

GENERAL SPECIFICATION

CORROSION

GS EP COR 001

Corrosion control on production facilities: Design and construction

Rev.	Date	Purpose of the revision
06	11/2017	General revision
05	09/2015	General revision
04	05/2015	Organisation change - January 2015
03	01/2012	General review; New chapter 8: Interventions of TEC/COR in projects. "Corrosion management documents" have been specified in more detail
00	10/2005	First issue

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

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1. Scope & Application

1.1 Scope

This specification defines the "corrosion management" bases to be used for the design and construction of any production facility, with a particular emphasis on:

- Functional requirements applicable to the performance of both an internal and an external "corrosion assessment"
- Functional requirements for defining appropriate corrosion mitigation solutions, as a result of this corrosion assessment.

1.2 Application

For internal corrosion, this specification applies to all components of a production installation which are in contact with process fluids (produced and injected fluids). Unless otherwise specified, internal corrosion of service and utility fluids is not relevant to this specification.

For external corrosion, this specification applies to onshore as well as offshore environments and to aerial, immersed and buried conditions.

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
DNVGL-RP-O501	Managing sand production and erosion
ISO 12944-2	Paints and Varnishes. Corrosion protection of steel structures by protective paint systems - Part 2: Classification of environments
ISO 9223	Corrosion of metals and alloys - Corrosivity of atmospheres - Classification, determination and estimation

Total General Specifications

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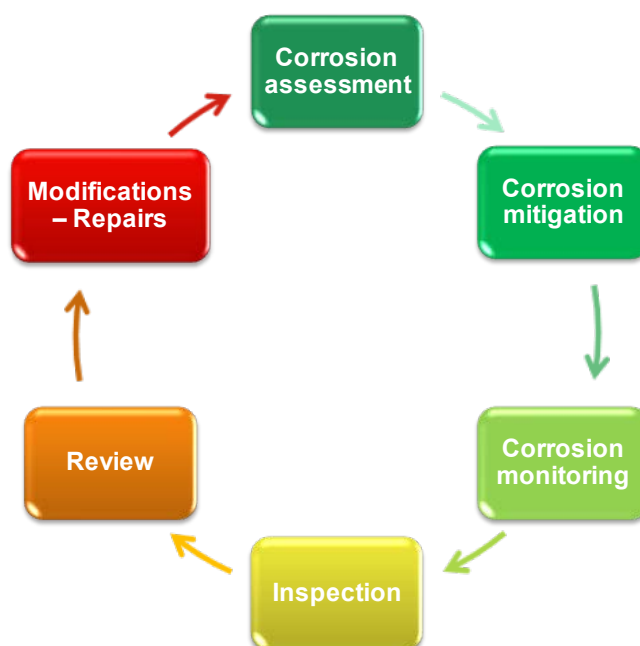
Reference	Title
GS EP COR 002	Corrosion control on production facilities: Field operations
GS EP COR 004	Limiting flow velocities calculations for erosion corrosion purpose
GS EP COR 005	Material selection for oil and gas production systems

Reference	Title
GS EP COR 110	External cathodic protection of onshore structures
GS EP COR 161	Internal corrosion and erosion-corrosion monitoring: Design and installation
GS EP COR 163	Chemical treatments for corrosion control: Engineering and construction requirements
GS EP COR 170	Materials for upstream sour service application - Specification for selection and design

3. Definitions - Abbreviations

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

- "Corrosion management": The overall Corrosion Management process for any production facility is summarized in the following loop, which is applicable both during the Design and Construction and during the Field Operation:



The present document mostly covers the three first steps of this loop, i.e. the corrosion assessment, the corrosion mitigation, and the definition of corrosion monitoring.

- "Corrosion assessment": An explicit and quantified evaluation of:
 - The Corrosiveness of the fluids / environments (internal and external) to which a material / an equipment is exposed
 - The Corrosion Likelihood of the equipment / facilities of the concerned facilities.

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- Depending on the stage of the development process, the corrosion assessment has different objectives and different deliverables, as detailed in paragraph 6. During design, an evaluation of the likelihood and the extent of corrosion damages if the installation is designed with the most standard material (usually carbon steel) and not subject to any mitigation action against corrosion.
- "Corrosion Loop": A defined section of a process / utility network with similar corrosion mechanisms and comparable operating conditions and materials. A corrosion loop can be composed of separated sections. Its limits are precisely defined.
- "Corrosion mitigation": The complete set of methods to be implemented for preventing corrosion and for verifying the efficiency of these methods.
- "Corrosion monitoring": The complete set of methods to be used in order to verify the proper implementation and efficiency of selected mitigation solutions if any, or to verify the lack of corrosiveness when no mitigation solution is used.
- Corrosiveness (of a fluid / an environment): Capacity of a fluid / an environment to induce a certain weight loss corrosion to the material to which it is exposed due to all possible corrosion mechanisms, assuming that no preventive action is applied. It is expressed as an average corrosion rate, in mm/yr or mpy (= *"How quick will it corrode, without any prevention?"*).
- NCL = Natural Corrosion Likelihood (of an equipment): The likelihood, expressed in years of service life, that the evaluated equipment may lose its physical integrity, hence resulting in leakage or spillage, due to all possible corrosion mechanism(s), considering its original thickness and also considering that no preventive action is implemented (= *"How long would it last, if nothing was done to prevent corrosion?"*).
- EFF = Efficiency of / Confidence in the applied mitigation solutions (to an equipment). This factor defines the level of confidence, from poor to very high, given to any corrosion prevention solution applied during field operations (= *How many years of service life are gained with the applied prevention solutions?"*).
- CL = Actual Corrosion likelihood (of an equipment): The likelihood that this equipment may lose its physical integrity, hence resulting in leakage or spillage, due to the combination of its Natural Corrosion Likelihood (NCL) and to the eventual positive effect of the Efficiency (EFF) of the applied preventive actions, also considering the corrosion status of the equipment at the date of evaluation. *For new facilities, this Status is considered as new, i.e.; with no pre-existing corrosion damage.* CL is currently expressed in years of remaining service life (= *"How long will it last from now?"*).
- "Inhibitor availability": The proportion of time during which the inhibitor is injected to protect the equipment considered at an injection flow rate $\geq 80\%$ of the specified injection rate. Depending on the number and on the reliability of injection systems used, inhibitor availability values of 95 to 98% are currently specified.
- BLC = Bottom-Line Corrosion: It does not characterize a specific corrosion mechanism, but a location where corrosion proceeds because produced water is present, i.e. mostly on the bottom part of production facilities (as opposed to the Top of Line Corrosion). Includes either CO₂ corrosion, H₂S + CO₂ corrosion, corrosion under deposits, preferential weld corrosion, all induced by produced water.

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- TLC = Top of Line Corrosion: Corrosion due to water condensing on the upper section of gas - condensate facilities (as opposed to BLC), this water being acidified by a combination of CO₂, H₂S, and organic acids supplied by the gas and the produced water.
- CO₂ corrosion: Corrosion occurring either as BLC or TLC, due to water containing dissolved CO₂ and other species promoting corrosion such as organic acids. Usually a localized weight loss corrosion mode with typical corrosion rates within 0.01 to 10 mm/y. Only occurs when the H₂S content is low to nil (H₂S / CO₂ < 0.05). Within this document, CO₂ corrosion includes "corrosion under deposits" and "preferential weld corrosion".
- H₂S + CO₂ corrosion: Localized weight loss corrosion occurring either as BLC or TLC, due to water containing dissolved CO₂ + H₂S and species promoting corrosion such as organic acids. Only considered when the H₂S / CO₂ ratio is ≥ 0.05. Includes "corrosion under deposits" and "preferential weld corrosion".
- MIC = Microbiologically Induced Corrosion
- CRA = Corrosion Resistant Alloy
- CS = Carbon Steel
- SHWHP = Shut-in Well Head Pressure
- IJ = Insulation Joint
- ITP = Inspection and Test Plan
- MSD = Materials Selection Diagram
- PPS = Project Particular Specification
- PQT = Procedure Qualification Trial
- PPM = Pre Production Meeting
- PPT = Pre Production Test
- SOR = State of Requirement

4. The "Corrosion Management" during design and construction phases

As part of the corrosion management process during the design and construction phases a plan of solutions, actions and deliverables shall be defined, aiming at preventing corrosion failures susceptible to compromise the major functionality's of production facilities with regards to safety, environment, and production capabilities during their expected lifetime.

The Corrosion Management assures, via appropriate documents, processes and organization, that the selected actions / solutions are implemented, verified and registered until being delivered to Operations.

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The Corrosion Management process shall be expressed over the successive phases of a Project up to production start-up through dedicated documents. The following table summarizes the main content of these documents over these phases:

Content	Conceptual studies	Pre-Project	Basic engineering	Field Operations
Corrosion assessment	Vs C Steel, without preventive action	Up-dated and covering most components	By corrosion loops, including prevention measures and equipment as new	Same, with consideration of the actual status of the equipment
Corrosion mitigation	X	More detailed	Detailed to all facilities	As built / as to be applied
Corrosion monitoring		X	Detailed to all facilities	X
Associated inspection requirements		X	X	X
Unknowns and uncertainties	X	X		
Impact of adopted solutions to Field operations		X	X	X

4.1 Conceptual and pre-project phase

A first document, currently labelled "Corrosion control Philosophy", shall be issued during "Conceptual Studies". It shall be up-dated during the Pre-Project phase to cover eventual changes and to include additional details / components of the production facilities. This document shall summarize, for all production facilities involved:

- A first Corrosion Assessment (internal and external), assuming bare carbon steel is used and no mitigation is applied. It includes a Corrosiveness evaluation of the fluids / environments involved and a Natural Corrosion Likelihood evaluation of the facilities and equipment considered at the stage of the study.
- The appropriate corrosion prevention solutions to be used, considering the corrosion assessment results and specific characteristics of the production facilities under evaluation:
 - Material selection for main equipment
 - Requirements for chemicals injection, including injection facilities, inhibitor availability target, injection flow rates and control equipment, and the location of injection points
 - Internal and external coating and cathodic protection requirements, where needed
 - Corrosion allowances

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- Limiting flow velocity criteria to be used for the various process flows
- Any other requirement needed for mitigating corrosion (pigging, purging, blanketing, etc.).
- A preliminary list of corrosion monitoring equipment.
- Key inspection requirements associated with the selected mitigation methods.
- It may also define what uncertainties / unknown exist which may impact the considered development, if any. Uncertainties given will be addressed during the next stage of the Project.
- A list of reference documents to be used (normative documents, standards and Recommended Practices, Company General Specifications).
- This document shall cover all eventual future packages altogether. It will highlight particular interface issues requiring specific attention.
- A typical table of content is given in Appendix 1 for this document issued at the end of Conceptual Studies and Pre-Projects.

4.2 Basic and detailed engineering phase

The minimal set of documents to be delivered during Basic and Detailed Engineering phases is listed in Appendix 3. This appendix also specifies the minimal content of these documents.

5. Corrosion assessment

Depending on the development stage, corrosion assessment studies within Design and Construction phases shall deliver part or all of the following results, as indicated in paragraph 5:

- The corrosiveness of fluids in contact with the equipment
- The Natural Corrosion Likelihood - NCL - of the equipment
- The estimated efficiency - EFF - of selected prevention measures
- The actual corrosion likelihood - CL - of the equipment.

The Natural Corrosion likelihood is evaluated from the combination of:

- The estimated corrosiveness over the evaluation period
- The wall thickness of the equipment under evaluation
- The allowable thickness loss below which no corrosion failure occurs: this allowable thickness may be significantly higher than the sole corrosion allowance, particularly for localized corrosion mechanisms.
- The Efficiency of the selected corrosion prevention solution is evaluated with consideration of the practical conditions and difficulties under which it will be applied over the field life.