Base Load Power Hub (BLPH)

Technical Specification for CS Horizontal Pressure Vessels in H2 Service

Document Number: 123A90-DDL-MAC-SP-50026

Document Class: 2

02	27/06/2024	Accepted for Construction (AFC)	FM	MM	DL
01	21/11/2023	Accepted for Construction (AFC)	FM	MM	DL
00	29/08/2023	Issue for Review (IFR)	FM	MM	MD
Rev.	Date	Description	Prepared	Reviewed	Approved

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Revision / Change Log

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

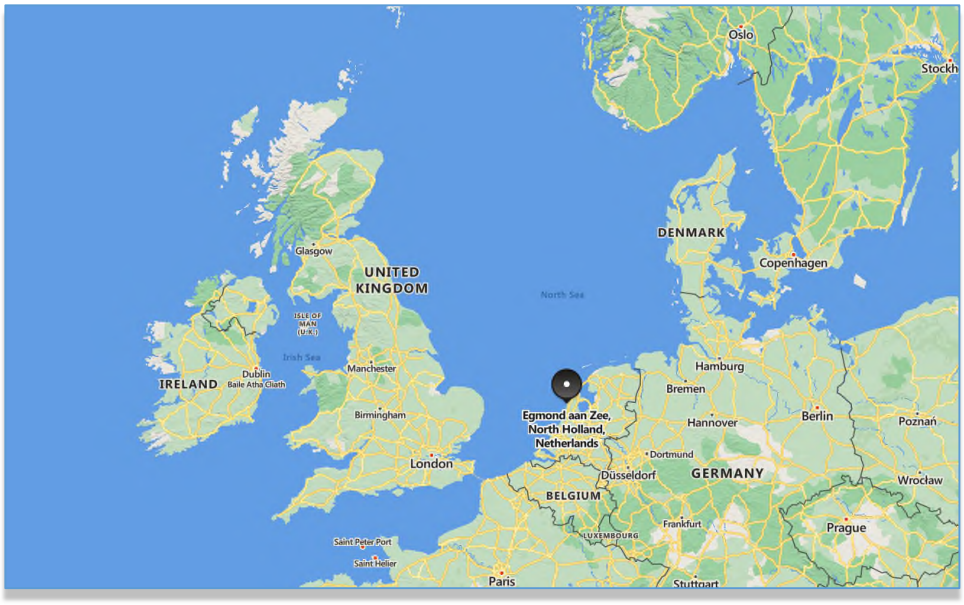


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

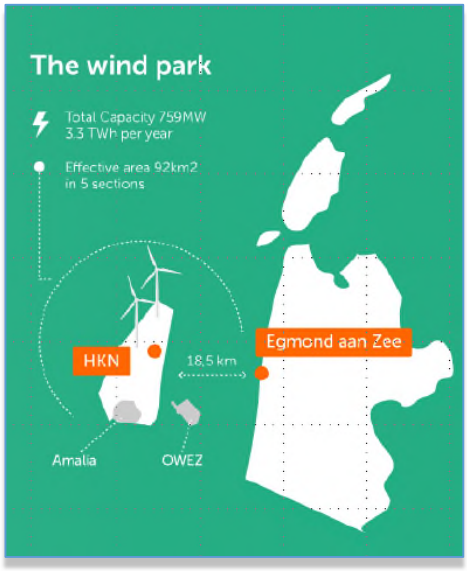


Figure 2 - Wind Park Details

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.

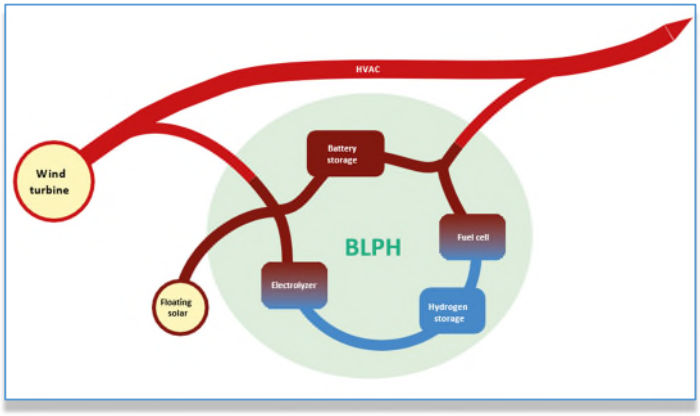


Figure 3 – BLPH Concept

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.

2 DOCUMENT SCOPE

This specification describes the design, manufacturing, inspection, testing and supply requirements for CS Horizontal Pressure Vessels in Hydrogen Service.

The Supplier is responsible for the equipment design, quality of materials, and full compliance with the requirements of all the applicable specifications, data sheets, standards, codes, and regulations. Any deviation from the present specification shall be clearly highlighted in writing by SUPPLIER during to the Bid Phase and must be approved in writing by COMPANY/CONTRACTOR before proceeding with any kind of activity.

Following items are covered by this specification.

- V-25001 A-F Hydrogen Storage Vessel
- V-43001 Hydrogen Vent KO Drum

2.1 REFERENCES

2.1.1 General

Pressure Vessels shall be designed, manufactured tested and delivered according to the requirements of this specification, referenced project documents, data sheets and appropriate European and International standards. Codes and Standards to be used shall be the latest revisions including all addenda available at the date of the requisition for enquiry.

2.2 INTERNATIONAL CODES, STANDARDS AND REGULATIONS

Applicable International Codes, Standards, Rules and Regulations, addenda are listed below:

Doc. No.	Description
2014/68/EU	Directive 2014/68/EU (PED - ''Pressure Equipment Directive'').
ASME B 16.47	Large diameter steel flanges – NPS 26 through NPS 60.
ASME B 16.5	Pipe flanges and flanged fittings – NPS ½ through NPS 24.
ASME VIII Div 1	Boiler and Pressure Vessel Code - Rules for Construction of Pressure Vessels
ASME IX	Welding, Brazing, and Fusing
ASME V ed. 2021	Non Destructive Examination
ASME II ed. 2023	Ferrous Material Specification
NACE TM 0284 ed. 2016	Evaluation of Pressure Vessels Steels for Resistance to HIC
ASME B 16.5 ed. 2020	Pipe Flanges and Pipe Fittings
ASME B 16.47 Series B ed. 2020	Large Diameter Steel Flanges (over 24")
ISO 12944 ed. 2018	Corrosion Protection
EN 10204:2004	Metallic products - Types of inspection documents
ISO 9001	Quality Management Standard

Table 1 - Reference Documents

The Supplier shall provide the Company/Contractor, with a detailed listing of the Codes, Standards and Regulations complied with in the Supplier's proposal.

Equivalent alternatives may be offered but shall be highlighted in the Supplier's proposal.

Any applicable local Government Regulation, including any additional production / inspection / test / certificate requirement shall be considered by SUPPLIER during Detailed Engineering Phase

2.3 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

2.4 ABBREVIATIONS

Following abbreviation can be used in this specification, instead or in conjuction with the full definition, indicated in the table below

ASME	American Society of Mechanical Engineers
ATEX	ATmosphères ed EXplosives
CS	Carbon Steel
CE	Carbonium Equivalent
DM	Diametre Nominal
EN	European Norms
FEA	Finite Elements Analisys
HIC	Hydrogen Induced Cracking
ISO	International Standards Organisation
ITP	Inspection and Test Plan
LPI	Liquid Penetrant Inspection
MPI	Mgnetic Particle Inspection
NDE	Non-Destructive Examination
NDT	Non-Destructive Test
NBR	National Board registration
PWHT	Post Weld Heat Treatment
PED	Pressure Equipment Directive
RT	Radiographic Test
TDS	Technical Data Sheet

QCP	Quality Control Plan
UNC	Unified National Coarse
8-UN	8-thread series
UT	Ultrasonic Test
PQR	Performance Qualification Records
WPS	Welding Procedure Specification
WRC	Welding Research Council

Table 3 - Abbreviations

3 DESIGN BASIS

3.1 GENERAL

- The pressure vessels shall meet the process and mechanical design conditions specified on the equipment data sheets and document CWHKN-INN-BPH-DTS-00005 - BLPH Platform Site And Engineering Data.
- Technical offer shall include a description of the system's capabilities and limitations.
- Supplier shall offer standard alternatives, where possible, which meet the intent of this specification and adhere to all relevant statutory requirements in a cost-effective manner. Differences between these alternatives and the request outlined in this specification shall be quoted as priced options with any potential impact to fabrication, schedule and/or costs clearly stated. If required, alternate bids shall be submitted separately to allow Supplier to meet timelines stated for the requested bid
- Supplier shall provide As-Built fabricated dimensions for all nozzles, as soon as they become available dimension within +/- 1/4" of the elevation and projection from reference
- Supplier shall provide all nuts, bolts, and gaskets for all flanges supplied with mating flanges (e.g. mounting nozzles, spare nozzles, manways
- Supplier shall provide 3D model files (i.e., outputs of Solid Works, 3D AutoCAD, STAAD, etc. in STEP AP203 format) if used for their equipment design. The 3D files shall be provided along with the equipment dimensional approval and final drawings. The model files need not contain equipment internal details or other proprietary detail
- The Suppliers quotation shall be segregated into clearly defined parts so that the individual major components and options being offered can be readily evaluated

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technically and commercially.
The quotation shall also include the following:

- Technical description of the system being offered
- Details of any equipment and / or utilities which is outside of their scope but is necessary for operation
-

The scope of supply shall include but not be limited to, the following:

a) Mechanical design, complete fabrication of vessel (shell, heads, nozzles, support saddle, skirt, legs, etc.), certification & guarantee of the vessel, supports and any internals, as specified in the data sheets
b) Process design as specified in data sheet
c) Mechanical calculation, according to ASME VIII Div.1, including nozzles loads verification, foundation loads calculation, FEA analysis thought well known software (Supplier to declare name and version used already into the bid) anchor bolts check-up, structural calculation, lifting and transportation calculation, etc.
d) Supplier's standard Inspection and Test Plan listing Tests, Inspection, Non-Destructive Examination (NDE), heat treatment(s), pressure testing and HIC Test in accordance with Company/Contractor approved Test and Inspection Data Sheet and/or others applicable documents.
e) AISI 316L Stainless Steel Nameplates & Bracket.
g) Surface preparation and Painting as per C3 Corrosivity Category of ISO 9223
h) Piping clips, platforms and ladders clips, (option), instruments support clips (as specified), insulation support rings, manholes, inspection opening, nozzles including relevant davit, flanges, blind flanges/cover plates as per Data Sheet, earthing bosses/plates, internal ladder rungs and fireproofing supports.
i) Lifting lugs, trunnions and tailing lugs (as specified).
j) Sizing/Design and material specification for foundation bolting. Supplier shall also make provision for embedded plates, levelling screws and shims. If required, the supplier shall provide a foundation template for the vessel.
k) DELETED.
l) HIC Test according to ISO 15156
m) RT examination on pressure retaining weld (RT% as specified in dedicated TDS)

n) Poste Weld Heat Treatment (PWHT) on welds
o) Preservation, packing and preparation for shipment including temporary saddles, supports or bracing as required, and nozzle covers. Transportation load calculations shall be provided by Supplier.
p) Certified lifting frame complete with all necessary lifting tackle, including slings and shackles as required to enable a single point lift.
q) Commissioning and start-up spare parts
r) Recommended operational spare parts list for 2 years operation (quotation only with separate, optional price)
s) Drawings and documentation for fabrication, installation, Final Books (Operation and Certifications Manuals)
t) Quality documents and Procedures e.g., QCP, Welding procedures (WPS/WPQR), welders/operators' qualification, inspection, and test procedures, etc.
u) Special tools, if any, for installation, commissioning, maintenance and start up.
v) ASME code "U" stamp, and/or others applicable documents and also NBR
w) PED/ATEX certification as specified in the data sheets and/or others applicable documents.
z) Supplier and sub-supplier material certification
Foundation Bolts.,
za) Third Party Certification when specified.
zb) Hydrogen Vessel Fatigue Design Report

3.2 DESIGN LIFE, RELIABILITY AND MAINTENANCE

The pressure vessels shall be designed for a minimum service life of 2 years, for outdoor operation, generally in offshore marine environment and/or as specified on the datasheet and others applicable documents. Thus, equipment components should be of a proven design for reliability and shall require minimum maintenance.

3.3 LOCATION AND HAZARDOUS AREA CLASSIFICATION

The environmental design criteria and Hazardous area classification is identified has Zone IIB T1 + H2

4 DESIGN REQUIREMENTS

4.1 GENERAL

Unless otherwise indicated in relevant Data Sheet, pressure vessels shall be designed in accordance with ASME Section VIII, Division 1 or 2 according to dedicated TDS.

The Supplier is responsible for ensuring that the pressure vessel and components provided are suitable for the operating conditions stated in the datasheets and/or others applicable documents, and available utility supplies.

Pressure vessels shall be designed for the most severe loads combination, which may be experienced in construction/fabrication, hydrotest, site erection, normal operation, and maintenance activities. The load combinations shall be defined as per applicable design code.

The Supplier shall co-ordinate the complete design and supply of all the equipment and ensures the satisfactory performance of any sub suppliers. Where the Supplier provides equipment that he has not manufactured, he shall ensure that the items are compatible with all other equipment supplied. The Supplier shall be responsible for guaranteeing all equipment including that provided by any sub suppliers.

4.2 MECHANICAL DESIGN REQUIREMENTS

4.2.1 Shell and Heads

Unless otherwise indicated in the relevant Data Sheet, the heads shall be semi-elliptical with 2:1 ratio. The minimum thickness of the cylindrical part of a head shall not be less than the minimum required thickness of the connecting shell.
Design drawings shall show the minimum wall thickness of the knuckle zone after forming.

4.2.2 Minimum Thickness

The Supplier shall supply their own wall thickness calculations, for which the Supplier shall be fully responsible.

Minimum thickness of shell and heads for carbon and low alloy steel, excluding corrosion allowance and after forming shall be 5 mm for vessels up to 2500 mm inside diameter, And 8 mm for larger diameters.

Minimum thickness of shell and heads for high alloy steel shall be 5 mm after forming.

The minimum wall thickness for support skirts to be 10 mm.

4.3 DESIGN LOAD COMBINATIONS

The design of the equipment, internals, attachments, anchor bolts, supports and saddles shall accommodate all the external loads in the following combinations:

a) Erection: Weight, wind and seismic at ambient temperature. Wind and seismic do not act simultaneously.

b) Hydraulic Test: Test weight, 25% of wind loading and test pressure at ambient temperature.

c) Normal Operation: Operating weight, pressure, wind, seismic, local mechanical loads, and local thermal loads (at design temperature and pressure). Wind and seismic do not act simultaneously.

d) Transportation: transportation weight, transportation acceleration shall be considered for vessel check-up and design of transportation saddles.

4.3.1 Design Pressure, Design Temperature and MAWP

Design pressure (internal/external) and design temperature shall be considered as specified in doc n°

123A90-DDL-MAC-DS-50027 TDS - H2 Storage Vessel - V-25001 A-F

123A90-DDL-MAC-DS-50028 - TDS - Hydrogen Vent KO Drum - V-43001

Design and pressure shall be assumed to act at the top of the vessel.

Minimum design temperature shall be also considered in vessel design as indicated in Data Sheet.

MAWP (Maximum allowable working pressure) based on the fabricated thickness of shell, heads, flange rating, etc. shall be calculated by Supplier. MAWP shall not be limited by minor components as nozzle necks or reinforcement.

4.3.2 Wind Design

According to prescriptions of document n° CWHKN-INN-BPH-DTS-00005 – BLHP PLATFORM SITE AND ENGINEERING DATA

4.3.3 Earthquake Design

According to prescriptions of document n° CWHKN-INN-BPH-DTS-00005 – BLHP PLATFORM SITE AND ENGINEERING DATA

4.3.4 Transportation Loads

If not otherwise specified, the supplier shall design vessels, supports and internals, which shall be capable of withstanding all transportation forces. Vessel, saddle supports and/or transportation saddles shall be designed for the following transportation loads acting simultaneously:

- 0.7 g in each horizontal plane / 1.5 g vertically downwards
- 0.7 g in each horizontal plane / 0.5 g vertically upwards

4.3.5 Local Loading

Unless the maximum acceptable actual nozzle loads are indicated in the datasheet and/or others applicable documents, the nozzle loads given in appendix 1 shall be used. The supplier shall prove by calculation that process nozzles of DN 50 or larger withstand these loads.

For all nozzle configurations the calculation method shall be in accordance with ASME VIII or WRC Bulletin 537/297 as applicable. The calculated stress intensity shall not exceed the stress limits as specified in ASME VIII.

4.3.6 Cyclic Loading/Design

Vessel and components subjected to local loads, fatigue, thermal stresses, cyclical service, etc., not addressed by ASME Section VIII, Div. 1 shall be designed per ASME Section VIII, Div. 2.

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Where required by the fatigue design rules, vessels subject to cyclic loading shall have all butt welds ground smooth internally and externally and all fillet welds shall be ground to blend smoothly into the parent material.

Note for V-25001 A-F

Vendor shall provide the Hydrogen Vessel Fatigue Design Report, as applicable, taking into consideration that Contractor should expect that the number of full charge/discharge cycles (from full to empty) will be 180 during the year. In other words, it is expected that:

- Fuel cell will utilize the full hydrogen inventory from the storage vessels 180 times per year (full discharge).
- Electrolyser will fully recharge the hydrogen vessels (from empty to full) 180 times per year (full charge).

Hence Vendor shall issue the Hydrogen Vessel Fatigue Design Report considering at least N° 4 (four) full charge and discharge cycles per day for each Vessel."

4.4 VESSEL SUPPORTS

The vessels including the supports shall be designed to be self-supporting. The type of vessel supports shall be as indicated in relevant Data Sheet.
Vessels supported on saddles shall be analyzed in accordance with Design Code. As a minimum saddle support shall be designed and calculated for the following loads:

a) operating weight
b) test weight
c) wind loading (if applicable)
d) Seismic loading (if applicable)
e) transportation acceleration (where applicable)

Horizontal vessels shall be supported on two saddle supports designed in accordance with Design Code. Saddle supports shall provide support over a minimum of 120° of the circumference of the vessel wall. Saddle supports shall be provided with the reinforcement plates. Saddle supports shall not be located at circumferential welded seams on the vessel.

Unless the Project Applicable Documentation dictates otherwise, vertical vessels shall be supported on skirt, or legs.

Anchor bolts. Minimum number of anchor bolts shall be four and thereafter, multiples of four. Horizontal vessels shall be provided with one fixed and one sliding saddle. Saddle material in direct contact with the pressure parts shall be of the same material as the vessel shell.

Fixed saddles shall be provided with bolt holes for fixing to the foundation. The sliding saddle shall be provided with the slotted holes to accommodate the thermal expansion of the vessel. DELETED
Saddles shall be designed and fabricated such that distortion does not occur during PWHT.

4.5 NOZZLES

Nozzles use WN flanged connections as per ASME B 16.5. Nozzles shall be attached to the vessel by full penetration welds. The minimum size of nozzles and connections shall be DN 50 unless otherwise specified. Nozzles of DN 400 and smaller shall be made of seamless pipe forgings. Nozzles larger than DN 400 may also be fabricated from rolled plate.
Electric resistant welding pipe is not acceptable for the nozzle necks fabrication.

The longitudinal weld seam in nozzles fabricated from plate shall be subjected to 100% radiographic inspection.

Nozzle openings/necks shall be flush with the inside surface of the vessel. The inside edges of nozzle necks, inspection openings, hand holes and manholes shall be rounded off to a minimum radius of 3mm.

Nozzle flanges shall be of the welding-neck type or long welding-neck type with raised face. Slip-on flanges are not permitted unless otherwise specified.

Flanges of DN 600 and smaller shall comply with ASME B 16.5.

Flanges larger than DN 600 shall comply with ASME B 16.47 Series B

Bolt holes in all the flanges of nozzles, inspection openings and hand holes shall straddle the center lines of the connections.

The faces of flanges shall be smooth finish. Smooth finish shall be achieved in accordance with ASME B16.5.

Gaskets shall comply with ASME B 16.20. Unless otherwise indicated, Gaskets shall be stainless steel, spiral- wound, graphite filled, with epoxy-coated carbon steel centering ring and stainless-steel inner ring.

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4.5.1 Nozzle Reinforcement

Reinforcing pads shall preferably be of one-piece construction. If this is not possible, the welds in segmented reinforcing pads shall be aligned in the direction of the vessel's circumference.

Reinforcing pads shall be provided with one ¼" NPT telltale hole. Two-piece reinforcing pads shall be provided with two telltale holes (one per segment). After testing, the telltale hole shall be plugged. Reinforcing pads shall not be located on the welded seams.

Reinforcing pads shall not be used for the following:

a) On designs where fatigue analysis is required.

b) Where specified otherwise on the vessel data sheets.

c) Where the shell and head thickness exceed 40mm.

Internal reinforcing pads are not permitted.

4.5.2 Nozzle Projections

Nozzle projections shall be in accordance with Table 1 below, unless noted otherwise.

Pipe Size	Nozzle					
	150#	300#	600#	900#	1500#	2500#
2''	200	200	200	200	200	200
3''	200	200	230	200	230	250
4''	200	200	250	225	250	300
6''	200	200	280	300	310	350
8''	200	230	300	325	330	400
10''	200	250	350	350	380	450
12''	250	280	360	480	410	500
14''	250	280	380	400	430	-
16''	250	300	410	430	460	-
18''	250	300	410	430	460	-
20''	280	330	430	480	500	-
24''	300	360	460	510	530	-

Table 4 -Standard Nozzle Projections

Notes:

a) Above standard nozzle projections are measured from the flange face to the outside surface of the vessel at center line of nozzle, unless noted otherwise.

b) Nozzle standouts shall be dimensioned from vessel centerline or tangent line to flange face. Round up to nearest 10mm.

c) Above standard nozzle projections shall be utilized for hillside or tangential nozzles where the projection is measured at outside diameter of flange face to outside of shell at short side of neck, unless noted otherwise.

d) Nozzle projections shown are minimum. If greater projections are required due to nozzle type (i.e., for integral reinforcement), Vessel Supplier shall advise accordingly on its quotation.

e) Standard nozzle projections include an allowance for insulation up to and including 40mm in thickness. For insulation thickness greater than 40mm, the nozzle projections shall be increased by insulation thickness minus 40mm.

Nozzle projections for larger size and higher ratings are to be by agreement of Contractor and Company.

4.5.3 Bolting

Flanges shall be through-bolted with stud bolts, threaded full-length with a removable nut on each end. The length of the stud bolts shall be selected such that after assembly the length of the stud protruding beyond the nut is 3.5mm – 7.5mm.

Bolting and threads shall comply with ASME B 1.1, coarse-thread series (UNC) for bolting of 1 inch and smaller and 8-pitch series (8UN) for larger sizes.

For pressurized flanged joint hydraulic tensioners shall be used on bolts 50 mm diameter or greater. Pipe classes equal to and greater than 600# shall use hydraulic tensioners on bolts 38mm and larger. For bolts which are tightened with bolt-tightening equipment, extra-long studs shall be used which provide an additional length of thread equal to one diameter of the stud protruding beyond the nut.

Any galvanizing action/corrosion protection of bolting shall ensure electrical continuity is maintained.

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4.6 INSPECTION OPENINGS

Covers for manways, inspection openings and hand holes with a weight of 25kg and more shall be provided with a davit. Manways shall be circular.
Internal ladder rungs shall be provided for side entry manways when the centerline is more than 1200 mm above a suitable foot support. Rungs shall have provision to prevent foot sliding-off end of rung.

4.7 EXTERNAL ATTACHMENTS

External attachments welded to the pressure envelope shall be the same material specification as the shell.

External attachments shall be designed and constructed to shed water and shall be attached with continuous fillet welds all round.

Supplier shall check the vessel against the localized stress due to external attachments to avoid exceeding of the allowable limits as required into Design Code.

4.8 NAMEPLATES

a) Manufacturers name.
b) Manufacturers serial number.
c) Purchasers order number and item number
d) Manufacturers type designation (if applicable)
e) Tag number (if applicable)
f) Operating Process Conditions
g) Design Process Conditions
h) Weights
i) PED CERTIFICATION
j) ASME "U" STAMP + NBR CERTIFICATION (if applicable)
k) Hazardous area classification (if applicable)

Nameplates shall be made of stainless steel AISI 316L with the information being punched or engraved on.

PWHT vessels shall additionally be marked with letters 150mm high:

"HEAT TREATED VESSEL – DO NOT WELD OR CUT"
ASME "U" STAMP + NBR.

4.9 MATERIALS

If not otherwise specified in Data Sheet, materials used shall be new and shall be exclusively those listed in the relevant tables of the applicable Design Code. Materials quality shall be as specified in the datasheets. However, the supplier shall confirm the suitability of specified materials in accordance with the process conditions, environmental conditions, design codes and good industry practice. The use of different materials from the specified ones shall require the written approval of the Company/Contractor during to the Bid Phase.

All Carbon Steel Materials shall be supplied in fully killed and normalized conditions. Low temperature materials shall be supplied with impact test at the minimum design temperature. If not otherwise specified in Data Sheet, maximum carbon content on ladle analysis and maximum carbon equivalent base on ladle analysis shall be maintained in the suitable range as per applicable materials standards to assure the metal weldability.

CS Fabrication material for Pressure Vessels in Hydrogen Service shall have CE (Carbon Equivalent) max. = 0.35%.

DELETED
Plate material shall not be used for flanges. Only forged materials shall be used for nozzle and manholes flanges.
Gaskets containing asbestos shall not be allowed.
Materials substitution during manufacturing activities is forbidden.
Materials shall be certified EN 10204 type 3.1 for pressure parts and type 2.2 for other parts.

4.10 FABRICATION

4.10.1 General Requirements

Prior to commencement of manufacture, the Supplier shall submit fabrication drawings and welding, heat treatment, Coating, NDT and final testing procedures for Company/Contractor review and approval.
Upon completion of construction, testing, and final acceptance the Supplier shall provide as- built drawings.

All welds joining pressure-containing parts and welds which are subjected to mechanical loading, shall be made in accordance with a dedicate WPS/PQR which complies with ASME Section IX. A separate WPS shall be defined for weld repairs, including all relevant details about the repair procedure.

Testing shall be carried out on welds in their final condition (after post weld heat treatment if applicable). The test records shall be verified by the Company/Contractor inspector.

Welders/operators employed on the fabrication of pressure vessels within the scope of this specification shall be qualified in accordance with ASME IX. The PQR shall be verified by the Company/Contractor before starting of fabrication activities.

The vessel or parts of the vessel that require PWHT shall be supported and protected so that deformation cannot occur. Machined surfaces, flange faces, etc., shall be protected from oxidation during heat treatment. No welding, hammering or deformation is permitted after PWHT.

4.10.2 Shell and Heads

Cylindrical shells shall be fabricated from seamless pipe or rolled plate or forgings as required on relevant data sheets. Where the shell is fabricated from two or more parts, the longitudinal welds shall be completed before making the circumferential welds. The longitudinal welds of adjacent shell sections shall be staggered over ten times the nominal wall thickness of the shell, with a minimum of 150mm.

Shell courses having a diameter equal to, or less than 2.5 m shall have only one longitudinal weld. Unless otherwise indicated, plates of different thicknesses shall be aligned along the internal surface of the vessel.

Welded seams shall be arranged such that nozzles and/or reinforcement plates do not overlap or interfere with these welds. The minimum distance between the edge of the nozzle welds or reinforcement plate welds and the edge of the welded seam shall be as follows:

a) for a longitudinal weld, the greater of 100mm and 2xt (where t is the wall thickness);

b) for circumferential weld; the greater of 50mm and 2xt.

Vessel Supplier shall provide following information with quotation: Shell and head thickness after forming, method of forming and number of plates proposed for head manufacture. Heads shall be 2:1 semi-ellipsoidal, however, hemi-spherical heads may be proposed for thick wall vessels.

Heads shall preferably be one-piece construction, wherever possible.

Where heads are formed in one piece and from more than one plate, weld seams shall be fully radiographed before forming and again in the knuckle region after forming. 100% surface crack detection shall be made after forming.

Cold formed carbon steel heads shall be normalized after forming.

Heads straight flange thickness after forming shall not be less than the minimum design thickness of the shell course to which it will be attached.

In the case of clad or weld overlayed vessels, the cladding thickness or weld overlay thickness shall not be considered as contributing to thickness for calculation purposes.

Nozzles and manways shall not penetrate pressure envelope weld seams.

Reinforcing pads, saddle wear plates, backing pads, clips or any other attachments, shall not cover welds in the pressure envelope.

4.11 QUALIFICATION OF WELD PROCEDURES

Welding procedures that are used, qualified by a previously Recognized Authority approved by the Company/Contractor at Supplier's expense, shall be approved by the Company/Contractor and shall be in compliance with the codes referred to in the drawings or specifications and by the laws in force in the locality where the vessel is to be installed.

Welds on pressure vessels shall be carried out by welders or welding operators suitably qualified for the welding procedure, the filler material used and the position of the welds to be made.

All welding parameters detailed in the ASME IX WPS format shall be measured during weld procedure qualification. Each welding pass shall be monitored for Volts, Amps, travel speed and arc time and an average Heat Input calculated.

Preheat and interpass temperatures shall be continuously monitored throughout the qualification.

4.12 PRODUCTION CONTROL TEST PLATES

Production test plates shall be carried out at a frequency of 2(two) per vessel and shall be attached to a longitudinal seam chosen by the Company/Contractor. The test plate shall be continuously welded either as a run-on or run-off plate for the longitudinal seam.
Fabrication test coupons shall include as minimum 1(one) test piece of base material before PWHT and another 1(one) of material with PWHT.

All plates shall be hard stamped and fully identifiable throughout its manufacturing route and to the test laboratory. Test plates shall be of the same heat of the shell material used in the construction of the vessel and shall be heat treated with the vessel in the same furnace when applicable. Surplus test material shall be retained for minimum of 6 months after load out of the associated vessel

4.13 FABRICATION TOLERANCES

Unless otherwise indicated, standard construction tolerances for fabricated vessels shall comply with relevant Design Code requirements.

5 INSPECTION AND TESTING

5.1 GENERAL

The responsibility for inspection and testing rests in the Supplier scope of work. However, Rosetti Marino and Crosswind Representative reserves the right to inspect the vessels at any time during fabrication to ensure that the materials and workmanship are in accordance with the specification and drawings.

Inspection and testing shall be carried out by the Supplier in accordance with the quality inspection and testing plan submitted by the Supplier and approved by Rosetti Marino and Crosswind Representative.

Witnessed points of ITP will be attended also by Crosswind Representative

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Material certificates shall be available at the time of inspection. The material markings shall be stamped on the material used for the pressure vessels and shall be ringed in white.

5.2 VISUAL INSPECTION

The pressure vessel shall be visually inspected to assure conformity with the approved design drawings, datasheets, and specifications. The visual inspection shall be in accordance with the approved test and inspection plan and will include the following as a minimum:

a) dimensional check.
b) surface quality.
c) paint quality.
d) execution of appurtenances.
e) die-stamped identification.
f) marking and shipping requirements.

5.3 NON-DESTRUCTIVE EXAMINATION (NDE)

Unless otherwise indicated, the butt-welds of pressure parts (shell, heads, nozzles) shall be 100% Radiographic examinated (RT) after fabrication as indicated in vessel Data Sheet. Radiographic examination, technique and evaluation shall be in fully compliance with ASME V. If radiography is not possible ultra-sonic (UT), magnetic-particle (MPI) or liquid penetrant (LPI) examination shall be carried out, in that order.

NDE reports shall be verified by the purchaser's inspector.

Pressure vessels requiring radiographic inspection, ultrasonic and PWHT shall be subject to ultrasonic (radiographic as per Supplier requirements) examination before PWHT and radiographic examination after PWHT.

5.4 HYDROSTATIC TEST

All slag, loose scale, dirt, grit, welding splatter, paint, oil, and foreign materials shall be removed thoroughly prior to the hydrostatic pressure test and the final inspection of the pressure vessel.

Hydrostatic testing shall be carried out before installing removable internals and before coating and painting. The test shall be carried out using potable water with less than 50 ppm of chlorides content
Unless otherwise indicated, the test pressure shall be held for at least 1(one) hour per 25 mm of plate thickness but in no case less than 1(one) hour
Hydraulic test certificate shall be released by the Supplier. Hydraulic test chart, gauges calibration certificates, water test certificate, etc., shall be attached to the hydraulic test certificate.
Gaskets used for the pressure tests shall be of the same type and quality as the service gaskets. No repairs, welding or heat treatment should take place after hydrostatic testing without the Company/Contractor permission.

Welds on reinforcing pads shall be tested with bubble (soap) solution and compressed air at a pressure of 0.5 to 1.0 bar (g), before PWHT and hydrostatic testing of the vessel.

After completion of hydrostatic test, all vessels shall be drained and thoroughly dried. DELETED.

5.5 SUPPLIERS QUALITY SYSTEM

The Supplier's quality control system shall be in accordance with the applicable codes. Moreover, the following requirements shall be met:

a) Identification of the materials used in the fabrication of the vessel or parts thereof ensuring that parts taken from semi-finished materials are punch marked.
b) Welding procedure qualifications and qualifications of manual welders and automatic welding machine operators shall be available before beginning fabrication.
c) Employers' approval of any type of repair.
d) Availability of documents for repairs attesting that they have been carried out using appropriate methods required by the codes and specifications.
e) Availability of documents relating to all heat treatment performed on the vessel or parts thereof.

f) Availability of documents relating to non-destructive tests performed on the vessel or parts thereof. If the results of examinations and inspections show defects, the Supplier shall take the necessary corrective action. In the event of serious or systematic deficiencies or of difficulty in interpreting the result of checks the Supplier shall carry out additional examinations and consider alternative tests and inspection. In particular:
   - Ultrasonic examination of welds where radiographs are difficult to interpret.
   - Re-qualification of the welding procedure if there are systematic defects.

6 APPENDIX 1 – FORCES AND MOMENTS

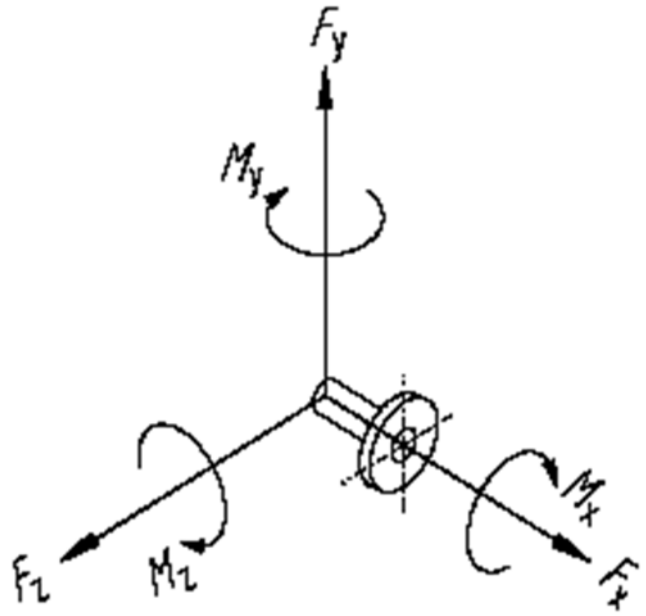
	Fx = Force in radial direction Fy = Force in circumferential direction Fz = Force in longitudinal direction Mx = Torsional moment My = Longitudinal moment Mz = Circunferential moment

Table 5- Forces and Moments

Each nozzle (Process, Drain, Spare, Relief, Blowdown etc.) of DN 50 and larger shall be capable of withstanding forces and moments exerted by external piping under normal operating conditions.

Inspection Openings and instrument connections are exempt from the above consideration.

All forces and moments are considered to be acting at the nozzle/shell and nozzle/head interface simultaneously and should therefore be considered in calculating shell and head thicknesses.

The forces and moments are as follows:
a) $F_x = \alpha \times 80 \times D(N)$

b) $F_y = \alpha \times 60 \times D$ (N)
c) $F_z = \alpha \times 40 \times D$ (N)

d) $M_x = \beta \times 0.24 \times D^2$ (N-m)
e) $M_y = \beta \times 0.208 \times D^2$ (N-m) f) $M_z = \beta \times 0.16 \times D^2$ (N-m)

In the above formulas *D* is the nominal diameter in millimeters.
The value of α and β in the formulas depends on the rating of the nozzle flange and are as stated in table 3.

ANSI/ASME Class	α	β
150	0.6	0.6
300	0.7	0.7
600	0.8	0.8
900	0.9	0.9
1500	0.9	0.9
2500	0.9	0.9

Table 6- Coefficients α β

7 APPENDIX 2 - IDS

PRESSURE VESSELS (IDS)

CONCERNED COMPANIES:

C COMPANY B EPC CONTRACTOR T CERTIFYING AUTORITY S SUPPLIER

CERTIFYING AUTHORITIES:

OTHER: OFFICIAL AUTHORITY: **PED**

TYPE OF INTERVENTION:

H BINDING PRESENCE. The cycle continuationis bound to the presence
P BINDING PRESENCE FOR THE % INDICATED IN THE NOTES
W NOT BINDING PRESENCE. In case of unw itnessed test the Supplier is authorized to continues the production cycle supplying the appropriate documents.
R CHECK OF THE CERTIFICATES AND/OR DOCUMENTS.
C CHECK CARRIED OUT WITH RELEASE OF CERTIFICATE.
N CHECK CARRIED OUT WITHOUT RELEASE OF CERTIFICATE.
D SIMPLE DOCUMENTATION.

SPECIFICATIONS / DRAWINGS / REFERENCE STD:

INTERNATIONAL CODE AND STD:

1) **ISPESL**
2) **PED DIRECTIVE**
3) **ATEX DIRECTIVE**
4) **ANSI / ASME**
5) **ASME VIII**

PRESSURE VESSELS / FILTERS (IDS)

ITEM	DESCRIPTION OF CHECKS AND TESTS	CODE OF INTERVENTION				REFERENCE
		C	B	T	S	
1	Drawings, Data Sheets & Calculations approval check	R	R		D	
2	Review of unrefined materials certificates (visual/dimensional, NDT, chemical analysis & mechanical properties)	R	R		R	
3	Welding procedures and welders qualification (WPS+WQP+PQR) approval check	R	R		D	
4	Test procedure approval check	R	R		D	
5	Ultrasonic examination of steel plates (if any)	R	R		R	
6	Ultrasonic examination of cladded head after forming	W	W		C	
7	Magnetic particle examination of formed heads on the external knuckle radius surface	W	W		C	
8	100% RT examination on head welds after heat treatment	H	H		C	
9	Ultrasonic examination of forgings	W	W		C	
10	Magnetic particle examination of edges to be welded (for thickness> 30 mm)	W	W		C	
11	Magnetic particle examination of welds before backwelding	W	W		C	
12	Ultrasonic examination around the nozzles opening, prior to attachment of the nozzles, in case of set-on nozzles	W	W		C	
13	Magnetic particle examination, inside the vessel, of the welds to be covered, before a weld deposit overlay with stainless steel or other alloy	W	W		C	
14	Ferrite check, prior to heat treatment	W	W		C	
15	100% RT examination on beweled ends welds	H	H		C	
16	Test on production test-plates, in accordance with the Supply Specification	W	W		C	
17	Chemical analysis check, prior to final heat treatment, of the clad restoring area or of the weld deposit overlay	W	W		C	
18	Visual and dimensional examination of internal parts prior to installation	W	W		C	
19	Dimensional check, thickness check prior to postweld heat treatment	W	W		C	
20	Inner and outlet visual examination of vessel, prior to hydrostatic testing or, if applicable, prior to final heat treatment	H	H		C	
21	Visual and dimensional check of the assembled vessel	H	H		C	

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PRESSURE VESSELS

ITEM	DESCRIPTION OF CHECKS AND TESTS	CODE OF INTERVENTION				REFERENCE
		C	B	T	S	
22	Check of material identification, prior the hydrostatic test or, if applicable, prior to final heat treatment	H	H		N	
23	Check of temperature/time diagram concerning heat treatment	W	W		C	
24	Liquid penetrant examination, after hydrostatic test, of all weld areas and weld deposit overlay vessels	W	W		C	
25	Ultrasonic examination of all pressure retaining welds after heat treatment	W	W		C	
26	Hardness test, after heat treatment, of all pressure retaining welds in accordance with the Supply Specification	W	W		C	
27	Hydrostatic test	H	H		C	Note 1
	Helium Leak Test	H	H		C	
28	HIC TEST ACCORDING TO ISO 15156	H	H		N	
29	Check of filtering elements disassembly	H	H		N	
30	Visual and correct operation check of traps components: Q.O.C., pig arresters, pig signalers	H	H		N	
31	Weight control	W	W		D	
32	Check of name plate and marking	H	H		N	
33	Painting inspection (type, colour, surface preparation, primer, final, dry film thickness and certifications)	W	W		C	
34	Spare parts check (type, quantity and labelling)	W	W		N	
35	Completeness supply check according to the purchase order	H	H		N	
36	Packing, marking and packing list Check	W	W		N	
37	Final documentation review (Data Book)	H	H		D	
38	Check of CE certifications (PED, ATEX where applicable, etc.)	H	H		D	

PRESSURE VESSELS

NOTES:

1) Water containing no more than 30 ppm chlorides in the case of clad or weld deposit overlay vessels.

2) Interventions of EPC Contractor and Certifying Authority (where applicable) to be confirmed / defined by the involved parties.

3) The present document lists and defines the typical inspection activities to be performed.
Inspections and tests will be performed according to Supplier procedures and inspection plan (QCP), submitted to and approved by Company and Certifying Autority.
In case of lack of above procedures, tests will be performed according to the codes referred in the equipment data sheets / specifications.

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8 ATTACHMENT 1 - SMIR

GENERAL NOTES:

1) All documents must be issue in PDF file created from native file.

2) The Supplier shall re-issue the documents including Contractor and/or Company comments within 2 weeks from the relevant transmittal.

3) All documents necessary for the tests, must be issued for Construction and approved by Rosetti Marino.

4) If necessary, Supplier has issue Technical Clarification / Deviation Request before to proceed with activities in order to receive approval.

5) Manufacturer Record Book must be sent in PDF files with bookmarks, also native file of all documents (final copy approved) must be supplied.

6) The editable file is attached and, in case of order Supplier shall issue it as a separate document

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SMIR - REGISTRO DOCUMENTI / *SMIR - SUPPLIER MASTER INFORMATION REGISTER*

Ordine n°/*order nr.*			Fornitore/*Supplier*:			
data / *dated:*			Codice F./ *S. Code:*			
Commessa / *Job:*			Indirizzo/ *address* :			
Descrizione / *Description*	PRESSURE VESSEL		Persona di riferim./ *contact person:*			
Macrofase / *Phase*						

Pos.	Document nr. Client (1)	Doc Client Rev. (1)	Document nr. Internal	Document nr. Internal Rev. (2)	Document nr. Supplier (3)	Doc Supplier Rev. (3)	Titolo Documento / *Document title* *PRESSURE VESSEL*	Disciplina / *Discipline*	Blocco Classe / *Class Block (6)*	Docum. Format (7)	first issue date (8)	Third Party Approval (I/A)	Design KEY Document	Document subject to Liquidated Damages	Document Approval (I/A)
							CONTROL DOCUMENTS								
1							SUPPLIER MASTER INDEX REGISTER (SMIR)	MAC					Y		A
2							SUB-SUPPLIER LIST	EXP							A
3							FABRICATION / PRODUCTION SCHEDULE (Bar Chart [A3 max.]) / PROGRESS REPORT	EXP						Y	A/I
4							SUB-ORDER SCHEDULE / SUB-ORDER COPIES	EXP							I
							QUALITY DOCUMENTS								
6							QUALITY CONTROL PLAN or INSPECTION AND TEST PLAN	QUA		A4				Y	A
							ENGINEERING DOCUMENTS								
7							PRESSURE VESSEL MECHANICAL CALCULATION (INCLUDING EARTH QUAKE- BLASTING- TRANSPORT)	MAC							I
8							FOUNDATIONS STRUCTURE CALCULATION	MAC							I
9							GENERAL ARRANGEMENTS (Maximum size A1. drawing scale)	MAC					Y	Y	A
10							FOUNDATION LOADING DIAGRAM AND SUPPORT DETAILS (Max. dwg size A1)	MAC					Y	Y	A
11							ACCEPTABLE NOZZLE LOADS (A3/A4 document)	MAC					Y	Y	A
12							CROSS SECTION/EXPLODED VIEW DRAWING WITH PART LIST	MAC							I
13							INSULATION / LINING DETAILS (Scale drawing)	MAC							I
14							NAMEPLATE DRAWING	MAC							I
15							WEIGHT DATA SHEET (Purchaser's A4 sheet completed by Supplier)	MAC					Y		A
16							EQUIPMENT DATA SHEETS (Purchaser's A4 sheets completed by Supplier)	MAC					Y	Y	A
17							SAFETY (COSHH) DATA SHEETS	MAC							A
18							SPECIAL PARTS LIST (A3/A4 listing)	MAC							I
19							COATING PROCEDURE (including surface preparation)	MAC							A
20							FATIGUE STUDY (REF PARA 4.3.6 OF Technical Specification for CS Horizontal Pressure Vessels in H2 Service)								
							PROCEDURES								
21							NON-DESTRUCTIVE EXAMINATIONS PROCEDURES (NDE) (Supplier's procedure) INCLUDING PMI	QUA							A
22							NDE OPERATORS LIST AND QUALIFICATIONS	QUA							A
23							FORMING AND HEAT TREATMENT PROCEDURES (inc. PWHT)	WEL							A
24							HYDROSTATIC AND/OR PNEUMATIC TEST PROCEDURES	MAC							A
25							FLUSHING PROCEDURE (A4 procedure)	QUA							I
26							WEIGHT CONTROL / WEIGHING PROCEDURE (A4 Procedure)	QUA							I
27							FACTORY ACCEPTANCE TEST (FAT) PROCEDURE	MAC							A
28							WELD LOCATION PLAN (Detail drawings to scale. Maximum drawing size A1)	QUA							I
28							WELD PROCEDURE SPECIFICATION (WPS) AND QUALIFICATIONS (PQR) RECORDS (Supplier's standard forms in accordance with purchaser's requirements)	WEL							A
29							WELD OPERATORS LIST and WELDER QUALIFICATIONS RECORDS (WPQ)	WEL							A
30							PRE-COMMISSIONING / COMMISSIONING PROCEDURES (A4 procedure)	COM							A
31							EQUIPMENT MANUFACTURERS RECORD BOOK (FINAL DOSSIER) - INDEX	QUA					Y		A
							CERTIFICATES (ref. to notes in the RDDS)								
32							FACTORY ACCEPTANCE TEST (FAT) REPORT (A4 report)	QUA							I
33							ATEX REGISTER	MAC /QUA							A
34							WELDING REGISTER	QUA							A
35							EQUIPMENT MANUFACTURERS RECORD BOOK – COMPLETE (A4 bound volume(s) to Purchaser specifications)	CERT					Y	Y	A
36							PURCHASER's RELEASE NOTE (Issued by Purchaser)	EXP							I
37							CERTIFYING AUTHORITY RELEASE NOTES / WAIVERS	QUA							I
							SPARES AND MAINTENANCE DATA								
38							SPARE PART INDEX REGISTER (COMMISSIONING, OPERATION AND INSURANCE)	COM							I
39							TECHNICAL OPERATING AND MAINTENANCE MANUAL – COMPLETE (A4 bound volumes to Purchaser's specification)	MAC						Y	I
40							TECHNICAL OPERATING AND MAINTENANCE MANUAL – INDEX	MAC						Y	I
41							SPECIAL TOOLS LIST (A4 listing)	MAC							I
							HANDLING, SHIPPING & SITE INSTALLATION								
42							PREPARATION FOR SHIPPING PROCEDURES (A4 procedure)	LOG							I
43							PREPARATION FOR HANDLING AND STORAGE PROCEDURES (A4 procedure)	COSTR							I
44							ERECTION AND INSTALLATION PROCEDURES (A4 Manuals & Drawings)	METODI							A
45							LIFTING BEAM / FRAME / SLING DRAWINGS / LIFTING ARRANGEMENT DRAWINGS	MAC							I

Notes:

(1) Numero documento Cliente
Document number assigned by final Client

(2) Numero documento interno
Document number internal

(3) Numero documento Fornitore (assegnato dal Fornitore)
Document number assigned by Supplier

(4) Assegnare il Titolo del documento (assegnato dal Fornitore)
Fill in the document title (to be assigned by Vendor)

(5) Specific are la disciplina (compilato da Rosetti)
Process, Piping; Electrical, Expediting, Inspection, Commissioning, Quality, ecc (to be filled by Rosetti)

(6) Blocco Classe: Specifica, Disegno, Report, Data Sheet, etc. (compilato da Rosetti)
Procedure, list, drawing, data sheet, etc. (to be filled by Rosetti)

(7) A4, A3, A1 (compilato dal Fornitore)
A4, A3, A1 (Supplier)

(8) Data prevista per l'emissione del documento (compilato dal Fornitore)
Foreseen date for the first issue (Supplier)

9 ATTACHMENT 2 – STATEMENT OF COMPLIANCE

STATEMENT OF COMPLIANCE	

List of proposed deviations

All deviations shall be clearly stated on this sheet, with reference to SUPPLIER's quotation. Each proposed deviation shall be supported by a Deviation Request Form.
A proposed deviation is accepted if the related Deviation Request Form as been reviewed by Purchaser and APPROVED by COMPANY before the Purchase Order placement.
No deviations shall be accepted after the Purchase Order has been sent to SUPPLIER.

Item #	Subject	Proposed deviation description + reference to the section of the Requisition and SPECIFICATIONS concerned by the deviation

Remarks :

Date : Signature :

Name : Function :

Purchaser	**XXX**	**Requisition no**	**XXX**
PO number	**XXX**	**Sheet**	**1 of 1**
Project		**Rev.**	