

DEP SPECIFICATION

TLP TENDON AND FLOATING STRUCTURE TOP-TENSIONED RISER GIRTH WELDING AND INSPECTION REQUIREMENTS

DEP 39.01.20.36-Gen.

February 2014

ECCN EAR99

DESIGN AND ENGINEERING PRACTICE



© 2014 Shell Group of companies
All rights reserved. No part of this document may be reproduced, stored in a retrieval system, published or transmitted, in any form or by any means, without the prior written permission of the copyright owner or Shell Global Solutions International BV.

This document contains information that is classified as EAR99 and, as a consequence, can neither be exported nor re-exported to any country which is under an embargo of the U.S. government pursuant to Part 746 of the Export Administration Regulations (15 C.F.R. Part 746) nor can be made available to any national of such country. In addition, the information in this document cannot be exported nor re-exported to an end-user or for an end-use that is prohibited by Part 744 of the Export Administration Regulations (15 C.F.R. Part 744).

This document has been supplied under license by Shell to:
UOP Honeywell ted.fuger@honeywell.com 20/04/2018 04:25:05

PREFACE

DEP (Design and Engineering Practice) publications reflect the views, at the time of publication, of Shell Global Solutions International B.V. (Shell GSI) and, in some cases, of other Shell Companies.

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.

The objective is to set the standard for good design and engineering practice to be applied by Shell companies in oil and gas production, oil refining, gas handling, gasification, chemical processing, or any other such facility, and thereby to help achieve maximum technical and economic benefit from standardization.

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.

When Contractors or Manufacturers/Suppliers use DEPs, they shall be solely responsible for such use, including the quality of their work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will typically expect them to follow those design and engineering practices that will achieve at least the same level of integrity as reflected in the DEPs. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal.

The right to obtain and to use DEPs is restricted, and is typically granted by Shell GSI (and in some cases by other Shell Companies) under a Service Agreement or a License Agreement. This right is granted primarily to Shell companies and other companies receiving technical advice and services from Shell GSI or another Shell Company. Consequently, three categories of users of DEPs can be distinguished:

- 1) Operating Units having a Service Agreement with Shell GSI or another Shell Company. The use of DEPs by these Operating Units is subject in all respects to the terms and conditions of the relevant Service Agreement.
- 2) Other parties who are authorised to use DEPs subject to appropriate contractual arrangements (whether as part of a Service Agreement or otherwise).
- 3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) or 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

Subject to any particular terms and conditions as may be set forth in specific agreements with users, Shell GSI disclaims any liability of whatsoever nature for any damage (including injury or death) suffered by any company or person whomsoever as a result of or in connection with the use, application or implementation of any DEP, combination of DEPs or any part thereof, even if it is wholly or partly caused by negligence on the part of Shell GSI or other Shell Company. The benefit of this disclaimer shall inure in all respects to Shell GSI and/or any Shell Company, or companies affiliated to these companies, that may issue DEPs or advise or require the use of DEPs.

Without prejudice to any specific terms in respect of confidentiality under relevant contractual arrangements, DEPs shall not, without the prior written consent of Shell GSI, be disclosed by users to any company or person whomsoever and the DEPs shall be used exclusively for the purpose for which they have been provided to the user. They shall be returned after use, including any copies which shall only be made by users with the express prior written consent of Shell GSI. The copyright of DEPs vests in Shell Group of companies. Users shall arrange for DEPs to be held in safe custody and Shell GSI may at any time require information satisfactory to them in order to ascertain how users implement this requirement.

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

TABLE OF CONTENTS

1.	INTRODUCTION	5
1.1	SCOPE.....	5
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	5
1.3	DEFINITIONS	5
1.4	CROSS-REFERENCES	7
1.5	SUMMARY OF MAIN CHANGES	7
1.6	COMMENTS ON THIS DEP	8
1.7	DUAL UNITS.....	8
1.8	NON NORMATIVE TEXT (COMMENTARY).....	8
1.9	INSPECTION AND TEST PLAN AND QUALITY MANAGEMENT SYSTEM.....	8
2.	GENERAL.....	9
2.1	ATTRIBUTES TO BE SPECIFIED BY THE PRINCIPAL	9
2.2	ANSI/AWS A3.0	9
2.3	FABRICATION PROCEDURE SPECIFICATION / PROCESS CONTROL PLAN	9
2.4	UNDERLYING INDUSTRIAL WELDING CODE.....	9
2.5	MANUFACTURER/SUPPLIER'S BASIC RESPONSIBILITIES.....	9
2.6	QUALIFICATIONS	9
2.7	JOINT DETAILS.....	9
2.8	WELDING PROCESSES.....	10
2.9	WELDING PROCEDURE PROPOSALS.....	11
2.10	IDENTIFICATION AND QUALIFICATION RECORDS OF WELDERS AND WELDING UNITS/POWER SUPPLIES	11
2.11	IDENTIFICATION OF WELDMENTS AND ROOT FACE LOCATION	11
2.12	PROCEDURE QUALIFICATION TEST WITNESS REQUIREMENTS	12
2.13	AVAILABILITY OF WPS	12
2.14	LOWEST ANTICIPATED SERVICE TEMPERATURE.....	12
2.15	WELD DATA LOGGING REQUIREMENTS	12
2.16	PRE-PRODUCTION MEETING.....	13
3.	MATERIAL REQUIREMENTS	13
3.1	BASE METAL.....	13
3.2	WELDING CONSUMABLES.....	14
4.	WELDING PROCEDURE SPECIFICATION	16
4.1	GENERAL	16
4.2	ESSENTIAL VARIABLES	17
5.	PROCEDURE QUALIFICATION REQUIREMENTS.....	22
5.1	GENERAL	22
5.2	NONDESTRUCTIVE TESTING OF wPQT WELDS	23
5.3	TENSILE TESTS	23
5.4	CHARPY V-NOTCH TESTS	24
5.5	CTOD TESTING FOR LEVEL 1 WELDS	27
5.6	MACROSECTION, HARDNESS SURVEY AND BEAD ON PLATE TESTS	28
5.7	CRACKING TESTS	31
5.8	NICK BREAK TESTS.....	31
5.9	CONSISTENCY TRIALS	32
5.10	FULL-SCALE FATIGUE TESTING	32
6.	WELDER AND WELDING UNIT/POWER SUPPLY QUALIFICATIONS	37
6.1	WELDER QUALIFICATIONS.....	37
7.	EXTENT OF WELDING.....	38
7.1	COMPLETE JOINT PENETRATION GIRTH WELDS.....	38
7.2	TACK WELDS.....	38
7.3	REFINEMENT LAYER.....	38
8.	WORKMANSHIP AND TECHNIQUE.....	39
8.1	PREHEAT, INTERPASS AND SR/PWHT TEMPERATURE	39
8.2	ELECTRODE AND FLUX MOISTURE CONTROL	40

8.3	REMOVAL OF SLAG/SPATTER AND ARC STRIKES	40
8.4	REPAIR PROCEDURES	40
8.5	BACK GOUGING	41
8.6	PREPARATION	41
8.7	WELD REPAIRS	44
8.8	STRESS RELIEF/POSTWELD HEAT TREATMENT PROCEDURES	44
9.	QUALITY OF WELDS	44
9.1	VISUAL EXAMINATION (VT)	44
9.2	NONDESTRUCTIVE TESTING (NDT) REQUIREMENTS	46
9.3	RADIOGRAPHIC EXAMINATION (RT)	47
9.4	ULTRASONIC EXAMINATION (UT)	47
9.5	MAGNETIC PARTICLE EXAMINATION (MT)	48
9.6	UT WALL THICKNESS MEASUREMENT	49
9.7	NDT "0" REFERENCE STAMP	49
10.	REFERENCES	50

APPENDICES

APPENDIX A	TOUGHNESS COMPATIBILITY (LEVEL 1 WELDS ONLY)	52
-------------------	---	-----------



1. INTRODUCTION

1.1 SCOPE

This new DEP specifies minimum requirements and gives recommendations for welding and inspection of Level 1 and Level 2 carbon and low alloy steel girth welds, and repair welds to Level 1 and Level 2 girth welds for use in the fabrication of tension leg platform (TLP) tendons and floating structure top-tensioned risers.

Requirements for Level 1 girth welds are more stringent than those for Level 2 girth welds. Level 1 and Level 2 welds will be identified by the Principal. Typically all TLP tendon girth welds are Level 1. Floating structure top-tensioned risers generally utilize Level 1 girth welds near the upper and lower terminations of the riser where fatigue loading is more severe and Level 2 welds in the mid-riser length section where fatigue loading is less severe.

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

This DEP supersedes, Shell Oil Company Supplement 4, dated March 1992, which has been previously used for welding and inspection of Shell TLP tendons and floating structure top-tensioned risers.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorized 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 authorized access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in offshore facilities related to oil and gas production. It is primarily intended for use in the fabrication of TLP Tendons and Floating Structure Top-Tensioned Risers. This DEP may also be applied in other similar facilities.

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 authorized to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Term	Definition
Inspection and Test Plan	Plan that includes inspection and test requirements and provides columns or spaces for the Principal to indicate third party inspector (TPI) inspection activities, e.g., monitor, witness, hold points, etc. for the operations to be undertaken. It is required that the ITP be approved by the Principal (1.8). An Inspection and Test Plan (ITP) is also known as a Quality Plan.
repair weld	A rework on a completed weld that requires welding in order to correct a fault or defect in the weld that has been discovered by visual inspection or nondestructive testing (NDT) and the fault/defect is beyond the limits of acceptability specified by this DEP or its referenced standards.

1.3.3 Abbreviations

Term	Definition
BI	Boniszewski Basicity Index
BOP	bead on plate
CEV	carbon equivalent value
CGHAZ	coarse grained heat affected zone
CTOD	crack tip opening displacement
CVN	Charpy V-notch
DEP	Design and Engineering Practice
ECA	Engineering Critical Assessment
FCAW-GS	gas shielded flux cored arc welding
FPS	Fabrication Procedure Specification
GMAW-P	pulsed gas metal arc welding
GTAW	gas tungsten arc welding
HAZ	heat affected zone
ID	inside diameter
ITP	Inspection and Test Plan
LAST	lowest anticipated service temperature
MOC	Management of Change
MT	magnetic particle examination
MTR	materials test report
NDT	nondestructive testing
OD	outside diameter
Pcm	composition parameter
PCP	Process Control Plan
PT	liquid penetrant examination
PWHT	postweld heat treatment
pWPS	proposed welding procedure specification
Q&A	quenched and aged
Q&T	quenched and tempered

Term	Definition
RT	radiographic examination
SAW	submerged arc welding
SDH	side-drilled hole
SI	International System (units)
SMYS	specified minimum yield strength
SR	stress relief
TLP	tension leg platform
TDC	top dead centre
TMCP	thermo-mechanical control process
TPI	Principal-appointed third party inspector
USC	US Customary (units)
UT	ultrasonic examination
VT	visual examination
wPQR	welding procedure qualification record
wPQT	welding procedure qualification test
WPS	welding procedure specification
WTM	weld test matrix

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 (10).

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://sww.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 .

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 parentheses. 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.

1.9 INSPECTION AND TEST PLAN AND QUALITY MANAGEMENT SYSTEM

1. This DEP supplements project specifications which govern overall fabrication of TLP tendons and floating structure top-tensioned risers.
2. 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 Inspection and Test Plan (ITP) and Quality Management System.
3. The ITP shall specify all inspections and the sequence in which they are to be performed during welding and inspection of girth welds for TLP tendons and floating structure top-tensioned risers. The ITP shall also specify the level of involvement for the Manufacturer/Supplier's quality control/inspection personnel, Principal-appointed third party inspectors (TPIs), and the Principal.
4. Approval from the Principal shall be obtained for the ITP and any revisions prior to commencement of welding and inspection.
5. The Quality Management System shall be in compliance with ISO 9001.

2. GENERAL

2.1 ATTRIBUTES TO BE SPECIFIED BY THE PRINCIPAL

1. Any special dimensional or fit up tolerances, weld or weld bevel configurations, nondestructive testing (NDT), or other requirements which differ from, or augment those specified in this DEP or its referenced standards, may be specified by the Principal in tender/contract documents or drawings.
2. Specified minimum yield strength (SMYS) of base metals, required fatigue performance S-N curve, and weld surface profile (i.e., grinding flush, etc.) will be specified by the Principal in tender/contract documents or drawings.

2.2 ANSI/AWS A3.0

1. All welding terms used in this DEP shall be interpreted in accordance with the definitions given in ANSI/AWS A3.0.

2.3 FABRICATION PROCEDURE SPECIFICATION / PROCESS CONTROL PLAN

1. The Manufacturer/Supplier shall prepare a Fabrication Procedure Specification /Process Control Plan (FPS/PCP) which specifies, as a minimum, all steps in the welding and inspection sequence as well as fabrication and handling methods.
2. The Principal shall approve the FPS/PCP and those work instructions/documents referenced in the FPS/PCP which the Principal requests to be approved prior to commencement of production welding and fabrication.

2.4 UNDERLYING INDUSTRIAL WELDING CODE

1. The underlying industrial welding code for welding and inspection of Level 1 and Level 2 girth welds shall be AWS D1.1, with exceptions, clarifications, or additions as specified in this DEP.
2. In addition, welds shall comply with the requirements of ASME Section IX and API STD 1104.
3. If the Manufacturer/Supplier discovers a difference in a requirement between the three referenced industrial welding codes above, it shall be brought to the attention of the Principal. The Principal shall decide which requirement prevails. However, generally, the more stringent requirement between these three codes shall govern, as determined by the Principal.

2.5 MANUFACTURER/SUPPLIER'S BASIC RESPONSIBILITIES

1. Complying with the requirements/recommendations specified/given in this DEP shall not relieve the Manufacturer/Supplier of the following basic responsibilities.
 - a. Establishing and implementing procedures and techniques which ensure:
 - i. integrity of resulting weldments
 - ii. good workmanship appearance
 - b. Compliance with the minimum requirements of AWS D1.1, ASME Section IX and API STD 1104.

2.6 QUALIFICATIONS

1. Welding procedures shall be separately qualified by each Manufacturer/Supplier for welding and weld repair of all girth welds governed by this DEP.

2.7 JOINT DETAILS

1. All girth welds shall be welded with complete joint penetration groove welds.

2. Joint details shall be shown in the welding procedure specifications (WPSs) and shall conform to joint details specified by the Principal.
3. The minimum groove angle shall be 35° for the pulsed gas metal arc (GMAW-P) welding process.

2.8 WELDING PROCESSES

2.8.1 Primary welding process options

1. Unless otherwise specified or further restricted by the Principal, welding processes for girth welds governed by this DEP shall be limited to the following two process combination options:
 - a. Option 1
 - i. Submerged arc welding (SAW, single electrode, without metal powder addition) in the 1G-Rotated position with both ID and OD passes.
 - ii. If the ID will be machined or ground flush, then welding may be accomplished from the OD only against backing which is subsequently removed, provided positive melt-through is visually confirmed for the full ID circumference prior to ID machining or grinding and the melt-through is subsequently machined or ground flush.
 - b. Option 2
 - i. Gas tungsten arc welding (GTAW, with or without consumable inserts, pulsed or non-pulsed) of the root pass from the OD, followed by hot, fill, and cap passes from the OD by either:
 - o GTAW (pulsed or non-pulsed),
 - o Automatic/mechanized GMAW-P (spray transfer only),
 - o Submerged arc welding (SAW) (single electrode, without metal powder addition) or
 - o a combination thereof.
 - ii. An ID pass with either SAW (single electrode, without metal powder addition) or GTAW (autogenous or with filler, pulsed or non-pulsed), is required unless the OD root pass was deposited using automatic / mechanized GTAW (pulsed or non-pulsed) in the 1G-rotated position or the ID will be machined or ground flush.
 - iii. If the ID is to be ground flush then positive melt-through shall be visually confirmed for the full ID circumference prior to ID machining or grinding.

2.8.2 Buttering

1. When welding base metal which requires postweld heat treatment (PWHT) to base metal which does not require PWHT, a low-carbon, low-alloy consumable "butter" layer shall be applied to the base-metal requiring PWHT using one of the process options in (2.8.1). The butter layer shall then undergo PWHT with the base metal requiring PWHT prior to subsequently being bevelled and welded without PWHT to form the "closure" weld to the base metal which does not require PWHT..
2. Minimum width of the butter layer shall be 20 mm (0.75 in) prior to welding for the initial primary closure weld.

2.8.3 Repair welding and in-process remediation

1. Repair welding of girth welds shall be accomplished by:
 - a. GTAW,
 - b. automatic/mechanized/semiautomatic GMAW-P (spray transfer only),

- c. automatic/ mechanized/ semiautomatic FCAW-GS (gas-shielded flux core arc welding) or
 - d. SAW (without metal powder addition).
- 2. A repair weld shall be defined to be any rework on a completed weld that requires welding in order to correct a fault or defect in the weld that has been discovered by visual or NDT and the fault/defect is beyond the limits of acceptability specified in this DEP or its referenced standards.
- 3. In-process remediation involving welding from the OD to a weld layer which is (1) prior to deposition of subsequent weld layers and (2) utilizing the same welding process and procedure as the primary production welding procedure for the layer being remediated, is not defined as a repair weld, unless such remediation is made to the cap layer and is not full-circumference.
- 4. Any remediation involving welding to the OD cap layer when not full-circumference or from the ID shall be defined as a repair weld.
- 5. There shall be no repairs to burn-throughs (i.e., a complete cutout and re-bevel is required).

2.9 WELDING PROCEDURE PROPOSALS

- 1. Proposed welding procedure specifications (pWPSs), including those for the repair of weld defects, shall be transmitted to the Principal for review and comment prior to initiating welding procedure qualification testing (wPQT).
- 2. Welding procedure proposals shall have the format of complete WPSs.

2.10 IDENTIFICATION AND QUALIFICATION RECORDS OF WELDERS AND WELDING UNITS/POWER SUPPLIES

2.10.1 Identification

- 1. A system of identification shall be established for:
 - a. each welder,
 - b. automatic/mechanized/semi-automatic welding procedures,
 - c. each welding unit and power supply.
- 2. The identification shall be unique to an individual or welding unit/power supply and shall not be transferred for the duration of the work.
- 3. Each welder shall be supplied with a paint or ink marker to enable the welder's work to be indelibly marked.
- 4. An identification card, showing name, photograph and identification symbol shall be furnished to each welder. This card shall be carried at all times during welding of girth welds and shall be presented, upon request, to the Principal-appointed third party inspector (TPI) or the Principal.

2.10.2 Qualification test results

- 1. Records of qualification test results for welder and for automatic/mechanized/semiautomatic welding procedures, welding unit and power supply shall be presented upon request to the Principal-appointed TPI or the Principal with a summary sheet showing the qualifications and identification designation or symbol of each.

2.11 IDENTIFICATION OF WELDMENTS AND ROOT FACE LOCATION

- 1. The Manufacturer/Supplier shall utilize a weld identification system providing each weld with a unique identification number which is traceable to mother joint/section number, weld data logging records, NDT records, and to the welders who participated in making the weld.

2. Each weld shall be identified with the weld identification number on the adjacent steel surface using an indelible paint or ink marking system.
3. The work of each welder shall be identified at each weld or portion of weld with the welder's unique identification symbol using an indelible paint or ink marking system.
4. The location of the root face/root edge for each girth weld shall be indicated on the OD surface by a permanent reference mark or stamp 100 mm (4 in) from the root face/root edge on one side of the girth weld in such a way that the precise location of the root face/root edge can be identified after weld completion.
5. Marking or stamping shall be low stress intermittent dot type, vibratory pencil or indelible paint or ink.

2.12 PROCEDURE QUALIFICATION TEST WITNESS REQUIREMENTS

1. wPQT welds, NDT of wPQT welds, specimen layout and identification for mechanical properties tests, and scribing for notching of CTOD and CVN specimens shall be witnessed by the Principal, a Principal-appointed TPI or shall be performed by an independent test laboratory approved by the Principal as not requiring such witnessing.

2.13 AVAILABILITY OF WPS

1. Principal-approved WPSs shall be posted at each applicable work location and shall be readily available to each welder and the Principal-appointed TPIs.

2.14 LOWEST ANTICIPATED SERVICE TEMPERATURE

1. Unless otherwise specified by the Principal, lowest anticipated service temperature (LAST) shall be 0 °C (32 °F).

2.15 WELD DATA LOGGING REQUIREMENTS

1. For Level 1 production welds, automatic data logging as specified below shall be implemented.
 - a. Real time voltage and current at the welding arc shall be continuously measured and recorded for each pass during wPQT with calibrated automatic weld data logging equipment at a minimum of 60 Hz sampling rate.
 - b. If pulsed welding is used, the pulse parameters shall be supplied to the Principal to ensure that the weld data logging sampling rate and recording frequency is sufficient to adequately represent the RMS, high and low values for the pulsed parameters.
2. For Level 2 production welds.
 - a. Automatic data logging as specified above shall be implemented as follows:
 - i. for the first production weld for each shift,
 - ii. for the first production weld after any welding equipment disassembly, electrical parameter modification or adjustment, and
 - iii. whenever the Principal-appointed TPI has reason to believe welding is being conducted outside WPS parameters.
 - b. Travel speed shall also be recorded for each pass during wPQT and for all production welds.
 - c. The specific Manufacturer and model designation of the weld data logging system/equipment to be used shall be approved by the Principal prior to commencement of wPQT.
 - d. The Manufacturer/Supplier shall report the travel speed recorded for each pass and welding data from the weld data logger to the Principal in electronic

spreadsheet format or an agreed alternative, in the welding procedure qualification record (wPQR) documentation.

- e. Start/stops that ramp up/down and any short duration non-typical values will be excluded from the high and low values considered qualified.

2.16 PRE-PRODUCTION MEETING

1. Prior to commencement of production welding, a pre-production meeting shall be held between the Manufacturer/Supplier, the Principal and Principal-appointed TPIs in order to assure that all parties fully understand applicable requirements.
2. Attendance by regulatory representatives, e.g., CVAs, may also be requested by the Principal.

3. MATERIAL REQUIREMENTS

3.1 BASE METAL

3.1.1 General

1. Level 1 welds shall require base metals conforming to the Principal's DEP Specifications for Level 1 materials, as specified by the Principal.
2. Level 2 welds shall require base metals conforming to the Principal's DEP Specifications, for either Level 1 or Level 2 materials, as specified by the Principal.

3.1.2 Base metal manufacturing process

1. For the purposes of this DEP, the following shall be considered as different base metal manufacturing processes:
 - a. As-rolled plate subsequently formed into tubular
 - b. Thermo-mechanical control processed (TMCP) plate subsequently formed into tubular
 - c. Controlled rolled plate subsequently formed into tubular
 - d. Normalized plate subsequently formed into tubular
 - e. Quenched and tempered (Q&T)/quenched and aged (Q&A) subsequently formed into tubular
 - f. Cold-formed seam welded tubulars
 - g. Warm-formed seam welded tubulars
 - h. Press-bend formed tubulars
 - i. Roll-bend formed tubulars
 - j. UOE-formed tubulars
 - k. Seam-welded tubulars heat treated after forming
 - l. Normalized seamless tubular product formed by mandrel or plug-mill
 - m. Q&T/Q&A seamless tubular product formed by mandrel or plug mill
 - n. Normalized seamless tubular product formed by extrusion
 - o. Q&T/Q&A seamless tubular product formed by extrusion
 - p. Normalized open-die forging
 - q. Normalized closed-die forging
 - r. Normalized ring-rolled forging
 - s. Q&T/Q&A open-die forging

- t. Q&T/Q&A closed-die forging
- u. Q&T/Q&A ring-rolled forging

3.1.3 Base metal defects

1. Any base metal anomalies, discontinuities or defects observed by the Manufacturer/Supplier shall be brought to the attention of the Principal.
2. Repair of base metal shall require Principal's approval on a case-by-case basis and shall be accomplished only with documented Principal-approved procedures.

3.2 WELDING CONSUMABLES

3.2.1 Toughness compatibility for Level 1

1. All welding electrodes and electrode/flux combinations for Level 1 girth welding (including those used for weld repair) shall be qualified for toughness compatibility in accordance with (Appendix A).
2. Toughness compatibility testing shall test the consumables in the welding process / mode in which they are to be used in production and in combination with all base metals for which each particular electrode or electrode/flux combination is to be utilized to weld in production.

3.2.2 Consumable overmatching requirements

1. Electrode and electrode/flux combinations shall be utilized which result in deposited weld metal which has the following attributes:
 - a. a 0.2 % offset yield strength that is no more than 34 N/mm² (5 ksi) below the specified maximum yield strength for the base metal and
 - b. not more than 138 n/mm² (20 ksi) above the specified maximum yield strength for the base metal.
2. Deposited weld metal tensile strength shall meet the specified minimum for the base metal. If there is no specified maximum yield strength for the base metal, then these criteria shall be based on the specified minimum tensile strength for the base metal.
3. If base metals of different strength levels are joined by the weld, then:
 - a. the acceptance criterion for deposited weld metal minimum yield strength shall be based on the base metal with the lower specified yield strength and
 - b. the acceptance criterion for deposited weld metal maximum yield strength shall be based on the base metal with the higher specified yield strength.
4. Percent elongation (%EL) and percent reduction in area (%RA) for the deposited weld metal shall be greater than, or equal to, the minimums specified for the base metal.
5. If base metals of different requirements for %EL and %RA are utilized, then acceptance criteria for these properties of the deposited weld metal shall be based on the base metal with the lower specified minimum requirements.

3.2.3 Consumable chemical composition and extra-low hydrogen consumable requirements

1. If sour service requirements have been specified by the Principal then as-deposited weld metal chemical composition shall be in compliance with NACE MR0175/ISO 15156.
2. Extra-low hydrogen consumables in accordance with AWS D1.1, Annex I, Clause I, 6.2.2(1), shall be utilized.

3.2.4 Consumable production lot

1. For purposes of this DEP, a production lot of welding consumables shall be defined as follows:
 - a. SAW fluxes: AWS A5.01, Class F2.
 - b. FCAW electrodes: AWS A5.01, Class T3.
 - c. Bare solid electrodes and consumable inserts: AWS A5.01, Class S3.
2. Each production lot of welding consumables, as defined above, shall have consumable Manufacturer's certificates of compliance to the relevant AWS filler metal or consumable insert specification or proprietary specification.
 - a. Certificates of compliance, on a per production lot basis, shall include actual deposited weld metal chemical composition, mechanical properties and the deposited weld metal average diffusible hydrogen level as determined and reported in accordance with AWS A4.3 or ISO 3690.
 - b. Certificates of compliance for SAW fluxes shall include the flux moisture content and the Boniszewski Basicity Index (BI), as given by the following equation:

$$BI = \frac{CaO + CaF_2 + MgO + K_2O + Na_2O + 1/2(MnO + FeO)}{SiO_2 + 1/2(Al_2O_3 + TiO_2 + ZrO_2)}$$

- c. BI shall be greater than or equal to 1.0 for all SAW fluxes.

3.2.5 Consumable storage and handling plan

1. The Manufacturer/Supplier shall submit a consumable storage and handling plan for the Principal's review and approval.
2. Consumable storage and handling procedures shall ensure that low hydrogen characteristics specified for the consumables and ceramic backing tapes are maintained.
3. The consumable storage and handling plan shall ensure full traceability of all consumables.
4. The Principal may audit consumable storage and handling records for compliance with the approved plan at any time. This audit may include sampling of consumables and testing for compliance with deposited weld metal average diffusible hydrogen level requirements.

3.2.6 Shielding gases

1. Shielding gases shall be premixed and bottled and shall have certificates of compliance to the gas composition requirements of the WPS.

3.2.7 Consumable inserts

1. Consumable inserts, if utilized, shall have nominal chemical composition that matches one of the following:
 - a. one of the base metals being joined
 - b. one of the solid wire electrodes being utilized

3.2.8 Tungsten electrodes

1. Tungsten electrodes for use with the GTAW process shall be prepared using a grinding wheel or device specifically reserved for this purpose.
2. Tungsten electrodes shall comply with the EWTH electrode classification of AWS A5.12.

3.2.9 AWS classified electrodes

1. All electrodes shall have an AWS classification.
2. Usage of AWS "G" class electrodes shall require specific Principal approval prior to initiating weld procedure qualification.
3. Usage of AWS "G" class electrodes may require special consumable procurement requirements in which chemical composition ranges and mechanical properties are restricted to those closely similar to that achieved during weld procedure qualification, as deemed necessary by the Principal.

4. WELDING PROCEDURE SPECIFICATION**4.1 GENERAL**

1. Conditions under which welding of girth welds or weld repair is to be done shall be limited to those specified in a Principal-approved WPS, which shall include written documentation of parameters covering all essential variables for the welding process (See AWS Form N-1) and required wPQT results.
2. Written WPSs for all girth welding procedures (including those for repair of surface imperfections or damage to base metal and those for repair of weld defects, both partial and full thickness) shall be transmitted to the Principal for review and approval and shall be accompanied by wPQRs of supporting wPQT welds.
 - a. The WPS shall show the allowable ranges of welding parameters, based on actual qualification data.
 - b. The Manufacturer/Supplier shall submit repair procedures that detail repair and inspection steps to be taken for each type of repair that is to be permitted, such as the repair of surface imperfections and weld defects.
3. A WPS written with more than one supporting wPQR shall not permit optional processes, but shall uniquely specify the process for each pass.
4. The WPS shall include all data that is shown in the AWS D1.1 format and shall include the following as a minimum:
 - a. The specific arc welding process, and whether it is manual, automatic, mechanized, semiautomatic or a combination of these shall be stated. If the welding process is pulsed, then this shall also be stated.
 - b. AWS steel strength group and preheat category and steel Manufacturer. The Manufacturer need not be listed for the Shell A707-Modified alloys in the WPS; however, the manufacturer of the material utilized in the wPQT shall be identified in the wPQR.
 - c. Base metal chemical composition specification and grade. Proprietary steel name or designations for special non standard modifications to standard chemical compositions shall be stated.
 - d. Base metal manufacturing process.
 - e. Thickness and diameter range.
 - f. Joint configuration and detail dimensions, tolerances and usage of consumable inserts, grooved ceramic backing tape or rings, flux dams or grooved copper backing rings or shoes or a combination of these shall be stated.
 - g. Type of line up clamp shall be designated.
 - h. Welding position(s) and direction of welding for each pass.
 - i. The number of welders required or permitted at any one time for each pass.

- j. Electrode, flux and consumable insert manufacturer, trade name and production lot designations uniquely identifying the product shall be stated. For consumable inserts the AWS Class, Style and nominal dimensions per AWS A5.30 shall be included.
- k. Maximum allowable deposited weld metal average diffusible hydrogen level.
- l. AWS welding consumable classification. For consumable inserts, this shall include Class and Style.
- m. The following shall be designated for each pass:
 - i. size of electrodes,
 - ii. type and angle of tip for tungsten electrodes, if applicable,
 - iii. voltage, current (and pulse rate or frequency for pulsed procedures),
 - iv. wire feed speed (and pulse rate or frequency for pulsed procedures),
 - v. polarity,
 - vi. nominal electrical stick out,
 - vii. head angle and
 - viii. electrode spacing from top dead centre (TDC) (for 1G-rotated welding),
 - ix. electrode spacing (for welding with multiple electrodes),
 - x. travel speed and
 - xi. heat input
- n. Welding unit and power supply type, manufacturer and model number shall be stated for automatic, mechanized or semiautomatic welding procedures.
- o. Shielding gas mixture, moisture limits or dew point and range of flow rates.
- p. A sketch of cross-sectional sequence and anticipated relative bead width and thickness.
- q. Depth of backgouging and method, if applicable, and minimum required radius (not to be less than 4.8 mm (3/16 in) at the base of the backgouge).
- r. Minimum allowable weld repair length, minimum spacing between repairs and minimum required radius (not to be less than 4.8 mm (3/16 in) at base of excavated cavities for weld repair).
- s. Preheat and interpass temperature requirements or limitations. The method of preheating and temperature measurement method shall be stated.
- t. Postweld treatments (e.g., machining, grinding, peening, stress relief/postweld heat treatment, etc.) of any kind.
- u. Stress relief/postweld heat treatment temperature, time at temperature, method of heating up, method of cooling down and maximum elapsed time allowed prior to commencement of stress relief/postweld heat treatment.

4.2 ESSENTIAL VARIABLES

4.2.1 General

1. Essential variables for welding procedure qualification shall be as specified in AWS D1.1, ASME Section IX and API STD 1104 as modified/augmented in this section.
2. Changes to essential variables outside the ranges allowed by this DEP or AWS D1.1, ASME Section IX and API STD 1104 shall require requalification of the welding procedure.