Base Load Power Hub (BLPH)

Alarm System Requirements Specification
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1 INTRODUCTION

1.1 PROJECT OVERVIEW

Crosswind, a Shell and Eneco joint venture, was awarded the tender to develop the offshore Hollandse Kust Noord (HKN) wind farm, located 18.5km off the coast of Netherlands near the town of Egmond aan Zee. The consortium plans to have HKN operational in 2023 with an installed capacity of 759MW generating at least 3.3TWh per year. This is sufficient renewable power to supply more than 1 million Dutch households with green electricity.

Offshore wind farms produce intermittent electricity and balancing these dips and peaks and integrating this electricity into the national energy system requires new technologies. For this reason, the offshore wind farm will include several new technologies that could be implemented at full-scale in the future. The new technologies being explored include a floating solar park, a short-duration battery storage as well as long-term storage via green hydrogen produced by water electrolysis and subsequently consumed in a fuel cell. The combination of these individual measures, herein referred to as the Base Load Power Hub (BLPH) will ensure a continuous power supply regardless of the wind situation.

1.1.1 Project Location

The Hollandse Kust Noord (HKN) wind farm is located 18.5km off the coast of the Netherlands near the town of Egmond aan Zee.

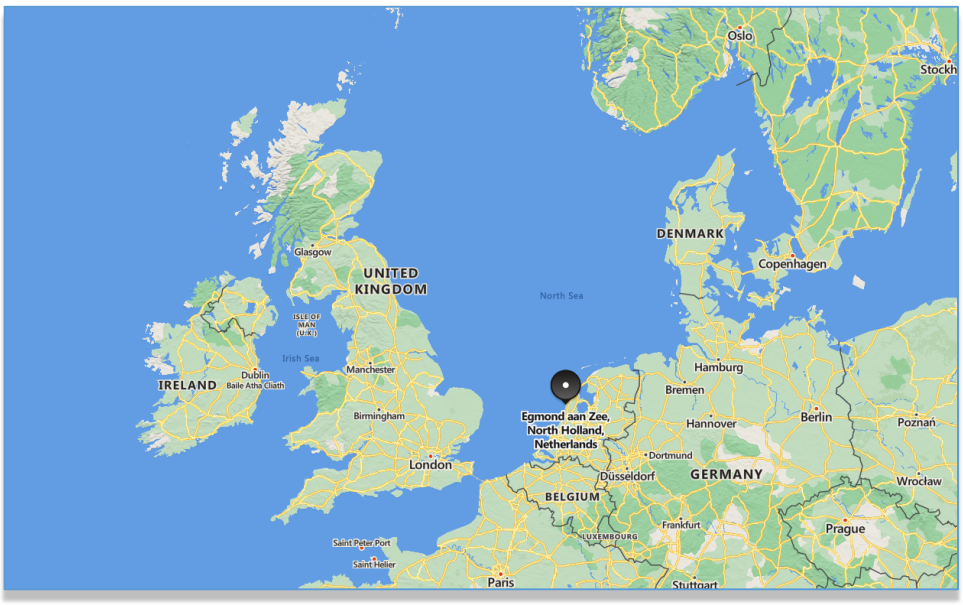


Figure 1 - HOLLANDSE KUST NOORD WIND PARK Location Map

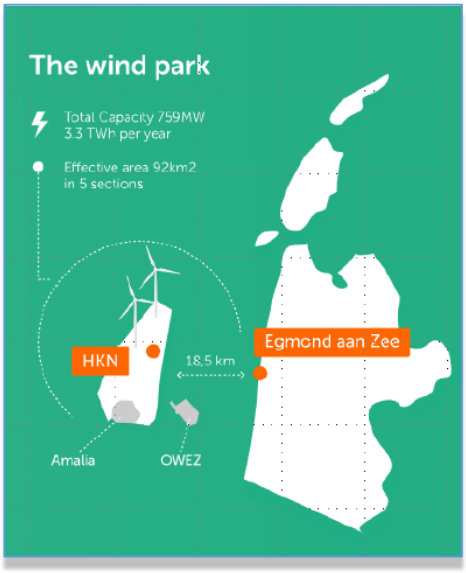


Figure 2 - Wind Park Details

The wind farm will consist of No. 69 x 11.5MW wind turbine generators each to be installed on a dedicated monopile structure. A 70th monopile located on coordinates E 590719.1, N 5841602.3 is reserved for installing the platform accommodating the BLPH. The monopile structure was designed and installed by Van Oord Offshore Wind (VooW) and therefore not part of the BLPH scope.

1.1.2 Project Concept

All components included in the BLPH will be integrated onshore on a topsides and installed in an offshore location within the boundaries of the HKN wind farm. At its simplest, the BLPH will store energy during periods of high electricity generation from renewable sources (a wind turbine generator and the floating solar PV farm) and release it during periods of low generation. In practice. It is expected that the energy stored will supplement generation from renewable sources to ensure that at least 1.0MW of power is exported to the electrical grid regardless of wind/solar availability.

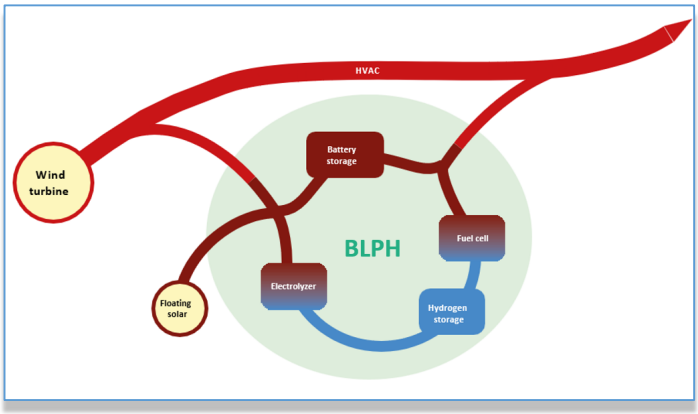


Figure 3 – BLPH Concept

Electricity in the BLPH will be stored in the form of electrons in a battery energy storage system (BESS) as well as converted into green hydrogen via water electrolysis. When the power output from the connecting wind turbine drops to below 1 MWe, the BLPH will return its stored energy to supplement the remaining power output. This will be by discharging the BESS, while stored hydrogen will be converted back into electricity using a fuel cell to extend the discharge duration.

The purpose of the BLPH s to function as a testbed for the integration of energy storage technologies with renewable generation. It is expected that equipment installed on the BLPH will operate as Normally Unmanned Installation for at least two (2) years with no or minimal maintenance and it will have its own independent control room with the ability to communicate with Crosswind's control room.

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2 DOCUMENT SCOPE

The alarm system requirements specification (ASRS) is developed based on the alarm philosophy and can be an important part of control system procurement.

The ASRS documents the alarm functionality expected of the control system.

The ASRS requirements are used to help evaluate alarm systems and guide the detailed alarm system design. During implementation, the ASRS can serve as the basis of function testing of the alarm system. The ASRS specifies the alarm system functionality necessary to satisfy the alarm philosophy.

The ASRS is updated throughout the implementation stage to ensure consistency with the targeted capabilities of the chosen control system and in driving design, testing, and training activities.

Changes to functionality can occur during the life of the alarm system. These changes can be managed and documented via the MOC procedure.

The ASRS includes 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 management life cycle activities.

The document pertains to all personnel involved in the design, implementation, operation, maintenance, and modification of alarm systems. The guidelines in this document apply to alarms originating from the following systems:

- ⇒ Safety System - SIS system
- ⇒ Fire and gas System - FGS system
- ⇒ F&G detection equipment that interface to FGS system
- ⇒ Process Control System - PCS
- ⇒ EMCS and interfaces to Electrical Switchgear
- ⇒ Electrolyser
- ⇒ Fuel cell
- ⇒ BESS
- ⇒ HVAC system
- ⇒ Water Treatment Package
- ⇒ Instrument Air Package
- ⇒ Nitrogen Package
- ⇒ Navaids
- ⇒ H2 Storage system
- ⇒ Vent system
- ⇒ Intrusion Detection system

2.1 SOURCE DOCUMENTS

The Main sources of Alarms included in the Review are listed below.

Doc. No.	Description
123A90-DDL-PR-PID-80021	BLPH PIPING AND INSTRUMENTATION DIAGRAM SEA-WATER INTAKE SYSTEM SHEET 1
123A90-DDL-PR-PID-80022	BLPH PIPING AND INSTRUMENTATION DIAGRAM SEA-WATER INTAKE SYSTEM SHEET 2
123A90-DDL-PR-PID-80011	BLPH PIPING AND INSTRUMENTATION DIAGRAM ELECTROLYSER PACKAGE
123A90-DDL-PR-PID-80013	BLPH PIPING AND INSTRUMENTATION DIAGRAM HYDROGEN STORAGE VESSELS HEADER (INLET)
123A90-DDL-PR-PID-80015/16/17/18/19/20	BLPH PIPING AND INSTRUMENTATION DIAGRAM HYDROGEN STORAGE VESSEL A/B/C/D/E/F
123A90-DDL-PR-PID-80014	BLPH PIPING AND INSTRUMENTATION DIAGRAM HYDROGEN STORAGE VESSELS HEADER (OUTLET)
123A90-DDL-PR-PID-80012	BLPH PIPING AND INSTRUMENTATION DIAGRAM FUEL CELL PACKAGE
123A90-DDL-PR-PID-80029	BLPH PIPING AND INSTRUMENTATION DIAGRAM HYDROGEN VENT DRUM
123A90-DDL-PR-PID-80025	BLPH PIPING AND INSTRUMENTATION DIAGRAM WATER DISPOSAL SHEET 1
123A90-DDL-PR-PID-80026	BLPH PIPING AND INSTRUMENTATION DIAGRAM WATER DISPOSAL SHEET 2
123A90-DDL-PR-PID-80027	BLPH PIPING AND INSTRUMENTATION DIAGRAM INSTRUMENT AIR PACKAGE
123A90-DDL-PR-RE-80031	Process Control, Operation, Start-up and Shutdown Philosophy
123A90-DDL-SAF-RE-30006	HAZOP Report
123A90-DDL-SAF-RE-30036	LOPA Allocation Report
123A90-DDL-IN-CE-40000	Process Safety Cause & Effect Matrix
123A90-DDL-IN-CE-40002	Fire & Gas Cause & Effect Matrix
123A90-DDL-IN-LIS-40089	Instrument I/O List
123A90-DDL-EL-LIS-20157	Electrical I/O Signal List

Table 1 - Source Documents

2.2 REFERENCES

Doc. No.	Description
IEC 62682:2022	Management of Alarm Systems for the Process Industries
EEMUA 191 Publication 191	Alarm systems - a guide to design, management and procurement, Third Edition.

123A90-DDL-IN-RE-40025	Alarm Management Workshop Terms of Reference
123A90-DDL-IN-RE-40026	Alarm Management Workshop Report
K559-2254-IC-LST-001	Preliminary Alarm Database
123A90-DDL-IN-LIS-40027	Master Alarm Database

Table 2 - Reference Documents

2.3 ABBREVIATIONS

COMPANY or Client (CPY)	Crosswind
CONTRACTOR (CTR)	ROSETTI MARINO S.p.A.
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project
ALARP	As Low As Reasonable Practicable
AMS	Alarm Management System
ARM	Alarm Response Manual
ASRS	Alarm System Requirement Specification
BLPH	Base Load Power Hub
BPCS	Basic Process Control System
CBL	Consequential Business Loss
CFA	Critical Fault Alarms
PCS	Process Control System
DEP	Design and Engineering Practice
EMCS	Electrical Management Control System
FGS	Fire and Gas System
HAZOP	Hazard and Operability
HEMP	Hazards and Effects Management Process
HER	Hazard and Effects Register
HMI	Human Machine Interface
HKN	Hollandse Kust Noord
HSE	Health, Safety and Environment
HMA	Highly Managed Alarm
HVAC	Heating Ventilation Air Conditioning
ISU	Initial Setup

LOPA	Layer of Protection Analysis
LOPC	Loss of Primary Containment
LV	Low Voltage
MA	Mitigation Alarm
MAD	Master Alarm Database
MOC	Management of Change
MOS	Maintenance Override Switch (bypass switch)
MV	Medium Voltage
OTL	Operation Team Leader
PACO	Process Automation, Control & Optimisation
PAS	Process Automation System
PEFS	Process Engineering Flow Scheme
PFD	Process Flow Diagram
PHA	Process Hazard Assessment
P&ID	Process and Instrumentation Diagram
PLC	Programmable Logic Controller
RAM	Risk Assessment Matrix
SCADA	Supervisory Control and Data Acquisition
SIF	Safety Instrumented Function
SIS	Safety Integrated System
SRA	Safety Related Alarms
TOR	Terms of Reference
UPS	Uninterrupted Power Supply

Table 3 - Abbreviations

2.4 TERMS AND DEFINITION

2.4.1 Absolute Alarm

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

2.4.2 Acknowledge

Operator action that confirms recognition of an alarm.

2.4.3 Active

Alarm state in which the alarm condition is true. 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.

2.4.4 Adaptive Alarm

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

2.4.5 Adjustable Alarm (operator-set alarm)

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

2.4.6 Advanced Alarming

Collection of techniques that can help manage annunciations during specific situations (e.g. state-based alarming).

2.4.7 Alarm

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

2.4.8 Annunciation (Alarm Annunciation)

Function of the alarm system to call the attention of the operator to an alarm.

2.4.9 Alarm Attribute

Setting for an alarm within the control system (e.g. alarm priority).

2.4.10 Alarm Banner

Graphic element that lists annunciated alarms with selected information. Return to normal indications can also appear on the alarm summary.

Information can include the date, time, priority, and alarm type.

2.4.11 Alarm Class

Group of alarms with common set of alarm management requirements (e.g. Safety related alarm class).

2.4.12 Alarm Deadband

Change in signal from the alarm setpoint necessary for the alarm to return to normal.

2.4.13 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).

2.4.14 Alarm Group

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

2.4.15 Alarm Historian

Long term repository for alarm records.

2.4.16 Alarm Log

Short term repository for alarm records.

2.4.17 Alarm Management (Alarm System management)

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

2.4.18 Alarm Message

Text string displayed with the alarm indication that provides additional information to the operator (e.g. message with operator action or probable cause).

2.4.19 Alarm Off-delay

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

2.4.20 Alarm On-delay

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

2.4.21 Alarm Philosophy

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

2.4.22 Alarm Priority

Relative importance assigned to an alarm within the alarm system to indicate the urgency of response (e.g. priority can use seriousness of consequences and allowable response time to determine urgency).

2.4.23 Alarm Rate

Number of annunciated alarms, per operator, in a specific time interval.

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2.4.24 Alarm Record

Set of information which documents an alarm state change.

2.4.25 Alarm Response Procedure

Guidance for response to an alarm. The guidance can be in many forms and not only in the form of a procedure document.

The guidance can include operator action, probable cause, and other information.

2.4.26 Alarm Setpoint (Alarm trip point)

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

2.4.27 Alarm Summary (Alarm list)

Display that lists annunciated alarms with selected information. Return to normal indications can also appear on the alarm summary.

Information can include the date, time, priority, and alarm type.

2.4.28 Alarm System

System for generating and handling alarms to help the operator manage abnormal situations.

2.4.29 Alarm System Requirements Specification

Document which describes the functional requirements of the alarm system.

2.4.30 Alarm Type

Alarm attribute which gives a distinction of the alarm condition (e.g. Low process variable alarm, high process variable alarm, and discrepancy alarm).

2.4.31 Allowable Response Time

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

2.4.32 Annunciator

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

2.4.33 Assessment

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

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2.4.34 Audit <of alarm management>

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

2.4.35 Bad-Measurement Alarm

Alarm generated when the signal for a process measurement is outside the expected range (e.g. Bad-measurement alarm generated at 3,8 mA for a 4 mA to 20 mA signal).

2.4.36 Basic Process Control System (BPCS)

System which responds to input signals from the process, its associated equipment, other programmable systems and/or operators and generates output signals causing the process and its associated equipment to operate in the desired manner but which does not perform any safety instrumented function.

A BPCS includes all of the devices necessary to ensure that the process operates in the desired manner.

A BPCS typically may implement various functions such as process control functions, monitoring, and alarms.

2.4.37 Benchmark

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

2.4.38 Bit-pattern Alarm

Alarm that is generated when a pattern of digital signals matches a predetermined pattern.

2.4.39 Calculated Alarm

Alarm generated from a calculated value instead of a direct process measurement.

2.4.40 Call-Out Alarm

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

2.4.41 Chattering Alarm

Alarm that repeatedly transitions between the active state and the not active state in a short period of time.

2.4.42 Classification

Process of separating alarms into alarm classes based on common requirements. Requirements can include testing, training, and auditing.

2.4.43 Console

Hardware, software, and furniture or enclosure at which users monitor and/or control the process, which can include multiple stations, communication devices, and other devices. The span of control of the operator is usually determined by the information available at the operator console.

2.4.44 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. The control system can include one or more basic process control systems (BPCS), safety instrumented systems (SIS).

2.4.45 Controller-Output Alarm

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

2.4.46 Decommission

Process to remove an alarm from the alarm system.

2.4.47 Deviation Alarm

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

2.4.48 Discrepancy Alarm

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

2.4.49 Display

Visual representation of information used by the operator for monitoring and control.

2.4.50 Dynamic Alarming

Automatic modification of alarm attributes based on process state or conditions.

2.4.51 Dynamic Suppression

Automatic suppression of specific notifications resulting from an event (such as a facility trip) if the operating circumstances following the event make it impossible for a hazardous situation to arise from the associated limits being exceeded. Dynamic suppression does not change alarm parameter settings; it only suppresses the notification.

2.4.52 Enforcement

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

2.4.53 Event

Representation of a solicited or unsolicited fact indicating a state change (e.g. mode changes and device state changes).

2.4.54 Facility

The group of physical equipment that functions together, as a single unit, to perform a specific operation such as crude oil/gas production well, refining or chemical process, storage, transfer, (un)loading stations, treating or any other operations involved in the production, manufacturing and handling of crude oil, gas, oil products and/or chemicals, including but not limited to, process units (operating and idle), utilities, water and effluent treating units, tank farms and other storage, pipelines, pumping, compression, loading and unloading stations.

2.4.55 First-out Alarm

Alarm determined to be the first in a multiple-alarm scenario. The first alarm is determined by logic.

2.4.56 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.

2.4.57 Highly Managed Alarm (HMA)

Alarm belonging to a class with additional requirements above general alarms (e.g safety related alarm). Regulatory requirements can be additional requirements.

2.4.58 Human Machine Interface (HMI)

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

2.4.59 Implementation

Transition stage between design and operation during which the alarm is put into service. Implementation includes activities such as commissioning and training.

2.4.60 Instrument Diagnostic Alarm

Alarm to indicate a field device or signal fault (e.g. Out-of-range alarm).

2.4.61 Interim Alarm

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

2.4.62 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.

2.4.63 Master Alarm Database

Authorized list of rationalized alarms and associated attributes. The list can be in many forms and not only in the form of a database.

2.4.64 Monitoring

Measurement and reporting of quantitative (objective) aspects of alarm system performance.

2.4.65 Nuisance Alarm

Alarm that annunciates excessively, unnecessarily, or does not return to normal after the operator action is taken (e.g. chattering alarm, fleeting alarm, and stale alarm).

2.4.66 Operator

Person who monitors and makes changes to the process.

2.4.67 Operator Alert

Audible and/or visible means of indicating to the operator an equipment or process condition for evaluation when time allows which could result in a response.

2.4.68 Out-of-service

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

2.4.69 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.

2.4.70 Plant State or Plant mode

Defined set of operational conditions for a process plant (e.g. Shutdown, normal operation).

2.4.71 Prioritization

Process of assigning a level of operational importance to an alarm.

2.4.72 Process Area

Physical, geographical or logical grouping of resources determined by the site.

2.4.73 Rate-of-change Alarm

Alarm generated when the change in process variable per unit time (dPV/dt) exceeds a defined setpoint.

2.4.74 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.

2.4.75 Re-alarming Alarm

Alarm that is automatically re-annunciated under certain conditions.

2.4.76 Recipe-Driven Alarm

Alarm with setpoints that depend on the recipe that is currently being executed.

2.4.77 Remote Alarm

Alarm from a remotely operated facility or directed to a remote interface.

2.4.78 Reset

Operator action that unlatches a latching alarm.

2.4.79 Return to Normal

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

2.4.80 Safety Instrumented System (SIS)

A function comprising one or more sensors, a Logic Solver and one or more Final Elements whose purpose is to prevent or mitigate hazardous situations. A SIF is intended to achieve or maintain a safe state for the process, in respect of a specific hazardous event.

A SIF is designed to achieve a required SIL which is determined in relationship with the other protection layers participating in the reduction of the same risk. Previously referred to as an Instrumented Protective Function (IPF).

2.4.81 Safety Related Alarm

Alarm that is classified as critical for the protection of human life or the environment (e.g. an alarm indicating a potential asphyxiation hazard).

2.4.82 Setting

The value as set in the device (e.g., a switch) or BPCS (e.g., an alarm setting) to generate the notification at the desired limit. The setting will be in the engineering units of the device or BPCS, depending on the type of setting.

2.4.83 Shelve

Temporarily suppress an alarm, initiated by the operator, with engineering controls to unsuppress the alarm. Engineering controls can include time limits.

2.4.84 SIF Limit

The value at which the Safety Instrumented Function takes automated action to prevent or mitigate hazardous situations.

2.4.85 Silence

Operator action that terminates the audible alarm indication.

2.4.86 Stale Alarm

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

2.4.87 State-Based Alarm

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

2.4.88 Static Suppression

Operator-initiated suppression of specific notifications that are associated with a facility or piece of equipment that is out of service. The out of service status of the unit or equipment makes associated notifications redundant if no hazardous situation could possibly arise from the limit being exceeded.

2.4.89 Statistical Alarm

Alarm generated based on statistical processing of a process variable or variables.

2.4.90 Suppress

Prevent the annunciation of the alarm to the operator when the alarm is active (e.g. shelve, suppress by design, remove from service).

2.4.91 Suppress by Design

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

2.4.92 System Diagnostic Alarm

Alarm generated by the control system to indicate a fault within the system hardware, software or components (e.g. communication error).

2.4.93 Tag

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

2.4.94 Unacknowledged

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

2.4.95 Unshelve

Transition from the shelved alarm state to the normal or unacknowledged state.

2.4.96 Unsuppress

Transition from a suppressed alarm state to the normal or unacknowledged state.

2.4.97 Variable

Property or condition which can be measured (instrumented or not). A variable can also be calculated from measured variables.

2.4.98 Variable Table

See Master Alarm Database. This is an alternative name.

3 ALARM PHILOSOPHY

3.1 SCOPE

The alarm philosophy has been developed to align with requirements/recommendations of IEC 62682:2022.

The primary functions within the alarm system are:

- to communicate indications of abnormal process conditions or equipment malfunctions to the operators, the personnel monitoring and operating the process,
- to include a mechanism for communicating the alarm information to the operator via an HMI, usually a computer screen or an annunciator.
- an alarm and event log, an alarm historian, and the generation of performance metrics for the alarm system.

The alarm system includes both the basic process control system (CCS) and the safety system (SIS), each of which uses measurements of process conditions and logic to generate alarms for BLPH project.

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

3.2 ALARM MANAGEMENT LIFE CYCLE

3.2.1 Alarm management life cycle model

The alarm management life cycle covers alarm system specification, design, implementation, operation, monitoring, maintenance, and MOC (management of change) activities from initial conception through decommissioning.

Alarm management is the set of practices and processes that ensures an effective alarm system.

The life cycle is applicable for the installation of new alarm systems or managing an existing system (see Figure 4).

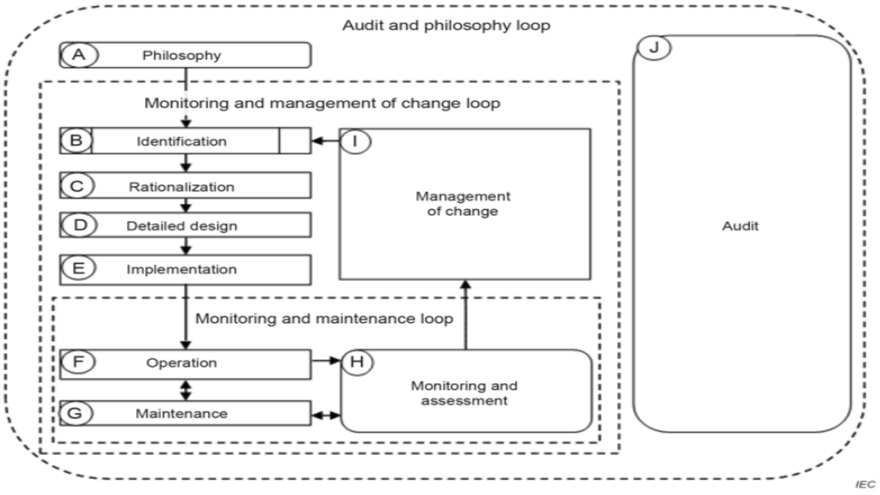


Figure 4 - Alarm management life cycle (IEC 62682:2022)

3.2.2 Alarm management life cycle stages

3.2.2.1 Philosophy (A)

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 development of the ASRS is included in the philosophy stage of the life cycle.

3.2.2.2 Identification (B)

The identification stage is a collection point for potential alarms proposed by one of the methods for determining if an alarm is necessary.

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 the rationalization phase.

3.2.2.3 Rationalization (C)

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 also 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.
- The activity of classification during which an alarm is assigned to one or more classes to designate requirements (e.g., testing, training, monitoring, and audit requirements).

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.

3.2.2.4 Detail design (D)

In the design stage, the additional alarm attributes are specified and designed based on the requirements determined by rationalization.

There are three areas of design:

- basic alarm design for each alarm follows guidance based on the type of alarm and the specific control system.
- HMI design that includes display and annunciation for the alarms, including the indications of alarm state and alarm priority.
- design of advanced alarming techniques (e.g., state-based alarming) improve the effectiveness of the alarm system beyond the basic alarm and HMI design.

3.2.2.5 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.

3.2.2.6 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.

3.2.2.7 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.

3.2.2.8 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.

3.2.2.9 Management of change (I)

In the management of change stage, modifications to the alarm system are proposed and approved.

3.2.2.10 Audit (J)

In the audit stage, periodic reviews are conducted to evaluate the effectiveness management process and maintain the integrity of the alarm system.

3.3 ALARM MANAGEMENT LIFE CYCLE STAGE INPUTS AND OUTPUTS

The alarm management life cycle stages are connected as the outputs of one stage are often the inputs to another stage. The below Table 4 provides more information on the relationships between the inputs and outputs of the life cycle stages.

Alarm management life cycle stage		Activities	Clause number	Inputs	Outputs
Stage	Title				
A	Philosophy	Documenting the objectives, guidelines and work processes for alarm management, and ASRS	6, 7	Objectives and standards, audit recommendations	Alarm philosophy and ASRS
B	Identification	Determining potential alarms	8	PHA report, P&IDs, operating procedures	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	Installing alarms, implementation testing, and implementation training	13	Completed alarm design, master alarm database, and 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

Table 4 – Alarm management life cycle stage input and output (IEC 62682:2022)

3.4 ALARM SYSTEM CORE ASSUMPTIONS

This alarm philosophy is based on the following core assumptions:

1. Alarm management does not replace constant surveillance by qualified personnel. Operators are expected to survey the BLPH operation and pre-empt any developing abnormal situations;
2. Operators are trained on the alarm management strategy;
3. Alarm priorities shall define the order of the operator's response in an event of multiple alarms;
4. The alarm system logs will be routinely reviewed and maintained, and documentation will be kept up to date;

5. The alarm system is reserved for events that require a response from the operator. Only such events shall be configured as alarms. Events that are useful for information, but do not require a specific action, will be presented as alerts.
6. Alarms shall be produced only for abnormal conditions and situations. Alarms should not activate as a result of routine changes of process variables. Normal conditions or operations shall not generate alarms.
7. Alarms shall be defined, configured, and handled such that a single process event does not produce multiple alarms indicating the same event, as far as reasonably practicable.

3.5 ALARM STATES

3.5.1 General

The alarm state transition diagram shown in below Figure 5 represents the states and transitions for typical alarms.

The circles in Figure 5 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.

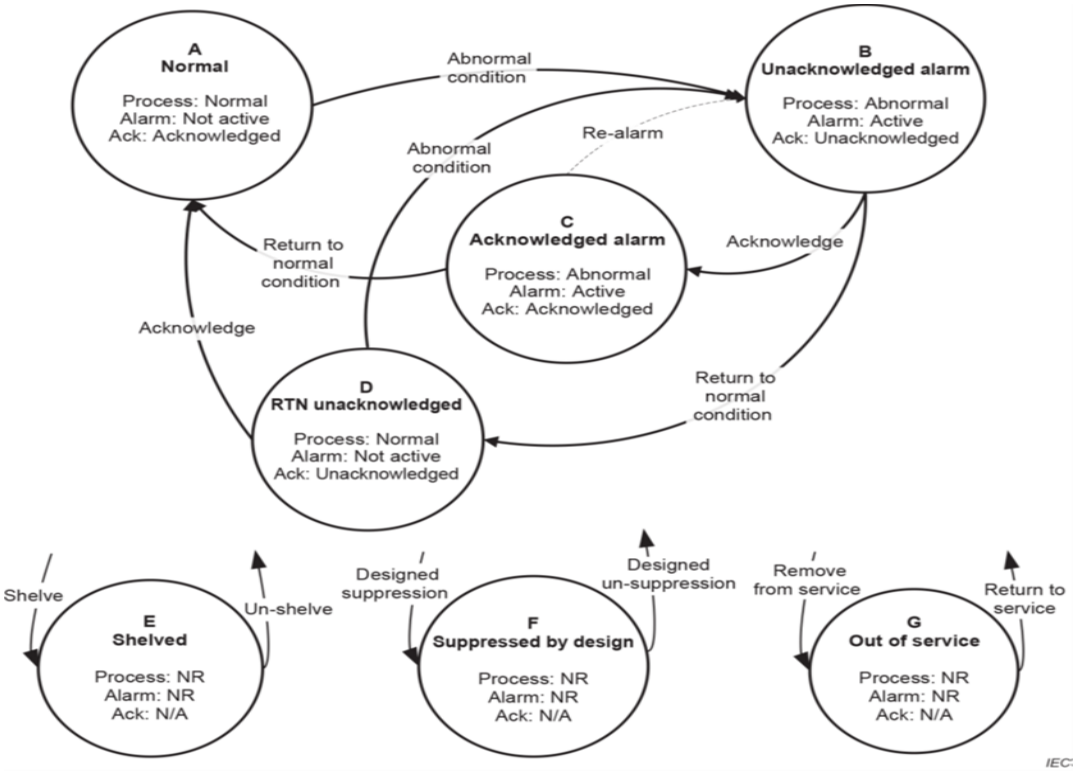


Figure 5 - Alarm state transition diagram (IEC 62682:2022)

3.5.2 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.

3.5.3 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.

3.5.4 Acknowledged state (C)

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

3.5.5 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.

3.5.6 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.

3.5.7 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.

3.5.8 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 in the maintenance stage of the life cycle.

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

3.5.9 Summary of alarm states

The alarm status, annunciation status, and acknowledge status of different alarm states are summarized in the below Table 5.

ID	Mnemonic	State name	Process condition	Alarm status	Annunciation 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-design state	Normal or abnormal	Not active or active	Suppressed	Not Applicable
G	OOS RV	Out-of-service alarm state	Normal or abnormal	Not active or active	Suppressed	Not Applicable

Table 5 – Summary of alarm states (IEC 62682:2022)

3.6 ALARM RESPONSE TIMELINE

3.6.1 General

The below Figure 6 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. This figure illustrates only one possible scenario to clarify the definition of terms related to time.

Ack delay, operator response delay and process deadtime can be zero.

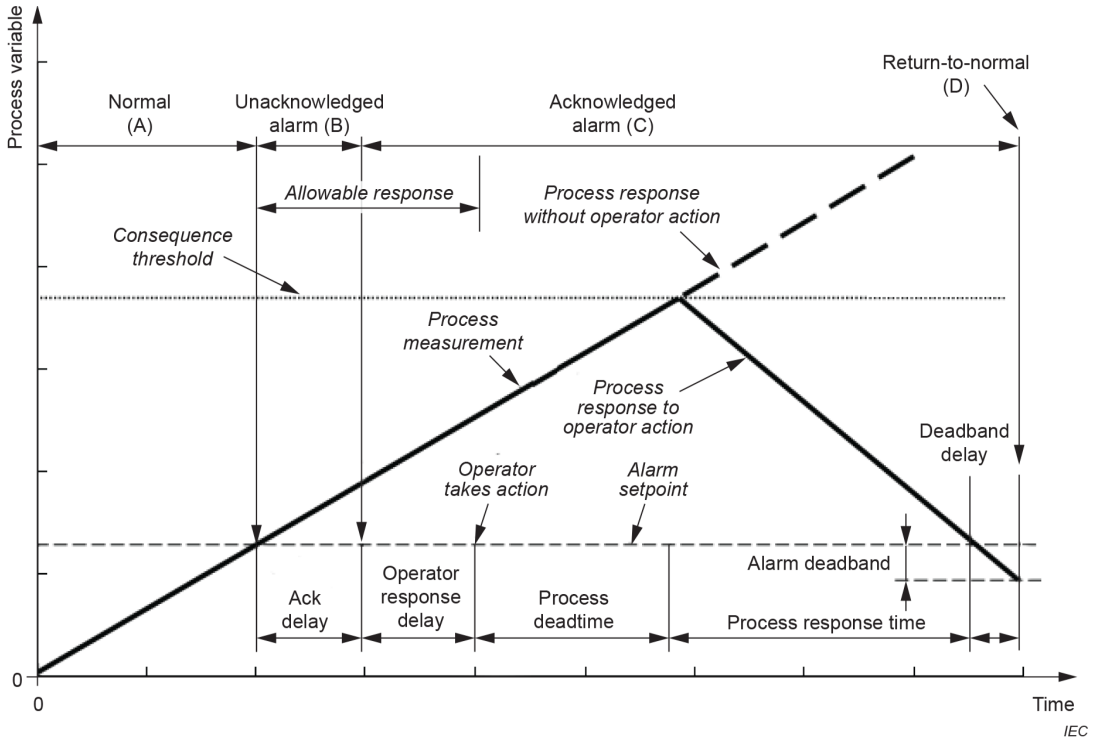


Figure 6 – Alarm response timeline (IEC 62682:2022)

3.6.2 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 alarm occurrences have been acknowledged.

3.6.3 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.

3.6.4 Acknowledeged (C) and response

The acknowledged alarm state is reached when an operator acknowledges the alarm, after the acknowledge delay. In this state the alarm is active. The operator can take action before or after acknowledging the alarm. 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.

3.6.5 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.

3.6.6 Allowable response time

The allowable response time is the time beginning with the alarm annunciation and ending at the last moment operator action can prevent the consequence. It can be estimated working backwards from the consequence threshold, considering the process deadtime, the rate of change of the process variable and the separation between the alarm setpoint and the consequence threshold. In Figure 6, the operator response delay is shown within the allowable response time.

3.6.7 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.

3.6.8 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.

3.6.9 Alarm deadband

The deadband delay shown in Figure 6 illustrates that the alarm does not return to normal immediately after crossing the alarm setpoint.

3.6.10 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.

4 ROLES AND RESPONSIBILITIES

The responsibilities for developing and implementing the Alarm Management Philosophy shall be split between the Technical Safety, Process Engineering, Operations, and Instrumentation & Control disciplines.

Strong operations management support is essential for effective alarm management and consistent implementation. Operations management shall ensure that the alarm system's lifecycle adheres to the philosophy and guidance as outlined in this document. Operations own the alarm system and are ultimately responsible for its effective performance.

The Alarm Management program will involve several roles of onshore/offshore personnel for the BLPH Development Project (Unmanned platform). This section defines each of the roles and responsibilities to the Alarm Management program.

4.1 CONTROLS TECHNICAL AUTHORITY

The Controls Technical Authority is responsible for the overall engineered and technical design to the control and alarm system.

- Reviews all alarm management related Engineering Queries to ensure they adhere to the Alarm Management Philosophy.
- Reviews monthly alarm management assessments.
- Ensures the Alarm Management Philosophy is kept up to date and relevant to the facility.
- Conduct annual performance audits measured against the alarm philosophy.
- Be involved in any Alarm Rationalisation Process.

If any areas lie outside of the desired performance region, then:

- If the problems are with a small number of tags, then ensure these are resolved.
- If the problems are not isolated, initiate an appropriate corrective action on the area.

4.2 CONTROL AND INSTRUMENTATION ENGINEER

The responsibility for the design aspects of alarm system shall be assigned to the lead control and instrumentation engineer. The lead control and instrumentation engineer shall be accountable for:

- Approval of any change requests to the alarm systems;
- Alarm system design (as an integral part of the automation system) to satisfy ARM requirements about build, testing and commissioning;
- Automation system and field equipment diagnostic alarms. The responsibility and accountability for diagnostic alarms that are generated by other equipment (e.g. electrical systems) may be delegated to the corresponding discipline lead (e.g. Electrical Lead Engineer);
- "As built" documentation of alarm system.

The responsible engineer may delegate aspects of alarm system design and implementation to a third party (e.g. EPC).

4.3 TECHNICAL SAFETY ENGINEER

The responsibly for technical and safety aspects of the alarm system shall be assigned to the lead technical safety engineer. The technical safety engineer shall be accountable for:

- Specifying any safety critical alarms (from HAZOP / LOPA studies);
- Ensuring that human factor issues are identified and considered in developing the ARM;
- Approving set points for the alarms.

4.4 MAINTENANCE TEAM LEADER

The Maintenance Team Leader leads the maintenance team to provide technical and specialist discipline support for the maintenance and integrity of BLPH Project and equipment. Within this remit, he would typically ensure that personnel are available to maintain the alarm system.

Other typical responsibilities include:

- Ensure the control room operators have an adequate means to detect and respond to abnormal situations
- Review monthly assessment reports
- Mediate/decide any corrective actions required for the alarm system in accordance with the Alarm Philosophy.

4.5 OPERATION TEAM LEADER

The OTL ensures the alarm system is maintained and utilised for the protection of personnel and equipment under their direction. Ensure that the alarm system and management tools are available, operational, used and maintained according to the Alarm Philosophy.

Ensure employees recognise personal responsibility for alarm management practices

The OTL is responsible for:

- The maintenance and update of the Alarm Response Manual
- Review of operator reported alarm issues and ensures incident review recommendations adhere to Alarm Philosophy guidelines.
- Creation of work requests based on issues raised by the operators.
- Investigation alarm performance following major upsets and events.

4.6 OPERATIONS CO-ORDINATOR / CONTROL ROOM OPERATOR

The quality of the alarm system impacts operations most directly. Consequently, to achieve operational acceptance, representatives from this group must be included in the decision process. As such, the Operations Co-Ordinator and Control Room Operators are responsible for the following activities:

- Raise notifications on the event of nuisance alarms.
- Raise recommendations for the change of alarm set points.
- Acknowledge, diagnose and respond to alarms.
- Involvement in rationalisation of alarm system.

4.7 RESPONSIBLE INSTRUMENT PERSON

The Responsible Instrument Person's primary responsibility for the alarm management system is to maintain and repair the instrumentation and equipment that provides the input signals to the distributed control system that generates the alarm events. The Responsible Instrument Person is also responsible for initiating resolution to alarm problems that relate to instrumentation and equipment.

- Provide and maintain instrumentation and equipment for the alarm management system.
- Schedule alarm testing according to the Preventative Maintenance Plan.
- Identify alarm and control problems that require resolution.
- Create, maintain and issue work orders pertaining to the alarm management program.
- Be involved during any Alarm rationalisation process.

4.8 INSTRUMENT TECHNICAL

- Complete work orders pertaining to the improvement of the instrumentation that are affecting the alarm system.
- Report any faulty equipment or instrumentation that will have an adverse effect on the alarm system.

4.9 PAS HEALTHCARE CONTRACTOR

The PAS Health Care Contractor provides services to maintain the alarm system. They have administrative access to the system. The responsibilities are;

- Implement changes from alarm rationalisation on the HMI.
- Provide a list of new tags to the Technical Area Authority for review provided new tags are not being created as a result of rationalisation recommendations.
- Review of Engineering Queries that will change the alarm system.
- Prepare and maintain the accuracy of the Master Alarm Database.
- Contributes logic and alarm configuration data to incident reviews
- Implement changes to configuration of alarms raised through MOC.

5 IDENTIFICATION AND RATIONALIZATION

5.1 IDENTIFICATION

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 life cycle for the recommended alarms or alarm changes. Identified alarms are an input to rationalization.

Potential alarm signals can be generated from several sources. For BLPH Project facilities, main sources of alarm signals are:

- ⇒ Safety System - SIS system
- ⇒ Fire and gas System - FGS system
- ⇒ F&G detection equipment that interface to FGS system
- ⇒ Process Control System - PCS
- ⇒ EMCS and interfaces to Electrical Switchgear
- ⇒ Electrolyser
- ⇒ Fuel cell
- ⇒ BESS
- ⇒ HVAC system
- ⇒ Water Treatment Package
- ⇒ Instrument Air Package
- ⇒ Nitrogen Package
- ⇒ Navaids
- ⇒ H2 Storage system
- ⇒ Vent system
- ⇒ Intrusion Detection system

Whatever its source, every alarm should be justified (safety, environmental or business needs), engineered and be consistent with the overall alarm philosophy and risk assessments.

To enable comprehensive identification of signals, the following documents shall be available at the start of the review:

- Process and Instrumentation Diagrams (P&IDs);
- Cause and effect matrix (SIS and FGS);
- Simplified logic diagrams;
- Details of any controlled sequences;

- Configuration details for any complex points, such as digital composites;
- HAZOP Report
- LOPA Report

Raw alarm database is the term given to collection of all signals which have a potential alarm configured in the control system.

The BLPH facility shall operate as an unmanned facility connected to a remote Central Control Room (CCR) via a Fibre Optic (FO) cable.

For BLPH Project, the onshore is designated as the main control room for the unmanned offshore BLPH facility.

The interface of all the packages with the PAS will be via hard wiring, or data links like Modbus TCP/IP or Profinet. Packages will have its own standalone UCP.

The monitoring and control data will be communicated between the UCP and PAS via data link such as Modbus or Profinet and the safety will be through hardwired communication between the UCPs panels and safety system (SIS and FGS).

Signals from the field mounted instrumentation and packages will be interfaced to the PAS by:

- Hardwired from the field to the PAS input/output modules via field junction boxes to the marshalling cabinets.
- Modbus TCP/IP, ProfiNET data links from the major package control equipment to the PAS. HART data from packages via serial interface from package.
- IEC61850 or Modbus TCP/IP for Switchgear Interface.
- HART interface for all hardwired smart transmitters including shutdown systems (SIS and FGS).

An Alarm Objective Analysis shall be conducted as a workshop activity. Its primary objectives are:

- For each signal being assessed, establish if there is a valid reason to generate an alarm;
- For those signals judged to be a valid alarm initiator, subject them to classification and prioritisation;

For non-alarm signals, categorise them into the following categories:

- Alerts; or
- Remove alarm

For genuine alarm signals, identify the following:

- the consequence threshold (e.g., constraint),
- the operator response,
- the consequence of inaction,
- the probable cause, and
- the rationale for the consequence threshold.

The output from the Alarm Objective Analysis is an Intermediate Alarm Database.

5.2 RATIONALIZATION

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 alarm philosophy.

Rationalization produces the detail design information, documented in the master alarm database, necessary for the design stage of the alarm management life cycle.

The activities of rationalization are:

- alarm type,
- alarm priority,
- alarm class,
- alarm setpoint or logical condition (e.g., off-normal),
- operator action,
- consequence of inaction, and
- plant state.

Rationalization should determine and document the following for every alarm, for each applicable plant state:

- the maximum allowable response time,
- the probable cause,
- the rationale for the alarm setpoint,
- the identification method, and
- the need for advanced alarming techniques, if necessary.

The goals of the alarm rationalisation are to:

- Design an alarm system that is useful to the operator during normal operation as well as during periods of high alarm traffic, such as process upsets or ESD trips.
- Select the minimum number and the proper type of alarms that best indicate the root problems that an operator may experience.
- Define the appropriate alarm limits and the unique response for each alarm.
- Assign alarm priorities based on the severity of the potential abnormal condition and the urgency required to respond to the condition.
- Develop the Master Alarm Database that defines all of the required alarms and alarm information, such as tag, trip point, priority, and required corrective action to restore normal operation.

- Provides an auditable process for alarm system design.

The rationalisation process will involve a team of people from operations, engineering, and an impartial facilitator sitting in a room together and methodically reviewing each alarm on a per process system basis.

5.2.1 Plant State

Plant states for BLPH include:

a. start-up (including purging of H2 tanks)

b. normal operation (including charging and discharging of H2 tanks)

c. shutdown

5.2.2 Alarm Justification

The criteria from the definition of alarm include that:

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

All alarms are systematically reviewed, usually by progression through engineering drawings, databases, or HMI displays.

Alarm justification should verify that:

a. the alarm will not become a nuisance, and

b. the alarm does not duplicate another alarm.

5.2.3 Alarm Setpoint determination

Effective methods to determinate the alarm setpoints use information including:

1. the allowable response time,
2. the complexity of the operator action,
3. the time necessary to complete the operator action,
4. the normal operating range,
5. other operating or design boundaries, and
6. knowledge of the process operation and history.

For each limit with an alarm, the alarm shall be set such that all of the following are achieved:

a. No alarm occurs from normal process fluctuations and signal noise;

b. There is sufficient time available for the operator to respond and prevent the consequence;

c. The process does not exceed the equipment or process limit, assuming correct and timely operator action and a credible process dead time;

d. Inaccuracies in the process measurement – at the point of the desired limit – are taken into account;

e. Uncertainties in the equipment or process limits are taken into account.

5.2.4 Prioritization

Alarms and Alerts are collectively called notifications.

Alarm Priority is the relative importance assigned to an alarm within the alarm system to indicate the urgency of response.

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

As per feed document "Preliminary Alarm Master Database" n° K559-2254-IC-LST-001, the Alarm Priority shall only be populated for packages that have serial communication with the PAS.

In this study, Priority will use seriousness of consequences and allowable response time to determine urgency.

The table below should be used to determine alarm priority.

	Event consequence -->		
Urgency	Large	Medium	Small
Immediate	P1	P1	P2
Prompt	P1	P2	P3
Soon	P2	P3	P3

Table 6 – Alarm Priority

The following priority descriptions will be used:

- High priority (P1)
- Medium priority (P2)
- Low priority (P3)

Alarm priorities are to be assigned based on the required action upon receipt of alarm. All alarms, including system alarms shall be prioritised. Key factors in determining alarm priority shall be time available for operator action, consequence of failure to take corrective action and if they are HSE-critical. Priority shall be distinguished by display location and/or colour as per guidelines in the relevant standards.

5.2.4.1 High Priority (P1)

A priority assigned to alarms that require immediate operator attention and action for emergency responses. This is meant for those emergencies or events that may lead to have major impact on HSE e.g. a catastrophic / major environmental incident, unplanned unit shut down and economic loss to the Company. These include Fire and Gas alarms and alarms tied to executive functions.

5.2.4.2 Medium priority (P2)

A priority assigned to alarms that require very fast operator attention and action to prevent a serious operational upset or shut down. This is meant for those events that are likely to lead to serious / moderate process upset, unit shutdowns, serious / moderate economic loss and minor HSE issues.

5.2.4.3 Low priority (P3)

A priority assigned to alarms that do not require fast operator action, but which should nevertheless be brought to the operator's attention. This is meant to cover those incidents that have minor significance. Delayed response should never pose a threat to Company's HSE matters, or a stable operation of the unit.

Here below the Table 7 with the Assigning of Activities & Alarm Priorities Based on Urgency of Operator Response:

Activity Type	Action Type	Priority
Fire	Immediate	P1
Gas release		
Major rupture		
Emergency		
Plant shutdown	Prompt	P2
System failure to plant shutdown		
Major equipment shutdown		
Major process upset		
Equipment trip/shutdown	Soon	P3
Normal process upset		
MOS/OOS switching		
System faults, but plant in operation		
Stand by in operation	Record	Journal
Events		
Set point changes		
Mode changes		
Operational messages		
Raise work order (Note-6)		

Table 7 – Assigning of Activities & Alarm Priorities Based on Urgency of Operator Response

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 8.

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.	

Table 8 – Example annunciated alarm priority distribution (IEC 62682:2022)

- Less than 5% of all alarms should be in a process unit should be High priority
- Less than 15% of all alarms should be in a process unit should be Medium priority
- Greater than 80% of all alarms in a process unit should be Low priority.

5.2.4.4 Urgency

As per feed document "Preliminary Alarm Master Database" n° K559-2254-IC-LST-001, the urgency shall only be populated for packages that have serial communication with the CCS.

a. Urgency is the difference between TTE and ORT and represents how much time an operator has available before beginning alarm response.

b. For Serial packages, Urgency shall be categorised into three bands

Urgency	TTE-ORT
Immediate	> 5 minutes and ≤ 10 minutes
Prompt	10 minutes to 30 minutes
Soon	> 30 minutes to end of shift

Table 9 – Urgency

5.2.4.5 Time to event (TTE)

TTE is the amount of time (in minutes) between the activation of an alarm and the point at which operator action can no longer influence the consequence. The suggested TTE periods that can be entered are listed below. However, the TTE will be discussed and agreed during alarm rationalisation and may differ from the values below.

- 10 minutes
- 30 minutes
- 60 minutes
- 90 minutes

- 2 hours
- 6 hours
- 12 hours
- 24 hours
- 48 hours
- 72 hours

5.2.4.6 Operator Response Time (ORT)

ORT shall only be populated for packages that have serial communication with the CCS.

ORT is the Total time required for the operator to complete the following:

a. correctly analyses an alarm.
b. identifies the initiating cause.
c. verifies by checking other indications to validate accuracy of the identified alarm.
d. acknowledge alarm to convey to system that operator has verified alarm.
e. ascertains the potential consequences.
f. takes all necessary actions to avoid escalation of the abnormal situation and prevent the potential consequences related to the alarm.
g. monitors the effectiveness of the response actions to ensure the consequence has been averted. i.e. where there is a long process response time, this should be factored into the ORT determination.

5.2.5 Alarm class definition

Alarm classes are used to set common requirements for managing alarms. An alarm may belong to more than one class. Definition of the alarm classes can include the following:

a. alarm prioritization considerations,
b. alarm documentation,
c. HMI design,
d. operating procedures associated with the alarms,
e. training and training documentation,
f. alarm maintenance,
g. alarm testing,
h. alarm monitoring and assessment,
i. alarm MOC,
j. alarm history retention,

k. alarm audit.

5.2.6 Highly managed alarm (HMA)

Highly managed alarm (HMA) classes are classes of alarms that require more administration and documentation than others. The designation of alarm classes as highly managed should be based upon one or more of the following:

a) alarms critical for the protection of human life (e.g., safety related 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,
h) alarms for company policy

The Highly Managed Alarms (HMA) Sub-categorie sthat be considered for BLPH project are:

- SRA-Safety Related Alarms

SRA assignment shall include, but not be restricted to, alarms which are formally documented as providing quantified risk reduction (safety or environmental), for example, by a LOPA or QRA study. In BLPH project the SRA alarms have been not found.

- CFA-Critical Fault Alarms

The following alarms shall be categorised as critical fault alarms.

1. Alarm indicating control or protective systems running on batteries.
2. Alarm indicating low instrument air pressure to a site or unit.
3. Alarm indicating unavailability or failure of F&G detector
4. Alarm indicating bad PV on SRA or BPCS layer of protection.
5. Alarm indicating degraded redundancy in an SIS or F&G logic solver.
6. Others as deemed appropriate by alarm class owners.

- MA-Mitigation (F&G alarms)

The following alarms shall be categorised as mitigation alarms.

1. Fire detection alarms.
2. Flammable gas detection alarms.
3. Manual call point activation alarms.
4. O2 exceding atmosphere alarms.

5.2.6.1 HMA implementation testing

Implementation testing is required prior to putting the alarms into operation. The testing shall be documented, as follows:

- The alarm setpoint or logical conditions
- The alarm priority
- The audible and visual indications for the alarm
- Any other functional requirement for the alarm as specified
- The persons conducting the test
- The method of testing and acceptance criteria
- The results of the testing and resolution of any failures or non-compliance
- The date of the testing and
- The date the alarm was put into service

For the HMA alarms (apart from the SRA alarms), the test frequency shall be as per the maintenance procedure.

5.2.6.2 HMA Shelving and Out-Of-Service

The shelving of HMA alarms shall follow authorisation and re-authorisation requirements.

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

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

- The name of the tag in alarm
- The alarm type
- Approval details
- Details concerning interim alarms or procedures if required
- The reason for taking the alarm out of service

5.2.6.3 HMA Training

Implementation and refresher training shall be performed and shall include:

- The alarm rationalisation information(e.g. consequence, causes for alarm, corrective action, etc.)
- The audible and visual indications for the alarm

The following training information on highly managed alarm shall be documented:

a. the persons trained,
b. the method of training, and
c. the date of the training.

d. a summary of the training material,

5.2.7 Master Alarm Database (MAD)

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.

The MAD is an authorized list of rationalized alarms and associated attributes (the list can be in many forms and not only in the form of a database).

The Attribute Description has been considered as per feed doc. "Preliminary Alarm Master Database" n° K559-2254-IC-LST-001.

6 DETAIL DESIGN

The detail design addresses the design consideration to implement the alarms within a specific control system as specified by the rationalization process.

The design for alarms shall be consistent with the alarm philosophy and the overall control system design philosophy.

6.1 USAGE OF ALARM STATES

6.1.1 Alarm State triggering

The source for each alarm should be documented. Changes in alarm state can be triggered from various sources within a control system including:

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

b. the control system (i.e., PCS, SIS, packaged system), and

c. the HMI.

6.1.2 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 functions (e.g., as an interlock setpoint) in addition to operator notification, then documentation, training and MOC can be impacted.

Additionally, the impact of modifying alarm attributes as well as the use of designed suppression should be clearly identified, documented, and potentially restricted (e.g., extra confirmation and higher access level required). This information should be specifically documented in the alarm philosophy under alarm design principles.

6.1.3 Alarm suppression and other logic functions

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

6.2 ALARM TYPE

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

The available alarms for BLPH will be classified into the following categories:

- ABSOLUTE: Comparison of variable signal against a defined alarm setting.
- BAD MEASUREMENT: Variable is outside its pre-set range.
- BIT PATTERN: Comparison of digital signals against a predefined pattern.
- CALCULATED: Comparison of the output of a functional calculation with a defined alarm setting.

- SYSTEM: Faults within the automation system.
- DEVIATION: Comparison of the difference between two variables to a predefined setting.
- DISCREPANCY: Comparison of expected plant state against actual plant state.
- FIRST UP FAULT: Indicates the initiating trip in a cascade of trip events.
- GROUP ALARM: Indicates that at least one of several abnormal conditions, identified by a group of initiators is present.
- RATE OF CHANGE: The rate of change of a variable exceeds a defined setting.
- STATISTICAL ALARM: Generated on statistical processing of a process variable or variables.

Alarm types should be selected carefully based on engineering judgment.

6.3 ALARM ATTRIBUTES

During the basic design process, the alarm attributes should be selected for each alarm that has been rationalized and set based on engineering judgment. Attributes such as alarm 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.

Alarm attributes should include:

- alarm description,
- alarm setpoint or logical conditions,
- alarm priority,
- alarm deadband,
- on-delay or off-delay
- alarm group, and
- alarm message.

6.3.1 Alarm description

All alarms shall have an informative text provided as a tag description, or alarm description, or both. A structured layout and consistent wording should be used in the description.

6.3.2 Alarm setpoints

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

6.3.3 Alarm priority

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

6.3.4 Alarm deadbands

The Alarm deadband is the change in signal from the alarm setpoint necessary for the alarm to return to normal. Alarm deadband is an alarm attribute used to reduce the number of times an alarm is triggered for a given abnormal condition, which ideally would be only once. It prevents an alarm from returning to normal until the alarm 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 in eliminating nuisance alarms.

The control system shall provide the functionality to implement deadband.

Engineering judgment should be employed when setting deadbands in order to minimize nuisance alarms while maintaining process vigilance and plant/personnel safety.

The EEMUA 191 guidance suggests the following defaults:

- Flow: 5%
- Level: 5%
- Pressure: 2%
- Temperature: 1%

Increased values for dead-bands will often reduce the number of "repeating" alarms.

6.3.5 Alarm on-delay and off-delay requirements

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

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 determination should take into consideration the 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 delay on operator response. Settings should be reviewed during commissioning and after sufficient operating experience.

6.4 PROGRAMMATIC CHANGES TO ALARM ATTRIBUTES

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

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

b. advanced alarming techniques,

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

The alarm philosophy should detail the use and limitations of the functionality for programmatic changes. For each alarm, it should be identified and documented which programs of the system will have access to modify alarm attributes during operation and which changes will be subject to MOC procedures.

6.5 REVIEW OF BASIC ALARM DESIGN

A typical control system provides the ability to implement numerous different alarm types for a single process variable. The basic alarm design results should be reviewed against the master alarm database to ensure that only the required alarms are implemented.

7 HUMAN-MACHINE INTERFACE DESIGN FOR ALARM SYSTEM

7.1 PURPOSE

The indication of alarms is only one component of the HMI design and contributes to effective operator–process interaction.

If implemented on the BPCS, alerts shall be distinguishable from alarms.

a. Alerts shall use a separate alert list and not be included in the alarm list.

b. Alerts should not be audible.

c. Alerts shall not require acknowledgement.

7.2 HMI FUNCTIONS

7.2.1 General

The HMI design for alarms shall 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.

7.2.2 HMI information requirements

The HMI shall clearly indicate:

a) unsuppressed active alarms,

b) alarm states,

c) alarm priorities

d) alarm types

7.2.3 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,

g) display alarm messages.

7.2.4 HMI functional recommendations

The HMI should provide the ability for the operator to access the alarm response procedures.

7.2.5 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,
f) out-of-service summary displays.

7.2.6 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,
f) time and date of occurrence of the alarm state change.

7.2.7 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),
e) alarm message.

7.3 ALARM STATES INDICATIONS

7.3.1 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,
d) return-to-normal unacknowledged alarm,
e) shelved alarm,
f) suppressed-by-design alarm,
g) out-of-service alarm.

7.3.2 Recommended alarm state indications

7.3.2.1 Normal states indication

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

7.3.2.2 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 colours and symbols (e.g., shape, text, a combination or shape and text). The visual indication for an unacknowledged alarm should include a blinking element.

7.3.2.3 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, text, a combination or shape and text), and should be related in colour to the unacknowledged alarm indication. A blinking element should not be used in the visual indication for an acknowledged alarm.

7.3.2.4 Return-to-normal unacknowledged state indication

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

7.3.2.5 Shelved alarm state indication

The shelved alarm state should be visually indicated in the HMI. The visual indication for a shelved alarm should not include a blinking element. The shelved alarm state indication should be unique. No audible indication should be used to identify shelved alarms.

7.3.2.6 Suppressed-by-design alarm state indication

The suppressed-by-design alarm state should be visually indicated in the HMI. The visual indication for an alarm suppressed by design should not include a blinking element. The suppressed-by-design alarm state indication should be unique. No audible indication should be used to identify alarms suppressed by design.

7.3.2.7 Out-of-service alarm state indication

The out-of-service alarm state should be visually indicated in the HMI. The visual indication for an out-of-service alarm should not include a blinking element. The out-of-service alarm state indication should be unique. No audible indication should be used to identify out-of-service alarms.

7.3.2.8 Summary of alarm state indication

The audible and visual alarm state indications for typical alarms are summarized in the below Table 10.

Alarm state	Audible indication	Visual indications		
		Colour	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	Combination		No
Suppressed-by-design alarm	No	Combination		No
Out-of-service alarm	No	Combination		No
NOTE 1 "Yes" signifies the indication type is used to indicate the alarm state. NOTE 2 "No" signifies the indication type is not to be used to indicate the alarm state. NOTE 3 "Combination" signifies the indication is a combination of visual colour and symbol indications. NOTE 4 "Optional" signifies the indication is not required.				

Table 10 – Recommended alarm state indication (IEC 62682:2022)

7.3.3 Audible alarm state indications

The audible alarm indication for unacknowledged alarms may also be 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, series of lights).

7.4 ALARM PRIORITY INDICATIONS

7.4.1 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.

7.4.2 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.

7.4.3 Colour alarm priority indication requirements

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

7.4.4 Recommended alarm priority indications

7.4.4.1 Symbol alarm priority indications

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

7.4.4.2 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.

7.5 ALARM MESSAGE INDICATIONS

7.5.1 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.

7.5.2 Recommended alarm message indications

The following alarm message indications is common industry practice:

a) visual alarm message indications,

7.5.2.1 Visual alarm message indications

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

7.6 ALARM DISPLAYS

7.6.1 General

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

The displays can 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,
i) out-of-service alarm display.

The displays are described with required or recommended functions.

7.6.2 Alarm summary display

7.6.2.1 Alarm summary display requirements

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.

7.6.2.2 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,
f) the alarm type.

7.6.2.3 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,

d) the alarm message.

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

- the number of alarms in the summary list,
- the number of unacknowledged alarms in the summary list.

7.6.2.4 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,

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

7.6.2.5 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,

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

g) filtering of alarms by tag name,

h) time limits for filters,

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.

7.6.3 Alarm summary status

7.6.3.1 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.

7.6.3.2 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,

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

7.6.3.3 Functional recommendations

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

7.6.4 Alarm log displays

7.6.4.1 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).

7.6.4.2 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,

h) the alarm type.

7.6.4.3 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,

d) filtering by priority,

e) filtering by alarm type, and

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

7.6.5 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,

e) the alarm type.

7.6.6 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,

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

7.6.7 Other graphic elements

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

7.7 ALARM SHELVING

7.7.1 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 a functionality, such as a time limits, to ensure the integrity of the alarm system is maintained.

7.7.2 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,

f) a record of each alarm shelve action with timestamp,

g) a record of each unshelve event with timestamp.

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

7.7.3 Alarm shelving functional recommendations

The alarm shelving function should be designed to prevent unshelving alarm floods by automatically unshelving active alarms too quickly. The state transitions from shelving are:

- a manually unshelved alarm should transition to the acknowledged alarm state,
- an automatically unshelved alarm should transition to the unacknowledged alarm state.

The shelving function should record the identity of the person that shelved the alarm.

7.7.4 Shelved alarm displays

7.7.4.1 General

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

7.7.4.2 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,

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

7.7.4.3 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,

c) sorting of alarms by tag,

d) individual unshelving of alarms.

7.7.4.4 Functional recommendations

Shelved alarm displays should provide the following functions:

a) filtering of alarms by priority,
b) filtering of alarms by alarm state,
c) filtering of alarms by process area,
d) operator entry of the reason the alarm was shelved,
e) unshelving of alarms by group,
f) navigational link to a process display,
g) navigational link to the tag detail display.

7.8 OUT-OF-SERVICE ALARMS

7.8.1 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.

7.8.2 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,
e) a record of each out-of-service action with timestamp,
f) a record of each return-to-service event with timestamp.

7.8.3 Out-of-service alarm displays

7.8.3.1 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.

7.8.3.2 Information requirements

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

a) tag name for alarm,

b) tag description or alarm description,

c) alarm type,

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

e) the alarm priority,

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

7.8.3.3 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,

e) individual return to service of alarms.

7.8.3.4 Functional recommendations

Out-of-service alarm displays should provide the function for operator entry of the reason the alarm was suppressed and the approximate anticipated duration of the suppression (e.g., less than an hour, less than a day, less than a week, less than a month).

7.9 ALARM SUPPRESSED BY DESIGN

7.9.1 General

The designed suppression of alarms is a required function and it is 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.

7.9.2 Designed suppression functional requirements

The designed suppression function shall provide the following:

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

b) a record of each suppress-by-design event with timestamp,

c) a record of each unsuppress-by-design event with timestamp.

7.9.3 Designed suppression functional recommendations

The designed suppression function should be designed to prevent alarm floods when active alarms are automatically unsuppressed. An automatically unsuppressed alarm should transition to the unacknowledged alarm state if the alarm is active.

7.9.4 Suppressed-by-design displays

7.9.5 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.

7.9.6 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., active or not active),
e) the alarm priority,
f) the time and date the alarm was suppressed.

7.9.7 Information recommendation

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

7.9.8 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,
d) sorting of alarms by process area.

7.9.9 Functional recommendation

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

7.10 ALARM ANNUNCIATOR INTEGRATION

7.10.1 General

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

7.10.2 Alarm annunciator integration recommendations

Alarm annunciators should be integrated in a manner that provides the following functions:

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

b) prevention of redundant alarms in the control system,

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

8 IMPLEMENTATION

Implementation is a separate stage of the alarm management life cycle, which is the transition from design to operation.

Implementation planning should include the following considerations:

a. disruption to operation,

b. availability of competent resources,

c. functional testing or verification,

d. verification of documentation, and

e. operator training.

8.1 IMPLEMENTATION TRAINING

Operators shall be trained on the response to all new or modified alarms.

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

1. the persons trained,
2. a summary of the training material,
3. the method of training, and
4. the date of the training.

Training of new alarm system should include:

a. the audible and visual indications for alarms,

b. the methods for silencing an alarm,

c. the distinction of alarm priorities,

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

e. the methods for shelving and suppression, and

f. the methods for removing an alarm from service.

8.2 IMPLEMENTATION TESTING AND VERIFICATION

Alarms should be tested during implementation prior to putting the alarms in operation. 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 if specified.

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.

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

1. tag name for alarm,
2. tag description or alarm description for alarm,
3. alarm type,
4. priority,
5. alarm setpoint value or logical condition,
6. operator action,
7. method of testing and acceptance criteria, and
8. results of the testing and resolution of any failures or non-compliance.

9 MONITORING AND ASSESSMENT

9.1 PURPOSE

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 can trigger maintenance work or identify the need for changes to the alarm system or operating procedures.

Without monitoring an alarm system is likely to degrade over time.

This stage verifies that design, implementation, rationalization, operation, and maintenance are satisfactory.

The intent of monitoring and assessment is to identify and correct deviations from expected performance. Monitoring the alarm systems involves analysis of the alarm records to calculate performance and diagnostic metrics.

Alarm system assessment is the comparison of performance metrics against the targets specified in the alarm philosophy.

9.2 ALARM SYSTEM PERFORMANCE METRICS

Both initial alarm system assessment and on-going monitoring should include the measures like those shown in the Table 11:

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 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	

Table 11 – Recommended alarm performance metrics summary (IEC 62682:2022)

In general, at least 30 days of data is practical for calculating the metrics.

9.3 AVARAGE ALARM RATE PER OPERATION 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) are shown in Table 12. 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.

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

Table 12 – Average alarm rates (IEC 62682:2022)

Sustained operation above the manageable guidelines indicates an alarm system that is annunciating more alarms than an operator is likely able to manage and can impact the probability of operator error.

9.4 PEAK ALARM RATE PER OPERATOR CONSOLE

For peak alarm rate analysis, annunciated alarms are counted in regular 10-minute intervals. The peak alarm rate is the highest number of alarms annunciated in one interval.

The recommended target is a peak alarm rate less than 10.

Additionally, as a recommended target, less than 1 % of the 10-minute intervals should contain more than 10 alarms.

9.5 ALARM FLOOD

The alarm flood Is the condition during which the alarm rate is greater than the operator can effectively manage (e.g. more than 10 alarms per 10 minutes). Alarms floods during upset conditions can cause a minor event to es-calate into a more serious incident.

Alarm floods are variable-duration periods of alarm activity with annunciation rates likely to exceed the ability of the operator to respond. 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 a 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 a reduced alarm rate (e.g., an alarm rate of less than 5 alarms per 10 minutes).

As a recommended target, an alarm system should be in flood for less than 1% of the time.

9.6 ALARMS MANAGEMENT PROCESS

All configured alarms shall either be assigned to one of the pre-defined alarm categories or analysed individually.

Following the realisation and commissioning of the alarm system, the performance of the alarm system is measured. If performance is satisfactory, the review process is completed. If performance is not acceptable further improvement effort shall follow.

The alarm study (or alarm review process) is split into two phases. The first phase of the alarm study is intended to establish whether an alarm is really necessary or appropriate, or whether the risk associated with the hazardous situation becomes ALARP with an alarm.

The first phase also establishes expected operator response times, process safety time and the severity of consequences if the alarm is not responded to. The alarm priority is derived from the process safety time and the severity of the consequences.

The second phase of the alarm study establishes the required operator actions, suppression requirements and other relevant parameters.

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