Base Load Power Hub (BLPH)

Evacuation, Escape and Rescue Assessment (EERA) Report

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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 6
2 DOCUMENT SCOPE 8
2.1 MAIN REFERENCES 8
2.2 DEFINITIONS AND ABBREVIATIONS 9
2.2.1 Definitions 9
2.2.2 Abbreviations 11
3 METHODOLOGY 12
3.1 POPULATION INSIDE THE PLATFORM 12
3.2 ESCAPE ROUTE AND MUSTER POINT IDENTIFICATION 12
3.3 MUSTER POINT AND ESCAPE ROUTE IMPAIRMENT CRITERIA 15
3.4 TIME FOR LEAVE THE PLATFORM 18
3.5 APPRECIATION OF AN INCIDENT (t_{ALARM}) 19
3.6 MOVEMENT TO MUSTER AREA (t_{MOV}) 19
3.6.1 Time to reach the primary muster point (t_{MOV-1}) 20
3.6.2 Time to reach the secondary muster point (t_{MOV-2}) 21
3.7 TIME TO MAKE DECISION TO ABANDON (t_{MUSTER}) 22
3.8 EVACUATION ROUTE ($t_{EVACUATION}$) 22
3.9 ESCAPE ROUTE (t_{ESCAPE}) 22
4 RESULTS 24
5 CONCLUSION 25
ATTACHMENT 1 IMPAIRMENT OF ESCAPE ROUTE/MUSTER POINT 27
ATTACHMENT 2 EVACUATION ROUTE 32
ATTACHMENT 3 ESCAPE ROUTE 37

List of Figures

Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map 5
Figure 2 - Wind Park Details 6
Figure 3 – BLPH Concept 6
Figure 4 – Primary muster point location 13
Figure 5 – Secondary muster point location 13

List of tables

Table 1 - Reference Documents 9
Table 2 - Definitions 10
Table 3 - Abbreviations 11
Table 4 - Reference Scenario 15
Table 5 – EERA main point 18
Table 6 – Escape typical speeds 20
Table 7 – Time for reach the primary muster point 21
Table 8 – Time for reach the secondary muster point 21
Table 9 –Evacuation total time 24
Table 10 –Escape total time 24

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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.

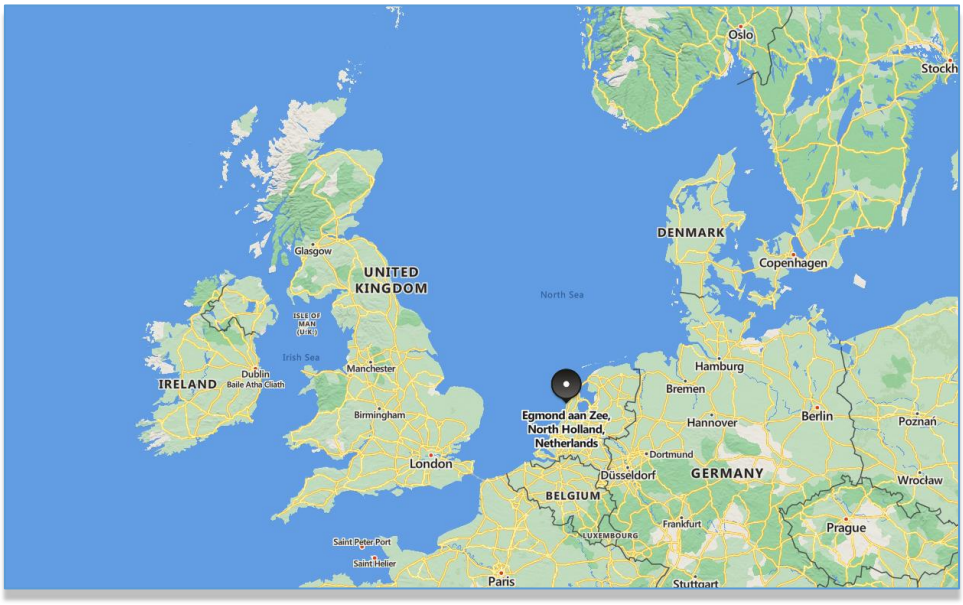


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

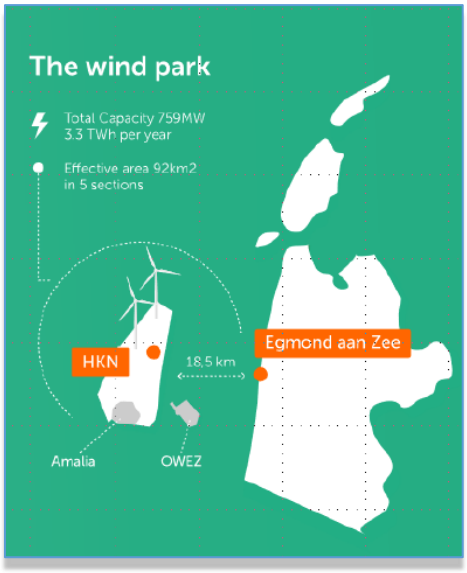


Figure 2 - Wind Park Details

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.

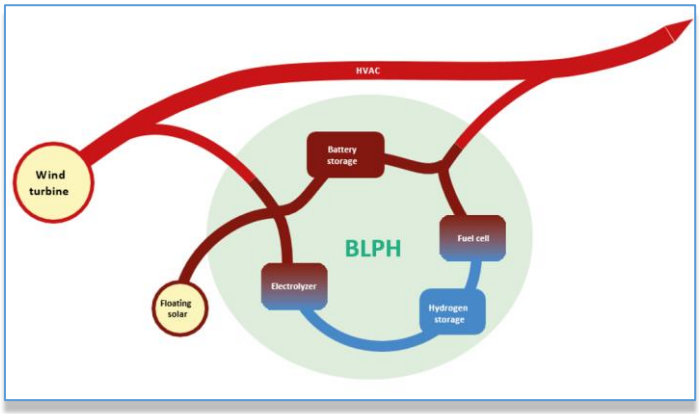


Figure 3 – BLPH Concept

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 has the purpose of detailing the results of Escape, Evacuation and Rescue Analysis (EERA) study. The EERA scope is to:

- evaluate possible escape routes/muster point impairment from platform hazardous scenarios; this requires to use the consequence data from the risk studies (QRA, FERA) in terms of consequences and frequency of occurrence of incidental events on the platform in order to verify if there is the chance to have impairment and potential trapping of the personnel;
- calculate the maximum operators exiting time from platform by performing a series of action; first it is necessary to identify the evacuation procedure, then it is needed to define the duration of each step of the evacuation procedure, including the identification of possible escape paths (primary and secondary escape routes) for personnel on the various area of the platform.

2.1 MAIN REFERENCES

Ref.	Description
1	123A90-DDL-SAF-LIS-30014 – Assumption Register, rev. 02
2	123A90-DDL-SAF-DL-30025 rev00 – Escape routes, fire fighting, life saving equipment and safety equipment layout drawings. Rev 0
3	123A90-DDL-SAF-DL-30026_rev00 Escape routes, fire fighting, life saving equipment and safety equipment layout drawings. Rev 0
4	123A90-DDL-PR-RE-80040 – Process Design Philosophy
5	123A90-DDL-PR-DG-80003 rev 01 //123A90-DDL-PR-DG-80005 rev 01- PFD
6	123A90-DDL-PR-PID-80011, rev 01//123A90-DDL-PR-PID-80020 rev01, – P&ID
7	Risk assessment data directory, document no. IOGP 434_14 – 2013 - Vulnerability of humans
8	Risk assessment data directory, document no. IOGP 434_19 – 2023 – Escape, evacuation and rescue
9	DNVGL-OS-A101 - Safety principles and arrangements, 2019
10	K559-2254-SE-REP-008 - BLPH - Escape, Evacuation and Rescue Assessment (EERA) (note: study for FEED phase)
11	123A90-DDL-SAF-RE-30019 - Quantified Risk Assessment (QRA) Report

Ref.	Description
12	123A90-DDL-SAF-RE-30020 - Fire and Explosion Risk Analys (FERA) report
13	3D model (last main revision available at BLPH-CROSSWIND-25-03-2024)

Table 1 - Reference Documents

2.2 DEFINITIONS AND ABBREVIATIONS

2.2.1 Definitions

COMPANY or Client (CPY):	Crosswind
EPC CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project
Accidental event	A process abnormal condition or a leakage that generates or can generate hazard to personnel or equipment.
Escape (route)	Escape from an Accidental Event is the process of personnel moving along escape routes towards Muster Point.
Escape (sea)	Escape to sea is the process of leaving the installation in an emergency when the evacuation system is not accessible or has failed; it may involve entering the sea directly and is the 'last resort' method of getting personnel off the installation. Means of escape cover items which assist with descent to the sea, such as chute systems, ladders and individually controlled descent devices (e.g., donuts); and items which personnel can board on reaching the sea such as throw-over life rafts. Scramble nets and knotted ropes may also be considered as means of escape but are less desirable since they require a degree of strength and dexterity and are therefore not controlled descent devices. If no other means of escape are available, workers may have to jump into the sea from height.
Evacuate	Evacuation is the planned method of leaving the installation without directly entering the sea. Evacuation is the process of leaving an installation and its vicinity, in an emergency, in a systematic manner and without directly entering the sea. Successful evacuation will result in persons being transferred to a place of safety, by which is meant a safe onshore location, or a safe offshore location or marine vessel with suitable facilities. Means of evacuation may include helicopters, bridge transfer and lifeboats. In some locations, davit-launched life rafts may also be considered as a means of evacuation where there is insufficient provision of lifeboats to evacuate all personnel. In multi-platform

	installations connected by bridges it may be considered that, provided the separation of the platforms is sufficiently great, a worker crossing to a platform other than the one on which the incident occurred may be considered to have evacuated.
Fire	The outcome of combustion of flammable substance released in the atmosphere as consequence of a LOC, which can produce effects to exposed persons and to process equipment and structure due to thermal radiation.
Flash Fire	An accelerated combustion of a vapour cloud without significant overpressure consequences.
Hazard	Situation having the potential to cause harm, including ill health and injury, damage to property, production losses or increased liabilities.
Impairment	Condition under which a piece of equipment, shelter or escape route is no longer able to perform as required. This does not necessarily mean that persons using that facility become fatalities.
LOC	Loss of Containment. The event associated the release of hazardous substance from an equipment leading to a potential accident scenario.
Muster point	Muster is the process of assembling personnel in a muster area where it is safe to assemble allowing time for the emergency to be assessed and for control to be taken. Generally, a muster area should either be inside a Temporary Refuge (TR) or provide protection against a foreseeable major incident for a specified endurance period.
Scenario	The name for identification of the potential development (in terms of fire, explosion and dispersion in atmosphere) of the accident sequence

Table 2 - Definitions

2.2.2 Abbreviations

BDV	Blow down valve
BESS	Battery Energy Storage System
BLPH	Base Load Power Hub
CTV	Crew Transfer Vessel
EER	Escape, Evacuation and Rescue
EERA	Escape, Evacuation and Rescue Assessment
FERA	Fire and Explosion Risk Assessment
HKN	Hollandse Kust Noord
IOGP	International Association of Oil & Gas Producers
LFL	Lower Flammable Limit
LOC	Loss Of Containment
P&ID	Piping and Instrumentation Diagram
PFD	Process Flow Diagram
POB	Personnel On Board
PSV	Pressure safety valve
QRA	Quantitative Risk Assessment
TSO	Top Of Steel
VCE	Vapour Cloud Explosion

Table 3 - Abbreviations

3 METHODOLOGY

3.1 POPULATION INSIDE THE PLATFORM

According to project information, the platform is unmanned, and people presence are foreseen only during maintenance activities. At this stage of the project, planned maintenance activities are foreseen for 1 day each 6 months, meaning 2 days (16 hours) in 365 days (8760 hours), for a maximum of POB equal to 10 operators. The reference scenario for EERA study considers the evacuation from the platform due to an accidental event occurring on platform during maintenance activities.

In case of evacuation from platform, the operators, in sequences:

- leave the working area through available escape route;
- reaches the primary muster point (or secondary muster point);
- evacuate the platform via supporting vessel or via life raft, if required.

Muster point location on platform and availability of escape route are described in the following chapters.

3.2 ESCAPE ROUTE AND MUSTER POINT IDENTIFICATION

Muster point

The functional requirements of the muster point are as follows:

- provide a place where the total maximum POB of 10 can muster without undue risk and require external intervention;
- maintain communications with all parties potentially involved in the emergency actions;
- if necessary, carry out a safe and complete evacuation.

The Muster point shall be able to accommodate a minimum space of 0.8 m^2 per person for the maximum POB.

The BLHP platform is provided with two muster points, "primary" and "secondary", according to the evacuation scenarios.

The "primary evacuation route" means that the personnel will move to the primary muster area, and then leave the platform via CTV. The "primary muster point" is located in main access platform (EL. approx. +17 m TOS) and is reported in the following figure.

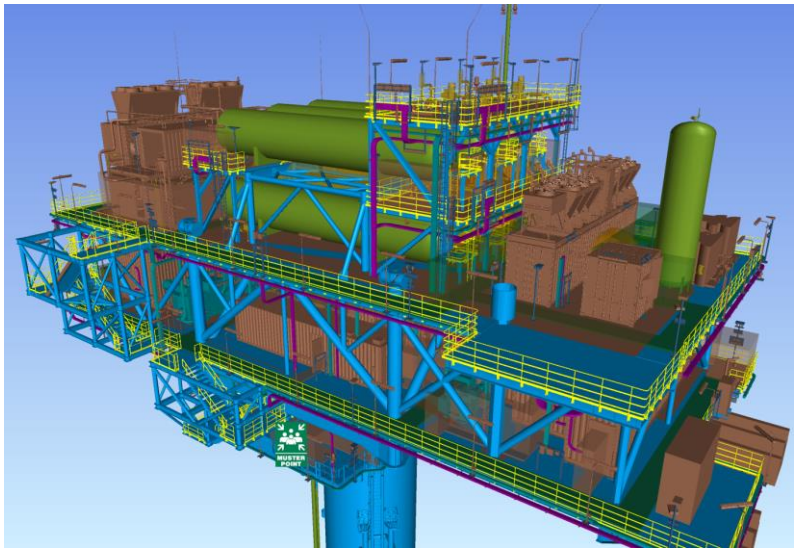


Figure 4 – Primary muster point location

The "secondary evacuation route" means that the personnel will move to the secondary muster area, located at the north-east corner of lower deck (EL. Approx. +23 m TOS.), and then leave the platform via life rafts. Secondary muster point location in the following figure is reported.

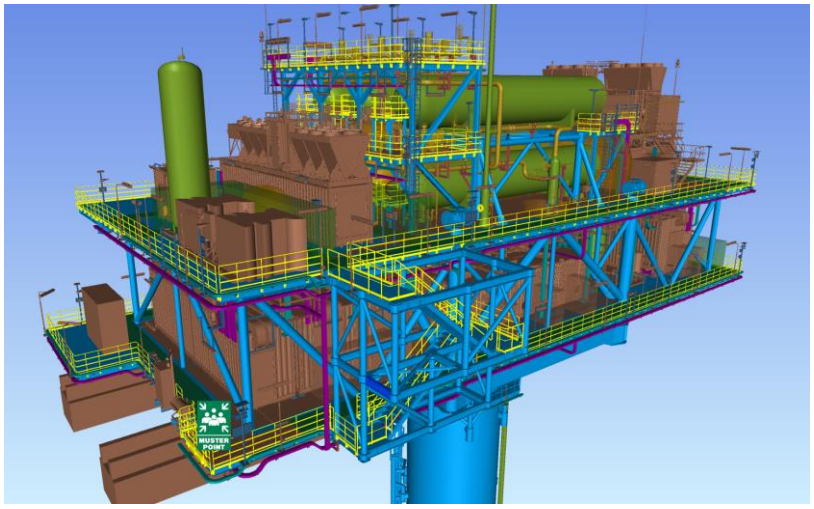


Figure 5 – Secondary muster point location

Muster point is intended to represent an inherently safer location away from hazardous areas for personnel to assess the situation, perform roll calls, conduct search and rescue operations as well as prepare to evacuate the platform.

Escape route

Primary and secondary escape routes are provided to ensure the safe evacuation of personnel from any location on the installation. Escape routes are arranged to provide direct access to the muster areas. These escape paths are designed in order to minimize the likelihood of having both routes impaired during an emergency. From the project documentation and layout [2,3], it is possible to conclude that for the upper deck, where are located equipment which significant hold up of hydrogen (storage vessel) personnel can escape in at least 2 directions towards muster points. In particular:

- the platform located above storage vessel on upper deck is provided with two ladders on opposite direction (east-west, EL. approx. +37m TOS), in order to connect the elevated platform to upper deck;
- the upper deck is provided with two staircases in opposite location (north-west; south-east, EL. approx. +30 mTOS), in order to connect the upper deck to lower deck (and secondary muster point).

For main access to the platform, from the lower deck, a dedicated staircase in the west side (EL. approx. +23 m TOS) is located in order to connect the lower deck to main access platform, where is located the primary muster point (EL. approx. +17 TOS).

Main escape routes are at minimum 1200 mm wide and 2300 mm minimum headroom. Secondary escape routes are at minimum 800 mm wide and 2300 mm height.

Every escape route shall be at all times unobstructed, readily accessible and shall be adequately illuminated by the emergency power supply source.

Safety Equipment

Platform is equipped with the following safety system and equipment, well distributed in strategic position near the escape route on decks, which includes:

- life buoy;
- eyewash station;
- resuscitation unit (ITER cabinet);
- evacuation stretcher;
- first aid kit;
- escape mask;
- immersion suits (inside cabinets);
- life jacket (inside cabinets);

- liferafts and descend device located on lower deck (sized for POB of 10, 2 located in lower deck).
- electrical safety kit (HV/MV switchroom)

In particular, each muster point is provided with following safety equipment:

- Primary muster point: 1 first aid kit, 10 life jacket, 10escape mask
- Secondary muster point: 1 first aid kit, 10 life jacket, 10 escape mask, 10 immersion suits, descent device.

Two life rafts are provided in the platform; one is located in north-west side, and the second one is located in the secondary muster point. The two life rafts, located in opposite direction, is required in order to allow the selection of the most-favourable location to descent to the sea according to sea condition.

3.3 MUSTER POINT AND ESCAPE ROUTE IMPAIRMENT CRITERIA

The major accident events that are considered in the EERA are those that are considered and developed in the QRA/FERA study, mainly due to loss of containment from equipment/piping. Considering the characteristic of hydrogen, the reference hazardous scenarios are jet fire, explosion and flammable gas dispersion.

With reference to and project documentation, [1, 7] the following impairment criteria for EER facilities are considered.

Scenario	Value	Description
Explosion overpressure	0.35 bar	Severe damage to equipment, obstruction of escape route.
Flammable gas dispersion	LFL	Possible fatalities or severe injuries for operator involved in a flammable gas cloud inside LFL concentration in case of ignition.
Thermal radiation	6.3 kW/m^2	Evacuation route impairment (corresponding to the maximum radiant heat intensity where emergency action lasting up to 30 seconds).
	12.5 kW/m^2	Thermal radiation over 12.5 kW/m2 does not allow the evacuation across the escape route, e.g. 50% fatalities for outdoor personnel
	37.5 kW/m^2	Thermal radiation over 12.5 kW/m2 does not allow the evacuation across the escape route, e.g. 100% fatalities for outdoor personnel

Table 4 - Reference Scenario

In addition to the consequences analysis, the frequency of occurrence of hazardous scenarios needs to be evaluated in order to identify the impairment of escape route/muster points.

On the basis of [8], for fires and explosions, a design accident load or return frequency of one in ten thousand years (1.0E-04 per year) is often used for escape route / muster point impaired criteria. DNV's guidance on Safety Principles and Arrangements [9] states that accidental loads affecting safety functions should have an individual (per load type) frequency of occurrence not exceeding a value the order of 1.0E-04 per year.

In the following paragraphs the possible impact in terms of platform evacuation and impairment of escape routes are described for each hazardous scenario.

Jet fire impairment

The escape routes/muster point are impaired if exposed to thermal radiation exceeding 6.3kW/m^2 with frequency of occurrence higher 1.0E-04 occ/year. On the basis of results of QRA/FERA studies [11, 12], in Attachment 1 are reported the consequences of thermal radiation of 6.3 kW/m^2 from jet fire. As expected, the 6.3 kW/m^2 thresholds can impact a part of the platform for full bore rupture scenarios, considering that the dimensions of the platform are comparable which the damage distances calculated.

It should be noted that a jet fire is directional and can only impair one escape route at a time, meaning that there are two routes of escape from any point on the platform in case one of them is impaired. Scenarios where personnel are trapped is not considered credible. Under all major accident event scenarios, surviving personnel will have the means to evacuate the platform due to the provisions of diverse escape routes and the redundant means of evacuation.

In addition, the frequencies of occurrence of jet fire scenarios for all the section are well below the 1.0E-04 occ/year target frequency for impairment, which confirms the acceptability of the escape and muster point location.

VCE fire impairment

The escape routes/muster point are impaired if exposed to overpressure of 0.35 bar with frequency of occurrence higher 1.0E-04 occ/year. On the basis of results of FERA studies [11], in Attachment 1 are reported the damage distances of 0.35 bar from VCE scenarios. According to the damage distances, there is not a single overpressure scenario which are able to involves all the platform, meaning that one escape route will be available for each deck.

In addition, the frequencies of occurrence of VCE scenarios for all the section are well below the 1.0E-04 occ/year target frequency, which confirms the acceptability of the escape and muster point location.

Flash fire impairment

The escape routes/muster point are impaired if exposed to LFL concentration from gas cloud with frequency of occurrence higher 1.0E-04 occ/year. On the basis of results of QRA/FERA studies [11, 12], in Attachment

1 are reported the consequences of LFL damage distances from flash fire scenarios. As largely expected, the LFL thresholds can impact a significant part of the platform for full bore rupture scenarios, considering that the dimensions of the platform are comparable which the damage distances calculated.

On the basis of the characteristic of hydrogen (lower density compared to air), the gas clouds will move upward and considering that the upper deck represent the deck which higher risk and the muster points are located below this deck, the impairment of musters point can be considered very unlikely.

Flash fire can be considered as a directional scenario: the gas cloud will move according to wind direction and can impair only one escape route at a time, meaning that there are two routes of escape from any point on the platform in case one of them is impaired.

In conclusion, with reference to the impairment criteria described above, the muster point and escape route are classified as acceptable considering that:

- no scenario (fire, explosion and flash fire) is able to cause impairment to both means of evacuation, considering the orientation of the scenarios or/and the expected damage distances. In addition, on the basis of operator activities, some equipment will be not in service or depressurized, meaning that no risk is expected (e.g in case of maintenance activities on PSV/BDV valves, the storage vessel will be depressurized; electrolyze and fuel cell package are always not in service during maintenance activities).
- the primary muster point area is at the main access platform. This muster point is located in an open deck space and is considered safe by location due to elevation difference and protection afforded by the deck above; no critical threshold for damage scenario is expected in such location.
- the secondary muster point is an open deck area located in the lower deck and is provided with life rafts. Considering that, in case of presence of operators, the electrolyze and fuel cell package are not in service, the jet fire/flash fire/explosion risk from such equipment can be considered negligible; meaning that the risk on secondary muster point location is still lower. Nerveless, in the lower deck additional life raft are located in the opposite direction of secondary muster point (south-east side).
- it was also verified that explosion, jet fire and flash fire scenarios can occur with frequency well below the 1E-04 occ/year target criterion.

3.4 TIME FOR LEAVE THE PLATFORM

This EERA is based on the philosophy that in case of emergency all personnel will move directly to the Muster Area, and if necessary, abandon the platform. In reality, the possible development of events prior to emergency evacuation of an installation is difficult to predict. In order to simplify the range of possibilities, events are normally assumed to follow the sequence below [8], EER evaluation can be performed considering the following main points:

1. Alarm: detection of an incident and communication of the emergency;
2. Movement from immediate area of the hazardous condition to Muster point;
3. Entering in Muster point;
4. Evacuation, leaving the installation (without directly entering in the sea);
5. Escape, if the evacuation points are inaccessible (possible entering in the sea);
6. Rescue and subsequent recovery, where personnel are brought to a place of safety.

Additional information for each point in the table below is reported.

Generic Description	Typical Specific Descriptions
Alarm: Appreciation of an incident	Operator decides that there is an emergency and starts emergency procedure.
Movement: from immediate area of the hazardous condition	Personnel become aware that they should leave their work area. They move out of the immediate area.
Muster Area Personnel assemble on muster area	Personnel assemble in a designated muster area.
Evacuation	Evacuation means the leaving of an installation and its vicinity, in an emergency, in a systematic manner and without directly entering the sea. Successful evacuation will result in persons being transferred to a place of safety, by which is meant a safe onshore location, or a safe offshore location or marine vessel with suitable facilities.
Escape	Escape means the process of leaving the installation in an emergency when the evacuation system has failed; it may involve entering the sea directly and is the 'last resort' method of getting personnel off the installation. For the scope of this project, escape means leave the platform via life rafts.

Table 5 – EERA main point

In order to calculate the total time for evacuation from platform, is required to calculate the required time for each of these phases:

$$t_{LEAVE} = t_{ALARM}+t_{MOV}+t_{MUSTER} + t_{EVACUATION} \text{ (OR) } t_{ESCAPE}$$

Where:

t_{LEAVE}= total time for leave the platform;

t_{ALARM}= required time for operators for respond to the alarm;

t_{MOV}= required time for operators to reach the muster point from working area;

t_{MUSTER}= required time for operators to take decision regarding the action to be taken;

$t_{EVACUATION}$= required time for operators in order to evacuate the platform.

$t_{ESCAPE=}$ required time for operators in order to escape the platform.

These times are described in the following chapters.

3.5 APPRECIATION OF AN INCIDENT (t_{ALARM})

t_{ALARM} is the time required to inform all personnel on the installation that a major incident has occurred and the response that is necessary. Personnel then act in accordance with the relevant emergency procedures. The platform is provided with detectors for flame and gas release, which activate emergency action; in addition, in each main areas of platform are available sounders and fire/flammable beacons in order to warn the operator.

Consider the dimensions of the platform and the number of detectors and sounders, in case of accident is it possible to estimate, after the start of an incident, 60 seconds to detect and initiate an alarm.

After the alarms have been activated it takes 120 seconds for personnel to acknowledge the alarm and make their work area safe (e.g., recognizing and questioning the validity of the alarm, turning off machinery). This value is considered very conservative on the basis of foreseen working activities: it not expected that operators perform complex activities on process equipment with the use of dedicatee machinery.

In conclusion, t_{alarm} is assumed equal to 180 seconds.

3.6 MOVEMENT TO MUSTER AREA (t_{MOV})

T_{MOV} is the time required for all personnel to travel from their place of work to the muster area. This time includes an allowance for personnel to respond to instructions.

This time is strictly dependent on the position of the operator and the route for reach the muster point. Assuming the availability of escape route, the estimated travel time along any escape ways is calculated using the typical speeds summarized below.

Route	Time (m/s)
Walkways	1.0
Staircase	0.8
Ladders	0.3

Table 6 – Escape typical speeds

The estimated time to reach the muster point (t_{MOV}), following the starts of an emergency procedure, is based on a controlled evacuation from the affected area. Two different time are calculated:

- t_{MOV_1}: which is the required time to reach the primary muster point;
- t_{MOV_2} :which is the required time to reach the secondary muster point;

Owing to the numerous possible escape route combinations, as a conservative approach, the furthest point in order to reach the muster point has been considered. In particular, as a conservative approach, for both escape routes is considered as starting point the platform located above storage vessel in upper deck. As for conclusion of vent study, this area will be accessible for maintenance activities on BDV/PSV valve only after complete depressurization of storage tank. In this case, major accident is no more credible due to loss of flammable substances in the platform. In the following chapters the required time is calculated.

The impact on escape route/muster point of hazardous scenarios from Electrolyser package A-20000, Fuel Cell and Battery energy storage system is deemed negligible, since the most critical location is the platform at the hydrogen tanks where operators could be for inspection reasons.

3.6.1 Time to reach the primary muster point (t_{MOV-1})

In **Attachment 2** the evacuation towards primary muster point is reported. In the following table, the required time for each tract is calculated.

Starting point: Platform above storage vessel on upper deck						
Time to primary muster point (t_{MOV_1})						
FROM	**TO**	**DESCRIPTION**	**DISTANCE (m)**	**TYPE**	**SPEED [m/s]**	**ESCAPE TIME [s]**
0	1	Horizontal travel on platform above storage vessel to ladder on east side	10	WALKWAYS	1	10.0
1	2	Travel down with ladder to upper deck	8	LADDER	0.3	26.7
2	3	Horizontal travel on upper deck to staircase to lower deck	25	WALKWAYS	1	25.0
3	4	Travel down the staircase to lower deck	7	STAIRCASE	0.8	8.8
4	5	Horizontal travel on lower deck to staircase to main access platform	7	WALKWAYS	1	7.0
5	6	Travel down the staircase to primary muster point	6.5	STAIRCASE	0.8	8.1
6	7	Horizontal travel from staricase to reac primary muster point	10	WALKWAYS	1	10.0
Total distance:			73.5		**t MOV_1 (s)**	**95.5**

Table 7 – Time for reach the primary muster point

The time required to reach the primary muster point (t_{MOV_1}) is equal to 95.5 seconds.

3.6.2 Time to reach the secondary muster point (t_{MOV-2})

In Attachment 3 the evacuation towards secondary muster point is reported. In the following table, the required time for each tract is calculated.

Starting point: Platform above storage vessel on upper deck						
Time to secondary muster point (t_{MOV_2})						
FROM	**TO**	**DESCRIPTION**	**DISTANCE (m)**	**TYPE**	**SPEED [m/s]**	**ESCAPE TIME [s]**
0	1	Horizontal travel on platform above storage vessel to ladder on east side	10	WALKWAYS	1	10.0
1	2	Travel down with ladder to upper deck	8	LADDER	0.3	26.7
2	3	Horizontal travel on upper deck to staircase to lower deck	25	WALKWAYS	1	25.0
3	4	Travel down the staircase to lower deck	7	STAIRCASE	0.8	8.8
4	5	Horizontal travel on lower deck to staircase to secondary muster point	49	WALKWAYS	1	49.0
Total distance:			99		**t MOV_1 (s)**	**119.4**

Table 8 – Time for reach the secondary muster point

The time required to reach the secondary muster point (t_{MOV_2}) is equal to 119.4 seconds.

3.7 TIME TO MAKE DECISION TO ABANDON (t_{MUSTER})

T_{MUSTER} is the time required for personnel to make decision to abandon the platform after all personnel is assembled, and is assumed equal to 60 seconds is assumed as the time required to make the final decision to abandon the platform.

3.8 EVACUATION ROUTE ($t_{EVACUATION}$)

According to [8], Evacuation means*: "the leaving of an installation.. in an emergency, in a systematic manner and without directly entering the sea. Successful evacuation will result in persons being transferred to a place of safety ….Evacuation may include lifeboats and bridge-links*".

Thus, for the scope of the present report, the "Evacuation" means that all operators, form the starting point via escape route reach the muster point and subsequently, leave the platform in a safe condition.

$T_{EVACUATION}$ is the time required for all personnel to travel from muster area to the CTV. It is assumed that a dedicated CTV allocated will be permanently stationed in the field during maintenance periods, although, for certain operations, it may be supporting other facilities nearby and in these cases response times to the BLPH would be increased.

The time from primary muster point to CTV vessel is assumed the sum following time/actions:

- Personnel descent to CTV (t_{EMBARK}): in order to reach the CTV vessel, from the primary muster point is required to descent from a 17meters vertical ladders. Considering 0.3 m/s, the total time is equal to about 56 seconds. Anyway, in order to take into account that is not possible for 2 persons to use the ladders simultaneously, the total time to descend ladder is calculated adding 5 seconds of delay for other 9 operators, meaning a total time for descending equal to 101 seconds [56s +(5s*9s)].
- Board the Vessel ($t_{BOARDING}$)**:** It is assumed that it takes 10 seconds per person to board the vessel; considering POB equal to 10, a total of 100 seconds are considered.

In conclusion, $t_{EVACUATION}$ from primary muster point to CTV vessel is assumed equal to:

$$t_{EVACUATION} = t_{EMBARK} + t_{BOARDING} = 101+100 = 201 \text{ seconds}$$

3.9 ESCAPE ROUTE (t_{ESCAPE})

According to [8], Escape means*: "the leaving the installation in an emergency when the evacuation system has failed; it may involve entering the sea directly and is the 'last resort' method of getting personnel off the installation..personnel leave the installation by controlled descent provisions, including life rafts, or uncontrollably by jumping*".

Thus, for the scope of the present report, the "Escape" means that all operators, form the starting point via escape route reach the secondary muster point and subsequently, leave the platform via life raft.

T_{ESCAPE} is the time required for all personnel to escape from platform via life raft from secondary muster point.

Note that additional life raft is provided in the opposite location of secondary muster point.

The time to escape via life raft is assumed the sum following time/actions:

- Don life vest (t_{VEST}): 60 seconds is assumed as the time required for distribution and donning of life vests for operators in the muster area;
- Launch and inflation of life raft ($t_{LIFERAFT}$): 180 seconds is assumed as the time required for launch and inflate the life raft;
- Preparation to use the descent devices (t_{DEVICE}): 60 seconds is assumed as the time required to use the descent device;
- Operators descent to life raft ($t_{DESCENT}$): in order to reach the life raft vessel, from the secondary muster point is required to descent from lower deck (EL. About +23m TOS.) via descent device.

  This time is assumed equal to 5 minutes; the winch system is used as a safety harness rather than actually winching the personnel down [10].

In conclusion, t_{ESCAPE} from secondary muster point via life raft vessel is assumed equal to:

$$t_{ESCAPE} = t_{VEST} + t_{LIFERAFT} + t_{DEVICE} + t_{DESCENT} = 60+180+60+300+= 600 \text{ seconds}$$

4 RESULTS

Platform is a normally unmanned area where inspection, maintenance or other works are expected to be two times per year. Two main scenarios are identified for the purpose of this study :

- Scenario 1: Evacuation due to an accidental via "primary evacuation route" (leave the platform via transfer vessel).
- Scenario 2: Escape due to an accidental via "secondary evacuation route" (leave the platform via life raft, considering the impairment of primary muster point/primary escape route).

The total time required for leave the platform is calculated as sum of different interval, as for chapter 3.

In the table below the required time for each scenario are reported.

Scenario 1: evacuation

Time for evacuation the platform		
$t_{LEAVE} = t_{ALARM} + t_{MOV} + t_{MUSTER} + t_{EVACUATION}$		
Time	**Description**	**Time [s]**
t_{ALARM}	required time for operators for respond to the alarm	180.0
t_{MOV-1}	required time to reach the primary muster point	95.5
t_{MUSTER}	required time for operators to take decision regarding the action to be taken	60.0
$t_{EVACUATION}$	required time for operators to evacuation the platform via CTV vessel	201.0
Total time to leave the platform during evacuation scenario:		536.5
		9 minutes

Table 9 -Evacuation total time

Scenario 2: escape

Time for escape from platform		
$t_{LEAVE} = t_{ALARM} + t_{MOV} + t_{MUSTER} + t_{ESCAPE}$		
Time	**Description**	**Time [s]**
t_{ALARM}	required time for operators for respond to the alarm	180.0
t_{MOV-2}	required time to reach the primary muster point	119.4
t_{MUSTER}	required time for operators to take decision regarding the action to be taken	60.0
t_{ESCAPE}	required time for operators to escape from platform via life raft	600.0
Total time to leave the platform during escape scenario:		959.4
		16 minutes

Table 10 -Escape total time

5 CONCLUSION

The general purpose of this study is to evaluate the efficacy of Escape, Evacuation, and Rescue (EER) equipment for BLPH platform. The impairment of the escape routes and facilities was evaluated taking into account risk studies [11,12] results in terms of impact of hazardous events and frequency of occurrence. Finally, the maximum exiting time was estimated in case of evacuation and escape.

With reference to the evaluation of escape routes and facilities impairment, the following results are obtained:

- no scenario (fire, explosion and flash fire) is able to cause impairment to both means of evacuation, considering the orientation of the scenarios or/and the expected damage distances. In addition, on the basis of operator activities, some equipment will be not in service or depressurized, meaning that no risk is expected (e.g in case of maintenance activities on PSV/BDV valves, the storage vessel will be depressurized; electrolyze and fuel cell package are always not in service during maintenance activities).
- the primary muster point area is at the main access platform. This muster point is located in an open deck space and is considered safe by location due to elevation difference and protection afforded by the deck above; no critical threshold for damage scenario is expected in such location.
- the secondary muster point is an open deck area located in the lower deck and is provided with life rafts. Considering that, in case of presence of operators, the electrolyze and fuel cell package are not in service, the jet fire/flash fire/explosion risk from such equipment can be considered negligible; meaning that the risk on secondary muster point location is still lower. Nerveless, in the lower deck an additional life raft are located in the opposite direction of secondary muster point (south-east side).
- it was also verified that explosion, jet fire and flash fire scenarios can occur with frequency well below the 1E-04 occ/year target criterion.

In conclusion, with reference to the impairment criteria described above, the muster point and escape route are classified as acceptable

With reference to required time to leave the platform, the following results are obtained:

- the time for evacuation of the 100% of POB via CTV is about to 9 minutes;
- the time for escape of the 100% of POB via life raft is equal to 16 minutes;

Considering the limited hold up of H_2 in piping and the presence of detectors which automatically close valves, in case of release after the intervention of ESD the duration of scenario will be limited; in addition, in case of operator presence some equipment are totally depressurised (electrolyzer, fuel cell) or partially depressurized (storage vessel), meaning that the reference MHA calculated in terms of consequences and duration need to be considered as conservative.

Scenarios with higher frequency of occurrence are characterized with damage consequences limited to the area near the release; instead, large scenario show lower frequency of occurrence.

This means that escalation effect, also according to FERA result, is very unlikely.

In case of release from storage vessel, platform structural beams are not potentially involved in the fire; in addition, even if is not possible to quantify, the presence of platted deck should be considered as an additional safeguard in order to allows safe evacuation of operator, limiting the thermal radiation to other deck.

Generally, for on shore installation an evacuation time in the order of 30 minutes is considered adequate.

In conclusion, on the basis of calculated evacuation and escape time (about 15 minutes) and the characters of the release (in terms of duration/frequency/consequences), these times are consistent with expected platform structural resistance and are considered adequate.

The present document is elaborated considering that no deck hatches opening or equipment storage areas or obstacles of any type are located on primary or secondary egress/access routes (normal housekeeping operation is considered in place).

ATTACHMENT 1

IMPAIRMENT OF ESCAPE ROUTE/MUSTER POINT

Jet fire

In the table below the expected damage distance from jet fire are reported, including the 6.3 kW/m^2 threshold which is the reference threshold for the impairment for escape route/muster point. Additional information regarding calculation and methodology are reported in Assumption register and FERA reports [1,11,12].

Reference LOC	Release hole (mm)	Jet Fire scenario (m)		
		37 kW/m2	12.5 kW/m2	6.3 kW/m2
1.1 Release from electrolyser outlet piping to storage section	5	3.6	4.4	5
	25	16.6	20.5	24.5
2.1 Release from storage connection piping	5	3.6	4.4	5
	25	16.6	20.5	24.5
	37.5 (1.5 inches)	24.0	30.0	36
2.2 Release from BDV connecting piping on top of storage vessel (3 inches)	5	3.6	4.4	5
	25	16.6	20.5	24.5
	75 (3 inches)	45.5	57.5	69.5
3 Release from vessels outlet piping to fuel cell package	5	3.8	4.5	5
	25	17.5	21.5	25.5
	50 (2 inches)	32.5	40.5	48.5

As already discussed, in case of presence of operators, the electrolyze and fuel cell package are not in service, meaning the jet fire risk from the LOC 1.1, 2.1 and 3 reported in the above table are not applicable.

In addition, in case of maintenance activities on PSV/BDV, the storage vessel will be depressurized, meaning that also the LOC 2.2 will be not more applicable.

The frequencies of occurrence of jet fire scenarios for all the section are well below the 1.0E-04 occ/year target frequency for impairment of escape route/muster point.

VCE

In the table below the expected damage distance of 0.35 bar from VCE are reported, which is the reference threshold considering potential severe damage to the structure, leading possible impairment due obstacles/debris on escape routes. Additional information regarding calculation and methodology for resummation are reported in Assumption register and FERA reports [1,11].

In order to properly calculate the expected consequences in case of explosion, in the FERA a detailed analysis was performed with the aim to identify, for each LOC, the amount of flammable gas included in the platform boundary, considering four main release direction. This flammable mass is selected for consequences simulation. In the below table is reported the maximum distances calculated for each release hole/direction.

Reference LOC	Hole size (mm)	Weather	0.35 bar (m)
1.1 Release from electrolyser outlet piping to storage section	5	F2	4.4
	25	F2	16

Reference LOC	Hole size (mm)	Weather	0.35 bar (m)
2.1 Release from storage connection piping	5	F2	4.4
	25	F2	15.0
	37.5 (1.5 inches)	F2	22.0

Reference LOC	Hole size (mm)	Weather	0.35 bar (m)
2.2 Release from BDV connecting piping on top of storage vessel (3 inches)	5	F2	4.4
	25	F2	15.0
	75 (3 inches)	F2	35.9

Reference LOC	Hole size (mm)	Weather	0.35 bar (m)
3.1 Release from vessels outlet piping to fuel cell package	5	F2	4.5
	25	F2	15.5
	50 (2 inches)	F2	31.5

Reference LOC	0.35 bar (m)
BESS TR explosion Scenario (m)	5.2

As already discussed, in case of presence of operators, the electrolyze and fuel cell package are not in service, meaning the VCE fire risk from the LOC 1.1, 2.1 and 3 reported in the above table are not applicable. In addition, in case of maintenance activities on PSV/BDV, the storage vessel will be depressurized, meaning that also the LOC 2.2 will be not more applicable. The frequencies of VCE scenarios for all the sections are well below the 1.0E-04 occ/year target frequency for impairment of escape route/muster point.

Flash fire

In the table below the expected damage distance from flash fire are reported, including the LFL threshold which is the reference threshold for the impairment for escape route/muster point. Additional information regarding calculation and methodology for resummation are reported in Assumption register and QRA/FERA reports [1,11,12].

Reference LOC	Hole size (mm)	Weather	LFL (m) (horizontal)	LFL (m) (down impingement)
1.1 Release from electrolyser outlet piping to storage section	5	F2	5.7	6.7
		D5	6.0	8.0
		D10	5.5	7.6
	25	F2	27.5	23.3
		D5	32.0	32.0
		D10	32.5	92.5

Reference LOC	Hole size (mm)	Weather	LFL (m) (horizontal)	LFL (m) (down impingement)
2.1 Release from storage connection piping	5	F2	6.7	6.7
		D5	8.0	8.0
		D10	7.6	7.6
	25	F2	23.3	23.3
		D5	32.0	32.0
		D10	92.5	92.5
	37.5 (1.5 inches)	F2	6.7	29.0
		D5	8.0	38.5
		D10	7.6	127.0

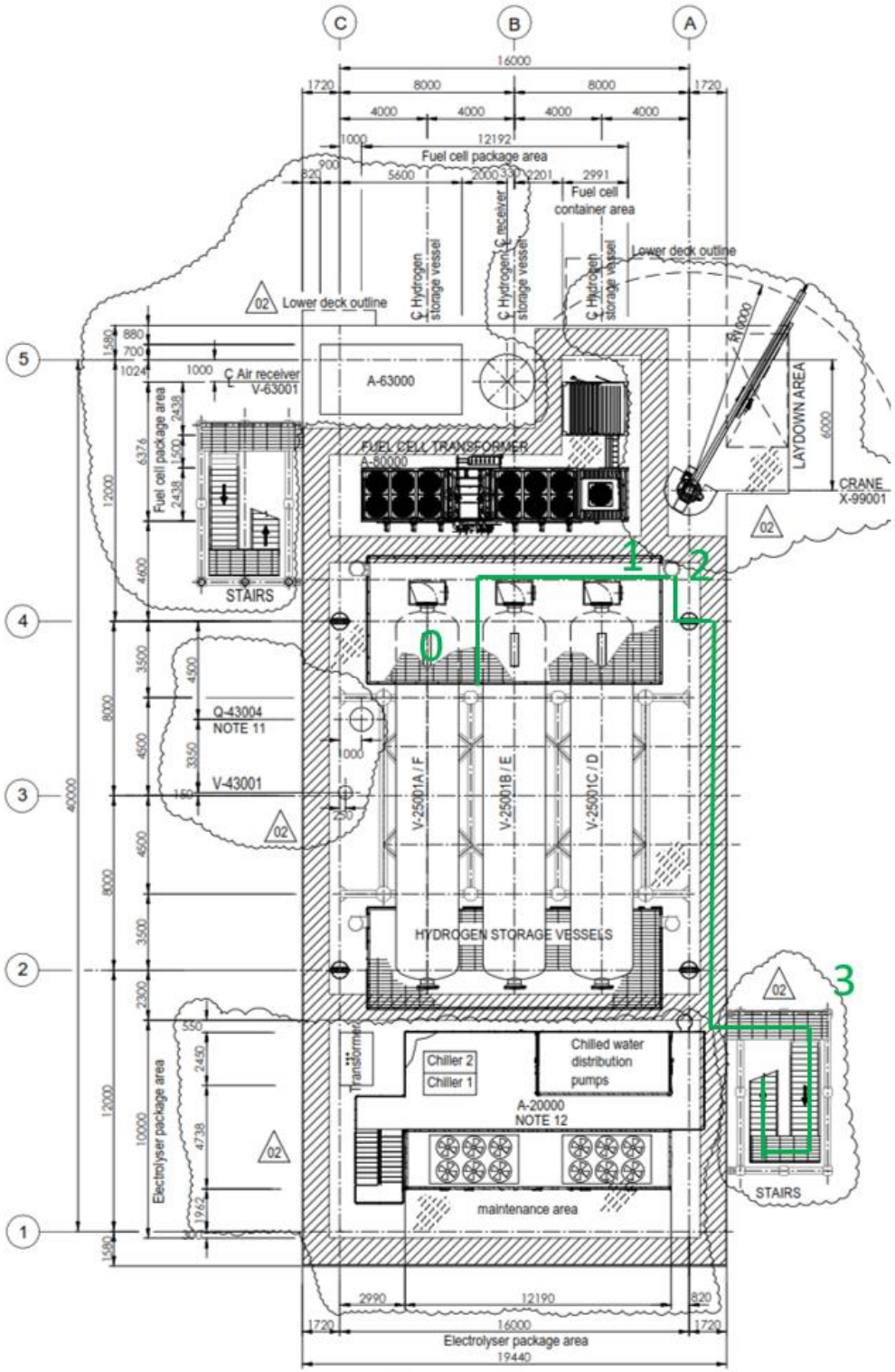
Reference LOC	Hole size (mm)	Weather	LFL (m) (horizontal)	LFL (m) (down impingement)
2.2 Release from BDV connecting piping on top of storage vessel (3 inches)	5	F2	5.7	6.7
		D5	6.0	8.0
		D10	5.5	7.6
	25	F2	27.5	23.3
		D5	32.0	32.0
		D10	32.5	92.5
	75 (3 inches)	F2	68.0	44.0
		D5	81.0	54.0
		D10	88.0	69.0
Reference LOC	Hole size (mm)	Weather	LFL (m) (horizontal)	LFL (m) (down impingement)
3.1 Release from vessels outlet piping to fuel cell package	5	F2	6.0	7.0
		D5	6.0	8.5
		D10	6.0	8.0
	25	F2	29.0	24.0
		D5	34.0	35.0
		D10	34.5	98.0
	50 (2 inches)	F2	51.0	35.5
		D5	62.0	45.5
		D10	67.0	60.0

As already discussed, in case of presence of operators, the electrolyze and fuel cell package are not in service, meaning the flash fire risk from the LOC 1.1, 2.1 and 3 reported in the above table are not applicable.

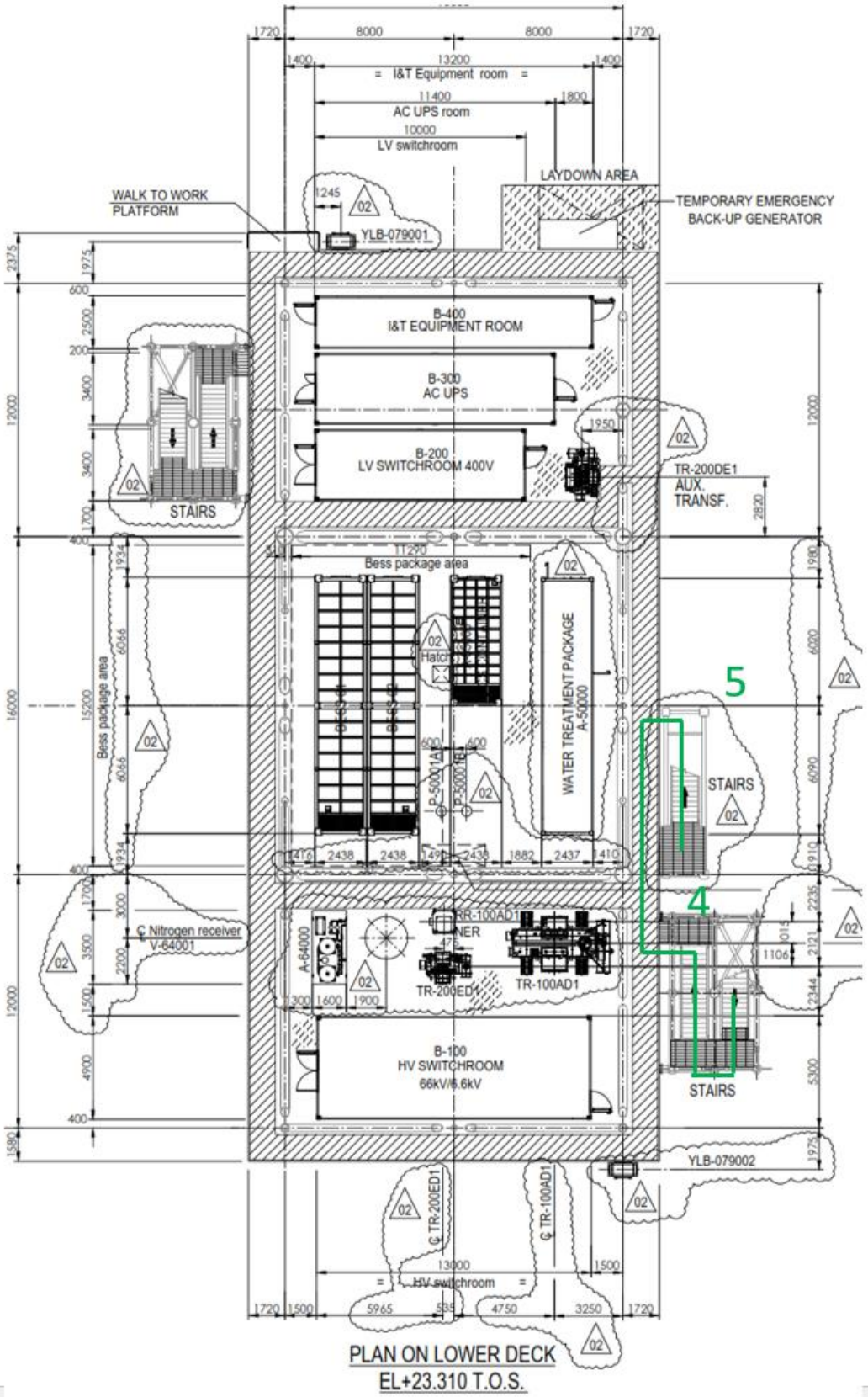
In addition, in case of maintenance activities on PSV/BDV, the storage vessel will be depressurized, meaning that also the LOC 2.2 will be not more applicable.

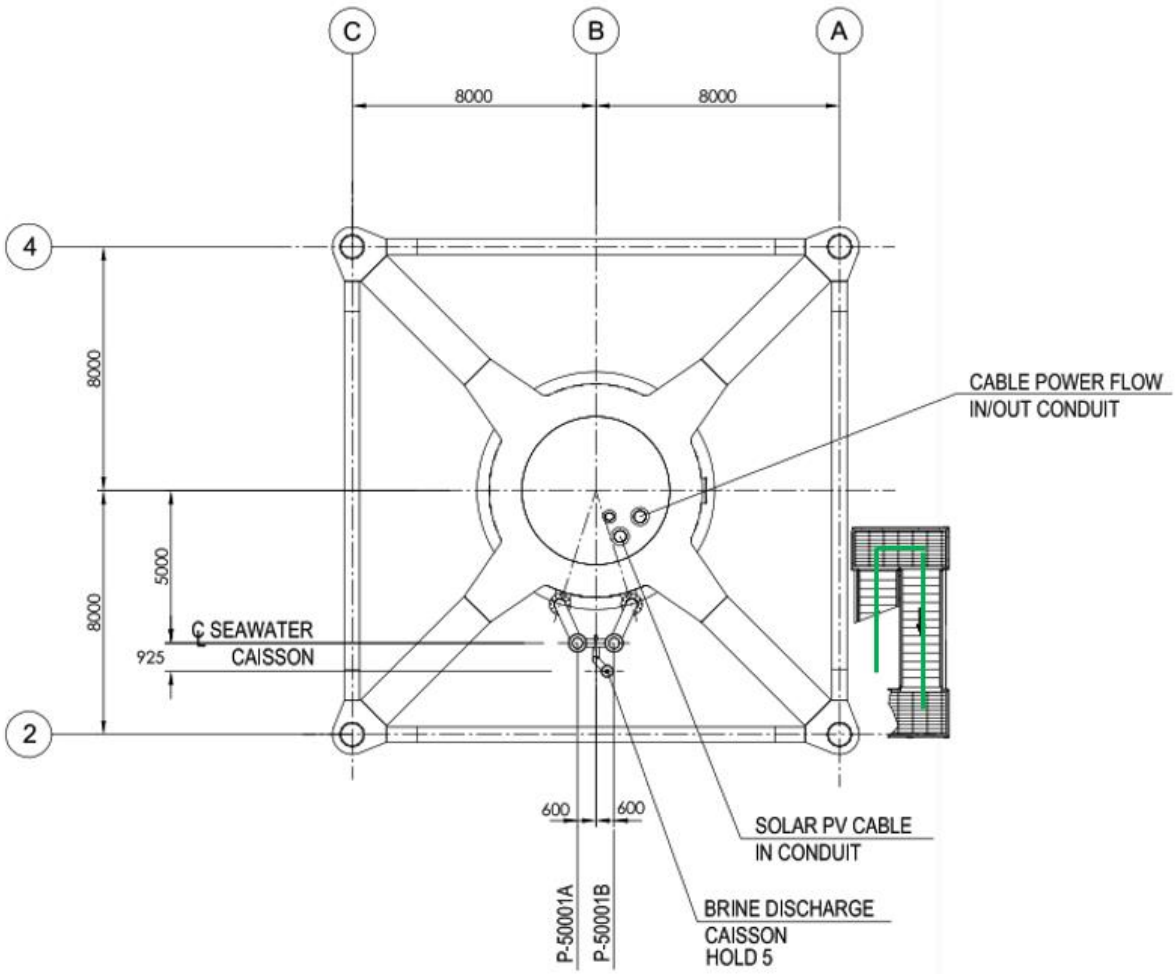
The frequencies of occurrence of flash fire scenarios for all the section are well below the 1.0E-04 occ/year target frequency for impairment of escape route/muster point.

ATTACHMENT 2
EVACUATION ROUTE

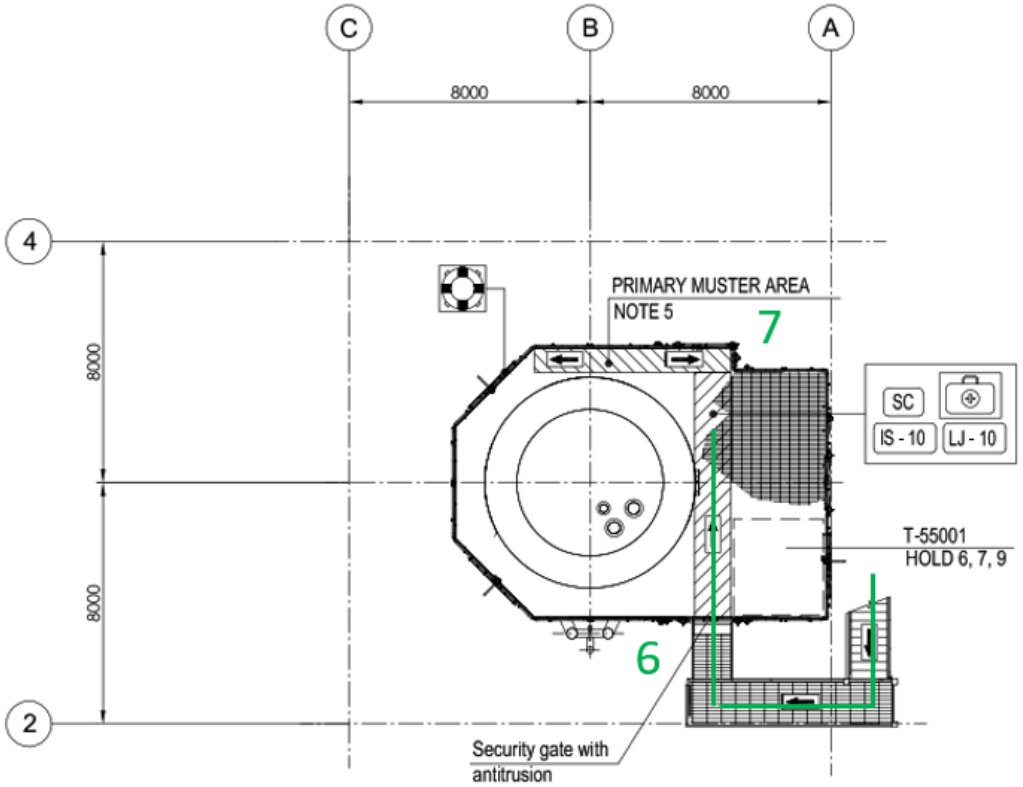


PLAN ON UPPER DECK
EL+30.310 T.O.S.


WALK TO WORK PLATFORM
YLB-079001
LAYDOWN AREA
TEMPORARY EMERGENCY BACK-UP GENERATOR
B-400 I&T EQUIPMENT ROOM
B-300 AC UPS
B-200 LV SWITCHROOM 400V
TR-200DE1 AUX. TRANSF.
STAIRS
Bess package area
WATER TREATMENT PACKAGE A-50000
Hatch
Nitrogen receiver V-64001
TR-100AD1
TR-200ED1
B-100 HV SWITCHROOM 66kV/6.6kV
YLB-079002
HV switchroom
5
4
PLAN ON LOWER DECK
EL+23.310 T.O.S.



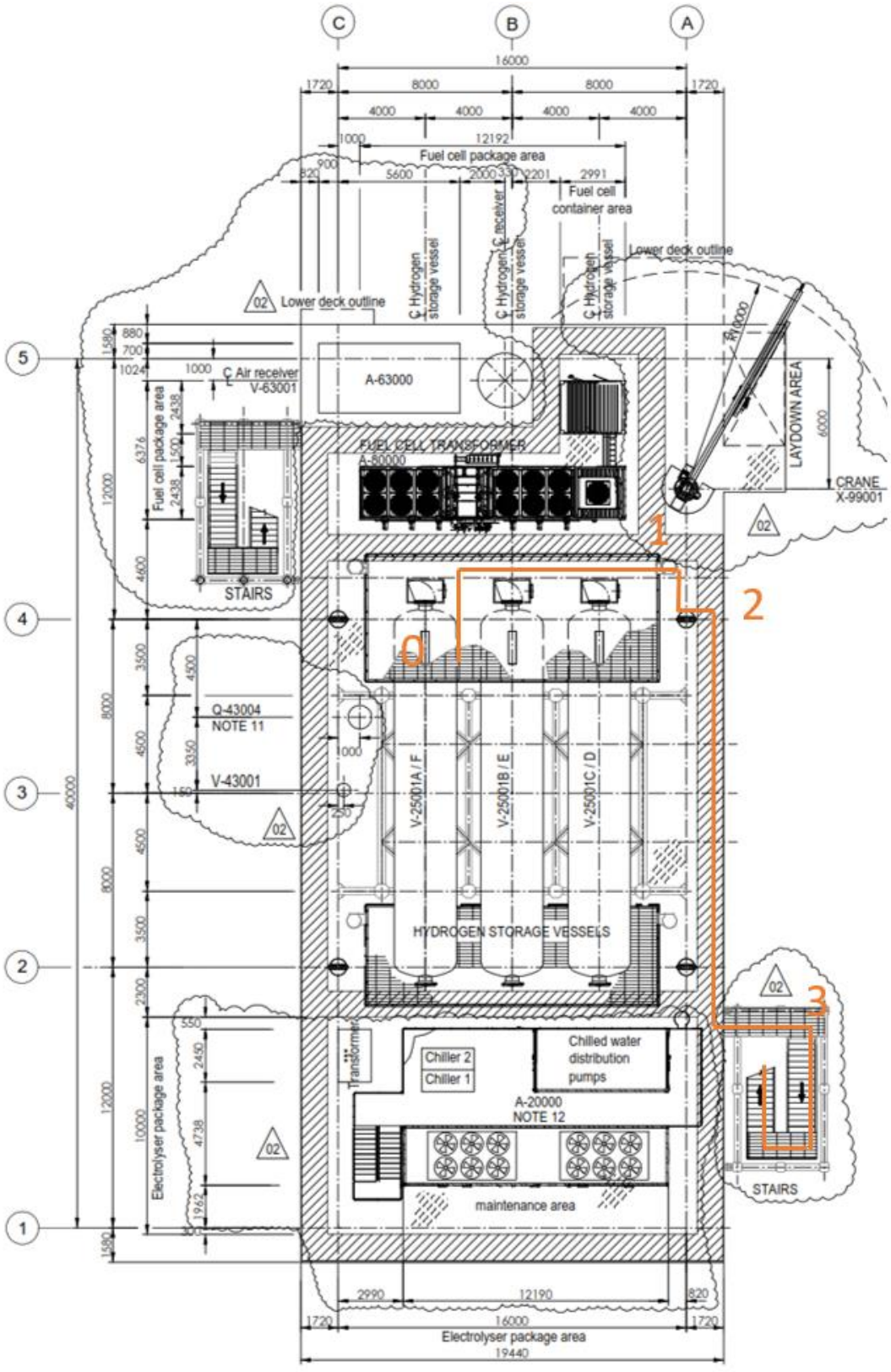
PLAN ON TRANSITION PIECE
EL+21.710 T.O.S.



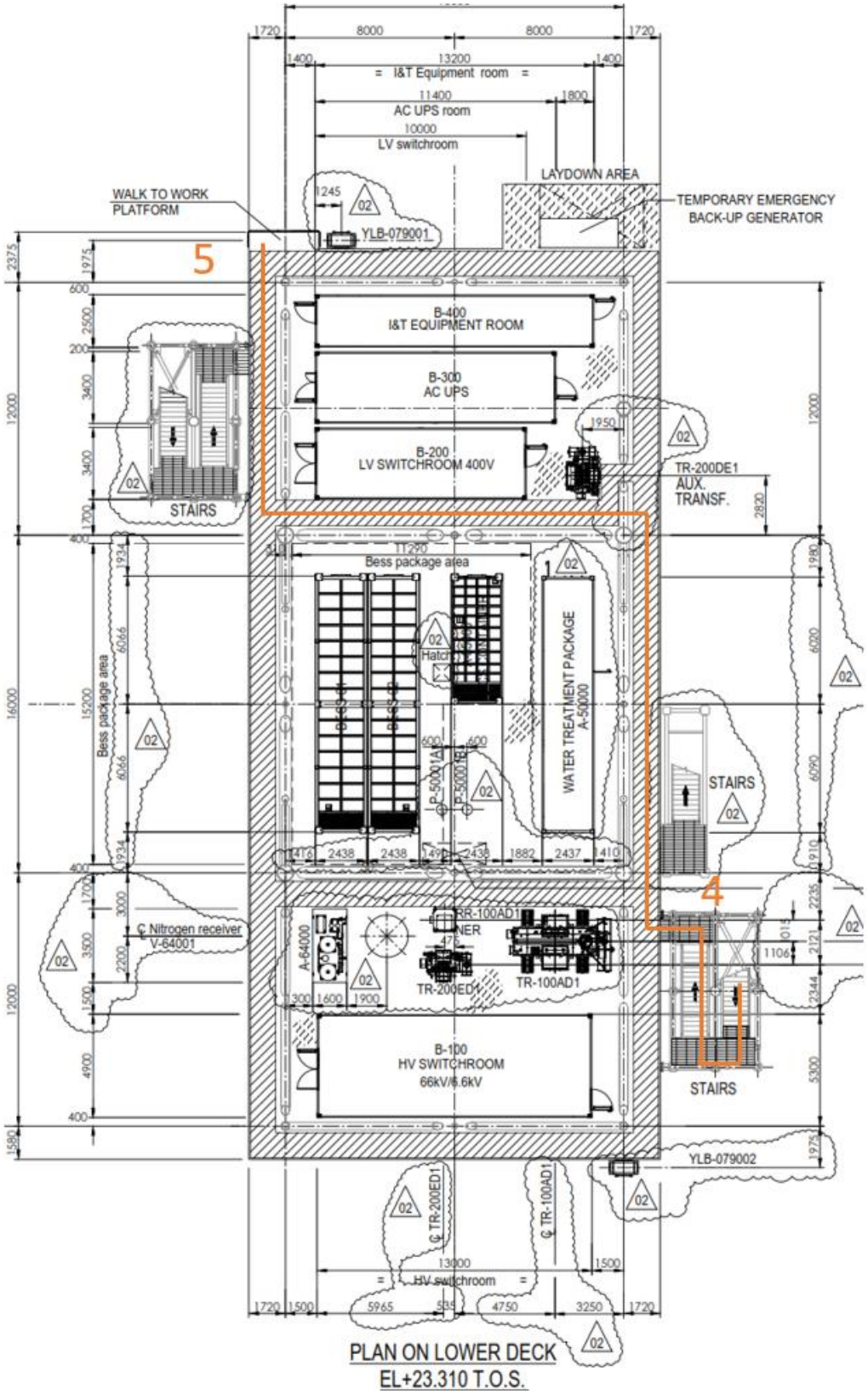
PLAN ON EXISTING
PLATFORM AT
EL+16.860 T.O.S.

ATTACHMENT 3

ESCAPE ROUTE



PLAN ON UPPER DECK


WALK TO WORK PLATFORM
LAYDOWN AREA
TEMPORARY EMERGENCY BACK-UP GENERATOR
YLB-079001
5
B-400 I&T EQUIPMENT ROOM
B-300 AC UPS
B-200 LV SWITCHROOM 400V
TR-200DE1 AUX. TRANSF.
STAIRS
Bess package area
WATER TREATMENT PACKAGE A-50000
P-50001A
P-50001B
STAIRS
4
Nitrogen receiver V-64001
A-64000
TR-100AD1
TR-200ED1
B-100 HV SWITCHROOM 66kV/6.6kV
STAIRS
YLB-079002
HV switchroom
PLAN ON LOWER DECK
EL+23.310 T.O.S.