Base Load Power Hub (BLPH)

Human Factors Engineering Report

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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.

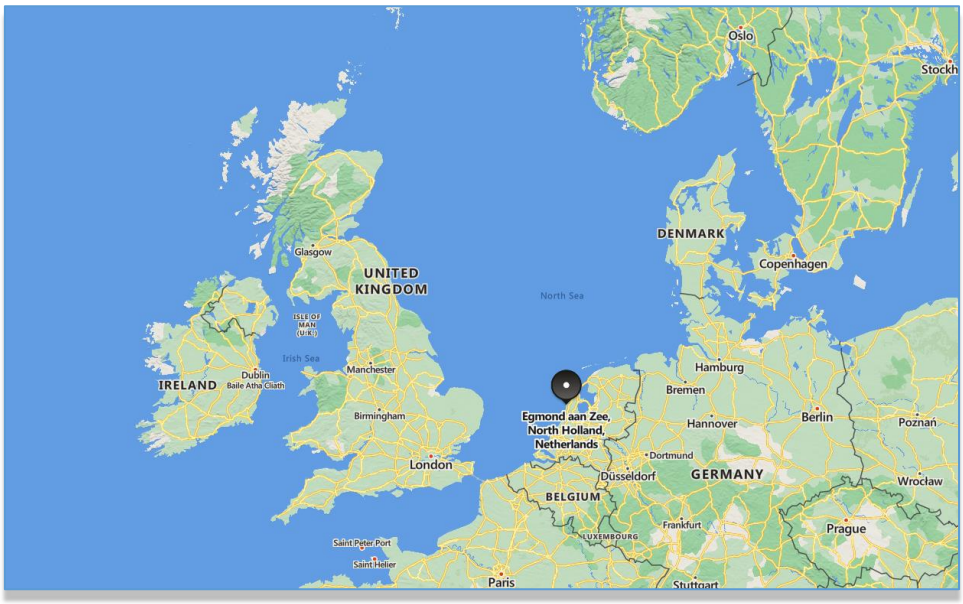


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

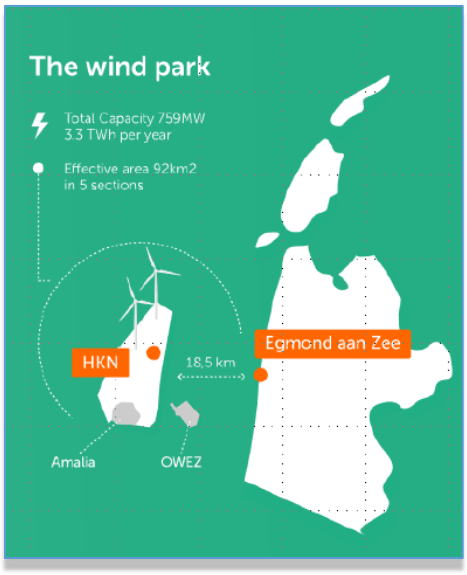


Figure 2 - Wind Park Details

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.

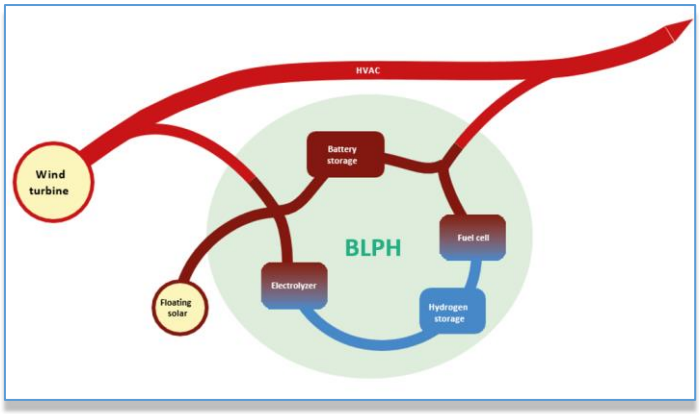


Figure 3 – BLPH Concept

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 EXECUTIVE SUMMARY

This document has the purpose of detailing the results of the Human Factors Engineering Workshop for the new Base Load Power Hub (BLPH) which will be installed in the framework of HOLLANDSE KUST NOORD WIND PARK Project. The scope of this document is limited to the topsides structure and associated facilities up until connection with the monopile, excluding the calculations related to CPIs packages, which risk are taken into account in the overall study. The monopile itself is not within the scope of this document.

Following objectives are included in the scope of the study:

- Verify that the design is as per HFE design principles.
- Walk through Model to identify any design issues or improvement opportunity.
- to identify specific mitigation and actions to be incorporated in the design to ensure that the identified risks are as low as reasonably practicable.

To achieve this objective, a thorough HFE Model Verification is conducted on 3D Model 60% completion for the purpose to verify that the design complies with human factor design principles project on all homogeneous areas identified in the platform:

1. Interface Level
2. Lower Deck: workplaces
3. Lower Deck: Technical rooms
4. Upper Deck

A specific HFE Check list has been applied to identify any possible deviation to HFE design principles and layout and workplaces technical standards requirements.

The main findings of the HFE Model Verification study are reported in the worksheets in Attachments 2.

It is necessary to point out that the platform is completely unmanned and the presence of operators is expected once every 6 months for a total period of 2 years only to perform maintenance activities, with the platform that is shut-down. Operators will visit the platform a total of 4 times during the life of the platform.

For these reasons, some aspects are considered partially applicable or not applicable to the BLPH. In addition, other aspects such as platform evacuation and the presence of hazardous areas have been addressed (or will be addressed) through specific studies and are partially taken into account in this study.

Following actions are recommended:

- General requirement (where applicable considering the presence of rungs):
  - Consider providing non-slip surface to the rungs of vertical ladders
- BLPH Interface level:
  - Verify the type and position of the stairs for transition piece entrance in order to avoid possible interference with primary muster point

- BLPH Lower deck workplaces: equipment inspection activities:
  - Ensure adequate space for maintenance activities of water pumps in the final position
  - Ensure adequate space for maintenance activities for flanges/ valves near the WTP
  - Ensure that the access will be equipped with vertical ladder to reach equipment on top of TP.
  - Rosetti to investigate if sample collection is needed to check biocide concentration
- BLPH Lower deck Technical rooms
  - Rosetti to provide portable step ladders in case of operation in the top of cabinets

Further details are given in paragraph 5 "Conclusions and recommendations" (see Table 6).

2.1 MAIN REFERENCES

Ref.	Description
1	Human factors engineering in projects, IOGP Report No. 454, 2020
2	EU Framework Directive: Council Directive of 12 June 1989 on the introduction of measures to encourage improvement in the safety of workers at work
3	DEP 30.00.60.20-Gen. 2011 - Human Factors Engineering – Workspace Design
4	OFFSHORE STANDARDS DNVGL-OS-A101 Safety principles and arrangements July 2019
5	NORSOK Standard S-002 Working Environment, 2018
6	ICARO Guideline, 2017 - "Specification for Human Factor Engineering in projects"
7	ISO 14122, Safety of machinery - Permanent means of access to machinery
8	BLPH_MODEL_26-02-24 (3D model of platform)
9	123A90-DDL-ST-DD-90035 rev.01 – Standard drawing – Stairways
10	123A90-DDL-ST-DD-90036 rev.01 – Standard drawing – Ladders
11	123A90-DDL-ST-DD-90037 rev.01 – Standard drawing – Handrails
12	123A90-DDL-PR-RE-80040 – Process Design Philosophy
13	123A90-DDL-SAF-RE-30046 – HSE Design Philosophy
14	123A90-DDL-SAF-RE-30048 - Human Factors Terms of Reference

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
FREQUENCY	The estimated number of events per defined unit of time (normally refereed to one-year time).
HAZARD	Situation having the potential to cause harm, including ill health and injury, damage to property, production losses, or increased liabilities
RECOMMENDATIONS	Improvements /actions required to reduce the identified risk.

Table 2 - Definitions

2.2.2 Abbreviations

ALARP	As Low As Reasonably Practicable
BESS	Battery Energy Storage System
BLPH	Base Load Power Hub
CPI	Company Provided Item
HFE	Human Factor Engineering
HKN	Hollandse Kust Noord
HSE	Health, Safety and Environment
IOGP	International Association of Oil & Gas Producers
TOR	Terms of Reference
TP	Transition piece
WTP	Water Treatment Package

Table 3 - Abbreviations

3 HFE MODEL VERIFICATION

HFE is a multidisciplinary approach to engineering that focuses on the integration of following five elements:

- People: The characteristics, capabilities, expectations, limitations, experiences and needs of the people who will operate, maintain, support and use the facilities.
- Work: the nature of the work involved in operating, maintaining and supporting the facility.
- Work organization: How the people are organized, in terms of, for example, team structures, responsibilities, workings hours and shift schedules.
- Equipment: the equipment and technology used, including the way equipment is laid out and the elements that people need to interact with, both physically and mentally.
- Environment: the work environment in which people are expected to work, including the climate, lighting, noise, vibration and exposure to other health hazards.

HFE activities during the design stage consist of the HFE design analysis and verification. They are critical to analyze the design HFE risks as well as to identify specific mitigation and actions to be incorporated in the design to ensure that the identified risks are as low as reasonably practicable (ALARP).

The study has been developed according to the following steps:

- Identification of platform homogeneous areas: during the workshop, as a first step, all the working areas in the platform and the main activities performed by the operators have been identified and conclusions shared between the participants of the workshop;
- Application of the HFE Check list: the HFE Check list has been applied to all identified homogeneous areas. All the results of the check list application have been shared and agreed between the participants. The compilation of the checklists was projected on a shared screen with the participants present and with those connected via TEAMS;
- Identification of possible actions: mitigations and actions to be incorporated in the design to ensure that the identified risks are as low as reasonably practicable have been identified. The conclusions have been shared between the participants of the workshop.

More details on the methodology and HFE workshop refer to Human Factors Terms of Reference, ref. 14.

The list of workshop participants is reported in Attachment 1.

The application of the methodology is reported in the following paragraphs.

3.1 IDENTIFICATION OF PLATFORM HOMOGENEOUS AREAS

During the workshop, as a first step, all the working areas in the platform and the main activities performed by the operators have been identified and conclusions shared between the participants of the workshop.

Following homogeneous areas have been identified in the platform:

1. Interface Level
2. Lower Deck: workplaces
3. Lower Deck: Technical rooms
4. Upper Deck

3.1.1 Interface Level

Main activities considered in the area were: access to platform, equipment and workplaces inspection, evacuation in case of emergency.

Main items analysed in the Interface Level homogenous area were:

- Access to platform
- Transition piece
- Waste water tank
- General workspaces and lay-out requirements.

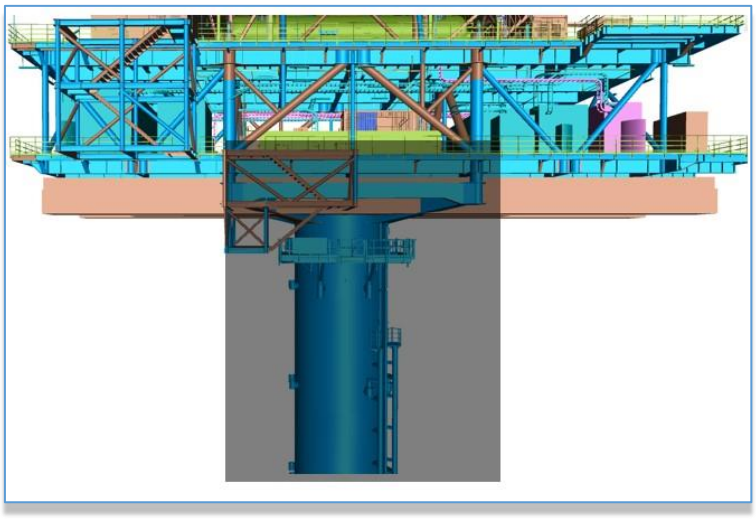


Figure 4 – Interface Level

3.1.2 Lower Deck: workplaces

Main activities considered in the area were: equipment and workplaces inspection and evacuation in case of emergency.

Main items analysed in the **Lower Deck: workplaces** homogenous area were:

- Water pumps area
- CPI BESS containers (external)
- Hatch access between lower deck and TP
- Primary muster point
- General workspaces and lay-out requirements.

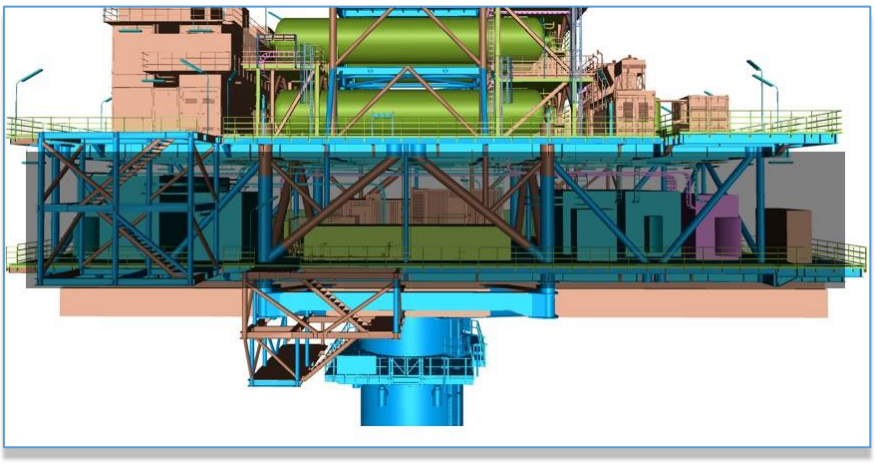


Figure 5 – Lower Deck- workplaces

3.1.3 Lower Deck – Technical rooms

Main activities considered in the area were: equipment and workplaces inspection and evacuation in case of emergency.

Main items analysed in the **Lower Deck: technical rooms** homogenous area were:

- Technical rooms
- CPI BESS containers (access)
- General workspaces and lay-out requirements.

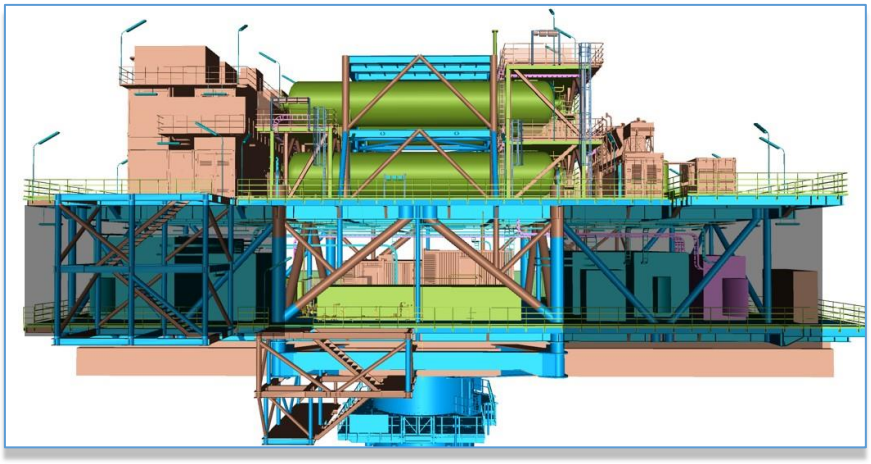


Figure 6 – Lower Deck – Technical rooms

3.1.4 Upper Deck

Main activities considered in the area were: equipment and workplaces inspection and evacuation in case of emergency.

Main items analysed in the **Upper Deck: workplaces** homogenous area were:

- Equipment inspection activities
- H_2 Storage vessels area
- Crane
- Secondary muster point
- General workspaces and lay-out requirements.

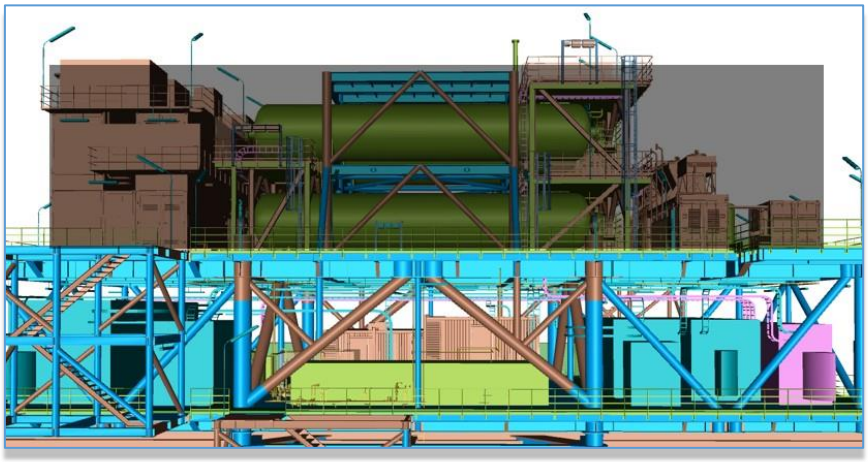


Figure 7 – Upper Deck

3.2 APPLICATION OF THE HFE CHECK LIST

A specific HFE checklist has been applied to verify that the layout and workplaces comply with the technical standards requirements of applicable regulations and to identify the potential human factors issues associated with workplaces and equipment.

The HFE Check list has been prepared specifically for the Base Load Power Hub (BLPH), based on the principles and requirements reported in:

- NORSOK Standard S-002 Working Environment, 2018
- ICARO Guideline, 2017 - "Specification for Human Factor Engineering in projects"
- OFFSHORE STANDARDS DNVGL-OS-A101 Safety principles and arrangements July 2019
- ISO 14122, Safety of machinery - Permanent means of access to machinery

In the following table are the main requirements analyzed in the HFE check list:

Requirement	
Access	Horizontal / vertical distances (access to equipment, control devices, visual displays, etc.)
	Pipes and flanges
	Guardrails
	Stairs
	Ladders and stepladders
	Gates
	Hatches and manways
	Doors
Safety principles	Storage of dangerous goods
	Cranes and lay down areas
	Railings and barriers
	General principles for Hazardous area
	Escape routes
	Muster areas
	Emergency lighting
	Marking and warning signboards
	Communications and alarms

Requirement
Ergonomics
Safety precautions
Hazardous substances

Table 4 – HFE Checklist requirements

All details and relevant information of the application of the HFE Check list on the platform homogenous areas are reported in Attachments 2 according to the following nodes:

Attachment 2 - Homogeneous area
Interface Level
Lower Deck: workplaces
Lower Deck: Technical rooms
Upper Deck

Table 5 – Completed HFE Checklists

The verification was performed on the 3D model and construction drawings available on the 27th February 2024 [BLPH_MODEL_26-02-24 (3D model of platform)]. Considering the progress of the project and the 3D modelling available at the workshop date, some requirements could not be verified in all the platform area since they were not yet finalized at the present project stage.

3.3 IDENTIFICATION OF POSSIBLE ACTIONS

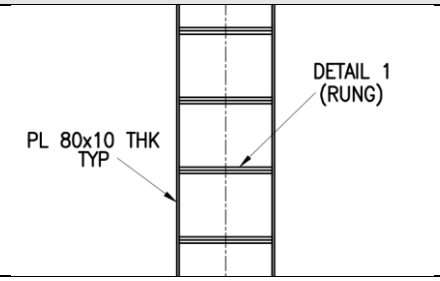
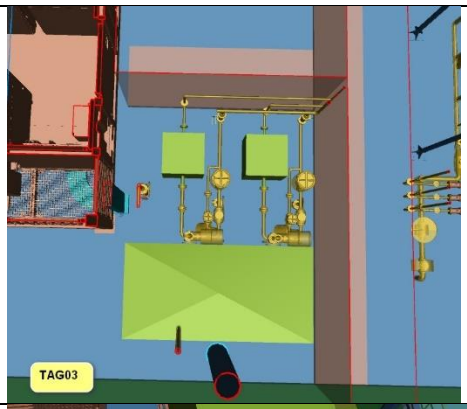
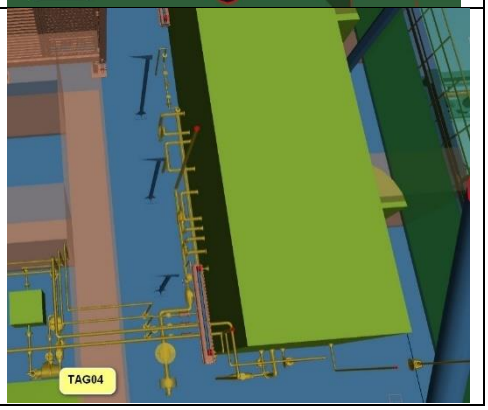
The actions that emerged from the review sessions were recorded by the Secretary using dedicated worksheets. These worksheets were projected onto a screen during the sessions so that the workshop team could view the generated content as it was produced.

4 RESULTS

Some actions emerged from the workshop on the basis of the HFE check list application. All the outcomes have been reported in Attachment 3 - HFE ACTION RESPONSE SHEET.

5 CONCLUSIONS AND RECOMMENDATIONS

In the following table have been resumed all the recommendation emerged during the workshop. For further details see **Attachment 3 – HFE Action Response Sheet.**

n.	Platform area	Recommendation	
1	General requirement (where applicable considering the presence of rungs)	Consider providing non-slip surface to the rungs of vertical ladders	
2	BLPH Interface level	Verify the type and position of the stairs for transition piece entrance in order to avoid possible interference with primary muster point	--
3	BLPH Lower deck workplaces: equipment inspection activities	Ensure adequate space for maintenance activities of water pumps in the final position	
4	BLPH Lower deck workplaces: equipment inspection activities	Ensure adequate space for maintenance activities for flanges/ valves near the WTP	

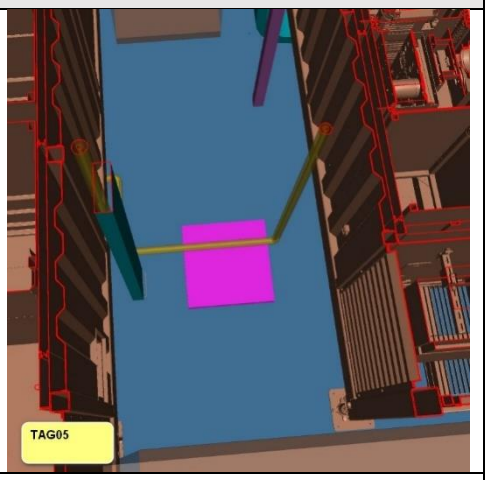
n.	Platform area	Recommendation	
5	BLPH Lower deck workplaces and equipment inspection activities	Ensure that the access will be equipped with vertical ladder to reach equipment on top of TP.	
6	BLPH Lower deck workplaces and equipment inspection activities	Rosetti to investigate if sample collection is needed to check biocide concentration	--
7	BLPH Lower deck Technical rooms	Rosetti to provide portable step ladders in case of operation in the top of cabinets	--

Table 6 – Recommendation