

GENERAL SPECIFICATION

SUBSEA SYSTEMS

GS EP SPS 029

Metallic Materials for Subsea Production Facilities
--

06	10/2017	Update with new DNVGL-RP-B202
05	11/2015	Update with new DNVGL-RP-0034 and GS EP SPS 036
04	09/2014	General revision
03	09/2013	General revision
00	01/2011	First issue
Rev.	Date	Purpose of the revision

Owning entity: DSO/IP/TEC	Managing entity: DSO/IP/TEC/SBS
Other Approving entity(ies):	

General Specification		GS EP SPS 029
Metallic Materials for Subsea Production Facilities		
Rev.: 06	Effective date: 10/2017	Page: 2 of 37

Contents

1. Scope	4
2. Reference documents	4
3. Abbreviations	7
4. Internal corrosion control.....	9
4.1 Material selection	9
4.2 Specific requirements for CRA components	9
4.3 Specific requirements for CS components	10
4.4 Chemical lines/service lines/hydraulic lines	10
5. External corrosion control	10
5.1 Corrosion control of materials without CP	10
5.2 Corrosion control in marine atmosphere	11
5.3 Subsea corrosion control	11
6. Hydrogen embrittlement.....	12
6.1 General requirements under CP	12
6.2 Duplex stainless steels under CP	14
6.3 Dissimilar welded connections under CP	14
6.4 Bolting under CP	16
6.5 Other applications	17
7. Material selection for specific equipment	17
7.1 General requirements	17
8. QA/QC	21
8.1 General requirements	21
8.2 Contractor approved Vendor list and follow up of supply chain	21
8.3 Certification	21
8.4 Positive Material Identification	21
9. Manufacturing of components	21
9.1 General requirements	21
9.2 Material requirements	22

General Specification		GS EP SPS 029
Metallic Materials for Subsea Production Facilities		
Rev.: 06	Effective date: 10/2017	Page: 3 of 37

9.3	Heat treatments	26
9.4	Test requirements	28
10.	Induction and cold bending	30
10.1	Induction bending.....	30
10.2	Cold bending.....	31
11.	Weld overlay	32
12.	Welding of large bore piping	32
12.1	Duplex stainless steels.....	32
12.2	Buttered F22/CRA closure welds	33
12.3	Buttered F22/C-Mn closure welds	33
12.4	F60 or F65 /CRA closure welds	34
13.	Welding of small bore piping	34
13.1	Welding procedure qualification and production welds	34
13.2	Essential variables	35
13.3	Non destructive examination	35
Appendix 1	Typical materials for subsea applications	37

General Specification		GS EP SPS 029
Metallic Materials for Subsea Production Facilities		
Rev.: 06	Effective date: 10/2017	Page: 4 of 37

1. Scope

This specification describes Company requirements for the selection and fabrication of metallic materials used for subsea equipments. Particular attention is also drawn on specific material aspects to consider during projects and life of field to ensure safety, environment and production availability.

Equipments concerned by this General Specification are listed below:

- Christmas trees
- Jumpers
- Connectors including hubs and pup pieces
- Valves including pup pieces
- Wellheads
- Manifolds
- Umbilicals, Flying leads and Termination Heads
- Other equipment (pressure vessels, etc.).

2. Reference documents

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

External Documents

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

Reference	Title
API SPEC 20E	Alloy and Carbon Steel Bolting for Use in the Petroleum and Natural Gas Industries
API SPEC 5L	Specification for Line Pipe
ISO 3183	Petroleum and natural gas industries - Steel pipe for pipeline transportation systems
API SPEC 6A	Specification for Wellhead and Christmas Tree Equipment
ISO 10423	Petroleum and natural gas industries - Drilling and production equipment - Wellhead and christmas tree equipment
API STD 6ACRA	Age-hardened Nickel-based Alloys for Oil and Gas Drilling and Production Equipment
ASME B31.3	Process piping
ASME B31.8	Gas transmission and distribution piping systems

Metallic Materials for Subsea Production Facilities

Rev.: 06

Effective date: 10/2017

Page: 5 of 37

Reference	Title
ASME BPVC Section IX	Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators
ASTM A182	Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A193	Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194	Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A262	Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
ASTM A320	Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service
ASTM A388	Standard Practice for Ultrasonic Examination of Steel Forgings
ASTM A434	Standard Specification for Steel Bars, Alloy, Hot-Wrought or Cold-Finished, Quenched and Tempered
ASTM A453	Standard Specification for High-Temperature Bolting, with Expansion Coefficients Comparable to Austenitic Stainless Steels
ASTM A694	Standard Specification for Carbon and Alloy Steel Forgings for Pipe Flanges, Fittings, Valves, and Parts for High-Pressure Transmission Service
ASTM A707	Standard Specification for Forged Carbon and Low Alloy Steel Flanges for Low Temperature Service
ASTM A923	Standard Test Methods for Detecting Detrimental Intermetallic Phase in Duplex Austenitic/Ferritic Stainless Steels
ASTM A960	Standard Specification for Common Requirements for Wrought Steel Piping Fittings
ASTM A991	Standard Test Method for Conducting Temperature Uniformity Surveys of Furnaces used to Heat Treat Steel Products
ASTM E562	Standard Test Method for Determining Volume Fraction by Systematic Manual Point Count
ASTM G28	Standard Test Methods for Detecting Susceptibility to Intergranular Corrosion in Wrought, Nickel-Rich, Chromium-Bearing Alloys

General Specification		GS EP SPS 029
Metallic Materials for Subsea Production Facilities		
Rev.: 06	Effective date: 10/2017	Page: 6 of 37

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
DNV-RP-F112	Design of Duplex Stainless Steel Subsea Equipment Exposed to Cathodic Protection
DNVGL-RP-0034	Steel forgings for subsea applications
DNVGL-RP-B202	Steel forgings for subsea applications - Quality management requirements
ISO 10474	Metallic products - Inspection documents
ISO 11699-1	Non-destructive testing - Industrial radiographic film - Part 1: Classification of film systems for industrial radiography
ISO 15156 (Parts 2; 3)	Petroleum and natural gas industries - Materials for use in H ₂ S-containing environments in oil and gas production - Parts 2; 3
ISO 15590-1	Petroleum and natural gas industries - Induction bends, fittings and flanges for pipeline transportation systems - Part 1: Induction bends
ISO 18265	Metallic materials - Conversion of hardness values
ISO 898-1	Mechanical properties of fasteners made of carbon steel and alloy steel - Part 1: Bolts, screws and studs with specified property classes - Coarse thread and fine pitch thread
NORSOK M-650	Qualification of Manufacturers of Special Materials

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and addendums, is the latest revision published.

Reference	Title
GS EP COR 001	Corrosion control on production facilities: Design and construction
GS EP COR 161	Internal corrosion and erosion-corrosion monitoring: Design and installation
GS EP COR 170	Materials for upstream sour service application - Specification for selection and design
GS EP COR 220	Three layer polyethylene external coating for pipelines
GS EP COR 221	Three layer polypropylene external coating for pipelines
GS EP COR 233	Riser Coatings

Reference	Title
GS EP COR 350	External protection of offshore and coastal structures and equipment by painting
GS EP COR 356	Corrosion Protection of Fasteners
GS EP COR 420	External field joint coatings of pipelines
GS EP PJC 501	Requirements for Contractor Quality Management
GS EP PJC 502	Requirements for Contractor criticality rating of a Unit
GS EP PJC 503	Requirements for Contractor Quality Surveillance
GS EP PLR 160	Design, fabrication and testing of Subsea Umbilicals
GS EP PLR 226	Fabrication of hot bends for pipelines
GS EP PLR 241	Fabrication of Super-Duplex Stainless Steel Small Bore Seamless Tube for Umbilical
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 PVV 618	Fabrication of alloy UNS 06625 grade 1 materials
GS EP SPS 004	Subsea Valves
GS EP SPS 006	Service valves in subsea stations
GS EP SPS 009	Corrosion protection of subsea stations
GS EP SPS 016	Subsea Choke Valves
GS EP SPS 035	Material specification for Duplex 22Cr and Superduplex 25Cr stainless steels subsea equipments
GS EP SPS 036	Welding of pressure and non pressure containing equipment for subsea applications
GS EP SPS 037	Welding of Duplex 22Cr and Super Duplex 25Cr Stainless Steels for subsea equipment
GS EP SPS 038	Subsea Structures design & fabrication

3. Abbreviations

F22	ASTM A182 F22
F60	ASTM A694 F60
F65	ASTM A694 F65
8630	AISI 8630
4130	AISI 4130
316L	AISI 316L

General Specification		GS EP SPS 029
Metallic Materials for Subsea Production Facilities		
Rev.: 06	Effective date: 10/2017	Page: 8 of 37

22Cr, 25Cr and other listed material abbreviations: see Table A.1 in Appendix 1

AYS	Actual yield strength
BM	Base metal
C-Mn steel	Carbon-Manganese steel
CP	Cathodic protection
CRA	Corrosion resistant alloy according to ISO 15156-3 Standard definition (includes all materials other than C-Mn and LAS)
DP	Dye penetrant
Duplex	Austenitic-ferritic stainless steel grades including 22%Cr and 25%Cr
EC	Eddy current
GTAW	Gas Tungsten Arc welding
HAZ	Heat affected zone
HB	Brinell hardness
HIC	Hydrogen induced cracking
HIP	Hot isostatic pressing
HRC	Rockwell hardness C
HT	Heat treatment
HV	Hardness Vickers
LAS	Low alloy steel
NDE	Non destructive examination
NDT	Non destructive testing
MPS	Manufacturing process specification
MPQP	Manufacturing process quality plan
OEM	Other Engineering Manufacturers
OD	Outer diameter
PMI	Positive material identification
PWHT	Post weld heat treatment
QT	Quenched and tempered
SSC	Sulfide stress cracking
SMSS	Supermartensitic stainless steel
SMYS	Specified minimum yield strength
SOHIC	Stress Oriented Hydrogen Induced Cracking

General Specification		GS EP SPS 029
Metallic Materials for Subsea Production Facilities		
Rev.: 06	Effective date: 10/2017	Page: 9 of 37

SS	Stainless steel
UT	Ultrasonic testing
WM	Weld metal

4. Internal corrosion control

4.1 Material selection

Subsea installations require a high degree of integrity and reliability. Hence special precautions are required for the corrosion control of these facilities.

The following **general base case rules** shall be obeyed:

1. Corrosion resistant alloys (plain or clad/weld overlaid CS) shall be used for all components in contact with production fluids.
2. C-Mn and LAS shall be used for components in contact with injected treated water and injected gas.
3. Sour service materials shall be used for all facilities in contact with injected gas and production fluids regardless of H₂S level.
4. Sour service materials are not required for water injection facilities unless their function may be changed to production during their service life.

In exceptional cases where CS is used for production wetted components it shall be documented with a formal corrosion assessment that the fluid corrosiveness, possibly combined with mitigation methods is low enough to assure the corrosion resistance of these components over the whole field life. This corrosion assessment shall be carried out as per **GS EP COR 001** requirements and shall cover all listed internal corrosion modes (including erosion corrosion and erosion) relevant to these components.

4.2 Specific requirements for CRA components

For nickel alloys (clad/weld overlay or solid) and other CRAs such as austenitic or duplex SS localized corrosion and cracking risks shall be assessed. Material selection and corrosion mitigation (if any) shall be implemented accordingly.

Specific environmental conditions (including in situ pH, chloride content, maximum operating pressure and temperature) defined in **ISO 15156-3** shall be determined. All intended and unintended exposure conditions shall be considered for this assessment.

Based on these environmental conditions, the stress corrosion cracking (SCC) and sulfide stress cracking (SSC) of CRA materials shall be avoided by using materials as per limits given in **ISO 15156-3** and **GS EP COR 170**.

In particular 17-4PH and alloy 500 nickel-copper alloy in direct contact or in contact in case of failure of the primary containment with production fluids shall not be selected for sour service.

For clad/weld overlay the C-Mn steel or LAS base metal shall be sour service. If this requirement cannot be fulfilled; Company acceptance shall be based on demonstration by Contractor that 100% coverage of the base metal by clad/overlay is achieved by NDT. In

General Specification		GS EP SPS 029
Metallic Materials for Subsea Production Facilities		
Rev.: 06	Effective date: 10/2017	Page: 10 of 37

addition it shall be demonstrated that the integrity of the clad/weld overlay cannot be affected by other damage mechanisms over the field life.

Martensitic Stainless steels (13% Cr, F6NM, 17-4-PH...) shall not be used on sea water injection facilities.

Although CS is the base material for deaerated and treated sea water, nickel alloys or other appropriately selected CRAs (titanium, cobalt alloys...) shall be used on SPS equipment when aerated sea water is considered for injection.

Erosion by solid particles shall be assessed in case of sand production and sand management shall be implemented. **GS EP COR 161** shall be used for sand monitoring.

4.3 Specific requirements for CS components

Considering the high degree of reliability required for subsea installations, Company requires that all CS components in contact with production or injected gas be manufactured for severe sour service (Region 3) unless otherwise specified.

Prevention of cracking by H₂S shall follow **ISO 15156-2** and **GS EP COR 170**. Additional restrictions shall apply on specific materials when necessary. The cracking of C-Mn and LAS by SSC, HIC and SOHIC shall be prevented using **ISO 15156-2** and **GS EP COR 170**.

4.4 Chemical lines/service lines/hydraulic lines

Even though no chemical injection is needed for SPS equipment built in CRA, the SPS equipment shall include all injection systems needed to protect CS lines downstream SPS, either against corrosion or for any other function. The compatibility of materials in contact with chemicals injected for mitigation of corrosion, scale, hydrate or any other purpose shall be assessed as regards corrosion and other chemical damages on organic and elastomeric components.

Materials shall be also compatible with other fluids (hydraulic etc.) including accidental seawater ingress.

In case of doubts or lack of experience material selection shall be checked by specific corrosion tests. These tests shall be defined in agreement with Company.

5. External corrosion control

The requirements of **GS EP SPS 009** shall be followed concerning painting, coating and cathodic protection (CP). All the GS EP COR relevant to coatings (**GS EP COR 220**, **GS EP COR 221**, **GS EP COR 233** and **GS EP COR 420**) and painting (**GS EP COR 350**) shall be used.

5.1 Corrosion control of materials without CP

The corrosion protection of materials for subsea facilities shall be ensured for the following conditions:

1. During transportation at sea
2. During storage in marine atmosphere

General Specification		GS EP SPS 029
Metallic Materials for Subsea Production Facilities		
Rev.: 06	Effective date: 10/2017	Page: 11 of 37

3. When laid on the sea bottom before hook-up and production start-up
4. During production if not connected or when shielded from CP.

5.2 Corrosion control in marine atmosphere

When exposed to marine atmosphere C-Mn and LAS shall be protected by coatings or by a temporary protection. Both internal and external surfaces shall be protected.

Acceptable solutions are:

- Oil or grease for temporary protection
- Hot dip galvanizing
- Organic coatings provided they do not isolate steels from the CP system when immersed
- Plugs + dessicators for hollow components.

Martensitic SS (13%Cr type) and more corrosion resistant SS grades (316L, duplex 22Cr, 25Cr) shall be protected from the marine environment to prevent pitting, crevice corrosion and stress corrosion cracking.

In all cases SS components shall be free of ferritic contamination resulting from cutting, machining and welding of C-Mn and LAS during fabrication and installation. Pickling and/or mechanical brushing shall be used to remove contamination from base materials and welds. A passivation treatment shall be applied after decontamination.

5.3 Subsea corrosion control

C-Mn and LAS shall always be used with a combination of coating and CP. **GS EP SPS 009** gives the requirements for coatings and CP. Coating specifications are given in **GS EP COR 350**.

For CRAs:

- All SS shall be protected by CP
- When CP cannot be used or is not expected to be efficient, Table 1 gives the maximum allowable temperature for the more highly alloyed materials.
- When CP is not used or is not efficient, any CRA shall be resistant to crevice corrosion. Thus Alloy 718, **ASTM A434** Gr 660, or any CRA material susceptible to crevice corrosion at the operating temperature shall not be used.

This Table addresses natural seawater conditions in the absence of biocide. It is applicable for **moderate crevice severity (tightness)**. **If threaded connections or severe (very tight) crevices are present in the system the maximum temperatures given in Table 1 shall be decreased by at least 10°C.**

General Specification		GS EP SPS 029
Metallic Materials for Subsea Production Facilities		
Rev.: 06	Effective date: 10/2017	Page: 12 of 37

Table 1 - Maximum acceptable temperature in (non treated) natural seawater

Alloy	Max temperature BM (°C)	Max temperature WM (°C)
Ti-Pd	> 100	-
Ti alloys	≥ 60	-
Ni-Cr-Mo (C-2000, 59, 686)	60	-
Ni-Cr-Mo (C-276, C-22)	50	-
Alloy 625	40	-
25Cr duplex	30	20
22Cr duplex	20	10

6. Hydrogen embrittlement

6.1 General requirements under CP

For CRA and high strength steel materials, the risk of hydrogen stress cracking (HSC) is of main concern when cathodic protection is applied.

The bare material shall be chosen to withstand a negative potential limit of -1.05 V Ag/AgCl.

For submerged parts that may be exposed to cathodic protection, materials which are coated shall be considered as exposed to cathodic protection unless it is demonstrated that the coating will remain tight for the specified design life.

HSC susceptible materials are listed in Table 2. The mandatory requirements to mitigate HSC are indicated in this table.