

REPORT No 11989

Date of issue: August 14, 2026

Status: FiNAL REPORT

NACE TM 0284

EVALUATION OF PIPELINE AND PRESSURE VESSEL STEELS FOR RESISTANCE TO HYDROGEN-INDUCED CRACKING

Program: SQO-M4 (Round 18)

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1. FOREWORD

This report summarizes the results of the **SQO-M4 (Round 18)** proficiency testing program on the evaluation of the resistance of pressure vessel plate steels to HIC caused by hydrogen absorption from aqueous sulfide corrosion. This program is carried out under a simultaneous participation format, as described in clause A.2.2 of ISO/IEC 17043: 2023 (Types of PT schemes).

South Quality conducted the testing program in June/July 2026. The aim of the program was to assess laboratory ability to competently perform the nominated tests.

2. ORGANIZATION

Program Coordinator:	Eng. Alfredo Schmidt
Assistant Technician:	Sergio Andrada
Statistics:	Lic. Manuel Tozaki
Supervision:	Eng. Emiliano Medina

3. OBJECTIVE

The objective of this proficiency testing program is to evaluate the resistance of pressure vessel plate steels to HIC caused by hydrogen absorption from aqueous sulfide corrosion, using the following standard:

Standard
ANSI/NACE TM0284: 2016

Batches of steel samples have been selected.

Participants in this program have not been previously informed of the values or the expected range of values for the samples they will receive.

4. PARTICIPANTS

In the present round, 20 laboratories have participated with the following details:

CODE	Country	ISO 17025 Accredited	Results delivered
01	France	Yes	Yes
02	Hong Kong	Yes	No
03	Germany	Yes	Yes
04	Brazil	Yes	Yes
05	Pakistan	Yes	Yes
06	Italy	No	Yes
07	England	Yes	Yes
08	South Africa	No	Yes
09	Spain	Yes	Yes
10	Australia	Yes	No
11	USA	Yes	Yes
12	France	Yes	Yes
13	Brazil	Yes	No
14	Germany	Yes	Yes
15	Germany	No	Yes
16	Argentina	No	Yes
17	Mexico	Yes	Yes
18	Italy	Yes	Yes
19	Japan	Yes	Yes
20	Spain	Yes	Yes

5. HOMOGENEITY

Several batches were prepared identically by South Quality staff.

Subsequently, a homogeneity study was conducted with an ISO 17025 accredited laboratory.

The control process followed ISO 33405: 2024, clauses 7.4.1.1 / 7.4.1.2. Stratified random sampling was applied, and the samples were selected using random-number-generation software.

The results of these tests are presented below:

Size of each batch: **150 samples**

Tested samples from each batch: **30 samples**

DETERMINATION (SOLUTION A)	HOMOGENEITY OF RESULTS IN THE ANALYZED SAMPLES - LOW CARBON STEEL -		
	BATCH: LM3954	BATCH: LM3955	BATCH: LM3956
CSR	YES	YES	YES
CLR	YES	YES	YES
CTR	YES	YES	YES

Size of each batch: **150 samples**

Tested samples from each batch: **30 samples**

DETERMINATION (SOLUTION B)	HOMOGENEITY OF RESULTS IN THE ANALYZED SAMPLES - STAINLESS STEEL -		
	BATCH: LM4127	BATCH: LM4128	BATCH: LM4129
CSR	YES	NO	YES
CLR	YES	NO	YES
CTR	YES	NO	YES

Samples for this program are taken from selected batches identified as **LM3955** and **LM4129**.

The analysis of the test data indicated that the selected samples exhibited sufficient homogeneity for the program. Therefore, the results of participants identified as outliers cannot be attributed to sample variability.

6. SAMPLE INFORMATION

The following samples were sent for testing (Participant **Code 19**):

Batch:	LM3955
Sample ID:	28 + 70 + 131
Characteristics:	Carbon steel (SAE 1010) - 100 x 19 x 9 mm

Batch:	LM4129
Sample ID:	35 + 86 + 142
Characteristics:	Stainless steel (AISI 304) - 100 x 19 x 9.5 mm

7. IMAGES



8. ASSIGNED VALUES

The assigned values are obtained from the results reported by all participants (**Consensus values**).

9. PARTICIPANTS' RESULTS

LABORATORY CODE	LM3955			LM4129		
	MEAN			MEAN		
	CSR	CLR	CTR	CSR	CLR	CTR
01	1.6	9.9	8.1	0	0	0
03	0.8	11.4	8.1	0	0	0
04	1.3	11.3	8.2	0	0	0
05	0.6	6.8	17.4	0	0.02	0.06
06	1.3	12.0	9.2	0	0	0
07	1.1	11.0	8.2	0	0	0
08	0.5	11.4	6.6	0	0	0
09	0.3	8.8	7.1	0	0	0
11	0.8	8.6	8.2	0	0	0
12	1.1	8.7	5.8	0	0	0
14	1.0	11.1	7.7	0	0	0
15	1.3	8.1	7.2	0	0	0
16	1.6	7.4	8.2	0	0	0
17	1.0	6.9	6.3	0	0	0
18	0.8	10.0	8.5	0	0	0
19	0.9	12.0	8.0	0	0	0
20	0.1	10.5	8.2	0	0	0

ASSIGNED VALUES				
PARAMETER	LM3955		LM4129	
	AVG	SD	AVG	SD
CSR	0.947	0.419	0	-
CLR	9.759	1.775	0	-
CTR	7.725	0.892	0	-

10. STATISTICS

The results must be treated as qualitative as quantitative.

According to B.4.1.3 of ISO 17043 the appropriate technique is to compare participant results with the assigned values.

- a) For qualitative results (Values equal to zero), the comparison will be made directly against the assigned value, and any difference will be evaluated as **Unsatisfactory**.
- b) For quantitative results the comparison will be made through **z score** :

$$z = \frac{x - X}{\hat{\sigma}}$$

x is the participant's result

X is the assigned value

$\hat{\sigma}$ is the standard deviation

The performance evaluation of each sample is carried out with the following criteria:

$|z| \leq 2.0$ indicates "satisfactory" performance and generates no signal;

$2.0 < |z| < 3.0$ indicates "questionable" performance and generates a warning signal;

$|z| \geq 3.0$ indicates "unsatisfactory" performance and generates an action signal;

11. EVALUATION OF PERFORMANCE

LABORATORY CODE	z score - BATCH: LM3955		
	CSR	CLR	CTR
01	1.56	0.08	0.42
03	0.35	0.92	0.42
04	0.84	0.87	0.53
05	0.83	1.67	10.85
06	0.84	1.26	1.65
07	0.37	0.70	0.53
08	1.07	0.92	1.26
09	1.54	0.54	0.70
11	0.35	0.65	0.53
12	0.37	0.60	2.16
14	0.13	0.76	0.03
15	0.84	0.93	0.59
16	1.56	1.33	0.53
17	0.13	1.61	1.60
18	0.35	0.14	0.87
19	0.11	1.26	0.31
20	2.02	0.42	0.53

Laboratory Code 01: The laboratory obtained **SATISFACTORY** results for the determination of all assigned values in both samples.

Laboratory Code 02: The laboratory did not submit the results before the deadline.

Laboratory Code 03: The laboratory obtained **SATISFACTORY** results for the determination of all assigned values in both samples.

Laboratory Code 04: The laboratory obtained **SATISFACTORY** results for the determination of all assigned values in both samples.

Laboratory Code 05: The laboratory obtained **UNSATISFACTORY** results for the determination of the **CTR** parameter in the sample from batch **LM3955**, and for the **CLR** and **CTR** parameters in the sample from batch **LM4129**. However, **SATISFACTORY** results were obtained for all other parameters in both samples.

Laboratory Code 06: The laboratory obtained **SATISFACTORY** results for the determination of all assigned values in both samples.

Laboratory Code 07: The laboratory obtained **SATISFACTORY** results for the determination of all assigned values in both samples.

Laboratory Code 08: The laboratory obtained **SATISFACTORY** results for the determination of all assigned values in both samples.

Laboratory Code 09: The laboratory obtained **SATISFACTORY** results for the determination of all assigned values in both samples.

Laboratory Code 10: The laboratory did not submit the results before the deadline.

Laboratory Code 11: The laboratory obtained **SATISFACTORY** results for the determination of all assigned values in both samples.

Laboratory Code 12: The laboratory obtained a **QUESTIONABLE** result for the determination of the **CTR** parameter in the sample from batch **LM3955**. However, **SATISFACTORY** results were obtained for all other parameters in both samples.

Laboratory Code 13: The laboratory did not submit the results before the deadline.

Laboratory Code 14: The laboratory obtained **SATISFACTORY** results for the determination of all assigned values in both samples.

Laboratory Code 15: The laboratory obtained **SATISFACTORY** results for the determination of all assigned values in both samples.

Laboratory Code 16: The laboratory obtained **SATISFACTORY** results for the determination of all assigned values in both samples.

Laboratory Code 17: The laboratory obtained **SATISFACTORY** results for the determination of all assigned values in both samples.

Laboratory Code 18: The laboratory obtained **SATISFACTORY** results for the determination of all assigned values in both samples.

Laboratory Code 19: The laboratory obtained **SATISFACTORY** results for the determination of all assigned values in both samples.

Laboratory Code 20: The laboratory obtained a **QUESTIONABLE** result for the determination of the **CSR** parameter in the sample from batch **LM3955**. However, **SATISFACTORY** results were obtained for all other parameters in both samples.

GLOBAL PERFORMANCE - SUM OF ABSOLUTE Z SCORE

POSITION	LABORATORY CODE	z SCORE
1 st	14	0.91
2 nd	18	1.36
3 rd	11	1.54
4 th	07	1.60
5 th	19	1.68
6 th	03	1.70
7 th	01	2.06
8 th	04	2.24
9 th	15	2.37
10 th	09	2.79
11 th	20	2.97
12 th	12	3.12
13 th	08	3.25
14 th	17	3.33
15 th	16	3.42
16 th	06	3.76
17 th	05	13.34

12. CONCLUSIONS

The overall performance in the **SQO-M4 (Round 18)** program, based on expected results from the participating laboratories, was as follows:

- Laboratories Codes **01, 03, 04, 06, 07, 08, 09, 11, 14, 15, 16, 17, 18, and 19** have obtained a **SUFFICIENT** performance according to the expected results and should not take action;
- Laboratories Codes **12, and 20** have obtained an **ALMOST SUFFICIENT** performance according to the expected results and must evaluate if it is necessary to take corrective action.
- Laboratory Code **05** has obtained an **INSUFFICIENT** performance according to the expected results and must take corrective action (See Appendix B).

The criteria used for the evaluation of the overall performance are the following:

- **SUFFICIENT** performance: No unsatisfactory/questionable results obtained.
- **ALMOST SUFFICIENT** performance: No unsatisfactory results were obtained, but one questionable result was found.
- **INSUFFICIENT** performance: An unsatisfactory result or two questionable results were obtained.

APPENDIX A

A1 - PARTICIPANT DATA

Company: **NIPPON STEEL TECHNOLOGY Co. Ltd.**

Country: Japan

Client ID: S367

Contact person: Hinano Fukuda
Technical Manager
fukuda.4n4.hinano@jp.nipponsteel.com

A2 - PARTICIPANT RESULTS

 **SOUTH
QUALITY**
PROFICIENCY TESTING PROVIDER

INSTRUCTIONS & RESULTS FORM

PROGRAM:	Evaluation of pipeline and pressure vessel steels for resistance to hydrogen-induced cracking
CODE:	SQO-M4
ROUND:	18
STANDARD:	NACE TM 0284
COORDINATOR:	Eng. Alfredo Schmidt (aschmidt@ptsouthquality.com)

DSQ-012 - REV 06 - SQO-M4 R18 June 2026 1 de 5

1 - General

This document is intended to be filled with the results of the **SQO-M4 (Round 18)** program.

Results must be typed, not handwritten.

2 - Standard

ANSI/NACE TM0284: 2016

3 - Participant

NIPPON STEEL TECHNOLOGY Co. Ltd.	CODE 19
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4 - Tests involved

TEST
Evaluation of the resistance of pressure vessel plate steels to HIC caused by hydrogen absorption from aqueous sulfide corrosion

5 - Samples

CODE	SAMPLE	QUANTITY
LM3955-XX	Steel - 100 x 19 x 9 mm	3
LM4129-XX	Steel - 100 x 19 x 9.5 mm	3

6 - Notes

- The deadline for the delivery of results is **July 17, 2026**.
- Tables in this document may be modified to include additional data or observations.
- The samples must be kept until the end of the program, which concludes with the submission of the final report.
- Participants may improve the surface to ensure a better testing area. If so, the procedure must be described in the observations box.
- Samples **LM3955** are to be tested using **solution A**.
- Samples **LM4129** are to be tested using **solution B**.
- The samples are to be handled as routine lab samples, with all testing, documentation, and reporting adhering to ANSI/NACE TM0284.
- To review the results, the submission of images of the tests is appreciated. These images can be attached at the end of this document or sent via email.
- Upon completion of this document, please convert it to a PDF file and send it to the program coordinator.

7 - Test results

Test date:	July 11, 2026	Solution:	A
Sample preparation:	Grinding ☒	Test duration:	July 4-8, 2026
	Sawing ☐	pH at start of test:	3.3
	Machining ☒	pH at end of test:	3.8
Polished grade:	# 320	Solution temperature:	25 °C
Method of testing of adequacy degreasing:	Atomizer test in accordance with ASTM F21	H ₂ S concentration (mg/L):	Start: 2352, End: 2505
		Purged inert gas:	N ₂

SAMPLE	DIMENSIONS (mm)		
	LENGTH	WIDE	THICKNESS
LM3955-28	99.3	16.5	8.1
LM3955-70	99.3	16.5	8.1
LM3955-131	99.0	16.5	8.1

SAMPLE	SECTION	RESULTS (%)		
		CSR	CLR	CTR
LM3955-28	I	0	1.0	0
	II	0	5.8	2.2
	III	0.7	9.4	9.9
LM3955-70	I	3.7	30.1	19.1
	II	0.2	8.0	8.0
	III	0.1	5.3	2.8
LM3955-131	I	3.3	42.6	30.0
	II	0	3.5	0
	III	0	2.4	0
MEAN		0.9	12.0	8.0

OBSERVATIONS
d) Surface improvement procedure : The four sides of the specimen were machined on a milling machine to remove the curved surfaces and obtain flat surfaces. The specimen was then ground on a surface grinder to achieve the final surface finish.

Test date:	July 11, 2026	Solution:	B
Sample preparation:	Grinding ☒	Test duration:	July 4-8, 2026
	Sawing ☐	pH at start of test:	5.1
	Machining ☒	pH at end of test:	5.1
Polished grade:	# 320	Solution temperature:	26 °C
Method of testing of adequacy degreasing:	Atomizer test in accordance with ASTM F21	H ₂ S concentration (mg/L):	Start: 2675, End: 2914
		Purged inert gas:	N ₂

SAMPLE	DIMENSIONS (mm)		
	LENGTH	WIDE	THICKNESS
LM4129-35	100.6	16.8	8.8
LM4129-86	100.3	16.8	8.8
LM4129-142	100.1	16.8	8.8

SAMPLE	SECTION	RESULTS (%)		
		CSR	CLR	CTR
LM4129-35	I	0	0	0
	II	0	0	0
	III	0	0	0
LM4129-86	I	0	0	0
	II	0	0	0
	III	0	0	0
LM4129-142	I	0	0	0
	II	0	0	0
	III	0	0	0
MEAN		0	0	0

OBSERVATIONS
d) Surface improvement procedure : The four sides of the specimen were machined on a milling machine to remove the curved surfaces and obtain flat surfaces. The specimen was then ground on a surface grinder to achieve the final surface finish.

PHOTOGRAPHS

I will attach the photos separately. The file names of the photos include the sample number, section number, and respective sub-number.

APPENDIX B

VOID

----- END OF REPORT -----