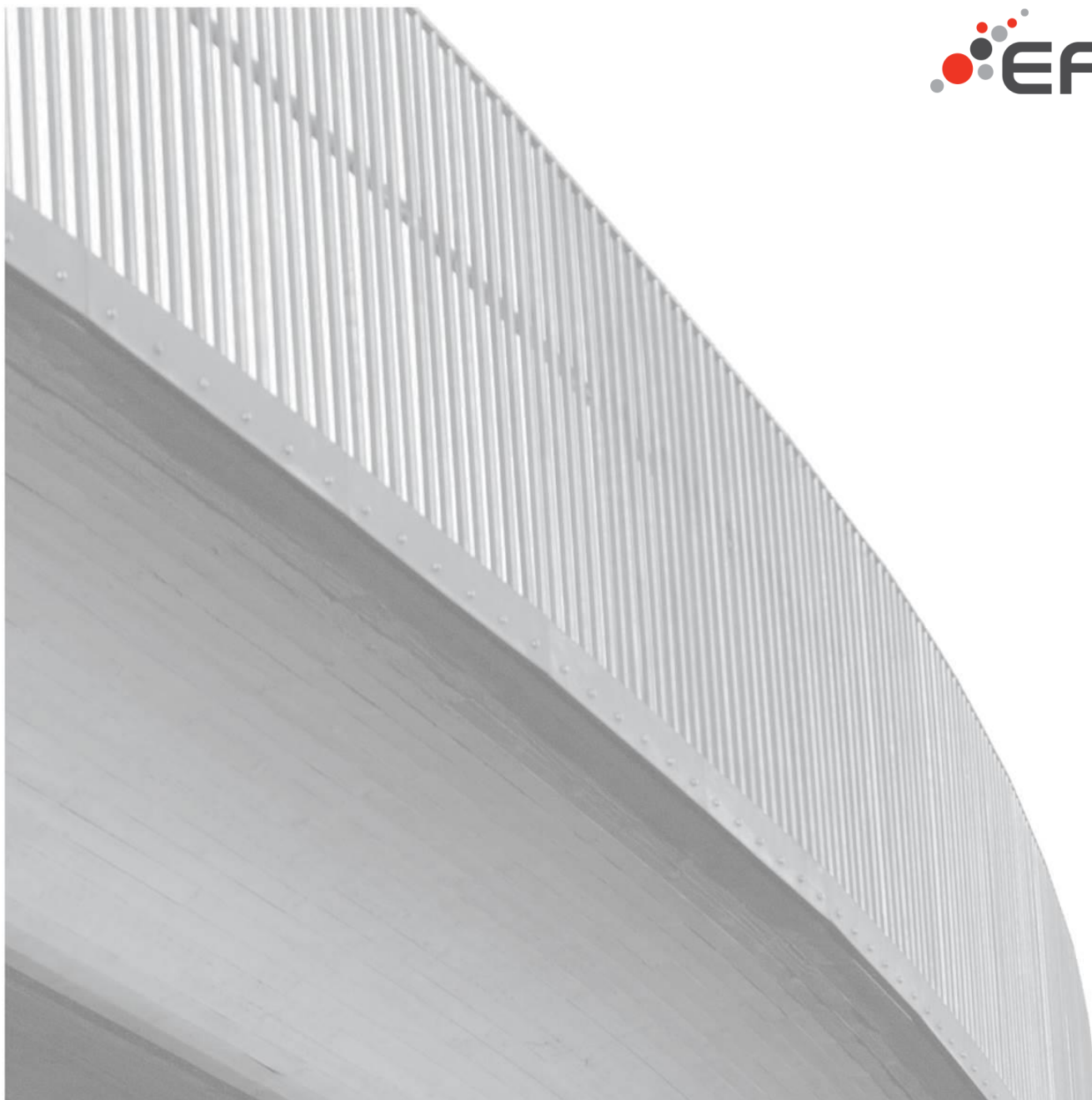
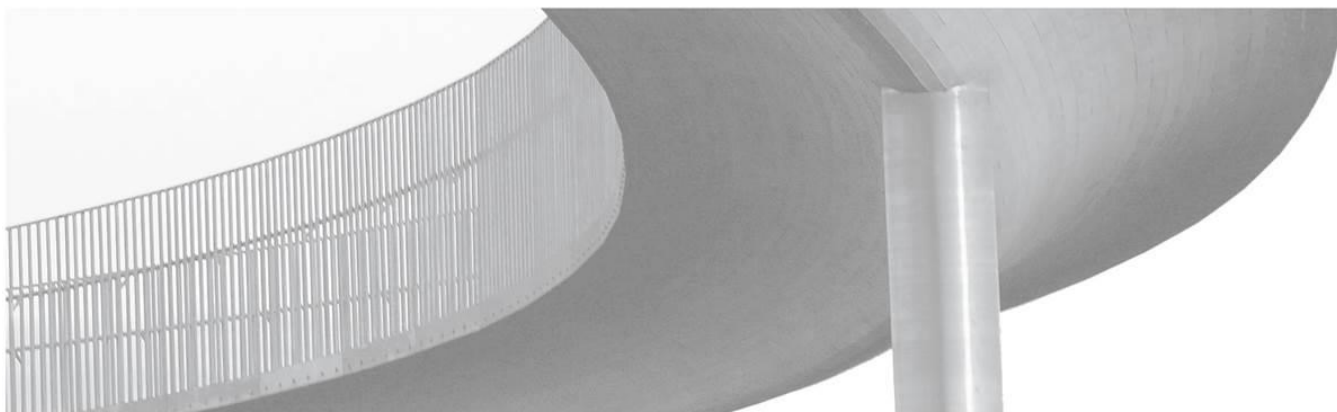




TÆRING Á RYÐFRÍU STÁLI Í ÍSLENSKU SJÁVARUMHVERFI

Áfangaskýrsla 4, niðurstöður eftir fjögur ár

02.06.2026



SKÝRSLA – UPPLÝSINGABLAÐ

SKJALALYKILL

2970-247-SKY-009-V01

SKÝRSLUNÚMÉR / SÍÐUFJÖLDI

2970-247-SKY-009/ 18

VERKEFNISSTJÓRI / FULLTRÚI VERKKAUÐA

Ólafur Sveinn Haraldsson

VERKEFNISSTJÓRI EFLA

Baldvin Einarsson

LYKILORÐ

Ryðfrítt stál, tæring

STAÐA SKÝRSLU

- ☐ Drög
☐ Drög til yfirlstrar
☒ Lokið

DREIFING

- ☐ Opin
☒ Dreifing með leyfi verkkaupa
☐ Trúnaðarmál

TITILL SKÝRSLU

Tæring á ryðfríu stáli í íslensku sjávarumhverfi

VERKHEITI

Tæring á ryðfríu stáli

VERKKAUÐI

Rannsóknarsjóður Vegagerðarinnar

HÖFUNDUR

Baldvin Einarsson

ÚTDRÁTTUR

Birtar eru niðurstöður á tæringu á fimm tegundum af ryðfríu stáli eftir fjögurra ára veðrun á Kársnesi í Kópavogi og við Veðurstofu Íslands í Reykjavík.

Þessi skýrsla er framhald af skýrslum síðustu þriggja ára þar sem birtar eru niðurstöður rannsóknarinnar eftir eitt, tvö og þrjú ár. Um framkvæmd rannsóknarinnar er vísað í fyrri skýrslur.

Allnokkur pittamyndun og litabrigði komu fram á einni stáltegund, 1.4404 (AISI 316L). Sýni úr því stáli hafa fallið um einn flokk milli ára. Engin tæring hefur ennþá komið fram á öðrum sýnum úr ryðfríu stáli.

ÚTGÁFUSAGA

NR.	HÖFUNDUR	DAGS.	RÝNT	DAGS.	SAMÞYKKT	DAGS.
01	Baldvin Einarsson	2.6.26	Vigdís Bjarnadóttir	2.6.26	Baldvin Einarsson	2.6.26
	Lýsing					

SAMANTEKT

Vorið 2022 voru sett upp sýni úr ryðfríu stáli í tvo tæringarrekkka. Annar þeirra er staðsettur á fyllingu utarlega á Kársnesi í Kópavogi þar sem ráðgert er að byggja brú, Fossvogsbrú, yfir til Reykjavíkur. Hinn tæringarrekkinn er staðsettur við aðsetur Veðurstofu Íslands á Háaleiti í Reykjavík.

Sýnin eru úr fimm mismunandi tegundum af ryðfríu stáli og af einni tegund eru tvö sýni með mismunandi yfirborðáferð, á allt því sex sýni. Stálsýnin voru fengin hjá stálframleiðanda, Outocumpu í Svíþjóð. Flest sýni eru af Duplex stáli en eitt sýni er úr stáli 1.4404 (AISI 316L) sem er algengt stál til nota utandyra hér á landi.

Í hvorum tæringarrekkka voru sett upp tvö sýni af hverri tegund. Annað sýnið er óvarið, þ.e.a.s. undir beru lofti en hitt sýnið er í skjóli í hálflokuðum kassa. Tilgangurinn með þessu fyrirkomulagi er að finna mun á tæringu á stálinu þar sem regn skolar óhreinindum af yfirborðinu annars vegar og hins vegar þar sem skjól er fyrir regni og óhreinindi safnast fyrir.

Í þessari Áfangaskýrslu 4 eru niðurstöður mælinga á tæringu eftir fjögur ár lagðar fram. Niðurstöður eftir eitt, tvö og þrjú ár voru lagðar fram í Áfangaskýrslum 1, 2 og 3.

Eftir fjögurra ára tæringu í tæringarrekkka eru helstu niðurstöður þessar:

- Nokkrar breytingar á tæringu og litabrigðum reyndust á sýnum frá fyrra ári. Stál 1.4404 hefur fallið um einn flokk frá fyrra ári.
- Fram kom munur á tæringu og litbrigðum á stáli 1.4404 á milli mælistaða þar sem meiri tæring var á Kársnesi en við Veðurstofuna.
- Það eru komnar vísbendingar af pittatæringu í stáli 1.4404 eftir fjögur ár.
- Fyrir stál 1.4404 þá er einnig kominn marktækur munur á tæringu/litabrigðum á óvörðu stáli og stáli í skjóli. Það á líka við um önnur sýni þó í litlum mæli sé.
- Allt annað stál en 1.4404 sýndi engin merki um tæringu eða og lítil merki um litabrigði.

Eftir mælingu og skoðun voru sýnin sett aftur upp í tæringarrekkana og standa vonir til að frekari niðurstöður fáiist um tæringu á ryðfríu stáli á komandi árum.

Skýrslan er skrifuð á ensku þar sem stálframleiðandinn, Outocumpu, sem lagði til stálsýnin okkur að kostnaðarlausu óskaði eftir því að fá mæliniðurstöðurnar. Þykir sjálfsagt að verða við því.

Höfundar skýrslunnar bera ábyrgð á innihaldi hennar. Niðurstöður hennar ber ekki að túlka sem yfirlýsta stefnu Vegagerðarinnar eða álit þeirra stofnana eða fyrirtækja sem höfundar starfa hjá.

EFNISYFIRLIT

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TÖFLUSKRÁ	ERROR! BOOKMARK NOT DEFINED.
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1 INTRODUCTION

In a previous memo (2970-440-MIN-005-V01) from Desember 2023 the results of corrosion tests on stainless steels at two test sites were reported after one year of exposure. In the Memo the following characteristics of the test sites were also reported:

- The locations of the test sites
- Map showing the location
- Clima characteristics for the IMO Reykjavík test station
- Corrosion category of test sites in Iceland

Tests og constructions steel at the same test sites indicated that the Corrosion category of the test sites was C3 for Kársnes and C2 for the IMO site.

The test rack was moved last year to a new location 150 m to the west from the previous location at Kársnes. The construction of a new bridge, The Fossvogur bridge, started at the beginning of the year 2026 and is expected to contiuue for over two years. It is still hoped that the test samples can be monitored for several more years at the site.

The stainless steel samples were, after inspection, remounted in the test racks. After one more year of exposure (May 2026) they were inspected and photographed. The results are reported in this memo.

Overview of the stainless steel samples is in table 1.

TAFLA 1 Samples at test sites.

ID	EN TYPE	OUTOKUMPU NAME	SURFACE	NO.	PREN	NOTES
A	1.4404	Supra 316L/4404	1E	4	24	Commonly used outdoors in Iceland
B	1.4362	Forta EDX 2304	2E	4	28	Steel in bridge columns in Reykjavík
C	1.4662	Forta LDX 2404	2E	4	34	
D	1.4462	Forta DX 2205	2E	4	35	Common Duplex steel
E	1.4462	Forta DX 2205	2E Brushed	4	35	Same steel, different surface
F	1.4410	Forta SDX 2507	2E	4	43	Duplex stál in highest CRC

The samples were originally mounted on 20.5.2022 and retrieved on 24.5.2023 after one year and 4 days exposure. After two years the samples were retrieved on 22.5.2024 and remounted on 5.6.2024.

After three years the samples were retrieved 12.5.2025 and remounted on 9.6.2025. After four years the samples were retrieved 20.5.2026 and remounted on 1.6.2026.

2 RESULTS AFTER FOUR YEARS EXPOSURE

2.1 Stainless steel samples

The stainless steel samples were evaluated by two independent observers and the rating is shown in table 2 for the Kársnes site and table 3 for the Reykjavík IMO site. The rating is according to draft ISO International Standard ISO/DIS 23721:2021¹ which is under review and comment.

Each of the specimens were rated by comparing the surface to a photographic standard with 10 different stages of rust from 0% to 100%. Each of these photos is assigned a rating number (RN) from 0 to 9. RN0 corresponds to when the total area of rust and stains cover almost 100% of the sample and RN9 corresponds to when rust and stains cover less than 0,01%. Where the rating of the two persons were not identical and an average could not be calculated, the rating numbers of both individuals are indicated such RN9/8 in the table below.

¹ ISO/DIS 23721:2021: Corrosion of metals and alloys – Rating method by appearance of rust and stains of atmospheric corrosion for stainless steels.

TAFLA 2 Kársnes. Test results after four years exposure.

Stainless steel grade	Type of specimens	Surface finish	Result after 4 years					
			Open condition			Sheltered condition		
			Sample ID	Corrosion performance	Appearance rating	Sample ID	Corrosion performance	Appearance rating
1.4404 Supra 316L	Plate	1E	A1f	Some pits forming More staining	RN6/5	A3f	Some pits forming Extended staining	RN5/3
		1E	A1b	Corrosion spot Minor staining	RN6/6	A3b	Some pits forming Extended staining	RN5/3
1.4362 Forta EDX 2304	Plate	2E	B1f	No corrosion No staining	RN9/8	B3f	No corrosion Minor staining	RN8/6
		2E	B1b	No corrosion No staining	RN9	B3b	No corrosion No staining	RN9/8
1.4662 Forta LDX 2404	Plate	2E	C1f	No corrosion No staining	RN9/9	C3f	No corrosion No staining	RN8/7
		2E	C1b	No corrosion No staining	RN9	C3b	No corrosion No staining	RN9/8
1.4462 Forta DX 2205	Plate	2E	D1f	No corrosion No staining	RN9	D3f	No corrosion No staining	RN8/7
		2E	D1b	No corrosion No staining	RN9	D3b	No corrosion No staining	RN9/9
1.4462 Forta DX 2205	Plate	2E br.	E1f	No corrosion No staining	RN9	E3f	No corrosion No staining	RN8/8
		2E br.	E1b	No corrosion No staining	RN9	E3b	No corrosion No staining	RN9/9
1.4410 Forta SDX 2507	Plate	2E	F1f	No corrosion No staining	RN9	F3f	No corrosion No staining	RN8/8
		2E	F1b	No corrosion No staining	RN9	F3b	No corrosion No staining	RN8/8

Note: Axf = front side of plate, Axb = back side of plate. Green cell = no corrosion (pitting) was observed, Red cell = corrosion was observed, * = Possibly some small pits. RN9/8 = results of two independent assessments.



A1 (1)



A1 (2)



A3 (1)



A3 (2)



B1 (1)



B1 (2)



B3 (1)



B3 (2)



C1 (1)



C1 (2)



C3 (1)



C3 (2)



D1 (1)



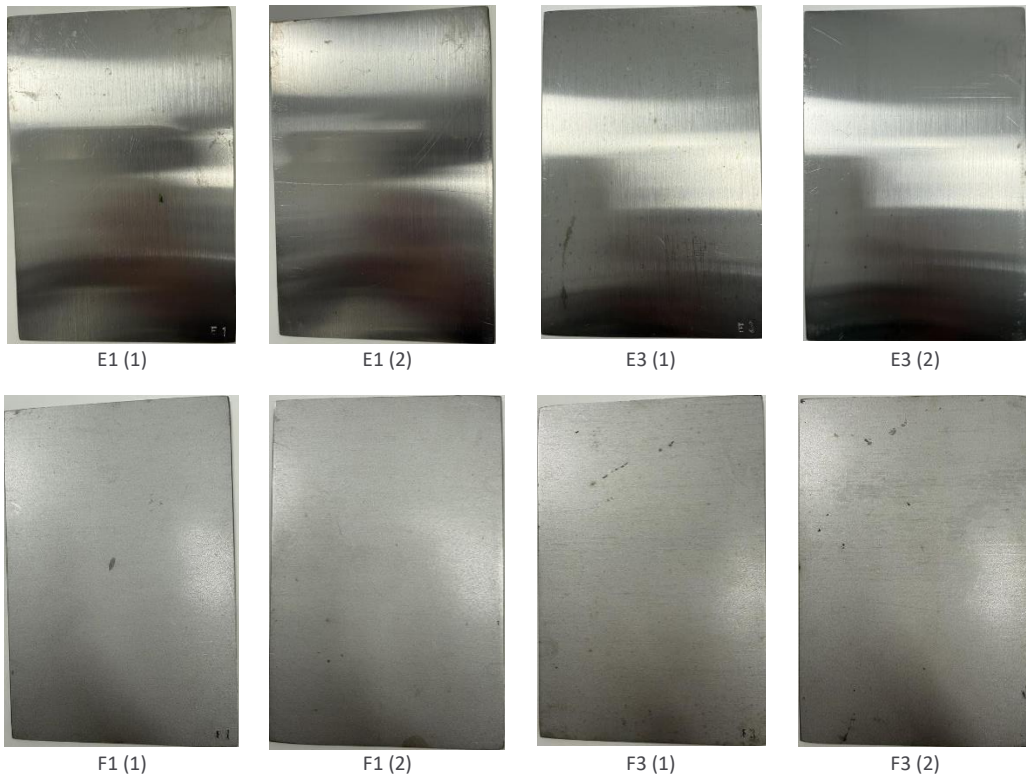
D1 (2)



D3 (1)



D3 (2)



MYND 1 Kársnes, the appearance of plate specimens after 4 years of exposure. Left: open condition, right: sheltered condition. (1) refers to front of specimen, (2) refers to back side of specimen.

TAFLA 3 Reykjavík IMO. Test results after four years exposure.

Stainless steel grade	Type of specimens	Surface finish	Result after 4 years					
			Open condition			Sheltered condition		
			Sample ID	Corrosion performance	Appearance rating	Sample ID	Corrosion performance	Appearance rating
1.4404 Supra 316L	Plate	1E	A2f	No corrosion* Minor staining	RN7/7	A4f	No corrosion* Staining	RN7/4
		1E	A2b	No corrosion* Minor Staining	RN7/6	A4b	No corrosion* More staining	RN6/4
1.4362 Forta EDX 2304	Plate	2E	B2f	No corrosion No staining	RN9	B4f	No corrosion No staining	RN9/8
		2E	B2b	No corrosion No staining	RN9	B4b	No corrosion No staining	RN9/9
1.4662 Forta LDX 2404	Plate	2E	C2f	No corrosion No staining	RN9/9	C4f	No corrosion No staining	RN9/8
		2E	C2b	No corrosion No staining	RN8/9	C4b	No corrosion No staining	RN9/8
1.4462 Forta DX 2205	Plate	2E	D2f	No corrosion No staining	RN9	D4f	No corrosion No staining	RN9
		2E	D2b	No corrosion No staining	RN9	D4b	No corrosion No staining	RN9
1.4462 Forta DX 2205	Plate	2E br.	E2f	No corrosion No staining	RN9	E4f	No corrosion No staining	RN9
		2E br.	E2b	No corrosion No staining	RN9	E4b	No corrosion No staining	RN9
1.4410 Forta SDX 2507	Plate	2E	F2f	No corrosion No staining	RN9	F4f	No corrosion No staining	RN9
		2E	F2b	No corrosion No staining	RN9	F4b	No corrosion No staining	RN9

Note: Axf = front side of plate, Axb = back side of plate. Green cell = no corrosion (pitting) was observed, Red cell = corrosion was observed, * = Possibly some small pits.



A2 (1)



A2 (2)



A4 (1)



A4 (2)



B2 (1)



B2 (2)



B4 (1)



B4 (2)



C2 (1)



C2 (2)



C4 (1)



C4 (2)



D2 (1)



D2 (2)



D4 (1)



D4 (2)



E2 (1)



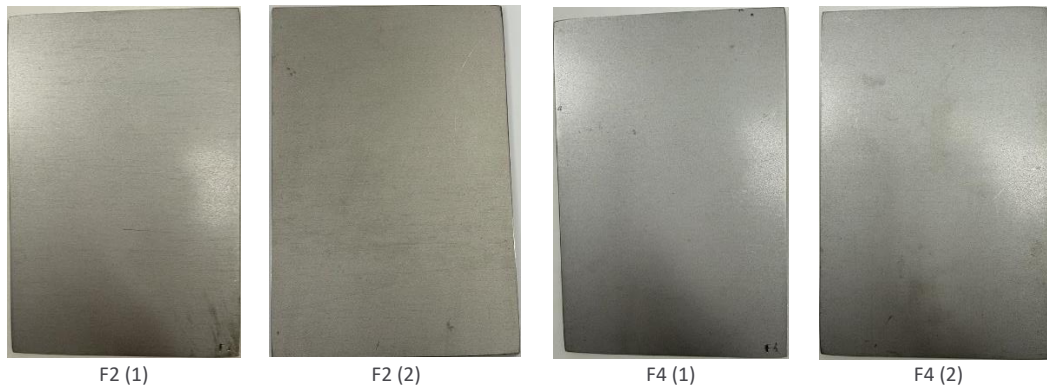
E2 (2)



E4 (1)



E4 (2)



MYND 2 Reykjavík IMO, the appearance of plate specimens after 4 years of exposure. Left: open condition, right: sheltered condition. (1) refers to front of specimen, (2) refers to back side of specimen.

The results after four years exposure of the stainless steel samples can be summarized as follows:

- There is little change in corrosion or staining of the samples from previous year except for steel 1.4404.
- For steel 1.4404 a difference in staining is observed between the two test sites with samples at Kársnes showing considerable more staining.
- There is more evidence of pitting in steel 1.4404 than after three years.
- There is now visible difference of samples in open air or sheltered conditions for samples of 1.4404 and other samples are showing the same trend but at a much smaller scale.
- Very little staining or corrosion was observed on any other steel samples from either test station.

The only stainless steel to give any results that are possible to represent grafically is 1.4404. The RN rating is taken to be the average of the score of two independent observers og both sides of the specimens; i.e. of four numbers.

