KME 708 High temperature corrosion in used wood fired boilers

Part 1 2014-16

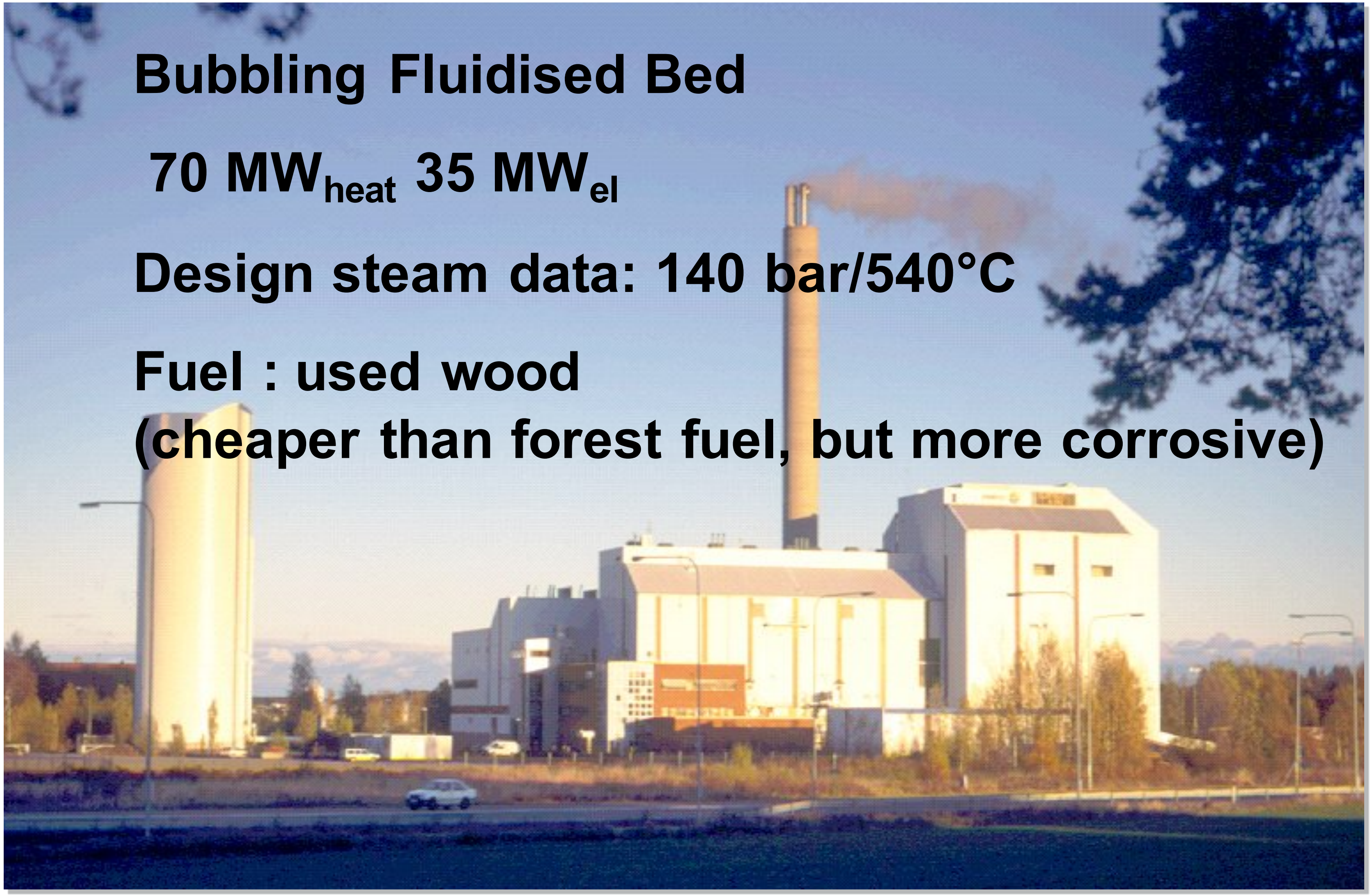
Scope and goals

- The aim is to reduce high temperature corrosion, in a cost-effective way, in heat and power boilers that burn mainly used (recycled) wood.
- Most of the effort will be directed towards furnace walls. The main goal is to reduce furnace wall corrosion.
- A secondary goal is to evaluate materials suitable for superheaters.
- Information on corrosion rates of different materials is obtained from power boilers burning mainly waste wood or similar fuel mixes.
- Different materials including newly developed alumina-forming alloys are tested.
- The effect of fuel quality is investigated.
- The expected results are information on how the corrosion rate varies with the material and fuel mix and a greater understanding of fuel chemistry on the corrosion of furnace.

Participants

- Vattenfall Research and Development: Project management, probe testing
- Vattenfall Nordic Heat: plant owner, corrosion testing, fuel supply
- Sandvik Materials Technology: supply of materials
- Sandvik Heating Technology: supply of materials
- E.ON: plant owner , corrosion testing
- Fortum: plant owner, activities to reduce corrosion
- Foster Wheeler: boiler manufacturer, corrosion testing
- KTH: microscopy, analysis, ThermoCalc
- KIMAB: microscopy, analysis – take over after KTH
- SP: fluidised bed reactor – fuel quality testing

Testing performed in Idbäcken line 3 (CHP) in Nyköping



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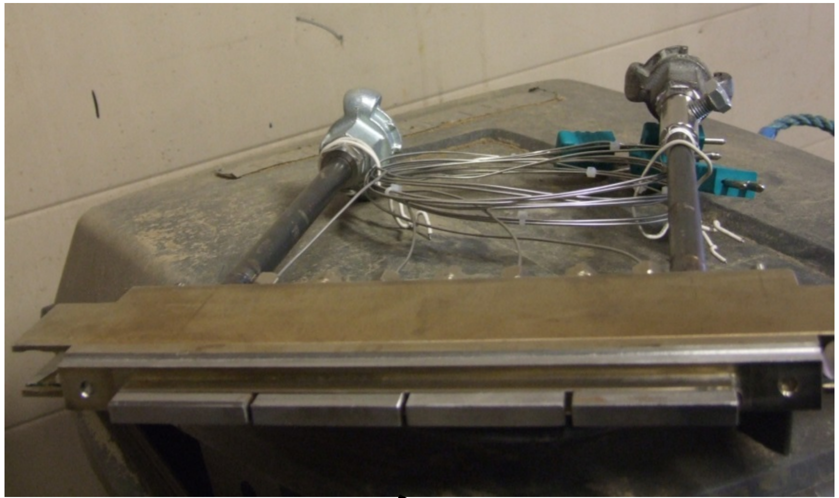
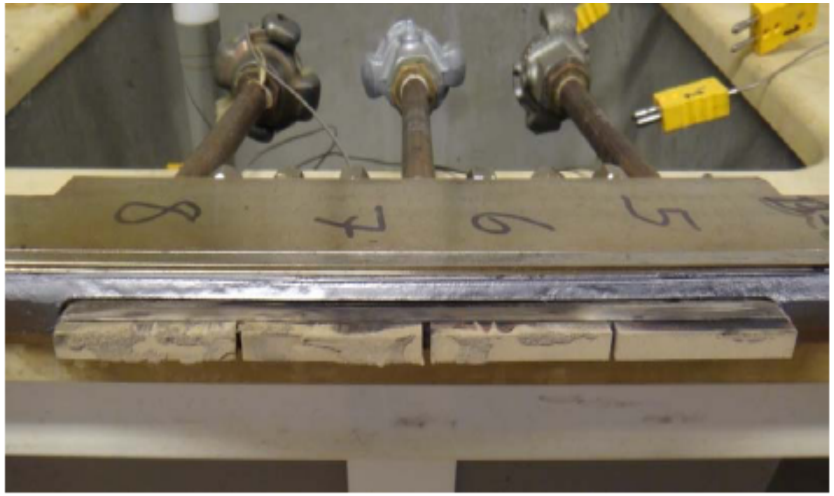
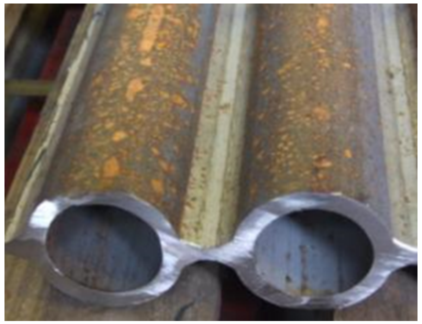
Corrosion probe testing – air-cooled furnace wall probe







Vattenfall's in-house probe. Sits between the tubes in the furnace wall. 4 specimens on each probe. Thermocouple in each specimen for individual temperature measurement. Control temp 350 and 400°C

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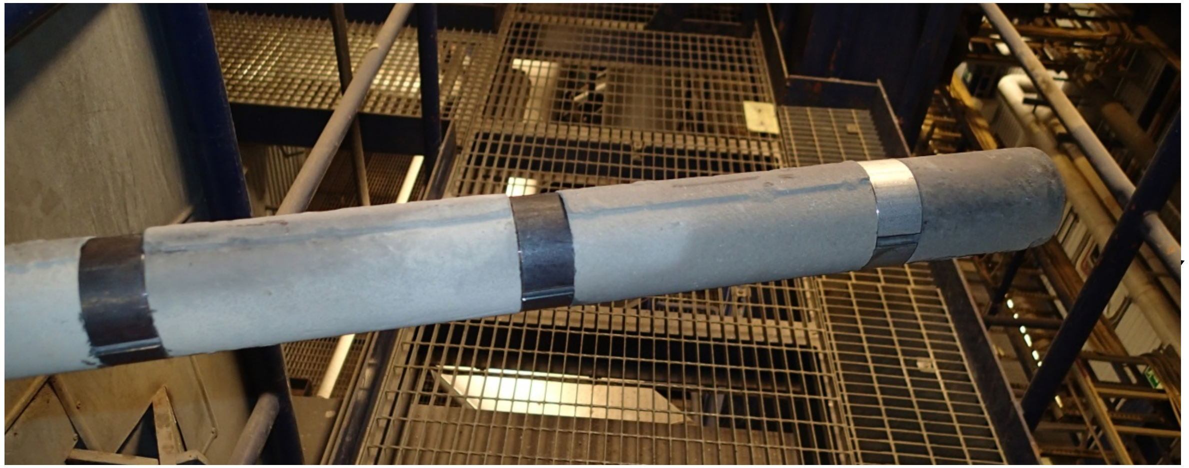
Deposit probe testing in SH region

Air cooled probe

Three rings at temperatures 350, 450, 550°C
(equivalent to steam temp ~520°C)



- Weigh ring before and after exposure for deposit growth rates.
- Analyse deposit with SEM for info on corrosion risk

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Chemical composition of investigated alloys in Nyköping

Name	Chem comp wt%	Notes
16Mo3	Mn 0.55, Si 0.22, Mo 0..3.	
13CrMo44	Cr 0.9, Mn 0.8, Si 0.22, Mo 0.5	
153MA	Cr 18.5, Ni 9.5, M0 0.22, Mn 0.62 + Ce	Outokumpu
253MA	Cr 21, Ni 11, Mo 0.2, Mn 0.4, Ce 0.03	Outokumpu
304L	Cr 18, Ni 8, Mo 0.3, Mn 1.6	Outokumpu
3R12/TP304L	Cr 18, Ni 10, Mo 0.3, Mn 1.2	Sandvik
25-20/310S	Cr 25. Ni 20, Ce 0.004	Outokumpu
San 28	Cr 27, Ni 31, Mo 3.4, Mn 1.7, Cu 1.0	Sandvik
Alloy 625 (standard)	Ni 63, Cr 21 Mn 0.35, Si .02, Mo 9.0, Ti .25, Al .19, Nb+Ta 3.5	From welded tube
Alloy 625 (Harald Pihl)	Ni 60, Cr 22, Mo 9, Nb 3.5, Fe 4, Mn 0.06, Ti 0.28, Al 0.17, Ta 0.01	Deutsche Nickel
APMT	Cr 21, Al 5, Mo 3	Sandvik
Alkrothal 14	Cr 14, Al 4.3, Mn 0.15, Si 0.13,	Sandvik

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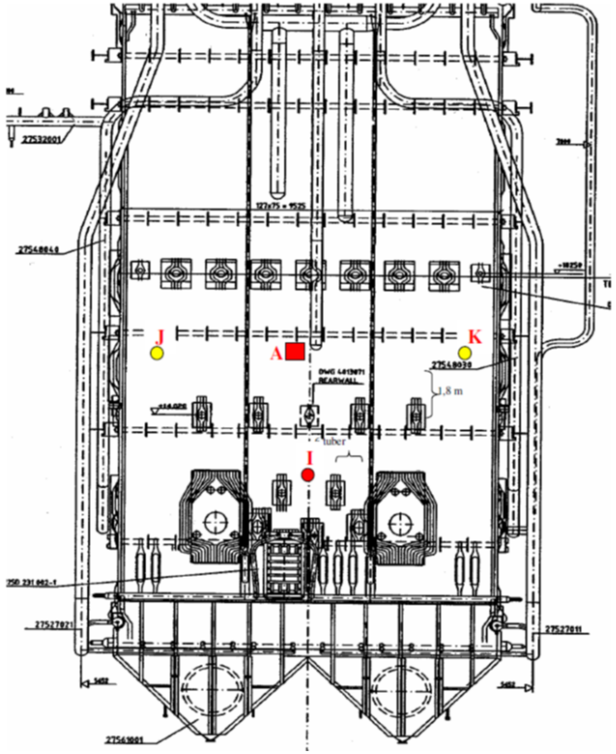
Corrosion testing on back wall



Corrosion testing previously made in centre position A on back wall. This hole is not easily accessable on outside of boiler. Safety issues. Two new testing holes made between A and J on back wall.

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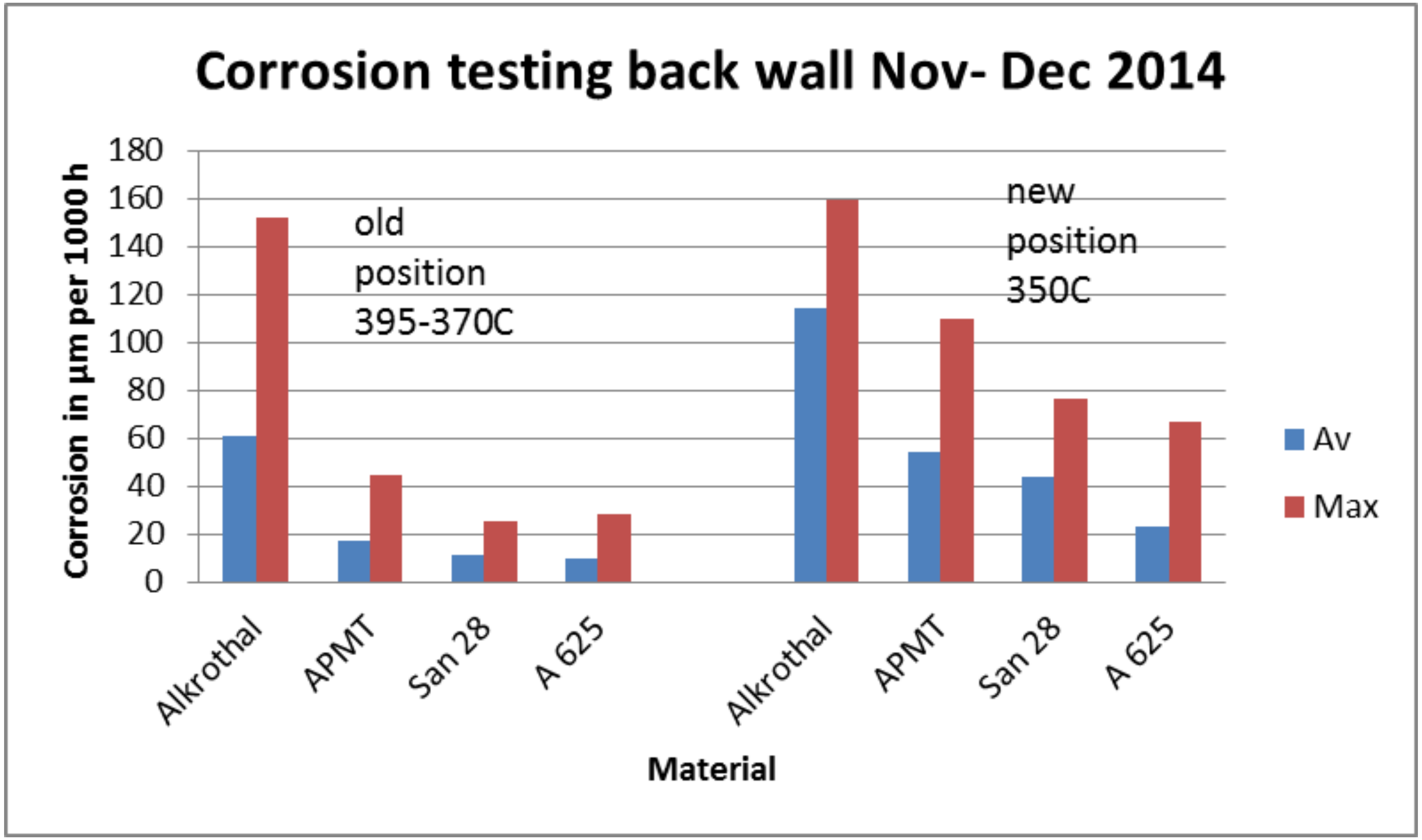
1000 h corrosion testing autumn 2014. Nov-Dec



APMT has surface oxide removed. Corrosion seems higher in new position.

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Fuel quality testing Spring 2015

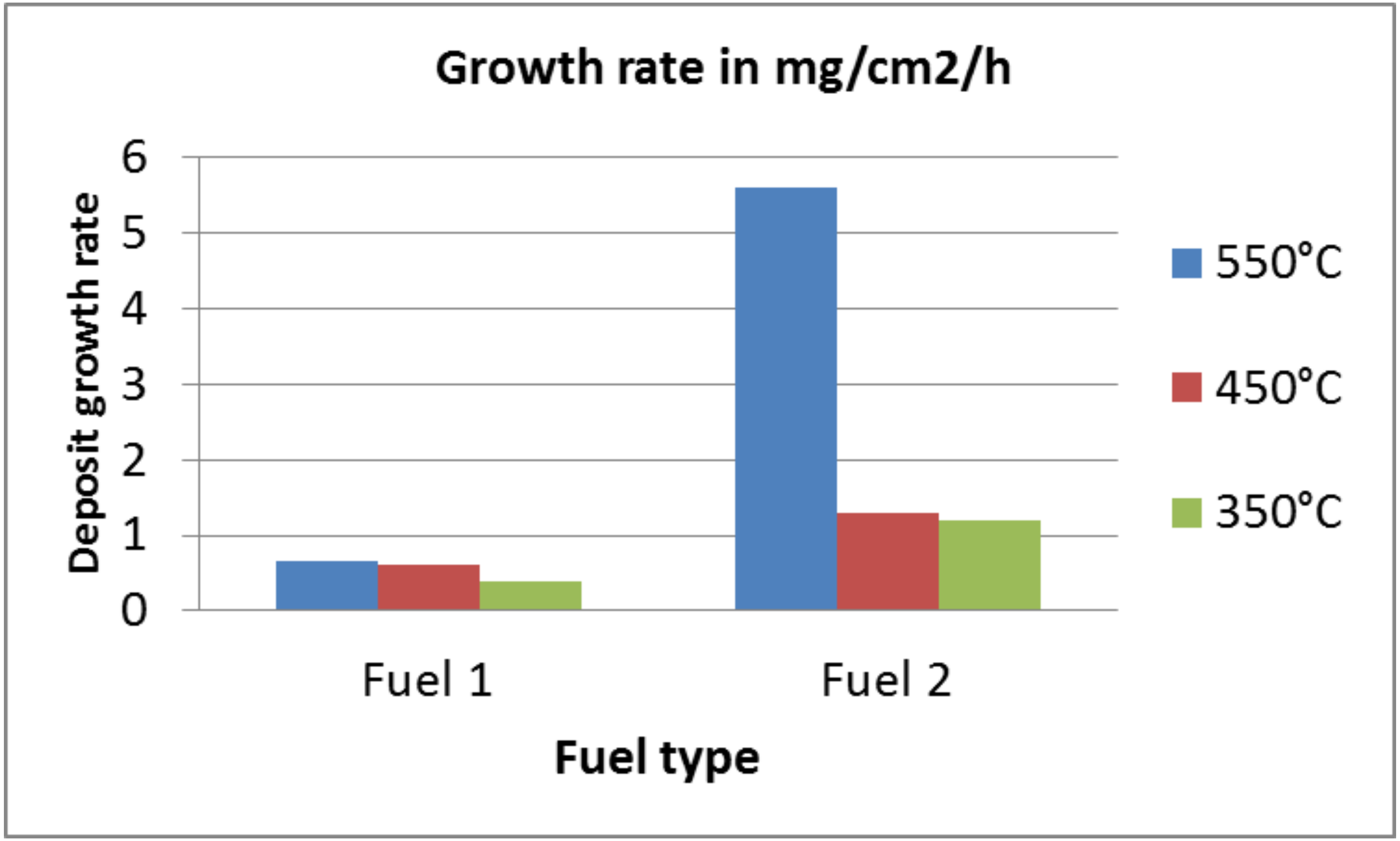
- Two fuel grades. 2 x 2 weeks tests. 2 wall probes each test, 350°C and 400°C. 2x16Mo3 and 2x Alloy 625 on each probe.
- Also 3 h deposit probe tests near superheaters

	Moist-ure %	Ash % d.s.	Cl % d.s.	S % d.s.	N % d.s.	K ppm d.s.	Na ppm d.s.	Pb ppm d.s.	Zn ppm d.s.
Used wood 1	34.9	6.2	0.13	0.07	1.1	1141	1783	36	390
Used wood 2	22.3	6.9	0.17	0.07	1.5	927	1019	119	111

UW 1 – low Cl, low Pb, higher Zn. UW 2 - high Cl, high Pb, lower Zn

These fuels have been supplied to SP for lab. testing

Fuel quality - 3 hour deposit testing near SH2 position



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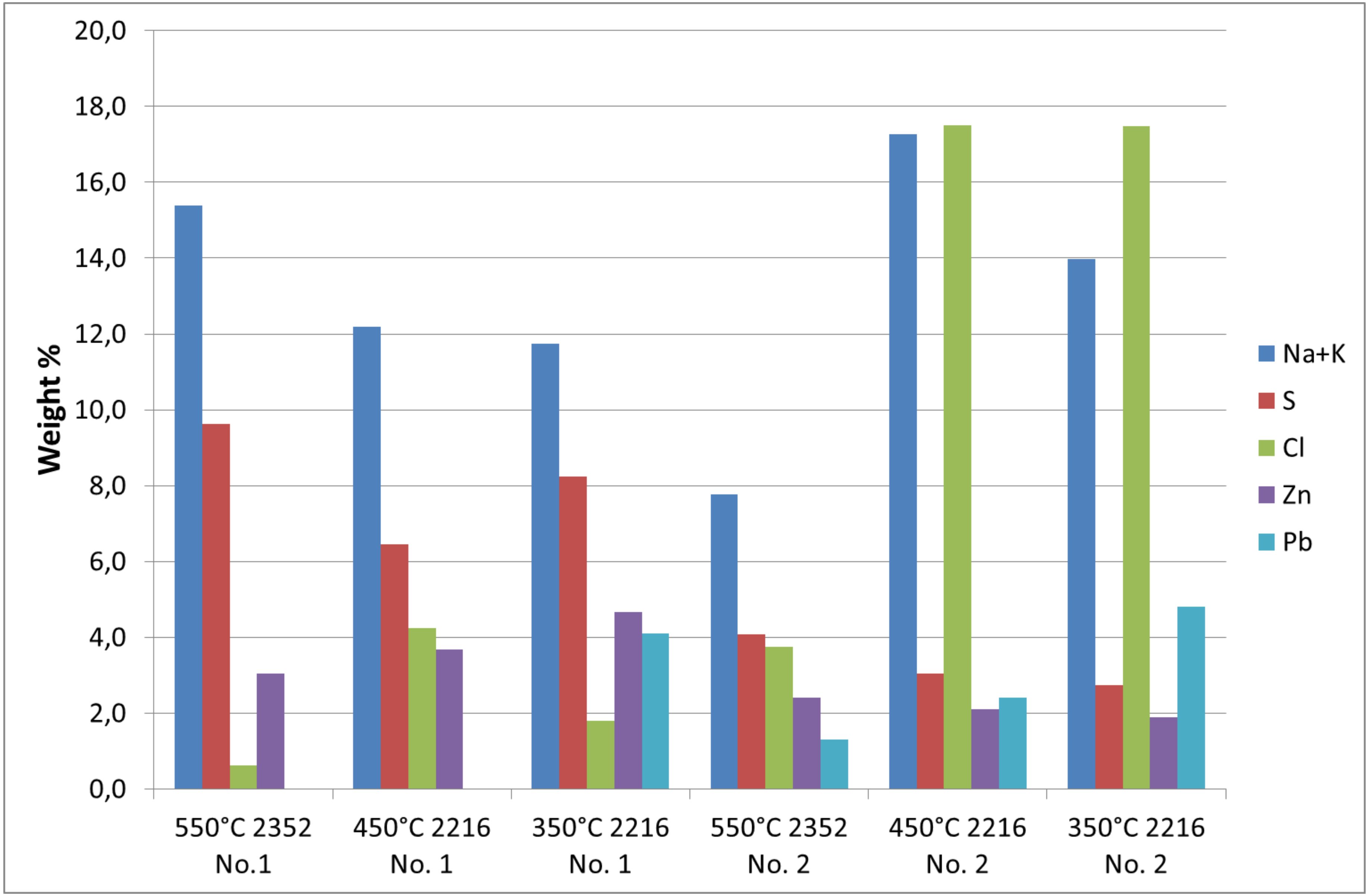
Fuel quality - 3 hour deposit testing near SH2 position



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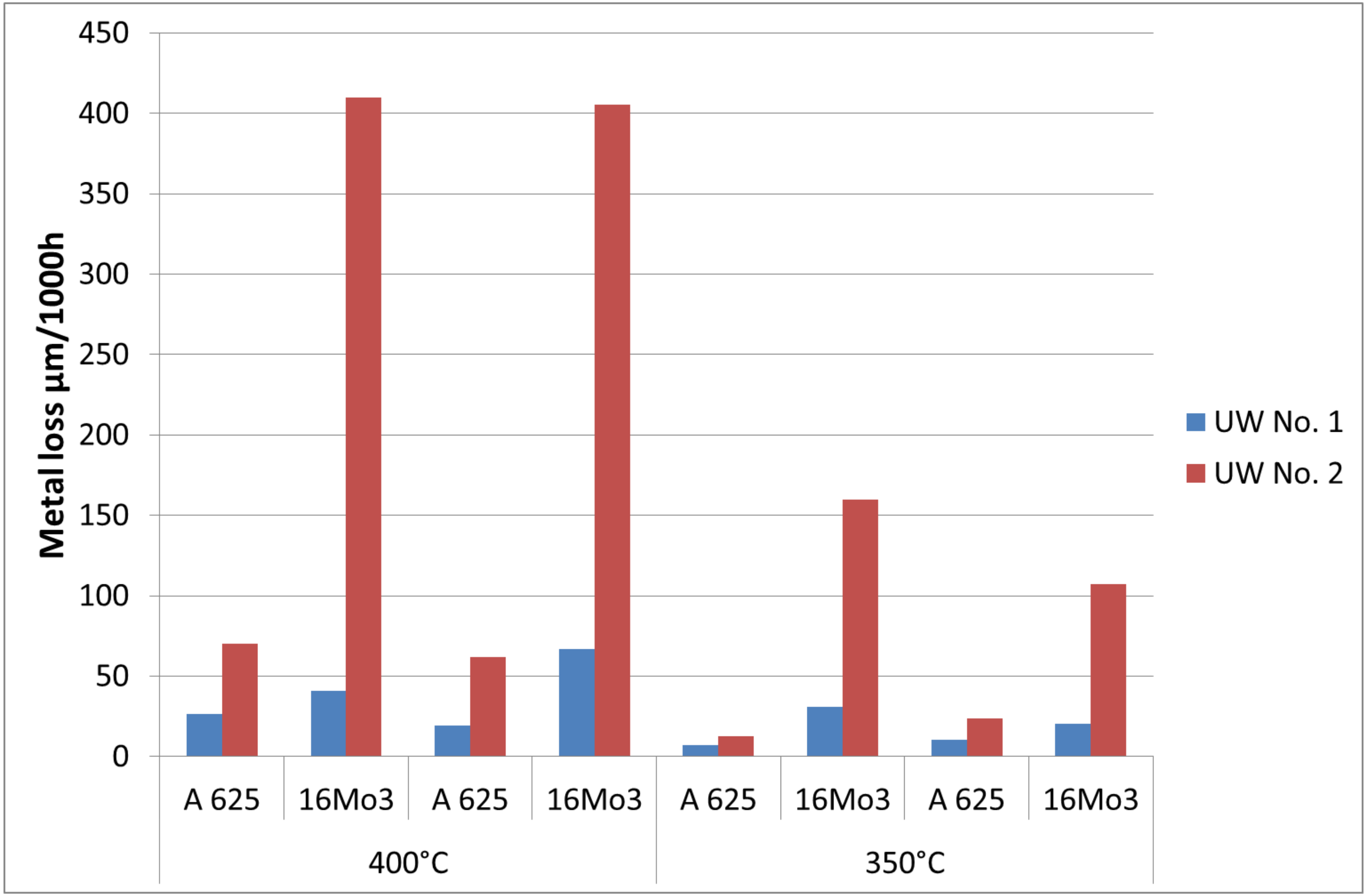
Fuel quality – Quick look at 2 week wall corrosion tests



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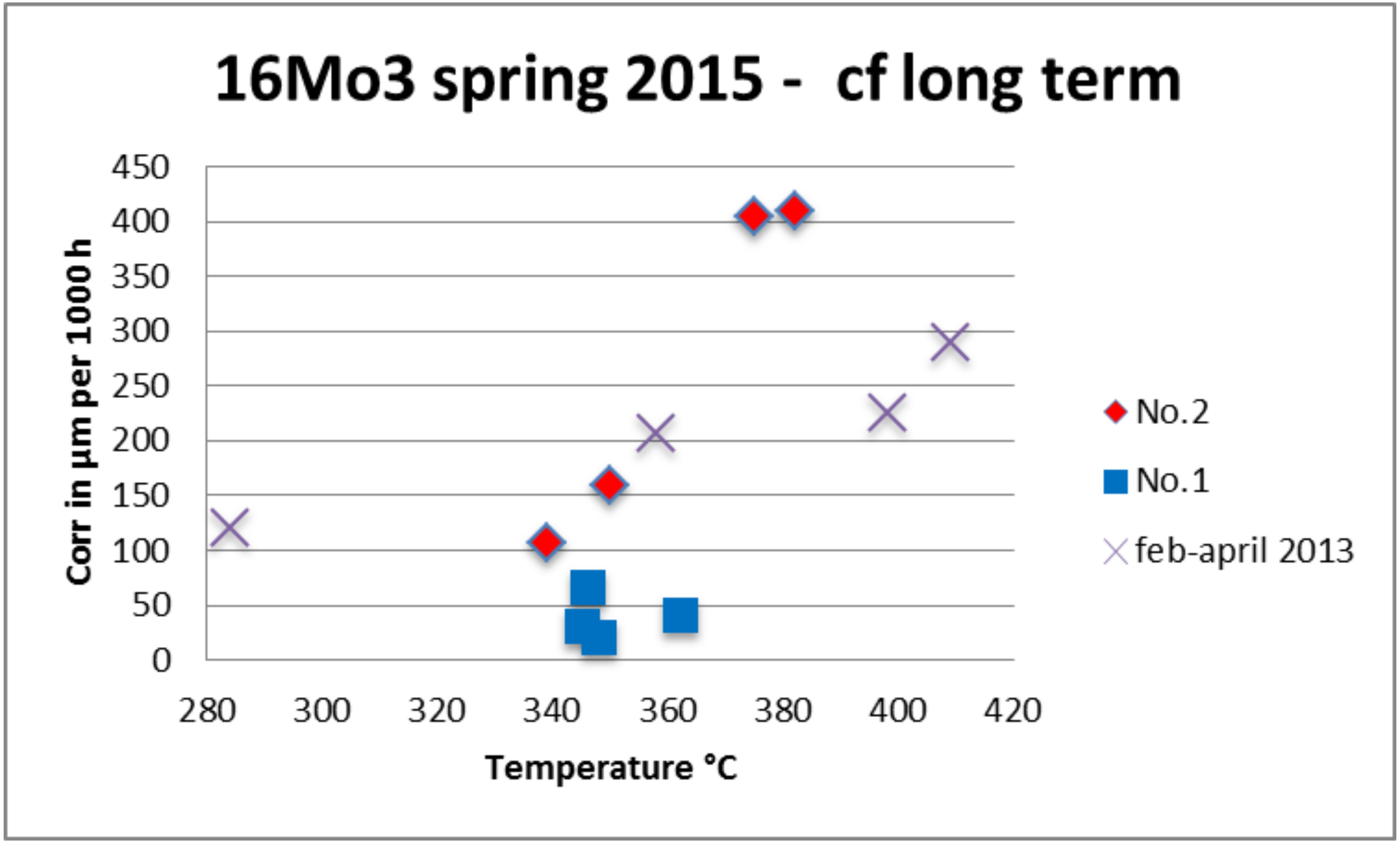
Fuel quality testing Spring 2015



Fuel no. 2 (High Cl and Pb) causes more corrosion on 16Mo3 and is more temperature sensitive.

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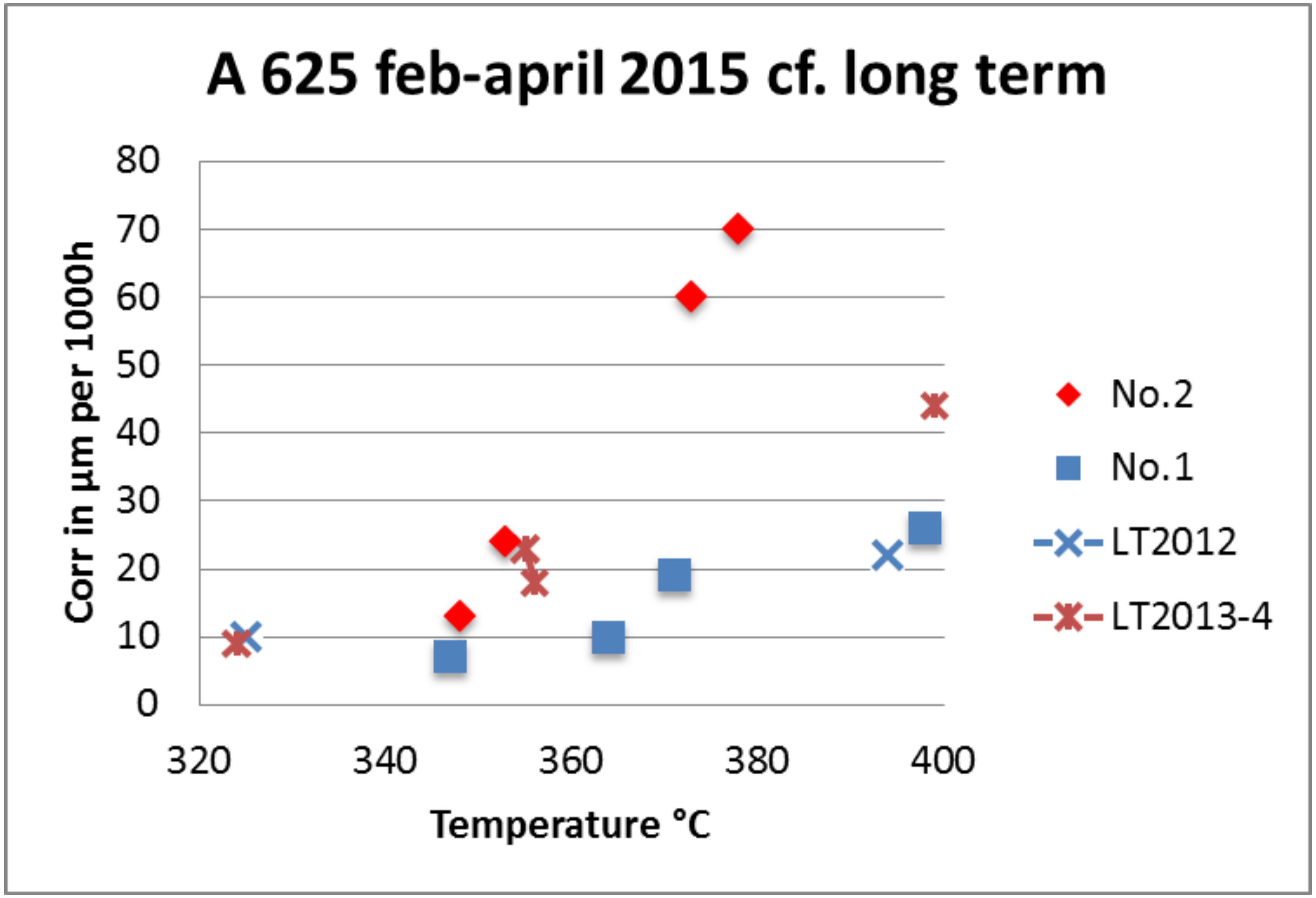
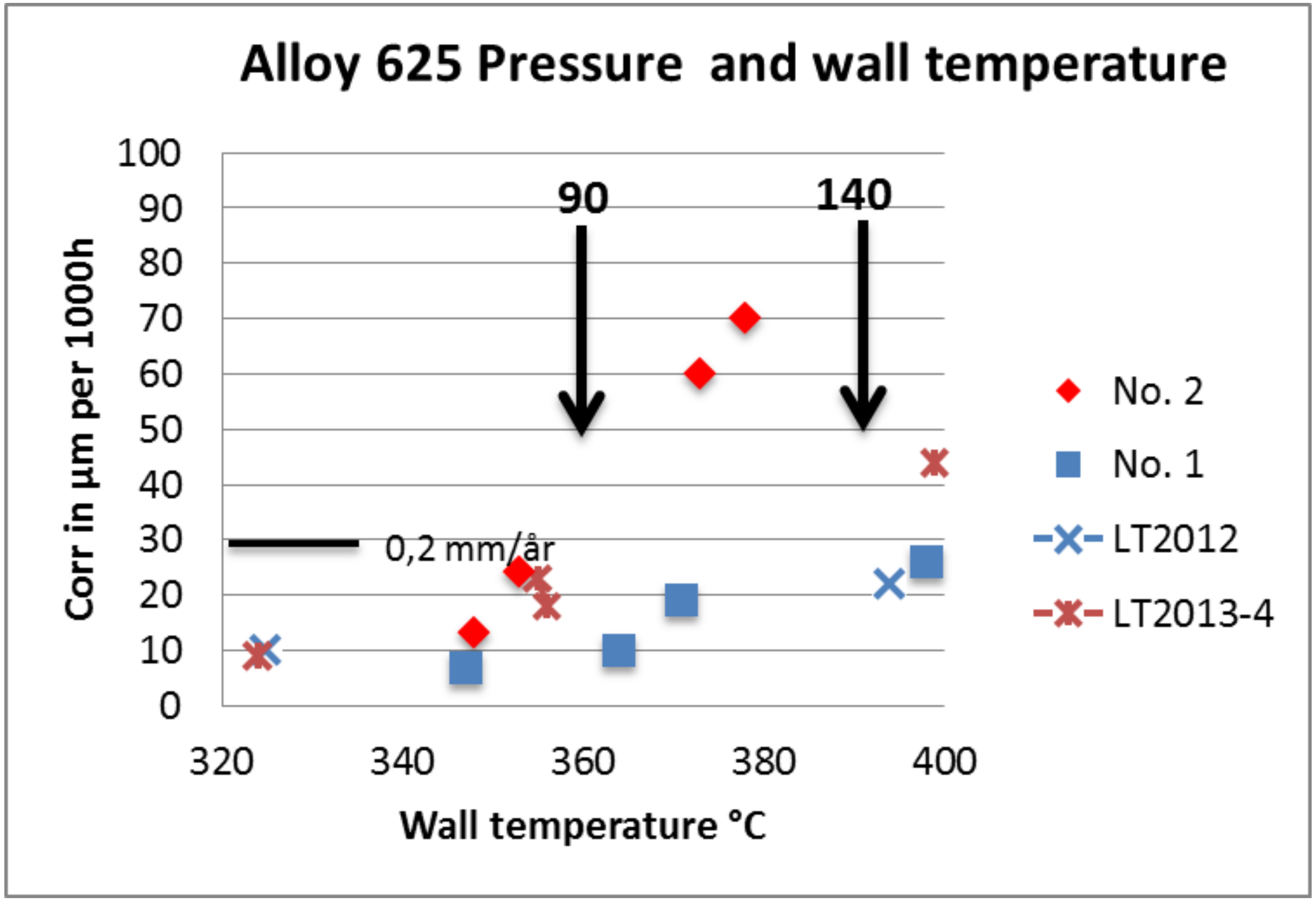
Fuel quality testing Spring 2015



Fuel no. 2 (High Cl and Pb) causes more corrosion on Alloy 625 and is more temperature sensitive

Wall temperature and pressure



Reducing final pressure from 140 to 90 bar reduces the wall temperature from 390 to 360°C. (Water temp from 340 to 310°C).

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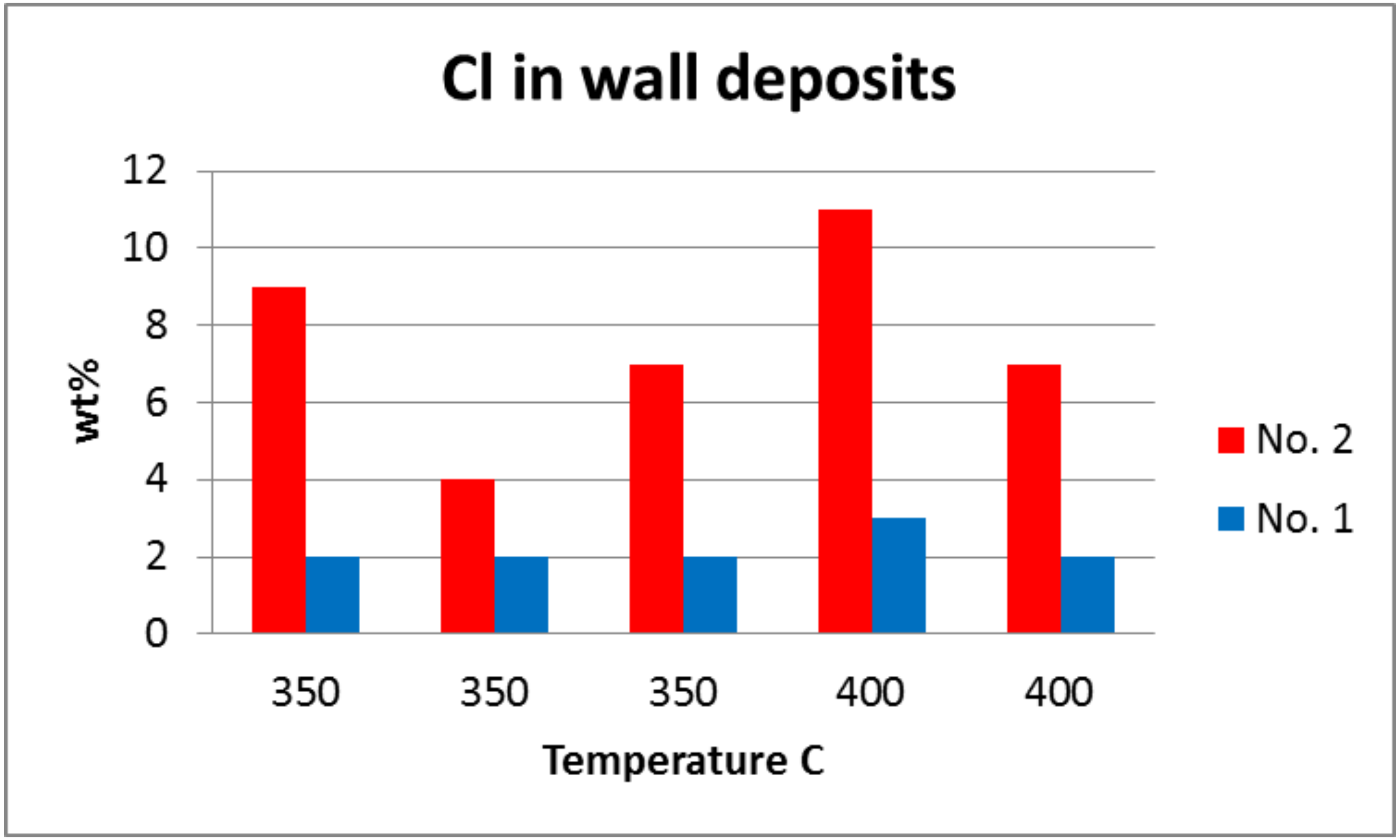
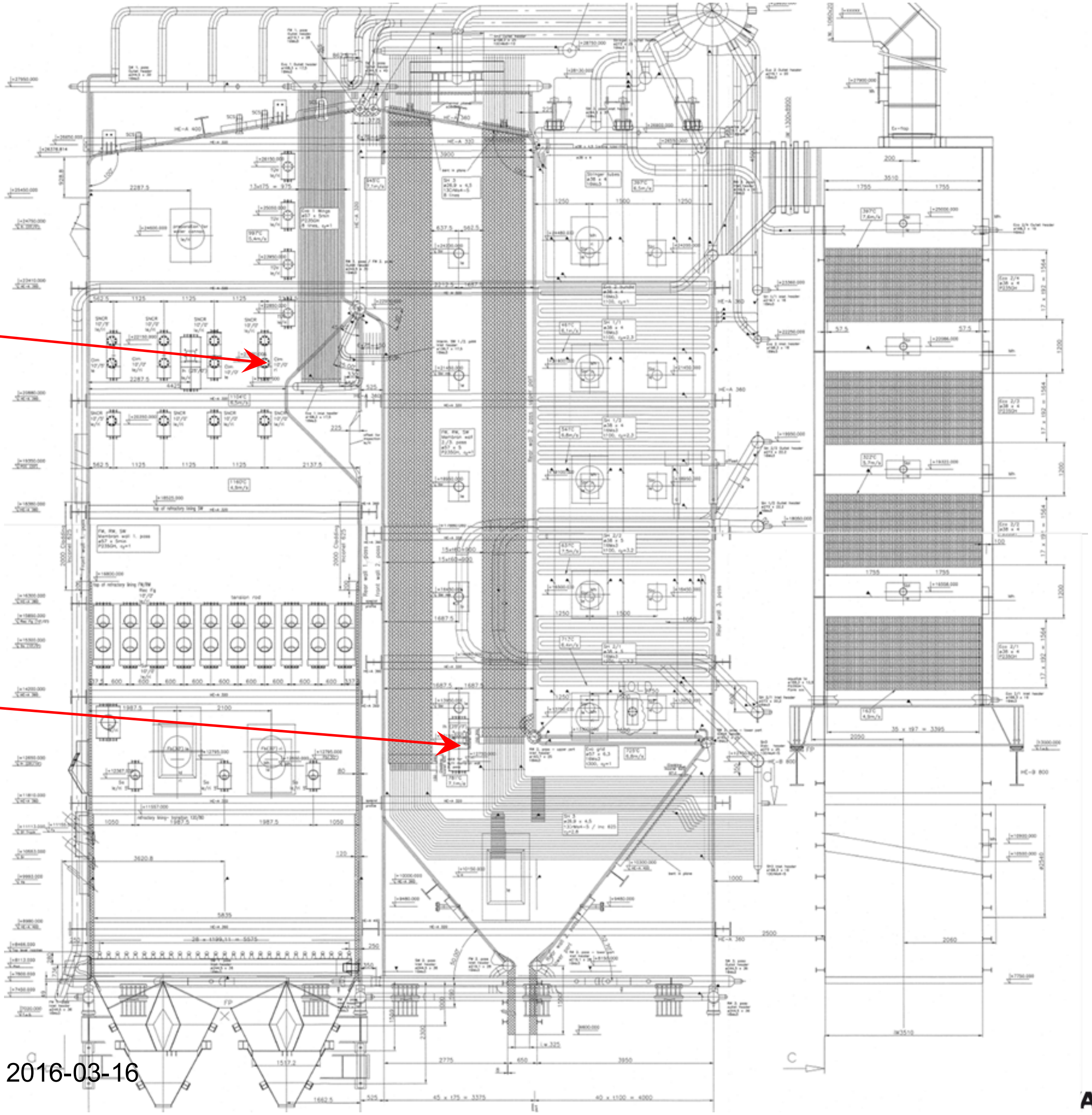
Fuel quality testing Spring 2015



More Cl in wall deposits with high Cl fuel (no.2). Similar results to 350C SH deposit probe.

E.ON: Blackburn Meadows BFB 97MWth 82 bar, 487°C



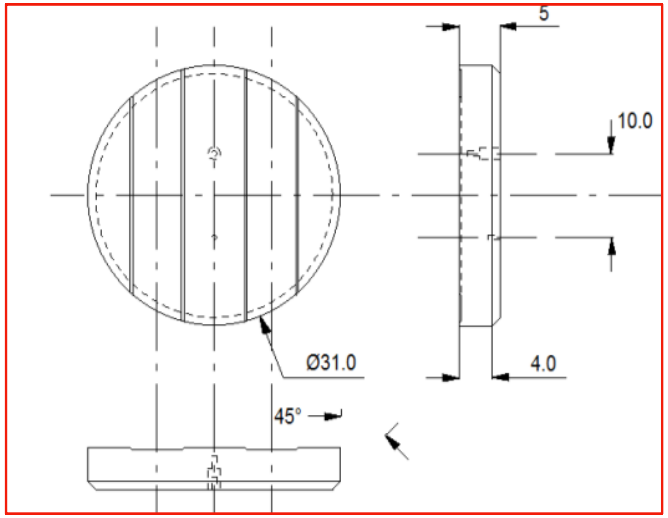
Furnace Wall Probes

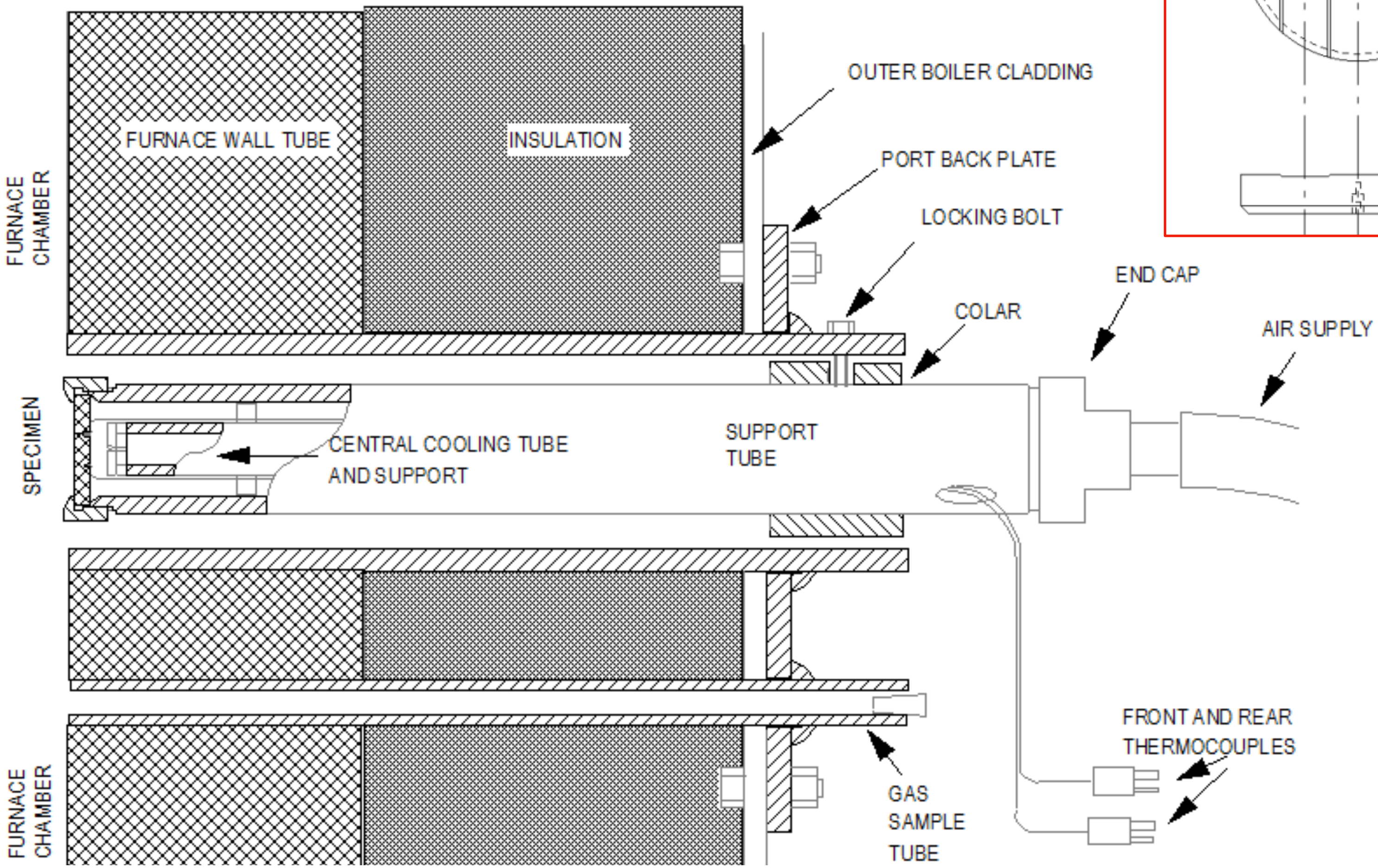
Superheater Probe

E.ON's Furnace Wall Corrosion Probe – 70 h exposure

2 coatings - FeCrAl and IN625 on 16Mo3 base

16Mo3 corrodes 4-6 times faster than the coatings





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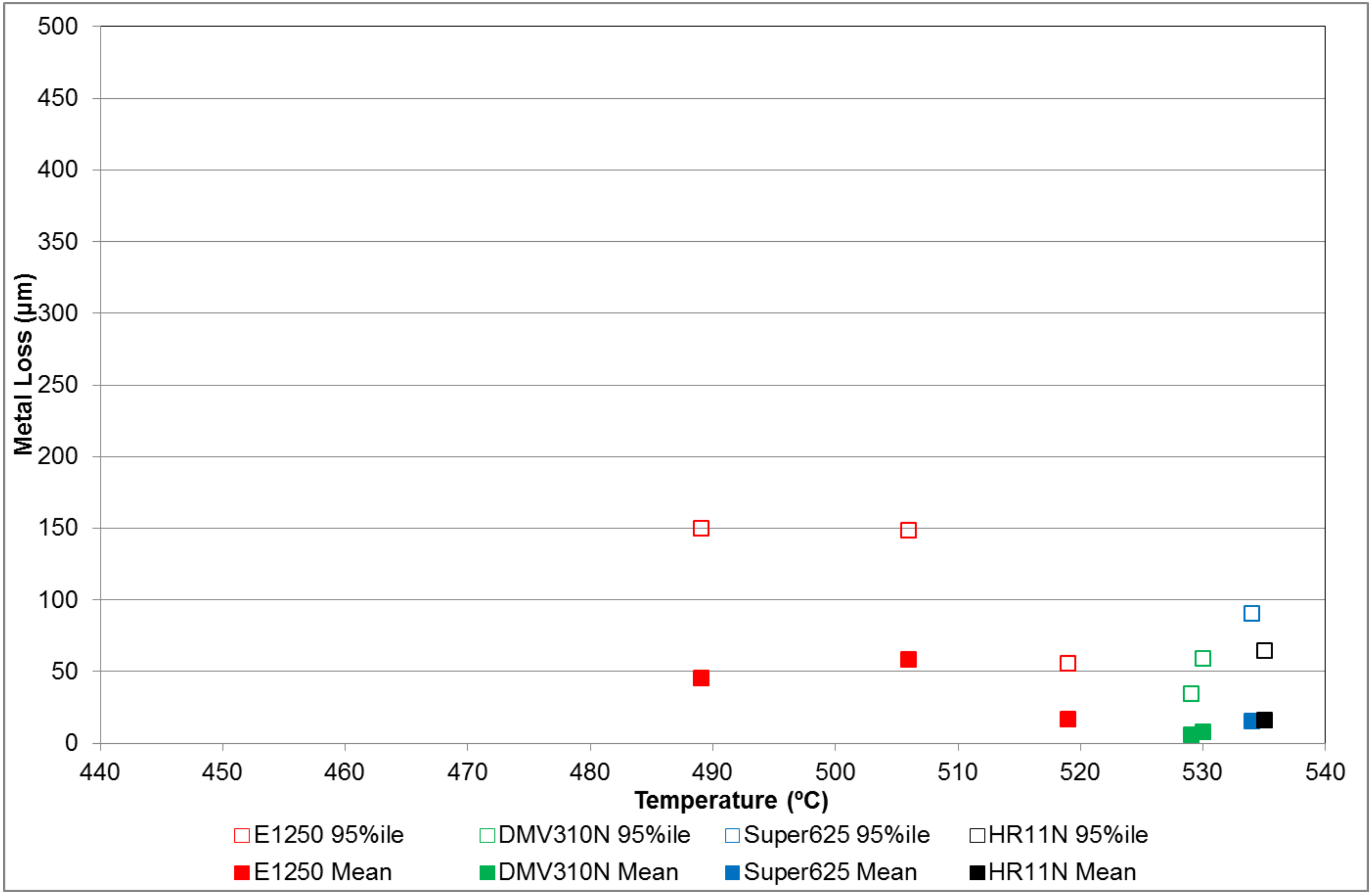
E.ON's superheater corrosion probe - 890 hours

Superheater Austenitic / Nickel Alloy Specimens 890 h



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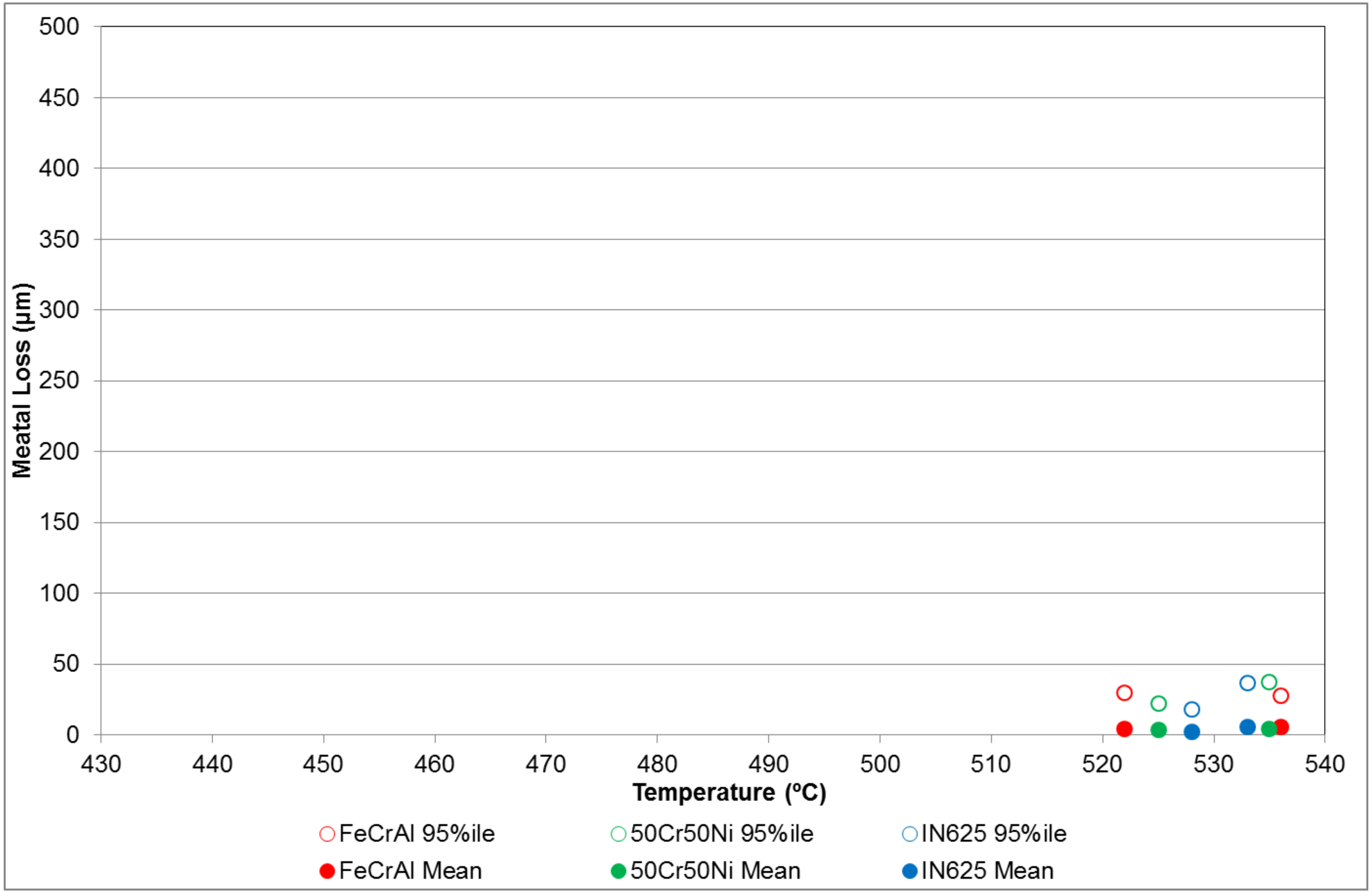
Superheater Laser Clad Specimens 890 hours



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Summary of results obtained during last year

- Alloy 625, APMT, FeCrAl and Sanicro 28 all performed well as furnace wall materials. (21 to 28% Cr)
- Alkrothal 14 did not perform well. (Contains 14% Cr and no Mo)
- Used wood no. 2 (0.17%Cl, 119ppmPb) caused 3-4 more times corrosion on Alloy 625 and 6-8 more times on 16Mo3 at 400°C compared to used wood no.1 (0.13%Cl, 36 ppm Pb).
- Corrosion was more temperature dependent for fuel no. 2
- Wall deposits contained more Cl when burning fuel 2
- Superheater deposits (3h testing) contained more Cl at all temperatures and more Pb at 450 and 550°C indicating an increased risk for superheater corrosion when burning used wood no. 2.
- Stainless steels and Ni-base alloys performed well as superheater alloys when burning used wood
- Small differences in chemical composition of used wood can cause large differences in corrosion rate

Future work

KME 708

- Fuel quality testing with UW 1 and UW 2 in SP's FB combustion rig.
- More long term corrosion testing of coatings
- Project finish December 2016

- Starting up continuation project KME 718
- Participants similar to KME 708 Plus Andritz and MH Engineering. Minus SP and KTH
- KME 718 is investigating longer term testing with digested sewage sludge (14 h tests performed in KME 508)
- KME 718 – find another waste sludge product as an alternative to sewage sludge and test
- KME 718 – more long term testing of coatings.

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Unexpected tube failures ?

No thanks

The End

Thank you

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