

DEP SPECIFICATION

FLOATING STRUCTURE TOP-TENSIONED RISER SEAMLESS TUBULAR REQUIREMENTS

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DESIGN AND ENGINEERING PRACTICE



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PREFACE

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These views are based on the experience acquired during involvement with the design, construction, operation and maintenance of processing units and facilities. Where deemed appropriate DEPs are based on, or reference international, regional, national and industry standards.

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The information set forth in these publications is provided to Shell companies for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual Operating Units to adapt the information set forth in DEPs to their own environment and requirements.

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All administrative queries should be directed to the DEP Administrator in Shell GSI.

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1. INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for the manufacture, testing and inspection of Level 1 and Level 2 carbon steel and low-alloy steel tubulars meeting the following criteria, for use as Floating Structure Top-Tensioned Risers:

Specified minimum yield strength (SMYS)	345 MPa – 690 MPa (50 ksi - 100 ksi)
Wall thickness	10.2 mm – 25.4 mm (0.4 in - 1 in)

It is intended that individual tubulars are suitable for fabrication into longer lengths by girth welding. The technical requirements in this DEP result in exceptionally high heat-affected zone (HAZ) fracture toughness of resulting weldments. In addition, precise control of inside diameter and out-of-roundness minimizes axial misalignment (high-low) of fabrication girth welds.

Level 1 seamless tubular requirements are more stringent than those for Level 2. Level 1 and Level 2 seamless tubulars will be identified by the Principal.

Floating Structure Top-Tensioned Risers generally utilize Level 1 seamless tubulars near the upper and lower terminations of the riser length where fatigue loading is more severe and Level 2 seamless tubulars in the mid-riser length section where fatigue loading is less severe.

This DEP is a revision of, and supersedes, Shell Offshore Inc. Supplement 8, dated April 1995, and Shell Deepwater Development Inc. Supplement 22, dated June 1997, which have been used for manufacture, testing and inspection of all previous Shell TLP and Floating Structure Level 1 and Level 2 Top-Tensioned Risers. This DEP combines the two aforementioned Supplements, and therefore contains requirements for both Level 1 and Level 2 TTR seamless tubulars.

The custodianship of this DEP in Shell is under the Civil, Structures and Offshore (CSO) Engineering Discipline.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorisation to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to offshore oil and gas production. It is primarily intended for use as Floating Structure Top-Tensioned Risers within the above mentioned specified minimum yield strength (SMYS) range and wall thickness range. However, its application to other types of equipment and structures, SMYSs or wall thicknesses outside of the ranges mentioned herein is not precluded. Application to other types of equipment and structures shall be as required by Principal.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Abbreviations

Term	Definition
AC	alternating current
B	Thickness
BOP	bead-on-plate
CGHAZ	coarse-grain HAZ
CR	controlled rolled
CRT	Cathode Ray Tube
CTOD	crack tip opening displacement
CVN	Charpy V-notch
DAC	distance amplitude correction
DC	direct current
DEP	Design and Engineering Practice
FSC	full scale of chart
FSH	full screen height
HAZ	heat-affected zone
ICHAZ	intercritical HAZ
ID	inside diameter
ITP	Inspection and Test Plan
LAST	Lowest anticipated service temperature
MOC	Management of Change
MPS	Manufacturing Procedure Specification. Reference ISO 9000 Paragraphs 2.7.2.c, 2.7.2.e, 3.4.5 and 3.7.3.
MT	Magnetic Particle
N	Normalized
OD	outside diameter
PQ	Prequalification
Q&A	quenched and aged
Q&T	quenched and tempered

Term	Definition
QP/ITP	Quality Plan (QP). Reference ISO 9000 Paragraphs 2.7.2.b and 3.7.5. A QP is also known as an Inspection and Test Plan (ITP).
RGL	Reference gain levels
RL	Reference Line
SCHAZ	subcritical HAZ
SI	International System units
SMYS	specified minimum yield strength
SR	stress-relieved
THAZ	Transformed HAZ
TLP	tension leg platform
TPI	Third-party inspector appointed by the Principal to represent the Principal in matters pertaining quality, inspection and testing at the manufacturing facility (mill)
TMCP	thermo-mechanically control processed
USC	US Customary units
UT	Ultrasonic inspection
VHAZ	visible HAZ
VT	visual examination
W	Width
WT	Wall Thickness

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (14).

1.5 SUMMARY OF MAIN CHANGES

This is a new DEP.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://www.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.

DEP Standard Form (Other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .
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Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

2. GENERAL

2.1 QUALITY CONTROL / QUALITY PLAN (QP/ITP)

1. This DEP supplements project specifications, which govern overall fabrication of Floating Structure Top-Tensioned Risers. Unless specifically deleted / waived by this DEP, all provisions of the applicable project specifications shall apply, including the requirement for development and implementation of a written Quality Management System and ITP.
2. The QP/ITP shall define all inspections and the sequence in which they are to be performed during manufacture, testing and inspection of Floating Structure Top-Tensioned Riser seamless tubulars and levels of involvement for the Manufacturer / Supplier's quality control / inspection personnel, Principal-appointed third party inspectors (TPI), and the Principal. The QP/ITP shall include inspection and test requirements and provide columns or spaces for the Principal to indicate 3rd-party inspector inspection activities, e.g., monitor, witness, hold points, etc. for the operations to be undertaken.
3. Principal approval shall be obtained of the QP/ITP and any revisions prior to commencement of pipe manufacture.
4. The Quality Management System shall be in compliance with ISO 9001.

2.2 MANUFACTURING PROCEDURE SPECIFICATION (MPS)

1. The tubular Manufacturer/Supplier shall prepare an MPS which contains, as a minimum, allowable ranges for the applicable process control variables listed in (Table 1). The MPS shall clearly define the sequence of operations and process controls to be implemented at each manufacturing step as well as specifically annotate any procedures, processing parameters, or requirements that deviate from this DEP.
2. The MPS and any revisions shall be transmitted to the Principal for review and approval.

2.3 CONTRACTOR PROCUREMENT SPECIFICATION AND APPROVAL OF THE TUBULAR MANUFACTURER/SUPPLIER AND MANUFACTURING FACILITIES AND SUBCONTRACTED CHEMICAL ANALYSIS OR MECHANICAL TESTING LABORATORIES

1. Principal prefers that this DEP be used directly for procurement; however, if approved by Principal; the Contractor may prepare a detailed Procurement Specification which is compatible with Contractor's document format and quality system. As a minimum, Contractor's Procurement Specification shall incorporate all requirements contained herein and shall require approval by the Principal.
2. The Manufacturer/Supplier and manufacturing facilities, as identified in the manufacturing procedure specification (MPS), shall require approval by Principal.
3. Any subcontracted chemical analysis or mechanical testing laboratories shall be approved by Principal.
4. Chemical analysis and mechanical testing laboratories shall hold a current accreditation by an independent third-party organization to ISO 17025.

2.4 LOWEST ANTICIPATED SERVICE TEMPERATURE

1. Lowest anticipated service temperature (LAST) shall be specified by Principal. It is quite common for different portions of the TTR string to be grouped into different values of LAST. For example, in the Gulf of Mexico, commonly specified values are 0 °C (+32 °F) for tubulars which are continuously exposed during their service life to splashzone or marine atmospheric service and +4.4 °C (+40 °F) for tubulars which are continuously exposed during their service life to subsea-only service.

2.5 PREQUALIFICATION

1. Prior to the start of full production, the tubular Manufacturer shall produce a PQ tubular of the maximum WT specified for each SMYS to be provided.
2. If only one WT but several different diameters are specified, then the PQ tubular shall have the largest diameter specified.
3. The PQ tubular shall be fully tested and inspected for compliance with all requirements of this DEP.
4. Additional requirements for PQ shall be as defined in (Appendix A) of this DEP.

2.6 DIMENSIONS AND SPECIAL ATTRIBUTES

1. Tubular outside diameter (OD), WT, length requirements, and any special or additional dimensional tolerances, non-destructive testing, or other requirements not covered specifically by this DEP will be specified by the Principal.
2. Inside diameter (ID) will not be specified independently; however, for the purposes of this DEP, it shall be defined as $ID = OD - (2 \times WT)$.

2.7 UNDERLYING INDUSTRY SPECIFICATION

1. Tubulars shall be manufactured and tested in accordance with API SPEC 5L. Application of the API monogram, however, is not required.

Seamless top-tensioned riser tubulars have service requirements which share certain characteristics of structural pipe, OCTG casing and linepipe. As such, it is impossible to base requirements solely on one single underlying industry code, i.e., API SPEC 2B, API SPEC 5CT or API SPEC 5L. Hence, this DEP has requirements taken from all three underlying industry codes as well as some requirements not in, or differing from, them. However, for the purposes of not having to completely re-write a "stand alone" specification, it was decided to base the requirements on API 5L and then add to, take away from, or modify as appropriate.

2. Unless specifically deleted/waived by this DEP, all provisions of API SPEC 5L shall apply.

Modifications to API SPEC 5L and specific deletions or identification of nonapplicable parts are identified herein.

Some statements and/or required values in API 5L may be repeated in this DEP for clarity or special emphasis

3. Alternative underlying industry specifications (e.g. ISO, BSI, EEMUA, JIS, DIN, EN, etc.) may be approved on a case-by-case basis. The underlying industry specification shall be identified in the MPS.

2.8 TRACEABILITY

1. Full traceability of tubulars and test results shown on mill certificates shall be maintained with respect to the following, as applicable:
 - a. Heat
 - b. Production Lot
 - c. Tubular Serial Number
2. A description of the traceability plan shall be included in the MPS.

2.9 PRODUCTION LOT

1. For the purposes of this DEP, a production lot shall be defined as all tubulars with the same nominal dimensions from the same heat of steel which are heat treated together either as a batch or sequentially in an uninterrupted continuous operation, not to exceed 25 tubulars.

2. Correlation shall be maintained between test results shown on mill certificates and the production lots they represent.

2.10 INFORMATION TO BE CONVEYED TO MANUFACTURER

1. Table 2 provides a summary of minimum information that shall be conveyed to Manufacturer in order for Manufacturer to be able to properly accomplish Work in compliance with this DEP.

2.11 SUMMARY OF DOCUMENT SUBMITTALS AND ACTIVITIES REQUIRING PRINCIPAL ACTION

1. Table 3 provides a summary of required document submittals and activities that shall be complied with, together with appropriate Principal actions.

Various documents and activities are identified by this DEP as requiring transmittal to the Principal for specific action, e.g. Review, Approval, Acceptance, etc.

2. Documents shall be transmitted to the Principal in a timely manner as specified in the Contract or otherwise by the Principal's representative, in order to allow formal review.

2.12 PREPRODUCTION MEETING

1. Prior to commencement of production, a preproduction meeting shall be held between the tubular Manufacturer, the Principal, the Contractor, if applicable, and appropriate third-party inspection personnel in order to assure that all parties involved fully understand and mutually agree to applicable requirements.

2.13 POST-JOB HISTOGRAMS

1. At the end of each order, post-job histograms of all measured chemical, mechanical and dimensional properties for the job shall be prepared by the Manufacturer and transmitted to the Principal.

3. PROCESS OF MANUFACTURE AND CHEMICAL COMPOSITION

3.1 TUBE-FORMING PROCESS

1. Tubulars shall be manufactured by the seamless process. Cold drawn tubular products without subsequent heat-treatment are not acceptable.
2. A general, but comprehensive, description of the tube-forming process shall be included in the MPS.

3.2 STEELMAKING AND CASTING PROCESS

1. Steel from which tubulars are subsequently formed shall be fully killed and shall be produced by a steelmaking practice that includes vacuum degassing of the molten metal.
2. A general, but comprehensive, description of the steelmaking and casting process shall be included in the MPS.

3.3 FINE GRAIN SIZE

1. Tubulars shall meet the following prior-austenitic grain size requirements:

Type	Grain size (maximum) per ASTM E112
Level 1	ASTM 7
Level 2	ASTM 5

2. One test per heat shall be required.
3. Test results shall be included in the certification documentation for each heat.

3.4 CHEMICAL COMPOSITION

3.4.1 Ranges

1. Chemical composition ranges shall be proposed by the tubular Manufacturer for both heat and product analyses for approval by Principal.
2. The Principal-approved ranges and specific target (aim) values for all elements to be added or analysed shall be listed in the MPS.

3.4.2 Elements

1. Only those elements included in the approved chemical composition specification shall be added.
2. Any element intentionally added and any element listed in (3.4.3) shall be reported.
3. All elements included in the P_{cm} equation given in (3.4.5) shall be reported in the certification documentation for each heat.

3.4.3 Elemental limits

1. Unless more restrictive ranges are required by the approved chemical composition specifications, the following elemental limits shall apply to the heat analysis:

Element	Weight Percent (wt%) (maximum)
Carbon (C)	0.16
Sulfur (S)	0.006 (Level 1)/0.010 (Level 2)
Phosphorous (P)	0.015 (Level 1)/0.020 (Level 2)
Titanium (Ti)	0.020 ⁽¹⁾
Vanadium (V)	0.050 (Level 1)/0.080 (Level 2) ⁽¹⁾
Niobium (Nb)	0.060 ⁽¹⁾
Nb+V	0.060 (Level 1)/0.080 (Level 2) ⁽¹⁾
Nitrogen (N) ⁽²⁾	0.009 if Ti ≤ 0.010 (Level 1) 0.012 if Ti > 0.010 (Level 1) 0.012 (Level 2)
Calcium (Ca)	0.0050
Boron (B) ⁽³⁾	0.0005
Antimony (Sb)	0.010
Arsenic (As)	0.010
Tin (Sn)	0.010
P+Sb+As+Sn	0.035

NOTES: (1) These limits apply only if the element is intentionally added; otherwise, residual levels shall be 0.010 (Level 1)/0.015 (Level 2) wt% maximum for each element.

(2) For Level 1 only, total nitrogen shall be ≥ 0.0030 wt% and Ti/N ratio shall be controlled to Approved limits for Ti-treated steels. If Titanium is intentionally added then the steel shall be considered a Ti-treated steel.

(3) This limit applies to residual boron. Intentional boron additions shall be made only at precise levels proposed by the tubular Manufacturer as approved by the Principal and within +3 ppm, -5 ppm of that determined for the PQ tubular, refer to (2.5) and (Appendix A).

3.4.4 Inclusion shape control

1. Inclusion shape control shall be required.
2. The method of inclusion shape control and verification shall be described in the MPS.

3.4.5 P_{cm}

1. The Ito-Bessyo P_{cm}, based on heat analysis, shall be less than or equal to the values proposed by the tubular Manufacturer and approved and within +0.02 wt%, -0.03 wt% of that determined for the PQ tubular, refer to (2.5) and (Appendix A).
2. P_{cm} shall be calculated by utilizing the equation given below:

$$P_{cm} = C + (Si/30) + [(Mn+Cu+Cr)/20] + (Ni/60) + (Mo/15) + (V/10) + (5B)$$

3.5 HOT-WORK REDUCTION

1. The overall hot-work reduction from ingot or strand-cast bloom to finished tubular shall be greater than or equal to 4 to 1.
2. Ingot size and/or bloom size and any intermediate billet size and tube sizes shall be identified in the MPS.

3. The hot-work reduction for individual hot-work operations shall be defined as starting cross-sectional area divided by final cross-sectional area for the particular hot-work operation.
4. The overall hot-work ratio shall be defined as the product of all intermediate hot-working operations.
5. The computation of each individual hot-work operation's reduction (including nominal start and finish dimensions) as well as the computation of the overall hot-work reduction shall be included in the MPS.

3.6 THERMO-MECHANICAL PROCESSING AND HEAT TREATMENT

1. Tubulars shall be normalized (N), controlled rolled (CR), thermo-mechanically control processed (TMCP), or quenched and tempered/aged (Q&T or Q&A). Normalizing, controlled rolling, or TMCP treatments may also be followed by a tempering/ageing treatment.
2. The specific thermo-mechanical steps to be followed and a full description of all heat-treatment steps, including times and temperatures, shall be included in the MPS.

3.7 STRAIGHTENING

1. Hot gag press or rotary straightening may be performed during the cool-down from final heat-treatment, down to 500 °C (932 °F) minimum. Unless otherwise approved, cold gag press or rotary straightening shall require subsequent stress relief, tempering, or ageing at a temperature equal to or greater than 510 °C (950 °F); however, for quenched and tempered or quenched and aged tubulars, stress relief temperature shall not be higher than 30 °C (50 °F) below the previous tempering or ageing temperature.
2. The method of straightening and any subsequent thermal processing shall be described in the MPS.

3.8 END SWAGEING/EXPANSION, SIZING, OR MACHINING

1. Special end expansion, swageing and expansion, or machining (counterboring) shall be performed to achieve specified ID control and out-of-roundness for the tubular ends (which eventually will be fabricated into riser joints by girth-welding).
2. Cold end expansion or swageing and expansion may be performed without subsequent stress relief, but shall be limited to total circumferential strain of $\leq 2\%$, unless otherwise approved.
3. Machined (counterbored) ends shall extend for a distance of 150 mm (6 in) from the end, shall have a transition radius to the ID of not less than 75 mm (3 in) and a surface finish equal to or better than 3.2 μm (125 μin) RMS.
4. The specific method of end expansion, sizing, or machining shall be described in the MPS.

4. CHEMICAL PROPERTIES AND TESTS

4.1 HEAT ANALYSIS

4.1.1 Samples

1. The heat analysis for each heat of steel shall be included in the documentation package.
2. The heat analysis shall include a determination of the hydrogen content of the liquid steel after all elemental additions and vacuum degassing, for information only.
3. The details of precisely when the heat and hydrogen analysis samples are to be taken and which of the heat and hydrogen analysis samples are to be reported in the certification documentation shall be described in the MPS.

4.1.2 Certification documentation

1. The P_{cm} shall be calculated for the heat analysis and reported in the certification documentation each heat.

4.1.3 Intermix chemistry control

1. The procedure for intermix chemistry control when employing the continuous-casting process shall be fully described in the MPS.

4.2 PRODUCT ANALYSIS

1. A minimum of two product analyses per heat shall be performed and reported in the certification documentation.
2. A best-effort attempt shall be made to insure that one of the product analyses comes from a tubular that originated from material cast near the beginning of the cast and that the other product analysis comes from a tubular that originated from material cast near the end of the cast.