Base Load Power Hub (BLPH)

STRUCTURAL MATERIAL SPECIFICATION FOR FLANGE AND BOLTS

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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.

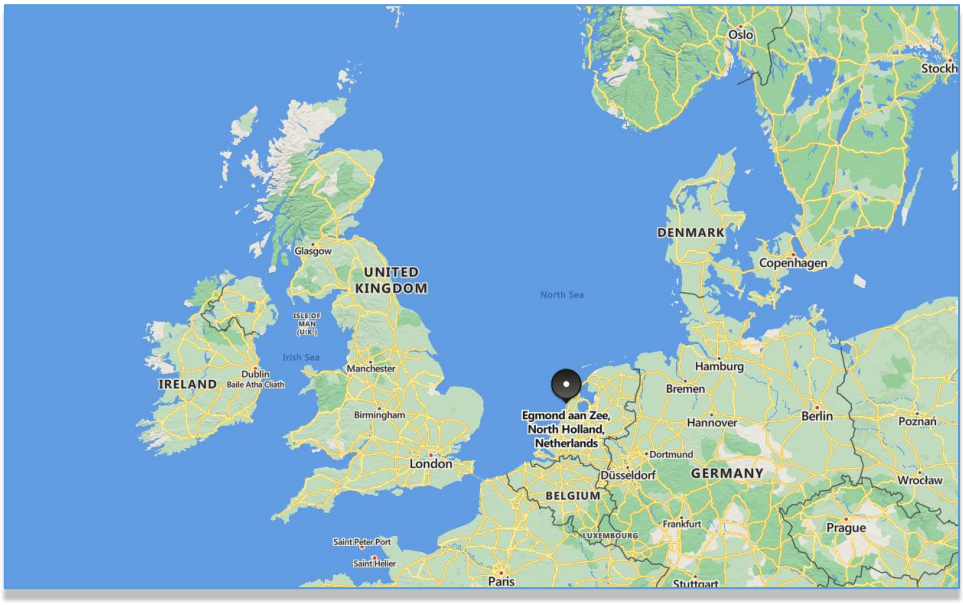


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

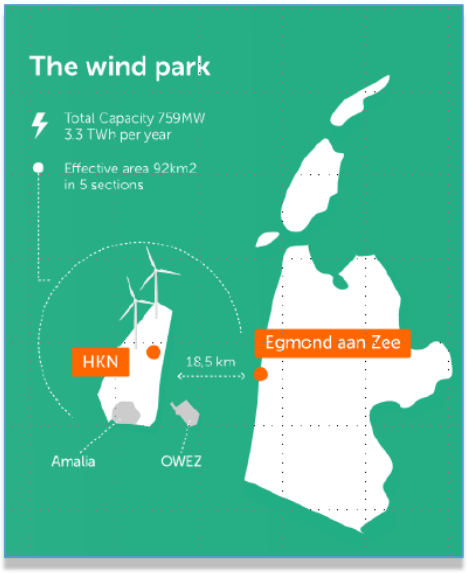


Figure 2 - Wind Park Details

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.

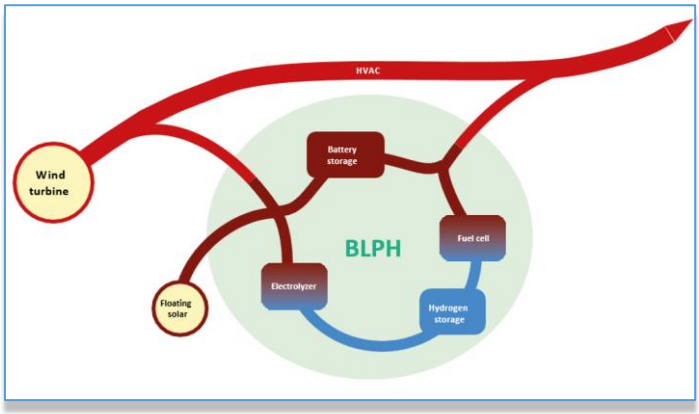


Figure 3 – BLPH Concept

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 flange and Bolts.

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 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
11. DNV-ST-0145	DNV, Offshore substations, 2021
12. DNV-OS-B101	Metallic materials, 2021
13. DIBt Richtlinie für Windenergieanlagen	Einwirkungen und Standsicherheitsnachweise für Turm und Gründung, Oktober 2012 – Korrigierte Fassung März 2015

Table 1 - Reference Codes and Standards

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2.2 REFERENCE DOCUMENTS

Doc. No.	Description
14. 123A90-DDL-ST-SP-90017	Structural Design Premises
15. 123A90-DDL-ST-DD-90083	TP – Flange connection drawing
16. K559-2254-MT-SPE-001	Fabrication Specification rev 1

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
TT	Through-thickness;
TP	Transition piece
CVN	Charpy V-notch
SHS	Seamless hollow section
DC	Design class
SQL	steel quality
TP	Transition Piece

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

4 FLANGE STEEL GRADE SELECTION

Steel designation, impact test temperature and List of options required for flange are shown in the following table.

Flange material S420 NL according to EN10025-3 + TT properties required according to EN10164, Ref. 7 .

			EN10025-3				
Design Class	**Complexity**	**SQL**	**Hot rolled bar**	**THK**	**CVN inpact test**	**Material Designation**	**List of Options (EN10225-1 to -4) & EN10025-3**
DC1 TP to monopile flange connection	High	**I** **(Z properties)**	EN 10025 S420 NL	t > 50	-40	DC1-I-420-40_Z	1, 2, 3, 4, 6, 12, 18, 24, 30

Table 7 – Steel designation, impact test temp. and List of options

Mechanical properties for structural materials are presented in Table 8.

- 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
63 < t < 80	500	390	I
t > 250mm	460	320	I
Note: 1) Type I steel has Z (through the thickness) properties.			

Table 8 – Mechanical properties of Flange (EN10025)

4.1 DESIGN CLASSIFICATION ACCORDING TO DNV CODE

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 TP to monopile flange connection	High	**I** **(Z properties)**	**Special cat.** **"S"**	EHS VL E420 (3)(4)			
(3) Z35 option							
(4) certification and test temp. for artic areas							

Table 9– Material Selection DNV approach and corresponding ISO

4.1.1 Inspection category

Table 10 below shows the inspection category:

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

Table 10– Material Inspection Category, Ref..10

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

4.2 IMPACT TEST

Test temperature = -40 deg. Minimum required average CVN impact fracture toughness values are shown in EN10025-3, ref 5 and DNV code, Ref 12.

Impact test in long. direction Average ≥ 42 J (no single value < 33J)

Impact test in transv. direction Average ≥ 28 J (no single value < 20J)

4.3 MATERIAL CERTIFICATES

Steel materials and products shall be delivered with inspection documents as defined in EN 10204, Ref.6, Certificate 3.2 required.

5 BASE MATERIAL FOR UPPER FLANGE

Appendix 1 presents the design drawing of the upper flange to be fabricated according to this specification.

Appendix 2 shows for information, the drawings of the existing lower flange, to which the flange described in this specification shall couple.

According to Ref. 10, section 4.2.5.1 the guidance for selection of flange material with a weld neck may be according to DiBT (Ref.13). The DiBT provides in section 13.4.2 the following guidance on material selection:

13.4.2 Maßgebende Erzeugnisdicke bei Ringflanschverbindungen

Die maßgebende Erzeugnisdicke ist für Ringflansche wie folgt zu wählen:

- Bei Ringflanschen mit Ansatz (Vorschweißflansch) die Blechdicke der anschließenden Turmwand (b gemäß Bild 12); der Abstand vom Schweißnahtübergang einschließlich des Übergangsradius (l + r gemäß Bild 12) muss dabei mindestens der halben anschließenden Blechdicke entsprechen, ansonsten ist der Flansch als "ohne Ansatz" zu bewerten.

Figure 4 – Guidance on material selection

In short translation:

The governing product thickness for determination of the material quality for a forged flange out of one piece may be based upon the flange neck thickness *b* (Figure 5) if the following condition is met:

Neck length (l+ r) > 0.5 *b* (see Figure 5).

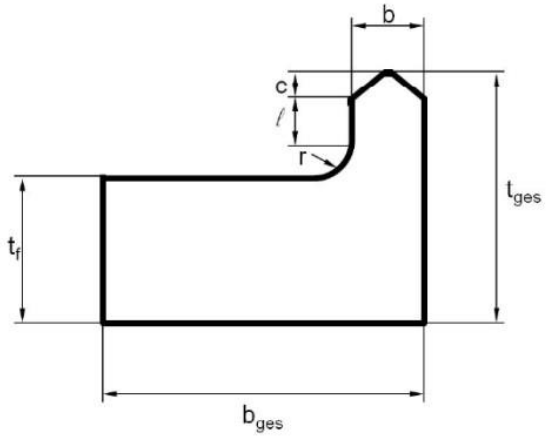


Figure 5 - Flange size parameters DiBt ref. 13.

In Figure 6:

(l+r) = (280-120-50*sin30-10*4-50) = 53 mm > 0.5*b = 0.5*75 =37.5 mm.

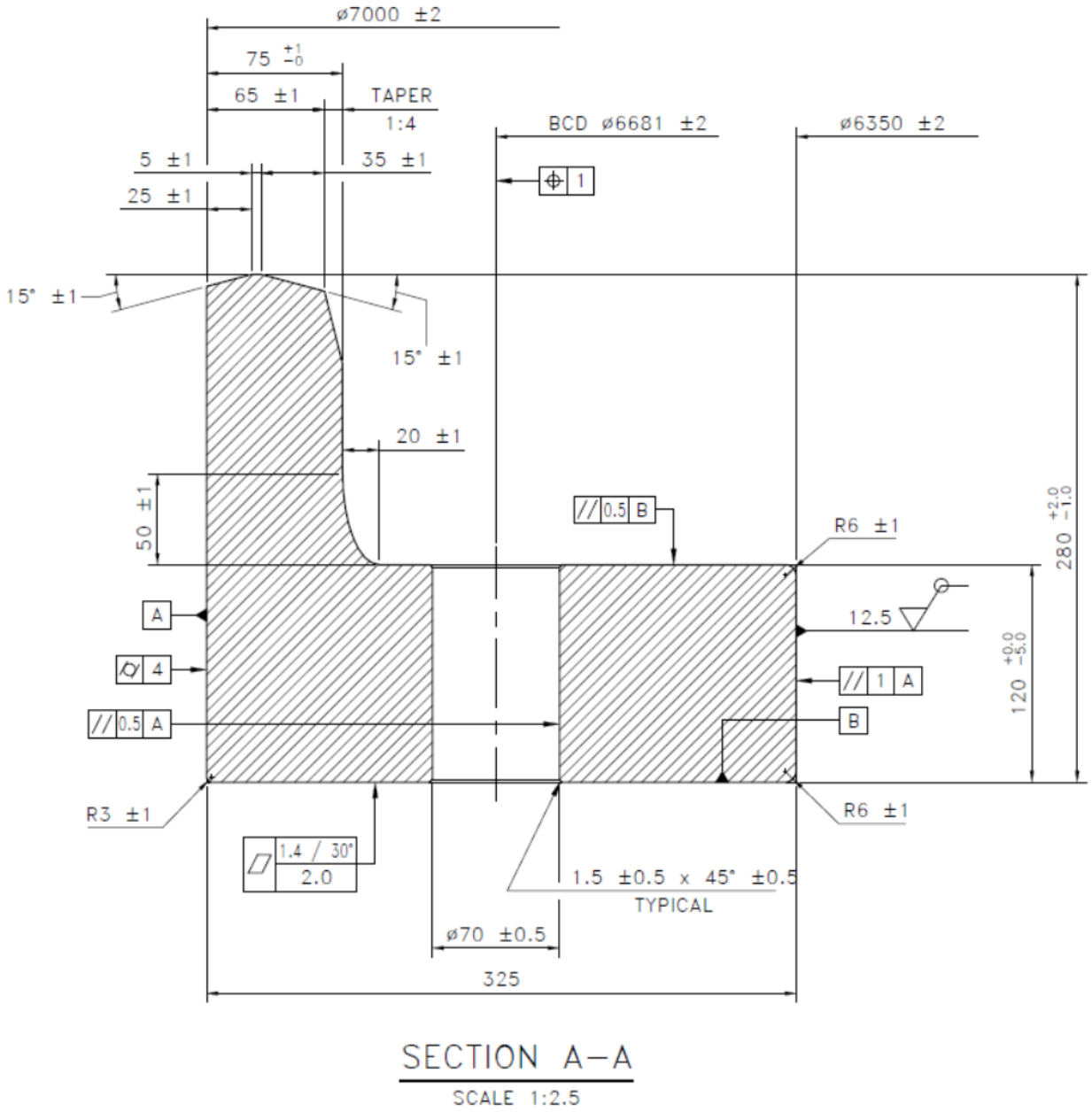


Figure 6 – TP Flange size parameters (ref. 15 and Attachment 1)

5.1 FORMED PRODUCT REQUIREMENTS FOR CERTIFICATION

- Tolerance on product as per as-built drawing of existing bottom Flange;
- All surfaces shall be 100% visually inspected.
  - Surface defects at plate edges bordering longitudinal welds may be accepted, on a case-by-case evaluation and shall be reported in an NCR-document.
  - Surface defects at plate edges bordering circumferential welds are not permitted, but may be accepted on a case-by-case evaluation, which then shall be reported in an NCR-document;
  - Surface defects in plates at positions of welded attachments, or closer than 300 [mm] from such welds are not permitted but may be accepted in a case-by-case evaluation and shall be applied for by NCR;
  - Any repair by grinding shall blend smoothly with the contour of the base material and in the direction of the stress (in general axial pile direction).
- Holing, punching not allowed.
- Neck length of flange should be long enough to accommodate the 1/4 t CVN tests
- Flange ovality: the maximum allowable unroundness [Dmax – Dmin] <= 5 [mm].
- Maximum local flatness of flange top surface:
  - 1.4 [mm] for local flatness for sector of 30 [DEG] on the outside horizontal part
- Maximum overall/global flatness of flange bottom surface:
  - ≤ 2.0 [mm] on the outside horizontal part;
- Number of flatness measurements along flange surface is ≥ 46. Flatness measured must be final flatness for fully assembled vertical structure. If measured horizontally, a FEM analysis will be required for calculation of correction horizontal to vertical.
- Angular displacement of each flange to be in line with the technical drawing;
- Dimensions and holes of each flange to be in line with the technical drawing;
- The tolerance on the theoretical outside diameter may not exceed +/- 2 [mm] (e.g. 6.3 [mm] on circumference). The bolt circle diameter (BCD) tolerance shall be +/-2 [mm]. The positional tolerance of individual bolt holes is +/-1 [mm].

It is allowed to machine, but the final shape must have its yield strength properties based on the final dimensions, test values of the processed flanges must be in the direction of the thickness:

- At elliptical radius: >75 [mm] fyk ≥ 320 [N/mm2];
- Neck: 75 [mm] fyk ≥ 320 [N/mm2];
- Flange thickness: 120 [mm] fyk ≥ 320 [N/mm2];
- Flange width: 325 [mm] fyk ≥ 320 [N/mm2].

5.2 PWHT

Heat treatments will be performed after welding (PWHT), hence all internal welding tensions will be mitigated, so do not need the CTOD TESTs in production process for welded flange piece as per flange supplier WQPRs .

5.3 TEST COUPONS TO BE PROVIDED FOR ROSETTI WPQR EXAMINATIONS & TESTS

The test coupons to be supplied for future WPQR , shall be fully representative of the material and, where relevant, shall not be sampled from the material until heat treatment is completed. It is allowed to be taken from other pieces but with same heat number / chemical analysis and same heat treatment performed on final piece. The test pieces shall not be separately heat treated in any way.

Test specimen shall be min. 2 pieces with preferred dimensions of 1400x600x (min. thickness = 65mm),or if not possible due to production size, 1400x320xThk (min. thickness = 65mm).Coupons shall be supplied square cut ,not beveled or prepared on the perimeter.

Supplier shall carry out the BLANK TEST on the supplied specimen material.

Mechanical blank test shall include:

- Tensile: one set of three transverse to rolling direction through thickness + one set longitudinal to rolling direction.
- Impact test CVN: two sets of three specimens, transverse direction: one at ¼ of thickness (Min 28J Avg/ 20J Single) – and one set of three specimens at 1/2 thickness 28 Avg/20 Single @-40°C

  + one set of three specimens, longitudinal to rolling @-40°C 42J Minimum Avg and 33J Minimum Single .

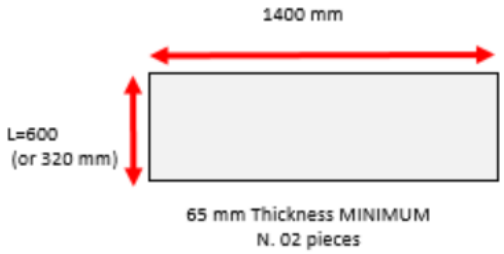


Figure 7: Dimensions of tests to coupons to be supply

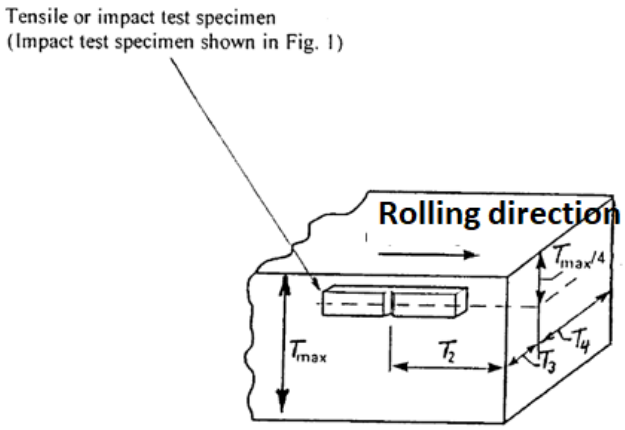


Figure 8: Sampling example for coupons

Mechanical tests on coupons shall be certified 3.2.

5.4 TESTS REQUIRED FOR WELDED FLANGE

In accordance with document 16:

ULTRASONIC TESTING (UT)

Extent: 100%

Reference code: ISO 17640

Acceptance Criteria: ISO 11666 Level 2 + ISO 23279

MAGNETIC PARTICLE INSPECTION (MPI)

Extent: 100%

Reference code: ISO 9934-1

Acceptance Criteria: EEMUA 158 Edition 3, 2014 - § 7.5.5

NDT shall be performed before and after PWHT.

5.5 QA/QC

Required documentation for Vendor Data Book in accordance with Ref. 5 part 3, section 5.

- MPS or Execution Plan
- ITP
- Welding Book
- Welders list
- Welding Consumables

- NDT procedure + reports
- NDE operator list
- Cert material 3.2
- Dimensional procedure + reports
- Welding log
- Traceability materials
- Index for MRB

6 STRUCTURAL MATERIAL FOR BOLTS

Bolts will be classified primary structure (or DC2), purchased in accordance with Ref. 8 and 10.

The selection of bolts Material shall be performed with ref to ISO 898-1, as defined in Ref. 10, sect 4.2.6.

The bolt property class for interfaces between TP and monopile foundation shall be designed with the equivalent bolt property class of 10.9, see ISO 898-1, M64, to avoid the risk of hydrogen embrittlement.

Mechanical/locking devices of nuts shall be provided for bolted connections between structural members pertaining to DC1 and DC2.

6.1 REQUIREMENTS AND RECOMMENDATIONS FOR BOLTS SELECTION

The following requirements and recommendations apply (Ref. 8):

- For preloaded bolts, the effective length of the bolt (between the underside of the head and the nut) shall be sufficiently long to minimize the consequence of creep in reducing the tension in the bolt. Preloaded bolts should have a minimum effective length of L/D > 5 or collars should be added.
- A 2nd re-tightening of the bolts shall be performed at a minimum of 40mins after the initial tightening.
- A reduction in pretension over the life of the bolted connection (20 to 50 years) due to creep of 20% shall be assumed for bolts with any protective coating applied to the bolt surface.
- Bolt hole edges shall be rounded, and the connection shall be sealed with a durable sealant, or a durable paint system, or both or metallizing.
- Washers shall be used beneath both bolt heads and nuts to minimize coating damage. Loose washers (plain or spring) should not be used.
- The nut should be prevented from loosening under vibration by chemical bonding (e.g. Loctite) of the nut to the bolt thread.
- Marking symbols shall indicate the property class of the respective bolt set. Bolt set components may be used from one manufacturer only. Using single bolt set components from different manufacturers is not allowed, see EN 14399
- Corrosion protection of bolted connections shall be assured by the adoption of corrosion resistant alloy or high durability coating or metallizing. All surfaces that are in contact or inaccessible after assembly should be coated in aluminum spray. ISO 898 Gr 10.9 bolts shall be coated with a liquid applied Zn/Al based coating system in conformance with ASTM F1136 Gr3 or ASTM F2833 Gr1. After final assembly, accessible parts of the bolts shall be overcoated with an organic coating system to match the surrounding structure. Cadmium-plated bolts shall not be used as they can emit a lethal toxic fume when heated (Ref. 8)
- Regular inspection of bolted connections should be specified.
- Structural bolts should be tensioned using one of the following:
    - Proprietary bolt tensioning devices (e.g. Hydratight)

- Turn of nut procedures
- Direct tension indicating devices or bolts (e.g. rotabolts)
- Bench calibrated wrench

- The chemical composition and Charpy values for structural bolts shall be in accordance with ISO 898-1.

Use of High Stress bolts subject to shearing stresses shall not be permitted in non-sheltered areas opened to projections or dripping of liquids. Utmost care shall be taken to ensure assembly resistance to corrosion.

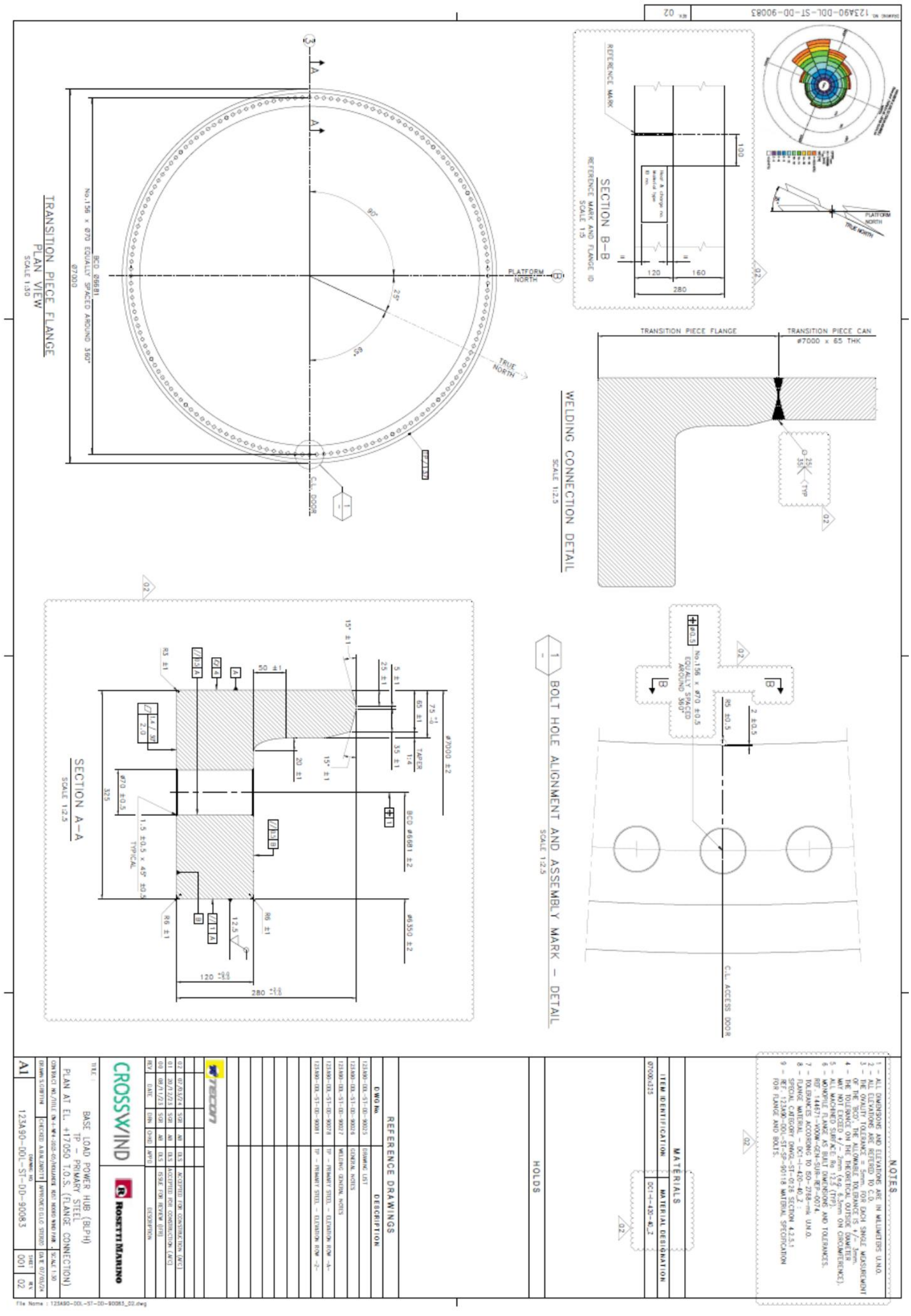
Stainless steel grades of bolting e.g. ASTM A193 B8 are not permitted in pressure retaining application due to Chloride Stress Corrosion Cracking risk.

The responsible party for supply shall provide full certification in accordance with the reference standard, meeting Type 3.2 of EN 10204 or equivalent.

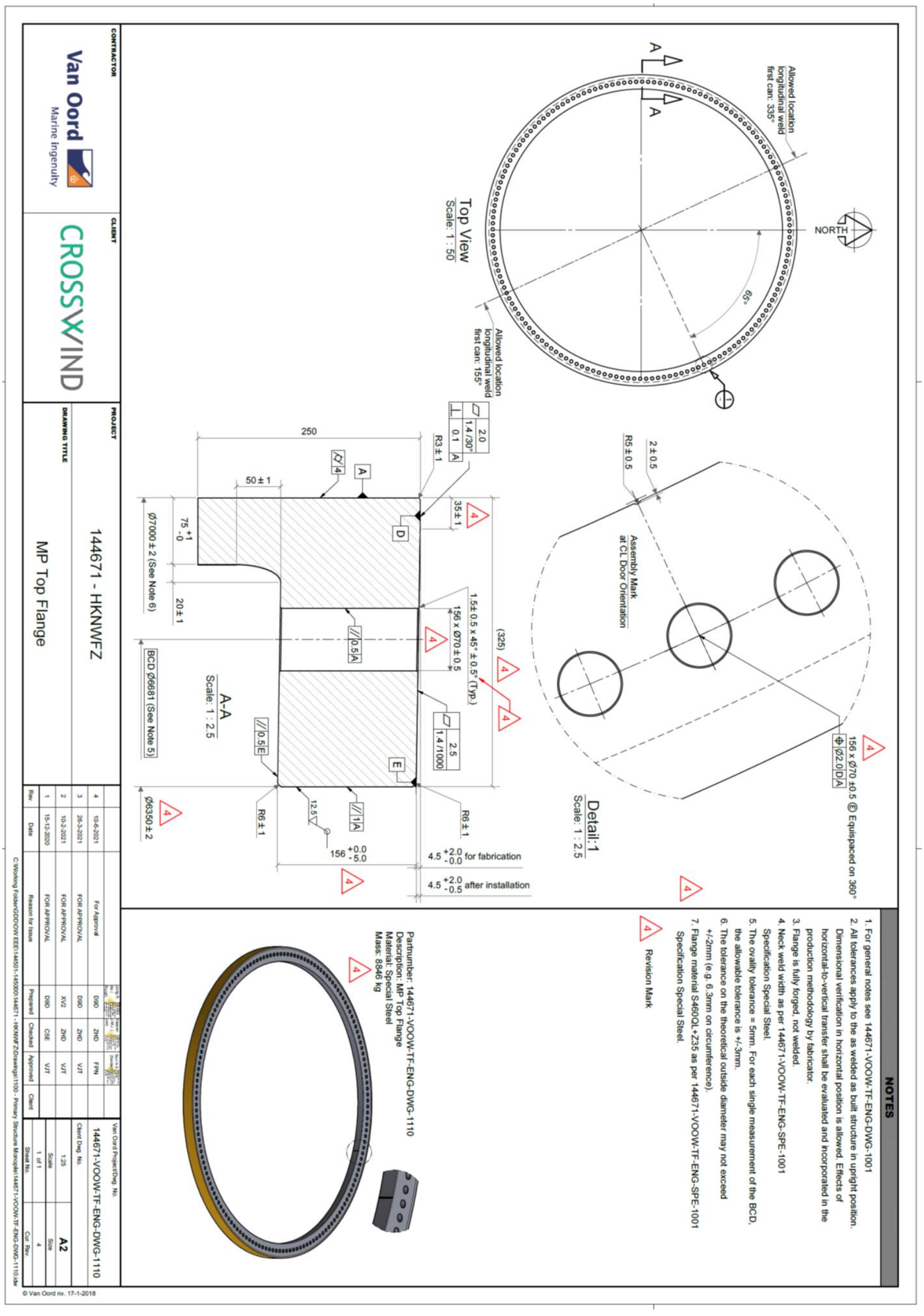
The bolted connections shall be designed and preloaded to be slip-resistant at ultimate external loadings.

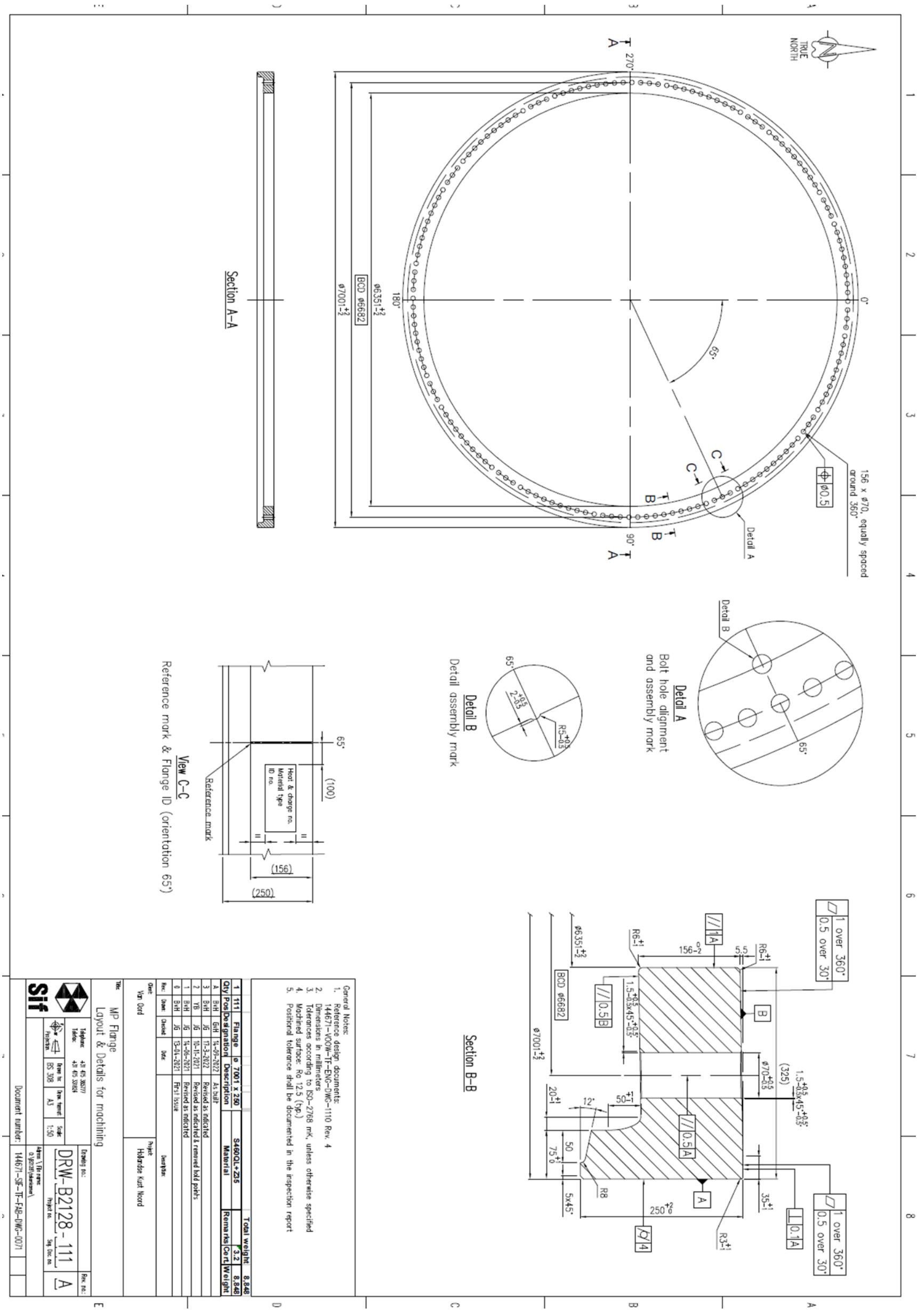
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Attachment 1 – Design Drawing of Upper Flange



Attachment 2 – Existing bottom Flange Design and As-built drawings – For information



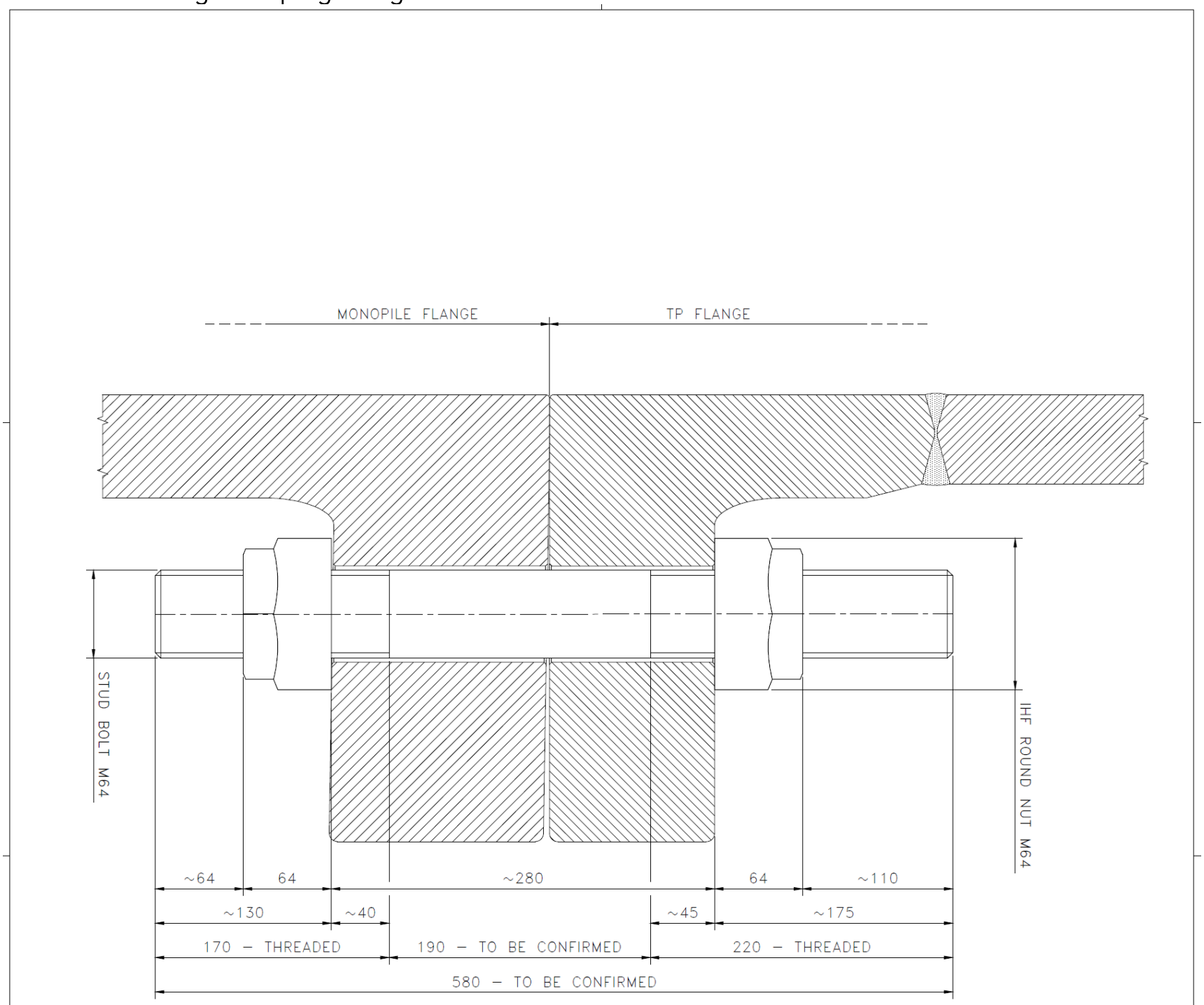


General Notes:
1. Reference design documents:
   144671-VOOW-TF-ENG-DWG-1110 Rev. 4
2. Dimensions in millimeters
3. Tolerances according to ISO-2768 mK, unless otherwise specified
4. Machined surface: Ra 12.5 (typ.)
5. Positional tolerance shall be documented in the inspection report

Qty	Pos	Designation	Description	Material	Remarks	Cert	Weight
1	111	Flange ø 7001 x 250		S460QL+Z25		3.2	8.848
A	BvH	GvH	14-06-2022	As built			
3	BvH	JG	17-3-2022	Revised as indicated			
2	YB	JG	10-11-2021	Revised as indicated & removed hold points			
1	BvH	JG	14-06-2021	Revised as indicated			
0	BvH	JG	13-04-2021	First issue			
	Drawn:	Checked:	Date:	Description:		Total weight	8.848

Client: Van Oord
Project: Hollandse Kust Noord
Title: MP Flange
Layout & Details for machining
Drawing no.: DRW-B2128-111
Rev. no.: A
Scale: 1:50
Paper format: A3
Drawn to: BS 308
Project no.
Seq. Doc no.
Document number: 144671-SIF-TF-FAB-DWG-0071

Attachment 3 – Bolted Flanges Coupling arrangement



TYPE OF FASTENER ISO STUDS WITH IHF–NUTS	M64
PROPERTY CLASS	10.9 (ISO 898–1)
TENSION (kN)	1700
TWO–STAGE TIGHTENING 1st STAGE / 2nd STAGE (kN)	YES 1700 1700
WIDTH ACROSS FLATS (mm)	134
CENTER HOLE to CENTER HOLE	
LOCKING AGENT REQUIRED	NO

ROS1783 – SK–045_00 19.12.2024