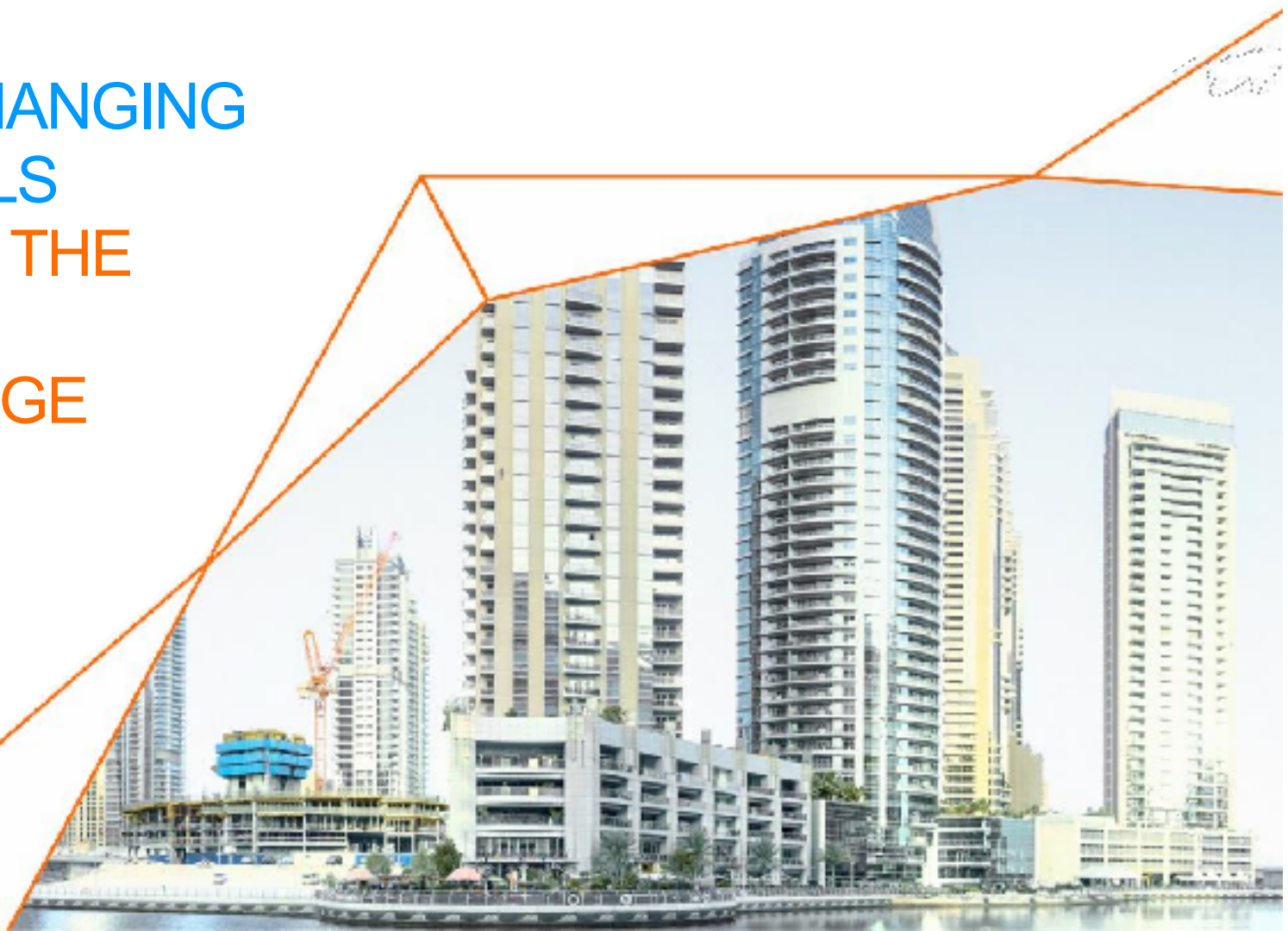
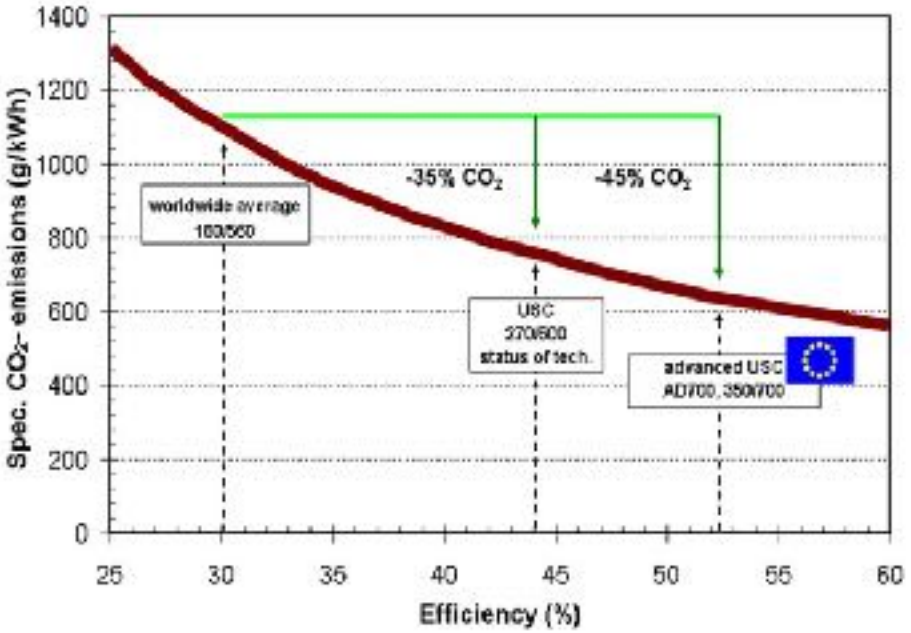
GAME-CHANGING MATERIALS MEETING THE ENERGY CHALLENGE



EMISSION REDUCTION REQUIREMENT



- To achieve a plant net efficiency of >50% new technologies and new materials are needed to increase coal fired boilers' efficiency.
- 630°C, 650°C and 700°C projects have started with objectives on the edge of the currently used alloys boilers

MATERIAL REQUIREMENT

- Creep strength- base metal and weldment
- Thermal fatigue-large diameter
- Toughness
- Corrosion resistance
  - hot corrosion
  - steam oxidation
- Weldability- crack
- Workability- bending, machining
- Cost-material cost and addition cost

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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	0.2	0.5	≤0.025	≤0.015	22.5	25	0.23	3.6	1.5	3.0	0.5

PATENTS：

- America: No. 6,485,679
- Sweden： No. SE 9900555-5
- China： No. 00803866.X

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SANICRO™ 25 FOR HIGH TEMPERATURE BOILERS

INTERNATIONAL APPROVALS

- 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

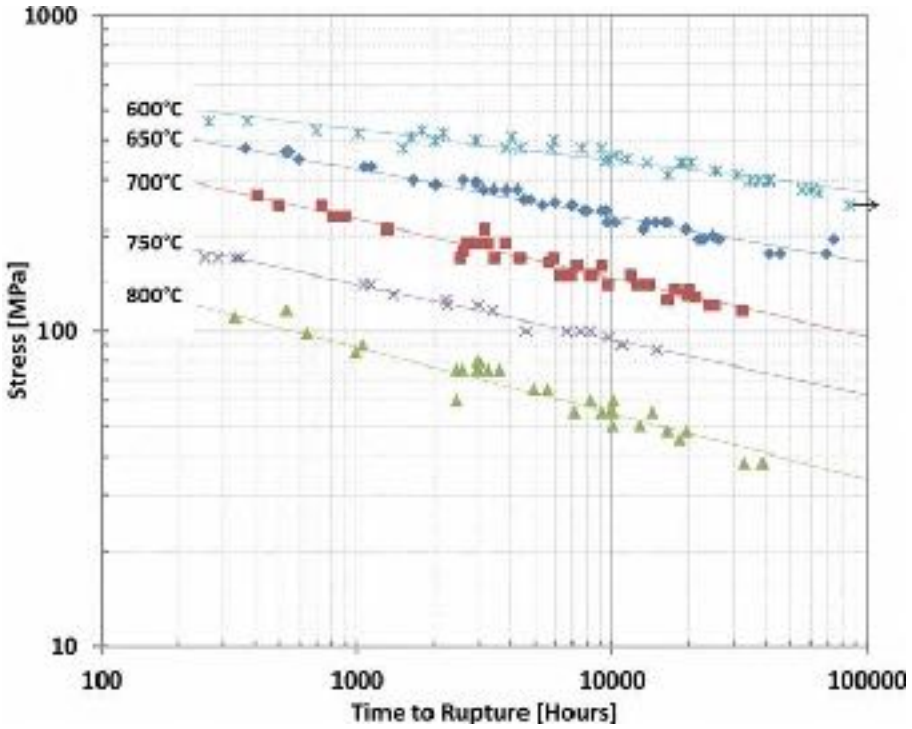
SANICRO™ 25 CREEP RUPTURE STRENGTH

TEST CONDITIONS

- Creep tests have been carried out at temperatures of 600°C, 650°C, 700°C, 750°C and 800°C
- Until now, 86 000 hrs.

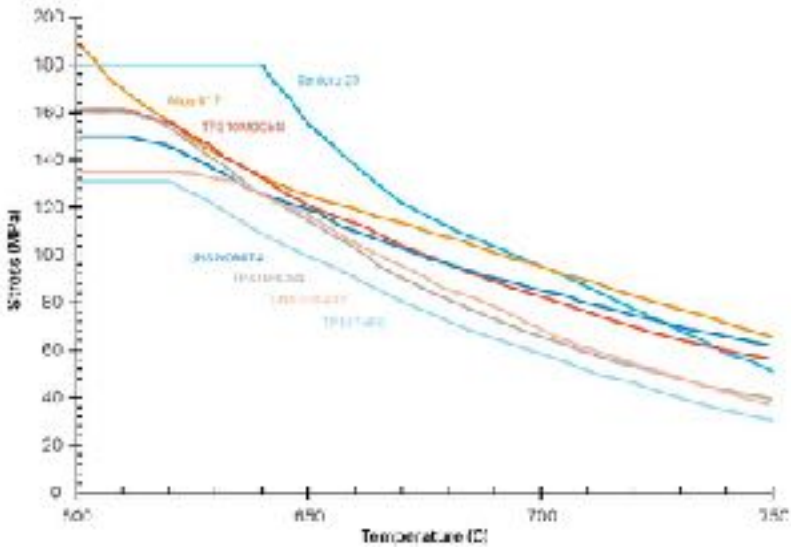
SUMMARY

- By extrapolation of Larson-Miller curve, the creep strength of 100,000 hours at 700°C is 104MPa
- By calculation of temperature model, the creep strength of 100,000 hours at 700°C is 99±3MPa

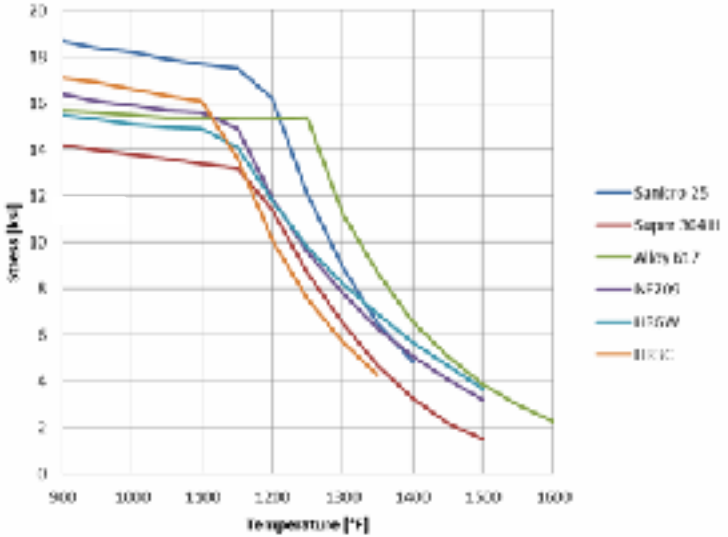


SANICRO™ 25 CREEP RUPTURE STRENGTH

NOMINAL CREEP STRENGTHS VALUES
AS PER VDTUV BLATT 555



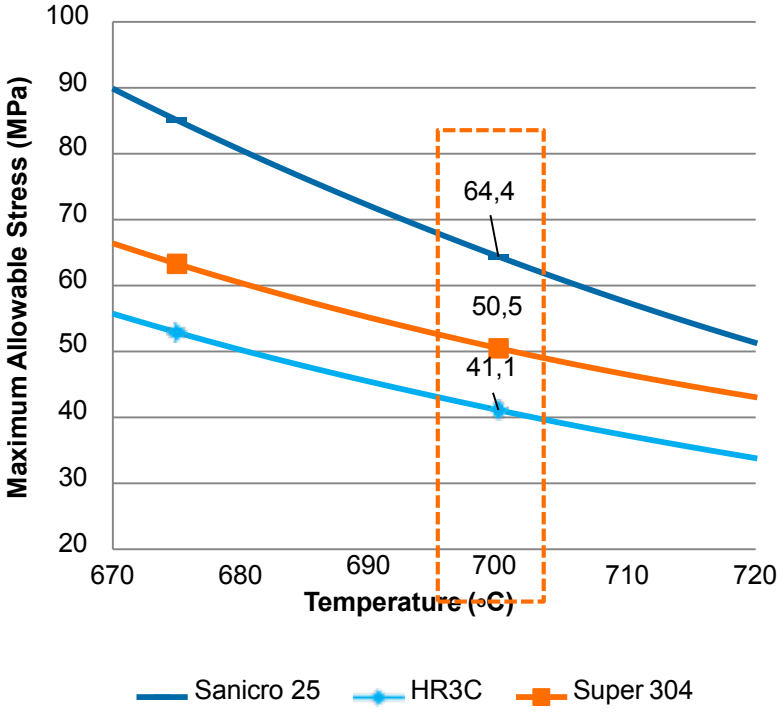
MAXIMUM ALLOWABLE STRESS IN
MPA DN DEGC



Creep data for 100 000 hours from PED (European Pressure Equipment Directive /VdTUV)
PED (European Pressure Equipment Directive) approval is available since 2008.
ASME Code Case available, #2753 for Section I and #2752 for Section VIII Division 2013

SANICRO™ 25 IDEAL FOR BOILER TUBES

ASME CODE CASE VALUES



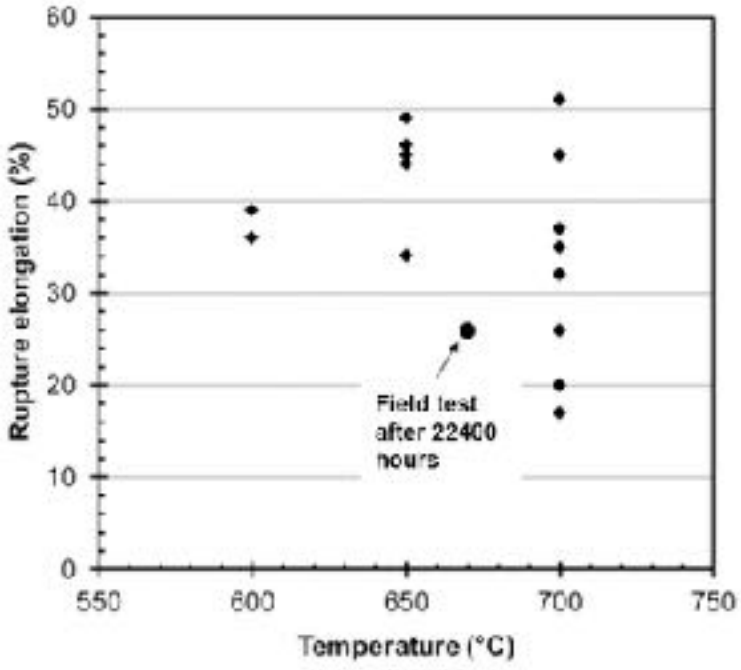
700DG COMPARISON

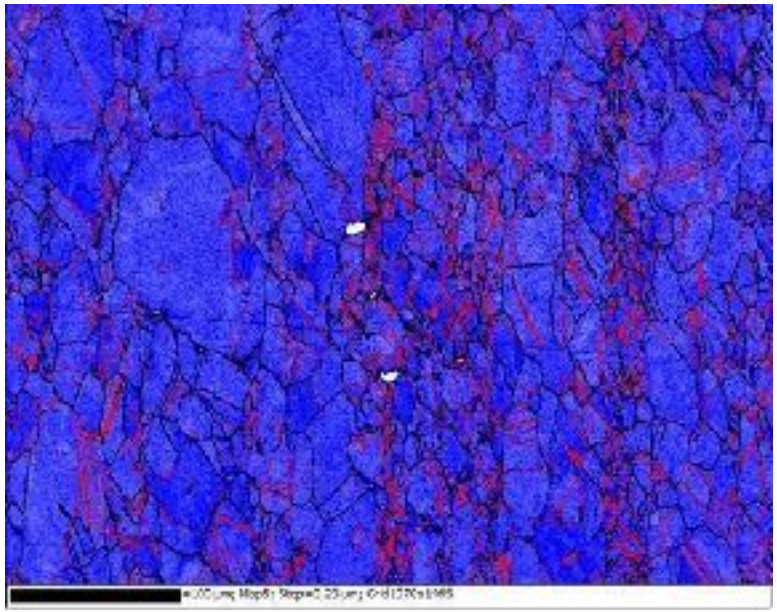
- Sanicro 25 = 64.4 Mpa @ 700DG
- **27.5% stronger** than S304H @ 50.5 MPa
- **56% stronger** than HR3C @ 41.1 MPa

CURRENTLY USED AUSTENITIC STEELS

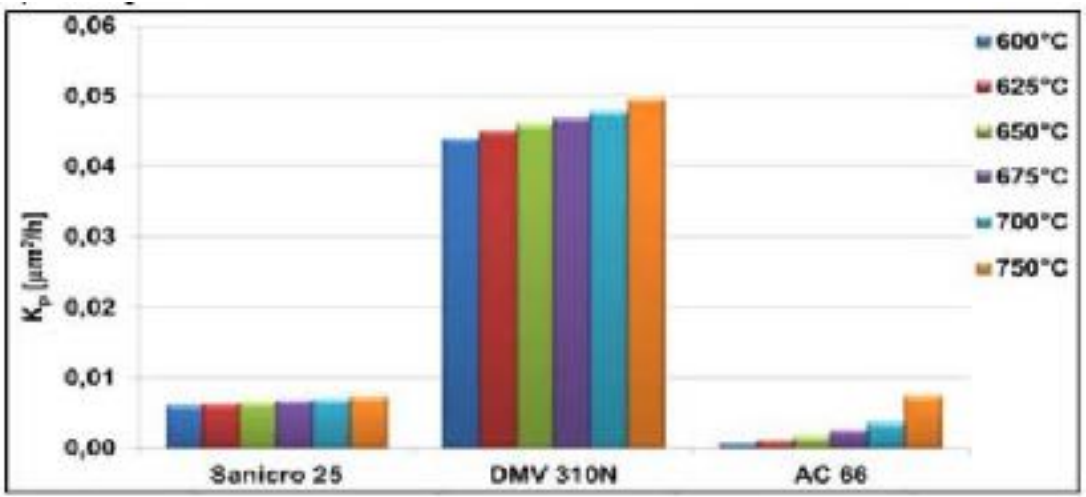
THE SANICRO™ 25 ADVANTAGE

SANICRO™ 25 CREEP RUPTURE DUCTILITY





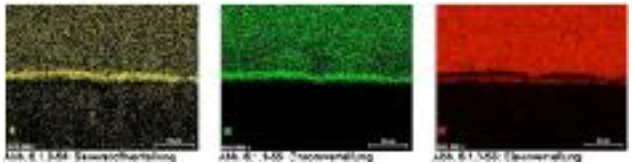
SANICRO™ 25 CORROSION RESISTANCE STEAM OXIDATION 20 000HRS



MPA Stuttgart Otto-Graf-Institut

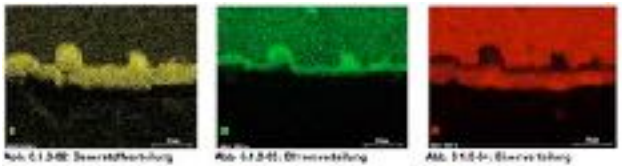
SANICRO 25

Probe H05 @ 21,354 HRS 651DG
Medium Oxidization = 2.3 microns



DMV 310N

Probe J05 @ 21,321 HRS 649DG
Medium Oxidization = 6.1 microns



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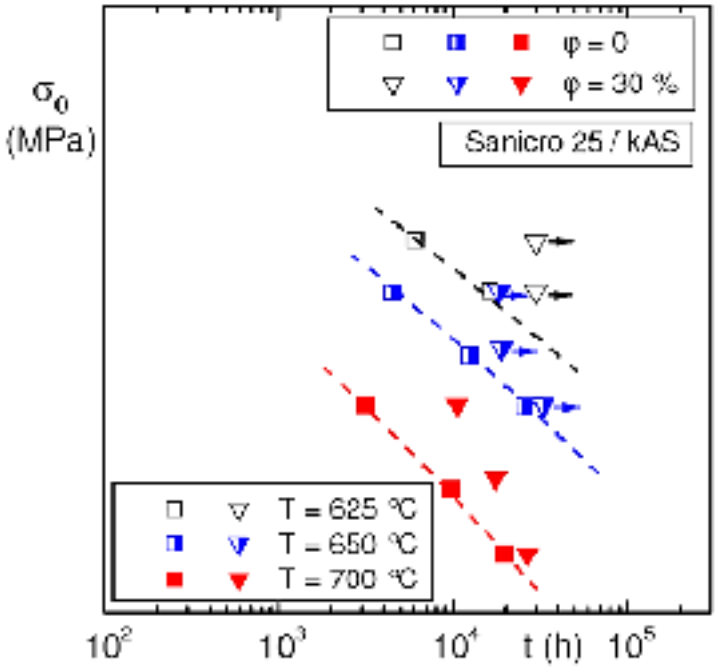
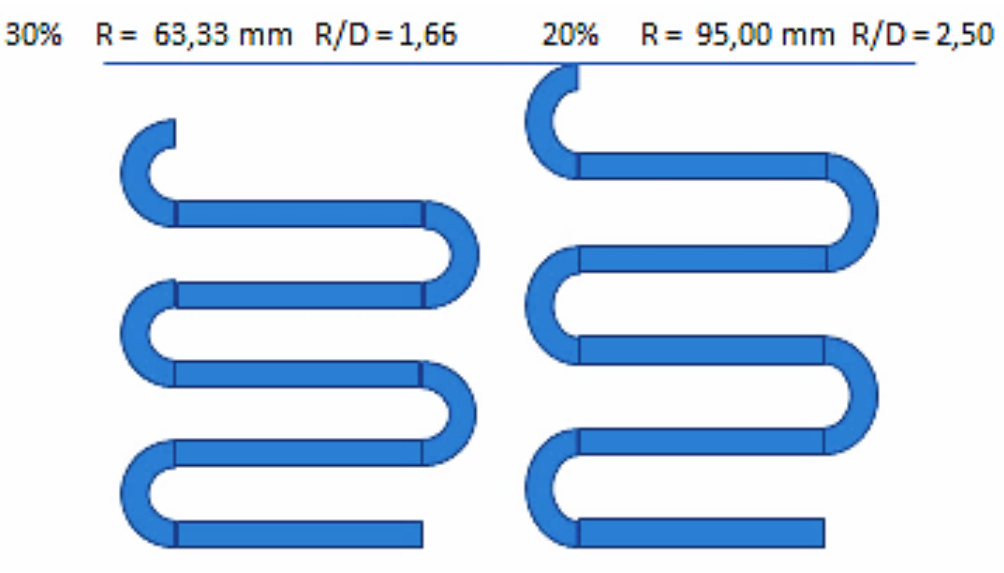
SANICRO™ 25 BENDING





IWM Freiburg 30 000 hrs

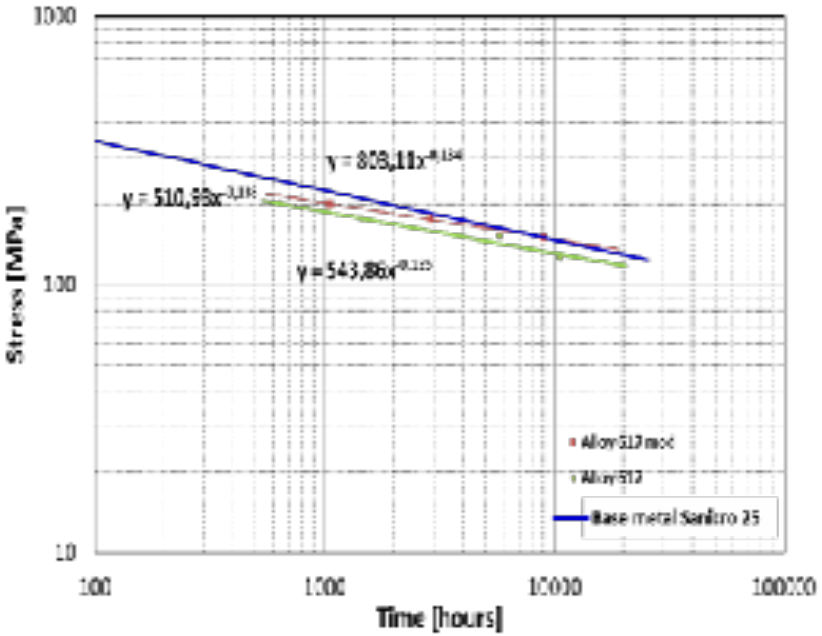
SANICRO™ 25 WELDING

- Good Weldability
- The properties of thermal expansion and thermal conductivity requires
  - Welding with low heat input
  - Interpass temperature below 100°C
- GTAW with Sanicro 53 (Alloy 617) or Alloy 617 Mod filler metal
  - Wire and rod with ø1.0- 2.4 mm diameter
- U-joint or V-joint geometry recommended depending on Tube thickness
- No need for PWHT

VIEW THE WELDING GUIDELINES

CREEP PROPERY OF WELDED SANICRO™ 25 TUBE MATERIAL WITH ALLOY 617/617M FILLER

TEST RESULTS AT 700°C



DISSIMILAR WELDING CREEP TEST MATRIX

ALL WELD JOINTS PRODUCED WITH ALLOY 617 MOD. AS FILLER GRADE

- Sanicro 25 / A617mod (dissimilar), 3 variants:
  - Unaged and pre-aged 10,000 hours at 650°C and 10,000hrs at 700°C before creep testing
- Sanicro 25 / UNS 30432 (dissimilar), 3 variants:
  - Unaged and pre-aged 10,000 hours at 650°C and 10.000hrs at 700°C before creep testing
- Sanicro 25 / TP310HCbN (dissimilar), 3 variants:
  - Unaged and pre-aged 10,000 hours at 650°C and 10,000hrs at 700°C before creep testing
- PWHT has deliberately not been performed in any case before creep testing

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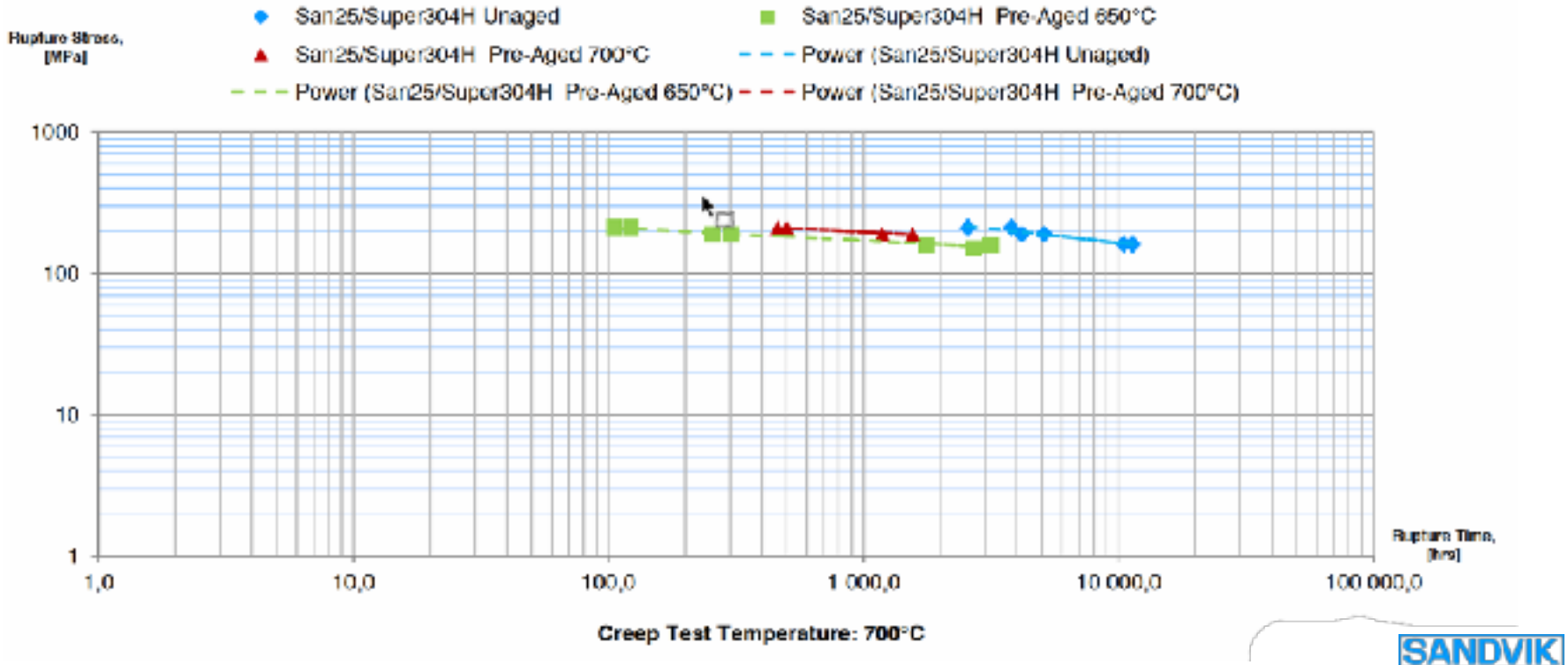
SANICRO™ 25 / UNS 30432 - FILLERA617MOD



CHINA USC TECHNOLOGY DEVELOPMENT WITH CANDIDATE MATERIALS

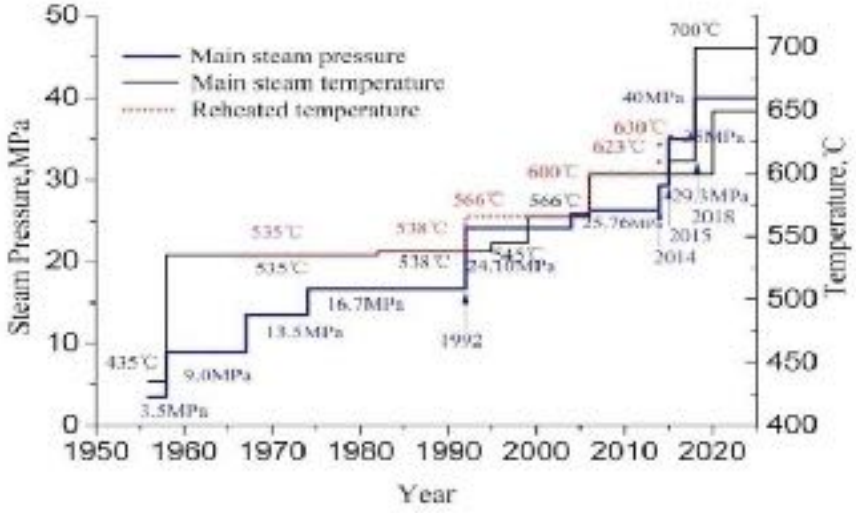


Figure 2 Steam parameter evolution of Chinese USC power plants

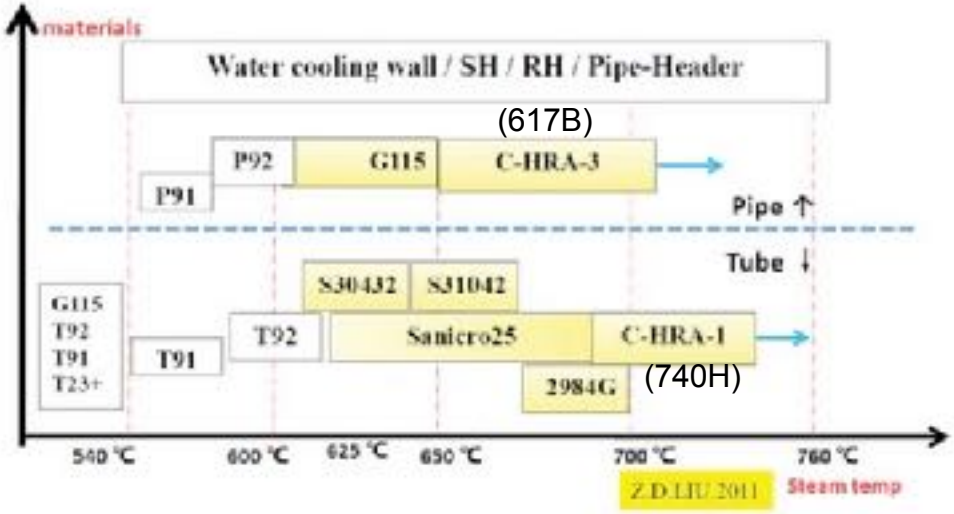
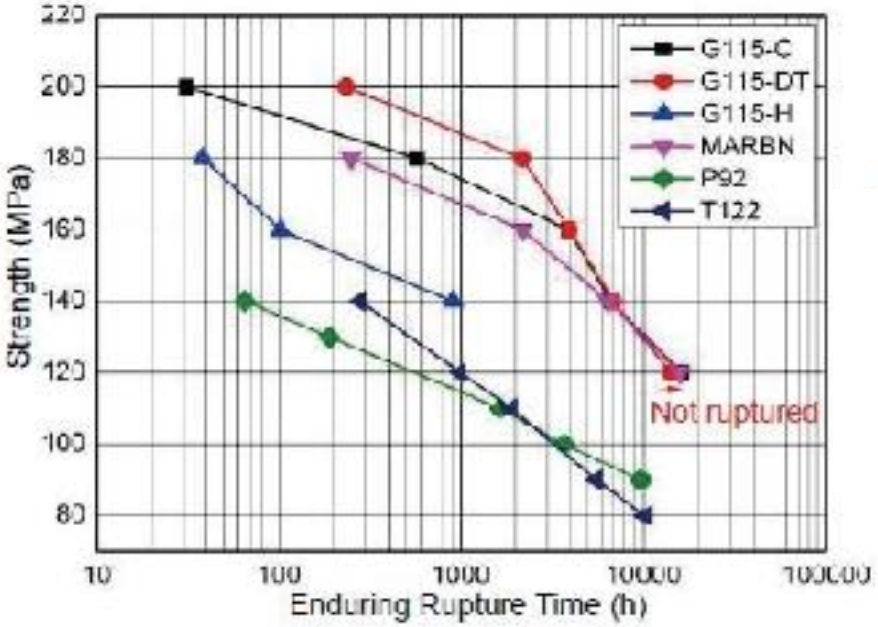
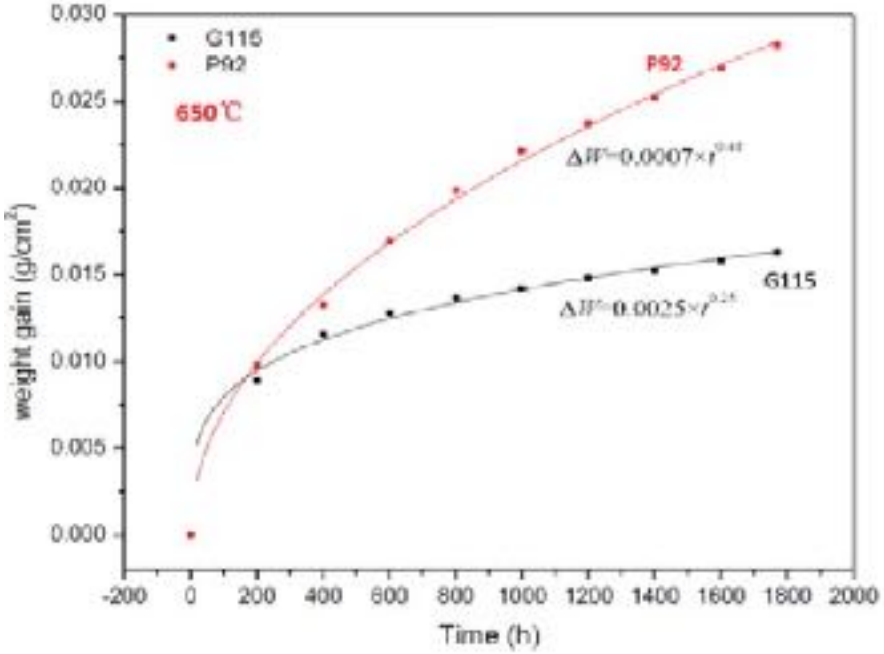


Figure 3 Chinese candidate materials used for 630-700℃ boiler

G115


G115-C
G115-DT
G115-H
MARBN
P92
T122
Not ruptured
Strength (MPa)
Enduring Rupture Time (h)
220
200
180
160
140
120
100
80
10
100
1000
10000
100000


G115
P92
650℃
P92
G115
weight gain (g/cm²)
Time (h)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
-200
0
200
400
600
800
1000
1200
1400
1600
1800
2000

COMPOSITIONS OF MATERIAL CANDIDATES

ALLOY	P93	G115	SANICRO 25	HR6W	617B	740H
Si	0.3	-	0.4	1	1	1
Cr	9	9	22	23	22	25
Mo	-	-	-	0	9	2
Ni	**0.2**	**0.2**	**25**	**47**	**52**	**41**
Co	**0.1**	**3**	**1.5**	**-**	**13**	**20**
Al	0.03	-	-	-	1.5	2
Cu	-	1	3	-	0.5	0.5
W	**3**	**2.8**	**3.5**	**7**	**-**	**-**
Nb	0.05	0.05	0.6	0.35	-	2.5
Ti	-	-	-	0.2	0.6	2.5
Fe	Bal.	Bal.	Bal.	20	-	2
	MARTENSTIC		AUSTENITIC	NICKLE BASE		

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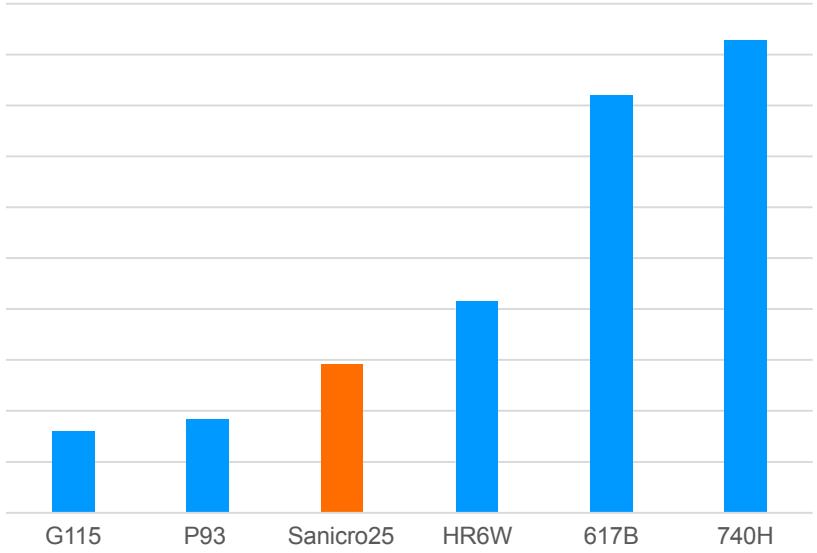
FEASIBILITY FROM MATERIAL COST

RAW MATERIAL COST PER ALLOY DEC 2017

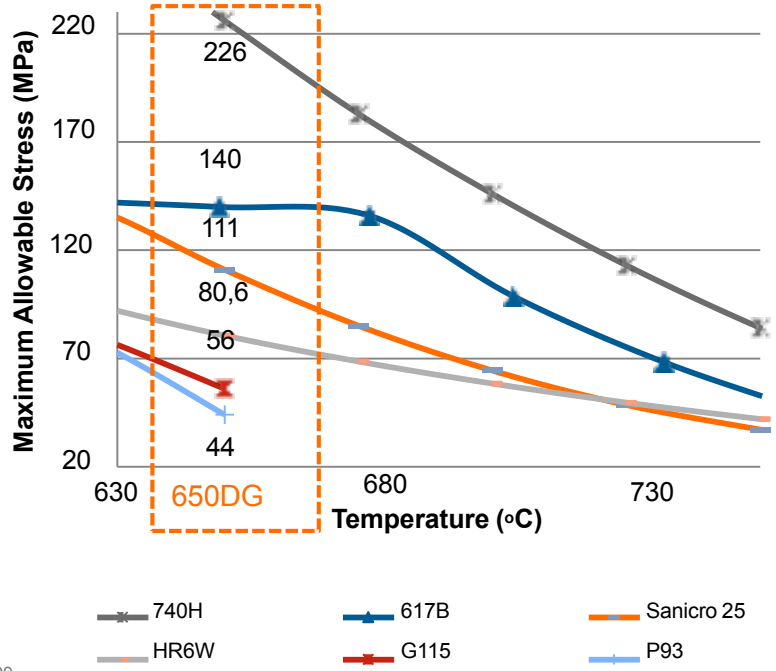


FEATURED LME PRICES

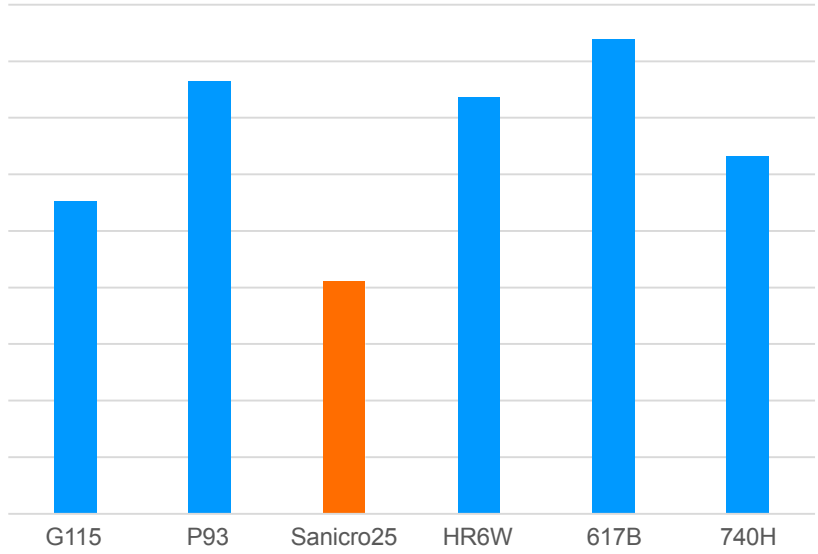
US$/tonne for 13 December 2017	
LME Aluminium	1,997.00
LME Copper	6,885.00
LME Zinc	3,161.50
LME Nickel	11,085.00
LME Lead	2,515.00
LME Tin	18,876.00
LME Aluminium Alloy	1,790.00
LME NASAAC	1,850.50
LME Cobalt	72,000.00

WHAT ABOUT MAXIMUM ALLOWABLE STRESS?

MAXIMUM ALLOWABLE STRESS



RELEATVIE MATERIAL COST – ADJUSTED FOR MAX ALLOW STRESS



WHY SANICRO 25 PIPE?

650DG PLATFORM ALLOY COMPARISONS

SECTION	ALLOY	SIZE	WEIGHT KG / M	PRESSURE MPA	DESIGN TEMP (DG C)	WEIGHT COMPARISON
EXAMPLE 1	SANICRO 25	OD 559 X 100 MM	1164	XX MPA	XXX	BASE
	HR6W	OD 559 X 125 MM	1376	XX MPA	XXX	+ 18%
	G115	OD 610 X 150 MM	1749	XX MPA	XXX	+50%
EXAMPLE 2	SANICRO 25	OD 457 X 85 MM	802	XX MPA	XXX	BASE
	HR6W	OD 457 X 100 MM	905	XX MPA	XXX	+13%
	G115	OD 559 X 140 MM	1487	XX MPA	XXX	+85%

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SANICRO 25 – PORTFOLIO DEVELOPMENT

SANDVIK PORTFOLIO DEVELOPMENT	STATUS – MARCH 2017
COLD FINISHED BOILER TUBE SANICRO 25 *TUV, ASME, C-BPV Approved* Outer Diameter: 25mm-114.3mm Wall thickness: 3-14mm lengths of up to 16 meters	PRODUCT READY FOR COMMERCIAL ORDERS **APPROVED AND PRODUCTION READY**
COLD FINISHED BOILER TUBE SANICRO 25 Same production route as boiler tubes Outer Diameter: 114.3 – 223 mm Wall thickness: based on requirements	PRODUCT READY FOR CO-DEVELOPMENT WITH INDUSTRY **SIZE RANGE TO BE QUALIFIED** - Qualification based on market orders
HOT EXTRUDED PIPE SANICRO 25 Outer Diameter: 223 – 800 mm Wall thickness: 20 – 120 mm	**PRODUCTION TRIALS INITIATED** - Ingots produced – 800MM OD 8 TON - Initial extrusion trial size – 457 x 73MM - Properties to be verified

SUMMARY

- Based on the current materials available, are 700-800DG A-USC really feasible considering the relative material cost verses the increased efficiency gain?
- Candidate materials for 630-670DG A-USC platforms balance material cost verses efficiency gains enabling technology shift today. P93, G115, HR6W and Sanicro 25
- Reality sees 630, 650 and 670DG platforms being the key opportunities for the next 10 years until lower cost alloys for 700-800DG platforms available.
- If we want to make a difference, and ensure coal power has a place in the energy mix, we need to ensure the technology is increasing efficiency, lowering emissions and COMMERCIALY FEASIBLE!
- 630-670DG steam technology ensures this future and is where coal has a sustainable future!
- Sanicro 25 is an ideal candidate enabling a balance of increased steam and cost.

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