

DEP SPECIFICATION

**WELDING OF DEEPWATER PIPELINES, FLOWLINES AND
STEEL CATENARY RISERS
(AMENDMENTS AND SUPPLEMENTS TO API 1104)**

DEP 37.81.40.31-Gen.

February 2017

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DESIGN AND ENGINEERING PRACTICE

DEM1



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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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PART I INTRODUCTION

1.1 SCOPE

This DEP (based on API Standard 1104) specifies the requirements for onshore and offshore welding and inspection of deepwater pipelines, flowlines, steel catenary risers and related facilities. Underwater welding is excluded. Where deepwater pipelines extend into shallow water, this DEP may also be used for the shallow water segment of such pipelines and associated risers, if so specified in the contract documents. This DEP also applies to riser hull piping on floating production facilities that connect the deepwater riser to topsides piping.

This DEP covers the following main topics:

- a. Standard Requirements for all applications including NDE and destructive testing.
- b. Supplemental requirements for Steel Catenary Risers.
- c. Supplemental requirements for Reeled and High Strain welds.
- d. Supplemental requirements for PLETs, Manifolds and Jumpers.
- e. Supplemental requirements for Buttered Welds.
- f. Supplemental requirements for Clad Pipe Welds.
- g. Instructions for Engineering Critical Assessment for the above type welds.

Specifically excluded from this DEP are detailed requirements for automatic ultrasonic inspection of these welds, which are covered in Principal's AUT specifications, as defined in the List of Project Specifications and the following DEPs:

- ⌚ DEP 37.81.40.32-Gen.
- ⌚ DEP 37.81.42.35-Gen.

Part III of this DEP is written in the form of amendments and supplements to clauses of API 1104 (Twentieth edition, October 2005 with Errata/Addendum of July 2007 and December 2008, Reaffirmed April 2010). The clause numbering in Part III of this DEP follows that of API 1104.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual (DEM) 1 – Application of Technical Standards.

This is a revision of the DEP of the same number dated February 2014; see (1.5) regarding the changes.

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 authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to deepwater pipeline, flowline and riser projects. It is intended for use by Exploration and Production, Manufacturing, Chemicals or Supply/Distribution companies which require the use of line pipe. 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 authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

The word **may** is an option to be confirmed with Principal.

The word **may** indicates a permitted option.

1.3.2 Abbreviations

Term	Definition
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
AUT	Automated Ultrasonic Testing
AWS	American Welding Society
BS	British Standard
CRA	Corrosion Resistant Alloy
CTOD	Crack Tip Opening Displacement
CVN	Charpy V-notch
DSAW	Double Submerged Arc Welded
ECA	Engineering Critical Assessment
EFC	European Federation of Corrosion
ERW	Electrical Resistance Welding
FBE	Fusion Bonded Epoxy
FCAW	Flux Core Arc Welding
FCAW-GS	Gas Shielded Flux Core Arc Welded
FEA	Finite Element Analysis
GMAW	Gas Metal Arc Welding
GTAW	Gas Tungsten Arc Welding
HAZ	Heat-Affected Zone
HV₁₀	Vickers Hardness (10 kg load)
ID	Internal Diameter
ISO	International Standards Organization
NDE	Non-Destructive Examination
OD	Outside Diameter
PWHT	Post Weld Heat Treatment
PLET	Pipeline End Termination
pH₂S	Partial Pressure H ₂ S



Term	Definition
QA/QC	Quality Assurance / Quality Control
RMS	Root Mean Square
SAW	Submerged Arc Welding
SCR	Steel Catenary Riser
SMAW	Shielded Metal Arc Welding
SWE	Single Wall Exposure
SWV	Single Wall Viewing
TDR	Technical Deviation Request
TOFD	Time of Flight Diffraction
WDL	Weld Data Logger
WPP	Welding Procedure Proposal
WPQR	Welding Procedure Qualification Record
WPQT	Welder Performance Qualification Test
WPS	Welding Procedure Specification

1.3.3 Specific definitions

Term	Definition
Sour Service	Exposure to oilfield environments that contain H ₂ S and can cause cracking of materials by the mechanisms referred to in ISO 15156 (equivalent to NACE MR 175).

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 (Part IV). Cross-references to parts of API 1104 give section numbers without brackets.

1.5 SUMMARY OF MAIN CHANGES

This DEP is a minor revision of the DEP of the same number dated February 2014. The changes followed a requirements quality review and were not a technical update. .

The following are the main, non-editorial changes.

Section/Clause	Change
All	Restructured and clarified requirements, enforced use of shall / should / may for normative statements and separation of requirements.
1.1	Restructured DEM1 requirement
5.1	Restructured DEM1 requirement
14.2	Restructured DEM1 requirement

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://swwww.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 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.

PART II GENERAL REQUIREMENTS**1.1 GENERAL**

Part III of this DEP is written as amendments and supplements to API Standard 1104 (Twentieth edition, October 2005 with Errata/Addendum of July 2007 and December 2008 and Reaffirmed 2010). For ease of reference, the clause numbering of API 1104 has been used throughout Part III of this DEP.

1. Wherever reference is made to API 1104, it shall be understood to mean API Standard 1104 (Twentieth edition, October 2005 with Errata/Addendum of July 2007 and December 2008 and Reaffirmed 2010), as amended/supplemented by this DEP.
2. Clauses in API 1104 which are not mentioned in this DEP shall remain valid as written.

1.2 INFORMATION TO BE SUPPLIED BY THE PRINCIPAL

1. Project specific information (typically provided in a Table by the Principal) shall be applied in conjunction with this DEP and API 1104.
2. This Table may include the following:
 - a. nominal OD of line pipe(s);
 - b. nominal wall thickness of line pipe(s) and appurtenance material(s);
 - c. grade and designation of the line pipe(s) and component material(s);
 - d. the type of external coating;
 - e. pipeline minimum design temperature;
 - f. pipeline maximum design temperature;
 - g. service environment (fluid composition, pH, chloride, CO₂, H₂S, etc.);
 - h. whether specific Contractor quality procedures are to be submitted for agreement;
 - i. whether previously qualified welding procedure specifications are to be considered for agreement;
 - j. whether post-weld heat treatment is acceptable/required;
 - k. specific requirements for weld identification marking and weld map;
 - l. whether partial penetration re-repairs can be performed;
 - m. whether all NDT indications are to be reported or only those that are evaluated as defects;
 - n. whether specific radiograph identification requirements are to apply;
 - o. the requirements for final documentation;
 - p. whether alternative acceptance standards for girth welds can be applied and the circumstances under which they are to be applied;
 - q. test temperature for CTOD tests if different from the default of 0 °C (32 °F) and need, if any, to conduct supplemental tests at other temperatures;
 - r. test temperature for Charpy tests if different from the default of -46 °C (- 50 °F) for any subsea equipment welds (manifolds, well jumpers, PLET's and Sleds designed to ISO 13628/API 17 D);
 - s. test temperature for Charpy tests if different from the default of -20 °C (- 4 °F) for all other pressure containing weldments;
 - t. if any additional Charpy tests, at other temperatures are required due to special service conditions;

- u. pipe sizes that require fatigue testing, if different than the default in this DEP;
- v. sour service requirements, including p H₂S level;
- w. service category when (Appendix K) is invoked;
- x. appendices to be invoked;
- y. listing of approved AUT contractors for flow line/pipeline and riser weld inspection;
- z. acceptance criteria for welds, if different from the default criteria in section (Appendix K);
- aa. acceptance criteria and NDE methodology for CRA weld overlay and clad pipe near the weld bevel, prior to welding;
- ab. pipeline or riser regions that require fatigue testing (e.g., critical regions of SCRs) (see also (5.6.11));
- ac. whether end dimensioning will be conducted by the contractor;
- ad. whether counter boring will be conducted by the contractor; and,
- ae. additional information as required.

PART III AMENDMENTS/SUPPLEMENTS TO API 1104

(Twentieth edition, October 2005 with Errata/Addendum of July 2007 and December 2008 and reaffirmed April 2010)

1 GENERAL**1.1 SCOPE**

Add the following:

1. Welding shall not be carried out by plasma arc welding, oxyacetylene welding or flash butt welding processes.
2. The self shielded FCAW process shall only be used on structural weldments.
3. Filler metal SHALL [PS] be used for all passes.
4. The use of roll welding shall be subject to approval by the Principal.
5. GMAW, GTAW, and gas-shielded FCAW shall be restricted to construction areas protected against wind and draught.

2 REFERENCED PUBLICATIONS

Add the following:

1. See also (Part IV) of this DEP.

3 DEFINITION OF TERMS**3.2 DEFINITIONS****3.2.3 Company**

Delete this subsection and replace with the following:

1. This term is to be understood to mean the Principal as defined in (Part I, 1.3.1).

Add new subsections:

3.2.21 O'clock

1. When a specific clock position is stated in this DEP it may also include the region of ± 1 hour.

3.2.22 WPQR

1. WPQR is used to describe both the record of a qualification or the qualification welds and any acts associated with making the qualification welds.

3.2.23 Penetrameter

1. Term used in API 1104 which is to be taken to mean IQI as used in ISO 17636.

3.2.24 Sour Service

1. As defined in (1.3.3)

4 SPECIFICATIONS

4.1 EQUIPMENT

Add the following:

1. Contractor shall furnish all welding and data logging equipment, of the same type to be used in production, and prepare all spools used in WPQR testing.
2. Welding machines shall not be operated beyond their rated capacity.
 - a. Instruments shall be installed on the machines to accurately measure voltage and amperage.
 - b. The machines shall be maintained in good working order and promptly repaired or replaced if deemed defective.
3. Welding equipment with internal weld data logging capabilities should be calibrated every 6 months.
4. In lieu of current calibrations, accuracy may be demonstrated using an external secondary calibrated weld data logger or calibrated amp-/volts meters.
5. If (4.1 item 4) is used in lieu of current calibration, performance checks of weld data logging equipment, wire feed speed, travel speed, and gas flow rate shall be verified during production welding at a rate agreed with the Principal.
6. Welding machine leads shall be fastened to the base metal securely by means of clamps or other mechanical means (not by welding).
7. Connections shall avoid notch damage to the pipe.
8. There shall be no arcing between the leads and the pipe.
9. Any leads with insulation damaged should be discarded or safely repaired to meet applicable safety standards.
10. The length of leads and their gauge shall be documented during WPQR welding and not changed more than 10% from that qualified.
 - a. Contractor may submit for consideration an alternative method for controlling voltage drop if the change in lead length desired is greater than 10%.

4.2 MATERIALS

4.2.2 Filler Metal

4.2.2.1 Types and Size

Delete this subsection and replace with the following:

1. All welding electrodes, rods, and fluxes shall be of size and kind suitable for the material being welded and subject to approval by Principal.
2. These consumables shall be supplied meeting Schedule I, with the Manufacturer's Certified Report of tests called for in Table 2, of AWS Standard A5.01.
3. If lot certificates are not available, or the certificates are not acceptable, the Contractor shall (a) obtain replacement filler materials or (b) conduct a testing program which satisfies the requirements above.

4.2.2.2 Storage and Handling of Filler Metals and Fluxes

Delete this subsection and replace with the following:

1. Manufacturer's recommended welding materials handling and storing procedures shall be followed.
2. Any unidentified, damaged, wet or otherwise deteriorated welding materials shall not be used.
3. Electrodes, filler wires and fluxes shall be stored in a dry storage room in accordance with the Manufacturer's instructions.
4. Filler materials and fluxes shall remain in their original containers and be marked with the Manufacturer's name, the consumable trade name and the batch number.
5. Principal condemned welding materials and/or filler materials and fluxes in containers that are not identifiable and traceable shall be removed from the work site.
6. The storage room should have a maximum relative humidity of 50%.
7. Contractor should submit consumable handling procedure for Principal approval.
8. This procedure should address daily issued welding consumable handling and storage of unused portions.
9. Low hydrogen bare and covered electrodes and flux cored electrodes shall be procured and stored to limit diffusible hydrogen to 4.0 ml/100 g deposited metal.
 - a. This shall be verified prior to and during procedure development, procedure qualification and production welding.
10. Low hydrogen shielded metal and flux cored electrodes shall not be used if their protective container/packaging is damaged allowing atmospheric exposure.
11. Any opened box containing welding rods for production welding shall be stored in "hot boxes".
12. Reclamation of SAW flux or slag shall not be allowed.

4.2.3 Shielding Gases

4.2.3.1 Types

Add the following:

1. Shielding gas shall conform to the requirements of AWS A5.32 or alternative industry specification with Principal agreement.
2. All gases shall be supplied with certified analysis.
3. Shielding gas containing CO₂ shall not have greater than 15 ppm O₂ or 19 ppm moisture content (approximate dew point of -55 °C).
4. Shielding gas containing 95% or greater Argon shall not exceed 10 ppm O₂ or 15 ppm moisture content (approximate dew point of -60 °C).
5. Contractor shall verify with gas Supplier at what temperature the specific gas components can separate.
 - a. Contractor shall incorporate heaters and agitators if the ambient temperature drops below that temperature.
6. For two mixed gases, the minor gas mixture tolerance shall not exceed ±10 percent of the specified percentage amount.

For example for a 95% Ar / 5% He, the allowable range for He would be 4.5% - 5.5%.

7. Flow meters shall be used for accurate flow rate measurement when shielding gases are used.
8. Flow meters shall be periodically checked against calibrated flow meters for accuracy during WPQ and production welding.
9. If a compound gas mixture is mixed in the field, the gases shall be stored separately.
10. Individual flow meters shall be used to measure flow rates of each gas being mixed as well as the resulting mixed gas.
11. If a compound gas mixture is mixed in the field, certified gas analyzers shall be available at the work site for checking compositions of gases.
12. A certified bottle of gas shall also be available on the work site for calibration of the gas analyzer when the analyzer needs to be used.
13. Gas analyzers shall be used on all gases which are not premixed and certified by gas supplier.

4.2.3.2 Storage and Handling

Add the following:

1. Gases in containers that are unidentifiable shall not be used.

5 QUALIFICATION OF WELDING PROCEDURES FOR WELDS CONTAINING FILLER-METAL ADDITIVES

5.1 PROCEDURE QUALIFICATION

Add the following:

1. A WPS SHALL [PS] be available for all welds made.
2. Each WPS SHALL [PS] be qualified and the results documented on a WPQR.
3. The procedure shall be qualified in accordance with the requirements of this DEP, including non-destructive testing to default acceptance criteria were applicable, unless otherwise specified by or agreed to by the Principal.
4. Prior to commencement of qualifications, Contractor shall submit to Principal for approval a matrix of all WPSs, WPQRs, and WPQTs to be performed.
5. Preliminary WPSs to be qualified shall be submitted to Principal for review and comment prior to qualification testing.
6. After approval of the weld matrix and upon completion of WPQT program, the Contractor shall conduct a process capabilities test program for automatic or mechanized welding processes subject to Principal approval.
7. Sectioning of a weld or welds shall be done at the Principal's request, based on the non-destructive examination results.

Procedures for cross-sectioning and destructive analysis of test welds are included in DEP 37.81.40.32-Gen.
8. Contractor shall submit qualified welding procedures for Principal approval.
9. Contractor shall bear all costs connected with the tests other than the cost of pipe and/or forgings that may be supplied by Principal.
10. Contractor shall specify in their bid the amount of pipe that they will need for welding procedure qualification and welder tests and practice welding, including pipe for reeling trials and fatigue tests.

Such pipe will be furnished by Principal, unless otherwise noted.

11. Low hydrogen welding processes shall be used.
12. Contractor shall give Principal representative 48 hours notice prior to weld qualification activities.
13. Hull Piping for floating facilities should be qualified per Section (5).
14. For half shell assemblies the long seam and circumferential welds shall be tested per the requirements of this DEP.
 - a. Backing material may be applied, with Principal agreement, to the long seam.
 - i. If backing material is applied to the long seam, it shall have similar chemistry to that of the half shell material and prior to welding have been subjected to a manual UT inspection to assure volumetric soundness.
 - b. Contractor shall submit legible copies of the backing strip mill certificates to Principal for review and approval prior to WPQT and field fabrication.
 - c. Sulfur content in backing material should be less than 0.006% by weight.
 - d. Full mock ups of the half shell assembly shall be used in position during WPQT.
15. The process capability program shall consist of fifty (50) consecutive welds with no less than forty five (45) meeting the non-destructive testing acceptance standards of API 1104 Section 9, or Default criteria in (Appendix K) as applicable, for pipeline welds.
16. Non-destructive testing shall be performed using x-ray radiography, fine grain film technique with resulting radiographic quality level (sensitivity) better than or equal to 1-1T and the AUT system approved for production weld inspection.
17. Mechanical tests shall be conducted on at least one of the fifty welds and include:
 - a. one flat cross weld tensile;
 - b. two bends;
 - c. one set ID weld metal Charpy tests;
 - d. one hardness traverse;
 - e. one set of weld metal CTODs; and
 - f. one set of HAZ CTODs.

5.2 RECORD

Add the following:

1. Welding parameters should be recorded by means of a calibrated weld data logging system with printout facility.
2. The procedure qualification record shall include the following:
 - a. all Essential and non-Essential variables;
 - b. printouts from the weld data logging system as applicable;
 - c. original NDT reports;
 - d. original laboratory test reports, including macro photographs of the weld metal, HAZ, and the base material with a scale (not magnification factor), and micro photographs (as required) with a scale (not magnification factor) clearly showing the microstructure;
 - e. originals or verified copies of the Manufacturer/Supplier's certification documents for the test coupon materials; and
 - f. original or verified copies of the Manufacturer/Supplier's certification documents or lab test results for the welding consumables.
3. The WPQR shall be submitted to the Principal with the WPS for approval prior to production welding as per (14).

5.3 PROCEDURE SPECIFICATION

5.3.1 General

Add the following:

1. The WPS shall show the following non-technical information:
 - a. date;
 - b. revision number;
 - c. contract number;
 - d. project title;
 - e. Contractor's name; and,
 - f. reference to this DEP.

5.3.2 Specification Information

5.3.2.2 Pipe and Fitting Materials

Delete this subsection and replace with the following:

1. The materials to which the procedure applies shall be identified.
2. Separate procedures shall be qualified for each specification and grade of pipe or fittings to be welded.

5.3.2.3 Diameters and Wall Thickness

Add the following:

1. The allowable ranges shall be as defined in (5.4.2.5) and (5.4.2.16).

5.3.2.4 Joint Design

Add the following:

1. Permanent backing rings shall not be used for girth welds of pipes containing production fluids or gases.
2. All joint details, dimensions and tolerances shall be listed in the WPS.
3. Joint design, including bevel angle, shall conform to the appropriate Code and be subject to approval by Principal.
4. Compound bevels should not be used.
5. In cases where wall thickness transition is required, Contractor shall submit design for Principal approval.
6. Where counter boring is applied, the counter bored region shall be within 1 degree of parallel to the OD surface and have a surface roughness of less than 3.2 μm RMS.
 - a. The transition from the counter bore to the minimum of 4:1 taper shall be at least 3.2 mm radius.

5.3.2.5 Filler Metal and Number of Beads

Add the following:

1. The number of passes deposited and filler metal sizes used for each pass shall be recorded for each wall thickness used during WPQR.
2. Filler metal shall contain less than 1% Ni except as modified by (Appendix I) or with Principal approval.
3. One strip pass or layer may be used to compensate for varying pipe wall thickness around the pipe circumference.
4. If one strip pass or layer is used for (5.3.2.5 item 3), the strip pass welding parameters shall be either:
 - a. established during WPQR testing or,
 - b. use the qualified parameters of the weld pass preceding the strip pass.

5.3.2.6 Electrical Characteristics

Add the following:

1. Where applicable, electrical stick out, contact tube-to-work distance, contact tip, oscillation parameters (width, dwell, speed or frequency), and wire feed speed shall be specified for each weld pass.
2. For any pulse welding method, Contractor shall submit pulse parameters.
3. Contractor may submit either the program parameters ranges of peak and background current, peak duration, and frequency or record screen shots of each wire feed speed range using an calibrated oscilloscope.

5.3.2.8 Position

Add the following:

1. The specification shall designate the qualified angle range.

5.3.2.10 Time between Passes

Add the following:

1. Each pass shall be completed before starting the next pass.
2. The second pass (hot pass) shall be deposited as soon as practical after the first pass (root pass).
3. If an interruption is qualified during WPQR a weld may be left with two complete passes (root and hot pass) with Principal approval.
4. Whenever root pass welding has been stopped at least 3 passes should be completed in all stations.
5. No welds shall be left more than 12 hours with less than 2 passes.
6. Welds should be completed up to and including the last weld with a completed root pass whenever the root pass welding is stopped for any reason.

5.3.2.11 Type and Removal of Lineup Clamp

Add the following:

1. Procedure shall specify the type of line-up clamp used during qualification and the minimum number of passes completed prior to removal.
2. For automatic or mechanized welds, internal line-up clamps shall be used, unless pipe diameter is too small for its use (generally pipe diameters less than 6 in nominal OD), or during operations where both pipes are fully supported and aligned using an external hydraulic or similar mechanical system (i.e., double joint, field tie in, etc).
3. Internal line-up clamps shall be left in place until the root pass is completed.
4. External line-up clamps shall be left in place until a minimum fifty (50) percent of the root pass is completed.
5. For small diameter pipe that external line-up clamps do not permit adequate space to meet the minimum fifty (50) percent root pass completion before clamp removal requirement, the Contractor may propose an alternate completion percentage for Principal approval.
 - a. The root pass shall be evenly distributed along the circumference prior to OD clamp removal.

5.3.2.12 Cleaning and/or Grinding

Add the following:

1. Cleaning and/or sanding techniques used during WPQR shall be recorded and cleaning instructions included on the WPS.
2. Pipe surface cleaning shall be conducted by wire brushes, sanding or flapper wheels.
 - a. Pipe surface cleaning shall not be conducted by grinding or any process that causes uneven metal removal.

5.3.2.13 Pre- and Post-heat Treatment

Add the following:

1. The location where preheat and inter-pass temperature measurements are taken during WPQR, shall be specified.
2. WPQRs conducted using two or more automatic welding bugs shall include both the temperature measurement location as well as the timing.

5.3.2.14 Shielding Gas and Flow Rate

Add the following:

1. When applicable, the backing gas composition and flow rate shall be qualified.
2. The WPS shall include the requirements for backing gas purge prior to commencement of welding, the number of weld passes for which backing gas flow is maintained, and for monitoring of backing gas oxygen content as qualified by WPQR.

5.3.2.15 Shielding Flux

Add the following:

1. The AWS flux classification, the Manufacturer, brand name, and the size shall also be specified.

Add the following new subsection:

5.3.2.17 Number of Welders

1. The WPS shall designate the number of root pass welders and second pass welders.

5.4 ESSENTIAL VARIABLES

5.4.1 General

Add the following:

1. If the essential variables are exceeded during production welding, the weld shall be removed and the joint re-prepared.

5.4.2 Changes Requiring Requalification

5.4.2.2 Base Material

Add the following:

1. Each change in the process of manufacture, a change to the heat treatment condition, and/or pipe or fitting Manufacturer shall be an essential variable.

5.4.2.3 Joint Design

Add the following:

1. Welding procedures shall be qualified using the same type of cutting, beveling, positioning, alignment, and welding equipment that will be used during production welding.
2. For automatic or mechanized welding, bevel dimension tolerances shall not exceed ± 0.2 mm (0.008 in) unless otherwise demonstrated during the WPQT.

5.4.2.4 Position

Add the following:

1. Any change in the angle of the axis of the pipe greater than 15° from that used for qualification shall constitute a change in essential variable.

5.4.2.5 Wall Thickness

Add the following:

1. A wall thickness range of more than 9.6 mm (3/8 in) shall be considered an essential variable
 - a. This may be ± 3.2 mm (1/8 in) or other unbalanced division combinations.

5.4.2.6 Filler Metal

Add the following:

1. For manual groove welds in material greater than 3.2 mm (1/8 in) and less than 6.4 mm (1/4 in) wall thickness, a minimum of three weld passes should be deposited.
2. Four or more weld passes shall be deposited for pipe wall thickness greater than or equal to 6.4 mm (1/4 in).
3. Manufacturer, trade name, size and heat number shall be considered an essential variable.

5.4.2.7 Electrical Characteristics

Add the following:

1. For the GMAW process, a change in transfer mode shall constitute an essential variable.
2. Software version, welder control limits or the program variables shall also constitute an essential variable.
3. Range of amperage and voltage shall be similar to that used during qualification and be subject to approval by Principal.

5.4.2.8 Time between Passes

Add the following:

1. Production delays while depositing the root pass shall be less than 30 minutes with preheat maintained.
2. An increase in the time delay between completion of the hot pass and start of the third pass shall constitute an essential variable.
3. When the weld procedure is qualified using an overnight (not less than 12 hours) delay with the preheat re-established before starting the third pass, the delay during production welding shall be no greater than 96 hours.

5.4.2.10 Shielding Gas and Flow Rate

Add the following:

1. A major change shall be defined as 2.4L/min (5 ft³/hour).

5.4.2.12 Speed of Travel

Add the following:

1. Range of travel speed should be similar to that used during qualification.
2. Range of travel speed shall be subject to approval by the Principal.

5.4.2.13 Pre-heat

Add the following:

1. The minimum preheat temperature specified shall be that qualified during WPQR.

5.4.2.14 Post-weld Heat Treatment (PWHT)

Add the following:

1. Welds shall not be stress relieved unless specifically approved by Principal or required by applicable Codes and if qualified during WPQR.
2. To avoid damage to valve seals, pipe to weld-end valves welds shall not be stress relieved unless this is specifically approved by Principal and input/guidance from valve Manufacturer has been obtained.
3. Cold-expanded pipe welds shall not be stress relieved.
4. Methods, equipment type and controls shall be documented and specified.

Add the following new subsections:

5.4.2.15 Removal of Lineup Clamp

1. Removal of the line-up clamp at a stage earlier than qualified during WPQR shall constitute a change in essential variable.

5.4.2.16 Diameter

1. A diameter change of more than ± 2 nominal outside diameter shall be considered an essential variable.
2. For manual welding only, other diameter ranges may be used with Principal approval.
3. Pipe sizes shall be defined as those in table 22 of API 5L 44th (e.g., 141 mm (5.563 in), 168 mm (6.625 in), 219 mm (8.625 in), 324 mm (10.75 in)).

5.4.2.17 Repair Welds

1. Partial penetration repairs that penetrate closer to the ID surface compared to the qualification welding shall be considered as a change in essential variable.

5.4.2.18 Welding Consumables Containing Flux

1. Each batch (lot) of flux shall be subjected to a complete welding procedure qualification test, as described herein.
 - a. Each change of wall thickness or grade of pipe shall be considered an essential variable.
2. When multiple welding procedures are used for a given flux, any new batch of flux shall be qualified using one of these welding procedures.
3. The procedure with the highest heat input should be used.
4. The procedure with PWHT shall be used if applicable.

5.4.2.19 Heat Input and Welding Parameters

1. The minimum and maximum heat input allowed in production welding shall be that qualified during procedure qualification, unless Principal agrees to allow the nominal heat input qualification process described below.
2. Parameters shall be subject to approval by Principal.
3. The welding parameters shall be recorded by a calibrated weld data logging at a minimum of 60 Hz.
4. If programmable welding equipment is used, the program variables shall be supplied to the Principal to ensure sampling frequency is sufficient to fairly represent the RMS, high and low values recorded during data logging.
5. Contractor shall report this weld data to the Principal in electronic spreadsheet format or an agreed alternative, along with the proposed high and low values for amperage, voltage and travel speed.

6. Start / Stops that ramp up / down and any short duration non-typical values may be excluded, by agreement, from the high and low values considered qualified.
7. The maximum allowable difference between the high and low heat input should be no more than 25% of the low heat input value.
8. Where a range greater than 25% is needed for a pass or pass grouping, high and low heat inputs should be qualified separately.
9. When qualified separately, full mechanical testing as required in subsequent sections of this document shall be conducted on both the minimum and maximum heat inputs to be used in production.
10. For the purpose of heat input qualification, passes with similar nominal welding parameters (such as the fill passes) may be grouped together.

For example, the fill pass heat input range can be established using one fill pass run at high heat input and another fill pass run at low heat input. This will qualify all the fill passes with the same nominal parameters to be welded using the heat input range between the high and the low values qualified.

11. For nominal heat input weld procedure qualification, the heat input should not be <0.5 Kj/mm or >3.0 Kj/mm.
12. The weld data recorded from each WPQT shall be submitted to the Principal.

This data will be used to determine the average heat input for each pass or pass grouping.

- a. If the data is incomplete or lost, the weld shall be rejected and replaced with a new weld.
- b. The heat input limit for each pass grouping on the WPS may then be expanded up to 10%.

This might result in a qualified range slightly outside the 0.5 Kj/mm–3.0 Kj/mm range allowable for WPQT welds.

Heat input is calculated by multiplying amps by volts by 60 and dividing by the travel speed. Multiple units are demonstrated below:

Joules/mm = Amps X Volts X 60 ÷ mm per minute

Kilo Joules/mm = Joules/mm ÷ 1000

Joules/inch = Amps X Volts X 60 ÷ Inches per Minute

Kilojoules/inch = Joules/inch ÷ 1000

5.4.2.20 Interpass Temperature

1. The maximum inter-pass temperature shall be that established during WPQR testing.
2. For seamless pipe for deepwater pipelines and flow lines, the maximum interpass temperature qualified shall not exceed 315 °C (600 °F).
3. For welded pipe (ERW or DSAW), the maximum inter-pass temperature qualified shall not exceed 370 °C (700 °F).
4. Forced air cooling to lower the weld temperature before starting the next weld pass may be used if qualified during welding procedure qualification.
5. If forced air cooling is used, clean, dry air in conjunction with air cooling rings or jackets shall be used to insure uniform cooling around the girth weld circumference.
6. Artificial heating to the maximum interpass temperature prior to cap pass welding shall not be allowed.

5.5 WELDING OF TEST JOINTS – BUTT WELDS

Add the following:

1. All NDE required for production welds shall also be performed on welds made for WPQR, but no sooner than 48 hours after completing the weld, and submitted to Principal for review.
2. For welding procedures utilizing low Hydrogen consumables with less than 4.0ml/100g of Hydrogen, NDE may be conducted 24 hours after completing the weld.

5.6 TESTING OF WELDED JOINTS - BUTT WELDS

5.6.1 Preparation

Add the following before the first paragraph:

1. The NDE shall be as stated in (9) and (11).
2. Any weld which fails to meet the acceptance criteria shall not be offered for destructive testing.
3. On completion of welding, all WPQR test pieces should be cooled to room temperature or another temperature approved by the Principal, such as in the case of a Post Weld Hydrogen Removal Soak, before being subjected to NDE.
4. Contractor may, at their expense, conduct NDE prior to the 48 hour hold period for information only.
5. Project pipe and/or forgings shall be used for WPQR unless otherwise approved by Principal.

Add the following:

6. Macro examinations shall be removed from the 12 o'clock and 6 o'clock locations.
7. For pipe sizes greater than 219 mm (8.625 in) diameter additional samples shall be removed and examined from the 9 o'clock location.
8. A round cross weld tensile shall be taken.
9. Charpy testing shall be taken from the 3 and / or 9 o'clock positions.
10. If additional Charpy tests are required for testing at more than one temperature, sufficient test spools shall be made available for such tests
11. CTOD specimens shall be taken.
12. If additional CTOD tests are required for testing at more than one temperature, sufficient test spools shall be made available for such tests.
13. Additional tests shall be taken as required by the relevant appendices within this DEP.
14. In addition to the requirements of API 1104, the type of tests required shall be as shown in Table 5.6.1-1 below for the relevant conditions as defined by the Principal:

Table 5.6.1-1 Required Tests

Type of Test	Standard API 1104	Flowlines and Pipelines	Appendix E SCR	Appendix F High Strain Applications	Appendix G PLET and Jumper
Flat Cross Weld Tensile	X	X	X	X	X
All Weld Tensile	X	X	X	X	X
Round Cross Weld Tensile		X	X	X	
Nick Break	X	X	X	X	X
Bends	X	X	X	X	X
Charpy		X	X	X	X
Macro Examination	X	X	X	X	X
Hardness	X	X	X	X	X
CTOD		X	X	X	X ¹
Fatigue Testing			X	X ²	
Reeled Testing		For Reeled Installations	For Reeled Installations	X	NA
Sour Service Testing		For Sour Service Conditions	For Sour Service Conditions		For Sour Service Conditions

- NOTE 1: for fracture critical components, CTODs are required.
2: for fatigue critical components, fatigue testing is required.

15. Procedures, calibrations records, training records, operator qualification records, approval records and any other quality documents deemed appropriate by the Principal shall made available upon request.
16. Although the Principal may not specifically approve a test facility, the selection of laboratories to be used for destructive and/or non-destructive testing shall be submitted prior to their use.

The Principal reserves the right to exclude the use of specific facilities either prior to or during their use based on safety, quality, service or any other factor as deemed relevant. Use of multiple facilities and change of facilities is permitted with the above conditions being met.

5.6.2 Tensile-strength Test

5.6.2.1 Preparation

Add the following subsections:

5.6.2.1.1 Flat Weld Tensile

1. The tensile-strength test specimens (see Figure 4) shall be of sufficient length to allow a minimum of 30 mm (1.2 in) either side of the weld outside the gripping area.
2. The width shall be 25 mm $\pm$ 0.5 mm (1 in $\pm$ 0.02 in) with the maximum deviation between measurements along the entire parallel of 0.35 mm (0.014 in).
3. The number of samples and location shall be as specified in Table 2 and Figure 3.
4. Specimens shall be removed and prepared in such a manner that neither the base nor weld properties are affected.
5. Thermal cutting shall not be done unless any flame cut edges are removed by mechanical machining techniques to clean base material.

5.6.2.1.2 All Weld Tensile

1. All weld tensile shall be taken from the longitudinal weld direction for each weld consumable used.
2. The diameter of the tensile should be maximized with the minimum being 4 mm (0.157 in).
3. Before testing, the final machined specimen should be etched to confirm that only weld metal is being tested.
4. In the case of narrow gap, where multiple consumables are used or other cases where it is not possible to obtain an all weld from a procedural weld, other techniques such as welding on a plate may be considered.

5.6.2.1.3 Round Cross Weld Tensile

1. Where required, round cross weld tensile specimens shall be removed from the mid wall location.
2. A standard sample size shall be selected such that the original gauge length of the extensometer used to determine the yield is as a minimum covers the weld, HAZ and extends into both base materials.
3. Unless the requirements of (5.6.2.1.3 item 2) cannot be met, the sample size selected should be as large as possible up to a maximum of 12.7 mm (1/2 in) diameter.

5.6.2.2 Method

Add the following:

1. All tensile testing shall be in accordance with ASTM A370 or ASTM E8.

5.6.3 Nick-break Test

5.6.3.1 Preparation

Add the following:

1. Specimens shall be removed and prepared in such a manner that neither the base nor the weld properties are affected.
2. Where the use of thermal cutting is used, any burnt edges and heat affected zones shall be removed by mechanical machining techniques.
3. The width tolerance of the Nick-break test specimens shall be 25 mm $\pm$ 0.5 mm (1 in $\pm$ 0.02 in).

5.6.3.2 Method

Add the following:

1. Fracture may be by alternate bending from the side faces.
2. If fracture is done by alternate bending from the sides, bending should be such that the fracture is a result of fatigue and not bend overload.

5.6.4 Root-and Face-bend Test

5.6.4.1 Preparation

Add the following:

1. The width of the root- and face-bend test specimens should be 25 mm (1 in).
2. Specimens shall be removed and prepared in such a manner that neither the base nor the weld properties are affected.
3. Where the use of thermal cutting is used, any burnt edges and heat affected zones shall be removed by mechanical machining techniques.

5.6.4.2 Method

Add the following:

1. The fixture for bending shall have a tolerance of ± 1 mm (0.04 in).
2. Wrap round type bend fixtures shall not be used.

5.6.5 Side-bend Test

5.6.5.1 Preparation

Add the following:

1. The width for side-bend test specimens should be 12.7 mm (1/2 in).
2. Side-bend test specimens shall be machine cut, or be oxygen cut to approximately a 19 mm width (3/4 in) and then machined or ground to the 13 mm (1/2 in) width.
3. Specimens shall be removed and prepared in such a manner that neither the base nor the weld properties are affected.
4. Where the use of thermal cutting is used, any burnt edges and heat affected zones shall be removed by mechanical machining techniques.

5.6.5.2 Method

Add the following:

1. The fixture for bending shall have a tolerance of ± 1 mm (0.04 in).

Add the following new sections and subsections:

5.6.6 Charpy testing

5.6.6.1 Preparation

1. Charpy test sample shall be prepared in accordance with either ASTM A370 or ASTM E23.
2. For each stated location, three (3) specimens shall be removed and tested with both the individual results and average of the set of three being reported.
3. Where possible, the samples shall be as standard full sized 10 mm x 10 mm x 2 mm "V" notch.
4. When the pipe dimensions preclude the preparation of a full sized specimen, a sub-sized specimen shall be prepared with the maximum feasible thickness as taken from the Table 5.6.6.1-1.

Table 5.6.6.1-1 Standard Charpy Sizes

Specimen Size (mm)
10 x 10 x 2V
10 x 7.5 x 2V
10 x 5.0 x 2V
10 x 2.5 x 2V

5. The samples shall be taken longitudinal to the pipe flow direction with a circumferential notch direction, i.e., L-C as per ASTM E399.

Due to the curvature of the pipe and the depth requirement of the individual Charpy samples, it is often required that Charpy samples be cut from the weld as individual specimens as pads may result in inconsistent locations.

6. Samples shall be taken from the weld and HAZ as specified in API 1104 Appendix A section A.3.2.2.1 with the weld samples at the same depth as the HAZ samples.
 - a. The samples shall be taken from the 3 and / or 9 O'clock position.
7. For material thicknesses in excess of 20 mm, additional sets of Charpy specimens shall be removed and tested from the bore region such that the bottom of the Charpy samples (the face closest to the pipe bore) shall be between 1 mm and 2 mm from the ID surface.
8. For these HAZ samples the fusion line shall intersect at a depth of 3.33 mm from the bottom of the Charpy specimen.
9. For all sizes of pipe, a set of mid wall base samples shall be taken with the notch in the same through thickness orientation as the weld samples.

5.6.6.2 Method

1. Charpy tests shall be performed in accordance with either ASTM A370 or ASTM E23 at the temperature specified by Principal.
2. See also (Part II, 1.2, items r, s and t).
3. If specified by Principal, additional tests shall be conducted at more than one temperature.