Base Load Power Hub (BLPH)

STRUCTURAL MATERIAL SPECIFICATION FOR TP AND TOPSIDE

Document Number: 123A90-DDL-ST-SP-90018

Document Class: 2

02	25/06/2024	Accepted for Construction (AFC)	A.Balzarotti	D.Casadio	D.LoSterzo
01	11/12/2023	Issue for Approval (IFA)	A.Balzarotti	D.Casadio	D.LoSterzo
00	09/10/2023	Issue for Review (IFR)	A.Castiello	A.Balzarotti	D.LoSterzo
Rev.	Date	Description	Prepared	Reviewed	Approved

TECON

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Revision / Change Log

Rev.	Description
00	Issue for Review (IFR)
01	Issue for Approval (IFA)
02	Accepted for Construction (AFC)

HOLDS LIST

No.	Description
1	
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.

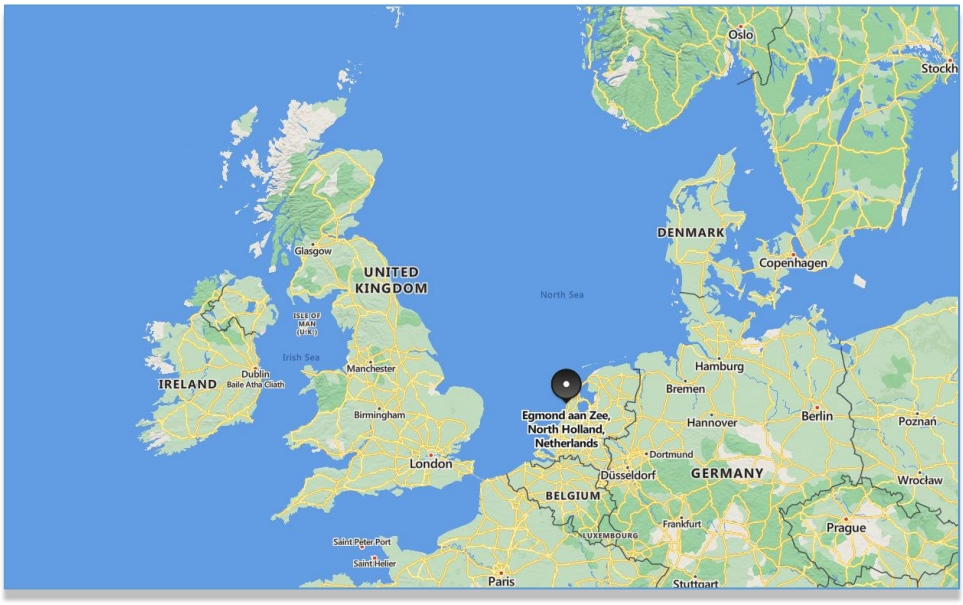


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

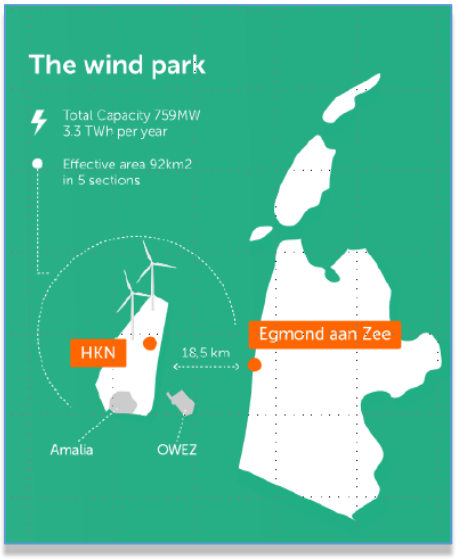


Figure 2 - Wind Park Details

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.

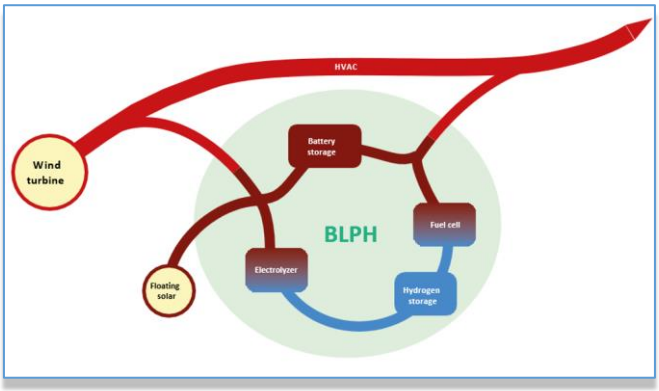


Figure 3 – BLPH Concept

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

The scope of this document is to provide the selection of the structural steels to be used in the construction of offshore platforms of BLPH Topside, in particular it is dedicated to Transition Piece and Topside.

The material selection criteria are based on the requirements of ISO 19906:2019, ISO 19902:2020 and ISO 19901-3:2014. The materials are in accordance with the EN standard 10225:2019 and 10025:2019 and are suitable for plates, rolled sections and welded / seamless tubulars.

2.1 REFERENCE CODES

Doc. No.	Description
1. ISO 19906:2019	Petroleum and Natural gas industries – Artic offshore structures, Second edition 2019-07
2. ISO 19902:2020	Petroleum and Natural gas industries – Fixed steel offshore structures, Second edition 2020-11
3. ISO 19901-3:2014	Petroleum and Natural gas industries – Specific requirements for offshore structures – Part 3: Topside Structure, Second edition 2014-12-15
4. EN 10225:2019	Weldable structural steels for fixed offshore structures, part 1 to 4, 2019
5. EN 10025:2019	Hot rolled products of structural steels, part 1 to 6, 2019
6. EN 10204:2004	Metallic products Types of inspection documents
7. EN 10164:2018	Steel products with improved deformation properties perpendicular to the surface of the product - Technical delivery conditions
8. DEP 37.19.00.12-Gen	DEP Specification – Offshore Topsides structures (ADOPTION OF IOGP S-631-04, AMENDMENTS/SUPPLEMENTS TO ISO 19901-3: 2014)
9. IOGP S-631-04	Supplementary specification for Offshore topside Structures, April 2023
10. DNVGL-ST-0126	Support structures for wind turbine, 2018
11. DNV-ST-0145	DNV, Offshore substations, 2021
12. DNV-OS-B101	Metallic materials, 2021

Table 1 - Reference Documents

2.2 REFERENCE DOCUMENTS

Doc. No.	Description
13. 123A90-DDL-ST-SP-90017	Structural Design Premises
14. 123A90-DDL-ST-SP-90019	Fabrication specification

Table 2 – Reference documents

2.3 DEFINITIONS AND ABBREVIATIONS

2.3.1 Definitions

COMPANY or Client (CPY):	Crosswind
CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project

Table 3 - Definitions

2.3.2 Abbreviations

NA	Not applicable
THK	Thickness
LAST	Lowest anticipated service temperature
TP	Transition Piece
TT	Through-thickness;
CVN	Charpy V-notch
SHS	Seamless hollow section
DC	Design class
SQL	steel quality

Table 4 - Abbreviations

3 DESIGN CLASSES

The selection of the steel quality (SQL) is performed according to ISO 19902:2020, sect 19.6, Ref. 2 using Design Class approach.

Table 19.6-1 — Design class classification of structural components

Design class	Component complexity [a]	Consequences of failure
DC 1	High	Applicable to joints and members where failure has substantial consequences [b] and the structure possesses limited residual strength [c]
DC 2	Low	
DC 3	High	Applicable to joints and members where failure does not have substantial consequences [b] because of the structure's residual strength [c]
DC 4	Low	
DC 5	Any	Applicable to joints and members where failure does not have substantial consequences [b]

[a] High joint complexity means joints where the geometry of connected elements and weld type leads to high restraint and to a triaxial stress pattern, e.g. typically multi-planar plated connections with full penetration welds and unstiffened leg nodes subject to high stress concentrations.

[b] "Substantial consequences" in this context means that failure of the joint or member could entail one or more of the following:

— loss of human life;

— significant pollution;

— major financial consequences.

[c] A structure may be assumed to have adequate residual strength, if it meets the ALS requirements when the component under consideration is damaged.

Table 5 – Design Class classification

The minimum requirements for material selection (SQL) are shown in Table 5.

Table 19.6-2 — Correlation between DC and SQL

Design class	SQL			
	I	II	III	IV
DC 1	✓			
DC 2	(✓)	✓		
DC 3	(✓)	✓		
DC 4	(✓)		✓	
DC 5				✓

(✓) = Select when joint strength through-thickness ductility is required.

Table 6 – Correlation between DC and SQL

SQL's are defined as follows:

- SQL I steels – steels for which the most stringent requirements apply (see ISO 19902:2020 sect.19.6.3.2) and that are used for the most critical parts of the structure. SQL I steels are used in cases where through-thickness properties are required.
- SQL II steels – steels with somewhat lower quality than SQL I steels and that are used for DC 2 and DC 3 components.
- SQL III steels – steels with lower quality than SQL II steels and that are used for DC 4 components.
- SQL IV steels – steels with lower quality than SQL III steels and that are used for DC 5 components.

The list of the options requested by each steel quality is given in the Table 8.

Plates with SMYS 420 MPa and above are specified to have the same minimum yield strength for all thicknesses. This is normally achieved through adjustments of the chemical composition and minor changes in the manufacturing process.

4 LOWEST ANTICIPATED SERVICE TEMPERATURE (LAST)

Ref. ISO 19906:2019, ref. 1

In arctic and cold regions, LAST is determined as the extreme level (EL) temperature.

An extreme level event is based on an annual probability of exceedance not greater than 10^{-2}.

The Structural design premises documents, Ref.13, provides the minimum operational offshore air temperature statistics, as follows:

Minimum air temperature in the offshore area: -8.4°C

The selected LAST values are shown in the following table. The temperatures are specified for the exposed structural steel in air.

LAST in air
-10°C

Table 7 – LAST temperature

The LAST values establish the temperature for CVN test, which shall be taken as LAST minus the temperature margin shown in table 19.6-3 of ISO 19902:2020.

4.1 CHARPY V NOTCH

Minimum required average CVN impact fracture toughness values are shown in Table 7.

Table 19.6-3 — CVN impact fracture toughness test temperatures and energy requirements

SQL	I		II		III	IV
SMYS	≤400	400 ≤ 500	≤400	400 ≤ 500	355 ≤ 500	275 ≤ 355
Material thickness (mm)	Test temperature (°C)					
t ≤ 12	L +10	L - 10	L + 10	L + 10	L + 10	L + 20
12 < t ≤ 25	L - 10	L - 30	L + 10	L - 10	L + 10	L + 20
25 < t ≤ 50	L - 30	L - 30	L - 10	L - 30	L - 10	NA
t > 50	L - 30	L - 30	L - 30	L - 30	L - 30	NA
Energy requirement	50 J	60 J	50 J	60 J	40 J	27 J

L: LAST: Lowest Anticipated Service Temperature. For LAST lower than -10 °C, see Annex F and ISO 19906.

SMYS: Specified Minimum Yield Strength in MPa

NA: Not Applicable

Table 8 – CVN temperature and energy requirements

5 STRUCTURAL STEEL GRADE SELECTION

Ref. ISO 19902:2020 Annex D, ref. 2

The steel selection for plates and open and hollow sections is made using EN 10025, EN 10225 and API code.

			ISO EN 19902:2020						
Design Class	**Complexity**	**SQL**	**Plates and Welded Tubular**	**Sections**	**SMLS pipes**	**THK**	**CVN inpact test**	**Material Designation**	**List of Options (EN10225-1 to -4) & EN10025-3**
DC1 Complex lift-nodes and element connection to topside, Lift points, main complex joints	High	**I (Z properties)**	EN 10225 S420 QLO / ML	NA	NA	25 < t <= 50	-40	DC1-I-420-40_Z	2, 7, 8, 11, 12, 17, 18
						t > 50	-40		
DC2 simple joints, primary deck girders and beams of Topside and TP, column and diagonal to lift points, main columns, Davit crane support, Bolts	Low	**II**	EN 10225 S420 QLO / MLO	NA	NA	t < = 12	0	NA	-
						12 < t <= 25	-20	DC2-II-420-20	2, 7, 8, 11 17 for t > 40mm
						25 < t <= 50	-40	DC2-II-420-40	
						t > 50	-40		
DC3 all other columns and diagonals, stiffeners, Secondary deck beams, Grillage and sea fastening	High	**II**	EN 10225 S355 NLO / MLO	EN 10025 S355 MLO	EN 10225 S355 NLHHO / QLHHO API 5L X52	t < = 12	0	DC3-II-355-0 / DC3-II-X52-0	2, 7, 8 11 for plate 17 for t > 40mm
						12 < t <= 25	-20	DC3-II-355-20 / DC3-II-X52-20	
						25 < t <= 50	-40	DC3-II-355-40 / DC3-II-X52-40	
						t > 50	-40		
DC4 Equipment and vessel supports, modules supports, equipment fixing bolts	Low	**III**	EN 10025 S355 J2	EN 10025 S355 J2	API 5L X52 EN 10210 S355 J2H	t < = 12	0	DC4-III-355-0 / DC4-III-X52-0 / DC4-III-X60-0	-
						12 < t <= 25	0		
DC5 floor plating, grating, Walkways, stairs, handrails	Any	**IV**	EN 10025 S235 JR EN 10025 S275 J0 EN 10025 S355 J0	EN 10025 S235 JR EN 10025 S275 J0 EN 10025 S355 J0	API 5L Gr.B EN 10210 S235 JRH / EN 10210 S275 J0H / EN 10210 S355 J0H	t < = 12	10	DC5-IV-235-10 / DC5-IV-275-10 / DC5-IV-355-10 / DC5-IV-GRB-10	-
						12 < t <= 25	10		

Table 9 – Steel grade material list

Note: if TT properties are required, ref. is to EN10164, Ref. 7.

Mechanical properties for structural materials are presented in Table 9, Table 10 and Table 11.

- Young's Modulus = 205,000 N/mm^2
- Density = 7850 kg/m^3
- Poisson's Ratio = 0.3

Thickness (mm)	Min. Tensile Strength (N/mm²)	Min. Yield Strength (N/mm2)	Steel Type
t ≤ 16	500	420	I & II
16 < t ≤ 40	500	400	I & II
40 < t ≤ 63	480	390	I & II
63 < t ≤ 100	480	380	I & II
Note: 1) Type I steel has Z (through the thickness) properties.			

Table 10 – Mechanical properties of Plates

Thickness (mm)	Min. Tensile Strength (N/mm²)	Min. Yield Strength (N/mm2)	Steel Type
t ≤ 20	460	355	III
20 < t ≤ 40	460	345	III

Table 11 – Mechanical properties of Structural Seamless Tubulars

Thickness (mm)	Min. Tensile Strength (N/mm2)	Min. Yield Strength (N/mm2)	Steel Type
t ≤ 16	460/360	355/275	IV
16 < t ≤ 40	460	345	IV

Table 12 – Mechanical properties for Structural Sections

The minimum supplementary requirements, according to Ref. 4, shall be:

For SQL I and II (1) and (2) and for Z35 (12)

Other options apply based on good practise.

5.1 DESIGN CLASS FOR TOPSIDE STRUCTURAL ELEMENTS

The table 12 here after links the structural elements to the design class and therefore to Steel quality.

Design Class	Component	SQL
DC1	Complex lift-nodes and element connection to topside, Lift points, Main complex joints,	I
DC2	simple joints, primary deck girders and beams of Topside, column and diagonal to lift points, main columns, Davit crane support	II
DC3	all other columns and diagonals, stiffeners, Secondary deck beams, Grillage and sea fastening	II
DC4	Equipment and vessel supports, modules supports.	III
DC5	floor plating, grating, Walkways, stairs, handrails	IV

Table 13 – Material Selection

5.2 DESIGN CLASSIFICATION ACCORDING TO DNV CODE

BLPH project is based on ISO / EN codes, third party is DNV, therefore equivalent material selection is presented.

According to DNV code Ref. 11, the selection of steel material shall follow DNV-OS-C101 Ch.2 sec.3.

In case steel materials according to EN 10225, EN 10025, EN 10210, EN 10219, API Spec 2Y, API Spec 2W or others shall be used, selection shall be according to the flow chart in Figure 4-1. Selection of equivalent steel grades shall consider the following parameters:

- chemical composition especially CEV and sulfur-value–mechanical properties including impact properties
- service temperature
- location and orientation of impact test pieces
- other relevant steel manufacturing parameters.

The DNV code, Ref. 11, section 4.6 defines the steel materials, allowing for EN codes by using equivalent steel the following table presents the equivalent steel selection.

			DNV-ST-0145, 2021				
Design Class	**Complexity**	**SQL**	**Classification of Structural members (DNV-OS-C101)**	**Hot rolled bar (DNV-ST-0126)**	**Plates and Welded tubular**	**Sections**	**SMLS pipes**
DC1 Complex lift-nodes and element connection to topside, Lift points, main complex joints	High	**I (Z properties)**	**Special cat. "S"**		NV E420 / NV E460 (3)(4)		
DC2 simple joints, primary deck girders and beams of Topside and TP, column and diagonal to lift points, main columns, Davit crane support, Bolts	Low	**II**	**Primary category members "1"**		NV D420 (3)(4)		
DC3 all other columns and diagonals, stiffeners, Secondary deck beams, Grillage and sea fastening	High	**II**	**Primary category members "1"**		NV F36 (4)	NV F36 (4)	NV F36 (4)
DC4 Equipment and vessel supports, modules supports, equipment fixing bolts	Low	**III**	**Secondary category members "2"**		NV A36 / AW 36	NV A36 / AW 36	NV A36 / AW 36
DC5 floor plating, grating, Walkways, stairs, handrails	Any	**IV**	**Non structural members (NS)**		NV A NV A27S	NV A NV A27S	NV A27S
(3) Z35 option							
(4) certification and test temp. for artic areas							

Table 14– Material Selection DNV approach and corresponding ISO

5.2.1 Inspection category

Table 14 below shows the inspection category:

Table 4-21 Inspection category

Inspection category	*Structural category (see Table 4-1)*
I	Special
II	Primary
III	Secondary

Table 15- Material Inspection Category, Ref. 10.

Welds between flanges and adjacent shells shall be assigned to the inspection category I.

The longitudinal welds in the transition piece segments shall be inspected according to category I.

5.3 MATERIAL CERTIFICATES

Steel materials and products shall be delivered with inspection documents as defined in EN 10204, Ref. 6, with reference to Table 10-1 of ref. 11.

Certification process	*Material certificate (EN10204)*	*Structural category*
Test certificate as work certificate, inspection and tests witnessed and signed by an independent third party body	3.2	special
Work certificate test results of all specified tests from samples taken from the products supplied. Inspection and tests witnessed and signed by QA department	3.1	primary
Test report confirmation by the manufacturer that the supplied products fulfil the purchase specification, and test data from regular production, not necessarily from products supplied	2.2	secondary

			ISO EN 19902:2020							DNV-ST-0145, 2021				
Design Class	**Complexity**	**SQL**	**Plates and Welded Tubular**	**Sections**	**SMLS pipes**	**THK**	**CVN inpact test**	**Material Designation**	**List of Options (EN10225-1 to -4) & EN10025-3**	**Classification of Structural members (DNV-OS-C101)**	**Hot rolled bar (DNV-ST-0126)**	**Plates and Welded tubular**	**Sections**	**SMLS pipes**
DC1 Complex lift-nodes and element connection to topside, Lift points, main complex joints	High	**I (Z properties)**	EN 10225 S420 QLO / ML	NA	NA	25 < t <= 50	-40	DC1-I-420-40_Z	2, 7, 8, 11, 12, 17, 18	**Special cat. "S"**		NV E420 / NV E460 (3)(4)		
						t > 50	-40							
DC2 simple joints, primary deck girders and beams of Topside and TP, column and diagonal to lift points, main columns, Davit crane support, Bolts	Low	**II**	EN 10225 S420 QLO / MLO	NA	NA	t < = 12	0	NA	-	**Primary category members "1"**		NV D420 (3)(4)		
						12 < t <= 25	-20	DC2-II-420-20	2, 7, 8, 11 17 for t > 40mm					
						25 < t <= 50	-40	DC2-II-420-40						
						t > 50	-40							
DC3 all other columns and diagonals, stiffeners, Secondary deck beams, Grillage and sea fastening	High	**II**	EN 10225 S355 NLO / MLO	EN 10025 S355 MLO	EN 10225 S355 NLHHO / QLHHO API 5L X52	t < = 12	0	DC3-II-355-0 / DC3-II-X52-0	2, 7, 8 11 for plate 17 for t > 40mm	**Primary category members "1"**		NV F36 (4)	NV F36 (4)	NV F36 (4)
						12 < t <= 25	-20	DC3-II-355-20 / DC3-II-X52-20						
						25 < t <= 50	-40	DC3-II-355-40 / DC3-II-X52-40						
						t > 50	-40							
DC4 Equipment and vessel supports, modules supports, equipment fixing bolts	Low	**III**	EN 10025 S355 J2	EN 10025 S355 J2	API 5L X52 EN 10210 S355 J2H	t < = 12	0	DC4-III-355-0 / DC4-III-X52-0 / DC4-III-X60-0	-	**Secondary category members "2"**		NV A36 / AW 36	NV A36 / AW 36	NV A36 / AW 36
						12 < t <= 25	0							
DC5 floor plating, grating, Walkways, stairs, handrails	Any	**IV**	EN 10025 S235 JR EN 10025 S275 J0 EN 10025 S355 J0	EN 10025 S235 JR EN 10025 S275 J0 EN 10025 S355 J0	API 5L Gr.B EN 10210 S235 JRH / EN 10210 S275 J0H / EN 10210 S355 J0H	t < = 12	10	DC5-IV-235-10 / DC5-IV-275-10 / DC5 IV-355-10 / DC5-IV-GRB-10	-	**Non structural members (NS)**		NV A NV A27S	NV A NV A27S	NV A27S
						12 < t <= 25	10							

(3) Z35 option

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