Base Load Power Hub (BLPH)

HSE Design Philosophy

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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.

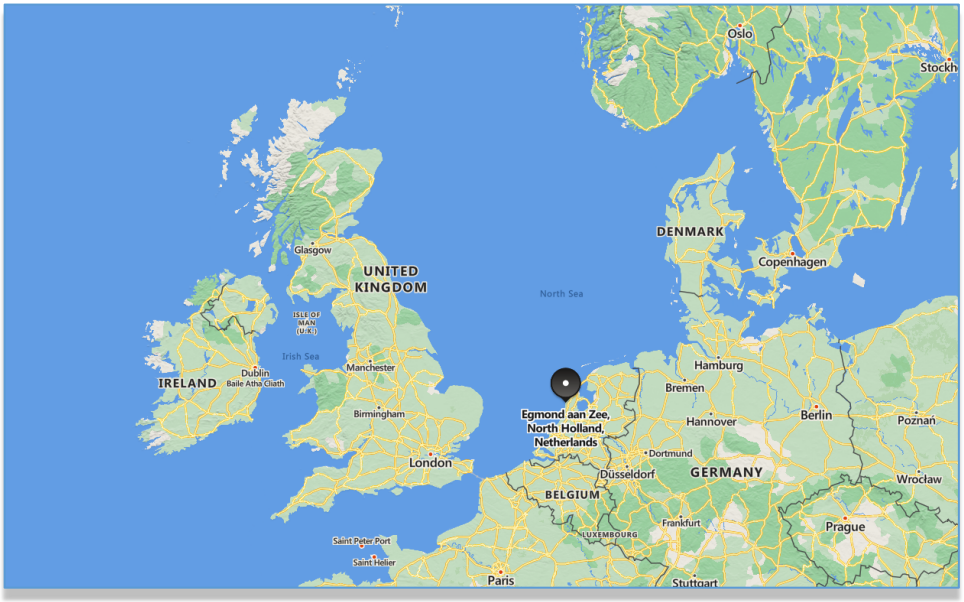


Figure 1 - HOLLANDSE KUST NOORD WIND PARK Location Map

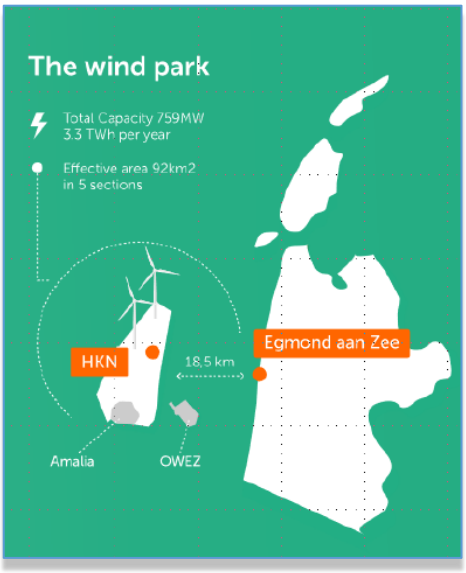


Figure 2 - Wind Park Details

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.

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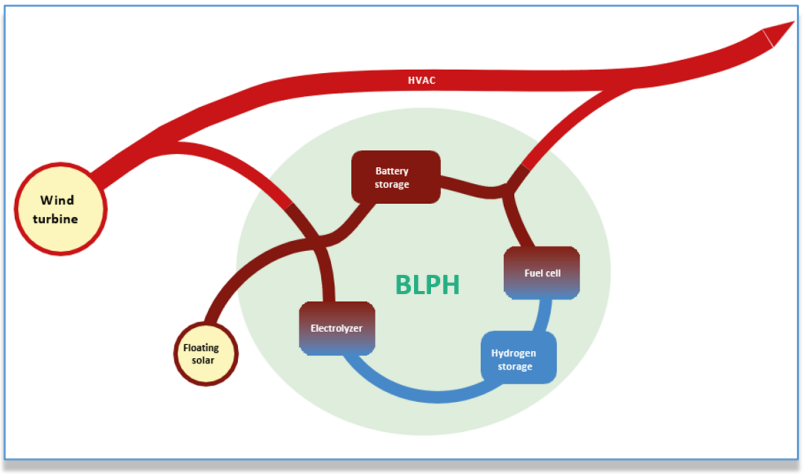


Figure 3 – BLPH Concept

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 purpose of this project HSE Design Philosophy is to outline the principles to be implemented during EPC to ensure the facilities design meets the requirements in accordance with national codes, practices and regulations. The purpose of this philosophy is to:

- Ensure that potential Health, Occupational & Process Safety Hazards and corresponding risks associated with the project are identified and assessed using appropriate tools and are mitigated through application of risk management techniques.
- Ensure a safe design will be achieved by the application of good engineering practice, implementing inherently safer facilities as far as possible and ensuring that risks have been reduced to ALARP.

The aim of this HSE Design Philosophy at EPC stage is to achieve a safe design, that will be subject to subsequent systematic revisions, to minimise personnel risks, impacts upon the environment and surrounding populations. This approach guarantees an effective HSE Management Risk brings information and supports the decision-making process in applying the necessary mitigation measures in order to avoid, reduce, control or mitigate the consequences of the hazards envisaged.
The hierarchy to be considered in this phase and in the following ones for the risk management is:

- Eliminate hazards at source;
- Substitute hazardous substances and materials with less harmful ones;
- Avoid personnel to be involved in the consequences of hazardous events;
- Install control systems to minimise the possible consequences of hazardous events;
- Risk mitigation by isolating consequences, reducing personnel exposure level, treating emissions and effluents and adequately managing wastes;
- Supply and utilisation of adequate Personal Protective Equipment (PPE);
- Risk evaluation of the workplace as well as an adequate management of permit to work system and guarantee of information and training of specialised workforce for operations and maintenance activities.

HSE minimum goals shall be pursued and reached; if any aspects of the design do not meet these objectives, attention shall be paid by highlighting the potential issues that could arise. The following high-level goals shall be applied:

- Any risks for personnel shall be avoided or reduced as much as possible taking into account the best industry practices and design standards;
- The consequences of an incidental event shall not involve the personnel in the nearby or expose the workforce to hazards that can compromise the evacuation procedures;
- The environmental impacts and risks of impacts shall be avoided to the best extent practicable.
- The emergency systems have to be designed to be working upon an incidental event and in an independent configuration in order to reduce the causes of a malfunctioning.

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2.1 REFERENCES

Doc. No.	Description
[1] K559-2254-PM-PLN-003	COMPANY, "Basis for Design Base Load Power Hub (BLPH)", Revision 01.
[2] 123A90-DDL-SAF-RE-30002	Design HSSE Plan, rev 03
[3] 123A90-DDL-SAF-RE-30001	Fire Protection Philosophy, rev 03
[4] 123A90-PML-PM-TQ-00015	Environmental Thresholds For Liquid Discharges At Sea
[5] 123A90-PML-PM-TQ-00034	Environmental Concentration Limits For Liquid Discharges At Sea
[6] EI 15	EI Model code of safe practice Part 15: Area classification code for installations handling flammable fluids
[7] NFPA 10	Standard for Portable Fire extinguishing system (2022)
[8] NORSOK S-002	Working environment
[9] NORSOK C-002	Architectural components and equipment

Table 1 - Reference Documents

2.2 DEFINITIONS AND ABBREVIATIONS

COMPANY or Client (CPY):	Crosswind
CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project

Table 2 - Definitions

ALARP	As low as reasonably practicable
BDV	Blowdown Valve
BESS	Battery Energy Storage System
BLPH	Base Load Power Hub
CCS	Central Control System
DCS	Distributed Control System

DEP	Design and Engineering Practice
EN	European Norm
EPC	Engineering Procurement Construction
ESD	Emergency Shutdown
ESDV	Emergency Shutdown Valve
EMCS	Electrical Managment Control System
FERA	Fire and Explosion Risk Assessment
F&G	Fire and Gas
HAZID	Hazard Identification Study
HAZOP	Hazard and Operability Study
HKN	Hollandse Kust Noord
I/O	Input / Output
LOPA	Layers of Protection Analysis
LSD	Local Shut Down
MAH	Major Accident Hazard
NFPA	National Fire Protection Association
PFP	Passive Fire Protection
PLC	Programmable Logic Controller
PPE	Personal Protective Equipment
PSD	Process Shut Down
PSV	Pressure Safety Valve
QRA	Quantitative Risk Assessment
SDV	Shutdown Valve
SECE	Safety and Environmental Critical Element
SIL	Safety Integrity Level
UPS	Uninterrupted Power Supply

Table 3 - Abbreviations

3 HAZARDS AND EFFECTS MANAGEMENT

3.1 Overview

The project's overall objectives with regard to protection of personal, occupational health, safety and environment during the execution phases of the project are set out in the Design HSSE Plan document [2]. This philosophy sets out the process safety design objectives for EPC. The objectives for hazards management in the design are as follows:

- compliance with client requirements, and project codes and standards report 123A90-PML-PM-RE-00038
- minimise the need for operator presence
- manage hazards so as to achieve levels of risk that meet project objectives, in order to reduce risk to an acceptable level or ALARP as defined within COMPANY's risk matrix (shown in Figure 5 below)
- document all hazards and the required hazard management measures (safeguards) so that they can be further developed during detailed design.

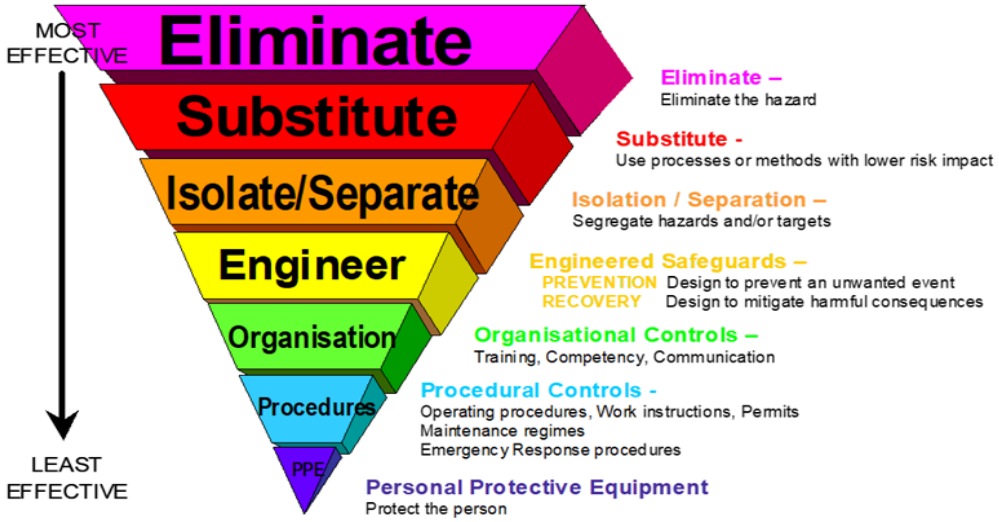
The engineering strategy for management of hazards will be based on compliance with regulations, codes and standards as a minimum, supported and enhanced by formal safety assessments such as HAZID, HAZOP, FERA and SIL that systematically identify hazards and potential accident scenarios, and assess risks, so that decisions can be made with regard to selection of safeguards (protection barriers).EERA will be performed.The objective of the EERA is to assess the performance of the evacuation, escape and rescue (EER) facilities of an installation in the event of a MAH being realised. Human Factors (HF) study will be performed to reduce risks and to maximise performance through optimising the fit between the people, the hardware, and the procedures, and minimising the frequency and consequence of human error.

Hazard management measures will be selected and incorporated where necessary to reduce the potential frequency or mitigate the consequence of potential accidents, in accordance with the following hierarchy of risk control:

- Inherent safety/prevention
- Detection and control
- Mitigation
- Escape, evacuation and recovery

An Illustration of the hierarchy of risk control can be seen in Figure 4:

Figure 4 – Illustration of Hierarchy of Risk Control



The intent is for a design that is inherently safe and then to add features such as containment, instrumented alarms and trips, where necessary to reduce risk to an acceptable level. Operating procedural controls should only be considered as a means of reducing risks if further engineering / design measures are not reasonably practicable.

3.2 Risk Acceptance Criteria

Risk acceptance criteria applicable to the project are defined in the risk ranking matrix in Figure 5.

Risks are categorised based on:

- people (safety)
- assets
- community
- environmental

Risk acceptance criteria is defined by the colour scheme shown in Figure 5. Where consequences have severity 5 or fall within the red area, the hazard are identified as Major Accident Hazards (MAHs) and require risks reduction measures. The yellow zone indicates the ALARP range where additional risk reduction is required if any mitigation measures are found to be practicable. The other regions indicate the more tolerable regions of risk.

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Figure 5 – Risk Assessment Matrix (RAM

SEVERITY	CONSEQUENCES				INCREASING LIKELIHOOD				
	People	Assets	Community	Environment	A	B	C	D	E
					Never heard of in the Industry	Heard of in the Industry	Has happened in the Organisation or more than once per year in the Industry	Has happened at the Location or more than once per year in the Organisation	Has happened more than once per year at the Location
0	No injury or health effect	No damage	No effect	No effect					
1	Slight injury or health effect	Slight damage	Slight effect	Slight effect					
2	Minor injury or health effect	Minor damage	Minor effect	Minor effect					
3	Major injury or health effect	Moderate damage	Moderate effect	Moderate effect					
4	PTD or up to 3 fatalities	Major damage	Major effect	Major effect					
5	More than 3 fatalities	Massive damage	Massive effect	Massive effect					

3.3 Framework for Hazards and Effects Management

Compliance with the applicable regulations, codes and standards will form the basis for development of the design, as well as implementation of all project activities. This baseline will be supported and enhanced by systematically identifying potential hazards and assessing risks so that decisions can be made with regard to selection of hazard management measures that reduce risks to meet the risk targets provided in this philosophy.

3.4 Strategy for Hazards and Effects Management

The following approach will be used for the engineering design for the project.

- identify potential hazards, or activities that can realise a hazard
- identify hazard management measures already in place
- determine how likely each hazard is to occur (frequency) based on exposure and likelihood
- assess the potential consequences if the hazard is realised
- record the significant hazards and effects evaluate (assess) the risks (consequence x frequency)
- identify and implement suitable hazard management measures
- document the findings and hazard management measures

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Whilst hazard management measures should be put in place for all hazards, the risk assessment elements of the process will provide guidance regarding any hazard management measures necessary to meet criteria. The risk assessment of all hazards will be quantitative, based upon the COMPANY risk ranking matrix, taking into account likelihood of the hazard and severity of consequences. Where consequences are identified as being a consequence 5 or the risk identified as a red risk as per the RAM (Figure 5), the hazards will be identified as major accident hazards (MAH). Any significant residual risks will be captured into the Design ALARP Demonstration Report, that will provide for each hazard (giving enphasis to the MAHs) a sheet showing the initial and final risk level with all the safeguards and barriers installed..

During the detailed design phase hazard management measures provided to reduce risks associated with MAHs shall be classified as safety and environmental critical elements (SECEs), and minimum performance standards developed for each. The identification of SECEs will be completed at this .

3.5 Major Accident Hazards

For the purposes of risk assessment and management of hazards in accordance with this plan, MAHs are defined as any unplanned and uncontrolled event that has the potential to lead to severe or catastrophic consequences to people, assets, the environment and/or business continuity and reputation. The consequences can be immediate or delayed; they may also have potential for escalation. MAHs tend to fall into the following categories:

- an incident involving an explosion, fire, or release of gas or dangerous substances with a significant potential to cause multiple fatalities
- an incident leading to serious damage to the asset involving, or with a significant potential to cause, multiple fatalities
- any other incident with a potential to lead to greater than 3 fatalities
- any major environmental incident resulting from incidents referred to in points above
- In general, the main hazards / concerns associated with hydrogen could include:
- Hydrogen gas has a propensity to leak due to its very low viscosity, therefore it is difficult to prevent systems from developing leaks. Leaks from hydrogen systems could occur through welds, flanges, seals, gaskets etc. especially when the material used is not suitable for hydrogen service.
- Hydrogen can also cause embrittlement to high strength steels, titanium and aluminium alloys with cracking and catastrophic failure of the metals at stress levels below the yield stress.

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- Mixtures of hydrogen and air are flammable over a considerably wider range of concentrations (4-74%), compared to conventional fuels (natural gas 5-15%),
- Ignition sources that normally do not represent a significant hazard may readily ignite hydrogen-air mixtures (hydrogen is easily ignitable with ignition energy of less than one tenth that of other fuels such as methane).
- Hydrogen also has the possibility to spontaneously ignite on sudden release from pressurised storage.
- The burning velocity of hydrogen-air mixture is about 8 times greater than those for methane or propane air mixture. Whilst the high burning velocity of hydrogen reduces heat transfer to the surroundings (therefore reducing risk of secondary fires), higher burning velocity would result in higher explosion pressures in the right conditions.
- Hydrogen-air mixture is highly reactive and has more of a propensity to detonate than other flammable air mixtures. This is likely to occur in confined or congested spaces.
- Additional hazards are created by the oxygen rich stream. Even a small increase in the oxygen level in the air – to just 24% – can create a dangerous situation where:
- It becomes easier to start a fire, which will then burn hotter and more fiercely than in normal air; it may be almost impossible to put the fire out.
- Pure oxygen is also very reactive.
- Oxygen can react violently with common materials, such as oil and grease.
- Other materials may catch fire spontaneously. Nearly all materials, including textiles, rubber and even metals, will burn vigorously in oxygen.
- Oxygen can adhere onto hair and clothing for a considerable period of time after exposure.

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3.6 Inherent Safety and Selection of Safeguards

Where hazards are identified, hazard management measures will be selected as far as practicable in accordance with the following preferential hierarchy:

- prevention (inherent safety)
- detection and control / limitation
- mitigation
- escape / recovery

Inherent safety is an approach that tries to achieve facilities and processes that exclude hazards and are therefore by their nature simpler and safer to operate. The aim will be to avoid hazards, or to minimise the likelihood of hazards occurring, through design wherever practicable, in preference to implementation of measures to control, limit or mitigate the effects of a hazard.

The intent will be firstly to design facilities that are inherently safe as far as possible and then to add features such as containment, instrumented alarms and trips, if necessary, to reduce risk to an acceptable level. The approach to selection of hazard management measures, will therefore be to:

Inherent safety (prevention) – process options or design basis that aim to remove hazards or minimise the potential for hazards to be realised. For example: substituting hazardous chemicals for less hazardous materials, reduction in volumes, reduction in temperatures and pressures

Detection and control – measures to detect potential incidents prior to occurrence, or as early as practicable after occurrence, and automatically control or initiate alarms that enable operators to intervene. Examples include dedicated process instrumentation initiating automatic shutdown, and gas detection following loss of containment

Mitigation – measures to reduce, or where possible eliminate, the effects of consequences when a hazard is realised. Examples include fire protection systems that limit the effects of ignited releases

Escape, evacuation and recovery – measures to ensure that personnel can remove themselves to a place of safety and be recovered. Examples are escape routes and safety equipment

Operating procedural controls should only be considered as a means of reducing risks if further engineering/design measures are not reasonably practicable.

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3.7 Engineering And Design

Hazards will be systematically identified and managed during design so that facilities can be constructed/installed/operated to enable safe, secure, healthy and environmentally sound performance, throughout the operational life of the facilities, and safely decommissioned with minimum impact on the environment. Identification of hazards and development of hazard management measures will be commenced as early as possible.

During this stage the EPC contractor will manage hazards and their effects through identification and application of appropriate design codes and standards backed up by a risk-based approach that enables the identification of hazards, assessment of their risks and determination of suitable engineered hazard management measures in accordance with the hierarchy described in this plan.

The key HSE deliverables at EPC stage and their inter-relationships and sequence of development through to end of design activities ensure the integrity and operability of the new facilities.

The documentation delivered will define the safety aspects of the scope for design, construction and installation, and provide information for ongoing management of hazards and their effects through subsequent stages of the project into operations. Relevant technical safety and environmental design documentation should be updated in each phase, if appropriate, to incorporate the development of the overall design.

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4 HSE ENGINEERING

4.1 Hazard Identification

Hazard identification and assessment studies will be performed for all areas of the project, and for specific packages or scopes of work to:

- identify the hazards to be addressed during the design process (HAZID)
- confirm the design has provided adequate hazard control measures and will operate as intended without introducing additional hazards (HAZOP)

Formal hazard identification studies will be carried out as team exercises involving Company, EPC Contractor and other specialists as necessary and an independent facilitator.

Terms of reference will be issued to all team members prior to the meetings. After the meetings a report will be issued, and actions transferred to an action management system register. Risks will be ranked qualitatively providing the basis for identification of MAHs to be assessed.

Individual actions will be issued to the actionee, and their responses recorded in the register. Actions will be closed out and implemented into Detailed Design

4.2 SIL Assessment

A Safety Integrity Level (SIL) assessment will be conducted applying LOPA methodology as per DEP standards. The workshop will be done after Hazop and based on identified SIF's.

This Study will cover the safety instrumented functions (SIF) identified in Hazop and are part of SIS incorporating safety instrumented functions such as ESD (Emergency Shut Down), PSD (Process Shut Down), LSD (Local Shut Down) systems. The SIL Allocation will define, for each SIF examined, the target level of safety integrity requested expressed numerically as SIL class (SIL 1, SIL 2, SIL 3, SIL 4).

The F&G logic system shall be designed, manufactured, and certified as SIL 2 as minimum. All F&G detection devices (including push buttons) and final elements (e.g., relays, solenoid valves, etc.) connected to the main system shall be independently minimum SIL-1 compliant and certified by an approved third-party Company (e.g., TUV, EXIDA, SIRA).

For further details, refer to Design HSSE Plan [2].

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4.3 Fire, Blast and Explosion Risk Analysis

A fire and explosion risk analysis (FERA) including blast risk will be carried out to assess the consequences of all the identified fire, blast and explosion MAHs. The assessment will:

1. identify hazardous inventories for credible releases
2. evaluate
    - the gas cloud dispersion
    - fire impacts
    - blast and explosion consequences
3. recommend mitigation measures in design

4.4 Other Studies

As well as the FERA, a QRA, an escape, evacuation and rescue analysis will be completed to determine adequate platform design and provisions for personnel to escape any MAH events should one occur whilst they are there. dropped object and ship collision studies will also be undertaken to ensure mechanical impact MAH events are assessed.

4.5 Loss Prevention

4.5.1 FIRE PROTECTION AND FIRE AND GAS DETECTION

Layout drawings, calculations and specifications will be prepared to provide engineering definition for fire and gas detection and firefighting/safety equipment and systems.

Types and locations of equipment will be selected in accordance with the principles in this safety and loss prevention philosophy to address the findings of hazard identification studies.

These will include fire, and flammable gas detection, manual call points, fire protection (active and passive) designed against credible fire scenarios. These will be provided in the fire zone layout, passive fire protection layout and the fire and gas detection layouts.

4.5.2 HAZARDOUS AREA CLASSIFICATION

A hazardous areas classification study will be carried out for installations handling flammable fluids (amendments/supplements to EI 15 and chapter 3 of EI 15 [6]to define locations where flammable atmospheres may be expected to occur. A hazardous area classification schedule and hazardous area classification layout will be prepared. The electrical and control and instrumentation discipline will then ensure that electrical equipment, including instrumentation located in hazardous areas will be specified and certified in accordance with the prepared schedule and layouts.

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4.5.3 EMERGENCY RESPONSE, ESCAPE, EVACUATION AND RESCUE

Equipment, systems and facilities necessary for effective escape, shelter, muster and evacuation will be defined. This will be set out on the firefighting and safety equipment layouts and will also include:

- escape routes
- safety, escape and rescue equipment (including for example,escape masks, life jackets and immersion suits, first aid kit etc. ,).

Layout drawings and specifications for all equipment and systems will be produced in sufficient detail to enable enquiries to be issued.

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5 PREVENTION MEASURES

5.1 General

In accordance with the hierarchy of risk management above, achieving a design that is inherently safe, or ensures prevention of incidents, is preferable to dealing with hazards and their potential consequences. Inherent safety is an approach that tries to achieve facilities that exclude hazards and are by their nature simpler and safer to operate. Measures aimed at preventing or minimizing the occurrence of hazardous incidents will therefore be adopted as far as practicable to achieve a design that aims for inherent safety.

5.2 Containment

The facilities will be designed to minimize the probability for accidental release of potentially flammable, hazardous and toxic materials, through:

- Always rating piping, vessels, pipelines and equipment in accordance with maximum foreseeable operating pressures and temperatures.
- Ensuring that material selection is fully compatible with existing materials at tie-in points, and that thicknesses take account of fatigue, corrosion and erosion potential for the expected operating life, with cathodic protection and coatings where applicable.
- Minimization of potential leak sources including valves, instrument fittings and flanges as far as is practicable, whilst allowing for safe operation and maintenance.

Since Hydrogen can leak through valves and flanges, to lower the likelihood of releases, welds are a preferred option for fittings. Moreover, as Hydrogen can be absorbed into storage materials and make them more prone to cracking, the material selection should also take account of hydrogen embrittlement.

Fixed process piping will be flanged and fully welded as far as practicable. Screwed and/or threaded fittings or connections will not be permitted in high pressure and/or hazardous service except for instrument connections. Small bore lines should be protected and routed to minimize risk of mechanical damage.

All piping should be subject to a review, taking into account mechanical handling requirements, and protected accordingly. Piping and equipment will take account of potential vibration so that no defined design and/or operating conditions can contribute to potential for failure and loss of containment.

5.3 Process Design

Process design will be in accordance with the requirements of:

- applicable codes and standards
- Company supplied project design data, standards and practices where necessary

In the event that existing arrangements obstruct compliance with the above, EPC Contractor will propose a solution to be agreed with Company.

All changes in design pressure will be clearly identified and protection provided against the potential for overpressure of the downstream system. This should be based upon mechanical solutions such as appropriate pressure ratings, isolation valves and pressure relief valves where practicable. Otherwise, dedicated instrumentation and isolation, which has been subject to SIL assessment will be used.

5.4 Facility Layout and Segregation

The layout and relative locations of equipment can make a significant contribution to the management of hazards. The layouts will consider as far as practicable:

- grouping equipment with similar fire potential within the same fire area, but without making each fire area too large
- locating ignition sources as far as possible from other equipment having flammable inventory
- maximizing natural ventilation to minimize potential build-up of flammable atmospheres
- ensure that venting to atmosphere is to a safe location via dispersion modelling.
- reducing the possibility for fire in one area to spread to an adjacent area by segregation or provision of barriers so as to define fire zones
- arranging the layout such that it is possible to attend and fight a fire from at least two sides of the fire zone
- ensuring that there are at least two different routes from each work area leading to the primary or secondary muster point.

Segregation should be achieved by separation as far as is practicable. Where segregation by separation is not practicable, physical barriers may be required to provide protection against hazardous events provided they are designed for the magnitude and duration of the consequences defined by the safety studies. Barriers may include:

- fire rated walls designed to delay the spread of fire, or its effects (heat, smoke) between zones for a defined period of time
- explosion / blast walls

5.5 Hazardous Area Classification

The primary objectives of Hazardous Area Classification are to:

- Reduce to an acceptable minimum level the probability of coincidence of a flammable atmosphere and an electrical or other source of ignition;
- Ensure that electrical and mechanical apparatus is of an appropriate design;

- Provide input into location of air inlets for ventilation systems or combustion equipment.

All electrical equipment which may be required to operate in an emergency shutdown under confirmed gas conditions shall be certified for use in a Zone 1 area. Such equipment includes, but is not limited to:

- Fire and gas detection and protection equipment;
- ESD equipment;
- Telecoms equipment;
- Escape lighting (luminaires);
- Uninterruptible Power Supply (UPS) battery isolation devices.

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6 DETECTION MEASURES

6.1 General

Detection measures refer to hazard management measures that are provided to detect process excursions or loss of containment incidents and initiate automatic controls to prevent or limit hazardous consequences, and/or alarms that warn operators. These include fire and gas detection, and process safety systems that may be instrument or mechanical based.

A key safety objective for detection and control systems will be to minimize the extent of personnel exposure to hazardous scenarios and requirements for any local intervention on the normally unmanned facility. Safety systems will therefore be designed to be autonomous, and to monitor continuously process systems and platform areas for potentially hazardous excursions, and automatically initiate functions without the need for local operator intervention, as far as practicable.

Systems will incorporate redundancy of components where necessary to achieve the levels of integrity that are defined herein as a minimum, or as required by the findings of the SIL assessment.

The Control and Safety System developed for BLPH shall comprise of two (2) interconnected, but independent systems:

· A Central Control System (CCS); and

· A combined Fire and Gas System (FGS) and Safety Instrumented System (SIS), which shall be referred to collectively as the Safety System.

The CCS shall be responsible for the monitoring and control of the facility, whilst the Safety System shall be responsible for the overall safeguarding of BLPH.

The CCS will provide basic process control functions for normal operation, while the SIS will monitor dedicated process instruments for excursions (failure of basic process control) and initiate automatic control actions aimed at bringing the process to a safe condition.

The fire and gas system will monitor all areas of the facilities for fire and gas events, and provide automatic initiation of alarms, signals to the SIS system, and/or fixed fire protection systems as appropriate to the hazards.

Each of the systems will be designed to operate fully independently, but all will be capable of seamless integration so as to provide fully integrated operator monitoring and control facilities. Although, the platform is normally unmanned and designed to be autonomous – all key CCS, SIS and F&G data is communicated to the main Crosswind Control Centre. The systems will also be capable of interfacing with existing systems that remain, and equipment unit control systems.

Independence and segregation between the safety systems will be ensured by using dedicated logic solvers, input/output (I/O) modules, power supplies and intercommunications so there can be no domino effect if one or other of the systems fails and to avoid common mode of failure.

The SIS and fire and gas systems will be designed for safety and will be capable of performing automatic diagnostic routines on system performance, I/O module condition, I/O line monitoring, power supply unit faults and communication errors.

6.2 Fire and Gas System Overview

The fire and gas detection system will continuously monitor all areas for unplanned process releases and fire events. The prime objective of the system will be to detect hazardous situations as early as practicable so as to prevent escalation of the initiating event and limit damage, as well as potential for harm to personnel.

The overall philosophy for fire and gas detection will be to:

- monitor spaces where fire or accumulations of potentially flammable gas may occur
- alert personnel to fire/gas events
- initiate timely actions to minimize the consequences of the event
- initiate isolation of non-rated equipment prior to leaked gas migration from a hazardous area to a non-hazardous area

The Safety System will be independent of the process control system and be based upon SIL certified PLCs, incorporating redundancy.

Maintenance over-ride facility (selector switch) will be provided for each area to prevent false alarm or executive actions being initiated whilst work is taking place in the affected area. This will be controlled via an appropriate work permit process and critical systems deactivation procedure.

Status and alarm information will be available at the operator workstation indicating the type of alarm and the location. The operator must be able to monitor all fire zones, with the display showing individual fire and gas detection activity in each area.

The routing of fire and gas detection cables should minimize potential for damage, due to excessive heat exposure. All fire and gas cables must be fire resistant according to appropriate international standards.

The system will include field mounted detectors and manual call-points, powered from the F&G system, with type and coverage selected on the basis of the hazards present at each location and guidance given in the following sections. The design will keep to a minimum the different types of detectors in order to restrict the range of spares.

On fire or gas detection, the F&G system will automatically notify personnel via audible and visible alarms, including flashing beacons in high noise areas. Confirmed detection will initiate signals to the SIS system to shut down and isolate process inventory, and mechanical/electrical systems.

Where enclosed spaces, are protected by fixed extinguishing systems, confirmed (voted) fire detection will also initiate extinguishant release. Detector status, voting and control actions, including extinguishing system operation, will be indicated on dedicated operator workstations in the control room.

For further details on F&G detection system, refer to Fire Protection philosophy [3]

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7 CONTROL AND MITIGATION MEASURES

7.1 General

Mitigation measures refer to arrangements that aim to manage and reduce, or eliminate, the effects of accident events. These include minimization of potential leak sources including valves, instrument fittings and flanges as far as is practicable, whilst allowing for safe operation and maintenance fire and explosion protection, and systems to contain and limit the spread of accidental releases.

7.2 Emergency Shutdown, Isolation and Depressurization

The SIS system will comprise dedicated process instrumentation, control system, and output devices such as isolation valves and motor control center functions that can initiate executive actions independently of the basic process control system.

The purpose of the SIS system is to ensure safe isolation and shutdown of the process in the event of a detected process upset, or a fire and gas incident.

The system will be autonomous but monitoring and control of the system will be provided in the control room. The system logic requirements will be defined on ESD cause and effect diagrams.

The SIS system will be designed and implemented so as to achieve a SIL for each function determined as a result of the SIL assessment. Logic solvers will be SIL certified in accordance with IEC 61508 following the HAZOP and LOPA workshops.

Emergency shutdown buttons will be provided at the control room and at locations around the platform. These should be designed with two action operation, such as lift flap and turn switch, to minimize the risk of accidental operation. Following a shutdown event, the reset of actuated devices will be undertaken locally in the field or remote reset/ restart (if required) as part of a formally documented re-instatement protocol.

The blowdown system will reduce the pressure and inventory of hazardous materials from BDV's.

7.3 Active Fire Protection

It has been assumed that there will be no requirement for a firewater system on the platform given there are no significant flammable liquid inventories. The objective of the active fire protection systems shall be as far as practicable to:

- control fires and limit the potential for escalation
- reduce the effects of a fire to allow personnel to evacuate
- extinguish the fire where it is considered safe to do so limit damage to structures and equipment.

The philosophy for the design of Fire Suppression systems will be based on the following:

- Only portable fire extinguishers are foreseen in the facility e.g Dry powder extinguishers and CO_2 portable extinguishers in accordance with NFPA 10[7]
- Portable extinguishers will be provided at strategic locations to allow trained personnel to attack small fires where it is safe to do so. In the event of a large fire, or escalation beyond the initial fire area, the philosophy will be to limit the spread of fire via fireproofing materials, and sufficient separation distances.
- Fire protection requirements and the design of systems shall be based on international standards and local regulations.

For further details on active fire protection system, refer to Fire Protection philosophy [3]

7.4 Passive Fire Protection (PFP)

A FERA study will be undertaken to identify requirements for passive protection against jet fires. In general steel structures start to lose a significant proportion of their structural integrity after two- or three-minutes direct exposure to hydrocarbon jet fire flames. In the case of hydrogen jet fires, the flame temperature is higher and therefore this structural integrity time is likely to be lower. However, hydrogen flames also have a lower emissivity therefore non-impinging fires tend to be less hazardous than hydrocarbon flames.

PFP may be provided to protect critical structures and equipment from the effects of fire for long enough to enable personnel to escape safely, to mitigate impact to the environment, and for safety critical functions to be completed. This will include, as a minimum, protection of:

- escape routes
- emergency shutdown valves
- cables in fire protection and ESD service
- structures, where collapse could result in further escalation of a fire

PFP will be achieved by application of fire-resistant coatings to steelwork, physical barriers between equipment, or coverings for specific equipment such as emergency shutdown valves/actuators. The type and thickness of PFP application to protect against hydrogen jet fires will be determined also.

For transformers, dividing walls between transformers and enclosures will be designed to provide 2 hours fire resistance where required. Decision will take account of the type of oil used for transformer cooling and separation distances.

All cables of the fire and gas system, ESD instruments and supplying safety devices (ESDV, SDV and BDV) must be fire resistant according to international standards.

For further details on passive fire protection system, refer to Fire Protection philosophy [3]

7.4.1 EXPLOSION AND BLAST PROTECTION

A preliminary estimate of credible explosion and blast loadings has been made during FEED phase, this study will be updated during the detail phase, but currently following measures are considered with no particular blast requirements:

- Study hydrogen storage vessel fire failure analysis confirming 15-minute depressurizing time is sufficient to protect the vessels from an explosive rupture.
- Ensure a robust fire and gas detection design with good coverage and rapid response is provided in the hydrogen storage area.
- Assess of oxygen vent design in terms of adequate dispersion and prevention of any interaction with hydrogen vent plume once vendor data is available.

The main objective of explosion and blast mitigating measures is to minimize potential for harm to personnel and Safety Critical Elements as far as reasonably practicable. Another objective is protecting structures and pipe racks from being damaged by explosions. Design overpressure loads shall be estimated at this stage and with defined critical equipment locations and will be used as the basis for specification of explosion and blast ratings.

7.5 Drainage And Spill Control

The drainage system will be designed to:

- provide a route for the safe and environmentally acceptable disposal of liquid inventory.
- protect the environment from any chemical spills.

8 ESCAPE, EVACUATION AND RECOVERY MEASURES

8.1 Escape Routes

Escape routes shall meet the following key objectives:

- escape routes shall be directed away from possible hazards and lead to a designated muster area
- clear and diverse escape routes shall be provided to enable personnel to rapidly leave the scene of an incident, and must be always unobstructed
- all areas of the facilities are provided with two separate and diverse escape routes, which will be readily accessible and unobstructed.
- escape routes will be as straight as possible and without obstruction.
- for areas the maximum allowable distance to a single exit, leading either outside or onto a protected escape route, will be 5m
- at least two exits in diverse directions will be installed for locations if distance is greater than 5m
- dead end corridors or platforms shall not exceed 5m
- Main escape routes will be at least 1.2m wide
- All secondary escape routes will be sized with minimum 0.8m width
- All the escape routes have minimum height clearance of 2.3 m
- The staircase width is designed for 1.2m and is sized for the passage and turning of stretchers.
- The width of escape routes shall never be reduced by opening doors (entrance or cabinets), unless not reasonably practicable. In that case a formal deviation request shall be raised to Company.
- Corners shall be kept clear of bulkhead mounted equipment.
- All escape routes will be suitably painted for ease of identification in an emergency, and properly marked with safety signs:
  - The escape routes on plated decks shall be marked by continuous photo-luminescent color painted on floor with yellow bands on both sides of the escape route and arrows indicating direction of escape as per ISO 24409-1 requirements.
  - The escape routes on grated decks shall be marked by with yellow painted plates bolted to the grating to form an intermittent line along both sides of the escape route.
  - The escape routes shall have anti-slip coating to minimize the risks of slippage and falling. This includes the stairs and landings.

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- The escape routes are Illuminated so that they are readily identifiable in an emergency.

Consideration will be given to the evacuation of injured personnel on stretchers. Emergency lighting with standby power supplies will be provided on all escape routes.

The escape routes shall have anti-slip coating to minimize the risks of slippage and falling. This includes the stairs and landings.

8.2 Muster Areas

Muster areas will be provided for the platform facilities, where personnel can assemble during an incident considering the project's formal safety assessments.

Alarm information and instructions will be available at muster area to allow all personnel to take any further instructed emergency actions (i.e., rescue by a dedicated CTV at boat landing area or to deploy life rafts).

A secondary muster point will be on the walk to work platform on the northwest of BLPH Hub.

This platform is not normally manned. The maximum POB at the platform is 10. Although the expected POB is a maximum of 10 personnel, and the size of the muster areas are designed to provide additional capacity due to redundancy requirements.

8.3 Evacuation facilities

Evacuation facilities provided on the BLPH are specific based the different evacuation scenarios identified. The means of evacuation of the BLPH are:

- Primary means of evacuation via primary muster area (main access platform) and then to Crew Transfer Vessel at the boat landing.
- Secondary means of evacuation via secondary muster area (walk to work platform) and then to the life raft located on the northwest of BLPH Hub(a second life raft located on the southeast of BLPH Hub will be available).

8.4 Emergency Communications

The platform will not be equipped with a Public Address system, but instead all personnel are to carry hand-held radio devices to facilitate communication with workers in emergency and non-emergency situations. Requirements will be further defined in the project specification for telecommunication systems. There will be a General Alarm system driven from the F&G system. This will ensure that on detection of any fire or gas event, the platform sounders and beacons will alert personnel on the platform, at which point they will proceed to the appropriate muster location.

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8.5 Emergency Power

Emergency power to the vital (also known as critical) loads shall be supplied by UPS batteries backed up with an essential power system.

The UPS system shall as a minimum support the facilities for the duration necessary to achieve emergency shutdown, personnel egress, and evacuation.

The following vital systems shall be provided with a UPS:

- CCS/DCS;
- ESD system;
- F&G system;
- EMCS System;
- Fire suppression systems;
- Navaids;

8.6 Human Factor Requirements

Human Factors (HF) analysis seeks to reduce risks and to maximize performance through optimizing the fit between the people, the hardware, and the procedures, and minimizing the frequency and consequence of human error. The overall objective of the HF support is to provide input to the design process to:

- Enhance operability, maintainability, and safety of the BLPH.
- Ensure compliance with statutory and company requirements.

The Human factors requirements and guidelines will be considered into the design and included by each discipline in layout development, in addition interdisciplinary checks will be performed during the detail phase to allow safety team to verify proper application of the requirements. Finally, verification of applicable requirements will be conducted during the 60% model review, in order to allow the project for closure or deviation of any action.

The design team will follow a checklist approach to verify compliance with HFE requirements. The following checklist is proposed.

Access

- Centre heights of control devices for standing operations (including valve handles) should be max. 1800 mm above base
- Centre heights of control devices for normal operation controls and for controls where access in an emergency should be between 900-1500 mm above base
- Free space between handrail, knee rail and toe plate should be not more than 380 mm
- Space between fixed cabinets and floor should be minimum 250 mm

- The minimum workspace envelope for crawling work should be 550mm in height and 950mm deep
- Minimum horizontal distance for semi-kneeling work should be 1200mm

Material handling

In the following table the recommended maximum weight for manual handling is shown:

- The maximum weight to be lifted and/or carried (by one (1) person using two (2) hands and standing erect with item held close to the body (max reaching distance 300 mm) should be 16 kg. Above limits are allowed to an object with uniform mass distribution and compact size not exceeding 450 mm high, 450 mm wide
- The maximum weight to be lifted and carried for non-ideal lifting circumstances (bent over or when reaching out more than 300 mm from the front of the body) should be 11 kg.
- The maximum weight of an object carried at a person's side, with a top handle, should be 14 kg.

Ergonomics

Working environment area limits shall be according to limits to NORSOK S-002[8] – Annex A-1. In particular following items should be checked:

PIPES AND FLANGES

- Spaces between pipe bottoms and floor should be min. 150 mm
- Spaces between external diameter of flanges and fixed obstructions should be min. 250 mm

GUARDRAILS

- Guardrails provided on elevations should be higher than 500 mm
- Height from floor to top of the guardrail should be min. 1100 mm
- Free space between handrail, knee rail and toe plate should not be more than 380 mm
  Minimum two knee rails should be included
- Toe boards of min. 100 mm height should be provided on passageways located over frequented areas and open sea
- The opening between floor and toe board should be max. 15mm
- The diameter of handrails should be within the range 25–50mm or in compliance with NORSOK C-002 [9]

- Stairways, stepladders and inclined ladders should be provided with continuous railing on both sides, from the top to the lower level and safely terminated at both ends
- The distance between handrails and any obstruction should be of min. 75 mm

STAIRS

- Stairs or ladders should be provided where there is a change of elevation exceeding 350 mm and access is required
- Stairs should be provided where daily access is required
- Width of stairway passage should be min. 1000 mm, as measured between the inside of handrails (or min. 1200 mm for access to more than two levels) or in compliance with NORSOK C-002
- Inclination of stairways should be within the range 21° - 45° (Recommended range 30° - 38°)
- Following requirements for steps should be met:

  a) Height riser (h) ≤ 250 mm

  b) Going (g) ≥ 100 mm

  c) 600 mm ≤ g+2h ≤ 660 mm

LADDERS AND STEPLADDERS

- The inclination of:

  - fixed ladders should be within the range 76° - 90°

  - fixed stepladders should be within the range 46° - 75°
- The width between upright bearers should be at least 400 mm
- Horizontal clearance should be of 650 mm in front of ladders, and a horizontal clearance of 200 mm behind the front of the rungs (150 mm for discontinuous obstacles)
- Rungs should be evenly spaced, with vertical spacing min. 250 mm and max 300 mm.
- Rungs should be provided with a non-slip surface
- Safety cages, should be starting at height 2200 - 3000 mm, provided for ladders higher than 3000 mm
- The rest landing should be arranged at each 6000 mm for ladders above 10,000 mm

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GATES

- Self-closing gates should be arranged at the top of ladders

HATCHES AND MANWAYS

- Hatches should have an access opening of min. 800x800 mm (min. 600x600 mm for access to cofferdams and tanks from floor/platform)
- Access openings in vertical partitions into cofferdams, tanks etc. should be equipped with hand grips on both sides above the opening
- Inspection hatches should be side hinged
- Are openings in deck larger should be than 100x100 mm secured by guard-rail or similar

DOORS

- Doors should have a clear opening of at least 750 mm width and 2050 mm height

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9 ENVIRONMENTAL RISK MANAGEMENT

Environmental management is based on principles of prevention, protection, information and participation, and aims to:

- Identify and evaluate environmental aspects
- Mitigate environmental impacts
- Monitor environmental components during the project lifecycle
- Manage a system for preventing adverse environmental events and/or environmental crimes.

The Project Environmental requirements shall meet, as a minimum, and be managed according to legal requirements, International standards and guidance, Good International Industry Practice and relevant Company corporate policies. Company standards Best Available Techniques (BAT) shall be used, and methodologies shall be developed to prevent, minimise, render harmless and manage polluting releases, and to consider all environmental media both in the short and long term.

Risk assessment, for offshore activities, shall be performed, to determine if adequate barriers are in place to prevent spills, dropped objects left on seabed, violation of Law and permits and unacceptable impact on the marine environment, minimize environmental pollution, and avoid mortality or injury events of marine mammal and birds.

9.1 Emissions To Air

9.1.1 VENTING OF HYDROGEN AND OXYGEN VENTS

Segregated vent systems are provided for hydrogen and oxygen. The Hydrogen Vent is provided for emergency relief and depressurization purposes. Emergency flows will be routed to the atmospheric Hydrogen Vent. The hydrogen vent will be designed for unintended ignition.

All Hydrogen releases and relief flows will be minimized as far as reasonably practicable and only generally be vented during planned shutdowns or during emergency scenarios and they are all convey to the Hydrogen Vent. Vented flows will be intermittent, small flows, for short durations meaning the delta in environmental impact is envisaged to be small. Relief systems will be installed to ensure the safe disposal of fluids in process upset conditions.

The exhaust from the Hydrogen Fuel Cells is predominately air (with reduced oxygen level), hot water vapor and tiny amount of hydrogen.

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Although hydrogen is not a direct Green House Gas (GHG), it has an indirect global warming potential when reacting with radicals in the earth's atmosphere, therefore its unburnt release to the atmosphere will be minimized as much as practicable.

Research on the GHG potential of hydrogen is currently ongoing as it is becoming more widely used in energy generation. As the project develops, it is envisaged that emissions limit values, environmental regulations and guidance will develop in this area, including the need for monitoring and reporting.

Hydrogen only releases water vapor when burned so a vent system with intermittent relief flow to the atmosphere will have a higher environmental impact than a flare system.

The platform has two points of oxygen releases at safe location, one is from the Electrolyzer, and the second is from the nitrogen package production. Oxygen releases does not pose any environmental risks; however, it could create safety risks if segregated at high concentration or if mixed with hydrogen, since highly concentrated sources of oxygen promote rapid combustion.

From the Nitrogen Generation Package (A-63000) the oxygen rich stream is vented to safe location, the release remains inside Supplier package.

Within the Electrolyser the oxygen will be vented continuously via the Oxygen Vent from the Oxygen Separator.

Nitrogen will be present in the Hydrogen Vent stream. It does not pose any known environmental risks.

9.1.2 FUGITIVE EMISSIONS

Fugitive emissions are leaks or unintended releases of pollutants from a contained source into the surrounding atmosphere. Fugitive emissions shall be kept at a minimum by minimizing the number of flanges in piping and by provision of spiral wound gasket materials.

The main sources of fugitive emissions will be:

Fugitive process emissions:

- a subset of diffuse emissions and sources potentially include valves of all types, flanges, pump and compressor seals, pressure relief valve, sampling connections and process drains.

Leakage associated with hydrogen systems:

- flanges, valves and fittings and hydrogen embrittlement,
- hydrogen storage

9.1.3 EMISSIONS TO AIR IN EMERGENCY SCENARIOS

In the unlikely event of emergency, there will be potential emissions to air, e.g., as a result of thermal runaway and / or from BESS Vent.

9.1.4 OZONE DEPLETING SUBSTANCES

Attention should be paid to the selection of high voltage switchgear material: this type of equipment must not contain sulfur hexafluoride (SF_6) in order to avoid any potential for ozone depletion in the project.

9.2 Discharge to sea

As per [4] during normal operation a maximum of 1000 kg/hour of fresh water is needed to produce hydrogen, thus about 3000 kg/hour (circa 3 m^3/hour) of sea water is pumped up. At the same time, about 2500 kg/hour (circa 2.5 m^3/hour) of brine (sea water with a higher concentration of salts at around 28%) is discharged through the caisson into the sea. As per [5], this must comply with permitted discharges from facility & water decree from RWS, which states that:

- Sodium [Na] content should be from 20000 to 24000 ppm;
- Potassium [K] content should be from 750 to 780 ppm;
- Calcium [Ca] content should be from 750 to 850 ppm;
- Magnesium [Mg] content should be from 2500 to 2700 ppm;
- Chloride [Cl] content should be from 35000 to 41000 ppm;
- Sulfate [O_4S^{-2}] content should be from 5000 to 5400 ppm;
- Carbonate [CO_3^{-2}] content should be from 250 to 300 ppm;
- Oxygen [O_2] content should be from 12 to 16 ppm.

The expected demand for sea water intake and consequent discharge volumes will need to be closely monitored, including local baseline surveys to ensure no adverse impacts to local marine fauna and flora, as well as associated fisheries.

9.3 Biodiversity and Environmental Commitments

For preventing birds from forming habitats on asset screen bird will be installed where required at vents or other strategical location; in addition, Bird deterrent system will be installed. Impact on marine life due to brine discharges from the process will be assessed and will be confirmed to comply with permitted discharges from facility & water decree from RWS as stated in the previous paragraph.

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10 PERSONAL HEALTH AND SAFETY

10.1 General

The project design will minimize risks to all personnel on and near to the site by eliminating or minimizing exposure to hazards.

All health risk will be assessed during the HAZID workshop. A health professional shall be involved in the workshop, to highlight specific hazards, as already found out during FEED for legionella risk. The assessment shall include the following hazards and controls:

- Physical (e.g. noise, lighting, heat/cold stress, radiation, vibrations),
- Biological (e.g. legionella, vector-borne diseases),
- chemical (e.g. acute and long-term toxics)
- psychological hazards and controls.

Where practicable, the exposure to health hazards will be minimized by adopting the hierarchy of controls:

- Elimination of a hazard by modifying the process;
- Substitution: replacing a chemical with a less hazardous substance;
- Engineering controls: Isolation of the process to prevent exposure to harmful substances or conditions.

10.2 Noise And Vibration

Where practicable, the facilities will be designed to comply with criteria for area noise levels and sound pressure levels. Noise levels shall be limited throughout the installations to:

- Minimize the risk of hearing damage to personnel
- Ensure alarms are audible
- Allow adequate speech, telephone or radio communication
- Maintain working efficiency

As BLPH has been designed with a relatively short operational life and is planned to be operationally un-manned, only having maintenance operatives aboard for commissioning, essential maintenance and for de-commissioning. The requirements for noise control have therefore been focused on ensuring that any maintenance operatives attending the plant are safe and that noise exposure levels will be compliant with the EU Directive 2003/10/EC – Noise and with the Shell DEP 31.10.00.31 "Noise Control" which requires that noise control measures shall be included at the planning and design phases of new facilities and a noise limit of 85 dBA applies to any work area which cannot be restricted to access during normal operations.

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10.3 Safety Signs

Safety signs will be provided throughout the platform as per Machinery Directive and ISO 7010 standards. Signs will be pictorial as far as possible, and where text is required, it will be in English and Dutch languages. Safety signs will be in accordance with applicable national and international regulations.

10.4 Personnel Protection

Escape masks shall be located at strategic location to allow operators for use as appropriate. Lifejackets and suitable immersion suits for personnel protection will be provided inn in accessible areas. Safety cabinets shall be provided to store safety and firefighting equipment.

Rotating equipment will be provided with guarding to prevent personnel injury from contacting moving parts and CE markings will be applied as per machinery directive.

The design should not rely on personnel wearing gloves or other personal protective equipment (PPE), except for items such as handrails, which may exceed 60°C due to solar heating and where the use of insulation would be impractical.

Electrical earthing system will be applied for electric equipment systems to reduce the risk of accumulation of electrostatic charges which could cause sparks and start a fire/ explosion in Hydrogen regions and to protect the persons from an electric shock.

Eye wash shall be brought by operators on board in those areas where personnel may handle chemicals that cause irritation or damage in contact with skin or eyes. These may include:

- Chemical storage / injection areas;
- Battery Rooms.

The eye wash shall be such that personnel can use them in the shortest practicable time to mitigate the effects of chemical exposure.

Electrical Safety Kit, primarily for the purposes of protecting personnel from live electrical sources during periods of emergency response and rescue, shall be provided within the Technical Room. Evacuation stretcher of an approved type shall be provided for general personnel rescue and evacuation

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