

GENERAL SPECIFICATION

PIPELINES - RISERS

GS EP PLR 426

**Site welding of carbon steel and CRA pipelines
(sweet and sour service, onshore and offshore)
according to DNVGL-ST-F101**

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1. Scope

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

- Carbon steel material up to grade X80 in sweet service and grade X65 for sour service (For sour service region 1, the grade may be extended to X70 with prior approval from Company)
- CRA full thickness (except 13Cr grades), clad and overlaid pipes.
- Onshore and Offshore
- Butt and fillet welds.

This specification should be used in conjunction with Project Particular Specifications (PPS) detailing the specific design conditions of a pipeline project.

2. Reference documents

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

This specification shall supplement, as amended, the requirements of standard [DNVGL-ST-F101](#) and [DNVGL-RP-F108](#). For subjects that are not covered by this specification, [DNVGL-ST-F101](#) and [DNVGL-RP-F108](#) shall automatically apply.

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

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 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	ASME Boiler and Pressure Vessel Code (BPVC), Section II- Materials - Part C: Specifications for Welding Rods, Electrodes, and Filler Metals
ASME BPVC Section IX	ASME Boiler and Pressure Vessel Code (BPVC), Section IX- Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators
ASME BPVC Section V	ASME Boiler and Pressure Vessel Code (BPVC), Section V- Nondestructive Examination
ASNT/SNT-TC-1A	Personnel Qualification and Certification in Nondestructive Testing

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Reference	Title
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 A380	Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM E384	Standard Test Method for Microindentation Hardness of Materials
ASTM E562	Standard Test Method for Determining Volume Fraction by Systematic Manual Point Count
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
ASTM G48	Standard Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution
AWS A 5.18	Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding
AWS D 18.2	Guide to Weld Discoloration Levels on Inside of Austenitic Stainless Steel Tube
BS 7608	Guide to fatigue design and assessment of steel products
BS 7910	Guide to methods for assessing the acceptability of flaws in metallic structures
BS 8701	Full ring ovalization test for determining the susceptibility to cracking of linepipe steels in sour service - Test method
CSWIP	Certification Scheme for Personnel
DNVGL-RP-C203	Fatigue Design of Offshore Steel Structures
DNVGL-RP-F108	Assessment of flaws in pipeline and riser girth welds
DNVGL-RP-F112	Duplex stainless steel - design against hydrogen induced stress cracking
DNVGL-RP-F118	Pipe girth weld automated ultrasonic testing system qualification and project specific procedure validation
DNVGL-ST-F101	Submarine Pipeline Systems
DNVGL-ST-F201	Dynamic Risers
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 Environments in Oil and Gas Production

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Reference	Title
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
Force Report 94-34	Reference Colour Charts - for purity of purging gas in stainless steel tubes
ISO 11699-1	Non-destructive testing - Industrial radiographic film - Part 1: Classification of film systems for industrial radiography
ISO 14175	Welding consumables - Gases and gas mixtures for fusion welding and allied processes
ISO 14344	Welding consumables - Procurement of filler materials and fluxes
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 - Parts 1; 2
ISO 17640	Non-destructive testing of welds - Ultrasonic testing - Techniques, testing levels, and assessment
ISO 19232 (Parts 1; 5)	Non-destructive testing - Image quality of radiographs - Parts 1; 5
ISO 5579	Non-destructive testing - Radiographic testing of metallic materials using film and X- or gamma rays - Basic rules
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 Buttwelding Ends
NACE TM 0177	Laboratory testing of metals for resistance to sulfide stress cracking and stress corrosion cracking in H ₂ S environments
NACE TM 0316	Four-Point Bend Testing of Materials for Oil and Gas Applications
NORSOK N-006	Assessment of structural integrity for existing offshore load-bearing structures
R6 PANEL	Assessment of the integrity of structures containing defects

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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 PJC 501	Requirements for Contractor Quality Management
GS EP PLR 100	Submarine pipeline systems
GS EP PLR 430	Ultrasonic Testing for girth welds inspection according to DNV Standards
GS EP PLR 431	Real time radiography inspection
GS EP PVV 175	Cleaning of piping systems
GS EP SPS 001	Subsea Production Systems General Design Requirements

3. Abbreviations

For the purpose of this document, the following terms apply.

AUT	Automatic Ultrasonic Testing
AW	As Welded
AYS	Actual Yield Strength
BM	Base Material
BMT	Base Metal Tensile
CE	Carbon Equivalent
CMT	Cold Metal Transfer
CR	Cap Repair
CRA	Corrosion Resistant Alloys
CRR	Cap Re-Repair
CTOD	Crack Tip Opening Displacement Test
CSSC	Cyclic stress strain curve
D	Diameter
DPI	Dye Penetrant Inspection
ECA	Engineering Critical Assessments
EDX	Energy-Dispersive X-ray Spectroscopy

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ENV	Environment
EPMA	Electron Probe Micro Analyzer
ET	Eddy Current Testing
EXT	Extrados
FCAW	Flux Cored Arc Welding
FCC	Ferrite Content Check
FCGR	Fatigue Crack Growth Rate
FL	Fusion Line
FPB	Four Point Bend
FROT	Full Ring Ovalisation Test
FT	Fracture Toughness test
GMAW	Gas Metal Arc Welding
GS-FCAW	Gas Shielded Flux Cored Arc Welding
GTAW	Gas Tungsten Arc Welding
HAZ	Heat Affected Zone
HDPE	High Density PolyEthylene
HHI	High Heat Input
HI	Heat Input
HV	Hardness Vickers
ID	Internal Diameter
IQI	Image Quality Indicators
INS	Installation
INT	Intrados
LCF	Low cycle fatigue
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
MT	Magnetic particle Testing
MUT	Manual Ultrasonic Testing
NA	Not Applicable

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NDT	Non Destructive Testing
OD	Outside Diameter
OPE	Operation
PA	Phased Array
PGMAW	Pulsed Gas Metal Arc Welding
POD	Probability Of Detection
PPS	Project Particular Specification
PRL	Primary Reference Level
PT	Penetrant testing
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
RT	Radiography Testing
RT°	Room Temperature
SAW	Submerged Arc Welding
SCF	Stress Concentration Factor
SEM	Scanning Electron Microscope
SMAW	Shielded Metal Arc Welding
SMTS	Specified Minimum Tensile Strength
SMYS	Specified Minimum Yield Strength
SS	Stainless Steel
SSC	Sulfide Stress Corrosion Crack
ST	Segment Test
STT	Surface Tension Transfer
TAWT	Transverse All Weld Tensile
TFM FMC	Total Focusing Method Full Matrix Capture
TTR	Through Thickness Repair
TTRR	Through Thickness Re-Repair
VT	Visual Testing
WCL	Weld Center Line

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WT	Wall Thickness
WM	Weld Metal
WPQ	Welding Procedure Qualification
WPQR	Welding Procedure Qualification Record
WPQT	Welding Procedure Qualification Test
WPS	Welding Procedure Specification

4. Company approval/Quality Control/Quality Assurance

4.1 Company approval

All contractors, sub-contractors and 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 for approval. Non approved contractors or suppliers shall not be considered on Company projects.

Company can suspend an approval due to a negative feedback concerning 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 equipment: 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 equipment he can use 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,

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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 the additional section 5.

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.

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. Documentation

5.1 Pipe and weld log

Contractor shall maintain a welding log (within a pipe tracking system) and shall update it as the work progresses.

This document shall include, but is not restricted to, the following information:

- Number, origin, steel grade, nominal diameter and nominal thickness of each pipe, flange or fitting in its order of installation
- Actual length of each pipe laid/welded and cumulative length
- Date and time each weld or repair was made
- Number of each weld and welder/operator(s) used
- Location of each weld with respect to the pipeline kilometeric point or with respect to one end of the pipeline, as appropriate or agreed with Company
- Location of obstacles, accessories, anodes, potential test points, etc., and their location with respect to neighbouring welds
- Information pertaining to weld inspections carried out (results, defects found, repairs, etc.)
- Cut off lengths.

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This document shall be available to the Inspector at all times for information and review.

5.2 Final dossier

Upon completion of the fabrication and/or installation work, Contractor shall provide Company with a final dossier including at least the following documents:

- The laying/welding log merged with the pipe or material history system
- The Welding Procedure Specifications (WPS) for main welds and repair welds
- The Welding Procedure Qualification Test Records (WPQR) for main welds and repair welds and the mechanical test summary matrix (format and quantity of information to be agreed with Company representative)
- The H₂S embrittlement test procedure and test reports
- The welder and welding operator qualification certificates
- The NDT procedures and qualification test reports
- The NDT operator qualification certificates
- The technical data sheets of welding consumables (coated electrodes, wire, fluxes), the Mill certificates and Contractor tests per batch, the consumables procedure for handling, drying and traceability
- The non-destructive inspection reports
- The pickling and passivation reports (if applicable)
- The Quality Control Plan
- The present specification and related PPS.

The PPS shall state the number of originals and copies of the final dossier which is to be supplied to the Company.

The final dossier shall be completed and submitted to Company within one month after completion of site welding.

5.3 Dossier for bid submission

Upon submission of his proposal, Contractor shall provide Company with the following minimum information and documentation:

1. The specification data of the equipment to be used in the production welding line (offshore, onshore):
 - Layout and make-up of the production welding line: welding stations, repair welding station, NDT station, etc., together with location of tensioners
 - Maximum and minimum pipe lengths which are acceptable for welding with the welding installation
 - Technical data of welding equipment for main line, double joints, etc.

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- Technical characteristics of preheating and post-weld heat treatment equipment (where applicable)
 - Alignment clamp type and technical data
 - Bevelling machine for main line, double joints, etc.
2. Same data as above (where applicable) for pre-installation work (e.g. double jointing, expansion loop prefabrication, etc.).
 3. The proposed WPSs for welds and repair welds with execution sequence of the various passes in relation to the welding stations used or types of weld.
 4. The welder qualification scheme.
 5. The location where WPS and welders will be qualified.
 6. The nominated Company for performance of NDT.
 7. The preliminary NDT procedures, together with data sheets on the equipment used.
 8. The nominated laboratory for conducting the H₂S embrittlement tests, with preliminary SSC procedure or typical procedure, when SSC tests are required.
 9. Quality Assurance Certification.
 10. Contractor's past experience in welding/installing pipeline similar to that of the Project (e.g. past experiences from similar jobs performed successfully, WPS and WPQR previously used in production, etc.).
 11. Deviations to present specification, if any.

6. Non-Conformance Reports

Any work performance or test result which is found, after Contract Award, not in conformance with Company specifications or agreed procedure shall be subject to a Non-Conformance Report (NCR) to be issued by the Contractor for submission to Company. NCR report shall indicate corrective action intended by the Contractor and shall follow the requirements of the **GS EP PJC 501** and the quality management applicable PPS.

7. Amendments to **DNVGL-ST-F101** - Submarine Pipeline Systems - December 2017

The statements of this specification are modifications to **DNVGL-ST-F101** and are identified as **Add** or **Modify to Read**.

The section numbers in this specification correspond to **DNVGL-ST-F101**.

Paragraphs of **DNVGL-ST-F101** that are not revised remain applicable.

Additional sections listing Company documents/lists are highlighted in **red**.

Section 5 Design - Limit state criteria

5.4.8.3 & 5.4.8.6

Modify to read

The fatigue and fracture limit state assessment shall follow the following process:

- A fatigue S-N assessment shall be conducted in order to confirm that the design is acceptable and to define the fatigue category of the welds (as per section **5.4.8.10** amended here below).
- A full ECA (fracture mechanic assessment), including an ECA fatigue as per **Section 5** of **DNVGL-RP-F108** shall be performed for:
 - all welds classified as fatigue sensitive “FS1”
 and:
 - all welds with total nominal longitudinal strain $\varepsilon_n \geq 0.4\%$
 - all CS welds exposed to sour service
 - all CRA welds.

When the S-N design is not acceptable, an in air S-N full scale fatigue testing might be performed to justify a greater S-N curve; In these condition a full ECA is required. Similarly, the applicable *in situ* FCGR curves might be challenged with performing project specific *in situ* testing.

Add

Low Cycle Fatigue (LCF) S-N assessment

Fatigue shall be considered in the LCF regime when the cycles longitudinal strain range is defined as $\Delta\varepsilon_n \geq 0.4\%$. All fatigue cycles with a strain range beyond this level shall be accounted in the damage analysis thanks to the below methodology (reeling, lateral buckling...). The LCF S-N assessment shall be performed as per **NORSOK N-006** Commentary 8.4.5 followed by a damage analysis as per **5.4.8.10** considering the defined pseudo stress. The overall damage being defined as follow:

$$D = DLCF + DHCF$$

Where:

- D* Overall damage that shall be verified below 1
- DLCF* Accumulated damage from low cycle fatigue
- DHCF* Accumulated damage from high cycle fatigue

5.4.8.9

Add

When qualification of greater S-N curve than the one specified in **5.4.8.13** is required (in case of failing the accumulated damage criteria) a full scale fatigue test might be conducted in air as follow.

- The fatigue performance of a welding procedure detail shall be evaluated with not less than 12 tests (3 stress levels, 4 tests per weld).
- The stresses ranges levels and load ratio shall be evaluated in order to be representative of the weld life load block ranges and agreed with company representative.
- The cap and root welding details shall be evaluated independently. The assessment shall be based on the actual stress range at wall thickness skin adjacent to the detail of interest and taking into account the SCF (**5.4.8.13**) due to the misalignment.
- The intercept of log N-axis by qualified in air S-N design curve shall be determined following [BS 7608](#) in order to keep up with a confidence level of 99% and a probability of survival of 97.5% (more detail can be found in [BS 7608](#)):

$$\log a_{new} = \text{MIN}[\log N_{fi} + m \log \left(SCF_i \cdot \Delta\sigma_i \cdot \left(\frac{t}{t_{ref}} \right)^k \right)] - 2.33 \times SD \times n^{-0.5} - 2 \times SD$$

Where:

N_{fi} is the number of cycle to failure for test i

$\Delta\sigma_i$ is the local stress range for test i (considering the o'clock position and the stress at the skin)

SCF_i is the Stress Concentration Factor related to misalignment for test i at the o'clock failure position

SD is the Standard deviation equal to 0.2 or the SD of the test population if greater

n is the number of test which is equal to 12

$\log a_{new}$ is the intercept of log N-axis by the qualified design S-N qualified

m is the negative inverse slope of the S-N curve, to be considered as $m = 3$

t , t_{ref} and k are defined in [DNVGL-RP-C203](#).

The qualified in air S-N is then defined with the above intercept and a negative inverse slope m equal to 3 and appropriate KDF_{S-N} and SCF. It is the responsibility of the contractor to define the test runout targets with regards to its design.

- When the stress variates along the fatigue test, an equivalent stress range shall be considered and calculated as follow:

$$\Delta\sigma_{eq} = \left[\frac{\sum_{i=1}^k (N_i \Delta\sigma_i^m)}{\sum_{i=1}^k N_i} \right]^{\frac{1}{m}}$$

Where:

$\Delta\sigma_i$ is the average stress range in block i

N_i is the number of cycles completed in stress block i

m is the negative inverse slope of the S-N curve, here shall be defined such as $m = 3$.

5.4.8.10

Add

Fatigue sensitive welds definition

The fatigue sensitivity definition shall be based on a fatigue S-N assessment as follow.

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

Miner's rule shall be used to combine all cyclic load cases and evaluate the accumulated fatigue damage:

$$D = \sum_1^i \frac{N_i}{N_{fi}} < 1$$

Where:

D is the accumulated fatigue damage

N_i is 10 times the number of cycles (as required in [GS EP PLR 100 § 19.7](#)) which corresponds to fatigue safety factor (DFF_{S-N}) "HIGH" in [DNVGL-ST-F101](#) and [DNVGL-ST-F201](#).

N_{fi} is the number of fatigue cycles associated with a 97.7% probability of survival for $\Delta\sigma_i$.

The design shall ensure that the total accumulated fatigue damage does not exceed 1. In the present specification, the following differentiation applies:

- Fatigue sensitive welds ("FS1" designation) are those which the accumulated fatigue damage is $1 > D \geq 0.5$.
- Non fatigue sensitive welds ("FS0" designation) are those which the accumulated fatigue damage is $D < 0.5$.
- Welds not acceptable to fatigue ("FS2" designation) are those which the accumulated fatigue damage is $D \geq 1$

As a minimum 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.

5.4.8.12

Modify to read

The DFF_{S-N} shall be 10 for all the safety classes as specified in **GS EP PLR 100** § 19.7.

5.4.8.13

Modify to read

Weld S-N fatigue classes and assessment guideline

For the purpose of the fatigue S-N assessment, S-N fatigue classes shall be selected as per the table below (in reference to **DNVGL-RP-C203** table 2-5):

Weld detail	Process	Fatigue class as per DNVGL-RP-C203	Thickness exponent	KDF_{S-N}	SCF
Single side & Double side Girth Weld cap toe	"As welded"	F1	0.15	(3)	(1)
	Levelled cap ⁽⁴⁾	D	0.15	(3)	(1)
Single side Girth Weld root toe	No backing	F1	0	(3)	(1)
	With temporary backing	F3	0	(3)	(1)
	GTAW, CMT, STT	To be agreed with Company representative	0	(3)	(1)
Other Weld toe	-	To be agreed with Company representative	-	(3)	(2)

- (1) The Stress Concentration Factors (SCF) are given by **DNVGL-RP-C203** section 2.10.1. The misalignment δ can be defined by the following relation:

$$\delta = \frac{hi/lo_{root} + hi/lo_{cap}}{2}$$

With hi/lo_{cap} and hi/lo_{root} fabrication tolerances which are limited to 2 mm. When a lower tolerance is specified, a post weld ID hi/lo measurement tool shall be used. A table of acceptance for hi/lo_{root} depending on the hi/lo_{cap} measured in its vicinity (at the same o'clock position); based on a mid-thickness misalignment tolerance may be proposed.

This hi/lo tolerances shall be in line with the one considered in the ECA SCF analysis and specified for the fabrication.

- (2) SCF to be defined through Hot Spot Stress analysis as per **DNVGL-RP-C203** through a finite element analysis accounting for the worst tolerances to be allowed for fabrication.
- (3) The Knock Down Factor fatigue S-N (KDF_{S-N}) applies when the geometry assessed is exposed to a particular environment and is defined such as:

$$KDF_{S-N} = \frac{N_{f,air}}{N_{f,env}}$$

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Environment	Loading frequency	KDF	Slope(s) as per DNVGL-RP-C203
Air	-	1	Double
Seawater with cathodic protection	$f > 10^{-4}$ Hz	2.5	Double
	$f < 10^{-4}$ Hz such as Lateral Buckling	9	Single
Sweet corrosion	-	3	Single
Sour corrosion	-	$2 \times 10^{2.63 + 0.34 \log pH_2S - 0.46 pH}$ (minimum 10) or Contractor may propose a KDF based on specific data	Single

(4) Levelled cap solution is prohibited when root is exposed to sour service.

The proposed curves might be challenged at the bid stage by the Contractor via submission of relevant track records. The Company might agree on greater curves than the one proposed and may require full scale testing to be held during the project execution.

5.4.8.18

Modify to read

The recommended practice [DNVGL-RP-F108](#) shall be followed whenever ECA is required.

5.4.8.18

Modify to read

For sour service exposed welds, an ECA according to [DNVGL-RP-F108](#) is required. Whenever an ECA is required; the ECA testing shall be performed in a representative environment.

5.6.1.7

Add

A transition piece compliant with subsea pipeline specification shall be used for wall thickness transition as stipulated in [GS EP PLR 100](#). As stipulated in [GS EP SPS 001](#), the valves and connectors located into subsea pipeline structures shall be designed and manufactured according to SPS specification but still compliant with [DNVGL-ST-F101](#).

5.6.1.13

Modify to read

Where C-Mn and low alloys steels pipes or fittings of unequal wall thickness are to be welded, the end preparation shown in [ASME B31.4](#) Fig. 434.8.6 or [ASME B31.8](#) Fig. I-5 (where applicable) shall be used for FS0 welds. Any taper shall not be steeper than 1:4. If transitions to

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these requirements are not feasible, a transition piece shall be inserted. For FS1 welds, a taper shall be positioned on a transition piece respecting a distance of four times the elastic length to the adjacent girth welds. The elastic length is defined in section **5.6.1.7** and in [DNVGL-RP-C203](#) App. D.

Section 8 Construction - Components and Pipeline Assemblies

8.6 Pipeline Assemblies

8.6.7 Welding and NDT

8.6.7.4

[Modify to read](#)

Requirements to automated ultrasonic testing (AUT) are given in [GS EP PLR 430](#), [DNVGL-RP-F118](#) and the [DNVGL-ST-F101](#) - appendix E. The most stringent shall apply.

8.6.7.14

[Modify to read](#)

For welds where allowable defect sizes are based on an ECA, automated ultrasonic testing (AUT) shall be performed.

Section 10 Construction Offshore

10.5 Welding and Non-destructive Testing

10.5.1 General

[Add](#)

For clad and lined pipe applications, 100% dimensional check of bevel preparation with go no-go gage shall be performed.

10.5.2 Welding

10.5.2.3

[Modify to read](#)

In case multiple welding stations are used on the installation vessel, the root and the first filler pass shall, as a minimum, be completed at the first welding station before moving the pipe. Moving the pipe at an earlier stage may be permitted provided:

- The root pass is not performed by SMAW using cellulosic coated electrode.
- The root pass is 100% completed.

- It is demonstrated that the stress level in the weld does not exceed 20% of the parent material SMYS.
- An analysis is performed showing that this can be performed without any risk of introducing defects in the deposited weld material. This analysis shall consider the maximum misalignment allowed, the height of the deposited weld metal, the possible presence of flaws, support conditions for the pipe and any dynamic effects.
- The pipe is fully supported by rollers to ensure a smooth transfer.

In any case, the pipes on both sides of the joint shall not be raised or lowered until one third (1/3) of the weld filling is completed all around the pipe circumference.

10.5.3 Non-destructive testing

10.5.3.1

Modify to read

The table below specifies the minimum production NDT which may be selected:

	Surface Examination				Volume Examination			Other
	VT	PT	MT	ET	RT	MUT	AUT	FCC ⁽³⁾
Main requirements applicable to all welds								
Main procedures	100%	/			100% RT or AUT			/
Repairs	100%	/			100% RT or AUT and MUT			/
Additional requirements for ECA welds								
Main and Repairs	/	/			+ 100% AUT			/
Additional requirements for CRA welds								
Main procedures	+ 100% ⁽¹⁾	/			+ 100% AUT - Sectorial Scan			/
Additional requirements for FS1 ID geometry and Sour exposed ID								
Main procedures	+ 100% ⁽¹⁾	/			/			/
Additional requirements for FS1 OD geometry and Sour exposed OD								
Main	/	+ 100% ET ⁽²⁾			+ 100% AUT - Creeping Waves			/
Additional requirements for FS1 OD levelled cap								
Main	/	+ 100% ET ⁽²⁾			+ 100% AUT - Creeping Waves + MUT thickness check			/

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	<i>Surface Examination</i>	<i>Volume Examination</i>	<i>Other</i>
Additional requirements for duplex			
Main and Repairs	/	/	20%
Additional requirement for Golden welds			
Main procedures	/	+ 100% DPI, MPI or ET	+ 100% RT and AUT
Repairs	/	+ 100% DPI, MPI or ET	+ 100% RT and MUT and AUT

(1) If specified in the PPS, Internal visual inspection is required in addition to the OD inspection by means of a color camera associated to a laser profile. The laser profile shall allow to characterise the internal misalignment and ID surface flaws. Details are given in Appendix **D.2.8** amendments.

(2) If required by the PPS. Details are given in Appendix **D.2.7** amendments.

(3) FCC means Ferrite Content Check: the ferrite content shall be measured using the magnetic induction method, and the portable device for measurement (e.g. FISHER Ferritscope MP30E) shall be approved by Company. Measurements shall be taken on both, weld metal caps and HAZ. Each measurement shall be the average of three measurements and the averages values obtained shall be within the Ferrite content range of 35% to 65%. The measurement shall be performed as follows:

- 3 locations around the pipe at 120° (one at 12 O'clock position)
- For each location, 3 measurements shall be taken on HAZ area and 3 measurements shall be taken on weld metal area
- For each area (weld metal cap or HAZ weld toe) on each location, the average of 3 measurements shall be done.

10.5.3.6

Modify to read

For "Golden Welds" (critical welds e.g. tie-in welds that will not be subject to pressure testing, etc.) 100% ultrasonic testing (AUT shall be performed whenever possible), 100% radiographic testing, and 100% magnetic particle testing or 100% liquid penetrant testing of non-ferromagnetic materials shall be performed.

The number of golden welds shall be minimized.



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Appendix A

Appendix A Fracture limit state of girth welds

Refer to amendments to [DNVGL-RP-F108](#) in section 9.

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Appendix B Mechanical Testing and Corrosion Testing

B.2 Mechanical Testing and Chemical Analysis

B.2.2 Chemical analysis

Chemical analysis of weld overlay

B.2.2.2

Add

Spark Optical Emission Spectroscopy (OES) or Induced coupled plasma emission spectroscopy (ICP-OES or ICP-AES) method shall be used associated with thermal desorption or fusion method for light elements such as C, N, S, O, B, H. The selected method shall insure the proper tolerance level with regards to the elements composition range.

B.2.2.2

Modify to read

The chemical composition of the weld overlay shall be obtained at 1.5 mm minimum distance from the CS/CRA interface.

B.2.11 Strain and ageing

B.2.11.2

Add

- Welds with total nominal longitudinal strain $\geq 0.4\%$.

B.2.11.4

Modify to read

For reeling installation simulation; bend formers shall have the correct radius and the back tension applied shall correspond to the max load defined through the spooling analysis. Pipe thinning and ovality shall be measured. The welds shall be distant by a minimum of 1.5 time the OD. The ovality shall be measured at the weld location and at center of the pipe section and thinning at center of pipe section. Any pipe kink or local buckling shall be considered as a failure and the way forward agreed conjointly with the Company.

B.2.11.8 & B.2.11.9

Add

The characteristic strain shall for cut material (segments or strip specimens) be defined as the mean value of the strains measured on the outside and inside of the pipe side with the lowest strain. In case there is too much discrepancies in the reading and if the subsequent test is affected by local strain concentration (fracture toughness specimens with notches meant to be embedded in the wall thickness), it is acceptable to pre-machine the strained strip.

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B.3 Corrosion testing

B.3.4 Pitting corrosion test

B.3.2.2

Modify to read

The pitting and intergranular corrosion tests shall be performed for the materials listed hereafter, even if they are used as a CRA layer (clad/lined):

- On **Nickel based alloys UNS N06625** materials, corrosion testing according to [ASTM G28](#) method A (Streicher test) shall be performed in boiling solution.
- Test duration shall be 120 hours.
- The maximum allowable corrosion rate shall be 1.0 mm/y. No localized corrosion in HAZ and weld metal, no intergranular attack shall be evidenced and the corrosion shall be uniform.
- On **Nickel based alloys UNS N06625** materials, corrosion testing according to [ASTM G48](#) method A shall be performed.
- Test temperature shall be 50°C ± 1°C.
- Test duration shall be 24 hours.
- The maximum allowable weight loss is 4.0 g/m².
- There shall be no evidence of pitting, under visual examination with a magnification of x20
- On **Nickel based alloys UNS N08825** materials, corrosion testing according to [ASTM A262](#) method C (Huey test) shall be performed.
 - Test duration shall consist of a minimum of 3 periods of 48h each. (Refer to [ASTM A262](#) method C, section 20.4 and Note 16.)
 - The maximum allowable corrosion rate shall be 0.8 mm/year.
- On **Nickel based alloys UNS N08825** materials, corrosion testing according to [ASTM G48](#) method A shall be performed.
- Test temperature shall be 22°C ± 1°C.
- Test duration shall be 24 hours.
- The maximum allowable weight loss is 4.0 g/m².
- There shall be no evidence of pitting, under visual examination with a magnification of x20.

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- On **Duplex stainless steel (LC65-22Cr and LC65-25Cr)** materials, corrosion testing according to [ASTM G48](#) method A shall be performed. Test temperature and test duration shall be as listed below:

Duplex stainless steel - Pitting corrosion test conditions		
Alloy	Temperature	Exposure time
Duplex- LC65-22Cr	22°C ± 1°C	24 Hours
SuperDuplex - LC65-25Cr	40°C ± 1°C	24 Hours

- The maximum allowable weight loss is 1.0 g/m²/day.
- The specimen shall reveal no indication through a PT inspection and shall not have evidence of pitting under visual examination with a magnification of x20.
- For **Austenitic stainless steels** (UNS S31603 and UNS N031703) [ASTM A262](#) Practice A and E shall be performed.
- The sensitization heat treatment is not required.
- There shall be no cracking and no indication of intergranular attack.

B.3.2.4
Modify to read

The test specimen shall be machined perpendicular to the weld axis, with dimensions of full wall thickness by 25 mm along the weld and 50 mm across the weld. The test shall expose the external and internal surface and a cross-section surface including the weld zone in full wall thickness. For welds, at least 15 mm of the base material on each side of the weld shall be included in the test specimen.

B.3.2.5
Add

For [ASTM G28](#) testing it is acceptable that the specimen is thinner than 1 mm, the specimen can be machined using an EDM.

B.3.2.6
Add

The root and the cap side of the welds are only to be prepared with the intention of removing loose material that will interfere with weighing prior to and after testing. Cut faces shall be ground (600 grid) and sharp edges smoothed off. All the surfaces shall be degreased in acetone bath, cleaned by ultrasound and rinsed in ethanol, air dried and weighed using a precision of 0.001 g or better.

Specific requirements for [ASTM G48](#) method A:

- The surface of the specimen shall not be chemically passivated subsequent to grinding the surface.

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- The specimen should be cleaned with magnesium oxide paste or equivalent, rinsed well with water, dipped in alcohol or acetone, and air dried. The specimen shall be weighed to the nearest 0.001 g or better. It should be stored in a desiccator until ready for testing.

B.3.2.7

Add

Specific requirements for [ASTM G48](#) method A:

- Perform the test using ferric-chloride solution with a volume at least the larger of 150 mL or 20 mL/cm² (125 mL/in.2) of the specimen surface area. Fill the test container with the required volume, transfer to the constant temperature bath, and allow to come to equilibrium at the desired test temperature.
- The pH of the test solution shall be adjusted to approximately 1.3 prior to beginning the test by the addition of HCl or NaOH, as required.

B.3.4 Sulfide stress cracking test

Add

The below amendments apply to the testing of circular welds and repair welds of pipelines by means of sulfide stress cracking tests using the Four Point Bending (FPB) test method as per [NACE TM 0316](#). Full Ring Ovalisation Test (FROT) as per [BS 8701](#) might be considered ([C.7.5.8](#)), and the test conditions specified in the PPS.

The Supplier shall prepare a fully detailed test procedure proposal based upon this specification and submit it to the Company for prior approval.

B.3.4.5

Modify to read

Each specimen shall be prismatic with the following dimensions: 115 to 140 mm long x 15 mm wide x 5 mm thick. All specimen surfaces shall be prepared to a consistent repeatable finish with $R_a \leq 0.2 \mu\text{m}$. The test specimen shall be made carefully at an appropriate machining rate to avoid overheating and undesirable cold work of the surface. Test identification shall be marked on each specimen by an approved method.

B.3.4.6

Modify to read

For the FPB, the test arrangement and loading of specimens shall be as per [NACE TM 0316](#).

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Test environment:

The test environment shall be selected according to the below table:

SSC Tests Conditions								
PIPELINE ⁽¹⁾ SOUR SERVICE	AREA ⁽¹⁾	PIPELINE EFFLUENT	TEST SOLUTION	p[H ₂ S] (bara)	p[CO ₂] (bara)	pH	TEMPERATURE (°C)	STRESS LEVEL (%AYS)
Mild	0 & 1	All	NA	NA	NA	NA	NA	NA
Intermediate & Severe	2 & 3 ⁽²⁾	All	NACE TM 0177 Solution A	1	NA	2.7 to 4	24±3	80
Specific	2 & 3	All	EFC Publication No. 16	(3)	(3)	(3)	(3)	(4)

(1) Refer to definitions in specification [GS EP COR 170](#).

(2) Limited to p[H₂S] below 1 bara, pH above 4 and stress based design.

(3) Based on the most severe conditions which shall be specified in the PPS and approved by Company.

(4) To be agreed with Company, but not beyond 90%AYS.

- Solution [NACE TM 0177](#)

The temperature of the solution shall be recorded from start to test completion on a daily basis.

The pH of the solution shall be recorded at the start and at the end of the test. The pH values shall be within the limits of [NACE TM 0177](#) (i.e. initial pH = 2.7 ± 0.1 and pH max = 4.0 at the end of test). Concentration of H₂S shall be controlled at start and end of test (to be greater than 2700 ppm).

Tests shall have a minimum duration of 30 days (720 hours under full H₂S saturation).

- Specific application based on [EFC Publication No. 16](#) solution

Application-specific testing shall be carried out following the principles of [ISO 15156-2](#) Option 2 in an environment according to [EFC Publication No. 16](#) procedure.

H₂S and CO₂ gas purity shall be 99.5% minimum. Gases or gases mix certificates shall be provided detailing the gases purities and mix ratios. The gases balance shall be within a tolerance of H₂S+4%/-0%. The temperature of the solution shall be recorded on a daily basis from the start to the end of the test within a tolerance of ± 3°C. The volume of test solution to the total exposed surface area of test specimens shall be 30 ± 10 ml/cm² minimum. Tests durations shall be of 30 days (720 hours under full H₂S saturation) minimum.

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- Atmospheric pressure tests

The initial pH shall be adjusted to the specified pH via addition of HCl or NaOH. Throughout the test, pH shall be measured, recorded and periodically adjusted to the specified pH with an allowance of ± 0.1 by addition of HCl or NaOH. The Supplier shall ensure that both the deaeration and H₂S saturation is obtained as described in § 7.1.4/7.1.5 of [NACE TM 0316](#). The solution shall be saturated by using H₂S + CO₂ gas mixtures to obtain the desired H₂S partial pressure and shall be maintained at the required level during the test by continuous bubbling. Hydrogen sulfide concentration in the solution shall be measured by the iodine titration method. The H₂S concentration of the solution shall be recorded after initial H₂S saturation at the start of the test and at the end of the test. The value shall be equal or greater than the estimated H₂S concentration corresponding to the applied H₂S partial pressure.

- Tests under pressure

The supplier shall present a procedure demonstrating that target pH and H₂S and CO₂ partial pressures are at targeted values in the pressurized autoclave throughout the test duration. The methodology shall be presented to Company and approved prior the commencement of the test. The pH shall be adjusted to the specified value through addition of proper acid/alkali/buffer solution before the test. The Supplier shall ensure that an oxygen concentration below 10 ppb of oxygen is obtained as described in § 7.1.4/7.1.5 of [NACE TM 0316](#). When the test is performed in a sealed autoclave gas cap shall not be less than 30% of the volume. When bubbling the gas during the test, the pressure inlet of the mixture and exhaust shall be monitored as required and pressure/ flowrate recorded on a daily basis. If there is any pressure drop, the pressure shall be adjusted (tolerance: ± 0.1 bar).

Specimen examination

Following failure or at the end of the test (whichever happens first), visual examination and photographs shall be taken at x1 and x10 magnifications of the stressed surfaces of each specimen further to cleaning, dye penetrant and MPI examination. Whenever a crack is found, the specimen shall be cross sectioned, polished and etched at the crack location. Photographs shall be made at a suitable magnification before and after etching. Any cracks in weld shall be categorized by location namely: Base Metal, HAZ and Weld Metal. The metallurgical features shall be documented with photomicrographs.

Test acceptance criteria

Test specimens shall be evaluated for any evidence of hydrogen cracking including surface breaking and sub-surface cracks. All cracks shall be considered regardless of whether it is interpreted as sulfide stress cracking (SSC), stress-oriented hydrogen induced cracking (SOHIC), soft zone cracking (SZC) or hydrogen induced cracking (HIC). No crack (or rupture) shall be accepted in any of the tested specimens (in HAZ, weld or base metal) within the 30 days period for any of the tests carried out. Samples not broken containing welding defects clearly identified that may have generated cracks with length not exceeding 0.2 mm in the through thickness direction are acceptable. Small grooves or pits caused by corrosion shall not be considered, in mutual agreement between Supplier and Company.

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Reporting

At the end of the test, the Supplier shall provide a test report giving the following information:

- Measurement of the actual applied stress (strain gauges, etc.).
- Individual result for each specimen tested per set, with photographs and photomicrographs (when applicable).
- Type of solution used for the tests. pH of solution at start and end of test and during the test for [EFC Publication No. 16](#) solutions at 1 bara. H₂S concentration at start and end of test.
- Results of Software simulation for tests under pressure if any.
- The test temperature recording.
- Location and dimensions of specimens.
- Mill certificates of materials tested showing full chemical analysis and mechanical properties.
- Testing procedure specification.

Conclusions and pertinent explanations (where needed) or concluding information. Any failure shall be analyzed by the Supplier and the cause of failure made clear to the Company before any re-test or remedial actions.

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Appendix C

Appendix C Welding

C.1 General

C.1.2 Application

C.1.2.2

Modify to read

The base materials covered by this appendix are:

- C-Mn and low alloy steels
- Corrosion resistant alloys (CRA) including ferritic austenitic (duplex) steel, austenitic stainless steels, other stainless steels and nickel based alloys
- Clad and lined steels.

The base material requirements of pipes and fittings supplied by Company are defined in Company General Specifications listed in section Reference documents of this specification.

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Appendix C
C.1.2.3

Modify to read

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 (only in double side welding configuration for SS).	m-SAW	m-SAW
	m-GMAW with or without copper or ceramic shoes (for OD > 4.5" only).	m-GMAW	m-GMAW
	m-PGMAW without copper or ceramic 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 is not permitted for SS welding).	SMAW - basic coated rods.	SMAW - basic coated rods.
	GTAW is mandatory for pipe diameter less than 2" 3/8 (60 mm).	GTAW is mandatory for pipe diameter less than 2" 3/8 (60 mm).	GTAW is mandatory for pipe diameter less than 2" 3/8 (60 mm).
		GS-FCAW (subject to Company approval) ⁽¹⁾	GS-FCAW (subject to Company approval) ⁽¹⁾
	<u>Particular requirement for sour service:</u> Welding on copper or ceramic shoes is not allowed.		
FATIGUE SENSITIVE LINE (FS1)	m-SAW (double side welding).	m-SAW	m-SAW
	m-GMAW without copper or ceramic shoes (copper or ceramic shoes might be acceptable provided fatigue performance is checked by full scale testing).	m-GMAW	m-GMAW
	m-PGMAW without copper or ceramic shoes.	m-PGMAW	m-PGMAW
	GTAW is mandatory for pipe diameter less than 2" 3/8 (60 mm).	GTAW is mandatory for pipe diameter less than 2" 3/8 (60 mm).	GTAW is mandatory for pipe diameter less than 2" 3/8 (60 mm).
	<u>Particular requirement for sour service:</u> Welding on copper or ceramic shoes is not allowed.		

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Welding processes approved for use - Tie-in procedures (and stalks welding)			
	Root	Fill	Cap
NON FATIGUE SENSITIVE LINE	m-GMAW	m-GMAW	m-GMAW
	m-PGMAW	m-PGMAW	m-PGMAW
	GTAW	GS-FCAW (subject to Company approval) ⁽¹⁾	GS-FCAW (subject to Company approval) ⁽¹⁾
	SMAW - basic coated rods (cellulosic coated rods are not permitted for tie-in and repairs; SMAW is not permitted for SS welding). 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

(1) 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 impact test results shall exceed the requirement of this specification by more than 50J). The Company reserves the right to reject such a process when its reliability is not satisfactory.

Only basic coated low hydrogen electrodes shall be used for all fillet welds.

Welding processes for anode connecting welds or any other welds to electrically connect attachments shall have prior approval of Company.

When special internal cleanliness is required by the PPS, the root side shall be continuously purged with appropriate inert gas. This is also a requirement for C-Mn steels.

C.1.3 Definitions

Add

The following definitions shall be considered in this specification:

Inspector 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".

PPS This designates the Project Particular Specification as defined before in this present specification.