



Exploration & Production

GENERAL SPECIFICATION

CORROSION

GS COR 163

Application of chemical treatments for corrosion control

02	10/04	Include chlorination treatments. Include practical chemical dosage
01	09/03	Change of Group name and logo
00	10/02	First issue
Rev.	Date	Notes

Contents

1. Scope	3
2. Reference documents	3
3. Specific requirements per type of chemical	4
3.1 Corrosion inhibitor treatments.....	4
3.2 Biocide treatments	4
3.3 Oxygen scavenger	4
3.4 pH stabiliser	5
3.5 Chlorination.....	5
4. Equipment design and sizing.....	6
4.1 Injection flow rates	6
4.2 Storage tanks.....	8
4.3 Injection pumps.....	9
4.4 Injection nozzles	9
4.5 Pump-injection nozzle connections	10
4.6 Level gauge	10
4.7 Specific requirements for batch inhibitor treatments of pipelines	10
5. Inhibitor selection	12
5.1 Preliminary evaluation	12
5.2 Final evaluation.....	12
6. Treatment start-up and optimisation	13

1. Scope

Detailed requirements related to the design, construction and field implementation of following anti-corrosion chemical treatments:

- Corrosion inhibitors
- Biocides
- Oxygen scavengers
- pH stabilisation
- Chlorination (with regard to corrosion control purpose)

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

2. 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
Not applicable	

Professional Documents

Reference	Title
Not applicable	

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
GM COR 018	Design and Biocide treatment of closed and open drain vessels and circuits

Total General Specifications

Reference	Title
GS COR 162	Internal corrosion control in petroleum production installations

3. Specific requirements per type of chemical

3.1 Corrosion inhibitor treatments

Unless otherwise specified, corrosion inhibitor treatments are based on continuous injection.

An inhibitor availability of 95% shall be assured for flowlines (considering only one injection point). For trunklines, or when at least 2 fully independent injection devices are used, the inhibitor availability shall be of 98%.

Injection pump redundancy, detectors of injection shut-down, minimum storage capacity, injection flowmeters shall be adapted to these inhibitor availability requirements.

In particular cases batch treatments of pipelines are needed. Specific requirements for such treatments are part of this specification.

A specific inhibitor selection shall be performed as part of the project. The planning of this selection study shall allow the inhibitor availability on site from the start-up date, including all necessary time schedule for inhibitor fabrication and supply to the production site.

3.2 Biocide treatments

The most usual biocide treatment is a "shock treatment" at high concentration during a limited time period.

A pig is sent prior to a shock biocide treatment. Pig traps shall be made available for such pigging operations.

A continuous biocide treatment may be applied to water injection circuits during a limited time period (usually 3 months) when a reservoir souring must be prevented. If this treatment is needed, a specific injection system shall be installed for this purpose. This system may be a temporary one.

Specific biocide treatments may also be specified for closed and open drain facilities. The COMPANY shall supply the GM COR 018 document for the design and application of such specific treatments when needed.

3.3 Oxygen scavenger

Unless otherwise specified, no oxygen scavenger is required on production circuits.

Oxygen scavenger injection is required on water injection circuits involving aerated water (from sea, rivers, lakes, etc.).

The injection point is located in the middle of the stripping tower, below packing but above the water level.

Oxygen scavenger concentrations given on Table 12 are based on a product requiring 15 ppm/ppm of oxygen. In case of more concentrated or diluted products concentrations and flow rates shall be adjusted accordingly.

It shall be assumed that "catalyzed" oxygen scavengers are used when necessary (e.g. fresh water). Consequently, a complementary injection of a catalyst is not necessary, hence neither a storage tank nor any special injection system are required for the injection of the catalyst.

3.4 pH stabiliser

pH stabilisation is currently applied to glycol used for hydrate inhibition on gas pipelines.

MDEA, NaOH, KOH are among acceptable pH stabilisers. Other chemicals shall be subjected to Company's approval.

pH stabiliser concentration in the glycol shall be calculated for assuring a minimum in situ pH of 6.5 in sweet gas pipelines and 7.0 in sour gas pipelines at the highest operating pressure and at ambient temperature. The necessary concentrations are calculated with dedicated tools to be supplied by the Company, which take account of CO₂ and H₂S contents, glycol concentrations and operating pressure.

pH stabilisation is also applied to glycol used in gas dehydration facilities (DEG or TEG). Concentrations are determined according to GM COR 013, to be supplied by the Company.

The pH stabiliser is homogeneously mixed to the glycol prior to start-up. Further pH stabiliser addition is made in case of progressive pH decline. Such addition is currently performed every one to 3 months (depending on monitoring results). The added volume is of 5 to 10% of the initial volume. This addition is made progressively (injection duration of 12 to 24 hours) at the outlet of the glycol storage tank.

3.5 Chlorination

Chlorination must be applied to aerated water pumped for permanent water injection, for 3 distinct purposes:

- Preventing fouling,
- Preventing severe bacterial growth inside sand and multimedia filters, if any,
- Minimising the nutrient content of the injected water.

Following requirements apply to chlorination with regard to corrosion aspects:

- The injection is continuous as long as the water is pumped,
- The injection is automatically stopped during pumping shut-down.
- The chlorination unit shall be designed to provide 1 ppm residual chlorine content at the inlet of the deaeration tower, in addition to the content needed for reducing the maximum organic Carbon present in the water.

4. Equipment design and sizing

4.1 Injection flow rates

The design of injection systems is based on 3 different concentrations (Max, Average and Min.) and a 4th concentration is given as a basis for field implementation (Practical concentration), as defined here below:

- **Max concentration:** This concentration is used for calculating the max injection flow rate. The injection pump shall be designed for assuring this injection flow rate at the injection point, pressure losses in injection capillaries being included.
- **Average concentration:** This concentration is used for designing storage capacities. Unless otherwise specified, storage capacity shall be based on a 3 weeks availability when injected at the nominal concentration. In case of shock or batch treatments, are also indicated for calculating storage capacities are calculated with consideration of periodicities and duration indicated on table 1.
- **Minimal concentration:** Injection pumps shall be designed for assuring a reliable flow rate at this minimal concentration.
- **Practical concentration:** This concentration is a typical one applied in normal field operating conditions. This concentration is not considered for design.

Flow rates used for design are calculated by reporting these concentrations to the maximum water flow rate during the whole production period.

These concentrations are given on table 1 and 2 respectively for treatments applicable to production and injection facilities,

Table 1 - Chemicals injection rates for production facilities

Chemical	Inject mode	Condition	Max concent/ Water	Average concent/ Water	Minimal concent/ Water	Practical concentr/ Water	Periodicity/ Duration
WS Inhibitor	Continuous	Oil-Water line $T < 50^{\circ}\text{C}$	50 ppm	30 ppm	5 ppm	20	
		$50 \leq T < 80^{\circ}\text{C}$	100 ppm	50 ppm	10 ppm	50	
		$80 \leq T < 110^{\circ}\text{C}$	150 ppm	100 ppm	15 ppm	100	
		$T \geq 110^{\circ}\text{C}$	250 ppm	200 ppm	25 ppm	150 to 200	
WS Inhibitor	Continuous	Gas/condensate line, $T < 50^{\circ}\text{C}$	20 l/MSm ³	15 l/MSm ³	5 l/MSm ³	10 l/MSm ³	
		$50 \leq T < 80^{\circ}\text{C}$	25 l/MSm ³	15 l/MSm ³	5 l/MSm ³	15 l/MSm ³	
		$80 \leq T < 110^{\circ}\text{C}$	30 l/MSm ³	20 l/MSm ³	5 l/MSm ³	20 l/MSm ³	
		$T \geq 110^{\circ}\text{C}$	50 l/MSm ³	30 l/MSm ³	10 l/MSm ³	30 l/MSm ³	
Biocide	Shock	Oil or gas lines	1000 ppm	500 ppm	100 ppm	400 ppm	1 week / 5 hrs
Biocide + ox. scavenger		Long term cocooning of prod facility			500 ppm biocide + 100 to 200 ppm Ox scav. Or 1000 ppm multi-purpose chemical.		

Table 2 - Chemicals injection rates for injection facilities

Chemical	Inject mode	Condition	Max concent/ Water	Average concent/ Water	Minimal concent/ Water	Practical concent/ Water	Periodicity/ Duration
Chemical deaeration							
O ₂ scavenger	Continuous	Final deaeration of sea water	100 ppm	10 ppm	2 ppm	0 to 10 ppm	
Biocide treatments							
Biocide	Shock	Downstream deaeration	1000 ppm	500 ppm	100 ppm	400 ppm	1 week / 5 hrs
Biocide	Continuous	Souring prevention on Water injection	40 ppm	20 ppm	5 ppm	20 ppm	
Inhibition							
WS inhibitor	Continuous	Deaeration with produced gas with CO ₂	30	20	5	10	

Concentrations given on table 1 and 2 are based on following considerations:

- The commercial products are injected pure,
- Concentrations in active component are of 35% minimum.

The concentration in active component must be documented by the Supplier. In case of concentrations lower than 35%, injection rates must be adjusted accordingly.

In the case of gas lines or gas wells a dilution might apply at a 25 to 10% level, if the injection flow rate of pure product should be lower than 25 l/day. In this case, the injection flow rate and the storage tank shall be sized to accommodate this dilution. The solvent shall be adapted to the inhibitor used (long term stability of the mixture) and to the fluids to be inhibited.

All anti-corrosion chemicals (pure or diluted) shall have the minimum following requirements:

- A flash point above 45°C
- A freezing point lower than the minimum expected temperature in the conditions where it shall be stored. In case of too low service temperatures, a heating system shall be installed on the storage tank, or the whole injection system shall be installed in a temperature controlled environment.

4.2 Storage tanks

A tank shall be scheduled for each product.

Tanks shall be made of materials resisting corrosion from the stored product, especially for the oxygen scavenger which is generally corrosive when concentrated. Blanketing may be required for chemicals which are volatile or easy to be oxidised.

Each tank shall be equipped with an individual system for filling enabling:

- Filling from product delivered in container (bulk)
- Filling from product delivered in drums.

Any tank whose capacity exceeds 2 m³ shall be equipped with an inspection hole.

Replaceable containers (≈ 1 m³ volume) are another possible option. Such containers shall be installed in an easily accessible location for periodic installation/removal by crane. An easily connecting device shall be used for connecting the container to the pumping unit.

It is the responsibility of the Contractor to document which type of storage tanks must be selected, based on existing practices and equipment on surrounding facilities.

Each tank or container shall be equipped with reglementary safety devices corresponding to the class of the stored products.

Each tank or container shall be equipped with a level gauge.

Tanks used for products or mixtures with a tendency to precipitate or separate shall be equipped with a mixer.

4.3 Injection pumps

Pumps shall be of the volumetric type with variable flow obtained via control of the piston path. Flow rate controlled by stroke frequency are not allowed (no more continuous in case of frequencies < 1 stroke/s).

It shall be possible to measure the injection flow rate either with a dedicated flow meter or by pumping for 30 sec to 1 minute from a calibrated gauge.

Multiple head pumps are acceptable.

One pump or pump head per injection point is mandatory.

Under no circumstances shall parallel injection over several points be allowed unless instruments are provided to control the injection rate at each point.

For each injected product, a minimum of one complete spare pump shall be provided. The total number of heads in reserve shall not be less than 25% of the number of heads in service.

For each injected product, an auxiliary tank with a graduated level gauge enabling control and monitoring of the flow shall be installed next to the pumps. All piping and valves required for proper operation shall be provided.

Auxiliary tank size and design shall be such that level fluctuation is approximately 2.5 cm per minute for nominal flow rate.

Each head shall be equipped with a safety valve to limit discharge pressure to the required pressure value.

The discharge line shall be looped back to the storage tank.

A pressure gauge shall be installed on each outlet for enabling regulation of pressure in the piping.

4.4 Injection nozzles

Injection nozzles shall be of a model that assures proper atomisation/distribution of the inhibitor in the effluent.

They shall be designed so as to limit cooking and plugging to a minimum and shall be equipped with a device to prevent any accidental back up of effluent into the inhibitor injection system.

Injection nozzles shall be fitted with a device enabling their installation and removal without previous decompression or draining of the system on which they are installed.

They shall be installed as far upstream of the system to be protected as possible, preferably in a region of strong turbulence to favour dispersal of the inhibitor.

4.5 Pump-injection nozzle connections

Pump-injection nozzle connections shall be constructed with corrosion resistant materials likely to resist both to the products themselves and to the external environment.

So as to reduce transfer time between pump and injection nozzle to a minimum, connections shall be along the shortest possible path and having the smallest diameter compatible with allowable pressure drop.

Systems shall be designed to withstand a pressure equal to the pump safety value setting pressure, as specified by the MANUFACTURER, increased by 10%.

If maximum design pressure for the protected system is greater than the value defined above, the inhibitor system shall be designed on the same basis as the protected system.

The injection system outlet shall be equipped with a shut-off valve and drain valve.

4.6 Level gauge

The tank and/or pump level gauge shall be maintained clear in order to always have good visibility of leveling the products or precise injection dosage adjustment. It shall be made from the materials which will never be blurred by the products. Glassware is preferable.

4.7 Specific requirements for batch inhibitor treatments of pipelines

Two types of periodic treatment may be envisaged depending on whether the protected lines are equipped with pig traps or not.

Treatment may be performed either by:

- Sending out a batch of diluted inhibitor between two pigs
- Sending out a high concentration of inhibitor (typically 1000 to 5000 ppm) in the produced fluid over a determined period of time (concentration and duration to be specified within particular requirements of each project)
- Increasing the nominal injection rate by a factor 3 during 24 hours.

4.7.1 Batch treatment between two pigs

The diluted inhibitor quantity is calculated assuming that there will be 0.1 mm of inhibitor on the pipe surface.

$$Q = 3.14 \times 10^{-4} \cdot D \cdot L$$

Where:

D: pipe internal diameter in meter

L: pipe length in meter

Q: pure inhibitor volume in m³

At the pipe end, the “remaining volume” of the batch should be sufficient to have about “T” seconds of contact time. The remaining volume is:

$$RQ = T \times V \times D^2 \times 0.785$$

V: flow velocity of batch (m/s)

T minimum value shall be of 5 s.

The total volume (filling and remaining solution) is:

$$TQ = Q + RQ = 3.14 \times 10^{-4} \cdot D \cdot L + T \times V \times D^2 \times 0.785$$

In addition to pig traps this type of treatment requires an isolated spool piece directly downstream from the pig trap, equipped with an additional shut-off valve. This sleeve length shall be at least equal to L1+L2; L2 being equal to the length of the pig used and L1 the length of the sleeve whose internal volume in liters corresponds to the volume of the corrosion inhibitor diluted as a 10% solution in diesel or other solvent.

This sleeve shall have:

- Two drain holes connected to the main drainage system and located so as to enable:
 - Positioning of the first pig at the sleeve end
 - Emptying of the sleeve after the first pig is positioned
- A hole for filling the sleeve with inhibitor
- A 2" access fitting with valve and quick connector, enabling connection to the filling system.

Unless otherwise indicated in the list of special requirements, filling is carried out from mobile units.

When pipeline diameter and/or length is such that a sleeve with this size cannot be built, especially for offshore units, a simplified procedure shall be adopted, i.e., sending out a batch of inhibitor immediately after the pig is sent out.

Unless otherwise indicated in the list of special requirements the access fitting shall be 2", immediately upstream of the pig launcher shut-off valve, which allows for sending out of another pig during the batch injection period.

4.7.2 Sending out of a batch of inhibitor for a determined period of time

In this case there is no pig traps. Increasing the injection rate during a period of time is also possible.

A 2" access fitting with shut-off valve and quick connector shall be provided upstream of the system to be protected.

Inhibitor concentration and injection duration, as well as any dilution if needed shall be included in the list of specific requirements. Storage and injection capabilities shall be designed accordingly.

Unless otherwise specified, a specific injection system shall be allocated to this treatment (possible distinct product). Using a portable injection system shall be considered as a possibility.

4.7.3 Temporary increase of continuous injection rate.

This case shall be considered similarly as continuous injection, using the same product, the same injection system and same storage tanks.

Unless otherwise specified, the temporary concentration shall be 3 times higher than the nominal concentration (indicated on table 3), the injection duration shall be of 24 hours and the frequency shall be weekly. Pump injection rate and storage tank sizing shall be adjusted to these complementary injection requirements.

5. Inhibitor selection

Inhibitors shall be selected via a two-step procedure:

5.1 Preliminary evaluation

The expected service conditions and fluid compositions shall be given to MANUFACTURERS.

The preliminary evaluation shall be a pre-selection of about ten products from those proposed by various MANUFACTURERS. Pre-selection shall be based on test results provided by the MANUFACTURERS themselves or on results obtained from previous field experience.

Based on these conditions, the MANUFACTURER shall propose 1 or 2 products. For each product, the MANUFACTURER must provide as a minimum:

- Test results obtained in comparable conditions, or results obtained from previous field experience
- ½ L of sample
- The Finger Print of the product obtained by an appropriate technique
- Safety, technical, and toxicity data sheets.

Chemical SUPPLIER shall also check if its products can satisfy local environmental regulations.

The pre-selection shall consist in verifying that the documentation and results provided satisfy to the minimal requirements for the application considered with regard to Health and Safety, environmental issues and inhibitor performance.

5.2 Final evaluation

Ranking of pre-selected products after a new series of tests in a laboratory designated by the COMPANY.

The test series shall include, as minimum:

- Solubility/Dispersibility tests.

- Emulsion and foaming tendency tests, done to find the minimum inhibitor concentration which can create the emulsion problems and to provide comparative emulsion and foaming performance of the tested products.
- Inhibitor efficiency tests, including LPR and/or ER tests + weight loss measurements, at predetermined optimum dosages in static conditions (bubble test). Testing conditions (water composition, temperature, CO₂ and H₂S contents, etc., shall be selected to be representative of actual service conditions.
- Partitioning tests, performed to estimate the Oil-Water partitioning of the inhibitor and the residual fraction of inhibitor remaining in the water.
- Thermal stability tests (solid formation/deposition, separation and inhibitor efficiency test before and after ageing).
- Tests for compatibility with other envisaged additives.
- Flow loops testing and/or water jet impingement testing of best three products having the best performances in previous tests.

Selection studies shall allow determining the minimum inhibitor concentration required for the application considered.

In addition to the complete test results the following documentation shall be delivered for the 2 or 3 products finally selected:

1. Safety and technical data sheet
2. Eco-toxicity data
3. A detailed inhibitor titration procedure applicable on site.

6. Treatment start-up and optimisation

The chemical SUPPLIERS shall optimise the treatment within three months after the start-up of the installation in the presence of COMPANY representatives.

The chemical SUPPLIER shall provide the necessary test material for optimisation and shall advise about the adequacy of the corrosion monitoring system.

At the end of the operation, the SUPPLIER shall submit a report summarizing his observations and specific instructions.

He shall undertake to intervene free of charge upon the request of the COMPANY, if treatment efficiency is inadequate. He will check whether his instructions have been followed and whether the injection rates are those corresponding to optimum treatment.