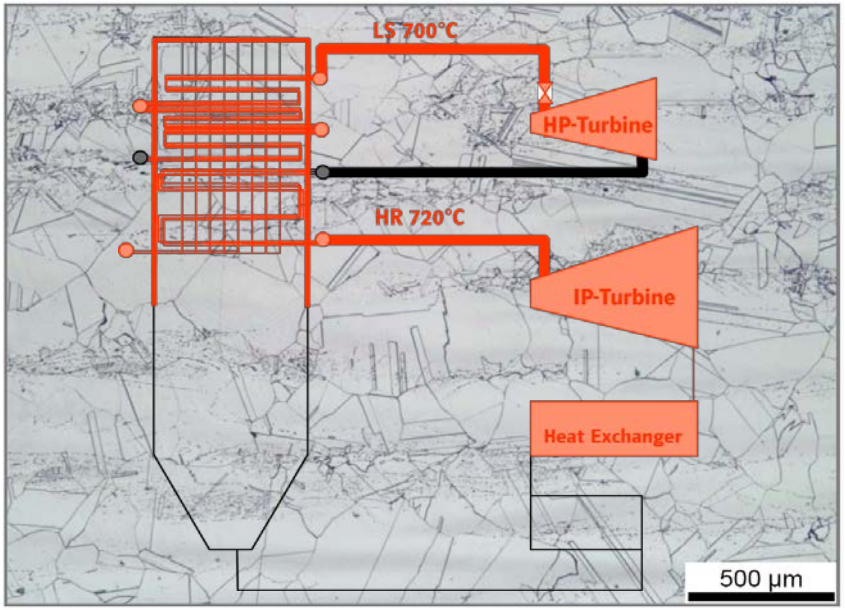


From the 600/620°C to the 700/720°C-USC-PP

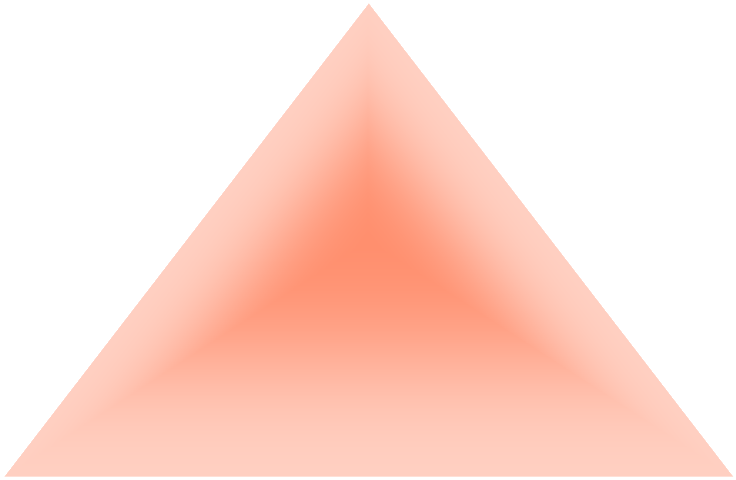
History and Status

Dr M. Bader

The Motivation

Global Basic Conditions for the Energy Industry

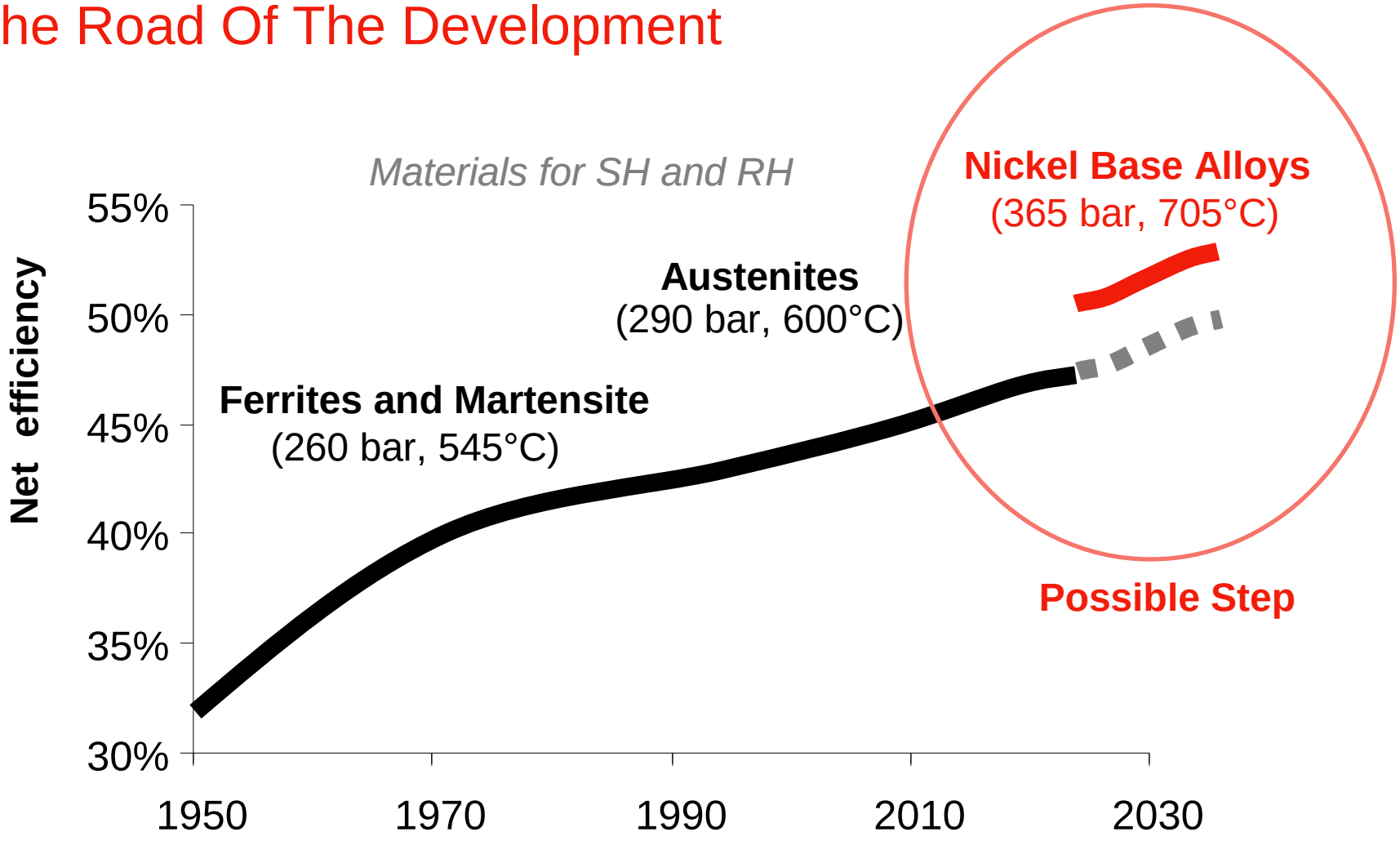
Economics
Competition in the European Market



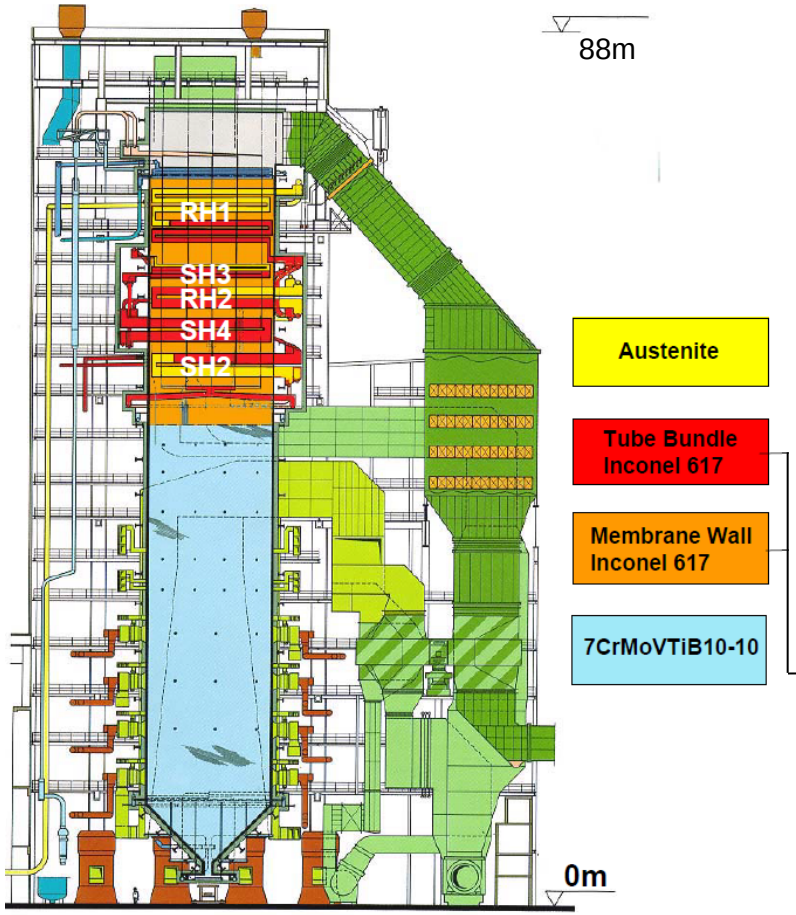
Security of Supply
Resources, mix of power production and political framework

Environmental Impact
Climate protection and new technologies

The Road Of The Development



700/720°C Boiler (Demo- 500MW)



Austenite

Tube Bundle
Inconel 617

Membrane Wall
Inconel 617

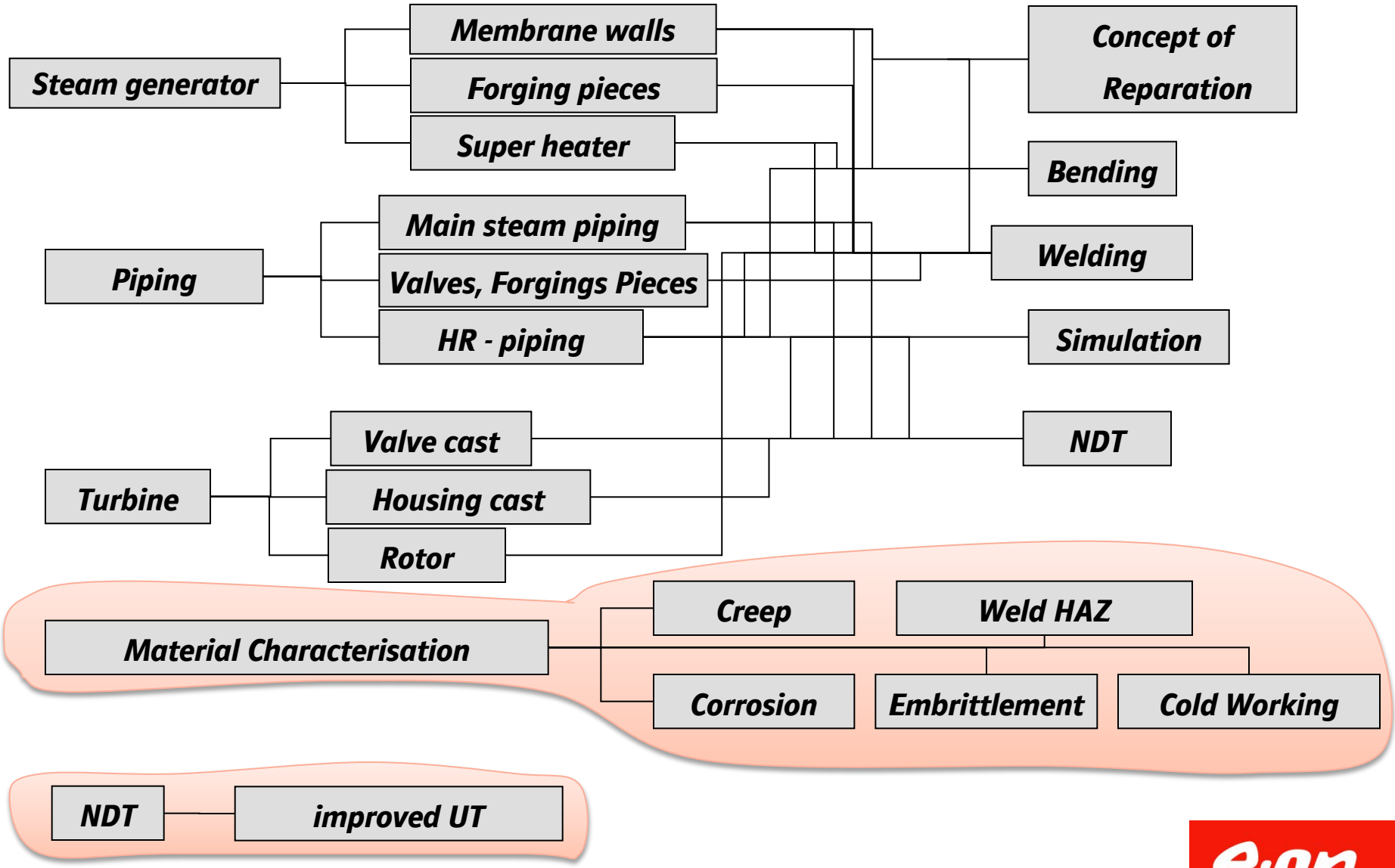
7CrMoVTiB10-10

Ni base alloys:
- Material data
- Design by analysis
- Manufacturing
- Welding

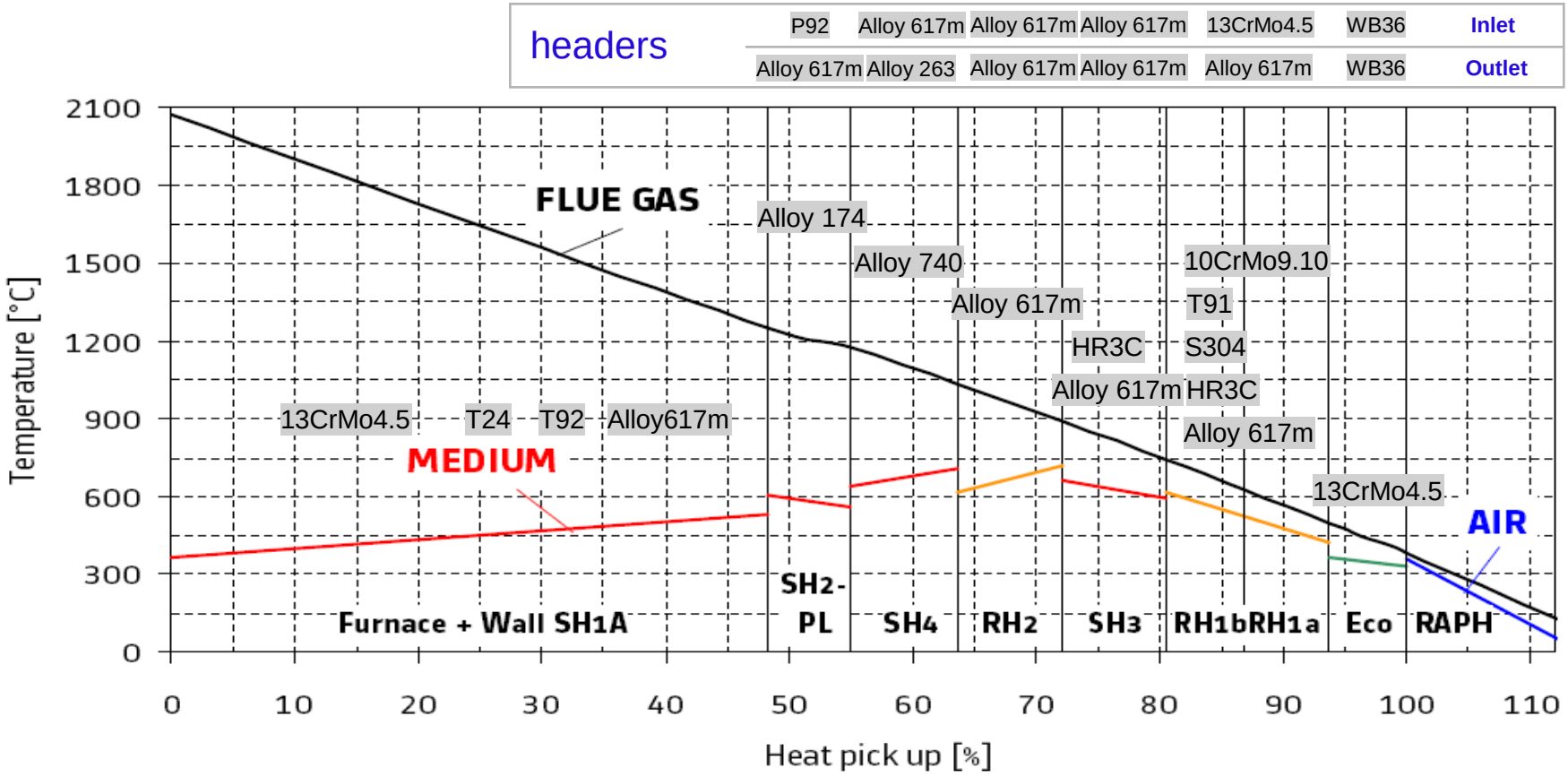
High pressure part	
Steam rating	334kg/s; 1024t/h
Allowable operating pressure (gauge)	390 bar
SH-Outlet temperature	705 °C
Reheater	
Steam rating	285 kg/s
Allowable operating pressure (gauge)	81 bar
RH-Outlet temperature	720 °C

[Hitachi Power Europe GmbH Duisburg]

R&D from 2007 - 2012

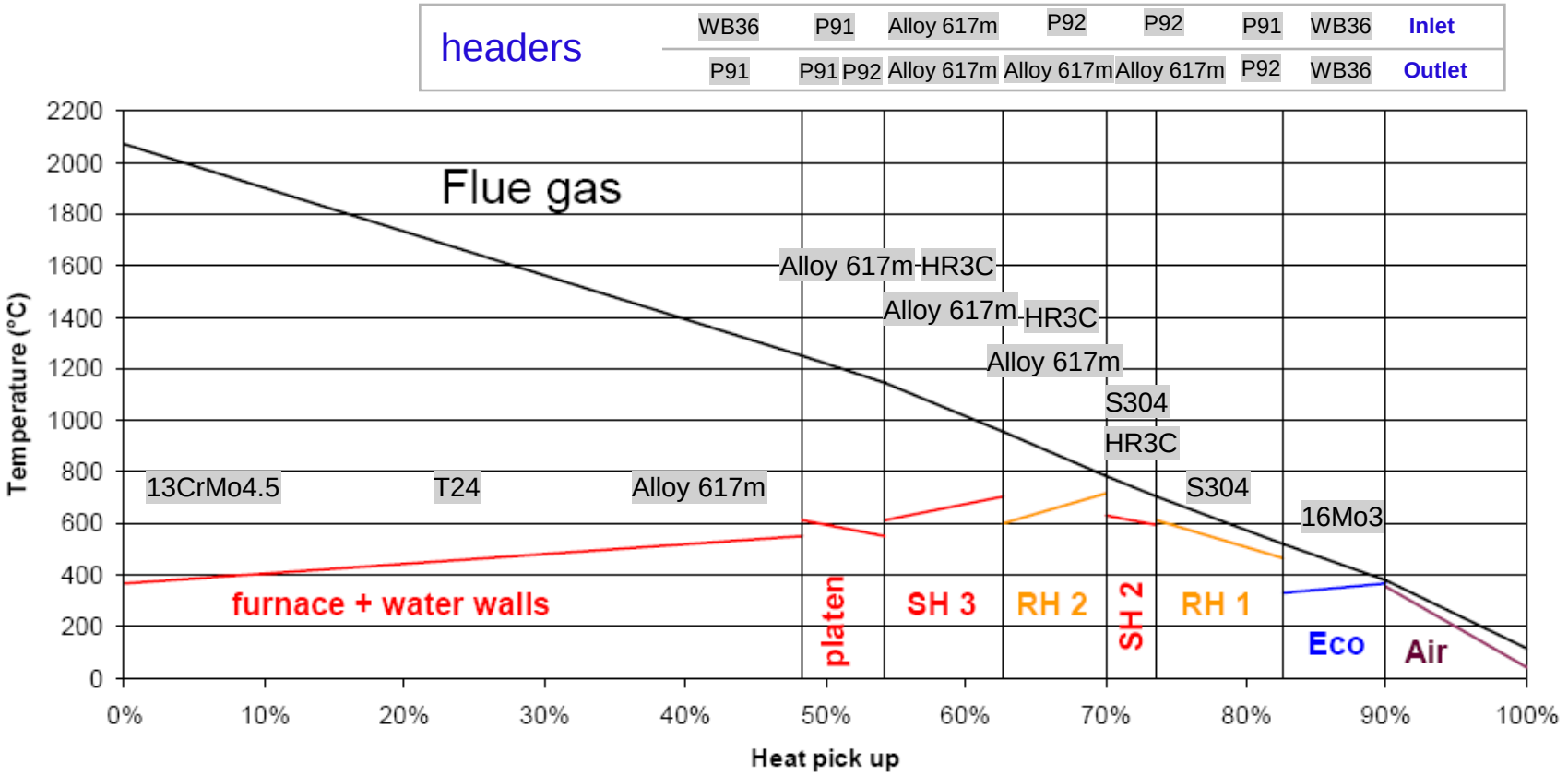


700°C Boiler - Material Concept



[NRWPP700, Variant A]

700°C Boiler - Material Concept



[NRWPP700, Variant B]

Damage → SRC…?

Crack initiation

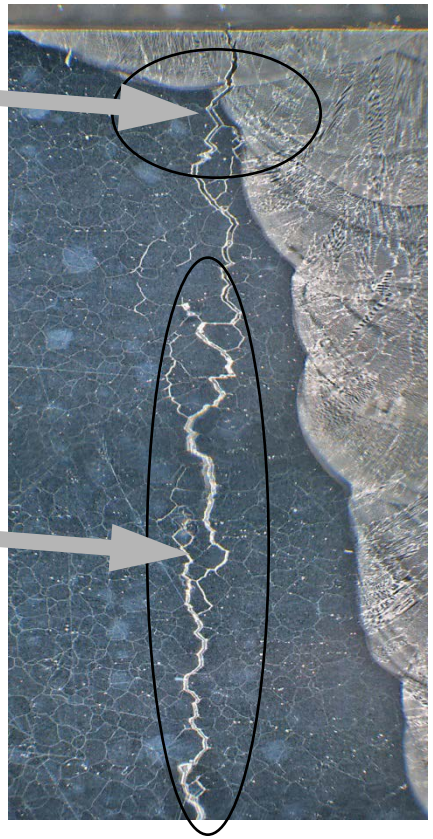
In the welding area:

1. Shrinking stresses (σ_{res})
2. In the HAZ (heat affected zone)
3. At the outer surface
   (stresses caused by bending)

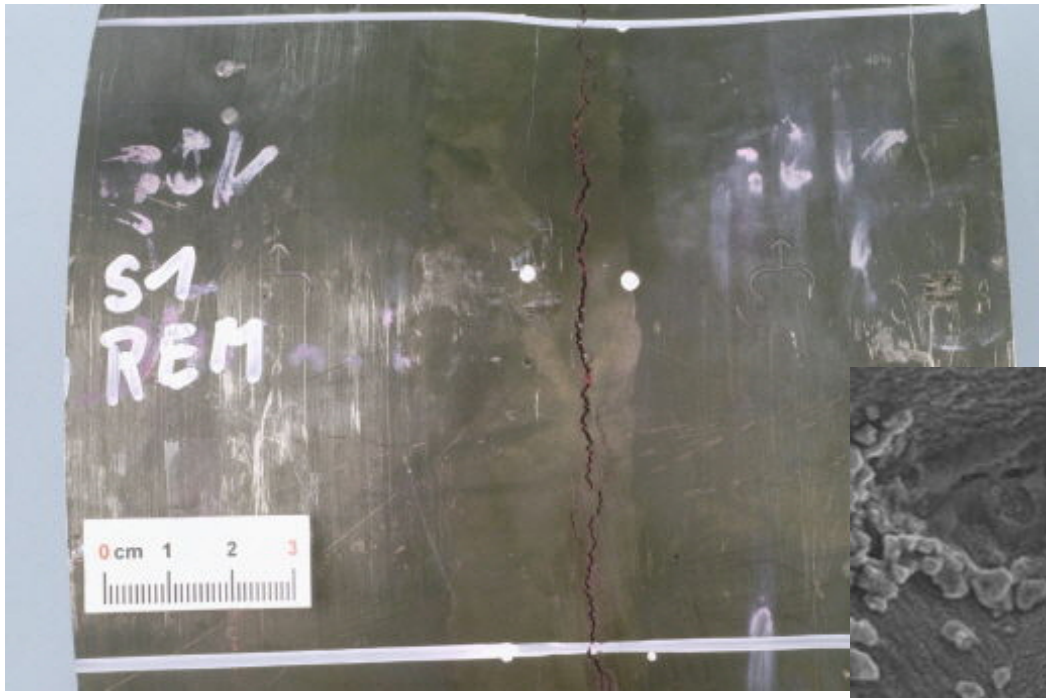
Crack propagation

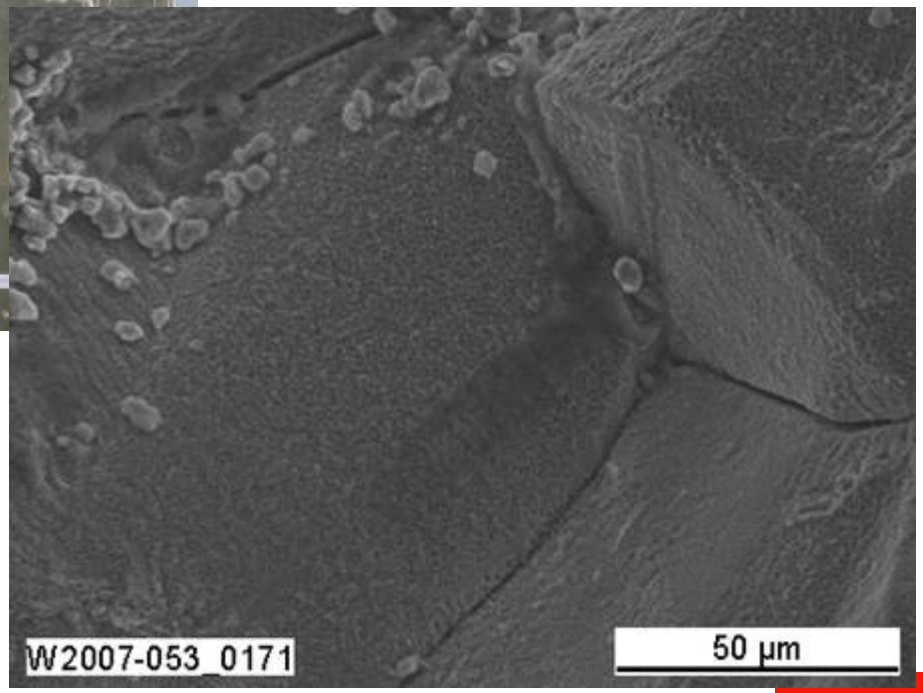
Mainly in the base material:

1. Steered by the stress
   (no different between HAZ and Parent Mat)
2. Intergranular crack (IC)

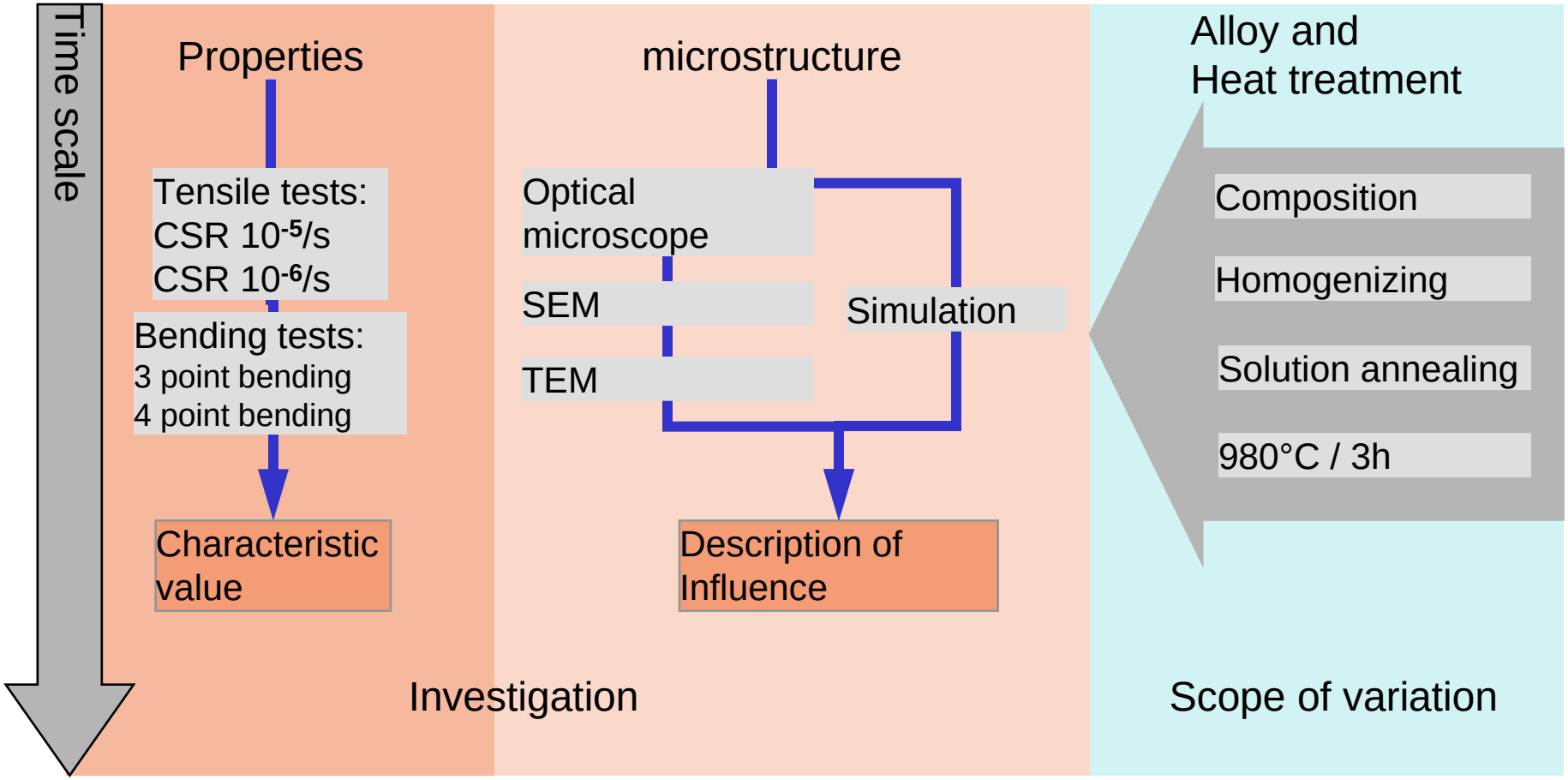


Relaxation Cracking At A617-Welds





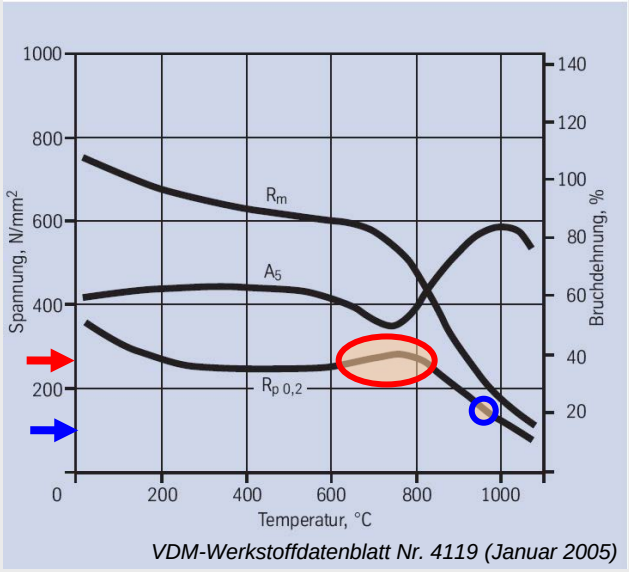
R&D Road Regarding The SRC-Behaviour



Welding: Influence of PWHT on Alloy617

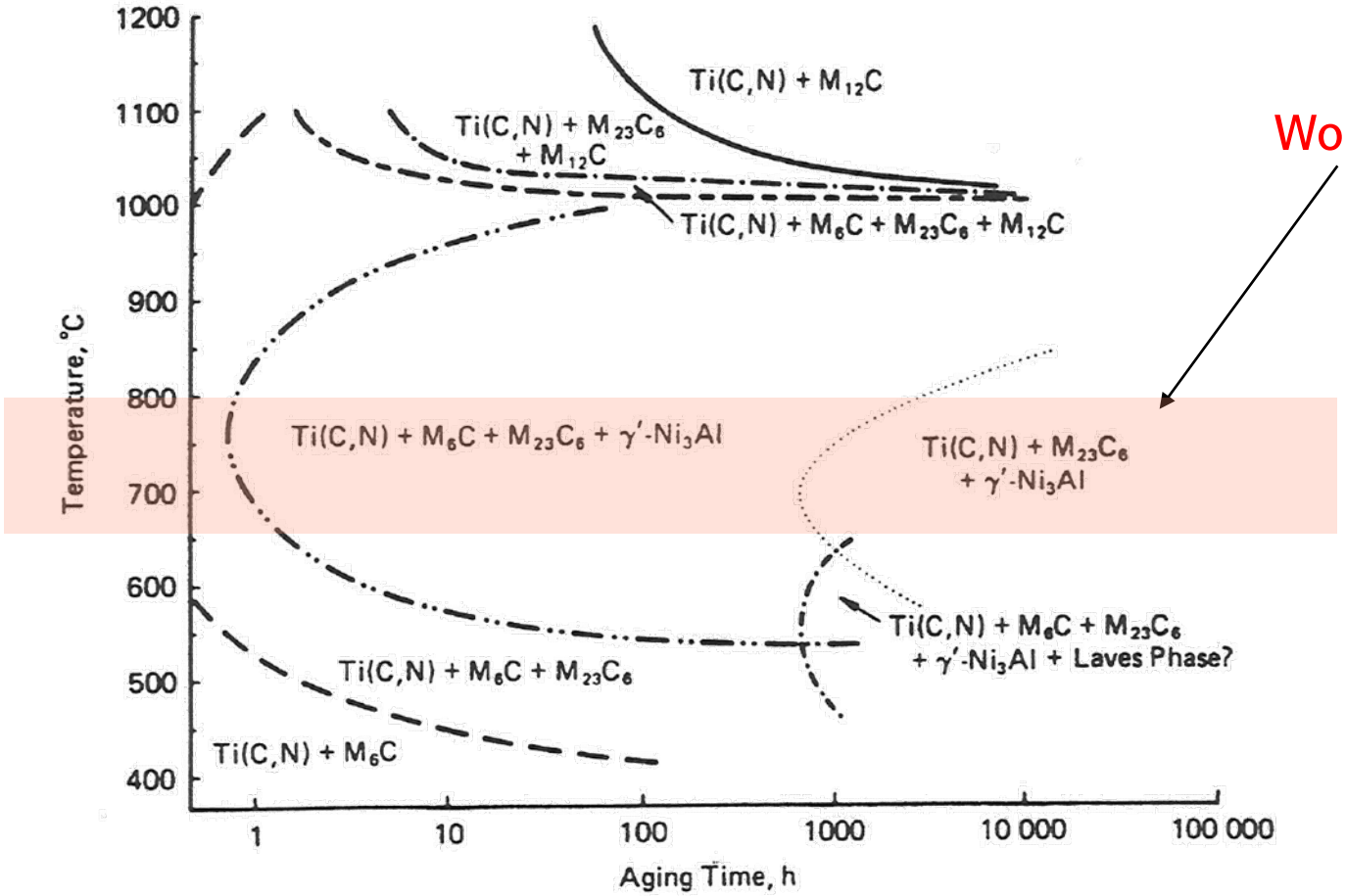
- Welding = Casting = Shrinkage Stresses
- Heavy-walled → a Stress Relief Annealing is necessary
- Normal Hardening of Nickel Base Alloy at 700°C (no plastic relaxation over dislocation gliding) and stress induced gamma prime formation in HAZ

Operating area
Stress relief annealing



VDM-Werkstoffdatenblatt Nr. 4119 (Januar 2005)

Welding: Influence of PWHT on Alloy617 – Influence of Working Temp.



[Kirchhöfer, H. et al: Precipitation Behaviour of Hastealloy X and A617 (1984)]

Status Of The Welding Technology For A617

Virgin material:

- As-delivered condition: solution annealed
- After welding: stress relief heat treatment (SRHT) 980°C/3h

For repair:

- Before welding:
  Variant I: 980°C/3h (removal of γ'-phase) – necessary
  Variant II: 1160°C/1h (additional -removal of carbide-precipitations at grain boundaries ≅ reset the material structure in the initial status) – better weldability (however a challenging heat treatment)
- After welding: stress relief heat treatment (SRHT) 980°C/3h

Remark: ongoing, tests of the repair methods in test rig "Enzio" and additional investigation programs

Résumé

- The classic process is technologically limited.
- The main increase in efficiency is only possible with higher steam temperature and afterwards with the steam pressure.
- 80% of R+D for the 700°C-PP is done.
- No all solutions for the special technical questions are sophisticated.

History → New technical levels brought also unexpected issues and failure.