Base Load Power Hub (BLPH)

Lightning Protection System Calculation 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.

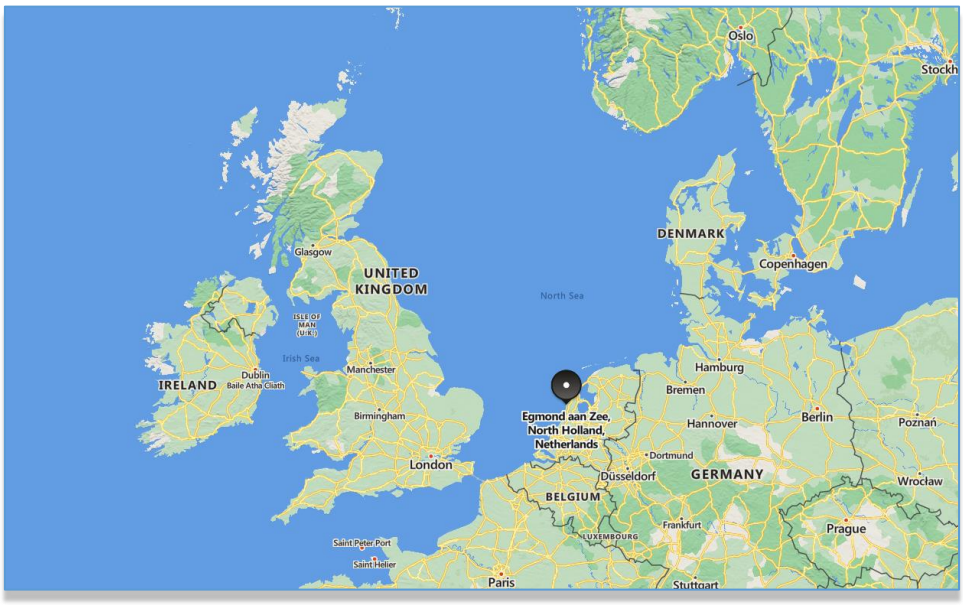


Figure 1 - HOLLANDSE KUST NOORD WIND PARK Location Map

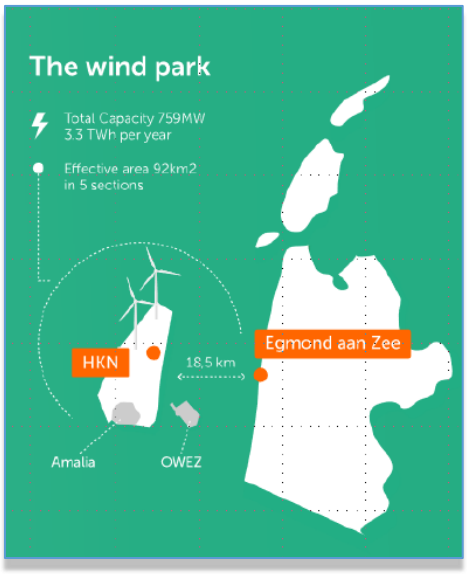


Figure 2 - Wind Park Details

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.

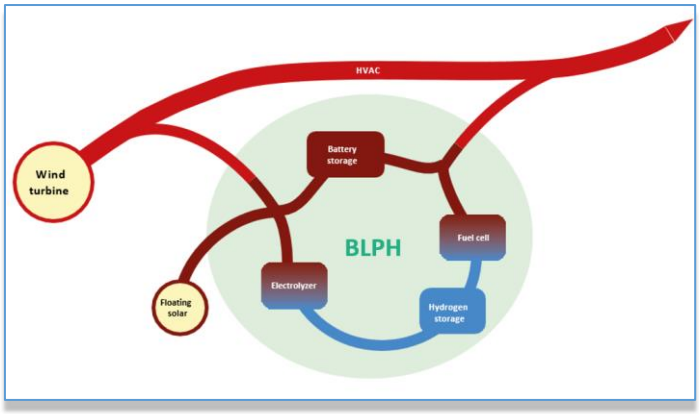


Figure 3 – BLPH Concept

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 DOCUMENT SCOPE

The scope of this document is the basis for the study of the lightning protection system in BLPH.

2.1 REFERENCES

Doc. No.	Description
123A90-DDL-PP-DL-70070	Base Load Power Hub (BLPH) Plot Plan – Lower & Upper Deck
123A90-DDL-PP-DL-70072	Base Load Power Hub (BLPH) Plot Plan – Elevation Looking North & East
K559-2254-PM-PLN-003	Basic Design Engineering Package
K559-2254-EL-PHI-002	Electrical System Description & Design Philosophy
K559-2254-SE-PLN-002	Fire Protection Basis of Design
123A90-DDL-EL-DG-20158	Overall / Key Single Line Diagram
123A90-DDL-EL-DD-20090	Electrical Typical Installation Earthing System
DEP 33.64.10.10	DEP Specification - Electrical Engineering Design
DEP 33.64.10.33	DEP Specification - Electromagnetic Compatibility
K559-2254-SE-HAD-001-001	Base Load Power Hub Hazardous Area Classification Layouts

Table 1 - Reference Documents

2.2 DEFINITIONS AND ABBREVIATIONS

COMPANY or Client (CPY):	CROSSWIND
CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project
AC	Alternating Current
Cu	Copper
DC	Direct Current
ELPS	External Lightning Protection System
EMC	Electromagnetic Compatibility
LV	Low Voltage
LSZH	Low Smoke Zero Halogen
LPL	Lightning Protection Level
LPS	Lightning Protection System
LPZ	Lightning Protection Zone
N/A	Not Applicable
SPD	Surge Protective Device
UPS	Uninterrupted Power Supply

Table 2 - Definitions and Abbreviations

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3 APPLICABLE CODES AND STANDARDS

IEC - International Electro technical Committee (latest edition shall be applied).

IEC 61643-11	Low voltage surge protection devices Part-11 surge protection devices connected to low voltage power distribution systems – Requirements and test methods
IEC 61643-12	Low voltage surge protection devices Part-12 surge protection devices connected to low voltage power distribution systems – Selection and application principles
IEC 60099-6	Surge arresters – Part 6: Surge arresters containing both series and parallel gapped structures – Rated 52 kV and less
IEC 61892-6	Mobile and fixed offshore units - Electrical installations - Part 6: Installation
IEC 61892-7	Mobile and fixed offshore units - Electrical installations - Part 7: Hazardous areas
IEC 62305-1	Protection against lightning. Part-1: General principles
IEC 62305-2	Protection against lightning. Part-2: Risk management
IEC 62305-3	Protection against lightning. Part-3: Physical damage to structures and life hazard
IEC 62305-4	Protection against lightning. Part-4: Electrical and electronic systems within structures

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4 ENVIRONMENTAL AND OPERATING CONDITIONS

The Metrological and Oceanographic Data are as given below (source: HKN2018 data @ 1979-2018)

Description	Value	Unit
Ambient Conditions		
Ambient Temperature (min/nom/max) – hourly @ +10m	-8.4 / 10.5 / 25.0	° C
Atmospheric Pressure (nominal) – hourly @ +10m	1013.7	mbar
Specific Humidity (min/nom/max) – hourly @ +10m	4.2 / 6.5 / 9.5	x 10^{-3}
Wind conditions		
Annual average wind speed (at 100m)	9.56	m/s
Extreme Wind Speed for 1-Year Recurrence Period (at 100 m)	33.1	m/s
Extreme Wind Speed for 50-Year Recurrence Period (at 100 m)	41.0	m/s
Marine conditions		
Sea Water Temperature (min/max)	1.2 / 20.2	° C
Average Sea Water Density	1025	Kg/m^3

Table 3 - Metrological and Oceanographic Data

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5 LIGHTNING PROTECTION STUDY

5.1 LIGHTNING ACTIVITY

The map below shows the Thunderstorm days for Netherlands as 20. Lightning flashes/km^2/year is calculated as 0.1 x Thunderstorm days (as per IEC 62305-2, Equation A.1), therefore 0.1 x 20 = 2 lightning flashes/km^2/year is considered as the criteria for the BLPH offshore flatform lightning protection system.

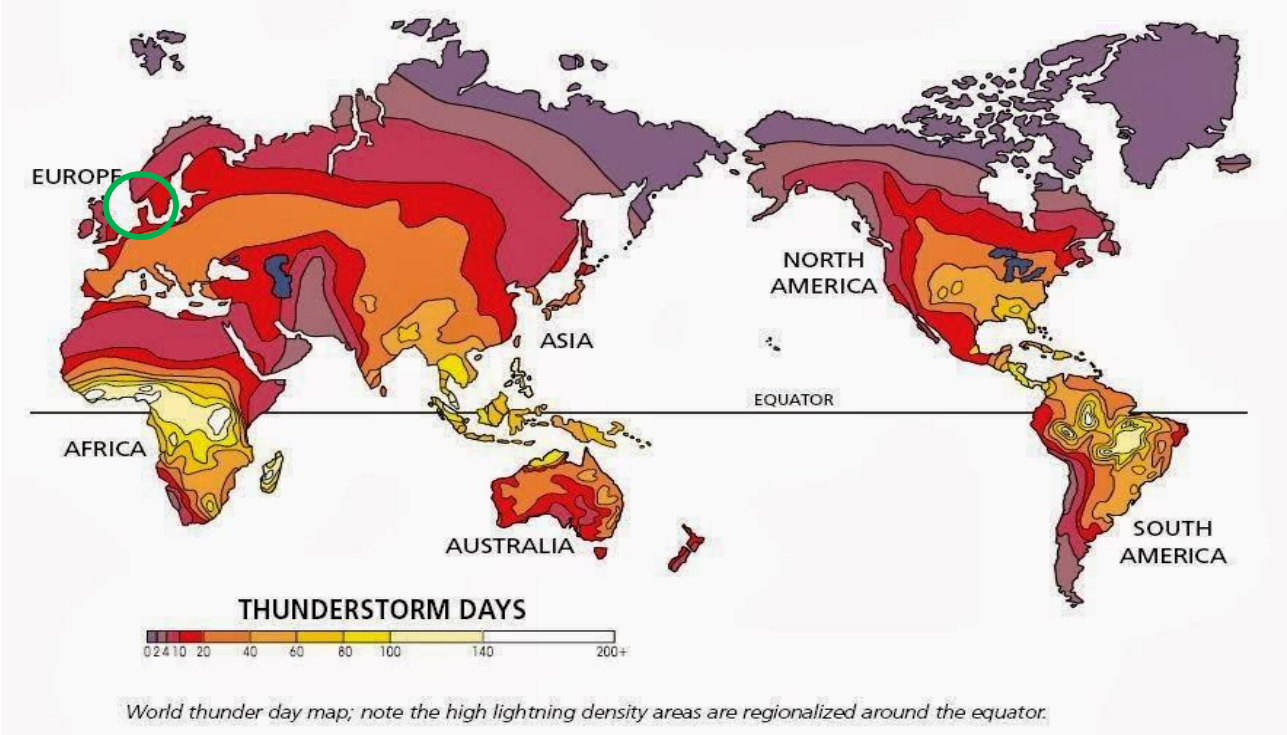


Figure 4 - Thunderstorm days map

5.2 LIGHTNING PROTECTION LEVEL (LPL)

The determination of the level of lightning protection from the IEC standards is impracticable for the following reasons:

- IEC 62305-1: Lightning protection for offshore installation out of the scope of this standard
- IEC 61892-6: This standard does not allow calculating the level of protection.

As per IEC 62305-2, Clause 5.4, Note-2, "*Where protection against lightning is required by the authority having jurisdiction for structures with a risk of explosion, at least a* ***class II LPS*** *should be adopted. Exceptions to the use of lightning protection level II may be allowed when technically justified and authorized by the authority having jurisdiction*."

In addition to level II lightning protection, complementary measures of Surge Protection Device (SPD) on the power network are installed.

5.3 EFFICIENCY OF THE LPS

For the protection level **LPL II**, the lightning current parameters are given in the following table (IEC 62305-1 Table 3)

Current Parameters	Symbol	Protection Level
Peak Current	I	150 kA
Specific energy	W/R	5600 kJ/Ω
Time parameters	T1/T2	10/350 µs

Table 4 - Lightning current parameters

The interception effectiveness Ei of the air-termination system is concomitant with the class of lightning protection system i.e. which percentage of the prospective lightning strike is safely controlled by the air-termination system.

The relation between lightning protection level, interception criterion Ei, final striking distance hB and minimum peak value of current is given in the following table (IEC 62305-1 Table 4 & 5).

Lightning Protection Level LPL	Interception Criteria Ei	Radius of the Rolling sphere (final striking distance hB) R in m	Min. Peak value of Current I in kA
IV	0.84	60	16
III	0.91	45	10
II	**0.97**	**30**	**5**
I	0.99	20	3

Table 5 - Lightning protection levels

5.4 DESCRIPTION OF STRUCTURE

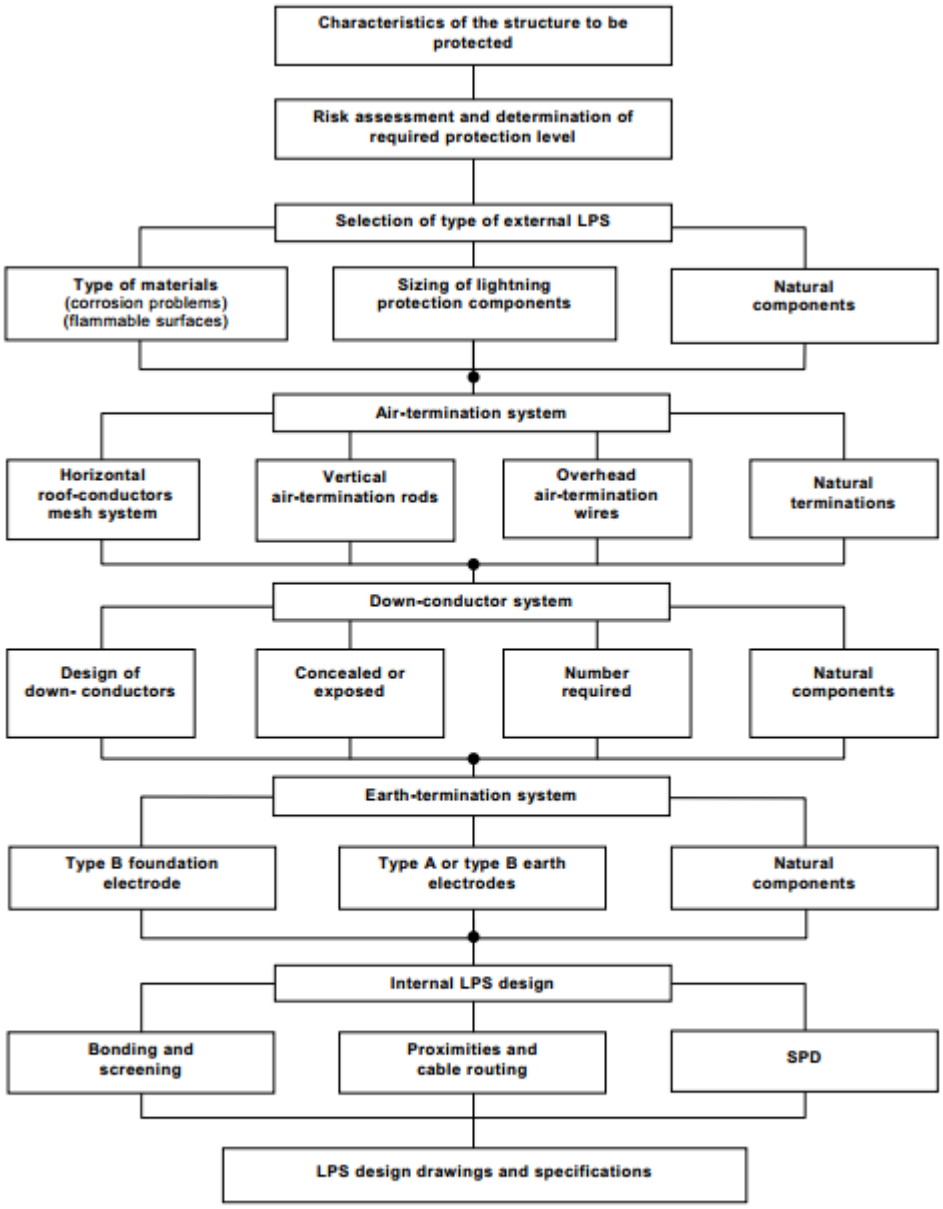
Structural Member - Monopile

Non-Structural Members - Accessory and finishing elements, i.e. not participating in the overall strength of the platform structures (hand-rails, stairs, ladders, grating, etc.).

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5.5 DESIGN OF AN LPS

The LPS design must comply with IEC 62305-3 - Figure E.1 (LPS design flow diagram).



NOTE Interfaces ● require the full cooperation of the architect, engineer and lightning protection designer.

Figure E.1 – LPS design flow diagram

The function of the air termination system is to prevent the direct lightning strokes from damaging the volume to be protected.

Air termination system can consist of the following equipment:

- Lightning rods
- Intermeshed conductors
- Naturals components made of conductive parts which always remain in the structure and will not be modified (e.g. interconnected reinforced steel, metal framework of the structure, etc.).

Three methods can be used to determine the arrangement and the sitting of the air-termination systems:

- Rolling sphere method
- Mesh method
- Protective angle method.

For the offshore structure, the rolling sphere method is the universal method of design particularly recommended for geometrically complicated applications.

The location of the air termination systems is determined by the fictive rolling sphere method of 30 m radius for lightning protection class II and the views in ANNEXES 6.1.2, 6.1.3 show impact points on the structure.

Note:
Metal structural parts such as offshore platform are used as natural components must exceed prescribed minimum requirements to be accepted as forming part of an air termination system to the class of lightning protection system as per Table-3 of IEC 62305-3

Class or Level of LPL	Thickness (mm)	Material of Natural Component
II	4	Steel (Stainless, Galvanized)

Table 6 - Material Thickness of Natural component

On the offshore platform, the thickness of the natural component parts is up to the minimum thickness shown in table above and no complementary measures are required.

5.6 LIGHTNING PROTECTION ZONE (LPZ)

The offshore platform is divided in different lightning protection zones (see IEC 62305-1). Below, the values, characterizing parameters of impulse electric and magnetic fields and surges in power and signal nets are presented.

5.6.1 LPZ 0A:

Equipment are in this zone are exposed to direct lightning strikes with full lightning current and the full lightning electromagnetic field. Internal systems may be subjected to full or partial lightning surge current. The parameters characterizing impulse electromagnetic field carry out:

- Electric field intensities till 500 kV/m
- Magnetic field intensities till 10 kA/m

5.6.2 LPZ 0B:

Devices are exposed to direct influence full lightning electromagnetic field, similarly as in zone 0A, but not to direct lightning strikes and the lightning induced surges. The values of over voltages in:

- Electric low-voltage nets - 10 kV
- Signal transmission lines - 6 kV

5.6.3 LPZ 1:

Devices are protected against direct lightning strikes; surge current is limited by current sharing and by surge protective devices (SPDs) at the boundary; spatial shielding may attenuate the lightning electromagnetic field.

The transient voltages in zone 1 should be limited to the levels below:

- 6 kV in power networks,
- 4 kV in signal lines.

5.6.4 LPZ 2/ 3/ 4:

Surge current is further limited by current sharing and by additional surge protective devices (SPDs) at the boundary. The values basic parameters characterizing overvoltage in each zone are presented in the table below;

Parameters	Zone 2	Zone 3	Zone 4
Over voltage in supply Nets	4 kV	2.5 kV	1.5 kV
Over voltage in signal lines	2 kV	1 kV	0.5 kV
Electric field	5 kV/m	50 V/m	5 V/m
Magnetic field	100 A/m	1 A/m	0.1 A/m

Table 7 - Overvoltage parameters

5.7 LPS REQUIREMENTS

5.7.1 ELPS (External Lightning Protection System)

a) Air Termination

The air termination must be composed of the natural termination components (metal structure);

- Structural members of the upper deck: Monopile structure,
- Non-structural Members of the upper deck: hand-rails, stairs

Air termination rods are installed on the upper deck of the BLPH platform as per rolling sphere method of 30m radius for class II lightning protection. The lightning protected zone shall be at least 1 m higher than the ATEX Hazardous zone.

The thickness of the metal structural parts that are exposed to the lightning strike is up to 4 mm metal and it is not necessary to install lightning rod.

b) Down Conductors

For air terminal rods, the down conductor using a Copper / Aluminium alloy conductor of size 50mm^2 (Cu.) / 70 mm^2 (Al.) connected to the air terminal rod base by a stainless-steel lug welded to the structure of the platform.

The down conductors are made up of the natural components:

- Structural members: Monopile structure
- Subsea structures.

No complementary measure is required.

c) Earth Terminations

The earth termination must be made up by the natural earth electrode of the platform:

- Subsea structures: assembled piles of the platform

No complementary measure is required

d) Hydrogen Vent (V-43001)

The Hydrogen vent (V-43001) is considered as natural air-termination, without any additional lightning protection components, because the metal thickness of the Hydrogen vent is more than 4mm, which can be used as natural component of an air termination system as per IEC 62305, Table-3.

The down conductor using a Copper conductor of minimum size 35mm² connected at 2 earthing points 180° apart on the base of Hydrogen vent and welded to the structure of the platform.

5.7.2 ILPS (Internal Lightning Protection System)

a) Lightning Equipotential Bonding

All the equipment has to be connected to the metallic structure of the platform, in order to obtain good electrical equipotentiality.

The natural component must be bonded to the metallic structure of the platform:

- Non-structural Members of the BLPH Platform: hand-rails, stairs, etc.
- Equipment: Skids and packages etc. (two points at the bottom)

The electrical equipment must be bonded directly to the earthing network:

- Metal ducting: pipe supports, cables ladders, conduits, etc.
- Electrical equipment: junction boxes, motors, etc.

b) General Routing of Cables

All the cable ladders must be in the LPZ 0B, LPZ 1, LPZ 2/3/4 defined by the rolling sphere method. (Refer Annexes I).

c) Shielding Requirement for the Cables

Power & Instrument Cables:

Armour of Power, Instrument cables must be earthed at the both ends by earth straps. Earthing of the armour must comply with the requirements of the 123A90-DDL-EL-DD-20090 – Electrical typical Installation Earthing System.

5.8 SURGE PROTECTIVE DEVICES

5.8.1 Selection of SPD

The LV network must be protected against surge voltage by LV SPD: Type 1 and type 2 in compliance to IEC 61643-11.

The basic arrangement, observing the rules described in the IEC 62305-3 and IEC 62305-4, must be the following:

- Type 1 for the main distribution board
- Type 2 for the secondary distribution board
- Type 2 for the UPS AC & DC distribution board

5.8.2 Selection of the Voltage Protection Level (Up)

The voltage protection level (Up) of the surge Protective Devices (SPDs) must be in compliance with:

- Overvoltage categories described in IEC 60664-1: 2500 V
- Minimum voltage protection given by IEC 60364-4-534: 2500 V
- Lightning Protection Zone concept given by IEC 62305-4.

5.8.3 Selection of SPD

The SPD must be installed in accordance with IEC 62305-4 and IEC 61643-12:

- The protection against SPD short-circuits must be performed by over current protective device: disconnector device
- The connecting conductor from the line conductor to the surge protective device and from the surge protective device to the main earthing terminal must not exceed 0.5 m

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5.8.4 Coordination SPD

The coordination must be proved by the following:

- The coordination energies
- Application of inter coordinated SPD's families.

According to IEC 62305-4, the energies coordination SPD's must be declared by the manufacturer of SPD's.

The surge protection device characteristics must be as follows:

Location	SPD	Earthing Neutral
6.6kV Switchboard	Type-1 – Class-I Ur: 9 kV Uc: 7.2kV In: 10kA	Not applicable
400V Switchboard	Type -1 & 2 Class - I & II U_C: 255 V Up: $\leq$ 1.5kV I_n: 25 kA	TN-S 3Ph+N+PE
400V-230V Distribution board	Type -1 & 2 Class - I & II U_C: 255 V Up: $\leq$ 1.5kV I_n: 25 kA	TN-S 3ph+N+PE / 1ph+N+PE
400V-230V UPS Distribution board	Type – 1 & 2 Class – I-II U_C: 440 V Up: $\leq$ 2.5kV I_n: 25 kA	TN-S 3ph+N+PE / 1ph+N+PE
110V DC Distribution board	Type - 2 - Class - II U_N (a.c): 120V Uc (d.c): 200V Up: $\leq$0.7kV I_n : 15 kA	TN-S 2+PE

24V DC Nav-Aids system	Type – 3 - Class – III U_C: 275 V a.c Up: < 1.0 kV I_n : 3 kA	TN-S 2+PE
	Type - 2 Class - II Uc: 275 V a.c Up: ≤ 1.35 kV I_n : 20kA	

Where,

Ur = Rate voltage
Uc = Continuous operating voltage
Up = Protection level voltage
I_n = Nominal discharge current (8/20 µs)

5.9 EARTHING AND GROUNDING NETWORK

5.9.1 Earthing system Platform

The main functions ensured by the earthing network are:

- Safety of person against electric shocks
- Equipotentiality for internal and external conductive parts of the lightning protection system
- Electrostatics discharges.

Equipotential network must comprise:

- Earth reference point
- Equipotential bonding bar or earth bar
- Bonding conductors
- Earth bosses

Earth reference point (Earth boss) must be installed at the following locations:

- On the piles of the structure near the equipotential bonding bar
- Cage ladders
- Staircase handrails
- Metal surface equipment such as Vessels, Containers, Electrolyser, Fuel Cell, Crane etc.

Refer to 123A90-DDL-EL-DD-20090 – Electrical typical Installation Earthing System.

No complementary measure is required.

5.9.2 Earthing System - Container Room

This system must comprise:

- Two, tinned copper earth bars of size 280x50x5mm with 2 earthing boss, shall be installed on south and west corners at an elevation of 2.5m from the container floor. Earthing boss shall be installed at the same elevation 2.5m.
- The electrical distribution panels inside containers are earthed on a welded base-frame. The panels are provided with tinned copper, protective earth bar (PE) of size 50x5mm at opposite corners of the panels.
- The electrical panels that are not welded to the base-frame are connected to the earth bars in the container with a 35mm^2 Y/G insulated copper conductor.

The earthing system must ensure the following function:

- PE bus bar (for containers B-100, B-200, B-300 and B-400)
- IPE bus bar (for container B-400 only)
- IE bus bar (for container B-400 only)
- ISE bus bar (for container B-400 only)

The metal platform floor must be bonded to the earthing system.

5.9.3 Electrical System Earthing

- 6.6kV Resistance Earthed (NER) system
- 400V / 230V Solidly earthed system

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5.10 CONCLUSION

For the offshore platform the lightning protection level is II (Level defined in IEC 62305-1) is provided with air-terminal rods. Refer Annex 6.1 for air termination rod location details.

The air termination is composed of the natural termination components (metal structure) of platform and the Air termination rod installed on the upper deck of the BLPH platform. Moreover, complementary measures will be added such as Surge arrestors in 6.6kV system and LV Surge Protection Device (SPD) on the LV network.

Air termination rod (AT) height details:

AT	Height
AT-1	6m
AT-2	6m
AT-3	6m
AT-4	8m
AT-5	8m

Following table shows the SPD components selected:

Component	SPD Description	Equipment Tag No.	Equipment Description
Container B-100 - HV/MV SWITCHROOM 66kV/6.6kV			
SPD	Type-1 – Class-I Ur: 74 kV Uc: 59.2 kV I_n: 10kA	HNA6-AFA70	66kV Switchgear (GIS)
SPD	Type-1 – Class-I Ur: 9 kV Uc: 7.2kV I_n: 10kA	SG-100D1	6.6kV Switchgear incoming & outgoing feeders
SPD	Type - 2 - Class - II U_N (a.c): 120V Uc (d.c): 200V Up: ≤0.7kV I_n : 15 kA	UP-200F1	DC UPS Panel Positive & Negative bus

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Component	SPD Description	Equipment Tag No.	Equipment Description
SPD	Type - 2 Class - II Uc: 335V a.c Up: ≤ 0.8kV I_n : 30kA	B100-HSB-001	HVAC Panel – HV/MV Container
Container B-200 – LV SWITCHGEAR ROOM 400V			
SPD	Type -1 & 2 Class - I & II U_C: 255 V Up: ≤ 1.5kV I_n: 25 kA	SG-200N1	400V Switchgear
SPD	Type -1 & 2 Class - I & II U_C: 255 V Up: ≤ 1.5kV I_n: 25 kA	DP-200N1	DB for lighting and small power B.O.P.
SPD	Type – 2 - Class - 2 U_C: 260V a.c Up: ≤ 1.5kV I_n: 20kA	CN-200N1	ICCP Panel External Anode JB
	Type – 1 & 2 Class – 1 & 2 UC: 75 V a.c, 100V d.c Up: < 0.4kV In: 12.5A		
SPD	Type - 2 Class - II Uc: 335V a.c Up: ≤ 0.8kV I_n : 30kA	B200-HSB-001	HVAC Panel – LV Room
SG-200D2 – ACB Panel for Solar package			
SPD	Type -1 - Class - I U_C: 440 V a.c Up: ≤ 2.5kV I_n : 35 kA	SG-200D2	ACB Panel for Solar package

Component	SPD Description	Equipment Tag No.	Equipment Description
Container B-300 - AC UPS ROOM			
SPD	Type -1 & 2 Class - I & II U_C: 440 V Up: $\leq$ 2.5kV I_n: 25 kA	UP-200F3	AC UPS - PAS
SPD	Type -1 & 2 Class - I & II U_C: 440 V Up: $\leq$ 2.5kV I_n: 25 kA	UP-200F4	AC UPS – Fire & Gas
SPD by NAVAID Vendor	Type – 3 - Class – III U_C: 275 V a.c Up: < 1.0 kV I_n : 3 kA Type - 2 Class - II Uc: 275 V a.c Up: $\leq$ 1.35 kV I_n : 20kA	NC-200F2	Navaid system
SPD	Type - 2 Class - II Uc: 335V a.c Up: $\leq$ 0.8kV I_n : 30kA	B300-HSB-001	HVAC Panel – UPS Room

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Container B-400 – I&T EQUIPMENT ROOM			
SPD Not Required	Utilities in the downstream are considered to be protected by AC UPS - PAS SPD at its incomer.	B400-NET-001	System server / Network Cabinet
SPD Not Required		B400-EMCS-001	EMCS Controller + FTC cabinet
SPD Not Required		B400-PCS-001	PCS Controller + FTC Cabinet
SPD Not Required		B400-SIS-001	SIS Controller + FTC Cabinet
SPD Not Required		B400-FGS-001	F&G Controller + FTC cabinet
SPD Not Required		B400-SRV-001	Server cabinet ITER
SPD	Type - 2 Class - II Uc: 335V a.c Up: $\leq$ 0.8kV I_n : 30kA	B400-HSB-001	HVAC Panel – I&T Room
A-20000 – Electrolyser Package			
SPD is provided by Electrolyser Vendor	Type- 1 - Class-1 Ur: 9 kV Uc: 7.2 kV In: 10 kA	A-20000	Electrolyser – 6.6kV power supply from Switchgear SG-100D1
SPD	Type – 2 & 3 Class – II & III U_C: 440 V Up: < 2kV V I_n : 15 kA	A-20000	Electrolyser – 400V Auxiliary loads power supply from LV Switchgear

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A-63000 – Instrument Air Package			
SPD	Type - 2 Class - II Uc: 255 V Up: < 1.2kV I_n : 20 kA / pole	A-63000	230V Power supply from AC UPS - PAS
SPD	Type - 2 Class - II Uc: 255 V Up: < 1.2kV I_n : 20 kA / pole	A-63000	LV power supply Distribution from B.O.P
A-80000 – Fuel Cell Package			
SPD is provided at the outgoing feeder of 6.6kV Switchgear SG-100D1 (Refer drg. 123A90-DDL-EL-DG-20158)	Type- 1 - Class-1 Ur: 9 kV Uc: 7.2 kV In: 10 kA	A-80000	Fuel Cell – 6.6kV power supply from Switchgear SG-100D1
SPD	Type - 2 Class - II Uc: 277 V Up: $\leq$ 1.5 kV I_n : 25kA	A-80000	Fuel Cell – 400V Auxiliary loads power supply from LV Switchgear
A-85000 – BESS Package			
SPD is provided at the outgoing feeder of 6.6kV Switchgear SG-100D1 (Refer drg. 123A90-DDL-EL-DG-20158)	Type- 1 - Class-1 Ur: 9 kV Uc: 7.2 kV In: 10 kA	A-85000	PCS cabinet – 6.6kV power supply from Switchgear SG-100D1
SPD	Type – 1 & 2 Class - I & II Uc: 350 V a.c Up: $\leq$ 1.5 kV I_n : 25kA	A-85000	BESS – 400V power supply from LV switchgear
SPD	Type – 1 & 2 Class - I & II U_{OCSTC}: $\leq$ 1250V d.c Up: $\leq$ 4.5 kV I_n : 20kA	A-85000	BESS – DC system

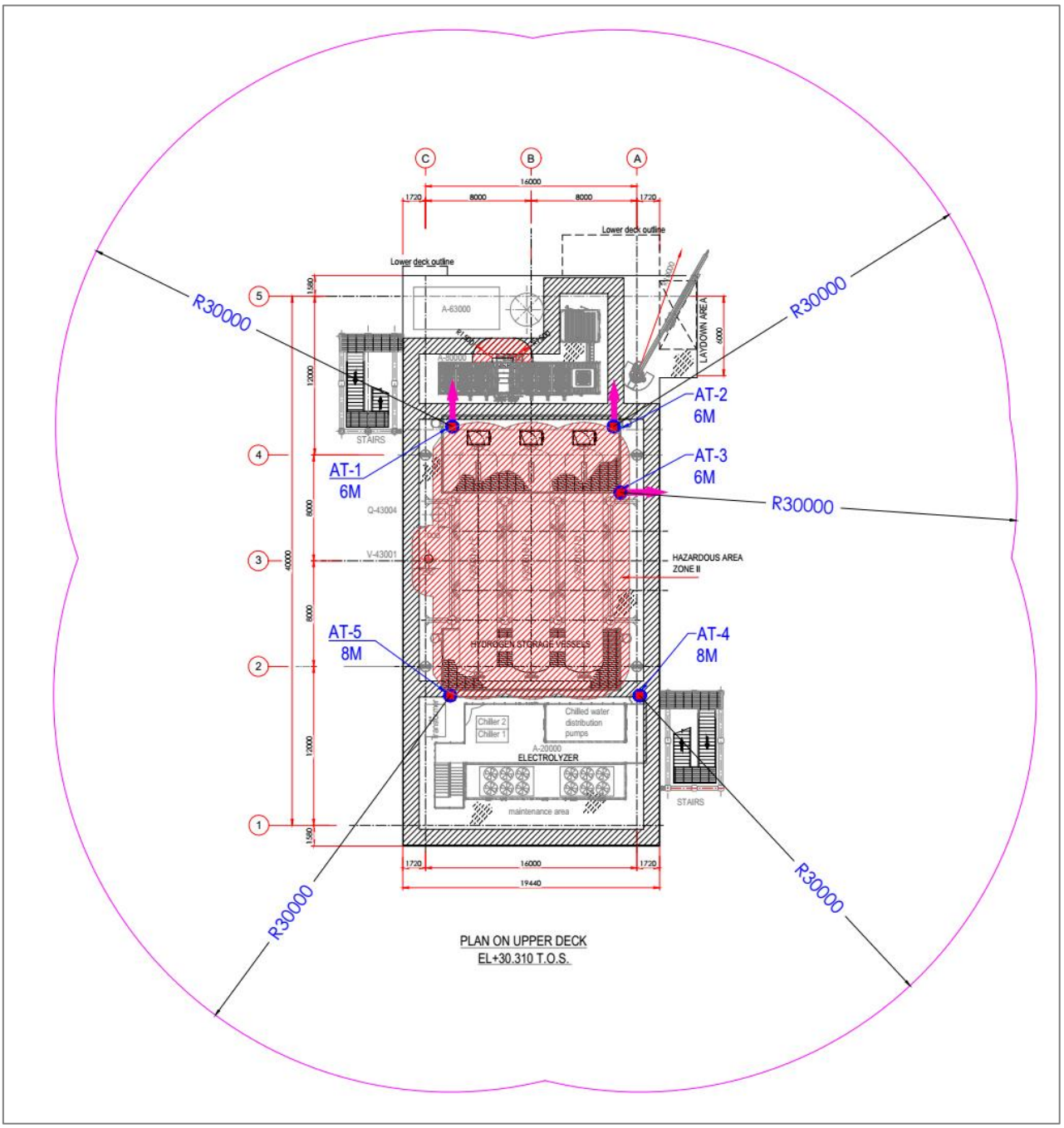
A-50000 - Water Treatment Package			
SPD	Type - 2 Class - II Uc: 275 V Up: ≤ 1.5kV I_n : 20 kA	50-LP-001	400V Power supply from LV Switchgear
SPD	Type - 2 Class - II Uc: 275 V Up: ≤ 1.5kV I_n : 20 kA	50-LP-001	230V Power supply from AC UPS - PAS

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6 ANNEXES

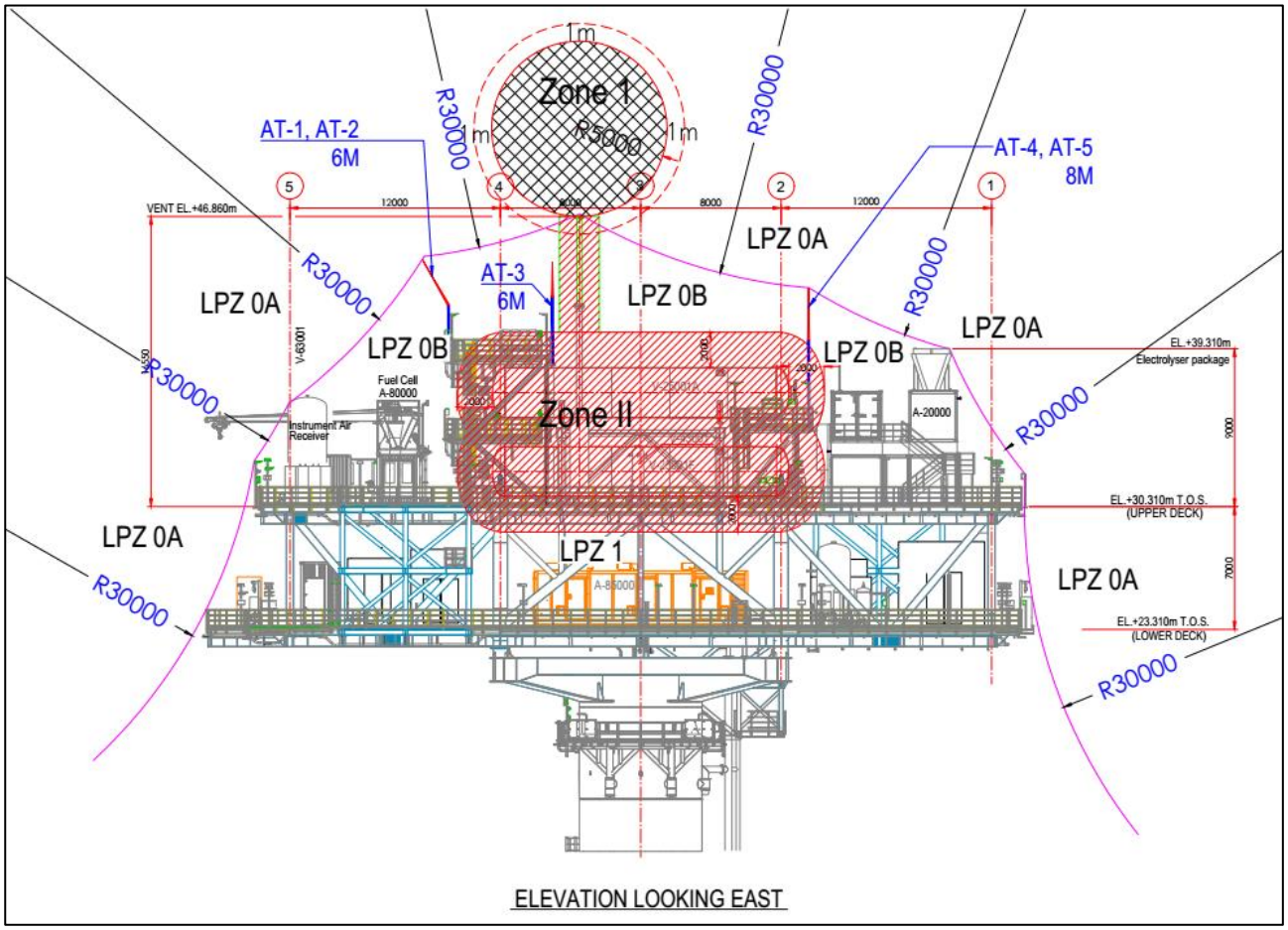
6.1 ROLLING SPHERE METHOD (CLASS II - 30M RADIUS)

6.1.1 Plan View



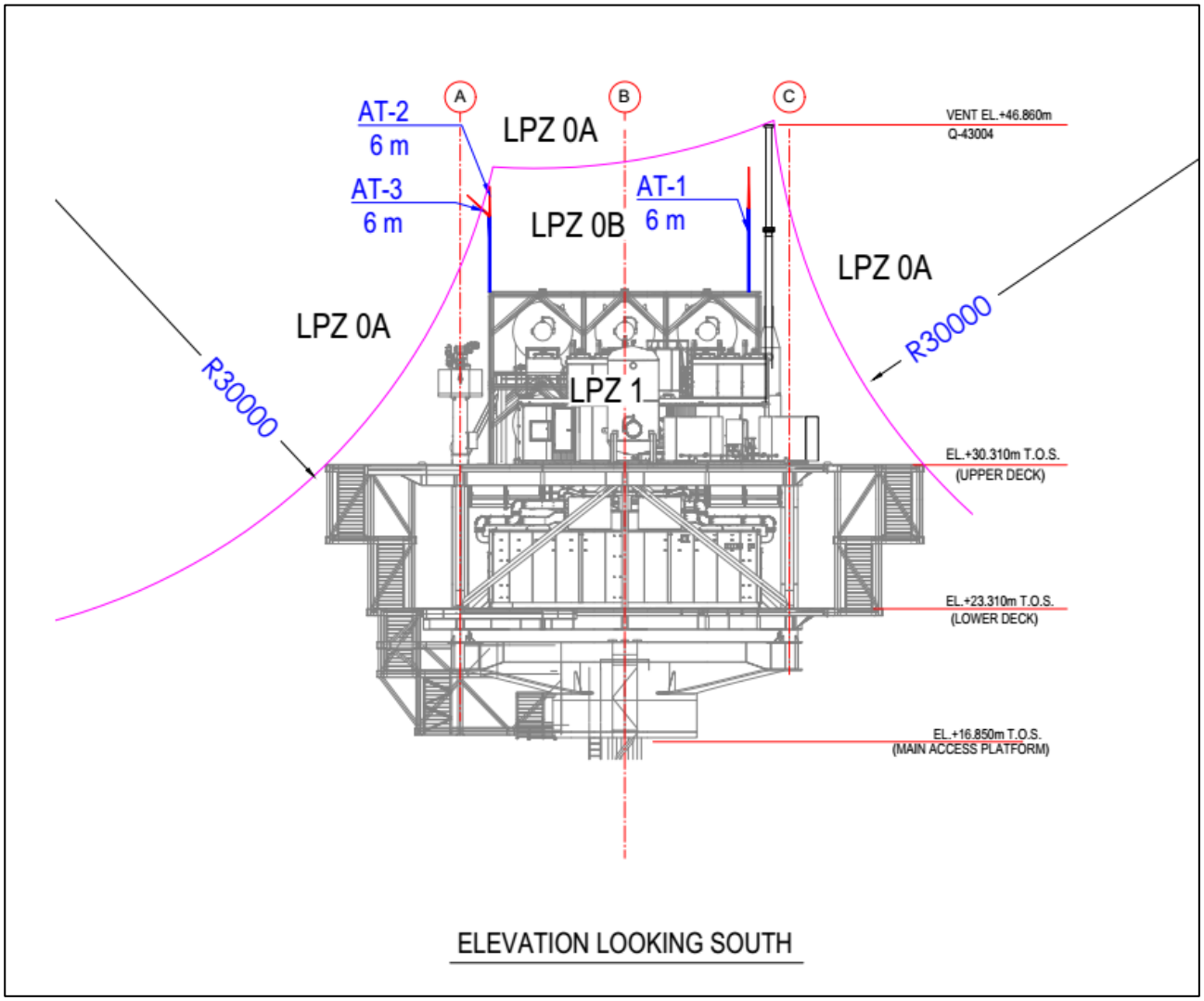
AT – Air Termination Rod

6.1.2 East Elevation View



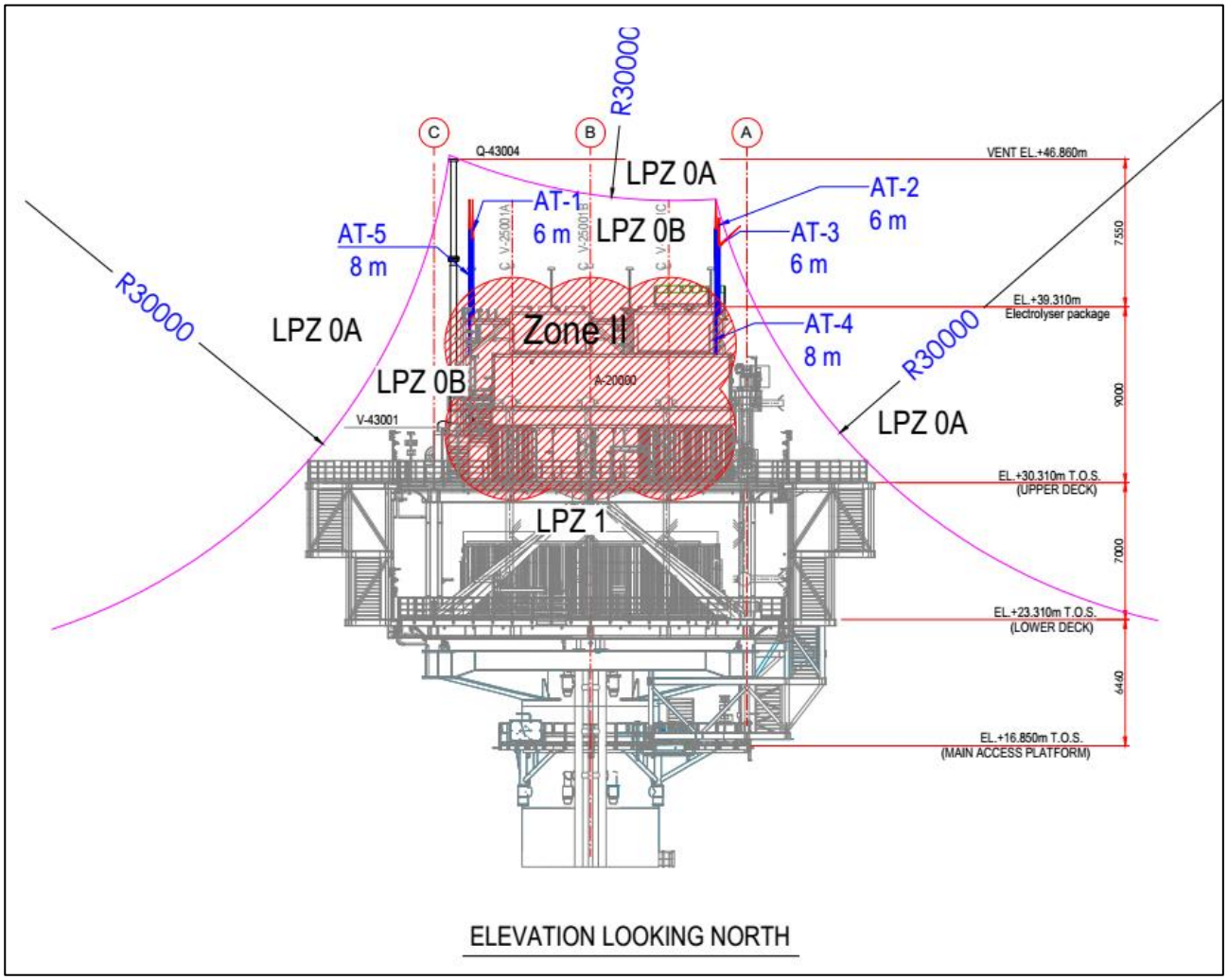
AT – Air Termination Rod

6.1.3 South Elevation View



AT – Air Termination Rod

6.1.4 North Elevation View



AT – Air Termination Rod

6.1.5 Welded Earth Boss

Connection: Welded boss Ø 50 mm

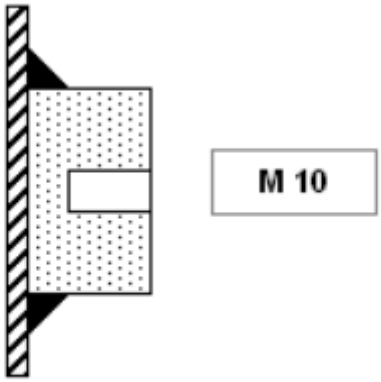


Figure 5 – Connection: Welded boss Ø 50 mm

6.2 IEC 62305 REFERENCES

6.2.1 IEC 62305-2 – Clause 5.4 – Specific procedure to evaluate the need of protection.

NOTE 2 Where protection against lightning is required by the authority having jurisdiction for structures with a risk of explosion, at least a class II LPS should be adopted. Exceptions to the use of lightning protection level II may be allowed when technically justified and authorized by the authority having jurisdiction. For example, the use of lightning protection level I is allowed in all cases, especially in those cases where the environments or contents within the structure are exceptionally sensitive to the effects of lightning. In addition, authorities having jurisdiction may choose to allow lightning protection level III systems where the infrequency of lightning activity and/or the insensitivity of the contents of the structure warrants it.

6.2.2 IEC 62305-3 – Table-2 – Minimum value of rolling sphere radius

Table 2 – Maximum values of rolling sphere radius, mesh size and protection angle corresponding to the class of LPS

	Protection method		
Class of LPS	**Rolling sphere radius *r*** m	**Mesh size w_m** m	**Protection angle** $\alpha°$
I	20	5 × 5	See Figure 1 below
II	30	10 × 10	
III	45	15 × 15	
IV	60	20 × 20	

6.2.3 IEC 62305-3 – Table-3 – Minimum thickness of metal in air-termination system

The metal parts of the structure can be considered as natural air termination components, complying with the minimum thickness recommended in IEC 62305-3, Table-3.

Table 3 – Minimum thickness of metal sheets or metal pipes in air-termination systems

Class of LPS	**Material**	**Thickness[a] *t*** mm	**Thickness[b] *t'*** mm
I to IV	Lead	–	2,0
	Steel (stainless, galvanized)	4	0,5
	Titanium	4	0,5
	Copper	5	0,5
	Aluminium	7	0,65
	Zinc	–	0,7

[a] *t* prevents puncture.

[b] *t'* only for metal sheets if it is not important to prevent puncture, hot spot or ignition problems.

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6.2.4 IEC 62305-3 – Table-6 – Minimum cross-sectional area of conductors

Table 6 – Material, configuration and minimum cross-sectional area of air-termination conductors, air-termination rods, earth lead-in rods and down-conductors [a]

Material	Configuration	Cross-sectional area mm²
Copper, Tin plated copper	Solid tape	50
	Solid round [b]	50
	Stranded [b]	50
	Solid round [c]	176
Aluminium	Solid tape	70
	Solid round	50
	Stranded	50
Aluminium alloy	Solid tape	50
	Solid round	50
	Stranded	50
	Solid round [c]	176
Copper coated aluminium alloy	Solid round	50
Hot dipped galvanized steel	Solid tape	50
	Solid round	50
	Stranded	50
	Solid round[c]	176
Copper coated steel	Solid round	50
	Solid tape	50
Stainless steel	Solid tape [d]	50
	Solid round [d]	50
	Stranded	70
	Solid round [c]	176

[a] Mechanical and electrical characteristics as well as corrosion resistance properties shall meet the requirements of the future IEC 62561 series.

[b] 50 mm² (8 mm diameter) may be reduced to 25 mm² in certain applications where mechanical strength is not an essential requirement. Consideration should in this case, be given to reducing the spacing between the fasteners.

[c] Applicable for air-termination rods and earth lead-in rods. For air-termination rods where mechanical stress such as wind loading is not critical, a 9,5 mm diameter, 1 m long rod may be used.

[d] If thermal and mechanical considerations are important then these values should be increased to 75 mm².

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6.2.5 IEC 62305-3 – Table-7 – Minimum dimensions of earth electrodes

Table 7 – Material, configuration and minimum dimensions of earth electrodes [a, e]

Material	Configuration	Dimensions		
		Earth rod diameter mm	Earth conductor mm^2	Earth plate mm
Copper Tin plated copper	Stranded		50	
	Solid round	15	50	
	Solid tape		50	
	Pipe	20		
	Solid plate			500 × 500
	Lattice plate [c]			600 × 600
Hot dipped galvanized steel	Solid round	14	78	
	Pipe	25		
	Solid tape		90	
	Solid plate			500 × 500
	Lattice plate [c]			600 × 600
	Profile	[d]		
Bare steel[b]	Stranded		70	
	Solid round		78	
	Solid tape		75	
Copper coated steel	Solid round	14 [f]	50	
	Solid tape		90	
Stainless steel	Solid round	15 [f]	78	
	Solid tape		100	

[a] Mechanical and electrical characteristics as well as corrosion resistance properties shall meet the requirements of the future IEC 62561 series.

[b] Shall be embedded in concrete for a minimum depth of 50 mm.

[c] Lattice plate constructed with a minimum total length of the conductor of 4,8 m.

[d] Different profiles are permitted with a cross-section of 290 mm^2 and a minimum thickness of 3 mm, e.g. cross profile.

[e] In case of a type B arrangement foundation earthing system, the earth electrode shall be correctly connected at least every 5 m with the reinforcement steel.

[f] In some countries the diameter may be reduced to 12,7 mm.

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6.2.6 IEC 62305-2 – Table-C.5 – Reduction factor r_f as a function of risk of fire or explosion of structure

Table C.5 – Reduction factor r_f as a function of risk of fire or explosion of structure

Risk	Amount of risk	r_f
Explosion	Zones 0, 20 and solid explosive	1
	Zones 1, 21	10^{-1}
	Zones 2, 22	10^{-3}
Fire	High	10^{-1}
	Ordinary	10^{-2}
	Low	10^{-3}
Explosion or fire	None	0

NOTE 4 In case of a structure with risk of explosion, the value for r_f may need a more detailed evaluation.

NOTE 5 Structures with a high risk of fire may be assumed to be structures made of combustible materials or structures with roofs made of combustible materials or structures with a specific fire load larger than 800 MJ/m^2.

NOTE 6 Structures with an ordinary risk of fire may be assumed to be structures with a specific fire load between 800 MJ/m^2 and 400 MJ/m^2.

NOTE 7 Structures with a low risk of fire may be assumed to be structures with a specific fire load less than 400 MJ/m^2, or structures containing only a small amount of combustible material.

NOTE 8 Specific fire load is the ratio of the energy of the total amount of the combustible material in a structure and the overall surface of the structure.

NOTE 9 For the purposes of this part of IEC 62305, structures containing hazardous zones or containing solid explosive materials should not be assumed to be structures with a risk of explosion if any one of the following conditions is fulfilled:

a) the time of presence of explosive substances is lower than 0,1 h/year;

b) the volume of explosive atmosphere is negligible according to IEC 60079-10-1[2] and IEC 60079-10-2[3];

c) the zone cannot be hit directly by a flash and dangerous sparking in the zone is avoided.

NOTE 10 For hazardous zones enclosed within metallic shelters, condition c) is fulfilled when the shelter, as a natural air-termination system, acts safely without puncture or hot-spot problems, and internal systems inside the shelter, if any, are protected against overvoltages to avoid dangerous sparking.