

GENERAL SPECIFICATION

CORROSION

GS EP COR 170

**Materials for upstream sour service application
Specification for selection and design**

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1. Scope

This General Specification (GS) specifies Company general requirements for the selection and qualification of materials used in the construction of equipment handling wet hydrogen sulfide (H₂S) containing fluids in upstream hydrocarbon production and transportation. It only deals with corrosion cracking mechanisms in the presence of H₂S covered by [ISO 15156](#). The purpose of this GS is to clarify, supplement and amend certain requirements and/or measures specified in the Standard. This GS excludes measures necessary to control other types of corrosion threats associated with such applications. It also contains:

- Additional requirements and amendments where necessary
- Associated types of cracking caused by H₂S specifically in amine units that are not covered in [ISO 15156](#)
- Qualification of materials for exposure to wet H₂S containing fluids
- References to other documents including [EFC Publication 16](#) and [EFC Publication 17](#), [NACE TM 0177](#) and [NACE TM 0284](#) where required.

1.1 Scope background

Exposure to wet H₂S containing media or sour service has wide ranging implications on the integrity of materials, hence requiring clear and comprehensive measures to mitigate its threat. The provision of safety, security, reliability and the safeguarding of economic operations are contingent on the effective implementation of such measures.

These measures and requirements are based on Company experience acquired during involvement in design, construction, operation, risk assessment and maintenance of upstream units and facilities. In this context, selection and optimisation of appropriate materials which can tolerate sour production scenarios are the underpinning issue.

This GS is dedicated to projects and defines the requirements for equipment in oil and gas fields, transmission lines and oil and gas treatment plants. It is applicable whenever the purpose design conditions are such that sour service, as defined within this GS, may be encountered.

1.2 Application

The requirements of this GS and [ISO 15156](#) shall apply to materials intended for exposure to wet H₂S containing fluids. All upstream components which are in “direct” or “indirect” contact with measurable level of H₂S shall meet the requirements of [ISO 15156](#) and this GS. These include:

- Direct contact: all fluid wetted parts which are continually or intermittently in direct contact with wet H₂S containing fluids
- Indirect contact: all attachments which are not freely vented to the atmosphere (insulated, buried, shielded equipment, etc.) and are liable to be exposed to H₂S in case of containment loss. This shall include all components that act as secondary containment, external insulation for topside pipework, subsea lines and other related facilities.

This GS may refer to certain local, national or international regulations but the responsibility to ensure compliance with legislation and any other statutory requirements lies with Company.

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Company shall adapt or supplement this GS in addition to those of [ISO 15156](#) to ensure compliance with the specific application.

When Contractors or Manufacturers/Suppliers use this GS, they shall be solely responsible for such use, including the quality of their work and the adherence to the required design and engineering standards. In this respect, detailed operational parameters shall be sought from the Company to assist them in the final decision. The proposed list of materials and manufacturing procedures shall be submitted to Company for approval by the Corrosion Specialist or Technical Adviser.

The requisites set out in this GS are essential components of Company requirements to provide safety and integrity. These shall be followed in conjunction with competent technical judgement.

1.3 Principal features of this GS

The requirements in this GS are intended for use in the technical/commercial assessment of projects and in prospect evaluation. It can also be utilised for the refurbishment of facilities not normally designed for sour service.

Management and necessary measures in addressing other types of corrosion threats are dealt with in other Company Corrosion specifications and in particular in [GS EP COR 001](#) and [GS EP COR 002](#).

1.4 Feedback and further information

Users are encouraged to provide feedback, comments and experiences in the application of this GS, to assist in the process of its continual improvement.

2. Coverage

The items and equipments specified by this GS are those covered by [ISO 15156](#) and are divided into three sub-sections:

Section 8 gives amendments and supplements to clauses of [ISO 15156-1](#).

Section 9 gives amendments and supplements to clauses of [ISO 15156-2](#).

Section 10 gives amendments and supplements to clauses of [ISO 15156-3](#).

For ease of reference, where required, the clause numbering of the ISO Standard has been referenced throughout this GS.

In addition, requirements/measures in relation to various items of equipment are dealt with in sections 11 to 13 of this GS. Particular reference is made to production facilities and other equipment for which specific Company GS exists. The requirements of such GSs apply in all respects, except as modified or supplemented by this GS for sour service.

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3. Company approval

Where indicated in this GS, Company approval requires the following documentations:

- Data demonstrating that the option offered provides adequate sour service resistance, in the form of appropriate test data and/or documented service experience in line with the requirements of [ISO 15156](#) and this GS as outlined in section 7.5.
- Relevant demonstrations that the manufacture, fabrication, installation and use of components are according to Company requirements.

4. Clarifications and notes

A number of clarifications shall be noted when using this GS including:

- Note 1: [ISO 15156](#) is also called [NACE MR 0175 / ISO 15156](#). As a consequence, in all related Company GS, [ISO 15156](#) document automatically applies when reference is made to [NACE MR 0175 / ISO 15156](#) or [NACE MR 0175](#).
- Note 2: In this GS reference to H₂S containing fluids, sour service, sour media are considered equal and refer to conditions prevailing when handling wet hydrogen sulfide containing fluids in upstream operations.
- Note 3: Wherever reference is made to [ISO 15156](#), it shall be understood to mean the ISO Standard as amended/supplemented by this GS.
- Note 4: Wherever reference is made to [ISO 15156](#), it shall be understood to mean its most current edition unless otherwise specified.
- Note 5: Technical Corrigenda published between two publications of [ISO 15156](#) shall be taken as part of the Standard.
- Note 6: References have been made to the 3 parts of [ISO 15156](#). In this GS, these are simplified in terms of [ISO 15156-1](#), [ISO 15156-2](#) and [ISO 15156-3](#) respectively.
- Note 7: This GS is not intended for downstream hydrocarbon operations.
- Note 8: This GS is not intended for fluids that never contain any water, namely dry fluids containing H₂S.
- Note 9: Where a reference to API and ISO standard covering a common theme is made, these shall be considered concurrently unless versions diverge in which case the latest edition of each shall apply.
- Note 10: Some sections of [ISO 15156](#) are recalled in this GS to provide clarity of purpose. When used, respective section is denoted as a 'clause'.

5. 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 6A	Specification for Wellhead and Christmas Tree Equipment
API SPEC 5CRA	Specification for Corrosion Resistant Alloy Seamless Tubes for Use as Casing, Tubing and Coupling Stock
API SPEC 5CT	Specification for Casing and Tubing
API SPEC 5L	Specification for Line Pipe
API STD 619	Rotary-Type Positive-Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries
ASTM A439	Standard Specification for Austenitic Ductile Iron Castings
ASTM A516	Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
EFC Publication 16	European Federation of Corrosion Publication No. 16; Guidelines on Material Requirements for Carbon and Low Alloy Steels for H ₂ S - Containing Oil and Gas Field Service
EFC Publication 17	Corrosion Resistant Alloys for Oil and Gas Production: Guideline on General Requirements and Test Methods for H ₂ S Service
ISO 10423	Petroleum and natural gas industries — Drilling and production equipment — Wellhead and Christmas tree equipment
ISO 10440-1	Rotary-type positive-displacement compressors - Part 1 : process compressors
ISO 11960	Steel pipes for use as casing or tubing for wells
ISO 13680	Petroleum and natural gas industries — Corrosion-resistant alloy seamless tubes for use as casing, tubing and coupling stock — Technical delivery conditions
NACE MR 0175	Petroleum and natural gas industries - Materials for use in H ₂ S-containing environments in oil and gas production
ISO 15156 (Parts 1; 2; 3)	Petroleum and natural gas industries — Materials for use in H ₂ S-containing environments in oil and gas production — (Parts 1; 2; 3)
ISO 3183	Steel pipe for pipeline transportation systems
NACE TM 0177	Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H ₂ S Environments
NACE TM 0284	Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking

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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 002	Corrosion control on production facilities: Field operations
GS EP FP 330	Manufacturing and Qualification Specification for new seamless OCTG carbon & low allow material
GS EP INS 114	Instrument Tubing and Fittings
GS EP INS 120	Control and Choke Valves
GS EP INS 137	On/Off Valve Control Panels and Actuators
GS EP INS 900	Instrument Hook-up diagrams
GS EP MEC 251	Supply of Axial and Centrifugal Compressors and Expander-compressors according to API Standard 617
GS EP MEC 261	Packaged Reciprocating Compressors for Oil and Gas Production Services According to ISO 13631
GS EP MEC 271	Centrifugal Pumps for the Petroleum, Chemical and Gas Industry Services According to API Standard 610
GS EP MEC 273	Supply of Centrifugal Pump class II according to ISO 5199
GS EP PLR 109	Design, fabrication and testing of submarine unbounded flexible pipes and risers
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 226	Fabrication of hot bends for pipelines
GS EP PLR 227	Carbon Steel Flanges, Branch Outlet Fittings and Forged Components for Pipelines
GS EP PLR 228	Carbon steel tees for pipelines
GS EP PLR 241	Fabrication of Super-Duplex Stainless Steel Small Bore Seamless Tube for Umbilical
GS EP PLR 242	Fabrication of duplex & super duplex stainless steel In seamless Pipe for Pipeline
GS EP PLR 243	Fabrication of Duplex & Super-Duplex Stainless Steel Seam Welded Pipe for Pipeline

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Reference	Title
GS EP PLR 244	Fabrication of Duplex & Super-Duplex Stainless Steel Seamless Hot Bend for Pipeline
GS EP PLR 425	Site welding of carbon steel pipelines (sweet and sour service, onshore and offshore) according to API STD 1104
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 612	Piping and equipment subject to severe sour service. Metallurgical and welding requirements
GS EP PVV 613	Valves materials requirements for use in sour service
GS EP PVV 622	Piping and equipment subject to mild and intermediate sour service. Metallurgical and welding requirements
GS EP SPS 029	Metallic materials for subsea production facilities

6. Abbreviations and definitions

6.1 Abbreviations

API	American Petroleum Institute
ASTM	American Society for Testing and Materials
BS	British Standard
CE	Carbon Equivalent
CLAS	Carbon and low alloy steel
CRA	Corrosion resistant alloy
DIN	Deutsche Institute für Normung
DSS	Duplex stainless steel
EFC	European Federation of Corrosion
FMT	fluorescent magnetic particle testing
GHSC	Galvanically induced hydrogen stress cracking
GS	General Specification
HIC	Hydrogen Induced Cracking
HRC	Rockwell Hardness Scale C
HV	Vickers Hardness
HQ	Head quarters

ISO	International Organization for Standardization
NDE	Non destructive evaluation
NACE	National Association of Corrosion Engineers
PREN	Pitting resistance equivalent number
F_{PREN}	$wt\% Cr + 3.3(wt\% Mo + 0.5wt\% W) + 16wt\% N$
PV	Pressure vessel
PWHT	Post Weld Heat Treatment
QA	Quality Assurance
QC	Quality Control
SOHIC	Stress Orientated Hydrogen Induced Cracking
SS	Stainless steel
SSC	Sulfide Stress Cracking
SCC	Stress Corrosion Cracking
SWC	Step Wise Cracking
Wt	Weight

6.2 General definitions

Contractor	The party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility.
Manufacturer/Supplier	The party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.
Specialist	Company representative in charge of the specific technical subject
Limits of application	Environmental and operating conditions within which different materials are permitted to use.
Company requirements	Company requirements in this GS are as follows: • SHALL is used to indicate that a provision is MANDATORY • SHOULD, if referred to, is used to indicate that a provision is not mandatory but RECOMMENDED as good practice • MAY, if referred to, is used to indicate a provision is OPTIONAL.

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7. Evaluation process and definition of sour service conditions for materials selection

7.1 Corrosion cracking threats in sour media

This GS covers the necessary metallurgical requirements on all aspects of corrosion cracking for materials in relation to exposure to wet H₂S containing fluids in upstream operations, covered in [ISO 15156](#) including:

- Sulfide stress cracking (SSC) occurring primarily at ambient temperature conditions
- Stress corrosion cracking (SCC) in the presence of H₂S occurring primarily at elevated temperature conditions
- SSC/SCC occurring at mid-range temperature conditions
- Hydrogen blistering occurring primarily at ambient temperature conditions
- Stepwise cracking/hydrogen induced cracking (SWC/HIC) occurring primarily at ambient temperature conditions
- Stress-oriented hydrogen induced cracking (SOHIC) occurring primarily at ambient temperature conditions
- Soft zone cracking (SZC) occurring primarily at ambient temperature conditions
- Galvanically induced hydrogen stress cracking (GHSC) occurring primarily at ambient temperature conditions.

7.2 The approach to materials selection

The approach to materials selection and testing has been standardised and is described in the applicable sections of this GS.

Selection of materials for application in wet H₂S containing environments shall adhere to the requirements of this section and all relevant sections of this GS. In particular, the selection of materials for a particular sour duty shall take into account:

- Requirements arising from this GS
- Resistance to general or other types of corrosion
- Mechanical properties, including low temperature toughness requirements where necessary
- Fabrication constraints including welding, forming etc.
- Availability and economy where appropriate.

Company Corrosion Specialist shall be consulted where appropriate and will have full discussion with Production Chemist, Process Engineer, Wells/Production Engineer and/or Pipeline Engineer to achieve consensus that all corrosion threats are addressed and materials are selected or qualified in compliance with this GS.

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7.3 Definition of sour service

In accordance with the definition of [ISO 15156](#) and this GS, the presence of any measurable (or used for design) levels of H₂S can result in a sour service environment.

The severity of sour service to cause SSC enhances with decreasing pH, increasing H₂S partial pressure and other operating parameters as described in section 7.4 requiring increasingly stringent metallurgical requirements or more corrosion resistant options.

Operational conditions to determine sour service severity shall be provided or verified by the Company Corrosion Specialist.

The materials selection, testing and post weld heat treatment (PWHT) requirements shall be based upon an assessment of the severity of the environment and susceptibility of materials to each potential damage mechanism anticipated or experienced, as defined in this GS. These shall be followed in conjunction with competent technical judgements.

7.4 Principle parameters affecting the performance and choice of materials for sour service applications

Principle parameters affecting the performance and choice of carbon and low alloy steels (CLAS) and corrosion resistant alloys (CRAs) are denoted in [ISO 15156-2](#) (Clause 6) and [ISO 15165-3](#) (Clause 5), respectively taking into consideration elements outlined in section 7.6.

7.5 Materials for sour service

Materials for sour service application shall be considered qualified by fulfilling one of the following four options meeting [ISO 15156-1](#) (Clause 8) and additional requirements described in this GS:

- Option i: The material is listed, fulfils the metallurgical requirements and it is used within the limits stated in [ISO 15156](#) and this GS.
- Option ii: The material is passed the appropriate sour service qualification tests under a simulated environment representing the worst case field conditions.
- Option iii: The material has been used under the same expected conditions for which positive experience had been acquired for a minimum of 2 years and is fully documented.
- Option iv: Data and limits of application of individual material provided by the Company

7.6 Implementation procedures

The procedure, roadmap and necessary steps in applying this GS is shown in Figure 1 including:

- i. Operating conditions shall be defined as follows:
 - Maximum value of H₂S using maximum operating pressure (or bubble point pressure where applicable)
 - Acidity (in-situ pH) using appropriate methods
 - Minimum and maximum operating temperatures