

GENERAL SPECIFICATION

PIPELINES - RISERS

GS EP PLR 425

Site welding of carbon steel pipelines (sweet and sour service, onshore and offshore) according to API STD 1104

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1. Scope

This specification defines the Company general requirements for welding and inspection of flowlines components within the following scope:

	Sweet		Sour	
Operating conditions	X		X	
	Sweet service carbon steel	Sour service carbon steel	Clad and lined pipes	CRA pipes (duplex and superduplex)
Materials	X (up to X70 grade)	X (up to X65 grade)	X	Not applicable
	Onshore		Offshore (S-lay, J-lay ...)	
Types of welding activities	X Including welding activities in yard and mill (stalks welding, double or triple joints...)		X (Welding according to DNV-OS-F101 and GS EP PLR 426 should be the preferred option unless API STD 1104 is required by local regulations)	
	Butt welds		Fillet welds	
Types of welds	X		X	

It applies to all welding combinations between pipes, bends, flanges and forgings supplied according to [GS EP PLR 205](#), [GS EP PLR 226](#), [GS EP PLR 227](#) and [GS EP PLR 228](#).

The definitions of sweet and sour service conditions are stated in the specification [GS EP COR 170](#).

In mild, intermediate and severe service, due to the presence of sour effluent, all welds shall have a good resistance to any kinds of H₂S embrittlement.

This specification shall be used in conjunction with a Project Particular Specification (PPS) to be made for purpose detailing the additional tests and requirements or the possible modifications to the present specification, based on the special design conditions of the pipeline project.

2. Reference documents

The reference documents listed below form an integral part of this General Specification.

Welding shall be carried-out to [API STD 1104](#) and the amendments contained in this specification.

All codes, specifications, standards and other documents which are referenced in this specification are listed hereafter.

The order of precedence of the applicable documents shall be:

- The Contract
- The Project Particular Specification (PPS)

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- The present General Specification
- The codes and standards in reference.

Unless otherwise specifically indicated in writing by the Company, the Contractor shall work in accordance with the requirements specified herein and the applicable requirements of the latest editions at date of Contract award of the referenced Codes and Standards, whenever requested in the present specification.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the effective date of this document.

Reference	Title
API SPEC 5LC	CRA Line Pipe
API SPEC 5LD	Specification for CRA Clad or Lined Steel Pipe
API STD 1104	Welding of Pipelines and Related Facilities
ASME B31.4	Pipeline Transportation Systems for Liquid and Slurries
ASME B31.8	Gas Transmission and Distribution Piping Systems
ASME BPVC Section II Part C	Specifications for Welding Rods, Electrodes, and Filler Metals
ASME BPVC Section IX	Welding, Brazing, and Fusing Qualifications
ASME BPVC Section V	Nondestructive Examination
ASTM A262	Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
ASTM A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM E23	Standard Test Methods for Notched Bar Impact Testing of Metallic Materials
ASTM E384	Standard Test Method for Knoop and Vickers Hardness of Materials
ASTM E562	Standard Test Method for Determining Volume Fraction by Systematic Manual Point Count
ASTM E647	Standard Test Method for Measurement of Fatigue Crack Growth Rates
ASTM E709	Standard Guide for Magnetic Particle Testing
ASTM G28	Standard Test Methods of Detecting Susceptibility to Intergranular Corrosion in Wrought, Nickel-Rich, Chromium-Bearing Alloys

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Reference	Title
ASTM G48	Standard Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution
AWS A5.18	Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding
BS 7448 (All parts)	Fracture mechanics toughness tests - All parts
BS 7910	Guide to methods for assessing the acceptability of flaws in metallic structures
CSWIP	Certification Scheme for Personnel
DNV-OS-F101	Clad or Lined Steel Linepipe - Section 7D
DNV-OS-F201	Dynamic Risers
DNV-RP-C203	Fatigue Design of Offshore Steel Structures
DNV-RP-F108	Fracture control for pipeline installation methods introducing cyclic plastic strain
DNV-RP-F112	Design of duplex stainless steel subsea equipment exposed to cathodic protection
DNV-RP-F118	Pipe girth weld AUT system qualification and project specific procedure validation
EFC Publication No. 16	European Federation of Corrosion Publication No. 16; Guidelines on Material Requirements for Carbon and Low Alloy Steels for H ₂ S - Containing Oil and Gas Field Service
EN 10160	Ultrasonic testing of steel flat product of thickness equal or greater than 6 mm (reflection method)
EN 10204	Metallic products - Types of inspection documents
EN 1435	Non-destructive examination of welds. Radiographic examination of welded joints
EN 50504	Validation of arc welding equipment
ISO 11699-1	Non-destructive testing - Industrial radiographic film - Part 1: Classification of film systems for industrial radiography
ISO 14344	Welding consumables - Procurement of filler materials and fluxes
ISO 148-1	Metallic materials - Charpy impact test - Part 1: Test method
ISO 15156-2	Petroleum and natural gas industries - Materials for use in H ₂ S-containing environments in oil and gas production - Part 2 Cracking-resistant carbon and low-alloy steels, and the use of cast irons
ISO 17636 (Parts 1; 2)	Non-destructive testing of welds - Radiographic testing of fusion-welded joints - Parts 1; 2

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Reference	Title
ISO 17640	Non-destructive testing of welds - Ultrasonic testing - Techniques, testing levels, and assessment
ISO 19232-1	Non-destructive testing - Image quality of radiographs - Part 1: Determination of image quality value using wire-type image quality indicators
ISO 5579	Non-destructive testing - Radiographic testing of metallic materials using film and X- or gamma rays - Basic rules
ISO 7539-2	Corrosion of metals and alloys. Stress corrosion testing - Part 2: Preparation and use of bent-beam specimens
ISO 9001	Quality managements systems - Requirements
ISO 9712	Non-destructive testing - Qualification and certification of NDT personnel
ISO/TS 29001	Petroleum, petrochemical and natural gas industries - Sector-specific quality management systems - Requirements for product and service supply organizations
MSS SP-97	Integrally reinforced forged branch outlet fittings - Socket welding, threaded and butt welding ends
NACE TM 0177	Laboratory testing of metals for resistance to sulfide stress cracking and stress corrosion cracking in H ₂ S environments

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published in the applicable yearly collection.

Reference	Title
GS EP COR 170	Materials for upstream sour service application - Specification for selection and design
GS EP COR 401	Installation of anodes on submerged pipelines
GS EP PLR 100	Submarine pipeline systems
GS EP PLR 205	Carbon steel, clad and lined pipe manufacturing for linepipe applications according to API SPEC 5L and DNV-OS-F101 (sweet and sour service, onshore and offshore)
GS EP PLR 226	Fabrication of hot bends for pipelines
GS EP PLR 227	Carbon Steel Flanges, Branch Outlet Fittings and Forged Components for Pipelines
GS EP PLR 228	Carbon steel tees for pipelines

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Reference	Title
GS EP PLR 426	Site welding of carbon steel and CRA pipelines (sweet and sour service, onshore and offshore) according to DNV-OS-F101
GS EP PLR 430	Automated Ultrasonic Testing of pipeline girth welds according to DNV standards
GS EP PLR 431	Real time radiography inspection

3. Project Particular Specification (PPS)

The PPS shall contain welding datasheets as per Appendix C requirements with at least the following information:

1. Details about pipe geometry and pipe material.
2. Clarification on the details of end bevels.
3. Materials ordered with a simulated PWHT.
4. The sour service severity and pipeline effluent to clarify the H₂S test conditions, in the case of mild, intermediate and severe service.
5. Impact test temperature(s) and impact test absorbed energy requirement for WT above 25 mm.
6. CTOD tests requirements (if any): number of specimens, sampling location, specimen geometry, test environment, test temperature and minimum CTOD values.
7. FCGR tests requirements (if any): number of specimens, sampling location, specimen geometry, test environment, test temperature and targeted FCGR.
8. Full scale fatigue tests requirements (if any): number of specimens, sampling location, specimen geometry, test environment, test temperature and targeted fatigue class according to [DNV-RP-C203](#).
9. Strip tests fatigue tests requirements (if any): number of specimens, sampling location, specimen geometry, test environment and test temperature.
10. Knockdown factors to account for effects of sour environment on fatigue strength (if applicable).

4. Company approval/Quality Control/Quality Assurance

4.1 Company approval

All suppliers shall be previously approved on the financial, HSE, quality and technical sides by Company.

As part of this approval process, a technical audit shall be performed by HQ Pipeline & Riser department and the supplier shall be approved. Non approved suppliers shall not be considered on Company projects.

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Company can suspend the approval of a manufacturer due to a negative feedback concerning pipe quality, delivery time, missing documentation or HSE issues.

4.2 Inspection by the company

All procedures shall have prior approval of HQ Pipeline & Riser department.

For each project, Company appoints inspector(s) to supervise welding procedures qualifications and production.

All qualification tests shall take place under the supervision of the inspector.

Welding contractor shall ensure, prior to the commencement of welding qualification, a one day training to company inspector (s) with the following objectives:

- Show the equipments: power source, welding bug, clamp, preheating device...
- Explain to company inspector the main steps of the inspection and test plan and show in particular how hi-lo, preheat temperature, interpass temperature and cap profile are checked
- Explain to company inspector how welding parameters are monitored/recorded and how the welding heat input is calculated
- Explain to company inspector which type of equipments he can used and where he can do the measurements to cross-check welding parameters.

4.3 Quality Control

Responsibility for quality control shall rest with the Contractor aided by such staff as may be required.

Four weeks prior to commencement of any work the Contractor shall prepare and submit a Quality Control Plan which describes the systematic control of the construction, inspection and testing, as dictated by the overall Contract quality program. The Quality Control Plan shall set forth "witness", "hold", "review" and "monitor" points. It shall be written following the format given in Appendix D.

Regarding inspection, the Quality Control Plan shall include:

- A flowchart illustrating each inspection point and its relative location in the procedure cycle, where conformance of characteristics is verified.
- The characteristics to be inspected at each inspection point, the procedures and acceptance criteria to be used. The procedures shall be provided to the Company, as requested.
- Copies of specific forms used by Contractor to record the results of each inspection.

The Contractor shall maintain quality records as documentary evidence of compliance with quality requirements. Quality records shall be available to the Inspector for analysis and review.

All Contractor inspection systems shall be subject to evaluation and checks by the Inspector to ensure that the system is effectively applied and meets the requirements of this specification.

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The Contractor shall employ competent supervisors to ensure that both the standard of workmanship and the quality of materials used comply with the requirements of this specification.

4.4 Quality Assurance

The Contractor shall operate a Quality Assurance system in accordance with [ISO 9001](#) or [ISO/TS 29001](#), approved by a Company recognized authority. The Quality assurance Manual shall be submitted prior the start of work.

5. Fatigue sensitive welds definition

All contributions to fatigue shall be considered in fatigue calculations: ViV, slugging, shutdowns.

Miner's rule shall be used to combine all cyclic load cases:

$$\sum_1^i \frac{N_i}{Nf_i} < 1$$

Where:

N_i is the number of cycles corresponding to a lifetime of 10 times the field lifetime (as required in [GS EP PLR 100](#) § 19.7) and corresponding to fatigue safety factor "HIGH" in [DNV-OS-F101](#) and [DNV-OS-F201](#).

Nf_i is the number of fatigue cycles to failure for $\Delta\sigma_i$.

In the present specification, fatigue sensitive lines ("FS1" designation) are those which the accumulated fatigue damage is ≥ 0.05 (including the safety factor of 10 as required in [GS EP PLR 100](#)).

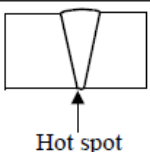
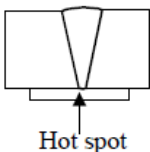
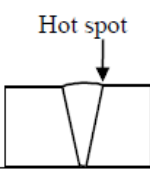
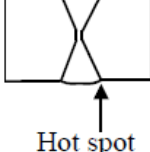
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The fatigue class shall be as per [DNV-RP-C203](#) for the relevant class detail and environment:

<i>Description</i>		<i>Tolerance requirement</i>	<i>S-N curve</i>	<i>Thickness exponent k</i>	<i>SCF</i>
<i>Welding</i>	<i>Geometry and hot spot</i>				
Single side		$\delta \leq \min(0.15t, 3 \text{ mm})$	F1	0.00	1.0
		$\delta > \min(0.15t, 3 \text{ mm})$	F3	0.00	1.0
Single side on backing		$\delta \leq \min(0.1t, 2 \text{ mm})$	F	0.00	1.0
		$\delta > \min(0.1t, 2 \text{ mm})$	F1	0.00	1.0
Single side			D	0.15	Eq. (2.10.1)
Double side			D	0.15	Eq. (2.10.1)

For D-class, the Stress Concentration Factor (SCF) is given by:

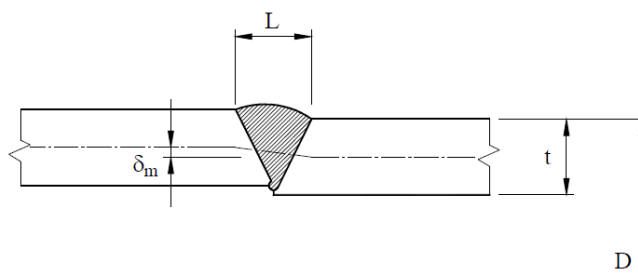
$$SCF = 1 + \frac{3 \cdot \delta_m}{t} e^{-\sqrt{t/D}}$$

Where:

t is the pipe nominal thickness

D is the pipe outside nominal diameter

δ_m is the misalignment which shall be determined as follow:



For seamless pipes, the value of δ_m shall be replaced by δ_{tot} :

$$\delta_{tot} = \sqrt{\delta_{Thickness}^2 + \delta_{ovality}^2}$$

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$$\delta_{thickness} = \frac{(t_{max} - t_{min})}{2}$$

$$\delta_{ovality} = (D_{max} - D_{min})$$

Fatigue Crack Growth Rate (FCGR) shall be as per [BS 7910](#): mean + 2SD in the relevant environment.

The following table specifies the FCGR values that shall be considered in Engineering Critical Assessments (ECA):

Environment	FCGR
Air	BS 7910 in air, Mean + 2SD
Sea water + CP	BS 7910 in air, Mean + 2SD with a multiplying factor of 9
Sour	BS 7910 in air, Mean + 2SD with a multiplying factor equal to the knockdown factor

Every time the contractor wants to consider a better fatigue class, full scale fatigue tests and FCGR tests shall be performed to demonstrate the actual fatigue performance.

Alternatively, results of full scale or FCGR tests from past experience can be considered provided the tested welding procedures are within the acceptable range of the following essential variables:

Variables			Changes requiring new full scale or FCGR tests
1. Welding process	FCGR	Full scale or strip	
The process(es) used	X	X	Any change.
The order of processes used	X	X	Any change when multiple processes are used.
Manual, partly-mechanized, mechanized or automatic welding	X	X	Any change between manual, partly-mechanized, mechanized and automatic welding.
2. Welding equipment	FCGR	Full scale or strip	
Welding	X	X	Any change in make, type and model for partly-mechanized, mechanized and automatic welding.
Welding equipment	X	X	Any change in type for manual welding.
Number of wires	X	X	Change from single wire to multiple wire system and vice versa (e.g. going from tandem/twin to single wire). This does not apply to multiple torch systems where the wires feed into separate weld pools.

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Variables			Changes requiring new full scale or FCGR tests
3. Base materials	FCGR	Full scale or strip	
Material grade	X	X	A change of material grade.
Supply condition	X	X	A change in material supply condition (TMCP or Q/T).
Manufacturing process	X	X	A change in manufacturing process (rolled, seamless, forged).
4. Material thickness and diameter	FCGR	Full scale or strip	
Material thickness (t = nominal thickness of test joint.)	X	X	- t ≤ 25 mm: A change outside 0.75 t to 1.5 t. - t > 25 mm: A change outside 0.75 t to 1.25 t.
D/t ratio		X	Any change of ± 10%.
5. Groove configuration	FCGR	Full scale or strip	
Groove design/configuration.	X	X	Any change from J to V bevel. Any change in groove dimension ± 10%.
6. Alignment	FCGR	Full scale or strip	
Line-up clamp	X	X	Omission of a line-up clamp and a change between external and internal line-up clamp.
Backing		X	Any change from copper shoes to no copper shoes and vice versa.
Internal misalignment		X	Any increase.
7. Welding consumables	FCGR	Full scale or strip	
Welding consumables	X	X	Any use of a welding consumable type (standard designation) or a change in tensile or impact properties of more than ±10%.

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Variables			Changes requiring new full scale or FCGR tests
8. Electrical characteristics and pulsing data	FCGR	Full scale or strip	
AC, DC or pulsed current	X	X	Any change in type of current and a change from normal to pulsed current and vice versa.
Pulse frequency range in pulsed manual welding	X	X	Any change in: Pulse frequency for background and peak current exceeding $\pm 10\%$ and pulse duration range exceeding $\pm 10\%$.
9. Welding techniques	FCGR	Full scale or strip	
Welding direction	X	X	A change from upwards to downwards welding and vice versa.
Stringer/weave	X	X	A change from stringer to weave of more than 3X electrode/wire diameter or vice versa.
Sequence of deposition of different consumables	X	X	Any change in the sequence.
Sequence of sides welded first and last (double sided welds)	X	X	Any change in the sequence.
Passes welded from each side	X	X	Change from single to multi pass welding and vice versa.
10. Preheating	FCGR	Full scale or strip	
Preheat temperature	X	X	Any reduction.
Initial temperature when preheat is not used	X	X	Any reduction.
11. Interpass temperature	FCGR	Full scale or strip	
Maximum and minimum interpass temperature	X	X	Any increase above 25°C for C-Mn and low alloy steel.
12. Heat input	FCGR	Full scale or strip	
Heat input range	X	X	Any change exceeding $\pm 5\%$.

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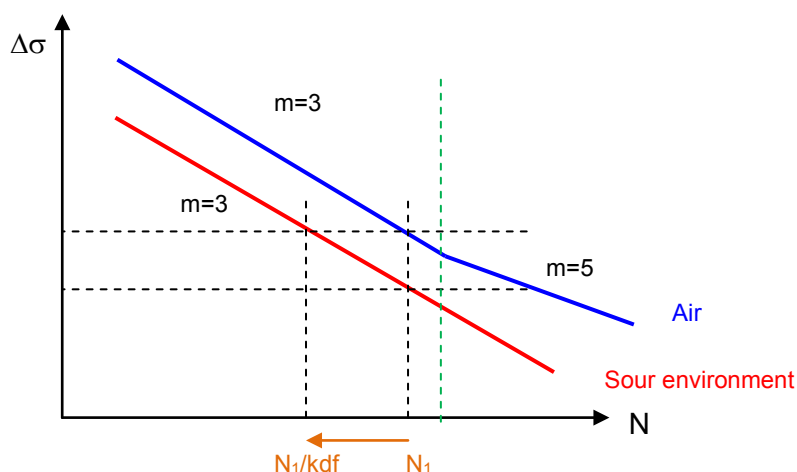
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Variables			Changes requiring new full scale or FCGR tests
13. Post weld heat treatment	FCGR	Full scale or strip	
Post weld heat treatment	X	X	Addition or deletion of post weld heat treatment. Any change in holding temperature exceeding $\pm 20^{\circ}\text{C}$. Any change in heating and cooling rates outside $\pm 5\%$.
Holding time	X	X	Any change in holding time outside $\pm 5\%$
14. Weld profile	FCGR	Full scale or strip	
Cap extension beyond the fusion line		X	Any change above ± 2 mm.
Cap external profile		X	Any change in height of more than ± 1.5 mm.

In sour environment, a knockdown factor might be applicable. This shall be specified in the PPS.

Knockdown factors shall be incorporated in fatigue design calculations as follow:

- The reference curve shall be that used for design calculations i.e. D, F, F1 or F3 (the reference curves shall also be specified in the PPS).
- No limit at 10^7 cycles shall be considered.
- The slope of the S-N curve: $m = 3$ shall be used.
- For the same stress amplitude level, the fatigue life shall be reduced by the knockdown factor (see here below).



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A pre-classification of welds (between non fatigue sensitive and fatigue sensitive “FS1”) shall be mutually agreed at the bid stage.

As a guideline and in the absence of any data from the basic engineering, the following welds shall be considered “FS1” at the bid stage:

- Riser welds (at least hanging and touchdown areas)
- Riser base spool welds
- Flow-lines welds in buckling initiation areas.

6. Abbreviations

AUT	Automatic Ultrasonic Testing
CE	Carbon Equivalent
CR	Cap Repair
CRR	Cap Re-Repair
CT	Compact Tension
CTOD	Crack Tip Opening Displacement Test
DPI	Dye Penetrant Inspection
ECA	Engineering Critical Assessments
EDX	Energy-Dispersive X-ray Spectroscopy
ELUC	External Line-up Clamp
EPMA	Electron Probe Micro Analyzer
ET	Eddy Current Testing
EU	External Undercutting
FCAW	Flux Cored Arc Welding
FCGR	Fatigue Crack Growth Rate
FL	Fusion Line
GMAW	Gas Metal Arc Welding
GS-FCAW	Gas Shielded Flux Cored Arc Welding
GTAW	Gas Tungsten Arc Welding
HAZ	Heat Affected Zone
HHI	High Heat Input
I.D.	Internal Diameter
IC	Internal Concavity
ILUC	Internal Line-up Clamp
IU	Internal Undercutting

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LHI	Low Heat Input
m-GMAW	mechanized Gas Metal Arc Welding
m-PGMAW	mechanized Pulsed Gas Metal Arc Welding
m-SAW	mechanized Submerged Arc Welding
MPI	Magnetic Particles Inspection
MPQT	Manufacturing Procedure Qualification Test
MUT	Manual Ultrasonic testing
NDT	Non Destructive Testing
O.D.	Outside Diameter
Pcm	Parameter of Crack Measurement
PGMAW	Pulsed Gas Metal Arc Welding
PPS	Project Particular Specification
PTR	Partial Thickness Repair
PTRR	Partial Thickness Re-Repair
PWHT	Post-Weld Heat Treatment
pWPS	preliminary Welding Procedure Specification
QC	Quality Control
RPR	Root Pass Repair
RPRR	Root Pass Re-Repair
RT	Radiography Testing
SAW	Submerged Arc Welding
SCF	Stress Concentration Factor
SEM	Scanning Electron Microscope
SMAW	Shielded Metal Arc Welding
SMYS	Specified Minimum Yield Strength
SSC	Sulfide Stress Corrosion Crack
TTR	Through Thickness Repair
TTRR	Through Thickness Re-Repair
W.T.	Wall Thickness
WM	Weld Metal
WPQ	Welding Procedure Qualification

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WPQR	Welding Procedure Qualification Record
WPQT	Welding Procedure Qualification Test
WPS	Welding Procedure Specification

7. Amendments to **API STD 1104**

The following **API STD 1104** - Welding of Pipelines and Related Facilities revision is considered:

- TWENTIETH EDITION, OCTOBER 2005
- ERRATA/ADDENDUM, JULY 2007
- ERRATA 2, DECEMBER 2008
- REAFFIRMED, APRIL 2010.

The statements of this specification are modifications to **API STD 1104** and are identified as Add or Modify to Read.

The section numbers in this specification correspond to **API STD 1104**.

Additional sections listing Company requirements are highlighted in red.

Paragraphs of **API STD 1104** that are not revised remain applicable.

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1. General

1.1 Scope

[Modify to read](#)

The range of applicability of this specification is stated in table of section 1 Scope. The welding processes authorised by Company are listed in section 4.3 Welding Process.

2. Referenced publications

/

3. Definition of terms

3.1 General

/

3.2 Definitions

[Add](#)

<i>Inspector</i>	Company's authorized representatives or members from Company elected inspection agencies for the time being or from time to time duly appointed in writing by the Company to act as its representative for the purpose of the Contract shall be referred to herein as the "Inspector".
<i>PPS</i>	This designates the Project Particular Specification as defined before in this present specification.
<i>Site</i>	This term designates the sites, workshops, worksites, barges, ships or other locations where the prefabrication, welding and installation of the pipeline is performed complete or in part.
<i>Approval</i>	Authorization in writing given by Company to Contractor to proceed with the performance of a specific part of the work without releasing in any way Contractor from its obligations and liabilities under the Contract or at law. Approve, Approved and Approval shall be construed accordingly.

4. Specifications/Requirements

4.1 Equipment

/

4.2 Materials

/

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4.2.1 Pipe and Fittings

Add

Pipes and fittings supplied by Company are supplied according to Company General Specifications listed in section Reference documents and related PPS.

Unless otherwise stated in the PPS, pipes and fittings supplied by Company will be finished with ends beveled (refer to line pipe specifications of the order). If the Contractor elects to weld the pipes using a bevel design different from the one supplied, then re-beveling shall be made by Contractor.

When Post Weld Heat Treatment (PWHT) is to be applied to certain weldments, the related welded materials must have been previously tested (e.g. at time of materials order) for tensile and toughness properties after performance of the said PWHT.

4.2.2 Filler metal and fluxes

Add

- 1) All welding consumables shall conform to [ASME BPVC Section II Part C](#) or approved equivalent standard.
- 2) SAW flux procurement, packing, storage and use shall comply to the requirements of section 19 of the present specification.
- 3) Each heat, lot (or so called batch herein) of consumables shall be subject to inspection and approval by the Inspector. 3.1 (according to [EN 10204](#)) Mill test certificates from consumables Manufacturers showing test results actually obtained on the said lot shall be submitted to the Inspector.

The lot and the level of testing are specified as per [ISO 14344](#) as follows:

- a) Covered electrodes: class C5 or alternatively C3 provided it is limited to one heat number and when the chemical composition of wet mixes is controlled by raw material analysis and computerized weighing.
- b) Bare solid electrodes and rods: class S3.
- c) Flux cored electrodes and metal cored electrodes and rods: class T3.
- d) Flux for submerged arc welding: class F2.

The level of testing shall be as per [ISO 14344](#) - Schedule 4 as a minimum.

In addition, for SAW flux, testing of granulometry and testing of diffusible hydrogen and/or moisture, shall be required.

Note: For SAW, re-cycling of flux is not permitted.

- 4) All welding consumables shall be supplied in sealed, dirt and moisture proof containers. Unopened containers shall be stored in a dry location where a temperature of 20°C and humidity of less than 40% are maintained.
- 5) All welding consumables shall, as a minimum, be stored and handled in accordance with the written Manufacturer's recommendations. Contractor's procedure relative to storing handling, drying, recycling and traceability of consumables shall be approved by the Inspector before commencement of production welding.

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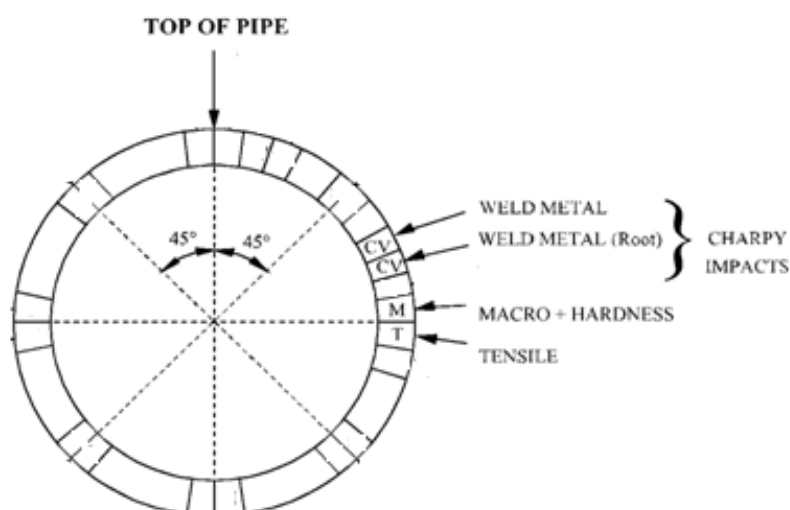
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- 6) Each tin or packet of electrodes, or reel of filler wire and bag of flux shall be clearly marked with the respective batch no. In the event of consumables being unmarked or showing signs of deterioration or other damage, they shall be discarded.
- 7) Each batch of welding consumables shall be subject to the following welding tests under the same conditions and with the same equipment as used for the relevant approved welding procedure:
 - Tensile-strength Test
 - Charpy V-notch Impact Test
 - Macro + Hardness Survey
 - CTOD Test (only when required in the PPS).

The location of each specimen is shown below:



No retests shall be permitted unless an explanation for the failure is accepted by the Company.

- 8) The weld deposits obtained from these consumables shall satisfy the Impact Toughness, CTOD (when required) and Hardness requirements stated in the other sections of this specification.

The Tensile-strength specimen of the weld deposits shall have a yield strength which overmatches the base material SMYS by at least 80 MPa for S-lay and J-lay applications. For reel lay, the weld deposit shall have a yield strength which overmatches base material SMYS by minimum 120 MPa.

All these properties shall be verified during the welding procedure qualification tests or batch testing.

- 9) The use of cellulosic coated electrodes is subject to conditions described in section 4.3.
- 10) Consumable batches and combinations used during WPQ are considered tested.
- 11) In sour service conditions, the nickel content in consumables shall not exceed 1.0% and the use of C 0.5 Mo consumables is not permitted.

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- 12) In sour service conditions, the consumable selected by the contractor shall be guaranteed by the manufacturer for such use or benefits from a positive track record (successful SSC tests on previous projects).

4.2.3 Shielding Gases

Add

The purity of the shielding gases shall be at least 99.99%.

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4.3 Welding Process

- 1) The following welding processes are approved for use:

Welding processes approved for use - MAINLINE PROCEDURES (AND DOUBLE JOINTS)

	Root	Fill	Cap
Non Fatigue sensitive line	m-SAW	m-SAW	m-SAW
	m-GMAW with or without copper shoes (for OD > 4.5" only).	m-GMAW	m-GMAW
	m-PGMAW without copper shoes (for OD > 4.5" only).	m-PGMAW	m-PGMAW
	SMAW - basic coated rods (cellulosic coated rods are only permitted for grades X56 and below and provided impact tests temperature is < -20°C).	SMAW - basic coated rods.	SMAW - basic coated rods.
	GTAW	GTAW	GTAW
	GTAW	GS-FCAW (subject to Company approval)	GS-FCAW (subject to Company approval)
	GTAW	m-GMAW	m-GMAW
	GTAW	m-PGMAW	m-PGMAW
	Particular requirement for <u>sour service</u>: Welding on copper shoes is not allowed.		
Fatigue sensitive line (FS1)	m-SAW (double side welding shall be required when targeting a D-class or more).	m-SAW	m-SAW
	m-GMAW without copper shoes (copper shoes might be acceptable provided fatigue performance is checked by full scale testing)	m-GMAW	m-GMAW
	m-PGMAW without copper shoes.	m-PGMAW	m-PGMAW
	GTAW	GTAW	GTAW
	GTAW	m-GMAW	m-GMAW
	GTAW	m-PGMAW	m-PGMAW
	Particular requirement for <u>sour service</u>: Welding on copper shoes is not allowed.		

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Welding processes approved for use - TIE-INS PROCEDURES (AND STALKS WELDING)

	Root	Fill	Cap
Non fatigue sensitive line*	m-GMAW	m-GMAW	m-GMAW
	m-PGMAW	m-PGMAW	m-PGMAW
	GTAW	GTAW	GTAW
	GTAW	m-GMAW	m-GMAW
	m-PGMAW	m-PGMAW	GTAW
	GTAW	GS-FCAW (subject to Company approval)	GS-FCAW (subject to Company approval)
	SMAW - basic coated rods (cellulosic coated rods are not permitted for tie-in and repairs). Vertical-up welding.	SMAW - basic coated rods (cellulosic coated rods are not permitted for tie-in and repairs). Vertical-up welding.	SMAW - basic coated rods (cellulosic coated rods are not permitted for tie-in and repairs). Vertical-up welding.
Fatigue sensitive line (FS1)	m-PGMAW	m-PGMAW	m-GMAW
	m-PGMAW	m-PGMAW	m-PGMAW
	GTAW	GTAW	GTAW

- 2) For mechanized and semi-automatic welding systems the Contractor shall give evidence at the bid stage of long and successful practice of the system on similar jobs and requirements, to the satisfaction of Company. Otherwise, the Company will specify special welding and NDT trials, to be completed successfully, before the proposed technique can be approved to proceed for the qualification testing.
- 3) FCAW process shall be thoroughly controlled at all times by Contractor to avoid any excessive scatters in the mechanical properties (and specially impact properties) of weld deposits. In that view, mechanical test results of qualification test welds shall show sufficient safety margins against requirements of this specification. The Company reserves the right to reject such process when its reliability is not satisfactory.
- 4) Basic coated low hydrogen electrodes shall be used for all fillet welds.
- 5) GTAW is mandatory for pipe diameter less than 2" 3/8 (60 mm).
- 6) In each case where a semi-automatic and/or automatic welding process or system is approved for use, a manual welding procedure shall be qualified as back up. This requirement may be waived for automatic welding only when Contractor can give evidence of successful past experience and when so specially agreed with Company at the bid stage.
- 7) Welding processes for anode connecting welds or any other welds to electrically connect attachments shall have prior approval of Company.
- 8) No relaxation shall be granted for SMAW using cellulosic coated electrode in downhill welding for the root pass.

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- 9) Electrical connecting weld shall be qualified and connection method shall be as per section 16.

5. Qualification of welding procedures for welds containing filler-metal additives

5.1 Procedure Qualification

Add

- 1) Welding procedures qualified for previous jobs shall not be accepted.
- 2) Contractor shall demonstrate by qualification tests that the proposed Welding Procedure Specification (WPS) as well as the equipment he intends to use enable performance of welds and weld repairs meeting the quality and properties required in this specification.
- 3) Extreme welding conditions, such as the following ones, which may occur during production welding, shall require qualification tests:
 - For any position/location around the weld, when the heat input variation exceeds $\pm 5\%$ in between minimum and maximum, then the minimum and the maximum heat input shall be individually qualified.
 - Interpass temperature beyond 250°C up to 280°C.
 - Barge move-up/pipe move-up after root pass.
 - When copper shoes are used, Contractor shall perform a qualification before production welding (refer to section 5.6.18 of this specification). That qualification test shall demonstrate that there is no detrimental effects in the root face due to copper pick up and/or copper contamination).
- 4) Non-Destructive Testing procedures shall conform to the requirements of section 11 of this specification and, anyway, subject to Company prior approval.
- 5) The test welds shall be fully visually inspected and then non-destructively tested according to section 11 prior to conducting the destructive tests. If these inspections indicate the presence of flaws or other defects exceeding the levels permitted in this specification, the reason of this shall be investigated and explained, to the satisfaction of Inspector, before re-welding a test weld to the same (or any other) procedure.
- 6) All welding procedure qualification tests shall be conducted in the presence of the Inspector and a third party.
- 7) The Contractor shall notify the Company of the date and location of the welding procedure qualification tests at least seven (7) working days before the start of the tests.
- 8) Company shall give final acceptance and approval of all welding processes, systems and procedures.
- 9) The Inspector shall witness all non-destructive examinations and destructive testings and shall review and approve all related results. All mechanical testings shall be carried out by a certified testing facility subject to prior approval of the Company.

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- 10) The energy definitions and a procedure for welding parameters recording and heat input calculation shall be established before starting the WPQ and shall apply during both qualification and production.

The heat-input shall be calculated as the average of each pass for root, hot pass and cap and the average of all passes for fill provided heat input variations do not exceed $\pm 5\%$. If this is not the case, the weld circumference shall be divided so that heat input variations do not exceed $\pm 5\%$ in each angular sector.

Heat input calculation methodology shall be submitted to Company approval but shall at least be in accordance with the following:

- For non waveform controlled welding:

$$E \text{ (J/mm)} = \frac{60 * U \text{ (V)} * I \text{ (A)}}{v \text{ (mm/min)}}$$

- For wave form controlled welding, Appendix H of [ASME BPVC Section IX](#) (true energy) shall be used. The program shall be printed-out and be part of qualification process. Any change on this program shall require re-qualification welding procedure.

Electrode stick-out shall be within 10% of the qualified one or maximum 2 mm.

During the qualification and production, the welding equipment shall be equipped with measuring device with high frequency sampling capable of displaying instantaneous welding energy or power. The sampling rate shall be sufficiently high to measure the welding energy or power following the waveform.

- 11) A procedure for welding equipments calibration shall be established before the commencement of the WPQ and shall apply during both qualification and production.
- 12) Welding equipment used for both qualification and production shall be calibrated as per [EN 50504](#) and certificate of calibration shall be valid within a year and will not be expired during the welding production period.

5.2 Record

Add

The data sheets of as-deposited runs (format to be approved by Inspector) shall also be filled in during performance of each test welds and shall be included in the final Welding Procedure Qualification Record (WPQR).

5.3 Procedure Specification

5.3.1 General

Add

The pWPS for both the main welding procedures and weld repair procedures shall be submitted to Company two weeks minimum before the start of qualification tests. The pWPS shall be accompanied by a summary table showing: process, consumables, direction of welding, type of weld, pWPS no., test weld wall thickness and scope of qualification. The welding procedure qualification tests shall not be undertaken until the Inspector has given his approval of the principle on the said pWPS.

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The pWPS shall specify the additional following details:

- Manufacturer and trade name of consumables
- Minimum and maximum preheating temperature
- Interpass temperature (minimum and maximum)
- Time lapse between end of root pass and start of hot pass, and end of hot pass and start of 3rd pass
- Minimum number of runs before joint is allowed to cool down
- The type of line-up clamp
- Time at which removal of line-up clamp is allowed
- Nozzle diameter for automatic welding (if applicable)
- Fit-up tolerances and bevel dimensional tolerances
- Oscillation width, dwell and frequency for automatic welding (if applicable)
- Electrode stick-out length (if applicable).

Scope of qualification in terms of material sourcing, steel grade, O.D. and W.T. groups, CE, P_{cm} and C%.

5.3.2 Specification Information

5.3.2.1 Process

/

5.3.2.2 Pipe and Fitting Materials

Add

Pipe, valves, flanges and fittings from different chemical compositions or grades, or made from material from different sources, or in different supply conditions shall be treated separately and shall require separate procedure qualification. Identical welding procedures qualified on materials (pipes, bends, forgings ...) from different sources will also qualify joints between materials (pipes, bends, forgings ...) from the two sources and vice-versa provided that both side of HAZ are tested (i.e.: A/A + B/B do qualify A/B or A/B does qualify A/A and B/B).

5.3.2.3 Diameters and Wall Thicknesses

Add

Grouping rules for diameters and thickness are given in sections 5.4.2.5 and 5.4.2.17 of this specification.

5.3.2.4 Joint Design

Add

Permanent backing rings or consumables inserts shall not be permitted.

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The root gap for fillet welds shall be between 1.0 to 2.5 mm.

5.3.2.5 Filler Metal and Number of Beads

Add

The number and position of weld beads shall be chosen to give to the completed weld a substantially uniform cross-section. Two weld beads shall not start at the same point, unless the area is dressed clean and sound before the second bead is started.

Basic coated low hydrogen electrodes with a minimum of two weld passes shall be used for all fillet welds.

For any automatic process, the number of passes shall always be established by a welding test made on each different wall thickness.

Single pass welds or internal root sealing welds shall be minimized. This does not apply to an automatic back pass applied internally that is an integral part of the butt weld procedure.

5.3.2.6 Electrical Characteristics

/

5.3.2.7 Flame Characteristics

Modify to read

Oxyacetylene welding is not allowed by Company.

5.3.2.8 Position

Add

Roll welding and position welding as defined in [API STD 1104](#) shall be qualified separately.

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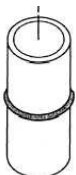
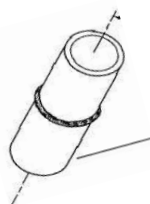
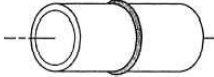
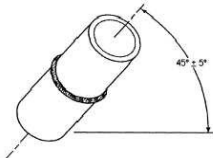
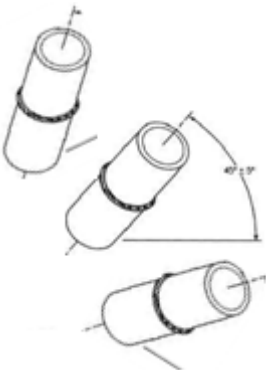
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For position welding, the following shall apply:

Position welding qualification

Position during qualification	Range qualified		
 2G	 -15°	 2G	 +15°
 5G	 -15°	 5G	 +15°
 6G	 60° - 6G (45°) - 30°		

2G + 5G qualifies 6G. However, the 6G position shall not qualify the 2G and/or 5G position.

5.3.2.9 Direction of Welding

/

5.3.2.10 Time between Passes

Add

When vertical-down welding is used, the second run (hot pass) shall be deposited immediately after completion of the root run (stringer bead), and the time lapse between the completion of the root bead and the start of the hot pass is an essential variable. It shall not be greater than that used in the procedure qualification test, with a max. of 15 minutes.

No welds on fittings, tie-ins and repairs shall be allowed to cool below preheat temperature prior to their completion. This requirement also applies to pipe to pipe welds in offshore work. For onshore pipe to pipe welds, a minimum of four runs or one third of weld thickness, whichever is the greater, shall be completed before cooling below preheat temperature provided that this is confirmed by a qualification test. No welds shall be left partially completed overnight.

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5.3.2.11 Type and Removal of Line-up Clamp

Add

For pipe to pipe welds on pipes with outside diameters above 4.5", an Internal Line-Up Clamp (ILUC) shall be used, unless impracticable (e.g. tie-in welds).

External Line-Up Clamp (ELUC) can also be used but shall be submitted to Company approval at the bid stage. The line-up performance shall be in particular demonstrated.

5.3.2.12 Cleaning and/or Grinding

/

5.3.2.13 Pre/ Post-heat Treatment and Interpass Temperature

Add

A minimum preheat of 100°C (-0/+30°C) shall apply to the welding of fittings, repair welds, tie-ins and fillet welds. The measuring control shall be carried at 50mm distance from bevel ends.

Inter-passes temperature in construction shall not exceed the maximum value achieved in the welding procedure qualification test (WPQ). If the Contractor wishes to exceed 250°C in the qualification test, a similar preheat (minimum value) shall be required for the cap in all production welds unless a supplementary procedure test is qualified at a lower inter-passes temperature.

Pipe temperature shall be measured and recorded before cap welding during MPQT.

During production, pipe temperature shall be checked before cap welding and shall be minimum the temperature measured and recorded during MPQT.

5.3.2.14 Shielding Gas and Flow Rate

/

5.3.2.15 Shielding Flux

/

5.3.2.16 Speed of Travel

/

5.4 Essential Variables

5.4.1 General

/

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5.4.2 Changes Requiring Requalification

5.4.2.1 Welding Process or Method of Application

Add

Any change in Company which performed the qualification test or site where the qualification test weld was produced.

5.4.2.2 Base Material

Add

Any change in material source, supply condition or manufacturing route of pipe or fitting. A change from seamless to welded pipe and vice-versa. A change between rolled, forged or cast process.

A higher grade shall qualify for a lower grade, but not vice-versa, in each group.

Any increase in P_{cm} , CE (IIW) or carbon content of more than 0.02% respectively.

5.4.2.3 Joint Design

Add

Any internal hi-lo exceeding 2.0 mm.

Any change in extension beyond the original weld preparation of more than 2 mm each side.

5.4.2.4 Position

Add

For position welding, any position outside the range mentioned in the section 5.3.2.8.

5.4.2.5 Wall Thickness

Add

Any change in pipe wall thickness beyond $\pm 25\%$ against that used at qualification test.

5.4.2.6 Filler Metal

Add

Any change in specified consumable in trade name, classification, source of origin, size or combination.

5.4.2.7 Electrical Characteristics

Add

Any change in welding heat input outside the one qualified is not permitted.

Any change in electrical source of supply, type of current or polarity.

5.4.2.8 Time between Passes

/

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5.4.2.9 Direction of Welding

Add

Any change in direction of welding.

5.4.2.10 Shielding Gas and Flow Rate

/

5.4.2.11 Shielding Flux

Add

Any change in shielding flux manufacturer or brand constitutes an essential variable.

5.4.2.12 Speed of Travel

/

5.4.2.13 Pre-heat

Add

The pre-heat temperature may be increased up to 30°C without re-qualification but any increase of inter-passes over 250°C shall be previously qualified.

5.4.2.14 Post-weld Heat Treatment (PWHT)

/

5.4.2.15 Heat input

The following two options can be considered by the welding contractors:

Options	Qualification	Qualified range for production
1	Nominal (NHI)	NHI $\pm$ 5%
2	LHI and HHI	From LHI to HHI (not outside)

5.4.2.16 Impact test

Any change in impact test requirements (notch location in weld or test temperature). However, for a stated energy absorption requirement at impact test, a lower test temperature qualifies for a higher test temperature.

5.4.2.17 Pipe diameter

Any change in pipe diameter from one to another of the following ranges:

- O.D. < 100 mm
- $100 \leq \text{O.D.} \leq 325$ mm

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- $325 < \text{O.D.} \leq 610 \text{ mm}$
- $\text{O.D.} > 610 \text{ mm}$

5.4.2.18 Number of passes

For automatic welding no change is permitted in the number of passes for a same WT. The number of welding passes may vary in production (-/+ one bead) in accordance with the pipe WT tolerances.

Any change of more than $\pm 25\%$ (rounding to highest integer number is not permitted) in the number of passes obtained at procedure qualification test, for manual and semi-automatic welding.

5.4.2.19 Additional welding equipments/accessories

Any change in distance between wires or welding bugs if weld temperature does not drop below 250°C before the subsequent pass.

Any removal of line-up clamp or any pipe/barge move-up at an earlier stage.

5.4.2.20 Plastic strain

In the case of a total nominal longitudinal strain $\geq 0.4\%$ (i.e.: reeling, etc.), a specific welding procedure qualification program shall be addressed.

5.4.2.21 Removal method for weld repair preparation

The removal method for weld repair preparation is an essential variable. Defect removal by grinding does not qualify defect removal by arc-gouging before weld repair.

5.5 Welding of Test Joints-Butt Welds

Add

- 1) The welding equipment shall be the same as or equivalent to that which are intended for use during installation. The test shall be performed on line pipe or other materials, as supplied for the Project, under similar conditions as those expected during installation.
- 2) Materials to be used in the tests shall be selected with a Carbon Equivalent and P_{cm} on the upper side of the analysis of the supplied materials and shall be subject to Inspector's prior approval.
- 3) A minimum of five consecutive welds satisfying NDT acceptance criteria shall be performed before starting qualification tests (destructive tests).
- 4) For on-line barge welding (automatic welding), procedure approval test welds shall be made on the pipelay barge. Each pass shall be deposited at the welding station intended to be the normal location for it in production welding.

However, this requirement may be waived and qualification tests may be carried out under simulated site conditions if the same equipment are used and if the specified welding procedure is fully reproduced and representative of site work (removal of line-up clamp, time lapse between passes, pipe movement, etc.) to the satisfaction of Company. This shall be clarified by Contractor and agreed with Company at the bid stage.

Site welding of carbon steel pipelines (sweet and sour service, onshore and offshore) according to API STD 1104

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Test welds shall be made between full pipe lengths. The use of less than full pipe lengths requires the prior agreement of Company. Anyway, the minimum length of each pipe to be used shall not be less than 3 meters.

- 5) For stalks, yard and tie-in welding, procedure approval test welds shall be made on site (spool base, yard...). Each pass shall be deposited at the welding station intended to be the normal location for it in production welding.

This requirement may be waived and qualification tests may be carried out under simulated site conditions if the same equipment are used and if the specified welding procedure is fully reproduced and representative of site work to the satisfaction of Company. However in that case, a production test will have to be performed on site when production starts. Tests required for this production tests are the same than those required for original WPQT.

This shall be clarified by Contractor and agreed with Company at the bid stage.

Test welds shall be made between full pipe lengths. The use of less than full pipe lengths requires the prior agreement of Company. Anyway, the minimum length of each pipe to be used shall not be less than 1.5 meters.

- 6) For manual or semi-automatic welding tests made on pipe nipples of reduced length (1 metre minimum), a sufficient number of internal strong backs shall be fully fillet welded on pipe to give realistic restraint during welding.
- 7) Grinding of weld passes between runs shall not be of more extent than that expected on production.
- 8) When manual welding is to be used, a minimum of one complete test joint is to be made for each Welding Procedure.
- 9) The positions of the longitudinal seams should be chosen to avoid all mechanical test pieces apart from the additional macro-section/hardness tests. The longitudinal seams may be aligned.

5.6 Testing of Welded Joints-Butt Welds

5.6.1 Preparation

[Modify to read](#)

The test specimens shall be cut from the joint at the locations shown below. Cutting sheets defining samples location and marking requirements shall be submitted to company for approval before starting qualification. For qualification of welding in the PA (1G rotated) and PC (2G) the sampling positions are optional.