Base Load Power Hub (BLPH)

Assumption Register

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ICARO					

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Revision / Change Log

Rev.	Description
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HOLDS LIST

No.	Description
1	The applicability of this study for the project is still under discussion between Company and Contractor, based on that agreement the objectives of the Dropped Object study will be defined
2	
3	
4	

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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.

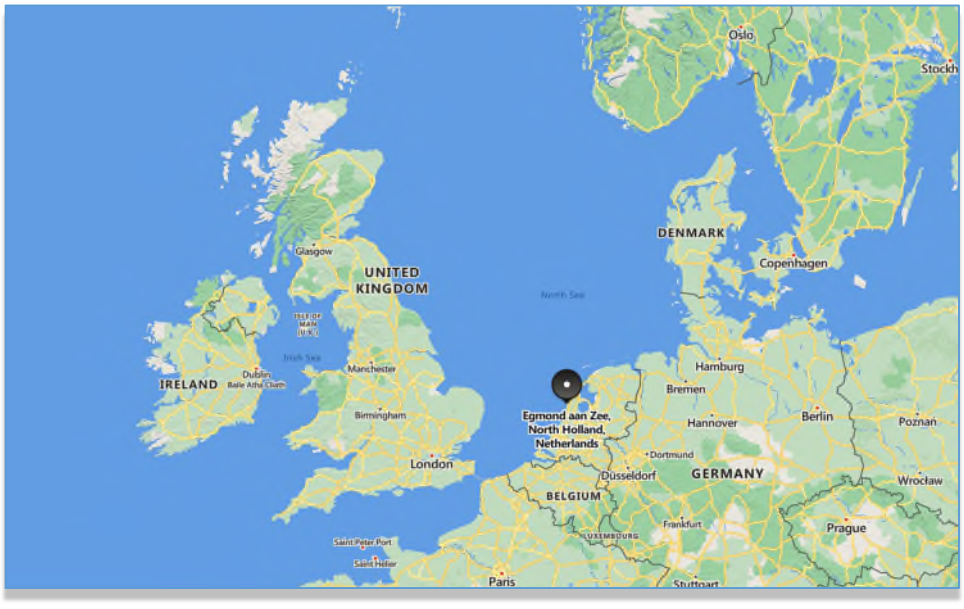


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

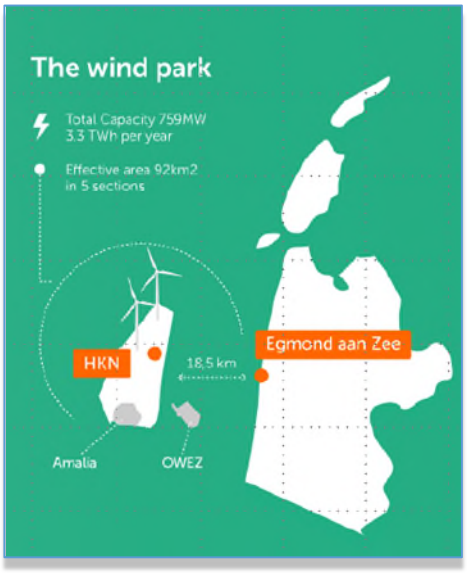


Figure 2 - Wind Park Details

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.

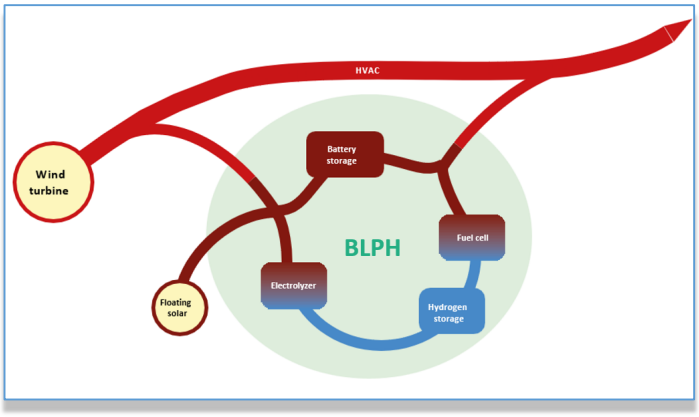


Figure 3 – BLPH Concept

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 main Assumption for the HSE studies in the scope of BLPH project. It recollects the common backgrounds and assumptions taken for developing the following study:

- QRA/FERA;
- EERA;
- Noise Study;
- Dropped object.

The main objective of this document is to clearly state the rule sets applied for the studies, references to generic data utilized, recommended impact criteria adopted, and relevant assumptions applied in the studies.The studies are carried out by ICARO, a 3rd party qualified specialist, not involved in the project development. ICARO is a consulting & engineering company located in Cortona, (Italy), established in 1985, which in 38 years has cumulated, for the major Oil & Petrochemical Industries in Italy and abroad, a deep experience and worldwide references in Risk Assessment & Management Systems, Firefighting and Safety Engineering, Environmental Protection and Contaminated Sites Reclamation, Chemical Substance Hazards and Occupational Health Management, Training and Risks.

2.1 MAIN REFERENCES

Ref.	Description
1	Risk assessment data directory, document no. IOGP 434_1– 2019 - Process Release Frequency
2	Hydrogen Risk Assessment Models (HyRAM) Version 3.0 Technical Reference Manual, Sandia National Laboratories, United States Department of Energy USA, September 2020
3	Flammable Gases and Liquids and their hazard, United States Environmental Protection Agency, February 1994
4	Review of Methods for Estimating the Overpressure and Impulse Resulting From a Hydrogen Explosion in a Confined-Obstructed Volume, Air liquid R&D, ENSI de Bourges, PRISME institute, 2009
5	Risk assessment data directory, document no. IOGP 434_7 – 2010 - Consequences modelling
6	Risk assessment data directory, document no. IOGP 434_14 – 2013 - Vulnerability of humans
7	Risk assessment data directory, document no. IOGP 434_15 – 2010 - - Vulnerability of plant/structure

Ref.	Description
8	Guidance on ALARP Decisions in COMAH – UK Health and Safety Executive (UK HSE), SPC/Permissioning/37, 2001
9	DNVGL-OS-A101 - Safety principles and arrangements, 2019
10	ISO 15544:2000 Petroleum and natural gas industries – Offshore production installations – Requirements and guidelines for emergency response, 2021
11	EU DIRECTIVE 2003/10/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise) (update with the amendment by Regulation (EU)2019/1243 of 20 June 2019)
12	ISO 3746:2010 "Acoustics, Determination of sound power levels and sound energy levels of noise sources using sound pressure
13	API Standard 521-Pressure-relieving and Depressuring Systems (2020)
14	K559-2254-SE-REP-008 - BLPH - Escape, Evacuation and Rescue Assessment (EERA) (note: study for FEED phase)
15	K559-2254-SE-REP-013-01 - Noise Report (note: study for FEED phase)
16	ISO 9613 Attenuation of sound during propagation outdoors
17	K559-2254-SE-REP-007 - Fire and Explosion Risk Analyses (FERA) (note: study for FEED phase)
18	BLPH_MODEL_FINAL_29-03-23 (3D model of platform)
19	K559-2254-PI-PPL-001 - BLPH Base Load Power Hub Plot Plan (note: study for FEED phase)
20	K559-2254-PR-REP-001 – Process Description (note: study for FEED phase)
21	123A90-DDL-PR-DG-80003//123A90-DDL-PR-DG-80005- PFD
22	K559-2254-PR-PID-001// K559-2254-PR-PID-014-001 – P&ID
23	123A90-DDL-SAF-RE-30046 – HSE Design Philosophy, rev 01, 16/10/2023
24	123A90-DDL-PR-BL-80002 – H&MB, rev 01, 09/11/2023

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Ref.	Description
25	123A90-DDL-OEM-LIS-02012 - Mechanical Handling - Lifting equipment requisition and location list (See HOLD List #1)
26	123A90-DDL-OEM-PRO-02011 - Mechanical Handling - removal & replacement procedures (See HOLD List #1)
27	DNV-RP-F107, 2001 - Risk assessment of pipeline protection
28	K559-2254-PM-PLN-003 – BDEP – Basic Desing Engineering Package revision 1
29	123A90-DDL-SAF-RE-30019 - Quantified Risk Assessment (QRA) Report
30	123A90-DDL-SAF-RE-30020 - Fire and Explosion Risk Analys (FERA) report
31	123A90-DDL-SAF-RE-30015 - Evacuation, Escape and Rescue Assessment (EERA) Report
32	123A90-DDL-SAF-RE-30041 - Noise Assessment Study Report

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
CONSEQUENCES	The outcome of an event. For the purpose of this project, the outcome is identified in terms of harm to exposed persons and assets.
EVENT	Occurrence or change of a particular set of circumstances.
EVENT TREE	Logical qualitative and quantitative representation of accident sequences, from initial release to final scenarios (fire, explosion, and flammable / toxic gas dispersion).
FAILURE	Damage of equipment which can lead to release of substances from the process.
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.
FIRE	The outcome of combustion of flammable substance released in the atmosphere as a 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 vapor cloud without significant overpressure consequences.
FREQUENCY	The estimated number of events per defined unit of time (normally refereed to one-year time).
IRPA	Frequency at which an individual may be expected to sustain lethal levels of harm from the realisation of specified hazards. It is usually taken to be the risk of death and expressed as a risk per year.
JET FIRE	It is a turbulent diffusion flame resulting from the combustion of a fuel continuously released with some significant momentum in a particular direction or directions. Jet fires can arise from releases of gaseous, flashing liquid (two phase) and pure liquid inventories.
LSIR	Risk expressed as likelihood of fatality per year at a particular location on the basis of continuous exposure (24 hours per day, and 365 days per year)
LOC	Loss of Containment. The event associated with the release of a hazardous substance from equipment leading to a potential accident scenario
PARTS COUNT	The counting of any piece of equipment pertaining to a given isolatable section. This task is handled in order to calculate a generic leak frequency value for generic types of cause
POOL FIRE	The fire developed from the ignition of a liquid pool of flammable substances.
QRA	Quantitative Risk Assessment. For the purpose of this study, a comprehensive risk evaluation focused on the identification of the impact to persons (workers and external population) due to effects of accident scenarios due to LOCs of hazardous substance handled in equipment to be installed during project development.
RANDOM LOSS	A loss of containment from piping and equipment due to random causes which leads to a release of a hazardous substance in the environment.
RISK	Combination of frequency and consequence of scenarios. For the purpose of the present project, the risk is evaluated on exposed persons and on project equipment, due to the effects of events caused by LOC of hazardous substances
RISK CONTOUR	A risk contour is the locus of points that geographically describes the location of a specific risk level. This risk will be defined by a pre-determined type of harm (e.g., fatality) at a specific frequency (e.g., 1.0 x 10-6/year).

Table 2 - Definitions

2.2.2 Abbreviations

ALARP	As Low As Reasonably Practicable
BESS	Battery Energy Storage System
BLPH	Base Load Power Hub
DNV	Det Norske Veritas
EERA	Escape, Evacuation and Rescue Assessment
ESDV	Emergency Shut-Down valve
F&G	Fire and Gas
FERA	Fire and Explosion Risk Assessment
H&MB	Heat and Material Balance
HKN	Hollandse Kust Noord
HyRAM	Hydrogen Risk Assessment Model
HSE	Health, Safety and Environment
IOGP	International Association of Oil & Gas Producers
IRPA	Individual Risk Per Annum
LFL	Lower Flammable Limit
LSIR	Location Specific Individual Risk
LOC	Loss Of Containment
NNF	Normally No Flow
P&ID	Piping and Instrumentation Diagram
PFD	Process Flow Diagram
QRA	Quantitative Risk Assessment
SPL	Sound pressure levels
VCE	Vapour Cloud Explosion

Table 3 - Abbreviations

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3 ASSUMPTIONS

The assumptions for studies developed are recorded in a specific format ("Assumption sheet") that is presented below.

Study:	The applicability of the assumption to specific study		
Subject:	A brief description of the assumption for easy searching		
Assumption #	Unique assumption number	**Rev.**	Current revision number
Reference:	Main reference for the assumption		
Description: This section presents the details of the assumption, main references and impact of the assumption on the results of the assessment.			

Table 4 – Assumption sheet template

Study:	QRA, FERA		
Subject:	Isolatable Sections		
Assumption #	1	Rev.	1
Reference:	5, 17, 21, 22,29,30		

On detection of a gas release, it will be considered that the process is automatically shut down and isolated by means of Emergency Isolation Valves and depressurized via blow-down valves whenever applicable; the result of isolation process is the division of the plant in section separated each other and isolated by isolation elements. For this reason, the hazard identification process treats each isolatable section of the plant as a distinct hazard considering its relative inventory, which will be calculated considering process equipment volume and pipe length.

The identification of Isolatable Section will be performed considering project PFDs and P&IDs.

Following assumptions are made for determining isolatable sections.

- An isolatable section is defined as section between shutdown valves and/ or within dead-end like a blind flange, or normally closed valve.
- Each package in the scope of the Crosswind (electrolyser, fuel cell package, BESS) will be considered as a separate section. The studies (e.g QRA, FERA) will includes the risk for these equipment in terms of frequency of occurrence and hazardous scenarios as for vendor information (if available; otherwise, information as for FEED QRA will be considered).

For isolatable section definition, following exclusion will be considered:

- Sections containing non-hazardous material.
- Sections defined as Normally No Flow, make up line, start up lines as there is no hazardous material continuously present inside in normal operation.
- Additionally, pipes in which the flow is not continuous in normal operation are not considered in the definition of the sections.
- Drains, emergency vents are generally, NNF type and will not be considered in inventory analysis or for identifying isolatable sections.

Table 5 – Assumption #1

Study:	QRA, FERA		
Subject:	Failure Case Selection and release diameters		
Assumption #	2	Rev.	1
Reference:	1, 17, 29,30		

Failure Case Selection

Loss of Containment (LoC) events include hydrogen leaks from process equipment and associated piping, due to random causes such as corrosion, impacts etc. or other. The selection of LOC cases takes into consideration the risks associated to process hazards. For similar dangerous substances and similar inventory, the items with more critical operating conditions are preferably selected. On the basis of process condition inside an isolable section one or more LOC will be defined.

Identified LOCs shall be defined in terms of location, material released, quantity released, release conditions, inventory size, temperature, pressure, leak size, leak direction, leak frequency and ignition probability.

Leak diameter

The representative leak hole sizes to be modelled are selected to ensure that the entire range of potential hole size is represented in the modelling. Three leak hole size will be selected, representative for small, medium and full-bore cases.

Generic data for leak frequencies of individual items of process equipment together with the distribution of leak sizes are derived from IOGP report 434-1 2019. In IOGP database, release frequencies for wide range of holes and equipment types are available. Considering that specific failure rates for equipment which handling H_2 with the same grade of accuracy are not available in literature, in the present report IOGP database is selected as representative, even if specific for hydrocarbon process plants. Some examples of IOGP failure rate application for piping are reported below. In the platform, piping shows diameter between 1 and 3 inches. The 2" is the smallest data set available from IOGP, meaning that the release frequencies for other line diameter is derived as per table below.

Release Size	IOGP Hole range diameter (mm)	Selected hole diameter (mm)	1"DIA (25 mm)	1.5"DIA (37.5 mm)	2"DIA (50 mm)	3"DIA (75 mm)
Small hole	3 - 10	5	6.40E-06	6.40E-06	6.40E-06	6.40E-06
Medium hole	10 - 50	25	3.80E-06	2.80E-06	2.80E-06	2.80E-06
Full bore	50 -150	Full bore	--	1.00E-06	1.00E-06	1.00E-06

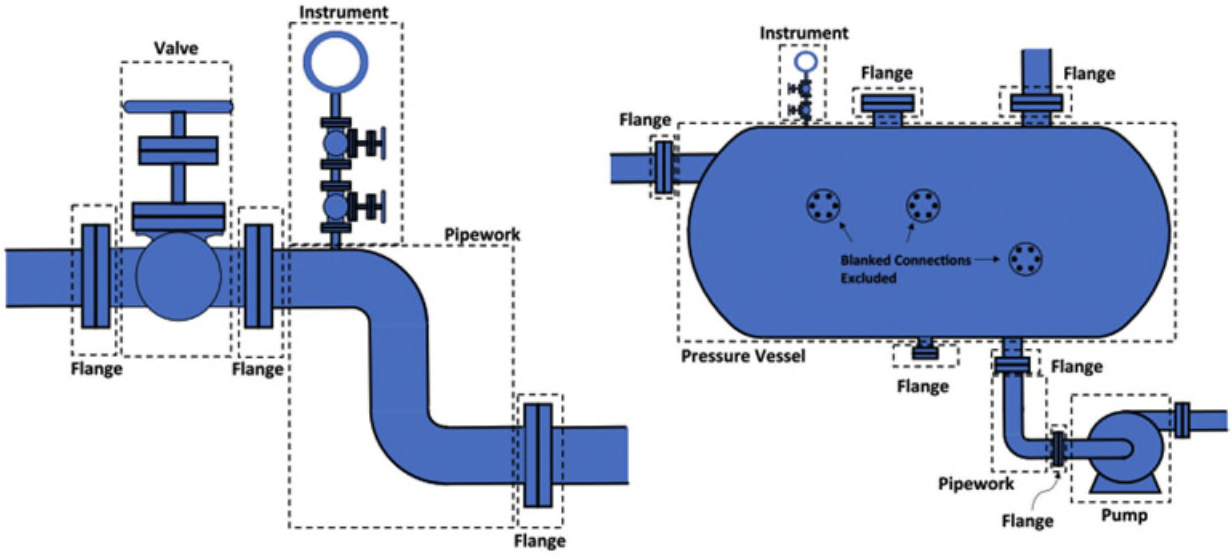
Same approach will be followed for other equipment (e.g valves, flanges..).

Table 6 – Assumption #2

Study:	QRA, FERA		
Subject:	Parts Count & Failure Frequency		
Assumption #	3	Rev.	0
Reference:	1, 17, 22, 29,30		

LOC frequency inside each isolatable section will be calculated by means of "Parts Count" methodology, summing basic frequency associated to each process element present in the isolatable section under analysis (e.g. vessels, reactors, piping, valves, etc.). Necessary information is derived from the available P&IDs together with estimates of line lengths and elevations from plot plans / 3D model.

The estimation of the release frequencies of equipment packages is based on the generic release frequency data and counting rules derived from standard. Example of main equipment identification in the process are reported below.



For example, in part count the scope of valve includes the valve body, stem, and packing but excludes flanges. These flanges shall be counted separately. Normally opened valve assembly may be counted as one valve and two flanged joints; whereas normally closed valve assembly (where only leaks from one side of valve would cause the consequence) may be counted as 1 times of the valve and one flange joint.

Based on P&ID; sample parts count methodology is reported below.

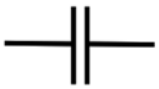
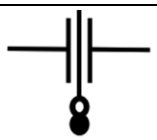
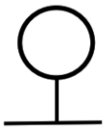
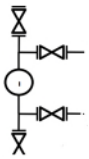
Symbol	Equipment	Part count
	Flange Joint	One flange of the appropriate line size
	Open Spectacle Plate	Two flanges of the appropriate line size
	Any type of valve (including check or non-return valves)	Two flanges and one valve of the appropriate type (actuated / manual) and size
	Instrument	One instrument connection
		

Table 7 – Assumption #3

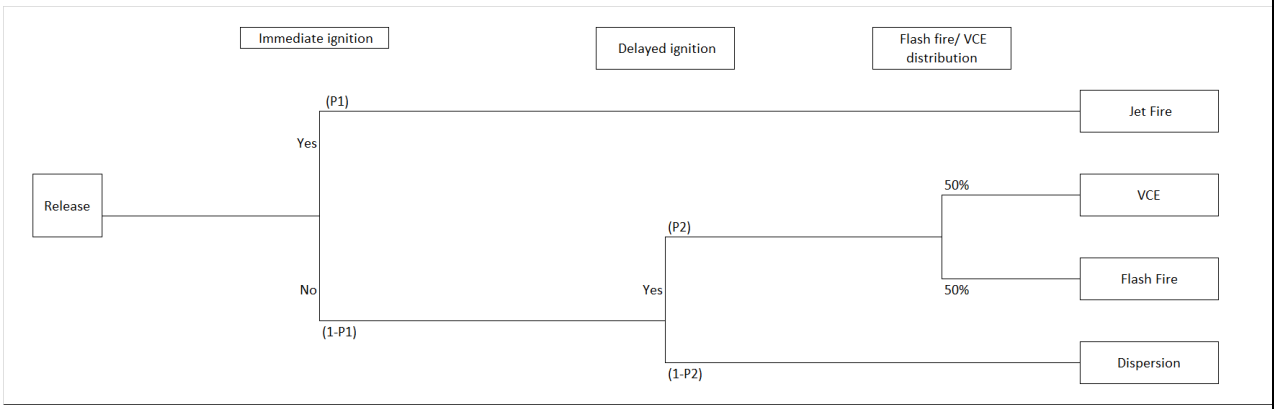
Study:	QRA, FERA		
Subject:	Scenario frequency calculation: event tree analysis		
Assumption #	4	Rev.	1
Reference:	3, 17, 29,30		

Scenario types and frequency is depending on the release and its evolution in the environment. In case of release and ignition of flammable gas clouds, following scenarios are expected:

- Jet fire (immediate ignition);
- Flash fire (delayed ignition);
- Confined Vapor Cloud Explosion (delayed ignition);

In order to qualify and quantify all potential outcome scenarios, the "Event Tree" technique is applied. The event tree in case of release of hydrogen is reported below.

Selection of ignition probability follows the criteria reported in assumption 5.



The scenario modelling needs to take into account the probability of failure of detection and isolation system. Additional information regarding event tree which will be used in the report are reported in Assumption 6.

BLEVE (Boiling Liquid Expanding Vapor Explosion) scenario is not applicable considering that are no present in the platform storage vessel containing low boiling liquid or liquefied gases (as LPG).

Table 8 – Assumption #4

Study:	QRA, FERA		
Subject:	Ignition Probability Data and congestion grade		
Assumption #	5	Rev.	1
Reference:	2, 4, 17, 29,30		

Ignition probability

Immediate ignition upon release will result in jet fire (provided sufficient pressure and process inventory exist). If hydrogen gas does not immediately ignite upon release and subsequently accumulates within a congested area, its delayed ignition would result in a flash fire or explosion.

For the release of hydrocarbons several well established ignition probability models exist. For hydrogen particularly in offshore scenarios there is greater uncertainty due to the lack of such studies, however it is reasonable to assume that the likelihood of immediate and delayed ignition is greater than for natural gas due to the low ignition energy required to ignite a hydrogen release. As a reference the Hydrogen Risk Assessment Model (HyRAM) specifies the release rate dependant ignition probabilities given in the table below. The HyRAM is a basic software for conducting risk assessment and consequence modelling for hydrogen infrastructure and transportation systems (Issued by Sandia National Laboratories, USA), and is specific for H_2.

Release rate (kg/s)	Immediate (P1)	Delayed (P2)
< 0.125	0.0080	0.004
0.125 – 6.25	0.0530	0.0270
>= 6.25	0.23	0.12

The delayed ignition is split in 50% of delayed ignitions result in explosion and 50% resulting in flash fire.

Congestion factor

The UVCE scenario consequences will be calculated according to the "TNO Multi -Energy" method. The method, starting from the flammable mass of the substances, determines the expected values of pressure waves around the source of ignition. The intensity of pressure waves is calculated by means of a "Confinement Strength" factor, which is calculated on basis of confinement strength of the area where the flammable gas clouds is foreseen. It is demonstrated that a higher confinement grade will increase the

overpressure associated to the UVCE. Calculation of Confinement Strength is based on a set of criteria connected to following elements, based on criteria provided by reference technical documentation [4];

- value of ignition energy of selected substances (a lower value ignition energy will determine higher susceptibility to ignition and increase the potential effects of explosion);
- obstacle density (a higher obstacle density will create conditions for gas cloud accumulation and increase the potential effects of explosion);
- confinement level (a higher confinement level will create conditions for gas cloud accumulation and increase the potential effects of explosion).

According to the standard, the selected confinement grade is calculated as per below table.

Element	Configuration on present study
Ignition energy	Low
Obstacle density	High
Confinement	Existing
Suggested Value	Range 5-7
Selected Value	7

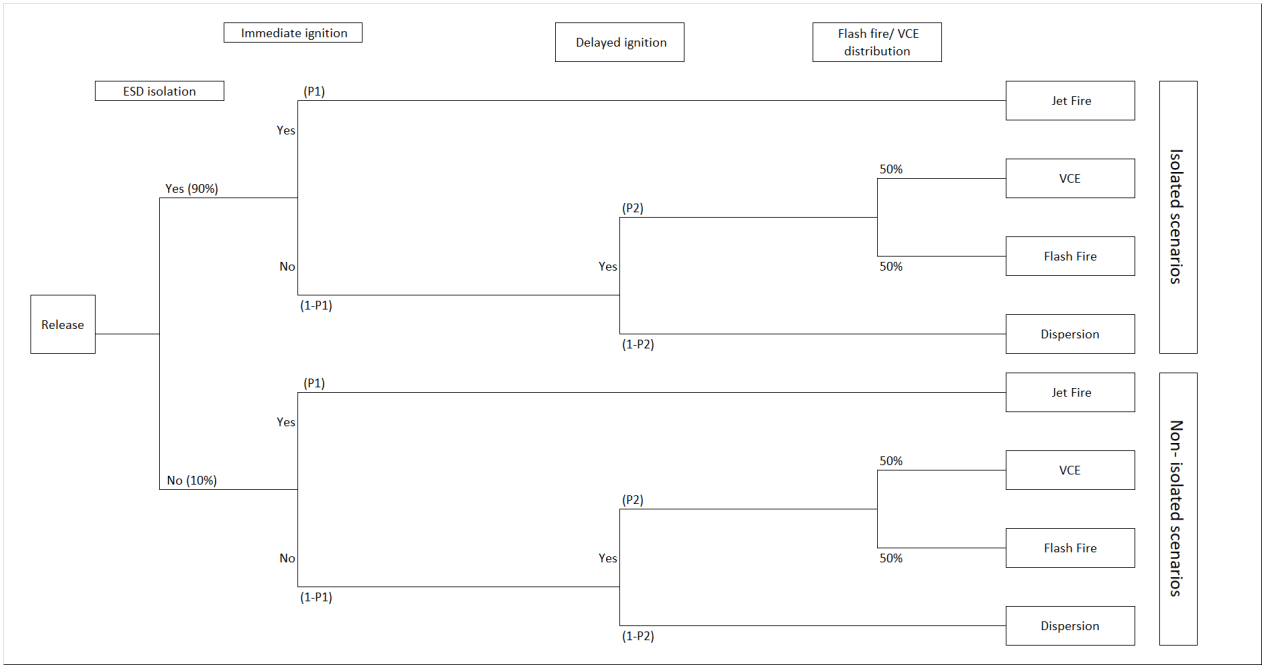
According to the above table, the selected confinement grade is considered equal to 7 (conservative value).

Table 9 – Assumption #5

Study:	QRA, FERA		
Subject:	ESD failure and Scenario duration		
Assumption #	6	Rev.	1
Reference:	17, 29,30		

The isolation can be performed automatically by the protection system (ESD), which is assumed 90% reliable, considering that will be maintained and tested in appropriate manner, thus the probability of failure on demand is very low (considering also the lifetime of platform, equal to 2 years).

The event tree which considers the probability of failure of ESD, which will be used in the QRA/FERA development, is reported below.



If a leakage is successfully detected and isolated, the minimum inventory released will be restricted by the isolatable section inventory.

Leak duration is a parameter with a high level of uncertainties.

Release duration is calculated as a sum of the following time intervals:

Scenario duration= Time for detection + Time for isolation + Time for emptying the circuit

Time for detection

The rapidity of detection of a leak of a flammable substance is related to the extent of the release itself but also to the capacity of the detection systems available in the unit.

Time for isolation

Once the leak is identified the isolatable section can be isolated by closing the on-off valves by the intervention of F&G system. The time for the intervention is limited to the required time to close the valves, which show diameter less than 3 inches. Considering that a typical valve closure velocity is 2 second for inch, the isolation time is in the order of some seconds.

Time for emptying the circuit

Emptying of the isolatable section is function of dimension of the release hole and the hold up of the isolatable section.

In conclusion, in case of effective intervention of ESD system, the total release time for each hole diameter in the table below is summarized.

Type of release	Detection/Isolation (minutes)	Emptying
Small release	10	Depending on hold up of the section and release rate from the hole (calculated via Phast software, considering the dynamic flow rate)
Medium hole	5	
Full bore	1	

In case of ineffective intervention of ESD system, the scenarios will be not-isolated for each release hole, and the duration is assumed higher that 10 minutes (which is the threshold for escalation effects, see assumption 7).

Table 10 – Assumption #6

Study:	QRA, FERA		
Subject:	Scenario consequences calculation and reference threshold for QRA / FERA		
Assumption #	7	Rev.	1
Reference:	5, 6,7, 13, 17, 24, 29,30		

Scenario consequence modelling

The scenario consequences will be modelled with the package Phast released by DNV (8.9 latest revision available), in order to assess the spatial distribution of physical effects of scenarios. Operating pressure and temperature and composition of the hazardous fluid will be selected from H&M Balance project documentation. For gas releases the pressure in the system, and hence the release rate, could slowly decrease following isolation, resulting in a time dependent release. As a conservative approach, the calculated initial release rate is assumed constant over the release duration for such scenarios; the scenarios consequences will be evaluated at time = 0, where the release flow rate shows the maximum value. The orientation of the release is an important factor because it will define the orientation of jet fires and their impact. The orientation of release will be modelled as follows:

- horizontal non-impinged for jet fire, in order to maximize damage distances scenarios.
- horizontal (50 % of probability) and down impingement (50 % of probability) for flammable gas dispersion (FF and explosion), in order to maximize damage distances scenarios.

Reference thresholds for QRA

This paragraph provides information on the vulnerability of humans.

Jet fire exposure:

The values for humans' fatality are reported below:

- 37.5 kW/m^2: Probability of human lethality: 100%
- 12.5 kW/m^2: Probability of human lethality: 30%
- 4.73 kW/m^2: Probability of human lethality: 3%

Flash fire exposure:

The values for humans' fatality are reported below:

- LFL: Probability of human lethality: 100%
- LFL/2: Probability of human lethality: 50%

Overpressure exposure:

The values for humans' fatality are reported below:

- 0.5 bar: Probability of human lethality: 100%
- 0.3 bar: Probability of human lethality: 50%

Reference threshold for FERA

This paragraph provides information on the effects of fire and explosion on asset and structure.

Jet fire exposure:

The 37.5 kW/m^2 represent the threshold which unprotected steel will reach thermal stress temperatures that can cause failure. Anyway, for determination of escalation effect it is required to calculate the time which the target is involved in such critical thermal radiation. According to generally adopted exclusion criteria related to the duration of fire scenarios, a possible escalation effect can be expected in case of exposure to jet fire from more than 10 minutes.

For the determination of probability of escalation, a dedicated iso-damage contours will be calculated as the sum of all jet fire scenarios which duration equal or higher than 10 minutes.

Overpressure exposure:

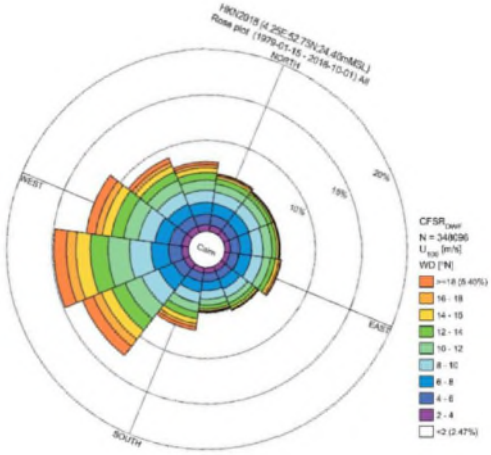
The values for vulnerability to explosion for asset and structure are reported in the tables below.

Overpressure (bar)	Effect on asset/structure
0.35	Collapse of steel girder framed buildings
0.27	Frameless, self-framing steel panel building demolished
0.15	Partial collapse of roofs and walls of buildings.
0.07	Large and small windows usually shattered; occasional damage to windows frame.

Table 11 – Assumption #7

Study:	QRA, FERA		
Subject:	Weather condition		
Assumption #	8	Rev.	1
Reference:	17, 28, 29,30		

Project wind distribution are reported below.



Modelling of physical effects of each scenario will be carried out with reference to n. 3 representative meteorological cases, on the basis of wind percentages distribution:

- wind speed 2 m/s and Pasquil stability Factor "F" for approx. 6 % of time (this weather condition including, as a conservative approach, also 2,5% of "calm condition" of wind lower than 2 m/s;
- wind speed 5 m/s and Pasquil stability Factor "D" for approx. 50 % of time (value corresponding to blue wind speeds in the figure);
- wind speed 10 m/s and Pasquil stability Factor "D" for approx. 44 % of time (value corresponding to green and orange wind speeds in the figure).

The risk will be also calculated taking into consideration the distribution of wind directions according to the wind rose. Additional weather data for consequences simulation are reported below:

- Ambient temperature (nom) (°C) : 10.5°C
- Relative humidity (%): 83
- Solar Radiation (kW/m^2): 0.5
- Surface Roughness: 0.11

Table 12 – Assumption #8

Study:	QRA		
Subject:	QRA Risk recombination and acceptability criteria		
Assumption #	9	Rev.	0
Reference:	8, 29		

Risk recombination

The Location Specific Individual Risk (LSIR) is the expected frequency of death of a hypothetical person assumed to be continuously present at a specific location. It is usually expressed as a risk of death per year and presented in form of risk contours. The risk exposure is calculated for all identified hazards and each contribution is summed to provide the overall risk for the area of the installation. The main steps for risk contours calculation are reported below:

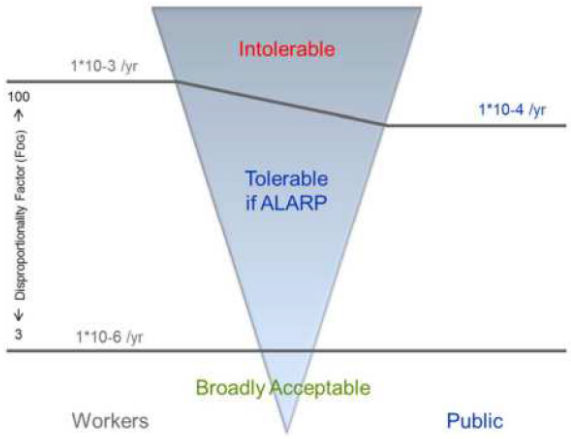
- frequency calculation of the hazardous scenario (e.g., flash fire, jet fire events);
- calculation of consequence of each scenario (in terms of thermal flux or flammable gas cloud extension or overpressure);
- assessment of fatality probability for each scenario consequences;
- geo-referencing of each scenario in the plant layout;
- contour plot calculation by definition of a squared grid around the plant.

Calculations will be performed by application of a dedicated ArcGis 9.3 model for geographical data management.

Acceptability criteria

Reference IRPA (Individual Risk Per Annum) risk acceptability thresholds are indicated in the following figure. People distribution and manning level will be based on project information, considering that platform is unmanned, and people presence is limited only to maintenance activities.

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This approach is related to the identification of three risk regions (unacceptable, ALARP and broadly acceptable), to which is assigned different frequency values for unacceptable risk threshold. Reference Individual Risk acceptability thresholds are indicated in the following table.

LOCATION	**IRPA (fatality/ year)**		
	Risk region: **Unacceptable**	**Risk region:** **ALARP**	**Risk region:** **Broadly acceptable**
Platform area	> 1 x 10-03	1 x 10-03 ≥ IR ≤ 1 x 10-06	IR < 1 x 10-06

Table 13 – Assumption #9

Study:	FERA		
Subject:	FERA Risk recombination and acceptability criteria		
Assumption #	10	Rev.	0
Reference:	9, 17,30		

Risk recombination

The iso-damage contours plots are defined on basis of all the identified scenarios, each one characterized by its frequency value and damage distances. Calculation of the risk at a specific geographical location for a risk type (overpressure, fire), is equal to the sum of the selected threshold frequency of occurrence at that point, posed cumulatively by all other scenario (with the same threshold) from other LOC identified within the plant. The main steps for risk contours calculation are reported below:

- frequency calculation of the hazardous scenario (overpressure, jet fire1 events);
- calculation of consequence of each scenario (in terms of thermal flux or overpressure);
- geo-referencing of each scenario in the plant layout;
- contour plot calculation by definition of a squared grid around the plant.

Calculations have been performed by application of a dedicated ArcGis 9.3 model for geographical data management. The software provides the sub-division of the overall complex by means of a specific grid. In each position (x,y) of the grid, the total frequency is calculated as composition (numerical sum) of the frequencies of impact of the single impact scenario.

Acceptability criteria

A Fire and Explosion Risk Analysis (FERA) will be performed in order to evaluate the risk of possible escalation of the initial scenario (e.g. Jet Fire, explosion) in a complex accident scenario, involving severe damage in a secondary equipment with loss of containment and propagation of the hazard scenario in multiple plant units.

This method marks the 1E-04 occurrence per year threshold as the maximum tolerable for asset/structure involved in a fire or explosion scenario [9].

This approach requires the elaboration of dedicated iso-contour plots, where all jet fire and explosion scenarios frequencies are summed in each point of the area under investigation. The method requires to

[1] For jet fire iso-damage contours, only scenario with duration which allows escalation effect will be considered.

ensure that there are no incidents which, alone or when summed, fall just below the 1E-04 occ./year cut-off threshold.

The acceptability criteria are reported below:

- the frequency of iso-damage contours representing the exposure of a thermal radiation (calculated as a sum of thermal radiation from jet fires) of 37.5 kW/m^2 in a target shall be less than 1E-04 occ./year;
- the frequency of iso-damage contours representing the exposure of an overpressure threshold of 0.3, 0.14, 0.07 bar (each considered separately) in target shall be less than 1E-04 occ./year.

Table 14 – Assumption #10

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Study:	EERA		
Subject:	Estimated travel time		
Assumption #	11	Rev.	0
Reference:	10, 14, 31		

The estimated travel time along any escape ways will be calculated using the typical speeds summarized below.

Route	Time (m/s)
Walkways	1.0
Staircase	0.8
Ladders	0.3
Man-rider winch (Also used for winching down to liferaft)	0.2

Table 15 – Assumption #11

Study:	Noise Study		
Subject:	Methodology and Mathematical model		
Assumption #	12	Rev.	0
Reference:	15, 16, 32		

The noise impact assessment methodology will include the following steps:

- Creation of the model input data:
  - definition of flat model of the terrain and assign water propagation data,
  - definition of calculation area
  - creation of a three-dimensional grid of calculation limited to perimeter;
  - identification and characterization of the noise sources,
  - creation of a three-dimensional model of installation including all the noise sources;
- calculation of values of sound pressure levels (SPL) in the study area using the simulation model including all sources, on the entire noise study area, outside of containers and equipment cabinets.
- analysis of results and comparison with the limit values identified for the project.

The mathematical model that will be used will be SoundPLAN 7.3 released by Braunstein + Berndt GmbH / SoundPLAN International LLC, an engineering services and software company headquartered in Germany. SoundPLAN is an advanced program designed to simulate the acoustical behaviour of any arbitrary enclosed volume, any open space or a combination of both.

SoundPLAN models the physics of acoustical propagation, including specular and diffuse reflections against physical boundaries, wall adsorption and air adsorption, diffraction across screens and transmission through walls.

The calculation results will be shown by acoustic pressure maps by the "maps graph" application of the software. The simulation of industrial noise source will be performed applying ISO 9613 noise propagation standard.

Table 16 – Assumption #12

Study:	Noise Study		
Subject:	Sources		
Assumption #	13	**Rev.**	0
Reference:	12, 15, 32		

Starting from the available project documents (i.e. equipment list), the list of the noise sources will be characterized according to following main information:

- Noise source name/description
- Project coordinates (x,y,z) refer to layout reference point 1-A ,
- Sound power levels [dB(A)].

The Sound Power Level for each source will be calculated by the sound pressure level data or derived from other similar project, from vendors end /or specific databases.

Equipment noise levels and spectra used in the model will be based on equipment datasheet, or according to field measurement experience for similar design/capacity equipment and estimated for level based upon their maximum anticipated operational duty at normal operating conditions.

The definition of the total Sound Power Level (Lw) will be carried out considering the:

- Enveloping surface dimension of each noise source, where the enveloping surface is the minimum surface, which contains the noise source itself and it is determined by the examination of the Unit plot plans.
- Sound Pressure Level (Lp) referred to 1 meter distance from each noise source, determined by relevant noise equipment datasheet and project specifications.

In order to obtain the Sound Power Level (Lw) of each noise source starting from the Sound Pressure Level (SPL) of the noise source, the calculation will be conduct according to the UNI EN ISO3746 "Acoustics, Determination of sound power level of noise sources - Survey Method".

Table 17 – Assumption #13

Study:	Noise Study		
Subject:	Evaluation Grid		
Assumption #	14	Rev.	1
Reference:	15,28, 32		

The computing grid will be created starting from the elevation of the study area and setting a mesh size of 1 m x 1 m. It allows the model to build the noise contours by interpolating values of sound pressure calculated at each node of the grid.

In order to consider the noise levels at each deck of installation, multiple grids will be created, one for each deck. Each deck simulation considers all the noise sources of the installation area.

The software will be settings with the following parameters:

- Grid size: 1.0 m;
- Calculation height: 1.5 m above each deck level;
- Number of reflections: 3.

The environmental data introduced in the simulation software are the following:

- Temperature: 10.5°C,
- Humidity condition: 83%,
- Atmospheric pressure: 1013.3 mbar,
- Ground factor G: 0.0 (corresponding to hard ground such as asphalt, water or industrial site).

Table 18 – Assumption #14

Study:	Noise Study		
Subject:	Noise limit		
Assumption #	15	Rev.	0
Reference:	11, 15, 32		

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

The general work area noise limit is 85 dB(A). The area noise level limits defined therein shall apply as the maximum sound pressure level at any location within a working area, but not closer than 1 m to equipment and other noisy installations. Where the area noise limit of 85 dB(A) is unfeasible, the limit of 90 dB(A) shall apply. The individual employee's daily noise exposure Leq,8h (dB(A)) shall be lower than 85 dB(A) (equivalent to the exposure reported in the following table).

Exposure Time	Noise LevelLAeq [dB(A)]
24 hours	80
16 hours	82
12 hours	83
10 hours	84
8 hours	85
4 hours	88
2 hours	91
1 hour	94
30 minutes	97
15 minutes	100

Limits applicable for operation condition only and not for start-up, shut down, emergency or any other unusual condition. In any case the sound pressure level in the work area shall never exceed 110 dB (A). These limits will be considered as a reference basis for the evaluation of noise compatibility within all areas identifiable as a working environment, outside of containers and equipment cabinets.

Table 19 – Assumption #15

Study:	Dropped Object study		
Subject:	Dropped Object scope and main data		
Assumption #	16	Rev.	0
Reference:	25 ,26, 27, 32		

The objective of the Dropped Object Study is to assess the potential to drop lifted objects during normal operations and maintenance activities of the platform, and to assess the expected impact energy over potentially vulnerable areas.

After dropping, the object might hit the platform leading to possible damage to process equipment, to the decks' structure and/or to injury/fatality of workers.

The analysis of impact on the platform will be based on international standard based on the location of critical equipment handling dangerous substances and on the distribution of workers (considering that the platform is designed as unmanned, and the presence of working personnel is limited to the maintenance activities).

The study will be based on information reported in the equipment list; the typology and the frequency of lifting activities will be based on information reported in the handling study.

Table 20 – Assumption #16