



Materials System Specification

01-SAMSS-035

3 March 2014

API Line Pipe

Document Responsibility: Materials Engineering Standards Committee

Saudi Aramco DeskTop Standards

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I Scope

This Specification is an addendum to API 5L which covers seamless and submerged-arc welded (SAW), straight-seam and spiral-seam, steel line pipe manufactured in accordance with API SPEC 5L (45th Edition, December 2012) to Product Specification Level 2.

Unless stated to the contrary in the Purchase Order, pipe manufactured to this specification must be suitable for internal and external coating with fusion bonded epoxy and other applicable coating materials. See paragraphs 9.10.7, 9.11.3.3 c and 9.13.2.2 c.

Commentary Note:

See Saudi Aramco Engineering Standard SAES-L-136 for restrictions on use of spiral welded pipe and for company policy on procurement of seamless pipes for sour service.

II Conflicts and Deviations

- A. Any conflicts between this specification and other applicable Saudi Aramco Materials System Specifications (SAMSSs), Engineering Standards (SAESs), or industry standards, codes, and forms shall be resolved in writing by the Company or Purchaser Representative through the Manager, Consulting Services Department of Saudi Aramco, Dhahran.
- B. Direct all requests to deviate from this specification in writing to the Company or Purchaser Representative, who shall follow internal company procedure SAEP-302 and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

III References

The manufacture and purchase of material covered by this specification shall comply with the latest edition (as per the purchase order date) of the references listed below, as noted.

A. 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-L-131

Fracture Control of Line Pipe

SAES-L-136

Pipe, Flange and Fitting Material Requirements

Saudi Aramco Inspection Requirements

<i>Form <u>175-010210</u></i>	<i>HIC Testing: ANSI/ASTM/API SPEC 5L Line Pipe</i>
<i>Form <u>175-010700</u></i>	<i>Pipe: Beveled End, Seamless or Submerged Arc Welded, Straight or Spiral Seam, Carbon Steel Pipe Size</i>

B. Industry Codes and Standards

American Petroleum Institute

<i><u>API SPEC 5L</u></i> <i>(Modified)</i>	<i>Specification for Line Pipe</i>
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American Society of Mechanical Engineers

<i><u>ASME SEC IX</u></i>	<i>Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators</i>
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American Society for Nondestructive Testing, Inc.

<i><u>ASNT SNT-TC-1A</u></i>	<i>Recommended Practice for Personnel Qualification and Certification</i>
<i><u>ASNT CP-189</u></i>	<i>Standard for Qualification and Certification of Nondestructive Testing Personnel</i>

International Standardization Organization

<i><u>ISO 9000 - 9004</u></i>	<i>Quality Management and Quality Assurance Standards</i>
<i><u>ISO 10893-9</u></i>	<i>Part 9: Automated Ultrasonic Testing for the Detection of Laminar Imperfections in Strip/Plate used for the Manufacture of Welded Steel Tubes</i>
<i><u>ISO 10893-8</u></i>	<i>Part 8: Automated Ultrasonic Testing of Seamless and Welded Steel Tubes for the Detection of Laminar Imperfections</i>

National Association of Corrosion Engineers

<i><u>NACE MR0175/ISO 15156</u></i>	<i>Petroleum and Natural Gas Industries- Materials for use in H₂S-Containing Environments in Oil and Gas Production</i>
<i><u>NACE TM0284</u></i>	<i>Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen Induced Cracking</i>

European Standard

EN 473

*Non-Destructive Testing - Qualification and
Certification of NDT Personnel - General
Principles*

IV Modifications to API SPEC 5L

The following paragraph numbers refer to API SPEC 5L (45th Edition, December 2012), which is the basis of this specification. The text in each paragraph below is an addition or modification to API SPEC 5L (45th Edition, December 2012), as noted. Paragraph numbers not appearing in API SPEC 5L (45th Edition, December 2012) are new paragraphs to be inserted in numerical order.

1 Scope [modification]

All pipes shall be manufactured to PSL 2, with the additional requirements contained in this specification. Manufacturing procedure qualification as per Annex B is required for all pipes.

4 Terms and Definitions

4.57 Pseudo-HIC Resistant Steel [addition]

Plate/Strip that is not fabricated utilizing the quality control/assurance and fabrication measures to intentionally produce HIC resistant steel.

4.58 Class IV Service [addition]

This class is for gas, two-phase flow, and liquid lines such as NGL, whose vapor pressure exceeds 100 psia.

6 Pipe Grade, Steel Grade and Delivery Condition

6.1 Pipe Grade and Steel Grade [addition]

6.1.2 Heat treatment condition of the pipe is at the discretion of the manufacturer and shall be in compliance with the Tables (1 and 3) of the current API SPEC 5L. Seamless pipes shall not be delivered in the as-rolled (R) or Normalized rolled conditions; a separate heat treatment cycle including Normalization (N) or Quenching and Tempering (Q&T) shall be conducted using a designated heat treatment facility.

6.1.4 Pipe manufactured as Grade X60 or X65 (for sour and non-sour) may be substituted for a lower grade if it meets all requirements for the lower grade except maximum yield strength. API SPEC 5L Grade X70 may be

substituted for a lower strength grade only for non-sour service. The pipe shall be marked with the actual grade.

Commentary Note:

Maximum design metal temperature limitation established in ASME piping code for X-grade pipe shall be noted when substituting the B-grade pipe.

7 Information to be Supplied by the Purchaser

7.2 c) Additional Information [modification]

Indicate in the Purchase Order only when required:

- a) Suitable for internal coating (See Scope, 9.10.7, 9.11.3.3 c and 9.13.2.2 c)
- b) Suitable for automatic welding (See 9.11.3.6 and 9.13.2.2 e)
- c) Suitable for sour service (paragraph 8.1.4, Annexes H and K shall apply)
- d) Non-sour service (See 11.1.5)
- e) Suitable for offshore service (Annexes J and K shall apply)
- f) If the line pipe is meant for Class IV service (Annex G shall apply), it shall be so specified (see G.1.3 for definition of Class IV service).

Notes:

- 1. Annexes B, N and O shall apply for all purchase orders.
- 2. Annex K is mandatory for all seamless pipes irrespective of service.

8 Manufacturing

8.1 Process of Manufacture [modification]

- 8.1.1 Welded pipe shall be made by the automatic submerged-arc process (fusion welded) in accordance with API SPEC 5L paragraphs 8.5 or 8.6.
 - 8.1.2 Double seam pipe is not acceptable for size smaller than 60 inches nominal diameter.
 - 8.1.3 Helical-seam pipe is limited to pipe with diameter ≥ 16 inches.

For other properties, the more restrictive specification applies in each case.
 - 8.1.4 HIC resistant Plates/coils intended for the manufacturing of pipes shall be procured from an approved Saudi Aramco steel mill.
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Commentary:

Contact Saudi Aramco buyer for a list of approved steel mills for supplying HIC resistant steel.

8.1.5 Seamless pipes in the as-rolled condition (R) are prohibited [addition].

8.4 Tack Welds [modification]

8.4.1 Tack welds shall be limited to Gas Metal Arc Welding (GMAW) and Flux Cored Arc Welding (FCAW) and such welding conditions shall be recorded and appear as part of the production welding procedure.

8.6 Weld Seams in SAW Pipe [modification]

For the production of weld seams in SAW pipe, a minimum of two welding passes on the outside and one on the inside is required. (Use of two or more wires is accepted as equal to two welding passes). For wall thickness 7.9 mm and less, one outside welding pass may be acceptable upon approval by the Purchaser.

All welding consumables, including SMAW electrodes used for repair, must be classified as per American Welding Society classification, unless approved by the Chairman of the Saudi Aramco Materials Engineering Standards Committee. All flux shall be baked before use.

8.9 Cold Sizing and Cold Expansion [modification]

8.9.2 SAW straight-seam pipe shall be cold expanded at least 0.8% of the pipe circumference, but shall not exceed 1.5%.

Heat-treatment of pipe may be used in lieu of cold expansion. The heat treatment shall not cause any adverse effect on the mechanical properties and pipe roundness.

Commentary Note:

Cold expansion of 0.8% - 1.2% has been found effective in controlling pipe dimensional and roundness tolerances, and minimizing residual stresses resulted from pipe forming and welding operation.

9 Acceptance Criteria

9.2 Chemical Composition [modification]

9.2.2 The product analysis shall not exceed the following:

Silicon : 0.38% for SAW and 0.40% for seamless

Titanium : 0.04%

Vanadium : 0.08% or as required by Table 5 of API SPEC 5L,
whichever is lower.

Sulfur : 0.004% Maximum for seamless

Boron content shall be shown in the heat analysis or product analysis and shall not exceed 0.0005%.

The carbon equivalent shall not exceed the maximum limits tabulated below, unless approved by the Chairman of the Saudi Aramco Materials Engineering Standards Committee.

Wall Thickness (inch)	Maximum C.E. (IIW) Value For C > 0.12%	Maximum C.E. (Pcm) Value For C ≤ 0.12%
≤ 0.375	0.43	0.24
0.50	0.40	0.22
0.625	0.39	0.22
0.75	0.37	0.21
0.875	0.36	0.20
1.00	0.34	0.19
1.25	0.35	0.19
1.50	0.36	0.20
1.75	0.37	0.21
1.969	0.38	0.22

The maximum C.E. value for intermediate wall thickness shall be interpolated linearly.

If a C.E. deviation from the above table is accepted for any order, each pipe length shall be marked in accordance with paragraph 11.1 showing the actual C.E. value. The value shall be marked on each end on both the I.D. and O.D. (i.e., four locations).

For thicknesses in excess of 1.969 inches, the C.E. value shall be proposed by the vendor and shall be approved by the Chairman of the Saudi Aramco Materials Engineering Standards Committee. The C.E. value shall be marked on each pipe as described in the paragraph above.

9.9

DWT Test for PSL 2 Welded Pipe [addition]

- 9.9.3 DWT test results shall be reported in accordance with Annex G.
- 9.10 Surface Conditions, Imperfections and Defects
- 9.10.7 Other Surface Imperfections [addition]
- d) For pipe that is intended to be subsequently coated (See Section I), the surfaces to be coated shall be essentially free of scabs, slivers, cold laps, burrs or other surface defects that would impair the coating.
- Inclusions or particles that are detrimental to welding, including tungsten carbide inclusions rolled into the surface, shall be considered to be defects regardless of depth and processed as permitted by API SPEC 5L.
- e) The surface of seamless pipes shall be free from excessive scale.
- 9.11 Dimensions, Mass and Tolerances [modification]
- 9.11.3.3c) Length shall be as specified in the Purchase Order, with tolerances shown in API SPEC 5L Table 12. If the length is not specified in the Purchase Order, 12-meter lengths shall be supplied with tolerances shown in API SPEC 5L Table 12, except that:
- i. No pipe lengths less than 32.8 ft will be accepted.
- ii. Pipe lengths less than 38.1 ft shall not exceed 2% of the total line item quantity.
- iii. Pipe intended for subsequent internal coating shall have a maximum length of 42.0 ft for any individual length.
- d) The total length of pipe supplied per item on an order shall not be less than the amount ordered and shall not exceed the amount ordered by more than three lengths, except by agreement.
- 9.11.3.5 On SAW pipe, local out-of-roundness (deviation from the normal cylindrical contour) of the seam shall not exceed 0.12 inch [addition].

Commentary:

One acceptable method of determining local out-of-roundness is measurement of the maximum gap between a template and the pipe exterior. The template must conform to a circle of the pipe's nominal diameter and the length of the template must be one-fourth of the nominal diameter, except that it need not be over 8 inches. Weld reinforcement may be removed for the measurement or the template may have a groove to accommodate the weld seam or another reliable alternative method shall be used. For spiral-seam pipe, an 8 inches straight template parallel to the pipe axis may be used.

9.11.3.6 Pipe that is to be joined using pipeline field automatic welding systems

Pipe that is designated in the Purchase Order as “Suitable for Automatic Welding” shall meet the following additional requirements:

- a) The difference in outside or inside diameter, at the ends, between any two lengths of the same Line Item shall not exceed 0.063 inch for 75% of the pipes produced.
- b) Out-of-Roundness at the ends shall not exceed 1.0% of specified (nominal) O.D. For pipe with $D/t < 75$, the difference between maximum diameter and minimum diameter shall meet the requirement of paragraph 9.11.3.1 [Table 10] of API SPEC 5L subject to a maximum of 0.24 inch.
- c) On SAW pipe for automatic welding, local out-of-roundness (deviation from the normal cylindrical contour) of the seam shall not exceed 0.063 inch at the end of the pipe. See commentary in 9.11.3.5 above [addition].

9.13 Tolerances for the Weld Seam [modification]

- 9.13.2.2 c) For pipe intended for subsequent internal coating, the inside weld bead shall not extend above the adjacent pipe surface by more than 0.118 inch.
- e) This requirement shall apply for pipe that is designated in the Purchase Order as “Suitable for Automatic Welding.”

9.16 Macro Residual Stress Test [addition]

Spiral welded pipe shall meet the testing and minimum acceptance criterion set forth in this paragraph. The residual stress test shall be done after the hydrostatic test.

9.16.1 Test Frequency

One specimen shall be tested for each grade, diameter and wall thickness at the beginning of production. In addition, the first produced pipe shall be tested after changing the production line equipment settings.

9.16.2 Test Specimen

The specimen consists of a 150 mm wide ring cut from the end of a pipe as shown in Figure 1. The specimen may be either flame cut or sawed from the parent pipe.

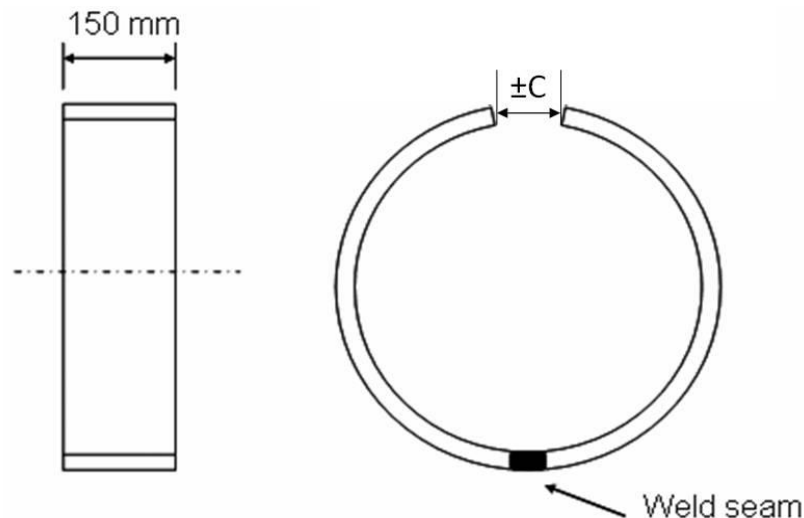


Figure 1 – Split Ring Test to Estimate Macro Residual Stress for Spiral Pipe

9.16.3 Testing

The specimen ring shall be cut, by flame or sawing, parallel to the longitudinal axis. The cut shall be 180 degrees from the spiral weld. Prior to cutting the ring, fiducial marks shall be placed on either side of the proposed cut location.

9.16.4 Computation of Macro Residual Stress

The change in circumference after cutting shall be measured using the fiducial marks established on the specimen prior to severing. The assumed residual stress shall be computed using the following formula:

$$S = \frac{E t C}{12.566 R^2} \quad (1)$$

where: S = residual stress (psi)
 C = \pm change in circumference (inch)
 t = nominal thickness (inch)
 E = $(29 \times 10^6 \text{ psi})$
 R = nominal pipe radius (inch)

9.16.5 Acceptance Criterion

The computed macro residual stress shall not exceed $\pm 10\%$ of the specified minimum yield strength of the pipe.

9.16.6 Reporting

All residual stress results shall be recorded as part of the mill report.

9.17 Hardness Tests [addition]

Hardness tests shall be conducted as per the requirements of Annex H and modifications stated in this Specification. Hardness test is required on all line items of every purchase order (including pipes ordered for non-sour service).

10 Inspection

10.1.1 General [addition]

10.1.1.3 Pipe purchased in accordance with this Specification is subject to the requirements of Saudi Aramco Inspection Form 175-010700.

10.1.1.4 The manufacturing processes and Inspection Tests Plan (ITP) shall be submitted prior to the start of work to Saudi Aramco Vendor Inspection Division/Quality Control Unit for approval.

10.1.3 Inspection document for PSL2 pipe [modification]

10.1.3.3 It shall be verified in the mill test certificate that the radiation levels in the pipes, the plate, coil or billet, are less than 100 beckerels/gram or 0.5 $\mu\text{SV/hr}$.

10.2.1 Inspection Frequency [modification]

10.2.1.2 DWT test is required only for Class IV service for all grades of line pipe, having diameters 20 inches and larger (Table 18).

10.2.1.2.1 Mechanical testing of units shall be uniformly distributed to cover the entire production for a particular line item [addition].

10.2.3 Samples and Test Pieces for Mechanical Tests [modification]

10.2.3.3 Consult Chairman or Vice Chairman of the Saudi Aramco Materials Engineering Standards Committee for sizes not covered by Table-22.

10.2.3.4 Test Pieces for the DWT Test

The type of notch for DWT test shall be as follows:

- a) For pipe order with specified minimum average CVN value less than or equal to 70 ft-lb, the pressed type notch shall be used for the DWT test.
- b) For pipe order with specified minimum average CVN value greater than 70 ft-lb, the Chevron type notch shall be used.

10.2.6 Hydrostatic Tests [modification]

10.2.6.1 Time of hydrostatic test shall be 10 seconds minimum irrespective of pipe size.

10.2.6.5 Each length of pipe shall be given a mill hydrostatic test at a pressure not less than the pressure necessary to obtain a hoop stress equal to 95% of the specified minimum yield strength of the material. Pipe furnished from Vendor inventory may be accepted with the standard API test pressure by negotiation.

The hydrostatic test shall be conducted after all manufacturing processes (including repairs and heat treatments) are completed.

Commentary Note:

Grinding repair per API SPEC 5L to remove discontinuities is acceptable after hydrostatic test.

11 Marking

11.1 General [addition]

11.1.4 The area of the pipe to be marked shall be clean and dry. The markings shall be paint stenciled using a medium and protective varnish that will provide a legible marking for at least one year of outside storage. The varnish coating shall be hard drying and the dry film thickness should not exceed 50 micrometers. The size of the lettering shall be commensurate with the diameter of the pipe, but in no case less than 0.75 inch (0.59 inch for diameter 6 inches and smaller) and in height for API markings and 13 mm in height for shipping markings.

11.1.5 Marking of Non-sour Service Pipe

Welded pipe purchased for non-sour service shall be identified by painting a white longitudinal stripe, 2 inches wide by 18 inches long, on the inside

surface of both ends. This requirement does not apply for seamless pipes. This stripe is intended to provide identification until the pipe is installed.

11.2 Pipe Markings [modification]

- 11.2.1 j) Each pipe shall be marked Saudi Aramco, followed by the destination, Purchase Order number/Item Number, heat number, and the Saudi Aramco 9COM or 9CAT stock number. If there is no assigned 9COM or 9CAT stock number, the pipe shall be marked “01-SAMSS-035.”

15 Handling, Packing and Transportation [addition]

- 15.1 Pipe ends shall be protected by end caps/bevel protector.
- 15.2 Pipes shall be stored on wooden bearing strips. If pipes are stored on rails or steel beams, rubber sheets shall be used to prevent direct contact between the pipes and the rails/beams. Storage and handling practice must ensure that there are no mechanical dents on the pipe surface.
- 15.3 API 5L1 and API 5LW shall be followed for transportation of pipes by rail road and marine transportation respectively.
- 15.4 API RP 5LT shall be followed for transportation of pipes by road. The following shall be ensured during transportation of pipes:
- (i) Truck beds and sides shall be inspected to ensure that there are no projections (rivet heads, etc.) that may cause fretting during transportation.
 - (ii) Pipe layers must be separated by wooden separators or by rubber sheet, at least 6 mm in thickness or by nylon ropes having a minimum diameter of 19 mm.
 - (iii) The packing list for transportation must include the pipe numbers, relative location in the truck and the truck number on which specific pipes are being transported.

Revision Summary

5 June 2013	Minor revision has been conducted in-light of the new version of API SPEC 5L 45 th Edition. Revised the “Next Planned Update.”
24 November 2013	Editorial revision to remove all references of Annex N, which no longer exists in the latest edition of API 5L standard.
27 November 2013	Editorial revision to remove references to the obsolete standards 01-SAMSS-024 and SAES-L-130.
25 December 2013	Editorial revision to correct the referenced ISO No. in paragraph K.5.2.2 from ISO 13663 to ISO 10893-8. Also, to clarify that as rolled pipe is not acceptable in paragraph 6.1.2. In addition, changed committee name to Materials Engineering Standards Committee.
3 March 2014	Editorial revision in paragraph 6.1.2 was conducted to clarify heat treatment requirements.

Annex B – Manufacturing Procedure Qualification for PSL 2 Pipe

- B.1 Introduction [modification]
- B.1.1 Manufacturing procedure qualification is mandatory for each line item in the purchase order.
- B.2 Additional Information to be Supplied by the Purchaser [modification]
- a) Qualification of the manufacturing procedure shall be done in accordance with clauses B.3 and B.4.
- B.3 Characteristics of the Manufacturing Procedure [addition]
- B.3.1 For welded pipe, the manufacturing Welding Procedure Specification (WPS) shall document, as a minimum, all essential variables listed in Annex D and those listed below. A complete product test as required by B.3 shall verify that the WPS is acceptable. The actual material details and welding parameters shall be documented in a Procedure Qualification Record (PQR).
- A Only electrodes and fluxes identified on the WPS shall be used.
- B The manufacturer, trade name and type of weld wires and fluxes used for the PQR shall be specified on the WPS as essential variables.
- C The heat input specified on the WPS shall not be less than 90% of that qualified by the production test and shall not exceed that qualified by the production test.
- D Recycling of crushed slag or contaminated flux is not permitted.
- E Brand name of “G” consumable, if used, is an essential variable.
- B.3.2 All electrodes and fluxes shall be properly stored to prevent moisture absorption, as recommended by the electrode and flux manufacturer.
- Separate welding procedure shall be written for making the skelp end weld for spiral welded pipe. The runoff for start and stop may extend up to one (1) inch at either end onto the base metal.
- Repair welding procedures for the weld seam shall meet the essential requirements and testing of Annex D. Only electrodes identified on the repair welding procedure shall be used.
-

The welding procedures shall be available for review by Saudi Aramco representative upon request.

B.4 Manufacturing Procedure Qualification Tests [modification]

- B.4.1 One set of mechanical test results from initial production run shall be submitted to Saudi Aramco Inspection Representative. Saudi Aramco Inspection Representative may select the pipe from initial production run. These test results can be considered as part of production tests.

Annex D – Repair Welding Procedure

- D.2 Repair Welding Procedure Qualification [modification]
 - D.2.1.1 Format for WPS and PQR shall be same as that suggested in ASME SEC IX.
 - D.2.2 Essential Variables [addition]
 - c) Welding Materials
 - 7) Brand name for the ‘G’ consumables and SAW flux is an essential variable.
 - 8) If the electrode is under matching with respect to the strength of the base material, change in batch number of the electrode shall be an essential variable.

Annex E – Non-Destructive Inspection for other than Sour Service or Offshore Service

- E.1 Qualification of Personnel [modification]
- E.1.3 Level 1 personnel may set up the equipment, perform tests, and report the results. Supervision of Level 1 personnel and interpretation of results shall be done by Level 2 employees. The primary Level 3 employee such as company employee, outside consultant, or third party inspector shall be certified in accordance with ASNT CP-189 or EN 473 or ASNT SNT-TC-1A or by an independent certifying body acceptable to Saudi Aramco. Working practice for qualification shall be submitted to Saudi Aramco for approval.
- E.3 Methods of Inspection (Weld Inspection) [modification]
- The full length of every welded seam shall be examined as required by API SPEC 5L paragraph E.3 except that fluoroscopic examination is not acceptable. If this examination is done before the hydrostatic test, the Purchaser's Inspector may, at his sole discretion, require re-examinations by manual ultrasonic method of any questionable areas after the hydrostatic test. Means shall be provided to mark the pipe when the nondestructive inspection equipment indicates an imperfection is present so that anomalous areas can be readily identified.
- Locations showing indications above the allowable limits may be re-examined by the manual ultrasonic method or by radiographic testing. If no defects are located during re-examination, the original findings may be ignored.
- Additional scanning may be required by the Purchaser's Representative to check questionable areas.
- E.8 Laminar Imperfection in the Pipe Body of EW, SAW and COW Pipes [modification]
- E.8.2 Ultrasonic inspection shall be carried out to verify that the strip/plate or the pipe body is free of lamellar imperfections. Verification shall be done as per ISO 10893-9 and the coverage of lamination detection shall be at least 25% of the strip/plate or pipe surface. The acceptance criteria for laminar imperfection shall be in accordance with ISO 10893-9:2011, acceptance level U1.
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E.9 Laminar Imperfections along the Strip/Plate Edges or Pipe Weld Seam of EW, SAW and COW Pipes [modification]

The plate/strip edges or areas adjacent to the weld seam shall be 100% ultrasonically inspected over a minimum band width of one (1) inch for the detection of laminar imperfections. The testing method shall be conducted in accordance with ISO 10893-9 or ISO1089-8, as appropriate. The acceptance criteria shall be as follows:

- a) ISO 10893-9 acceptance level U1 if such inspection is done prior to pipe forming
- b) ISO 10893-8 acceptance level U1 if such inspection is done after seam welding

Commentary Note:

This testing is required to prevent blocking of the ultrasonic testing beam during weld inspection.

E.10 Disposition of Pipe Containing Defects [modification]

All rejected pipe shall be identified as non-conforming, segregated from acceptable pipe and controlled to prevent unintended use or delivery and these requirements shall be implemented within the ISO 9001:2000 quality system.

Annex G – PSL 2 Pipe with Resistance to Ductile Fracture Propagation

G.1 Introduction [modification]

This annex is invoked when additional fracture toughness is required to control ductile fracture propagation in gas lines and liquids lines with a high vapor pressure.

It is applicable to pipe with wall thickness of 0.25 inch to 1.5 inches for use in cross-country pipelines, offshore pipelines, flowlines, and trunklines at design temperatures above 32°F.

Commentary Note:

This annex is not applicable to in-plant piping. Impact testing of in-plant piping shall be in accordance with ASME B31.3 and SAES-L-136.

G.1.3 Definition of Class IV Service [addition]

Class IV Service: This class is for gas, two-phase flow, and liquid lines such as NGL, whose vapor pressure exceeds 100 psia.

Commentary Note:

Reference to Class I service has been discontinued because PSL 2 pipe ordered to this specification meets the requirements for Class I service by default.

G.1.4 This annex is applicable only if the line pipe classification is specified as class IV in the purchase order [addition].

G.2 Additional Information to be Supplied by the Purchaser [modification]

G.2.1 Paragraph a) shall be applicable for all purchase orders.

G.2.2 a) CVN impact test temperature shall be at 32°F.

b) DWT test temperature shall be at 32°F.

G.3 Acceptance Criteria [modification]

G.3.1 All parent metal Charpy fracture surfaces for all diameters shall exhibit at least 85% average and 75% minimum shear per each set of test.

- G.3.2 Minimum average Charpy impact energy value shall be as specified by the Buyer in the relevant requisitions, quotation requests, and purchase orders as per SAES-L-131. For welded pipes, CVN test shall include weld, HAZ and base metal.

Commentary Note:

Saudi Aramco Engineering Standard SAES-L-131 is for reference by Saudi Aramco personnel only. This standard is not applicable to pipe manufacturers.

- G.3.4 For DWT test, specimens shall not exhibit less than 85% average and 75% minimum shear per each set of test. For SAWL pipes with wall thickness higher than 1.5 inches or for SAWH with wall thickness higher than 0.620 inch, value of shear area proposed by the vendor shall be approved by the Chairman or Vice Chairman of the Saudi Aramco Materials Engineering Standards Committee.

Commentary Note:

Each specimen must tear completely to give a readable fracture surface as shown in API RP 5L3 Figure 5 and Appendix A. Specimens that buckle, collapse, deform or rip are considered invalid and the test must be performed again. Specimens must be firmly mounted to promote acceptable test results.

- G.4 Test Frequency [addition]

- G.4.3 Specimen Orientation

All specimens shall be oriented transverse to the rolling direction. The orientation specified in Table 20 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).

Annex H – PSL 2 Pipe Ordered for Sour Service

H.4 Acceptance Criteria

H.4.1 Chemical Composition [modification]

Chemistry restrictions outlined in paragraph 9.2.2 shall apply.

For C.E./Pcm values, the more stringent of the values stipulated in Table H.1 and paragraph 9.2.2 of this specification shall apply.

H.4.3 HIC/SWC Test [modification]

- b) Crack length ratio (CLR) $\leq 10 \%$
- c) Crack thickness ratio (CTR) $\leq 3 \%$

The samples containing the weld shall free from cracks in the weld. If cracks are seen in the weld after HIC testing, the root cause of cracking must be analyzed by the pipe mill.

The defects listed below shall be disregarded:

- a) Features such as inclusions that cannot be definitely identified as cracks.
- b) Isolated, definitely identifiable cracks shorter than 0.1 mm in length.
- c) Blisters and their associated cracking which at no point extend more than 1 mm from the inner and outer pipe surfaces of the test specimen. If any part extends more than 1 mm from the surfaces, the entire blister/crack system shall be counted.
- d) Isolated longitudinal cracks (i.e., cracks having a thickness less than or equal to 0.1 mm) having no part more than 1.0 mm from the inner and outer pipe surfaces of the test specimen. If the cracks are located partly within 1.0 mm from the surface and partly deeper than 1.0 mm into the specimen, the entire crack shall be counted.

Pseudo-HIC Resistant steel shall not be used to fabricate equipment intended for sour service application. Steel that passes the HIC test, but has not been intentionally manufactured to be HIC resistant steel shall not be used.

H.4.4 Hardness Test [modification]

Maximum acceptable hardness, including weld cap, is 250 HV using 5 or 10 kg load.

H.5 Surface Conditions, Imperfections and Defects [modification]

H.5.2 Hardness exceeding 250 HV, even on the external surface, shall be considered as an unacceptable.

H.7 Inspection

H.7.1 Specific Inspection [modification]

The frequency of inspection for HIC test shall be one pipe from each of the first three heats supplied by each mill from each purchase order shall be tested and one pipe out of every five subsequent heats. The pipes for testing can be selected by the purchaser's representative from the heats containing the higher sulfur content. One set of three specimens is required for HIC testing. In case of failures in HIC test, the frequency of testing may be increased to cover 100% of the heats. HIC testing on pipes shall be carried out on all heats if the wall thickness is greater than 1-inch (25.4 mm).

If multiple pipe diameter and wall thicknesses are produced from the same heat, each combination of pipe diameter and wall thickness shall be tested.

H.7.2 Samples and Test Pieces for Mechanical and Technological Tests [addition]

H.7.2.2 In addition to testing on the pipe, raw material (plate, coil/skelp for line pipe) testing shall be performed as follows:

- Testing shall be carried out on all heats.
- Three samples shall be cut from one end, across the width of the plate. These samples shall be oriented longitudinally, i.e., along the principal rolling direction (Figure 2).
- If several thicknesses are produced from a coil or plate of a single heat, then the thinnest shall be tested.

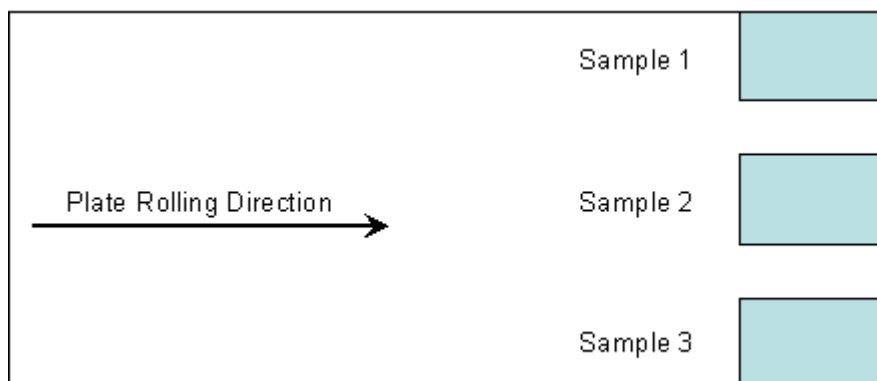


Figure 2 – Plate Sampling Location Diagram

H.7.3 Test Methods [modification]

H.7.3.1.1 The following shall be included in the HIC or Mill Test Certificate:

- a) The CLR results of the control sample.
- b) Location and dimensions of coupons, and whether taken from pipe or plate.
- c) pH of H₂S saturated solution at the start and end of the test.
- d) Chemical composition of material tested, including Al, B, C, Ca, Cr, Cu, Mn, Mo, Ni, Nb, N, P, Si, S, Ti and V.
- e) Results of cracking evaluation.

H.7.3.1.4 The CLR results of the control sample shall also be reported. For each section containing cracks, a photograph shall be taken of the complete cross-section.

H.7.3.1.5 HIC control samples, provided by the Manufacturer/Vendor, shall be used for all tests. These control samples shall have demonstrated HIC-cracking sensitivity, i.e., Average Crack Length Ratio (CLR) exceeding 20% in NACE TM0284 Solution A.

H.7.3.1.6 The purity of the H₂S gas shall be 99.5% minimum. H₂S gas generated from chemical reactions, e.g., Kipp's apparatus, is not acceptable as a source of H₂S gas.

H.7.3.1.7 Should the Vendor's HIC test results be rejected by Saudi Aramco, re-testing may be referred to an independent 3rd party laboratory approved by Saudi Aramco for resolution. This laboratory shall use HIC test methods and control samples in accordance with this specification.

H.7.3.1.8 Testing shall be performed by the Manufacturer/Vendor or 3rd party laboratory acceptable to Saudi Aramco. The Chairman or Vice-Chairman of the Materials Engineering Standards Committee shall approve all HIC Test Laboratories. The following minimum requirements shall be met:

- a) Verify the Inspection and Testing Requirements specified in Form 175-010210 HIC Testing are completely satisfied.
 - b) HIC control samples shall be used for all tests. These control samples shall have demonstrated HIC-cracking sensitivity, i.e., Average Crack Length Ratio (CLR) exceeding 20% in NACE TM0284 Solution A.
 - c) The purity of the H₂S gas shall be 99.5% minimum. H₂S gas generated from chemical reactions, e.g., Kipps apparatus, is not acceptable as a source of H₂S gas.
 - d) H₂S concentration shall be measured by iodometric titration as per the current NACE TM0284, i.e., $\geq 2,300$ ppm. Measurements shall be conducted at start of test, i.e., after 1 hour (saturation) and at the end of test (96 hours).
 - e) The HIC testing laboratory shall provide documentation supporting the adequate training of technicians or engineers undertaking the evaluation of CLR and CTR measurements.
 - f) The laboratory shall use HIC test methods and control samples in accordance with this specification.
 - g) Documentation for HIC testing facility, including, but not limited to the following:
 - Description of the HIC testing setup/apparatus (schematic required) to be used for qualifying the plates, or pipes.
 - Purity of the utilized salts and H₂S for the test solution.
 - Detailed procedure describing the testing, metallographic preparation and evaluation of HIC specimens.
 - Documentation confirming availability (with Manufacturer/Vendor) of HIC Control Samples with demonstrated HIC-sensitivity, i.e., average CLR exceeding 20% in NACE TM0284 Solution A.
 - The Manufacturer/Vendor shall qualify his test method using HIC control samples.
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- If the Manufacturer/Vendor does not have a HIC testing facility acceptable to Saudi Aramco or its representative, then he must provide documentation supporting that testing shall be conducted by an independent 3rd party laboratory meeting Saudi Aramco's approval.

H.7.3.1.9 HIC test verification shall be in accordance with Saudi Aramco Inspection Form 175-010210 Inspection and Testing Requirements - HIC Testing.

H.7.3.1.10 Retesting Requirements

A heat that fails the acceptance criteria above may be retested as follows:

- a) The plate or pipe that failed the test shall be rejected. However, two additional joints of pipe (or pieces of plate) may be selected at from the same heat for further testing. If both of the retest groups pass, all pipes in the heat are acceptable except the one from which the initial test coupons were taken.
- b) If one or both of the retest groups fail to meet the acceptance criteria, the heat shall be rejected and materials specified in the Purchase Order shall either be tested heat by heat or rejected entirely at the discretion of the Vendor.
- c) The manufactured pipes shall not be released prior to the completion and acceptance of all HIC test results.

H.7.3.1.11 Additional testing shall be required if the steel-making and/or pipe-making procedures are significantly altered during production [addition].

H.7.3.3 Hardness Test [modification]

H.7.3.3.1 Only Vickers hardness testers shall be used. The maximum hardness measured shall not exceed 250 HV using 5 or 10 kg load.

H.7.3.3.3 Dimension 'b' in Figure H.1 b) shall be 0.2 mm maximum from the fusion line on the HAZ instead of 0.75 mm. The indentation on the weld metal shall be separated from the indentation on the HAZ by at least 0.75 mm.

Annex J – PSL 2 Pipe Ordered for Offshore Service

J.4 Acceptance Criteria

J.4.1 Chemical Composition [modification]

Chemistry restrictions outlined in paragraph 9.2.2 shall apply.

For C.E./Pcm values, the more stringent of the values stipulated in Table J.1 and paragraph 9.2.2 of this specification apply.

J.4.3 Hardness Test [modification]

Maximum acceptable hardness for all grades is 250 HV.

J.8 Inspection

J.8.3.2 Hardness Test [modification]

J.8.3.2.1 Only Vickers hardness testers shall be used. The maximum hardness measured shall not exceed 250 HV using 5 or 10 kg load.

J.8.3.2.3 Dimension 'b' in Figure J.1 b) shall be 0.2 mm maximum from the fusion line on the HAZ instead of 0.75 mm. The indentation on the weld metal shall be separated from the indentation on the HAZ by at least 0.75 mm.

Annex K – Non-Destructive Inspection for Pipe Ordered for Sour Service and/or Offshore Service

Commentary Note:

This annex is mandatory for all seamless pipes irrespective of service.

- K.2 General Non-Destructive Inspection Requirements and Acceptance Criteria [modification]
- K.2.1.4 Each pipe ends shall be magnetic particle inspected for the detection of laminar imperfections.
- K.3 Non-destructive Inspection of SMLS Pipe
- K.3.4 Supplementary Non-destructive Inspection [modification]
- K.3.4.1 Seamless pipe shall be ultrasonically inspected for the detection of transverse imperfections in accordance with ISO 10893-8, acceptance level L2/C or ASTM E213.
- K.5 Non-destructive Inspection of SAW Pipe
- K.5.2 Laminar imperfections in the pipe body and on the strip/plate edges [modification]
- K.5.2.1 Coverage for ultrasonic inspection shall be at least 25%.
- K.5.2.2 Ultrasonic inspection shall be over a width of 25 mm. As an alternative, it is acceptable to carry out inspection for laminar imperfections on pipe adjacent to the weld seam in accordance with ISO 10893-8 with the acceptance criteria given in Table K.1.