Engineering Standard

SAES-L-310 25 July 2012

Design of Plant Piping

Document Responsibility: Piping Standards Committee

Saudi Aramco DeskTop Standards

Table of Contents

Previous Issue: 29 April 2007 Next Planned Update: 25 July 2017
Revised paragraphs are indicated in the right margin

Primary contact: Nasri, Nadhir Ibrahim on 966-3-8809603

1 Scope

1.1 This standard supplements ASME B31 codes and defines additional minimum design requirements for pressure piping located within plant areas.

1.2 Further requirements related to specific plant piping systems are covered by other Saudi Aramco Piping Standards as specified in SAES-L-100.

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 Procedure

SAEP-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*

Saudi Aramco Engineering Standards

SAES-A-112	*Meteorological and Seismic Design Data*
SAES-B-017	*Firewater System Design*
SAES-B-067	*Safety Identification and Color-Coding*
SAES-H-002	*Internal and External Coating for Steel Pipelines and Piping*
SAES-H-101	*Approved Protective Coating Systems*

SAES-L-100	*Applicable Codes & Standards for Pressure Piping Systems*
SAES-L-101	*Regulated Vendor List for Pipes, Fittings and Gaskets*
SAES-L-102	*Regulated Vendor List for Valves*
SAES-L-105	*Piping Materials Specifications*
SAES-L-108	*Selection of Valves*
SAES-L-109	*Selection of Flanges, Gaskets and Bolts for Pressure Piping Systems*
SAES-L-120	*Piping Flexibility Analysis*
SAES-L-125	*Safety Instruction Sheet for Piping and Pipelines*
SAES-L-132	*Material Selection for Piping Systems*
SAES-L-133	*Corrosion Protection Requirements for Pipelines/Piping*
SAES-L-136	*Pipe Selection and Restrictions*
SAES-L-140	*Thermal Expansion Relief in Piping*
SAES-L-150	*Pressure Testing of Plant Piping and Pipelines*
SAES-L-350	*Construction of Plant Piping*
SAES-L-460	*Pipeline Crossings under Roads and Railroads Saudi Aramco Standard Drawing*
SAES-L-610	*Nonmetallic Piping*
SAES-O-202	*Security Fencing*
SAES-X-400	*Cathodic Protection of Buried Pipelines*
SAES-X-600	*Cathodic Protection of Plant Facilities*

Saudi Aramco Standard Drawings

AC-036207	*Pipeline Spacing Arrangements*
AB-036521	*Bridge Weld and Typical Brace Seal Welded, Socket Welded Valves*
AE-036252	*Corrosion Bar Wear Support*
AD-036555	*Standard Wear Pads for Unrestrained Pipelines*
AC-036697	*Maximum Spans for Above Ground Unrestrained Pipelines 14" & Larger*

AC-036688	*Conical Pump Suction Screen for CL-150 & 300 Flanges Pipe Sizes 16 Inch and Larger*
AD-036080	*Conical Pump Suction Screen for Raised Face Flanges Pipe Sizes 2, 3 & 4 Inches*
AD-036495	*Conical Pump Suction Screen for Raised Face Flanges Pipe Sizes 6, 8 & 10, 12 & 14 Inches*
AD-036495	*Locally Mounted Instrument Piping Details*

Saudi Aramco Library Drawing

DC-950040	*Pressure Indicators and Switches Locally Mounting Instrument Piping Details*

Saudi Aramco Engineering Report

SAER-714	*Wind Induced Vibration of Pipelines*

Saudi Aramco Drafting Manual

3.2 Industry Codes and Standards

American Petroleum Institute

API RP 686	*Recommended Practices for Machinery Installation and Installation Design-(Chapter 6 -Piping)*
API SPEC 5L	*Specification for Line Pipe*

American Society of Mechanical Engineers

ASME B16.1	*Cast Iron Pipe Flanges and Flanged Fittings*
ASME B31.1	*Power Piping*
ASME B31.3	*Process Piping*
ASME B31.4	*Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids*
ASME B31.8	*Gas Transmission and Distribution Piping Systems*

American National Standards Institute

ANSI B16.9	*Factory-Made Wrought Steel Butt Welding Fittings*

Uniform Plumbing Code (UPC)

4 Definitions

Dead Legs: Piping sections that are potential for internal corrosion due to flow stagnation. Refer to Section 11 of this Standard for detailed criteria.

Design Agency: Refer to SAES-L-100.

Fully Restrained Piping: A pipe system that is restrained from axial and lateral movement by means of anchors, clamps and/or supports.

Unrestrained Piping: Piping system designed with sufficient flexibility to control stresses due to thermal or other movement.

Process-Utility Connection: The piping which joins the utility header root valve to the block (root) valve of the process pipe or equipment.

Temporary Connection: A connection made by means of metallic or non-metallic hose, or flanged break-away spool. The temporary connection is marked in a conspicuous manner and governed by plant operating instructions for use only under constant monitoring.

Process Equipment: Piping, vessels, tanks and other plant equipment that contain hydrocarbon liquid or gas, toxic chemicals, including acids or caustics.

Break Tank: A vented water reservoir controlled by the water level in the tank, from which the water can be pumped through a permanent connection with check valve and block valve into a single unit of process equipment.

Water Supply System: The entire network of piping between a source of water (well or tank) and all delivery points.

5 Responsibilities

5.1 It is the responsibility of the design agency to design pressure piping systems that meets the requirements of the applicable Code and the additional relevant Saudi Aramco Standards, Specifications and Procedures as a minimum.

5.2 Strict application of minimum standards does not prohibit nor alleviate the design agency from using good engineering practices and from producing innovative ideas, subject to the approval by the Piping Standards Committee Chairman or his representative.

5.3 Though this standard covers requirements related to design of piping systems, the design agency shall be acquainted with SAES-L-350 in order to design piping systems which will assess constructability with the most cost effective approach.

6 Applicable Codes and Standards

In addition to referenced Codes and Standards, the applicable Codes and Standards in accordance with SAES-L-100 shall apply.

7 Design Package

The design of pressure piping located inside plant areas shall include the preparation of the documents listed below.

These documents shall be given Saudi Aramco drawing numbers (where applicable in accordance with Saudi Aramco Drafting Manual) and become permanent plant records:

- Process Flow Diagram (PFD) or Utility Flow Diagram (UFD)
- Piping and Instrument Diagram (P&ID)
- Piping Designation Table (Saudi Aramco Form)
- Calculation sheets supporting major flow data and pressure drop data shown on the Piping Designation Table
- Safety Instruction Sheets (SIS) for critical piping per SAES-L-125
- Piping Plan Drawings (details and sections must be shown on separate drawings)
- Piping Section Drawings and details
- Isometric Piping Detail Drawing
- Piping flexibility calculations per SAES-L-120
- Hydrostatic Test Diagram
- Pipe support and foundation location drawing
- Pipe support and anchor detail drawings
- Valves operating diagram (VOD) as required by Operation
- Project Scope of Work or Project Specifications in which the piping shall be described, highlighting any special features or precautions such as concerning welding, adjustment of spring hangers, cold spring, etc.

8 Design Condition and Limitations

8.1 The design agency shall establish and/or verify that the design conditions are realistic and fulfill the targeted operational and design capacity.

8.2 The design agency may specify design conditions exceeding immediate design requirements if there are long term economical justifications for future capacity

increase.

8.3 Design Factors and Allowable Stresses

8.3.1 Plant piping designed in accordance with ASME B31.4 or ASME B31.8 the following shall apply:

- For MAOP and wall thickness calculations the design factor shall not be more than 0.5.
- Pressure variation under surge condition equals to 15% of MAOP is permitted for liquid service.
- For longitudinal stress under sustained load the allowable stress shall not exceed 0.72 of SMYS.
- The combined sustained and secondary stresses shall not exceed 0.90 SMYS in the piping system.

8.3.2 Plant piping designed in accordance with ASME B31.1 or ASME B31.3 shall follow the Code allowable.

8.3.3 Maximum Stresses

The calculated maximum principal stress due to test conditions shall not exceed the SMYS.

8.3.4 Occasional Loads and Pressure Variation

For design conditions which include occasional loads such as wind, earthquake, or external hydrodynamic forces, or occasional short-term pressure variation above the normal maximum, the pressure rating of components and/or the allowable stress may be increased as permitted by the applicable Code for such conditions without additional restrictions.

8.4 Design Pressure

8.4.1 Piping systems designed in accordance to ASME B31.4 or ASME B31.8 shall have the design pressure as close as possible to the MAOP.

8.4.2 Piping systems designed in accordance to ASME B31.1 or ASME B31.3 shall be designed to withstand the most severe combination of pressure and temperature.

8.4.3 The variation allowance by the Code in the internal pressure should be taken as an advantage for a cost effective design.

8.5 Design Temperature

8.5.1 The design agency shall specify the design temperature that matches the actual process conditions. Specific temperature conditions are addressed below.

8.5.2 Pipe Temperature

For the purpose to specify piping material, the metal temperature of the pipe and piping components shall be the same as the bulk temperature of the fluid transported by the piping system.

No credit should be given for ambient heat losses unless such losses can be demonstrated to have significant cost advantage.

8.5.3 Ambient Range

For fluid temperatures at or above ambient, the design temperature shall not be less than the maximum expected actual fluid temperature at design flow rate and design pressure.

8.5.4 Refrigerated Services

For the purpose of determining impact testing requirements, the design minimum temperature shall be established for piping carrying fluids which have been refrigerated below ambient temperature, based on process design conditions.

8.5.5 Auto-refrigeration

For systems normally at or above ambient temperature which can occasionally be exposed to lower temperatures due to a sudden reduction in pressure (including causes such as leaks or ruptures) or due to blowdown of equipment, the design minimum temperature shall be the coincidental temperature when the pressure reaches 25% of the design pressure.

8.5.6 Thermal Radiation Effects

All above ground piping systems shall be evaluated in accordance with SAES-L-140 for pressure build up due to the effects of solar radiation, ambient temperature, and other heat sources such as a flare or combination of these effects.

8.6 Dynamic Effect

The effects of dynamic forces external and internal dynamic forces shall be analyzed and the final design shall be suitable to accommodate such forces. Examples of such forces are earthquake, slug forces, pressure surge forces, etc.

8.7 Sustained Loads

8.7.1 Sustain load shall include effects of internal design pressure, weight effects of pipe, components and contents.

8.7.2 Traffic loads on buried piping shall be in accordance with SAES-L-460.

8.8 Meteorological and Seismic Design Data

Data for meteorological and seismic condition shall be in accordance with SAES-A-112.

8.9 Flow Velocity Consideration

8.9.1 Liquid Service

Limitation on flow velocities inside piping systems per SAES-L-132 shall apply.

8.9.2 Gas Service

8.9.2.1 Higher velocities may be permitted if there are technical and economical justifications, subject to the approval of the Chairman of the Piping Standards Committee and the Chairman of the Materials and Corrosion Control Standards Committee.

8.9.2.2 Piping systems shall be designed with considerations to avoid and/or minimize the potentials of noise and piping vibration due to high velocities, slug flow, two-phase flow, acoustic fatigue, etc. Piping system in gas service shall meet the requirements of paragraph 20.1.

9 Material Selection for Piping Components

9.1 All pressure piping components shall comply with Saudi Aramco Standards specified in the paragraphs listed below. However, it is the design agency responsibility to ensure selected material is adequate to the intended service.

9.1.1 Material procurement of pipes, fittings and gaskets shall be in compliance with the Regulated Vendor List SAES-L-101.

9.1.2 Material procurement of valves shall be in compliance with the Regulated Vendor List SAES-L-102.

9.1.3 Material specification and line classes shall be in accordance with SAES-L-105.

9.1.4 Material selection for line pipes and components shall be in compliance with, SAES-L-132, SAES-L-133, and SAES-L-136.

9.1.5 Valves selection for piping systems shall be in accordance with SAES-L-108.

9.1.6 Flanges, bolts and gasket shall be in compliance with SAES-L-109.

9.2 All non-metallic piping system shall be designed and constructed in accordance with SAES-L-610 in addition to the applicable ASME B31 Code.

9.3 Each pressure piping system located within a plant area shall be given a material specification code in accordance with SAES-L-105.

9.4 Items specified by brand names or proprietary names are not intended to exclude equivalent items offered by other manufacturers.

10 Limitations on Pipe Sizes and Thickness

10.1 Sizes of Pipes and Fittings

The outside diameter of steel pipe shall be in accordance with applicable API SPEC 5L and/or ANSI B16.9 standards. Intermediate sizes and the sizes: ⅛, ¼, ⅜, 1¼, 2½, 3½, and 5 inches shall not be used except when necessary to match equipment connections. In this case a suitable transition shall be made as close as practical to the equipment.

10.2 Pipe (excluding stainless steel tubing) smaller than ¾-inch nominal size shall not be used for hazardous services (including vents and drains) except for instrument connections (such as shown on Standard Drawings) and on Vendor-supplied skid-mounted equipment or other (interior) applications where the pipe is adequately protected against mechanical damage.

10.3 The wall thickness of the pipe and piping components shall meet the requirements of the applicable Code as a minimum.

10.4 Piping wall thickness selection shall be governed by greater of minimum calculated code thickness including corrosion allowance or the minimum structural thickness provided in Table 1.

Table 1 – Minimum Structural Pipe Wall Thickness (T_s)

Nominal Pipe Size (Inch)	Welded Pipe Including Seal/ Socket Welded		Threaded Pipe (Not Seal Welded)	
	(Inches)	(mm)	(Inches)	(mm)
½ Thru 1½	0.09	2.25	0.12	3.0
2 Thru 3	0.09	2.25	0.12 (1)	3.0 (1)
4 Thru 12	0.10	2.54	-	-
14 Thru 18	0.12	3.0	-	-
20 Thru 30	D/150 (2)	D/150 (2)	-	-
32 Thru 48	0.200	5.08	-	-
50 and up	0.250	6.35	-	-

Notes:

1. Threaded pipe is allowed up to NPS 2" for existing facilities in hydrocarbon services and up to NPS 3" for utility piping (refer to SAES-L-105).
2. "D" is the pipe outside diameter.
3. A stress analysis is required to confirm that the combined longitudinal stress does not exceed the code allowable limit based on factors such as pipe support spacing, allowable stress, design pressure, etc. This note applies to the entire Table 2.

10.5 For carbon steel piping, the minimum nominal wall thickness shall not be less than the values listed in Table 2.

Table 2 – Minimum Pipe Wall Thickness for Carbon Steel Pipes

Nominal Size (Inches)	Hydrocarbon Service	Low Pressure Utility Service (ASME B16.1 Class 125)
2 and smaller	SCH 80	SCH 40 (see 6.11)
3 through 10	SCH 40	SCH 40
12 through 32	6.3 mm	6.3 mm
34 and larger	Diameter/135	Diameter/135

10.6 The required corrosion allowance shall comply with the requirements of SAES-L-133.

Commentary Note:

For new piping, the corrosion allowance should be added to the retirement structural thickness or the pressure design thickness. Sometimes the minimum structural thickness can be greater than the pressure design thickness. This will ensure that the actual pipe thickness will not be reduced to below retirement

thickness before the corrosion allowance is depleted. This is in conjunction with fitness for service of plant piping once it becomes under operation.

11 Piping Layouts

11.1 General

The design agency is responsible to provide piping layout that is economic and follows sound engineering practices. The piping layout shall assure safe operation, ease of construction, provide adequate access for maintenance activities, minimize consequence due to fire and avoid congestion.

11.2 Hydraulic Considerations

11.2.1 The pipe size, layout and supports shall be designed such that all hydraulic requirements are met in terms of pressure drop and required through put.

11.2.2 Piping systems shall be designed with considerations to avoid and/or minimize the potentials of noise and piping vibration due to high velocities, slug flow, two-phase flow, acoustic fatigue, etc.

11.2.3 Piping systems in high gas velocities operating intermittently shall be designed with following considerations:

- Excessive noise and vibration are avoided due to high gas velocities and pressure drop.
- Smooth transitions at flow intersections by means of laterals and long radius bends.
- Pressure drop at intersections.
- Sufficient length of lead-lines downstream pressure and or flow control valves. A minimum of 5 times diameter shall be achieved.

11.3 Corrosion Considerations

The piping layout shall be designed in a way to minimize corrosion in the piping systems due to presence of water pockets, dead legs, and any other situation leading to internal or external corrosion.

11.4 Dead Legs

11.4.1 Dead legs leading to internal corrosion shall be avoided at the design stage.

11.4.2 A section of a piping system meeting the following criteria is

considered as a dead leg:

a) When a pipe section is connected to a flowing stream where it is not self-draining and is not normally flowing.

b) The piping material has the potential for corrosion in service.

c) When the length is longer than three times its pipe diameter, or 1.22 m (4 ft) whichever is less. The length of the dead leg is the distance measured from the outside diameter of the header (or run) to the near end of the branch valve.

For branch connections of 1-½ inch NPS and smaller, the length of the dead leg is the distance measured from the end of the boss to the near end of the valve.

Commentary Note:

A by-pass line that is designed for a specific function is not normally considered to be a deadleg. However, if a specific ruling is required the Chairman of Piping Standards Committee in CSD shall be contacted.

11.4.3 Exemptions to Dead Legs

A section of a piping system meeting the following criteria is not considered as a dead leg even if it meets the dimensional criteria above:

a) Piping system that is corrosion resistant by its nature.

b) The service is not corrosive and experience has demonstrated such claim.

c) The service is not wet.

11.4.4 In the case where a piping section is identified as dead leg and it is not avoidable from a construction point of view, then during project execution, a concurrence letter shall be signed by representatives from PMT (Project Manager), Proponent (Operation Engineering/Technical Supervisor), Projects Inspection (Supervisor), and CSD Piping and Material Unit Supervisors.

The Operating Organization shall periodically inspect such piping under the On Stream Inspection Program (OSI).

11.5 Piping Flexibility

11.5.1 The piping configuration shall be analyzed for adequate flexibility in accordance with SAES-L-120.

11.5.2 The piping system shall not be too flexible to the point that it becomes subject to piping vibration problems.

11.5.3 Expansion Joints

11.5.3.1 Swivel joints, expansion joints, flexible pipe (metallic or non-metallic), hoses or similar devices shall not be used to reduce the stiffness of the piping system or to reduce load on equipment nozzles in flammable, toxic and hazardous services.

11.5.3.2 They may be used for category D fluid service as defined in ASME B31.3.

11.5.3.3 Expansion joints on lube oil systems in vendor standard designed lube oil skids may be acceptable subject to review and approval by the Chairman of Piping Standards Committee in Consulting Services Department.

11.5.3.4 In the case where the use of expansion joint or others is unavoidable the installation proposal shall be approved by PMT (Project Manager), Proponent (Operation Engineering/Technical Supervisor), Projects Inspection (Supervisor), and CSD Piping Unit Supervisor.

Also, a detailed piping flexibility analysis shall be performed in accordance with SAES-L-120.

11.5.4 Pipe Expanded Joints shall not be used regardless of service type.

11.6 Pipeways

11.6.1 Above grade plant piping between plant equipment or between separate units within a plant area shall be designed and installed within pipeway boundaries as indicated on Plot Plans and Piping Plans.

11.6.2 The Plot Plans and Piping Plans shall be laid out such that they shall provide the necessary access to all areas for operations and maintenance. The elevations of intersecting pipeways shall normally be at different levels to allow for future piping.

11.6.3 When designing off-plot pipeways for process plants, consideration shall be given to providing extra rack space for future expansion. This consideration is subject to the approval of the Proponent's Operating Department.

11.7 Piping Connected to Rotating and Reciprocating Equipment

11.7.1 General Requirements

11.7.1.1 All Piping directly connected to the machinery, excluding lube oil and seal flush, shall be designed such that forces and moments imposed by thermal expansion, dead and operating loads on the machinery nozzles are within equipment/manufacturer allowable standard/limit.

11.7.1.2 All piping shall be routed and supported to allow access to machinery for operation, inspection and maintenance. Inlet and outlet isolation block valves around machinery shall be accessible from grade near machinery.

11.7.1.3 Isolation block valves are required in the inlet and outlet process piping to and from all machinery. A check valve shall be installed in the discharge line of all pumps. The check valve shall be located between the machine discharge flange and the discharge block valve.

Commentary Note:

The check valve is required to prevent the possibility of a reversal of flow or pressure surge (such as water hammer) under any condition. The location of the check valve should be specified based on the machine piping layout requirements (i.e., recycle line, etc.).

11.7.1.4 Pressure connections including isolation valves complying with Library Drawing DC-950040 shall be provided on the inlet and outlet piping to and from all machinery. The inlet pressure connection shall be located between the permanent or temporary strainer and the machinery inlet piping flange.

11.7.1.5 Inlet and discharge piping and isolation block valves shall be the same size or larger than the machinery inlet and outlet nozzle size respectively.

11.7.1.6 Temporary strainers shall be used during the commissioning and initial operating period of new plants to prevent foreign objects from entering the machinery.

11.7.1.7 Strainer shall be located between the inlet isolation block valve and the machinery inlet connection not closer than five pipe diameters to the machinery inlet nozzle.

11.7.1.8 Strainers shall be installed in a manner that facilitates frequent strainer removal and cleaning and shall be located in an easily accessible location.

11.7.1.9 Permanent strainers for critical machinery shall have a differential pressure switch to activate alarm on high differential pressure.

11.7.1.10 Machinery inlet and outlet piping shall be supported as near to the machine as practical. Only those supports specified as a result of the piping flexibility analysis shall be provided.

11.7.1.11 Piping vents and drains shall be located in break-out-spools on the inlet and outlet piping to the machine. These connections shall not be placed in angle sections of reducers.

11.7.1.12 A pulsation analysis and mechanical piping analysis shall be conducted on piping systems for reciprocating machinery or machinery subject to pulsating flow to minimize pressure pulsations and piping vibration. Piping routing, piping supports, restraints, and anchors in pulsating system shall be spaced to avoid resonant lengths and to restrain the generated dynamic forces.

11.7.1.13 Centrifugal equipment suction line shall have a straight run minimum of five pipe diameters between the suction flange and first valve, fitting or strainer to ensure stable and uniform flow at the machinery suction nozzle. The minimum length shall be calculated using the diameter of the pump inlet nozzle. Vertically suspended double casing pumps and horizontal self-priming pumps are exempted from this requirement.

11.7.2 Piping Connected to Pump

11.7.2.1 Pump suction piping shall be arranged such that the flow is as smooth and uniform as practicable at the pump suction nozzle.

11.7.2.2 Suction piping shall be designed to prevent the formation of gas or air pockets. Sufficient venting provisions shall be included.

11.7.2.3 The suction piping shall be sloped a minimum of 10 millimeters per meter *(⅛* inch per foot) toward the pump

at all points to prevent the accumulation of bubbles in case the fluid being pumped is near its vaporization temperature.

11.7.2.4 Reducers used on horizontal suction line shall be eccentric with the flat side on top. Eccentric reducer with the flat side on top shall be utilized for overhead piping into a top suction pump. Concentric reducer shall be used on the vertical suction line as required.

11.7.2.5 Suction and discharge piping for vertical in-line pumps shall have adjustable supports.

11.7.2.6 Temporary strainers in accordance with Standard Drawings AC-036688, AD-036080 or AD-036495 shall be used during the commissioning and initial operating period of new plants to prevent foreign objects from entering the pump. If strainers are required beyond commissioning and initial operating period, they shall be "T" or "Y" type with minimum ¼ inch openings and at least 150% flow area.

11.7.3 Piping Connected to Compressor

11.7.3.1 Compressor and blower piping layout requirements shall be closely coordinated and agreed upon by the Piping Engineer, Control System Engineer, compressor vendor and control systems vendor to insure piping and hydraulic requirements are satisfied for proper compressor operation, control and protection.

11.7.3.2 Inlet piping to compressors and blowers shall be free of sections where liquid may accumulate during normal operation, start-up, and or shutdown.

11.7.3.3 Horizontal reducers installed in the inlet piping to compressors or blowers shall be eccentric with the flat side on the bottom of the pipe to prevent the accumulation of any liquids.

11.7.3.4 Suction piping to compressors in condensing service shall be designed for automatic condensate removal from low points in the compressor piping systems when the machine shuts down.

11.7.3.5 Suction piping layout for wet gas compressors shall be free of sections where standing liquid may accumulate and shall

slope back toward the suction vessel. Adequate drains on the piping shall be provided to remove any standing liquids.

11.7.3.6 Suction piping to wet gas compressors shall be heat traced and insulated.

11.7.3.7 The suction line to each compressor or blower shall be provided with permanent or temporary strainer of an adequate strength.

11.7.3.8 Routing of compressor recycle lines shall be designed to be self-draining preventing liquid from accumulating in piping low points.

11.7.3.9 The anti-surge recycle line shall join the compressor discharge on a piping tee branch, located as close as possible to the compressor discharge. The anti-surge recycle line should join the compressor suction line at the suction knock-out drum or suction piping upstream of knock-out drum in a 45° angled connection directing the recycle flow towards the compressor.

11.7.3.10 The type of check valve required per paragraph 11.7.1.3 shall be non-slam internal-spring assisted type.

11.7.3.11 Reciprocating compressors suction piping downstream of the suction drums and pulsation suppression devices of compressors operating at or within 5°C of the gas saturation temperature shall be heat traced and insulated to ensure that condensation of liquids does not occur.

11.7.3.12 Positive displacement machinery shall be equipped with a pressure relief device. This pressure relief device shall be located between the machinery discharge connection and the first isolation block valve or blind. Pressure relief device discharge piping shall be routed to a designated system.

11.8 All pressure piping appurtenances shall be isolated to atmosphere by double isolation (e.g., double block valves or one block valve with plug or one block valve with blind flange).

12 Lines Spacing Requirements

12.1 Any deviation from requirements of this section shall be reviewed and approved by the Chairman of the Piping Standards Committee at the Consulting Services

Department or his representative.

12.2 The minimum spacing between lines supported on sleepers or pipe racks shall be as shown on Standard Drawing AC-036207.

12.3 Above-grade piping shall be supported to provide a minimum of 300 mm clearance between bottom of the pipe and the finished grade.

12.4 A minimum clearance of 50 mm shall be provided for inspection and freedom of pipe movement between above ground piping crossing with any structure (including pipe support structure). This clearance is also required for above ground piping crossing with another pipe.

12.5 Branch connections, 4 inch and smaller, including drain and vent valves and drip legs of all sizes, shall be located at a minimum horizontal distance of 610 mm (24 inches) from any fixed obstruction. This requirement does not apply to that part of the support which is attached directly to the piping, such as horizontal and vertical dummy extensions.

Exceptions:

a) Piping system in single phase gas service. Thermal piping stress analysis shall determine the required branch clearance with obstruction for such a service.

b) When the results of the piping stress analysis including the surge forces show that the branch clearance with obstruction is acceptable.

12.6 Where a grease fitting is provided on isolation valves it is the designer's responsibility to provide adequate maintenance access to the fitting.

13 Underground Piping

13.1 Underground pressure piping in any flammable and toxic services within the SSD fence shall not be used except as permitted in the following section.

13.2 Buried piping is permitted within SSD fence only at the following locations:

13.2.1 Road, fence and dike crossings.

13.2.2 New connections to existing buried lines.

13.2.3 One hundred percent of the buried line can be inspected by instrumented scrapers.

13.2.4 As required by SAES-O-202.

13.3 Underground pressure piping where permitted shall be subject to the following additional requirements:

13.3.1 No buried dead legs shall be allowed, including "effective" dead legs resulting from the buried portion of the line being frequently or normally valved off unless the line is designed to be self-draining and/or is internally coated per SAES-H-002.

13.3.2 The buried piping (including appurtenances) shall be cathodically protected with impressed-current or galvanic anodes system to meet the requirements of SAES-X-400 or SAES-X-600.

13.3.3 The minimum cover over underground pressure piping shall be 450 mm in unpaved or paved areas and 750 mm under paved roads, except under a reinforced concrete slab or other protection subject to approval by the Chairman of Piping Standards Committee.

13.3.4 The buried piping (including appurtenances) shall be externally coated with an approved coating, in accordance with SAES-H-002.

13.3.5 Underground piping subject to traffic loads (road crossings) shall meet the requirements of SAES-L-460.

14 Pipe Supports Design

14.1 Responsibilities

14.1.1 Any deviation to this section shall be resolved through concurrence from the Chairman of Piping Standards Committee or his representative.

14.1.2 It is the Design Agency responsibility to design the pipe supports, restraints, and anchors to meet the static and dynamic load effects.

14.2 Rigid pipe supports

14.2.1 The rigid pipe supports should be utilized to maximum extent thus avoiding the use of spring supports and rod hangers wherever design permits.

14.2.2 The designer shall ensure that all pipe supports will be active during operation of the lines, i.e., the pipe will be in full contact with the support and carries the load.

14.3 Hanger Rods

14.3.1 Rod hangers shall not be used for lines 12" NPS and larger in liquid

service or multi-phase flow.

14.3.2 Rod hangers shall be subjected to tensile loading only.

14.3.3 Rod hanger assemblies shall be designed to allow for anticipated thermal movement.

14.3.4 The maximum swing angle due to horizontal pipe movement shall be four (4) degrees.

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

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

14.3.7 Where atmospheric corrosion is a concern hanger rods shall be protected against external corrosion.

14.4 Spring Supports

14.4.1 Spring supports immediately downstream of rotating equipment shall be limited to 10-15% load variation.

14.4.2 Supports shall be designed so that they cannot be disengaged by movements of the supported pipe.

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

14.4.4 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."

14.4.5 Each spring hanger assembly must be capable of sustaining the hydrotest load.

14.4.6 Where atmospheric corrosion is a concern spring supports shall be protected against external corrosion.

14.5 Ring Girders

14.5.1 Above ground fully restrained piping shall be supported on ring girders, or 180-degree saddles with top strap, designed to prevent lateral buckling of the pipeline. Suitable electrical insulation strips

shall be provided between the pipe and the support if required to prevent dissipation of cathodic protection current.

14.5.2 If the ring girder supports of the above ground piping sections interfere with the cathodic protection of the buried sections (if some sections of the line are buried), electrical insulation between the pipe and the supports is required per SAES-X-400.

14.5.3 The pipe surface covered by the ring girder or saddle and top strap shall be coated with a SAES-H-101 approved epoxy coating such as APCS-26 to prevent corrosion of the pipe. Coating is not required if a fiberglass insulating spacer is epoxy bonded to the pipe after abrasive blasting the pipe surface to Sa 2-½ (near white metal blast).

14.6 Low Friction Supports

14.6.1 If Teflon sheets or similar low friction materials are used to reduce the design loads on piping and/or the supporting structure, 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.

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

14.7 Dummy Supports

14.7.1 The dummy supports shall not create excessive stresses at the attachment welds to the run pipe. This can be accomplished by minimizing the length of the supports and/or increasing the size of the supports.

14.7.2 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.

14.8 Support Spacing

To mitigate wind-induced resonant vibration of the above-ground piping with diameters larger than 12-inch supported at regular intervals, the basic support spacing shall be selected so that the natural frequency of the piping in operating condition is outside the range of wind induced frequencies plus or minus 10% for wind speed above 9 m/s (20 MPH) which will cause vortex shedding.

Commentary Note:

The Saudi Aramco Engineering Report SAER-714 "Wind Induced Vibration of Pipelines" or any other reliable engineering source could be used to perform these calculations.

15 Anchors and Guides

15.1 End Anchors

The Design Agency shall ensure that above-ground restrained and buried pipelines terminating at the plant facilities be provided with end anchors.

Commentary Note:

The design and construction of end anchors for pipelines are usually executed by different Design and Construction Agencies. Therefore, it is the PMT responsibility to coordinate between involved parties.

15.2 Intermediate Anchors, Guides, and Line Stops

15.2.1 The free movement of unrestrained piping, both in axial and lateral directions, shall be controlled and limited by properly located guides and anchoring points to within acceptable bounds.

15.2.2 Intermediate anchors or axial line stops shall be provided for above-ground unrestrained piping between and/or at the center of expansion loops or offsets. The design load for such intermediate anchors shall include the effect of friction forces.

15.2.3 Axial line stops and guides shall be provided for above ground unrestrained lines subject to slug forces in services listed below. Slug forces shall be estimated based on the worst case assumed velocity and average density of the liquid/vapor slug expected to occur.

The supporting structures shall be designed to withstand slug forces acting at changes in direction. However, the pipe guides and stops shall yield prior to the pipe.

The following are examples of services with potential slug flow, however this doesn't remove responsibility of the Deign Agency to identify others.

- Two-phase flow lines
- Liquid intermittent lines, such those used to control liquid level in the drums

- Pressurized drain lines
- Relief and blow-down lines
- Flare lines
- High-pressure gas lines

15.3 Dampening Anchors

Suitable dampening anchors shall be provided to hold down the piping and mitigate vibration as required at control valve stations, (surge) relief valves, and where flow surges can occur.

16 Non-Pressured Welded Attachments

16.1 During the design stage the following requirements shall be adhered to:

16.1.1 Welded attachment irrelevant to the piping systems shall be minimized such as those for electrical conduits. Design should minimize the use of bimetallic welds.

16.1.2 The pipe shall not be used to support other pipes and structures without an appropriate analysis.

16.1.3 All structural attachments, which transfer loads to the pipe through welds, shall be welded to full encirclement sleeves or saddle pads if the piping is designed to operate at a hoop stress in excess of 50% of the allowable stress. The corners of the pad shall be rounded corners. ASME B31.4 paragraph 421.1(d) and ASME B31.8 paragraph 834.5(b), if applicable, shall not be waived.

16.1.4 On the construction drawings, all welds to the pipe shall be shown as continuous with smooth finish.

16.2 Wear Pads and Saddles

16.2.1 Piping in hazardous services where condensation can form on the pipe, or operating within 30 m of the sea shall have wear pads or corrosion bars welded to the pipe at each support (see Standard Drawings AE-036252 and AD-036555).

16.2.2 Excluded from this requirement are low pressure systems with hoop stress at design pressure below 20% of Specified Minimum Yield Strength (SMYS) of the pipe.

16.2.3 Wear pads are also required for structural reinforcement as indicated in Standard Drawing AC-036697. Wear pads shall be fully welded to avoid ingress of moisture.

16.2.4 Saddle-type supports: Saddle-type supports with pads shall be provided for piping 30-inch NPS and larger. In case saddle pipe support cannot be installed, the line shall be analyzed for localized stresses. The analysis shall be submitted to the Piping Specialist of CSD for review and approval.

17 Firewater Systems

Piping systems designated for fire protection water systems in plant areas shall comply with SAES-B-017.

18 Plant Utility Piping System

18.1 This section of the standard defines additional limitations on piping used for connecting a supply of steam, water, air, nitrogen or other inert gas to process equipment in hazardous services except as stated below. It also includes connections for the purpose of purging or cleaning when the process equipment is not in operation.

18.2 This section does not apply to purge connections to open furnaces or fire boxes. It also does not cover connections to process equipment where the process flow and utility flow remain physically separated such as in cooling water or instrument air.

18.3 The design of utility Stations located in various plants within one plant area which are operated by one operating department or division shall be uniform and shall be such that the risk of accidental connection to the wrong utility is minimum zed.

18.4 The connectors and color coding in Table 3 shall be standardized for utility stations in new plants not governed by paragraph 18.3.

Table 3 – Connectors and Color Coding for Plant Utility Stations

Utility	Hose Connection	Color Code
Demineralized Water	1-inch brass Aeroquip 5101	Blue-White stripe
Raw Water	1-inch brass Aeroquip 5101	Blue
Air	¾-inch iron Dixon Air King AM-8	Green/Gray stripe
Steam	1-inch steel Dixon Boss Wf-36	White
Nitrogen	1-inch steel wing nut union	Green/Orange stripe

Commentary Note:

Each individual operating organization shall use additional striping to distinguish different types of water or steam within the above color coding scheme.

18.5 Hose connections, where applicable, shall be positioned at elevation not higher than 1200 mm above finished plant grade or above platform of multilevel equipment but not lower than 600 mm. They shall be pointing 45 degrees downward. The piping shall be securely bolted to a supporting structure and have adequate access. Utility connections shall be installed with minimum 150 mm clearance between each other.

18.6 Each utility take-off connection shall be located at the top of the horizontal main header or auxiliary header. Root valves shall be provided for each utility take-off connection from a main header or auxiliary header which can not be taken out of service without shutting down a complete processing unit or operating facility.

18.7 Instrument air take-off connections to the plant utility station shall always be provided with root valves.

18.8 Each utility line shall be provided with an isolation valve just upstream of the specified hose connector (see paragraph 18.4) at the termination. Ball or globe valves shall be used for air, water, and nitrogen services; globe or angle valves shall be used for steam service, unless otherwise specified by the Proponent Operating Department. Each line shall have a service name plate in Arabic and English indicating the service. The utility pipe and the ends of hoses provided with the station shall be color coded.

18.9 The steam line shall have a steam trap and shall be insulated for personnel protection except for utility steam take-off lines. Utility steam take-off lines shall be insulated but shall not be provided with steam traps. Utility steam stations located above the utility steam header shall be self-draining towards the utility steam header. Utility steam lines to utility stations below the utility steam header shall be allowed to gather steam condensate, which is removed by operations before applying the utility steam.

18.10 Water supply systems which deliver drinking water shall not be connected to process equipment as utility water source.

18.11 Firewater systems shall not be connected to process equipment except via a temporary connection when the equipment is not in operation and not under pressure. Otherwise, each connection and its specific application shall be reviewed and approved by the Chief Fire Prevention Engineer and the Chairman of Piping Standards Committee in Consulting Services Department.

19 Utility-Process Connections

Requirements of this section are specific to the Utility-Process Connections, in addition to the requirements of this standard.

19.1 Temporary Utility-Process connections with components listed in the direction of the utility flow shall be as follows:

19.1.1 The utility side shall have a block (root) valve, pressure gauge, check valve and a drain valve to depressurize the hose or the break-away spool. The process side shall also have a check valve, block valve and pressure gauge near the hose connection. When disconnected, both open piping ends shall be capped, or plugged, or fitted with blind flanges.

19.1.2 The break-away spool shall be designed such that when not in use, it can be easily disconnected and kept at a dedicated, fixed location. The spool shall be painted with stripes of color per the piping color code per SAES-B-067.

19.2 No permanent connections other than air or steam shall be made to process equipment operating above 100°C nor shall water or steam be permanently connected to equipment that operate below 0°C.

19.3 Permanent connections without a break tank shall not be made except when the required service is continuous or frequent (at least twice per week) or needed for emergencies. Permanent connections without a break tank shall consist of the following (in the direction of the utility flow):

19.3.1 The utility flow shall have instrumentation for automatic shut-off on low flow or low pressure (in addition to a check valve) in all cases where redundant protection against back flow is required by the Operating Department.

19.3.2 The utility side shall have a pressure gauge, block valve, bleed valve and spectacle blind or quick change blind (normally open).

19.3.3 The process side shall have a check valve, bleed valve or drain, block valve and pressure gauge.

19.3.4 The block valves of the connection shall be within sight of each other and shall be as close as practical to the process equipment. The pressure gauges and the position of the blind shall be clearly visible from a single point.

19.4 Air connections to asphalt or hot oil piping through which air is supplied to blow the product to tankage, shall be provided with a water knock-out (KO) drum

with drainage facilities. The line downstream of the KO drum shall not contain low points and shall have an additional drain valve immediately upstream of the process connection.

19.5 When air is injected as a reaction agent, such as in Merox and air sweetening units, the control shall be such that the hydrocarbon/air mixtures will not enter the flammable range unless required by the process. Instrumentation shall be provided to shut off the air flow if the process flow fails. In addition, a restriction orifice shall be provided.

19.6 The rating of all components of a permanent connection shall be suitable for the more severe of pressure/temperature of the process or the utility service.

19.7 For temporary connections the pressure/temperature rating of the process side shall extend to the hose or break-away spool.

19.8 If the process fluid requires internal lining or material other than used in the utility system, the lining or the material shall extend from and include the check valve on the process side. Valves with bodies of gray cast iron, ductile iron, or low melting point alloys (such as brass or bronze) shall not be used in a permanent connection including the utility side. Valve bodies and trim in a permanent connection shall be suitable for both the process and the utility fluid with regard to corrosion and pressure rating.

19.9 Operator access shall be provided to the block valves on either side and to the blind or break-away spool of the connection. Chain operated valves shall not be used.

20 Vibration Consideration

20.1 Piping shall be routed as close to grade or to heavy concrete foundations as possible. Rigid anchors and restraints, when required, shall be used effectively to properly secure the piping and shall be designed to provide lateral stiffness needed to restrain dynamic forces.

20.2 Branch connections (2" and smaller) in piping connected to rotating equipments or in location where vibration can occur (such as near control valves) shall meet the following requirements:

20.2.1 No branch connections shall be installed without a justifiable need. The number of branch connections shall be kept to an absolute minimum.

20.2.2 Branch connections shall be installed as far from the source of vibration as practical and should be located at points where the run line is anchored.

20.2.3 All branch connections shall be braced in accordance with Standard Drawing AB-036521. When bracing can not be provided, the requirement can exempted with one of the following conditions:

Schedule 160 close nipples shall be installed with reinforcing pad as required by the code or integrally reinforced outlets of approval design.

An extended body valve (with reinforcement as required by the code) shall be used.

20.3 Piping system in gas service operating intermittently with high velocities (0.2 MAC and higher) shall be designed with the following consideration:

- Excessive noise and severe vibration shall be avoided.
- Pipe intersections should be at 45 degree inclination rather than 90 degree.
- Pipe bends shall be of the long radius type with minimum 3 diameters.
- Lead-lines downstream the pressure and/or flow control valves shall have sufficient length to allow for flow development. A minimum length of 5 times diameter is recommended.
- For branches intersecting into another pipe at 90 degree having a diameter ratio less than halve, should be made with transition spool to increase this ration at the intersection point to 0.5 or more.
- An extended body valve (with reinforcement as required by the code) shall be used in 2" and smaller branch connection.

21 Chemical Cleaning Line Identification

Lines that require chemical cleaning during construction shall be identified and marked up on the appropriate P&ID's and Line Index Tables in accordance with SAES-L-350. The systems to be cleaned shall have high and low point vents and drains installed.

22 Testing and Inspection

22.1 The design of the piping systems shall facilitate effective pressures testing per the requirements of SAES-L-150.

22.2 Test procedures that may require special attention may be prepared during the design stage.

22.3 For capital projects where a project proposal will be developed, the scope of pressure testing requirements shall be prepared.

Revision Summary

25 July 2012	Revised the "Next Planned Update." Reaffirmed the content of the document, and reissued with editorial revisions.