

Bayu Undan / Darwin LNG Facilities Technical Delivery Terms

Material Description:		Hub Connectors	
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1 SCOPE

This document outlines the general technical requirements for the supply of Hub Connectors for the Santos Bayu-Undan Facilities, and takes precedence over all other documents.

The description Hub Connectors includes the following components:

ASME B31.3	Process Piping
ASME V	Non-destructive Examination
ASME B16.5	Flange fittings
ASME B16.25	Butt welding Ends
ASTM A29	General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought
ASTM A105	Carbon Steel Forgings for Piping Applications
ASTM A182	Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A193	Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194	Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A275	Magnetic Particle Examination of Steel Forgings
ASTM A320	Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service
ASTM A350	Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components
ASTM A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A521	Steel, Closed-Impression Die Forgings for General Industrial Use

ASTM A711	Steel Forging Stock
ASTM A788	Steel Forgings, General Requirements
ASTM A961	Common Requirements for Steel Flanges, Forged Fittings, Valves, and Parts for Piping Applications
ASTM E18	Standard Test Methods for Rockwell Hardness of Metallic Materials
ASTM E165	Liquid Penetrant Examination for General Industry
ASTM E1444	Standard Practice for Magnetic Particle Inspection
API 6FB	Specification for Fire Test for End Connections
NACE MR 0175	Sulfide Stress Cracking Resistant Metallic Materials for Oil Field Equipment
EN 10204	Metallic products – types of inspection documents
ALL/CMP/SPE/003	TDT 03: Coated Alloy Steel Bolting
ALL/CMP/SPE/002	TDT 02: Austenitic Stainless Steel and Superduplex Bolting
ALL/SUP/LOG/PRO/2000	Export Packing and Marking Logistics Procedure
DOC/ENG/SPE/0010	Project Coating Specification
H8-GEN-00-020-S01-0100	Bayu Undan Piping Material Specification

2 PRE-REQUISITION REQUIREMENTS

2.1 GENERAL

The proposal to supply hub connectors shall include, but not be limited to the following:

- Proof of extensive successful service application under comparable conditions with the choice of similar size, rating and materials.
- Documentation to demonstrate compliance with 304.7.2 of ASME B31.3 current edition.
- Type testing details as witnessed and certified by independent quality certifying organisations or similar.
- Leak test procedure for the hub connector joints.
- Details of production tests or scheme for sampling and testing.
- Equivalent or superior material specifications for components including information about relevant material properties, and material specifications for product forms used for manufacturing.
- The documentation provided shall demonstrate the following:
 - The design provides for joints that are leakage proof within the bursting pressure of pipe (of size and thickness as per the Piping Class) butt welded to the hub.
 - Pressure/Temperature rating for the hub connector is at least equal to ASME B16.5 for the same pressure class and material quality.
 - At rated design pressure, the hub connector is leak-free while being subject to

bending moments due to pipe loading. The quantified bending moment (in kNm) due to piping load that can be safely withstood by the hub connector (under full design pressure / temperature conditions) shall be listed for each size and pressure rating (covered under the relevant Piping Class in H8-GEN-00-020-S01-0100).

- Fatigue loading shall not cause any leakage in the bolted connection before a leak or failure will occur in adjoining welds or pipes, i.e. bolts or seals shall not be subjected to critical fatigue stress values at any cyclic load combination of pressure and bending as described above.
- The design complies with the fire test requirements of API Specification 6FB, parts I and II.

Note:

1. Leakage of hub connector joint shall be zero (no pressure drop/decay and visible leak) while hydrostatic tested under 1.5 times the design rated pressure.
2. Fugitive emissions from the flange joint shall effectively be zero. The supplier shall provide information to describe testing procedure and predicted leakage rate.

2.1 BOLT-UP REQUIREMENTS / ASSEMBLY PROCEDURE

For each applicable Piping Class furnish tables covering:

- Clamp, Hub, Seal Ring, Bolt size and length, and weight of each unit.
- Complete bolting up procedures including the following minimum information shall be provided along with the bid:
 - Requirements for alignment inclusive of tolerances (facial and lateral both)
 - Handling of seals
 - Description of tools
 - Bolt tensioning instructions
 - Bolt tensioning values
 - Guidelines for qualifying the personnel to carry out bolt up and assembly

3 MATERIALS

Material for all components shall be supplied in accordance with the ASTM specifications identified in this document. Supplemental and modified requirements to the identified ASTM material specifications are outlined under each item as necessary.

Repair by welding is not permitted.

Component material specifications required for Bayu Undan piping classes are summarised in Table 1.

TABLE 1 – HUB CONNECTOR MATERIAL SPECIFICATIONS

Piping Class ³	Material Type	Rated Temperature Range (°C)	Size Range mm	Hub incl. Blind	Clamp	Seal Ring	Bolt	Nut
DC1, DC2, DC2N, EC1, EC2, FC1, FC1N	CS & LTCS	-29 to +150	DN25 to DN300	A105N	AISI 4140 ^{1,5}	AISI 4140 ^{2,5}	A193 B7 ⁸	A194 2H
DD1N, ED1N, FD1N	Duplex S31803	-50 to +150	DN25 to DN300	A182 F51	A320 L7M ^{1,6}	A182 F55 S32760 SOLUTION ANNEALED ^{2,7}	A320 L7 ⁸	A194-4 A194-7
DL1, FL1	LTCS	-46 to +150	DN25 to DN300	A350 LF2 Class 1	AISI 4140 ^{1,5}	AISI 4140 ^{2,5}	A320 L7 ⁸	A194-4 A194-7
DS1, DS1N, ES1, FS1	316SS	-100 to +150	DN25 to DN300	A182 F316 ⁴	316SS	316SS ²	A193 B8M CL2 ⁸	A194 8M

Notes:

1. AISI 4140 and A320 L7M (MODIFIED) Clamps shall be supplied coated with Zinc Nickel, 10-12micron (corrosion resistance performance equivalent 1500hrs + against Salt Spray Fog Test as per ASTM B117-16.
2. Components exposed to the process shall comply with NACE MR0175 requirements.
3. Refer to respective Piping Class sheet for pressure / temperature ratings. Hub connector size range for all classes is DN20 to DN250, except that for ANSI Class 2500 size range up to DN300 is allowed. Usage other than as specified shall be approved by Santos Technical Authority.
4. A182 F316 Hubs, maximum carbon content = 0.035% (equivalent to 316L). All other properties shall meet ASTM A182-F316 requirements.
5. AISI 4140 Clamps and Seal Rings, all sizes, to be Charpy Impact Tested at -46°C, 41J average, 30J single minimum as per Galperti recommendation.
6. A320 L7M (MODIFIED) Clamps, all sizes, to be Charpy Impact Tested at -73°C, 27J average, 20J single minimum as per A320 Specification.
7. A182 F55 S32760 Seal Rings, all sizes, to be Charpy Impact Tested at -50°C, 50J average, 40J single minimum as per Galperti recommendation.
8. Bolting materials shall be as identified in the relevant Piping Class and in full compliance with requirements specified in ALL/CMP/SPE/002 or 003 as applicable to the type of material.

3.1 HUB

Hub Material shall be as specified for the piping class and as summarised in Table 1.

Maximum thickness under tolerance shall be 0.3mm

Bevel ends shall be in accordance with ASME B16.25

3.1.1 ASTM A105

ASTM A105 forgings shall be supplied in the normalised condition. Supplementary requirement S2 regarding heat treatment and marking shall apply.

For carbon steel material, carbon content shall not be more than 0.23% and carbon equivalent (CE) shall be 0.43% weight as determined by the formula:

$$CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$$

Note, this is more restrictive than S4 of A105 which specifies 0.47% for sections 2" thick or less, and 0.48% for sections above 2" thickness.

3.1.2 ASTM A350-LF2

Supplementary requirement S55 of ASTM A961 regarding MPI of the finished forging shall apply to 10% of the items with size DN50 and above. The acceptance criteria shall be in accordance with ASME VIII Div 1, Appendix 6.

Flanges shall be normalized. Hubs shall be quenched and tempered.

Impact test results shall be at least 27 Joules (for standard specimen 10 x 10 mm) as an average of three tests. One result may be lower than 27 Joules, but shall have a minimum of 21 Joules. For sub-size specimens, the impact values required by ASTM A350 shall be multiplied by 1.5.

3.1.3 ASTM A182-F316

Molybdenum content of the material shall not be less than 2.5% by weight.

All austenitic stainless steels shall be supplied and used in solution heat-treated condition.

Items shall be supplied in white pickled condition except for machined surfaces

Austenitic Stainless Steel used for hubs shall be dual stamped, i.e. carbon content of 316L and mechanical properties of 316.

3.1.4 ASTM A182-F51

Pitting resistance number (PREN) for the material shall be not less than 33 when calculated using the formula: $PREN = \%Cr + 3.3 * \%Mo + 16 * \%N$

Nitrogen content shall be 0.15% minimum.

For hubs, ferrite in the final heat treated condition shall be between 40 – 60%.

Charpy V-notch Impact testing shall be carried out at -50°C.

For a standard specimen, the average impact value of three specimens shall be 40J or more, with an allowable single value of 31J. For sub-size specimen, impact value less than 70% of the standard specimen is not acceptable.

Hardness shall be measured and shall be less than 28 HRC.

Repair welding is not permitted.

Items shall be supplied in white pickled condition.

3.2 CLAMP

The clamp shall be manufactured by forging. Cast construction is not acceptable.

The forging shall be manufactured in accordance with ASTM A788 including supplementary requirements S5, S13, S18 and S19.

Charpy Impact Testing to be carried out as follows:

- AISI 4140 Clamps, all sizes, to be Charpy Impact Tested at -46°C, 41J average, 30J single minimum.
- A320 L7M (MODIFIED) Clamps, all sizes, to be Charpy Impact Tested at -73°C, 27J average, 20J single minimum.

The billet used to produce alloy steel clamp forgings shall be produced in accordance with ASTM A788 with grade 4140 chemical composition in accordance with ASTM A29.

3.3 SEAL RING

Seal rings shall be machined from forged material of composition and grade specified for the piping class. All seal rings shall comply with NACE MR0175.

Charpy Impact Testing to be carried out as follows:

- AISI 4140 Seal Rings, all sizes, to be Charpy Impact Tested at -46°C, 41J average, 30J single minimum.
- A182 F55 S32760 Seal Rings, all sizes, to be Charpy Impact Tested at -50°C, 50J average, 40J single minimum.

3.4 BOLTS AND NUTS

Bolting materials shall be as identified in the relevant Piping Class and in full compliance with requirements specified in ALL/CMP/SPE/002 or 003 as applicable to the type of material.

4 APPLICABILITY OF NACE MR0175 REQUIREMENTS

For piping classes designated for sour service, the hub forging and seal ring shall be supplied in a condition that meets NACE MR0175 requirements for the material.

Additionally, for carbon steel, sulphur content shall be restricted to 0.010% by weight.

Material certificates/compliance statements shall clearly indicate the required property and NACE compliance requirement and the compliance details against each of those specified details.

5 NON-DESTRUCTIVE EXAMINATION

NDE methods and acceptance criteria, extent and sampling shall be in accordance with the ASTM Specification material design code and as specified herein.

5.1 Inspection Standards

Item	Type of Inspections	Applicable Standards
Forging (hub, clamp, seal ring)	Visual	ASME B31.3, 344.2
	Magnetic Particle Test (MT)	ASTM A275, ASTM E1444 and ASME V Article 7
	Dye Penetrant Test (PT)	ASTM E165 and ASME V Article 6
	Ultrasonic Test (UT)	ASME B31.3, 344.6 and ASME V Article 5
	Hardness Test (HT)	ASTM A370
	Impact Test	ASME B31.3, 323.3 and ASTM A370
	Bolts/nuts	Refer: ALL/CMP/SPE/002 (TDT 02) Austenitic Stainless Steel and Super Duplex Bolting ALL/CMP/SPE /003 (TDT 03) Coated Alloy Steel Bolting

Dye-Penetrant Test (PT) shall be carried out on the bevel ends plus a 25mm band adjacent to the bevel (both inside and outside surface) for 10% of the hubs.

Magnetic Particle Test (MT) may be applied instead of PT, if it is not feasible to carry out PT or when the work efficiency and detection rate of defects is better.

5.1 ACCEPTANCE CRITERIA

5.2.1 Visual Examination

Visual examination shall be carried out in accordance with ASME V Article 9.

Forgings shall be free from defects such as Cracks, Mechanical Marks, Abrasions, Pits, Scale, Fins etc Other item shall be free from defects and to a standard acceptable to the principal's inspector.

5.2.2 Magnetic Particle

The techniques specified in ASTM A275 and ASTM E1444 shall be used to determine the presence of any longitudinal and transverse flaws, using fluorescent particles. All flaws or indication of flaws shall be ground out to their full extent and the resultant wall thickness and diameter of the surface defect-free component shall comply with the product specification.

5.2.3 Dye Penetrant Tests

The techniques specified in ASTM E165 shall be used to determine the presence of any longitudinal and transverse flaws. All flaws or indication of flaws shall be ground out to their full extent and the resultant wall thickness and diameter of the surface defect-free component shall comply with the product specification.

Linear indications longer than 1.6mm are not acceptable.

6 TRACEABILITY AND CERTIFICATION REQUIREMENTS

All materials shall be supplied with EN 10204 3.1 certificates for each batch/heat traceable to the actual items/components being supplied. Certification for bolting shall comply with TDT 02 and TDT 03.

Certification for forged components and other product forms shall comply with the requirements of ASTM A788.

Both specified and actual mechanical properties and chemical compositions, inclusive of NACE MR0175 requirements (if applicable), shall be included in type II certificates.

Positive material identification test results for materials other than carbon steel shall be included in type II certificate.

All the documents relating to quality assurance and quality control including certificates shall be in English and readily legible. Documents provided in other languages or illegible shall not be accepted and shall be referred to Santos before clearing final inspection.

7 MARKING REQUIREMENTS

The items shall be low stress (round nose) stamped at the locations as follows:

Hub Connectors: On the outer rim

Clamps: On the outside surface along the centre line

Seal Rings: On the outer rim or on the label attached to the gasket.

Details of marking for hub connectors shall be in line with ASME B16.5 and shall include manufacturer unique symbol, model type and number, schedule number or specified wall thickness (mm) and the charge or heat number.

“N” shall be marked as a suffix to the material ASTM designation or UNS designation, to identify the component as suitable for Sour Service.

“LT” shall be marked suffix to the material ASTM designation or UNS designation, when identified as for Low Temperature Service.

8 PAINTING AND COLOUR IDENTIFICATION OF ITEMS

Colour identification shall be carried out after primer coating.

The items shall be colour identified for the purposes of transport, storage and handling.

Hand brush or machine application of paint is required; daubing is not acceptable.

If the items are primer coated or protective coated, colour identification shall be carried out after such coating.

Colour coding shall not obliterate other markings.

Hub Connectors shall be coded by painting the rim edge.

Zinc or lead pigments are not permitted and paints or inks shall be chloride free.

The colour identification shall be carried out in compliance with the table overleaf:

Hub incl. Blind Material	Visual Colour	BS4800 / Colour
A105N	Powder Blue	18E 49 Blue
A182 F51	Light Green	14E 51 Green
A350 LF2 Class 1	Grey Blue	18 C35 Blue
A182 F316	Light Brown	08 C37 Yellow-red
Bolting Materials	Refer: ALL/CMP/SPE/002 (TDT 02) Austenitic Stainless Steel and Super Duplex Bolting ALL/CMP/SPE /003 (TDT 03) Coated Alloy Steel Bolting	

9 DRAWING AND DOCUMENTATION REQUIREMENTS

The manufacturer shall provide documentation, which shall be available prior to shipment. Computerised data or photocopies of originals (verified and signed by the QA/QC-department) may be provided instead of originals.

The documentation shall include, as a minimum the following:

- Purchase order and identification of the items by serial number or manufacturer's code.
- Materials test reports and inspection certificates as specified.
- NDE reports, including sketches, if necessary, showing the locations of examination.
- list of applicable and authorised concessions, waivers and/or material substitutions.
- manufacturer's statement of compliance signed by an authorised representative.
- list of applicable manuals (e.g. assembly / maintenance manuals).

10 PRESERVATION, PACKING AND SHIPPING REQUIREMENTS

Packing and marking shall comply with Santos Export Packing and Marking Logistics Procedure ALL/SUP/LOG/PRO/2000.

Material shall be suitably packed to prevent damage during handling or loss or damage in transit. Preservation shall be applied so that, provided the package remains unopened, undamaged and handled in accordance with the vendor's marking and shipping instructions, negligible degradation will occur for a minimum period of twelve months from the date of despatch from the vendor's works.

Crating and packages shall be suitable for opening and resealing without difficulty or damage. Crating and packages shall be marked with clear handling, storage and warning instructions to protect against damage to the preservation applied.

The vendor shall include a packing list with each crate or package to contain as a minimum the following:

- Purchase Order Number.
- Purchase Order Item Numbers.
- Tag Number / Item Code.
- Details of content e.g. description, quantity etc.
- Method of packing e.g. created bundled, loose pieces etc.
- Number of packages of each type e.g. 2 crates, 2 bundles etc.
- Total number of packages.
- Package number.
- Total gross and net weights in Kg.
- Dimensions and cubic measurements of each package.
- Cubic measurement of entire shipment.
- Confirmation of inclusion of certification

10.1 SEAL RINGS

Seal Rings shall be packed in waterproof paper if ordered separately.

10.2 HUBS AND CLAMPS

Moisture-resistant discs of plastic (plastic caps) shall be used to blank off hub items
Butt weld ends shall be protected by plastic end caps.

All other openings shall be securely closed to prevent the ingress of moisture or foreign matter.