Base Load Power Hub (BLPH)

FAT PROCEDURE - Factory Acceptance test Procedure and Reports - HV CABLE AND ACCESSORIES

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reynard HIGH VOLTAGE SOLUTIONS

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Revision / Change Log

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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.

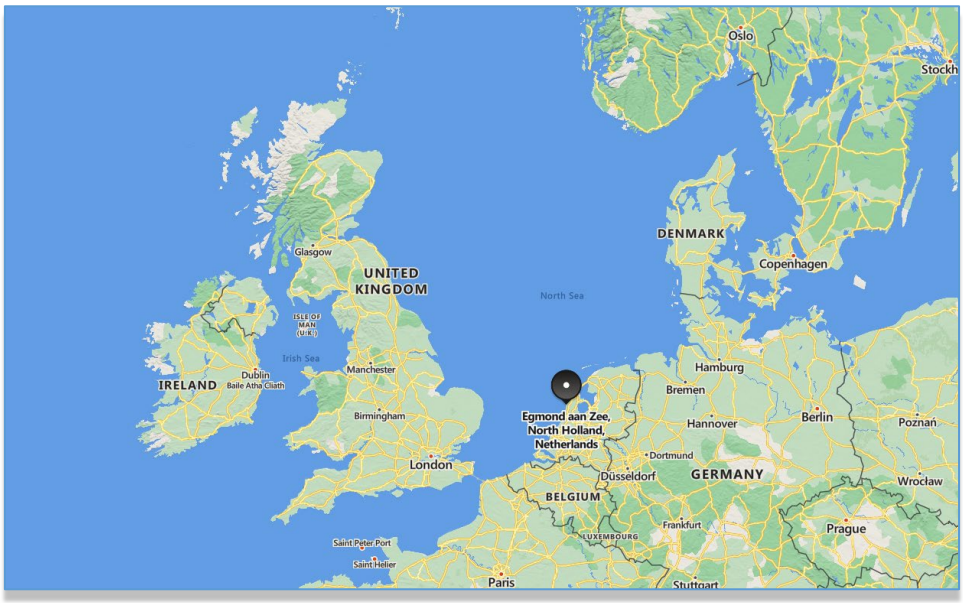


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

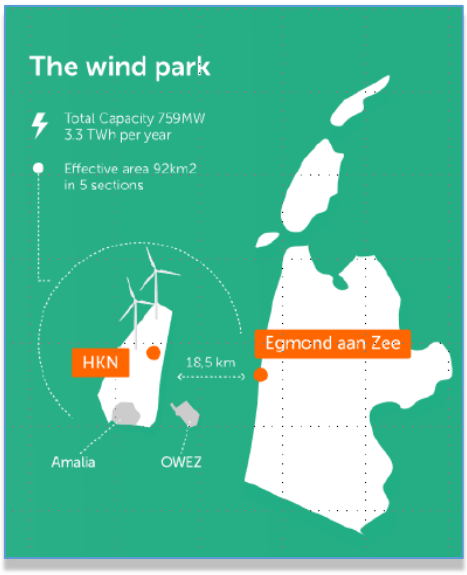


Figure 2 - Wind Park Details

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.

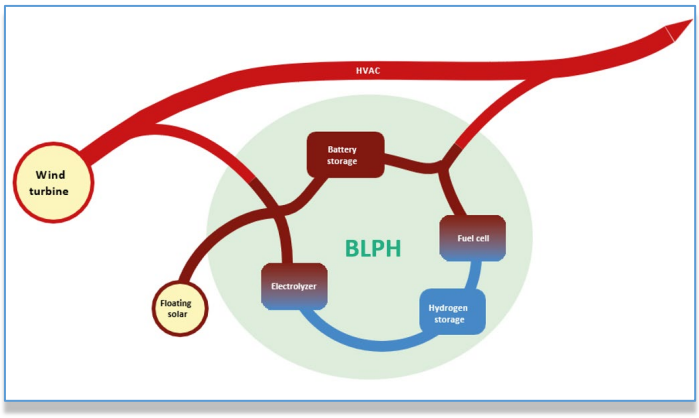


Figure 3 – BLPH Concept

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.

2 DOCUMENT SCOPE

The Factory Acceptance Test (FAT) document establishes a framework for assessing the performance, quality, and compliance of equipment or systems before delivery. It delineates the test plan, procedures, and acceptance criteria while ensuring alignment with technical specifications and regulatory standards. This document serves as an assurance tool to verify the readiness of the product for installation and commissioning in the field.

2.1 REFERENCES

Doc. No.	Description
1724002000-EL-DS-00003	DATA SHEETS - HV CABLE
1724002000-EL-DS-00004	DATA SHEETS - T-CONNECTORS
1724002000-QC-ITP-00002	INSPECTION AND TEST PLAN -HV CABLE AND ACCESSORIES

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

Table 2 - Definitions and Abbreviations

3 HV CABLE FACTORY ACCEPTANCE TEST

Cable Type: Cu/XLPE/CWS/LAT/LSZH 36/66 kV 1 x 240 / 50
Standards: IEC 60228:2023, IEC 60840:2020

3.1 PREPARATION AND VISUAL INSPECTION

3.1.1 Verification of Documentation

- Confirm that the cable under test matches the specification (type, dimensions, markings, etc.).
- Verify test equipment calibration certificates and compliance with standards.

3.1.2 Visual Inspection

- Examine the cable for any visible defects, such as surface irregularities, damage, or inconsistencies in the layers (sheath, insulation, etc.).
- Document any observations before proceeding to electrical tests.

3.2 CONDUCTOR RESISTANCE TEST

Standard: IEC 60228:2023, Table 4 & IEC60840:2020 §10.5

Objective: Verify that the DC resistance of the copper conductor complies with specified values.

Procedure:

1. Connect the conductor ends to a resistance measurement device.
2. Apply a stable DC current as per standard requirements.
3. Measure and record the conductor resistance at 20°C.
4. Verify compliance with IEC 60228:2023, Table 4 & IEC60840:2020 §10.5 values.

3.3 VOLTAGE TEST (WITHSTAND TEST)

Standard: IEC 60840:2020, §9.3

Objective: Verify the cable's insulation withstands the specified AC voltage without breakdown.

Procedure:

1. Mount the cable on insulated supports to avoid external interference.

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2. Apply an AC voltage of 2.5 x U0 (where U0 is the nominal voltage) for a duration of 30 minutes.
3. Gradually increase the voltage to avoid transients.
4. Monitor the cable for any signs of insulation failure or breakdown.
5. Document the test result as "Pass" or "Fail."

3.4 PARTIAL DISCHARGE TEST

Standard: IEC 60840:2020, §9.2

Objective: Assess the quality of the cable insulation by measuring partial discharge (PD) levels.

Procedure:

1. Set up the test system, including coupling capacitors and a PD measurement device.
2. Apply a voltage of 1.75 x U0 for 10sec and then decrease to 1.5 x U0.
3. Measure the PD levels during the test duration.
4. Ensure the PD values are within acceptable limits as specified in IEC 60840:2020, §9.2.

3.5 SCREEN RESISTANCE TEST

Standard: IEC 60840 §10.5 & IEC 60228:2023, Table 4

Objective: Confirm that the resistance of the cable's screen complies with the standard.

Procedure:

1. Connect the ends of the screen to a resistance measurement device.
2. Apply a stable DC current as specified.
3. Measure and record the resistance at 20°C.
4. Compare the measured resistance against the limits in IEC 60840 §10.5 & IEC 60228:2023, Table 4

3.6 CAPACITANCE TEST

Standard: IEC 60840:2020, §10.10

Objective: Measure the capacitance of the cable to verify the consistency of the insulation system.

Procedure:

1. Connect the test equipment to the conductor and the screen.
2. Apply an AC voltage within the specified range.
3. Measure the capacitance value per unit length.
4. Record the results and ensure they comply with the design specifications and IEC 60840:2020, §10.10.

3.7 FINAL REVIEW AND REPORTING

1. Compile all test results, including measured values, observations, and pass/fail status.
2. Ensure all tests meet the specified standards and contract requirements.
3. Prepare a detailed test report with supporting evidence (photos, measurements, and observations).
4. Submit the report for client approval and retain a copy for documentation.

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4 HV CABLE TEST REPORTS

Inspection & Test Plan

IEC 60840

Art. 58239

Cu/XLPE/CWS/LAT/LSZH 36/66 kV 1 x 240 / 50

FAT scheduled 23-01-2025

Document:	#58239
Version:	0.1
Date:	20/01/2025
Page:	1 of 1

Item	Test	Requirement	Standard	Test	CU	TPI	Results FAT	Signature
1	Partial discharge	Sensitivity ≤ 10pC 10 sec. 1.75Uo then decrease to 1.5Uo No detectable discharge exceeding the declared sensitivity	IEC60840: 2020 §9.2	RT	W	W	Pass / Fail	
2	Voltage test	30 min: 2,5 x 36 = 90 kV No breakdown	IEC60840: 2020 §9.3	RT	W	W	Pass / Fail	
3	Electrical test on oversheath of the cable, Spark test	15 kV	IEC60840: 2020 §9.4	RT	W	W	Pass / Fail	
4	Conductor resistance	Shall not exceed the maximum value:	IEC 60840 §10.5	RT	W	W	Pass / Fail	
		Max. 0,0754 Ohm/km	IEC 60228:2023, Table 4					
5	Screen resistance	Shall not exceed the maximum value:	IEC 60840 §10.5	RT	W	W	Pass / Fail	
		Max. 0,387 Ohm/km	IEC 60228:2023, Table 4					
6	Capacitance	Nom. 0,21 µF/km	IEC60840: 2020	ST	W	W	Pass / Fail	
		Max. 0,2268 µF/km	§10.10					
7	Nameplate marking, tagging, color coding & labeling			P	W	W	Pass / Fail	
8	Check of drums			P	W	W	Pass / Fail	
9	Inspection (Release) report				H	H	Pass / Fail	

Frequencies of Routine and Sample tests

Routine tests	According to IEC 60840
Sample tests	According to IEC 60840

Note:

TPI:	Third Party Inspector
CU:	Customer
FAT:	Factory Acceptance Test
H:	Hold Point
P:	Perform
RT:	Routine test
ST:	Sample test
TKF:	BV Twentsche Kabelfabriek (Manufacturer)
WSR:	Witness a Special Request -Hotset (seperate visit or document control as preferred by client)
W:	Witness Point

Inspection & Test Plan

IEC 60840

Art. 58239

Cu/XLPE/CWS/LAT/LSZH 36/66 kV 1 x 240 / 50

FAT scheduled 23-01-2025

Document:	#58239
Version:	0.1
Date:	07-11-2024
Page:	1 of 1

Item	Test	Requirement	Standard	Test	CU	TPI	Results FAT	Signature
1	Conductor resistance 0,07438	Shall not exceed the maximum value: Max. 0,0754 Ohm/km	IEC 60228:2004 Table 2	RT	W	W	Pass / ~~Fail~~	
2	Voltage test	30 min: 2,5 x 36 = 90 kV No breakdown	IEC60840: 2020 §9.3	RT	W	W	Pass / ~~Fail~~	
3	Partial discharge	Sensitivity ≤ 10pC 10 sec. 1.75Uo then decrease to 1.5Uo No detectable discharge exceeding the declared sensitivity	IEC60840: 2020 §9.2 0,7 PC	RT	W	W	Pass / ~~Fail~~	
4	Screen resistance 92607	Shall not exceed the maximum value: Max. 0,387 Ohm/km	IEC 60228:2004 Table 2	RT	W	W	Pass / ~~Fail~~	
5	Capacitance 198 nF	Nom. 0,21 µF/km Max. 0,2268 µF/km	IEC60840: 2020 §10.10	RT	W	W	Pass / ~~Fail~~	
6	Nameplate marking, tagging, color coding & labeling	Drum: 25228484 Production order: 5126600005		P	W	W	Pass / ~~Fail~~	

7	Check of drums			P	W	W	Pass / ~~Fail~~	
8	Inspection (Release) report				H	H	Pass / ~~Fail~~	

Frequencies of Routine and Sample tests

Routine tests	According to IEC 60840
Sample tests	According to IEC 60840

Note:

TPI:	Third Party Inspector
CU:	Customer
FAT:	Factory Acceptance Test
H:	Hold Point
P:	Perform
RT:	Routine test
ST:	Sample test
TKF:	BV Twentsche Kabelfabriek (Manufacturer)
WSR:	Witness a Special Request -Hotset (seperate visit or document control as preferred by client)
W:	Witness Point

BV TWENTSCHE KABELFABRIEK

Quality Certificate

Results of Final Inspection according to specification : IEC 60840

Cable Identification

Construction	: 58239 Cu/XLPE/CWS/LAT/LSZH 36/66 kV 1 x 240 / 50
Cable number	: 9999999997
Drum number	: 25228484
Length [m]	: 1006
Inspection date	: 23-01-2025

These results concern the total tested length of cablenumber :9999999997
The total length was dispatched.

Routine Test

Outer diameter of the cable	[mm]	: 49.10	
Test voltage	90 kV 30 minutes	: Passed	
Spark test oversheath acc. MIK		: Passed	
Partial discharge test 1.5 U0	[pC]	: 1.0	Limit Max: 10.0
DC-resistance: conductor	[Ohm/km]	: 0.0739	Limit Max.: 0.0754
Screen resistance	[Ohm/km]	: 0.259	Limit Max.: 0.387
Sheathmarking		: Approved	

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BV TWENTSCHE KABELFABRIEK

Quality Certificate

Results of Final Inspection according to specification : IEC 60840

Cable Identification

Construction	: 58239 Cu/XLPE/CWS/LAT/LSZH 36/66 kV 1 x 240 / 50
Cable number	: 5126600005
Drum number	: 25228484
Length [m]	: 1006
Inspection date	: 15-01-2025

These results concern the total tested length of cablenumber :5126600005
The total length was dispatched.

Routine Test

Test voltage	90 kV 30 minutes	: Passed	
Spark test oversheath acc. MIK		: Passed	
Partial discharge test 1.5 U0	[pC]	: 1.0	Limit Max: 10.0
DC-resistance: conductor	[Ohm/km]	: 0.0741	Limit Max.: 0.0754
Screen resistance	[Ohm/km]	: 0.259	Limit Max.: 0.387

Sample Test

		Results	Spec	
Sheathmarking according spec		: Yes		
Lengthmarking present		: Present		
Outer diameter of the cable	[mm]	: 49.4	Min:	45.7
Thickness of outer sheath	[mm]	: 2.59	Avg:	2.50
		: 2.36	Min:	2.03
Alu-foil thickness	[mm]	: 0.21	Max:	0.22
		: 0.20	Min:	0.18
Thickness counterspiral	[mm]	: 0.09		
Width counterspiral	[mm]	: 20.1		
Stroke length screen	[mm]	: 611		
Diameter over screen	[mm]	: 43.9		
Number of copper wires	[n]	: 46		
Thickness copper wires armouring	[mm]	: 1.15		
		: 1.15		

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BV TWENTSCHE KABELFABRIEK

Quality Certificate

Results of Final Inspection according to specification : IEC 60840

Cable Identification

Construction	: 58239 Cu/XLPE/CWS/LAT/LSZH 36/66 kV 1 x 240 / 50
Cable number	: 5126600005
Drum number	: 25228484
Length [m]	: 1006
Inspection date	: 15-01-2025

These results concern the total tested length of cablenumber :5126600005
The total length was dispatched.

Thickness of insulation screen	[mm]	: 0.82 : 0.79	Avg: Min:	0.80 0.75
Thickness of insulation	[mm]	: 9.45 : 9.40	Avg: Min:	9.50 9.00
Thickness of conductor screen	[mm]	: 0.85 : 0.75	Avg: Min:	0.80 0.75
Diameter over conductor	[mm]	: 19.03	Max:	19.100
Sheathmarking according datasheet		: Yes		

Sheathmarking:
{Length} TKF - Cu/XLPE/CWS/LAT/LSZH 36/66 kV 1 x 240/50 IEC 60840 - 2025 512660

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5 T-CONNECTORS TEST REPORTS (TE CONNECTIVITY)

Not available yet

6 T-CONNECTORS TEST REPORTS (NEXANS)

Not available yet