Defining Hydrogen-induced Cracking Test Criteria for Commodity-grade Line Pipe in Less Severe Sour Conditions

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Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue NW, Suite 1100, Washington, DC 20001, standards@api.org.

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Introduction

The API Subcommittee on Tubular Goods decided to have work performed to support the development of a moderate sour service commodity grade under API Specification 5L:2018 Annex H. The project aimed at defining HIC test conditions and exposure duration needed to assess the suitability of commodity-grade line pipe under less severe sour conditions compared with standard testing. The impact of varying test durations on the extent of hydrogen-induced cracking was assessed by using two sweet service submerged-arc longitudinally welded (SAWL) pipes of Grades X65 and X70 of different susceptibility to hydrogen-induced cracking. The test program consisted of 13 HIC test batches representing less severe sour test environments containing 1 %−10 % H_2S with pH between 3.5−4.5. Specimen preparation, exposure, ultrasonic testing (UT) and metallographic evaluation was performed in accordance with NACE TM0284:2016.

For all sour test environments and exposure durations between 4−14 days, the X70 Pipe B showed significant hydrogen-induced cracking, whereas the X65 Pipe A gave less HIC indications in terms of crack area ratios (CAR) obtained by UT and crack length ratios (CLR) obtained by metallographic evaluation.

With the clear benefit of shorter test duration in mind, the project focused on the question of whether hydrogen-induced cracking can stabilize earlier in HIC tests shorter than the 14 days specified in NACE TM0284:2016 and to what extent choice of solution pH and H_2S content could contribute to achieve this objective. Within the observed scatter, HIC tests conducted in solutions of higher acidity gave a tendency of higher levels of hydrogen-induced cracking at shorter exposure times than observed for exposure under lower acidity (higher pH) test conditions. Hydrogen-induced cracking did not, however, stabilize during exposure durations shorter than 14 days in those less severe sour test environments.

API Specification 5CT:2023 (NACE TM0177 Solution D) gave unexpectedly high cracking after four days exposure. Experience with this solution in HIC testing is limited. More work is needed before considering this solution, developed for SSC-DCB testing, as a standardized HIC test environment.

Considering the increase in hydrogen-induced cracking with longer test duration as an important result of this project, HIC test durations shorter than 14 days in the considered range of less severe sour test environments are not recommended.

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1 Scope

The work described herein is to support the development of a moderate sour service commodity grade under API Specification 5L:2018 Annex H, while maintaining harmonization with ISO 15156-1 and NACE TM0284:2016 as regards resistance testing to hydrogen-induced cracking (HIC).

To define the HIC test conditions and exposure duration needed for that purpose, the impact of varying test durations on the extent of cracking in less severe sour test environments was specifically assessed in solutions containing 1 %−10 % H_2S within pH values 3.5−4.5.

For the series of HIC tests conducted, sweet service test material from two different pipes was used, which showed different susceptibility to cracking in moderate sour conditions.

2 Normative References

There are no normative references in this document.

3 Terms, Definitions, Abbreviations, and Symbols

3.1 Terms and Definitions

There are no defined terms in this document.

3.2 Abbreviations

CAR	crack area ratio
CLR	crack length ratio
CSR	crack sensitivity ratio
CTR	crack thickness ratio
DCB	double cantilever beam
EPRG	European Pipeline Research Group
FSH	full screen height
HIC	hydrogen-induced cracking
OCTG	oil country tubular goods
SAWL	submerged-arc longitudinally welded
SOHIC	stress-oriented hydrogen-induced cracking
SSC	sulfide stress cracking
UT	ultrasonic testing

3.3 Symbols

Al_2O_3	alumina
CO_2	carbon dioxide gas
H_2S	hydrogen sulfide gas