

**API Ballot id# 5799
SC5 TGLP**

Work Item	4253 – Annex H SSC Guidance for TMCP
Distribution-type [Ballot (vote and comment), Comment-only (review), Recirculation (comment resolution), Re-ballot, etc.]	Ballot (comment and vote)
Document	SPEC 5L, 46 th Edition
Other Impacts	None
Revision Key	Current/unchanged content in BLACK; Track Changes as: 1) Additions in <u>underlined BLUE</u> 2) Deletions in stricken RED NOTE The “*****” indicates there is un-altered content above / below.

Work Item Charge:

Alert users and industry to potential sour service line pipe failure mechanism within steel manufactured from thermo-mechanical-controlled-process (TMCP) steel, and provide additional guidance on how to mitigate risk.

Edit 5L Annex H to include:

- 1) edit/add informative notes to alert users to phenomena of local hard zones (LHZ) and how they can affect sour cracking performance of line pipe,
- 2) develop general upgrades to language on how to execute and interpret SSC tests,
 - a) general edits: improved guidance on test execution and post-test analysis (e.g., reference NACE TM0316), and
 - b) TMCP-specific: improved guidance on sample selection, test coupon surface condition (e.g., no machined surface).

Ballot Rationale:

Work Group has met numerous times over the past year to discuss proposed changes, predominantly to Annex H, regarding large diameter line pipe manufactured from TMCP plate and the potential development of local hard zones. These LHZs have been found to lead to through wall cracking in severe sour service environments.

Work Group commenting has been led by operators, manufacturers, and testing laboratories with direct experience of LHZ identification and cracking performance. A running log of the comments, their acceptance/rejection, and rationale is attached as file “5L WI4253 Ballot Comments 1st Round Consolidated Dec21 revA.xlsx”

NOTE See the ballot email notification for additional information regarding this ballot.

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Line Pipe

API SPECIFICATION 5L
FORTY-SIXTH EDITION, APRIL 2018

API MONOGRAM PROGRAM EFFECTIVE DATE: MAY 1, 2019

ERRATA 1, MAY 2018

(Ballot) Draft—For Committee Review

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Line Pipe

2 Normative References

[NACE TM0316-2016, Standard Test Method — Four-Point Bend Testing of Materials for Oil and Gas Applications](#)

3 Terms, Definitions, Symbols, and Abbreviations

3.1 Terms and Definitions

[3.1.34](#) [local hard zone](#) [LHZ](#)

[Shallow regions approximately 200-500 microns deep on surface of C-Mn steel plate and subsequent pipe manufactured by thermomechanical rolled and accelerated cooling that have elevated hardness of approximately 300 vickers or higher.](#)

[3.1.34](#) to [3.1.65](#)

8 Manufacturing

8.3 Starting Material

8.3.7 For welded pipe with delivery condition M, critical variables of the coil/plate rolling practice (e.g. reheating, rolling and cooling temperatures, times, and tolerances) shall be defined and controlled to ensure that the mechanical properties throughout the pipe are suitably uniform considering:

- a) coil/plate characteristics and variability,
- b) sensitivity of properties to rolling practice,
- c) appropriate coil/plate cropping distances, and
- d) tensile property changes inherent in pipe forming.

The permissible ranges of critical variables for coil/plate rolling practice shall be documented.

[NOTE](#) [Near surface SSC susceptibility in Region 3 in Figure 1 of ANSI/NACE MR0175/ISO 15156-2:2020 has been found to be related to certain plate manufacturing practices and generation of local hard zones \(LHZs\); see Annex H and H.3.3 for further details.](#)

Annex H (normative)

PSL 2 Pipe Ordered for Sour Service

H.1 Introduction

Documented in-service failures of large-diameter pipes manufactured from thermomechanical rolled plate have led to concerns of local hard zones (LHZs) and their potential to initiate through-wall SSC failures in severe sour 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:

gg) NDT or alternate inspection method for plate surface hardness inspection.

H.3 Manufacturing

H.3.3 TMCP Manufacturing

The purchaser should consider the potential of LHZs in large-diameter pipes manufactured from TMCP plates when selecting and qualifying carbon and low-alloy steels for service conditions corresponding to Region 3 of the NACE diagram in Figure 1 of ANSI/NACE MR0175/ISO 15156-2:2020.

NOTE Documented in-service failures of large-diameter pipes manufactured from thermomechanical rolled plate have led to concerns of local hard zones (LHZs) and their potential to initiate through-wall SSC failures in severe sour service.

H.3.3H.3.4 Pipe Manufacturing

H.3.3.1H.3.4.1 to **H.3.3.6**H.3.4.6

H.3.4.7 If specified, NDT of plate surface hardness shall be performed in accordance with the provision of K.6. When the plate mill performs NDT for surface hardness only on the surface that is intended to form the pipe ID, identification of the surface tested shall made.

H.4 Acceptance Criteria

H.4.1 Chemical Composition

H.4.1.3 The manufacturer shall include in the MPS the target heat chemical composition and proposed range for both the heat and product. However, in no case shall the chemical composition be out from the limitations of Table H.1.

H.4.2 Hardness Test

The purchaser should determine if local hard zone (LHZ) cracking is relevant, and if so, define appropriate alternate hardness measurement criteria to mitigate LHZ risk. In these cases, more stringent hardness requirements have been successfully applied.

NOTE 1 ISO 15156-2 provides further guidance to the end user; requirements for the alternative hardness limits for the weld cap in ISO 15156-2 include that the weld cap is not exposed directly to the sour environment.

NOTE 2 The test is performed using the Vickers hardness test or using the Rockwell HR 15N indenter, and, where the latter is used, a conversion of hardness values can be made to Rockwell C scale if required.

NOTE 3 The local hard zone (LHZ) phenomena has initiated through-wall SSC failures in TMCP material compliant with the bulk ≤ 250 HV10 hardness requirement when exposed to certain severe sour service environments (e.g., NACE Region 3 in Figure 1 of ANSI/NACE MR0175/ISO 15156-2:2020); LHZs can be less than 500 μm thick, requiring alternate methods from HV10 to accurately identify.

H.4.3 SSC Test

~~After removal of the SSC test specimens (see H.7.3.2) from the test medium, the specimen surface previously under tension shall be examined under a low-power microscope at X10 magnification. SSC test execution and evaluation shall be in accordance with NACE TM0316-2016.~~ 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 SSC.

H.5 Surface Conditions, Imperfections, and Defects

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 on 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.

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

In severe sour service (region 3 of Figure 1 in NACE MR0175/ISO 15156-2:2020), areas less than 50 mm (in any direction) with identified hardness in excess of the limits stated in a) and b) shall be treated in accordance with C.3 b) or C.3 c).

If specified, NDT of plate surface hardness shall be performed in accordance with the provision of K.6.

When the plate mill performs NDT for surface hardness only on the surface that is intended to form the pipe ID, the surface tested shall be identified.

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

No	Type of Inspection	Type of Pipe	Frequency of Inspection

10	If specified, hard spot inspection by NDT methods	SAWL	Each full plate surface representing the pipe ID
11	If agreed, SSC test on the weld area	SAWL	One test comprising 3 specimens for each pipe provided for manufacturing procedure specification
12	If agreed, SSC test on parent material	SAWL	One tests comprising 3 specimens each at 90° and 180° from the weld for each pipe provided for manufacturing procedure qualification
<p>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.</p>			

H.7.2 Samples and Test Pieces for Mechanical and Technological Tests

H.7.2.3 Samples and Test Pieces for SSC Tests

H.7.2.3.2 Unless agreed otherwise, test pieces for four-point bending SSC tests shall be ≥ 115 mm (4.5 in.) long \times 15 mm (0.59 in.) wide \times 5 mm (0.20 in.) thick. [Sample identification shall be performed on each specimen by an accepted method, as appropriate according to the following.](#)

a) For [weld test pieces on](#) welded pipe, the test piece shall contain the longitudinal or helical seam weld in the middle of the tested area and the test piece shall be oriented transverse to the weld seam (Figure 5 b) and c) Key 1). [Additionally, SAW weld SSC specimens shall be machined square in accordance with Figure H.2 to remove the cap with minimal removal of the HAZ. No more than 0.5 mm shall be removed from the weld toe area.](#)

b) [For SAWL parent material tests on delivery condition M grades subject to severe sour service \(region 3 of Figure 1 in NACE MR0175/ISO 15156-2:2020\), the internal surface of the pipe intended to be exposed to the sour environment shall be left in the as-received condition where possible to account for any potential surface phenomena affecting cracking behavior \(e.g., LHZs\). If the as-received surface of the pipe cannot be retained, any subsequent machining shall be mutually agreed between the manufacturer and the purchaser. Test samples shall comply with the ANSI/NACE MR0175/ISO 15156 part 1 requirements for sampling materials for laboratory testing. Test samples shall be removed from first day production material and in the metallurgical condition that has the greatest susceptibility to cracking in H₂S service.](#)

NOTE [To aid in maintaining the as-received inner surface for SSC testing, longitudinal oriented samples for parent material tests have been used successfully.](#)

c) For seamless pipe, the sample shall be oriented longitudinal to the pipe body (Figure 5 a) Key 1).

~~a)~~d) If agreed, samples may be flattened. Unless otherwise agreed, samples shall be machined from the inside surface of the pipe.

H.7.2.4 Samples for Hardness Tests

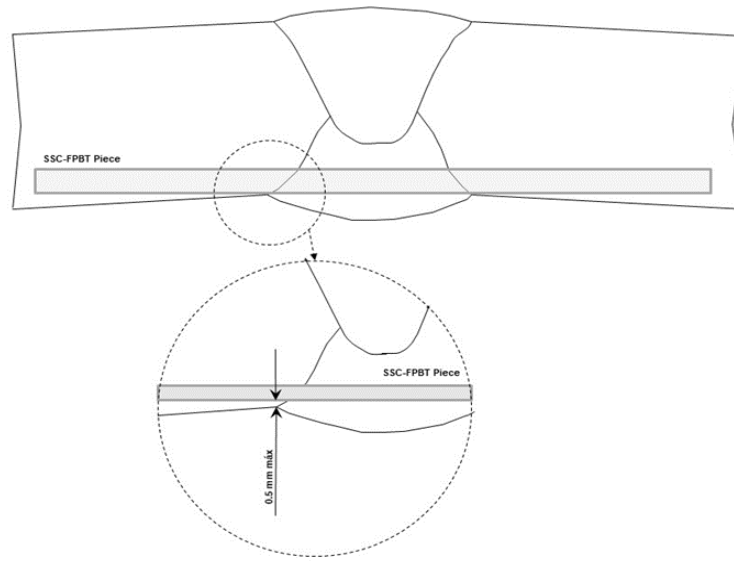


Figure H.2—Sampling Locations of SAW Weld SSC Specimens

H.7.3 Test Methods

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 TM0316](#) and as follows:

- ~~a) the test method solution control shall be in accordance with NACE TM0177 Method C;~~
- ~~b) a) the test piece shall be as defined in either [ISO 7539-2](#), [ASTM G39](#), [NACE TM0316](#) or H.7.2.3.2 of this specification;~~
- ~~e) b) the test solution shall be Solution A as defined in NACE TM0177. [If agreed, for pipe intended for use in the severe sour service region 3 of NACE MR-0175/ISO 15156-2:2020 Figure 1, the test environment \(e.g., solution, backing gas, partial pressures, buffering\) shall be representative of the intended application;](#)~~
- ~~d) c) the test duration shall be 720 hours.~~

Except as allowed by H.7.3.2.2, the test pieces shall be stressed to [a minimum](#) 0.72 times the specified minimum yield strength of the pipe.

NOTE 1 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 prequalified for sour service applications. [For pipe manufactured from TMCP plate material, give special consideration to the potential presence of LHZs and compliance of test samples to ISO 15156-2 as stated in clause d\) above.](#) For further advice on prequalification, refer to ISO 15156-2.

NOTE 2 [Documented testing of pipe manufactured from TMCP plate material has shown cracking resistance is not consistent within the severe sour service region 3 region of NACE MR-0175/ISO 15156-2:2020 Figure 1. It is not known whether this performance variability is limited to TMCP materials, thus give consideration of test environments more severe than Solution A if warranted by the intended exposure.](#)

Annex K (normative)

Non-destructive Inspection for Pipe Ordered for Sour Service, Offshore Service, and/or Service Requiring Longitudinal Plastic Strain Capacity

K.5 Non-destructive Inspection of SAW Pipe

K.5.5 Supplementary Non-destructive Inspection for Sour Service

If agreed, plate produced by the TMCP manufacturing process shall be subject to 100% surface hardness inspection by NDT or alternate method.

K.6 Alternate Supplemental Near Surface Hard Spot Non-destructive Inspection for Sour Service

If specified, the surface of thermo-mechanically rolled plates which is in contact with the sour effluent shall be inspected for the detection of surface hard layers.

K.6.1 Non-destructive Inspection Qualification Requirements

Surface hard layer inspection equipment and procedures shall be subject to pre-production qualification trial that demonstrates ability to detect hard spots. A pre-qualification document can be used in place of a pre-production qualification trial, subject to mutual agreement between manufacturer and purchaser.

K.6.2 Non-destructive Inspection Procedure Requirements

The procedure shall also address the following:

- a) Definition of blind zones;
- b) Inspection of blind zones in a grid pattern, or cropping of blind zones
- c) Grid dimensions
- d) Acceptance threshold and method of confirmation; and
- e) Method for removal of hard spots and reconfirmation of acceptability of affected plates.

K.6.3 Plate-to-Pipe Hardness Considerations

A hardness increase due to cold forming and ageing, if applicable, shall be considered. This hardness increase shall be documented by the manufacturer and used to define the plate maximum acceptable hardness value. This surface hardness value measured on the pipe surface shall not exceed 250 HV0.5, when measured either on the actual pipe surface or within 0.5 mm of the surface.

NOTE Qualification trial have shown the benefit of including a statistical analysis of the frequency of hard spot occurrence and the NDE capability to detect it. Qualification of an NDE techniques have shown capability to ensure 100 percent of delivered thermo-mechanically controlled process (TMCP) steel plate is free of hard spots. Qualification of such a technique may vary and thus metallurgical and NDT specialists should be involved in this process.
