Alloy Additions for Improved Creep-Rupture Properties of a Cast Austenitic Stainless Steel – CF8C-Plus With Cu, W

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Acknowledgements

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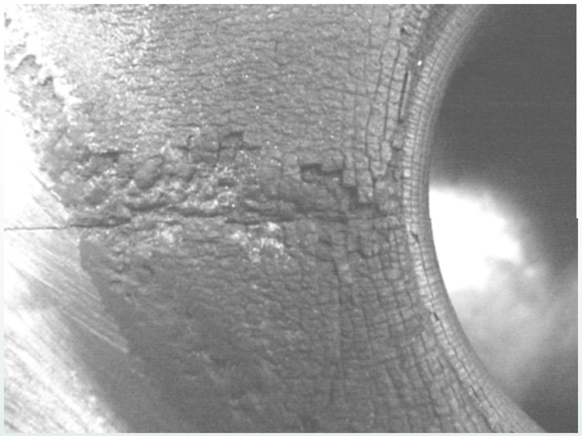
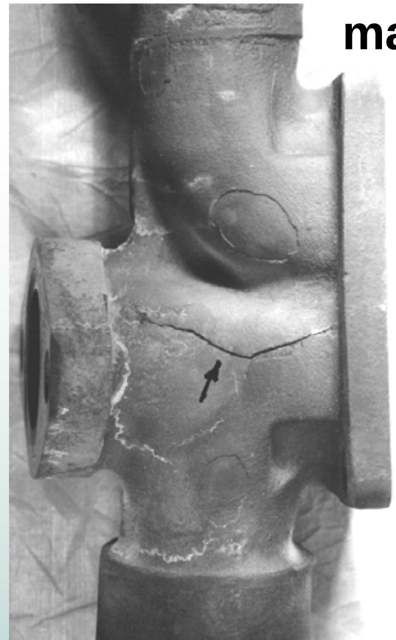
CF8C-Plus cast stainless steel was developed to have higher temperature capability and reliability for advanced diesel engine and gas turbine applications



turbo-housing



manifold

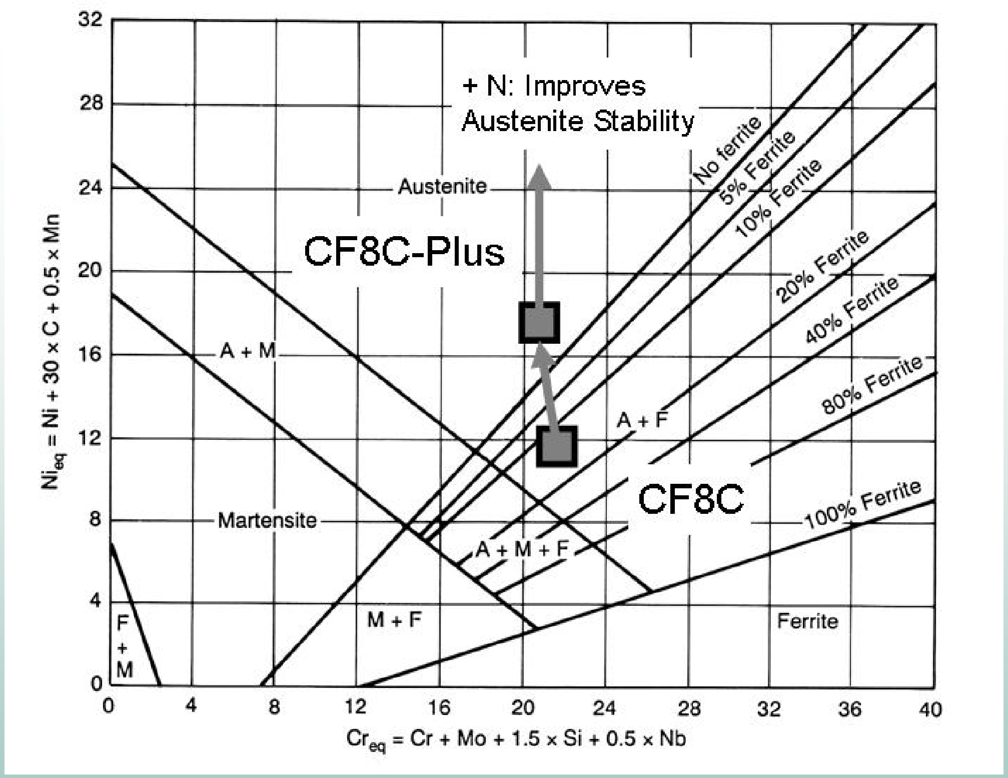
C-15, HD 14.6L HD On-Highway Diesel Engine

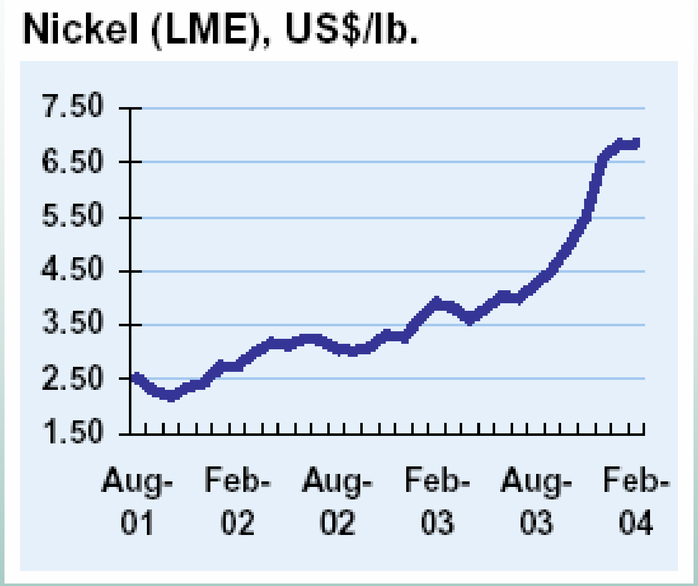
- Cast stainless upgrade for SiMo cast-iron diesel engine exhaust components
- Cast stainless upgrade for CF8C steel gas turbine structural components

Alloy Compositions (wt.%)

- SiMo Cast Iron – Fe-3.45C-4Si-0.6Mo-0.3Mn
- Ni-Resist – Fe-2Cr-35Ni-0.5Mn-5Si-1.9C
- CF8C-Fe-19Cr-10Ni-0.07C-1.0Nb-0.7Mn-1Si
- CF8C-Plus – Fe-19Cr-12Ni-0.07C-0.07Nb-0.4Si-+Mn+N(new heats + 3Cu-1W)
- CN-12 – Fe-25Cr-13Ni-0.4C-1Mn-1.7Nb-0.3N-0.15S
- Hitachi 20/20 – Fe-20Cr-20Ni-0.45C-2Nb-3W-1Mn-0.6Si-0.15S
- Diado KN2 – Fe-19Cr-12Ni-0.3C-0.7Nb-2Si(max)-1Mn(max)-0.1S(max)

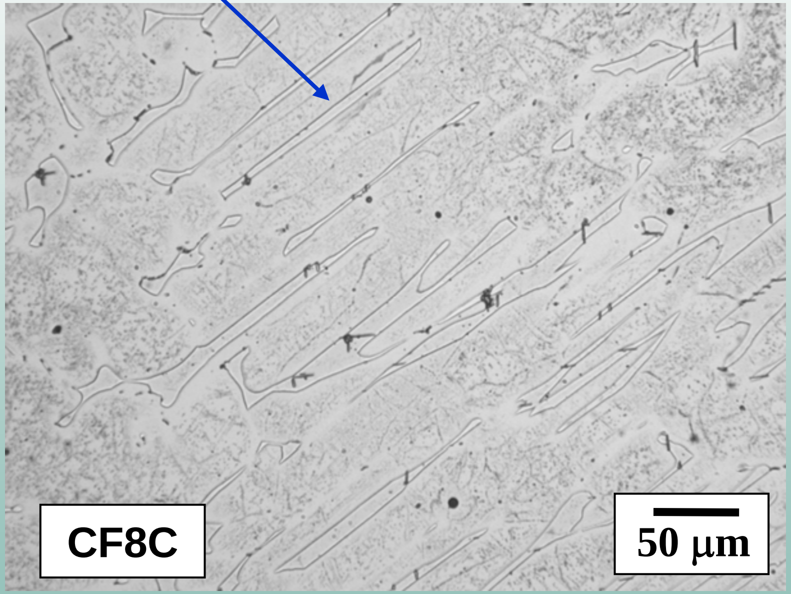
New CF8C-Plus was designed to have stable austenite equivalent to higher-Ni alloys, due to Mn+N additions, and now Cu and W additions

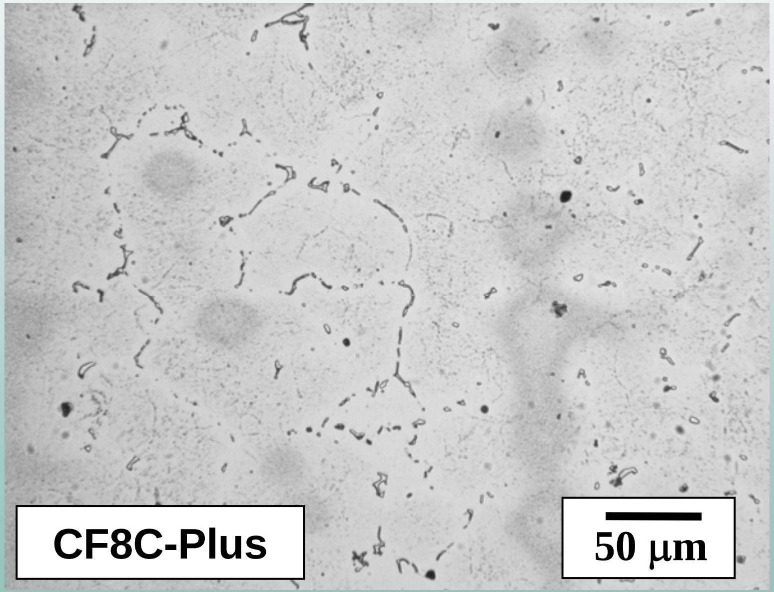




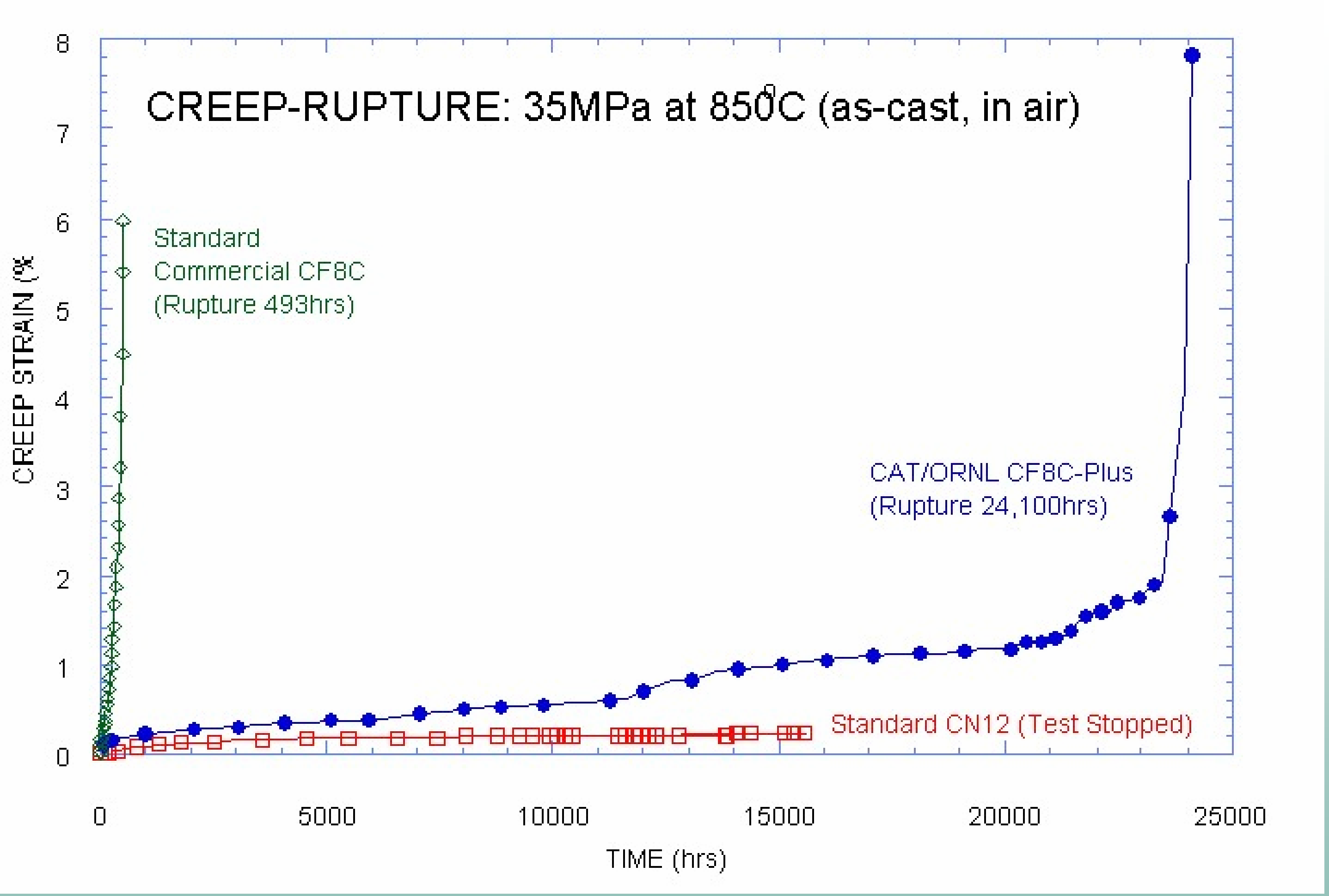
Engineered Microstructure – As Cast

- Centrifugal Castings
  - **CF8C: 15-20% δ-ferrite grains**
  - **CF8C-Plus: NbC plus austenite grains**



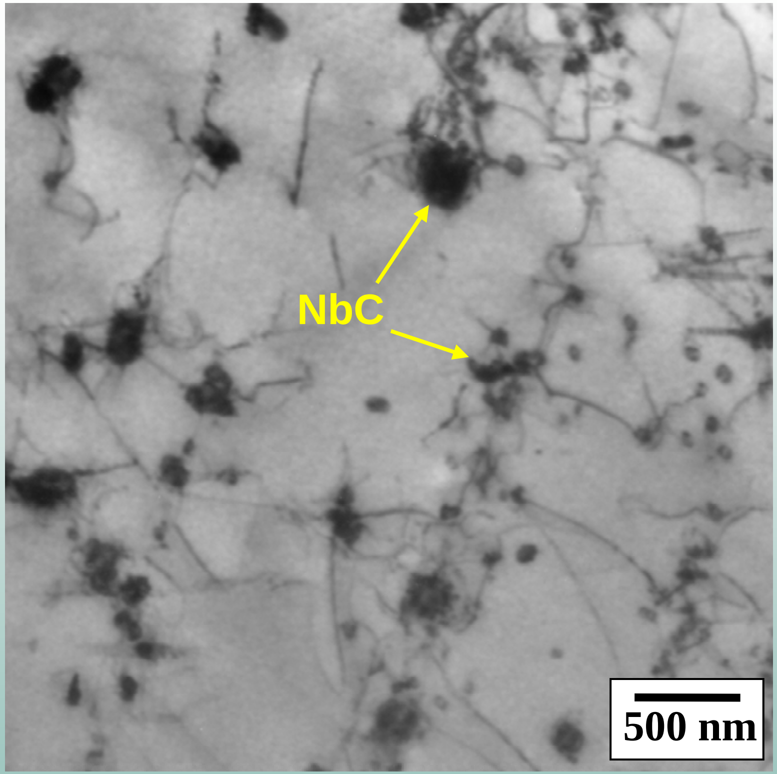


First creep of CF8C-Plus steel at 850^{o}C lasted 2 years. CF8C-Plus won 2003 R&D100 Award



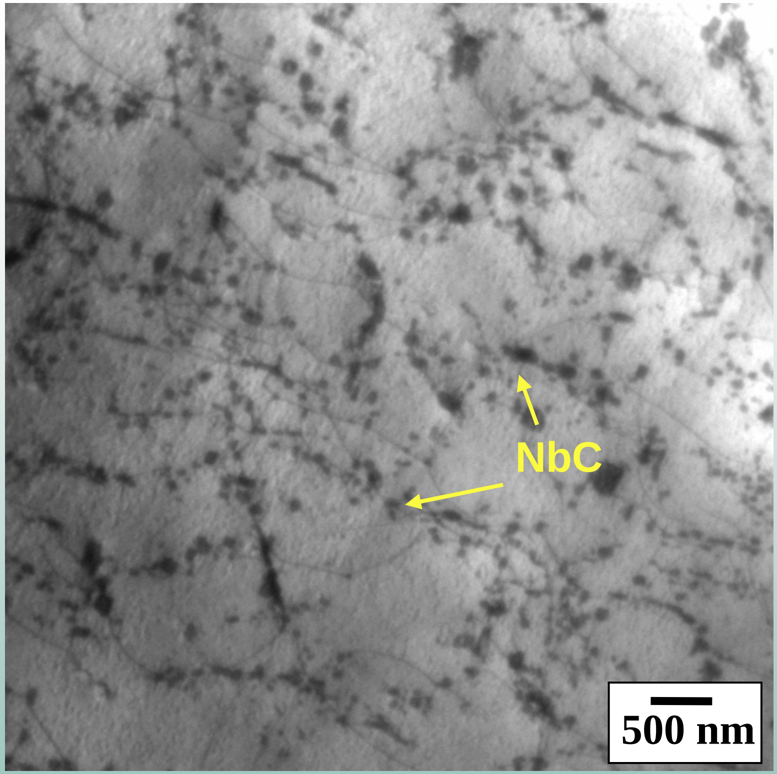
Engineered Microstructure Effect - CF8C-Plus Has "Super" Creep Resistance at 850°C Because Abundant, Stable Nano-Scale NbC Pin Dislocations

Commercial, Standard CF8C



Creep Tested 850°C/500 h

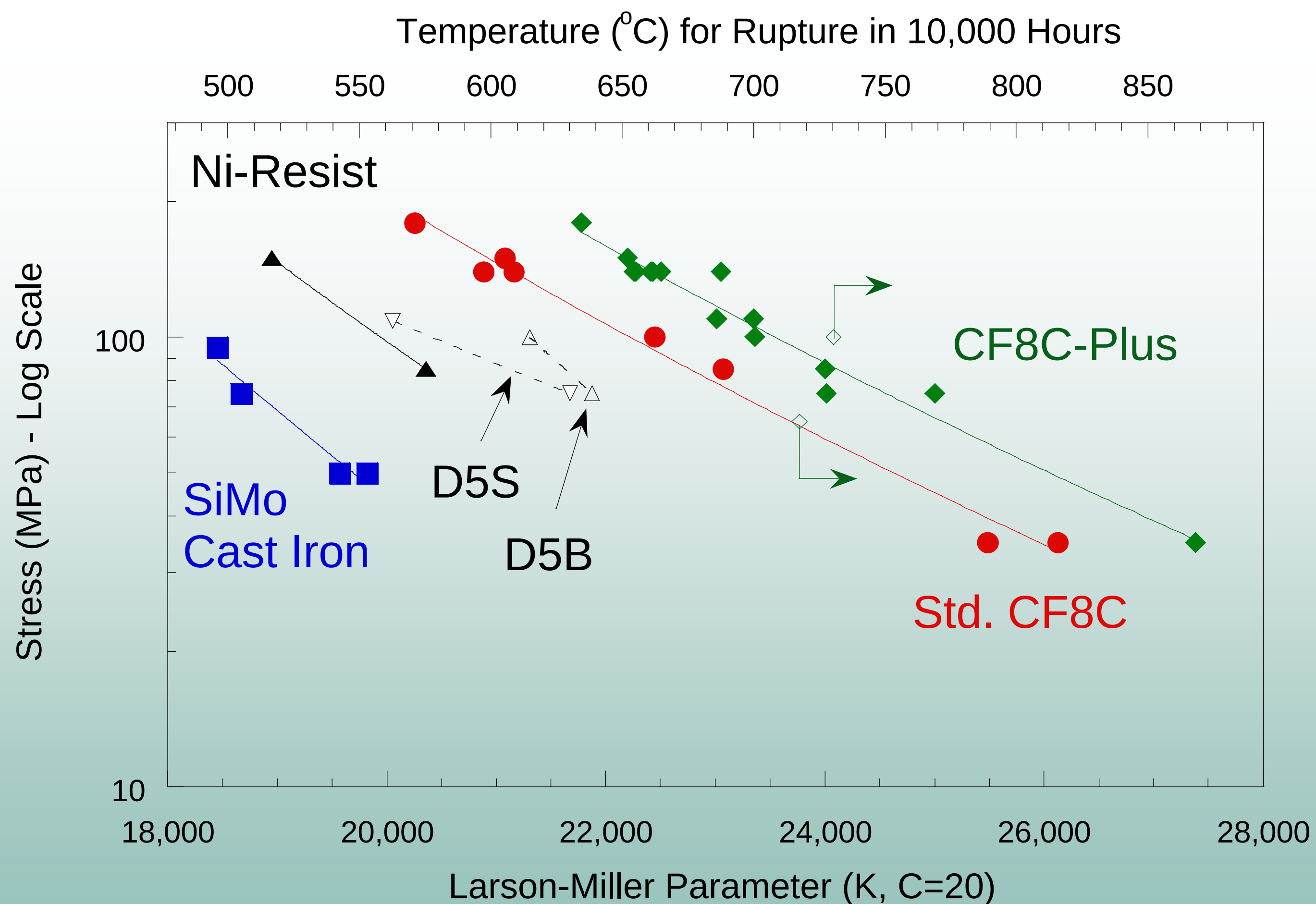
New CF8C-Plus



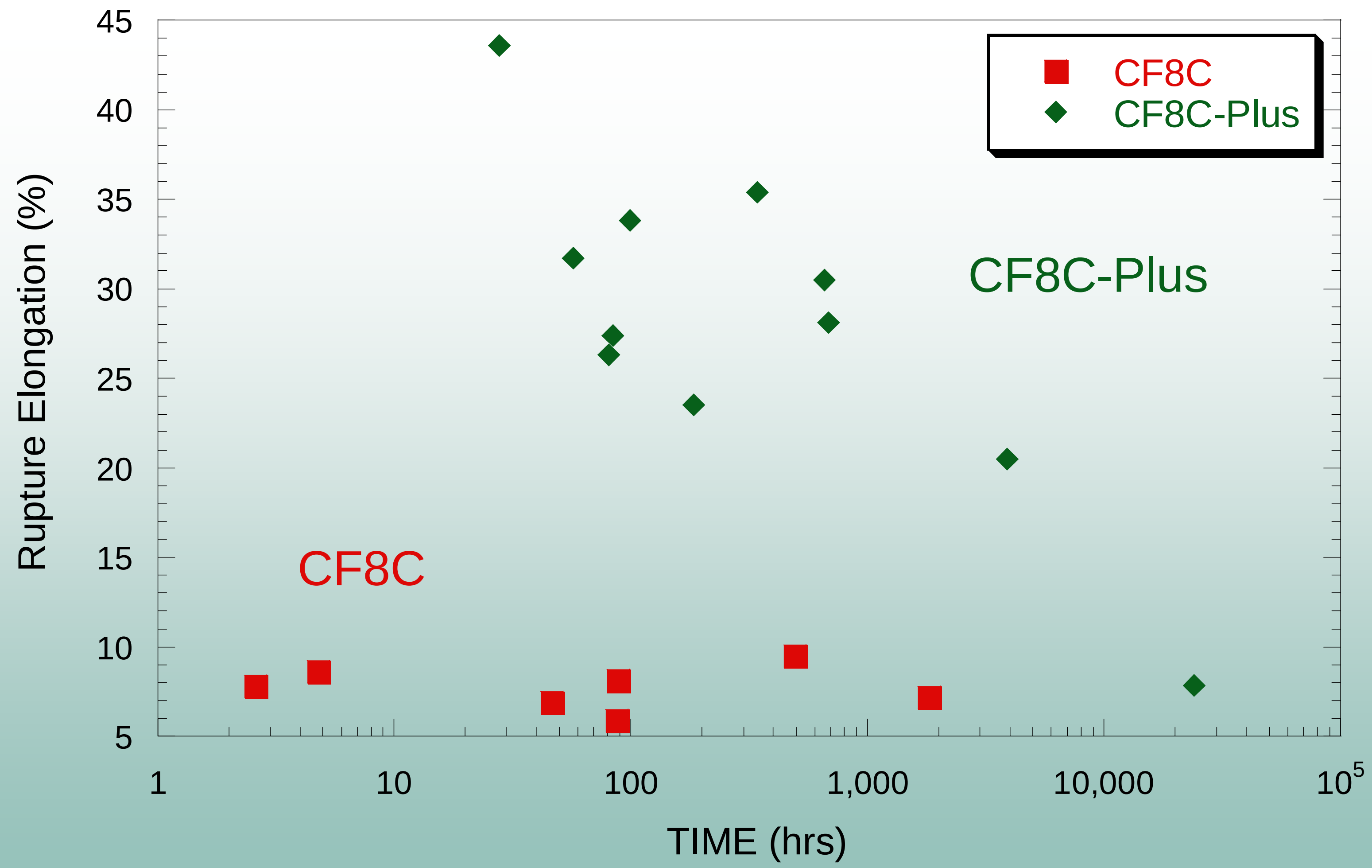
Creep Tested 850°C/23,000 h

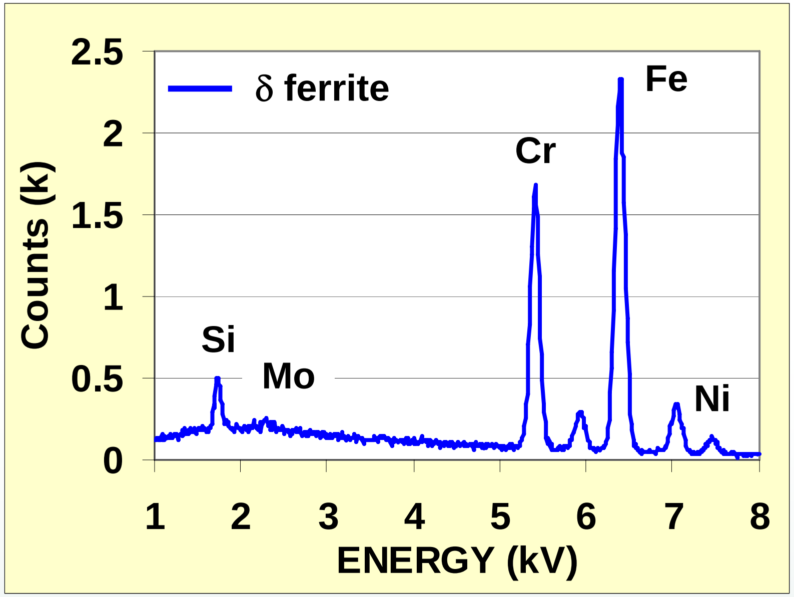
(TEM, as cast)

New CF8C-Plus cast steel has far more creep strength than SiMo cast-iron or Ni-resist, and more than CF8C steel



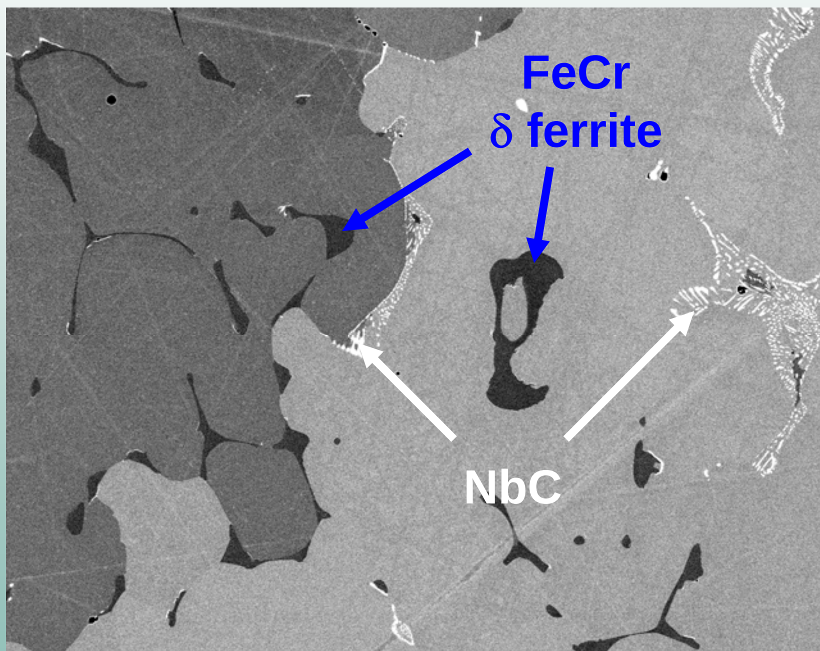
CF8C-Plus Steel Has Much Better Creep-Rupture Ductility Despite Being Stronger Than CF8C, Due to Lack of Sigma Phase



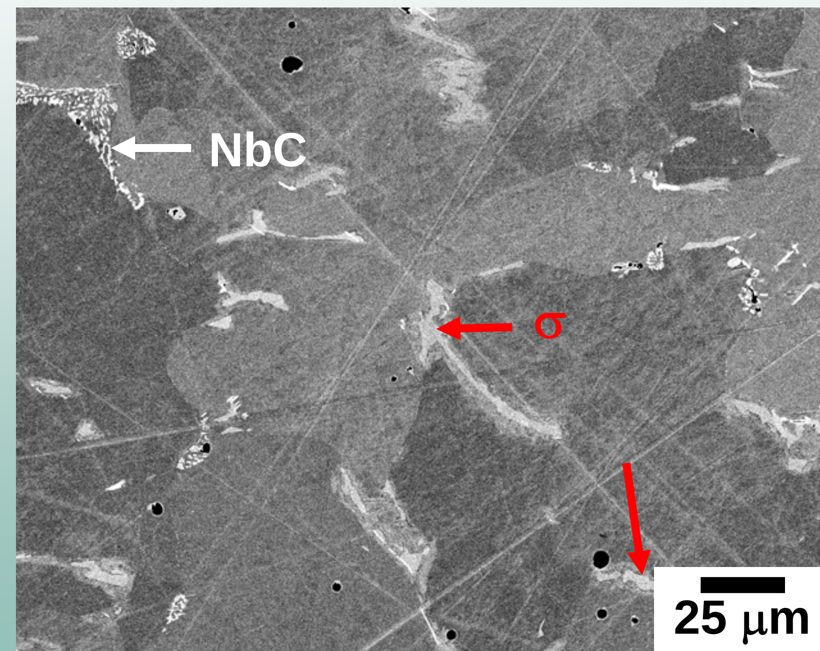


During Aging or Creep of CF8C steel, δ Ferrite Transforms to σ

as cast

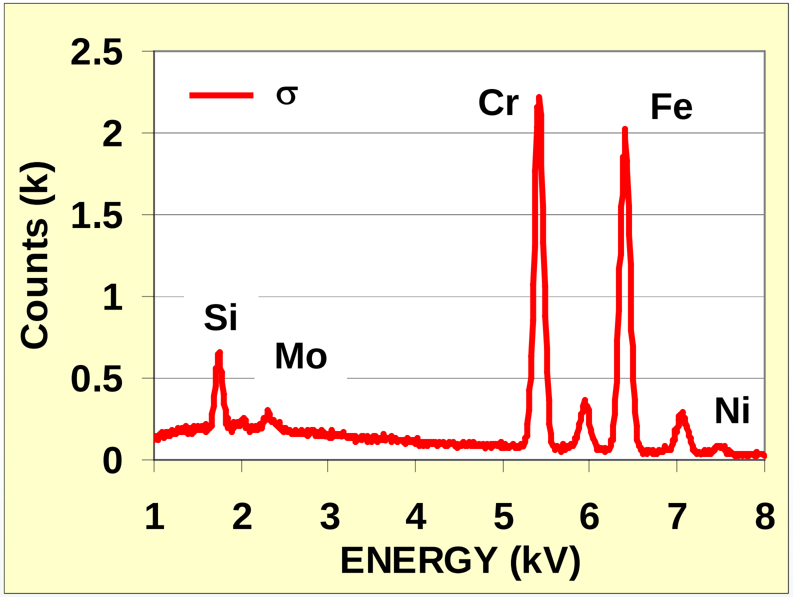


aged 750°C, 3000h

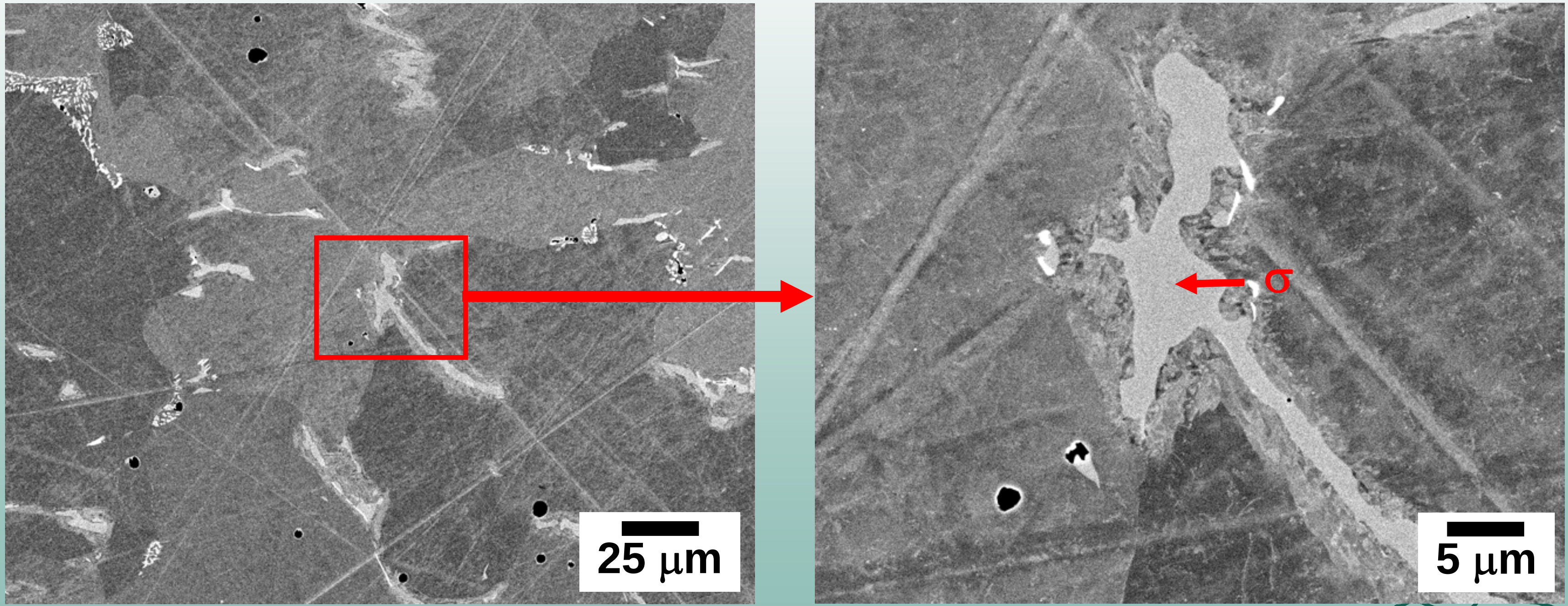


BSE SEM Images

During Aging or Creep of CF8C steel, δ Ferrite Transforms to σ

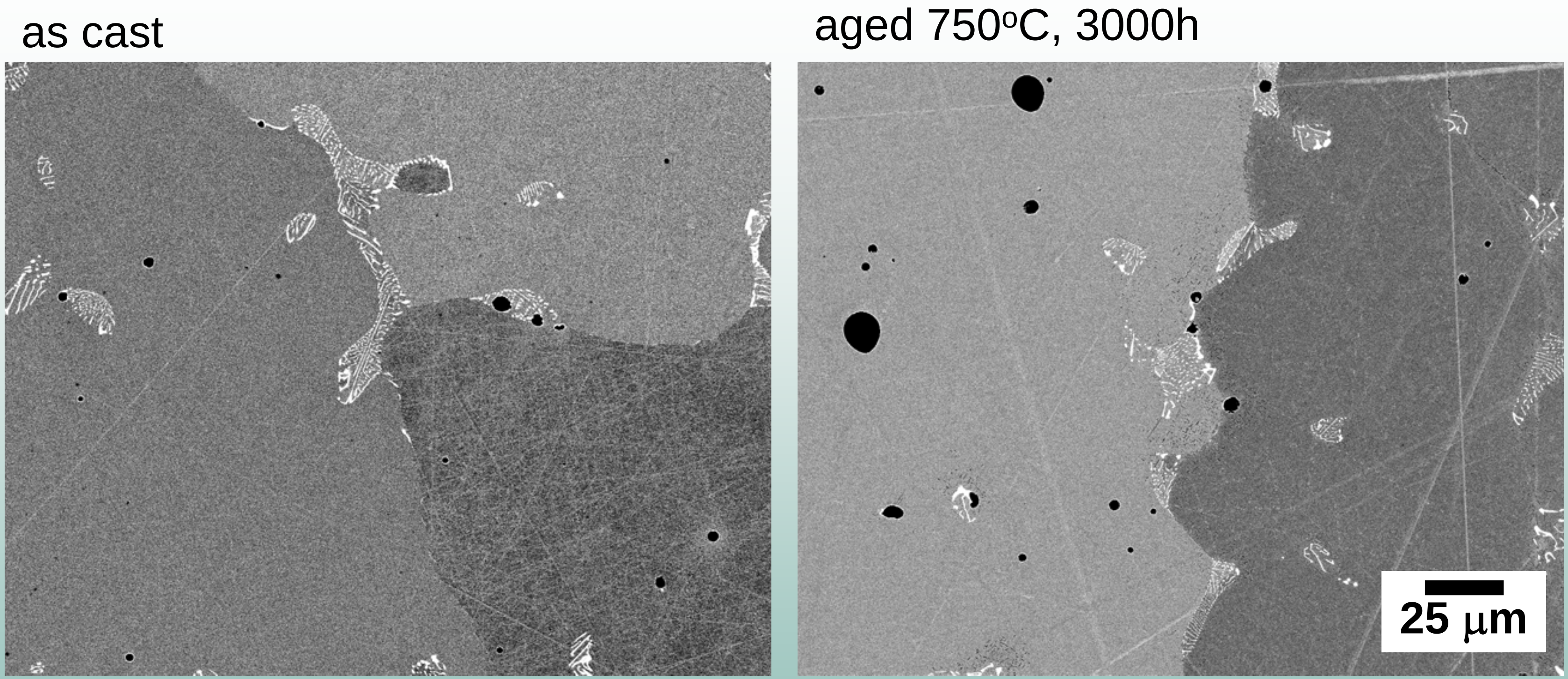


aged 750^{o}C, 3000h



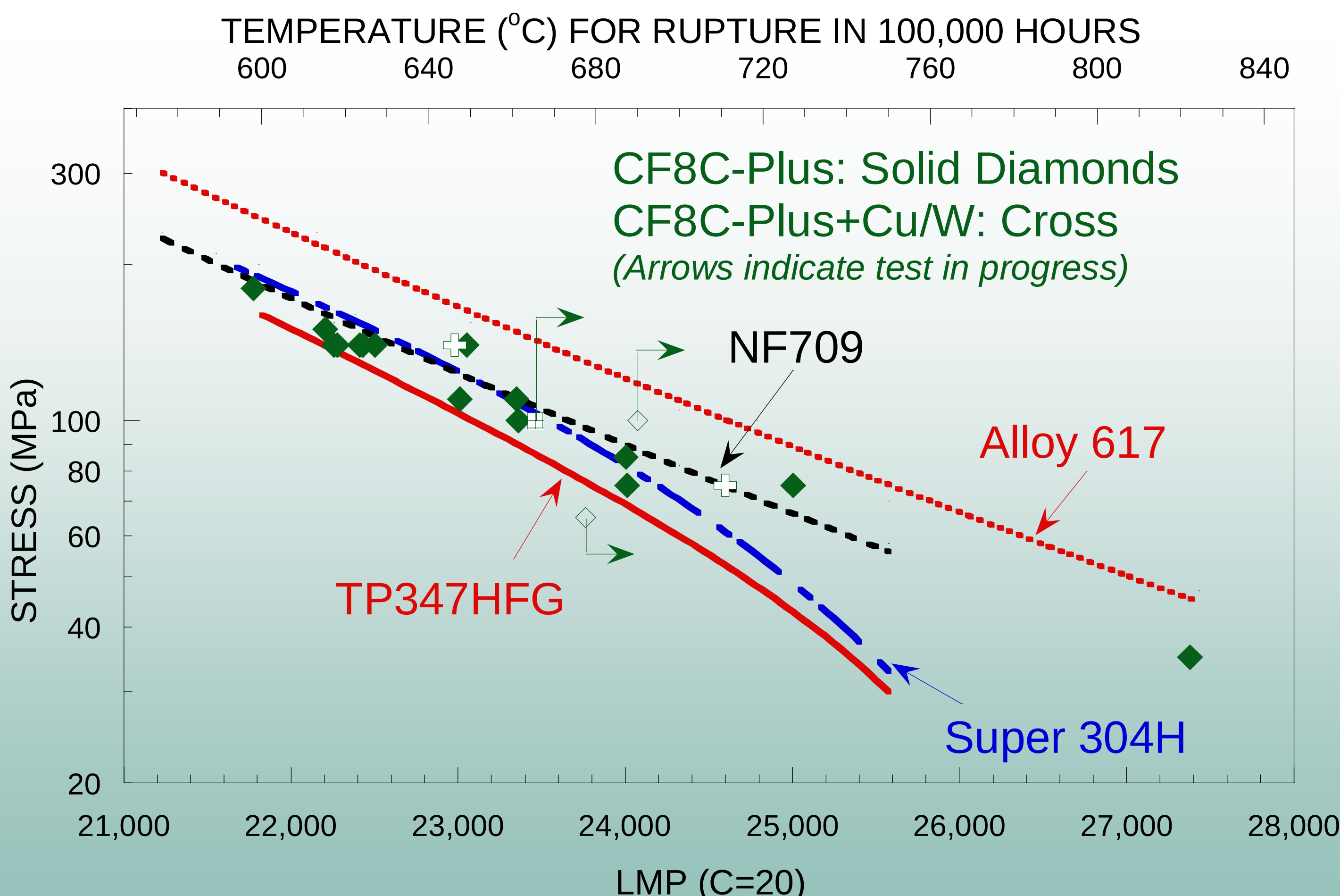
BSE SEM Images

CF8C-Plus Steel Does Not Form δ-Ferrite During Solidification, So σ Does Not Form During Aging or Creep

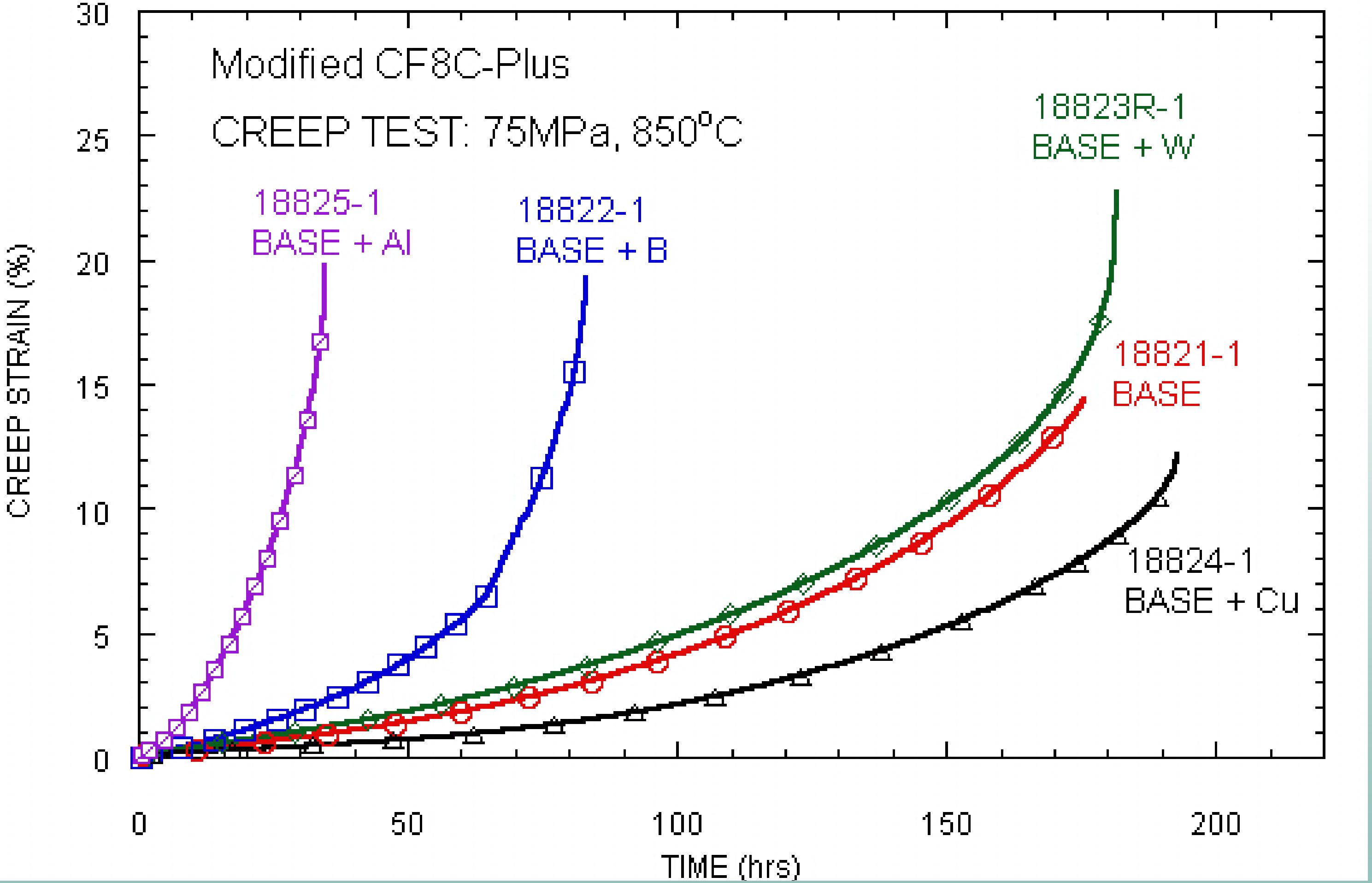


BSE SEM Images

CF8C-Plus has better creep strength than many other stainless steels and alloys, and approaches Ni,Co-based superalloy 617



To Improve Strength of CF8C-Plus Cast Steel >750°C, New Lab-Heats With Various Alloying Additions Were Made



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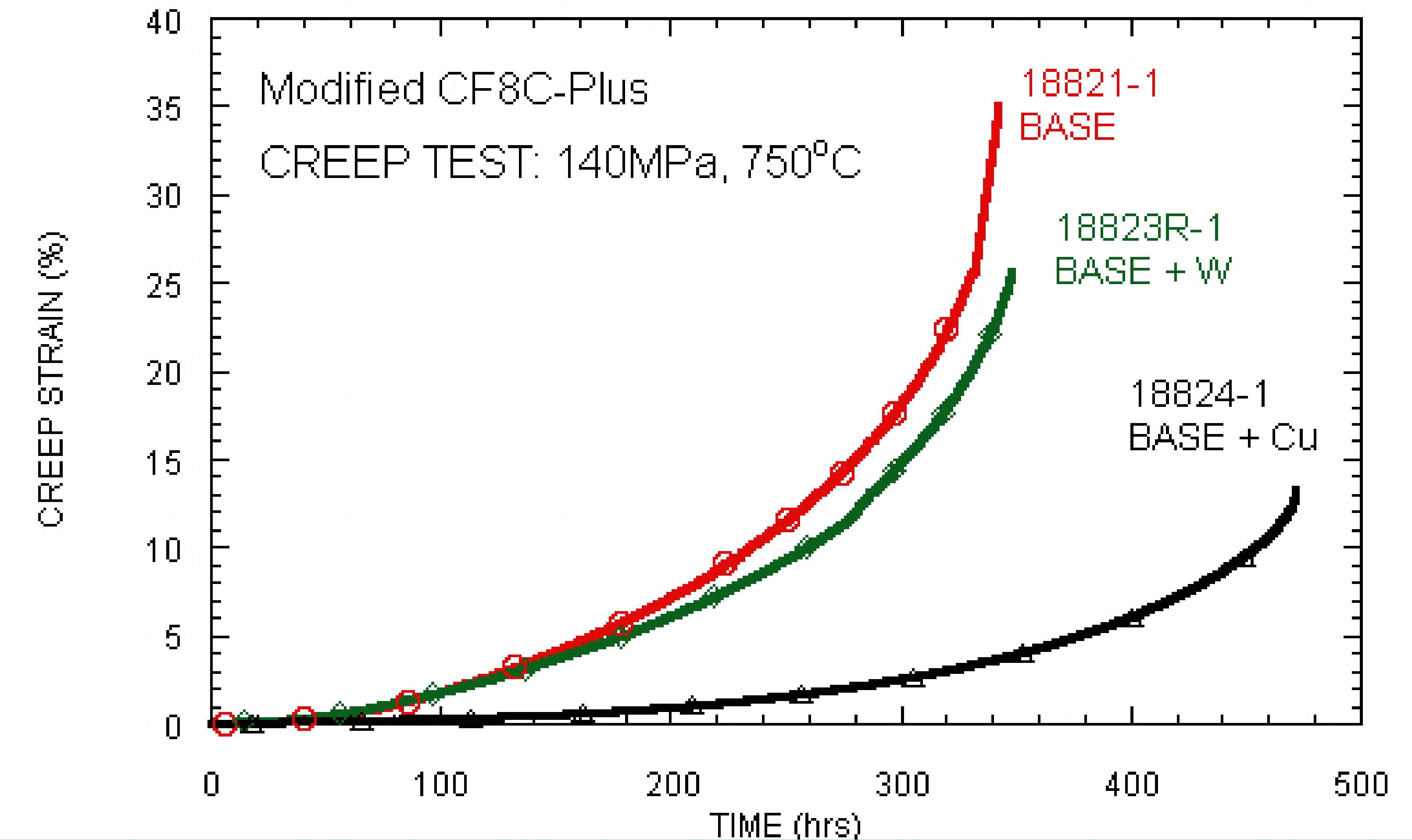
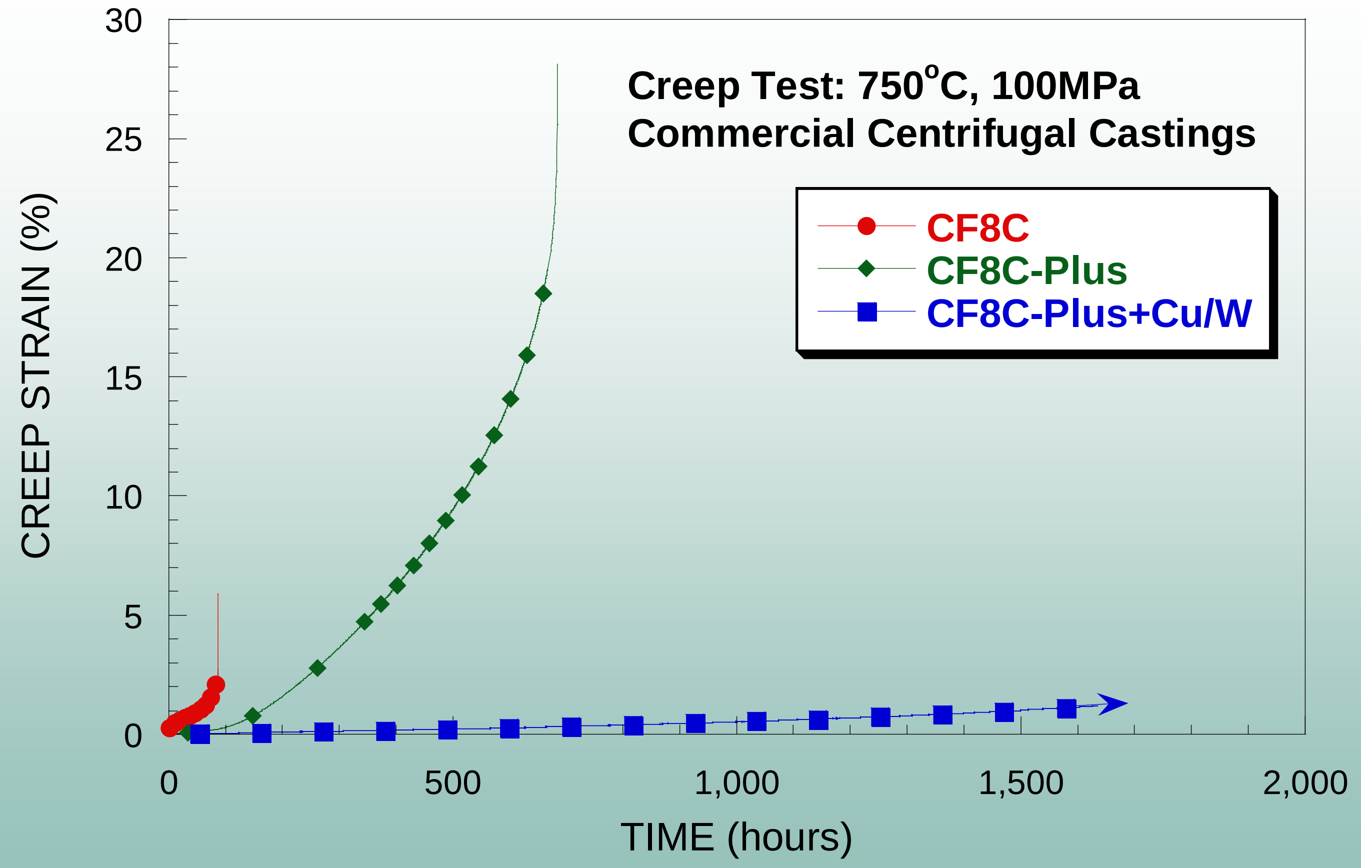


New commercial heats of CF8C-Plus Cu/W show significantly improved creep resistance at 750ºC



Technology Transfer of CF8C-Plus Cast Stainless Steel

6,700 lb **CF8C-Plus** end-cover cast by MetalTek for Solar Turbines Mercury 50 gas turbine

- MetalTek International, Stainless Foundry & Engineering, and Wollaston Alloys have trial licenses in 2005
- MetalTek has cast over 31,000 lb of CF8C-Plus steel through 2005 for Solar Turbines (end-cover, casings), Siemens-Westinghouse (large section tests for turbine casings), ORNL, and a global petrochemical company (tubes/piping).
- Stainless Foundry has cast CF8C-Plus exhaust components for Waukesha Engine Dresser NG engines

80 lb **CF8C-Plus** exhaust component cast by Stainless Foundry for Waukesha NG reciprocating engine