

DEP SPECIFICATION

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

DEP 37.81.40.31-Gen.

February 2011

(DEP Circular 49/12 has been incorporated)

ECCN EAR99

DESIGN AND ENGINEERING PRACTICE

DEM1



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TABLE OF CONTENTS

PART I.	INTRODUCTION	5
1.1	SCOPE.....	5
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	5
1.3	DEFINITIONS	6
1.4	CROSS-REFERENCES	7
1.5	SUMMARY OF MAIN CHANGES.....	7
1.6	COMMENTS ON THIS DEP	8
1.7	DUAL UNITS.....	8
PART II	GENERAL REQUIREMENTS	9
PART III	AMENDMENTS/SUPPLEMENTS TO API 1104.....	11
SECTION 1	GENERAL.....	11
1.1	SCOPE.....	11
SECTION 2	REFERENCED PUBLICATIONS	11
SECTION 3	DEFINITION OF TERMS	11
3.2	DEFINITIONS	11
SECTION 4	SPECIFICATIONS.....	11
4.1	EQUIPMENT.....	11
4.2	MATERIALS.....	12
SECTION 5	QUALIFICATION OF WELDING PROCEDURES FOR WELDS CONTAINING FILLER-METAL ADDITIVES.....	13
5.1	PROCEDURE QUALIFICATION	13
5.2	RECORD.....	14
5.3	PROCEDURE SPECIFICATION	14
5.4	ESSENTIAL VARIABLES	16
5.5	WELDING OF TEST JOINTS – BUTT WELDS.....	18
5.6	TESTING OF WELDED JOINTS - BUTT WELDS.....	19
SECTION 6	QUALIFICATION OF WELDERS.....	28
6.1	GENERAL	28
6.2	SINGLE QUALIFICATION	28
6.4	VISUAL EXAMINATION	29
6.6	RADIOGRAPHY – BUTT WELDS ONLY	29
6.7	RETESTING	29
6.8	RECORDS	29
SECTION 7	DESIGN AND PREPARATION OF A JOINT FOR PRODUCTION WELDING.....	29
7.1	GENERAL	29
7.2	ALIGNMENT	30
7.3	USE OF LINEUP CLAMP FOR BUTT WELDS	31
7.4	BEVEL.....	31
7.5	WEATHER CONDITIONS	32
7.7	CLEANING BETWEEN BEADS	32
7.8	POSITION WELDING	32
7.9	ROLL WELDING	32
7.12	SEPARATION OF GIRTH WELDS.....	32
7.13	ATTACHMENTS	32
SECTION 8	INSPECTION AND TESTING OF PRODUCTION WELDS	33
8.1	RIGHTS OF INSPECTION	33
SECTION 9	ACCEPTANCE STANDARDS FOR NON-DESTRUCTIVE TESTING	33
9.1	GENERAL	33
9.3	RADIOGRAPHIC TESTING.....	33
9.4	MAGNETIC PARTICLE TESTING.....	34
9.5	LIQUID-PENETRANT TESTING	34
9.6	ULTRASONIC TESTING	34

9.7	VISUAL ACCEPTANCE STANDARDS FOR UNDERCUTTING.....	35
9.8	VISUAL ACCEPTANCE STANDARDS FOR ALL WELDS	35
SECTION 10 REPAIR AND REMOVAL OF DEFECTS.....		35
10.1	AUTHORIZATION FOR REPAIR	35
10.2	REPAIR PROCEDURE.....	36
10.5	WELDER.....	37
SECTION 11 PROCEDURES FOR NON-DESTRUCTIVE TESTING		37
11.1	RADIOGRAPHIC TEST METHODS.....	37
11.2	MAGNETIC PARTICLE TEST METHOD	40
11.4	ULTRASONIC TEST METHOD.....	40
SECTION 12 MECHANIZED WELDING WITH FILLER METAL ADDITIONS.....		40
12.1	ACCEPTABLE PROCESSES.....	40
12.3	RECORD.....	41
12.4	PROCEDURE SPECIFICATION	41
12.5	ESSENTIAL VARIABLES	42
12.6	QUALIFICATION OF WELDING EQUIPMENT AND OPERATORS.....	42
SECTION 13 AUTOMATIC WELDING WITHOUT FILLER-METAL ADDITIONS		42
SECTION 14 DOCUMENTATION		43
14.1	GENERAL.....	43
14.2	PRE-WELDING DOCUMENTATION.....	43
14.3	FINAL DOCUMENTATION.....	44
APPENDIX A	ALTERNATIVE ACCEPTANCE STANDARDS FOR GIRTH WELDS.....	45
APPENDIX B	IN-SERVICE WELDING	46
APPENDIX C	REQUIREMENTS FOR STRUCTURAL STEEL.....	47
APPENDIX D	Interpipe® (ITP) WELDS.....	48
APPENDIX E	SUPPLEMENTAL REQUIREMENTS FOR SCR WELDS.....	49
APPENDIX F	SUPPLEMENTAL REQUIREMENTS FOR REELED AND HIGHLY STRAINED WELDS	54
APPENDIX G	REQUIREMENTS FOR PLET, MANIFOLD, HULL AND JUMPER PIPING WELDS.....	57
APPENDIX H	BUTTERING WITH LOW CARBON STEEL FILLER METAL	61
APPENDIX I	REQUIREMENTS FOR CRA CLAD PIPE AND CRA ALLOYS.....	62
APPENDIX J	REQUIREMENTS FOR ANODE WELDS	67
APPENDIX K	WELD ACCEPTANCE CRITERIA BASED ON ENGINEERING CRITICAL ASSESSMENT (ECA)	69
PART IV	REFERENCES	78

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). The clause numbering in Part III of this DEP follows that of API 1104. Clauses of API 1104 that are not amended or supplemented by this DEP remain valid as written.

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 2010; 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 should 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.

1.3.2 Abbreviations

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
FEA	Finite Element Analysis
FCAW	Flux Core Arc Welding
FCAW-GS	Gas Shielded Flux Core Arc Welded
GMAW	Gas Metal Arc Welding
GTAW	Gas Tungsten Arc Welding
HAZ	Heat Affected Zone
HV 10	Vickers Hardness (10 kg [22 lbf] load)
ID	Internal Diameter
ISO	International Standards Organization
NDE	Non Destructive Examination

OD	Outside Diameter
pH ₂ S	Partial Pressure H ₂ S (see Figure A-2 – NACE MR0175)
PLET	Pipeline End Termination
PWHT	Post Weld Heat Treatment
QA/QC	Quality Assurance / Quality Control
RMS	Root Mean Squared
SCR	Steel Catenary Riser
SAW	Submerged Arc Welding
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

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced by this DEP are listed in (Part III). Cross-references to parts of API 1104 give section numbers without brackets.

1.5 SUMMARY OF MAIN CHANGES

The previous edition of this DEP was dated February 2010 and was based on API 1104, Twentieth edition, October 2005 with Errata/Addendum of July 2007 and December 2008. The current revision is also based on API 1104, Twentieth edition, October 2005 with Errata/Addendum of July 2007 and December 2008, but follows the clause numbering of API 1104 for easy reference.

Other than editorial revisions, the following are the main changes to that edition:

Old section	New section	Change
General		Process safety requirements have been indicated by the use of the capitalised term "SHALL [PS]".
General		Numbering of the sections and subsections to match the clause numbering of API 1104.
Part III:		
2.2	5, 7 and 12	Additions/Changes to Welding Procedure Qualification
2.5	10	Additions/Changes to Repair Procedure Qualification
2.7	6 and 12	Additions/Changes to Welder Performance Qualification

Old section	New section	Change
2.8	4, 7 and 12	Additions/Changes to Preparation for Production Welding
2.9	7 and 10	Rejected Welds
5	Appendix C	Requirements for Structural Steel
6	Appendix D	Interpipe [®] (ITP) Welds
7	Appendix E	Supplemental Requirements for SCR Welds
8	Appendix F	Supplemental Requirements for Reeled and Highly Strained Welds
9	Appendix G	Requirements for PLET, Manifold and Jumper Piping Welds
10	Appendix H	Buttering with Low Carbon Steel Filler Metal
11	Appendix I	Requirements for CRA Clad Pipe and CRA Alloys
12	Appendix J	Requirements for Anode Welds
13	Appendix K	Weld Acceptance Criteria Based on ECA

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal <http://www.shell.com/standards> and on the main page of the DEPs DVD-ROM.

1.7 DUAL UNITS

**Amended per
Circular 49/12**

Dual units have been incorporated throughout this DEP.

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.

PART II GENERAL REQUIREMENTS

1.1 GENERAL

Part III of this DEP is written as amendments and supplements to API 1104 (Twentieth edition, October 2005 with Errata/Addendum of July 2007 and December 2008). Wherever reference is made to API 1104, it shall be understood to mean API 1104 (Twentieth edition, October 2005 with Errata/Addendum of July 2007 and December 2008), as amended/supplemented by this DEP.

For ease of reference, the clause numbering of API 1104 has been used throughout Part III of this DEP.

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

The following information should be provided by the Principal and applied in conjunction with this DEP and API 1104:

- a) nominal OD of linepipe(s);
- b) nominal wall thickness of linepipe(s) and appurtenance material(s);
- c) grade and designation of the linepipe(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 shall be submitted for agreement;
- i) whether previously qualified welding procedure specifications may 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 may 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);
- r) test temperature for Charpy if different from the default of -18°C (0°F);
- s) pipe sizes that require fatigue testing, if different than the default in this DEP;
- t) sour service requirements, including pH₂S level;
- u) service category when (Appendix K) is invoked;
- v) appendices to be invoked;
- w) listing of approved AUT contractors for flow line/pipeline and riser weld inspection;
- x) acceptance criteria for welds, if different from the default criteria in section (APPENDIX K);

- y) acceptance criteria and NDE methodology for CRA weld overlay and clad pipe near the weld bevel, prior to welding;
- z) pipeline or riser regions that require fatigue testing (e.g. critical regions of SCR's) (see also (5.6.11));and,
- aa) additional information as required.

PART III AMENDMENTS/SUPPLEMENTS TO API 1104

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

SECTION 1 GENERAL**1.1 SCOPE**

Add the following:

Welding may not be carried out by plasma arc welding, oxyacetylene welding or flash butt welding processes. The self shielded FCAW process may only be used on structural weldments.

Filler metal SHALL [PS] be used for all passes.

Roll welding may be accepted by the Principal when an automatic welding process is used. GMAW, GTAW, and gas-shielded FCAW shall be restricted to construction areas protected against wind and draught.

SECTION 2 REFERENCED PUBLICATIONS

Add the following:

See also (Part IV) of this DEP.

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

Delete this subsection and replace with the following:

This term shall be understood to mean the Principal as defined in (1.3.1).

3.2.21 O'clock

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

3.2.22 WPQR

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

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

3.2.24 Sour Service

As defined in DEP 31.22.20.31-Gen.

SECTION 4 SPECIFICATIONS**4.1 EQUIPMENT**

Add the following:

Contractor shall furnish all welding and data logging equipment and prepare all spools used in WPQR testing. Welding and data logging equipment used for WPQR shall be identical to that used for production welding.

Welding machines shall not be operated beyond their rated capacity. Instruments shall be installed on the machines to accurately measure voltage and amperage. The machines shall be maintained in good working order. Equipment that, in the opinion of the Principal, is defective shall be promptly repaired or replaced.

Welding equipment with internal weld data logging capabilities shall be calibrated every 6 months. In lieu of current calibrations, accuracy shall be demonstrated during WPQR welds using an external secondary calibrated weld data logger or calibrated amp-/volts. Performance of weld data logging equipment during production may be verified with an external secondary calibrated weld data logger or calibrated amp-/volts.

Welding machine leads shall be fastened to the base metal securely by means of clamps or other mechanical means (not by welding). Connections shall avoid notch damage to the pipe. No arcing between the leads and the pipe is permitted. Any leads with insulation damaged shall be discarded or safely repaired to meet applicable safety standards.

The length of leads and their gauge shall be documented during WPQR welding and shall not be changed more than 10% from that qualified.

4.2 MATERIALS

4.2.2.1 Types and sizes

Delete this subsection and replace with the following:

All welding electrodes, rods, and fluxes shall be of size and kind suitable for the material being welded and approved by Principal. They shall conform to this DEP and to the welding procedure. These consumables must be supplied meeting Schedule I, with the Manufacturer's Certified Report of tests called for in Table 2, of AWS Standard A5.01.

4.2.2.2 Storage and handling of filler metals and fluxes

Delete this subsection and replace with the following:

Manufacturer's recommended welding materials handling and storing procedures shall be followed. Any unidentified, damaged, wet or otherwise deteriorated welding materials shall not be used. Electrodes, filler wires and fluxes shall be stored in a dry storage room in accordance with the Manufacturer's instructions. Filler materials and fluxes shall remain in their original containers which shall be marked with the Manufacturer's name, the consumable trade name and the batch number. 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. The storage room should have a maximum relative humidity of 50 %.

Contractor should submit consumable handling procedure for Principal approval. This procedure should address daily issued welding consumable handling and storage of unused portions.

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 (0.14 fl oz/0.22 lbm) deposited metal. This shall be verified during the WPQR. Low hydrogen and flux cored electrodes shall not be used if their protective container/packaging is damaged allowing atmospheric exposure. Any opened box containing welding rods for production welding shall be stored in "hot boxes".

Reclamation of SAW flux or slag shall not be allowed.

4.2.3 Shielding and backing gas

4.2.3.1 Types

Add the following:

Shielding gases shall conform to the welding procedure. All gases shall be supplied with certified analysis. Shielding gas containing CO₂ shall not have greater than 0.0015% (15 ppm) O₂ or 0.0019% (19 ppm) moisture content (approximate dew point of -55°C [-67°F]). Shielding gas containing 95% or greater Argon shall not exceed 0.0010% (10 ppm) O₂ or 0.0015% (15 ppm) moisture content (approximate dew point of -60°C [-76°F]).

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% to 5.5%.

If a compound gas mixture is mixed in the field, the gases shall be stored separately. Individual flow meters shall be used to measure flow rates of each gas being mixed as well as the resulting mixed gas.

Flow meters shall be used for accurate flow rate measurement when shielding gases are used. Flow meters shall be checked against calibrated flow meters for accuracy.

Certified gas analyzers shall be available at the work site for checking compositions of gases. 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. Gas analyzers shall be used on all gases which are not premixed and certified by gas supplier.

Contractor shall verify with gas supplier at what temperature the specific gas components can separate and shall incorporate heaters and agitators if the ambient temperature drops below that temperature.

4.2.3.2 Storage and handling

Add the following:

Gases in containers that are unidentifiable shall not be used.

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

5.1 PROCEDURE QUALIFICATION

Add the following:

All welds SHALL [PS] be specified by a WPS and SHALL [PS] be qualified by a WPQR in accordance with the requirements of this DEP.

Prior to commencement of qualifications, Contractor shall submit to Principal for approval a matrix of all WPSs, WPQRs, and WPQTs to be performed. Preliminary WPSs to be qualified shall be submitted to Principal for review and comment prior to qualification testing. Contractor shall supply qualified welding procedures for Principal approval.

Contractor shall bear all costs connected with the tests other than the cost of pipe and/or forgings that may be supplied by Principal. Contractor shall specify in his bid the amount of pipe that he 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.

Low hydrogen welding processes shall be used.

Contractor shall give Principal representative 48 hours notice prior to weld qualification activities.

Use of automatic welding processes shall be subject to approval by Principal before qualifying the WPS. After approval and upon completion of successful mechanical and NDE testing, a process capabilities test program shall be conducted by the Contractor. Contractor shall produce fifty (50) consecutive welds with no less than forty five (45) meeting the non-destructive testing acceptance standards of API 1104, Section 9 for pipeline welds. 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 selected AUT system for production weld inspection. Mechanical properties, including fracture toughness, of at least one of the fifty welds also shall be determined. Sectioning of a weld or welds may be required by Principal 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.

Hull Piping for floating facilities shall be qualified per Section (5).

5.2 RECORD

Add the following:

Welding parameters should be recorded by means of a calibrated weld data logging system with printout facility.

The procedure qualification record shall include the following:

- printouts from the weld data logging system as applicable
- original NDT reports
- original laboratory test reports, including macro and micro photographs clearly showing the microstructure of the weld metal, HAZ, and the base material;
- originals or verified copies of the Manufacturer/Supplier's certification documents for the test coupon materials; and
- original or verified copies of the Manufacturer/Supplier's certification documents for the filler materials and flux employed for test welding.

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:

The WPS shall show the following non-technical information:

- date;
- revision number;
- contract number;
- project title;
- Contractor's name; and,
- 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:

The materials to which the procedure applies shall be identified. 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:

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:

Permanent backing rings are prohibited for girth welds of pipes containing fluids or gases.

All joint details, dimensions and tolerances shall be listed in the WPS. Joint design, including bevel angle, shall conform to the appropriate Code and subject to approval by Principal. The use and design of compound bevels shall be approved by Principal for welds requiring NDE by AUT.

In cases where wall thickness transition is required, Contractor shall submit design for Principal approval.

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 (0.13 mils) RMS. The transition from the counter bore to the minimum of 4:1 taper shall be at least 3.2 mm (1/8 in) radius.

5.3.2.5 Filler metal and number of beads

Add the following:

The number of passes deposited and filler metal sizes used for each pass shall be recorded for each wall thickness used during WPQR.

One strip pass or layer may be used to compensate for varying pipe wall thickness around the pipe circumference. The strip pass welding parameters can be either:

- established during WPQR testing or,
- use the qualified parameters of the weld pass preceding the strip pass.

5.3.2.6 Electrical characteristics

Add the following:

Where applicable, electrical stick out, contact tube-to-work distance, contact tip, and wire feed speed shall be specified for each weld pass.

If pulsed welding is used, background current and pulse parameters, e.g. waveform, peak current, duration and frequency, shall be fully specified.

5.3.2.8 Position

Add the following:

The specification shall designate the qualified angle range.

5.3.2.10 Time between passes

Add the following:

Each pass shall be completed before starting the next pass. The second pass (hot pass) shall be deposited as soon as practical after the first pass (root pass).

The hot pass, shall be completed up to and including the last completed root pass whenever the root pass welding is stopped for any reason and at the end of the day's work. No welds shall be left more than 12 hours with less than 2 passes.

First fill passes (at other weld stations) shall be completed up to and including the last completed root pass whenever the root pass welding is stopped for any reason.

If root pass welding is interrupted before completion, weld preheat shall be maintained until welding resumes. If the preheat drops below the minimum, the weld shall be cut out.

5.3.2.11 Type and removal of line-up clamp

Add the following:

Procedure shall specify the type of line-up clamp used during qualification and the minimum number of passes completed prior to removal.

For automatic welds, internal line-up clamps shall be used, unless pipe diameter is too small for its use (generally pipe diameters less than 150 mm (6 in) nominal), or during double jointing operations where both pipes are fully supported and aligned using an external hydraulic or similar mechanical system.

Internal line-up clamps shall be left in place until the root pass is completed. External line-up clamps shall be left in place until a minimum fifty (50) percent of the root pass is completed. 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 root pass must be completed to the maximum amount that the line-up clamp allows before removal. 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:

Cleaning and/or sanding techniques used during WPQR shall be recorded. The WPS shall include cleaning instructions. Pipe surface cleaning shall be conducted by wire brushes, sanding or flapper wheels and not by grinding or any process that causes uneven metal removal.

5.3.2.13 Pre- and post-heat treatment

Add the following:

The location where preheat and inter-pass temperature measurements are taken during WPQR, shall be specified. 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:

When applicable, the backing gas composition and flow rate shall be qualified. 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:

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

Add the following new subsections:

5.3.2.17 Number of welders

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:

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:

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:

It is required that onshore and offshore welding procedures be qualified using the same type of cutting, beveling, positioning, alignment, and welding equipment that will be used during production welding.

5.4.2.4 Position

Add the following:

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:

A wall thickness range of more than 6.4 mm (1/4 in) shall be considered an essential variable. Ranges defined in Section 6.2.2.e shall apply to welder qualifications.

5.4.2.6 Filler metal

Add the following:

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. Four or more weld passes shall be deposited for pipe wall thickness great than or equal to 6.4 mm (1/4 in).

Manufacturer, trade name, size and heat number shall be considered an essential variable.

5.4.2.7 Electrical characteristics

Add the following:

Range of amperage and voltage shall be similar to that used during qualification and shall be approved by Principal.

5.4.2.8 Time between passes

Add the following:

Root pass welding delays shall be less than 30 minutes and preheat shall be maintained. The hot pass and the third pass shall be as qualified. 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 shall be unlimited.

5.4.2.10 Shielding gas and flow rate

Add the following:

A change of flow rate beyond that qualified shall constitute an essential variable.

5.4.2.12 Speed of Travel

Add the following:

Range of travel speed shall be similar to that used during qualification and shall be approved by Principal.

5.4.2.13 Pre-heat

Add the following:

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

5.4.2.14 Post-weld heat treatment

Add the following:

Welds shall not be stress relieved unless specifically approved by Principal or required by applicable Codes and if qualified during WPQR. 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. Cold-expanded pipe welds shall not be stress relieved. Methods, equipment type and controls shall be documented and specified.

Add the following new subsections:

5.4.2.15 Removal of line-up clamp

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

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

5.4.2.17 Repair welds

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

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

5.4.2.19 Heat input and welding parameters

The minimum and maximum heat input allowed in production welding shall be that qualified during procedure qualification. The maximum allowable difference between the high and low heat input should be no more than 20% of the low heat input value. Where a range greater than 20% is needed for a pass or pass grouping, high and low heat inputs shall be qualified separately. When qualified separately, full mechanical testing as required in subsequent sections of this document must be conducted on both the minimum and maximum heat inputs to be used in production.

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 may 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. Parameters shall be subject to approval by Principal.

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

$$\text{Joules/mm} = \text{Amps} \times \text{Volts} \times 60 \div \text{mm per minute}$$

$$\text{Kilo Joules/mm} = \text{Joules/mm} \div 1000$$

$$\text{Joules/inch} = \text{Amps} \times \text{Volts} \times 60 \div \text{Inches per Minute}$$

$$\text{Kilojoules/inch} = \text{Joules/inch} \div 1000$$

5.4.2.20 Interpass temperature

The maximum inter-pass temperature shall be that established during WPQR testing. For seamless pipe for deepwater pipelines and flow lines, the maximum interpass temperature qualified shall not exceed 315°C (599°F). For welded pipe (ERW or DSAW), the maximum inter-pass temperature qualified shall not exceed 370°C (698°F). Forced air cooling to lower the weld temperature before starting the next weld pass can be used if qualified during welding procedure qualification. Clean, dry air in conjunction with air cooling rings or jackets shall be used to insure uniform cooling around the girth weld circumference.

5.5 WELDING OF TEST JOINTS – BUTT WELDS

Add the following:

All NDE required for production welds must also be performed on welds made for WPQR, but no sooner than 48 hours after welding. Results shall be submitted to Principal for approval and acceptable to the requirements of this DEP. Contractor may propose NDE be performed prior to 48 hours from completion of the weld for welding processes utilizing solid wire welding consumables without flux.

5.6 TESTING OF WELDED JOINTS - BUTT WELDS

5.6.1 Preparation

Add the following before the first paragraph:

The NDE acceptance criteria shall be as stated in (9). Any weld which fails to meet the acceptance criteria shall not be offered for destructive testing.

On completion of welding, all WPQR test pieces shall be cooled to room temperature or another temperature as agreed upon by Principal, such as in the case of a Post Weld Hydrogen Removal Soak, before being subjected to NDE. This shall be carried out prior to sectioning for mechanical testing. Contractor may at his expense conduct NDE prior to the 48 hour hold period for information only. Project pipe and/or forgings shall be used for WPQR unless otherwise approved by Principal.

Add the following:

Macro examinations shall be removed from the 12 o'clock and 6 o'clock locations. For pipe sizes greater than 100 mm (4 in) diameter an additional samples shall be removed and examined from the 9 o'clock location.

A micro hardness survey shall be made on a macro section from either 12 o'clock or 6 o'clock.

Additional Requirements for Flow-line applications:

A round cross weld tensile shall be taken.

Charpy testing shall be taken from the 3 and / or 9 O'clock positions.

CTOD specimens shall be taken.

Additional tests shall be taken as required by the relevant appendices within this DEP.

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 Stain 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		X	X	X	
Nick Break	X	X	X	X	X
Bends	X	X	X	X	X

Type of Test	Standard API 1104	Flowlines and Pipelines	Appendix E SCR	Appendix F High Stain Applications	Appendix G PLET and Jumper
Charpies		X	X	X	X
Macro Examination	X	X	X	X	X
Hardness	X	X	X	X	X
CTOD		X	X	X	
Fatigue Testing			X	X	
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

Procedures, calibrations records, training records, operator qualification records, approval records and any other quality documents deemed appropriate by the Principal shall be made available upon request. 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 test

5.6.2.1 Preparation

Add the following subsections:

5.6.2.1.1 Flat weld tensile

The tensile-strength test specimens see Figure 4 shall be of sufficient length to allow a minimum of 30 mm (1.18 in) either side of the weld outside the gripping area. The width shall be 25 mm (1 in) $\pm$ 0.5 mm (0.02 in) with the maximum deviation between measurements along the entire parallel of 0.35 mm (0.014 in). The number of samples and location shall be as specified in Table 2 and Figure 3. Specimens shall be removed and prepared in such a manner that neither the base nor weld properties are affected. Use of thermal cutting is not permitted unless any burnt edges are removed by mechanical machining techniques.

5.6.2.1.2 All weld tensile

All weld tensile shall be taken from the longitudinal weld direction for each weld consumable used. The diameter of the tensile should be maximized with the minimum being 4 mm (0.16 in). Before testing, the final machined specimen should be etched to confirm that only weld metal is being tested. 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

Where required, round cross weld tensiles shall be removed from the mid wall location. 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. Unless the above requirements 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:

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:

Specimens shall be removed and prepared in such a manner that neither the base nor the weld properties are affected. Where the use of thermal cutting is used, any burnt edges and heat affected zones shall be removed by mechanical machining techniques.

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:

Fracture by alternate bending from the side faces is permitted. If this method is selected, 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:

The width tolerance of the root- and face-bend test specimens should be 25 mm (1 in). Specimens shall be removed and prepared in such a manner that neither the base nor the weld properties are affected. 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:

The fixture for bending shall have a tolerance of ± 1 mm (0.04 in). Other types and designs on fixtures may be considered for approval by the Principal.

5.6.5 Side-bend test

5.6.5.1 Preparation

Add the following:

The width tolerance for side-bend test specimens should be 12.7 mm (1/2 in). They shall be machine cut, or they may be oxygen cut to approximately a 19 mm (3/4 in) width and then machined or ground to the 13 mm (0.51 in) width. Specimens shall be removed and prepared in such a manner that neither the base nor the weld properties are affected. 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:

The fixture for bending shall have a tolerance of ± 1 mm (0.04 in). Other types and designs on fixtures may be considered for approval by the Company.

Add the following new sections:

5.6.6 Charpy testing

5.6.6.1 Preparation

Charpy test sample shall be prepared in accordance with either ASTM A 370 or ASTM E 23.

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.

Where possible, the samples shall be as standard full sized 10 mm x 10 mm x 2 mm (0.4 in x 0.4 in x 0.08 in) "V" notch. 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 below. The samples shall be taken longitudinal to the pipe flow direction with a circumferential notch direction, i.e. L-C as per ASTM E399.

Table 5.6.6.1-1 Standard Charpy Sizes

Specimen Size (mm)	Specimen Size (in)
10 x 10 x 2V	0.4 x 0.4 x 0.08 V
10 x 7.5 x 2V	0.4 x 0.3 x 0.08 V
10 x 5.0 x 2V	0.4 x 0.2 x 0.08 V
10 x 2.5 x 2V	0.4 x 0.1 x 0.08 V

It should be noted that 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.

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 center samples at the same depth as the HAZ samples. The samples shall be taken from the 3 and / or 9 O'clock position.

For material thicknesses in excess of 20 mm (0.79 in), 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 (0.04 in) and 2 mm (0.08 in) from the ID surface. For these HAZ samples the fusion line shall intersect at a depth of 3.33 mm (0.13 in) from the bottom of the Charpy specimen.

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

Charpy tests shall be performed in accordance with either ASTM A 370 or ASTM E 23 at a maximum test temperature of -18°C (0°F).

5.6.6.3 Requirements

All samples shall meet the requirements as stated below in Table 5.6.6.3-1 at the given test temperature.

Table 5.6.6.1-1 Charpy Test Requirements

API Spec 5L Pipe Grade (Steel Grade)	Specimen size (mm)	Specimen size (in)	Charpy-V Requirement (Joules)		Charpy-V Requirement (ft-lbs)	
			min. average	min. single	min. average	min. single
L290* (X42*)	10x10	0.4x0.4	36	27	27	20
L320* (X46*)	10x10	0.4x0.4	36	27	27	20
L360* (X52*)	10x10	0.4x0.4	36	27	27	20
L390* (X56*)	10x10	0.4x0.4	40	30	30	22
L415* (X60*)	10x10	0.4x0.4	41	31	31	23
L450* (X65*)	10x10	0.4x0.4	45	34	34	26
L485* (X70*)	10x10	0.4x0.4	48	36	36	27

* donates the delivery condition of the material

For full sized specimens, the average of three (3) specimens shall not be less than the minimum average stated above with no more than one (1) sample below the average requirement and no single value less than that of the minimum specified single value.

In the case of sub-sized specimens which do not meet the requirements above, the requirement reduction factors shown below in Table 5.6.6.3-2, may be used to reduce the requirement acceptance criteria. Note that the reduction factor is applied to the requirement not the actual result obtained. The actual energy absorbed by any sub-sized specimens shall be reported without any conversion for size. No temperature adjustment is to be made in respect for specimen size.

Table 5.6.6.3-2 Reduction Factors

Specimen Size (mm)	Specimen Size (in)	Reduction Factor
10 x 10 x 2V	0.4 x 0.4 x 0.08 V	1
10 x 7.5 x 2V	0.4 x 0.3 x 0.08 V	5/6
10 x 5.0 x 2V	0.4 x 0.2 x 0.08 V	2/3
10 x 2.5 x 2V	0.4 x 0.1 x 0.08 V	1/2

5.6.7 Macro examination

5.6.7.1 Preparation

Samples for macro examinations shall be removed from the 12 O'clock and 6 O'clock locations. For pipe sizes greater than 219 mm (8.625 in) diameter an additional sample shall be removed and examined from the 9 O'clock location.

Specimens shall be prepared for macroscopic examination by grinding to a minimum of a 600 grit paper finish. The prepared surfaces shall be etched using a suitable etchant to reveal the grain structure.

5.6.7.2 Method

The samples shall be visually examined for discontinuities in the weldment.

5.6.7.3 Requirements

The type and size of any discontinuities observed shall be reported. Any liquid metal inclusions (e.g. copper), inter-granular cracking or discontinuities that cannot be shown to be acceptable to the NDE acceptance criteria shall be a cause for rejection. Any indications that cannot be clearly classified as acceptable shall be highlighted for Principal consideration.

5.6.8 Hardness testing

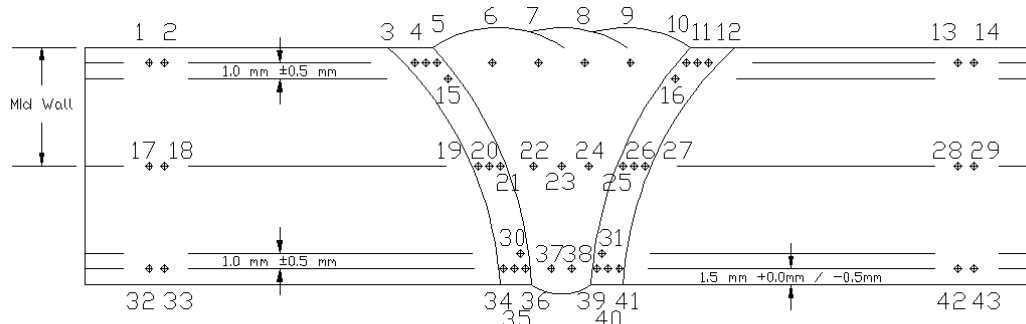
5.6.8.1 Preparation

The hardness surveys shall be made on the macro sections. If required, further machining and preparation of the macro sections shall be performed to ensure the sample is in accordance with the requirements of the testing specification, ASTM E 92.

5.6.8.2 Method

Testing shall be performed in accordance with ASTM E 92 using a 10 kgf (22 lbf) load.

The survey shall be made as shown in Figure 0-1 below.



Points 5 & 10 in HAZ of Final Pass or change of profile.
Points 1, 2, 13, 14, 17, 18, 28, 29, 32, 33, 42 & 43 in Base Material.
Points 6, 7, 8, 9, 22, 23, 24, 37 & 38 evenly spaced between fusion lines.
Points 5, 10, 15, 16, 21, 25, 30, 31, 36 & 39 within 1/2 ϕ of FL on BM side.
HAZ spacing between punches shall be 0.5 mm.
Base Material between punches shall be 1.0 mm.

Figure 0-1 Hardness Locations

Following hardness testing, a scaled photograph of the weld, clearly showing the weld and HAZ areas of the sample, shall be produced for the final report. The hardness indications in the weld and HAZ shall also be clearly visible in the photograph.

5.6.8.3 Requirements

For non-sour service, the maximum hardness shall be as per Table 5.6.8.3. For sour service, the surveys shall comply with the requirements of NACE MR0175 / ISO 15156-2:2003(E), Part 2, Section 7.3.3. The maximum hardness shall be as per Table 5.6.8.3.

Table 5.6.8.3 Permissible Hardness Values

Hardness Location	Weld Metal : Root & Midwall	Weld Metal : Cap	HAZ : Root & Midwall	HAZ : Cap
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