

BL2F – WP1

Materials selection and testing corrosion results at SINTEF

MidTerm Workshop,

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Levi Sandviken, Dirk Nolte, Judit Sandquist*

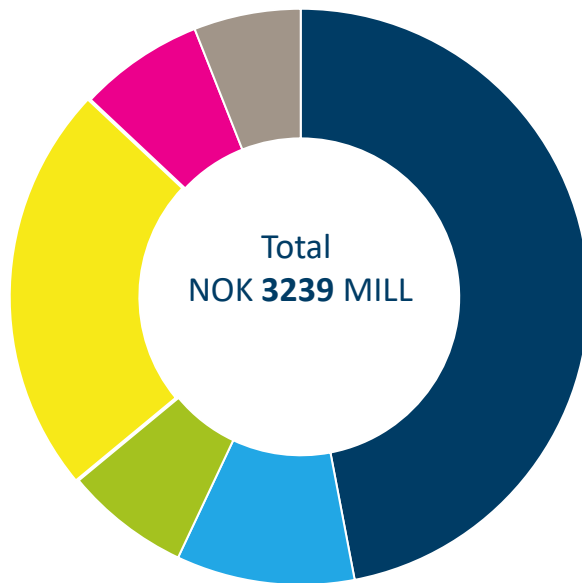


This project has received funding from the European Union Grant Number 884111

One of Europe's largest independent research organisations

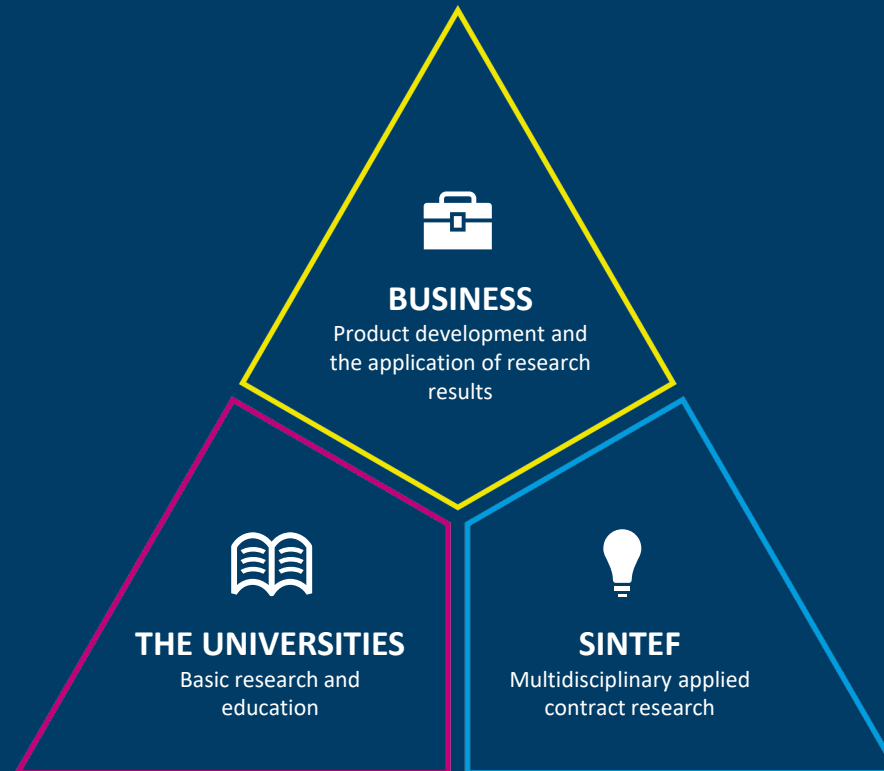


More than 90 percent of our **income** comes from contracts won in open competition



- Business and industry (Norway & international): 47%
- Public sector: 10%
- EU: 7%
- Project grants from The Research Council of Norway: 23%
- Basic grants from The Research Council of Norway: 7%

Close working relationships generate innovation and high quality



SINTEF Corlab facilities

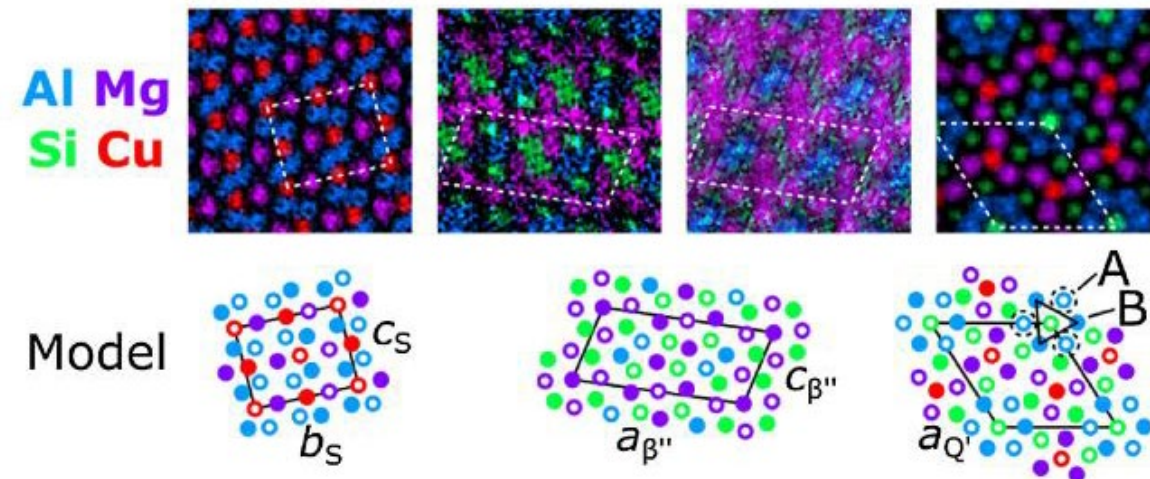
- Seawater laboratory
- H₂S Laboratory
- Electrochemistry laboratory
 - Potentiostats for polarization and EIS measurements, rotating disc electrodes, Scanning Kelvin probe, optical microscopes...
- Wear and tribology laboratory
- Humidity, salt spray and UV cabinets
- Power source for AC and DC anodizing
- Autoclaves certified for 300 bars and 200°C
- Access to first class workshop services
- Access to advanced surface characterization (SEM, TEM, EDS, AES, XPS, ToF-SIMS, GDOES...)
- Closely integrated with NTNU, professors, students etc.

Autoklav identifikasjonsdata		Materialkvalitet	Tillatt spenning v/ 150 °C (N/mm ²)	Trykk, max		Temp. max [°C]	Dimensjonerende komponent	Autoklav dim. (innvendig) D x h [mm]	Autoklav volum [L]	
STF-no	Antall			ID-nr. (tekn. nr.)	Beregnet [bar]					Til bruk [bar]
106	1	000352	984 LN, AST Storfors	100,0	30	5	300	Bunn	259x293	15
106	1	000353	984 LN, AST Storfore	100,0	30	-	300	Bunn	259x293	15
107	2	000354	Sanicro 28	115,7	8	5	160	Lokk	160x218	4
		000355	Sanicro 28	115,7	8	5	160	Lokk	160x218	4
108	2	000356	254SMO Lev 1992	159,3	38	35	160	Skruer	203x250	8
		000357	254SMO Lev 1992	159,3	38	35	160	Skruer	203x250	8
109	1	000359	254 SMO	159,3	8	5	150	Bunn	265x247	13,5
110	1	000360	AISI 316L	107,8	5	5	150	Bunn	298x298	20
111	2	000361	Sanicro 28	115,7	27	-	160	Flens		5
		000362	Sanicro 28	115,7	27	-	160	Flens		5
112	4	000363	254SMO	159,3	17	17	160	Flens	265x310	17
		000364	254SMO	159,3	17	17	160	Flens	265x310	17
		000365	254SMO	159,3	17	17	160	Flens	265x310	17
		000366	254SMO	159,3	17	17	160	Flens	265x310	17
113	3	000367	Titan Grad 2	125,9	35	35	160	Flens	320x300	24
		000368	Titan Grad 2	125,9	35	35	160	Flens	320x300	24
		000369	Titan Grad 2	125,9	35	35	160	Flens	320x300	24
114	2	000347	AISI 316	186,7	100	100	150	Bunn	101 5x130	1
		000348	AISI 316	186,7	100	100	150	Bunn	101 5x130	1
115	2	000370	Titan	300	300	300	200		200x1000	30
		000371	Titan	300	300	300	200		200x1000	30
Stripperer (blandedunk)	2	000372	Titan Grad 2	203,7	8	5	40	Flens	265x900	40
		000373	Titan Grad 2	203,7	8	5	40	Flens	265x900	40
F-nr 292 I	2	000395	Hastelloy C276	200	200	200	200	Lokk	150x150	2
F-nr 292 II	2	000396	Hastelloy C276	200	200	200	200	Lokk	150x150	2
Totalt ant.		25								



Advanced characterisation for evaluation of the corrosion mechanisms

- **Advanced characterisation:** Transmission and scanning electron microscopy (TEM and SEM), X-ray Photoelectron Spectroscopy (XPS), Auger, Atom Probe Tomography (APT), Focused Ion Beam (FIB)
- Materials **optics**, light and illumination
- Atomistic-, microstructure- and multiscale **modelling**
- Ontologies and interoperability
- Working within several domains:
 - (Light)metals - Thermomechanical treatment and microstructure
 - Battery materials
 - Catalyse
 - Semiconductors
 - Thin films



BL2F corrosion testmatrix

Pipe Nr	Plate	Marked	Grade	LY	H	C%	Si%	Mn%	P%	S%	Cr%	Ni%	Mo%	Co%	Cu%	Al%	N%	Fe%	H	O	Ti	V	Nb	Nb+Ta	W	Zr	Y
1		none (paper tube)	Ti grade 2	F#	88	0,006											50µg/g	0	6µg/g	1720µg/g	Bal.						
2		Sandvik 3R60	316	S#	21	0,02	0,45	1,64	0,03	0,007	17,3	13,12	2,63	0,12	0,26	0,003	0,037										
3		Sandvik SAF2507	25Cr SDSS	S#	33	0,013	0,28	0,44	0,02	0,0005	25,4	6,46	3,85	0,11	0,13	0,014	0,29										
4		2X22RK69	254smo	S#	17	0,012	0,44	0,43	0,025	0,0005	20	17,78	6,12	0,09	0,65	0,02	0,2										
5		01589422,006,WA, 1.49	X10CrMoVN	F#		0,095	0,31	0,5	0,014	0,001	8,23	0,27	0,85		0,07	0,01	0,045				0,2	0,066					
6		NiCr22Mo9Nb	Alloy625 inc	NO	#	0,023	0,19	0,07	0,005	0,002	21,6	61,41	8,6	0,03	0,03	0,15		4,2					3,35				
7		2.4819-4578	Hastelloy C-2	N1	#	0,003			0,005	0,003	16,1	57,01	16,14	0,46				5,8			0,19			3,44			
8		NiCroFer 6025 HT, NiCr2	Alloy 602 CA	N#	#	0,18	0,12	0,1	0,004	0,002	25,4	61,7			0,01	2,23		9,9							0,07	0,07	
9		30402	Alloy 699 XA	NO	#	0,2	0,05	0,01	0,002	0,002	29,6	67,8	0,01		0,01	2,2	0,017	0,1				0,14				0,03	

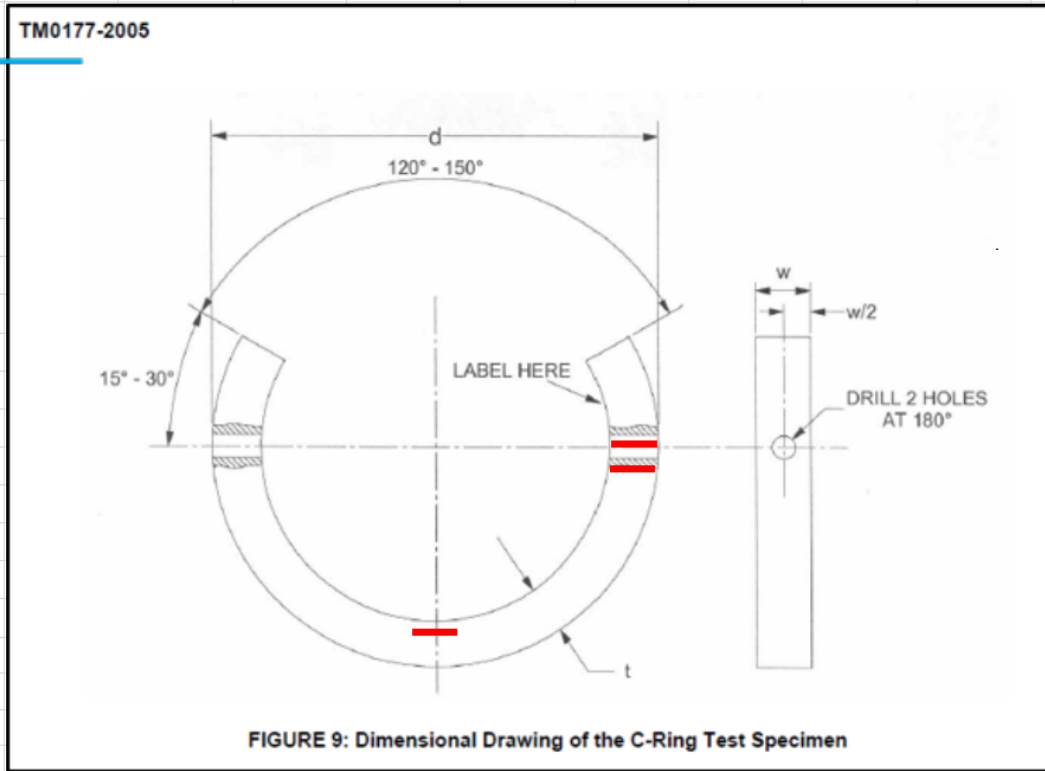


C-rings harvested from the 9 candidate materials

BL2F – Test conditions: Screening study in autoclave

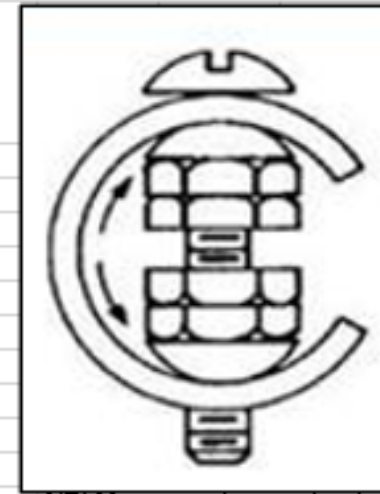
Description	Value
Test method	C-ring (inside in tension = hoop stress) in Autoclave (Ti gr 2, 30L)
Electrolyte composition	Standardised model composition of BL
Temperature	180 °C
Pressure	200 bars
Specimens dimensions	D: 40-60mm WT: 2-5mm
Dissolved oxygen limit	< 10 ppb (actual 2ppb, pH 12,47)
Surface finish	Ground to SiC 500
Stress level (by strain control)	Ref. NACE (100 % AYS)
Test duration	4 weeks
3 winner material candidates to be exposed in SINTEF ENERGY reactor @ supercritical conditions	

BL2F corrosion test methodology: simulating hoop stress



Hoop stress is the stress that occurs along the pipe's circumference when pressure is applied. Hoop stress acts perpendicular to the axial direction. Hoop stresses are tensile and generated to resist the bursting effect that results from the application of pressure

9

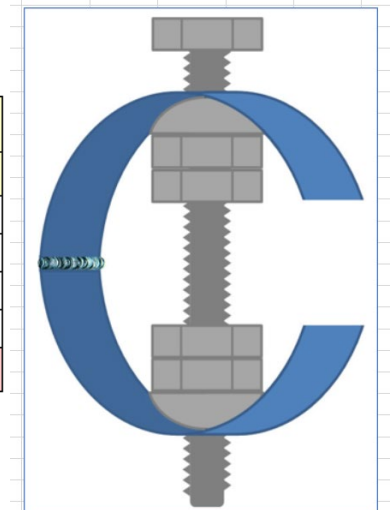


NB! Measure electrical isolation between bolt and ring!
hole liner PTFE

part	material	method
bolt	same as C-ring	
inlay	same as C-ring	sliced rod
nut	same as C-ring	
locknut	same as C-ring	
locknut	same as C-ring	
nut	same as C-ring	
inlay	same as C-ring	sliced rod

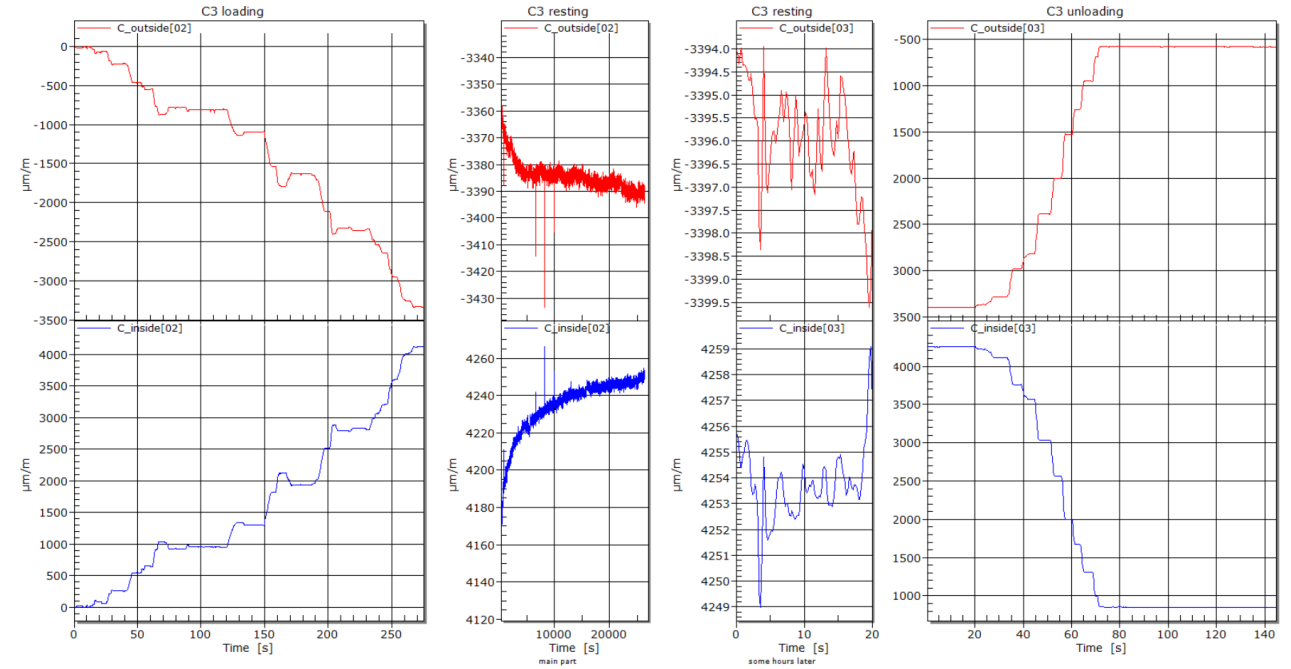
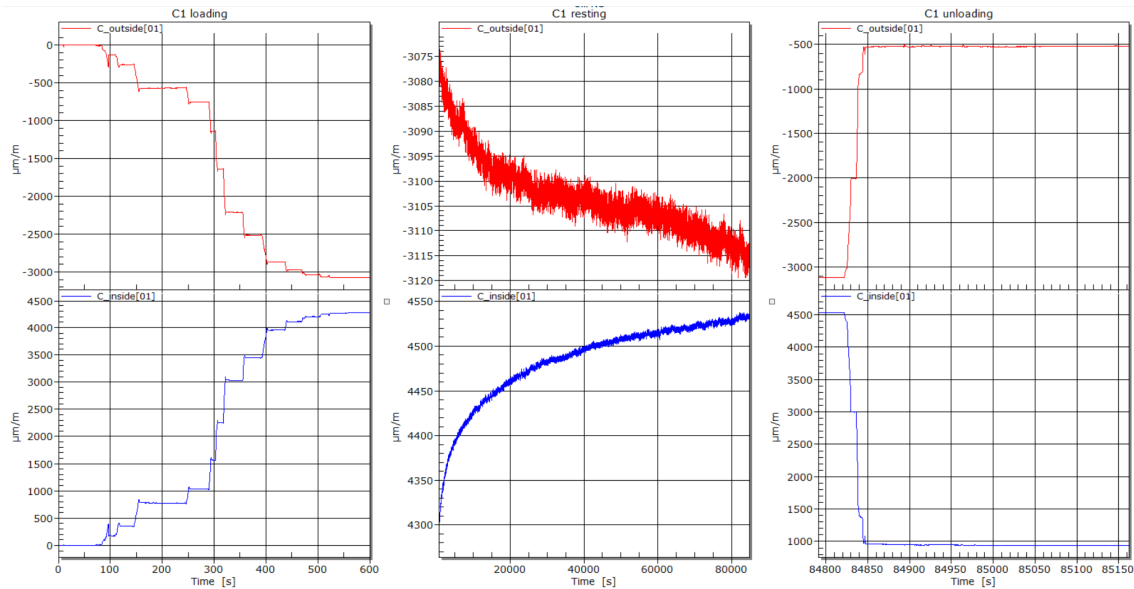
Kandidater	9
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Mottaker	Komponenter				
	C-ring	Strekk	Stang	Muttere	Hemi
CorLab	3	4	3	6	6
Judit	3		3	6	6
Spare	2	1	2	4	4
Sum	8	5	8	16	16
Totalt	72	45	72	144	144



Kilde <https://www.twi-global.com/te>

Pre-loading of C-rings with strain-gauge to achieve the desired yield strength. Empirically finding the needed outside stress by pre-loading to achieve the desired inside yield strength.



Candidate 1: Ti Grade 2

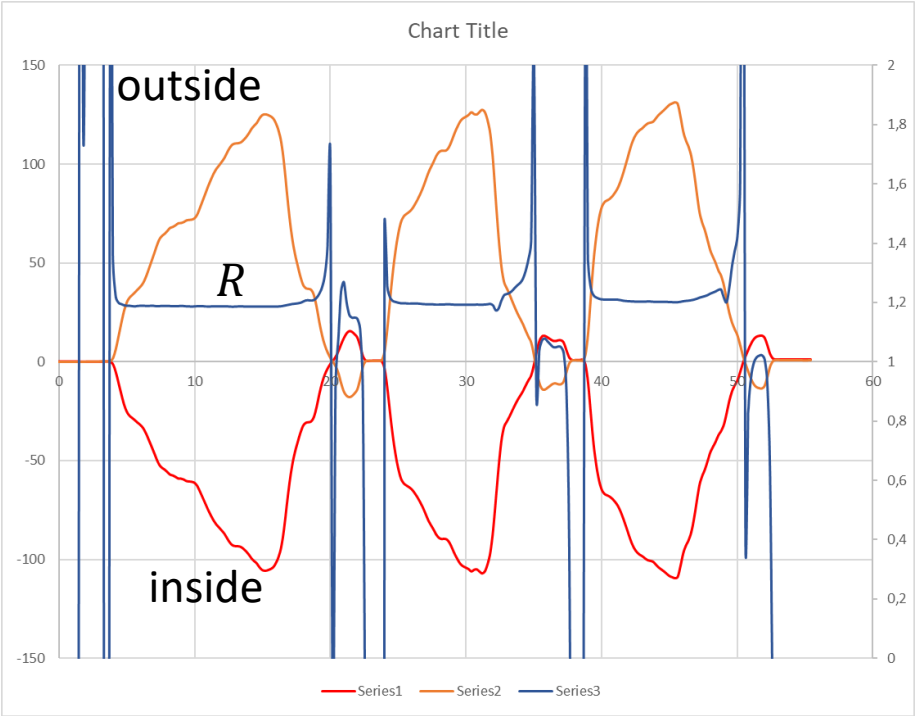
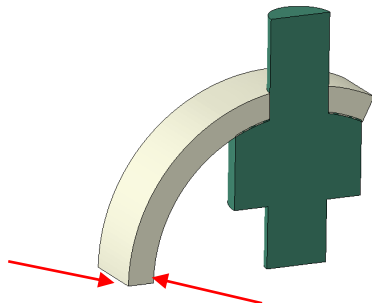


Candidate 3: SAF2507 (SDSS)

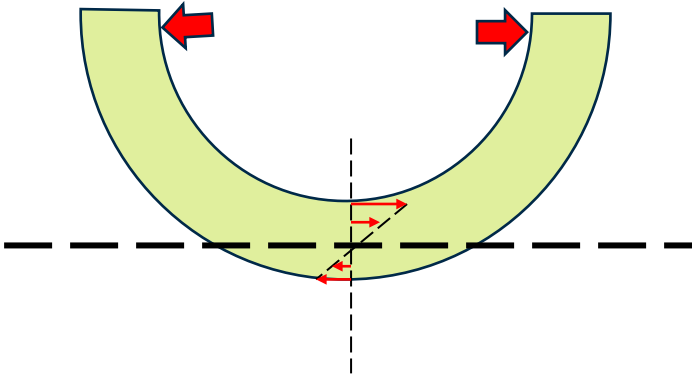
FEM simulation

Stress evolution

Ratio between outside stress (measured with strain gauge 6mm) and inside stress locally at 9 o'clock



- **R** is constant when loading elastically during pre-stress
- **R** value depends on diameter of C-ring



Ratio for Big C-Ring – test results with strain gauge

BL2F standard model water based black liquor sample for corrosion testing

Salt	wt.% in	g/kg	mmol/kg
	pristine BL		
NaOH	1.2	11.8	295.1
NaHS	0.2	2.3	41.3
Na ₂ SO ₄	1.8	17.6	124.0
Na ₂ CO ₃	1.7	16.6	156.7
NaCl	0.1	1.4	24.2
K ₂ SO ₄	0.6	6.4	47.5
Total	5.62	56.18	688.79
Sodium formate	0.5	4.9	71.8
Sodium acetate	0.3	2.5	30.8
Sodium D-gluconate	0.7	6.6	30.0
Sodium DL-lactate	0.7	7.3	65.2
Guaiacol	2.5	24.5	197.4
Total organics	4.58	45.77	395.20

- Security Data Sheet for Water Based Simulated BL has been created by KIWA
- Mixing a tot. Volume of 45L with the chosen composition (weighing) purged with N₂(g) while cooling

Source: Darius Yeadon, PSI: Mixing while cooling in de-aerated H₂O by bubbling with N₂(g). NaHS is dissolved first because it is oxidized. The organics are added as bases and the NaOH content adjusted.

AVSNITT 2: FAREIDENTIFIKASJON

2.1. Klassifisering av stoffet eller stoffblandingen

Klassifisering i henhold til CLP (EC) No 1272/2008 [CLP / GHS] Skin Corr. 1; H314

Dette dokumentet er utarbeidet i Publisher (EcoOnline)

Syntetisk vannbasert svartlut - Versjon 1

Side 2 av 12

Stoffets/blandings farlige egenskaper
Tilleggsinformasjon om klassifisering

Eye Dam. 1; H318
Gir alvorlige etseskader på hud og øyne.
Se utfyllende opplysninger (avsnitt 16).

AVSNITT 3: SAMMENSETNING/OPPLYSNINGER OM BESTANDDELER

3.2. Stoffblandinger

Komponentnavn	Identifikasjon	Klassifisering	Innhold	Noter
Guaiacol	CAS-nr.: 90-05-1 EC-nr.: 201-964-7 Indeksnr.: 604-031-00-6	Acute Tox. 4; H302; Eye Irrit. 2; H319; Skin Irrit. 2; H315;	2,5 vekt%	
Natriumkarbonat	CAS-nr.: 497-19-8 EC-nr.: 207-638-8 Indeksnr.: 011-005-00-2 REACH reg. nr.: 01-2119485498-19-XXXX	Eye Irrit. 2; H319;	1,7 vekt%	
Natriumhydroksid	CAS-nr.: 1310-73-2 EC-nr.: 215-185-5 REACH reg. nr.: 01-2119457892-27	Met. Corr. 1; H290 Skin Corr. 1A; H314 Eye Dam. 1; H318	1,2 vekt%	
Kaliumsulfat	CAS-nr.: 7778-80-5 EC-nr.: 231-915-5	Eye Irrit. 2; H319	0,6 vekt%	6

Dette dokumentet er utarbeidet i Publisher (EcoOnline)

Syntetisk vannbasert svartlut - Versjon 1

Side 3 av 12

Sodium hydrosulfide hydrate

CAS-nr.: 207683-19-0

Acute Tox. 3; H301
Skin Corr. 1B; H314
Eye Dam. 1; H318
Aquatic Acute 1; H400;
M-faktor 10

⁶Stoff oppgitt for å gi ytterligere informasjon

Beskrivelse av blandingen
Bemerkning, komponent

Vannbasert løsning.
CAS nr 1310-73-2 har spesifikke konsentrasjonsgrenser:
Skin Irrit. 2; H315: 0,5 % ≤ C < 2 %
Eye Irrit. 2; H319: 0,5 % ≤ C < 2 %
Skin Corr. 1B; H314: 2 % ≤ C < 5 %
Skin Corr. 1A; H314: C ≥ 5 %

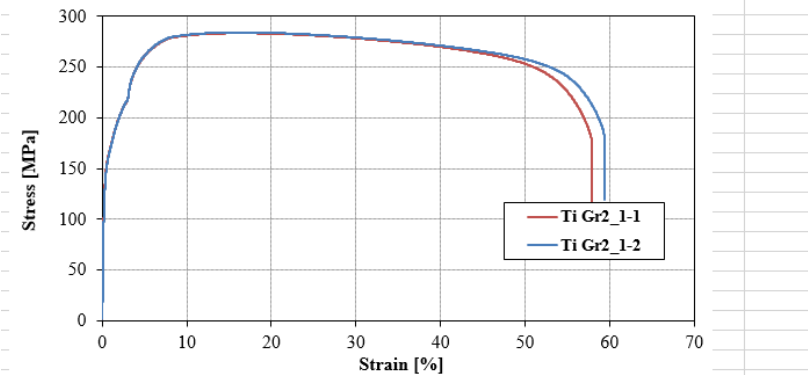
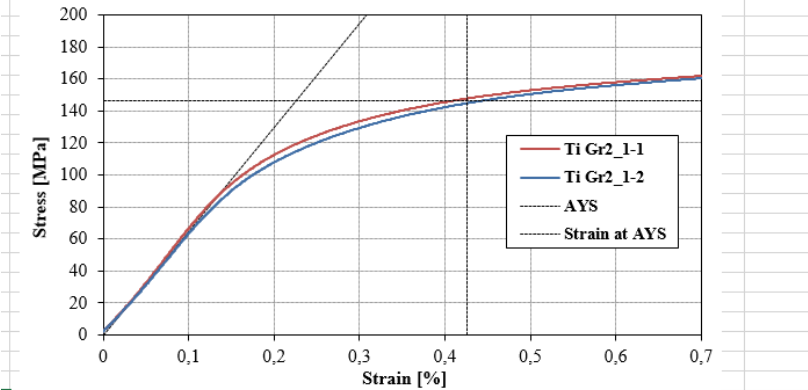
Komponentkommentarer

Se avsnitt 16 for forklaring av faresetninger (H).
For de stoffer som mangler REACH registreringsnummer er dette ikke angitt av produsent.

Stress-strain curves at 180degC

Specimen Id.	Width	Thickness	$R_{p0.2}$	$R_{t0.5}$	R_m	A_{gt}	A_5	Z	ϵ_{Rp}
	[mm]	[mm]	[MPa]	[MPa]	[MPa]	[%]	[%]	[%]	[%]
Ti Gr2_1-1	10,036	7,587	148	153	283	16	58	74	0,420
Ti Gr2_1-2	10,035	7,560	145	151	284	17	60	72	0,431
Average			146	152	284	17	59	73	0,426

Candidate 1



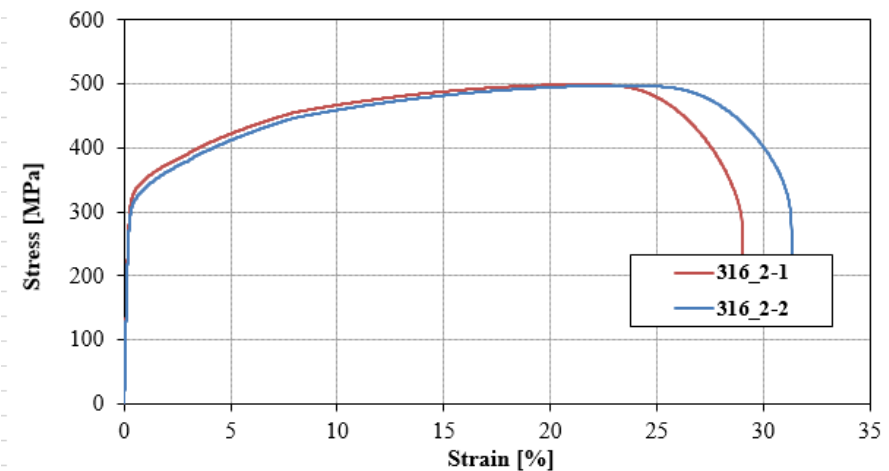
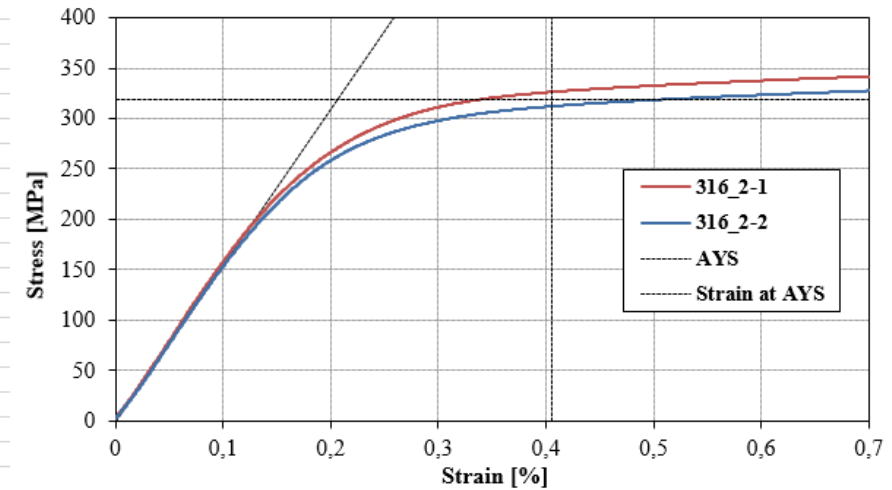
Specimen	AYS	Strain at AYS
1.1 and 1.2	[MPa]	[%]
Average @ 180°C	146	0,426



Stress-strain curves at 180degC

Candidate 2

Specimen Id.	Width	Thickness	$R_{p0.2}$	$R_{t0.5}$	R_m	A_{gt}	A_5	Z	ϵ_{Rp}
	[mm]	[mm]	[MPa]	[MPa]	[MPa]	[%]	[%]	[%]	[%]
316_2-1	10,036	6,451	327	333	499	22	29	71	0,411
316_2-2	10,075	6,758	312	318	498	23	32	68	0,401
Average			319	326	498	22	31	70	0,406

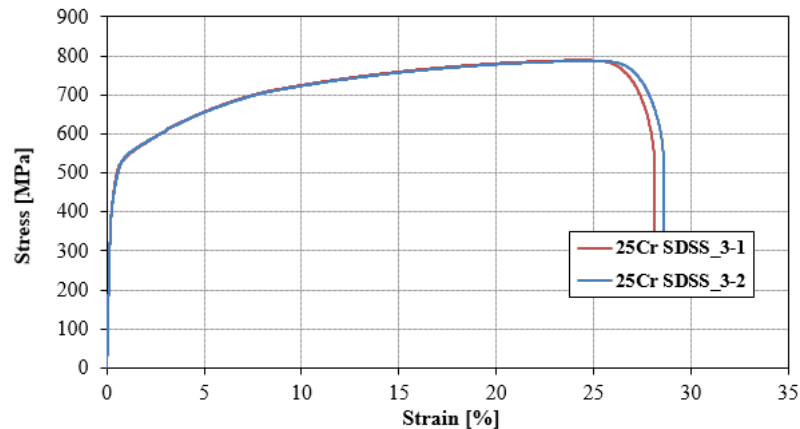
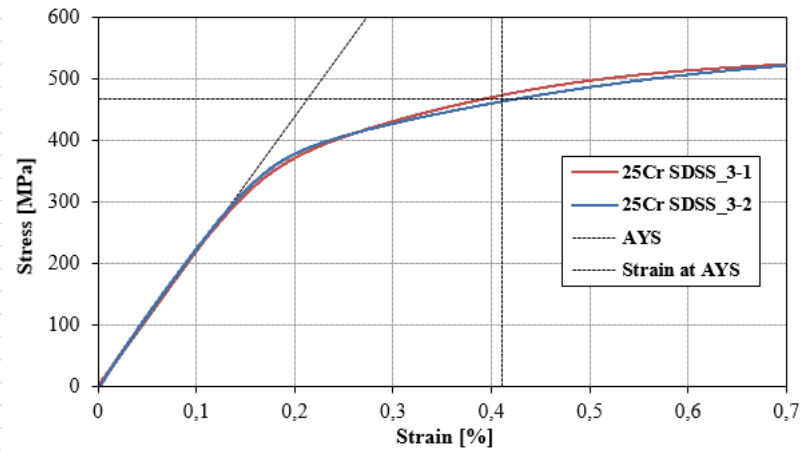


Stress-strain curves at 180degC

Candidate 3

Specimen Id.	Width [mm]	Thickness [mm]	R _{p0.2} [MPa]	R _{t0.5} [MPa]	R _m [MPa]	A _{gt} [%]	A ₅ [%]	Z [%]	ε _{RP} [%]
25Cr SDSS_3-1	10,088	3,773	475	497	789	24	28	65	0,416
25Cr SDSS_3-2	10,093	3,756	461	486	787	25	29	67	0,405
Average			468	492	788	25	28	66	0,411

Specimen	AYS [MPa]	Strain at AYS [%]
3.1 and 3.2		
Average @ 180°C	468	0,411



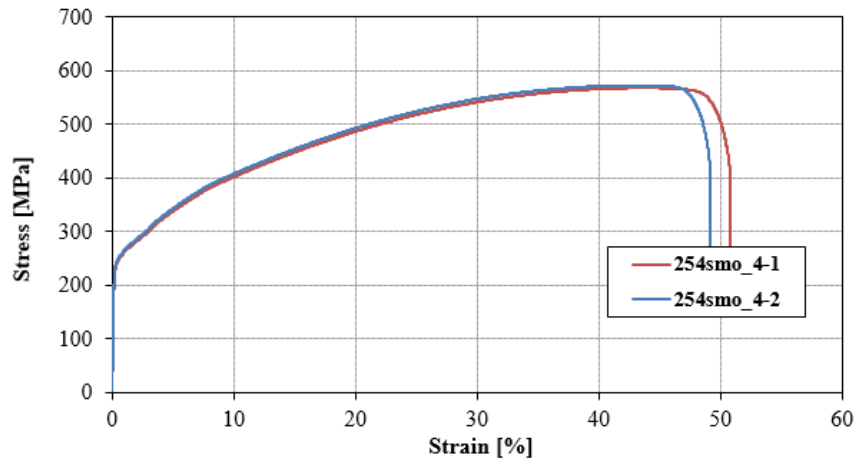
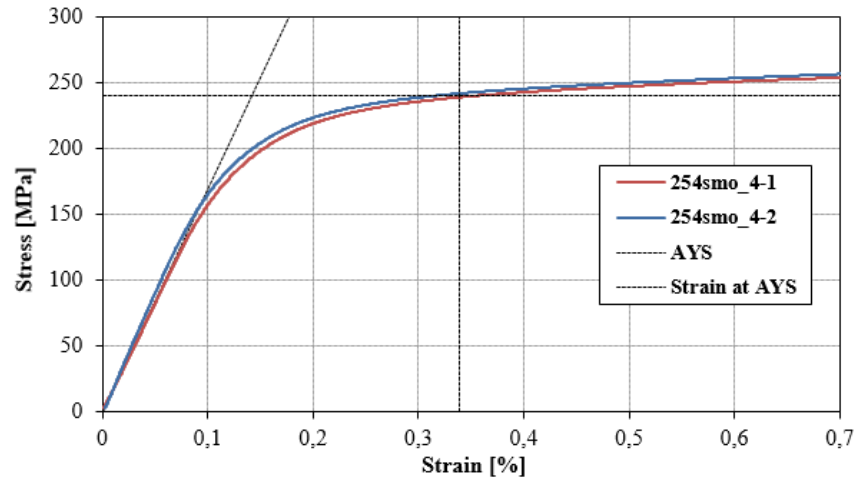
E-mod		
0	0	
2200	1	
	0,2	
	1,2	
0	0,411	Strain at AYS
600	0,411	
468,0	0	AYS
468,0	1	



Stress-strain curves at 180degC

Candidate 4

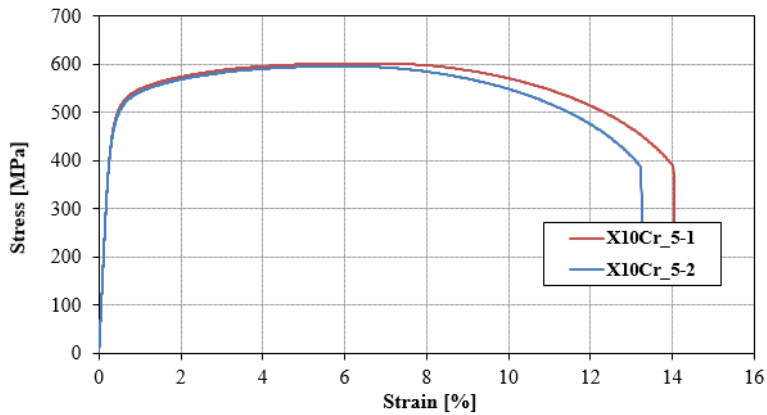
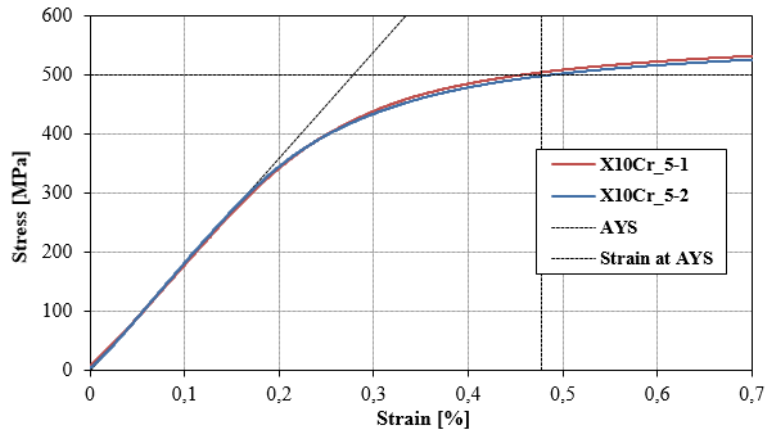
Specimen Id	Width [mm]	Thickness [mm]	$R_{p0.2}$ [MPa]	$R_{t0.5}$ [MPa]	R_m [MPa]	A_{gt} [%]	A_5 [%]	Z [%]	ϵ_{Rp} [%]
254smo_4-1	10,060	4,145	239	247	568	44	51	71	0,340
254smo_4-2	10,060	4,194	242	250	573	43	49	70	0,338
Average			241	249	571	44	50	70	0,339



Stress-strain curves at 180degC

Specimen Id.	Width	Thickness	$R_{p0.2}$	$R_{t0.5}$	R_m	A_{gt}	A_5	Z	ϵ_{Rp}
	[mm]	[mm]	[MPa]	[MPa]	[MPa]	[%]	[%]	[%]	[%]
X10Cr_5-1	10,043	4,576	505	508	602	6	15	74	0,481
X10Cr_5-2	10,048	4,528	497	502	596	6	14	73	0,473
Average			501	505	599	6	14	73	0,477

Candidate 5

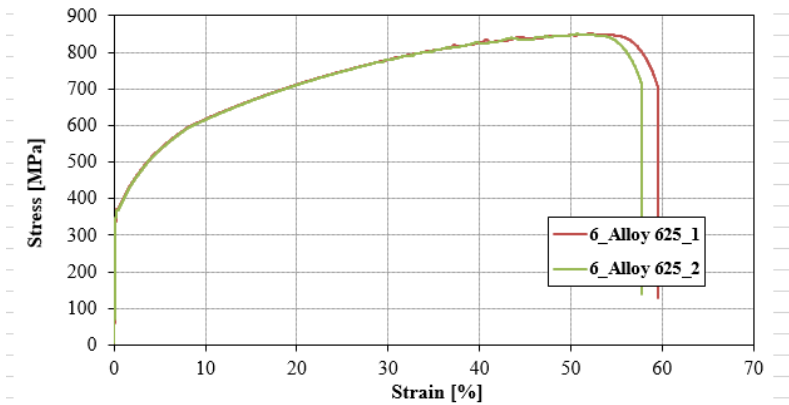
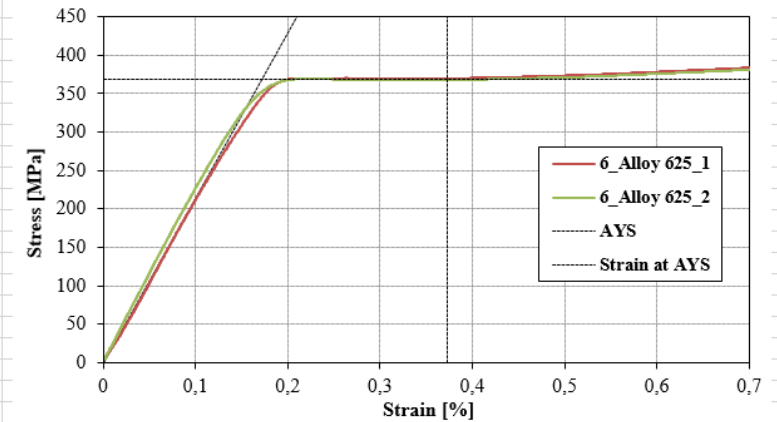


Specimen	AYS	Strain at AYS
5.1 and 5.2	[MPa]	[%]
Average @ 180°C	501	0,477

Stress-strain curves at 180degC

Candidate 6

Specimen Id	Diameter [mm]	R _{p0.2} [MPa]	R _{t0.5} [MPa]	R _m [MPa]	A _{gt} [%]	A ₅ [%]	Z [%]	ε _{RP} [%]
6_Alloy 625_1	6,018	370	373	851	52	60	59	0,380
6_Alloy 625_2	6,015	367	371	850	51	58	60	0,367
Average		369	372	851	51	59	60	0,374

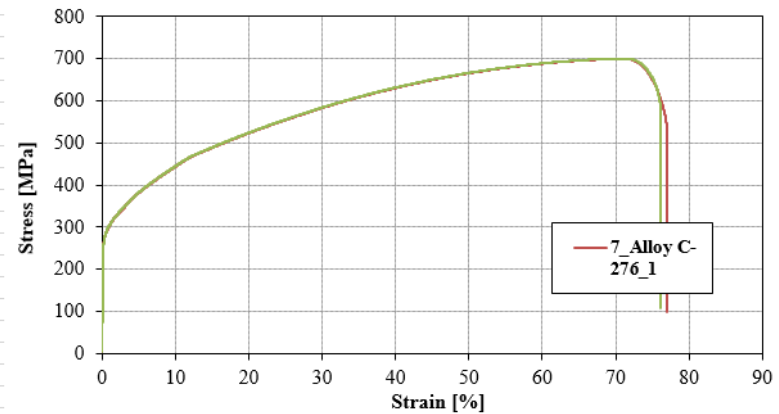
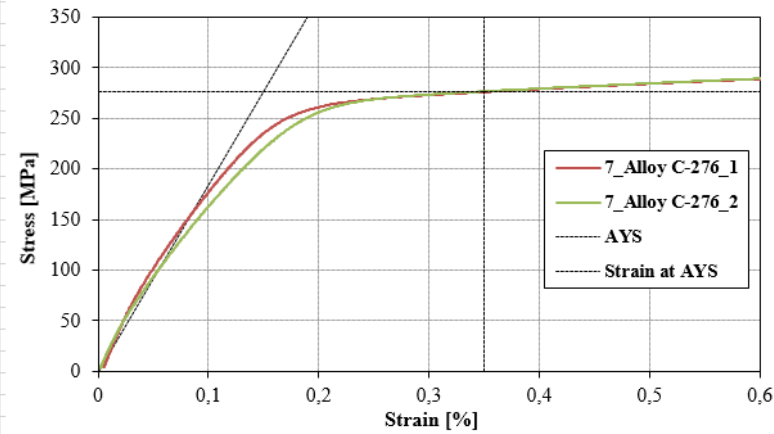


Specimen	AYS	Strain at AYS
6.1 and 6.2	[MPa]	[%]
Average @ 180°C	369	0,374

Stress-strain curves at 180degC

Candidate 7

Specimen Id.	Diameter [mm]	R _{p0.2} [MPa]	R _{t0.5} [MPa]	R _m [MPa]	A _{gt} [%]	A ₅ [%]	Z [%]	ε _{RP} [%]
7_Alloy C-276_1	6,013	276	284	699	71	77	72	0,345
7_Alloy C-276_2	6,014	277	285	700	71	76	65	0,354
Average		276	285	700	71	77	68	0,350

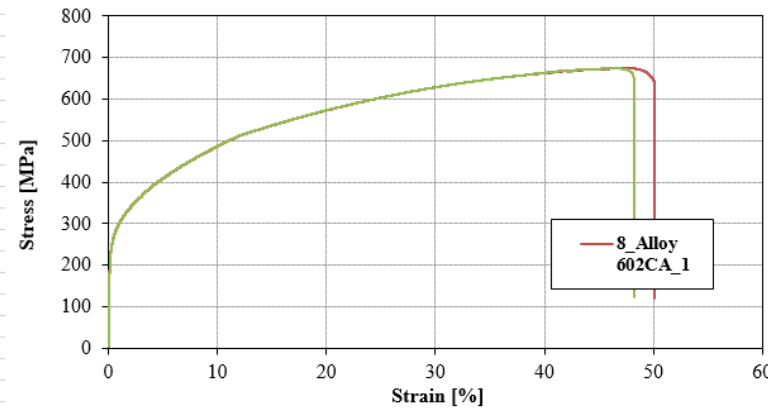
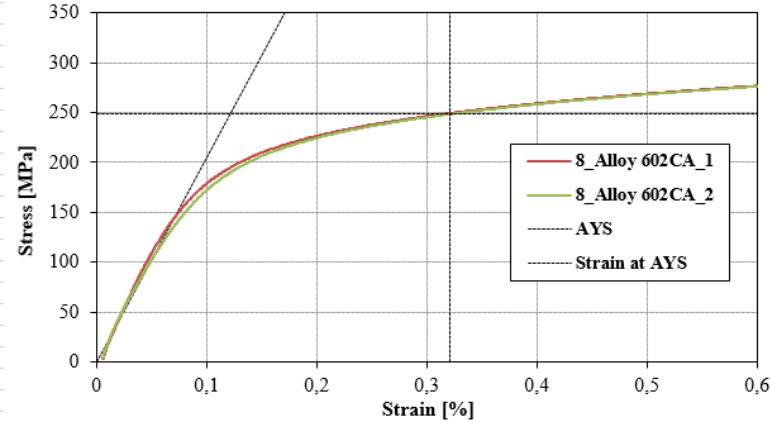


Specimen	AYS	Strain at AYS
7.1 and 7.2	[MPa]	[%]
Average @ 180°C	276	0,350

Stress-strain curves at 180degC

Candidate 8

Specimen Id.	Diameter [mm]	R _{p0.2} [MPa]	R _{t0.5} [MPa]	R _m [MPa]	A _{gt} [%]	A ₅ [%]	Z [%]	ε _{Rp} [%]
8_Alloy 602CA_1	6,015	249	269	675	47	50	45	0,319
8_Alloy 602CA_2	6,013	249	268	675	46	48	41	0,324
Average		249	269	675	47	49	43	0,322

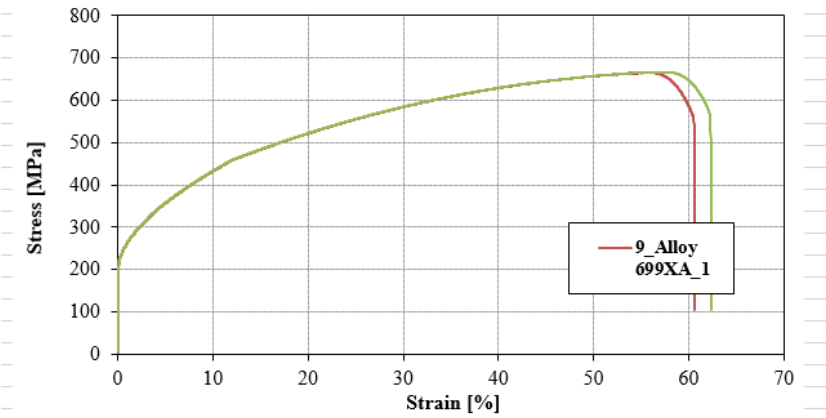
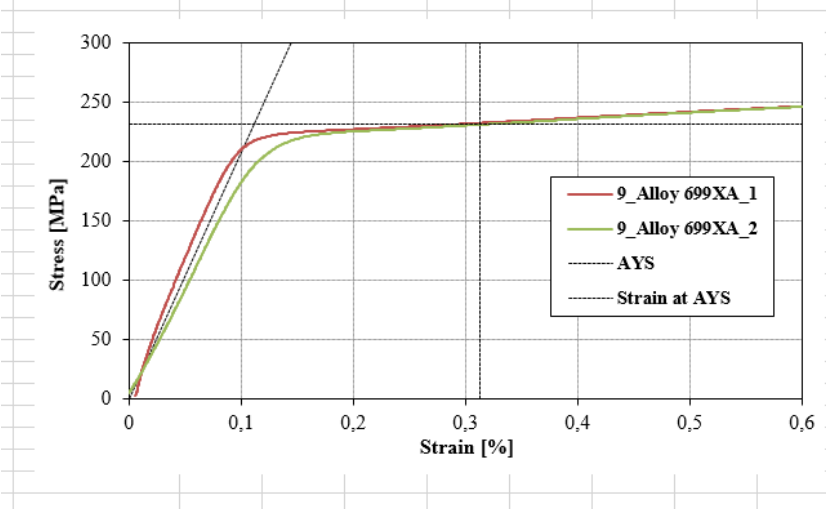


Specimen	AYS	Strain at AYS
8.1 and 8.2	[MPa]	[%]
Average @ 180°C	249	0,322

Stress-strain curves at 180degC

Candidate 9

Specimen Id.	Diameter [mm]	R _{p0.2} [MPa]	R _{t0.5} [MPa]	R _m [MPa]	A _{gt} [%]	A ₅ [%]	Z [%]	ε _{Rp} [%]
9_Alloy 699XA_1	6,012	232	242	665	56	61	62	0,303
9_Alloy 699XA_2	6,013	232	241	667	57	62	60	0,322
Average		232	242	666	56	61	61	0,313



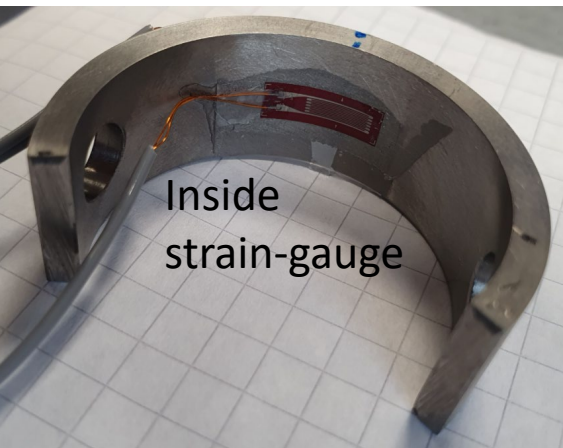
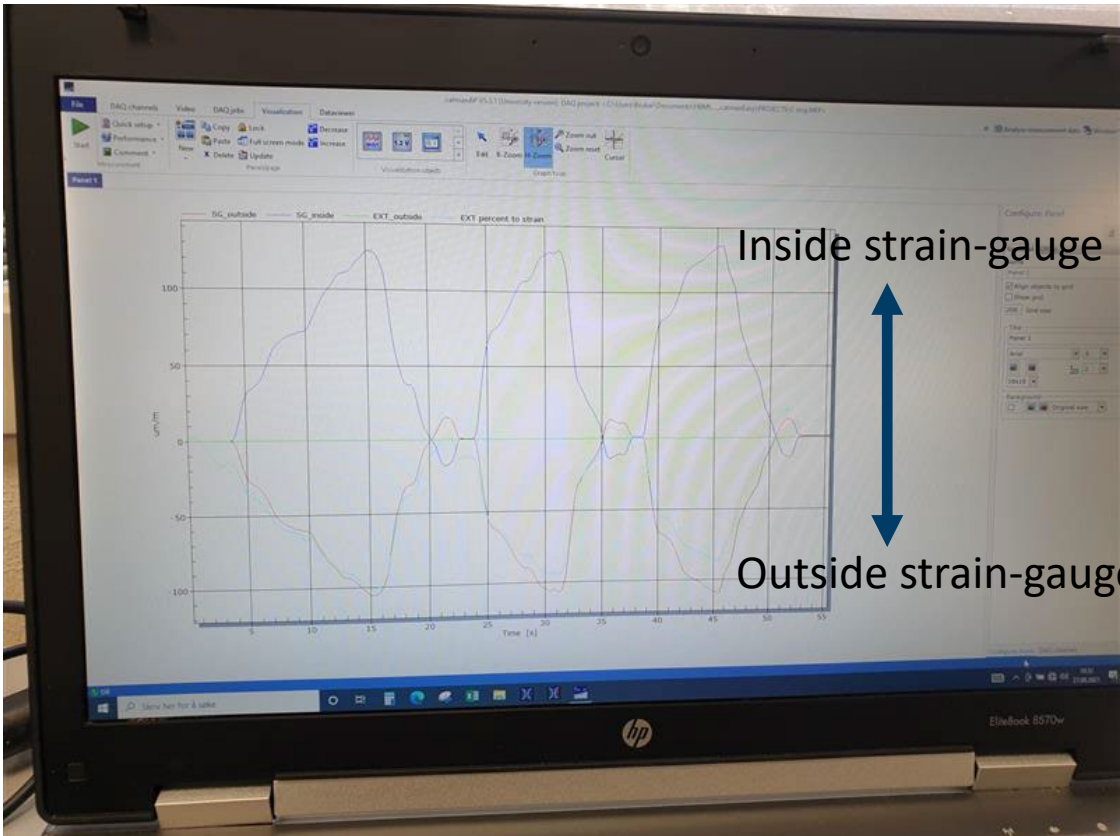
Specimen	AYS [MPa]	Strain at AYS [%]
9.1 and 9.2		
Average @ 180°C	232	0,313

Applied outside stress (compression) to achieve the desired inside yield strength of the actual samples



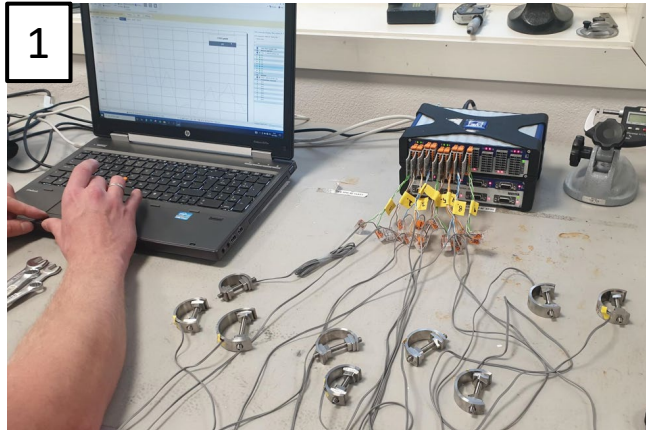
	Candidate	Sample	Target Compression outer (μm/m)	Applied Compression (μm/m)	AYS (Mpa)	Strain at AYS (%) (inner)	Outer Strain Gage (μm/m)	Inner Strain Gauge (μm/m)	Deviation in (%) applied comp./target comp.
Ti grade 2	1	1	-3074	-3052	146	0,426	-3074	4260	1%
		2	-3074	-3074	146	0,426	-3074	4260	0%
		3	-3074	-3074	146	0,426	-3074	4260	0%
316	2	4	-2966	-2982	319	0,406	-2966	4060	-1%
		5	-2966	-3005	319	0,406	-2966	4060	-1%
		6	-2966	-2977	319	0,406	-2966	4060	0%
25Cr SDSS	3	7	-3336	-3339	468	0,411	-3336	4111	0%
		8	-3336	-3335	468	0,411	-3336	4111	0%
		9	-3336	-3319	468	0,411	-3336	4111	1%
254smo	4	10	-2532	-2549	241	0,339	-2532	3390	-1%
		11	-2532	-2529	241	0,339	-2532	3390	0%
		12	-2532	-2525	241	0,339	-2532	3390	0%
X10CrMoVNb9-1	5	13	-3143	-3175	501	0,477	-3143	4770	-1%
		14	-3143	-3172	501	0,477	-3143	4770	-1%
		15	-3143	-3149	501	0,477	-3143	4770	0%
Alloy625 inconel	6	16	-2712	-2689	369	0,374	-2712	3740	1%
		17	-2712	-2719	369	0,374	-2712	3740	0%
		18	-2712	-2762	369	0,374	-2712	3740	-2%
Hastelloy C-276	7	19	-2489	-2485	276	0,35	-2489	3500	0%
		20	-2489	-2477	276	0,35	-2489	3500	0%
		21	-2489	-2477	276	0,35	-2489	3500	0%
Alloy 602 CA	8	22	-2147	-2147	249	0,322	-2147	3220	0%
		23	-2147	-2136	249	0,322	-2147	3220	1%
		24	-2147	-2153	249	0,322	-2147	3220	0%
Alloy 699 XA	9	25	-2273	-2264	232	0,313	-2273	3130	0%
		26	-2273	-2278	232	0,313	-2273	3130	0%
		27	-2273	-2292	232	0,313	-2273	3130	-1%

Pre-loading of C-rings with strain-gauge to achieve the desired yield strength. Empirically finding the needed outside stress by pre-loading to achieve the desired inside yield strength.



Status: Pre-loading of the C-rings

Corrosion test started at SINTEF. Duration 31 days. 180degC, 200Bar

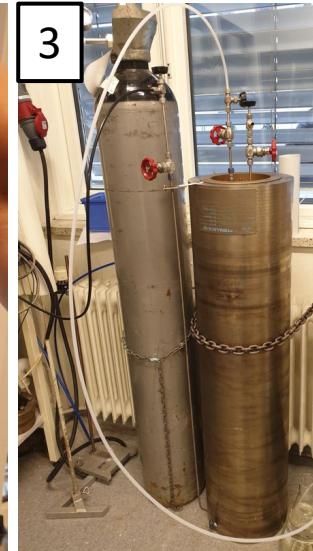


1 Applying stress



P91 in the bottom

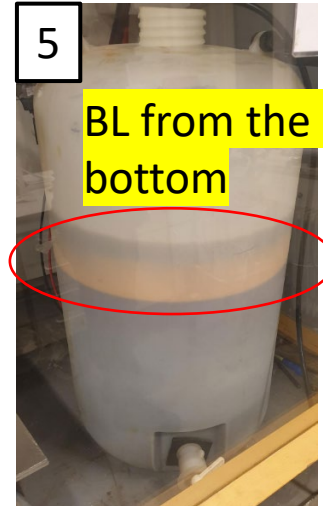
2 Inserting the samples to the autoclave and closing the lid



3 Introducing pressure by N₂(g) for deaeration and simulated model waterbased BL



4 Isolating the autoclave over the heating bands



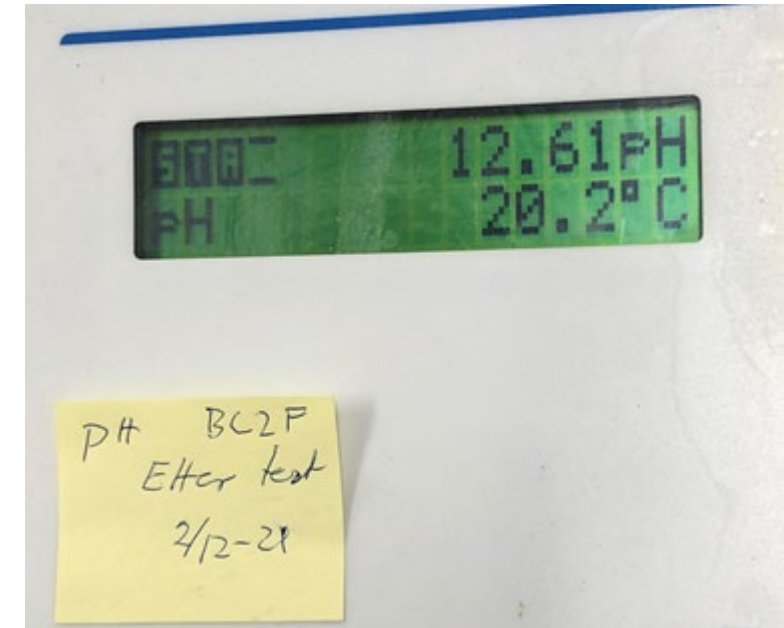
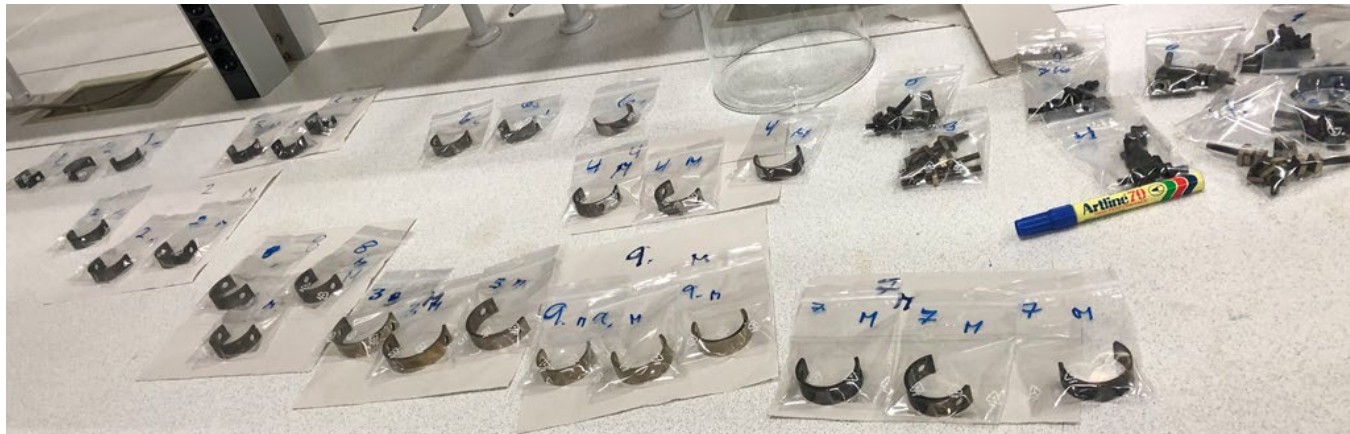
5 Emptying the autoclave after exposure

simulated model waterbased BL*

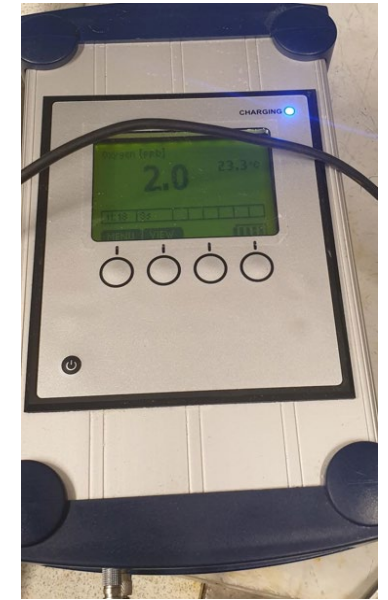
Salt	wt.% in pristine BL	g/kg	mmol/kg
NaOH	1.2	11.8	295.1
NaHS	0.2	2.3	41.3
Na ₂ SO ₄	1.8	17.6	124.0
Na ₂ CO ₃	1.7	16.6	156.7
NaCl	0.1	1.4	24.2
K ₂ SO ₄	0.6	6.4	47.5
Total	5.62	56.18	688.79
Sodium formate	0.5	4.9	71.8
Sodium acetate	0.3	2.5	30.8
Sodium D-gluconate	0.7	6.6	30.0
Sodium DL-lactate	0.7	7.3	65.2
Guaicol	2.5	24.5	197.4
Total organics	4.58	45.77	395.20

*as agreed upon in the project

Post test analysis



Optical O₂ measurement in the simulated water based BL = 2,0ppb, pH = 12,47



PreSense optical O₂ measurement device

form	substans	formel	molar mass (g/mol)	wt% in pristine BL	g/kg in pristine BL	innveing for 45L vannbasert løsnig (g)	faktisk innveid masse (g) 26okt21 til 45L tank purged with N2
	natriumhydroxid	NaOH	40	1,2	11,8	531	531
S	natrium hydrosulfide	NaHS	56,06	0,2	2,3	103,5	103,5
S	natriumsulfat	Na2SO4	142,04	1,8	17,6	792	793
S	natriumkarbonat	Na2CO3	105,99	1,7	16,6	747	747
S	natriumklorid	NaCl	58,44	0,1	1,4	63	63
S	kaliumsulfat	K2SO4	174,26	0,6	6,4	288	288
	natrium formate	HCOONa	68,01	0,5	4,9	220,5	220
	natrium acetate	CH3COONa	82,03	0,3	2,5	112,5	112,5
	natrium d-gluconate	NaC ₆ H ₁₁ O ₇	218,14	0,7	6,6	297	298
L	natrium DL-lactate	NaC ₃ H ₅ O ₃	112,06	0,7	7,3	328,5	328
L	Guaiacol	C ₇ H ₈ O ₂	124,14	2,5	24,5	1102,5	1102



post test analysis with evaluation matrix

The preliminary best corrosion resistant candidates: 699XA, 625

Inconel, P91, C276

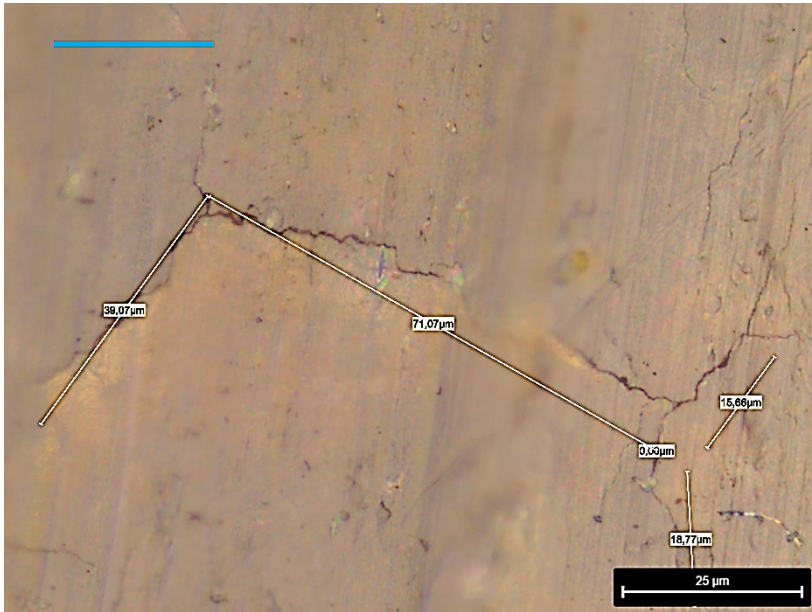
Preliminary failed due to corrosion: Ti Gr.2 , 316, 2507

Sample	Grade	Corrosion performance				Material aspects				commercial aspects			
		pitting	cracking	intergranular corrosion	general corrosion	weldability	machinability	forming	availability	price	delivery time	redundancy of suppliers	common practice
1	Ti grade 2	x	x										
2	316	x											
3	25Cr SDSS	x	x										
4	254smo	x											
5	X10CrMoVNb	x (few)				x	x		x				x
6	Alloy625 inconel				x (some)	x	x		x				x
7	Hastelloy C-276					x	x		x				x
8	Alloy 602 CA			x		x (N2, Ar)			x	?			
9	Alloy 699 XA	x (few)				x (Ar)	PSI		x	?			

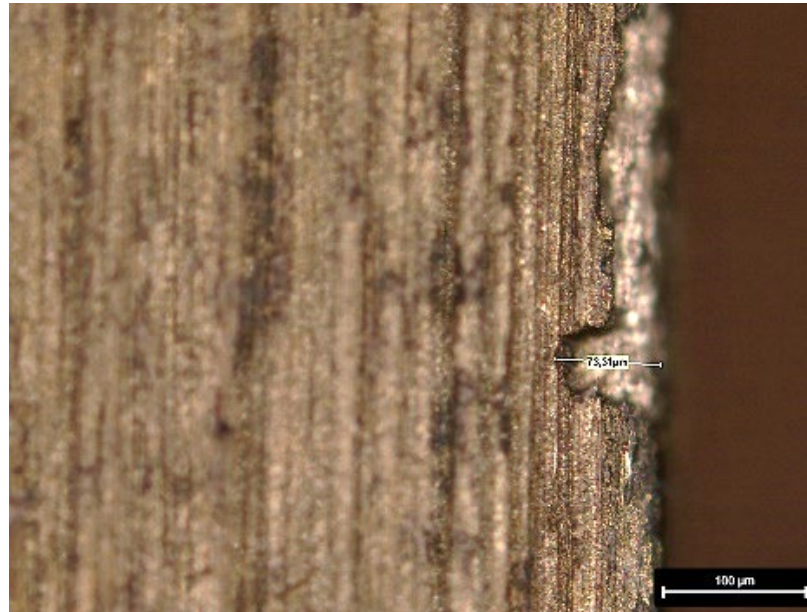
Preliminary status post test analysis:

Failed

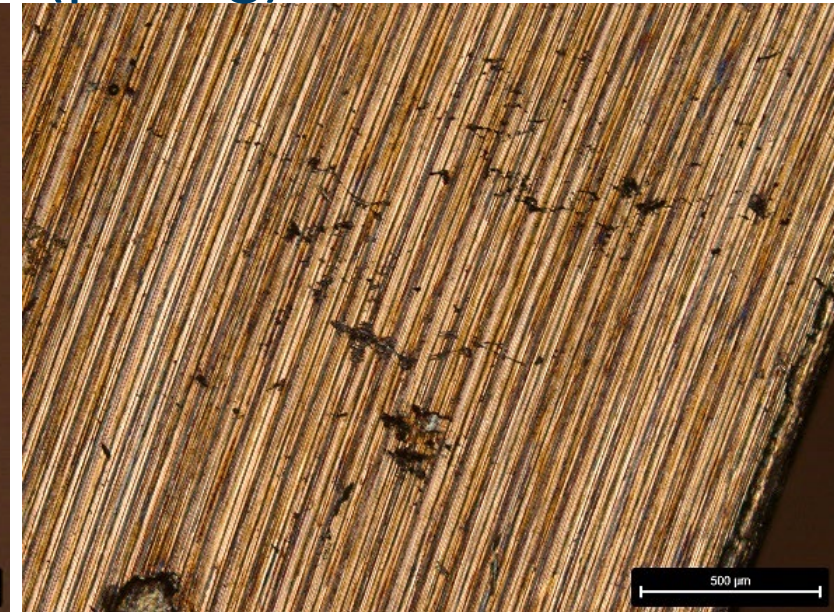
Sample 1, Ti grade 2
(pitting, cracking)



Sample 2, AISI 316
(pitting)



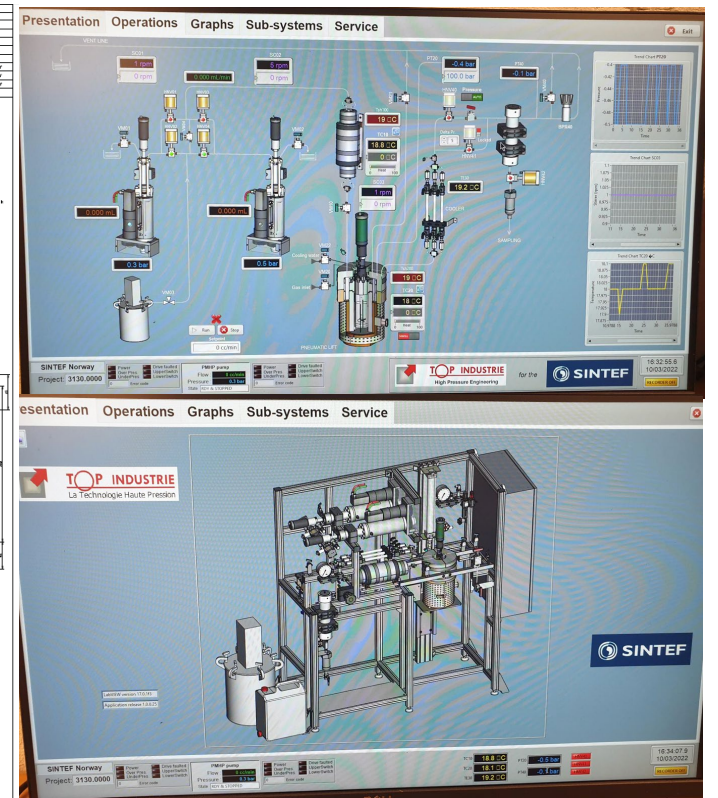
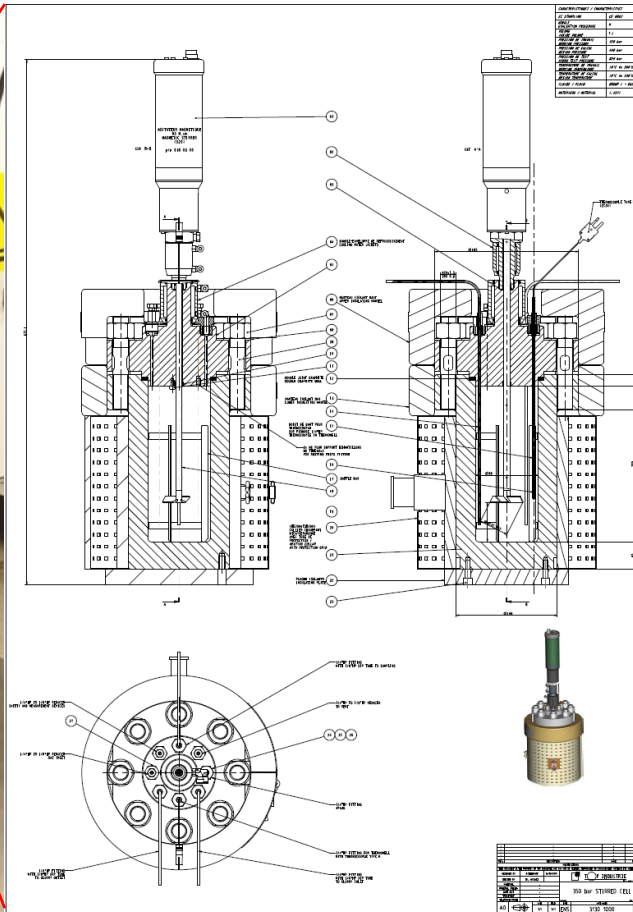
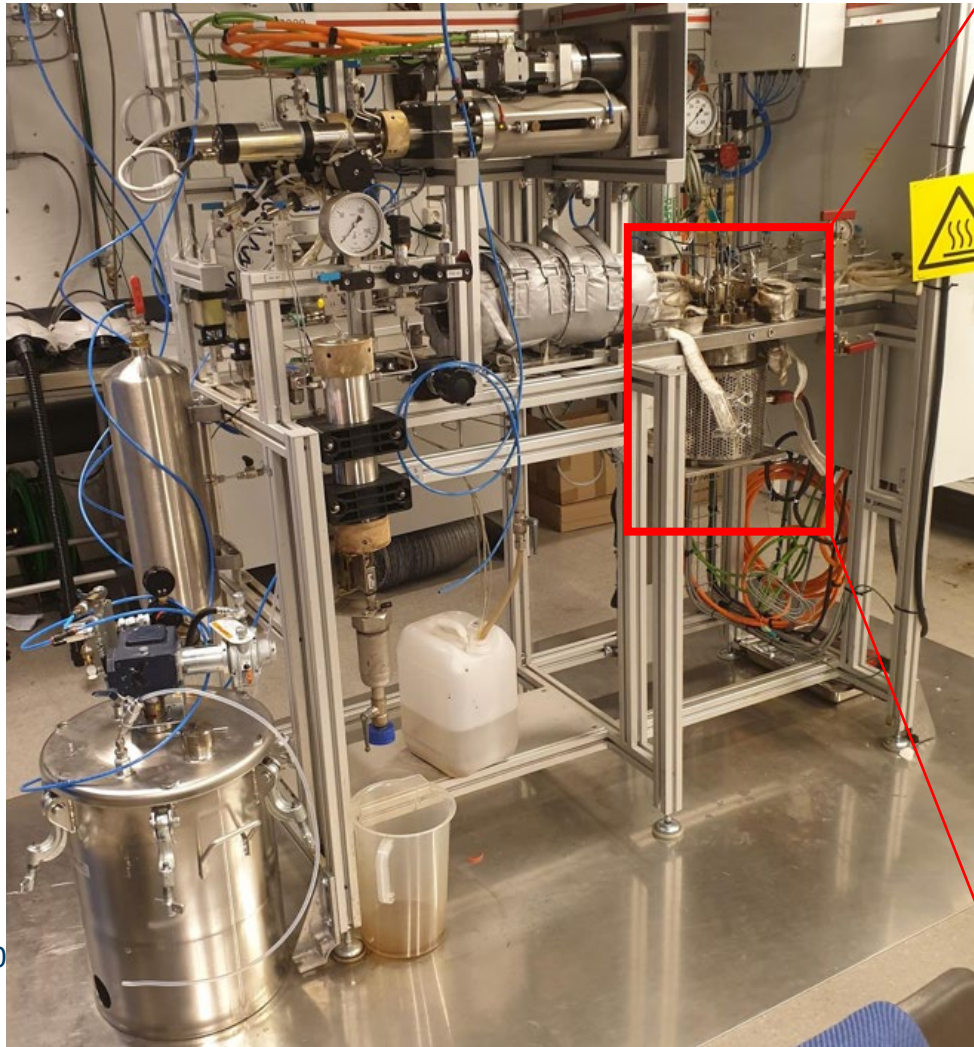
Sample 3, SAF
2507, SDSS
(pitting)



Way forward

- Further post test analysis to prove the 3 winner candidates through a matrix with criteria containing
 - 1) **Corrosion performance** (pitting, cracking, intergranular corrosion, general corrosion)
 - 2) **Material aspects** (forming, weldability, machinability)
 - 3) **Commercial aspects** (availability / delivery-time, price, redundancy of suppliers, common practice)
- Manufacturing of C-rings, rods and nuts from the 3 best candidate materials for
- Pre-loading of these C-rings with strain-gauges
- Exposure in the SINTEF ENERGY reactor with the same simulated water based BL + purging with N₂(g). Measurement of O₂-concentration.

Next step: exposure in SINTEF ENERGY reactor at supercritical conditions in standardised model black liquor



BL2F Partners:



This project has received funding from the European Union Grant Number 884111



Thank you!

Get in touch with the project:

• Coordinator: Prof. Dr. Tero Joronen, Tampere University

• Website: www.bl2f.eu



hello@bl2f.eu



@BL2F_EU



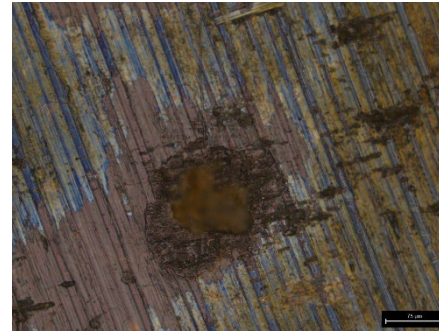
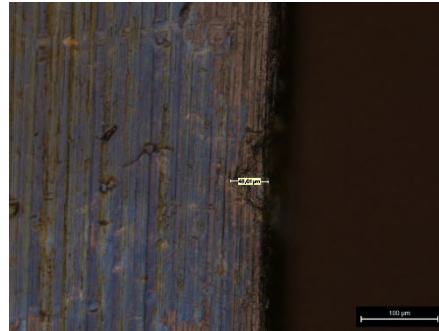
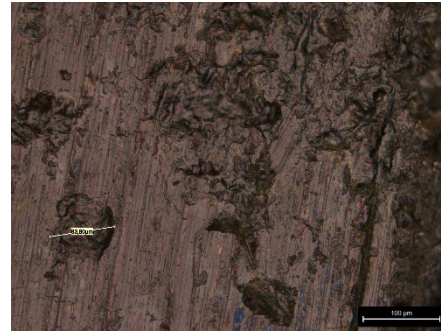
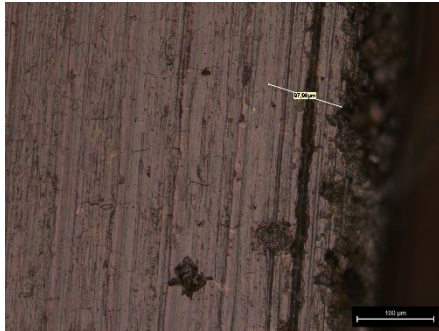
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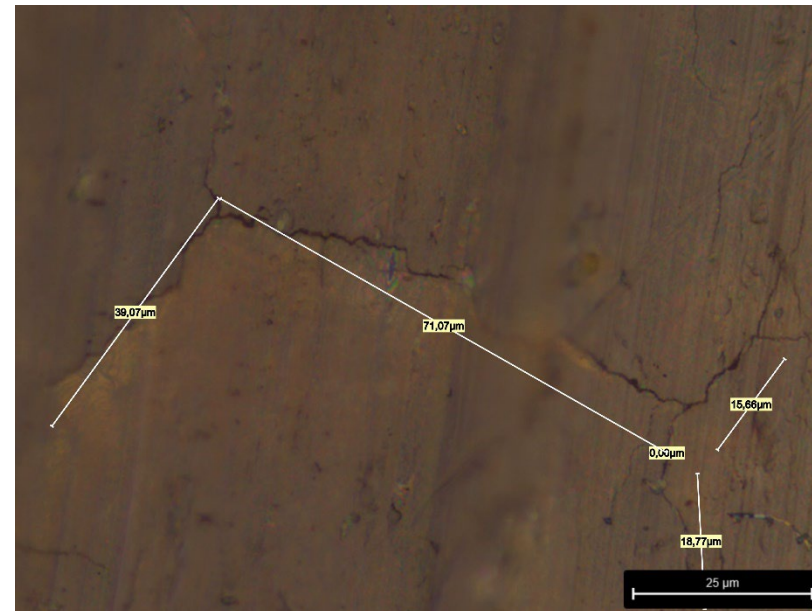
This project has received funding from the European Union Grant Number 884111

Backup

Sample 1 Ti grade 2, post test analysis (failed)

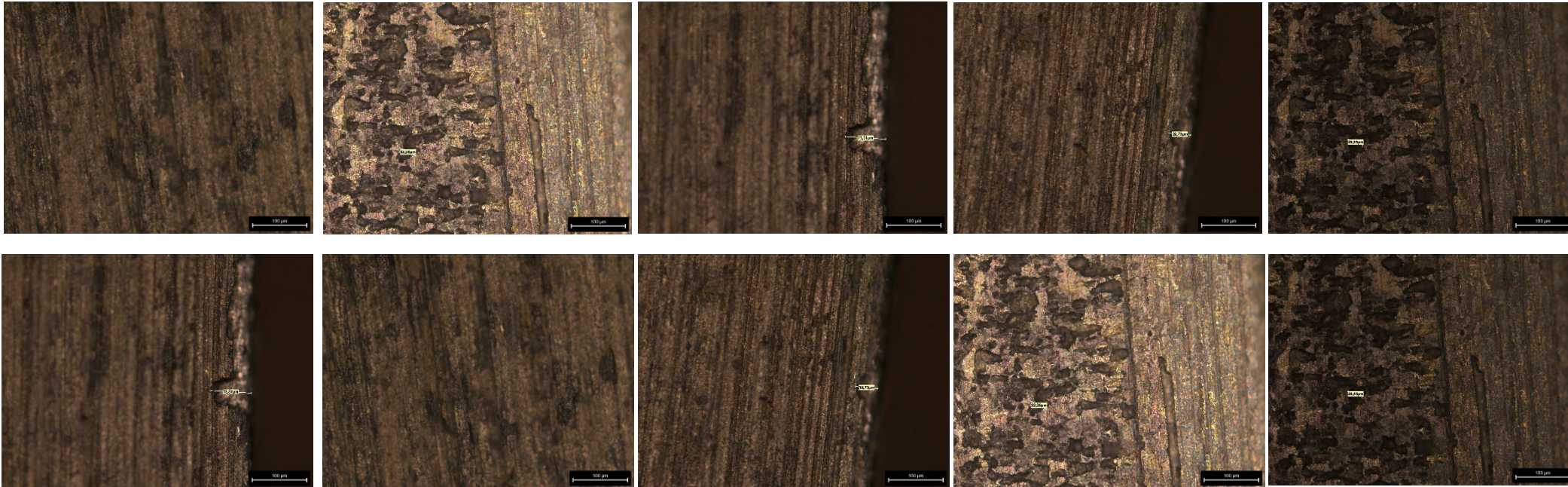
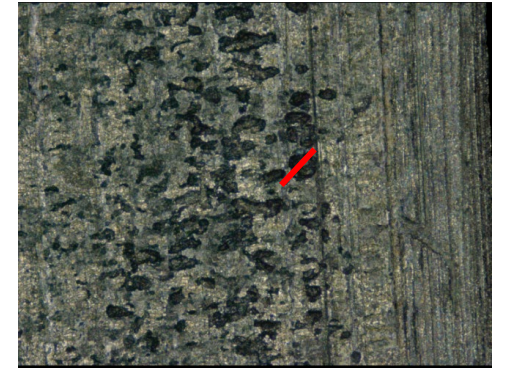
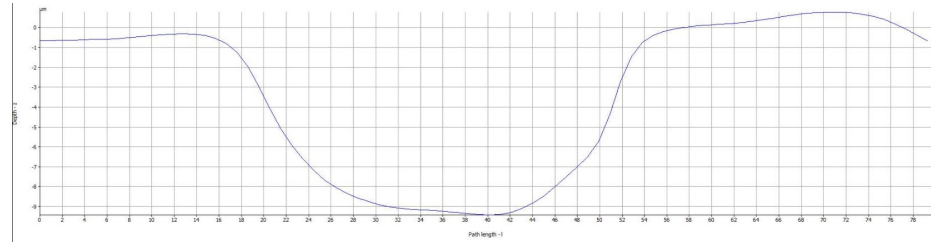
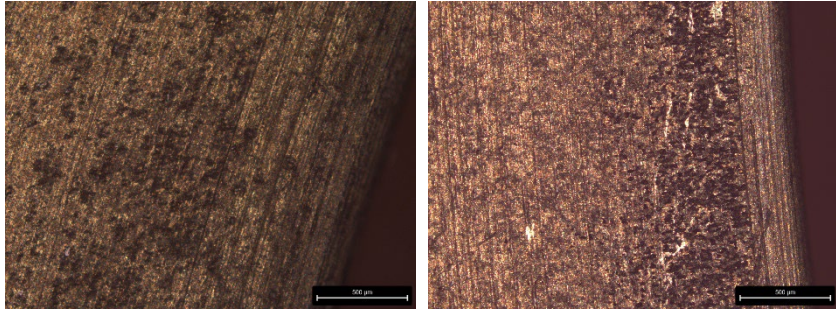


pitting

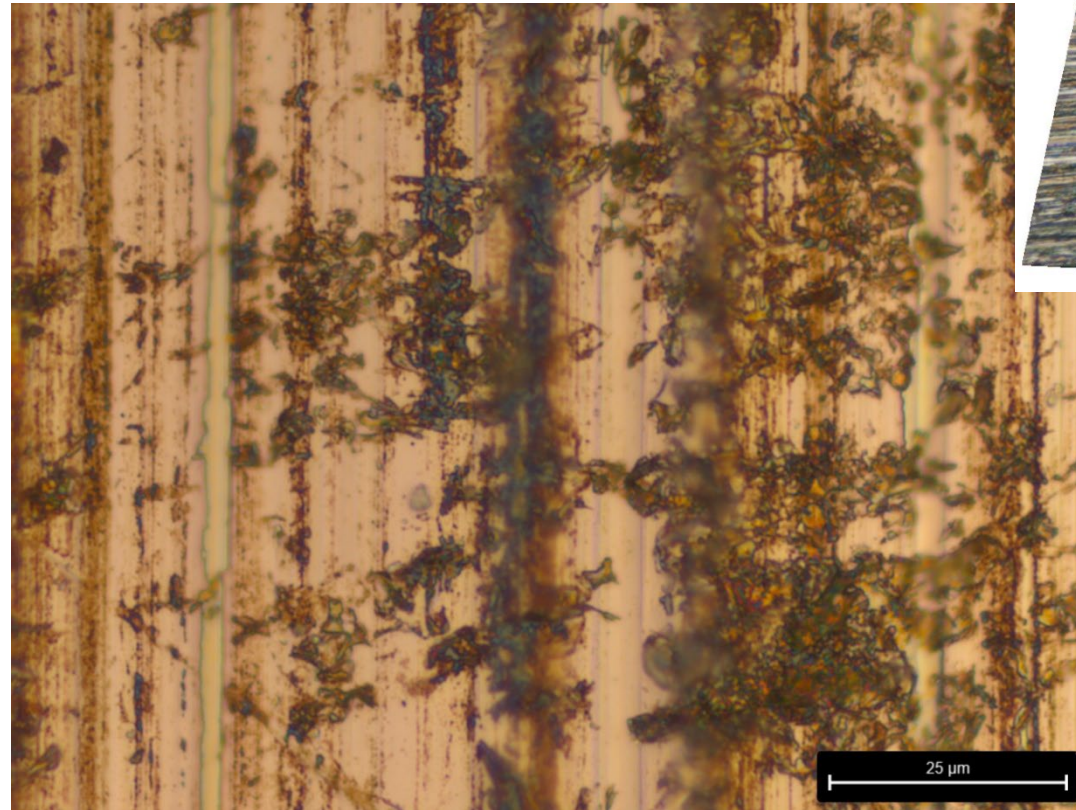
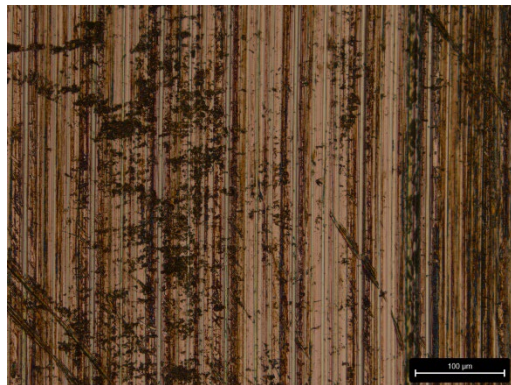
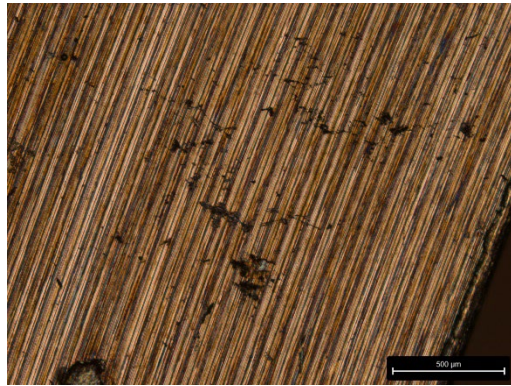


cracking

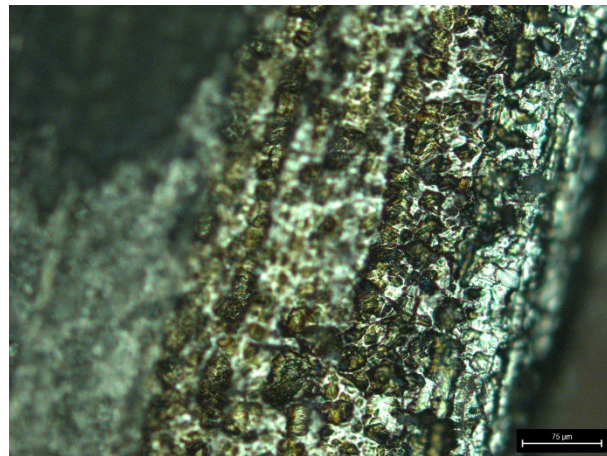
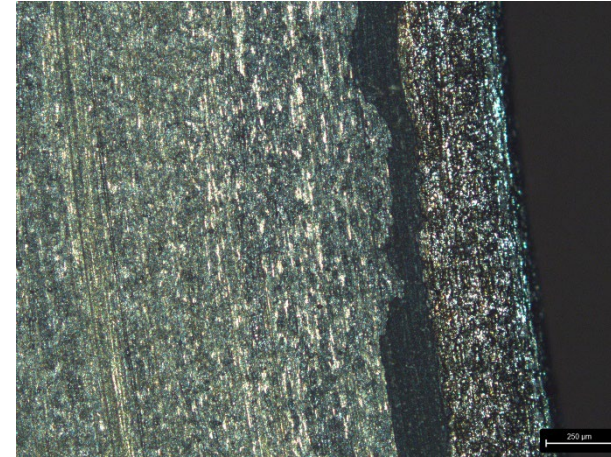
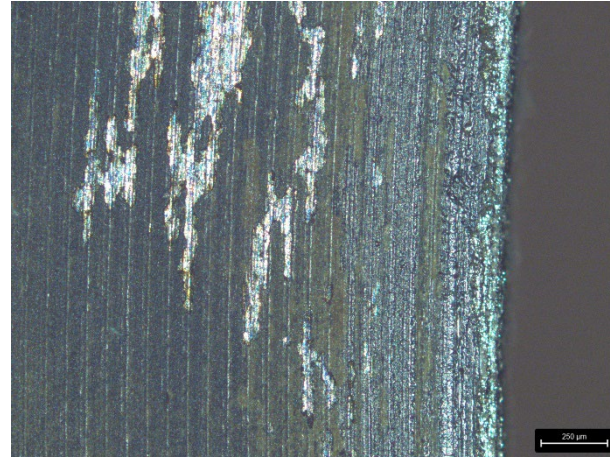
Sample 2, AISI 316, post test analysis (failed)



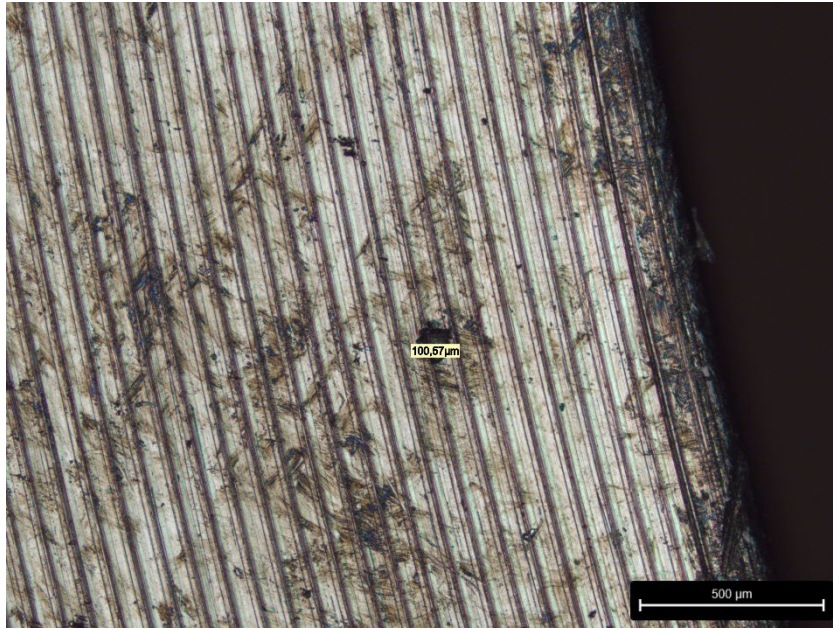
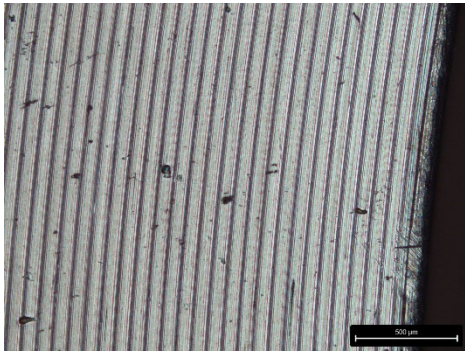
Sample 3, SAF 2507, SDSS, post test analysis (failed)



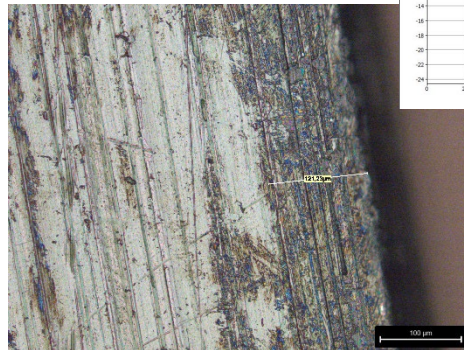
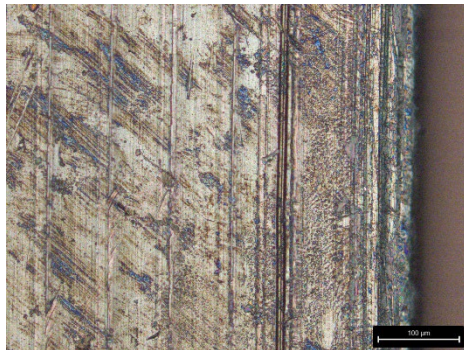
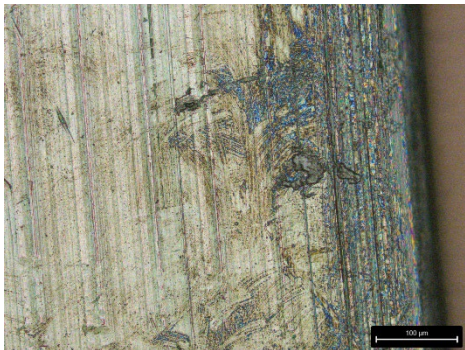
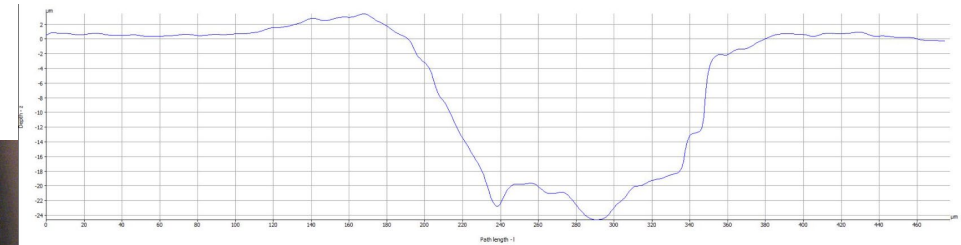
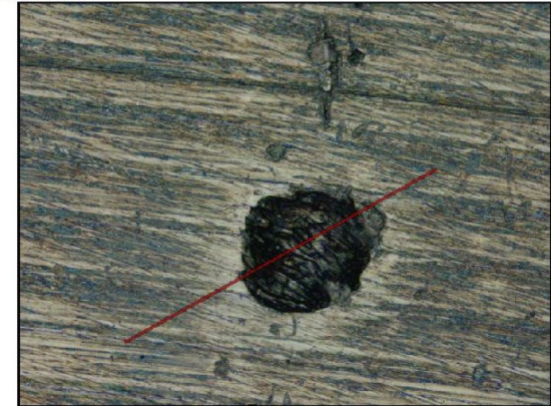
Sample 4, 254SMO (aus), post test analysis



Sample 5, P91 CrMo, post test analysis (passed)

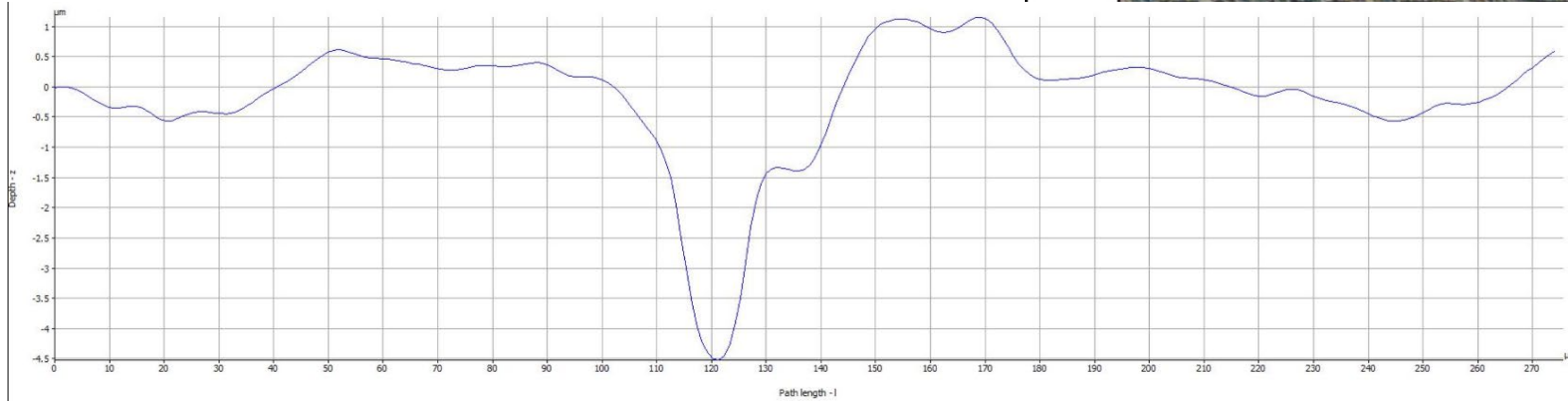


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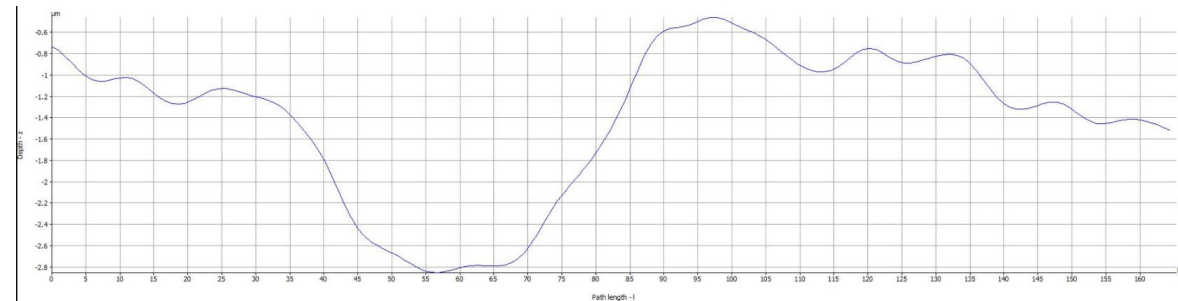
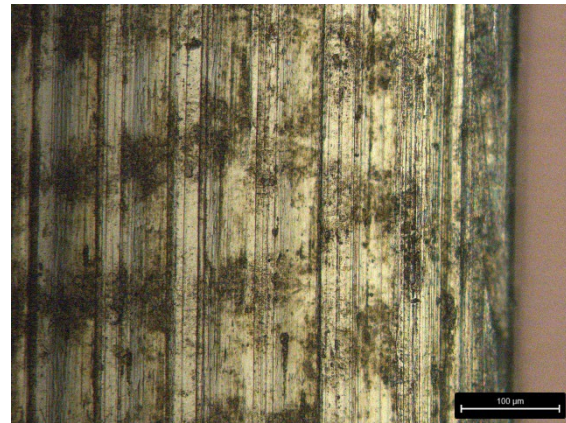
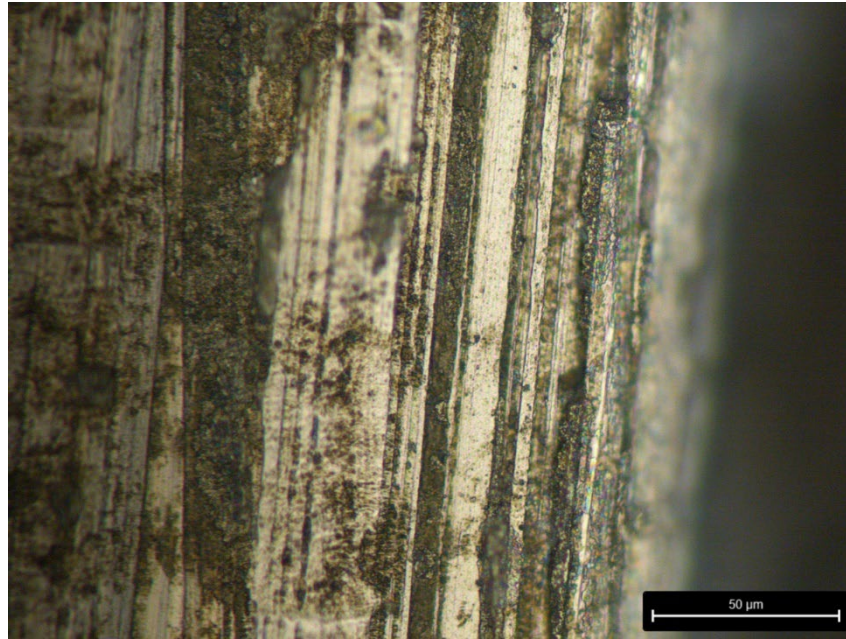
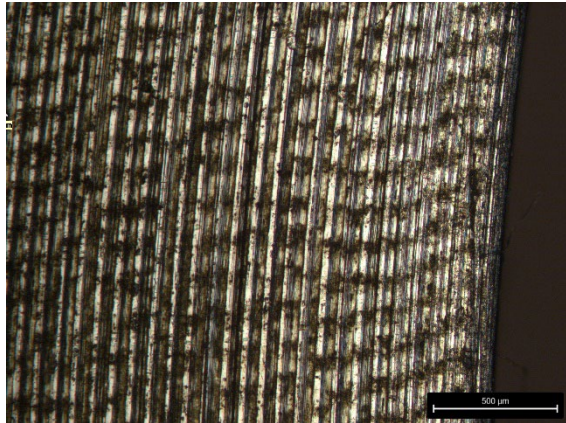


Sample 5, P91 CrMo, post test analysis (passed)

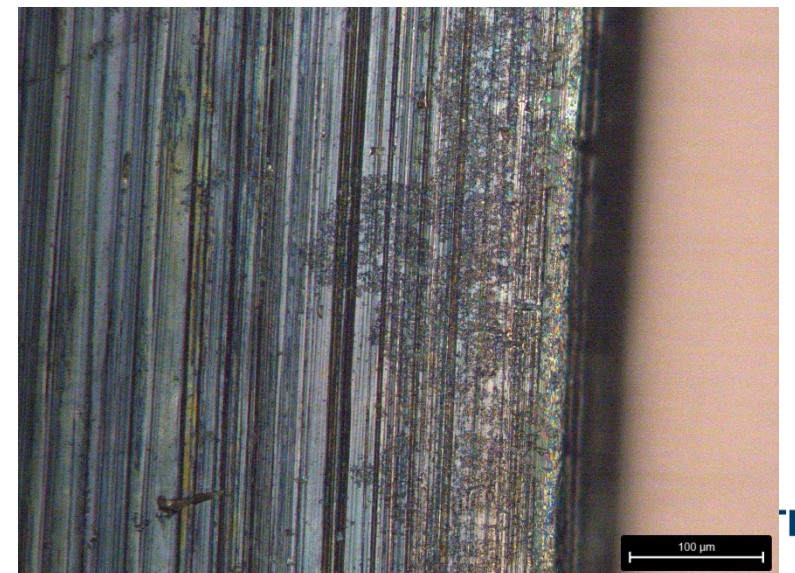
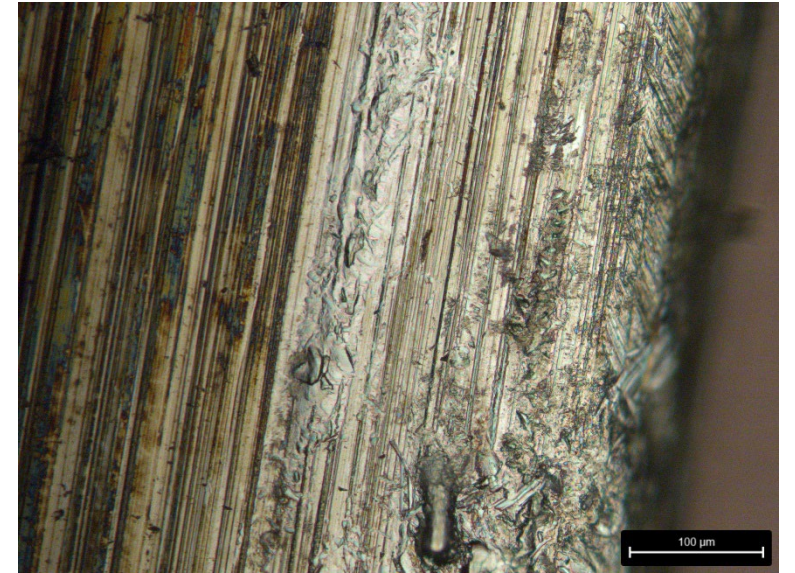
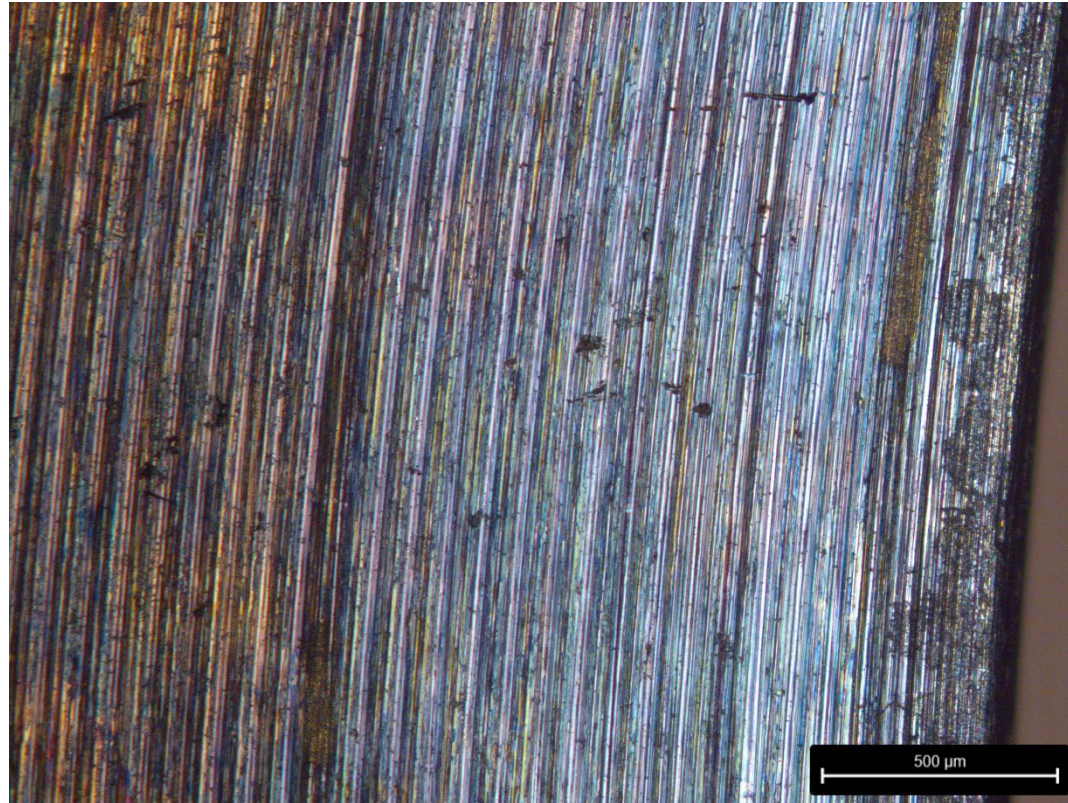
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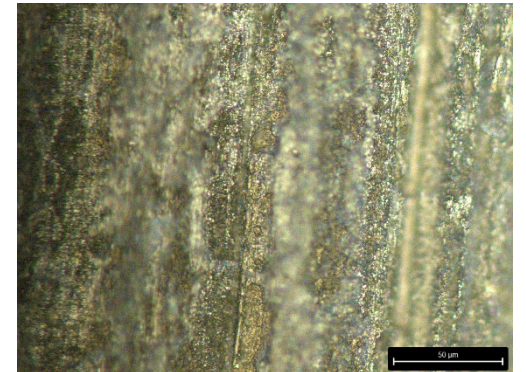
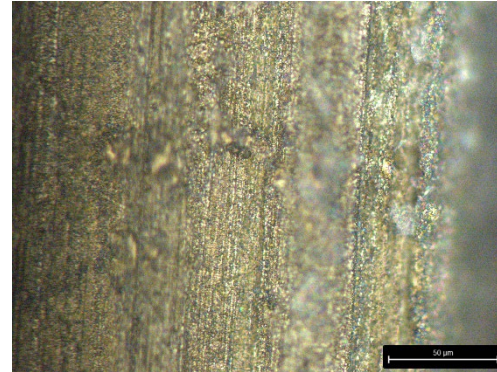
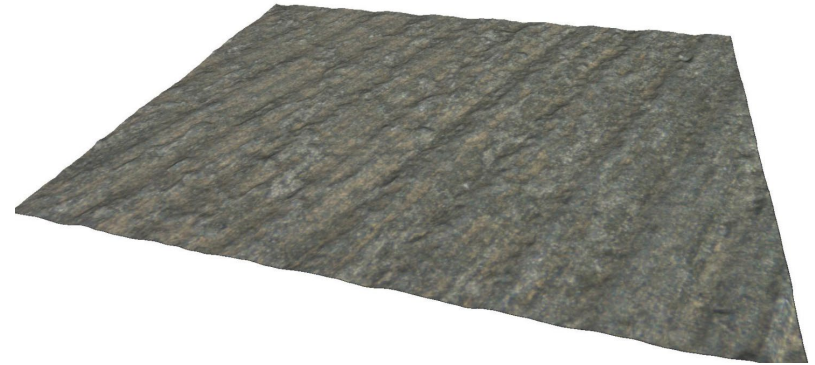
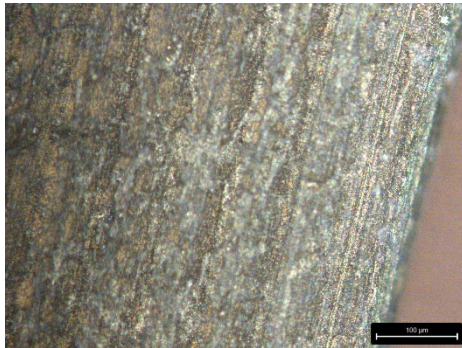
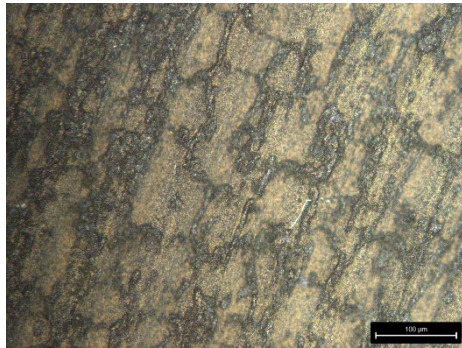
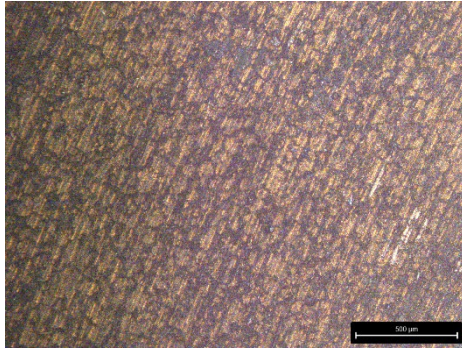
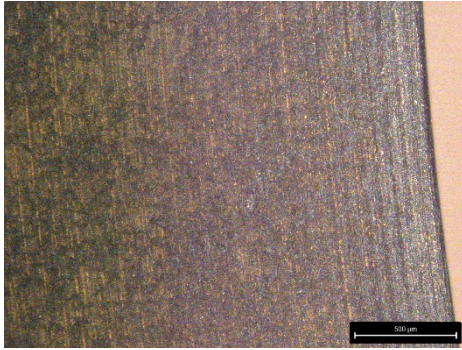
Sample 6, 625 Inconel, Ni-base, post test analysis (passed)



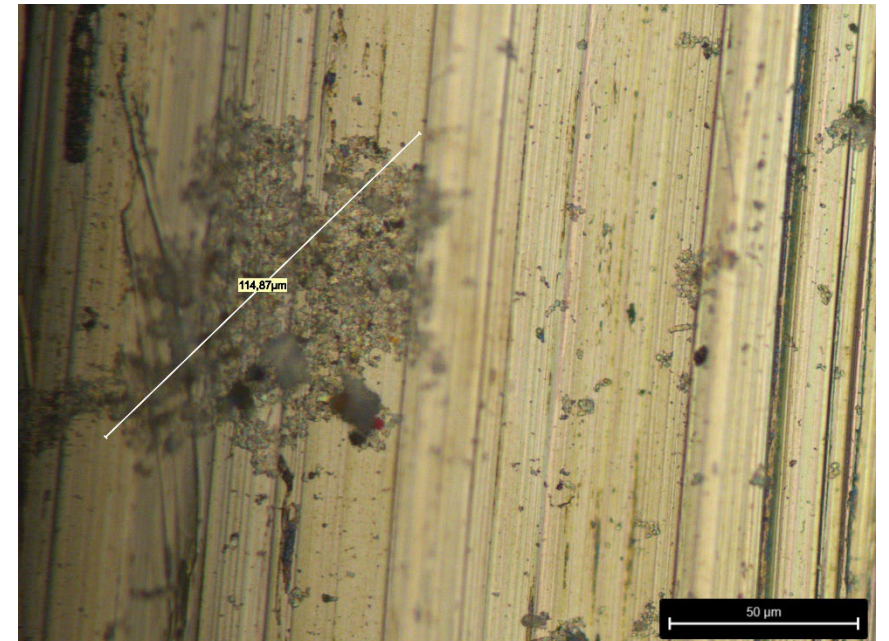
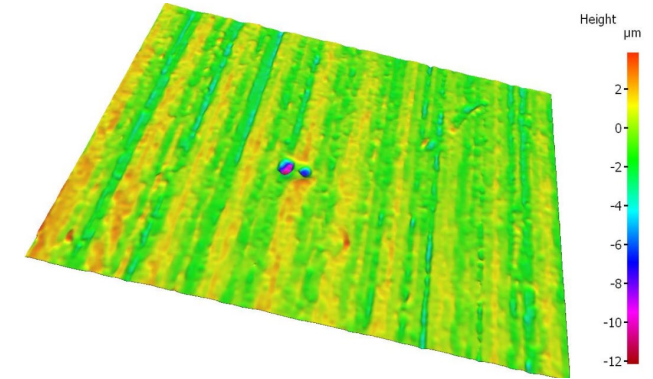
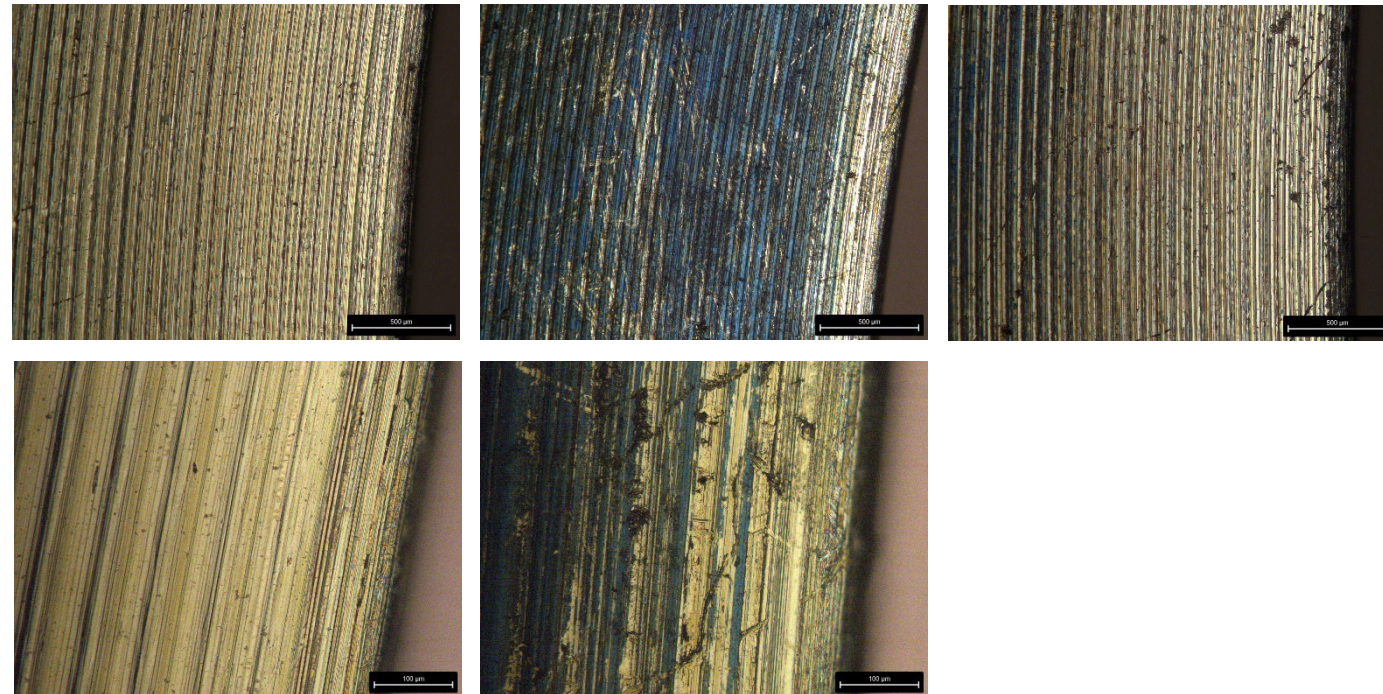
Sample 7, C276 (aus), post test analysis (passed)



Sample 8, 602CA, post test analysis



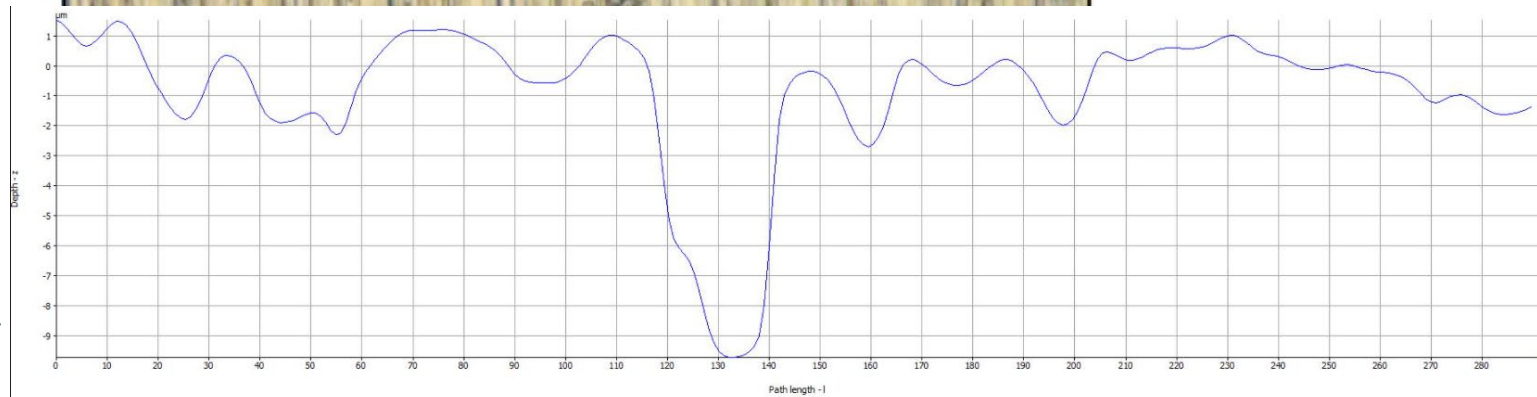
Sample 9, 699XA, NiCrAl, post test analysis



Sample 9, 699XA, NiCrAl, post test analysis

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— 70 år —
1950-2020

Teknologi for et bedre samfunn