Annex H
(normative)

PSL 2 pipe ordered for sour service

H.1 Introduction

This annex specifies additional provisions that apply for PSL 2 pipe that is ordered for sour service [see 7.2 c) 51)].

NOTE The consequences of sudden failures of metallic components used for the oil and gas production associated with their exposure to H₂S-containing production fluids led to the development of NACE MR0175/ISO 15156-1\[2\] and subsequently EFC Publication 16\[13\]. ISO 15156-2 used those sources to provide requirements and recommendations for materials qualification and selection for application in environments containing wet H₂S in oil and gas production systems. Carbon and low alloy steels selected using ISO 15156-2 are resistant to cracking in defined H₂S-containing environments in oil and gas production but are not necessarily immune to cracking under all service conditions. Different service conditions might necessitate the alternative testing that is dealt with in ISO 15156-2:2003, Annex B. That annex specifies requirements for qualifying carbon and low alloy steels for H₂S service by laboratory testing.

It is the purchaser's responsibility to select the carbon and low-alloy steels suitable for the intended service.

H.2 Additional information to be supplied by the purchaser

In addition to items a) to g) as specified by 7.1, the purchase order shall indicate which of the following provisions apply for the specific order item:

a) steel casting method for strip or plate used for the manufacture of welded pipe (see H.3.3.2.1);

b) ultrasonic inspection of strip or plate for laminar imperfections (see H.3.3.2.4);

c) supply of helical-seam pipe containing strip/plate end welds (see H.3.3.2.5);

d) chemical composition for intermediate grades (see H.4.1.1);

e) chemical composition for pipe with \( t > 25.0 \, \text{mm} \) (0.984 in) (see H.4.1.2);

f) chemical composition limits [see Table H.1, footnotes c), d), e), f), i), j) and k)];

g) frequency of hardness testing of the longitudinal seam weld of HFW or SAW pipe (see Table H.3);

h) SSC test for manufacturing procedure qualification (see Table H.3);

i) alternative HIC/SWC test methods and associated acceptance criteria (see H.7.3.1.3);

j) photomicrographs of reportable HIC cracks (see H.7.3.1.4);

k) alternative SSC test methods and associated acceptance criteria for manufacturing procedure qualification (see H.7.3.2.2);

l) for pipe with \( t \geq 5.0 \, \text{mm} \) (0.197 in), ultrasonic inspection for laminar imperfections within extended length of 100 mm (4.0 in) at the pipe ends (see K.2.1.3);

m) magnetic particle inspection for laminar imperfections at each pipe end face/bevel (see K.2.1.4);
n) increased coverage for ultrasonic thickness measurements for SMLS pipe (see K.3.3);
o) application of one or more of the supplementary non-destructive inspection operations for SMLS pipe (see K.3.4);
p) limitation of individual lamination size to 100 mm² (0.16 in²) (see Table K.1);
q) acceptance level L2/C or L2 for non-destructive inspection of the weld seam of HFW pipe (see K.4.1);
r) ultrasonic inspection of the pipe body of HFW pipe for laminar imperfections (see K.4.2);
s) ultrasonic inspection of the strip/plate edges or areas adjacent to the weld for laminar imperfections (see K.4.3);
t) non-destructive inspection of the pipe body of HFW pipe using the ultrasonic or flux leakage method (see K.4.4);
u) use of fixed depth notches for equipment standardization [see K.5.1.1 c]);
v) radiographic inspection of pipe ends (non-inspected ends) and repaired areas [see K.5.3 a]);
w) magnetic particle inspection of the weld seam at the pipe ends of SAW pipe (see K.5.4).

H.3 Manufacturing

H.3.1 Manufacturing procedure

All pipes shall be manufactured in accordance with a manufacturing procedure that has been qualified in accordance with Annex B, possibly supplemented with additional testing (see Table H.3).

H.3.2 Steel making

H.3.2.1 The steel shall be made to a clean steel practice using either the basic oxygen steel-making process or the electric furnace process and shall be killed.

H.3.2.2 Vacuum degassing or alternative processes to reduce the gas content of the steel should be applied.

H.3.2.3 The molten steel shall be treated for inclusion shape control. A procedure (e.g. metallographic examination) may be agreed between the purchaser and the manufacturer to assess the effectiveness of inclusion shape control.

H.3.3 Pipe manufacturing

H.3.3.1 SMLS pipe

SMLS pipe shall be manufactured from continuously cast (strand cast) or ingot steel. If the process of cold finishing was used, this shall be stated in the inspection document.

H.3.3.2 Welded pipe

H.3.3.2.1 Unless otherwise agreed, strip and plate used for the manufacture of welded pipe shall be rolled from continuously cast (strand cast) or pressure cast slabs. The pipe shall be SAWL, SAWH or HFW.

H.3.3.2.2 For HFW pipe, the abutting edges of the strip or plate should be sheared, milled or machined before welding.
H.3.3.2.3 Strip and plate used for the manufacture of welded pipe shall be inspected visually after rolling. Visual inspection of strip used for the manufacture of welded pipe may be either of the uncoiled strip or of the coil edges.

H.3.3.2.4 If agreed, such strip and plate shall be inspected ultrasonically for laminar imperfections or mechanical damage in accordance with Annex K, either before or after cutting the strip or plate, or the completed pipe shall be subjected to full-body inspection, including ultrasonic inspection.

H.3.3.2.5 If agreed, helical-seam pipe made from strip/plate and containing strip/plate end-welds may be delivered, provided that such welds are located at least 300 mm from the pipe ends and have been subjected to the same non-destructive inspection required in Annex K for strip/plate edges and welds.

H.3.3.2.6 Intermittent tack welding of the SAWL or SAWH groove shall not be used, unless the purchaser has approved data furnished by the manufacturer to demonstrate that all mechanical properties specified for the pipe are obtainable at both the tack weld and intermediate positions.

H.3.3.3 Jointers

Jointers shall not be delivered, unless otherwise agreed.

NOTE It is the responsibility of the purchaser and the manufacturer to agree procedures for welding specifications and qualification tests for specific sour-service jointers.

H.4 Acceptance criteria

H.4.1 Chemical composition

H.4.1.1 For pipe with \( t \leq 25.0 \text{ mm (0.984 in)} \), the chemical composition for standard grades shall be as given in Table H.1 and the chemical composition for intermediate grades shall be as agreed, but consistent with those given for the standard grades in Table H.1. The pipe designation shall be as given in Table H.1 and consists of an alpha or alphanumeric designation that identifies the grade, followed by a suffix that consists of a letter (N, Q or M) that identifies the delivery condition and a second letter (S) that identifies the service condition.

H.4.1.2 For pipe with \( t > 25.0 \text{ mm (0.984 in)} \), the chemical composition shall be as agreed, with the requirements given in Table H.1 being amended as appropriate.
### Table H.1 — Chemical composition for pipe with \( t \leq 25.0 \) mm (0.984 in)

<table>
<thead>
<tr>
<th>Steel grade</th>
<th>Mass fraction, based upon heat and product analyses</th>
<th>Carbon equivalent&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% maximum</td>
<td>% maximum</td>
</tr>
<tr>
<td></td>
<td>C&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Si</td>
</tr>
<tr>
<td>SMLS and welded pipes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L245NS or BNS</td>
<td>0.14</td>
<td>0.40</td>
</tr>
<tr>
<td>L290NS or X42NS</td>
<td>0.14</td>
<td>0.40</td>
</tr>
<tr>
<td>L320NS or X46NS</td>
<td>0.14</td>
<td>0.40</td>
</tr>
<tr>
<td>L360NS or X52NS</td>
<td>0.16</td>
<td>0.45</td>
</tr>
<tr>
<td>L245QS or BQS</td>
<td>0.14</td>
<td>0.40</td>
</tr>
<tr>
<td>L290QS or X42QS</td>
<td>0.14</td>
<td>0.40</td>
</tr>
<tr>
<td>L320QS or X46QS</td>
<td>0.15</td>
<td>0.45</td>
</tr>
<tr>
<td>L360QS or X52QS</td>
<td>0.16</td>
<td>0.45</td>
</tr>
<tr>
<td>L390QS or X56QS</td>
<td>0.16</td>
<td>0.45</td>
</tr>
<tr>
<td>L415QS or X60QS</td>
<td>0.16</td>
<td>0.45</td>
</tr>
<tr>
<td>L450QS or X65QS</td>
<td>0.16</td>
<td>0.45</td>
</tr>
<tr>
<td>L485QS or X70QS</td>
<td>0.16</td>
<td>0.45</td>
</tr>
<tr>
<td>Welded pipe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L245MS or BMS</td>
<td>0.10</td>
<td>0.40</td>
</tr>
<tr>
<td>L290MS or X42MS</td>
<td>0.10</td>
<td>0.40</td>
</tr>
<tr>
<td>L320MS or X46MS</td>
<td>0.10</td>
<td>0.45</td>
</tr>
<tr>
<td>L360MS or X52MS</td>
<td>0.10</td>
<td>0.45</td>
</tr>
<tr>
<td>L390MS or X56MS</td>
<td>0.10</td>
<td>0.45</td>
</tr>
<tr>
<td>L415MS or X60MS</td>
<td>0.10</td>
<td>0.45</td>
</tr>
<tr>
<td>L450MS or X65MS</td>
<td>0.10</td>
<td>0.45</td>
</tr>
<tr>
<td>L485MS or X70MS</td>
<td>0.10</td>
<td>0.45</td>
</tr>
</tbody>
</table>

<sup>a</sup> Based upon product analysis (see 9.2.4 and 9.2.5). The CE<sub>IIW</sub> limits apply if the carbon mass fraction is greater than 0.12 % and the CE<sub>Pcm</sub> limits apply if the carbon mass fraction is less than or equal to 0.12 %.

<sup>b</sup> For each reduction of 0.01 % below the specified maximum for carbon, an increase of 0.05 % above the specified maximum for manganese is permissible, up to a maximum increase of 0.20 %.

<sup>c</sup> Al<sub>total</sub> \( \leq 0.060 \) %; N \( \leq 0.012 \) %; Al/N \( \geq 2.1 \) (not applicable to titanium-killed or titanium-treated steel); Cu \( \leq 0.35 \) % (if agreed, Cu \( \leq 0.10 \) %); Ni \( \leq 0.30 \) %; Cr \( \leq 0.30 \) %; Mo \( \leq 0.15 \) %; B \( \leq 0.0005 \) %.

<sup>d</sup> For welded pipe where calcium is intentionally added, unless otherwise agreed, Ca/S \( \leq 1.5 \) if S \( \leq 0.0015 \) %. For SMLS and welded pipes, the calcium concentration shall be \( \leq 0.006 \) %.

<sup>e</sup> The maximum limit for sulfur concentration may be increased to \( \leq 0.008 \) % for SMLS pipe and, if agreed, to \( \leq 0.006 \) % for welded pipe. For such higher-sulfur levels in welded pipe, lower Ca/S ratios may be agreed.

<sup>f</sup> Unless otherwise agreed, the sum of the niobium and vanadium concentrations shall be \( \leq 0.06 \) %.

<sup>g</sup> The sum of the niobium, vanadium and titanium concentrations shall be \( \leq 0.15 \) %.

<sup>h</sup> For SMLS pipe, the listed value may be increased by 0.03.

<sup>i</sup> If agreed, the molybdenum concentration shall be \( \leq 0.35 \) %.

<sup>j</sup> If agreed, the chromium concentration shall be \( \leq 0.45 \) %.

<sup>k</sup> If agreed, Cr concentration shall be \( \leq 0.45 \) % and Ni concentration shall be \( \leq 0.50 \) %.
H.4.2 Tensile properties

H.4.2.1 The tensile properties shall be as given in Table H.2.

Table H.2 — Requirements for the results of tensile tests

<table>
<thead>
<tr>
<th>Pipe steel grade</th>
<th>Yield strength a ( R_{0.5} ) Mpa (psi)</th>
<th>Tensile strength a ( R_m ) Mpa (psi)</th>
<th>Ratio b ( R_{0.5}/R_m )</th>
<th>Elongation on 50 mm or 2 in</th>
<th>Tensile strength c ( R_m ) Mpa (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>minimum</td>
<td>maximum</td>
<td>minimum</td>
<td>maximum</td>
<td>maximum</td>
</tr>
<tr>
<td>L245NS or BNS</td>
<td>245</td>
<td>(35 500)</td>
<td>450</td>
<td>(65 300) d</td>
<td>415</td>
</tr>
<tr>
<td>L245QS or BQS</td>
<td>290</td>
<td>(42 100)</td>
<td>495</td>
<td>(71 800)</td>
<td>415</td>
</tr>
<tr>
<td>L245MS or BMS</td>
<td>320</td>
<td>(46 400)</td>
<td>525</td>
<td>(76 100)</td>
<td>435</td>
</tr>
<tr>
<td>L290NS or X42NS</td>
<td>360</td>
<td>(52 200)</td>
<td>530</td>
<td>(76 900)</td>
<td>460</td>
</tr>
<tr>
<td>L290QS or X42QS</td>
<td>390</td>
<td>(56 600)</td>
<td>545</td>
<td>(79 000)</td>
<td>490</td>
</tr>
<tr>
<td>L290MS or X42MS</td>
<td>415</td>
<td>(60 200)</td>
<td>565</td>
<td>(81 900)</td>
<td>520</td>
</tr>
<tr>
<td>L320NS or X46NS</td>
<td>450</td>
<td>(65 300)</td>
<td>600</td>
<td>(87 000)</td>
<td>535</td>
</tr>
<tr>
<td>L320QS or X46QS</td>
<td>485</td>
<td>(70 300)</td>
<td>635</td>
<td>(92 100)</td>
<td>570</td>
</tr>
</tbody>
</table>
Table H.2 — Requirements for the results of tensile tests (continued)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>For intermediate grades, the difference between the specified maximum yield strength and the specified minimum yield strength shall be as given in the table for the next higher grade, and the difference between the specified minimum tensile strength and the specified minimum yield strength shall be as given in the table for the next higher grade. For intermediate grades, the tensile strength shall be (&lt; 760 \text{ MPa (110,200 psi)}).</td>
</tr>
<tr>
<td>b</td>
<td>This limit applies for pipe with (D &gt; 323.9 \text{ mm (12.750 in)}).</td>
</tr>
<tr>
<td>c</td>
<td>For intermediate grades, the specified minimum tensile strength for the weld seam shall be the same value as was determined for the pipe body using footnote a).</td>
</tr>
<tr>
<td>d</td>
<td>For pipe with (D &lt; 219.1 \text{ mm (8.625 in)}), the maximum yield strength shall be (&lt; 495 \text{ MPa (71,800 psi)}).</td>
</tr>
<tr>
<td>e</td>
<td>The specified minimum elongation, (A_f), on 50 mm or 2 in, expressed in percent and rounded to the nearest percent, shall be as determined using the following equation:</td>
</tr>
<tr>
<td></td>
<td>[ A_f = C \frac{A_{KC}}{U^{0.9}} ]</td>
</tr>
<tr>
<td></td>
<td>where</td>
</tr>
<tr>
<td></td>
<td>(C) is 1 940 for calculations using SI units and 625 000 for calculations using USC units;</td>
</tr>
<tr>
<td></td>
<td>(A_{KC}) is the applicable tensile test piece cross-sectional area, expressed in square millimetres (square inches), as follows:</td>
</tr>
<tr>
<td></td>
<td>— for circular cross-section test pieces, 130 mm(^2) (0.20 in(^2)) for 12.5 mm (0.500 in) and 8.9 mm (0.350 in) diameter test pieces; and 65 mm(^2) (0.10 in(^2)) for 6.4 mm (0.250 in) diameter test pieces;</td>
</tr>
<tr>
<td></td>
<td>— for full-section test pieces, the lesser of a) 485 mm(^2) (0.75 in(^2)) and b) the cross-sectional area of the test piece, derived using the specified outside diameter and the specified wall thickness of the pipe, rounded to the nearest 10 mm(^2) (0.01 in(^2));</td>
</tr>
<tr>
<td></td>
<td>— for strip test pieces, the lesser of a) 485 mm(^2) (0.75 in(^2)) and b) the cross-sectional area of the test piece, derived using the specified width of the test piece and the specified wall thickness of the pipe, rounded to the nearest 10 mm(^2) (0.01 in(^2)).</td>
</tr>
<tr>
<td></td>
<td>(U) is the specified minimum tensile strength, expressed in megapascals (pounds per square inch).</td>
</tr>
</tbody>
</table>

H.4.3 HIC/SWC test

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 three sections per test specimen when tested in Solution (Environment) A (see ISO 15156-2:2003, Table B.3):

a) crack sensitivity ratio (CSR) \(< 2 \%\); 
b) crack length ratio (CLR) \(< 15 \%\); 
c) crack thickness ratio (CTR) \(< 5 \%\). 

If HIC/SWC tests are conducted in alternative media (see H.7.3.1.3) to simulate specific service conditions, alternative acceptance criteria may be agreed.

H.4.4 Hardness test

For test pieces subjected to a hardness test (see H.7.3), the hardness in the pipe body, the weld and HAZ shall be \(< 250 \text{ HV10 or 22 HRC (70.6 HR 15N)}\). 

The maximum acceptable hardness of an unexposed weld cap and external surface HAZ and base metal may be 275 HV10 or 26 HRC (73.0 HR 15N) where the equipment user agrees to the alternative weld cap hardness limit, the parent pipe wall thickness is greater than 9 mm, the weld cap is not exposed directly to the sour environment and the escape of hydrogen is not impeded, e.g. by cathodic protection.

H.4.5 SSC test

After removal of the SSC test specimens (see H.7.3.2) from the test medium, the tension surface of the specimen shall be examined under a low-power microscope at X10 magnification. The occurrence of any
surface breaking fissures or cracks on the tension surface of the test specimen shall constitute failure of the specimen unless it can be demonstrated that these are not the result of sulfide stress cracking.

**H.5 Surface conditions, imperfections and defects**

**H.5.1** Surface imperfections, other than undercuts in SAW pipe, disclosed by visual inspection shall be investigated, classified and treated as follows.

a) Imperfections that have a depth \( \leq 0.05 t \) and do not encroach on the minimum permissible wall thickness shall be classified as acceptable imperfections and treated in accordance with Clause C.1.

   **NOTE** There is a possibility of special requirements for disposition of surface imperfections being specified in the purchase order if the pipe is subsequently to be coated.

b) Imperfections that have a depth \( > 0.05 t \) and do not encroach on the minimum permissible wall thickness shall be classified as defects and shall be treated in accordance with Clause C.2, C.3 b) or C.3 c).

c) Imperfections that encroach on the minimum permissible wall thickness shall be classified as defects and treated in accordance with C.3 b) or C.3 c).

**H.5.2** For welded pipe, any hard spot larger than 50 mm (2.0 in) in any direction shall be classified as a defect if its hardness, based upon individual indentations, exceeds

a) 250 HV10, 22 HRC or 240 HBW on the internal surface of the pipe or repair to internal seam weld bead, or

b) 275 HV10, 27 HRC or 260 HBW on the external surface of the pipe or repair to external seam weld bead.

Pipes that contain such defects shall be treated in accordance with C.3 b) or C.3 c).

**H.6 Weld flash of HFW pipe**

The inside flash shall not extend above the contour of the pipe by more than 0.3 mm (0.012 in) + 0.05 \( t \).

**H.7 Inspection**

**H.7.1 Specific inspection**

The frequency of inspection shall be as given in Table 18, except as specifically modified in Table H.3.
Table H.3 — Inspection frequency

<table>
<thead>
<tr>
<th>Type of inspection</th>
<th>Type of pipe</th>
<th>Frequency of inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness testing of pipe with $D &lt; 508$ mm (20.000 in)</td>
<td>SMLS, HFW, SAWL or SAWH</td>
<td>Once per test unit of not more than 100 lengths of pipe with the same cold-expansion ratio$^a$</td>
</tr>
<tr>
<td>Hardness testing of pipe with $D \geq 508$ mm (20.000 in)</td>
<td>SMLS, HFW, SAWL or SAWH</td>
<td>Once per test unit of not more than 50 lengths of pipe with the same cold-expansion ratio$^a$</td>
</tr>
<tr>
<td>Hardness testing of hard spots in welded pipe</td>
<td>HFW, SAWL or SAWH</td>
<td>Each hard spot found on the internal or external surface of the pipe</td>
</tr>
<tr>
<td>If agreed, hardness testing of the longitudinal or helical-seam weld of welded pipe</td>
<td>HFW, SAWL or SAWH</td>
<td>As specified in the purchase order</td>
</tr>
<tr>
<td>Pipe diameter and out-of-roundness for pipe with $D \leq 168.3$ mm (6.625 in)</td>
<td>SMLS, HFW, SAWL or SAWH</td>
<td>Once per test unit of not more than 100 lengths of pipe</td>
</tr>
<tr>
<td>Pipe diameter and out-of-roundness for pipe with $D &gt; 168.3$ mm (6.625 in)</td>
<td>SMLS, HFW, SAWL or SAWH</td>
<td>Once per test unit of not more than 20 lengths of pipe</td>
</tr>
<tr>
<td>Non-destructive inspection</td>
<td>SMLS, HFW, SAWL or SAWH</td>
<td>In accordance with Annex K</td>
</tr>
<tr>
<td>HIC test</td>
<td>SMLS, HFW, SAWL or SAWH</td>
<td>One test for each of the first three heats applied; thereafter, one test for each test unit of not more than ten heats of steel</td>
</tr>
<tr>
<td>If agreed, SSC test</td>
<td>SMLS, HFW, SAWL or SAWH</td>
<td>One test for each pipe provided for manufacturing procedure qualification</td>
</tr>
</tbody>
</table>

$^a$ The cold-expansion ratio is designated by the manufacturer and is derived using the designated before-expansion outside diameter or circumference and the after-expansion outside diameter or circumference. An increase or decrease in the cold-expansion ratio of more than 0.002 requires the creation of a new test unit.

H.7.2 Samples and test pieces for mechanical and technological tests

H.7.2.1 General

H.7.2.1.1 For tensile tests, CVN impact tests, DWT tests, guided bend tests, flattening tests, hardness tests, HIC tests, bead on pipe tests, bead on plate tests and SSC tests, the samples shall be taken, and the corresponding test pieces shall be prepared, in accordance with the applicable reference standard.

H.7.2.1.2 Samples and test pieces for the various types of test shall be taken from locations as shown in Figures 5 and 6 and as given in Table H.4, taking into account the supplementary details in 10.2.3.2 to 10.2.3.7, 10.2.4 and H.7.2.2 to H.7.2.4.

H.7.2.2 Samples for HIC/SWC tests

Samples for HIC/SWC tests shall be taken in accordance with NACE TM0284.

H.7.2.3 Samples and test pieces for SSC tests

H.7.2.3.1 One longitudinal direction sample shall be taken from each test pipe provided for manufacturing procedure qualification; three test pieces shall be taken from each sample.

H.7.2.3.2 Unless agreed otherwise, test pieces for four-point bending SSC tests shall be $\geq 115$ mm (4.5 in) long $\times$ 15 mm (0.59 in) wide $\times$ 5 mm (0.20 in) thick and shall, for welded pipe, contain a section of the longitudinal or helical-seam weld at its centre. Samples may be flattened prior to machining test pieces from the inside surface of the pipe.
H.7.2.4 Samples for hardness tests

Samples for hardness tests shall be taken from the end of selected pipes and, for welded pipe, each sample shall contain a section of the longitudinal or helical seam at its centre (see Figure H.1).

Table H.4 — Number, orientation and location of test pieces per sample for hardness tests

<table>
<thead>
<tr>
<th>Type of pipe</th>
<th>Sample location</th>
<th>Number, orientation and location of test pieces per sample(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Specified outside diameter (D) mm (in)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(&lt; 508 (20.000)) (\geq 508 (20.000))</td>
</tr>
<tr>
<td>SMLS (^b)</td>
<td>Pipe body</td>
<td>(1T)</td>
</tr>
<tr>
<td>SAWL (^c)</td>
<td>Seam weld</td>
<td>(1W)</td>
</tr>
<tr>
<td>SAWH (^c)</td>
<td>Seam weld</td>
<td>(1W)</td>
</tr>
<tr>
<td>SAWH (^c)</td>
<td>Strip/plate end weld</td>
<td>(1WS)</td>
</tr>
<tr>
<td>HFW (^b)</td>
<td>Seam weld</td>
<td>(1W)</td>
</tr>
</tbody>
</table>

\(^a\) See Figure 5 for an explanation of the symbols used to designate orientation and location.

\(^b\) Applies for both cold-expanded and non-expanded SMLS pipe.

\(^c\) For double-seam pipe, both longitudinal weld seams in the pipe selected to represent the test unit shall be tested.

H.7.3 Test methods

H.7.3.1 HIC/SWC test

H.7.3.1.1 HIC/SWC tests shall be carried out and reported in accordance with NACE TM0284.

H.7.3.1.2 Except as allowed by H.7.3.1.3, HIC/SWC tests shall be conducted in a medium complying with NACE TM0284:2003, Solution A.

H.7.3.1.3 If agreed, HIC/SWC tests may be conducted

a) in an alternative medium (see ISO 15156-2:2003, Table B.3) including NACE TM0284:2003, Solution B,

b) with a partial pressure of \(H_2S\) appropriate to the intended application, and

c) with acceptance criteria that are equal to or more stringent than those specified in H.4.3.

H.7.3.1.4 Values of crack-length ratio, crack-thickness ratio and crack-sensitivity ratio shall be reported. If agreed, photographs of any reportable crack shall be provided with the report.

H.7.3.2 SSC test

H.7.3.2.1 Except as allowed by H.7.3.2.2, SSC tests shall be performed in accordance with NACE TM0177:2005, using test Solution A.

A four-point bend test piece in accordance with ISO 7539-2 or ASTM G 39 shall be used and the test duration shall be 720 h.

Except as allowed by H.7.3.2.2, the test pieces shall be stressed to 0.72 times the specified minimum yield strength of the pipe.
NOTE The use of an applied stress equal to 0.72 times the specified minimum yield strength in the SSC test does not necessarily provide sufficient technical justification that the material has been pre-qualified for all sour service applications. For further advice on prequalification, refer to ISO 15156-2.

H.7.3.2.2 If agreed, alternative SSC test methods, alternative environments (including a partial pressure of H₂S appropriate for the intended application) and associated acceptance criteria may be used (see ISO 15156-2:2003, Table B.1). If such tests are used, full details of the test environment and conditions shall be reported together with the test results.

H.7.3.3 Hardness test

H.7.3.3.1 Hardness testing on parent metal shall be performed using the Vickers test in accordance with ISO 6507-1 or ASTM E 92 or using Rockwell test HR 15N in accordance with ISO 6508 or ASTM E 18. In case of dispute, the Vickers method shall apply.

Hardness testing on the HAZ and weld shall be carried out in accordance with ISO 6507-1 or ASTM E 92.

For pipe body tests and parent metal tests, individual hardness readings exceeding the applicable acceptance limit may be considered acceptable if the average of a minimum of three and maximum of six additional readings taken within close proximity does not exceed the applicable acceptance limit, and if no such individual reading exceeds the acceptance limit by more than 10 HV10 units or 2 HRC units, whichever is applicable.

H.7.3.3.2 Hardness test locations for SMLS pipe shall be as shown in Figure H.1 a), except that

a) for pipe with \( \tau < 4.0 \text{ mm (0.156 in)} \), it is necessary to carry out only the mid-thickness traverse, and
b) for pipe with \( 4.0 \text{ mm (0.156 in)} \leq \tau < 6.0 \text{ mm (0.236 in)} \), it is necessary to carry out only the inside and outside surface traverses.

H.7.3.3.3 Hardness test locations for welded pipe shall include the weld cross-section. Indentations shall be made in the parent metal, in the visible HAZ and at the weld centreline, as shown in Figure H.1 b) and c), except that

a) for pipe with \( \tau < 4.0 \text{ mm (0.156 in)} \) it is necessary to carry out only the mid-thickness traverse, and
b) for pipe with \( 4.0 \text{ mm (0.156 in)} \leq \tau < 6.0 \text{ mm (0.236 in)} \), it is necessary to carry out only the inside and outside surface traverses.

H.7.4 Non-destructive inspection

For non-destructive inspection, see H.3.3.2.3 to H.3.3.2.5 and Annex K.

H.8 Pipe markings

In addition to the pipe markings required in 11.2, the pipe markings shall include an identification number that permits the correlation of the product or delivery unit with the related inspection document. The product specification level designation shall be followed by the letter “S” to indicate that the pipe is intended for sour service and that the requirements of Annex H applies.
Figure H.1 — Location of hardness tests
c) HFW pipe

a  Weld centreline.
b  0.75 mm (0.03 in) from fusion line.
c  1 \( t \) from fusion line.
d  1.0 mm (0.04 in) spacing in visible HAZ.
e  From inside and outside surfaces.

Figure H.1 — Location of hardness tests (continued)