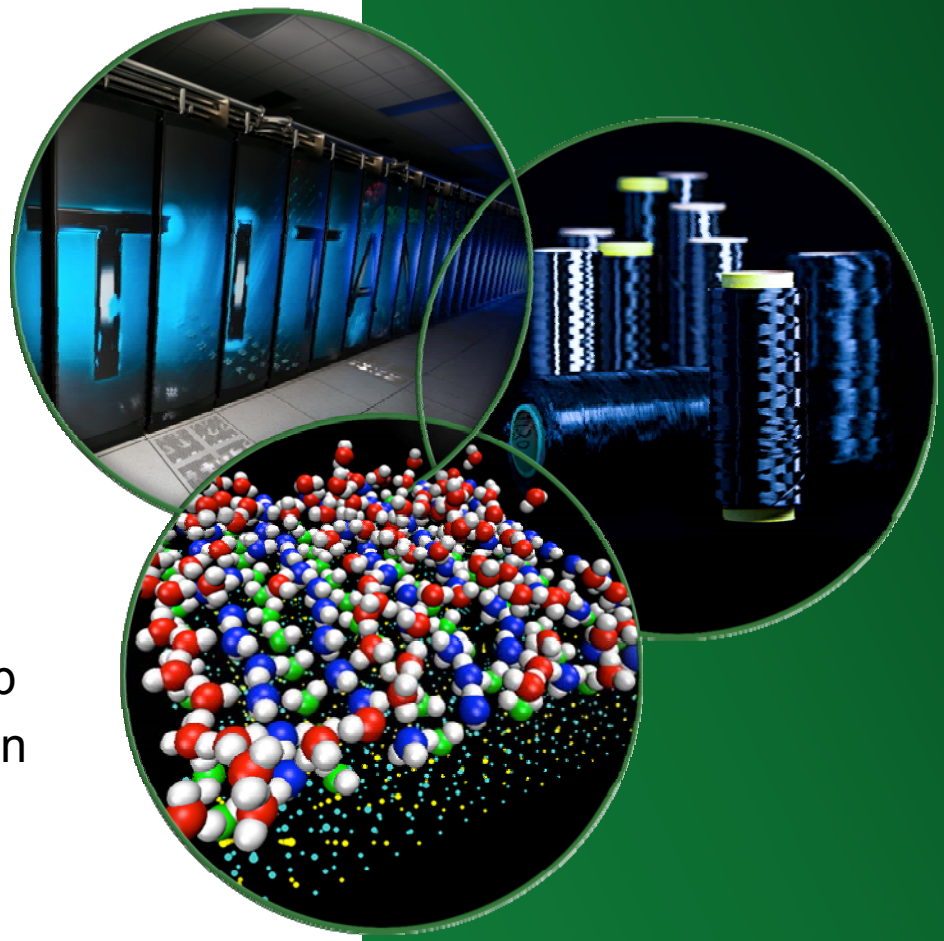
Experience with Thin-Walled High-Temperature Components

Laboratory Materials Research at ORNL



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Corrosion Science & Technology Group

Materials Science & Technology Division

Oak Ridge National Laboratory

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for the US Department of Energy

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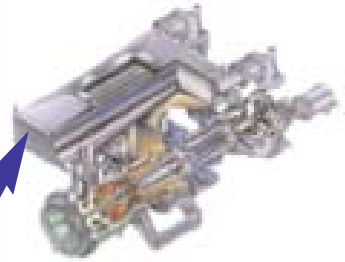
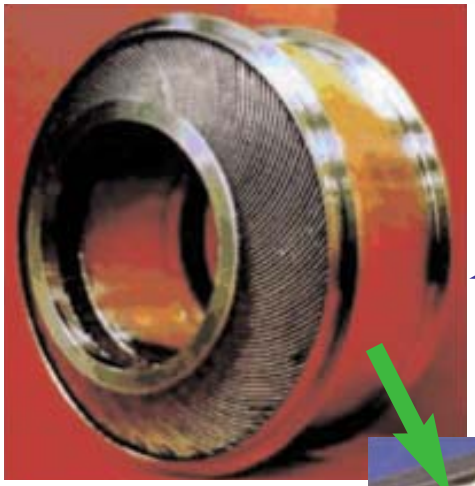
Primary surface recuperators for gas turbines are a great materials science problem

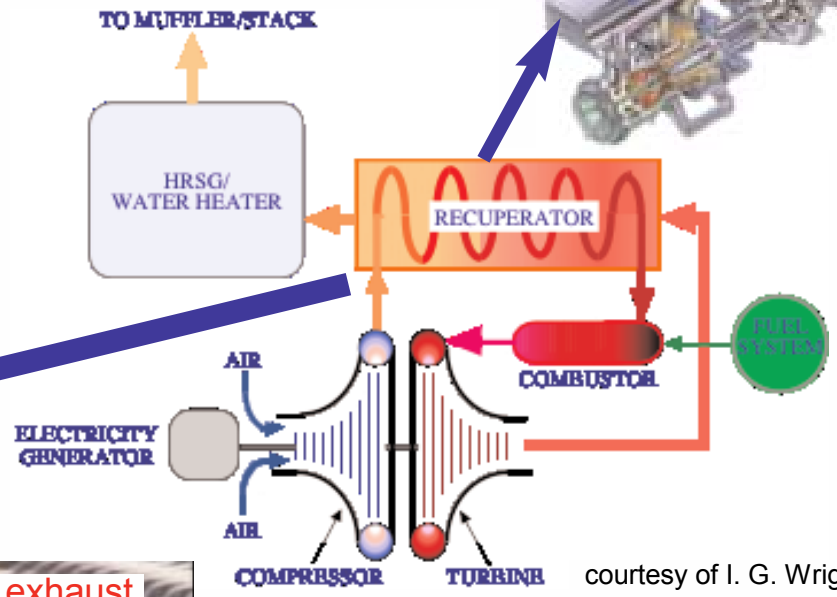
Require:
- creep resistance
- corrosion resistance
- fabricability (roll foil, fold, weld)
- cost

Solar Turbines
Mercury 50 4.6MW

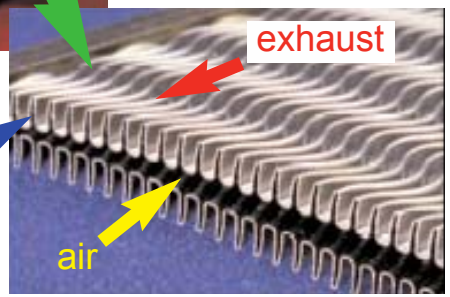


Annular recuperator
65 kW microturbine:





courtesy of I. G. Wright



~80μm foil

Foil not like bulk alloy:
- fine grain size (creep)
- limited Cr (Al) reservoir

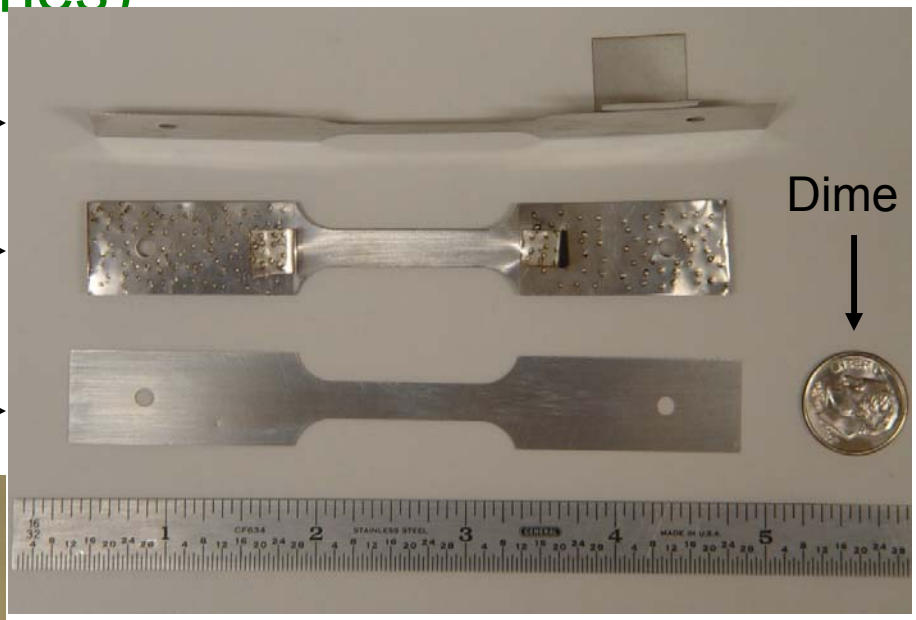
Specialized techniques for creep testing of thin foils
(Building on initial work of Montague at Solar Turbines)

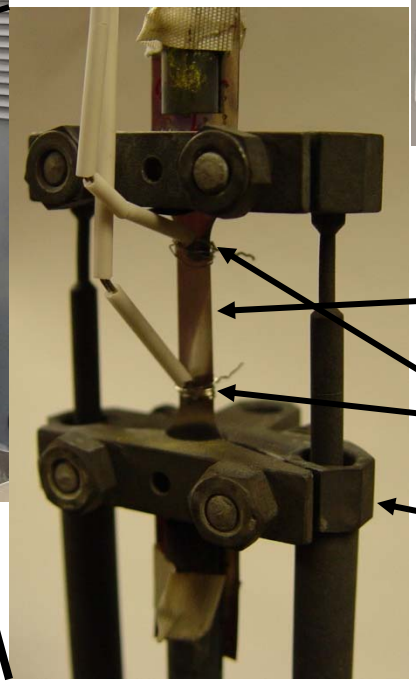
LVDTs for Continuous Monitoring of Creep Strain

4mil Thick Foil

Specimen w/Tabs

Specimen





Specimen

Thermocouples

Extensometer

J.P. Shingledecker

R.W. Swindeman

B.L. Sparks

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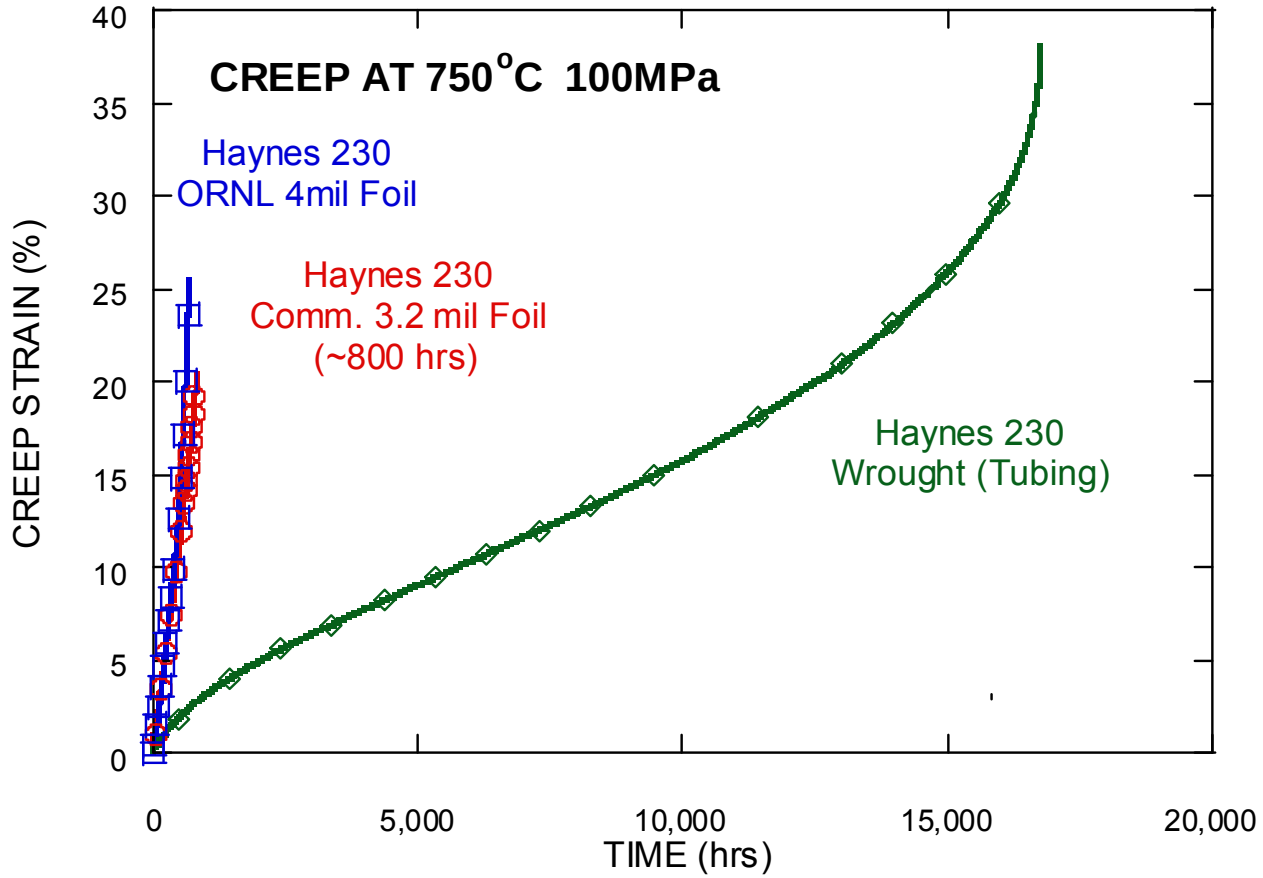
Why is testing needed?

HR230 (NiCrW) is sensitive to grain size, which makes the creep resistance of foils much less than thicker plate/tube



1382°F, 14.5ksi

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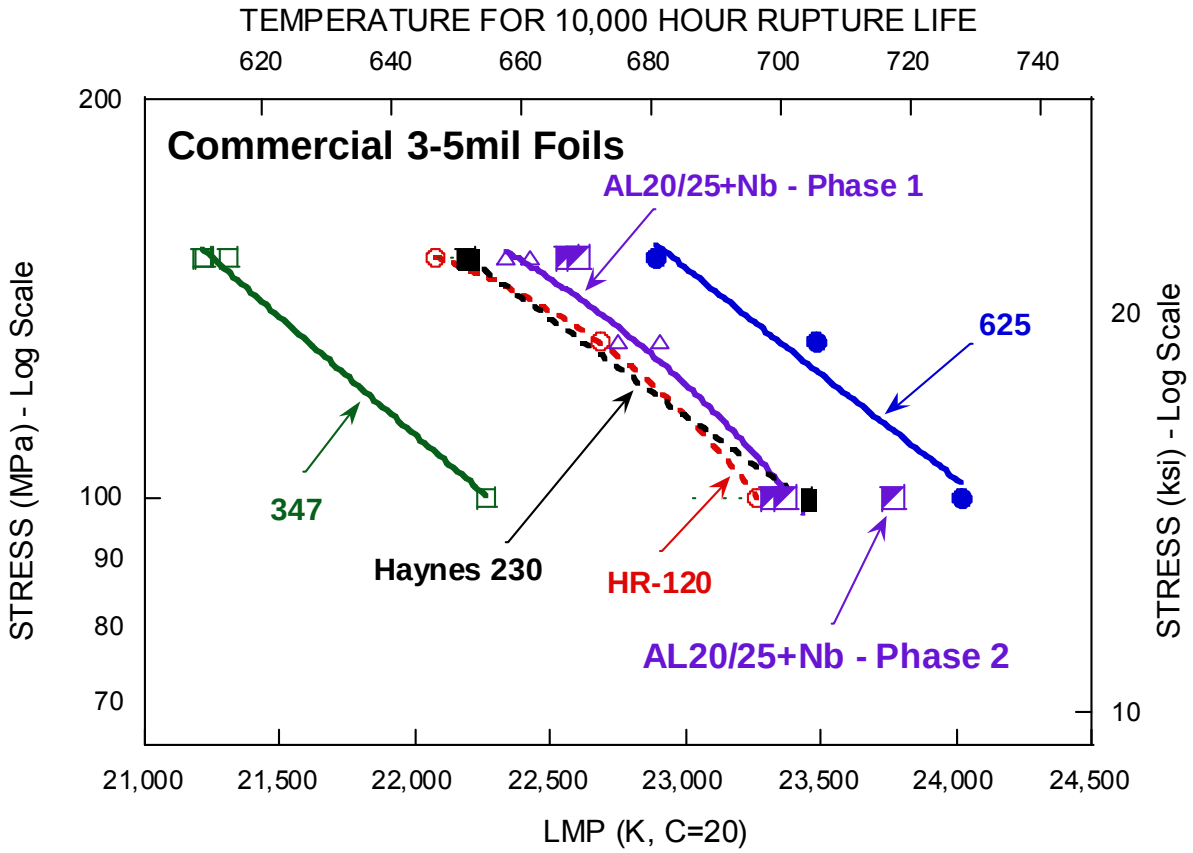
Several alloy foils were evaluated at 700°-750°C under DOE Office of Distributed Generation

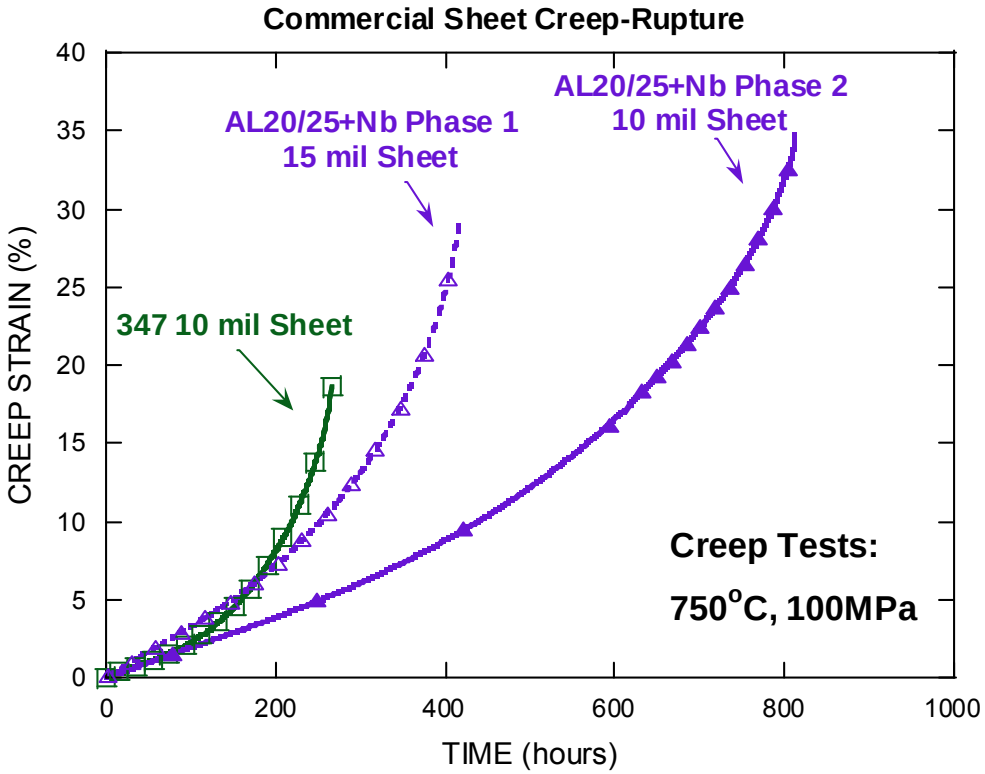


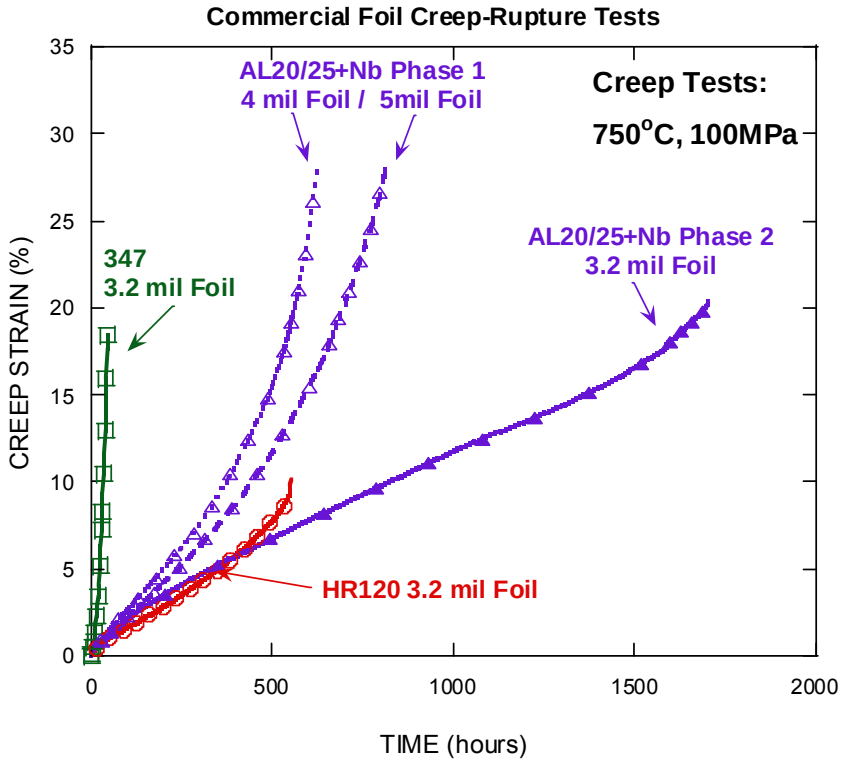
347: Fe-17Cr-11Ni
AL+Nb: Fe-20Cr-25Ni
120: Fe-25Cr-35Ni
230: Ni-23Cr-12W
625: Ni-23Cr-9Mo-4Nb

Also 214, PM2000

Not done:
- 617
- 740H
- 282

ORNL (Maziasz) helped improve the strength of commercial 347 and AL20/25+Nb foil by composition and processing control





1382°F, 14.5ksi

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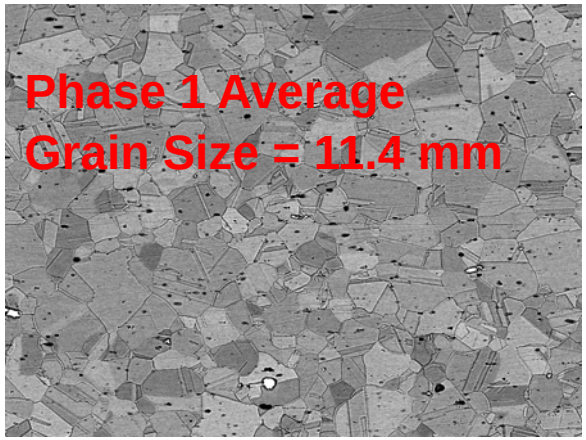
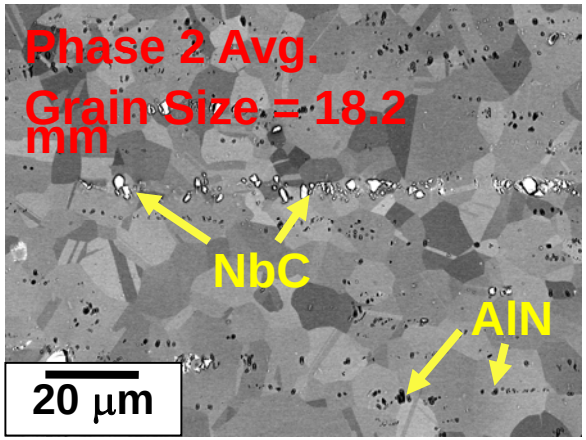
AL20-25+Nb optimized microstructure
Coarsened grain size and fine carbides



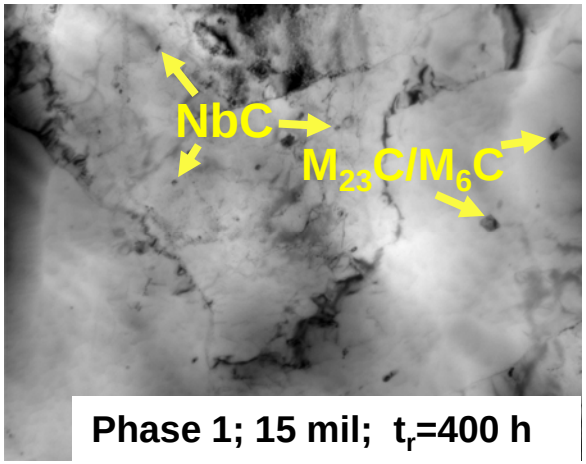
15 mil, as processed condition



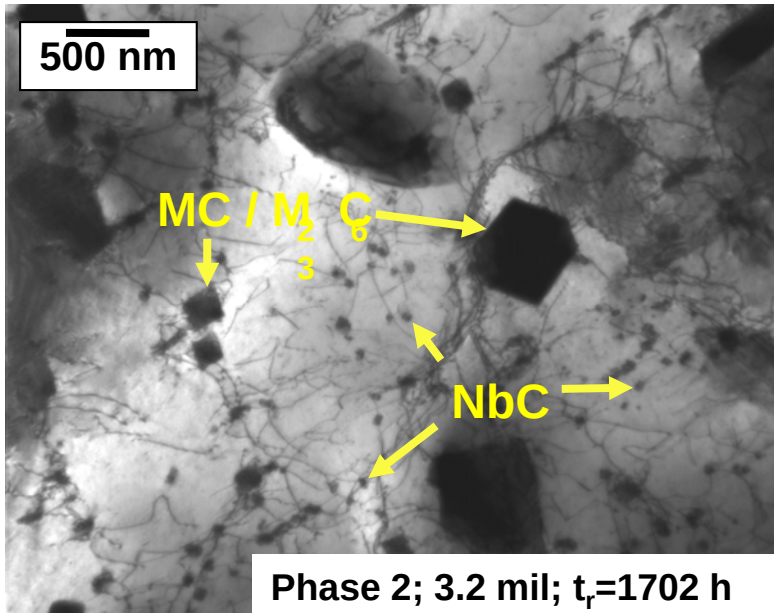
10 mil, as processed condition

SEM BSE images

TEM images



Phase 1; 15 mil; t_r=400 h



Phase 2; 3.2 mil; t_r=1702 h

specimens crept 750ºC, 100 MPa

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Summary & Closing Thoughts

- ORNL has 20 years experience evaluating and optimizing the high temperature properties of thin-walled alloys for gas turbine heat exchangers
  - International recognition for recuperator materials
  - High quality data base on creep and oxidation behavior
  - Alloy optimization and development impacted the industry
- Current small project supports the deployment of ORNL alumina-forming austenitic (AFA) steel foil
  - Evaluation of current alternatives
  - 8,000h durability test in 65kW engine in progress at ORNL
- ORNL expertise can assist in the development of new thin-walled heat-exchangers for supercritical CO_2
  - New alloys should be evaluated
  - Current materials have improved since ~1999-2006 data