Engineering Standard

SAES-L-440 28 February 2005

Anchors for Buried Pipelines

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Previous Issue: 30 September 2003 Next Planned Update: 1 March 2008
Revised paragraphs are indicated in the right margin

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1 Scope

This Standard covers the design requirements for reinforced concrete or structural steel anchors used on buried pipelines. The design of reinforced concrete anchor blocks shall also comply with the applicable sections of SAES-Q-005 and SAES-Q-001.

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 (CSD) 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.

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-Q-001	*Criteria for Design and Construction of Concrete Structures*
SAES-Q-005	*Concrete Foundations*

4 Design Load

Anchoring loads for pipelines shall be determined in accordance with the formula below (using consistent units):

The full thrust force is:

$$Fa = A\,[E * \alpha * \Delta T + (0.5 - \nu) * Sh] \quad (1)$$

Where:

A	=	Cross sectional area of the pipe wall
E	=	Modulus of elasticity
α	=	Coefficient of linear thermal expansion
ΔT	=	Design temperature minus tie-in temperature
ν	=	Poisson's ratio (0.3 for steel)
MAOP	=	Maximum Allowable Operating Pressure (P)
Sh	=	Hoop stress at MAOP = P*D/(2*t)
t	=	Pipe nominal wall thickness
D	=	Pipe outside diameter

4.2 The full thrust anchor force or differential anchor force, without any reduction on account of soil friction due to assumed anchor movement, shall be used for the design and stress calculations of the anchor, including structural steel design, welding details, attachment to the pipe, stability of the anchor against overturning, concrete stresses, and reinforcing bar selection.

4.3 Solely for sizing a concrete block drag anchor, credit may be taken for the soil friction on the length of pipe assumed to move a maximum of 25 mm at the drag anchor, if the connecting piping can accommodate the movement.

5 Forces Resisting Movement of Concrete Anchors

5.1 Unless reliable data is available for the specific site, the following basis shall be used for sizing concrete anchors:

a) In rock areas:

1) Direct bearing of a concrete anchor poured against limestone rock assuming a bearing value of 240 kPa (5000 lbs/ft²).

2) Friction between side of anchor and rock, assuming 48 kPa (1000 lbs/ft²).

3) Friction on bottom of anchor assuming a friction coefficient of 0.4.

b) In granular, well compacted soil above water table:

1) Total net soil resistance as follows:

$$R = C\,(h + b)\,H^2 \qquad (2)$$

in which:

R = soil force at maximum allowable anchor movement, N or lbf.

H = depth from surface to bottom of anchor, m or ft

h = height of anchor block, m or ft

b = width of anchor block face, m or ft

C = constant as follows:

	SI Units	Customary Units
Drag Anchors	23600	150
Full Thrust Anchors	18900	120

The pressure distribution of this force shall be assumed to be proportional to depth below ground.

2) Friction on both sides of the anchor assuming an active soil pressure of 6.25 kPa/m (40 psf/ft) times a friction factor of 0.4.

3) Friction on bottom of anchor assuming a friction coefficient of 0.4.

5.2 If the concrete anchor is partially below the water table or if the soil compaction specified in the construction specifications cannot be obtained, the resisting soil forces shall be reduced accordingly.

5.3 The axial friction force accumulating along the moving length of pipeline adjacent to a drag anchor shall be calculated based on the following:

a) Total radial soil pressure against pipe wall per unit length of pipe equals the weight of the soil cover over the pipe times the pipe circumference plus two times the weight of the pipe plus contents. The friction force per unit length equals the soil pressure times the applicable friction factor.

b) $$L = \sqrt{\frac{2\,A\,E\,d}{f}} \qquad (3)$$

in which:

L = length of pipe moving axially, m or ft

A = cross-sectional area of pipe metal, mm² or in²

E = modulus of elasticity, N/mm² or psi

d = end (anchor) movement of pipe, m of ft

f = friction force on pipe moving length, N/m or lbf/ft

c) The total friction force, F, for 25 mm end movement of a steel pipeline is:

$$F = C1 \sqrt{A f} \qquad (4)$$

in which:

Cl = 100 for SI units, or 2200 for Customary units

F = Friction Force, N or lbf

A and f as defined above.

6 Stability of Anchors

The resultant of all anchor forces shall have a line of action parallel and close to the centerline of the pipeline.

Commentary Note:

The approach in checking stability of concrete thrust anchor blocks, is totally different from that in checking the stability of foundations which is covered in SAES-Q-005. Factors of safety which are used in SAES-Q-005 are not applicable for burried pipeline anchor blocks. Stability of an anchor block against overturning is assured by alignment of the pipe thrust force and the resisting forces. A sliding stablility check per SAES-Q-005 is not required because pipeline anchor blocks are sized based on allowable movement criteria.

7 Anchor Attachments

7.1 For fabricated anchors, the attachment of the anchors to the pipeline shall be with a full encirclement sleeve welded at each end with continuous full size fillet welds not exceeding 1.4 times the pipe wall thickness. The sleeve shall have a strength at least equivalent to the pipe.

7.2 Welded anchor flanges embedded in concrete shall have adequate stiffness to ensure proper distribution of the load within the allowable concrete bearing stress.

7.3 The finished steel fabrication including the pipe, sleeve, and anchor flange or anchor plate inside the anchor block shall be coated per SAES-H-002.

7.4 A minimum distance of no less than 10 cm shall be provided between rebar and the sleeve or anchor flange to ensure adequate cathodic protection of the pipeline. In addition, four 60 pounds magnesium anodes shall be installed for the pipeline one at each quadrant of the anchor.

Revision Summary

28 February 2005	Added the standard SAES-Q-001 to the list of Saudi Aramco Engineering Standards and a Commentary Note 6. Revised the "Next Planned Update."