



# Engineering Standard

SAES-A-007

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## Hydrostatic Testing Fluids and Lay-Up Procedures

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## Saudi Aramco DeskTop Standards

### Table of Contents

1	Scope.....	2
2	Conflicts and Deviations.....	2
3	References.....	3
4	General Requirements.....	3
5	Carbon Steel and Low Alloy Steel Equipment.....	6
6	Stainless Steel Equipment.....	13
7	Special Requirements.....	14
8	Hydrostatic Test Water Preparation.....	17
9	Disposal.....	17
10	Safety.....	17
11	Corrosion Control, Water and Chemical Treatment Subcommittee.....	18
	Appendix 1 – Approved Oxygen Scavengers.....	20
	Appendix 2 – Dew Point of Natural Gases.....	21

## 1 Scope

- 1.1 This standard establishes requirements to control corrosion and microbiological damage during and after hydrotesting of new, revalidated, and refurbished equipment when equipment is hydrotested in accordance with SAES-A-004, SAES-L-150 or as required by other standards that specifically reference SAES-A-007.
- 1.2 Equipment covered by this standard includes, but is not limited to, storage tanks, pressure containing equipment, plant piping, and pipelines both onshore and offshore.
- 1.3 The procedures in this standard are designed to prevent corrosion due to oxygen (air) ingress and to prevent microbially induced corrosion. Hydrotest procedures and lay-up procedures shall prevent oxygen ingress except as specifically allowed in this standard.
- 1.4 Non-toxic liquids other than water may be used for pressure testing if the operating fluid or the equipment can be adversely affected by water or by freezing conditions. Water/methanol or water/glycol mixtures may be required in locations where freezing is a concern. Contact the Supervisor, Corrosion Technology Unit, Materials Engineering and Corrosion Control Division, Consulting Services Department (CTU/ME&CCD/CSD), for the selection and treatment of the appropriate fluid. Such a fluid shall not have a flash point below 54°C (129°F).
- 1.5 Special requirements for specific systems are presented in Section 7 of this Standard. If there is an apparent conflict between Section 7 and the general requirements in the remainder of the Standard, Section 7 shall govern.

## 2 Conflicts and Deviations

- 2.1 Any conflicts between this standard and other applicable Saudi Aramco Engineering Standards (SAESs), Materials System Specifications (SAMSSs), Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer's Representative through the Manager, Consulting Services Department of Saudi Aramco, Dhahran.
  - 2.2 Direct all requests to deviate from this standard in writing to the Company or Buyer's Representative, who shall follow internal company procedure SAEP-302 and forward such requests to the Manager, Consulting Services Department of Saudi Aramco.
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### 3 References

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities required by this Standard shall comply with the latest edition of the references listed below, unless otherwise noted.

- Saudi Aramco References

Saudi Aramco Engineering Procedures

<i>SAEP-302</i>	<i>Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement</i>
<i>SAEP-327</i>	<i>Disposal of Wastewater from Cleaning, Flushing, and Dewatering Pipelines and Vessels</i>
<i>SAEP-1026</i>	<i>Boilers Lay-up Procedures</i>

Saudi Aramco Engineering Standards

<i>SAES-A-103</i>	<i>Discharges to the Marine Environment</i>
<i>SAES-A-004</i>	<i>Pressure Testing</i>
<i>SAES-B-069</i>	<i>Emergency Eyewashes and Showers</i>
<i>SAES-J-901</i>	<i>Instrument Air Supply Systems</i>
<i>SAES-L-150</i>	<i>Pressure Testing of Plant Piping and Pipelines</i>
<i>SAES-S-060</i>	<i>Saudi Aramco Plumbing Code</i>
<i>SAES-S-070</i>	<i>Installation of Utility Piping Systems</i>

### 4 General Requirements

4.1 In the case of new construction, the construction agency shall be responsible for adhering to this specification; Projects Inspection shall be the monitoring authority. For existing facilities, the facility proponent Maintenance and Operations shall be responsible for adhering to this specification; the proponent's Operations Inspection organization is the monitoring authority.

4.2 Water Quality

4.2.1 Water quality of intended hydrostatic test waters shall be determined well ahead of the actual testing date so that alternative water sources may be identified if the original source water fails to meet requirements.

4.2.2 Water quality of hydrostatic test waters shall be reconfirmed by testing as close to the time of the hydrostatic test as practicable. In cases where

individual tanker trucks are used to supply a test, the water samples shall be drawn from a representative number of actual truck loads being delivered to the test site.

- 4.2.3 Water used for any part of the hydrotesting or subsequent lay-up shall have a sulfate reducing bacteria (SRB) count of  $10^3$  per ml or less as determined by the RapidChek II Method or alternative test method approved by Supervisor, CTU/ME&CCD/CSD. Water that has a higher bacteria count may be accepted at the discretion of the Supervisor, CTU/ME&CCD/CSD, after treatment with biocide and retesting.

*Commentary Note:*

*RapidChek is available by Direct Charge Purchase Requisition from:*

*Strategic Diagnostics Inc.,  
111 Pencader Drive  
Newark, DE 19702, USA  
Phone +1-(302) 456 6789*

*www.sdix.com Product SD50950*

*RapidChek provides a fast, field-friendly method of measurement. Other conventional bottle tests may take 4 to 6 weeks. The cost of a RapidChek test kit is on the order of \$10 per test, supplied as a ten test kit.*

- 4.2.4 If water from more than one source will be used, ensure that mixing the waters will not cause scaling.

*Commentary Note:*

*Saudi Aramco engineers may contact R&DC Formation Damage & Stimulation Unit to run scale prediction programs or tests as necessary.*

- 4.2.5 Water used for any part of the hydrotesting or subsequent lay-up shall be clean and free from suspended matter. Suspended matter in the water shall be extracted, before use, by a filter capable of removing 99% of all particles  $53\mu\text{m}$  (2.1 mil) in diameter and larger, or equivalent to using a 270 mesh wire mesh screen.

- 4.2.6 Water that could result in harm to humans must not be used for hydrotesting. For example, service water containing hydrogen sulfide levels that if released to atmosphere would result in air concentrations of 10 ppm hydrogen sulfide or greater in the immediate area of the hydrotest must not be used. Refer questions concerning the safety of waters to the Chief Fire Prevention Engineer, Loss Prevention Department, Dhahran.

*Exception:*

*Paragraph 5.2.2.1 describes controlled circumstances where water treated with a biocide may be used for the hydrotest itself.*

- 4.2.7 Water may be reused for hydrotesting, as in a pipeline tested segment by segment. The water must meet the requirements of Paragraph 4.2.3 and must have an oxygen level of less than 20 ppb, or additional chemical treatment will be required.

*Commentary Notes:*

*Oxygen levels can be easily determined in the field using CHEMetrics Self-Filling Ampoules for Colorimetric Analysis, dissolved oxygen test kit, K-7599 (0 - 100 ppb).*

*CHEMetrics equipment is available by Direct Charge Purchase Requisition from:*

*4295 Catlett Road  
Calverton, VA 20138, USA  
Phone +1-(540) 788-9026  
[www.chemetrics.com](http://www.chemetrics.com)*

- 4.2.8 See Paragraph 6.1 for restrictions on the quality of water used for testing austenitic stainless steels. Seawater or high TDS aquifer water shall not be used for this purpose. The construction contractor shall keep a permanent written record of the water supplied for testing stainless steels including a record of tests performed on the water.
- 4.3 Minimize the time between introducing hydrostatic test water and commissioning the equipment.
- 4.3.1 Schedule the hydrostatic test as close as possible to the start-up date.
- 4.3.2 Where there are limitations in this standard on contact time for hydrotest water, this shall be from the first introduction of water into the system until commissioning or until implementation of a complete lay-up. Partial or complete refilling of the system shall count as continuous, cumulative time. Time limitations requiring the initiation of a formal lay-up program shall be from the first introduction of hydrotest water.
- 4.4 Design the hydrostatic test and the lay-up procedure to protect the most corrosion-susceptible material in the system.
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## 5 Carbon Steel and Low Alloy Steel Equipment

### 5.1 Treatment of Hydrostatic Test Water

When the equipment contact time with hydrotest water may exceed 14 days, an approved oxygen scavenger (see Appendix 1) shall be added to the hydrostatic test water. Treat the water before it enters the system. Use batching scrapers and/or a slug of nitrogen to separate the air in the system from coming in contact with the treated water, and then fill the system with water injecting sufficient oxygen scavenger to maintain its residual concentration at greater than 20 ppm and an oxygen concentration of less than 10 ppb.

### 5.2 Lay-up Procedures

5.2.1 Equipment must be laid-up after hydrotesting unless it can be ensured that it will be returned to service within 30 days from the first introduction of hydrotest water to the system. Use one of the lay-up methods detailed below. See Paragraph 7 for requirements for specific systems. Lay-up procedures for pipelines under the responsibility of Pipelines Department shall be approved prior to hydrotest by the General Supervisor, Pipelines Technical Services Division (PTSD), and by the Manager of the concerned area. Approval of lay-up procedures for other equipment shall be the responsibility of the Saudi Aramco Engineering Superintendent or his designate.

#### 5.2.2 Wet Lay-up

5.2.2.1 Wet lay-up shall be achieved whenever possible by displacing the hydrotest water from the line after hydrotest and replacing with appropriately treated lay-up water. This minimizes the personnel safety and environmental risks of hydrotest ruptures releasing biocide-treated waters. In cases where this is not possible, wet lay-up will require the use of water adequately treated with oxygen scavenger and biocide at the beginning of the hydrotest and will require safety and environmental reviews of the procedure.

5.2.2.2 For wet lay-up, establish and maintain throughout the system a minimum residual oxygen scavenger concentration of 20 ppm in the water and a maximum oxygen concentration of 10 ppb. This includes dead legs. Analyze water sample(s) for residual levels of oxygen scavenger and the dissolved oxygen concentration at the location most remote from the oxygen scavenger inlet. Record the test results in the hydrostatic test

report. Once minimum residuals are verified, keep the system tightly closed to prevent air entry. Repeat tests and ensure chemical residuals every six months during lay-up unless the physical location of the line or equipment makes this impossible. If a leak occurs or air enters the system, lay-up the system again after completing repairs.

*Commentary Notes:*

*Sulfite can be determined in the field using CHEMetrics Titrets Sulfite visual test kit, K-9605 (5 - 50 ppm).*

*Oxygen levels can be easily determined in the field using CHEMetrics Self-Filling Ampoules for Colorimetric Analysis, dissolved oxygen test kit, K-7599 (0 - 100 ppb).*

- 5.2.2.3 Maintain the system under a positive pressure between 210 to 350 kPa (30 to 50 psig) using nitrogen, a sweet hydrocarbon gas, or hydraulic pressure of the treated water. In cases where the design pressure is lower than 350 kPa (50 psig), the pressures shall be adjusted accordingly. Install thermal relief for systems that are to be laid up with hydraulic pressure.
- 5.2.2.4 Use gauges with a scale range not exceeding three times the target pressure to monitor the positive pressure in the system during lay-up. The gauges must be capable of withstanding the design maximum allowable operating pressure (MAOP) of the system to which they are connected or must be protected with adequate gauge saver devices if they are not capable of withstanding system MAOP.
- 5.2.2.5 When the total equipment contact time with water may exceed 30 days, microbiological growth shall be controlled by **one** of the following methods.
  - 5.2.2.5.1 Use a proprietary combined biocide, corrosion inhibitor and oxygen scavenger at a concentration in the range of 350 – 500 ppm. The disposal plan for this treatment must be approved following SAEP-327. When using a combined product that contains oxygen scavenger, the oxygen scavenger component of the product will be considered sufficient to meet the requirements for oxygen control.

*Commentary Note:*

*Champion Blacksmith O-3670R (SAP)*

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*1000022136) is an example of this type of chemistry and is available through SAP.*

- 5.2.2.5.2 Use a combined biocide and corrosion inhibitor at a concentration in the range of 150 – 200 ppm. The disposal plan for this treatment must be approved following SAEP-327.

*Commentary Note:*

*Champion Bactron KK-27 is an example of this type of chemical.*

- 5.2.2.5.3 For discharge to environmentally sensitive locations, use THPS (Tetrakis hydroxymethyl phosphonium sulfate) which degrades to non-toxic components. 70% pure THPS shall be applied at 50 ppm. THPS is also available as blends with other products which may be less environmentally friendly. The disposal plan for this treatment must be approved following SAEP-327.

*Commentary Note:*

*THPS is available from Champion Technologies as Bactron K95 or from Baker Petrolite as XC-22013 by direct charge purchase requisition.*

- 5.2.2.5.4 Polyhexamethylene biguanide hydrochloride or PHMB) (SAP Material # 1000178704), may also be used in hydrotests at 200 ppm. The disposal plan for this treatment must be approved following SAEP-327.

*Commentary Note:*

*ATROS TK-1, Troskil-1, is an example of this type of chemistry.*

- 5.2.2.5.5 Other biocides may be used if approved by the Supervisor, Petroleum Microbiology Unit, Material Sciences R&D Division, R&DC and if approved by Environmental Engineering Division, Environmental Protection Department, per SAEP-327. Ensure that the biocide does not react with oxygen scavenger before using. In cases of doubt, contact Supervisor, Corrosion Technology Unit, Materials Engineering & Corrosion Control, CSD.
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### 5.2.3 Dry lay-up

5.2.3.1 Dry lay-up may be achieved using several different drying media. These include hot dry air, controlled dew point inert gas, and drying chemicals such as glycol or methanol applied between two pipeline scrapers or as a gelled scraper. The best results may be achieved by using a combination of these techniques.

**Safety Note:**

*See Paragraph 10 on safety issues.*

5.2.3.1.1 Dry lay-up using hot or dew point controlled air may *only* be used for systems where the dew point can be successfully reached within 1 week. Longer drying periods using air may contribute to the generation of excessive quantities of corrosion products in lines. Therefore, dry lay-up using air is only appropriate for systems that can be easily dried. One means to assure effective drying within the required time is to limit the length of the system being hydrotested at one time.

5.2.3.1.2 Sweet gas may be used for dehydration. However, before using sweet gas ensure that hydrate formation will not be a problem. Hydrate formation may occur at low temperatures and elevated pressures.

5.2.3.2 Remove the hydrotest water from the system. For facilities other than pipelines, drain the system completely, sweep and mop as required to ensure that no visible traces of water remain. For pipelines, dewatering shall be performed by scraping with a three- or four-cup displacement scraper or better system such as a gelled scraper. Scrapers shall be driven by nitrogen or sweet gas unless the use of dry air has been pre-approved.

5.2.3.3 When seawater or similar high salinity water has been used as the hydrotest media, remove salts from the metal surface by rinsing with a low-salinity water containing less than 4,500 ppm total dissolved solids. For pipelines, use a slug of low salinity water between two scrapers to rinse salts from the walls. The size of the slug will be dependent upon the length of the line. More than two scrapers may be required in cases

where a large slug of water is required. Present calculations and assumptions made to justify the size of slug to be used. The use of seawater/high salt hydrotest water in facilities under the responsibility of Pipelines Department must be pre-approved in writing by Pipelines Department, General Supervisor, PTSD, and the responsible area Manager. For equipment that is under the responsibility of other Departments, the use of seawater/high salinity water must be pre-approved in writing by the local corrosion engineer. All mitigation actions shall be presented for approval at design stage prior to commencement of construction or it will not be a permissible option once construction has commenced.

- 5.2.3.4 If using inert gas drying for a pipeline, first, remove remaining water with a methanol or glycol slug between two scrapers, in order to achieve drying in a short period. Then dry with dehydrated inert gas. Gelled chemicals may also be used. Ensure compatibility of dehydrating chemicals with all materials in the system.
- 5.2.3.5 If at all possible, hydrotests should be performed with the valves removed from the line. However, if this is not possible, valves must be carefully dewatered.

As the final stage of the dewatering process, remove water from pipeline valves and all other valves that may be damaged by trapped hydrotest water by blowing through the top drain with nitrogen and displacing fluid out of the bottom of the valve. Do not open or close valve during this dewatering sequence. When the bulk of the water has been removed, blow vapor phase corrosion inhibitor Cortec VpCI 309 or equivalent with nitrogen until it is visibly discharged at the bottom of the valve.

*Commentary Note:*

*Cortec VpCI-309 is available in Kingdom by direct charge from Kanoo. VpCI is suitable for carbon steel and stainless steel systems. For other systems consult with the Supervisor, CTU/ME&CCD/CSD.*

- 5.2.3.6 Immediately after dewatering, start drying the system to a dew point that will ensure a dew point of  $-1^{\circ}\text{C}$  or less at the final lay-up pressure at all exit points. Dry by blowing sweet gas, nitrogen, or, if pre-approved, heated dry air through the system for not less than 12 hours to allow any remaining moisture to
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come to equilibrium with the dry air. Check and ensure that all measurement locations are at or below the required dew point. Repeat the drying procedure if the measured dew point at any one location is above the set limit.

For pipelines, dew point readings must be done at the beginning, end, and all mainline valve locations.

Record the dew point temperature readings at each test location. Record the pressure of the line or system at the time of the dew point measurement. Record the pressure at which the dew point measurement is made if different to the actual system or line pressure.

If the dew point temperature is derived at a different pressure to the lay-up pressure, use Appendix 2 or equivalent conversion charts to yield the dew point at lay-up pressure.

**Safety Note:**

*See Paragraph 10.5.1 on separation of air and gas mixtures.  
See Paragraph 10.5.2 on safety issues concerning nitrogen.*

5.2.3.7 When the required dew point is reached, pressurize the system with nitrogen or sweet gas to the final lay-up pressure. Dry air may be used only if it has been pre-approved. The system shall be maintained at a positive pressure of at least 30 psig unless this exceeds the design pressure of the system. Pressures up to the normal operating pressure have been used for lay-up for some systems. The dew point at the final lay-up pressure must be lower than  $-1^{\circ}\text{C}$ .

5.2.3.8 Shut in the system, maintain and monitor the pressure per 5.2.2.4 during the lay-up period.

5.2.3.9 For pipelines, re-measure the dew point at all original test locations one week after reaching final lay-up pressure. If any dew point reading is found to be higher than  $-1^{\circ}\text{C}$  at the lay-up pressure, then the entire line must be dried again or an alternative preservation method must be implemented.

5.2.4 Inert Gas Lay-up

5.2.4.1 Displace the hydrostatic test water by positive pressure with nitrogen or sweet gas until no water drains out of the system. Shut in the system under positive pressure until commissioning

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and start-up. Ensure that systems being drained have vacuum relief valves and pressure relief valves as necessary to protect the system.

5.2.4.2 For pipelines, displace water by scraping with a three- or four-cup displacement scraper or better system such as a gelled scraper.

5.2.4.3 Microbial control per paragraph 5.2.2.5 is not required even though some residual water is left in the system.

### 5.2.5 Ambient Lay-up

5.2.5.1 Use ambient lay-up only if all of the following conditions apply:

- a. drains are available at all low points to ensure complete removal of water,
- b. corrosion allowance has been provided,
- c. pitting can be tolerated; and
- d. particulate rust can be tolerated.

5.2.5.2 Remove all water from the system. For facilities other than pipelines, drain the system completely, sweep and mop as required to ensure that no visible traces of water remain. For pipelines, dewatering shall be performed by scraping with a three- or four-cup displacement scraper (or better) unless system limitations make this option impracticable.

5.2.5.3 After removal of all water, close the system to prevent the entry of sand or rainwater.

5.2.5.4 Install a vacuum breaker unless it is demonstrated that the system will not collapse under vacuum.

### 5.2.6 Other lay-up methods

Other lay-up methods are acceptable with the prior written approval of the Supervisor, CTU/ME&CCD/CSD, and, in cases where safety concerns may arise, the approval of the Chief Fire Prevention Engineer, Loss Prevention Department.

5.3 At the end of the lay-up, commission and start up heat exchangers within 14 days, and other equipment within 60 days.

## 6 Stainless Steel Equipment

- 6.1 Type 300-series stainless steels shall be tested only with water that has very low chloride content in order to avoid pitting and stress corrosion cracking. The maximum allowable chloride concentration is 50 ppm. Verify the quality of the water following the requirements of Paragraph 4.2.

*Exceptions:*

*Type 300-series stainless steel valve trim shall not be a sufficient sole criterion for classifying a carbon steel system as "stainless" for the purpose of applying Section 6. For example, this section shall not apply to carbon steel pipelines with valves having stainless trim unless there are also other stainless steel components included.*

*In special cases, with the prior written approval of the Supervisor, CTU/ME&CCD/CSD, water of up to 250 mg/liter chloride ion is permitted, provided:*

- (a) that the hydrostatic test period is less than four days,*
  - (b) that the system is rinsed with steam condensate or demineralized water until the effluent chloride content reaches below 50 mg/liter, and*
  - (c) that the system is completely drained immediately after hydrostatic test and rinse.*
- 6.2 Type-400-series stainless steels are highly prone to atmospheric corrosion. Type 400-series stainless steel trimmed valves shall be removed from pipelines before hydrotest. If it impossible to remove such valves from the line, then written hydrotest procedures must be prepared and approved ahead of time allowing the valves to remain in place. When equipment containing any Type-400 series stainless steels is left in place, it shall be hydrotested in accordance with the requirements of Paragraph 6.3, 6.4, and 6.5 of this standard. The hydrotest procedure shall carefully detail measures prevent corrosion including lay-up of the equipment. Do not use ambient lay-up for equipment made of 400-series stainless steels.
- 6.3 Treat the hydrostatic test water with oxygen scavenger per paragraph 5.1 if the equipment contact time with water might exceed 4 days.
- 6.4 Lay-up the system following the requirements of Paragraph 5.2.
- 6.5 At the end of the lay-up, commission and start up the stainless steel equipment within 14 days.

## 7 Special Requirements

- 7.1 For carbon steel open-roof tanks, floating-roof tanks, or API atmospheric cone roof tanks not designed for service above atmospheric pressure, treatment of hydrostatic test water shall not be required. Immediately after completion of the hydrostatic test, drain and remove all traces of visible water.
- 7.2 Utility Systems
- 7.2.1 Utility and potable water systems shall be tested in accordance with SAES-S-060 or SAES-S-070, as appropriate.
- 7.2.2 Potable water systems shall be tested with fresh potable water only following the requirements of SAES-S-070, Paragraph 18.2. Oxygen scavengers and biocides shall not be used in potable systems.
- 7.2.3 For potable water systems, use dry lay-up per paragraph 5.2.3, inert gas lay-up using nitrogen per paragraph 5.2.4, or ambient lay-up per paragraph 5.2.5. However, for dry-up, sweet gas shall not be used. Methanol or other dehydrating chemicals shall not be used.
- 7.3 Dry Gas and Refined Hydrocarbon Product Pipelines and Piping
- 7.3.1 Hydrotest procedures for services in these categories under Pipelines Department jurisdiction shall be reviewed and approved by Pipelines Department: specifically, the General Supervisor, PTSD, and Manager of the respective area department.
- 7.3.2 Prevent corrosion during hydrotest and lay-up procedures for sweet sales gas, ethane, refined products such as gasoline, kerosene, diesel, etcetera, and processed NGL. Corrosion products and other contaminants introduced during construction, hydrotesting, and start-up can create major problems for many years.
- 7.3.3 Remove all debris from line before hydrotesting using brush scrapers and magnetic scrapers.
- 7.3.4 For pipelines and piping in dry gas or refined hydrocarbon product service, oxygen scavenger shall always be added to the hydrostatic test water, even when the hydrotest water contact time is less than 14 days specified in Paragraph 5.1. This does not apply to plant piping which shall be treated per paragraph 5.1.

Use batching scrapers and/or a slug of nitrogen to separate the air in the system from coming in contact with treated water, and then fill the

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system with treated water by injecting sufficient oxygen scavenger to maintain a minimum oxygen scavenger residual concentration of 20 ppm and an oxygen concentration less than 10 ppb.

7.3.5 Pipelines in dry gas or refined hydrocarbon product service shall be laid-up using either the wet lay-up method per Paragraph 5.2.2 or the dry lay-up method with the line pressurized with dry sweet gas or dry nitrogen, but not air.

7.3.6 When water is finally removed from the pipe, either at the end of the hydrotest or at the end of a wet lay-up, the system shall be thoroughly dried. Air drying shall not be used for pipelines. Air drying may be used for small in-plant piping systems if drying can be completed in no more than one week.

Refined product lines which are generally small (about 14" or less) may be dried with nitrogen from skid-mounted nitrogen generation units or from bulk tanks. Sweet gas pipelines that are generally large diameter will most usually be dried with sweet gas if available. Chemical desiccants such as glycol or methanol may also be used if necessary and specifically pre-approved in the hydrotest procedure.

7.3.7 An alternative to extensive drying operations and detailed hydrotest control is to use internal coatings to prevent corrosion and black powder formation. This decision must be taken early in the design process. Evaluate the economics of coating versus the economics careful hydrotest control. Obtain approval of the coating from the Supervisor, Cathodic Protection and Coatings Unit, Materials Engineering and Corrosion Control Division, CSD. Obtain approval of coating and hydrotest procedures from the Pipelines Department: General Supervisor, PTSD, and Manager of the respective area department.

#### 7.4 Sour Gas and Sour Oil Pipelines

7.4.1 Hydrotest procedures for sour gas, sour oil, or sour multiphase lines under Pipelines Department jurisdiction shall be reviewed and approved by Pipelines Department: specifically, the General Supervisor, PTSD, and Manager of the respective area department.

7.4.2 After the pipeline has been hydrotested, it shall be laid up following the methods detailed in Paragraph 5.2.

7.4.3 Prior to the introduction of sour process fluid into a new line, the line shall be dried. Drying is not required for existing lines.

- 7.4.4 Immediately prior to recommissioning new or existing lines, the lines shall be batch treated with a corrosion inhibitor. This shall be achieved by using a slug of corrosion inhibitor between two or more scrapers. The slug size shall be calculated as follows:

$$\text{Gallons of inhibitor} = \text{Pipelines length (km)} \times \text{Pipeline diameter (in)} \times 3$$

- 7.4.5 Where there is an unavoidable delay between signature of the Mechanical Completion Certificate and introduction of fluids into the line, PMT shall provide sufficient funds to the operating or other organization that will perform the inhibitor treatment to pay for all expenses associated with the inhibitor treatment.

## 7.5 Plant Piping

- 7.5.1 In general, new or existing pipework in plants and refineries will be hydrotested either on-site or in a plant fabrication shop. Due to the shorter physical length of this equipment, hydrotests can be effected in a shorter time than that which would require chemical treatment with oxygen scavengers or biocides per Paragraphs 5.1, 6.3, or 5.2.2. Therefore, unless these time limits are exceeded, no chemical treatment is required.

- 7.5.2 Due to the complexity of plant construction operations, often new plant pipework is laid up by drying following the requirements of 5.2.3 to achieve a dew point of  $-1^{\circ}\text{C}$ . Drying is normally achieved within a plant using dry air or sometimes nitrogen.

- 7.5.3 Chloride limits for 3xx-series stainless steels must be strictly followed.

- 7.6 For any galvanized pipe not covered by Paragraph 7.2, treat galvanized steel pipe per paragraph 5.1 and lay-up per paragraph 5.2.
- 7.7 Water shall not require treatment if used to pressure test completely internally coated or lined equipment, or systems entirely fabricated with non-metallic materials. No lay-up procedure is required for totally non-metallic systems (e.g., PVC pipe).
- 7.8 Lube oil systems shall be pressure tested following the requirements of SAES-L-150. Water shall not be used.
- 7.9 Instrument air systems shall be pressure tested following the requirements of SAES-J-901 and SAES-L-150. Water shall not be used.
- 7.10 Boilers shall be laid up per SAEP-1026.
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- 7.11 For heat exchangers, lay-up shall be required unless start up occurs within 14 days of commencing the hydrostatic test.
- 7.12 For yard or shop fabricated piping systems that are constructed abroad, hydrotested, then shipped to Saudi Arabia, PMT shall submit the hydrotest and layup procedure to the Supervisor, CTU/ME&CCD/CSD, for approval. In addition to one of the lay-up methods from Paragraph 5.2, the use of vapor phase corrosion inhibitors shall normally be required.
- 7.13 For all materials not specifically covered in this standard and for doubtful situations, obtain prior written clarification from the Supervisor, CTU/ME&CCD/CSD.

## **8 Hydrostatic Test Water Preparation**

- 8.1 Inject oxygen scavenger and other treatment chemicals continuously at a rate that will provide the specified concentration while filling the system for the hydrostatic test.
- 8.2 Where multiple treating chemicals are required, ensure that the chemicals proposed for use are compatible with one another. Use separate proportioning pumps for each chemical to avoid adverse reactions. Chemicals shall not be mixed prior to injection.
- 8.3 Monitor chemical injection rates on site using displacement gauges.

## **9 Disposal**

- 9.1 Hydrostatic test waters must be disposed of in accordance with the requirements of SAEP-327 and SAES-A-103.
- 9.2 Disposal plans must be approved prior to the start of any hydrotest.

## **10 Safety**

- 10.1 Follow procedures outlined in the Chemical Hazard Bulletins and Hazardous Materials Communications Program (HAZCOM) labeling provided by the Environmental Compliance Division, Environmental Protection Department for handling, storage, and mixing of the chemicals to be used for hydrostatic test water treatment.
- 10.2 Provide an effective eye wash station and emergency shower per SAES-B-069 at the mixing site of the chemicals.

- 10.3 Hydrotests shall avoid the use of biocide during the hydrotest itself unless absolutely essential. Lay-up water may be treated with biocide as necessary.
- 10.4 See paragraph 4.2.6 concerning water.
- 10.5 Hydrotest procedures may involve the displacement of hydrocarbon by fluids, the displacement of air, and the use of nitrogen.
- 10.5.1 Procedures must ensure that explosive mixtures of air and gas cannot occur. For example, the use of a single scraper in a pipeline is not sufficient to prevent a dangerous mixture occurring between sweet gas and air. Common practice is to use a train of scrapers with at least two batches of nitrogen separating air and combustible gas.
- 10.5.2 Methanol is a toxic and inflammable chemical and may be used only when adequate safety precautions are in place.
- 10.5.3 Caution must be exercised in the use of nitrogen. While nitrogen is not toxic, the exclusion of breathable air in confined spaces such as pipe trenches, vessel skirts, or vessels can lead to suffocation.
- 10.5.3 The hydrotest procedure shall include a complete copy of all relevant MSDS (Materials Safety Data Sheets) and chemical hazard bulletins for the chemicals used in the hydrotest. The hydrotest procedures shall address safety and environmental concerns listed in the MSDS or chemical hazard bulletin.
- 10.6 Hydrotests may involve pyrophoric iron sulfide. Caution should be maintained in situations where this may be a hazard.

## 11 Corrosion Control, Water and Chemical Treatment Subcommittee

<b>Ivan Cruz</b>	<b>Coordinator</b>
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Abdulatif Abdulhadi	Member
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	<b>Revision Summary</b>
5 October 2005	Major revision.
22 February 2006	Editorial revision.

### Appendix 1 – Approved Oxygen Scavengers

Scavenger Name	Formula	Feed ratio scavenger to oxygen by wt.	SAMS catalogue number	Description	SAP number	Comments
Catalyzed sodium sulfite	Na <sub>2</sub> SO <sub>3</sub>	10	2673327000	60 kg drum, 91% anhydrous powder	1000185026	Must be dissolved in water to give a 3-5% solution.
Catalyzed sodium meta bisulfite	NaHSO <sub>3</sub>	10	2685099000	25 liter drum of 25 wt% sodium meta bisulfite solution	1000186446	Tends to react with atmospheric oxygen over time. More acidic than ammonium bisulfite.
Ammonium bisulfite	NH <sub>4</sub> HSO <sub>3</sub>	10	2673327500	55 gallon drum of 37 wt% solution of NH <sub>4</sub> HSO <sub>3</sub>	1000185029	Chemical is often selected for use due to ease of handling. However, ammonium ion does provide an additional food source for bacteria.

#### Calculation of Oxygen Scavenger Requirement

Use the following steps:

- Calculate the mass of oxygen in solution.
- Multiply the mass of oxygen in solution (a) by the feed ratio.
- Add additional 20 mg/liter in excess.
- Take into account the concentration of the oxygen scavenger in the supplied chemical.

Example:

How much ammonium bisulfite (37%wt concentration) will be required to treat 10,000 liter of water containing 8 mg/liter of dissolved oxygen?

$$\begin{aligned}
 & [(10 \times 10,000 \text{ liter} \times 8 \text{ mg/liter}) + 10,000 \text{ liter} \times 20 \text{ mg/liter}] / 0.37 \\
 & (\text{feed ratio} \times \text{volume} \times \text{oxygen content}) + (\text{volume} \times \text{residual scavenger concentration}) / \text{concentration} \\
 & = (800,000 \text{ mg} + 200,000 \text{ mg}) / 0.37 \\
 & = 2,702,703 \text{ mg}
 \end{aligned}$$

This is approx. 2.7 kg of 37% wt. ammonium bisulfite

Assuming a specific gravity of 37 weight % ammonium bisulfite is 1.185

$$= 2.7 \text{ kg} / 1.185 \text{ kg/liter} = 2.3 \text{ liters of ammonium bisulfite to be injected.}$$

## Appendix 2 – Dew Point Of Natural Gases

