Base Load Power Hub (BLPH)

Alarm Management Workshop Terms of Reference

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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.

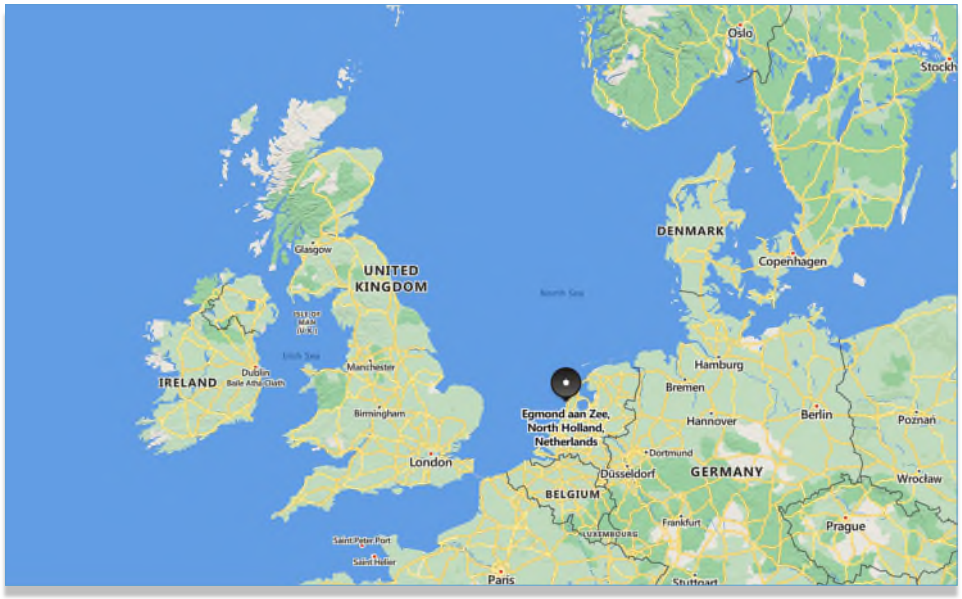


Figure 1 - HOLLANDSE KUST NOORD WIND PARK Location Map



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.

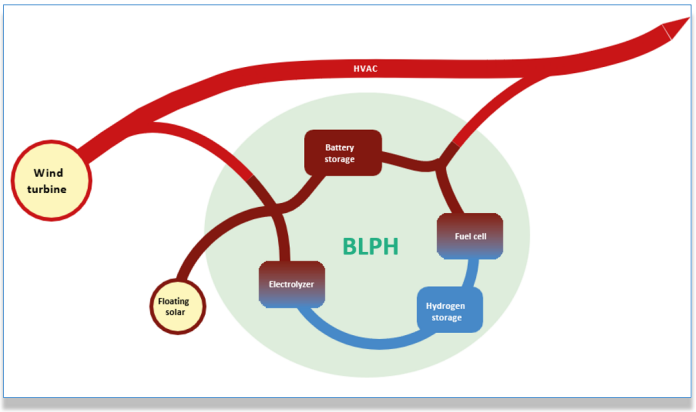


Figure 3 – BLPH Concept

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

This Terms of Reference document specifies the requirements for the Alarm Management Analysis of BLPH (Base Load Power Hub) Project by defining the objectives, methodology, process and review team required.

The following sources of Alarms systems will be considered as part of the Alarm Review:

1. Process Control System – PCS system
2. Safety System – SIS system
3. Fire and gas System – FGS system
4. FGS detection equipment that interface to FGS system
5. Electrolyser
6. Fuel cell
7. BESS
8. HVAC system
9. Water Treatment Package
10. Instrument Air Package
11. Nitrogen Package
12. Navaids
13. H2 Storage system
14. Vent system
15. Intrusion Detection system

The documents for the Main sources of Alarms 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-	BLPH PIPING AND INSTRUMENTATION DIAGRAM HYDROGEN STORAGE

80015/16/17/18/19/20	VESSEL A/B/C/D/E/F
123A90-DDL-PR-PID-80014	BLPH PIPING AND INSTRUMENTATION DIAGRAM HYDROGEN STORAGE VESSELS HEADER (OUTLET)
Doc. No.	Description
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-IN-RE-40095	Process Control Logics Description
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-PML-DIG-PRO-00002	Equipment and System TAG numbering
123A90-DDL-IN-SP-40024	Alarm System Requirements Specification

Table 1 - Source Documents

2.1 ABBREVIATIONS AND DEFINITIONS

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
ASRS	Alarm System Requirement Specification
BESS	Battery energy storage system
BLPH	Base Load Power Hub
BPCS	Basic Process Control System
CBL	Consequential Business Loss
CCS	Central Control System
C&E	Cause & Effect
CFA	Critical Fault Alarm
COMPANY or Client (CPY)	Crosswind
PCS	Process Control System
DEP	Design and Engineering Practice
DSUPR	Suppressed-by-design
EMCS	Electrical Management Control System
FGS	Fire and Gas System
GUI	Graphical User Interface
HAZOP	Hazard and Operability
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

ICSS	Integrated Control and Safety System
I/O	Input/Output
LLL	Low liquid level
LLLL	Low low liquid level
LOPA	Layer of Protection Analysis
LOPC	Loss of Primary Containment
LV	Low Voltage
MAD	Master Alarm Database
MV	Medium Voltage
MOS	Maintenance Override
N/A	Not Applicable
OOS	Operational Override
OOSRV	Out-of-Service
ORT	Operator Response Time
PACO	Process Automation, Control & Optimisation
PAH	Pressure alarm high
PAL	Pressure alarm low
PAS	Process Automation System
PCS	Process Control System
PEFS	Process Engineering Flow Sheets
P&ID	Process and Instrumentation Diagram
PFD	Process Flow Diagram
PV	Pressure Value
SIF	Safety Instrumented Function
SIS	Safety Integrated System
SRA	Safety Related Alarms
TOR	Terms of Reference
TTE	Time To Event
UPS	Uninterrupted Power Supply

Table 2 - Abbreviations and Definitions

3 OBJECTIVES

The primary function within the alarm system is to notify operators of abnormal process conditions or equipment malfunctions and support the response.

The AMS (Alarms Management System) shall be designed to minimise the number of alarms presented to operations during an upset condition.

All alarms shall be reviewed and justified before being implemented into the design. This includes minimising the generation of unnecessary alarms, e.g., when equipment is not running or is out of service, rather than generating and then masking.

The alarm management system shall conform to the requirements of IEC 62682.

The Alarm Management Analysis consists of two phases:

1 The Identification phase, requiring the initial set-up and pre-population of a Master Alarm Database (MAD).

2 The Rationalization phase, in which the Alarm Management Analysis workshop will be held to evaluate the pre-populated parameters in the Master Alarm Database, verify the associated trip and alarm settings, and define the alarm display and notifications.

The objective is to go through a rigorous and structured work process to identify and document the set of notifications that are included in the ASRS (Alarm System Requirement Specification).

4 ALARM MANAGEMENT METHODOLOGY

4.1 ALARM DEFINITION

Alarms are used to inform facility operator when the limits or a target has been exceeded or the occurrence of events.

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

The main definitions are reported below, for all the definitions (as per IEC 62682:2022) refer doc. "Alarm System Requirements Specification" n° 123A90-DDL-IN-SP-40024.

4.1.1 Absolute Alarm

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

4.1.2 Highly Managed Alarm (HMA)

Highly Managed Alarm (HMA) is an alarm belonging to a class with additional requirements above general alarms (e.g. Safety related alarm).

4.1.3 Mode-based Alarm

The mode-based alarm is an alarm that has attributes modified or is suppressed based on operating states or process conditions.

4.1.4 Event

Event is a representation of a solicited or unsolicited fact indicating a state change (e.g. Mode changes and device state changes).

4.1.5 Active

Alarm state in which the alarm condition is true.

4.1.6 Alarm Banner

Graphic element that lists annunciated alarms with selected information.

4.1.7 Alarm Deadband

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

4.1.8 Alarm Flood

Condition during which the alarm rate is greater than the operator can effectively manage.

4.1.9 Chattering Alarm

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

4.1.10 First-up Alarm

Alarm determined to be the first in a multiple-alarm scenario.

4.1.11 Alarm Group

Set of alarms with common association.

4.1.12 Alarm Class

Group of alarms with common set of alarm management requirements

4.1.13 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).

4.2 ALARM RESPONSE

When considering the design of an alarm system, it is reasonable to assume that operators and technicians are well trained and knowledgeable about the equipment they operate and maintain. The function of the alarm system is then to:

1. Notify operators of abnormal process conditions or equipment malfunctions and support the response.
2. Includes a mechanism for communicating the alarm information to the operator via an HMI, usually a computer screen or an annunciator.
3. Creates an alarm and event log, an alarm historian, and the generation of performance metrics for the alarm system.

A good alarm system should assist the operator in evaluating the situation, which is fundamental to identifying the correct actions. Depending on the circumstances, these actions can be directed either at preventing an event or mitigating its consequences.

4.3 ALARM PRIORITY

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.

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

Table 3 – Alarm Priority

The following priority descriptions will be used:

- High priority (P1)
- Medium priority (P2)
- Low priority (P3)
- Event (P4)

4.3.1 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.

4.3.2 Mediun 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.

4.3.3 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.

4.3.4 Event (P4)

- A change in plant or equipment condition
- Alarm setting that does not have any associated operator action and it is, therefore, not annunciated to the control room operator, but is captured in the Event log for the purposes of maintenance support and post-incident analysis.

In BLPH project the Operator intervention can prevent escalation of an alarm from PCS to ESD, but despite this, system is protected and operator intervention is not a must, but a recommendation to avoid tripping full platform for alarms that could be managed manually.

4.4 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:

a) alarm description:

All alarms shall have an informative text provided as a tag description, or alarm description, or both.

b) alarm setpoint or logical conditions:

Alarm setpoints shall be selected based on the information documented in the MAD.

c) alarm priority:

Alarm priority shall be selected based on the information documented in the MAD.

d) alarm deadband:

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.

e) on-delay or off-delay:

The alarm on-delay is the time before an alarm becomes active after the process measurement has exceeded the alarm setpoint.

The alarm off-delay is the time an alarm remains active after the process measurement has returned within the alarm setpoint.

The attributes on-delay and off-delay can be used to eliminate nuisance alarms.

The on-delay is used to avoid unnecessary alarms when a signal temporarily overshoots the alarm setpoint, thus preventing the alarm from becoming active until the signal remains in the alarm condition continuously for the delay time.

The off-delay is used to reduce chattering alarms by holding the alarm active for the delay period after the process condition has returned to normal.

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

f) alarm group:

The alarm group is a set of alarms with common association (e.g. grouping alarms by process unit, process area, equipment set, or service).

g) alarm message:

The alarm message is the text string displayed with the alarm indication that provides additional information to the operator.

4.5 ALARM SUPPRESSION

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

4.6 ALARM SHELVING

The Shelving operation is a temporarily suppress of an alarm, initiated by the operator, with engineering controls to unsuppress the alarm.

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.

The shelved alarm state should be visually indicated in the HMI (Engineering controls can include time limits).

This allows an Operator to temporarily move an alarm from the Alarm Summary to another display where the list of shelved alarms may be viewed at any time. The benefit is that the Alarm Summary is not filled by "standing alarms" that are well known to the Operator and reduce his effectiveness.

This also helps to reduce the number of standing alarms so that there will be less use of multiple pages of alarms on the Alarm Summary (IEC 62682 recommends that there should be less than 1 alarm per 10 minutes (average)).

In addition, there are the suppressed by design alarms.

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.

4.7 OUT-OF-SERVICE STATE

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

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 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.

4.8 HUMAN-MACHINE INTERFACE DESIGN FOR ALARM SYSTEM

It is widely recognised that alarm display is an important aspect of "best practice" alarm management.

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

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

- alarm summary displays,
- alarm indications on process displays,
- alarm indications on tag detail display,
- shelved alarm summary displays,
- suppressed-by-design summary displays, and
- out-of-service summary displays.

An alarm record is a set of information which documents an alarm state change. An alarm record shall have the following alarm record attributes:

- tag name for alarm,
- tag description or alarm description for alarm,
- alarm state,
- alarm type, and
- time and date of occurrence of the alarm state change.

4.9 USE OF A 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 master alarm database can also support mode-based alarming (which may be required for effective alarm suppression) and electronic "Operator Help".

5 ALARM RATIONALIZATION

5.1 PURPOSE

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.

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.

Alarms if not rationalized and managed can seriously impair the operator's ability to manage the process.

The activities of rationalization are:

a. alarm justification

b. alarm setpoint determination

c. alarm prioritization

d. alarm classification

e. rationalization review

5.2 ALARM PRIORITIES

For each alarm the activity type should be defined. Table below gives the typical example of the activity type and correspondingly the action type and priority.

Setting the priorities of alarms is meant to help the operator to prioritise his actions. However, if the alarm rate is low, prioritisation is not required. If the alarm rate is high, the operational situation is already deteriorated to such an extent that the operator no longer uses the alarm system to assess the situation and to prioritise his actions.

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 alarms specifications 123A90-DDL-IN-SP-40024.

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	Event
Set point changes		
Mode changes		
Operational messages		
Raise work order (Note-6)		

Table 4 – Assigning of Activities & Alarm Priorities Based on Urgency of Operator Response

Notes:

1. The response time available from the alarm notification to take operational corrective action should be taken into account while determining the consequences and the priorities. In case the response time (e.g. buffer volume in separator) available is very short and operator corrective action is not possible, then the presence of that pre-alarm has no meaning and as such should be removed rather than assigning with high priority.
2. Switching actions such as starting or stopping pumps or opening / closing valves as normal (on/off) control behaviour shall not be alarms.

3. Note that separate alarm analysis shall be carried out for each different setting as they have different functions and hence different actions to be taken upon alarm. For example, a high and low alarm to the same measurement may have different operation actions.
4. In case one setting has different required actions depending on the mode of operation, the most severe case needs to be assigned. Alternatively, different alarms are to be configured with the same setting of which only one is active in the appropriate mode of operation. The others are then automatically suppressed.
5. Bad Value alarms, normally configured for over or under range signals, have a potential for generating nuisance alarm floods during process upsets. They should, therefore, be used with care and not given high priorities. However critical measurements, which can lead to major upsets or shut down on failure, can be considered for high priorities.
6. Event is selected in case a work order is to be raised through work management system. Messages to be repeated to specific engineers alarm summary (if available).

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 5.

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

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

6 MASTER ALARM DATABASE (MAD)

6.1 GENERAL

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

As per feed doc. "Preliminary Alarm Master Database" n° K559-2254-IC-LST-001 the following Attribute Description has to be considered for each column (see Appendix A - MAD Template) of the project database document "Master Alarm Database" n° 123A90-DDL-IN-LIS-40027.

6.2 TAG NUMBER

Tag Number per the Tag Numbering Specification for the initiating device.

6.3 LOOP ID

Instrument, Fire & Gas or Telecommunications loop identifier.

6.4 ALARM TYPE

Identifies the type of alarm.

The available alarms 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.

6.5 ALARM CONDITION

Identifies the alarm condition - see available list of values as per Appendix B - Alarm Condition.

6.6 SERVICE DESCRIPTION

Meaningful description of the service / duty of the device - to enhance the information held in the I/O tag number.

6.7 ALARM SOURCE DOCUMENT

Document number which defines the alarm requirement. Only 1 document number needs to be given and the first document on which the alarm is shown should be given using the order below starting at 1 and working down:

1. P&ID
2. Process Description
3. Serial Link Definition

6.8 ALARM SOURCE DOCUMENT REV

Revision of Alarm Source Document used.

6.9 ALARM GROUP

Identifies alarms that make up a group including overall group alarm.

6.10 SET POINT

The process value at which the alarm is activated. The setting must be in the same units as the ICSS Range e.g. in % for level, not barg, mm etc.

6.11 SET POINT UOM

The engineering units of the alarm setpoint. These must be the same units as the ICSS Range e.g. in % for level, not barg, mm etc. (see Appendix C - Attribute Units of Measure).

6.12 DISCRETE ALARM STATE

The available discrete alarm state will be classified into the following categories:

- TRUE: The alarm condition is indicated when the tag is TRUE (1).
- FALSE: The alarm condition is indicated when the tag is FALSE (0).
- N/A: Analogue derived alarm, field not applicable.

6.13 INITIATING CAUSES(S)

Text describing the initiating causes(s) of alarm and the independent sources of operating data that could be used to confirm the cause.

6.14 INVALID OPERATION MODES

State if an alarm is invalid for any operating modes and across the operating envelope.

6.15 CONSEQUENCE DESCRIPTION (WITHIN PACKAGE BOUNDARIES)

Text describing the worst case unmitigated consequence based on the causes identified.

6.16 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

6.17 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.

6.18 URGENCY

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 6 – Urgency

6.19 ALARM PRIORITY

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

The table 7 below should be used as initial basis to determine alarm priority.

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

Table 7 – Alarm Priority

6.20 OPERATOR RESPONSE (IF KNOWN)

With respect to the package, accepting the supplier does not have knowledge of the wider impact to the facility, what response is required by the operator to prevent the consequence described.

6.21 LOOP DIAGRAM DOC NO

This is the drawing which shows the wiring and termination details of the field device which will provide the status on which the alarm will be generated.

6.22 RELATED DOCUMENTS

Reference of documents that use alarm. For example control narratives and C&E charts.

6.23 ALARM CATEGORISATION FLAGS

The Highly Managed Alarms (HMA) Sub-categories 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, Hazop or QRA study.

- CFA-Critical Fault Alarms

The following alarms shall be categorised as critical fault alarms.

1. Alarm indicating unavailability of emergency systems e.g. firewater pumps.
2. Alarm indicating loss of temporary refuge pressurisation.
3. Alarm indicating control or protective systems running on batteries.
4. Alarm indicating low instrument air pressure to a site or unit.
5. Alarm indicating dangerous SIF failure e.g. partial stroke test failure, SIF instrument failure diagnostic.
6. Alarm indicating unavailability or failure of FGS detector e.g. beam block alarm on line-of-sight gas detector.
7. Alarm indicating bad PV on SRA or BPCS layer of protection.
8. Alarm indicating degraded redundancy in an SIS or FGS logic solver.
9. Others as deemed appropriate by alarm class owners.

- MA-Mitigation (FGS alarms)

The following alarms shall be categorised as mitigation alarms.

1. Fire detection alarms.
2. Flammable gas detection alarms.
3. Toxic gas detection alarms.
4. Manual call point activation alarms.
5. O2 deficient atmosphere alarms.
6. Safety shower or eyebath activation alarms.
7. Imminent collision detection alarms.

6.24 ALARM DESIGN ORIGIN

Examples an alarm can originate from: HAZOP, LOPA, P&ID development, Mechanical Package, Instrument Package, Electrical Package, Process Safety Package, Control Narrative, FGS etc.

6.25 BASIS OF ALARM SETTING

Rules are often used to determine the alarm setting ex: 60% of trip value etc.

6.26 REVISION CONTROL

Revision Number - Approved modifications to an ARM database entry shall result in a new revision of the record.

7 MONITORING AND ASSESSMENT

7.1 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 System Requirements Specification" n° 123A90-DDL-IN-SP-40024. 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.

7.2 ALARM SYSTEM PERFORMANCE METRICS

Both initial alarm system assessment and on-going monitoring should include the measures like those shown in the Table 8:

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

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

7.3 AVERAGE 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 9. 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 9 – 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.

7.4 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.

7.5 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.

7.6 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.

8 REPORTING AND RECORDING

8.1 RESULT RECORDING

A Master Alarm Database (Excel Spreadsheet) shall be pre-populated from various Alarm sources detailed in Section 6.

The Technical Scribe will record the findings of the Review Team's discussions in real time using a laptop and projector so that the Review Team can read the worksheets and comment upon or change the recorded comments. When the meeting is concluded, the Master Alarms Database will be tidied up and distributed for comment. Master Alarms Database sample is provided in Appedix A.

8.2 REPORTING

The table of contents for the Alarms Management report will include the following section:

- Executive Summary;
- Section 1.0: Introduction;
- Section 2.0: Scope & Objectives;
- Section 3.0: Study Approach;
- Section 4.0: Findings;
- Appendices
  - Master Alarms Database worksheet;
  - Information needs (optional, if applicable); and
  - Attendance lists.

9 EXCLUSIONS

In the BLPH project the packages are interfaced with control system through software communication for monitoring purposes and the safety system through hardwired communication for essential signals to be managed.

In the alarm management study for BLPH the software alarms will not be analyzed as the packages involved are already safely interfaced with hardwired signals. The philosophy proposed for the priority of the serial alarms is the following:

- Priority P3 for the critical alarms whose cumulative is sent via hardwired to SIS (that will be analyzed during MAD workshop).
- Priority P4 for the remaining alarms.

Hardwired interface alarms between the packages and the safety system will be analyzed, since in the philosophy adopted these are the most critical alarms that require supervision and possible response by the operator.

10 WORKSHOP DETAILS

10.1 WORKSHOP ARRANGEMENTS

The following agenda is proposed. This will be adjusted on the basis of progress made at the discretion of the workshop team. An example of the agenda of workshop for the necessary days, is provided in Table 10 below:

Time	Activity
9:00 AM	Introduction / Fire Safety Briefing
9:05 AM	Project / Process Briefing
9:15 AM	Alarms Management Methodology Briefing
9:20 AM	Alarms Management Study
10:30 AM	**Break**
10:40 AM	Alarms Management Study
12:30 PM	**Lunch Break**
1:30 PM	Alarms Management Study
3:00 PM	**Break**
3:10 PM	Alarms Management Study
5:00 PM	Closeout

Table 10 – Workshop Agenda

10.2 ALARMS MANAGEMENT WORKSHOP ATTENDEES

The workshop will be facilitated by an independent chairperson and scribed by a technical scribe and should as a minimum consist of the following members:

- Chairperson;
- Recorder (Scriber);
- Engineering Manager
- Process Engineer;
- Technical Safety Engineer / HSE Engineer
- Process, Automation, Control and Optimisation (PACO)/Instrumentation Engineer.
- Operations representative.
- Automation Vendor (PAS) Vendor Representative

10.3 DOCUMENTATION AND MATERIAL

The following documentation shall be available during the Alarms Management Workshop:

- Cause & Effect Matrix
- Alarm System Requirements Specification
- Master Alarms Database;
- I/O list (including Alarm and Trip)
- Process Control, Operation, Start-up and Shutdown Philosophy
- Process Control Logics Description
- HAZOP Report;
- LOPA Report;
- Process Safety Cause and Effect Block Diagram

IEC 62682:2022	Management of Alarm Systems for the Process Industries
123A90-DDL-IN-SP-40024	Alarm System Requirements Specification
K559-2254-IC-LST-001	Preliminary Alarm Database
123A90-DDL-IN-LIS-40089	Instrument I-O List
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-PR-RE-80031	Process Control, Operation, Start-up and Shutdown Philosophy
123A90-DDL-PR-DG-80000	Process Safety Cause and Effect Block Diagram
123A90-DDL-IN-LIS-	Master Alarm Database

40027	
123A90-DDL-IN-RE-40095	Process Control Logics Description

Table 11 – Reference documents

11 APPENDIX

APPENDIX A – MAD Template

TAG NUMBER	LOOP ID	ALARM TYPE	ALARM CONDITION	SERVICE DESCRIPTION	ALARM SOURCE DOCUMENT	ALARM SOURCE DOCUMENT REV	ALARM GROUP	SET POINT	SET POINT UOM	DISCRETE ALARM STATE

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TAG NUMBER	INITIATING CAUSES(S)	INVALID OPERATION MODES	CONSEQUENCE DESCRIPTION	TIME TO EVENT (TTE)	OPERATOR RESPONSE TIME (ORT)	URGENCY	ALARM PRIORITY

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TAG NUMBER	OPERATOR RESPONSE	LOOP DIAGRAM DOC NO	RELATED DOCUMENTS	ALARM CATEGORISATION FLAGS	ALARM DESIGN ORIGIN	BASIS OF ALARM SETTING	REVISION CONTROL

APPENDIX B - Alarm Conditions

ATTRIBUTE NAME	ACCEPTED ATTRIBUTE VALUE	ATTRIBUTE VALUE DESCRIPTION
ALARM CONDITION	COMM_FAILURE	Communication Alarm
ALARM CONDITION	DEV	Voted transmitter Deviation Alarm (e.g. 2oo3)
ALARM CONDITION	DISC	Discrete Input Alarm
ALARM CONDITION	FAIL	Valve or Motor Failure Alarm (Valve fail to Open / Close ; Motor failed to start)
ALARM CONDITION	GRP	Group Alarm (See section 5.0)
ALARM CONDITION	HI	Analogue High Alarm
ALARM CONDITION	HI_HI	Analogue High High Alarm
ALARM CONDITION	I/O_FAIL	I/O Fail Alarm: Generated when the status of any I/O point becomes unhealthy.
ALARM CONDITION	INST_FAIL	Instrument Fail Alarm: Generated when the status of any instrument point becomes unhealthy.
ALARM CONDITION	LO	Analogue Low Alarm
ALARM CONDITION	LO_LO	Analogue Low Low Alarm
ALARM CONDITION	MCC_AVAIL	Motor Available Signal
ALARM CONDITION	MCC_RUN	Motor Running Signal - The motor is running.
ALARM CONDITION	MCC_TRIPPED	Motor Trip Alarm - The motor has tripped
ALARM CONDITION	MCC_TCS	MCC Trip Circuit Supervisory Alarm
ALARM CONDITION	OOR	Out Of Range Alarm
ALARM CONDITION	SYS	System Alarm
ALARM CONDITION	RATE	Analogue Rate of Change Alarm
ALARM CONDITION	DISCRP	Valve Input to Output Discrepancy - The valve command and output signal mismatch (for a given time) Surge and Motor Operated Valves (MOV) only
ALARM CONDITION	DISC	FGS Detector - Flame / Smoke / Heat / MAC / Oil Mist Discrete Alarm
ALARM CONDITION	HI_GAS	FGS Detector - Hi Gas Alarm
ALARM CONDITION	LO_GAS	FGS Detector - Lo Gas Alarm

ATTRIBUTE NAME	ACCEPTED ATTRIBUTE VALUE	ATTRIBUTE VALUE DESCRIPTION
ALARM CONDITION	GAS_HI_CONF	FGS PT Voted Detector - Confirmed High Gas Alarm
ALARM CONDITION	GAS_LO_CONF	FGS LOS Voted Detector - Confirmed Low Gas Alarm
ALARM CONDITION	FLAME_CONF	Flame Confirmed Alarm
ALARM CONDITION	HEAT_CONF	FGS Voted Confirmed Heat Alarm
ALARM CONDITION	OIL_MST_CONF	FGS Voted Confirmed Oil Mist Alarm
ALARM CONDITION	SMOKE_CONF	FGS Voted Detector - Smoke Confirmed
ALARM CONDITION	EXTNG_FAIL	FGS Extinguishant Failure Alarm
ALARM CONDITION	BEAM_BLOCK	FGS Detector - Beam Block
ALARM CONDITION	BEAM_MAINT	FGS Detector - SIS Maintenance, Pre-Warning
ALARM CONDITION	MAINT_SIGNAL	FGS Detector - Maintenance
ALARM CONDITION	MAINT_BG_IR	FGS Detector - Maint. Background IR
ALARM CONDITION	MAINT_OINTG	FGS Detector - Maint. Overall Integrity
ALARM CONDITION	MAINT_OPTIC	FGS Detector - Optical Maintenance
ALARM CONDITION	BYPASS_ON	FGS - Bypass Alarm
ALARM CONDITION	GENERAL_FAULT	FGS Detector - Fault General
ALARM CONDITION	IO_FAIL	FGS Transmitter and Detectors I/O Fail alarm due to Bad PV
ALARM CONDITION	BYPASS_FAIL	FGS Detector - Bypass Failed

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APPENDIX C – Attribute Units of Measure

ATTRIBUTE NAME	UOM PARAMETER	UNIT OF MEASURE	SYMBOL
SET POINT	ANGLE	DEGREE (ANGLE)	°
SET POINT	ANGULAR VELOCITY	REVOLUTION PER MINUTE	RPM
SET POINT	DENSITY	DEGREE PER API GRAVITY	API
SET POINT	DENSITY	DENIER	tex
SET POINT	DENSITY	DENIER PER FILAMENT	den/filament
SET POINT	DENSITY	GRAM PER CUBIC CENTIMETRE	g/cm³
SET POINT	DENSITY	GRAM PER MOLE	g/mol
SET POINT	DENSITY	KILOGRAM PER CUBIC METRE	kg/m³
SET POINT	DENSITY	KILOGRAM PER CUBIC METRE (15 °C : 101325 KPA)	KG1
SET POINT	DENSITY	MICROGRAM PER CUBIC CENTIMETRE	µg/cm³
SET POINT	DENSITY	MILLIGRAM PER CUBIC CENTIMETRE	mg/cm³
SET POINT	DENSITY	MILLIGRAM PER CUBIC METRE	mg/m³
SET POINT	DENSITY	POUND PER CUBIC INCH	lb/in³
SET POINT	DENSITY	RELATIVE DENSITY (DRY AIR)	RDA
SET POINT	DENSITY	RELATIVE DENSITY (WATER 60°F)	RDW
SET POINT	DENSITY	SPECIFIC GRAVITY	SG
SET POINT	DIMENSIONLESS RATIO	Count of Debris Particles	Debris Particles
SET POINT	DIMENSIONLESS RATIO	INDEX	index
SET POINT	DIMENSIONLESS RATIO	MOLE FRACTION	MOM
SET POINT	DIMENSIONLESS RATIO	PER MILLE	%0
SET POINT	DIMENSIONLESS RATIO	PERCENT	%
SET POINT	DIMENSIONLESS RATIO	RATIO	Ratio
SET POINT	ELECTRICAL CAPACITANCE	FARAD	F
SET POINT	ELECTRICAL CURRENT	MILLIAMPERE	mA
SET POINT	ELECTRICAL POTENTIAL	VOLT	V
SET POINT	FLOWRATE - MASS	KILOGRAM PER HOUR	kg/hr

ATTRIBUTE NAME	UOM PARAMETER	UNIT OF MEASURE	SYMBOL
SET POINT	FLOWRATE - MASS	KILOGRAM PER MINUTE	kg/min
SET POINT	FLOWRATE - MASS	KILOGRAM PER SECOND	kg/s
SET POINT	FLOWRATE - MASS	LONG TONNE (2240 POUNDS) PER DAY	LT/d
SET POINT	FLOWRATE - MASS	LONG TONNE (2240 POUNDS) PER DAY	LTD (annual avg)
SET POINT	FLOWRATE - MASS	MILLION TONNE PER ANNUM	Mt/a
SET POINT	FLOWRATE - MASS	POUND PER DAY	lb/d
SET POINT	FLOWRATE - MASS	POUND PER HOUR	lb/h
SET POINT	FLOWRATE - MASS	POUND PER MINUTE	lb/min
SET POINT	FLOWRATE - MASS	SHORT TONNE (2000 POUNDS) PER DAY	ST/d
SET POINT	FLOWRATE - MASS	THOUSAND POUNDS PER HOUR	Mlb/h
SET POINT	FLOWRATE - MASS	TON PER DAY	ton/d
SET POINT	FLOWRATE - MASS	TON PER YEAR	Ton/yr
SET POINT	FLOWRATE - MASS	TONNE PER DAY	t/d
SET POINT	FLOWRATE - MASS	TONNE PER HOUR	t/h
SET POINT	FLOWRATE - MASS	TONNE PER MINUTE	t/min
SET POINT	FLOWRATE - MOLAR	KILOGRAM MOLE PER HOUR	kmol/h
SET POINT	FLOWRATE - VOLUMETRIC	BARREL PER DAY	bbl/d
SET POINT	FLOWRATE - VOLUMETRIC	BARREL PER DAY	bpd
SET POINT	FLOWRATE - VOLUMETRIC	BARREL PER HOUR	bph
SET POINT	FLOWRATE - VOLUMETRIC	BARREL PER MINUTE	bpm
SET POINT	FLOWRATE - VOLUMETRIC	BILLION STANDARD CUBIC FEET PER DAY	Bcf/d
SET POINT	FLOWRATE - VOLUMETRIC	cubic centimetre per minute	cc/min
SET POINT	FLOWRATE - VOLUMETRIC	CUBIC CENTIMETRE PER SECOND	cm^3/s
SET POINT	FLOWRATE - VOLUMETRIC	CUBIC CENTIMETRE PER STROKE	$cm^3/stroke$
SET POINT	FLOWRATE - VOLUMETRIC	CUBIC FEET PER MINUTE	cfm
SET POINT	FLOWRATE - VOLUMETRIC	CUBIC METRE PER DAY	m^3/d
SET POINT	FLOWRATE - VOLUMETRIC	CUBIC METRE PER DAY (NORMAL)	Nm^3/d
SET POINT	FLOWRATE - VOLUMETRIC	CUBIC METRE PER DAY (STANDARD)	Sm^3/d
SET POINT	FLOWRATE - VOLUMETRIC	CUBIC METRE PER HOUR	m^3/h
SET POINT	FLOWRATE - VOLUMETRIC	CUBIC METRE PER HOUR (NORMAL)	Not
SET POINT	FLOWRATE - VOLUMETRIC	CUBIC METRE PER HOUR (NORMAL)	Nm^3/h

ATTRIBUTE NAME	UOM PARAMETER	UNIT OF MEASURE	SYMBOL
SET POINT	FLOWRATE - VOLUMETRIC	CUBIC METRE PER HOUR (STANDARD)	Sm^3/h
SET POINT	FLOWRATE - VOLUMETRIC	CUBIC METRE PER MINUTE	m^3/min
SET POINT	FLOWRATE - VOLUMETRIC	CUBIC METRE PER SECOND	m^3/s
SET POINT	FLOWRATE - VOLUMETRIC	GALLON (U.S.) PER MINUTE	USgal/min
SET POINT	FLOWRATE - VOLUMETRIC	LITRE PER DAY	l/d
SET POINT	FLOWRATE - VOLUMETRIC	LITRE PER HOUR	l/h
SET POINT	FLOWRATE - VOLUMETRIC	LITRE PER MINUTE	l/min
SET POINT	FLOWRATE - VOLUMETRIC	MILLION BARRELS PER DAY	MMbpd
SET POINT	FLOWRATE - VOLUMETRIC	MILLION CUBIC FEET PER DAY	MMcfd
SET POINT	FLOWRATE - VOLUMETRIC	MILLION CUBIC FEET PER HOUR	MMcfh
SET POINT	FLOWRATE - VOLUMETRIC	MILLION STANDARD CUBIC FEET PER DAY	MMscf/d
SET POINT	FLOWRATE - VOLUMETRIC	MILLION STANDARD CUBIC METRES PER DAY	$MMsm^3/d$
SET POINT	FLOWRATE - VOLUMETRIC	STANDARD CUBIC FEET PER DAY	scf/d
SET POINT	FLOWRATE - VOLUMETRIC	STANDARD CUBIC FEET PER HOUR	scf/h
SET POINT	FLOWRATE - VOLUMETRIC	STANDARD CUBIC FEET PER MINUTE	scf/min
SET POINT	FLOWRATE - VOLUMETRIC	US GALLON PER DAY	GPD
SET POINT	FLOWRATE - VOLUMETRIC	US GALLON PER HOUR	GPH
SET POINT	FLOWRATE - VOLUMETRIC	US GALLON PER MINUTE	GPM
SET POINT	LENGTH	AWG	awg
SET POINT	LENGTH	CENTIMETRE	cm
SET POINT	LENGTH	FOOT	ft
SET POINT	LENGTH	INCH	in
SET POINT	LENGTH	KILOMETRE	km
SET POINT	LENGTH	METRE	m
SET POINT	LENGTH	MICRON	micron
SET POINT	LENGTH	MILE (STATUTE)	mi
SET POINT	LENGTH	MILLIMETRE	mm
SET POINT	LENGTH	NANOMETRE	nm
SET POINT	LENGTH	YARD	yd
SET POINT	MASS	GRAM	g
SET POINT	MASS	GRAM GOLD	GAU

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ATTRIBUTE NAME	UOM PARAMETER	UNIT OF MEASURE	SYMBOL
SET POINT	MASS	HUNDREDWEIGHT	cwt
SET POINT	MASS	HUNDREDWEIGHT (SHORT)	HV
SET POINT	MASS	KILOGRAM	kg
SET POINT	MASS	METRIC TON	tonnes
SET POINT	MASS	MILLIMOLE	mmol
SET POINT	MASS	MOLE	mol
SET POINT	MASS	OUNCE (AVDP)	oz
SET POINT	MASS	OUNCE TROY	toz
SET POINT	MASS	POUND	lb
SET POINT	MASS	POUND (TROY)	TX
SET POINT	MASS	POUND MOLE	lbmol
SET POINT	MASS	TON (LONG) MASS	LT
SET POINT	MASS	TON (SHORT) MASS	ST
SET POINT	MASS	TONNE (METRIC TON)	te
SET POINT	MOMENTUM (RHOV2)	KILOGRAM PER METRE PER SECOND SQUARED	kg/m s^2
SET POINT	POWER	BTU PER HOUR	BTU/h
SET POINT	POWER	FOOT POUND FORCE PER SECOND	ft lb/s
SET POINT	POWER	HORSEPOWER	hp
SET POINT	POWER	HORSEPOWER (METRIC)	hp (metric)
SET POINT	POWER	HORSEPOWER HOUR	hp h
SET POINT	POWER	JOULE PER SECOND	J/s
SET POINT	POWER	KILOCALORIE PER HOUR	kcal/h
SET POINT	POWER	KILOGRAM-CALORIE PER MINUTE	kcal/min
SET POINT	POWER	KILOVOLT AMPERE	Kva
SET POINT	POWER	KILOVOLT-AMPERE REACTIVE	kVAr
SET POINT	POWER	KILOWATT	kW
SET POINT	POWER	MEGAJOULE PER HOUR	MJ/h
SET POINT	POWER	MEGAWATT	MW
SET POINT	POWER	MILLION BTU PER DAY	MMBTU/d
SET POINT	POWER	MILLION BTU PER HOUR	MMBTU/h
SET POINT	POWER	VOLT AMPERE	VA

ATTRIBUTE NAME	UOM PARAMETER	UNIT OF MEASURE	SYMBOL
SET POINT	POWER	WATT	W
SET POINT	PRESSURE	ATMOSPHERE	atm
SET POINT	PRESSURE	BAR (ABSOLUTE)	bara
SET POINT	PRESSURE	Bar (differential pressure)	bar
SET POINT	PRESSURE	BAR (GAUGE)	barg
SET POINT	PRESSURE	INCH OF MERCURY	in Hg
SET POINT	PRESSURE	INCH WATER GAUGE	in WG
SET POINT	PRESSURE	KILOGRAM PER SQUARE CENTIMETRE	kgf/cm²
SET POINT	PRESSURE	KILOGRAM-FORCE PER SQUARE CENTIMETRE ABSOLUTE	kgf/cm²a
SET POINT	PRESSURE	KILOGRAM-FORCE PER SQUARE CENTIMETRE GAUGE	kgf/cm²g
SET POINT	PRESSURE	KILOGRAM-FORCE PER SQUARE METRE	kgf/m²
SET POINT	PRESSURE	KILOPASCAL	kPa
SET POINT	PRESSURE	KILOPASCAL ABSOLUTE	kPaa
SET POINT	PRESSURE	KILOPASCAL GAUGE	kPag
SET POINT	PRESSURE	MEGAPASCAL	MPa
SET POINT	PRESSURE	METRE BAR PER SECOND	MBZ
SET POINT	PRESSURE	METRE PASCAL PER SECOND	MPZ
SET POINT	PRESSURE	MILLIBAR	mbar
SET POINT	PRESSURE	MILLIBAR ABSOLUTE	mbara
SET POINT	PRESSURE	MILLIBAR GAUGE	mbarg
SET POINT	PRESSURE	MILLIGRAM PER SQUARE CENTIMETRE	mg/cm²
SET POINT	PRESSURE	MILLINEWTON PER METRE SQUARED	mN/m²
SET POINT	PRESSURE	MM OF MERCURY	mm Hg
SET POINT	PRESSURE	MM WATER GAUGE	mm WG
SET POINT	PRESSURE	NEWTON PER SQUARE METRE	N/m²
SET POINT	PRESSURE	PASCAL	Pa
SET POINT	PRESSURE	POUND PER SQUARE FOOT	lb/ft²
SET POINT	PRESSURE	POUND PER SQUARE INCH DIFFERENTIAL	PSID
SET POINT	PRESSURE	POUND PER SQUARE INCH PER HUNDRED FEET	psi/100ft

ATTRIBUTE NAME	UOM PARAMETER	UNIT OF MEASURE	SYMBOL
SET POINT	PRESSURE	POUND-FORCE PER SQUARE INCH	PSI
SET POINT	PRESSURE	POUND-FORCE PER SQUARE INCH ABSOLUTE	PSIA
SET POINT	PRESSURE	POUND-FORCE PER SQUARE INCH GAUGE	PSIG
SET POINT	TEMPERATURE	DEGREE CELSIUS	°C
SET POINT	TEMPERATURE	DEGREE FAHRENHEIT	°F
SET POINT	TEMPERATURE	DEGREE RANKINE	°R
SET POINT	TEMPERATURE	KELVIN	K
SET POINT	VELOCITY	CENTIMETRE PER SECOND	cm/s
SET POINT	VELOCITY	FEET PER HOUR	ft/h
SET POINT	VELOCITY	FEET PER MINUTE	ft/min
SET POINT	VELOCITY	FEET PER SECOND	ft/s
SET POINT	VELOCITY	INCH PER SECOND	in/s
SET POINT	VELOCITY	KILOMETRE PER HOUR	km/h
SET POINT	VELOCITY	KILOMETRE PER MINUTE	km/min
SET POINT	VELOCITY	KNOT PER HOUR	kn
SET POINT	VELOCITY	METRE PER MINUTE	m/min
SET POINT	VELOCITY	METRE PER SECOND	m/s
SET POINT	VELOCITY	METRE PER WEEK	m/wk
SET POINT	VELOCITY	MILE PER HOUR	mph
SET POINT	VELOCITY	MILE PER MINUTE	mi/min
SET POINT	VELOCITY	MILLIMETRE PER HOUR	mm/h
SET POINT	VELOCITY	MILLIMETRE PER SECOND	mm/s
SET POINT	VELOCITY	MILLIMETRE PER YEAR	mm/a
SET POINT	VISCOSITY - DYNAMIC	CENTIPOISE	cP
SET POINT	VISCOSITY - DYNAMIC	PASCAL SECOND	Pa s
SET POINT	VISCOSITY - DYNAMIC	POISE	P
SET POINT	VOLUME	CUBIC METRE	m^3

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