

GENERAL SPECIFICATION

CORROSION

GS EP COR 161

**Internal corrosion and erosion-corrosion monitoring:
Design and installation**

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General Specification		GS EP COR 161
Internal corrosion and erosion-corrosion monitoring: Design and installation		
Rev.: 06	Effective date: 06/2012	Page: 2 of 20

Contents

1. Scope	3
2. Reference documents.....	3
3. Definitions.....	3
4. Aims	4
4.1 Corrosion monitoring.....	4
4.2 Erosion monitoring	4
4.3 Sand monitoring.....	4
5. Design	4
5.1 General requirements	4
5.2 Corrosion monitoring.....	5
5.3 Erosion monitoring	8
5.4 Sand monitoring.....	9
5.5 Polymer ageing monitoring.....	10
6. Installation requirements.....	11
6.1 Intrusive corrosion and erosion monitoring.....	11
6.2 Non intrusive erosion and sand monitoring	12
7. Commissioning and maintenance	14
7.1 Common requirements.....	14
7.2 Specific requirements for sand monitoring	14
8. Data retrieval	14
8.1 Corrosion and erosion monitoring	14
8.2 Sand monitoring.....	15
9. Documentation	16
9.1 Engineering study	16
9.2 Equipment list	16
10. Operating manual.....	17
Appendix 1 Monitoring techniques – Principles	18

General Specification		GS EP COR 161
Internal corrosion and erosion-corrosion monitoring: Design and installation		
Rev.: 06	Effective date: 06/2012	Page: 3 of 20

1. Scope

The present specification defines the minimal requirements applicable to:

- The selection of internal corrosion, erosion, and sand monitoring systems
- The design of the monitoring systems
- The installation and commissioning of the equipment.

The present specification is applicable to surface and subsea installations for oil and gas production. It does not apply to downhole equipment.

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 supplements, is the latest revision published at the effective date of this document.

Reference	Title
Not applicable	

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published in the applicable yearly collection.

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 PLR 109	Design, fabrication and testing of submarine unbounded flexible pipes and risers

3. Definitions

Corrosion monitoring: Measurement of the degradation (metal loss) caused by the electrochemical reactions involved in corrosion phenomena.

Erosion monitoring: Measurement of the final degradation (metal loss) due to the mechanical action of either liquids or solids, directly on the metal or on protective layers formed by corrosion reactions. *In practice, erosion monitoring measures the total metal loss resulting from erosion-corrosion due to both mechanical (by liquids or solids) and electromechanical effects.*

Sand monitoring: Technique aiming at detecting and/or quantifying sand production.

General Specification		GS EP COR 161
Internal corrosion and erosion-corrosion monitoring: Design and installation		
Rev.: 06	Effective date: 06/2012	Page: 4 of 20

4. Aims

4.1 Corrosion monitoring

Corrosion monitoring shall be carried out:

- To control/verify the corrosive behaviour of produced fluids, when no preventive action is implemented (such as corrosion inhibition, biocide treatment, pH stabilisation)
- To verify the practical application and efficiency of preventive treatments, when they are used.

4.2 Erosion monitoring

Erosion monitoring shall be carried out when the nature of the fluid is such that wear and wall thickness loss by mechanical damage is expected (unpredicted sand production, high flow velocities, etc.). Erosion monitoring is not intended to give quantitative measurements on the amount of sand production in the stream (scope of sand monitoring).

4.3 Sand monitoring

Sand monitoring shall be used when sand production is expected to:

- Quantify continuous sand production if relevant
- Detect massive sand production due to downhole sand control failure and raise alarm.

5. Design

5.1 General requirements

For harmonization, the monitoring system of new facilities shall be selected to be compatible with this used on adjacent assets.

At least, monitoring systems specified as part of the revamping or extension of given facilities shall allow the use of existing retrieval tools (if intrusive monitoring), as well as communication and analysis systems (e.g. software).

Non intrusive monitoring systems (i.e. not requiring the use of HP retrievers) shall particularly be considered for high pressure or hardly accessible conditions.

For intrusive monitoring:

- A 2" access fitting system shall be used. However, 1" access fittings are allowed for systems with operating pressure less than 5 bars. The type of fitting to be used among the two main types currently available on the market (mechanical or hydraulic retrieval type) shall be submitted for Company approval.
- The coupons and probes shall be inserted or removed using a special tool (retriever).
- Access fittings for a given installation shall be standardised and compatible with other access fittings on the market so that only one type of probes and retriever are needed.
- To avoid disruption of production, intrusive coupons and probes shall be mountable and removable at the operating pressure and temperature of the monitored equipment.

General Specification		GS EP COR 161
Internal corrosion and erosion-corrosion monitoring: Design and installation		
Rev.: 06	Effective date: 06/2012	Page: 5 of 20

- The retrieval system shall be of the non-telescopic type.
- Intrusive probes and coupons installed on lines subject to pigging shall be systematically flush-mounted.

5.2 Corrosion monitoring

The corrosion monitoring plan shall include a combination of several methods (see **GS EP COR 002** for details).

For each monitoring point one shall clearly defined whether monitoring is aimed at controlling the corrosive behaviour of the produced fluid or at verifying the application/efficiency of anti-corrosion treatments.

For both objectives, the applicable methods shall be:

- Corrosion samples: corrosion coupons (CC), bioprobes and spool pieces
- Corrosion probes: conventional electrical resistance probes (ERP), linear polarisation resistance probes (LPR), hydrogen probes (HP), high sensitivity probes ("CEION" type)
- Bacterial activity monitoring: bioprobes
- Sampling points (SP), chemical analyses, etc.
- A short description of the above techniques is given in Appendix 1
- Corrosion monitoring systems shall be based on typical corrosion monitoring requirements (applicable methods and effluents to be monitored) as summarized in Table 1.

Particular attention shall be given to the optimisation of the monitoring strategy to avoid multiplying unessential monitoring points.

Internal corrosion and erosion-corrosion monitoring: Design and installation

Rev.: 06

Effective date: 06/2012

Page: 6 of 20

Table 1 - Key corrosion monitoring points

EQUIPEMENT TO BE MONITORED		FLUID	MONITORING DEVICE	MONITORING LOCATION	COMMENTS
Pipelines	Unprocessed Fluids: Trunklines and long onshore Flowlines (> 1 km)	Multiphase (inhibited)	CC + ERP + SP Bioprobe	Inlet and outlet Outlet	
	Processed Fluids	<i>Oil (stabilized) export</i>	CC + ERP + SP	<i>Inlet</i>	Usually not required, only upon specific request
		<i>Dry gas export</i>	CC + ERP	<i>Inlet</i>	Usually not required, only upon specific request
		Wet gas	CC + ERP + SP	Inlet and outlet	
		condensate, oil water	CC + ERP + SP Bioprobe	Inlet and outlet	
		Gas condensate	CC + ERP + SP	Inlet and outlet	
	Injection	Water injection (SW)	CC + ERP or LPR ^[1] + bioprobe	Injection wells manifold inlet	
	Production	Produced water (PW)	CC + ERP + bioprobe	Inlet and outlet	
Flexible risers	Production	Multiphase	Polymer coupons	Outlet	Mandatory for PA11, on case by case basis for other polymers
Separation Process	1 st stage separator	Produced water	CC + ERP + SP	Water outlet of separator	
	Crude desalter	Produced water	CC + ERP + SP	Water outlet of desalter	
Water injection process	Filtration	Injection water	SP	Downstream filters, outlet of each filter	For bacterial monitoring purpose
	Deaeration	Injection water	CC + ERP or LPR ^[1] + bioprobe + SP	Deaeration tower outlet, upstream HP pump	Bioprobe to be placed upstream biocide injection point
Gas process	Hydrate control	MEG	SP	HP section downstream flash drum Lean and rich MEG	
	Dehydration	TEG	SP	Lean and rich TEG	
Utilities	Cooling/Heating medium	Water	SP	Hot section	

Note [1]: Use of LPR to be assessed at project stage.

- Recommendations, restrictions and limitations of sensitive element selection and position for corrosion probes are summarised for each technique in Table 2 and Table 3.
- Monitoring points dedicated to corrosivity measurements shall be installed upstream of corrosion inhibitor and biocide injection points (if any). Conversely, monitoring points aimed at verifying the treatment efficiency shall be located downstream the injection points.

Any other available method able to provide similar or superior monitoring results (particularly in terms of reliability and operability) shall be submitted to Company for approval.

5.2.1 Choice of sensitive element type and model

The choice of probe type and model shall be a function of:

- The composition of the effluent
- The operating pressure
- The flow rate and flow regime.

Guidelines for sensitive element selection are provided in Table 2.

At each location, at least two types of monitoring systems (e.g. coupons and probes) shall be used.

Table 2 - Guidelines for sensitive element selection

Technique	Fluid	Type of element and possible restrictions
ERP	Production	Tubular or flush, loop type not allowed
	Utilities (monophasic)	All, loop type allowed
CC	All	Strip, ladder or flush
LPR	Gas	Not allowed
	Other	Allowed only if fluid resistivity is $<10^{-5} \Omega \cdot \text{cm}$
H ₂ probe	H ₂ S containing fluids	Non intrusive (patch type) only
Bioprobe	Production	Flush
	Water injection	Side stream system with flush bioprobe is preferred
SP	All	Bottom, on horizontal line

5.2.2 Sensitive element position

For intrusive probes and coupons, the sensitive element shall be in contact with the corrosive free water in liquid phase. It shall therefore be positioned in relation to fluid flow conditions during normal production.

Requirements for sensitive element position are summarised in Table 3.

Table 3 - Sensitive element position

Effluent		Position within the fluid	Access fitting position around the pipe	Type of element	Comments/restrictions
Gas	Base case	Bottom position	6 o'clock ^[1]	Flush	Applies to 2 phases wet gas (gas with low water or gas condensate)
				Protruding	Only for gas mist flow
	Alternate	Bottom position	12 o'clock ^[2]	Protruding	Sensitive element placed 5mm above pipe bottom line
					Pipe $\varnothing \leq 8"$
					Flow velocity < 10 m/s ^[2]
Liquid	Base case	Bottom position	12 o'clock ^[2]	Protruding	No slug, stabilized flow
					Pipe $\varnothing \leq 12"$
	Alternate	Bottom position	6 o'clock ^[1]	Protruding	Sensitive element placed 5 mm above pipe bottom line
					Pipe $\varnothing > 12"$
				Flush	Segregated flow regime
					Sensitive element placed 5 mm above pipe bottom line
					Established BSW < 10%
Water	Base case	Unimportant	Unimportant ^{[1] [2]}	Protruding	High velocities
		Bottom position	6 o'clock	Flush	Bioprobes

Note [1]: The 6 o'clock position shall always be preferred. However, when sand production is expected, the 12 o'clock position shall be evaluated to avoid sand accumulation in the access fittings and coupon/probe damage during retrieval operations.

Note [2]: When the 12 o'clock position is selected, Contractor shall check that flow velocities are compatible with the selected monitoring system with Vendor.

Special care shall be taken to ensure that the monitoring device position is far enough from any piping component likely to disrupt the flow (e.g. to avoid non-representative results due to oil wetting in the case of a stratified flow regime). Monitoring devices shall be located, whenever possible, at a minimum distance of 2 m upstream/downstream bends, reductions, etc.

5.3 Erosion monitoring

Erosion monitoring shall be performed by means of either intrusive or non intrusive methods, such as:

- Erosion-corrosion probes (intrusive)
- Ultrasonic methods: Permanent UT-mats monitors (non intrusive). UT mats (strips) can also be used instead of CC/ERP for corrosion monitoring purpose when the area to be monitored is not easily accessible during retrieval operations.

General Specification		GS EP COR 161
Internal corrosion and erosion-corrosion monitoring: Design and installation		
Rev.: 06	Effective date: 06/2012	Page: 9 of 20

Note: UT-mats have temperature limitations and shall not be used for operating temperatures over 120°C. Note that this technique is not available for subsea use.

A short description of the above techniques is given in Appendix 1. Non intrusive methods shall be given preference for subsea facilities, high pressure or “hard to access” areas, and topsides equipment thermally insulated. However, electrical field measurement based non intrusive methods shall be prohibited.

Recommendations, restrictions and limitations are summarised for each technique in Table 4 and Table 5.

- Local UT measurements: In the particular case of subsea facilities where intrusive erosion probes are not allowed, erosion monitoring shall be performed manually by direct local measurement (ROV for subsea). In this case, a plug shall be provided in the insulation system to allow sensor and ROV access (subsea) to the pipe surface. The same shall apply for erosion monitoring of topsides thermally insulated equipment.

5.3.1 Sensitive element position: intrusive erosion probe

When probes are used for erosion purpose, the probes shall be located where erosion is expected to take place, and be positioned in the flow so that the solids bearing portion of the production stream is in contact with the sensitive element.

Table 4 - Erosion probe sensitive element position

Probe type	Location	Comments
Flush probe	Bend	The head of the probe fits flush to the pipe wall reducing the amount of disruption that the probe causes to the flow
Angle head probe	Straight pipe	In vertical section of piping, preferably with vertical up flow, where the sand will be evenly distributed across the pipe

5.3.2 Sensitive element position: non intrusive UT

The strips shall be placed where erosion is expected to occur. **A comprehensive erosion study shall be carried out to identify the piping components likely to be eroded.**

In all cases, the strips position shall be on the outside radius of a bend along the centre line.

5.4 Sand monitoring

Subsea and topsides sand monitoring shall be performed with non intrusive acoustic sand detectors (ASD) that are clamped on the piping component to be monitored.

5.4.1 ASD position

The location of the detector units on the lines is critical to their performance. The choice of location will depend on orientation, fluid velocities and proximity to the choke in some cases.

ASDs shall be placed on the extrado of a bend where high frequency (ultrasonic) noise made when sand strikes the wall of the bend is expected, and located along the centre line (Figure 1).

In all cases, and especially for subsea applications, Vendor shall be involved in the design of the monitoring system, including ASDs location.

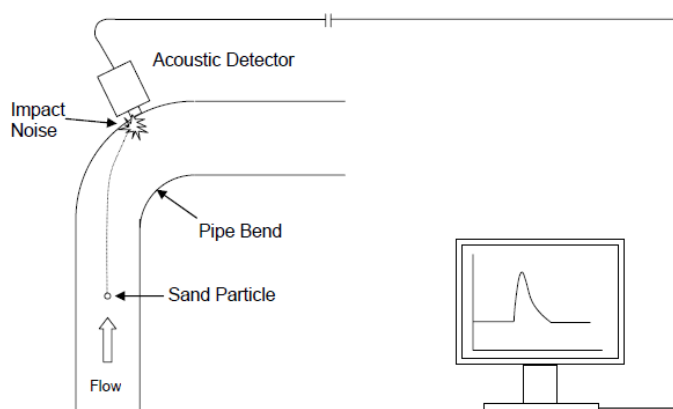


Figure 1 - ASD position

The choice of bend for optimum performance shall normally be in the following order:

1. Bend directing flow from vertically down to horizontal
2. Bend flowing vertically upwards to horizontal
3. Bend flowing horizontal to vertically downwards
4. Bend flowing horizontal to horizontal
5. Bend flowing horizontal to vertically upwards.

5.5 Polymer ageing monitoring

As per **GS EP PLR 109**, polymer coupons shall be installed on oil and gas production flexible risers' arrival to monitor polymeric pressure vault ageing.

This requirement is mandatory for production lines with PA11 pressure vault.

For PE, PVDF, XLPE pressure vaults, this requirement only applies if the operating conditions are close to the material limitations. This shall be assessed with Company polymer specialist on a case by case basis.

Polymer disc coupons shall be of the same material and from the same fabrication as the pressure vault to be monitored.

Polymer disc coupons shall be installed using the same access fittings as the one used for intrusive corrosion monitoring, and shall be inserted in the piping immediately downstream flexible line topsides connection.

A typical example of the polymer ageing monitoring arrangement is shown in Figure 2.

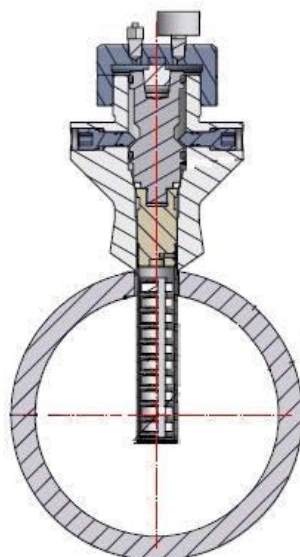


Figure 2 - Typical arrangement for polymer coupons

6. Installation requirements

6.1 Intrusive corrosion and erosion monitoring

- Access fittings shall preferably be placed in accessible areas. Position shall be such as to avoid use of scaffolding for retrieval operations. At worst, installation shall allow use of a cherry picker.
- Fittings shall preferably be located on pipework accessible from floor level or immediately adjacent to permanent walkways.
- If the pipe to be monitored is not accessible from the floor, a removable trap in the grating shall be provided to allow access from the immediately lower floor, with dimensions suitable for retrieval operations.
- As a minimum, access fittings shall be positioned with a 2 m long * 0.5 m diameter cylindrical clearance from the access fitting, to allow easy access and safe operability of the retriever tool during the whole installation/removal operation (Figure 3). This clearance shall be increased if necessary to comply with the dimensions of the selected retriever tool.

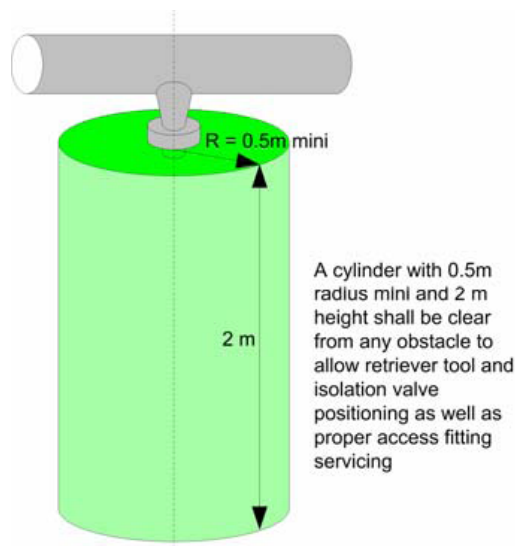


Figure 3 - Minimum clearance for access fittings

- When several access fittings are installed at the same location, a minimum distance of 1 meter between each fitting shall be provided.
- Corrosion monitoring points aiming at assessing the efficiency of corrosion inhibition shall be installed downstream and at a sufficient distance of the injection point, i.e. 10 m minimum for straight pipe sections and 5 m minimum for piping with complex geometry (2 tees or elbows, diameter change, etc.).
- Corrosion monitoring points shall preferably be installed at least at 2 m from any piping item disrupting the flow (e.g. elbow).

The particular requirements for the monitoring device installation shall be reported on the P&IDs during the detailed engineering phase.

The design as shown on the isometrics and its compliance with above requirements shall be verified and approved during construction by Company piping specialist assigned to the project.

6.2 Non intrusive erosion and sand monitoring

6.2.1 Common requirements

Non intrusive erosion and sand monitoring systems shall be placed between the mid-point of the bend and the end of the bend.

6.2.2 UT-mats

UT-mats shall be installed in a longitudinal position on the bend (Figure 4)

The strips shall be attached to the bare metal of the pipelines. Protective coatings shall be removed to facilitate a good contact between the sensors and the metal surface.

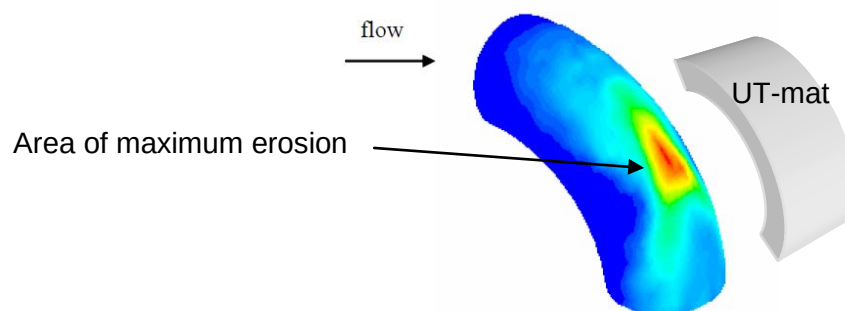


Figure 4 - Typical position of UT-mats on the bend

More than one strip can be used to cover a greater surface area. For pipes equal or less than 4", some difficulty may be encountered with sealing the edges of the strip on the pipe bend when fitting them along the centre-line. In such cases the strips may be fitted around the circumference but more than one strip may be required to detect erosion.

6.2.3 Acoustic sand detectors

Details of correct and incorrect installation of non-intrusive ASDs are shown in Figure 5.

The detectors should not be positioned upstream or at a long distance downstream of a bend as the noise produced when sand impacts on the surface will reduce in intensity with the distance from the source point, making detection difficult.

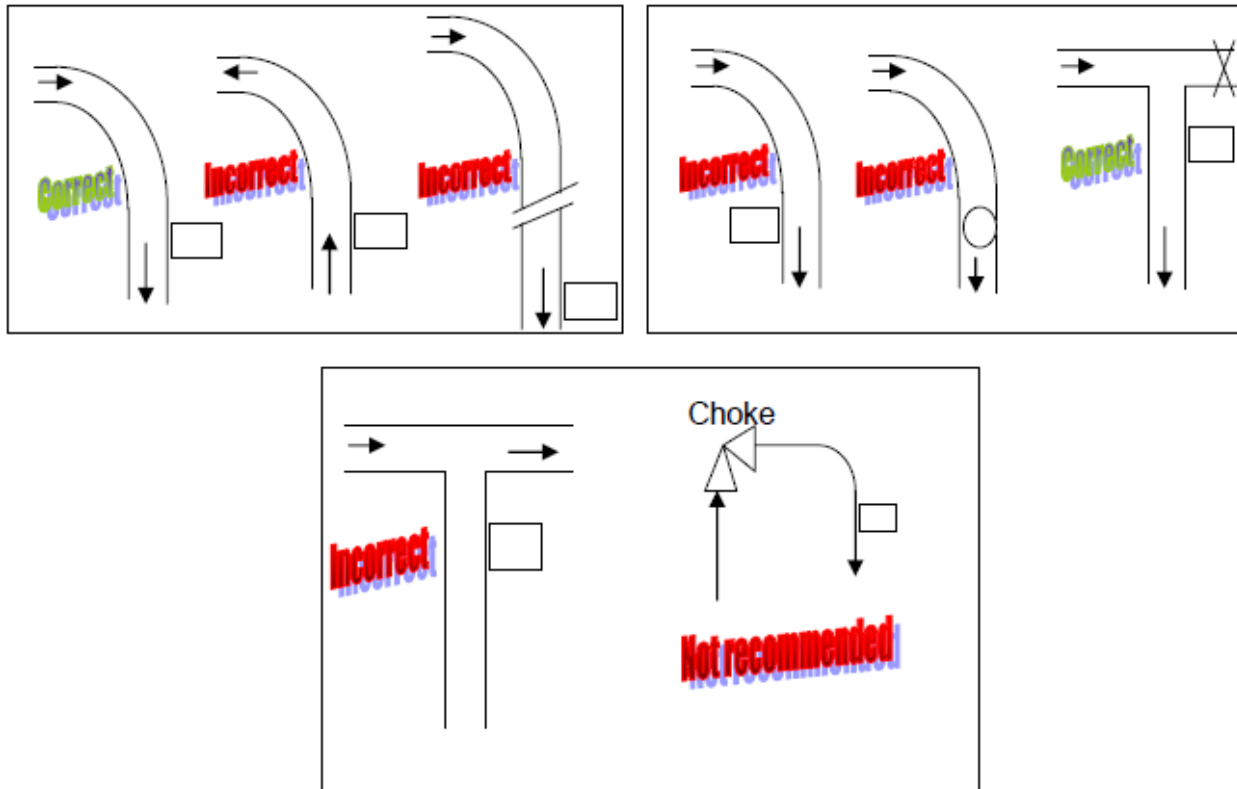


Figure 5 - Correct and incorrect installation position for ASDs

7. Commissioning and maintenance

7.1 Common requirements

A Specific Maintenance Contract shall be placed with the Vendor for installation and commissioning of the monitoring equipment.

In addition, if there is no specific maintenance Contract for the monitoring equipment within the subsidiary, the Contract shall also include maintenance services for at least 2 years.

7.2 Specific requirements for sand monitoring

The ASD Vendor shall be involved by Contractor during design, installation and commissioning.

The Contract placed with the Vendor for supply and commissioning of the sand monitoring system shall include training of the personnel for interpretation of data.

8. Data retrieval

8.1 Corrosion and erosion monitoring

Monitoring data shall be electronically retrievable using one of the following techniques, in order to subsequently be centralised in a Company corrosion monitoring system.

General Specification		GS EP COR 161
Internal corrosion and erosion-corrosion monitoring: Design and installation		
Rev.: 06	Effective date: 06/2012	Page: 15 of 20

For each type of monitoring technique, data retrieval system shall be selected depending on the context of the project. The choice shall, as a minimum, be based on:

- Power supply restrictions
- Number of monitoring devices
- Platform/plant accessibility (distance from shore, weather conditions, access road, etc.)
- Permanent inspection staff availability or inspection frequency.

The system shall be selected among the following possibilities:

- Periodic measurement, using a portable instrument
- Automatic periodic measurement with an autonomous device (data logger, usually battery powered) installed close to the monitoring point
- Automatic periodic measurement with data transmission to a centralised collecting system located in the Control Room or any equivalent location.

Typical guidelines for possible data retrieval solutions are provided in Table 5.

Table 5 - Guidelines for data retrieval system selection

Facility	Type of data retrieval system		
	Manual portable	Data logger	Control Room
Unmanned remote platform, difficult access		X	X
Manned but no permanent inspection staff		X	
Manned with permanent inspection staff–limited monitoring points	X	X	
Manned with permanent inspection staff–numerous monitoring points		X	
Complex plant			X

Portable equipment shall be able to read and store data from LPR and Electrical Resistance probes and transfer the corrosion data to a PC.

Data recovery from autonomous measuring devices shall be made by a remote data collector able to transfer the data to a PC.

The frequency of data collection shall be as per **GS EP COR 002** requirements.

8.2 Sand monitoring

Topsides and subsea monitoring systems shall be connected to an equipment rack (power supply and data conversion unit) and PC. The PC shall be able to read/write data from/to the control system.

General Specification		GS EP COR 161
Internal corrosion and erosion-corrosion monitoring: Design and installation		
Rev.: 06	Effective date: 06/2012	Page: 16 of 20

9. Documentation

9.1 Engineering study

A corrosion, erosion and sand monitoring plan shall be established for all facilities likely to be subject to corrosion or erosion failures, and sand production over their planned service life. The monitoring plan is established in compliance with **GS EP COR 001**.

The monitoring plan shall consist of:

- Selecting viable monitoring methods with regards to the objectives indicated in § 4:
 - The nature and severity of expected corrosion and/or erosion
 - The areas of highest risk
 - The selected corrosion and/or erosion prevention methods
 - The operating conditions.
- Drawing up of a consistent plan based on the reliability and limits of the monitoring methods applicable to the cases under study
- Special construction requirements for monitoring, such as fittings, special piping devices, etc. These requirements shall be reported on the P&IDs and implemented in the isometrics
- A list of equipment, spare parts and products needed for two years of operation
- Operating and maintenance instructions and, if necessary, methods of sampling and chemical analysis
- Results interpretation manual.

The Engineering Contractor shall be responsible for compiling this corrosion/erosion monitoring plan.

9.2 Equipment list

The full equipment list shall be divided into four separate sections.

- **Section 1:** retriever tool and monitoring devices to be mounted on the installations, including probes, coupons, coupon holders, etc. and a two year supply of spare parts.
- **Section 2:** special equipment for installing the probes and coupons, sampling facilities, etc. This equipment includes access fittings, shut-off valves, spools, etc.
- **Section 3:** portable or fixed measuring equipment, such as portable measuring devices, remote data collectors, computers and necessary software for data processing, pH-meters, etc., and the necessary accessories including adapters, safety barriers, etc.
- **Section 4:** equipment and chemical products to be used by the production laboratory for corrosion monitoring.

Internal corrosion and erosion-corrosion monitoring: Design and installation

Rev.: 06

Effective date: 06/2012

Page: 17 of 20

10. Operating manual

Engineering Contractor shall deliver, prior to commissioning of the monitoring system, an operating manual which shall include operating instructions, measuring and analysis frequencies, sampling and analysing methods, special precautions regarding storage, insertion and withdrawal of probes and coupons, instructions for the preparation and cleaning of probes and coupons before insertion and after withdrawal, coupon weighing instructions, etc.

General Specification		GS EP COR 161
Internal corrosion and erosion-corrosion monitoring: Design and installation		
Rev.: 06	Effective date: 06/2012	Page: 18 of 20

Appendix 1 Monitoring techniques – Principles

A. CORROSION MONITORING

1. Corrosion coupons

Corrosion monitoring with coupons consists in exposing a specimen (coupon of the same material as the one to be monitored) to the environment for a given duration, and measuring the resulting weight loss.

It can also be used to assess localised corrosion such as pitting, crevice, etc.

Coupons only provide data for long time exposure to the corrosive fluids.

2. Bioprobes

Bioprobes are coupons used for monitoring microbiologically influenced corrosion (MIC), and for collecting biofilm samples for subsequent microbiological analyses.

3. Electrical Resistance Probe (ERP)

This technique is based on measuring the change in electrical resistance of the section of a conductive metal (sensitive element).

Metal loss is calculated by using the following formulae: $R = \frac{\rho L}{S}$, where

- R is the electrical resistance (Ω)
- ρ is the electrical resistivity of the metal ($\Omega.m$)
- S is the surface of exposed section (m^2).

Thus for a given length of element, the resistance varies inversely with the cross sectional area. When the thickness of the element is decreased by uniform corrosion attack, the reduction in thickness will cause a predictable change in its resistance.

Because the electrical resistivity of a metal varies with temperature, temperature compensation is required, and is provided by way of an internal metallic reference not exposed to the fluids such that its changes in electrical resistivity are used to cancel the temperature effect on the sensitive element.

ER monitoring allows periodic or continuous "real time" monitoring to be established for one or a multiple number of probes. Corrosion can thus be related to process variables.

ER probes have poor performance in sour environment.

4. Linear Polarisation Resistance (LPR)

LPR probes measure the corrosion current flowing between anodic and cathodic half cells. Measurements are made by applying a small voltage to a corroding metal electrode and measuring the resulting current flow. The ratio of voltage to current -the polarisation resistance- is inversely proportional to the corrosion rate.

The LPR technique is restricted to continuous conductive environments (water) and the minimum required conductivity is $10^{-5} \Omega.cm$.

General Specification		GS EP COR 161
Internal corrosion and erosion-corrosion monitoring: Design and installation		
Rev.: 06	Effective date: 06/2012	Page: 19 of 20

Appendix 1

LPR allow instantaneous and continuous corrosion rate measurements. However, they only measure metal loss due to electrochemical process, and cannot be used on oil and oily water systems.

5. Hydrogen probes

Hydrogen monitoring is the detection of hydrogen in steel exposed to wet sour gas (H₂S). Under sour service conditions hydrogen may be directly absorbed into the steel and produce blistering, embrittlement, stress corrosion cracking and other hydrogen induced problems.

Hydrogen monitoring probes are either attached to the exterior of the pipe with a saddle assembly or used as a patch unit welded onto the outside of the steel pipe.

This probe monitors the amount of hydrogen diffusing through the steel wall. Hydrogen monitoring instruments indicate the susceptibility of steel to HIC and hydrogen blistering by measuring the rate of atomic hydrogen permeation.

B. EROSION MONITORING

1. Erosion probe

The probe is based on the electrical resistance (ER) principle, where metal loss on the element is measured as increased electrical resistance in a sensing element exposed to erosion (usually by sand). The elements of an intrusive erosion probe used to monitor sand are typically constructed from a corrosion resistant alloy. Thus only erosion due to sand/solids is measured rather than metal loss due to corrosion.

Company does not allow this intrusive method to be used for subsea monitoring.

Although sand quantification is possible from erosion probes by using an erosion model to back-calculate the amount of sand required to erode the measured metal loss at the given process conditions, this device shall normally not be used for routine sand.

2. UT-mats

This monitoring technique is based on ultrasonic measurements. 'Guided waves' are sent from and to a number of UT sensors arranged to cover an area of piping that may be susceptible to erosion. The ultrasonic signal is generated in one sensor and passes through the wall of the pipe to another sensor some distance away. The sound waves are recorded over a period of time and changes in the signal received can indicate general wall loss between the two sensors. The waves travel through the wall of the pipe in broad bands and thus a wide surface area is included in calculating the average wall loss between the sensors.

The strip/mat type measurement system has a number of discrete UT transducers along its length which measure the wall thickness at each of those points.

C. SAND MONITORING

1. Acoustic sand detectors

Acoustic sand detectors are able to record the noise produced by sand particles travelling in process fluids through piping systems. The sand particles have kinetic energy and, on impact, some of this energy is converted into a high frequency noise. The noise travels through the metallic pipe wall and is picked up by the acoustic detector positioned on the outer surface of the pipe.

General Specification		GS EP COR 161
Internal corrosion and erosion-corrosion monitoring: Design and installation		
Rev.: 06	Effective date: 06/2012	Page: 20 of 20

Appendix 1

The acoustic sensor converts the sand impact ultrasonic noise/pulse into an electrical signal (in mV) that is transmitted, after being amplified/filtered and converted to a digital signal, via a cable to a dedicated computer.

With the detector positioned on a suitable pipe bend transporting fluids, the equipment will normally record a steady baseline reading with respect to time. This reading (in mV) represents the noise generated by the surrounding process equipment that is within the frequency range recorded by the detector. When sand is produced (generally in bursts rather than continuously), high frequency noise is produced by the impacting sand particles. The increase in noise intensity is recorded by the equipment as an increase above the baseline.

Non-intrusive acoustic detectors perform best on steady flowing lines rather than lines where production/process conditions are constantly changing. Changes in process conditions cause the baseline to increase & decrease and/or oscillate and it can become difficult to pin-point sand events.

When possible, acoustic sand detectors shall be calibrated. Calibration is generally carried out by injecting a known quantity of sand (with a size similar to this expected for particles contained in the fluids) into the process stream and measuring the response under known process conditions. The results are then combined to produce a calibration graph for the system which can be used to set sand calculation coefficients. Sand injection also provides proof that the system is capable of detecting sand.

Subsea detectors cannot be calibrated by sand injection. The equipment settings must therefore be based on averaged response tables/graphs provided by Supplier from sand injection work on other fields.