OFFSHORE GRID NL

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Standard Offshore Substation Cable Pulling Methodology

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OFFSHORE GRID NL

STANDARD 700 MW AC OFFSHORE SUBSTATION

CABLE PULLING METHODOLOGY

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CONTENTS

1. INTRODUCTION

This document outlines the general methodology regarding the pulling of HV sea cables on the standard 700MW AC offshore substation. It's main purpose is to prove the feasibility of the HV sea cable pull-in.

This methodology will be the basis for the detailed cable pulling methods which will be established by the various cable contractors in close cooperation with the platform contractor during the detailed design phase of the project.

This document does not outline the scope demarcation between TenneT and the Offshore Wind Farm (OWF).

The scope demarcation is described in:

- ONL-TTB-03024-MA--T13 Installation Interface Management PP v2

Both documents are the result of the consultation process between TenneT and Offshore Wind farm developers. The consultation process and the documents could be found at:

http://www.tennet.eu/nl/grid-projects/projects-in-the-netherlands/grid-at-sea/consultation-process.html

1.1 Final deck configuration

The basic design of the standard 700MW AC offshore substation is shown in

- ONL-TTB-00206-MA-EN_01--Plotplans
- ONL-TTB-00216-MA-EN_00--Plotplan, Layout WPO Control Room
- ONL-TTB-00109-MA-EN_03--Jacket Structure - Primary Steel Drawings

The basic design of the standard 700MW AC offshore substation is based on the following deck designations and elevations:

Cable deck	EL. +20.000 T.O.S
Main deck	EL. +26.500 T.O.S
Utility deck	EL. +34.000 T.O.S
Control deck	EL. +38.000 T.O.S
Roof deck	EL. +42.000 / 44.000 Top of steel

Figure 1-1: Basic design deck configuration

However, the effective cable deck height to be considered during detail design follows from the preliminary drawings, which shows the current foreseen height of the cable deck so far:

- ONL-TTB-03556_01-MA--Cable Deck 66kV Infield Cable Routing

During detailed design, construction and installation, the following deck designations and elevations shall be used as basis:

Cable deck	EL. +20.000 T.O.S
Main deck	EL. +27.500 T.O.S
Utility deck 1	EL. +35.000 T.O.S
Utility deck 2	EL. +39.000 T.O.S
Roof deck	EL. +43.000 / 45.000 Top of steel

Figure 1-2: Final deck configuration

During detail design the Offshore Wind Farm(s), the export cable contractor and the platform contractor shall optimize the cable deck height. The following requirements shall be taken into account when detailing the cable routing:

- Bending radius for all cables during pulling and permanent installation
- It shall be possible to pull sea cables both before and after placement of the topside on the jacket.
- Crossing of cables
- Sufficient space for repair of cables
- Storage of cables on the cable deck before the installation of the topside

2. REGULATIONS, CODES AND STANDARDS

The governing codes and standards applicable to the cable pulling methodology are:

- DNV-OS-J201
- DNVGL-OS-D201
- GL Noble Denton 0027/ND

Offshore Wind Farms shall follow these codes when establishing their detailed cable pulling method.

3. BASIS OF DESIGN

This chapter states the relevant parameters used and the number of cables to be pulled:

- No. 2 off 220kV export cables
- No. 18 off 66kV array cables

The following cable specifications have been used for the basic cable pulling methodology and determination of the deck height and cable routes:

220kV sea cable (hang-off – 220kV GIS):

- Minimum bending radius (3 core cable) = 4200 mm
- Diameter of 3 core cable = 300 mm
- Minimum bending radius (1 core cable) = 2000 mm
- Diameter of (1 core cable) = 120 mm

66kV sea cable (hang off – 66kV GIS):

- Minimum bending radius (3 core cable) = 3000 mm
- Diameter of 3 core cable = 175 mm
- Minimum bending radius (1 core cable) = 1500 mm
- Diameter of (1 core cable) = 65 mm

For the detailed design, Offshore Wind Farms shall use the specifications of their intended cable supplier, which shall be above (bending radius) or below (diameter) the specifications given above.

4. CABLE PULLING METHODS

4.1 General

Three different methods are preferred to be used for pulling of the sea cables through the J-tubes: the cable ‘sledge’ method, the Samson post method and the ‘cable pulling A-frame’ method. If cable pulling is done when the topsides has not yet been installed, no structure will be present above the J-tubes, and therefore these three methods are preferred as no structure above the J-tubes is required. Below two installation sequences are mentioned, where one of them shall be followed; if cable pulling is performed before installation of topside, sequence 1. shall be used and if the topside has been installed, sequence 2. shall be used instead. Storage area for cables shall be defined in detail design phase, but the maximum height allowed is 3 meter in order not to intervene with cable ways installed on the topside.

1. Cable pull-in → Storage of cable → Topside installation → Cable routing to GIS
2. Topside installation → Cable pull-in → Cable routing to GIS

4.1.1 Cable pulling layout

A preliminary overall 220/66kV cableway layout on the cable deck has been made to indicate a feasible solution on routing the 220kV and 66kV sea- and internal platform cables, see:

- ONL-TTB-00135-MA-EN_01--Overall 220 66kV Cableway Layout Cable Deck

The preliminary layout drawing only indicates one placement of a cable pulling winch, but the detailed design phase shall determine two locations on the cable deck (one for each OWF), see chapter 4.2 for further information.
Furthermore the cable pits area has been shown with a dotted line, to indicate where the cable pits will be located underneath the 66kV GIS areas.
All cable ways sizes and deck penetrations are estimated and shall be detailed designed in the next phase.

4.1.2 The cable ‘sledge’ method

As seen in the figure below, this method consists of a sledge guiding system, which securely guides the sea cable from the J-tube onto the cable deck. The placement of the winch and the pulling pad eyes on the jacket structure allows for all sea cables to be pulled in one pull without the need of moving the pull-in head for further pulling. For this method the winch can be situated at one place and angled in three or more different positions in order to reach and pull all the array and export cables.

The sledge guiding system shall be sized and designed by the (OWF's) cable contractor(s) according to the minimum bending radius of their cable(s), having in mind the maximum height and other requirements to be fulfilled.

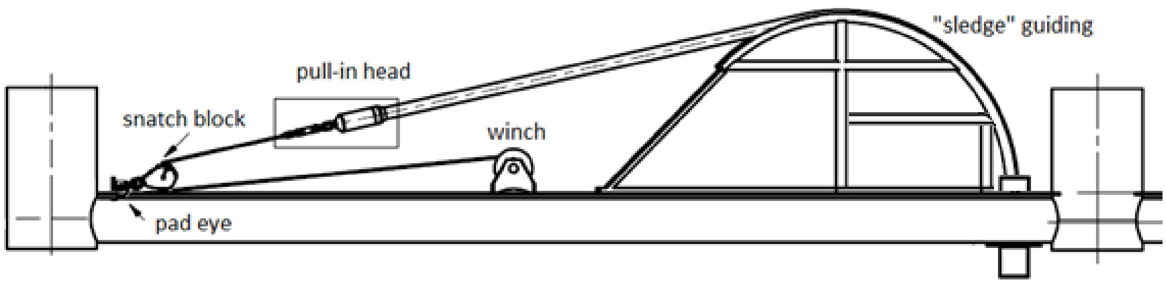

Figure 3-1: The cable ‘sledge’ method

The T.O.S. (Top Of Steel) elevation of the J-tubes will be positioned at a suitable elevation for using the sledge. A clearance of 300 mm between the Top of Grating (T.O.G.) and the flange is reserved for the installation of the cable clamp upon the flange. It assumed the flange will fit with standard type of hang-off clamps, which are compliant with DIN 2642. Nevertheless, the (OWF's) cable contractor(s) shall review and design the flange detail for fitting with the cable clamp chosen during detail design.

The structure of the cable deck is sized in order to carry the lifting equipment and its related design loads.

The structure supports a sledge guide, which may be oriented around the required directions; a pad eye, which is used for the installation of the snatch block and a winch. The sledge guide is bolted to the structure. If it is deemed necessary, due to local loads, the grating has to be replaced with plating.

4.1.3 The Samson post method

The cable is lifted vertically through a jack-up positioned on top of the post (see Figure 3-2). The structure is sized in order to provide the concentrated design reaction forces to the column. The Samson post is bolted to a flange located in correspondence with each J-tube.

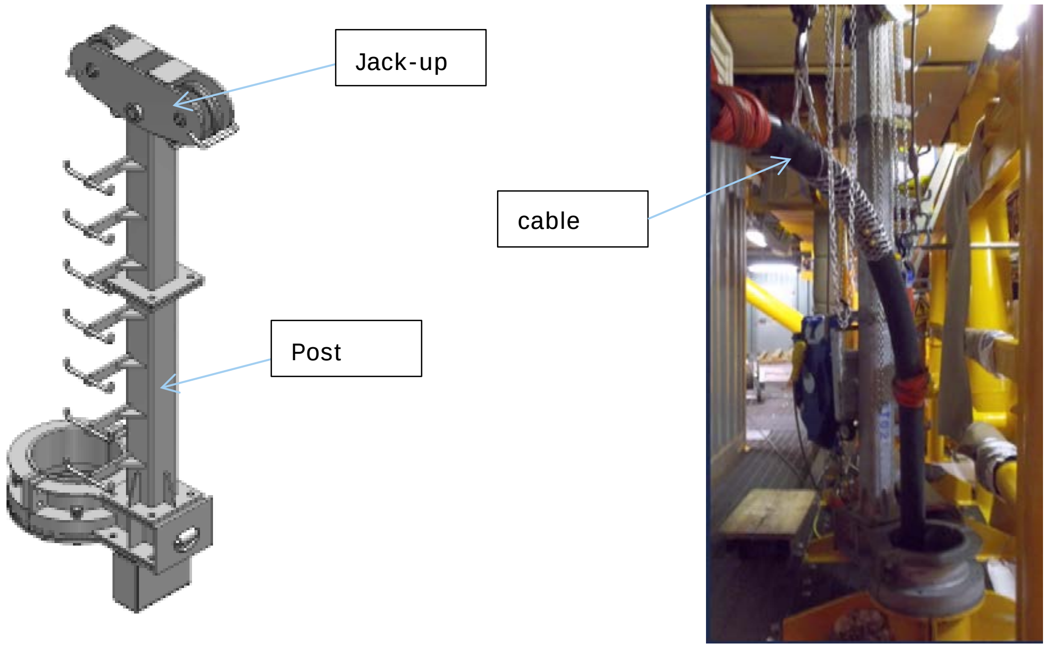

Figure 3-2: The Samson post method.

4.1.4 The cable pulling frame

The cable is lifted vertically through a mobile gantry crane (see the Figure 3-3). The deck structure is sized in order to provide the design reaction forces to the basement of the A-frame. The specific structural requirements for supporting the basement during lift operations and movement around the cable deck will be taken into account in detail design.

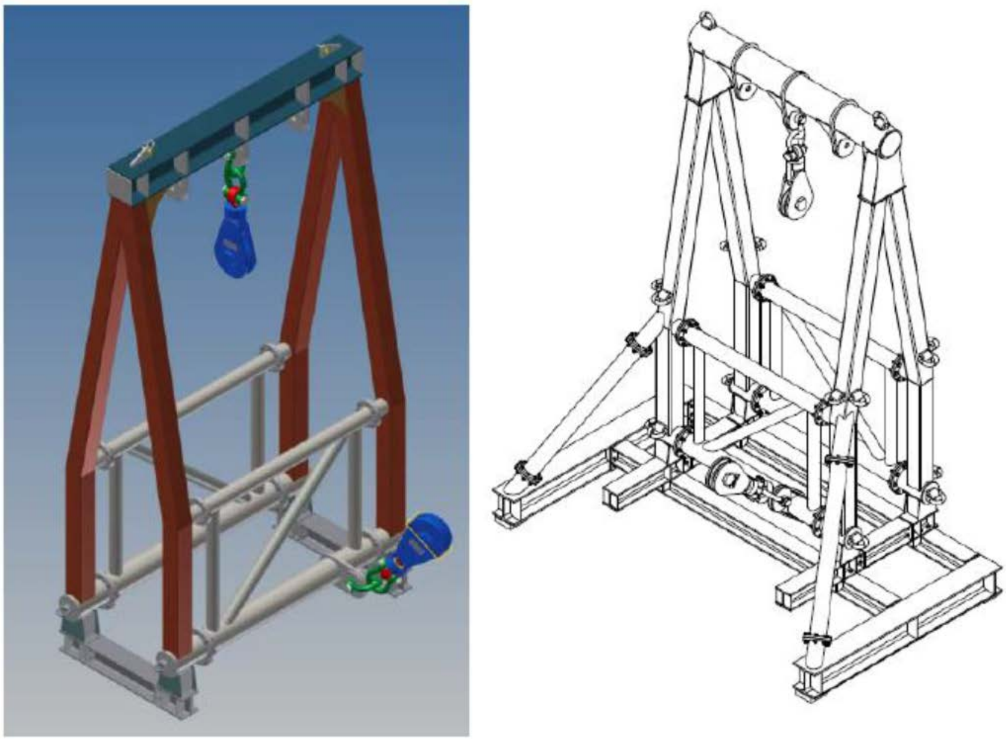

Figure 3-3: The pulling A-frame.

4.2 Cable pulling winch

The cable pulling winch shall be provided by the Offshore Wind Farm(s). Proposal is to mount the winch on a turn plate for easy rotation of the winch so the pulling wire can be directed through the snatch blocks, further over the chosen pulling method and down the J-tube. TenneT will provide two locations on the cable deck for the winch and the turn plates. The location and interface shall be determined during detailed design in consultation with the Offshore Wind Farm(s).

Design factors

The pulling force is multiplied by the following design factors:

- Weight contingency 1.05
- Dynamic effect 1.1
- Consequence factor 1.3
- ULS load factor 1.3

The dynamic effect makes reference to cable pull-in operation in other similar platforms. The weight contingency and consequence factor refer to Noble Denton guidelines for marine lifting & lowering operations, 0027/ND.

4.3 Sequence of cable pulling

A preferred sequence could be to start pulling sea cables from the south or north end, and afterwards follow the sequence one by one to the centre of the platform in order to gain the most possible working space for each pull, but this is not obligatory. The cable length has been estimated for the array to be between 19-25 metres and between 12-17 metres for export cables at the present J-tube placement.

4.4 Rigging equipment

The area between the boat landing cages and behind the boat landing cage towards south can be used for cable pulling rigging equipment and for placement of a small diesel generator providing the necessary power for the cable pulling winch, lighting fixtures and various other small consumers required during this phase. The Offshore Wind Farm(s) shall arrange power for their cable pulling operation.

4.5 Escape routes

If the permanent primary escape routes are blocked for some reason during the cable pulling phase, new alternative routes shall be determined in these periods.

4.6 Jacket structure

Inner diameter of J-tube shall be more than 2.5 times cable outer diameter. Therefore, based on the sizes of the cables, defined in the section “Basis of Design”, the inner diameter of 66 kV J-tube is chosen 450 mm and of the 220 kV J-tube is 700 mm.

J-tubes shall be located in such a way that one side of the Substation is kept free of cables, to allow a Jack-up vessel at that side. Furthermore the J-tubes shall be located so that the cables can be separated as much as possible on the seabed close to the Substation. Due to Remote Operating Vehicle “ROV” cable pull-in operations, the distance between J-tubes and seabed during cable pulling operation has to be coordinated with ROV supplier to ensure that the ROV can manoeuvre freely also with dynamic sand banks in mind. 2.5 meters between J-tubes and sea bed is a conservative approach and can be used as a guideline.

J-tubes will have minimum bending radius required for the cables, with single curvature and will be able to withstand the cable pulling forces with no jamming.

The J-tube inner surface shall be smooth, free of obstructions, sharp and cutting edges. The J-tube shall be checked by pigging or other suitable operation.

J-tube entrance shall be characterized by the presence of suitable smooth bell-mouth opening. The bell-mouth shall be suitably sealed allowing for an easy opening at the time of the pulling by means of a ROV. A simple example of a possible solution is shown in below sketch.

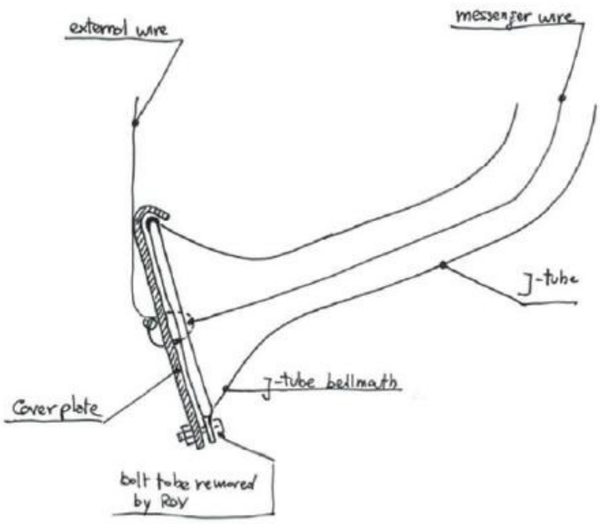

Figure 3-4: Typical bell-mouth arrangement

Design and construction of the bell-mouth shall include the following requirements:

- Bell-mouth elevation above seabed: 2.5 m, bell-mouth angle (from horizontal): 15°
- Bell-mouth exit angle: +/- 30° (see Figure 3-4)
- Bell-mouth exit angle shall guarantee the minimum bending radius of 3.4 m in the 66 kV J-tube and 5.6 m in the 220 kV J-tube.
- Bell-mouth shall be aligned with the exit direction of cable (route of the cable approaching the Platform)
- Bell-mouth exit point shall be outside the platform footprint for the ROV access
- Area in front of J-tube entrance shall be free of obstacles and shall allow safe approach of the cable laying vessel and ROV and ease pulling of the cable.

4.7 Screenshots from the 3D model

In this chapter four screenshots are shown which have been taken from the 3D model of the substation to give an impression of the cable deck size and available space. All four screenshot are taken before installation of the topside and therefore no cable ways will be shown in the screenshots.

1. Screenshot in Figure 3.5 shows an overview of the entire cable deck including the two placement of cable pulling winches, the two sledges and the Samson post pulling method. The pulling A-frame has not been inserted in the 3D model
2. Screenshot in Figure 3.6 shows the large sledge suitable for pulling of export cables
3. Screenshot in Figure 3.7 shows the small sledge suitable for pulling of array cables
4. Screenshot in Figure 3.8 shows the Samson post mounted on one of the array J-tubes

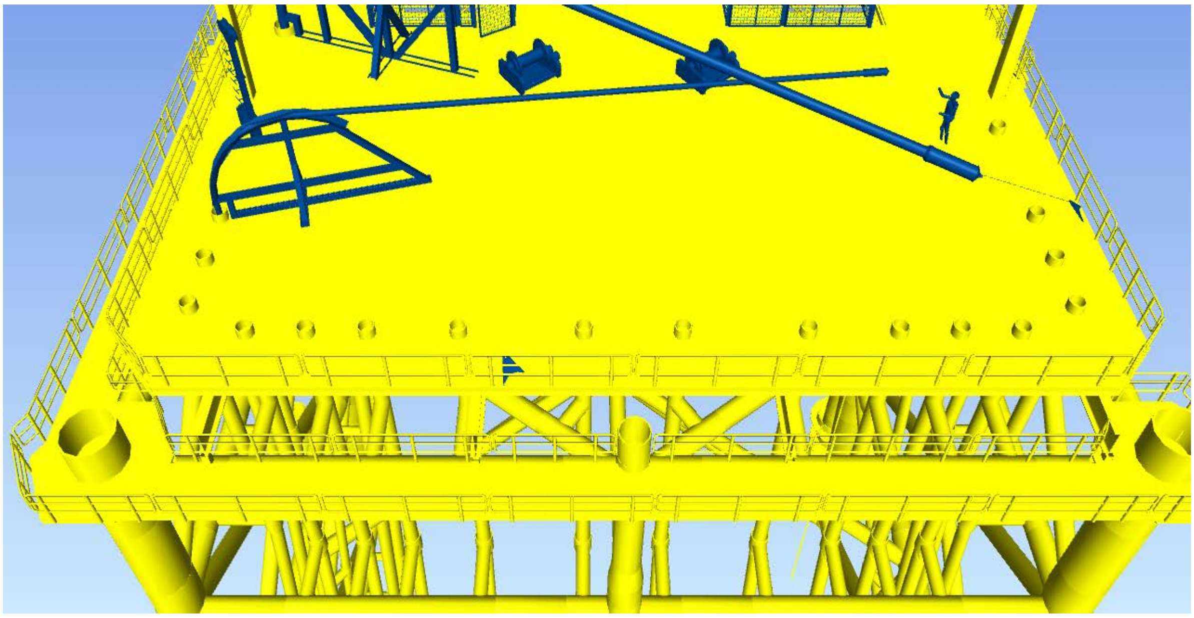

Figure 3-5: Overview of the entire cable deck.

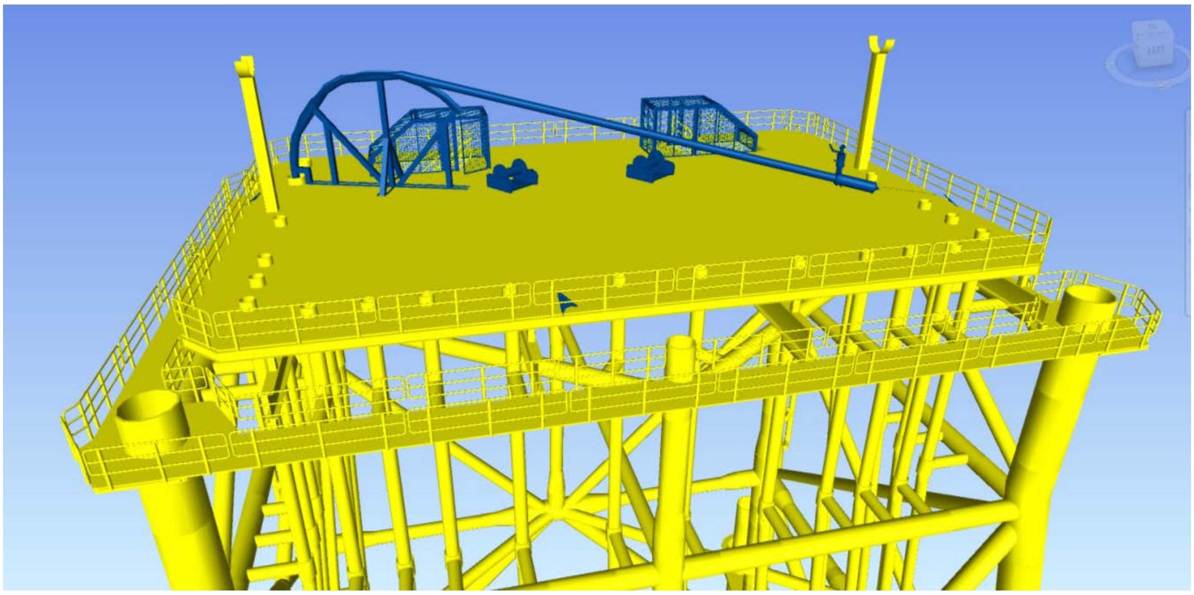

Figure 3-6: Shows the large sledge.

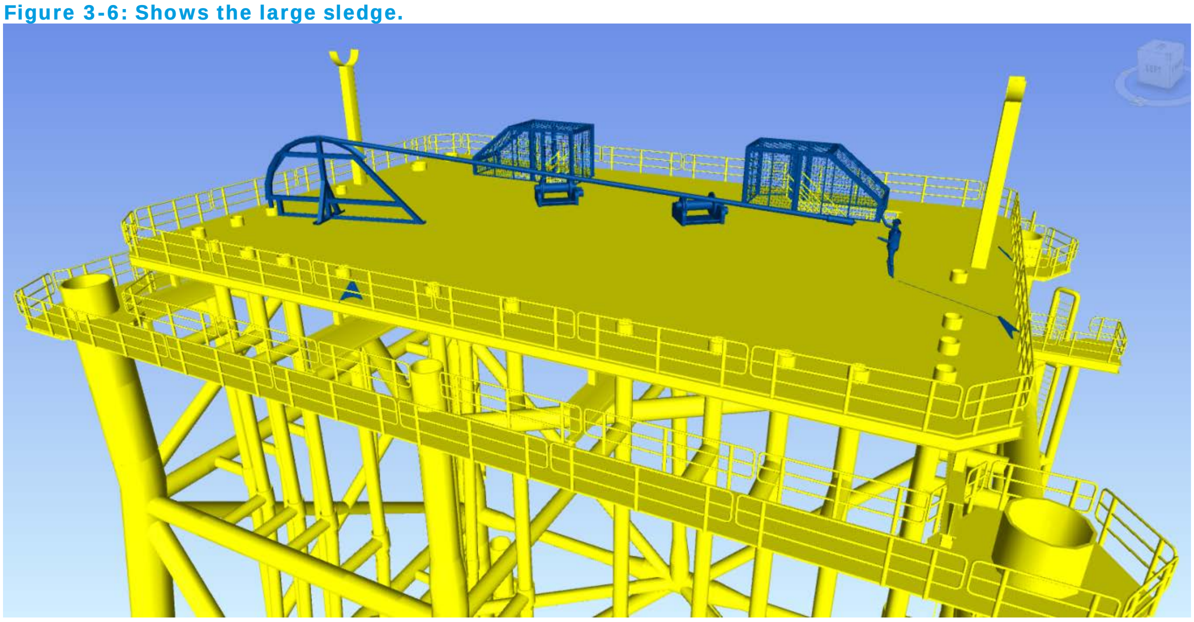

Figure 3-7: Shows the small sledge.

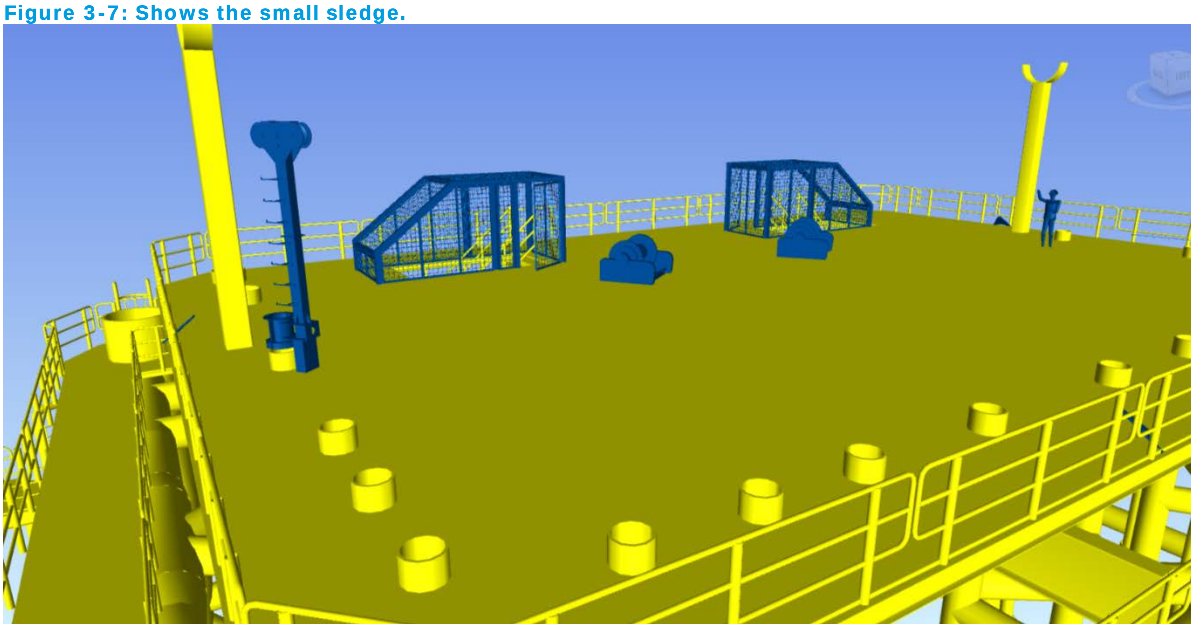

Figure 3-8: Shows the Samson post.

5. FIELD LAYOUTS

In the principle field layout the platform is located such that it is surrounded by the two wind park areas. The array cables enter the platform from three sides (north, west and south). The export cables to shore can optimally be connected to the platform on the north side, but connection on the south side will be kept open. The east side shall be kept free from cables on the seabed to secure future accessibility for a jack-up-based heavy lifting crane vessel for potential replacement of a main transformer, GIS or shunt reactor.

The principle field layout of Hollandse Kust Zuid is shown in:

- ONL-TTB-04016-MA-EN_00--Field_Lay_Out_HKZ_Alpha_(1-10)
- ONL-TTB-04017-MA-EN_00--Field_Lay_Out_HKZ_Beta_(1-10)
- ONL-TTB-04018-MA-EN_00--Field_Lay_Out_HKZ_Alpha_(1-20)
- ONL-TTB-04019-MA-EN_00--Field_Lay_Out_HKZ_Beta_(1-20)

These drawings show a preliminary lay-out. The lay-out shall be the basis for further optimization during detailed design between TenneT, Offshore Wind Farm, Platform Contractor and Cable Contractors.