

SANICRO 25 - A NEWLY DEVELOPED HIGH STRENGTH HEAT
RESISTANT AUSTENITIC STAINLESS STEEL FOR ADVANCED
HIGH EFFICIENT COAL FIRED POWER PLANTS



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OUTLINE

- Background
- Material development
- Structure stability
- Creep and fatigue behaviors
- Steam oxidation and high temperature corrosion
- Weldability
- Experience
- Concluding remarks



GAME-CHANGING MATERIALS FOR CLEANER COAL ENERGY

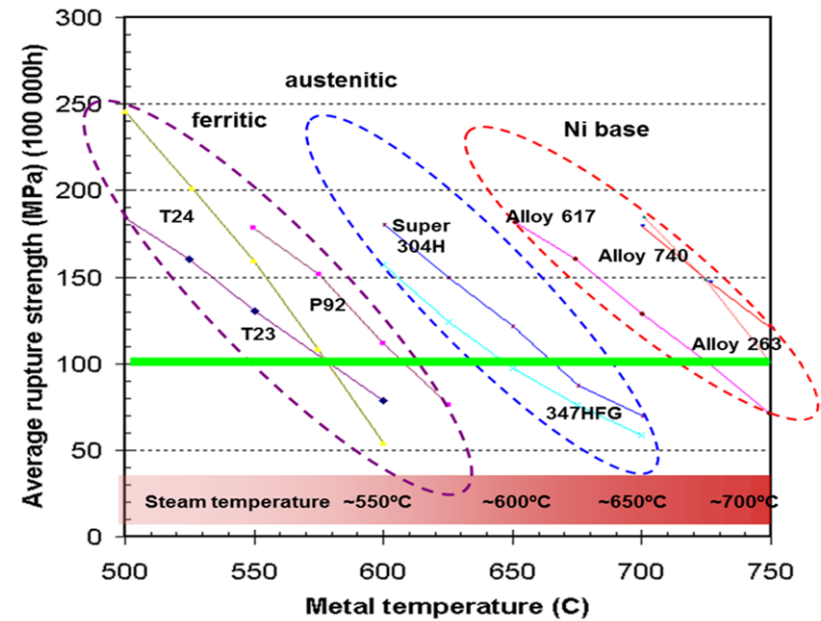
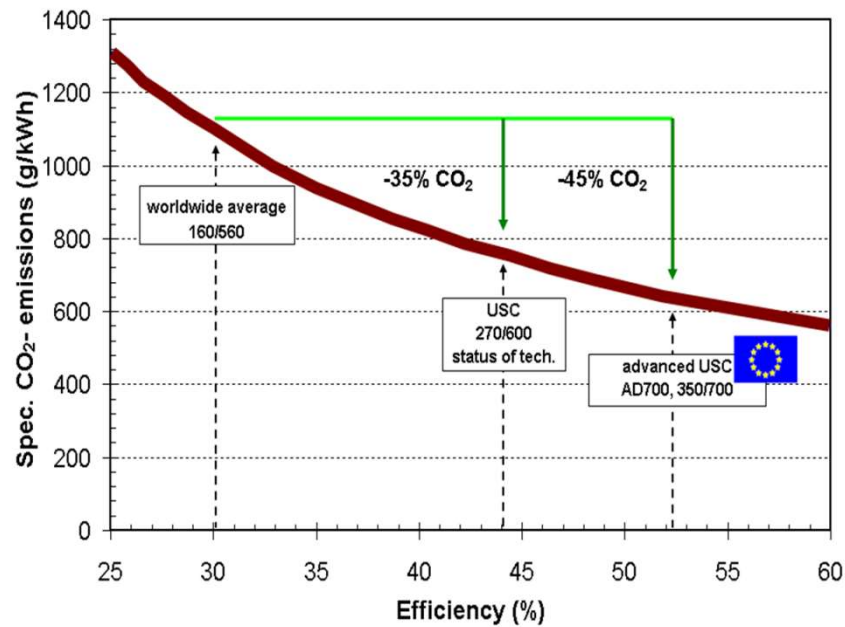
AMBITION

Plant average thermal
efficiency >50%
Boiler steam temp >700DG
Lower CO₂ emissions / unit of
energy produced

REALITY:

Global average
thermal efficiency
<35%
AUSC technology
years away

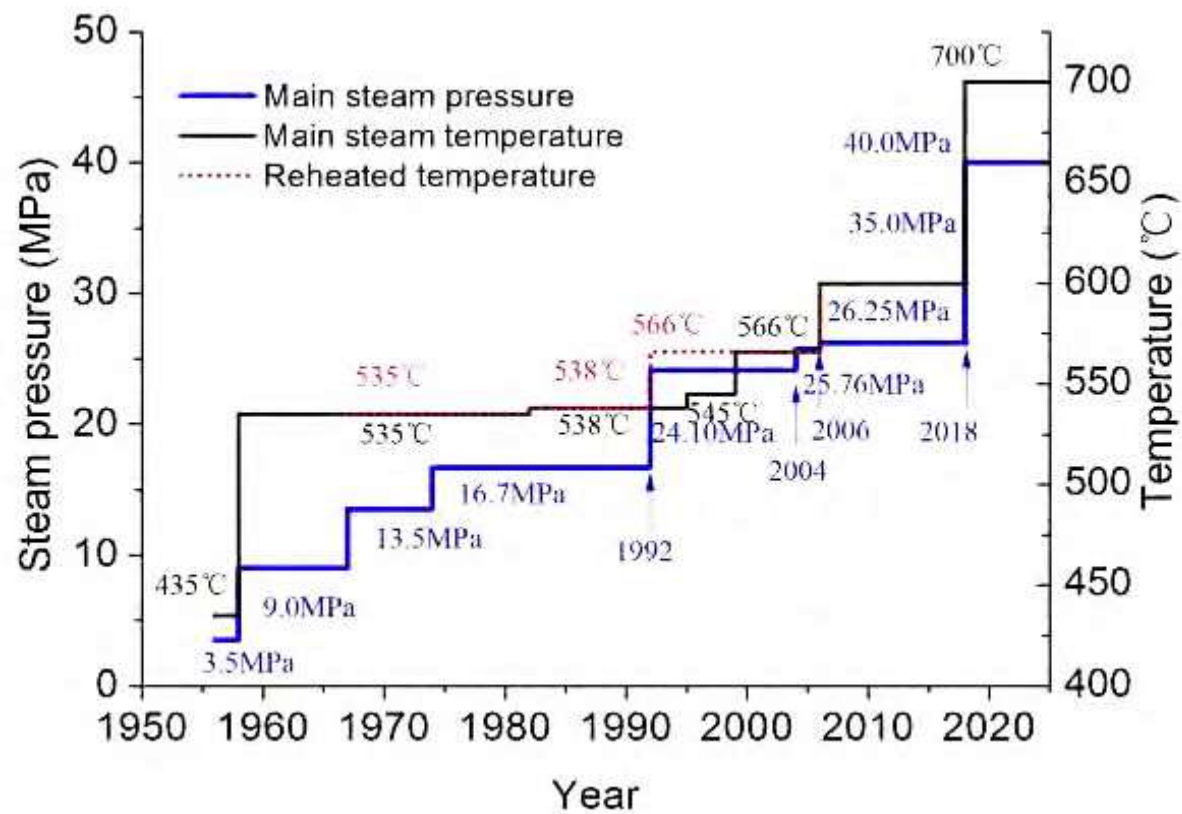
AUSC IN EUROPE AND MATERIAL REQUIREMENTS



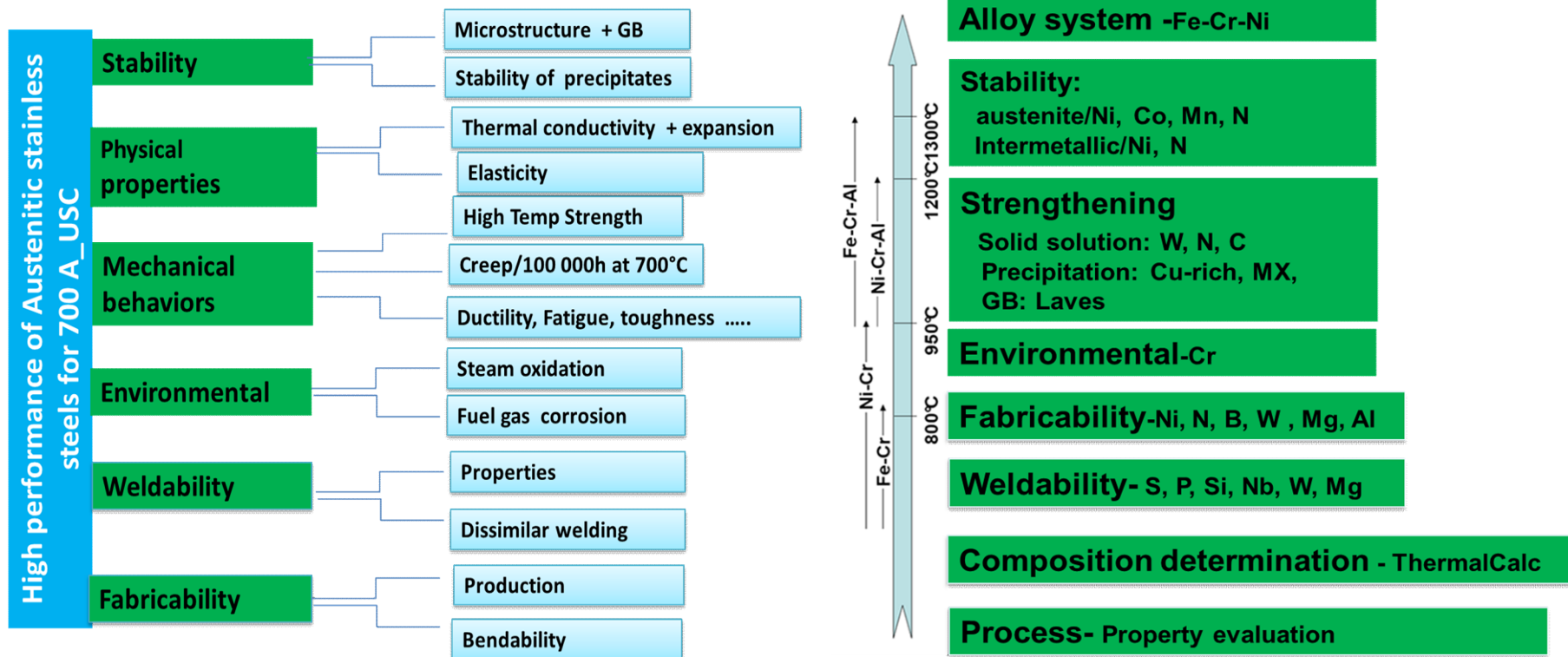
Nick Otter, Pathway to Low Emission Power Generation using Fossil Fuels, 2008



BOILER TECHNOLOGY TRENDS



MATERIAL REQUIREMENTS FOR AUSC GRADE



SANICRO™ 25 FOR HIGH TEMPERATURE BOILERS

- Sanicro 25 is an austenitic stainless steel material with excellent high temperature properties such as
 - High creep rupture strength
 - Excellent steam oxidation resistance
 - Good hot corrosion resistance
 - Very good fabrication and welding properties
- Designed for use in superheaters / and reheaters in coal fired power boilers at metal temperature up to 700°C (1290°F)
- Enabling increased boiler efficiency and reduced CO₂ emissions per unit of energy produced.



CREEP STRENGTH

100 MPa at
700°C for
100 000 hours



SANICRO™ 25 FOR HIGH TEMPERATURE BOILERS

CHEMICAL COMPOSITION (NOMINAL COMPOSITION WT.%):

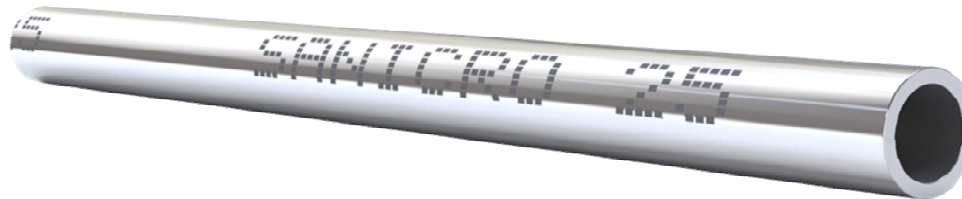
C _{max}	Si	Mn	P _{max}	S _{max}	Cr	Ni	N	W	Co	Cu	Nb
0.1	0.4 max	0.6 max	0.030	0.015	21.5	23.5	0.15	2.0	1.0	2.0	0.30
					-	-	-	-	-	-	-
					23.5	26.6	0.30	4.0	2.0	3.5	0.60

STANDARDS

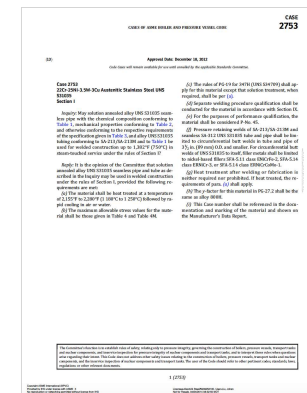
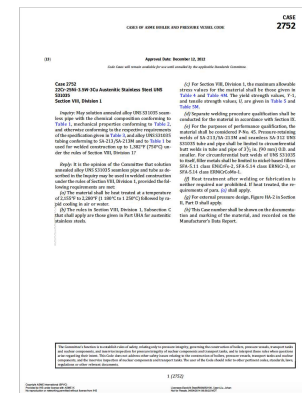
UNS S31035

EN Number 1.4990

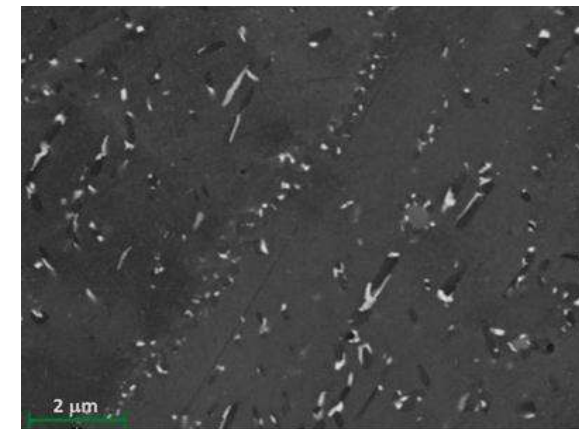
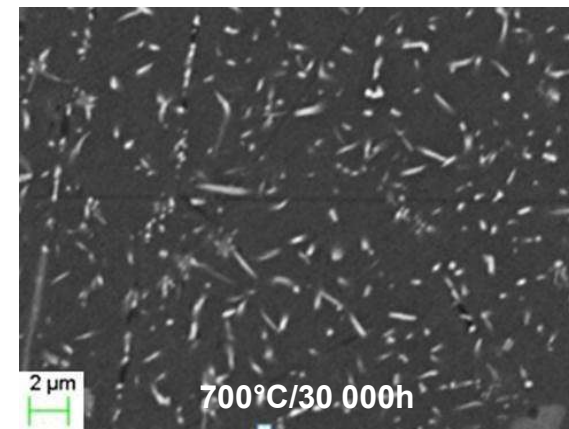
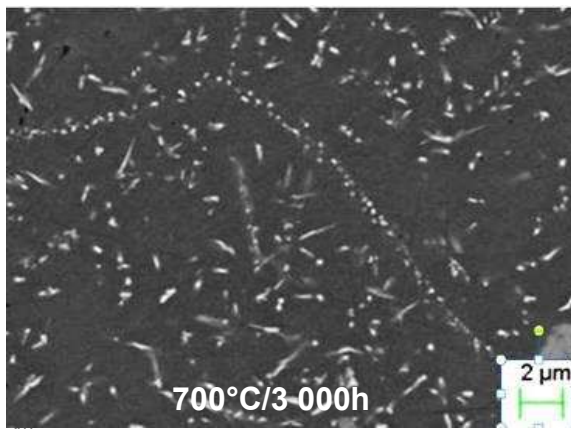
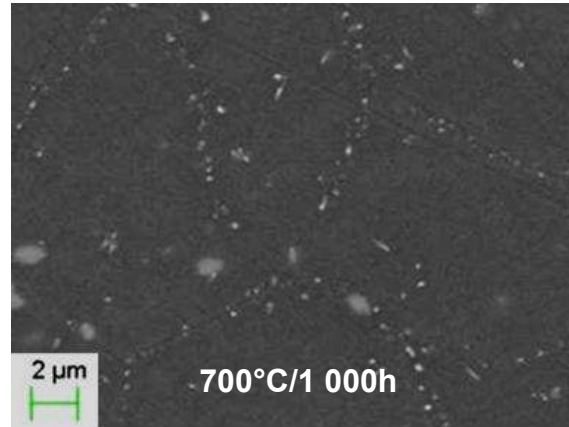
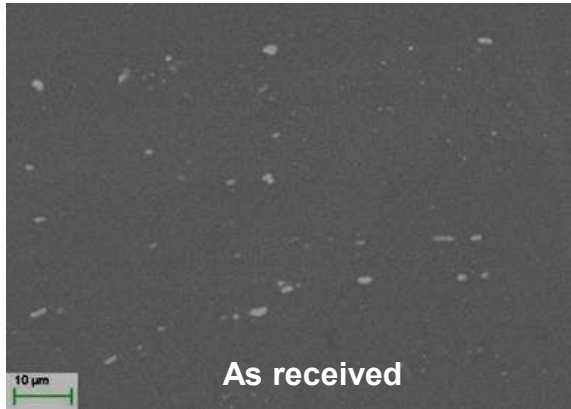
EN Name X7NiCrWCuCoNbNB25-23-3-3-2



- European Particular Material Appraisal (PMA)
- VdTÜV material data sheet 555, 09.2008
- The American Society of Mechanical Engineers (ASME) Boiler and Pressure
 - ASME Code Case 2753, Section I
 - ASME Code Case 2752, Section VIII Division 1
- China Pressure Vessel Approval CSCBPV BV-ME-210

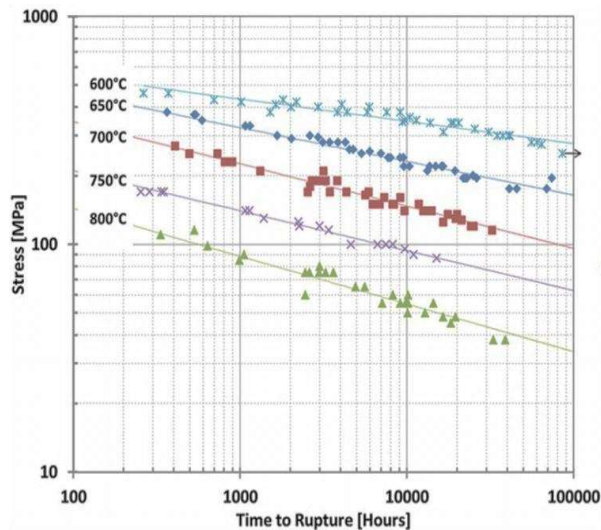


SANICRO™ 25 STRUCTURAL STABILITY

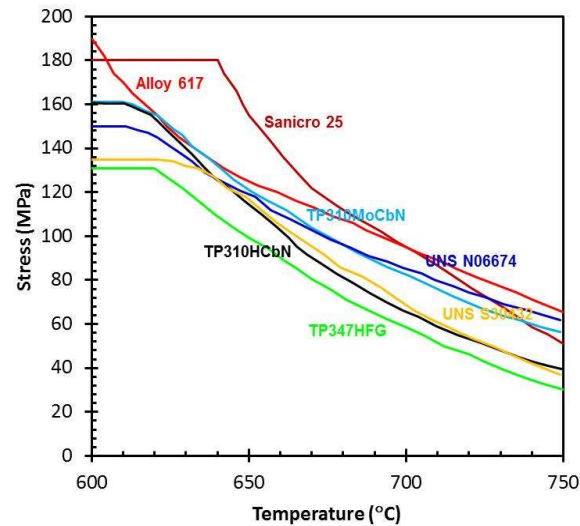


creep tested at 650°C/70.000 h

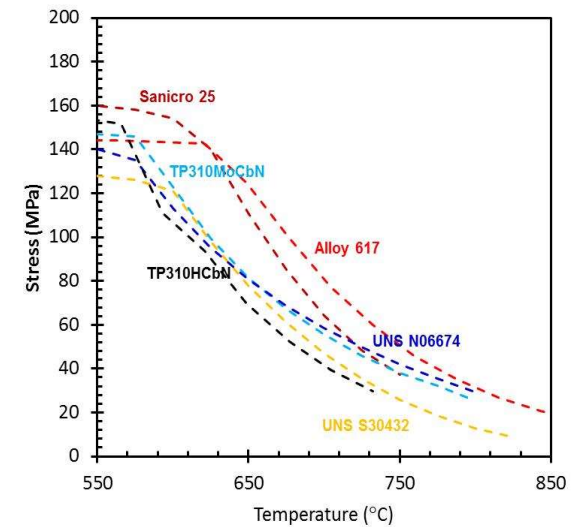
SANICRO™ 25 CREEP PROPERTIES



Experimental data



European Pressure Directive (PED)



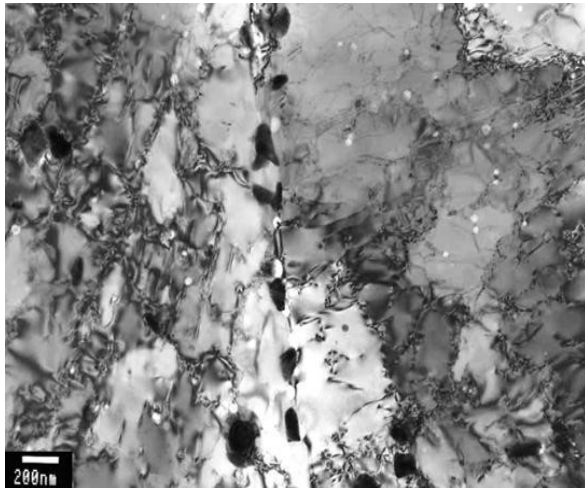
ASME, maximum allowable stress values used for design.

Values have been extrapolated to 100.000 hours.

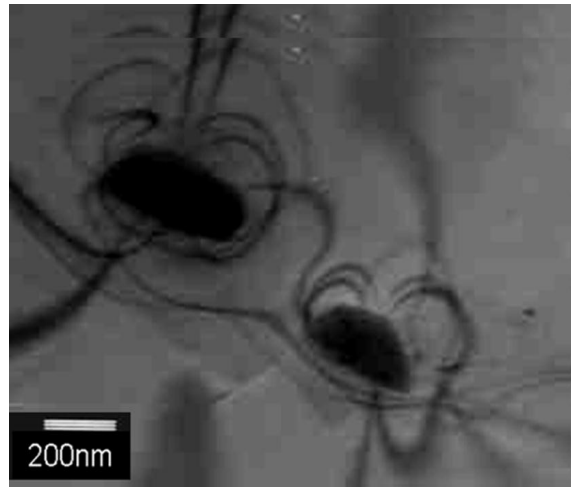
TP347HFG; UNS S30432; UNS No S31042 / TP310HCbN; TP310MoCbN (NF709); UNS N06674 (HR6W); and Alloy 617



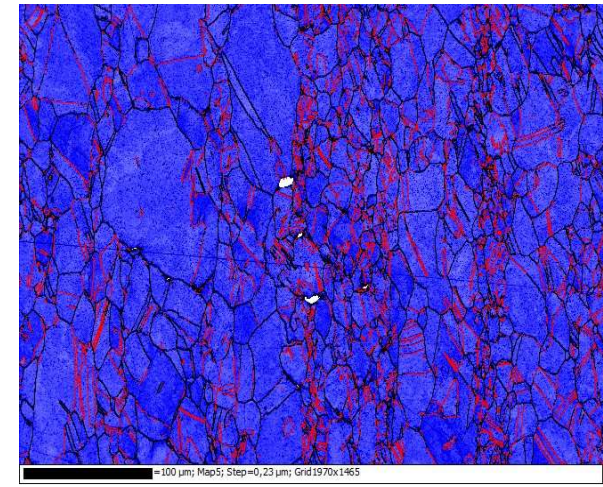
SANICRO™ 25 CREEP DEFORMATION MECHANISMS



Dislocation subcells

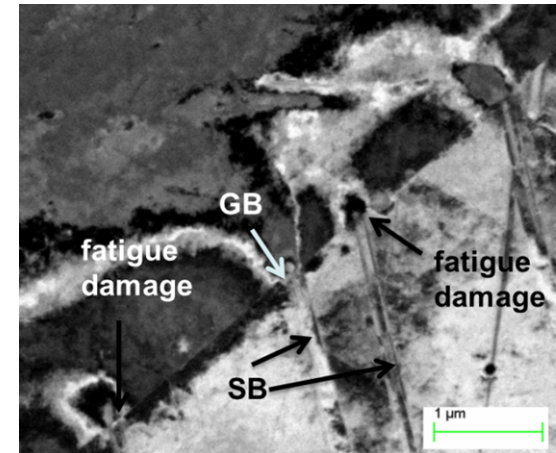
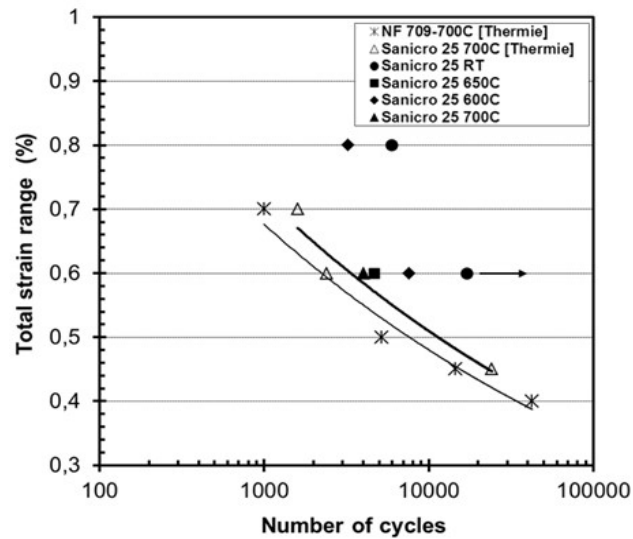
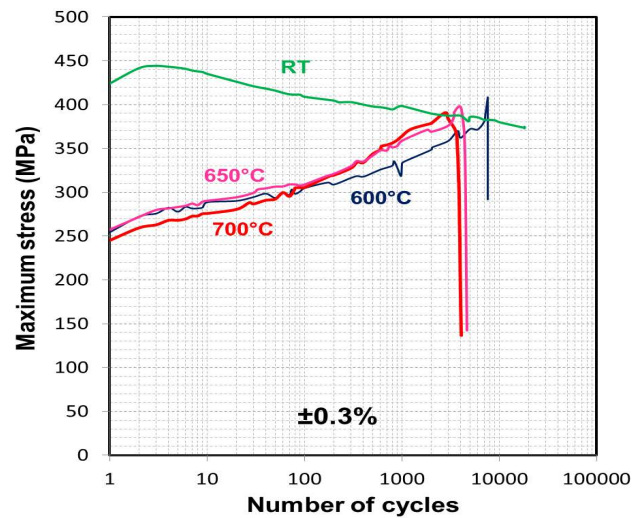


Dislocation interaction with precipitate



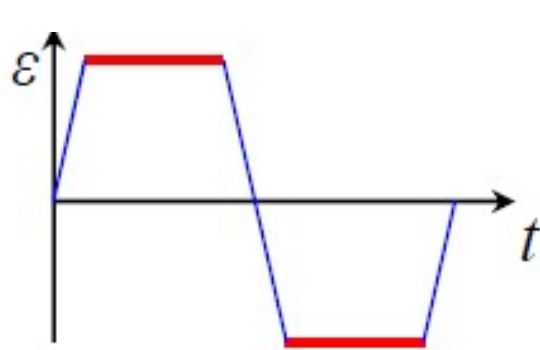
Creep induced twinning, 650°C/75000h
contribute to high creep ductility

SANICRO™ 25 LOW CYCLE FATIGUE BEHAVIOR

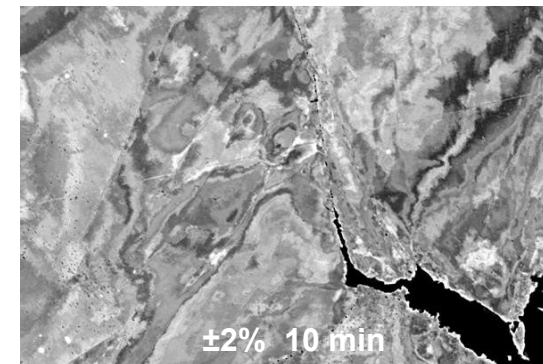
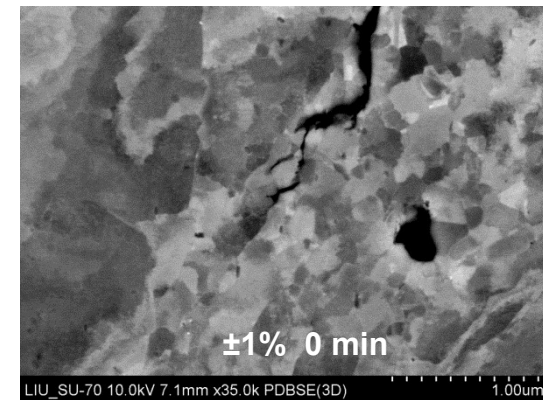
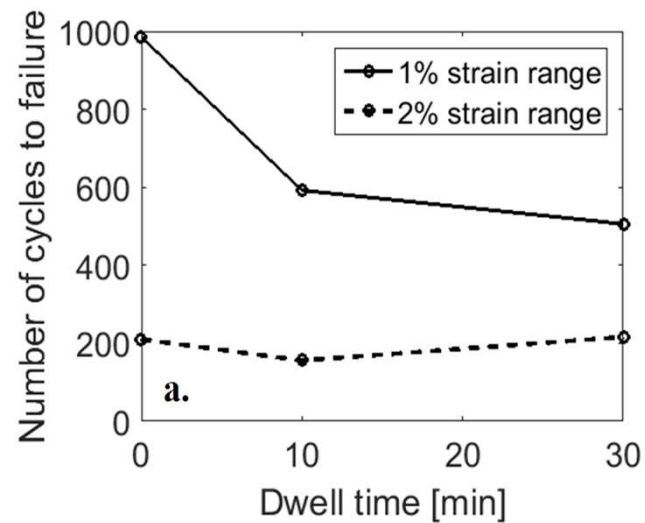


ECC image: 650°C,
 $\Delta\epsilon/2=0.6\%$, at 1571 cycles

SANICRO™ 25 CREEP AND LCF INTERACTION



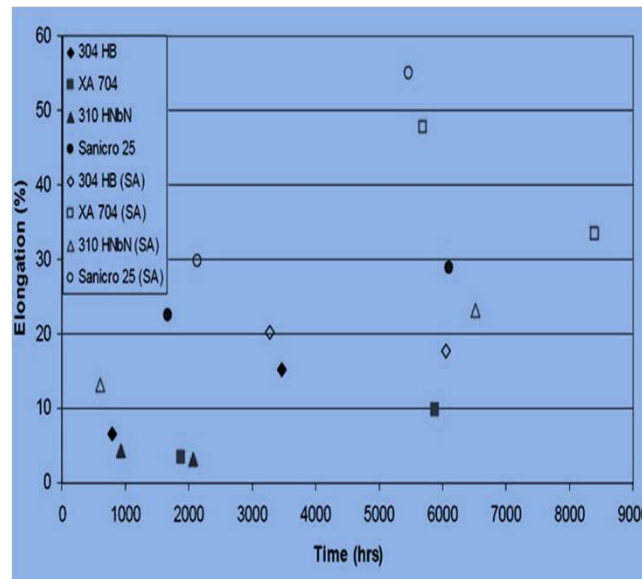
- Strain rate: 10^{-3} s^{-1} .
- Temperature: 700 °C.
- Strain controlled testing.
- Dwell times: 0, 10, 30 minutes.



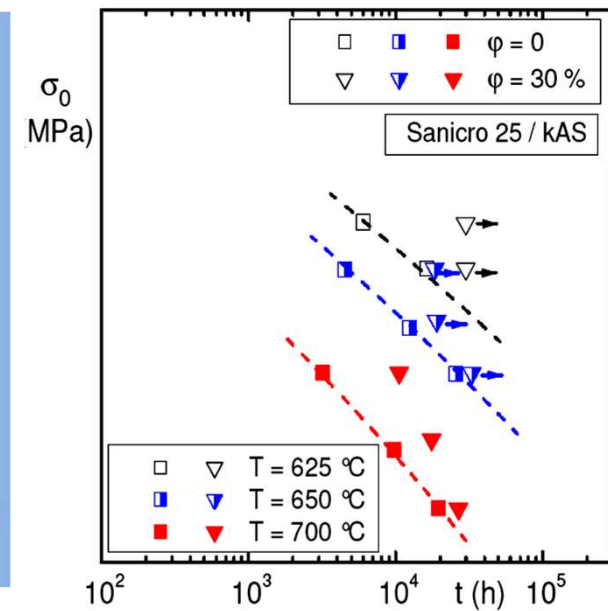
SANICRO™ 25 BENDABILITY AND COLD DEFORMATION EFFECT



ref. Doosan Babcock Energy Limited

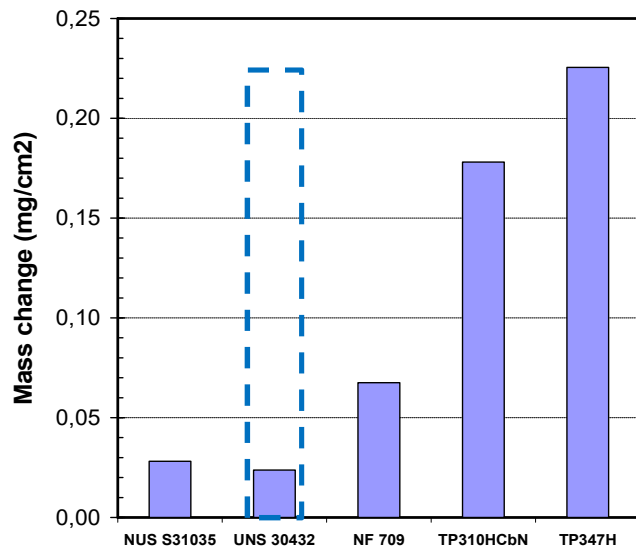


CW (15%), CW+solution annealing at 625°

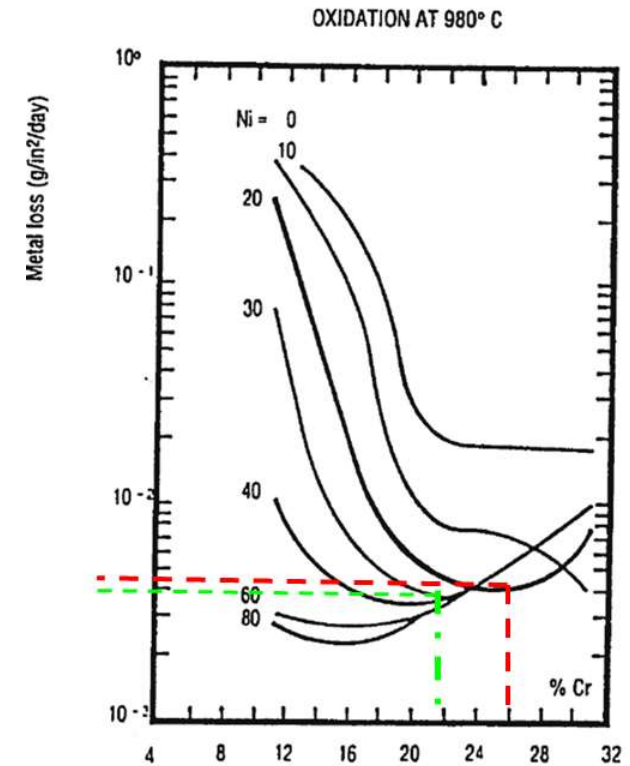
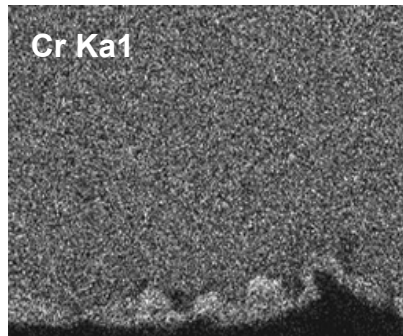
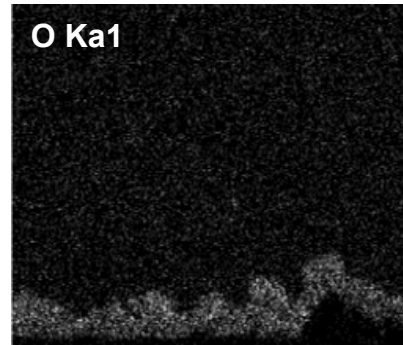


Falk Müller et al. Technische Universität Darmstadt

SANICRO™ 25 STEAM OXIDATION AND THE CR, NI EFFECT

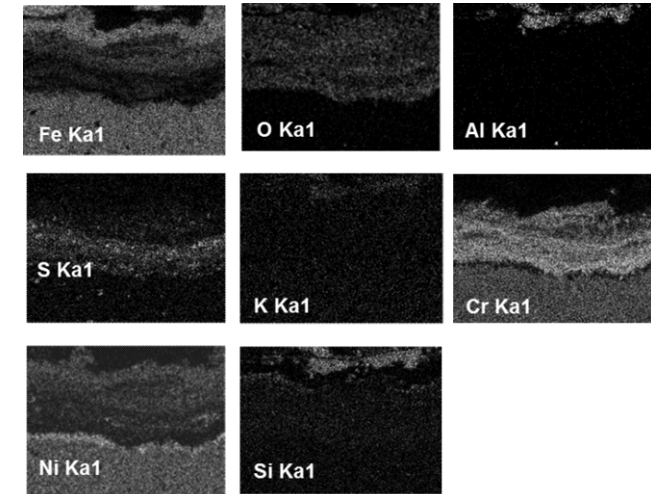
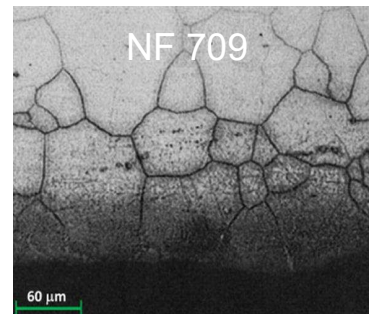
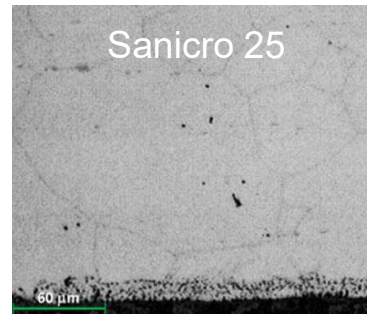
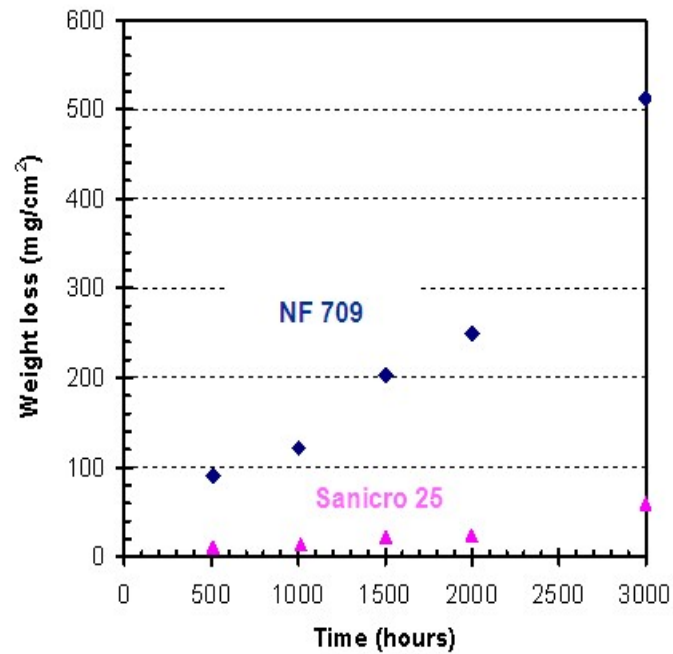


Steam oxidation, 700°C, 1000h
De-ionized water was fed into the furnace
corresponding to a gas flow of 10 mm/s



J. E. Croll and G. R. Wallwork, Oxid. Met., vol 1, 1969, pp 57.

SANICRO™ 25 HIGH TEMPERATURE CORROSION

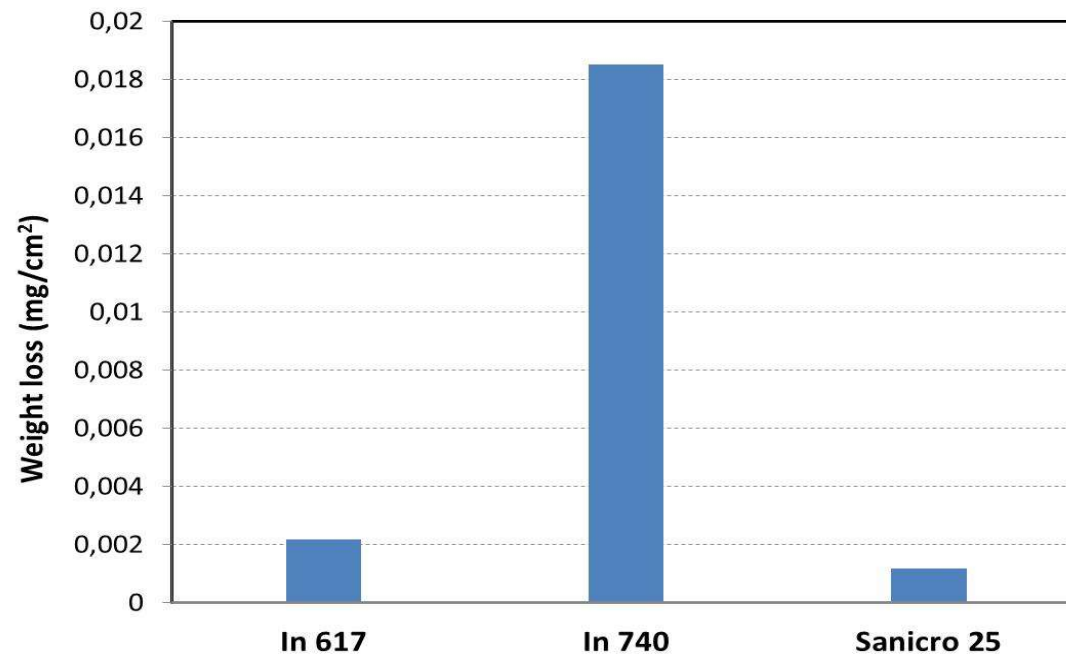


Surface layer analysis of Sanicro 25 material

Laboratory furnace at 700°C, the specimens were covered with ash which was renewed every 100h for the first 500h and then every 500h up to 3000h. Ash composition: 5% Na₂SO₄, 5% K₂SO₄, 30% Fe₂O₃, 30% Al₂O₃ and 30% SiO₂. Gas composition: 0.25% SO₂, 3.5% O₂, 15% CO₂ and balance N₂.



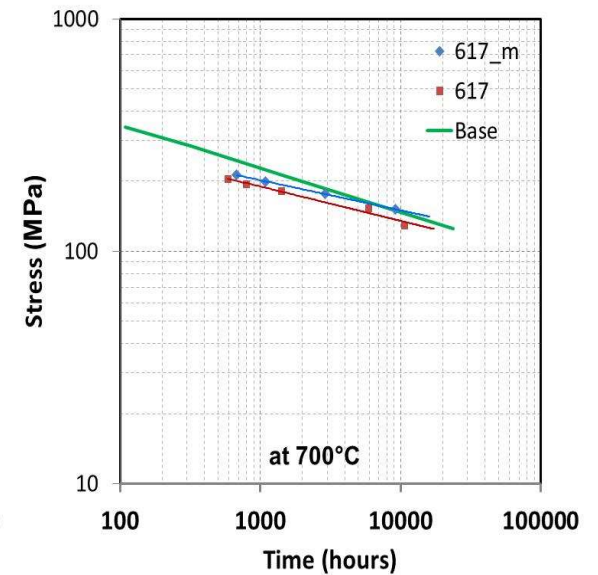
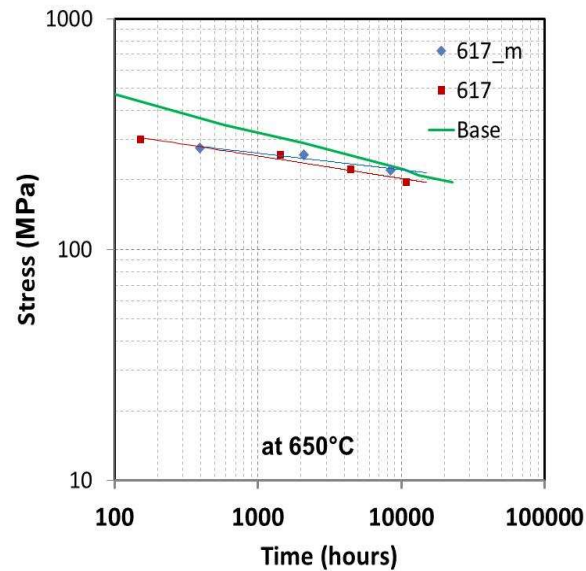
SANICRO™ 25 FLUE GAS CORROSION



Corrosion resistance in the flue gas environment, a comparison of the kinetics of oxidation of Sanicro 25 and nickel base alloys UNS N06617 and Alloy 740 in the environment $9\%O_2+0.2\%HCl+0.08\%SO_2+N_2$ at 700°C for 500 hours

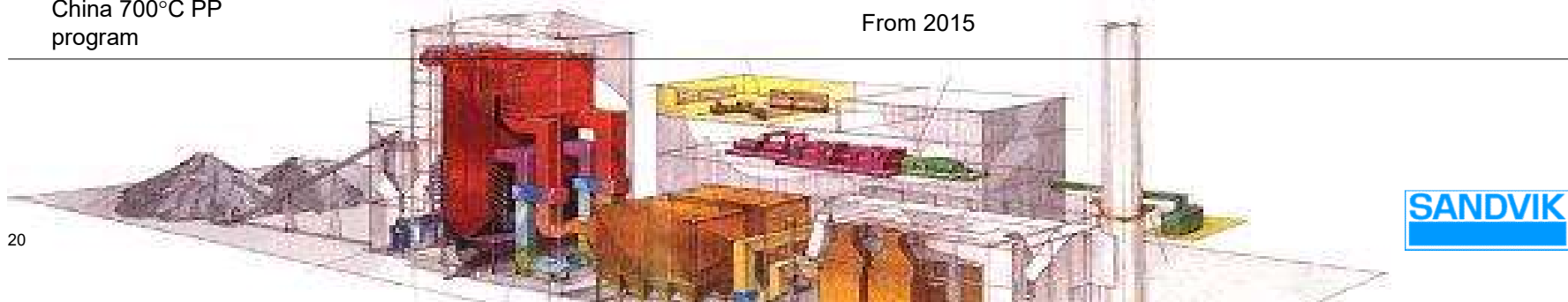
SANICRO™ 25 WELDABILITY

- Sandvik Sanicro 25 possesses good weldability
- TIG/GTAW is recommended
- Sanicro 53 (alloy 617) or alloy 617 mod. as filler metal
- High thermal expansion and low heat conductivity as all fully austenitic steels
- Interpass temperature <100°C
- Heat input <1.0kJ/mm

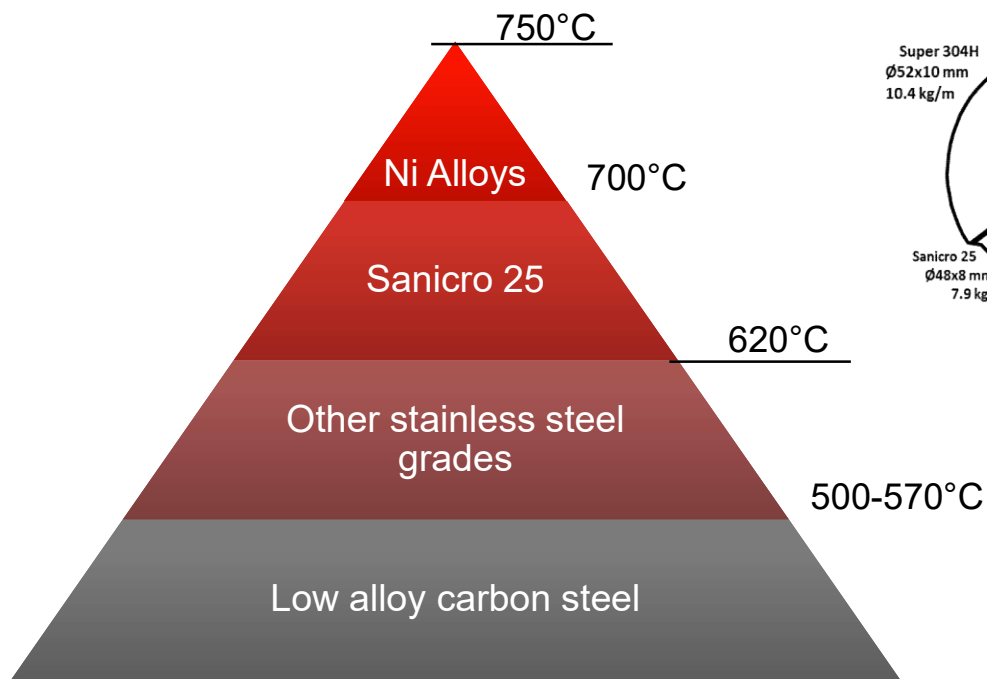


SANICRO™ 25 EXPERINECES

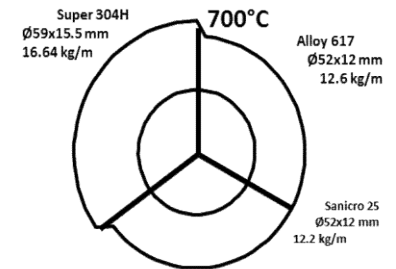
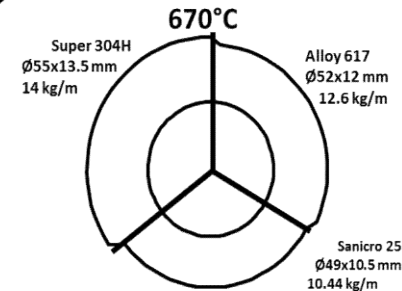
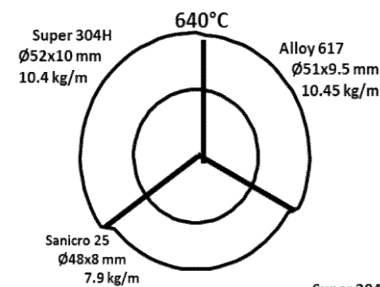
Power Plant	Steel Pipe Size, mm	Installation Length, m	Operation Parameter	Test Time	Engineering Company
GKW Mannheim	OD 38.8×8.8	110	Steam temp 630°C/165bar	2009-2013	Alstom
Vattenfall Boxberg	OD 57.0×4.0	220	Metal temp. 630°C	2008-	Hitachi Power
E.O.N, Scholven (COMTES 700)	OD 44.5×10	306	Metal temperature 610-630°C	2005-2009	Hitachi Power
Dong Energy, Esbjerg	OD 38.8×8.8	2.3	725°C superheated steam temp, sanicro25 metal temp 657°C	2004-2008	Alstom
RWE Weisweiler	OD 41.4×8.0	10	Metal temp. 655°C/169bar	2004-2008	Hitachi Power
China 700°C PP program			From 2015		



SANICRO™ 25 APPLICATIONS



METAL TEMPERATURE



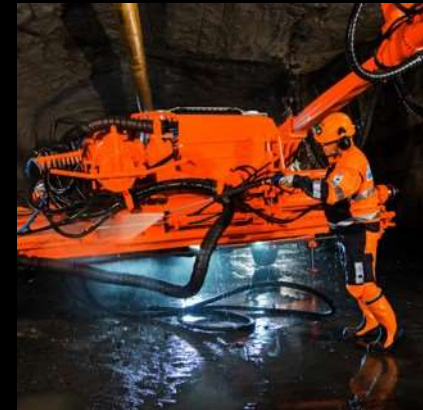
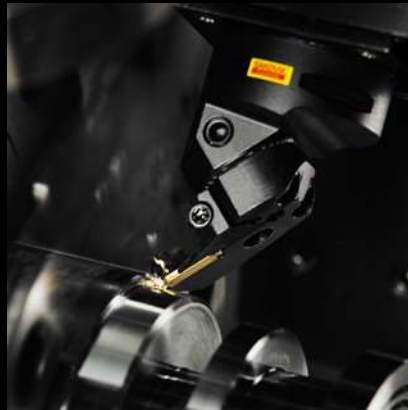
CONCLUDING REMARKS

A new austenitic stainless steel grade UNS S31035 (Sandvik Sanicro 25) has been developed for superheater and reheaters in high efficiency advanced coal ultra-super critical power plants, A-USC. Extrapolation from creep data with two methods gives creep strength of around 100 MPa at 700°C for 100.000 h, which is higher than that of other austenitic stainless steels available today.

The alloy has excellent steam oxidation resistance, good hot corrosion resistance, and very good fabricability and weldability properties.

This makes Sanicro 25 a cost efficient option in high-efficient coal fired boilers for superheaters and reheaters operating at metal temperatures up to 700°C. For such temperatures the only other option is to use more costly nickel-base materials.

Currently available materials (TP310HCbN, UNS S34042) allow use at metal temperatures up to around 650°C. Sanicro 25 is therefore an excellent option in steam applications in metal temperatures 650°C up to 700°C, the high creep strength makes it an interesting option for use in high pressure superheaters instead of currently available materials which would result in too heavy wall thicknesses.



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