Engineering Standard

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Design of Submarine Pipelines and Risers

Document Responsibility: Offshore Structures Standards Committee

Saudi Aramco DeskTop Standards

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1 Scope

This standard defines the minimum mandatory requirements governing the design and installation of submarine pipelines and risers supplementing the API RP 1111, Design, Construction, Operation and Maintenance of Offshore Hydrocarbon Pipelines, ASME Code for Pressure Piping, ASME B31.4, ASME B31.8 and SAES-L-410.

Environmental criteria for the design of submarine pipelines shall be taken from SAER-5697 "Arabian Gulf Hindcast Study" for the Arabian Gulf and from SAER-5565 "Red Sea Hindcast Study" for the Red Sea.

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-H-002	*Internal and External Coatings for Steel Pipelines and Piping*
SAES-L-109	*Selection of Flanges, Stud Bolts and Gaskets*

SAES-L-133	*Corrosion Protection Requirements for Pipelines/Piping*
SAES-L-410	*Design of Pipelines*
SAES-W-012	*Welding Requirements for Pipelines*
SAES-X-300	*Cathodic Protection of Marine Structures*

Saudi Aramco Engineering Reports

SAER-5565	*Red Sea Hindcast Study*
SAER-5697	*Arabian Gulf Hindcast Study Red Sea Hindcast Study*
SAER-5711	*Submarine Pipeline Engineering Guidelines*

Saudi Aramco Materials System Specifications

01-SAMSS-012	*Submarine Pipe Weight Coating*
09-SAMSS-089	*Shop Applied External FBE Coating*
09-SAMSS-090	*Shop Applied Extruded P. E. external Coating*

3.2 Industry Codes and Standards

American Petroleum Institute

API RP 1111	*Design, Construction, Operation and Maintenance of Offshore Hydrocarbon Pipelines*

American Society of Mechanical Engineers

ASME B31.4	*Liquid Petroleum Transportation Piping System*
ASME B31.8	*Gas Transportation and Distribution Piping System*
ASME SEC VIII D1	*Boiler and Pressure Vessel Code*

4 Definitions

Submarine Pipelines: All lines used for the transportation of fluids and/or gases, installed on or below the sea bed between an offshore facility and the demarcation point onshore or another offshore facility.

Demarcation Point: A point along the onshore portion of the line, established in the Project Proposal, to mark the location at which the submarine pipeline ends as referenced in the installation contract.

Riser: That part of a submarine pipeline that is situated between the connecting flange at the mudline nearest to the platform and the first flange above water level.

Pipeline End Manifold (PLEM) Piping: All piping components between the end flange of a submarine loading line and the connection to underbuoy hoses of a single point mooring.

Surf Zone: The area between the shore line and the outermost breaking wave which occurs when the water depth equals 130% of the 100-year maximum wave height.

5 Design Requirements

5.1 Wall Thickness Selection

The wall thickness selection for a given pipeline diameter shall be such that the stresses in the pipe wall resulting from the most unfavorable expected combination of loading conditions described below are within the permissible limits. The wall thickness selection shall take into consideration the corrosion allowances as outlined in SAES-L-133. These corrosion allowances should be subtracted from the wall thickness when calculating stresses for operational conditions. The wall thickness for risers and PLEM piping shall not be less than 12.7 mm.

5.1.1 Installation Stresses

During installation the maximum longitudinal stress in the pipe wall shall be limited to 80% of the SMYS (Specified Minimum Yield Stress) of the line pipe. Simultaneously, the stress in the concrete weight coating shall not exceed 20.7 N/ mm² (3000 psi). If the stresses in the concrete were found to exceed 20.7 N/ mm² (3000 psi), crack initiating devices or grooves shall be used in accordance with 01-SAMSS-012, Submarine Pipe Weight Coating specifications.

The longitudinal stress shall be calculated for the bending moments and axial tension resulting from the laying configuration, submerged weight, barge motions and current forces acting on the pipe.

5.1.2 External Pressure

The external pressure exerted by the water and the soil load in case of burial shall not exceed the maximum allowable determined in accordance with Boiler and Pressure Vessel Code, ASME SEC VIII D1, UG-28. A safety factor against collapse of at least 1.5 is required.

5.1.3 Internal Pressure

The stresses due to internal pressure shall be as limited by SAES-L-410.

5.1.4 Environmental Loads

Offshore pipelines and risers shall be designed for the forces based on loading conditions as stated in SAER-5711. The maximum equivalent stress shall not exceed the allowable stress as defined in SAER-5711.

5.2 Unsupported Spans

5.2.1 The maximum length of unsupported spans for pipelines resting on the sea bed shall be limited by the allowable bending stresses and/or possible vibration due to vortex shedding. The natural frequency of unsupported spans shall be at least 25% above the vortex shedding frequency.

5.2.2 Where necessary, the design shall provide for intermediate supports such as grout bags or fabricated supports which shall be installed as soon as feasible after pipe laying and in any case before the line is filled with water or other liquid to meet the criteria of 5.2.1 above.

5.3 Hydrodynamic Stability Requirements

5.3.1 The negative buoyancy of submarine pipelines including tie-in spools and the submerged portion of risers shall not be less than 10% of the weight of the displaced water when averaged over a length of two pipe joints or 24 m in the empty and totally submerged condition. In the case that this requirement is not satisfied, suitable weight coating must be added in accordance with 01-SAMSS-012, Submarine Pipe Weight Coating specifications.

5.3.2 In areas covered by SAER-5697, submarine pipelines resting on the sea bed shall be designed to withstand the forces resulting from the 100-year return period "extreme" wave conditions in combination with the 100-year return period "joint extreme" current. For areas covered by SAER-5565 or in areas not covered by SAER-5697 and where no information on the joint probability of waves and current is available the guidelines in SAER-5711 shall be used. The design practice in SAER-5711 may be used for general guidance. A minimum factor of safety of 1.10 shall be adopted when assessing the sliding and uplift stability of the pipeline.

The line shall be considered filled with the operating fluid.
The hydrodynamic coefficients shall be taken from SAER-5711.
Where the on-bottom stability requirement cannot be met, the line shall

be protected from the environmental forces by means of the protection methods per SAER-5711 or by trenching or anchoring in the surf zone or locations where wave breaking occurs. In coral areas, alternative methods of protection may be implemented subject to the approval of the Supervisor of Civil Engineering Unit of CSD.

5.4 Pipeline Routing

In selecting an optimum routing, consideration shall be given to the severity of the storm waves attacking the line broadside, to the protection of the ecology and environment, and to the proximity of platforms and other parallel or crossing pipelines. Pipelines approaching offshore facilities in general and well (production) platforms in particular, shall be routed within designated corridors wherever possible to ensure safe anchoring of vessels during workover and construction activities.

5.5 Expansion Provisions

Expansion offsets or loops shall be provided at all tie-in locations where thermal growth will cause loads to be exerted on adjacent pipe runs unless adequate anchoring is provided. Specifically, the offset at risers shall provide freedom of movement for the pipeline without significant load on the riser.

5.6 Stresses Due to Temperature Differential

Restraint pipelines are usually subject to large axial compressive forces at fluctuating temperatures. Therefore, stresses resulting from such conditions shall be considered.

5.7 Stresses Due to pipe curvature in the horizontal plane

Installing pipelines to meet certain routing requirements will subject the pipeline sections to stresses due to curvature. These stresses should be considered when calculating the allowable freespan for pipeline crossings with curved routes. Bend minimum radius shall comply with the requirements of SAES-L-410.

6 Piping Components

6.1 Bolted Flanges

The number of flanges in submarine pipelines shall be kept to a minimum as required for tie-in. The flanges shall have a minimum rating of ANSI Class 300. In a pair of mating flanges one shall be a slip-on, swivel ring or ball swivel flange per SAES-L-109 when the connection must be made under water.

Underwater flanges shall be of the ring joint type with extra length stud bolts for use with hydraulic tensioning equipment.

The excess length protruding from the nuts shall not be cut off but shall be shrouded to reduce the risk of hooking anchor lines or other wires.

6.2 Valves

The use of underwater valves shall be avoided if possible. Where required, flanged end ball valves with actuators specially designed for underwater use shall be applied. Underwater valves such as at a PLEM shall be protected with a suitable structural barrier.

7 Special Features

7.1 External Coating

Corrosion protective coating shall be applied in accordance with SAES-H-002. Concrete weight coating shall be in accordance with 01-SAMSS-012. When the compression method is used, fusion bonded epoxy or extruded polyethylene protective coatings may be used. Fusion bonded epoxy or polyethylene coatings may also be used when weight coating is not required. Fusion bonded epoxy coating shall be applied in accordance with SAES-H-002, APCS-104 and 09-SAMSS-089. Extruded polyethylene protective coatings shall be applied in accordance with SAES-H-002, APCS-105 and 09-SAMSS-090.

7.2 Field Joints

Upon completion of the weld inspection, the area of the field joints shall be coated in accordance with SAES-H-002.

7.3 Cathodic Protection

Cathodic protection of submarine pipelines, risers and associated components shall comply with SAES-X-300.

7.4 Riser Protection

Risers installed on the outboard side of an offshore platform shall be protected by suitable barriers to prevent impact by floating equipment and other objects.

7.5 Pipeline Markers

The pipeline route shall be marked with marker piles or by other suitable means in water depths less than 3 m, measured from Lowest Astronomical Tide (LAT). Applicable standard drawings shall be used for the design of the marker piles.

7.6 Underwater Welding

Underwater welding to the pipeline, in accordance with SAES-W-012, shall be permitted only when carried out in a dry environment (habitat or similar enclosure) and subject to the approval of the entire procedure by the Supervisor of Materials Engineering Unit of CSD.

Revision Summary

14 February 2009	Revised the "Next Planned Update." Reaffirmed the contents of the document, and reissued with editorial changes.
23 May 2011	Editorial revision to remove committee members' list.