

Engineering Standard

SAES-L-150

23 July 2020

Pressure Testing of Plant Piping and Pipelines

Document Responsibility: Piping Standards Committee

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Summary of Changes

Paragraph Number		Change Type (Addition, Modification, Deletion)	Technical Change(s)
Previous Revision (29 Jan. 2018)	Current Revision (23 July. 2020)		
3.1	3.1	Modification	<ul style="list-style-type: none">Added reference " SAEP-43 Layup and Preservation methods"Updated title of SAEP-302 "Waiver of a Mandatory Saudi Aramco Engineering Requirement"Updated title of SAEP-327 "Management of Washwater from Cleaning, Flushing and Dewatering Pipelines and Vessels"Updated title of SAES-A-007 "Hydrostatic Testing Fluids and Lay-up Requirements"Deleted reference of SAES-L-850.Updated title of 01-SAMSS-010 " Fabricated Steel Piping"
3.2	3.2	Modification	<ul style="list-style-type: none">Added international standard reference "API-1110 Recommended Practice for the Pressure Testing of Steel Pipelines for the Transportation of Gas, Petroleum Gas, Hazardous Liquids, Highly Volatile Liquids, or Carbon Dioxide"Modified title of ASME B31.4 "Pipeline Transportation Systems for Liquids and Slurries"
4.0	4.0	Modification	<ul style="list-style-type: none">Updated definition of hydrostatic test per ASME standard "A pressure test using water as the test medium."Added definition of test section "Hydrostatic Test Section: A hydrostatic test section is portion of pipeline between two mainline block valves"
5.3	5.3	Editorial	<ul style="list-style-type: none">Third line changed ASME B31.3 to ASME B31.1Fourth line changed ASME B31.1 to ASME B31.3

Paragraph Number		Change Type (Addition, Modification, Deletion)	Technical Change(s)
Previous Revision (29 Jan. 2018)	Current Revision (23 July. 2020)		
5.4	5.4	Modification	Added reference of "paragraph 5.7" into last line of paragraph 5.4.and deleted " the applicable code"
5.8	5.8	Editorial	Updated the last word of second paragraph, second line as "required"
5.14	5.14	Modification	<ul style="list-style-type: none">Third line changed ASME B31.3 to ASME B31.1Third line added "ASME B31.3"Added reference of SAES-L-109 "meet the requirement of SAES-L-109 paragraph 6.9"
-	5.15	Addition	Added new paragraph "Leak test shall be conducted before initial start-up and after T&Is as per SAES-A-004"
-	5.16	Addition	Added new paragraph "Subsea pipelines hydrotest shall follow the requirements of SAES-L-850"
6.1	6.1	Modification	Second line deleted "or submarine"
6.2	6.2	Modification	First line deleted "submarine" and added "scrapable"
-	7.5	Addition	Added new paragraph "For insulated piping, the line shall be hydrotest according to 7.1, where all welds shall be visible for leak detection during the hydrotest"

Paragraph Number		Change Type (Addition, Modification, Deletion)	Technical Change(s)
Previous Revision (29 Jan. 2018)	Current Revision (23 July. 2020)		
7.5	7.6	Editorial	Paragraph 7.5 to 7.6 were renumbered to correct the sequence.
7.5.5(a)	7.6.5(a)	Editorial	<ul style="list-style-type: none">Added “or” in second line to complete the sentence.Second line changed “ less than 035 KPa (ga) (150 Psig) to 1035 KPa (ga) (150 Psig)”
7.5.5(b)	7.6.5(b)	Modified	Modified “ Low pressure steam piping (designated as 60S in P&ID) designed for 90 psig or less
7.6	7.7	Modification	Paragraph 7.6 to 7.7 were renumbered to correct the sequence.
8.1	8.1	Modification	<ul style="list-style-type: none">Second line added the word “test” to read as “for every test section of newly”Last line added “100% of the” before SMYS.New commentary note added.
8.1	8.1	Modification	<ul style="list-style-type: none">Pipe length unit updated, 500 feet changed to 150 meter to align with SAES-L-410.
-	8.2	Addition	Added new paragraph “For strength test pressure testing where the intended test pressure would produce a hoop stress greater than 95%or of the SMYS, a pressure-volume plot shall be made, starting at a pressure low enough to establish straight-line proportionality as per the guideline provided in API-1110”

Paragraph Number		Change Type (Addition, Modification, Deletion)	Technical Change(s)
Previous Revision (29 Jan. 2018)	Current Revision (23 July. 2020)		
8.2	8.3	Editorial	Paragraph 8.2 renumbered to 8.3
8.3	8.4	Editorial	Paragraph 8.3 renumbered to 8.4
8.4	8.5	Editorial	Paragraph 8.4 renumbered to 8.5
9.2(4)	9.2(4)	Modification	<ul style="list-style-type: none">Sub item-4, second line deleted the repeated sentence “shall be tested” and added “shall be” in the first line.Removed the double hyphen.
9.2(4)	9.2(4)	Editorial	<ul style="list-style-type: none">Removed the double hyphen.
9.3	9.3	Modification	Second line changed the word operating to “designed”.
10.2	10.2	Modification	Added reference of “SAEP-43” and deleted reference of “SAES-A-007” in the second line of paragraph 10.2

1 Scope

- 1.1 This standard defines mandatory requirements governing pressure testing of newly constructed plant piping and pipelines which are designed and constructed in accordance with ASME B31.1, ASME B31.3, ASME B31.4, or ASME B31.8 codes as applicable excluding subsea pipelines which should follow SAES-L-850 requirements. This standard supplements ASME B31 and other applicable codes.
- 1.2 This standard covers mandatory requirements for pressure testing existing plant piping and pipelines for revalidation purposes or after repairs.
- 1.3 Exclusions to this standard are listed in SAES-A-004.

2 Conflicts and Deviations

Any conflicts between this document and other applicable Mandatory Saudi Aramco Engineering Requirements (MSAERs) shall be addressed to the EK&RD Coordinator.

Any deviation from the requirements herein shall follow internal company procedure SAEP-302.

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.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedures

SAEP-43	<i>Lay-up and Preservation Methods</i>
SAEP-302	<i>Waiver of a Mandatory Saudi Aramco Engineering Requirement</i>
SAEP-327	<i>Management of Wastewater from Cleaning, Flushing and Dewatering Pipelines and Vessels</i>
SAEP-1144	<i>Magnetic Particle Examination</i>
SAEP-1145	<i>Liquid Penetrant Examination</i>

Saudi Aramco Engineering Standards

SAES-A-004	<i>General Requirements for Pressure Testing</i>
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SAES-A-007

Hydrostatic Testing Fluids and Lay-Up Requirements

SAES-L-108

Selection of Valves

SAES-L-110

Limitations on Pipe Joints and Components

Saudi Aramco Materials System Specification

01-SAMSS-010

Fabricated Steel Piping

3.2 Industry Codes and Standards

American Society of Mechanical Engineers

ASME B31.1

Power Piping

ASME B31.3

Process Piping

ASME B31.4

Pipeline Transportation Systems for Liquids and Slurries

ASME B31.8

Gas Transmission and Distribution Piping Systems

API-1110

Recommended Practice for the Pressure Testing of Steel Pipelines for the Transportation of Gas, Petroleum Gas, Hazardous Liquids, Highly Volatile Liquids, or Carbon Dioxide

4 Definitions

Hydrostatic Test: A pressure test using water as the test medium.

Leak Test: A pressure test to ensure tightness of flanged and threaded joints at the test pressure. It is normally conducted before initial start-up and after T&Is. This leak test is different from tightness test specified below.

Pneumatic Test: A pressure test conducted using air or other approved gas as the test medium or in conjunction with liquid.

Revalidation Test: A pressure test performed to prove the integrity of existing pipelines or plant piping.

Service Test: A pressure test performed to prove the integrity of pipelines or plant piping using the service fluid at the maximum attainable operating pressure.

Strength Test: A pressure test at an internal pressure determined in accordance with this standard and the applicable Code to verify the integrity of the piping systems for service at the design pressure.

Commentary Note:

The strength test is the term used by ASME B31.8 code. It is the same as the hydrostatic leak test used in ASME B31.3 or the proof test in ASME B31.4.

Tightness Test: A pressure test to ensure tightness of the piping system (i.e., no leaks in the system) at the test pressure.

Hydrostatic Test Section: A hydrostatic test section is portion of pipeline between two mainline block valves.

5 General Requirements

- 5.1 The general test requirements of [SAES-A-004](#) shall apply.
- 5.2 Every pipeline, after construction and prior to initial operation, shall successfully pass a hydrostatic test. The test pressure shall be in accordance with section 8 of this standard but not less than the minimum requirements of ASME B31.4 or ASME B31.8 as applicable.
- 5.3 All newly constructed plant piping, and prior to initial operation unless exempted by this standard, shall be subjected to a hydrostatic strength test in accordance with the requirements of this standard and ASME B31.1, ASME B31.3, ASME B31.4 or ASME B31.8 as applicable.
- 5.4 Every existing plant piping and pipeline, after repairs or alterations have been made that affect the integrity of the pressure containing parts, shall successfully pass a hydrostatic test. The test pressure shall be in accordance with the requirements of paragraph 5.7.
- 5.5 Skid mounted piping systems which have been successfully shop tested in accordance to [01-SAMSS-010](#), and the test is witnessed by Saudi Aramco Inspector or his designated representative, are excluded from the in-situ field strength test. The shop test becomes invalid if the packaged piping system has been subsequently repaired, modified, or damaged.
- 5.6 Sampling piping systems shall be pressure tested as an integral part with the piping or equipment to which it is connected.
- 5.7 Provision shall be made to facilitate conducting a strength test to the tie-in butt welds of new piping to either new or existing piping system. The test pressure shall be based on the minimum required by Code if the tie-in is to an existing system.

If a strength test for the tie-in butt welds is deemed impractical, then it could be substituted with 100% NDT and subject to conditions and approval for the NDT in lieu of pressure testing stipulated in [SAES-A-004](#) Section 5.

Commentary Note:

In case of flanged tie-in connections, a flange tester could be utilized to conduct hydrostatic testing of the flange butt weld.

- 5.8 For piping systems, that has already passed a successful pressure testing, a second pressure testing is required if it is subjected to new welding activities and post weld heat treatment (PWHT) is mandated due to these new welds.

In case PWHT is not required and only for the following cases, second pressure testing is not required:

- 5.8.1 Seal welds of threaded connections.
- 5.8.2 Attachment welds of non-pressure containing parts, such as wear pads.
- 5.9 Piping such as drains, vents and piping downstream of pressure relieving devices that discharge directly to the atmosphere with a maximum internal pressure not exceeding 69 kPa (ga) (10 psig) can be excluded from in-situ pressure testing.
- 5.10 If block valves are used for blocking or isolating hydrotest sections, the differential pressure across the valve seat shall not exceed the seat test pressure during the strength test and shall not exceed the rated seat pressure during the tightness test.
- 5.11 The requirement for field hydrotesting of valves shall be per [SAES-L-108](#).
- 5.12 Instrument impulse lines shall be leak tested for at least 30 minutes duration as follows:
 - 5.12.1 The instrument impulse lines, whether piping or tubing, between the root isolation valve and the instrument isolation shall be pneumatically pressure tested (using air or nitrogen) at 1.1 times the design pressure of the piping system or process equipment to which it is connected. The test duration shall not be less than 30 minutes.
 - 5.12.2 Instrumentation that could be subject to damage due to the test shall be disconnected from the tested system.
 - 5.12.3 When pneumatic testing is not practical (e.g., physical configuration, etc.) testing with liquid is permitted.

When liquid is used for pressure testing, the instrument impulse lines shall be flushed of all liquid and debris and shall be blown dried.

If water is the testing media, its quality shall not affect the integrity of the instrument lead lines.

- 5.13 For internally Fusion Bonded Epoxy (FBE) coated piping system, the test pressure shall not produce hoop stresses in the pipe that could damage the internal coating. However, it shall not be less than the minimum required by the applicable Code.
- 5.14 Connections to blinds used for filling or connection pressure gauges shall meet the requirement of SAES-L-109 paragraph 6.9 and qualified in accordance with ASME B31.1, ASME B31.3, ASME B31.4, or ASME B31.8 as applicable.
- 5.15 Leak test shall be conducted before initial start-up and after T&I's as per SAES-A-004.
- 5.16 Subsea pipelines hydrotest shall follow the requirements of SAES-L-850.

6 Design Requirements

- 6.1 **Vents:** Vents shall be provided at all high points in the piping system. Cross-country pipelines may be exempted if a scraper will be used ahead of the test water to purge air from the lines before the test pressure is applied.
- 6.2 **Drains:** Excluding scrapable and buried pipelines, drains shall be provided at all low points of the piping system.
- 6.3 **Supports:** For above ground installation, the piping system shall be analyzed to foresee whether temporary supports are required during hydrostatic testing to limit the sustained longitudinal stresses to acceptable limits by the code. If temporary supports are found to be needed and more economical than permanent supports, this should be highlighted in the hydrotesting procedure.
- 6.4 Expansion joints and spring hangers or spring supports shall be provided with temporary restraints where needed to prevent excessive travel or deformation under the test loads.

7 Pressure Testing of Plant Piping

This section defines specific requirements, such as test pressure, duration, etc., for pressure testing of plant piping.

- 7.1 Unless limited by flanges, valves or other component in the line or specified in paragraph [7.6](#) below, the hydrostatic strength test pressure for every section of

new constructed line shall produce a hoop stress in the pipe of 90% of the specified minimum yield strength (SMYS) at the test temperature. The test pressure shall be calculated based on the pipe nominal wall thickness less the mill tolerance (manufacturer's minus tolerance). The test pressure shall not be less than the minimum test pressure per ASME B31.3 paragraph 345.4.2.

- 7.2 Except where specified in [7.6](#) of this standard, the test pressure shall be maintained for a sufficient time, but shall not be less than 30 minutes, to determine that there are no leaks.
 - 7.3 All joints including welded shall be left exposed for visual leak detection during the strength test. External coating and priming of such joints may be allowed if it meets the conditions of [SAES-A-004](#) Appendix D.
 - 7.4 For jacketed piping, the internal line shall be hydrotested according to [7.1](#). All field welds shall be visible for leak detection during the hydrotest. The jacket shall be hydrotested according to ASME B31.3. The maximum allowable external pressure for the internal line shall not be exceeded during the jacket pressure test. The differential pressure can be minimized by pressurizing the internal line.
 - 7.5 For insulated piping, the line shall be hydrotest according to [7.1](#), where all welds shall be visible for leak detection during the hydrotest.
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- 7.6 The following are specific cases of exemptions to either or both of [7.1](#) and [7.2](#) of this standard:
 - 7.6.1 Lube and seal oil piping shall be pressure tested with its own fluid. The test pressure shall be 1.5 times the design pressure or 690 kPa (ga) (100 psig) whichever is the greater. Test duration shall be in accordance with [7.2](#).
 - 7.6.2 Underground process piping shall be tested prior to backfilling. The test pressure shall be maintained for a minimum of 2 hours while the joints are inspected for leakage. If for justifiable safety reasons the line must be back-filled, then the joints shall remain exposed during testing, otherwise the test shall be a 24 hour recorded test. The test pressure is in accordance with [7.1](#).
 - 7.6.3 Flare lines 24-inch NPS and larger with a design pressure of 517 kPa (ga) (75 psig) or lower may be pneumatically strength tested in accordance with paragraph 345.5 of ASME B31.3. The pneumatic test checklist stipulated in [SAES-A-004](#) Appendix A shall apply.

- 7.6.4 Piping in vacuum service shall be pressure tested to 1.5 times the differential external pressure not less than 100 kPa (ga) (15 psig). Test duration shall be in accordance with [7.2](#).
- 7.6.5 Service test is acceptable for the following services:
- Plant utility piping in water, air, and inert gases services with a designed pressure and equal to or less than 1035 kPa (ga) (150 psig). This does not include fire water systems.
 - Low pressure steam piping designed for 625 kPa (ga) (90 psig) or less.
- 7.7 For revalidation purposes of existing plant piping, the test pressure shall be minimum required by the Code ASME B31.3. The actual wall thickness of the piping and flange rating shall be taken into consideration when calculating the test pressure.

8 Pressure Testing of Pipelines

This section defines specific requirements (such as test pressure, duration, etc.) for pressure testing of pipelines.

- 8.1 Unless limited by flanges or valves in the line, hydrostatic strength test pressure for every test section of newly constructed pipelines shall be calculated to produce a hoop stress of 90% of the SMYS of the pipe material based on the nominal wall thickness. The test pressure at the lowest point of the pipeline, considering the hydrostatic head, shall not result in a hoop stress greater than the 100% SMYS.
The strength test pressure shall be maintained for two hours.

Commentary Note:

Short pipe sections i.e. road crossing, trap inlet mainline and mainline 150 m from the plant fence will be considered as portion of hydrostatic test section. These individual sections will be tested with mainline by meeting the minimum pressure test requirements of applicable code, ASME B31.4 or ASME B31.8 for particular area classification.

- 8.2 For strength test pressure testing where the intended test pressure would produce a hoop stress greater than 95% of the SMYS, a pressure-volume plot shall be made, starting at a pressure low enough to establish straight-line proportionality as per the guideline provided in API-1110.
- 8.3 The strength test temperature shall not result in a combined longitudinal stress (calculated based on 0.7 hoop stress at the test pressure plus temperature stress plus bending stress) exceeding the SMYS.

- 8.4 A tightness test shall be conducted at 95% of the strength test pressure, immediately after the completion of the strength test. The tightness test pressure shall be maintained as long as required for the inspector to examine all exposed joints.

A 24-hour recorded tightness test shall be applied when the pipeline is buried or insulated, or is partially buried or insulated for more than 300 m (1,000 ft) or 10% of its total length whichever is less.

- 8.5 Existing pipelines if subjected to revalidation pressure testing, the test pressure shall be minimum of 1.25 times the MAOP for pipelines with 0.6 and 0.72 design factors; and shall be minimum of 1.4 times the MAOP for pipelines with 0.4 and 0.5 design factors. The flange rating shall be taken into consideration when calculating the test pressure.

The results of the latest pressure testing shall be documented in the “Safety Instruction Sheet.”

9 Pressure Testing for Minor Repairs

This section defines pressure testing requirements for existing facilities which are subjected to minor repairs as listed below:

- 9.1 In the case of small diameter threaded piping without pressure containing welds (all services and pressures), the hydrostatic pressure testing is not required when thread engagement and seal welding requirements per [SAES-L-110](#) are met. However, a service test shall be conducted for these welds.
- 9.2 In the case of socket welded piping, and when the Operations Engineering Unit determines that hydrostatic testing not to be practical, the piping may be pressure tested with its own product at its operating pressure when the following requirements are met:
- 1) A request of NDT in lieu of pressure testing is processed as detailed in [SAES-A-004](#) Section 5.
 - 2) Qualified welders and welding procedures are used.
 - 3) The weld gap verified and welding witnessed by the responsible Operation Inspection Unit.
 - 4) Weld(s) to be either magnetic particle (MT) or dye penetrant (PT) shall be tested in accordance with the requirements in [SAEP-1144](#) and [SAEP-1145](#).
- 9.3 Low pressure steel piping in water, instrument air, plant air, inert gas (Nitrogen, Argon, etc.), and steam systems operating at 1,035 kPa (ga) (150 psig) or lower,

may be strength tested with its own product at its design pressure (service test). This does not include fire water systems.

10 Test Procedures

- 10.1 The test Procedures shall be prepared and conducted in accordance with [SAES-A-004](#).
- 10.2 The requirements regarding test water quality and lay-up condition shall be in accordance to SAEP-43
- 10.3 The disposal sites for the test fluid shall be reviewed and approved prior to the hydrostatic test in accordance with [SAEP-327](#) “Disposal of Wastewater from Cleaning, Flushing, and Hydrostatic Tests.”
- 10.4 Where pressure variations due to test water temperature changes occur, such as in cross-country pipelines, thermocouples shall be installed to obtain accurate pipe metal temperature measurements to determine the acceptance of the pressure test. Chairman of the Piping Standards Committee in Consulting Services Department shall be consulted for any deviations on the 24 hour pressure chart.

Revision Summary

2 April 2014	Revised the Next Planned Update, reaffirmed the content of the document, and reissued as major revision.
24 December 2014	Editorial revision.
11 September 2017	Minor revision to align with the latest revision of <u>SAES-A-004</u>
29 January 2018	Editorial revision.
23 July 2020	Major revision.