Base Load Power Hub (BLPH)

Emergency Systems Survivability Assessment Report (ESSA)

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1 INTRODUCTION

1.1 Project overview

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

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

1.1.1 Project location

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

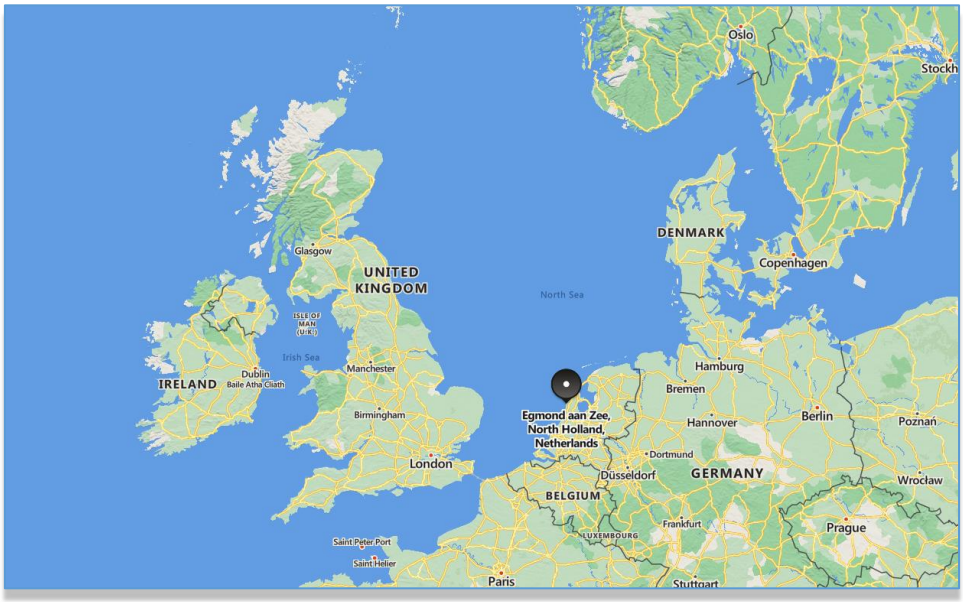


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

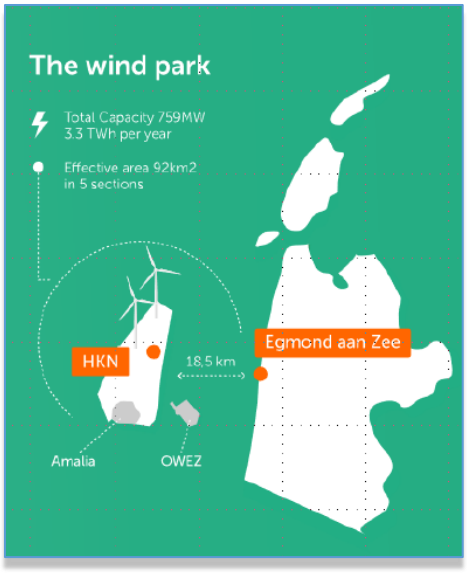


Figure 2 - Wind Park Details

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

1.1.2 PROJECT CONCEPT

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

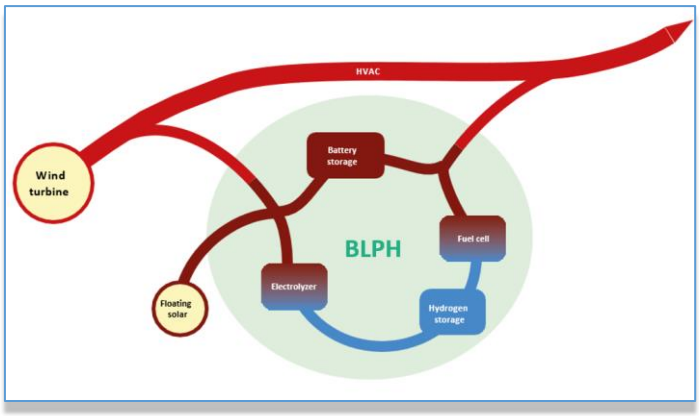


Figure 3 – BLPH Concept

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

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

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2 DOCUMENT SCOPE

This document has the purpose of detailing the results of Emergency Systems Survivability Analysis (ESSA) study. ESSA will qualitatively analyse the survivability of emergency equipment from specific Major Accident (MA) and its consequences based on the equipment vulnerability, failure mode and redundancy/diversity.

Emergency systems are the last line of defence to protect people and assets from the MA such as fire, explosion. Survivability of these equipment from the effects of MA is one of the mandatory requirements to ensure the emergency systems are able to perform their intended function during and/or after the MA.

2.1 Main references

Ref.	Description
1	123A90-DDL-SAF-RE-30019 - Quantified Risk Assessment (QRA) Report (rev01)
2	123A90-DDL-SAF-RE-30020 - Fire and Explosion Risk Analysis (FERA) report (rev02)
3	123A90-DDL-SAF-RE-30015 - Evacuation, Escape and Rescue Assessment (EERA) Report (rev01)
4	123A90-DDL-SAF-RE-30003 - Safety Critical Elements (SCE) and Performance Standard (rev 01)
5	Risk assessment data directory, document no. IOGP 434_15 – 2010 - - Vulnerability of plant/structure

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
Critical Element	Specific systems that are essential for maintaining safety in order to mitigate consequences in case of major Accident . Loss of critical functions could lead to catastrophic consequences, such as loss of life, environmental damage, or mission failure. In the present report, the
Escape (route)	Escape from an Accidental Event is the process of personnel moving along escape routes towards Muster Point.
Emergency System	A set of interconnected components, devices, and processes designed to provide immediate response and support during emergency situations. These systems aim to protect personnel, prevent further damage, and ensure the continuity of critical operations.
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.
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.
FERA	Fire and Explosion Risk Assessment. A comprehensive risk evaluation directed to the analysis of the effects of fire and explosion scenarios (due to LOCs of hazardous substance handled in an equipment to be installed during project development) on process equipment, structures and buildings.
MAJOR ACCIDENT	Major Accident can be defined as: - a fire, explosion or the release of a dangerous substance involving death or serious personal injury to persons on the installation or engaged in an activity on or in connection with it;

	- any event involving major damage to the structure of the installation or plant affixed thereto or any loss in the stability of the installation or major environmental impact
QRA	Quantitative Risk Assessment. For the purpose of this study, a comprehensive risk evaluation focused on the identification of the impact to persons (workers) due to effects of accident scenarios due to LOCs of hazardous substance handled in equipment to be installed during project development. Due to location of the installation, external risk for external people is considered not applicable.
Redundancy	The incorporation of additional components, subsystems, or paths to ensure system functionality in case of failure of the main system.
Survivability	The capability of a system or infrastructure to withstand and recover from adverse conditions (such as accidents) while maintaining its critical functions.
Vulnerability	The susceptibility of a system, component, or process to damage, disruption due to the exposition to a MA.

Table 2 - Definitions

2.2.2 ABBREVIATIONS

BDV	Blow Down Valve
BESS	Battery Energy Storage System
BLPH	Base Load Power Hub
EERA	Escape, Evacuation and Rescue Assessment
EPIRB	Emergency Position Indicating Radio Beacon
ESD	Emergency Shut Down system
ESSA	Emergency Systems Survivability Assessment
F&G	Fire and Gas
FERA	Fire and Explosion Risk Assessment
HAZID	Hazard Identification Study
HKN	Hollandse Kust Noord
HSE	Health, Safety and Environment
MA	Major Accident
PSV	Pressure Safety Valve
QRA	Quantitative Risk Assessment
SCE	Safety Critical Element
ESDV	Emergency Shut Down Valve
SART	Safety And Rescue Transponder
UPS	Uninterruptable Power System
UV-IR	Ultraviolet / Infrared (wavelengths)
VHF	Very High Frequency

Table 3 - Abbreviations

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3 METHODOLOGY

The purpose of the Emergency Systems Survivability Analysis (ESSA) is to identify the emergency systems that are necessary to protect personnel on the facility and to assess the effects of all Major Accident on the ability of those systems to operate as intended, i.e. reduce or mitigate the MA consequence and prevent escalation or enable escape, temporary refuge, evacuation and recovery during emergency situations.

The main process steps within an ESSA study are:

- Identification of the "criticality": based on MA, it is required to identify the elements which are required in function in order to mitigate the consequences;
- Identification of the "vulnerability": for each critical element, it is required to identify if the elements is vulnerable to MAs;
- Identification of the "Fail status": if the selected element is vulnerable to Mas, it is required to verify if the system fails safe and if it able to perform the safety action for the required duration;
- Identification of the "Redundancy/diversity": if the selected element has not a fail safe status, it is required to verify if the element is provided with redundancy or alternative system which are not vulnerable to MAs.

The proposed ESSA methodology is as shown in Figure illustrated here below.

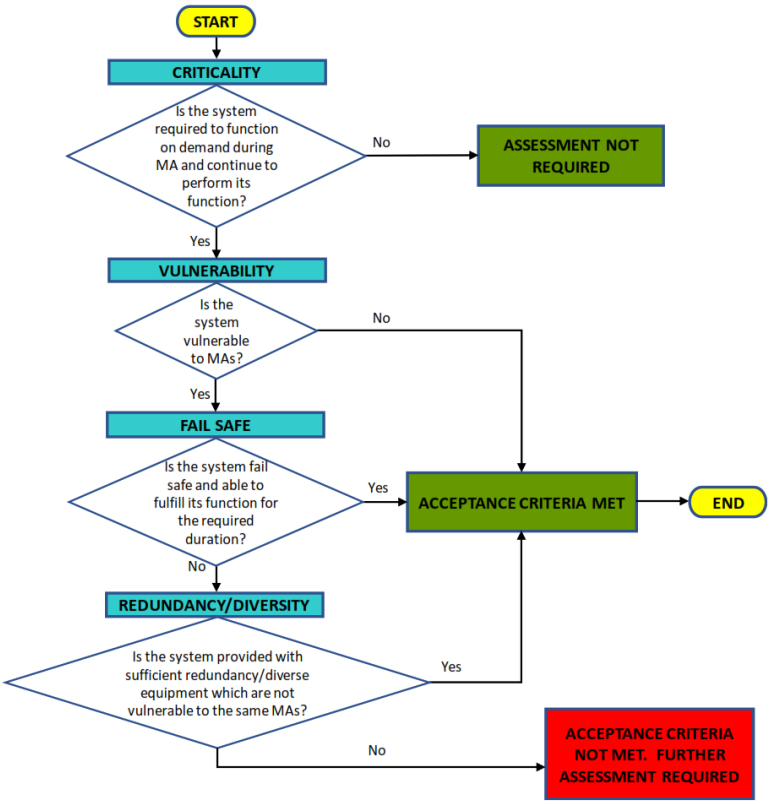


Figure 4 – ESSA workflow

The first phase is the identification of safety emergency elements and relative criticality (that is the need of the safety system in function during MA). If the system is not required in function during MA, the system is not considered "critical" and the assessment is not required. The criticality of an emergency system is also related to its protection role towards the escape routes and muster points, necessary to the escape and evacuation of the platform in case of emergency, taking into account the EERA results.

If the system is "critical", the further steps are the following:

- assess the vulnerability of the system regarding hazardous scenario as fire, dispersion and explosion from MAH. If a component was not found to be vulnerable in the context of the MA, then its survivability is not threatened, no further assessment is required. Duration is a very important criterion when determining the survivability of the emergency system. Some emergency systems are designed to perform and survive MAs while some other emergency systems may be sacrificial after performing its intended function. For example, the fire and gas detectors can fail once it has sent a signal to the fire and gas panel to initiate shutdown and alarm, thus need not survive the whole fire duration.

- verify the fail-safe status of the safety elements. The components of each identified emergency system shall be qualitatively evaluated to establish how they may fail under the effects of the MA identified. Where a critical system is deemed `fail safe', i.e. none of its components are deemed fail to danger, then further analysis for such a system is not required.

- verify the redundancy of the safety elements, meaning the presence of two or more independent components available that can perform the function of the emergency system of interest in case they fail due to exposure to MA effects.

At the end of the screening process, the goal is to verify, for each safety-critical element in terms of "SCE group" (which is a set of elements of the same primary type), whether the acceptance criteria are met. For each SCE group, a detailed table is created with all the required information to check if the system meets the ESSA requirements.

3.1 Identification of emergency system

The Safety Critical Elements (SCEs) are those items or structures or systems whose main objective is to prevent a major accident or mitigate the consequences related to a major accident, or whose failure can lead to a major accident or contribute to its occurrence/evolution.

SCE are defined in the document Safety Critical Elements (SCE) and Performance Standard [4]. For ESSA study, only the SCEs which are required in function during a MA are considered "critical" and need to be evaluated.

The SCEs identified for the platform are summarized in the below table, which included also the indication of the applicability for ESSA study

SCE Category		SCE Groups		Comment
SI	Structural integrity	SI001	Subsea structures	No critical structures vulnerable to MAs are identified based on the FERA study. Not included in ESSA study.
		SI002	Topside structures	
PC	Process Containment	PC001	Pressure vessel	The integrity of the process system shall be assured to prevent a MA. This system will not be required to function in the event of a MA. Not included in ESSA study.
		PC005	Piping system	
		PC007	Relief System (PSV)	
IC	Ignition Control	IC002	Non-Hazardous area ventilation	This system is provided to prevent formation of explosive atmosphere or control ignition source. This system will not be required to function in the event of a MA. Not included in ESSA study.
		IC003	Certified (ex-rated) electrical equipment	
		IC005	Electrical earthing continuity & bonding	
DS	Detection Systems	DS001	Fire and gas detection	The ability of this system to function is critical to prevent event escalation. **Included in ESSA study.**
PS	Protection Systems	PS002	Fire protection (Fire extinguisher)	Manual firefighting equipment are typically used for controlling small fires, not fires in the event of MA. Not included in ESSA study.
		PS015	Collision Avoidance System	These systems are provided to prevent a MA. The system will not be

SCE Category		SCE Groups		Comment
				required to function in the event of a MA.
SD	Shutdown system	SD001	Emergency Shutdown System (ESD)	The ability of this system to function is critical to prevent event escalation. **Included in ESSA study.**
		SD002	Blowdown Valves (BDV)	
		SD006	Emergency Shutdown Valves (SDV)	
		SD009	Utility Air	This system is not required to function during a MA. Not included in ESSA study.
ER	Emergency Response	ER001	Muster Area	Impairment of escape routes by MA are typically evaluated as part of the EERA study. Not included in ESSA study.
		ER002	Escape Routes	
		ER003	Emergency / Escape Lighting	The ability of this system to function is critical to enable personnel escape. **Included in ESSA study.**
		ER004	Communication System	The ability of this system to function is critical to alert personnel of a MA in order to escape from platform. **Included in ESSA study.**
		ER005	Power Supply System	The ability of this system to function is critical to provide power to critical emergency systems. **Included in ESSA study.**
LS	Life Saving	LS001	Personal Survival Equipment	The ability of this system is critical in order to escape from platform. **Included in ESSA study.**

Table 4 – SCE category

This study is based on the "SCE category" outlined in the SECE study [4]. For each "SCE category," one or more relevant "SCE groups" are identified. An "SCE group" refers to a set of elements of the same primary type. For many of the identified "SCE groups," there is no need to identify sub-elements, as the evaluations are common and applicable to all without distinction. For other systems, although the evaluation is conducted at the "SCE group" level, additional considerations are taken into account for specific element (e.g different type of detectors).

3.2 Reference Major accident

Basic information to perform ESSA study is retrieved from Platform FERA Report, which identifies the risk contour plots associated to the effects in terms of radiation and overpressure associated to the release of flammable gas from equipment and from HAZID study.

Not all MAs identified will be applicable in the context of ESSA. Only MA with the potential to cause impairment of the emergency system, or where survivability of the emergency system is critical after the MA shall be considered.

The criterion adopted to establish the vulnerability of the critical systems to the effects of the identified MA is consistent to the one adopted in the FERA methodology.

The system requires additional mitigation measure, being vulnerable to the effects of MAs, when it is reached by following levels of radiation/overpressure, with an expected frequency above 1.0E-04 occ/year:

- Radiation: 37 kW/m^2 for impact on equipment/ structure of platform.
- Radiation: 6.3 kW/m^2 for impact on muster point/escape route.
- Overpressure of 0.35, 0.27, 0.15 bar for potential impact on structure of platform.

The components of each identified emergency system shall be qualitatively evaluated to establish how they may fail under the effects of the MA identified.

4 RESULTS

For all the identified critical systems, the workflow indicated in chapter 3 of present document has been extensively applied in order to determine the criticality, the vulnerability, the fail-safe design and the redundancy of such system. These data articulated as indicated in the methodology work-flow allows the definition of the survivability of the system.

In following paragraphs, the detailed analysis for each critical elements are summarized by use of specific tables.

4.1 Fire and gas detection systems

The purpose of the fire and gas detection system is to detect a release or hydrogen/smoke or a fire in the platform and automatically initiate shutdown and depressurisation in order to achieve maximum safeguarding of personnel and assets. The system is composed by the following main elements:

• UV-IR flame detectors; • Ultra Sonic Hydrogen detectors; • Point Source Oxygen Detectors; • Point Source Hydrogen Detector; • Smoke Detectors in cabinets; • F&G control panel.

In following table, the survivability analysis is reported for each analysed system.

System	Criticality		Vulnerability	Fail safe	Redundancy/diversity
	Escalation	Escape/evacuation			
UV-IR flame detectors Ultra Sonic Hydrogen detectors Point Source Oxygen Detectors Point Source Hydrogen	Loss of detectors lead to delayed intervention and possible fire scenario escalation. System critical to prevent escalation	Failure of the system would affect the escape / evacuation through potential escalation. System critical for prevent safe escape/evacuation.	Detectors will act at the beginning of fire / gas release and can be considered available for the time required to send a signal to control panel in order to activate emergency action. Connecting cables to F&G control panel are fire resistant. Detectors on the lower deck are exposed to a radiation level of 37.5 kW/m², with a frequency of occurrence ranging from about 5.0E-07 occ/year to 1.0E-07 occ/year; on the upper deck, detectors are exposed to a frequency of occurrence ranging from 2.3E-05 occ/year to 1.0E-05 occ/year, depending on their position. Considering that, for each position, the risk is lower than target frequency of 1.0E-04 occ/year, the vulnerability level is acceptable for thermal radiation. Note that, the presence of plated deck can decrease the thermal radiation reached by the target element in the lower deck. Considering the 0.35 bar threshold, an impact on the detectors on each deck can be expected, with a frequency ranging from 6.8E-05 occurrences per year to 1.0E-05 occurrences per year, depending on their position. Since, for each position, the risk is lower than the target frequency of 1.0E-04 occurrences per year, the vulnerability level is considered acceptable for the explosion scenario.	Not required.	Not required. Anyway, each fire zones of platform are provided with several redundant detectors installed around the area in order to guarantee the maximum possible redundancy of detection.

System	Criticality		Vulnerability	Fail safe	Redundancy/diversity
	Escalation	Escape/evacuation			
F&G control panel	Loss of F&G panel leads to delayed intervention and impossibility to identify fire/gas release in platform. **System critical to prevent escalation**	Failure of the system would affect the escape / evacuation through potential escalation. System critical for prevent safe escape/evacuation.	F&G control panel is installed inside cabinets in lower deck (B-400), away from main equipment involving flammable substances with high inventory. Anyway, the F&G panel will activate emergency action after receiving the signal from the detectors, at the beginning of fire / gas release and can be considered available for the time required to send the signal to final elements Connecting cables to SDV valve are fire resistant. B-400 cabinets is installed in the lower deck and is exposed to a radiation level of 37.5 kW/m² with a frequency of occurrence equal to 5.0E-07 occ/year, which is lower than target frequency of 1.0E-04 occ/year, meaning that the vulnerability level is acceptable for thermal radiation. Note that the presence of the plated deck and the cabinet walls can reduce the thermal radiation reaching by F&G control panel. Considering the 0.35 bar threshold, an impact on the B-400 cabinets can be expected, with a frequency of approximately 2.0E-05 occurrences per year. This is lower than the target frequency of 1.0E-04 occurrences per year, indicating that the vulnerability level is acceptable for explosion risk.	Not required.	Not required.
Results	The analysed systems related to Fire and Gas detection meet ESSA requirements				
Recommendation	Not applicable.				

Table 5 – ESSA table for F&G

4.2 Emergency Shutdown system (ESD)

The Emergency Shutdown Systems are designed to protect personnel and assets during an incident by preventing escalation. The ESD system is immune to interference from control systems, ensuring a clear separation between control and shutdown functions. Additionally, in the event of an air supply loss, the valves move to their designated fail-safe positions as defined in the design. In case of a power failure, the ESD systems are supported by a dedicated power supply. The system is composed by the following main elements:

• Emergency Shutdown System (ESD); • Blowdown Valves (BDVs); • Emergency Shutdown Valves (ESDV).

System	Criticality		Vulnerability	Fail safe	Redundancy/diversity
	Escalation	Escape/evacuation			
Emergency Shutdown System (ESD)	Failure of ESD causes the incomplete isolation of process unit under emergency, leading to **other** possible scenario escalation. **System critical to prevent escalation**	Failure of the system would affect the escape / evacuation through potential escalation. System critical for prevent safe escape/evacuation.	ESD control panel is installed inside cabinet in lower deck (B-400), away from main equipment involving flammable substances with high inventory. The ESD panel will activate emergency action after receiving the signal from the detectors/transmitters, at the beginning of fire / gas release and can be considered available for the time required to send the signal to final elements All ESD loop are provided whit fire resistant cables. B-400 cabinets is installed in the lower deck and is exposed to a radiation level of 37.5 kW/m² with a frequency of occurrence equal to 5.0E-07 occ/year, which is lower than target frequency of 1.0E-04 occ/year, meaning that the vulnerability level is acceptable for thermal radiation. Note that the presence of the plated deck and the cabinet walls can reduce the thermal radiation reaching by F&G control panel. Considering the 0.35 bar threshold, an impact on the B-400 cabinets can be expected, with a frequency of approximately 2.0E-05 occurrences per year. This is lower than the target frequency of 1.0E-04 occurrences per year, indicating that the vulnerability level is acceptable for explosion risk.	Not required.	Not required.
Blowdown Valves (BDVs)	Failure of BDVs causes the incomplete depressurization of process unit under emergency, leading to **other** possible scenario escalation. **System critical to prevent escalation**	Failure of the system would affect the escape / evacuation through potential escalation. System critical for prevent safe escape/evacuation.	BDVs are installed in the upper deck and are exposed to a radiation level of 37.5 kW/m² with a frequency of occurrence about 2.0E-05 occ/year, which is lower than target frequency of 1.0E-04 occ/year, meaning that the vulnerability level is acceptable for thermal radiation. Considering the 0.35 bar threshold, an impact on BDVs is expected, with a frequency of approximately 5.0E-05 occurrences per year. Since the risk is lower than the target frequency of 1.0E-04 occurrences per year, the vulnerability level is deemed acceptable for the explosion scenario.	BDVs are designed as FO which represents the fail-safe position in case of emergency.	Not required since vulnerability level is acceptable and design is fail safe.

System	Criticality		Vulnerability	Fail safe	Redundancy/diversity
	Escalation	Escape/evacuation			
Emergency Shutdown Valves (ESDVs) in platform	Failure of ESDVs causes the incomplete isolation of process unit under emergency, leading to other possible scenario escalation. System critical to prevent escalation	Failure of the system would affect the escape / evacuation through potential escalation. System critical for prevent safe escape/evacuation.	ESDVs are installed in the upper deck and are exposed to a radiation level of 37.5 kW/m² with a frequency of occurrence between 2.0E-05 occ/year and 1.0E-05 occ/year, depending on each valve position. Since the frequency of occurrence is lower than target frequency of 1.0E-04 occ/year, the vulnerability level is acceptable for thermal radiation. ESDVs are installed in the upper deck and are exposed to a overpressure threshold of 0,35 bar with a frequency of occurrence between 6.0E-05 occ/year and 1.0E-05 occ/year, depending on each valve position. Since the frequency of occurrence is lower than target frequency of 1.0E-04 occ/year, the vulnerability level is acceptable for explosion scenario.	ESDVs are designed as FC which represents the fail-safe position in case of emergency.	Not required since vulnerability level is acceptable and design is fail safe.
Results	The analysed systems related to emergency shutdown and depressurisation system elements meet ESSA requirements				
ecommendation	Not applicable.				

Table 6 – ESSA table for shutdown system

4.3 Emergency Response

Identified critical equipment for emergency response are: • Emergency / Escape Lighting; • Communication System; • Power System .

System	Criticality		Vulnerability	Fail safe	Redundancy/diversity
	Escalation	Escape/evacuation			
Emergency / Escape Lighting	Failure of Emergency / Escape Lighting system is not a contributing factor to escalation. System not critical for prevent escalation.	Impossibility to provide adequate illumination of escape routes in the event of a major accident event (in case operator working inside a container). System critical for prevent safe escape/evacuation.	Escape Lighting are installed inside each cabinet in lower deck and upper deck. In the lower deck, cabinets are exposed to a radiation level of 37.5 kW/m², with a frequency of occurrence ranging from about 5.0E-07 occ/year to 1.0E-07 occ/year; on the upper deck, cabinets are exposed to a frequency of occurrence ranging from 2.3E-05 occ/year to 1.0E-05 occ/year, depending on their position. Considering that, for each position, the risk is lower than target frequency of 1.0E-04 occ/year, the vulnerability level is acceptable for thermal radiation. Note that, the presence of plated deck can decrease the thermal radiation reached by the target element located in the lower deck. Considering the 0.35 bar threshold, an impact on cabinets can be expected, with a frequency ranging from 6.8E-05 occurrences per year to 1.0E-05 occurrences per year, depending on their position. Since, for each position, the risk is lower than the target frequency of 1.0E-04 occurrences per year, the vulnerability level is considered acceptable for the explosion scenario.	Escape Lighting are provided with battery in case of loss of main power supply.	Not required.

System	Criticality		Vulnerability	Fail safe	Redundancy/diversity
	Escalation	Escape/evacuation			
Communication systems	Failure of internal communication system is not a contributing factor to escalation. System not critical for prevent escalation.	Impossibility to communicate in case of major incident between operators in the platform for alerting personnel and with rescue vessel. Note that, considering the dimension of platform, it is very unlikely that operators are not warned about MA. System critical for prevent safe escape/evacuation.	Emergency Communication system is redundant and well distributed in lower and upper deck. In the lower deck, Sounders are exposed to a radiation level of 37.5 kW/m², with a frequency of occurrence ranging from about 5.0E-07 occ/year to 1.0E-07 occ/year; on the upper deck, sounders are exposed to a frequency of occurrence ranging from 2.3E-05 occ/year to 1.0E-05 occ/year, depending on their position. Considering that, for each position, the risk is lower than target frequency of 1.0E-04 occ/year, the vulnerability level is acceptable for thermal radiation. Note that, the presence of plated deck can decrease the thermal radiation reached by the target element located in the lower deck. Considering the 0.35 bar threshold, an impact on sounders can be expected, with a frequency ranging from 6.8E-05 occurrences per year to 1.0E-05 occurrences per year, depending on their position. Since, for each position, the risk is lower than the target frequency of 1.0E-04 occurrences per year, the vulnerability level is considered acceptable for the explosion scenario.	Not applicable.	Emergency Communication system is redundant; in the platform are available: • VHF marine portable radio available. • Sounders for fire/gas located on each fire zone.
Power System	Failure of power systems causes the ESD failure and the incomplete isolation of process unit under emergency, leading to other possible scenario escalation. System critical for prevent escalation.	Escape and evacuation may be affected by loss of power systems, which supply facility communication systems and escape lighting. System critical for prevent safe escape/evacuation.	Power systems cabinets are located in the lower deck and are exposed to a radiation level of 37.5 kW/m², with a frequency of occurrence of 1.3E-07 occ/year for B-100 (switch room), 5.0E-07 occ/year for B-200 (LV switch room), B-300 (AC UPS) and for B-400 (I&T room). Considering that, for each cabinet, the risk is lower than target frequency of 1.0E-04 occ/year, the vulnerability level is acceptable for thermal radiation. Note that, the presence of plated deck can decrease the thermal radiation reached by the target element located in the lower deck. Considering the 0.35 bar threshold, an impact on cabinets can be expected, with a frequency ranging from 6.8E-05 occurrences per year to 1.0E-05 occurrences per year, depending on their position. Since, for each position, the risk is lower than the target frequency of 1.0E-04 occurrences per year, the vulnerability level is considered acceptable for the explosion scenario.	The loss of power causes the valves to move to their fail-safe positions as defined in the design (BDV valves opening; ESDV valves closing). Escape Lighting are provided with battery in case of loss of main power supply.	Emergency Communication system is redundant.
Results	The analysed systems related to emergency response system meet ESSA requirements				
Recommendations	Not applicable.				

Table 7 – ESSA table for emergency response system

4.4 Evacuation systems

The systems for evacuation consist of the following: stairs; designated routes, access to vessel, life rafts, life jackets and other life saving apparatus. Please note that survivability of these systems is typically evaluated as part of the Escape, Evacuation and Rescue Analysis (EERA).

System	Criticality		Vulnerability	Fail safe	Redundancy/diversity
	Escalation	Escape/evacuation			
Evacuation system	Failure of Evacuation system is not a contributing factor to escalation. System not critical for prevent escalation.	Life saving appliance are, by definition, critical to ensuring escape and evacuation during an incident. Designated routes and stairs must be kept clear, be robust against the conditions and be chosen such that the safest route possible is designated. System critical for prevent safe escape/evacuation.	Not applicable.	Not applicable.	The life saving appliance in the platform are distributed in strategic locations, in order to permit an adequate redundancy. Access to escape routes is possible in all weather conditions, and alternative routes are always available
Results	The analysed systems related to evacuation system meet ESSA requirements				
Recommendations	Not applicable.				

Table 8 – ESSA table for evacuation system

5 CONCLUSION

The conclusion emerged from the emergency systems survivability assessment is an acceptable risk for all the emergency systems, due to the low frequency of major accidental scenarios (on the basis of QRA and FERA study) and the adequate redundancy of main critical system.