



Engineering Standard

SAES-L-131

23 July 2011

Fracture Control of Line Pipe

Document Responsibility: Materials and Corrosion Control Standards Committee

Saudi Aramco DeskTop Standards

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1 Scope

This standard covers line pipe supplementary fracture toughness requirements to control crack propagation at temperatures above 0°C in carbon steel pipe used for off-plot transportation piping, such as cross-country pipelines, flowlines, trunklines, and testlines, as defined in [SAES-L-100](#). The requirements apply to line pipe with wall thicknesses of 6.35 mm to 38.1 mm (0.25 to 1.5 inch), in accordance with [API SPEC 5L](#), [01-SAMSS-035](#) and [01-SAMSS-333](#).

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 or modified by specific provisions of this standard.

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 Standard

[SAES-L-100](#)

*Applicable Codes and Standards for Pressure
Piping Systems*

Saudi Aramco Materials System Specifications

[01-SAMSS-035](#)

API Line Pipe

[01-SAMSS-333](#)

High Frequency Welded Line Pipe

3.2 Industry Codes and Standards

American Petroleum Institute

[API SPEC 5L/ISO 3183:2007](#) *Specification for Line Pipe
(Modified)*

4 Classification of Line Pipe

Line pipe, within the scope of this standard, is herein classified according to the fracture toughness acceptance criteria required for different types of fluid service.

- **Class IV Line Pipe:** This class is for gas, two-phase flow, and liquid lines such as NGL, whose vapor pressure may exceed 690 kPa (100 psia). This category also incorporates the former Class II and Class III.

Commentary Note:

Class I was originally for liquid lines with maximum vapor pressure up to 690 kPa (100 psia). This class has been discontinued because PSL 2 pipe ordered to [API SPEC 5L](#) meets the toughness requirement for Class I service by default. Class III was originally for buried gas pipelines and Class II has been used for liquids such as NGL, whose vapor pressure may exceed 100 psia. The former Classes II, III, and IV are now all in Class IV.

5 Testing Requirements

5.1 Class IV pipe shall be tested per [01-SAMSS-035](#) (parent metal, heat-affected zone, and weld metal Charpy V-notch tests). The [API SPEC 5L/ISO 3183](#) absorbed energy values (based on transverse specimens), from tests at 0°C, shall meet or exceed the values determined below. In no case may the required energy value be less than the minimum required value for PSL 2 pipe given in Table 8 of the current version of [API SPEC 5L](#). The energy values calculated below are considered to be the average energy of three specimens.

5.1.1 For lean natural gas (> 90% Methane) or liquids (with vapor pressure/MAOP < 0.35):

$$C_v = (0.0147) \sigma_H^2 (Dt/2)^{0.284} \quad (1)$$

C_v : Required Charpy V-notch absorbed energy (average of three full size transverse specimens) per [API SPEC 5L/01-SAMSS-035](#).

σ_H : Maximum allowable hoop stress, ksi
(This is normally the Design Factor x SMYS)

D : Outside diameter, inches

t : Nominal pipe wall thickness, inches

Toughness values listed in the attached Tables [1](#) through [4](#) are based on the above formula, at various design factors and strength levels (valid up to strength level X65).

Commentary Note:

The above equation is based on lean natural gas (> 90% methane, acoustic velocity 1300 fps) and no backfill over the pipe. The equation is conservative for the case of a buried pipeline.

5.1.2 For liquids (with vapor pressure/MAOP > 0.35), the formula in [Table 5](#) may be used. However, it is generally advisable to modify the design to increase the design pressure (MAOP) in order to reduce the ratio.

5.1.3 For “rich” gases containing significant amount of hydrocarbons or gases that do not meet the definition of lean gas, contact the Materials Engineering Unit of CSD for gas decompression and fracture velocity calculation to define the required fracture arrest toughness. The following information is needed:

- Gas composition
- Gas temperature and pressure
- Diameter and wall thickness of pipe
- Design factor
- Pipe strength grade (SMYS)
- Maximum allowable operating pressure (MAOP)

Commentary Note:

For rich gas service, gases other than methane and liquids with high vapor pressure like NGL, CSD can perform calculations using the computer programs GASDECOM and DUCTOUGH with the method outlined in NG-18 Report No. 208 "Final Report on Fracture Control Technology for Natural Gas Pipelines" from the Pipeline Research Committee International.

5.2 A correction factor shall be used for Charpy V-notch energies greater than 70 ft-lb (95 J) as follows:

$$\text{When } C_v \geq 70 \text{ ft-lb (95 J), } C_v = C_v + (0.00269) C_v^{2.04} - 21.18 \quad (2)$$

- 5.3 Specimen Orientation: All specimens shall be oriented transverse to the rolling direction. The orientation specified in [API SPEC 5L/ISO 3183](#) shall apply except that for spiral welded (helical seam) pipe, the specimen shall be transverse to the rolling direction of the skelp (perpendicular to the helical seam).

Revision Summary

- | | |
|-----------------|---|
| 8 February 2009 | Revised the "Next Planned Update." Reaffirmed the content of the document, and reissued with minor changes. |
| 23 July 2011 | Editorial revision to clarify paragraph 5.1. |

Table 1 – Required Charpy Values (ft-lbs) for Line Pipe in Lean Natural Gas (> 90% Methane) or Liquid (Vapor Pressure/MAOP < 0.35) Service

Design Factor = 0.72

Dt (inches ²)	36 ksi	42 ksi	52 ksi	60 ksi	65 ksi
2	20	20	21	27	32
3	20	20	23	31	36
4	20	20	25	33	39
5	20	20	27	36	42
6	20	20	28	37	44
7	20	20	29	39	46
8	20	20	31	41	48
9	20	21	32	42	49
10	20	21	33	43	51
11	20	22	33	45	52
12	20	22	34	46	54
13	20	23	35	47	55
14	20	23	36	48	56
15	20	24	37	49	57
16	20	24	37	50	58
17	20	25	38	50	59
18	20	25	38	51	60
19	20	25	39	52	61
20	20	26	40	53	62
21	20	26	40	53	63
22	20	27	41	54	64
23	20	27	41	55	64
24	20	27	42	56	65
25	20	28	42	56	66
26	20	28	43	57	67
27	21	28	43	57	67
28	21	28	44	58	68
29	21	29	44	59	69
30	21	29	44	59	69
32	22	30	45	60	71
34	22	30	46	61	72
36	22	31	47	62	73
38	23	31	48	63	74
40	23	31	48	64	75
42	23	32	49	65	76
44	24	32	50	66	77
46	24	33	50	67	78
48	24	33	51	68	79

Note: This table was generated for [API SPEC 5L](#) pipe from the formula in Paragraph 5.2.1.

- D : Outside diameter, inches
- t : Nominal pipe wall thickness, inches.

Table 2 – Required Charpy Values (ft-lbs) for Line Pipe in Lean Natural Gas (> 90% Methane) or Liquid (Vapor Pressure/MAOP < 0.35) Service

Design Factor = 0.6

Dt (inches ²)	36 ksi	42 ksi	52 ksi	60 ksi	65 ksi
2	20	20	20	20	22
3	20	20	20	21	25
4	20	20	20	23	27
5	20	20	20	25	29
6	20	20	20	26	31
7	20	20	20	27	32
8	20	20	21	28	33
9	20	20	22	29	34
10	20	20	23	30	35
11	20	20	23	31	36
12	20	20	24	32	37
13	20	20	24	32	38
14	20	20	25	33	39
15	20	20	25	34	40
16	20	20	26	34	40
17	20	20	26	35	41
18	20	20	27	36	42
19	20	20	27	36	42
20	20	20	28	37	43
21	20	20	28	37	44
22	20	20	28	38	44
23	20	20	29	38	45
24	20	20	29	39	45
25	20	20	29	39	46
26	20	20	30	39	46
27	20	20	30	40	47
28	20	20	30	40	47
29	20	20	31	41	48
30	20	20	31	41	48
32	20	21	31	42	49
34	20	21	32	43	50
36	20	21	33	43	51
38	20	22	33	44	52
40	20	22	34	45	52
42	20	22	34	45	53
44	20	22	34	46	54
46	20	23	35	46	54
48	20	23	35	47	55

Note: This table was generated for [API SPEC 5L](#) pipe from the formula in Paragraph 5.2.1.

D : Outside diameter, inches

t : Nominal pipe wall thickness, inches.

Table 3 – Required Charpy Values (ft-lbs) for Line Pipe in Lean Natural Gas (> 90% Methane) or Liquid (Vapor Pressure/MAOP < 0.35) Service

Design Factor = 0.5

Dt (inches ²)	36 ksi	42 ksi	52 ksi	60 ksi	65 ksi
2	20	20	20	20	20
3	20	20	20	20	20
4	20	20	20	20	20
5	20	20	20	20	20
6	20	20	20	20	21
7	20	20	20	20	22
8	20	20	20	20	23
9	20	20	20	20	24
10	20	20	20	21	25
11	20	20	20	21	25
12	20	20	20	22	26
13	20	20	20	23	26
14	20	20	20	23	27
15	20	20	20	23	28
16	20	20	20	24	28
17	20	20	20	24	29
18	20	20	20	25	29
19	20	20	20	25	29
20	20	20	20	25	30
21	20	20	20	26	30
22	20	20	20	26	31
23	20	20	20	26	31
24	20	20	20	27	31
25	20	20	20	27	32
26	20	20	21	27	32
27	20	20	21	28	33
28	20	20	21	28	33
29	20	20	21	28	33
30	20	20	21	29	34
32	20	20	22	29	34
34	20	20	22	30	35
36	20	20	23	30	35
38	20	20	23	31	36
40	20	20	23	31	36
42	20	20	24	31	37
44	20	20	24	32	37
46	20	20	24	32	38
48	20	20	25	33	38

Note: This table was generated for [API SPEC 5L](#) pipe from the formula in Paragraph 5.2.1.

D : Outside diameter, inches

t : Nominal pipe wall thickness, inches.

Table 4 – Required Charpy Values (ft-lbs) for Line Pipe in Lean Natural Gas (> 90% Methane) or Liquid (Vapor Pressure/MAOP < 0.35) Service

Design Factor = 0.4

Dt (inches ²)	36 ksi	42 ksi	52 ksi	60 ksi	65 ksi
2	20	20	20	20	20
3	20	20	20	20	20
4	20	20	20	20	20
5	20	20	20	20	20
6	20	20	20	20	20
7	20	20	20	20	20
8	20	20	20	20	20
9	20	20	20	20	20
10	20	20	20	20	20
11	20	20	20	20	20
12	20	20	20	20	20
13	20	20	20	20	20
14	20	20	20	20	20
15	20	20	20	20	20
16	20	20	20	20	20
17	20	20	20	20	20
18	20	20	20	20	20
19	20	20	20	20	20
20	20	20	20	20	20
21	20	20	20	20	20
22	20	20	20	20	20
23	20	20	20	20	20
24	20	20	20	20	20
25	20	20	20	20	20
26	20	20	20	20	21
27	20	20	20	20	21
28	20	20	20	20	21
29	20	20	20	20	21
30	20	20	20	20	21
32	20	20	20	20	22
34	20	20	20	20	22
36	20	20	20	20	23
38	20	20	20	20	23
40	20	20	20	20	23
42	20	20	20	20	24
44	20	20	20	20	24
46	20	20	20	21	24
48	20	20	20	21	25

Note: This table was generated for [API SPEC 5L](#) pipe from the formula in Paragraph 5.2.1.

- D : Outside diameter, inches
- t : Nominal pipe wall thickness, inches.

Table 5 – Required Charpy Values for Liquids if Vapor Pressure/MAOP > 0.35

$$C_v = 0.00263 \ln \sec \left(\frac{5.23 P_v}{(1.39 + n) MAOP} \right) \sigma^2 \left(\frac{Dt}{2} \right)^{1/2} \quad (3)$$

- C_v : Required Charpy V-notch absorbed energy (average of three full size transverse specimens) per [API SPEC 5L/ISO 3183](#) and [01-SAMSS-035](#), in ft-lb
- P_v : Vapor pressure of pipeline liquid, psi
- n : Constant with value as listed in the table below
- MAOP : Maximum allowable operating pressure (design pressure), psi
- σ : Flow stress = $\sigma_Y + 10$ ksi = $\sigma_{SMYS} + K + 10$, in ksi (K from the table below)
- σ_Y : Estimated actual yield strength = $\sigma_{SMYS} + K$, in ksi (K from the table below)
- σ_{SMYS} : Specified minimum yield strength, ksi
- D : Outside diameter, inches
- t : Nominal pipe wall thickness, inches

Computed and Assumed Constants

API Grade	K (ksi)	n
Gr. B	15	0.40
X42	13	0.33
X52	9	0.27
X60	6	0.23
X65	5	0.21
X70	5	0.20

Note: The equation in this form is valid for design factor of 0.72.