Base Load Power Hub (BLPH)

Fire Protection Philosophy

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2	
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Table of contents

1 INTRODUCTION 5

1.1 Project Overview 5

1.1.1 Project Location 5

1.1.2 Project Concept 7

2 DOCUMENT SCOPE 8

2.1 References 9

2.2 Definitions And Abbreviations 9

3 FIRE AND GAS DETECTION 11

3.1 Fire and Gas Detector Design Approach 11

3.2 Fire Zones 12

3.3 Flame Detectors 13

3.4 Smoke Detectors 13

3.5 Heat Detectors 14

3.6 Hydrogen Gas 14

3.7 HVAC System and Air Intakes 14

3.8 Fire and Gas Alarm System 14

3.9 Manual Call points 15

3.10 Public ADDRESS AND General Alarm System 15

3.11 Voting Logic 16

4 FIRE PREVENTION MEASURES 17

4.1 Organisational Measures 17

4.2 Technical Measures 17

4.3 Ventilation 17

4.4 Static Electricity 18

4.5 Oxygen Enriched Environment 18

5 FIRE PROTECTION MEASURES 21

5.1 Active Fire Protection 21

5.2 Passive Fire Protection 22

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6 CPI – Electrolyser, FUEL CELL AND BESS 24
6.1 ELECTROLIZER 24
6.2 FUEL CELL 24
6.3 BESS Design 25

List of Figures

Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map 5
Figure 2 - Wind Park Details 6
Figure 3 – BLPH Concept 7

List of tables

Table 1 - Reference Documents 9
Table 2 - Definitions and Abbreviations 10

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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.

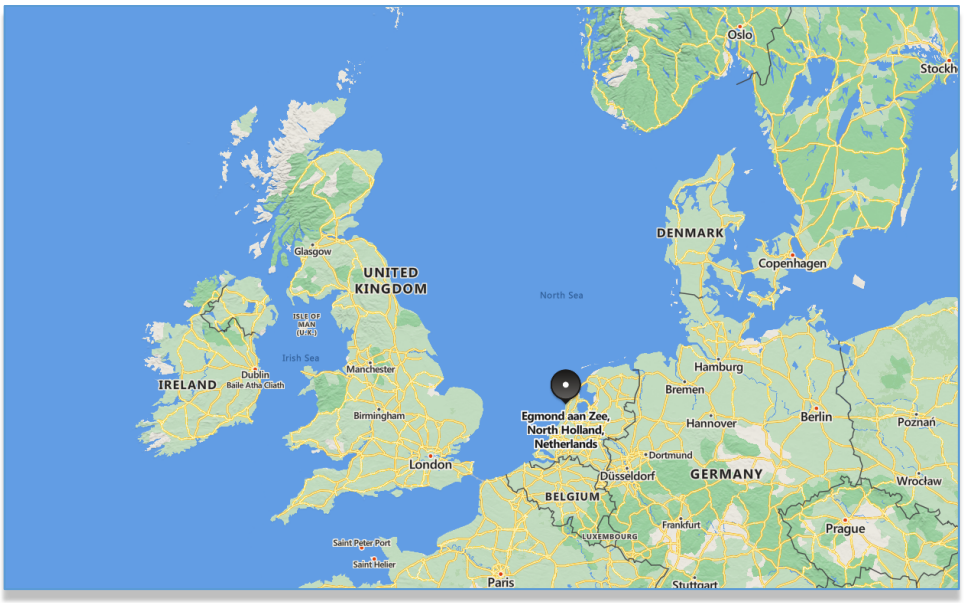


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

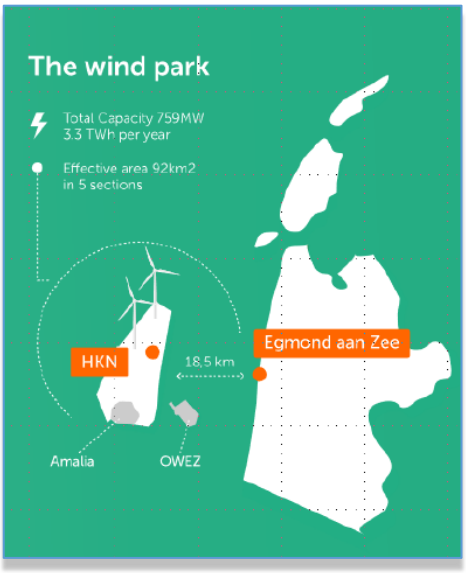


Figure 2 - Wind Park Details

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.

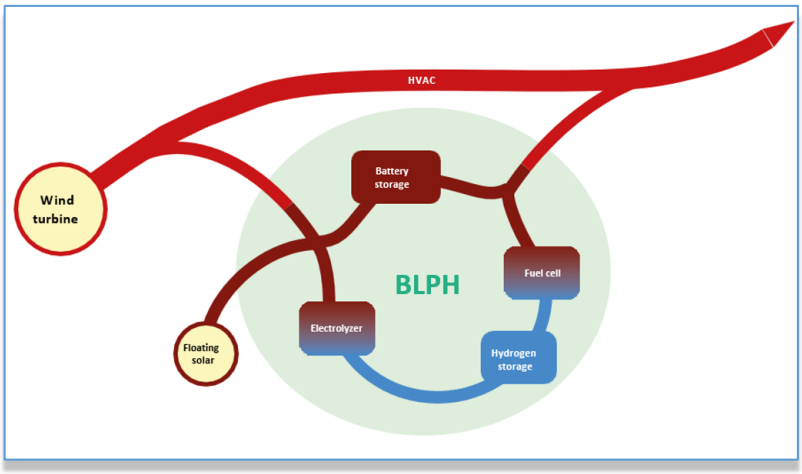


Figure 3 – BLPH Concept

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.

2 DOCUMENT SCOPE

This document outlines the Fire Protection Philosphy) for the BLPH Project. Scope of the present study is to outline the minimum requirements for the fire and gas detection system and related fire protection systems, both Active and Passive, to be considered for the design of the facility.

2.1 REFERENCES

Doc. No.	Description
[1] K559-2254-PM-PLN-003	Basis for Design Base Load Power Hub (BLPH), Revision 01
[2]123A90-DDL-SAF-RE-30002	Design HSSE Plan, Revision 00
[3]K559-2254-SE-PLN-002	Fire Protection Basis of Design, Revision 01
[4]K559-2254-SE-PHI-001	Fire Protection Philosophy, Revision 01
[5]123A90-DDL-SAF-RE-30046	HSE Design Philosophy

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

ALARP	As low as reasonably practicable
ASD	Abandon Shut Down
BESS	Battery Energy Storage System
BLPH	Base Load Power Hub
CPI	Company Supply Item
EIGA	European Industrial Gases Association
FGS	Fire & Gas Detection System
FERA	Fire and Explosion Risk Assessment
GES	Gaseous Extinguishing System
HKN	Hollandse Kust Noord
HMI	Human Machine Interface
HVAC	Heating, Ventilation and Air Conditioning
IR	Infrared
ITER	I&T container (plant instrument room)
LEL	Lower Explosive Limit
LV	Low-voltage
MAC	Manual Alarm Call Points
MFA	Manual Fire Alarm
MOB	Man Overboard
NFPA	National Fire Protection Association
TCD	Thermal Conductivity Detectors
UEL	Upper Explosive Limit
LFL	Lower Flammability Limit
UV	Ultraviolet
PAGA	Public Address and General Alarm

PFP	Passive Fire Protection
1ooN	One out of N Voting Logic where N=1,2,3…
2ooN	Two out of N Voting Logic where N=1,2,3…

Table 2 - Definitions and Abbreviations

3 FIRE AND GAS DETECTION

Fire and Gas Detection System is required to continuously monitor all areas to detect unplanned process releases and fire events so as to prevent escalation of the initiating event and minimize its consequences. The intervention of the system shall be as early as possible to enable raising of an alarm and swift intervention by the fire protection system. F&G system is installed at BLPH in case of confirmed fire and gas event, a site warning via speakers and beacons will be initiated. BLPH will perform ESD-1D/ESD-1 (fire zone emergency shutdown) where:

- Abandon Shut-Down will be actuated incase of smoke/hydrogen at ITG or UPS entrance or wherever ASD pushbutton will be located
- Process will be shut down with depressurisation by ESD-1D
- Process will be shut down without depressurisation by ESD-1
- Non-zone 1 hazardous rated equipment will shut down - on confirmed outdoor gas detection
- ATEX certified Portable radios without any RF power reduction will be on board (i.e. both non-hazardous rated marine radio base and fixed operation radio bases) - on confirmed gas detection
- Initiate automatic fire fighting actions (as required) - on confirmed fire detection

3.1 FIRE AND GAS DETECTOR DESIGN APPROACH

Design of the F&G Detector layout will be based on the following approach:

- Identify hazards and characterise their effects using results from the fire and explosion study
- Identify Fire and Gas Zones;
    - Develop design – Assess hazard characteristics in each Fire and Gas Zone and determine detector type, number, principle of operation and location. The layout design in each Fire and Gas Zone will consider: The ambient conditions and potential causes of impaired performance;
    - Dispersion behavior of gas and the potential beneficial locations for fire and gas detectors such as HVAC air intake ducts (for early warning of ingress into enclosed areas);
    - Possible failure modes, including risk of accidental damage, consequences of failure and the likelihood of false alarms;

- Maintenance access requirements.

The Fire and Gas Layouts shall be updated by Detailed Design Contractor once the 3D model is fully populated with all potential obstructions.

Design of the F&G system and voting configurations will provide input into development of the I/O count for the systems. Vendors will be required to provide F&G detection within their packages. Vendor F&G systems will be tied in the facility F&G system.

All fire and gas detectors shall be connected to Platform Fire & Gas Detection System (FGS) and shall be suitable for both the area where they will be installed and the detection system to which they need to be connected.

All field mounted flammable fire and gas detectors (i.e. excluding smoke detectors inside unclassified buildings) shall be certified for use in a hazardous area Zone 1, even where they are installed in areas that are normally classified as non-hazardous.

3.2 FIRE ZONES

Platform areas will be divided into a number of fire zones that may be defined by segregation distance, equipment functions, or fire rated divisions (in enclosures), so as to assist with identification of fire and gas event locations and to provide definition for detector voting groups as well as control of extinguishing systems.

Confirmed Fire:

- Initiate an audible and visual alarm at the control room;
- Initiate an audible general area alarm to alert any personnel that may be present;
- Initiate emergency shutdown and depressurization of fire zone;
- Close HVAC dampers if smoke detected at inlet;
- On detection within enclosure - initiate HVAC shutdown and closure of air intakes where necessary to control the spread of smoke, or to contain gaseous fire extinguishing media after discharge
- Initiate any automatic fixed gaseous fire protection systems as appropriate in fire zone.

Confirmed Gas:

- Initiate an audible and visual alarm at the control room;
- Initiate an audible general area alarm to alert any personnel that may be present;

- Isolate small power / welding sockets and non-Zone 1 electrical equipment as appropriate;
- Close HVAC dampers if gas detected at inlet and recirculate air.

During this phase, Cause and Effect charts will be developed by controls and instrumentation discipline to show all detectors and the required alarms and control actions for each fire zone, in accordance with the requirements of this philosophy or the updated version of this philosophy. These will include actions such as isolation and confirming isolation and letting a fire extinguish itself, due to the risk of re-ignition and explosion risk with hydrogen.

3.3 FLAME DETECTORS

Flame Detectors have to be positioned toward the areas where a flame is expected. Their exact location, numbers and spacing will be dependent on the layout of the area and will have to avoid any obstruction such as beams, piping and equipment.

Flame detectors are required around hydrogen storage vessels, which have to be emptied via the blow down vent in case of confirmed fire.

To avoid spurious flame detection for any detectors located in open areas, consideration will be given when locating detectors, to the position of external sources of flame (if any) and rising and setting sun. Hydrogen/air mixtures require very little energy to be ignited and hydrogen has a very large range between its Lower Explosive Limits (LEL) and Upper Explosive Limits (UEL). This means a hydrogen leak can easily result in a jet fire. Furthermore, hydrogen burns with an invisible flame, thus UV type flame detectors are necessary for detection of hydrogen fires. However, to avoid spurious detection from any detectors located in open areas, UV-IR flame detectors are preferred since they generate an alarm signal only if a flame is detected on both bands.

3.4 SMOKE DETECTORS

Optical type Smoke detectors can only be used for indoor locations, as outdoors smoke may be dispersed before it will reach a detector. Conventionally, in rooms where electrical equipment is installed and electrical fires as well as non-hydrocarbon fires could occur, point type smoke detectors using IR technology shall be provided at ceiling level. Where such rooms have elevated floors with cable spaces, detectors should also be provided in these spaces.

Smoke detectors, suitable to operate in an offshore environment, will be installed close to the location of air intakes to instrument / electrical equipment rooms and arranged to shutdown dampers (close the air intake) on confirmed smoke detection.

Smoke detectors are required within electrical and instrument containers, technical rooms, cabinet rooms and substations.

3.5 HEAT DETECTORS

Heat detectors will be installed in areas where flammable and combustible materials are handled or stored, or where local operating conditions are not suitable for installing the fast-reacting flame and smoke detectors, due to local environmental factors. They will generally be point-type detectors, single location rate of rise, installed in accordance with appropriate standard spacing requirements. The temperature settings of heat detectors will be selected to suit prevailing conditions and avoid spurious alarms.

3.6 HYDROGEN GAS

Electro-chemical point detectors for hydrogen gas will be located at high level, enclosed spaces and air intakes where the risk of hydrogen loss of containment exists. Low and high alarm points should be set at 5% and 10% LFL respectively for these detectors. Operations and maintenance personnel and the use of personal gas detection equipment shall also be taken into consideration. Hydrogen gas detectors shall be provided in container to detect potential emission of hydrogen gas which may be caused by overcharging the batteries or failure of the ventilation system. A minimum of two detectors will be provided at each fire zone to guarantee 2ooN voting logic.

The correct location of reliable sensors is crucial for timely detection and alarming of hydrogen leaks before an explosive mixture is formed. Hydrogen gas detectors shall be installed near possible leak sources (valves, hoses, flanges, connections, bellows, etc), at elevation, below ceilings of enclosed spaces, and in correspondence to forced ventilation system inlets and outlets.

In case hydrogen is detected at HVAC air inlet of a container with potential ignition sources (non ATEX equipment), the air inlet shall automatically be closed, and the HVAC system shall be switched to recirculation and non ATEX equipment shall shut down.

3.7 HVAC SYSTEM AND AIR INTAKES

Air intakes to enclosed spaces will be provided with gas and smoke detection located within ducting if present, or as close to the intake as practicable.

All intakes will incorporate a minimum of three gas detectors and three smoke detectors. Any two detectors in alarm will provide a confirmed gas or fire signal as appropriate. In case 1 detector is in fault it will be considered as in alarm.

Detection of either smoke or gas will initiate audible and visual alarms. Confirmed gas detection or confirmed smoke detection will initiate closure of intake dampers and shutdown the relevant HVAC system.

3.8 FIRE AND GAS ALARM SYSTEM

All flame detectors, smoke detectors and gas detectors shall be connected to the Platform FGS. The FGS will generate an alarm on the human machine interface (HMI) at the onshore continuously manned Control Centre. The FGS shall be independent of the Basic Process Control System and local override devices shall not be installed on FGS.

Alarm annunciation will be provided at the main fire and gas display in the control room for all fire and gas devices, to identify location and status (low or high alarm).

Platform audible alarms and flashing beacons (provided in high noise areas, if any such areas are identified) are to be driven by the FGS based on alarm signal from the fire and gas detection equipment. Tones to be differing based on event type and colors to be confirmed during detailed design but expected to be red for fire or manual call-point event, and blue for gas detection event.

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

3.9 MANUAL CALL POINTS

In the event of detection of a hazardous condition such as a release of gas or fire, personnel can raise alarms through the Manual Alarm Call Points (MAC). MACs shall be red in colour and of a type which prevents accidental activation (e.g. lift flap or pull handle type). MACs shall be provided with signs to enhance their visibility such that they are clearly recognizable from a distance to enable personnel to raise an alarm.

The general strategy is to place manual call points along paths of escape. The manual call points shall be located on exit routes, floor landings, exits to open air. Their function shall be the raising of a fire or man overboard alarm. The following type of Push buttons are foreseen:

MOB: For man Overboard alarm (located, for each deck on the opposite sides)

ASD: For platform abandon (located in dedicate areas, Lifeboats/liferafts,)

MFA: For manual fire alarm

The maximum distance that a person must travel to reach a Manual fire alarm call point cannot be more than 20 m. The standard height for a manual call point shall be 1.4 m above the ground at a minimum distance of 0.5m from any electrical equipment or 0.75m from miscellaneous items of furniture etc. MACs shall be of the ''Break-glass'' push-button type. MACs shall be connected in a single loop by fire zone. The duty fire pump shall be started on operation of a Fire Alarm MAC. Activation of MAC's shall also raise audible and visual alarm to the main control room.

3.10 PUBLIC ADDRESS AND GENERAL ALARM SYSTEM

A Public Address and General Alarm (PAGA) system is not a requirement for BLPH. As this platform is unmanned, personnel presence is only foreseen during maintenance activities. All visitors to the

BLPH platform shall have two-way radios. Emergency phones shall be located at muster stations to provide for necessary communications. General alarm functionality shall be provided by means of dedicated sounders and beacons which are part of the FGS. Manual call-points shall also be provided throughout the platform.

Audible and visual alarms shall be configured as follows. These alarm devices will be provided on the F&G system.

- Fire Horns and Red Flashing Lights, following activation of a fire detector or a manual alarm call point;
- Flammable Gas Horn and Blue Flashing Lights, following activation of a flammable gas detector

3.11 VOTING LOGIC

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 operator workstations in the control room.

To avoid spurious shutdowns and to ensure operational stability a 2ooN minimum voting logic shall be applied, as a general rule.

- Outdoor areas: 1ooN → alarm only
- Outdoor areas: 2ooN → confirmed detection will start executive actions
- Manual call points shall be used in voting configuration 1ooN when N≥1.
- Air intakes and air locks: 1ooN for alarm, 2ooN, being N ≥ 3 (minimum 3 in small areas and N > 3 for large areas) for executive actions;
- Indoor enclosures: 1ooN for alarm, 2ooN, being N ≥ 2, for executive actions

4 FIRE PREVENTION MEASURES

In order to prevent fires, specific organisational, directive and technical measures have to be implemented. An in-depth explanation of fire prevention measures is not within the scope of this document, however, the most important measures are listed below.

4.1 ORGANISATIONAL MEASURES

- Properly educated and certified maintenance personnel.
- Work permit procedure.
- Management of change.
- Emergency Response Procedure.
- Measures to prevent explosions, such as the use of portable equipment within hazardous area classification zones that is ATEX certified.

4.2 TECHNICAL MEASURES

- High reliability requirements for materials and systems used.
- Preventive alarms (gas detection).
- Ignition control by using ATEX certified electric and electronic equipment in areas with explosion hazards.
- Prevention of escalation by applying passive fire protection on critical equipment/supports.

4.3 VENTILATION

Fire and explosion prevention can be achieved by means of adequate ventilation both in open or enclosed spaces since dilutes the flammable gas concentration in air.

The ventilation regime for the battery rooms should be sufficient to ensure that the hydrogen concentration is normally maintained below 10% of the LFL (0.4% v/v for hydrogen), with only occasional temporary increases to 25% of the LFL being allowed.

Locations where ventilation will be required to create an explosion safe atmosphere will be determined on the basis of the Hazardous Area Classification drawings.

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4.4 STATIC ELECTRICITY

Because of the low ignition energy of hydrogen, static electricity can easily cause a fire or an explosion. To prevent buildup of static electricity, equipment must be provided with earthing connections.

Mobile equipment, equipment with moving parts, tools and clothing of personnel must be selected on the suitability to prevent build-up of static electricity.

4.5 OXYGEN ENRICHED ENVIRONMENT

The specific fire risks that can occur in oxygen systems are:

- Spontaneous combustion occurring inside the oxygen system, which can rapidly develop into a fire. Generally, this fire will extinguish after a few seconds, but the mass of oxygen released can create an oxygen-enriched atmosphere; and
- Combustion in oxygen-enriched air, which can be dealt with using conventional firefighting methods after the supply of oxygen has been cut off.

It is dangerous to enter an area with a high oxygen concentration in order to extinguish the fire or to help a person who is on fire since the rescuer's own clothing may also ignite.

Areas where an oxygen-enriched environment can exist should be designed in accordance with the guidelines of NFPA 53. Specifically, noteworthy are the general recommendations for material selection in NFPA 53, section 5.1:

- The rate of flame propagation and ignition susceptibility of materials of construction should be prime considerations in the promotion of safe design of systems associated with oxygen-enriched environments.
- The oxygen compatibility characteristics of all materials involved in oxygen-enriched environments should be carefully and completely evaluated under end-use conditions.
- Accelerated (time-temperature concentration) oxygen deterioration and degradation (by high-energy and ionizing radiation) tests for service durability also should be conducted for overall evaluation.
- When selecting materials for oxygen service, situational or configurational flammability should be evaluated.

For system design in the oxygen enriched areas EIGA Doc 13/20 should be consulted, to ensure that systems and materials are suitable for oxygen-enriched environments.

- The only effective way of dealing with oxygen fed fires is to isolate the supply of oxygen .

- Consideration shall be given to the location of the vent outlet, height, direction, adequate spacing, etc., in order to minimise risks due to oxygen-enriched atmosphere in the surroundings.
- Systems using gaseous oxygen as the service gas shall be installed in an outdoor or well-ventilated location to avoid the risk of oxygen-enriched atmospheres.
- For stations located inside enclosures, the risk of oxygen-enriched atmospheres, atmosphere monitoring, and ventilation requirements shall be considered.
- Large quantities of oxygen shall be vented to atmosphere, preferably outside buildings and enclosures, in a location where neither personnel nor vulnerable items of equipment are exposed to oxygen-enriched atmospheres.
- When using nitrogen, it shall be ensured that unauthorised access to the outlet is prevented and that no one can be endangered by either oxygen-enriched or oxygen-deficient atmospheres.
- Combustion in oxygen-enriched air, which can be dealt with using conventional firefighting methods after the supply of oxygen has been cut off.
- Persons who have been in oxygen-enriched air shall not come into contact with ignition sources and immediately leave the area. These people shall undo or loosen their clothing and ventilate it for at least 15 min in order to remove the excess oxygen.

Additionally, the recommendations as presented in EIGA Doc 04/18, section 9 should be taken into consideration, specifically, when the installation is in operation.

The key points to avoid incidents due to oxygen enrichment are summarised as follows:

- Ensure that people who are expected to work with oxygen are properly trained and informed of the risks caused by an excess of oxygen.
- Ensure that proper equipment is used, that it is leak-tight, and that it is in good operational order.
- Use only materials and equipment approved for use in oxygen service. Never use replacement parts, which have not been specifically approved for oxygen service.
- Use suitable clean clothing, free from oil, grease, and easily combustible contaminants.
- Never use oil or grease to lubricate oxygen equipment.
- Ensure that all existing firefighting equipment is in good condition and ready to be used.

- When working in confined spaces where oxygen is normally used, isolate the equipment, provide good ventilation, and use an oxygen analyser. Entry shall only be allowed by means of a permit issued by a trained, competent person.
- Prohibit smoking where there is any possible risk of oxygen enrichment.
- People catching fire in oxygen-enriched atmospheres cannot be rescued by a person entering the area to pull them out, as the rescuer will almost certainly also catch fire.
- People who have been exposed to oxygen-enriched atmospheres shall not be allowed to approach open flames, burning cigarettes, etc., until after adequate ventilation of their clothing.
- Ensure that all oxygen apparatus and equipment is appropriately identified; and
- Ensure that escape routes are kept clear at all times

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5 FIRE PROTECTION MEASURES

The prime purpose of fire protection measures is to prevent escalation of a fire. Fire protection measures can be divided in passive and active measures.

5.1 ACTIVE FIRE PROTECTION

A Systems that need to be activated in order to fulfil their function are called active fire protection systems. Such systems can be activated automatically, by means of fire detection systems, or manually by intervention of personnel.

Active fire protection can be extinguishing media for example fire water, foam, powder or gaseous extinguishing systems (GES). A gaseous extinguishing system extinguishes fires by depletion of oxygen. However, depending on the used extinguishing gas, the system can be designed to ensure sufficient oxygen in the room for personnel that may be present to survive. Furthermore, before activation of the system, a pre-warning alarm is given to ensure that personnel have time to leave the room.

Besides extinguishing fires, fire water could be used to cool adjacent equipment to prevent escalation.

The general approach for hydrogen fires, small or large, is not extinguish the fire, but shut off the supply of hydrogen, because of the danger of re-ignition or explosion of an accumulation of hydrogen. The recommended way of handling a hydrogen fire is to stop the hydrogen flow, disconnect power and cool the surrounding installations if required, to prevent the spread of fire.

Presently for the BLPH project, the installation of a fire water system is not considered because a fire water system will require significant more equipment, inspections and regular tests.
Furthermore, it requires activation and preferable persons to correctly aim the fire water flow in case a monitor is used. Therefore, if surrounding installations required additional fire protection, passive fire protection is preferred for unmanned platforms.

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. In the same way there is no need for any fixed automatic Gaseous Fire Suppression systems for the Technical Rooms (ITER, UPS room and the electrical containers), as per the results obtained in the document “Electrical/Iter Containers – Fire duration calculation”, doc. N. 123A90-DDL-SAF-CA-30047.

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.

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 isolation of the loss of containment, depressurization to reduce the quantity of flammable inventory, providing sufficient separation distances to minimize scalation probabilities and starting the evacuation procedures.

5.2 PASSIVE FIRE PROTECTION

Passive fire protection is provided by materials or systems that are able to withstand a fire for a certain period without any intervention.

Passive fire protection or fireproofing is generally applied to protect structures and equipment supports against a pool fire or a jet fire in fire hazardous areas, because it performs its function without relying on activation.

Furthermore, building walls (interior as well as exterior) can provide passive fire protection against a fire in a neighboring room or area.

As an alternative to fireproofing or a fire separation wall, passive fire protection can be obtained by separation distance. If the distance between equipment is large enough, a fire in one equipment will not affect the other equipment.

An updated 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 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 be taken considering the type of transformer selected (free-oil or type of oil) used for transformer cooling and separation distances.

- As regarding Hydrogen Storage Vessel, in case sufficient separation distance is not possible, or FERA result are showing non-acceptable risk level, additional passive fire protection may be required. Examples are passive fire protection at bottom flange or fireproof insultation on the hydrogen storage vessels.
- An automatic blow down system activated to release the hydrogen vessels inventory to safe location in case of a hydrogen leak or flame detection, will reduce internal pressure and piping stress.

6 CPI – ELECTROLYSER, FUEL CELL AND BESS

6.1 ELECTROLIZER

The most significant safety consideration in the operation of the Electrolyser is the release of hydrogen gas from a leak within the container, which if ignited may cause a sustained jet fire, or an explosion if ignition is delayed.

The electrolyser shall be designed in a way that ensures that the risk of fire and explosion is minimised, and that in the unlikely event of such an incident, the electrolyser container is capable of withstanding the effect of heat loading with the minimum amount of loss incurred.

Consideration should be given to the use of gas or dry powder for extinguishing electrical fires.

Flame and gas detection are required inside the electrolyser container as per Vendor experience. Smoke detection is required in the control system container.

The detection systems shall monitor continuously for the presence of a fire, gas or smoke build-up and provide warning to alert personnel and allow control actions to be initiated as soon as possible, to minimise the likelihood of escalation.

All fire and gas detection equipment shall be connected to the Platform Fire & Gas Detection System (FGS) and shall be designed to initiate shutdown of the Electrolyser.

The type, number and location of detectors within the Electrolyser and control systems container is determined by the Vendor.

6.2 FUEL CELL

The most significant safety consideration in the operation of the Fuel Cell is the release of hydrogen gas from a leak within the container, which if ignited may cause a sustained jet fire, or an explosion if ignition is delayed.

The Fuel Cell (and its container) shall be designed to ensure that the risk of fire and explosion is minimised, and that in the unlikely event of such an incident, the Fuel Cell container is capable of withstanding the effect of heat loading with the minimum amount of loss incurred.

The intermittent presence of maintenance personnel on the facility will be considered in determining the safety provisions in the design.

Consideration should be given to the use of gas or dry powder for extinguishing electrical fires.

Flame and gas detection are required in the Fuel Cell container. Smoke detection is required in the control system container.

The detection systems shall monitor continuously for the presence of a fire, gas or smoke build-up and provide warning to alert personnel and allow control actions to be initiated as soon as possible, to minimise the likelihood of escalation.

All fire and gas detection equipment shall be connected to the Platform FGS and shall be designed to initiate shutdown of the Fuel Cell.

The type, number and location of detectors within the Fuel Cell and control systems container is determined by the Vendor

6.3 BESS DESIGN

BESS design shall include the state-of-the-art preventative methods that are based on extensive cell-level monitoring, advanced sensors for gas-release detection and predictive data analytics. The battery management system (BMS) monitors voltages and temperatures at individual cells shall be capable of preventing thermal and/or electrical overload. The BMS shall also be capable of disconnecting a module or rack from the PCS in the event that abnormal behaviour is measured.

The most significant safety consideration in the operation of the BESS is the risk of fire or explosion from the catastrophic failure of battery cells releasing flammable hydrocarbon-based liquid, hydrogen and/or dissolved lithium salt solution (the electrolyte), which can ignite on contact with an open flame, spark or heated surface. Such failures may be caused by physical damage (e.g., puncturing), electrical overload (e.g., overcharging), and/or exposure to high temperature conditions during installation, commissioning, maintenance or operations. There is also a risk to personnel from the release of toxic gases (HF) from electrolyte decomposition.

The BESS shall be designed in a way that ensures that the risk of fire and explosion is minimised, and that in the unlikely event of such an incident, equipment and the BESS containers are capable of withstanding the effect of heat loading with the minimum amount of loss incurred (

Fire, gas & smoke detection is required within the BESS container. The detection system shall monitor continuously for the presence of a fire, gas or smoke build-up and provide warning to alert personnel and allow control actions to be initiated as soon as possible, to minimise the likelihood of escalation.

All Fire & Gas System (FGS) detectors shall be connected to the Platform Fire & Gas Detection System (FGS) and be designed to initiate shutdown of the BESS.

The type, number and location of detectors within the BESS shall be determined by the VENDOR and shall consider quantity and composition of the gas mixture released.

Where a failure / damage of the battery can lead to release of a flammable gas then gas detection shall be provided with sensors positioned to provide detection as early as possible. Gas detectors shall alarm at no more than 30% Lower Flammability Limit (LFL) and be effectively interlocked to ensure automatic disconnection of the battery. The system shall also de-energise (isolate) all electrical circuits within the space upon detection of not more than 60% LFL.

The only active (chemical) suppression in the BESS system are the Stat-x cartridges, which is located inside the battery cabinets inside the 2 BESS containers.