Engineering Standard

SAES-L-350 22 April 2009

Construction of Plant Piping

Piping Standards Committee Members

Nasri, Nadhir Ibrahim, Chairman
Dib, Tony Georges, Vice Chairman
Balhareth, Nasser Mohammad
Bannai, Nabeel Saad
Fadley, Gary Lowell
Holland, Brad John
Khashab, Jaafar M.
Lewis, Trevor
Mahmoud, Khalid Ahmed
Phan, Howard Cong
Rao, Sanyasi
Rasheed, Mahmood A.
Sharif, Talal Mahmoud
Shiha, Saad Mohammed
Swar, Ahmad H. (ABQ PLANTS)

Saudi Aramco DeskTop Standards

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Primary contact: Nasri, Nadhir Ibrahim on 966-3-8760162

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1 Scope

1.1 This standard supplements ASME B31 Codes and defines additional requirements governing the fabrication and installation of metallic plant piping systems including those on offshore structures.

1.2 This standard is applicable to piping assemblies associated with cross-country pipelines such as jumpovers, scraper trap facilities and valves stations.

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 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 Representative, who shall follow internal company procedure SAEP-302 and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

3 References

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities covered 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-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*
SAEP-351	*Bolted Flange Joints Assembly*
SAEP-1024	*Chemical Cleaning of New Boilers*

Saudi Aramco Engineering Standards

SAES-A-004	*General Requirements for Pressure Testing*
SAES-A-007	*Hydrostatic Testing Fluid and Lay-up Procedure*
SAES-B-067	*Safety Identification and Safety Colors*
SAES-H-002	*Internal and External Coatings for Steel Pipelines and Piping*
SAES-H-100	*Painting Requirements for Industrial Facilities*
SAES-H-200	*Storage, Handling and Installation of Externally Coated Pipe*
SAES-G-116	*Cleanliness Standard for Lube/Seal Oil Fluid Power Systems*
SAES-J-100	*Process Flow Metering*
SAES-L-101	*Regulated Vendor List for Pipes, Fittings and Gaskets*
SAES-L-102	*Regulated Vendor List for Valves*
SAES-L-109	*Selection of Flanges, Stud Bolts and Gaskets*
SAES-L-110	*Limitations on Pipe Joints and Components*
SAES-L-120	*Piping Flexibility Analysis*
SAES-L-150	*Pressure Testing of Plant Piping and Pipelines*
SAES-L-310	*Design of Plant Piping*
SAES-L-450	*Construction of Cross-Country Pipelines*
SAES-L-460	*Pipelines Crossings Under Roads and Railroad*
SAES-N-001	*Basic Criteria, Industrial Insulation*
SAES-W-011	*Welding Requirements for On-Plot Piping*
SAES-X-600	*Cathodic Protection of Plant Facilities*

Saudi Aramco Materials System Specifications

01-SAMSS-010	*Fabricated Carbon Steel Piping*
01-SAMSS-017	*Auxiliary Piping for Mechanical Equipment*

3.2 Industry Codes and Standards

American Society of Mechanical Engineers

ASME B31.4	*Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids*
ASME B31.8	*Gas Transmission and Distribution Piping Systems*
ASME PCC-1	*Bolted Flange Assembly*

4 Definitions

Construction Agency: The firm responsible of fabricating and erecting the piping system. This could be the construction contractor, the lump sum turnkey contractor, the sub-contractor or a Saudi Aramco design organization.

Inspection Agency: The firm responsible for conducting the inspection activities and enforcing the applicable standards, documents and procedures. This could be the Saudi Aramco Inspection or a third party Inspector.

5 Responsibilities

5.1 It is the responsibility of the construction agency to ensure that the construction of the piping is commenced in accordance with approved drawings.

5.2 It is the responsibility of the construction agency to ensure that construction of the piping systems is in compliance with the applicable Codes and Saudi Aramco Standards and Standard Drawings.

5.3 It is the responsibility of the inspection agency to enforce that construction of the piping systems is in compliance with the construction drawings and the applicable Codes and Saudi Aramco Standards and Standard Drawings.

6 Materials

6.1 All pipe and fittings shall have the material specification and grade stamped, stenciled, or otherwise clearly marked with permanent marking method.

6.2 All pipes, fittings, flanges, and gaskets material shall be sourced from approved manufacturers in accordance with SAES-L-101 and shall comply with the

applicable Saudi Aramco and Industry Specifications. This should be confirmed through proper material identifications and certifications.

6.3 Valves shall be sourced from approved manufacturers in accordance with SAES-L-102 and shall comply with the applicable Saudi Aramco and Industry Specifications.

6.4 Material substitution shall not be made without prior approval of the Design Agency, SA PMT and Inspection agency. CSD Material Engineering Specialist should be consulted as needed.

7 Storage

The following requirements shall apply to storage areas relevant to the particular project which includes, but not limited to, layout yards, receiving areas, warehouses, etc.

7.1 Pipe shall not be stored directly on the ground. Pipe shall be placed on mounds or sleepers.

7.2 Stacking of pipes shall be made in a manner to avoid damage to pipes or coatings. Refer to SAES-H-200.

7.3 Fittings and valves shall be stored in shipping crates or on racks.

7.4 End protectors on pipes, flanges, weld bevels, threads, and socket ends shall be firmly attached.

7.5 Stainless steel material shall be protected against exposure to seawater splash during shipment and storage.

8 Handling

8.1 All materials shall be handled with care during fabrication and installation to prevent damage.

8.2 Lined and coated pipes and fittings shall be lifted with wide fabric or rubber-covered slings and padding shall be used to prevent damage to lining or coating in accordance with SAES-H-200.

9 Pipe Fit-Up and Tolerances

9.1 The maximum tolerance for axial dimensions, face-to-face, center-to-face and location of attachments shall be ± 3 mm.

9.2 Flattening of bends, measured as the difference between the largest and the smallest outside diameter at any cross section, shall not exceed 5% of the

nominal diameter of the pipe. Flattening of bends at weld ends shall not exceed 3% of the nominal pipe diameter.

9.3 Lateral transition of branches and connections from the centerline of the run shall not exceed ± 1.5 mm.

9.4 Flange bolt holes shall be oriented as follows, unless otherwise indicated on the construction drawings:

a) Flange face vertical –bolt holes to straddle vertical centerlines.

b) Flange face horizontal–bolt holes to straddle horizontal centerlines.

c) Rotation of flanges, measured as the offset between elevations of bolt holes on opposite sides of a flange centerline, shall not exceed ± 2.4 mm.

d) The tilt of a flange measured at the periphery across any diameter shall not exceed 1.6 mm from the square position.

9.5 For piping over 3-inch NPS and connected to machinery/equipment, flange alignment shall be within the following limits unless piping analysis per SAES-L-120 shows that loads and moments are within the manufacturer's limits for the machinery/equipment nozzle:

a) Vertical bolt hole offset : ± 2.4 mm

b) Horizontal bolt hole offset : ± 2.4 mm

c) Rotational offset : ± 2.4 mm

d) Flange face tilt across diameter: 0.025 mm per 25 mm (0.001 inch per inch) of flange outside diameter up to a maximum of 0.672 mm (0.030 inch), and 0.254mm (0.010 inch) for all flanges with an outside diameter less than 10 inches.

e) Flange face separation, gasket thickness : ± 1.6 mm

f) Combination of vertical, horizontal and rotational offset : ± 3.2 mm

9.6 In the case where a spectacle plate is installed between two flanges, these tolerances can be increased by 30% except for tolerances for flange face tilt across diameter and flange face separation.

9.7 If the tolerances per paragraphs 9.1 through 9.5 cannot be achieved, the actual misalignment and piping layout shall be reviewed and approved by the Chairman of Piping Standards Committee in CSD.

Commentary Note:

When a piping flange is aligned to a machinery flange, the machinery alignment should be within the equipment vendor specified tolerances, after the stud bolts of the connecting flanges are removed following the completion of piping assembly.

10 Fabrication

10.1 Shop fabrication of piping shall be in accordance with 01-SAMSS-010. All welding and weld inspection of piping shall be in accordance with SAES-W-011.

10.2 Limitation on piping joints and branch connections shall be in accordance with SAES-L-110.

10.3 If post-weld heat treatment (PWHT) of pipe spools is required (refer to SAES-W-011), non-pressure containing welded attachments such as shoe support for insulated lines, dummy extensions and legs, and wear pads shall be welded to the pipe spools before stress relieving. PWHT of piping spools with flanged joints shall be done before flange assembly.

10.4 Orifice flanges shall comply with the following:

10.4.1 The requirements of SAES-J-100 shall apply.

10.4.2 The inside surface of welded joints at orifice flanges shall be ground or machined smooth.

10.5 Where, a spectacle plate is required by the design drawings, the fabricator shall drill a tap and install jack screws for the flanges.

10.6 Branch connections and their reinforcement shall not cover the girth welds.

10.7 Reinforcing pad material shall be of the same pipe material unless otherwise approved in writing by the SAPMT. Reinforcing pads should not be installed except where the design the drawings call for.

11 Welded Attachments

11.1 Welded attachment to the piping systems which irrelevant to the piping systems, such as those for electrical conduits, shall not be installed without prior permission by SAPMT in consultation the Chairman of the Piping Standards Committee.

11.1 The pipe shall not be used to support other pipes and structures, i.e. individual supporting is required. Prior approvals by SAPMT in consultation the Chairman

of the Piping Standards Committee is required at the detail design package development stage.

Commentary Note:

Pipe sizes 2" and smaller supported by not less than 4 times its diameter pipe are excluded from this requirements if the stresses on both pipe are within the code requirements.

11.2 All structural attachments, which transfer loads to the pipe through welds, shall be welded to full encirclement sleeves or saddle pads per ASME B31.4 paragraph 421.1(d) and ASME B31.8 paragraph 834.5(b) requirements.

11.3 All welds to the pipe shall be continuous with smooth finish. Spot welding is not acceptable.

12 Flanged Joints

12.1 Flanges to be installed shall meet the requirements of SAES-L-105.

12.2 Construction Agency shall verify that the material, type and class of the installed bolted flanges meet the line class specifications where such flanged assembly will be installed.

12.3 The flange joints shall be assembled and bolts tightened in accordance with SAEP-351.

12.4 Construction agency is permitted to submit specific procedures in lieu of SAEP-351. This shall be approved by Proponent, SAPMT, Inspection and the Piping Standards Committee Chairman or his representative. ASME PCC-1 could be used as a guideline to establish such procedures.

12.5 The flange joints shall not be used to support the piping system.

12.6 Blind flanges and blanks that meet the ANSI/ASME code shall be used for hydrotest.

12.7 Gaskets shall be handled in accordance with manufacture's instruction. Gasket shall be replaced whenever opening of flange assembly.

13 Pipe Supports and Hangers

13.1 Responsibilities

Violation to any requirement of this section shall be resolved through concurrence from the Chairman of Piping Standards Committee or his representative.

13.2 Dummy Supports

13.2.1 Installing additional dummy leg supports other than those in the design drawings shall not be installed without prior review and approval per 13.1 above.

13.2.3 A 6 mm weep hole shall be drilled for all dummy supports. The weep hole shall be located near the base plate for all vertical dummy supports, and near the run pipe at 6 o'clock position for all horizontal dummy supports.

13.3 Low Friction Supports

If Teflon sheets or similar low friction materials are used to function as low friction supports are to be installed, the following shall apply:

13.3.1 Sliding surfaces shall be protected during all construction activities including painting and sandblasting.

13.3.2 Provision shall be made to allow angular adjustment of the bearing surface during installation, so that an even distribution of the load can be assured.

13.3.3 Low friction supports shall be constructed such that sand or other debris cannot accumulate on sliding surfaces (by making the top surface larger than the bottom surface).

13.4 Spring Supports

13.4.1 The spring setting shall be verified that they are matching the design requirements.

13.4.2 The spring support shall be in full engagement with pipe.

13.4.3 All springs shall be in compression, so that failure will not result in the complete release of load.

13.4.4 Springs shall be factory set to the calculated cold settings by means of travel stops. Upper stops for load preset and lower stops for hydro-test shall be provided. These stops shall be banded or locked in place so they cannot be easily dislodged during erection or hydro-test. The travel stops shall be painted red and shall have a bright color tag indicating "Remove after Hydro-test."

13.4.5 Each spring hanger assembly must be capable of sustaining the load during hydrotesting, which is equal to 2 times the operating load.

13.5 Hanger Rods

Generally rod hangers should be avoided as practical as possible. Even they were specified on the design drawings, good workmanship and construction practices should be exercised to replace them with rigid pipe supports.

In case they are installed the following shall apply:

13.5.1 Rod hangers shall not be used for lines 12" NPS and larger in liquid service or multi phase flow.

13.5.2 All hangers shall be provided with means for vertical adjustment.

13.5.3 Suitable locking devices shall be used at all threaded connections of the hanger assembly (double nuts).

13.5.4 Rod hangers shall be subjected to tensile loading only.

13.5.5 Practicality for replacing them with rigid pipe supports should be evaluated and implemented, during construction.

13.6 Support Spacing

Support spacing as detailed in the design drawings shall be followed. If for practicality the spacing has to be altered, prior approval shall be granted and reviewed by the Piping Standards Committee Chairman or his representative.

14 Erection and Installation

14.1 All sensitive equipments to damage during cleaning and flushing of the piping system shall not be installed and shall be removed if installed prior to commencing the cleaning process. The list of these equipments shall be established during early stages of the execution of the project. Examples of sensitive equipments are: rotating machinery, orifices, control valves, flow-elements, soft-seated valves, globe valves, etc.

14.2 All erected piping systems and components shall be internally clean and free from foreign objects as detailed in the section 15.

15 Cleaning

15.1 During project proposal and detailed design, detailed procedures for cleaning and flushing of the piping spools and systems shall be established identifying acceptable methods that will be applicable for every individual system category. These procedures sall be agreed on by PMT, Proponent and Inspections Agency.

15.2 Prior to Installation

As a minimum and prior to installation and/or erection of pipe spools on the pipe racks and pipe supports the following shall be conducted:

15.2.1 All pipes shall be internally cleaned by air blowing. In addition, for large diameters pipes rag cleaning should be conducted if found practical.

15.2.2 All prefabricated pipe spools shall be visually inspected for cleanliness, and shall have foreign material removed from the inside.

15.2.3 The piping ends shall be covered after inspection to prevent unauthorized removal of the end cover prior to making the joint to the succeeding section of piping.

15.2.4 The method of covering the pipe ends shall be part of the procedures per paragraph 15.1.

15.3 During Assembly and Erection

15.3.1 During assembly and erection, the construction agency shall ensure that no foreign materials (such as welding consumables, lumbers, gloves, etc.) are left inside the piping system.

15.3.2 After assembly and installation, the piping shall be cleaned inside to remove all loose material. The cleanliness shall be verified visually and/or by video inspection techniques.

15.3.3 The assembled piping shall be cleaned by one or more of the methods outlined in Appendix-A or by a pre-agreed on procedures per paragraph 15.1.

15.4 Chemical or Vapor Phase or Foam Cleaning

15.4.1 The interior of the piping for the following specific services shall be cleaned after hydrostatic pressure testing to remove oil, grease, preservatives, rust and mill scale per approved procedures: (Refer also to 01-SAMSS-017, SAES-G-116, and SAEP-1024).

a) Boiler feed water and steam condensate.
b) Lube oil and seal oil.
c) Seal gas supply piping.
d) Steam supply line to turbines.
e) DGA, TEG, and Refrigerant systems.
f) If necessary to meet service fluid quality.

15.4.2 Chemical or Vapor Phase or Foam cleaning shall be done by qualified chemical cleaning contractors. Contractors shall submit for Material Engineering and Corrosion Control Division/CSD approval written cleaning procedures describing in detail the steps for degreasing, descaling, neutralization, and passivation.

15.4.3 Lines to be chemically cleaned shall be identified on the P&ID's and Line Index. The systems to be cleaned shall have high and low point vents and drains installed.

16 Buried Piping Installation

16.1 Buried metallic plant piping (if permitted by SAES-L-310) shall have corrosion protection in accordance with the applicable Saudi Aramco Coating Standards and SAES-X-600.

16.2 Buried installations shall comply with requirements in SAES-L-450 as applicable.

16.3 The minimum cover in paved or stabilized areas shall be in accordance with SAES-L-460.

16.4 Transition Zones

16.4.1 The transition zones of the metallic piping from above ground to underground shall not be encompassed by concrete or asphalt. A minimum of 1foot annuals of sweet sand capped with aggregate shall surround the transition section.

16.4.2 At the transition point the external coating shall be extended from the below ground to a minimum of 1 meter on the above ground section.

Commentary Note:

This was a recommended practice Company wide after AY-1 incident on September, 1997. The objective is to prevent accelerated corrosion at the transition section when the CP is shielded by the concrete and pavement. Also, it will provide easy access for on stream inspection activities.

17 Inspection

17.1 Fabricated and erected piping shall be inspected in accordance with the applicable Code as a minimum.

17.2 Inspection strategies and plans shall be prepared and agreed on prior to commencing of fabrication and erection.

18 Pressure Testing

Pressure testing of the piping systems shall be in accordance with SAES-A-004 and SAES-L-125.

19 Lay Up Requirements

19.1 Piping systems which have been completed as far as cleaning and pressure testing shall be properly laid up in accordance with SAES-A-007.

19.2 Lay up shall be performed and completed in a manner to avoid any damage to the piping systems and the associated process equipment connected.

19.3 The lay up method shall not affect the performance of the intended process of the piping systems.

20 Lines Marking

All lines shall be clearly marked to easily identify the following as a minimum:

a) Flow direction and service.
b) Line designation number, size, class and specification.
c) Color coding per SAES-B-067 shall apply.
d) Process equipments connected to the line as applicable and practical.
e) Color coding to the lines as applicable and detailed in the design drawings.

21 Lines Painting

21.1 Lines shall be painted in accordance with SAES-H-002 and SAES-H-100.

21.2 Painting should not be made prior to hydrotesting has been completed unless prior approval from Inspection Agency is obtained.

22 Lines Insulation

22.1 Lines insulation shall be installed per SAES-N-001 where required for personnel protection or process requirements.

22.2 Sections of the insulation shall be removable to allow for on stream inspection. In coordination with PMT, Proponent approval should be obtained prior to installation to identify the removable section locations.

Revision Summary

22 November 2008	Revised the "Next Planned Update". Reaffirmed the contents of the document and reissued with minor changes.
22 April 2009	Editorial change to correct the paragraph number to read 6.4 instead of 6.2.

Appendix A – Cleaning and Flushing of Plant Piping Systems

Water Flushing

Equipment which is sensitive to damage during water flushing shall be removed, blocked off or isolated. A list shall be prepared and be part of the flushing procedure. Ball valves shall be flushed in fully open position.

All piping systems shall be flushed using high pressure [60.8 mPa (8.8 ksi) minimum] jet such as rotating hose or rotating nozzle.

Below 4", use High Velocity Water Flushing (HVWF). On systems where high pressure jet flushing cannot be used due to complicated shapes and/or long runs use HVWF or slug flushing. Water velocity shall be a minimum of 3 m/s.

The general flushing medium shall be plant/ process water or raw water. Fire water may be used where process water is not available. Sea water is not acceptable.

When flushing stainless steel lines, the chloride ion content shall be less than 50 mg/L. After flushing, the piping systems shall be completely drained, dried to a dew point below -1°C and protected against corrosion.

Pneumatic Flushing

Pneumatic flushing with dry air (dew point -1°C or less) or steam with a minimum exit velocity of 15 m/s. Repeat flushing until cleanliness is verified by observing the absence of any solids impact on a polished metal target at the exit.

Pressurized Air Shock Blowing (PASB)

Use PASB for initial cleaning for instrument air, plant air and as an alternative method for initial cleaning of small bore pipe (less than 2 inch). Use PASB if there are problems removing trapped liquid in the piping, or to verify cleanliness of small bore pipe where video inspection is impossible or inadequate due to pipe dimension or configuration.

The air shocking pressure shall never exceed the working pressure of the system and shall never be more than 810 kPa (115 psi). Safety precaution shall be considered in consultation with Area Loss Prevention Division when this method is used.

Repeat PASB until cleanliness is verified by observing the absence of any solids impact on a polished metal target at the exit.

Mechanical Scrapers

Mechanical scrapers can be used under the condition that damage to the pipe interior surface shall not occur.