



Exploration & Production

GENERAL SPECIFICATION

CORROSION

GS EP COR 001

Corrosion control on production facilities: Design and construction
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03	01/2012	General review; New chapter 8: Interventions of TEC/COR in projects. "Corrosion management documents" have been specified in more detail
02	01/2011	General review, specification of a "corrosion management" document and inclusion of TLC and H ₂ S + CO ₂ corrosion assessment
01	10/2006	Remove reference to GM. Adjust prediction criteria on table 1
00	10/2005	First issue
Rev.	Date	Notes

Owner: DEV/TEC	Managing entity: DEV/TEC/COR
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Contents

1. Purpose.....	3
2. Application.....	3
3. Reference documents.....	3
4. Definitions - Abbreviations.....	5
5. The "Corrosion Management" document	6
6. Corrosion assessment.....	8
6.1 Internal corrosion assessment	8
6.2 External corrosion assessment	12
7. Corrosion mitigation	13
7.1 Internal corrosion mitigation	13
7.2 External corrosion mitigation	16
8. Intervention and project assistance by the Corrosion Department of the Company (TEC/COR)	17
8.1 Conceptual.....	17
8.2 Pre-project	17
8.3 Basic engineering	17
8.4 Detailed engineering	18
8.5 Construction and fabrication.....	18
8.6 Commissioning and start-up.....	19
Appendix 1 Typical table of content.....	20
Appendix 2 Interventions by TEC/COR in different phases of the project.....	21



1. Purpose

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.

"Corrosion management" is only one part of a complete "Integrity management system", Inspection activities complement corrosion management and the two tasks are very closely related. Although inspection activities are considered on a general basis within this document, they are not detailed here after as they are dealt with elsewhere.

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.

3. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Standards

Reference	Title
ISO 12944-2	Paints and Varnishes - Corrosion Protection of Steel Structures by Protective Paint Systems - Part 2: Classification of Environments
ISO 15156	Petroleum and natural gas industries - Materials for use in H ₂ S-containing environments in oil and gas production

Professional Documents

Reference	Title
API RP 14E	Recommended Practice for Design and Installation of Offshore Production Platform Piping Systems

**Regulations**

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	

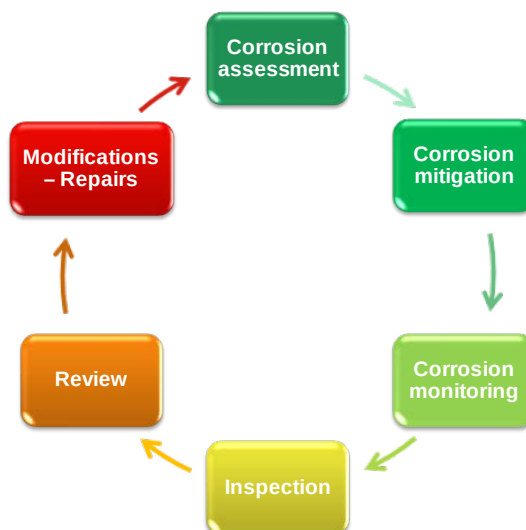
Total General Specifications

Reference	Title
GS EP COR 002	Corrosion control on production facilities: Field operations
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 sour service (upstream applications): Specification for design

4. 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": 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 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.
- "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 CO_2 corrosion, $\text{H}_2\text{S} + \text{CO}_2$ corrosion, corrosion under deposits, preferential weld corrosion, all induced by produced water.
- 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 CO_2 , H_2S , 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
- PPS = Project Particular Specification
- PQT = Procedure Qualification Trial
- PPM = Pre Production Meeting
- PPT = Pre Production Test
- SOR = State of Requirement
- TEC/COR: The Corrosion department of the Company.

5. The "Corrosion Management" document

The corrosion management document defines a plan of actions/solutions 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.

This document is an evolving document over the successive phases of a Project up to production start-up. The following table summarizes the main content of this document over these phases:

1. A first version, currently labeled "Corrosion control Philosophy", shall be issued during "Conceptual Studies" and may be up-dated during the Pre-Project phase in case of significant changes and to cover additional details/ components of the production facilities:
 - At these stages it shall establish a first Corrosion Assessment (internal and external) of all relevant production facilities, assuming bare carbon steel is used and no mitigation is applied,
 - The most appropriate mitigation solutions to be used, considering the corrosion assessment results and specific characteristics of the production facilities under evaluation. This definition is restricted to main facilities and to solutions significantly impacting the architecture, the feasibility, the cost or the reliability of the considered development.

- It may also define what uncertainties/ unknown exist which may impact the considered development, if any
 - At the stage of the Pre-Project, it shall define the basic corrosion monitoring and inspection requirements resulting from selected corrosion mitigation solutions, as well as what operational constraints may result from selected mitigation solutions during the Field Operation phase.
2. A second version, currently labeled "Corrosion Control Solutions" shall be established during the basic engineering. This document shall provide all details regarding corrosion mitigation solutions (material selection and others), corrosion monitoring, key inspection requirements, etc to allow all necessary equipments to be designed and built as needed to assure the satisfactory corrosion resistance.
 3. Another version, currently labeled "Corrosion Management during Field Operations" shall be established prior to the production start-up, to cover corrosion management requirements during the operational life of the facilities. The content of this document is defined in **GS EP COR 002**.

Content	Conceptual studies	Pre-Project	Basic engineering	Field Operations
Corrosion assessment	Vs C Steel	Up-dated		Vs existing facilities
Corrosion mitigation	X	More detailed	Detailed to all facilities	X
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	

A typical table of content is given in Appendix 1 for the "Corrosion Control Philosophy" document issued at the end of preliminary Studies and/or Pre-Projects. This document shall summarize, for all production facilities involved:

- The internal and external assessments as per requirements given in § 6
- The materials selection for main equipment, per categories such as wells, flowlines, pipelines, general process facilities
- The requirements for chemicals injection, including injection facilities, inhibitor availability target, injection flow rates and control equipment, and the location of injection points
- The internal and external coating and cathodic protection requirements, where needed

- The corrosion allowances
- The 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.

A list of reference documents to be used (normative documents, standards and Recommended Practices, Company General Specifications).

During the basic engineering studies, a more detailed document shall be provided, covering all components such as pressure vessels, exchangers, tanks, piping etc., as well as corrosion monitoring tools to be installed (sampling points, fittings, probes, monitoring equipment).

6. Corrosion assessment

6.1 Internal corrosion assessment

When Company does not provide the corrosion assessment, the requirements included in this paragraph shall apply for the work to be carried out by Contractor.

Depending on their nature and on the evaluation criteria available, internal corrosion likelihood shall be assessed using one of the following:

- Quantitatively, either as corrosion rates or lifetimes. The uncertainty on the delivered values shall also be provided
- On a Yes/No basis, in case of risks associated with "threshold" criteria
- With general categories. In such a case, the meaning of each category shall be described, such as in the recommended example below:

Corrosion likelihood	Failure risk	Approximate life-time vs. design life	Typical corrosion rate*
Very low	None	System will last much longer than required with no failures, without any preventive action	< 0.1 mm/y
Low	Negligible	System should reach its design life without a failure with available corrosion allowances, not requiring any complementary mitigation action	0.1-0.3 mm/y
Medium	Likely but delayed	System should reach 50% of its design life before a failure occurs, if no mitigation action is undertaken	0.3 to 1 mm/y
High	Very likely within a few years	A failure will occur after 25% of its design life, if no mitigation action is undertaken	1 to 3 mm/y
Very high	Certain and soon	The system will not even reach 25% of its design life, if no mitigation action is undertaken	> 3-5 mm/y

* Indicative only, since limits are dependent on wall thickness and design life.



The assessment shall consider the possibility that the equipment considered might lose its major functionality with regards to safety, environment and production capabilities during its expected lifetime.

6.1.1 Corrosion phenomena to be assessed

The following corrosion phenomena shall be considered in the internal corrosion assessment:

- CO₂ corrosion or H₂S + CO₂ corrosion due to produced water, i.e. as BLC
- Top of Line Corrosion (TLC)
- H₂S cracking corrosion (i.e. SSC, HIC and SOHIC)
- Erosion-corrosion
- Erosion by solid particles
- Micro-biologically influenced corrosion (MIC)
- Corrosion resulting from dissolved oxygen, if any (e.g. water injection)
- Effect of any additional species or fluid either permanently or temporarily present (i.e. acids, sulfur, brine, amine, etc.).

6.1.2 Assessment methodologies

The assessment methodologies and criteria used for the evaluation, when different from those of Company (General Specifications, Company's evaluation tools or criteria) shall be submitted to Company for approval.

A list of applicable Company tools and criteria is given in Table 1.

Table 1 - Applicable tools and criteria for corrosion assessment

Corrosion phenomenon	Calculation tools	Evaluation criteria	Comments
H ₂ S cracking (SSC, HIC)	CORPLUS	PH ₂ S-pH Severity areas, as per GS EP COR 170	Similar to ISO 15156 criteria. Approximate pH evaluation based on GS EP COR 170 . Precise evaluation with CORPLUS.
CO ₂ corrosion	CORPLUS	Based on corrosion risks and calculated corrosion rates	Reference shall be made to previous field experience, when available and documented within TOTAL or open literature.
H ₂ S + CO ₂ corrosion	None	Based on corrosion risk and estimated corrosion rates	Prediction based on in house qualitative criteria and on field experience, when available and documented, within TOTAL or open literature.
Top of Line Corrosion (TLC)	TopCorp & in house criteria	Based on corrosion risks and calculated corrosion rates	Prediction to be consistent with in house criteria and field experience when available.
Liquid erosion corrosion	CORPLUS	Included in Corplus guidelines	Limiting flow velocities defined as per API RP 14E , with various C factors, depending on fluid characteristics.
Solid erosion-corrosion and erosion	SPPS	Acceptable flow rates for erosion rates < 0.1, 1 and 10 mm/y during 20 years, 1 year and 1 month respectively	Provides an estimate of erosion rates in non-corrosive environments; Not directly relevant to erosion-corrosion in moderate erosive conditions, but can be used as a reference point.
MIC	None	Based on sulphate content, max & min temperature, liquid flow rates	MIC to be considered as a major issue in liquid flow conditions with no or limited gas production (water injection, oil production), with liquid velocities < 1.5-2 m/s.
Corrosion by dissolved O ₂		Max O ₂ content: 30 ppb in injected water	

A maximum use of previous field experience (either positive or negative) shall be made when assessing corrosion likelihood, in addition to any predictive tool and criteria. When no calculation tool is available, in house criteria are currently available, either as internal Guides and Manuals (GMs) or as international publications. GM EP COR documents are Company's technical documents. They shall be supplied when necessary.

6.1.3 Key input parameters to be used for corrosion assessment

The key input parameters for performing corrosion assessments are dictated by the tools and criteria employed. Values in Table 2 shall be used.

Table 2 - Inputs to be used for assessing internal corrosion

Corrosion phenomenon	Parameter	Current value	Particular cases/Comments
SSC	Pressure Temperature pH	MAOP Ambient Min calculated in situ pH	Well equipment: MIN (Bubble P, Reservoir P), Liquid line (no gas): MAOP of upstream separator Bottom-hole liners: min possible T Gas-Condensate wells and P vessels: pH of condensed water Oil wells and liquid lines: pH of produced water
HIC	Pressure and pH Temperature	Same as SSC T max	
(CO₂ and H₂S + CO₂ corrosion)	Pressure Temperature Water content Water composition Flow velocity	Nominal service pressure From min to max flowing temperature Max water-cut Representative water analysis, including organic compounds Max and Min possible flow velocity	Well equipment: MIN (Bubble P, Reservoir P), Liquid line (no gas): MAOP of upstream separator
TLC	Pressure Temperature Water composition Flow velocity	Nominal service pressure Maximum flowing temperature Condensing water in equilibrium with the produced water, including organic acids Max and Min possible flow velocity	TLC mostly limited to gas - condensate pipelines subjected to a stratified flow regime.
Liquid erosion- corrosion	Pressure Temperature Flow rates	Min service pressure Max T Max possible flow rates	The worst Pressure (i.e. the lowest) and flow rate (i.e. the highest) shall not be combined unrealistically, if not coincident. Only combine worst P and Flow rates possible at the same period in order to evaluate the worst flow velocity.
Solid erosion	P, T and Flow rates Sand produced Fluids density and viscosity	Same as liquid erosion-corrosion Max predictable flow rate and granulometry For each fluid	Same as above
MIC	Flow rates Water content Temperature	Min flow rates Max water-cut Min flowing temperature	



In the case where input parameters vary significantly during the lifetime of the installation, the evaluation shall be performed for several time periods to take into account these variations.

The values for input parameters shall be chosen as the most representative for each period of time.

6.2 External corrosion assessment

The external corrosion assessment shall formally cover:

- Onshore and/or offshore environments as applicable
- Aerial, submerged and buried environments as applicable
- Any transition zone between different types of environments (i.e. landfalls, river crossings, splash zones, etc.).

In many cases, the corrosive behaviour of external environments is well identified and conventional protective methods are systematically defined (*e.g. cathodic protection for corrosion in sea water*). In these cases, the corrosion assessment must focus on specific conditions where corrosion likelihood is unusual (either higher or lower than generally admitted), hence requiring specific mitigation actions and specific monitoring or inspection programs.

The following unusual corrosion issues shall be evaluated:

- Bacteria influenced corrosion
- Corrosion in saline or acidic soils
- Galvanic effects between distinct geologic/hydrologic layers
- Influence of surrounding facilities (stray currents, interferences, industrial atmospheres, etc.).

6.2.1 Aerial corrosion assessment

The corrosion assessment shall be performed as per [ISO 12944-2](#), with a classification from C1 to C5:

Typical conditions relevant to each of these classes are given in the following table, as a complement to [ISO 12944-2](#) criteria:

Corrosivity category	Typical conditions (location/ atmosphere/ climate)	Examples within TOTAL affiliates and OPCO's
C1 very low	Onshore internal offices/ all atmospheres/ cold, temperate, hot and dry	
C2 low	Not to be used	
C3 medium	Onshore external/ rural - urban/ temperate or hot - dry Onshore external / marine / cold Onshore internal workshops Offshore internal offices and workshops	Onshore production centres in France, Netherlands, Argentina, Syrian and Algerian deserts, etc.
C4 High	Onshore external/ industrial or marine/ cold, temperate or hot-dry	Lacq, Assaluyeh, Ras Laffan, etc.
C5-I Very high (industrial)	Not to be used. C4 C5-M to be used	
C5-M Very high (marine)	Onshore/ marine/ hot humid or close vicinity to shore Offshore external/ temperate or hot	Gulf of Guinea, Arabic Gulf, Indonesia, etc.

6.2.2 Corrosion assessment in immersed/ buried conditions

Corrosion assessment shall be performed as per [ISO 12944-2](#), with a classification from Im1 to Im3.

7. Corrosion mitigation

Selected mitigation solutions include those used during design and construction and those used during field operations.

The selection shall consider an adequate balance between these two categories based on:

- The expected corrosiveness evaluated in the Corrosion assessment
- The level of confidence which can be given to each mitigation solution
- The consequence of failure
- The constraints associated with each mitigation solution.

The Corrosion Management document shall explicitly define the retained solution and indicate the impact and constraints it may have during field operation.

7.1 Internal corrosion mitigation

The requirements included in this paragraph only apply to Contractor if the "Internal corrosion mitigation" program is not already supplied by Company.



7.1.1 Methodology

The selection of internal corrosion mitigation methods shall be based on the results of the corrosion assessment.

Methods selected for internal corrosion management may use one or several of the following solutions:

- The use of corrosion resistant materials (Corrosion resistant alloys, plastics and GRPs, cladding, etc.)
- Physical treatments: removal of either water or main corrosive species or favourable conditions for corrosion (Temperature, high flow rates, etc.)
 - Dehydration
 - CO₂ or H₂S removal
 - Cooling
 - Filtration
 - Etc.
- Adequate design, particularly with regards to:
 - Allowable flow velocities, within limitations of the "corrosion assessment" evaluation
 - Avoidance of water accumulation and trapping
 - Prevention of air entries (blanketing, sealing, etc.).
- Corrosion allowances, organic coatings, cathodic protection
- Chemical treatments: inhibition, biocide, pH control, oxygen removal, as covered in **GS EP COR 163** for design and **GS EP COR 002** for field application
- Internal coatings
- Internal cathodic protection.

7.1.2 Material selection

Sour resistant materials shall be used as soon as sour conditions are encountered (severity areas 1, 2 or 3, refer to **GS EP COR 170**). Nota: "*sour resistant*" material can be Carbon Steel (CS), hence not necessarily resistant to weight loss corrosion.

CS (including sour service CS) in combination with the use of additional mitigation actions when needed (such as inhibition, cathodic protection, etc.), shall be considered as the base case material as long as it can be documented that its use does not compromise Company integrity requirements during the expected lifetime.

CRAs shall be used when CS cannot guarantee the integrity of the equipment considered even with the use of mitigation actions or if these mitigation actions are not feasible, more expensive or unsafe with respect to safety or availability requirements for the installation.

CRAs shall be selected to provide complete corrosion resistance to the worst possible service conditions during the whole service life. All potential damaging effects from either external environmental conditions or temporary fluids/service conditions shall be taken into account when selecting the material.



A similar approach shall be used for organic or composite materials (plastics, FRP, flexible lines, plastic lined CS tubing or pipelines, etc.). Ad hoc design rules dedicated to their specific properties and characteristics shall be used for these specific materials.

7.1.3 Corrosion allowances

Corrosion allowances are used for CS equipment to compensate for:

- A temporary lack of application or efficiency of the specified mitigation actions
- Residual corrosion, particularly when no mitigation action is used.

Typical corrosion allowances shall be of 0, 1.5, 3 and 5 mm. Any higher or different value shall be justified by specific operating conditions or corrosive environments.

When continuous corrosion inhibition is used at operating temperatures $\leq 90^{\circ}\text{C}$, the residual corrosion rate is considered as negligible when the inhibitor is injected. The Corrosion allowance is then only aimed at covering unavailabilities.

For temperatures above 90°C a residual corrosion rate of 0.1 mm/y shall be added (i.e. 2 mm for 20 yrs lifetime) to the above typical values.

No corrosion allowance shall be provided for CRAs for corrosion or erosion-corrosion purposes. An allowance shall only be used when erosion by solid particles is expected.

On facilities operating under progressively decreasing MAOP (e.g. gas pipelines designed at the SHWHP), the extra-corrosion allowance obtained with time because of the decreasing operating pressure can be used to minimize the initial allowance, as long as it is accepted that the pipe will not be re-operated at its initial design pressure.

7.1.4 Internal coatings and cathodic protection

Internal coatings shall be used in combination with cathodic protection for all CS tanks and pressure vessels where water is likely to accumulate, unless:

- The water is not significantly corrosive
- Proper application of the coating cannot be guaranteed (low diameter, lack of accessibility, etc.)
- Coating integrity cannot be guaranteed, (e.g. too high service pressure or temperature)
- A CRA solution is more cost effective.

7.1.5 Flow velocity limitations

Flow velocity limitation criteria are defined for well tubing, pipelines and piping, considering possible erosion-corrosion and solid erosion risks. Limitations relate to:

- Whether the fluid is dry or wet
- Whether solid particles can be present or not
- The corrosive behaviour of the fluids transported
- The materials used
- The use of corrosion inhibition.



7.1.6 Preventing galvanic corrosion on CRA/CS connection on wet piping

In order to minimize galvanic corrosion when connecting CRA and Carbon Steel, the following rules shall be applied:

- A flange connection shall be privileged as much as possible
- Internal CRA cladding (typically AISI 316L) shall be applied only on the flange face of the CS side, including the ring groove, but with no overlap inside the flange
- A CRA ring joint shall be used between the CRA and the cladded CS sides.

This solution shall apply to wet piping, but is used neither on dry gas or dehydrated oil piping, nor on inert or non corrosive liquids (e.g. methanol, hydraulic oil, chemicals).

7.1.7 Internal corrosion monitoring

A corrosion monitoring program shall be defined, aiming at:

- Verifying the proper application and the efficiency of mitigation actions, if any
- Verifying that corrosion is low, when no mitigation action is deemed necessary.

Equipment needed for the corrosion monitoring program, as well as its positioning on or within the equipment shall be defined as per **GS EP COR 002** and **GS EP COR 161** within the corrosion management document.

7.2 External corrosion mitigation

External corrosion mitigation shall be based on a combination of material selection, painting or coating for aerial surfaces and coating and cathodic protection for immersed or buried equipment.

Reference shall be made to the dedicated Company General Specifications for painting, coating, thermal insulation and cathodic protection.

Although material selection is mostly dictated by internal corrosion issues, some specific requirements related to external environmental conditions shall apply as discussed below.

7.2.1 Instrument tubing

Corrosivity category	Material selection	Restrictions - Additional requirements
C1 to C4	AISI 316L	AISI 904L if sea water is used as fire water
C5-I	AISI 316L	AISI 904L if hot marine atmosphere
C5-M	AISI 904L	6 Mo if extreme severity conditions



7.2.2 Immersed CRAs

Material	Restrictions - Additional requirements	Comments
Martensitic SS (13% Cr, F6NM, 17-4 PH, etc.)	Not to be used	Including supermartensitic SS
AISI 316L	Cathodic protection required	Not resistant to sea water.
Duplex 22% Cr	Cathodic protection required	Hydrogen embrittlement risks associated with cathodic protection to be addressed, in case of high stress levels
Duplex 25% Cr	Cathodic protection required if service T > 15°C	Same

8. Intervention and project assistance by the Corrosion Department of the Company (TEC/COR)

The following subchapters define the intervention by TEC/COR in the different phases of a project from conceptual studies to commissioning. The objective is to ensure that the project's deliverables will be in accordance with General Specifications, norms, and standards in order to ensure satisfactory material selection and corrosion control throughout the lifetime of the installation.

Appendix 2 summarizes the information below in tabulated form.

8.1 Conceptual

TEC/COR shall participate in Conceptual studies when and if these studies are required. The purpose is to provide a preliminary "Corrosion Control Philosophy" for the proposed development, as defined in § 5. Any show stoppers, new materials, procedures, innovations etc. which require qualification to be field proven shall be identified.

8.2 Pre-project

At pre-project stage the basic materials selection and corrosion control solutions shall be defined by TEC/COR in an up-dated "Corrosion Control Philosophy" document as defined in § 5, unless no significant change and complement is needed with reference to the previous version

TEC/COR shall review the SOR.

8.3 Basic engineering

TEC/COR shall review any PPS (particular project specifications) related to materials selection and corrosion control.

TEC/COR shall perform a technical evaluation of the different tenders and shall answer clarifications and exceptions from PPS and GS related to materials and corrosion.



TEC/COR shall review the activities and documents of Contractor in order to verify that they are in accordance with General Specifications, with the "Corrosion Control Philosophy" document and with PPS.

TEC/COR shall issue the "Corrosion control solutions" document defined in § 5.

The TEC/COR review shall include, but not be limited to, the following topics:

- Materials selection
- Painting
- Coating, including field joint coating
- Thermal insulation
- Cathodic protection
- Corrosion monitoring
- Erosion monitoring
- Sand monitoring
- MSD (Material Selection Diagrams).

TEC/COR shall participate in PTR 2 performed at the end of the basic engineering, unless decided otherwise by OPS/EXP.

8.4 Detailed engineering

TEC/COR shall continue to review Contractor activities and projects documents related to corrosion.

If new materials, products, or technologies are proposed, TEC/COR shall participate in material testing and qualification by Contractors and sub Contractors.

TEC/COR shall especially review:

- Exact locations of corrosion and erosion monitoring
- Chemical injection points for corrosion prevention
- Inspection and test plans (ITP) for cathodic protection, pipeline/riser coating and painting
- Materials selection and corrosion protection of Vendor packages.

If a corrosion inhibitor is to be used, it shall be selected in a laboratory study carried out or validated by TEC/COR.

TEC/COR may participate in PTR 3 at the end of the detailed engineering at OPS/EXP request.

8.5 Construction and fabrication

During construction and fabrication TEC/COR shall participate in PPM's (Pre Production Meeting), PQT's (Procedure Qualification Trial), and PPT's (Pre Production Test) related to coating, painting, and cathodic protection. These activities can be subcontracted by TEC/COR to a third party inspection Contractor. In any case TEC/COR shall review and accept the reports of PQT and PPT.



TEC/COR may participate in the reception of materials such as coated pipe, painted items, cathodic protection including insulation joints upon project's request. In any case TEC/COR shall receive final documentation for these items.

TEC/COR shall participate in audits of any Vendor and Supplier which has not been approved in TEC Vendor database.

TEC/COR shall establish the "Corrosion management during field operations" which shall include the detailed corrosion chemical treatment program and the detailed corrosion and erosion monitoring program, as defined in § 5.

TEC/COR may participate in PTR 4 at the end of the construction and fabrication phase on OPS/EXP request.

8.6 Commissioning and start-up

TEC/COR shall participate in the commissioning and shall at least review the commissioning reports for the following equipment

- Impressed current cathodic protection
- Internal corrosion monitoring
- Erosion and sand monitoring
- Cathodic protection monitoring.

TEC/COR shall issue the final "Corrosion Management during field operations" document.



Appendix 1 Typical table of content

Contents

1. Introduction	5
2. Main conclusions	6
3. Scope	7
4. Applicable reference documents	8
5. Main results and practical requirements.....	9

Discussion of specific/ particular requirements, as a complement to table 1 and 2

Table 1: Recapitulative table for material and additional design requirements (*Material selection, corrosion allowances, coating, CP,...*)

Table 2: Recapitulative table for anti-corrosion chemical treatments (*Type of product, injection points, Max. Nominal and minimal injection rate or dosage...*)

Table 3: Recapitulative table for corrosion monitoring (*monitoring technique, location of monitoring points, particular requirements*).

Appendices

Appendix 1: Data and hypotheses used for corrosion assessment

Appendix 2: Internal corrosion likelihood evaluation: synthetic results

- Sour service conditions
- CO₂ corrosion
- Erosion-corrosion (no sand)
- Erosion & erosion-corrosion related to sand production
- Bacterial corrosion

Appendix 3: Applicable limiting Flow velocity criteria



Appendix 2 Interventions by TEC/COR in different phases of the project

Activity	Project phase					
	Conceptual	Pre Project	Basic Engineering	Detailed Engineering	Construction	Commissioning
Corrosion control philosophy	conduct	update				
Corrosion control solutions			establish	update		
Corrosion management during field operations					establish	finalize
Erosion study		conduct	update if req.			
Souring study		conduct	update if req.			
Top of line corrosion study		conduct	update if req.			
SOR		review				
PPS			review			
Corrosion Inhibitor selection			conduct			
Technical tenders			review & evaluate			
Contractor documents			review			
MSD			review			
New materials qualification				review/witness		
Corrosion inhibitor/biocide injection		*	review			
Corrosion and erosion monitoring		*	review			review/witness
Vendor & supplier				review & audit any new vendor		
Vendor package				review		
ITP (coating, painting, anodes, IJ, etc.)				review		
PPM (coating, painting)					participate	
PQT (coating, painting, anodes,)					review/witness	
PPT (coating, painting, anodes)					review/witness	
Material reception (coating, painting, anodes, IJ)					review/witness	
Impressed current cathodic protection		*	review			review/witness
Cathodic protection monitoring		*	review			review/witness
Derogations from GS			review and approve/reject			
PTR			shall participate	may participate	may participate	

* included in "corrosion control philosophy", "corrosion control solutions" and "corrosion management during field operations documents"