the following:

a) the job roles or personnel requiring training relating to the alarm system, and

b) when training is required.

6.2.20 Alarm shelving

The alarm philosophy should include guidance on how and when alarm shelving can be used, who can perform shelving, as well as authorization and documentation requirements. There are typically limits defined on which alarms can be shelved and shelving duration, based on class or priority.

6.2.21 Alarm system maintenance

The alarm philosophy shall specify the activities necessary to maintain the alarm system.

Specific elements that shall be covered in this section include the following:

a) alarm maintenance record keeping,

b) the requirements for out-of-service alarms, and

c) the policy on the use of interim alarms.

6.2.22 Testing of the alarm system

The alarm philosophy shall address testing based using alarm classes or other methods. Testing documentation may be in other systems.

6.2.23 Alarm system performance monitoring

The alarm philosophy shall specify methods for assessing alarm system performance.

Specific elements that shall be covered in this section include the following:

a) the objective for monitoring and assessment,

b) the monitoring metrics and target values,

c) guidance on frequency to review alarm system performance, and

d) guidance on the approach to improve performance on the metrics.

6.2.24 Alarm history preservation

The alarm philosophy should specify the retention of alarm related records (e.g., annunciations, acknowledgements, return to normal, and operator actions). In some industries or regions, regulatory agencies or local statutes might require preservation of this information.

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6.2.25 Management of change

The alarm philosophy shall identify the types of changes and the applicable MOC procedures. Types of changes may include:

a) temporary changes to alarms (e.g., out of service);

b) permanent changes to the master alarm database, alarm attributes, or enhanced and advanced alarming techniques.

The MOC procedure ensures that changes made during design, implementation, operation, or maintenance are appropriately evaluated, authorized and documented. This typically includes documented assessment of each change, description of each change, and authorization.

6.2.26 Alarm management audit

The alarm philosophy shall specify the requirements of periodic alarm management audits. These requirements may include:

a) audit frequency, which may be specified based on alarm class,

b) audit topics, and

c) process for operator interviews.

6.2.27 Related site procedures

The alarm philosophy should reference relevant procedures. The following documents can be related to the alarm philosophy:

a) standard operating procedures,

b) operator training policies and guides,

c) safety, health and environmental procedures,

d) maintenance procedures,

e) alarm handling policies,

f) application programming guidelines,

g) commissioning or qualification processes and procedures,

h) MOC procedure, and

i) other site procedures related to the alarm philosophy depending on the specific site.

6.3 Alarm philosophy development and maintenance

Personnel who apply the alarm philosophy should be involved in developing the alarm philosophy. The team involved should be equipped with detailed knowledge and understanding of design, operation, and maintenance of the process related to the site. Specific areas of expertise include

a) process operations,

b) process instrumentation,

c) control systems,

d) process technology,

e) mechanical/reliability engineering,

f) safety, health and environmental,

g) process safety,

h) human factors,

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i) alarm management, and

j) MOC process.

7 Alarm system requirements specification

7.1 Purpose

The alarm system requirements specification (ASRS), which may also be called an alarm functional requirements specification, is developed based on the alarm philosophy and can be an important part of control system procurement. Clause 7 provides guidance on the development and uses of an ASRS. The ASRS documents the alarm functionality expected of the control system. The ASRS is often a subset of the overall system requirements specification of a control system.

The ASRS is typically specific to a site, an individual control system, or group of similar control systems. While the ASRS is consistent with the alarm philosophy, it contains more detailed functional requirements of the alarm system than the alarm philosophy, including detailed user requirements and relevant site infrastructure requirements. These requirements are used to help evaluate systems, guide the detailed system design, and serve as the basis of alarm system function testing during implementation. It is important to distinguish an ASRS from individual alarm activities that occur later on in the lifecycle of a system. The ASRS specifies what alarm functionality to be available when rationalizing, designing, implementing, visualizing and recording individual alarms, and in analyzing alarm records.

The ASRS is typically generated early in the planning for a new control system. It is updated through the implementation stage to ensure consistency with the targeted capabilities of the chosen system and, in driving system design, system testing, and training activities. The ASRS is not normally updated following system implementation. Changes to alarm system functionality can occur during the life of a system. These changes can be managed and documented via MOC.

7.2 Recommendations

Planning for new control systems and major revisions to the alarm functionality of existing control systems should include an ASRS, with the ASRS containing specifications for some or all of the following:

a) alarm attributes,

b) alarm HMI,

c) alarm communication protocol,

d) alarm record logging,

e) alarm record analysis, and

f) other capabilities that facilitate alarm lifecycle activities.

There can be new control system projects in which it is determined that an ASRS is not necessary (e.g., replicating existing systems).

7.3 Development

The alarm system is only one of the functional systems within a control system and the performance of the overall system may require modification to the alarm system requirements to accommodate the control system capabilities. The alarm philosophy contains guidance that can be used to generate some of the alarm system requirements specification. The ASRS should include the following:

a) alarm priorities available,

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b) visible annunciation functionality, such as colors and symbols,

c) audible alarm annunciation functionality,

d) alarm summary display functionality,

e) alarm shelving functionality,

f) alarm suppression functionality,

g) alarm attribute functionality, such as deadband and on-delay and off-delay,

h) alarm log capabilities,

i) alarm monitoring and assessment functionality,

j) alarm system audit functionality, and

k) advanced alarming functionality.

NOTE Some alarm requirements can exist in other documents, such as in a safety requirements specification for SIS applications, as defined in ISA-84.00.01.

7.4 Systems evaluation

Alarm system functionality should be evaluated against requirements during control system selection. The alarm system functionality of control systems varies from the very limited to the very advanced. The ASRS provides a list of criteria which can support the comparative evaluation of different systems.

7.5 Packaged systems

If packaged systems are part of the control system, the ASRS should include guidance on how packaged systems will be interfaced to the alarm system.

7.6 Customization

If important system requirements in the specification are not met by standard commercial products, it may be necessary to develop custom solutions, or to reconsider the specification. The ASRS facilitates early recognition of the need for customized solutions, and can initiate associated cost /benefit analysis.

7.7 Alarm system requirements testing

Each alarm system requirement should be tested prior to the operations stage of the lifecycle.

8 Identification

8.1 Purpose

Identification is a general term for the different methods that can be used to determine the possible need for an alarm or a change to an alarm. The identification stage is the input point of the alarm management lifecycle for the recommended alarms or alarm changes. Identified alarms are an input to rationalization.

8.2 Alarm identification methods

This standard does not define or require any specific method for alarm identification. Alarms may be identified by a variety of good engineering practices or regulatory requirements. Some combination of identification methods should be used to determine potential alarms. The alarm identification method may affect the classification of an alarm. Where appropriate, alarm identification may be done during alarm rationalization.

Some common alarm identification methods are:

a) allocation of safety layers,

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b) process hazards analysis (PHA),

c) hazard and operability study (HAZOP),

d) layer of protection analysis (LOPA),

e) incident investigations,

f) environmental permits,

g) failure mode and effects analysis (FMEA),

h) current good manufacturing practice (cGMP),

i) quality reviews,

j) P&ID reviews,

k) operating procedure reviews, and

l) packaged equipment manufacturer recommendations.

8.3 Identification training

Personnel using any method for alarm identification should be trained on the alarm philosophy and the criteria for evaluating alarms.

8.4 Identification documentation

The information related to potential alarms should be captured during identification and used in alarm rationalization if available, including:

a) the consequence threshold (e.g., constraint),

b) the operator response,

c) the consequence of inaction,

d) the probable cause, and

e) the rationale for the consequence threshold.

9 Rationalization

9.1 Purpose

During rationalization, existing or potential alarms are systematically compared to the criteria for alarms documented in the alarm philosophy. If the proposed alarm meets the criteria, then the alarm setpoint, consequence, and operator action are documented, and the alarm is prioritized and classified according to the philosophy. Rationalization produces the detail design information, documented in the master alarm database, necessary for the design stage of the alarm management lifecycle.

The activities of rationalization are:

a) alarm justification,

b) alarm setpoint determination,

c) alarm prioritization,

d) alarm classification, and

e) rationalization review.

9.2 Rationalization documentation

9.2.1 Rationalization documentation requirements

Rationalization shall determine and document, at a minimum, the following for every alarm rationalized per the alarm philosophy for every applicable plant state:

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a) alarm type,
b) alarm priority,
c) alarm class,
d) alarm setpoint or logical condition (e.g., off-normal),
e) operator action, and
f) consequence of inaction.

Additional alarm attributes may be determined during alarm rationalization according to the alarm philosophy.

9.2.2 Rationalization documentation recommendations

Rationalization should determine and document the following for every alarm rationalized per the alarm philosophy for every applicable plant state:

a) the maximum allowable response time,
b) the probable cause,
c) the rationale for the alarm setpoint,
d) the identification method, and
e) the need for advanced alarming techniques, if necessary.

9.2.3 Plant states

Plant states may include:

a) start-up,
b) normal operation
c) operation, step, or phase in batch processes, and
d) shutdown.

9.3 Alarm justification

9.3.1 Alarm justification process

Every alarm requiring rationalization is compared to the criteria in the alarm philosophy to justify that it is an alarm.

The criteria from the definition of alarm include that:

a) the alarm is directed to the operator,
b) the alarm indicates a process deviation, abnormal condition, or equipment malfunction, and
c) the alarm requires a timely response.

9.3.2 Justification approach

The alarm justification process should:

a) utilize a team approach, including knowledge of the process and the control system, and
b) rely heavily upon operator input.

9.3.3 Individual alarm justification

All alarms to be rationalized are systematically reviewed. This usually is done either by progression through engineering drawings, databases, or HMI displays. The information to be captured for each rationalized alarm should be specified in the alarm philosophy, and typically includes:

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a) verification that the proposed alarm meets the criteria for an alarm stated in the philosophy;

b) the action(s) the operator may take in response to the alarm;

c) the consequence that will occur if action is not taken or is unsuccessful;

d) the allowable response time.

Those alarms for which the operator action is simply to relay the information to the appropriate person or group for action (e.g., instrument diagnostic alarms) should be reviewed to determine if an alternate method exists to transfer the information without burdening the operator or the alarm system.

9.3.4 Impact on alarm system performance

Alarm justification should verify that:

a) the alarm will not become a nuisance, and

b) the alarm does not duplicate another alarm.

Advanced alarming techniques (e.g., state-based alarming or logic based alarms) can be specified to prevent negative impact on the alarm system performance from the above listed conditions.

9.4 Alarm setpoint determination

Guidance for the determination of alarm setpoints stated in the alarm philosophy is applied. Effective methods use information including:

a) the allowable response time (see Figure 4),

b) the complexity of the operator action,

c) the time necessary to complete the operator action,

d) the normal operating range,

e) other operating or design boundaries, and

f) knowledge of the process operation and history.

9.5 Prioritization

Alarm priority is used to aid the operator in determining the order in which to respond to alarms. The method for priority assignment defined in the alarm philosophy is applied to the rationalized alarm and a priority is assigned. Effective prioritization typically results in higher priorities chosen less frequently than lower priorities. Most of the alarms should be assigned to the lowest alarm priority (least important) and the fewest to the highest alarm priority (most important), with a consistent transition between the two. The resulting priorities should have alignment with the consequence and allowable response time, such that the lowest priority alarms have the least severe consequences and longest allowable response times and the highest priority alarms have the most severe consequences (e.g., fire and gas alarms) and the shortest allowable response times. Alarm priority distribution metrics are provided in Clause 16.

Prioritization may include consideration for alarm classes (e.g., HMA classes) or identification methods (e.g., LOPA) to set alarm priority.

9.6 Classification

Alarms shall be assigned to one or more classes as defined in the alarm philosophy. Classification may occur prior to, during, or after the alarm justification and prioritization.

Alarms in the same class are not required to have the same priority.

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9.7 Review

Upon completion of the initial justification, prioritization, and classification of all the required alarms, the results should be reviewed to ensure consistent application of the criteria throughout the process. The results should be compared to any targets for number and priority of alarms that might be documented in the alarm philosophy.

9.8 Removal of rejected alarms

Existing alarms that are rejected for failing to meet the criteria for an alarm shall be documented along with the basis (i.e., criterion it failed to meet) justifying removal. Rejected alarms can be candidates for other forms of notifications (e.g., alerts). Those alarms should then be subject to further review by the MOC procedure to remove the alarm from the system.

9.9 Documentation

Rationalization shall be documented to become the basis for ensuring the integrity of the alarm system. The documentation (e.g., a master alarm database) is the link between each alarm and the alarm philosophy and can be used for several purposes, including:

a) input to the detailed design stage of the alarm lifecycle,

b) utilization as part of the MOC,

c) alarm response procedures,

d) training of and use by operators,

e) periodic auditing and reconciliation of the control system alarm settings, and

f) evaluation of alarm monitoring and effectiveness data.

10 Detailed design: basic alarm design

10.1 Purpose

Basic alarm design is part of the detailed design stage of the lifecycle. Clause 10 addresses the design considerations to implement the alarms within a specific control system as specified by the rationalization process. All design considerations related to the presentation of alarms will be contained in Clause 11.

10.2 Basic alarm design capabilities

The design for alarms should be consistent with the alarm philosophy and the overall control system design philosophy. The capabilities of the control system should be considered in the basic alarm design.

10.3 Usage of alarm states

10.3.1 Alarm state triggering

The source for each alarm in the system should be documented. Changes in alarm state can be triggered from various sources within a control system as shown in Figure 1, including:

a) the field device (e.g., sensors and final control elements),

b) the control system (i.e., BPCS, SIS, package system), and

c) the HMI.

10.3.2 Alarm states and other logic functions

Clear design guidance should be provided regarding the use of alarm state information with other logic functions (e.g., interlock actions). If alarm setpoints will be used for purposes in addition to operator notification (e.g., as an interlock setpoint), then documentation, training and MOC can be impacted. Additionally, the impact of modifying alarm attributes, as well as the use of

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designed suppression should be clearly identified, documented, and potentially restricted (e.g., extra confirmation or higher access level required). This information should be specifically documented in the alarm philosophy under alarm design principles.

10.3.3 Alarm suppression and other logic functions

The alarm suppression functionality shall not unintentionally impact other logic functions (e.g., interlock actions).

10.4 Alarm types

Alarm type shall be implemented based on the information documented in the master alarm database. The common alarm types may include the following:

a) absolute alarms,

b) deviation alarms,

c) rate-of-change alarms,

d) discrepancy alarms,

e) calculated alarms,

f) recipe-driven alarms,

g) bit-pattern alarms,

h) controller output alarms,

i) systems diagnostic alarms,

j) instrument diagnostic alarms,

k) adjustable alarms,

l) adaptive alarms,

m) re-alarming alarms,

n) statistical alarms,

o) first-out alarms, and

p) bad-measurement alarms.

The available alarm types that are included within a control system can vary. It could be necessary to create a custom alarm type as part of the engineering scope on a project. Alarms may be of a single type or a combination of types.

Alarm types should be selected carefully based on engineering judgment. Certain types, such as rate-of-change, deviation, bad-measurement, and controller output alarms, can be sources of nuisance alarms if they are not applied appropriately.

10.5 Alarm attributes

10.5.1 General

During the basic design process, the default alarm attributes should be selected for each alarm that has been rationalized and set based on engineering judgment. Attributes such as setpoint and deadband can be different depending upon the specific alarm type that will be implemented. Defining appropriate alarm attributes can help minimize the number of nuisance alarms that are generated during operation. Recommendations for the design of specific alarm attributes are provided in the following sub clauses. Alarm attributes should include:

a) alarm description,

b) alarm setpoint or logical conditions,

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c) alarm priority,

d) alarm deadband,

e) on-delay or off-delay,

f) alarm group, and

g) alarm message.

10.5.2 Alarm description

All alarms shall have an informative text provided as a tag description, or alarm description, or both. The use of a structured layout and consistent wording are recommended.

10.5.3 Alarm setpoints

Alarm setpoints shall be selected based on the information documented in the master alarm database.

10.5.4 Alarm priority

Alarm priority shall be selected based on the information documented in the master alarm database.

10.5.5 Alarm deadbands

10.5.5.1 General

Alarm deadband is an alarm attribute used to reduce the number of times an alarm triggers for a given abnormal condition, which ideally would be only once. It prevents an alarm from returning to normal until the alarm condition is cleared by the deadband, a defined increment or percentage of the range. Deadbands are typically set based on the normal operating range of the process variable, measurement noise, and the type of process variable. Application of deadbands can be very effective for eliminating nuisance alarms.

10.5.5.2 Alarm deadband requirements

The control system shall provide the capability for implementing deadband functionality.

10.5.5.3 Alarm deadband recommendations

The engineering basis for setting of deadbands should be documented in the alarm philosophy. Engineering judgment should be employed when setting deadbands in order to minimize nuisance alarms while maintaining process vigilance and plant / personnel safety. Excessive deadband, such as what might be calculated for an instrument with a large scale (e.g., flow of 0 to 100,000) can act as a latch, creating stale alarms. Settings should be documented and then reviewed during commissioning and after significant operating experience.

10.5.6 Alarm on-delay and off-delay

10.5.6.1 General

The attributes on-delay and off-delay (i.e., debounce timer) can be used to eliminate nuisance alarms. The on-delay is used to avoid unnecessary alarms when a signal temporarily overshoots the alarm setpoint, thus preventing the alarm from becoming active until the signal remains in the abnormal condition continuously for the delay time. The off-delay is used to reduce chattering alarms by holding the alarm active for the delay period after the process condition has returned to normal.

10.5.6.2 Alarm on-delay and off-delay requirements

The control system shall provide the capability for implementing on-delay and off-delay functionality.

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10.5.6.3 Alarm on-delay and off-delay recommendations

Engineering judgment should be employed when setting on and off delays in order to minimize nuisance alarms while maintaining process vigilance and plant or personnel safety. Delay times should consider allowable response time during all modes of operation and whether filtering is being applied to reduce signal noise. On-delay times should be applied only after careful evaluation of potential control system operational effects. Settings should be reviewed during commissioning and after sufficient operating experience.

10.6 Programmatic changes to alarm attributes

Some sites modify alarm attributes based on conditions such as product type, grade, or other conditions. Alarm attributes can typically be programmatically modified from one or more of the following sources:

a) the control logic (e.g., sequences, phases, state-based logic);

b) an advanced alarming technique;

c) a source external to the control system (e.g., manufacturing execution system (MES), enterprise resource planning (ERP) system).

The alarm philosophy should detail the use and limitations of this functionality. For each alarm the user should identify and clearly document which programs of the system will have access to modify alarm attributes during operation and which changes will be subject to MOC procedures. Advanced alarming techniques for modifying alarm attributes are covered in Clause 12.

10.7 Review basic alarm design

A typical control system provides the user with the ability to implement numerous different alarm types for a single process variable. To minimize alarm loading on the operator, the basic alarm design results should be reviewed so that the design matches the alarms in the master alarm database.

11 Detailed design: human-machine interface design for alarm systems

11.1 Purpose

The HMI design for alarm systems is part of the detailed design lifecycle stage. Clause 11 outlines the functionality to provide alarm indications and related functions to the operator and other HMI users. The indication and display of alarms is only one component of the HMI design, and contributes to effective operator-process interaction (see Figure 5). Guidance on general HMI design for control systems is outside the scope of this standard.

NOTE For further guidance see ANSI/ISA-101.01.

11.2 HMI functions

11.2.1 General

The HMI design for alarms should be consistent with the alarm philosophy and the overall HMI design philosophy. The capabilities of the control system should be considered in the HMI design.

11.2.2 HMI information requirements

The HMI shall clearly indicate:

a) unsuppressed active alarms,

b) alarm states,

c) alarm priorities, and

d) alarm types.

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11.2.3 HMI functional requirements

The HMI shall provide the ability to:

a) silence audible alarm indications (i.e., without acknowledging the alarm),
b) individually acknowledge alarms,
c) place alarms out of service through access controlled methods as allowed in the philosophy,
d) modify alarm attributes through access controlled methods only,
e) initiate an alarm shelving function,
f) support a designed suppression function, and
g) display alarm messages.

11.2.4 HMI display requirements

The HMI shall provide the capability for the following, or equivalent:

a) alarm summary displays,
b) alarm indications on process displays,
c) alarm indications on tag detail display,
d) shelved alarm summary displays,
e) suppressed-by-design summary displays, and
f) out-of-service summary displays.

11.2.5 Alarm records requirements

An alarm record is a set of information which documents an alarm state change.

An alarm record shall have the following alarm record attributes:

a) tag name for alarm,
b) tag description or alarm description for alarm,
c) alarm state,
d) alarm priority,
e) alarm type, and
f) time and date of occurrence of the alarm state change.

11.2.6 Alarm records recommendations

An alarm record should have the following alarm record elements:

a) process value at the time when the alarm record is recorded,
b) alarm setpoint,
c) alarm group or process area,
d) alarm class(es), and
e) alarm message.

11.3 Alarm states indications

11.3.1 General

The alarm state transition diagram (see Figure 3) defines the states of alarms.

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11.3.2 Required alarm state indications

A combination of visual indications, audible indications, or both, shall be used to uniquely distinguish the following alarm states:

a) normal,

b) unacknowledged alarm,

c) acknowledged alarm, and

d) return-to-normal unacknowledged alarm.

11.3.3 Recommended alarm state indications

11.3.3.1 General

The following recommended alarm state indications are common industry practice.

11.3.3.2 Normal state indication

The normal state should not use an audible indication. The normal state visual indication should be the same as indications without alarms.

11.3.3.3 Unacknowledged alarm state indication

The unacknowledged alarm state should use both an audible indication and visual indication. The audible indication should be silenced with a silence action or acknowledge action by the operator. The visual indication should be clearly distinguishable from the normal state indication by using colors and symbols (e.g., shape or text). The visual indication for an unacknowledged alarm should include a blinking element. There are some environments in which an audible indication is not an effective indicator of unacknowledged alarms.

11.3.3.4 Acknowledged alarm state indication

The acknowledged alarm state should not use an audible indication. The acknowledged alarm state visual indication should be clearly distinguishable from the normal state indication by using symbols (e.g., shape or text), and should be related in color to the unacknowledged alarm indication. A blinking element should not be used in the visual indication for an acknowledged alarm.

11.3.3.5 Return-to-normal unacknowledged state indication

The return-to-normal unacknowledged state should not use an audible indication. The return-to-normal unacknowledged state visual indication may be the same as the normal state or it may indicate an unacknowledged status with a blinking element.

11.3.3.6 Shelved alarm state indication

The shelved alarm state may be visually indicated in the HMI. The shelved alarm state indication should be distinct. No audible indication should be used to identify shelved alarms.

11.3.3.7 Suppressed-by-design alarm state indication

The suppressed-by-design alarm state may be visually indicated in the HMI. The suppressed-by-design alarm state indication should be distinct from the unacknowledged and acknowledged state indications. No audible indication should be used to identify alarms suppressed by design.

11.3.3.8 Out-of-service alarm state indication

The out-of-service alarm state may be visually indicated in the HMI. The out-of-service alarm state indication should be distinct from the unacknowledged and acknowledged state indications. No audible indication should be used to identify out-of-service alarms.

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11.3.3.9 Summary of alarm state indications

The recommended audible and visual alarm state indications for typical alarms are summarized in Table 4.

Table 4 - Recommended alarm state indications

Alarm state	Audible indication	Visual indications		
		Color	Symbol	Blinking
Normal	**No**	**No**	**No**	**No**
Unacknowledged alarm	**Yes**	**Yes**	**Yes**	**Yes**
Acknowledged alarm	**No**	**Yes**	**Yes**	**No**
Return-to-normal unacknowledged alarm	**No**	**Combination**		**Optional**
Shelved alarm	**No**	**Optional**		**N/A**
Suppressed-by-design alarm	**No**	**Optional**		**N/A**
Out-of-service alarm	**No**	**Optional**		**N/A**

NOTE 1 Yes signifies the indication type should be used to indicate the alarm state.
NOTE 2 No signifies the indication type should not be used to indicate the alarm state.
NOTE 3 N/A signifies not applicable or that the condition is not relevant to the alarm state.
NOTE 4 Combination signifies the indication is a combination of visual color and symbol indications.
NOTE 5 Optional signifies the indication is not required.

11.3.4 Audible alarm state indications

The audible alarm indication for unacknowledged alarms may be also used to indicate the priority, the process area, or the alarm group, depending on the alarm philosophy.

In environments where an audible indication of an unacknowledged alarm is not effective (e.g., high ambient noise level environments), a clear visual indication of an unacknowledged alarm that is always within view of the operator should be used (e.g., a light or series of lights).

11.4 Alarm priority indications

11.4.1 General

The alarm philosophy provides a set of alarm priorities used in the HMI to assist the operator in selecting the sequence of alarm response actions.

11.4.2 Alarm priority indication requirements

A unique combination of visual indications, audible indications, or both, shall be used to distinguish the alarm priorities within the alarm system.

All HMI stations in the control system, including packaged systems, shall provide the capability for at least three unique alarm priority indications.

11.4.3 Color alarm priority indications recommendations

A separate color indication should be used for each alarm priority, except in operating environments where this is not practical. The alarm priority colors should be reserved and should not be used for other elements of the HMI.

11.4.4 Recommended alarm priority indications

11.4.4.1 General

The following recommended alarm priority indications are common industry practice.

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11.4.4.2 Symbol alarm priority indications

A unique symbol (e.g., shape or text) should be used to indicate each alarm priority to reinforce color coding.

11.4.4.3 Audible alarm priority indications

A distinct audible indication should be used for each alarm priority. In environments where an audible indication is not used as a priority indication, a visual priority indication should be used.

11.5 Alarm message indications

11.5.1 General

The alarm message provides further clarification of the alarm beyond the tag name, state and priority indication. It may also include part of the operator action or a reference to the alarm response procedure.

11.5.2 Recommended alarm message indications

11.5.2.1 General

The following recommended alarm message indications are common industry practice:

a) Visual alarm message indications, and

b) Vocalized alarm message indications.

11.5.2.2 Visual alarm message indications

A visual alarm message should be generated for each alarm and displayed on the alarm summary. The visual alarm message is usually not directly displayed on process displays.

11.5.2.3 Vocalized alarm message indications

A vocalized alarm message may be used. The vocalized alarm message should be structured and brief. The vocalized alarm message should be silenced with a silence action or acknowledge action by the operator. A visual indication should be used in conjunction with a vocalized alarm message.

11.6 Alarm displays

11.6.1 General

Within an HMI there are several types of displays that are effective as part of the alarm system. The displays include the following:

a) alarm summary display,

b) alarm summary status display,

c) alarm log display,

d) process display,

e) tag detail display,

f) system diagnostic alarm display,

g) shelved alarm display,

h) suppressed-by-design alarm display, and

i) out-of-service alarm display.

NOTE The displays are described with required or recommended functions. The function may be provided through other methods.

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11.6.2 Alarm summary display

11.6.2.1 Alarm summary display requirements

At least one alarm summary display is required. The alarm summary provides a list of unsuppressed active alarms within the alarm system. There are several required and recommended functions for alarm summary displays.

11.6.2.2 Information requirements

The alarm summary display shall list only information for alarms. The display shall provide the following information for each alarm:

a) tag name for alarm,

b) tag description or alarm description for alarm,

c) the alarm state (including acknowledged status),

d) the alarm priority,

e) the time/date the alarm became active, and

f) the alarm type.

11.6.2.3 Information recommendations

The alarm summary display should provide the following information for each alarm:

a) the current process value,

b) the alarm setpoint,

c) the alarm group or process area, and

d) the alarm message.

11.6.2.4 Additional information recommendations

In addition to the information for each alarm, the alarm summary should display:

a) the number of alarms in the summary list, and

b) the number of unacknowledged alarms in the summary list.

11.6.2.5 Functional requirements

The alarm summary display shall provide the following functions:

a) sorting of alarms by chronological order,

b) sorting of alarms by priority,

c) individual acknowledgment of each alarm, and

d) acknowledgment of multiple alarms with access controlled methods as allowed in the alarm philosophy.

11.6.2.6 Functional recommendations

The alarm summary display should provide the following functions:

a) navigational link to the appropriate process display,

b) access to alarm response procedures,

c) filtering of alarms by time of alarm,

d) filtering of alarms by priority,

e) filtering of alarms by alarm type,

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f) filtering of alarms by alarm group or process area,

g) filtering of alarms by tag name,

h) time limits for filters, and

i) sorting of alarms by tag name.

Where filters are used in alarm summary displays, the display should clearly indicate when a filter is in use. The time limit is a function that removes the filter when the time period expires.

11.6.3 Alarm summary status

11.6.3.1 General

An alarm summary status display should be provided. The alarm summary status display provides an indication of the number of unsuppressed active alarms by priority for each process area.

11.6.3.2 Information recommendations

The alarm summary status display should provide the following information for each process area or other grouping:

a) the number of alarms in each alarm priority,

b) the number of unacknowledged alarms in each priority, and

c) an indication if all alarms in a priority are acknowledged.

11.6.3.3 Functional recommendations

The alarm summary status display should provide a navigational link to the appropriate process display.

11.6.4 Alarm log displays

11.6.4.1 General

An alarm log display should be provided. The alarm log display provides access to the alarm log, which contains an alarm record for each alarm state change (e.g., acknowledgment, return-to-normal, etc.).

11.6.4.2 Information recommendations

The alarm log display should provide the following information for alarm records:

a) tag name for alarm,

b) tag description or alarm description for alarm,

c) the alarm state (including acknowledged status),

d) the alarm priority,

e) the date and time of the alarm,

f) the date and time of acknowledgment,

g) the date and time of the return to normal, and

h) the alarm type.

11.6.4.3 Functional recommendations

The alarm log display should provide the following functions:

a) filtering by tag name,

b) filtering by time of alarm state change,

c) filtering by type of alarm state change,

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d) filtering by priority,

e) filtering by alarm type, and

f) filtering by alarm group or process area.

11.6.5 Process displays

The process displays provide a process context for the alarms. The process displays should provide the following information:

a) the tag name (through text or other access methods),

b) the alarm state, including acknowledge status,

c) the alarm priority,

d) the alarm suppression status, and

e) the alarm type.

11.6.6 Tag detail displays

The tag detail displays provide a detail for the tag in alarm. A detail display should provide the following information:

a) the alarm state (including acknowledge status),

b) the alarm priority,

c) the alarm group,

d) the alarm type,

e) the alarm setpoint,

f) the alarm suppression status, and

g) the current value of the process variable or state.

11.6.7 Other display elements

Other display elements (e.g., alarm banners) may be used to indicate alarm states.

11.7 Alarm shelving

11.7.1 General

The shelving of alarms is a required function. This temporary suppression of alarms by the operator is a common practice to keep nuisance alarms from interfering with the effectiveness of the alarm system. Shelving includes functionality to ensure the integrity of the alarm system is maintained.

11.7.2 Alarm shelving functional requirements

The alarm shelving function shall provide the following:

a) the ability to shelve alarms,

b) displays of shelved alarms, or equivalent list capabilities to indicate all alarms shelved,

c) a time limit for shelving,

d) access control for shelving of individual alarms,

e) the ability to unshelve alarms, and

f) a record of each alarm shelved.

The time limit is a function that unshelves the alarm when the time period expires.

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11.7.3 Alarm shelving functional recommendations

The alarm shelving function should be designed to prevent alarm floods when active alarms are automatically un-shelved. The recommended state transitions from shelving are:

a) a manually unshelved alarm should transition to the acknowledged alarm state, and

b) an automatically unshelved alarm should transition to the unacknowledged alarm state.

11.7.4 Shelved alarm displays

11.7.4.1 General

Shelved alarm displays, or equivalent list capabilities, for an alarm system with shelving functionality have several required and recommended functions.

11.7.4.2 Information requirements

Shelved alarm displays shall provide the following information:

a) tag name for alarm,

b) tag description or alarm description for alarm,

c) alarm type,

d) the alarm status (i.e., active or not active),

e) the alarm priority, and

f) the shelved time remaining or the time and date the alarm was shelved.

11.7.4.3 Functional requirements

Shelved alarm displays shall provide the following functions:

a) sorting of alarms by chronological order of shelving or shelved time remaining,

b) sorting of alarms by priority, and

c) individual unshelving of alarms.

11.7.4.4 Functional recommendations

Shelved alarm displays should provide the following functions:

a) sorting of alarms by tag,

b) filtering of alarms by priority,

c) filtering of alarms by alarm state,

d) filtering of alarms by process area,

e) operator entry of the reason the alarm was shelved,

f) group unshelving of alarms,

g) navigational link to a process display, and

h) navigational link to the tag detail display.

11.8 Out-of-service alarms

11.8.1 General

The suppression of alarms by placing an alarm out of service is a required function and a common practice to remove alarms from service to allow maintenance. There are several required and recommended HMI functions related to out-of-service alarms.

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11.8.2 Out-of-service alarm functional requirements

The out-of-service alarm function shall provide the following:

a) a method to individually remove each alarm from service,

b) a method to individually return each alarm to service,

c) displays of out-of-service alarms or equivalent list capabilities, to indicate all alarms out of service,

d) access control to place alarms out of service if allowed, and

e) a record of each alarm placed out of service.

11.8.3 Out-of-service alarm displays

11.8.3.1 Out-of-service alarm display requirements

Out-of-service alarm display, or equivalent list capabilities, shall be provided for the alarm system. Out-of-service alarm displays have several required and recommended functions.

11.8.3.2 Information requirements

Out-of-service alarm displays shall provide the following information:

a) tag name for alarm,

b) tag description or alarm description for alarm,

c) alarm type,

d) the alarm status (i.e., active or not active),

e) the alarm priority, and

f) the time and date the alarm was placed out of service.

11.8.3.3 Functional requirements

Out-of-service alarm displays shall provide the following functions:

a) sorting of alarms by chronological order of suppression,

b) sorting of alarms by priority,

c) sorting of alarms by alarm status (i.e., active or not active),

d) sorting of alarms by process area, and

e) individual return to service of alarms.

11.8.3.4 Functional recommendations

Out-of-service alarm displays should provide the function for operator entry of the reason the alarm was suppressed.

11.9 Alarms suppressed by design

11.9.1 General

The designed suppression of alarms is a required function and it is a common practice to suppress alarms that are not needed due to intended or actual operating conditions. This functionality supports the testing, maintenance, and operator understanding of designed suppression.

11.9.2 Designed suppression functional requirements

The designed suppression function shall provide the following:

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a) displays of alarms suppressed by design or equivalent list capabilities, to indicate all alarms suppressed by design, and

b) a record of each alarm suppressed by design.

11.9.3 Designed suppression functional recommendations

The designed suppression function should be designed to prevent alarm floods when active alarms are automatically un-suppressed.

An automatically unsuppressed alarm should transition to the unacknowledged alarm state if the alarm is active.

11.9.4 Suppressed-by-design displays

11.9.4.1 General

Suppressed-by-design displays, or equivalent list capabilities, shall be provided for the alarm system. Suppressed-by-design displays have several required and recommended functions.

11.9.4.2 Information requirements

Suppressed-by-design displays shall provide the following information:

a) tag name for alarm,

b) tag description or alarm description for alarm,

c) alarm type,

d) the alarm status (i.e., alarm status active or not active),

e) the alarm priority, and

f) the time and date the alarm was suppressed.

11.9.4.3 Information recommendations

Suppressed-by-design displays should provide an indication of the suppression method (e.g., designed suppression).

11.9.4.4 Functional requirements

Suppressed-by-design displays shall provide the following functions:

a) sorting of alarms by chronological order of suppression,

b) sorting of alarms by priority,

c) sorting of alarms by alarm state, and

d) sorting of alarms by process area.

11.9.4.5 Functional recommendations

Suppressed-by-design displays should provide the ability for the operator to unsuppress an alarm or disable the designed suppression.

11.10 Alarm annunciator integration

11.10.1 General

Alarm systems may include separate alarm annunciation devices. This sub-clause describes recommendations for integration of independent annunciators into an alarm system.

11.10.2 Alarm annunciator integration recommendations

Alarm annunciators should be integrated to provide the following functions:

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a) communication of alarm state information to the alarm log,

b) prevention of redundant alarms in the control system, and

c) prevention of the need for redundant acknowledgement in the control system.

11.10.3 Alarm annunciator display integration recommendations

Alarm annunciators should be integrated so that the alarm layout on the annunciator follows a consistent methodology.

11.11 Safety alarm HMI

11.11.1 General

An independent HMI can be required for some safety alarms by code or standards. The identification methods for safety alarms are outside the scope of this standard.

11.11.2 Independent safety alarm HMI

An HMI independent from the BPCS may be required for the following safety alarms:

a) safety alarms, depending on considerations (e.g., the risk reduction factor), and

b) system diagnostic alarms from the SIS that indicate dangerous faults, depending on considerations (e.g., the operator action, communication fault).

NOTE For further guidance see ISA-84.00.01.

12 Detailed design: enhanced and advanced alarm methods

12.1 Purpose

Enhanced and advanced alarming is part of the detailed design lifecycle stage. Clause 12 provides guidance and consideration for additional alarm management techniques beyond those which are normally employed in control systems. They generally provide added functionality over the basic alarm system design and are particularly useful to guide operator action during abnormal process conditions.

Enhanced and advanced alarming methods are additional layers of logic, programming, or modelling used to modify alarm attributes. Advanced alarming modifies alarm behaviors including logic based alarming, dynamic alarming, state-based alarming (i.e., mode-based alarming), and adaptive alarms. Most designed suppression methods are included in advanced alarming. In addition to advanced alarming techniques, enhancements to the alarm system provide additional information to the operator or redirect the alarm to the designated responder.

The basic alarm design methods may not be sufficient to reduce alarm floods, or mitigate their effect so enhanced and advanced techniques may be necessary. Methods described can reduce or eliminate floods.

12.2 Basis of enhanced and advanced alarming

12.2.1 General

Enhanced and advanced alarming methods are often used if the basic alarm design does not achieve the performance goals stated in the alarm philosophy. The alarm philosophy or alarm system requirements specification should include a list of approved enhanced and advanced alarming methods.

12.2.2 Effort, manpower requirements and complexity

The complexities of enhanced and advanced alarming techniques need additional resources for design, implementation, and maintenance. The MOC process should include a review of the impact of changes on the enhanced and advanced alarming techniques.

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The cost of additional alarm system complexity should be compared to the additional benefits of improved alarm system performance.

Risk analysis of failure scenarios for enhanced and advanced alarming techniques should be considered before approval and during design.

12.3 Information linking

Alarm systems can be enhanced by linking to information in the master alarm database (e.g., operator action or consequence). Information can also be linked from other sources including: operating procedures, operator logs, maintenance history, or design documents. These links should be easy to manage and maintain.

12.4 Logic-based alarming

12.4.1 General

Logic-based alarming is accomplished using techniques (e.g., Boolean logic or decision trees) to determine the modifications to be made to alarm systems. This may be implemented in the control system or externally to the control system.

12.4.2 Alarm attribute modification

The functional capability to modify some alarm attributes (e.g., alarm setpoints or priorities) is necessary for some enhanced and advanced alarming techniques.

12.4.3 Externally enabled systems

Externally enabled systems capture alarm and process data from the control system and use the information to determine plant operating conditions and the corresponding modifications to alarm attributes.

12.4.4 Logical alarm suppression and attribute modification

Logical alarm suppression techniques use alarm state conditions from some alarms to modify the alarm attributes of other alarms (e.g., first-out alarms).

12.4.5 State-based alarming

State-based alarming is an advanced alarm technique that modifies alarm attributes (e.g., setpoint, priority, or suppression status) based on defined operating states for equipment or processes. States are often determined through:

a) the status of a variable,

b) a defined process variable which reaches a specific limit,

c) logic that looks at many variables and indicators, and

d) operator selection.

The state determination and alarm modification can be manual, semi-automated (e.g., some combination of manual and automated), or fully-automated. The state should be clearly displayed to the operator.

12.5 Model-based alarming

Model-based alarming can be used in areas where a more complex system of annunciating an alarm is desired, where complex process parameters can produce a result based on multiple data points, or where an estimation or prediction of plant state can be derived from a model.

Model-based alarm systems should not be used as a replacement for the basic alarm system without thorough analysis.

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12.6 Additional alarming considerations

12.6.1 General

Some additional enhancements add value to the alarm system. These enhancements are often not available in the basic alarm system.

12.6.2 Remote alarm systems

Several situations can potentially exist in which the person responding to an abnormal situation is not in a control room. Such situations can benefit from the availability of a remote alarm system (e.g., paging, e-mail, etc.). Where remote alarm systems are used, the alarm philosophy should include these systems.

The reliability of the message delivery is a significant issue in remote alarm systems and should be considered. Periodic test messages should be used to improve reliability. A procedure to ensure response to the alarm should be considered.

It may be necessary to also provide remote acknowledgement.

12.6.3 Supplementary alarm systems

Supplementary alarm systems (e.g., expert system for alarm response) can replace the control system alarm notification system or make use of the existing graphics environment to provide a common interface. Alternatively, supplementary systems can be used in addition to the control system alarm functions to provide additional or alternative alarm information.

Special care should be taken to ensure that the additional information provides value. The system should be designed to ensure alarm availability and reliability are acceptable.

Where a supplementary alarm system is used, it shall comply with the requirements of this standard.

12.6.4 Batch process considerations

12.6.4.1 General

The process conditions, states, and phases may be used to modify alarms in batch processes. This is often implemented as state-based alarming.

12.6.4.2 Continuously variable alarm thresholds

Alarms for batch processes are often applicable only to specific steps of the process, or associated with changing control loop setpoints, or time varying process data trends. Unless special care is taken, batch processes are especially prone to the generation of nuisance alarms. Advanced alarming techniques can provide a structure for addressing these types of batch-related alarm problems.

12.6.4.3 Relative time versus absolute time

Data and alarm record time stamps are normally accomplished in computer systems using calendar time. For batch information, relative time (i.e., the time since the beginning of the batch or process step) is more relevant. A feature of advanced alarming is the ability to take calendar time stamps and electronic records indicating when the batch step or phase started and compute and display alarms in relative time.

12.6.4.4 Inclusion of lot number and other identifying marks

Some sites may specify the functionality to associate identification numbers (e.g., lot numbers) with alarms. Being able to sort records by the selected identification is also useful in generating official batch records of a production run and in comparing records of different production runs. Methods of extracting and attaching such identifying marks should be proven and reliable.

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12.7 Training, testing, and auditing systems

The alarm philosophy should specify steps to ensure advanced alarming techniques continue to operate, including training, testing, and auditing. Training, testing, and auditing procedures should include the enhanced and advanced alarming techniques.

12.8 Alarm attribute enforcement

To maintain the designed alarm attribute settings (e.g., alarm setpoints, and alarm priorities) at authorized values, there should be a regular comparison of the rationalized values with the settings in effect in the control system. Enforcement, the automatic verification and restoration of alarm attributes, is an enhanced alarm technique that performs functions associated with monitoring, assessment, and audit. Enforcement can be initiated on a scheduled basis or on request and should differentiate changes resulting from state-based alarming or alarm shelving methodologies.

13 Implementation

13.1 Purpose

Implementation is a separate stage of the alarm lifecycle, which is the transition from design to operation. Clause 13 covers general requirements to implement or modify an alarm or alarm system.

13.2 Implementation planning

The scope of the project or change will determine the extent of the work necessary. Implementation planning should include the following considerations:

a) disruption to operation,

b) functional testing or validation,

c) verification of documentation, and

d) operator training.

13.3 Implementation training

13.3.1 General

The training requirements for new alarms and modifications to existing alarms are determined by the classification of the alarm and the class requirements as detailed in the alarm philosophy.

13.3.2 Implementation training requirements for new or modified alarms

Operators shall be trained on the response to new or modified alarms as prescribed in the alarm philosophy or site MOC procedure.

13.3.3 Training documentation requirements for highly managed alarms for new or modified alarms

Documentation of the training for new or modified highly managed alarms shall include:

a) the persons trained,

b) a summary of the training material,

c) the method of training, and

d) the date of the training.

13.3.4 Training documentation recommendations for new or modified alarms

Documentation of the training should include:

a) the persons trained,

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b) a summary of the training material,

c) the method of training, and

d) the date of the training.

13.3.5 Implementation training requirements for new or modified alarm systems

Operators shall be trained on all new or modified alarm systems.

13.3.6 Implementation training recommendations for new or modified alarm systems

The training requirements for the modified alarm system should be appropriate for the nature of the change. The training requirements of new alarm system should include:

a) the audible and visual indications for alarms,

b) the methods for silencing an alarm,

c) the methods for acknowledging an alarm,

d) the distinction of alarm priorities,

e) the use of the alarm HMI features (e.g., alarm summary sorting and filtering),

f) the methods for shelving and suppression, and

g) the methods for removing an alarm from service.

13.4 Implementation testing and validation

13.4.1 General

Implementation testing requirements for new alarms and modifications to existing alarms are determined by the MOC procedure, the class requirements in the alarm philosophy, or other methods.

13.4.2 Implementation testing requirements for highly managed alarms

The alarm philosophy shall identify the testing requirements for highly managed alarms prior to putting the alarms in operation. The testing shall be documented including:

a) the alarm setpoint or logical conditions,

b) the alarm priority,

c) the audible and visual indications for the alarm,

d) any other functional requirement for the alarm as specified,

e) the persons conducting the testing,

f) the method of testing and acceptance criteria,

g) the results of the testing and resolution of any failures or non-compliance,

h) the date of the testing, and

i) the date the alarm was put into service.

13.4.3 Implementation testing recommendations for new or modified alarms

Alarms should be tested during implementation. The testing should include verification of the following:

a) the alarm setpoint or logical conditions,

b) the alarm priority,

c) the audible and visual indications for the alarm, and

d) any other functional requirement for the alarm as specified.

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13.4.4 Implementation testing requirements for new or modified alarm systems

Alarm systems shall be tested during implementation to ensure that appropriate items in the alarm philosophy and ASRS have been met. The testing of the modified alarm system shall be appropriate to the nature of the change, as determined by site MOC procedures. The testing of new alarm systems shall include:

a) the audible and visual indications for each alarm priority,

b) the HMI features, such as alarm messages in the alarm summary or equivalent,

c) the methods for removing an alarm from service and returning an alarm to service,

d) the methods for shelving,

e) the methods for alarm suppression,

f) any additional functions of enhanced or advanced alarming techniques, and

g) the methods of alarm filtering, sorting, linking of alarms to process displays.

13.5 Implementation documentation

13.5.1 General

There are several documentation requirements and recommendations for alarm system implementation.

13.5.2 Documentation requirements

The following documentation shall be provided:

a) the rationalization information documented,

b) sufficient information to perform testing of alarms,

c) the alarm response procedures,

d) any designed suppression or enhanced alarming documentation, and

e) test documentation, if required by the alarm philosophy.

Upon completion of the alarm system implementation, the rationalization information shall be updated in accordance with the site MOC procedure.

13.5.3 Implementation documentation recommendations

The reporting method, documentation format and structure should be in accordance with the project documentation procedures and the owner’s documentation requirements.

The testing methodology and documentation should be appropriate to the nature of change, as determined by site MOC procedures or alarm philosophy.

Information used in testing new and modified alarms may include the following:

a) tag name for alarm,

b) tag description or alarm description for alarm,

c) alarm type,

d) priority,

e) alarm setpoint value or logical condition,

f) date of testing and change,

g) method of testing and acceptance criteria, and

h) results of the testing and resolution of any failures or non-compliance.

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14 Operation

14.1 Purpose

Operation is a separate stage of the alarm management lifecycle. Clause 14 covers requirements for alarms to remain in and return to the operational state. The operational state is when an alarm is able to indicate an abnormal condition to the operator. The use of tools for alarm handling within the operational state is also described. Operation is the lifecycle stage following implementation and when returning from maintenance.

14.2 Alarm response procedures

14.2.1 Alarm response procedures requirements

Alarm response procedures shall be readily accessible to the operator as specified in the alarm philosophy.

14.2.2 Alarm response procedure recommendations

The alarm information recorded during alarm rationalization should also be made readily accessible.

Unless otherwise specified in the alarm philosophy, the alarm response procedures should include:

a) the tag name for alarm,

b) the tag description or alarm description for alarm,

c) the alarm type,

d) the alarm setpoint,

e) the potential causes,

f) the consequence of inaction,

g) the operator action,

h) the allowable response time, and

i) the alarm class.

14.3 Alarm shelving

14.3.1 Alarm shelving requirements

Alarm shelving shall be allowed as documented as detailed in the alarm philosophy.

14.3.2 Alarm shelving for highly managed alarms

If a highly managed alarm class is used, then shelving highly managed alarms shall follow authorization and reauthorization requirements as detailed in the alarm philosophy.

Documentation shall be maintained, including approval, interim alarms and procedures, and reauthorization details.

14.3.3 Alarm shelving recommendations

Shelved alarms extending beyond a single operating shift should be reviewed. The review procedure for shelving alarms should be documented in the alarm philosophy.

14.3.4 Alarm shelving record requirements

The following information shall be recorded for each shelved alarm extending beyond a time limit set in the alarm philosophy:

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a) the tag name for alarm,

b) the tag description or alarm description for alarm, and

c) the reason for shelving.

14.3.5 Shift change procedures and alarm review

Written procedures should be developed for the exchange or review of alarm status information at shift change.

14.4 Refresher training for operators

14.4.1 Refresher training requirements for operators

The training requirements for alarms shall be determined by the alarm classification or other methods as detailed in the alarm philosophy.

14.4.2 Refresher training documentation requirements for highly managed alarms

If a highly managed alarm class is used, then the following training information shall be documented:

a) the persons trained,

b) the method of training, and

c) the date of the training.

The frequency of training shall be specified in the alarm philosophy. The documentation of the training shall be retained for the period specified in the alarm philosophy or per company policy.

14.4.3 Refresher training content requirements for highly managed alarms

If a highly managed alarm class is used, then operators shall be periodically trained on the characteristics of each highly managed alarm. The content of the refresher training shall include:

a) the rationalization information of the alarm, and

b) the audible and visual indications for the alarm.

14.4.4 Refresher training recommendations for alarms

Operators should receive refresher training that involves alarm response procedures. The training should cover a broad range of process scenarios. The training should include:

a) the rationalization information of the alarm, and

b) the audible and visual indications for the alarm.

A record of refresher training should be kept indicating who received the training and the time it was received.

15 Maintenance

15.1 Purpose

Maintenance is a separate stage of the alarm management lifecycle. Clause 15 covers requirements for alarm system testing, replacement, and repair. It describes the transition of alarms to the out-of-service state and then return to service. Maintenance also requires refresher training for personnel maintaining the alarm system.

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15.2 Periodic alarm testing

15.2.1 General

Periodic alarm testing requirements shall be determined by the alarm classification or other methods as detailed in the alarm philosophy. The purpose of periodic testing is to ensure that the alarm continues to perform as designed.

15.2.2 Periodic alarm testing requirements

When tests are performed, a record shall be kept for a period specified in the alarm philosophy. The records shall contain the following:

a) date(s) of testing,

b) name(s) of the person(s) who performed the test or inspection,

c) unique identifier of equipment (e.g., loop number, tag number, and equipment number),

d) result of tests (e.g., the as-found and as-left conditions),

e) a reference to the testing procedure and methods used, and

f) cause of test failures.

If the alarm philosophy requires that some alarms be periodically tested, then the alarm philosophy shall provide guidelines on the frequency and manner of testing.

15.2.3 Periodic alarm testing for highly managed alarms

If highly managed alarm classes are used, then alarms belonging to these classes shall be periodically tested to ensure performance.

Any deficiencies found during periodic testing of highly managed alarms shall be repaired or else an interim alarm or procedure shall be put in place in a timely manner.

15.2.4 Periodic alarm test procedure requirements

Test procedures shall be provided for alarms requiring testing.

15.2.5 Periodic alarm test procedure recommendations

Procedures should contain:

a) steps for taking the alarm out of service prior to the test and returning the alarm to service after the test, including notification to the operator;

b) appropriate warnings regarding control loops or final elements that might be affected by the test;

c) steps to address advanced alarming techniques if applicable.

15.2.6 Periodic alarm testing recommendations

Test records should contain the following:

a) method of testing, and

b) planned interval before next test.

Any deficiencies found during periodic alarm testing should be repaired in a timely manner.

15.3 Out-of-service alarms

15.3.1 General

Requirements for the out-of-service procedure shall be determined by the alarm classification or other methods as detailed in the alarm philosophy.

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15.3.2 Out-of-service process requirements

Alarms that are placed out of service for extended periods (e.g., days, weeks, or months) shall be examined to determine if an interim alarm or procedure is necessary.

An authorization and documentation process (e.g., permit process) shall be used to take an alarm out of service.

The following information shall be recorded for each out-of-service alarm:

a) the name of the tag in alarm,

b) the alarm type,

c) approval details,

d) details concerning interim alarms or procedures if required, and

e) the reason for taking the alarm out of service.

15.3.3 Out-of-service highly managed alarms

If a highly managed alarm is taken out of service, appropriate interim alarms or procedures shall be identified considering risk reduction requirements and the plant state.

15.3.4 Out-of-service process recommendations

Approval requirements for taking alarms out of service and the duration of record retention should be specified.

15.3.5 Requirements for returning alarms to service

Prior to returning out-of-service alarms to the operational state, operators shall be notified to ensure they are aware of the returning alarm and the removal of the interim methods.

Interim alarms and procedures shall be removed, where applicable, when the original alarms are returned to service.

15.4 Equipment repair

Information related to an alarm malfunction should be available to the operator. Alarms affected by non-functioning equipment (e.g., equipment that is taken out of service for repair or preventative maintenance) should be placed out of service if the condition will not be resolved within a reasonable time as specified in the alarm philosophy.

15.5 Equipment replacement

The MOC procedure should address replacement equipment (e.g., measurement devices, valves, process equipment) that will change alarm attributes. If a replacement is made, then alarm validation may be required depending on the class of the alarm as specified in the alarm philosophy.

15.6 Refresher training for maintenance

15.6.1 General requirements

The refresher training requirements for the maintenance of alarms shall be determined by the class requirements as detailed in the alarm philosophy.

15.6.2 Refresher training requirements for highly managed alarms

If a highly managed alarm class is used, then personnel shall be periodically trained on the maintenance requirements for all highly managed alarms. The frequency of training shall be specified in the alarm philosophy. The documentation of the training shall be retained for the period specified in the alarm philosophy or per company policy.

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15.6.3 Refresher training recommendations for alarms

Maintenance personnel should receive refresher training on the maintenance requirements of alarms. A record of refresher training should be kept indicating who received the training and the time it was received. Evaluations should be conducted to ensure site maintenance procedures are clearly understood.

16 Monitoring and assessment

16.1 Purpose

Monitoring and assessment is a separate stage of the lifecycle. This stage verifies that design, implementation, rationalization, operation, and maintenance are satisfactory. Clause 16 provides guidance on the use of alarm system analysis for both on-going monitoring and periodic performance assessment. These activities use many of the same types of measures. Several performance measures are recommended for inclusion in the alarm philosophy.

Performance monitoring is fundamental to management and improvement of the alarm system. An alarm system will likely experience performance deterioration over time, as sensors age and process conditions change, or if an alarm change management policy is not in place. On-going performance measurement can determine when corrective action is needed.

Problems identified via alarm system monitoring may be resolved in several different parts of the lifecycle (e.g., design, maintenance, or management of change) depending upon the nature of the problem.

Once the alarm management lifecycle has been implemented, and nuisance alarms (e.g., chattering alarms) reduced, the resulting alarm rate more closely reflects the effectiveness of the control of the process, the operation practices and the maintenance systems. Alarm system performance can be further improved through process control, operation, or maintenance improvements. Advanced alarm techniques are often necessary to meet the performance targets in the alarm philosophy.

16.2 Performance monitoring

Alarm system performance shall be monitored. Monitoring and assessment of the alarm system performance shall be made against the target performance levels in the alarm philosophy.

16.3 Monitoring and assessment

Monitoring typically occurs at a higher frequency than assessment. The monitoring of some aspects of the alarm system performance is based upon continuous measurement. The intent of monitoring is to identify problems and take corrective actions to fix them.

The focus of the assessment process is to apply engineering judgment and review to determine whether the system is performing well. The evaluation of work processes relative to the alarm system is covered in Clause 18.

16.4 Alarm system performance metrics

16.4.1 General

Various types of alarm system analyses, key performance indicators, and methods are possible. Both initial alarm system assessment and on-going monitoring should include the measures like those shown in Table 7. The list of chosen analyses should match the alarm philosophy.

The two categories of data in a typical alarm system are alarm records (i.e., dynamic or real-time data) and alarm attributes. Both categories are valuable in alarm system performance measurement and are subject to different analyses.

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a) Alarm records contain alarm-related information and are produced by the system when alarms occur.

b) Alarm attributes make up the underlying structure which is necessary in order that alarm records are produced, including alarm types, alarm setpoints, priorities, deadbands, and similar items.

In general, at least 30 days of data is desirable for calculating the metrics. For batch operations, data corresponding to several similar batches is more applicable.

The target metrics described below are approximate and depend upon many factors (e.g., process type, operator skill, HMI, degree of automation, operating environment, types and significance of the alarms produced). Maximum acceptable numbers could be significantly lower or perhaps slightly higher depending upon these factors. Alarm rate alone is not an indicator of acceptability.

16.4.2 Average alarm rate per operator console

Analysis of alarm rate (i.e., annunciated alarm rate) is a good indicator of the overall health of the alarm system. Recommended targets for the average alarm rate per operator console (i.e., the span of control and alarm responsibility of a single operator) based upon one month of data are shown in Table 5. These rates are based upon the ability of an operator and the time necessary to detect an alarm, diagnose the situation, respond with corrective action(s), and monitor the condition to verify the abnormal condition has been corrected.

Table 5 - Average alarm rates

Very likely to be acceptable	Maximum manageable
~6 alarms per hour (average)	~12 alarms per hour (average)
~1 alarm per 10 minutes (average)	~2 alarms per 10 minutes (average)

Sustained operation above the maximum manageable guidelines indicates an alarm system that is annunciating more alarms than an operator is likely able to handle, and the likelihood of missing alarms increases, even if the average for that interval is acceptable.

16.4.3 Peak alarm rate per operator console

Alarm rates can exceed the operator capability for effective alarm response, (e.g., 10 alarms or more in a 10-minute time period) and result in missed alarms.

For peak alarm rate analysis, annunciated alarms are counted in regular 10-minute intervals (e.g., 13:00 through 13:09). The recommended target corresponding to one month of data is that less than ~1% of the 10-minute intervals should contain more than 10 alarms.

Both the peak and average alarm rates should be taken into account simultaneously because either measurement individually could be misleading. The number of intervals exceeding 10 alarms, and the magnitude of the highest peaks should be reported.

16.4.4 Alarm floods

Alarm floods are variable-duration periods of alarm activity with annunciation rates likely to exceed the operator response capability. Alarm flood calculations involve the determination of adjacent time periods where the alarm rate is high, thus producing an overall flood event.

The start of an alarm flood is indicated by high alarm rate (e.g., an alarm rate that exceeds 10 alarms per 10 minutes), and the end of an alarm flood is indicated by a return to reduced alarm rate (e.g., an alarm rate of less than 5 alarms per 10 minutes). Alarm floods should be of short

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duration and low total alarm count. As a recommended target, an alarm system should be in flood for less than ~1% of the time.

Improvements to the alarm system and process operation may be indicated by the analysis of alarm floods. No targets are provided for these metrics. Alarm flood analysis should include:

a) number of alarm floods,

b) duration of each alarm flood,

c) alarm count in each alarm flood, and

d) peak alarm rate for each alarm flood.

Advanced alarming techniques can mitigate alarm floods. Alarm floods may require advanced methodologies to address. These techniques are described in Clause 12.

16.4.5 Frequently occurring alarms

Relatively few individual alarms (e.g., 10 to 20 alarms) often produce a large percentage of the total alarm system load (e.g., 20% to 80%). The most frequent alarms should be reviewed at regular intervals (e.g., daily, weekly, or monthly). Substantial performance improvement can be made by addressing the most frequent alarms.

The analysis methodology is to use at least several weeks of data and rank alarm records from most to least frequent. High frequency alarms often have major skewing effects on other performance measurements.

The top 10 most frequent alarms should comprise a small percentage of the overall system load (e.g., 1% to 5%). Action steps based on this analysis include review for correct functioning and design.

16.4.6 Chattering and fleeting alarms

A chattering alarm repeatedly transitions between the active state and the not active state in a short period of time. Fleeting alarms are similar short-duration alarms that do not immediately repeat. In both cases, the transition is not due to the result of operator action.

It is possible for a chattering alarm to generate hundreds or thousands of records in a few hours. This results in a significant distraction for the operators. Chattering alarms are often high in the listing of the most frequent alarms. Chattering and fleeting alarm behaviors should be eliminated. There is no long-term acceptable quantity of chattering or fleeting alarms.

16.4.7 Stale alarms

Alarms that remain annunciated continuously for an extended duration (e.g., longer than 24 hours) can be considered stale. Such alarms provide little valuable information to the operators. Stale alarms should be examined to ensure that they were properly rationalized. Advanced alarming or resolving the root cause can eliminate stale alarms.

There should be few stale alarms per operator console, with action plans to address them. No alarm should be intentionally designed to become stale and there is no long-term acceptable number of stale alarms.

16.4.8 Annunciated alarm priority distribution

Effective use of alarm priority can enhance the ability of the operator to manage alarms and provide response. The effectiveness of alarm priority is related to the distribution of the alarm priorities: higher priorities should be used less frequently as shown in Table 6

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Table 6 – Example annunciated alarm priority distribution

Priority designation	Percentage distribution
3 priorities: low, medium, high	~80% low, ~15% medium, ~5% high
4 priorities: low, medium, high, highest	~80% low, ~15% medium, ~5% high, ~<1% highest
NOTE The ~<1% highest priority is sometimes used for a few alarms with severe consequences.	

Some alarm systems use an additional highest priority for a few alarms with severe consequences.

Additional priorities can be useful, such as a lowest priority for instrument diagnostic alarm with very limited operator action. There is no recommended frequency or percentage distribution for diagnostic alarms, since there is no recommended frequency for instrument failure. Low numbers are better.

Alarm priority distributions can vary based on process and industry. A target alarm priority distribution should be established in the alarm philosophy. Significant variance from the target priority distribution can indicate ineffective rationalization or ineffective application of the alarm prioritization methodology.

16.4.9 Rationalized alarm priority distribution

An effective alarm rationalization effort will produce an annunciated alarm priority distribution similar to the target distribution in the alarm philosophy. The annunciated alarm priority distribution will not match the rationalized alarm priority distribution since all alarms are not equally likely to occur. For alarm systems that do not allow a separate priority for instrument or system diagnostic alarms, these alarms can be excluded from the priority distribution calculations to prevent a skewed distribution.

16.5 Unauthorized alarm suppression

The alarm states of shelved, suppressed by design, and out of service are all intended as controlled suppression methodologies. It is possible for alarms to be suppressed outside of these methodologies. Uncontrolled suppression of alarms should be detected and reported. The potential for mistakes and the resulting risk are high.

Alarm state transitions to suppressed states and from suppressed states should be recorded. Analysis methods should be used to detect and report any alarms suppressed outside of these methods. There should be no alarms that are suppressed without authorization.

16.6 Alarm attribute monitoring

Unauthorized alarm attribute changes shall be detected and resolved by comparison of actual alarm attributes against rationalization information. Discrepancies shall be identified and resolved in a timely manner. The target value for unauthorized changes to alarms is zero.

16.7 Reporting of alarm system analyses

Alarm system analyses should be reported at the appropriate frequency to personnel (e.g., operators, staff and managers) concerned with the alarm system.

At various phases of an improvement effort, different analyses should be performed at different reporting periods (e.g., providing weekly reports at the start of an effort and monthly reports later on). Weekly analyses can still cover the prior 30 days of data to produce meaningful trends. The alarm philosophy should specify analysis and reporting frequencies.

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Action should be taken on problems identified by the alarm analyses. The progress and status of actions should be regularly reported.

16.8 Alarm performance metric summary

The alarm performance metrics and example target values previously described are summarized in Table 7.

Table 7 – Recommended alarm performance metrics summary

Alarm performance metrics based upon at least 30 days of data		
Metric	**Target value**	
Annunciated alarms per time	Target value: very likely to be acceptable	Target value: maximum manageable
Annunciated alarms per hour per operator console	~6 (average)	~12 (average)
Annunciated alarms per 10 minutes per operator console	~1 (average)	~2 (average)
Metric	**Target value**	
Percentage of 10-minute periods containing more than 10 alarms	~<1%	
Maximum number of alarms in a 10-minute period	≤10	
Percentage of time the alarm system is in a flood condition	~<1%	
Percentage contribution of the top 10 most frequent alarms to the overall alarm load	~<1% to 5% maximum, with action plans to address deficiencies.	
Quantity of chattering and fleeting alarms	Zero, action plans to correct any that occur.	
Stale alarms	Less than 5 present on any day, with action plans to address.	
Annunciated priority distribution	3 priorities: ~80% low, ~15% medium, ~5% high or 4 priorities: ~80% low, ~15% medium, ~5% high, ~<1% highest Other special-purpose priorities) excluded from the calculation	

17 Management of change

17.1 Purpose

Management of change is a separate stage of the lifecycle. Clause 17 covers requirements for alarm system changes pertaining to the addition of new alarms, removal of existing alarms, alarm attribute modification, changes to alarm system functions, authorization, and documentation. The purpose of management of change is to ensure that changes are authorized and subjected to the evaluation criteria described in the alarm philosophy. The MOC process ensures that the appropriate lifecycle activities are applied to alarm system changes.

17.2 Changes subject to management of change

The addition or removal of alarms and the modification of specified attributes shall require authorization through a MOC procedure. Permanent changes that result in a difference from the authorized values of the alarm setpoint, class, priority, consequence, setpoint rationale, suppression logic, or response time shall require evaluation through the MOC procedure.

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The MOC procedure shall ensure that the following considerations are addressed:

a) the technical basis for the proposed change,

b) the impact of change on health, safety and the environment,

c) modifications are in accordance with the alarm philosophy,

d) modifications for operating procedures,

e) time period for which change is valid,

f) authorization requirements for the proposed change,

g) the degree of safety is maintained if the alarm is implemented for safety reasons,

h) personnel from appropriate disciplines are included in the review,

i) changes to the alarm system, including system upgrades, follow all appropriate subsequent alarm management lifecycle activities, and

j) implementation of all changes adhere to procedures specified in the alarm philosophy.

17.3 Change documentation requirements

Documentation requirements shall be determined by the MOC procedure, class requirements as detailed in the alarm philosophy, or other methods.

17.4 Alarm removal recommendations

If an alarm is no longer needed, then it should be removed from the alarm system. Displays and related documentation should be modified within a reasonable time.

17.5 Alarm attribute modification recommendations

A list of referencing materials (e.g., graphics, control logic, P&ID, operating procedures, and PHA) should be generated and maintained. This reference list should be reviewed prior to making changes to alarms. This prevents introducing incorrect information into documentation and helps prevent automation logic and graphic errors.

18 Audit

18.1 Purpose

Audit is a separate stage of the lifecycle which is conducted periodically to maintain the integrity of the alarm system and alarm management processes. Audit of system performance can reveal gaps not apparent from monitoring. Execution against the alarm philosophy is audited to identify any requirements for system improvements, such as modifications to the alarm philosophy or the work process defined therein.

An audit reviews the managerial and work practices associated with the alarm system. It determines whether those practices are sufficient to adequately administer the system by reviewing practices against procedures and reviewing procedures against policy or requirements. Audit also includes comparison of the alarm management practices against industry guidelines. The frequency of the audit process is lower than monitoring and assessment.

18.2 Benchmark

18.2.1 General

All aspects of alarm management should be audited at the start of an improvement effort. An initial audit or benchmark should be made against a set of documented practices (e.g., the practices listed in this standard). A benchmark includes an initial iteration of the audit process, in order to capture any work practice concerns. The results of the initial audit can be used in the development of a philosophy.

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18.2.2 Audit or benchmark requirements

The audit frequency and the specific audit requirements stated in the alarm philosophy shall be followed for all alarms, as required by alarm class or other methods.

Audits shall address all applicable requirements of this standard.

18.3 Audit interviews

Personnel interviews or questionnaires should be conducted as part of the audit to identify performance and usability issues. Interview topics may include:

a) alarms occur only on conditions that require operator action,

b) alarm priority is consistently applied and meaningful,

c) operators have sufficient time to respond to alarms,

d) roles and responsibilities for the alarm system users and support personnel are defined and followed, and

e) training regarding the use and functioning of the alarm system is effective.

18.4 Audit recommendations

The alarm philosophy should be audited against industry guidelines and the requirements and recommendations of this standard. The work processes and procedures that ensure compliance with the alarm philosophy should be evaluated for effectiveness on a periodic basis. The audit should review all related documentation, which may include:

a) verification that alarms require operator action to avoid a defined consequence,

b) documentation of alarm attributes and rationalization,

c) MOC documentation of modifications to alarm attributes in the master alarm database,

d) alarm performance monitoring reports,

e) documentation of repairs to malfunctioning alarms, and

f) documentation for out-of-service alarms.

18.5 Action plans

Action plans should be developed for problems identified during the audit processes. When defining an action plan, timelines, accountability, and review of results obtained should be assigned to each item.

19 Bibliography

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