



Materials System Specification

01-SAMSS-043

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Carbon Steel Pipes for On-Plot Piping

Document Responsibility: Materials and Corrosion Control Standards Committee

Saudi Aramco DeskTop Standards

Table of Contents

1	Scope.....	<u>2</u>
2	Conflicts and Deviations.....	<u>2</u>
3	References.....	<u>2</u>
4	Definition.....	<u>5</u>
5	Information to be Supplied by the Purchaser..	<u>5</u>
6	Manufacture.....	<u>5</u>
7	Heat Treatment.....	<u>6</u>
8	Chemical Composition.....	<u>6</u>
9	Mechanical Tests.....	<u>7</u>
10	Additional Requirements for Sour Service.....	<u>8</u>
11	Non-Destructive Testing.....	<u>8</u>
12	Dimensional Requirements.....	<u>9</u>
13	Inspection.....	<u>9</u>
14	Marking.....	<u>10</u>
15	Handling, Packing and Transportation.....	<u>10</u>
16	Certification.....	<u>11</u>
	Annex A - Hardness Testing.....	<u>12</u>
	Annex B - Welded Pipe Ordered for Sour Service...	<u>13</u>

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Revised paragraphs are indicated in the right margin

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Page 1 of 16

1 Scope

This Specification covers welded and seamless carbon steel pipes (including low temperature Ni containing grades listed in ASTM A333 and A671) intended for on-plot piping applications. Alloy steel pipes containing Cr and Mo are outside the scope of this specification. The requirements stated in this specification are supplementary to the applicable ASTM standard.

Commentary Notes:

1. *High frequency welded pipes is not allowed for on-plot applications. See Saudi Aramco standard SAES-L-136 for applicable restrictions.*
2. *Pipes manufactured to API 5L are acceptable for use for on-plot piping, as permitted by Saudi Aramco standard SAES-L-105, provided the pipes are manufactured in accordance with Saudi Aramco specification 01-SAMSS-035. This specification (01-SAMSS-043) is not applicable for procurement of API 5L pipe.*

2 Conflicts and Deviations

- 2.1 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.
- 2.2 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.

3 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.

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-L-105

Piping Material Specifications

SAES-L-130*Material for Low Temperature Service*SAES-L-136*Restrictions on the Use of Line Pipe*

Saudi Aramco Materials System Specification

01-SAMSS-035*API Line Pipe*

Saudi Aramco Inspection Requirements

Form 175-010210*HIC Testing: ANSI/ASTM/API 5L Line Pipe*Form 175-010710*Pipe: Beveled End, Seamless or Welded, Straight Seam, Carbon Steel Pipe*

3.2 Industry Codes and Standards

American Petroleum Institute

*API 5L1**Railroad Transportation of Line Pipe**API 5LW**Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessels*

American Society of Mechanical Engineers

ASME SEC IX*Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators*

American Society for Nondestructive Testing, Inc.

ASNT SNT-TC-1A*Recommended Practice for Personnel Qualification and Certification*ASNT CP-189*Standard for Qualification and Certification of Nondestructive Testing Personnel*

American Society for Testing and Materials

ASTM E23*Standard Test Methods for Notched Bar Impact Testing of Metallic Materials*ASTM E92*Standard Test Method for Vickers Hardness of Metallic Materials*ASTM A106*Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*ASTM A333*Standard Specification for Seamless and Welded Steel Pipe for Low-Temperature Service*

<u>ASTM A530</u>	<i>Standard Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe</i>
<u>ASTM A671</u>	<i>Standard Specification for Electric-Fusion Welded Steel Pipe for Atmospheric and Lower Temperatures</i>
<u>ASTM A672</u>	<i>Standard Specification for Electric-Fusion-Welded Pipe for High-Pressure Service at Moderate Temperatures</i>
<u>ASTM A999</u>	<i>Specification for General Requirements for Alloy and Stainless Steel Pipe</i>
<u>ASTM E709</u>	<i>Standard Guide for Magnetic Particle Examination</i>

International Standardization Organization

<u>NACE MR0175/ISO 15156</u>	<i>Petroleum and Natural Gas Industries-Materials for use in H₂S-containing Environments in Oil and Gas Production</i>
<u>ISO 10124</u>	<i>Seamless and Welded (except submerged arc welded) Steel Tubes For Pressure Purposes – Ultrasonic Testing for the Detection of Laminar Imperfections</i>
<u>ISO 11496</u>	<i>Seamless and Welded Steel Tubes for Pressure Purposes – Ultrasonic Testing of Tube Ends for the Detection of Laminar Imperfections</i>
<u>ISO 12094</u>	<i>Welded Steel Tubes for Pressure Purposes - Ultrasonic Testing for the Detection of Laminar Imperfections in Strips/Plates used in the Manufacture of Welded Tubes</i>
<u>ISO 13664</u>	<i>Seamless and Welded Steel Tubes for Pressure Purposes – Magnetic Particle Inspection of the Tube Ends for the Detection of Laminar Imperfections</i>

NACE International

<u>NACE TM0284</u>	<i>Standard Test Method – Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking</i>
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European Standard

EN 473*Non-Destructive Testing – Qualification and Certification of NDT Personnel - General Principles***4 Definition**

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

5 Information to be Supplied by the Purchaser

If the pipes are intended for sour service, it shall be so stated in the purchase order.

Commentary:

Unless stated to the contrary in the purchase order, pipes manufactured to this specification must be suitable for external coating with fusion bonded epoxy at a later date by the purchaser. Pipe surfaces shall be essentially free of scabs, slivers, cold laps, burrs or other surface defects that would impair the coating.

6 Manufacture

- 6.1 Gas Tungsten Arc Welding, Gas Metal Arc Welding, Flux Cored Arc welding, Plasma Arc Welding, Laser Welding and Submerged Arc Welding (SAW) are acceptable welding processes. Shielded Metal Arc Welding is an acceptable process for carrying out weld repairs.
 - 6.2 All welding consumables, including those used for repair, must have AWS classification.
 - 6.3 Welding procedures, including procedures for repair, and welders/welding operators shall be qualified as per ASME SEC IX. FCAW wire and SAW flux trade name shall be considered as an essential variable.
 - 6.4 Weld repairs on seamless pipes and autogenously welded pipes are not permitted. Weld repairs on the pipe body of pipes welded with addition of filler metal are not permitted.
 - 6.5 The total length of repaired zones on each pipe weld shall be $\leq 5\%$ of the total length of the weld.
 - 6.6 All weld repairs must be carried out before heat treatment and hydrotest.
 - 6.7 Tab ends (run-in/run-off plates) used for welded pipes produced by batch process shall be made from carbon steel (any grade of carbon steel is acceptable).
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7 Heat Treatment

- 7.1 Seamless pipes ordered for sour service must be in the normalized, normalized and tempered or quenched and tempered condition. Pipes can be considered as normalized if the finishing temperature is above Ac3.
- 7.2 Batch-type furnaces shall be equipped with recording pyrometers and automatically controlled within a 10°C or lesser range. In lieu of pyrometers, it is acceptable to attach thermocouples to the pipe for monitoring the temperature.

8 Chemical Composition

- 8.1 Product analysis shall be reported in the mill test certificate.
- 8.2 The sulfur content for seamless pipes shall not exceed 0.004%.
- 8.3 Boron shall not be intentionally added to the steel. Boron content must be reported in the mill test certificate and shall not exceed 0.0005%.
- 8.4 The carbon equivalent (C.E.) shall not exceed the maximum limits tabulated below, unless approved by the Chairman of the Saudi Aramco Materials and Corrosion Control 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 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 and Corrosion Control Standards Committee. The C.E. value shall be marked on each pipe as described in the paragraph above.

Following formulas shall apply:

$$\text{C.E (IIW)} = \text{C} + \text{Mn}/6 + (\text{Cr}+\text{Mo}+\text{V})/5 + (\text{Ni}+\text{Cu})/15$$

$$\text{C.E (Pcm)} = \text{C} + \text{Si}/30 + \text{Mn}/20 + \text{Cu}/20 + \text{Ni}/60 + \text{Cr}/20 + \text{Mo}/15 + \text{V}/10 + 5\text{B}$$

9 Mechanical Tests

9.1 Hardness Testing

9.1.1 Hardness testing shall be performed using the Vickers test in accordance with ASTM E92 using 5 kg or 10 kg load. Testing shall be carried out on all grades for each lot. The mechanical testing lot definition as stated in applicable ASTM standard shall apply.

9.1.2 Location and number of indentations shall be as specified in Annex A.

9.1.3 Acceptance criteria shall be 248 HV maximum.

9.2 Impact Testing

9.2.1 Impact testing for pipes ordered to ASTM A333 and A671 shall be carried out at -45 degree centigrade or as required by the applicable ASTM standard, whichever is colder.

9.2.1 Acceptance criteria for pipes ordered to ASTM A333 shall be 34 J minimum for the average of three specimens and 27 J minimum for individual values based on full size specimen.

9.2.3 For pipes ordered to ASTM A671, impact testing shall be carried out in accordance with supplementary requirement S2 of ASTM A671. Acceptance criteria for base metal, weld metal and Heat Affected Zone shall be 34 J minimum for the average of three specimens and 27 J minimum for individual values based on full size specimen.

Commentary:

The above requirements pertaining to impact testing are in line with paragraph 4.2 of Saudi Aramco Engineering Standard SAES-L-130.

9.2.4 Pipes ordered to ASTM A106 shall be impact tested at 0°C in accordance with ASTM E23. One set (3 specimens) of impact testing

shall be carried out for each lot. Test specimens shall be obtained so that longitudinal axis of the specimen is parallel to the longitudinal axis of the pipe while the axis of the notch shall be perpendicular to the surface. Acceptance criteria shall be 34 J minimum for the average of three specimens and 27 J minimum for individual values based on full size specimen.

10 Additional Requirements for Sour Service

10.1 Seamless Pipes

The pipes shall be supplied either in normalized, normalized and tempered or quenched and tempered condition. Pipes in as rolled condition is not acceptable. Pipes can be considered as normalized if the finishing temperature is above Ac3.

Commentary:

HIC testing in accordance with NACE TM0284 and Annex B of this specification is not required for seamless pipes ordered for sour service.

10.2 Welded Pipes

10.2.1 All welded pipes must be subjected to a heat treatment process, i.e., stress relieved, normalized, normalized and tempered or quenched and tempered.

10.2.2 Pipes ordered for sour service must meet be HIC tested in accordance with Annex B.

10.2.3 HIC resistant plates/coils intended for the manufacturing of pipes shall be procured from an approved Saudi Aramco steel mill.

Commentary:

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

11 Non-Destructive Testing

11.1 Qualification of NDT Personnel

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.

11.2 Inspection for Laminations

11.2.1 Ultrasonic inspection shall be carried out in accordance with ISO 11496 to verify 50 mm wide zone at each pipe end. Laminar imperfections greater than 6.4 mm in the circumferential direction and having an area greater than 100 mm² shall be considered as defects.

11.2.2 Ultrasonic inspection shall be carried out on the pipe body in accordance with ISO 10124:1994 (except 4.2) or ISO 12094. Inspection for welded pipes may be carried out in the strip/plate mill or in the pipe mill. The coverage during automatic inspection shall be at least 25% of the pipe surface. Acceptance criteria shall be as per Table 1 below:

Table 1 – Acceptance Criteria for Laminations in the Pipe Body

Maximum Individual Imperfection		Minimum Imperfection Size Considered			Maximum Population Density
Area (mm ²)	Length	Area (mm ²)	Length (mm)	Width (mm)	
500	Not specified	150	15	8	10 (per 500 mm X 500 mm)

11.3 Each pipe shall be subjected to non-destructive test as per the applicable ASTM specification. NDT equipment should be set up to detect both longitudinal and transverse defects.

11.4 The end face/bevel at each pipe shall be inspected by magnetic particle testing for detection of laminar inspections in accordance with ISO 13664 or ASTM E709. Laminar imperfections greater than 6.4 mm in the circumferential direction shall be classified as defects. Residual magnetism after inspection shall not exceed 30 gauss.

11.5 In addition to non-destructive electric test, each pipe shall be subjected to hydrostatic testing as per ASTM A530/A999. Hydrotest shall be carried out at a pressure of 90% of the specified minimum yield strength for a period of 10 seconds minimum.

12 Dimensional Requirements

Pipes shall be supplied with beveled ends in accordance with Figure 4 of ASME B16.25 irrespective of wall thickness, unless otherwise specified in the Purchase Order.

13 Inspection

Pipes purchased in accordance with this Specification is subject to the requirements of Saudi Aramco Inspection Requirements Form 175-010710.

14 Marking

- 14.1 Each pipe shall be marked Saudi Aramco, followed by the destination, Purchase Order number/Item number, heat number, lot number and the Saudi Aramco 9COM or 9CAT stock number, if applicable. The marking shall ensure full traceability to melt and heat treatment lot.
- 14.2 The marking shall include the specification number 01-SAMSS-043 along with date of issue.
- 14.3 Pipes ordered for sour service shall be marked with alphabet 'S'.
- 14.4 Welded pipes ordered 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 stripe is intended to provide identification until the pipe is installed.

15 Handling, Packing and Transportation

- 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 The following shall be ensured for transportation of pipes by road:
 - (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) Wooden bearing strips shall be used.
 - (iii) 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.
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- (iv) The packing list for transportation must include the pipe numbers and the truck number on which specific pipes are being transported.

16 Certification

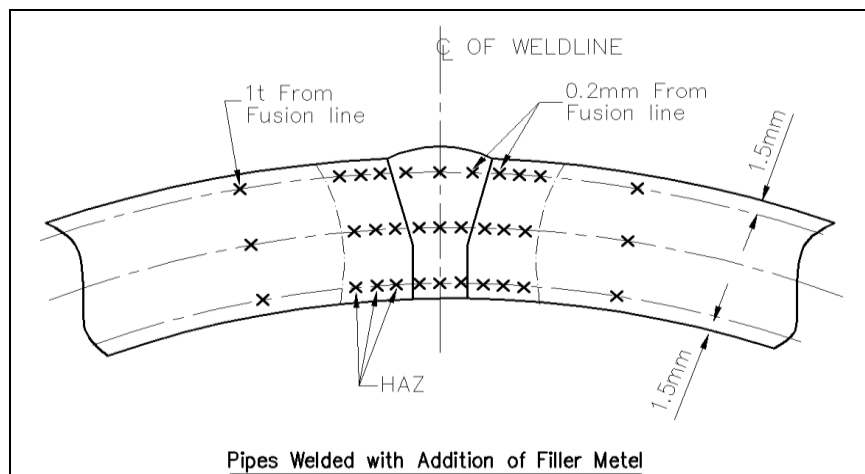
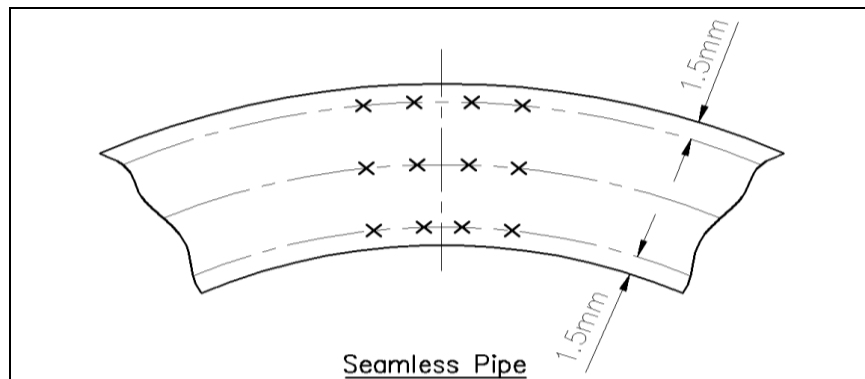
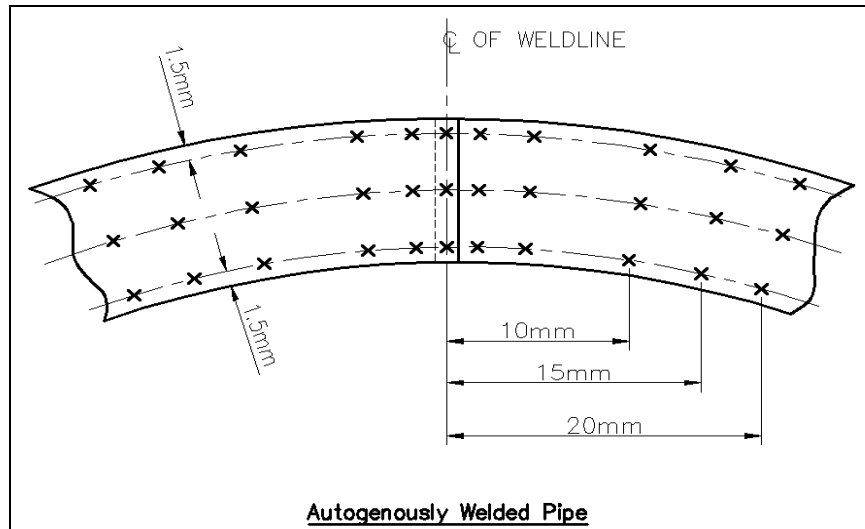
- 16.1 The pipe manufacturer shall furnish the mill test certificate in accordance with ASTM A530/A999.
- 16.2 Heat treatment temperature(s), soaking time and cooling media shall be reported in the mill test certificate.
- 16.3 It shall be certified that the radiation level of the pipes is less than 100 beckerel/gram. Certification can be based on measurements conducted by the steel mill and reported in the mill test certificates of the raw material.

Revision Summary

17 July 2010	New Saudi Aramco Materials System Specification.
25 December 2010	Editorial revision to remove the statement "sour service" from paragraph 8.2.
3 May 2011	Editorial revision to clarify the requirements of approved steel sources.
29 October 2011	Editorial revision to include the word "sour" in the commentary note of paragraph 10.1.

Annex A – Hardness Testing

Location and number of indentations shall be as shown in the figures below.



Annex B – Welded Pipe Ordered for Sour Service

B.2 HIC Test

B.2.1 Evaluation and Acceptance Criteria

The test for evaluation of resistance to hydrogen-induced cracking shall meet the following acceptance criteria, with each ratio being the maximum permissible average for 3 sections per test specimen when tested in solution A.

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

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 pipes 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.

B.2.2 Testing Frequency

The frequency of inspection for HIC test shall be one pipe from each heat. One set of three specimens is required for HIC testing.

B.2.3 Samples for HIC Tests

B.2.3.1 Samples for HIC tests shall be taken in accordance with NACE TM0284.

- B.2.3.2 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 only.
 - 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). In case the steel processing is conducted through ingot route, sampling shall include the ends of the two plates representing the head and the tail of the ingot.
 - If several thicknesses are produced from a coil or plate of a single heat, then the thinnest shall be tested.

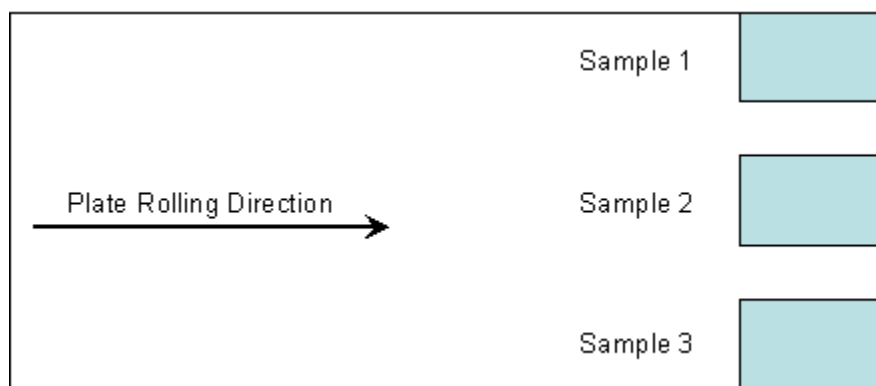


Figure 2 – Plate Sampling Location Diagram

- B.2.4 HIC Test Method
- B.2.4.1 HIC test shall be carried out and reported in accordance with NACE TM0284 and the requirements of this annex.
- B.2.4.2 HIC test shall be conducted in a medium complying with NACE TM0284:2003, Solution A.
- B.2.4.3 The following shall be included in the HIC test report or Mill Test Certificate
- a) 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 (CLR and CTR).
 - f) The CLR results of the control sample shall also be reported. For each section containing cracks only, a photograph shall be taken of the complete cross-section.
- B.2.4.4 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.
- B.2.4.5 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.
- B.2.4.6 Should the Vendor's HIC test results be rejected by Saudi Aramco, re-testing may be referred to an independent 3rd party laboratory acceptable to Saudi Aramco for resolution. This laboratory shall use HIC test methods and control samples in accordance with this specification.
- B.2.4.7 Testing shall be performed by the Manufacturer/Vendor or 3rd party laboratory acceptable to Saudi Aramco. The Chairman or Vice-Chairman of the Materials and Corrosion Control Standards Committee shall approve all HIC Test Laboratories following the review of the Vendor Inspection survey report. This report shall include the mandatory requirements specified below:
- a) Verify the Inspection and Testing Requirements specified in Form 175-010210 HIC Testing are completely satisfied. This task shall be carried out by Saudi Aramco Inspection Representative, e.g., Vendor Inspection Division.
 - b) 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.
 - 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
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the adequate training of technicians or engineers undertaking the evaluation of CLR and CTR measurements.

- f) Should the Vendor's HIC test results be rejected by Saudi Aramco, re-testing may be referred to an independent 3rd party laboratory acceptable to Saudi Aramco for resolution. This 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.
 - 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.

B.2.4.8 HIC test verification shall be in accordance with Saudi Aramco Inspection Form 175-010210 Inspection and Testing Requirements – HIC Testing.

B.2.5 Retesting Requirements

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 random from the same lot for further testing. If both of the retest groups pass, all pipes in the lot are acceptable except the one from which the initial test coupons were taken. If either of the retests fail, the entire lot shall be rejected.

B.2.6 Additional testing shall be required if the steel-making and/or pipe-making procedures are significantly altered during production.
