

## GENERAL SPECIFICATION

### CORROSION

#### GS EP COR 005

**Material selection for oil and gas production systems**

| 04   | 12/2017 | Update material selection for HE                               |
|------|---------|----------------------------------------------------------------|
| 03   | 11/2016 | Clarification on CuNi max. velocity, use of 23.04, air coolers |
| 02   | 09/2015 | Full re-write and inclusion of GS EP COR 104                   |
| 01   | 11/2014 | Updated in accordance with GS EP SAF 228                       |
| 00   | 09/2013 | First issue                                                    |
| Rev. | Date    | Purpose of the revision                                        |

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## 1. Scope

This Specification defines Company general requirements when performing selection of materials for pipelines, piping and equipment related to transport and processing of hydrocarbon production, including utility and injection systems for the entire design life of the installation. It includes all equipment from and including the well head, to and including pipelines for stabilized products. It supplements or modifies [ISO 21457](#) International Standard.

In this specification, material selection is first summarized in tables indicating, for different pieces of equipment and service conditions:

- The “base case” material selection, combined with eventual additional mitigation solutions and specific conditions determining the applicability of this solution
- Solutions to be used as alternates, if any of the decisive conditions indicated are fulfilled.

## 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                                                                                                                                                   |
|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| <a href="#">ISO 10423</a>     | Petroleum and natural gas industries - Drilling and production equipment - Wellhead and christmas tree equipment                                        |
| <a href="#">API SPEC 6A</a>   | Specification for Wellhead and Christmas Tree Equipment                                                                                                 |
| <a href="#">API STD 6ACRA</a> | Age-Hardened Nickel-Based Alloys for Oil and Gas Drilling and Production Equipment (Edition 2006)                                                       |
| <a href="#">ASTM A193</a>     | Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications |
| <a href="#">ASTM A453</a>     | Standard Specification for High-Temperature Bolting, with Expansion Coefficients Comparable to Austenitic Stainless Steels                              |
| <a href="#">ASTM B466</a>     | Standard Specification for Seamless Copper-Nickel Pipe and Tube                                                                                         |
| <a href="#">ASTM B467</a>     | Standard Specification for Welded Copper-Nickel Pipe                                                                                                    |
| <a href="#">DNV-RP-F112</a>   | Design of duplex stainless steel subsea equipment exposed to cathodic protection                                                                        |

| Reference                 | Title                                                                                                                                          |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| ISO 15156 (Parts 1; 2; 3) | Petroleum and natural gas industries - Materials for use in H <sub>2</sub> S containing environments in oil and gas production - Parts 1; 2; 3 |
| ISO 21457                 | Petroleum, petrochemical and natural gas industries - Materials selection and corrosion control for oil and gas production systems             |

### 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 004 | Limiting flow velocities calculations for erosion corrosion purpose                                                                                               |
| GS EP COR 100 | Cathodic protection of offshore structures                                                                                                                        |
| GS EP COR 170 | Materials for upstream sour service application - Specification for selection and design                                                                          |
| GS EP COR 350 | External protection of offshore and coastal structures and equipment by painting                                                                                  |
| GS EP COR 354 | External protection of onshore structures and equipment by painting                                                                                               |
| GS EP COR 356 | Corrosion Protection of Fasteners                                                                                                                                 |
| GS EP ELE 311 | Cable Trays/Ladders                                                                                                                                               |
| GS EP HVA 010 | Selection of Stainless Steel Grade for HVAC Equipment                                                                                                             |
| GS EP HVA 202 | Air Handling Unit(s) (AHU)                                                                                                                                        |
| GS EP HVA 400 | Ducts for HVAC systems                                                                                                                                            |
| GS EP INS 101 | Instrumentation Design                                                                                                                                            |
| GS EP INS 114 | Instrument Tubing and Fittings                                                                                                                                    |
| GS EP INS 120 | Control and Choke Valves                                                                                                                                          |
| GS EP INS 125 | Safety Relief Valves and Rupture Discs                                                                                                                            |
| GS EP INS 137 | On/Off Valve Control Panels and Actuators                                                                                                                         |
| GS EP PLR 160 | Design, fabrication and testing of Subsea Umbilicals                                                                                                              |
| 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 241 | Fabrication of Super-Duplex Stainless Steel Small Bore Seamless Tube for Umbilical                                                                                |

| Reference     | Title                                                                                  |
|---------------|----------------------------------------------------------------------------------------|
| GS EP PLR 245 | Fabrication of Super Duplex stainless steel Small bore seam welded tubes for umbilical |
| GS EP PVV 112 | Piping material classes                                                                |
| GS EP PVV 211 | Design and fabrication of pressure vessels according to ASME VIII                      |
| GS EP PVV 212 | Design and fabrication of pressure vessels according to BSI PD 5500                    |
| GS EP SPS 029 | Metallic Materials for Subsea Production Facilities                                    |

### 3. Abbreviations

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

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>13Cr</b>              | Martensitic Stainless Steel containing 13% Chromium minimum                                                                                                                                                                                                                                                                                                                                                          |
| <b>23.04</b>             | Lean duplex UNS S32304 or equivalent                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>22Cr</b>              | UNS S32205 or UNS S31803                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>25Cr</b>              | UNS S32750 or UNS S32760                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>310</b>               | UNS S31000                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>316</b>               | UNS S31600                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>316L</b>              | UNS S31603 (low carbon for welding)                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>6Mo</b>               | UNS S31254 or UNS N08926 or UNS N08367 (PREN ≥ 40)                                                                                                                                                                                                                                                                                                                                                                   |
| <b>904L</b>              | UNS N08904                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>A286</b>              | UNS S66286 ( <a href="#">ASTM A453</a> Gr 660 for bolting)                                                                                                                                                                                                                                                                                                                                                           |
| <b>CA</b>                | Corrosion allowance                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>C-Mn steel</b>        | Carbon-Manganese steel                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Clad carbon steel</b> | Clad carbon steel or weld overlay                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>CRA</b>               | Corrosion Resistant Alloy according to <a href="#">ISO 15156-3</a> Standard definition (includes all materials other than C-Mn and LAS)                                                                                                                                                                                                                                                                              |
| <b>CuNi 90/10</b>        | Copper Nickel (UNS C70600) as per <a href="#">ASTM B466</a> or <a href="#">ASTM B467</a>                                                                                                                                                                                                                                                                                                                             |
| <b>CuNi 70/30</b>        | Copper Nickel (UNS C71500) as per <a href="#">ASTM B466</a> or <a href="#">ASTM B467</a>                                                                                                                                                                                                                                                                                                                             |
| <b>CL</b>                | Corrosion likelihood (of an equipment): The likelihood that this equipment may lose its physical integrity, hence resulting in leakage or spillage, due to all possible corrosion damages after a certain period of time, considering the preventive actions possibly implemented and the corrosion status of the equipment at the date of evaluation. It is currently expressed in years of remaining service life. |

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| <b>Corrosiveness</b>       | Capacity of a fluid or an environment to induce weight loss corrosion to a material under the operating conditions considered and assuming that no preventive action is undertaken. It is expressed as a corrosion rate, in mm/yr or mpy. |
| <b>CS</b>                  | Carbon steel                                                                                                                                                                                                                              |
| <b>Duplex</b>              | Austenitic-ferritic stainless steel grades including 22Cr and 25Cr (UNS numbers are listed above)                                                                                                                                         |
| <b>GRP</b>                 | Glass-fibre Reinforced Plastic                                                                                                                                                                                                            |
| <b>HDG</b>                 | Hot dip galvanized                                                                                                                                                                                                                        |
| <b>HDPE</b>                | High Density Polyethylene                                                                                                                                                                                                                 |
| <b>HVAC</b>                | Heating Ventilation Air Conditioning                                                                                                                                                                                                      |
| <b>High grade Ni-Cr-Mo</b> | UNS N10276, N06022, N06200, N06059, N06686                                                                                                                                                                                                |
| <b>Hyperduplex</b>         | UNS S32707 (tubular heat exchangers)                                                                                                                                                                                                      |
| <b>LAS</b>                 | Low Alloy Steel                                                                                                                                                                                                                           |
| <b>LTCS</b>                | Low Temperature Carbon Steel                                                                                                                                                                                                              |
| <b>MOP</b>                 | Maximum operating Pressure                                                                                                                                                                                                                |
| <b>NAB</b>                 | Nickel-Aluminum-Bronze UNS C95800                                                                                                                                                                                                         |
| <b>PVDF</b>                | Polyvinylidene Fluoride                                                                                                                                                                                                                   |
| <b>PW</b>                  | Produced Water                                                                                                                                                                                                                            |
| <b>SCC</b>                 | Stress Corrosion Cracking                                                                                                                                                                                                                 |
| <b>SS</b>                  | Stainless Steel                                                                                                                                                                                                                           |
| <b>SW</b>                  | Sea Water                                                                                                                                                                                                                                 |
| <b>T<sub>s</sub></b>       | Metal skin temperature                                                                                                                                                                                                                    |
| <b>UNS</b>                 | Unified Numbering System (for Alloys)                                                                                                                                                                                                     |

## 4. Corrosion evaluation

Material selection is based on the corrosion and erosion assessment specified in **GS EP COR 001**, considering that carbon steel is used. All internal and external media shall be considered for the field design life. The assessment includes transportation, storage, installation, testing and preservation and any other transient situation to be faced by the equipment (pre-commissioning, start-up, shut-down, blow down, etc.).

The material selection from this GS is to be reported in the successive documents specified in **GS EP COR 001**.

In this document carbon steel means either low alloy steel, C-Mn steel sour or non sour service or low temperature carbon steel (LTCS).

Sour service requirements shall be established for all equipment according to **GS EP COR 170**.

For gas process material selection takes into account the lowest temperature due to gas blow down in case of rapid depressurization. Table 1 is given for reference. However, actual allowable minimum temperatures for the various materials is based on the relevant construction codes and Piping Valves Vessels General Specifications requirements.

**Table 1 - Allowable minimum temperatures for typical gas process materials**

| Material          | Temperature (°C) | Comments                                    |
|-------------------|------------------|---------------------------------------------|
| CS and LAS        | -29              |                                             |
| LTCS (Ni steel)   | -46 (-60)        | Temperature depends on steel nickel content |
| Duplex SS         | -46              |                                             |
| 9%Ni              | -196             |                                             |
| AISI 304/321/316/ | -196             |                                             |
| Ni alloys         | -273             |                                             |
| Al alloys         | -273             |                                             |

Material selection for piping, valves and fittings is based on the “Material selection & corrosion control solutions” report and the present general specification. “Piping material classes” is then to be selected from **GS EP PVV 112** for construction.

## 5. Production and process systems

The following material selection supersedes and is a complement to **ISO 21457** standard Section 7.2.

Material requirements defined in the **GS EP SPS 029** apply for subsea production equipment.

Main material selection bases for oil and gas production and processing systems are defined as per Table 2 here below, in combination with complementary requirements in following tables and paragraphs. Any equipment not listed in this table is to be selected consistently with the neighbouring equipment of this table.

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**Table 2**

| Equipment                  | Environment                   | Base case solution                                                   | Additional requirements                                                                          | Alternate solutions                           | Decisive reasons                                                                                                                              |
|----------------------------|-------------------------------|----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|-----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| <b>WH- Xtree</b>           |                               | Material classes per<br>ISO 10423 / API SPEC 6A and<br>API STD 6ACRA | Requirements of<br>Appendix 1                                                                    |                                               |                                                                                                                                               |
| <b>Piping &amp; valves</b> | Multiphase gas                | CRA, per limits of use of Appendix 2                                 | Flow velocities for erosion                                                                      | CS                                            | Condition 1                                                                                                                                   |
|                            | Multiphase oil,<br>Wet oil    | CS                                                                   | <ul style="list-style-type: none"> <li>Condition 2</li> <li>Flow velocity limitations</li> </ul> | CRA                                           | Condition 1 cannot be guaranteed                                                                                                              |
|                            | Gas process                   | CRA, per limits of use of Appendix 2                                 |                                                                                                  | CS                                            | <ul style="list-style-type: none"> <li>Dry gas</li> <li>Low water condensation rate and no risk of accumulation</li> <li>NCL ≤ Low</li> </ul> |
|                            | Produced water                | CS                                                                   | <ul style="list-style-type: none"> <li>Condition 2</li> <li>Flow velocity limitations</li> </ul> | GRP (MOP < 16 bars)<br>or CRA                 | Condition 1 cannot be guaranteed                                                                                                              |
| <b>Vessels</b>             | Wet oil and<br>Produced water | CS                                                                   | Internal coating + anodes                                                                        | CRA                                           | Dia < 1.5 m/s<br>P > 30 bars And NCL > Low                                                                                                    |
|                            | Wet gas                       | CRA, per limits of use of Appendix 2                                 |                                                                                                  | 1- CS + internal coating<br>2- CS, no coating | 1- NCL ≤ Medium and P < 30 bars and Dia > 1.5 m<br>2- NCL = Very Low                                                                          |
| <b>Plate HE</b>            | All                           | CRA, per Table 3                                                     |                                                                                                  |                                               |                                                                                                                                               |
| <b>Tubular HE</b>          | All                           | per § 5.2.2, Table 4                                                 |                                                                                                  |                                               |                                                                                                                                               |
| <b>Air coolers</b>         | All                           | per § 5.2.3, Table 5                                                 |                                                                                                  |                                               |                                                                                                                                               |

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| Equipment      | Environment | Base case solution     | Additional requirements                        | Alternate solutions                          | Decisive reasons                              |
|----------------|-------------|------------------------|------------------------------------------------|----------------------------------------------|-----------------------------------------------|
| Flare networks |             | CS, LTCS               | Auto draining profile & compatible with min. T | SS series AISI 300                           | Possible water accumulation or LT requirement |
| Flare tip      |             | AISI 310 or alloy 800H |                                                | Alloy 625 or other HT sulfur resistant alloy | Very severe corrosiveness                     |

**Condition 1:** Predicted Corrosion Likelihood evaluated as Low or Very Low, either because of a sufficient confidence given in prevention solutions over the estimated service life, or because of a low enough Natural Corrosion Likelihood.

**Condition 2:** Efficient chemical treatment, able to minimize the CL of all possible corrosion mechanisms to a Low or Very Low level.