

GENERAL SPECIFICATION

CORROSION

GS EP COR 560

Physical and chemical treatment of hydrostatic test water
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07	10/2012	Requirement to particle size reduced to 50 µm
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1. Purpose

This document defines the minimum requirements for physical and chemical treatments of water used for hydrostatic testing of pipelines.

2. Application

It applies to all production and injection pipelines, whatever the fluid contained in service. On the other hand it does not apply to surface piping, vessels and tanks.

It is limited to treatments required to prevent:

- Corrosion of materials during pressure testing, or after resuming operations, due to the presence of this water
- Massive contamination of the tested equipment by bacteria, which are likely to remain in the circuits after dewatering, in any case where these bacteria may have any further detrimental effect.

It does not cover specific pipeline treatments such as cleaning, decontamination, long term preservation, drying ...

3. 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
Not applicable	

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4. Treatment required

4.1 Water qualities

The following waters can be considered for pressure testing:

- Potable water, either from natural sources or dedicated processes,
- Water from wells or opened laguna
- Sea water from opened seas

The use of the following waters shall be avoided unless no other possibility exists:

- Brackish water
- Water from shallow lakes, ponds, rivers, closed laguna
- Sea water from harbors.

If there are no other possibilities than to use one of these waters, they shall be subjected to reinforced filtration and anti-bacterial treatments and to the approval of Company.

4.2 Physical treatment

4.2.1 Filtration

Unless otherwise specified, all the water used shall be filtered to a maximum particle size of 50 µm before use.

4.2.2 Water pumping

Unless incompatible with the water depth, the water shall be pumped at a depth below 20 m from surface and above 15 m from bottom. *This aims at minimizing in the water the amount of solid particles, bacteria and organic carbon acting as nutrients for micro-organisms.*

A filtration to 25 µm shall be done if these criteria cannot be fulfilled.

4.3 Chemical treatment

Applicable chemical treatments may consist in one or several of the following solutions, depending on the material of the pipeline, its function and the fluid it will contain, the temperature of the hydrotest water and how long the hydrotest water is maintained inside the pipeline:

- Treatment 1: Biocide treatment only
- Treatment 2: Oxygen scavenger treatment
- Treatment 3: Dual oxygen scavenger and biocide treatment, using a so-called "bi or tri-functional product"
- Treatment 4: Chloride control

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- Treatment 5: pH control of the water
- Treatment 6: Chlorination.

Specifications applicable to these six treatments are given in Appendix 1.

4.3.1 Choice of the base case treatment

Among the six treatments listed here above, Table 1 here after defines the base case one to be used, depending on the pipeline type and its inner material. As "base case" treatments they shall be applied by default, unless additional conditions defined in the following paragraph allow simplifying/ modifying them under specific conditions.

Table 1 - Base case treatments

Type of pipe & Inner material	Treatment mode	Comments	Alternate or modified solutions
Rigid, C Steel	3	Considering sea water or utility water	See § 4.3.2.1
Rigid, CRA	4	No sea water permitted	See § 4.3.2.2
Flexible, CRA carcass	4	No sea water permitted	See § 4.3.2.3

4.3.2 Alternate or modified treatments

In the following sub-paragraphs, alternate or modified treatments from those defined in Table 1 are defined in order to simplify field operations, under specific conditions regarding either:

- The total duration of the exposure with the hydrotest fluid
- The fluid which the pipeline is expected to transport during its field life (e.g. gas, oil, water...)
- The maximum temperature which the pipeline is expected to experience during its hydrotest.

Duration of exposure: This estimated maximum duration must include all possible planning contingencies such as operational delays related to drilling or installation operations. The end of exposure is the time when the hydrotest water is dumped out of the pipeline and replaced by an inert fluid with respect to corrosion modes prevented by the hydrotest fluid (e.g. replacing a treated sea water used as hydrotest water by a fresh non treated sea water does not represent the end of exposure).

Transported fluids during service life: The pipeline(s) under consideration shall be classified either as:

- **MIC susceptible:** Pipelines classified as such are those which are susceptible to experience Microbial Induced Corrosion (MIC) during their service life, i.e. requiring prevention of bacterial contamination from the hydrotest water. Included in this category are normally but not strictly restricted to: oil export pipelines, oil- water pipelines,

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multiphase oil pipelines, produced water pipelines, water injection pipelines, wet gas-condensate pipelines likely to contain reservoir water.

- **No MIC:** Pipelines classified as such are those which are not significantly susceptible to experience Microbial Induced Corrosion (MIC) during their service life, i.e. not requiring prevention of bacterial contamination from the hydrotest water. Included in this category are in general: Dry gas pipelines, wet gas - condensate pipelines only susceptible to transport condensed water, wet gas pipelines downstream a gas- liquid separation or downstream a compression process, gas-lift and gas injection pipelines, Methanol and glycol pipelines, condensate export pipelines.

The classification shall be submitted to Company's approval.

Maximum temperature during the hydrotest: This temperature is the stabilized maximum temperature during the hydrotest period, due to either the maximum sea water temperature if fully immersed, the maximum soil temperature if fully buried or the maximum temperature of the aerial section, if any. No transient temperature due to water filling or any other momentaneous operation is considered.

4.3.2.1 Alternate or modified treatments for C Steel pipelines

Table 2 defines alternate treatments which can be applied instead of the base case treatments if particular conditions of temperature, MIC susceptibility and duration are fulfilled.

Table 2 - Alternate treatments for C Steel pipelines

MIC susceptibility?	Duration < 1 month	1 to 6 months	>6 months
MIC susceptible	Treatment 6	Treatment 3	Treatment 3
No MIC & T ≤ 15°C	No treatment	No treatment	Treatment 2 or 5
No MIC & T > 15°C	No treatment	No treatment	Treatment 3

Additional modifications/ relaxation can also be envisaged on a case by case basis and submitted to Company approval in specific conditions described here after:

- **Removing the oxygen scavenger treatment, i.e. cancelling treatment 2 or moving from treatment 3 to 1:** This situation is acceptable if the following conditions are all fulfilled:
 1. No stainless steel section is present along the pipeline
 2. No internal coating inside
 3. The process downstream the pipeline is not susceptible being disturbed by iron oxide particles which may be formed inside the pipeline: As a base case an acceptable mass of 100 kg over the whole length is acceptable, corresponding to $D^2 * L < 8000$ (D = nominal diameter in inch and L = length in km).
- **Not applying any conventional biocide treatment** (as defined in treatments 1 and 3) because of large water volumes posing environmental issues due to discharge: Following alternate solutions may be considered:
 1. Use of potable water, if compatible with the necessary volumes

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2. Combining treatments 2 and 5 if an oxygen scavenger is needed as per previous criteria
3. Combining treatments 5 and 6 if MIC control is essential (MIC susceptible pipelines).

In any case the solution to be adopted for this particular conditions shall be specifically documented and subjected to Company's approval.

4.3.2.2 Alternate or modified treatments for rigid CRA pipelines (plain or internally clad)

The base case treatment consists in using fresh water with a low chloride content (variable depending on the CRA material used) as per Treatment 4, with no oxygen scavenger treatment.

Using more salty water up to sea water but not exceeding sea water salinity can be considered taking into account the restrictive conditions given in the following Table 3.

NB: The "MIC susceptible" criteria in the following table refers to downstream facilities in C Steel and not only to the pipeline in CRA itself (*bacterial development in the CRA section may be detrimental to downstream CS facilities*).

Table 3 - Possible conditions for using salty water/ sea water on CRA pipelines

CRA material	Additional condition	Duration < 1 month	1 to 6 months	> 6 months
Martensitic material, AISI 304L - 321		Cl ⁻ ≤ 250 mg/l + treatment 4 (O ₂ scavenger) - sea water not permitted		
AISI 316L	MIC sensitive, T < 15°C	No treatment	Treatment 3 (or 1 + 2)	Treatment 3 (or 1 + 2)
	MIC sensitive, T > 15°C	Treatment 2	Treatment 3 (or 1 + 2)	Treatment 3 (or 1 + 2)
	No MIC, T < 15°C	No treatment	Treatment 2	Treatment 2
	No MIC, T > 15°C	Treatment 2	Treatment 2	Treatment 2
Duplex 22 and 25% Cr	MIC sensitive, T < 15°C	No treatment	No treatment	Treatment 3 (or 1 + 2)
	MIC sensitive, T > 15°C	No treatment	Treatment 3 (or 1 + 2)	Treatment 3 (or 1 + 2)
	No MIC, T < 15°C	No treatment	No treatment	Treatment 2
	No MIC, T > 15°C	No treatment	Treatment 2	Treatment 2

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The quality of the deaeration of all the water used is essential when Treatments 2 or 3 are applied. All monitoring requirements specified in Appendix 1 for these treatments shall be defined in operating procedures and subjected to review by the Company. No water shall be injected without prior verification that the residual oxygen content is within the 0 - 50 ppb range. Water injection shall be interrupted in case of an higher value, until resuming a normal situation.

4.3.2.3 Alternate or modified treatments for flexible pipelines

Alternate treatments for flexible lines are selected by reference to the material the less resistant to corrosion among carcass and connectors.

The same alternate solutions given here above for rigid CRA pipelines can also be applied to flexible lines, apart for the following exception:

- Carcass material in AISI 304L or 321 is subjected to similar treatment capacities as for AISI 316L in rigid pipelines.

4.4 Selection of chemicals

Chemicals proposed by Contractor shall comply with the requirements defined in Appendix 1 and also meet any safety and environmental protection requirements.

4.4.1 Treatment application

Treatment application conditions shall ensure that the products used are **uniformly distributed at the recommended concentration throughout the volume** of test water.

The following Table 4 indicates acceptable treatment solutions, depending on how the water is supplied:

Table 4 - Acceptable treatment conditions, depending on water source

Water input		
Direct from water mains or by pumping	Surge tank between source and injection	Holding tank
A	A or B	C

A	Continuous injection of the product(s) before the water enters the pipeline, using a positive displacement pump with delivery adjusted to the water injection rate to obtain the required concentration.
B	Batch injection of the product at the inlet of the surge tank (to guarantee effective mixing). This addition must be made at a frequency corresponding to the drainage time of half of the effective volume of the surge tank.
C	Introduction of the product into the tank before it is filled.

When solution A is used, the distance and the reaction time upstream of the pipe inlet shall be sufficient to assure a uniform concentration over the treated fluid and to assure a relevant monitoring.

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Solution B shall not be used when an oxygen scavenging treatment is required (Treatments 2 and 3), unless the surge tank is blanketed.

When an oxygen scavenger is applied with solution C, the product shall be injected and mixed at the last possible moment, immediately prior to injection (within 1 minute before injection).

Contractor shall use one of these methods, or propose a method with an equivalent result.

4.4.2 Draining, rinsing and cleaning after test

Most treatments are designed for prolonged residence in the tested pipeline. No draining, rinsing and cleaning is currently required after hydrotesting for the sole corrosion control purpose. In particular cases where this should be required at the end of the test, conditions of these operations are described in Appendix 1.

Further treatment, such as decontamination, oil circulation or drying, shall be defined on a case-by-case basis.

4.4.3 Discharge of test fluids

Test fluids shall be discharged in full compliance with local regulations.

4.5 Monitoring

Monitoring shall be used to check that the result of the treatment meets the specifications.

The types of monitoring and acceptance criteria defined for each treatment in Appendix 1 shall be used.

5. Operating procedure documentation

The operating procedures submitted to the Company for approval shall include:

- The treatment method
- The chemicals used, their data sheets, material safety data sheets and, if necessary, certificates of conformity or analysis
- Monitoring procedures and associated acceptance criteria
- Conditions required for discharge of treated water.

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Appendix 1 Specification of treatment methods

1. Treatment method No. 1

1.1 Treatment purposes

Bactericidal, to minimize the flora of bacteria and prevent their corrosive behaviour.

1.2 Treatment chemicals

Function	Chemical composition	Minimum dose
Biocide	Glutaraldehyde	100 ppm vol of active component*
Biocide	Quaternary ammonium	100 ppm vol of active component*
Biocide	THPS	100 ppm vol of active component*

* i.e. 200 to 500 ppm vol of usual commercial products, depending on their concentration in active compounds.

1.3 Special treatment conditions

With Glutaraldehyde and THPS based biocides, dosages here above are for durations of 3 months maximum. This dosage is doubled for a 3 to 6 months duration and still doubled for a longer period than 6 months.

For quaternary ammonium biocide, the dosage is doubled only for more than 6 months duration.

1.4 Draining and rinsing

Draining and rinsing are not required from a corrosion point of view.

1.5 Discharge of fluids

As far as the water is disposed to the environment, the THPS biocide is the preferred solution, if compatible with local regulations.

The fluid discharge procedure shall be submitted to the Company for approval before the operation. The possible environmental impact shall be documented.

1.6 Monitoring required

Water samples shall be collected at the outlet of the line after filling for biocide analysis in order to monitor the compliance with the specified dosage. The acceptable level is 80% of the required dosage (minimum).

* These concentrations are specified for new equipment, not subject to massive biofilm growth prior to the pressure test. Higher concentrations (250 ppm active component) shall be specified for equipment previously in service or previously filled with untreated water.

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2. Treatment method No. 2

2.1 Treatment purposes

Remove the dissolved oxygen.

2.2 Treatment chemicals

Function	Chemical composition	Minimum dose
Oxygen scavenger	Catalysed sodium or ammonium sulfite or bisulfite	See here after*

* O_2 scavenger dosage (ppm vol) = Dissolved O_2 concentration in water (mg/l) * Stoichiometric oxygen scavenger efficiency (ppm vol/ mg/l of O_2) * 1.2:

- If not measured on site, the dissolved O_2 concentration can be roughly determined from the following table (in mg/l):
- The stoichiometric efficiency of the product used is given in the data sheet of the product used (currently 12 to 20 depending on the concentration of the active component).
- The 1.2 factor represents a 20% margin above stoichiometry.

Dissolved O_2 content (mg/l)	Fresh water	10 g/l salinity	Sea water
5 °C	12.8	12	9.9
10 °C	11.3	10.6	8.8
15 °C	10.1	9.5	7.9
20 °C	9.1	8.6	7.2
25 °C	8.3	7.8	6.6
30 °C	7.6	7.1	6.1

2.3 Special treatment conditions

Base case injection mode: on line with a dedicated pump, with no contact with air downstream the injection point.

If the oxygen scavenger must be mixed with the water in a tank, the mixture must be done immediately before starting the injection (mixing during a few seconds) to minimize the contact with air.

If a glutaraldehyde or THPS biocide must also be injected, it shall be injected on a separate injection point, downstream of the oxygen scavenger. The pipe length between the two injection points shall correspond to a reaction time of 30 seconds minimum for the oxygen scavenger mixed with water.

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Appendix 1**2.4 Draining and rinsing**

Draining and rinsing are not required from a corrosion point of view. The water can be kept in the pipeline for whatever time.

2.5 Discharge of fluids

No particular issue if no biocide is also added. Refer to Treatment 1 if a biocide is also added.

2.6 Monitoring required

Regular dissolved oxygen monitoring shall be done at the inlet of the pipeline at repeated periods during the injection phase is required (Stat-up then every 20% of the total volume to be injected).

A residual dissolved Oxygen content below 50 ppb shall be reached.

If the reaction time from injection point to sampling point is sufficient, the measurement can be done on line from the sampling point. If no sufficient reaction time, the treated water is collected in a bottle, fully filled and closed without contact with air. The measurement is carried out after 2-3 minutes to assure the necessary reaction time.

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3. Treatment method No. 3

3.1 Treatment purposes

Oxygen removal and biocidal treatment.

3.2 Treatment chemicals

Function	Chemical composition	Minimum dose
Oxygen scavenger + Biocide	Sulphite/bisulphite Glutaraldehyde or THPS	Same as for treatment n° 2 100 ppm of active component*
Multi-purpose (O ₂ scav. + biocide)	Sulphite/bisulphite + quaternary ammonium	500 ppm

* This treatment with 2 separate products (Glutaraldehyde or THPS as biocides), is equivalent to treatments 1 + 2. Dosages here above are for durations of 3 months maximum. This dosage is doubled for a 3 to 6 months duration and still doubled for a longer period than 6 months, as for treatment 1.

3.3 Special treatment conditions

If two separate chemicals are used (1st line of the table) reference shall be made to § 2.3 of treatment 2.

3.4 Draining and rinsing

Unecessary.

3.5 Discharge of fluids

As far as the water is disposed to the environment, the THPS biocide is the preferred solution, if compatible with local regulations.

The fluid discharge procedure shall be submitted to the Company for approval before the operation. The possible environmental impact shall be documented.

3.6 Monitoring required

3.6.1 At the injection point

During filling with test water: Same as for treatment 2 as regards the periodic dissolved oxygen monitoring.

3.6.2 At pipe outlet

Water samples shall be collected at the outlet of the line after filling for biocide analysis in order to monitor the compliance with the specified dosage. The acceptable level is 80% of the required dosage (minimum).

* These concentrations are specified for new equipment, not subject to massive biofilm growth prior to the pressure test. Higher concentrations (2.5 to 3 times higher) shall be specified for equipment previously in service or previously filled with untreated water.



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3.7 Observations

This treatment allows the water to remain for prolonged periods above one year as long as biocide dosages have been adjusted in the pipeline without any significant risk of corrosion. It also helps to avoid the formation of iron oxide deposits.

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4. Treatment method No. 4

- Type of water: Fresh or utility water
- Materials: Stainless Steels (plain or internally clad)

4.1 Treatment purposes

This so-called treatment is aimed at using a low chloride water without any additional treatment for the hydrotesting of stainless steels.

4.2 Water quality

This treatment mostly consists in simply using a water with a sufficient low amount of chlorides and dissolved iron, depending on the CRA material used. Chloride limits are given in the following table for Stainless Steel pipelines considering:

- No oxygen scavenger is applied
- Temperatures up to 40- 50°C on aerial sections (not buried nor immersed)
- No limitation of exposure.

Inner material	Maximum chloride contents	Additional requirements
Martensitic SS, AISI 304L, AISI 321	25 mg/l	Total iron content < 5 mg/l
AISI 316L	100 mg/l	Total iron content < 5 mg/l
Duplex 22 and 25% Cr	250 mg/l	Total iron content < 5 mg/l

4.3 Special treatment conditions

None, as no chemical is added.

4.4 Draining and rinsing

Rinsing shall be done with the produced fluid or a water of similar quality. No sea water allowed.

4.5 Discharge of fluids

Discharge is not an issue because of no applied chemical

4.6 Monitoring required

Chloride content shall be monitored before start-up and periodically along the injection phase. Samples shall be preserved for further analyses.

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5. Treatment method No. 5

- Type of water: Utility water or potable water

5.1 Treatment purposes

This treatment aims at increasing the pH of the water used for hydrotest.

5.2 Treatment chemicals

Function	Chemical composition	Minimum dose
pH increase	Sodium or potassium hydroxide, sodium carbonate	Increase the pH to 9

5.3 Special treatment conditions

This treatment applies to water containing a low enough amount of calcium to prevent deposition due to the pH increase.

This shall be verified by a lab test consisting in increasing the pH with the selected product up to the specified value and verifying that this addition has no visual effect on deposition or water clarity. This test also allows measuring the exact amount of product to be added to reach the required pH

5.5 Draining and rinsing

The pipeline can be either left full until production start up or completely drained, dried and inerted.

5.5 Discharge of fluids

The fluid discharge procedure shall be submitted to the Company for approval.

5.6 Monitoring required

The pH of the injected water shall be monitored periodically

5.7 Observations

After de-watering the line should be either put in service or dried and inerted with nitrogen.

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6. Treatment method No. 6

- Type of water: All

6.1 Treatment purposes

Bactericidal treatment with low environmental impact.

6.2 Treatment chemicals

Function	Chemical composition	Minimum dose
Chlorination	Sodium hypochlorite	25 ppm free chlorine (see note and § 6.3)
Note: 25 mg/l chlorine = 150 ppm vol of sodium hypochlorite at 48 chlorometric degrees		

6.3 Special treatment conditions

This treatment shall not be applied to any pipeline which consists of stainless steel sections, even short.

The TOC (Total Organic Carbon) of the water shall be measured prior to the operation, either directly or by measuring the immediate residual chlorine after having added to a water sample a known concentration of chlorine (the difference between the added concentration and the measured concentration representing the immediate chlorine concentration by the organic carbon contained).

The specified 25 mg/l free chlorine assumes an immediate consumption ≤ 5 mg/l. In case of higher consumption, the hypochlorite concentration is increased to achieve 20 mg/l minimum residual chlorine at the pipe inlet.

6.4 Draining and rinsing

Draining and rinsing are not required from a corrosion point of view. The water can be kept in the pipeline for whatever time.

6.5 Discharge of fluids

No particular issue, because of the rapid consumption of the chlorine to chloride inside the pipeline.

6.6 Monitoring required

- Measurement of chlorine consumption by the organic carbon shall be carried out prior to operation, in order to adjust hypochlorite injection rate (see § 6.3).
- Residual chlorine at the inlet of the pipeline shall be monitored regularly to verify the injection rate and adjust it if residual chlorine < 20 mg/l.