



**United States Nuclear Regulatory Commission**

# **BACKGROUND, BASIS, AND SCHEDULE FOR RESEARCH SUPPORT FOR 10 CFR 50.46 CRITERIA**

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Public Meeting  
February 10, 2005



# PURPOSE OF MEETING

- Present first ever post-LOCA ductility measurements on high-burnup fuel cladding.
- Compare results with current licensing criteria.
- Discuss continuation of testing at ANL and schedule for package of technical results.



## THE PROBLEM

- Ductility of cladding is reduced by burnup and related corrosion. Because 50.46 uses embrittlement criteria, the adequacy of current licensing analyses should be confirmed.
- Oxidation-related LOCA evaluation models might be affected by fuel burnup, and this needs to be checked out.
- 50.46 is currently limited to two cladding alloys (Zircaloy and ZIRLO), and other alloys need to be accommodated.

Slide from ACRS meeting 9/29/03



# THE METHOD OF RESOLUTION

- Generate a data base for high-burnup fuel and new cladding alloys
- Make a confirmatory check of current licensing analyses
- Develop a basis for a more inclusive rule

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## CURRENT FORM OF EMBRITTLEMENT CRITERIA IN 50.46

- (1) Peak cladding temperature shall not exceed 2200°F
- (2) Maximum cladding oxidation shall nowhere exceed 17% of cladding thickness
  - Includes ruptured cladding balloons, with double-sided oxidation
  - Oxidation should be calculated with the Baker-Just correlation
  - Corrosion thickness should be subtracted from 17% ("total oxidation")

These criteria only apply to Zircaloy and ZIRLO cladding.

Slide from ACRS meeting 9/29/03

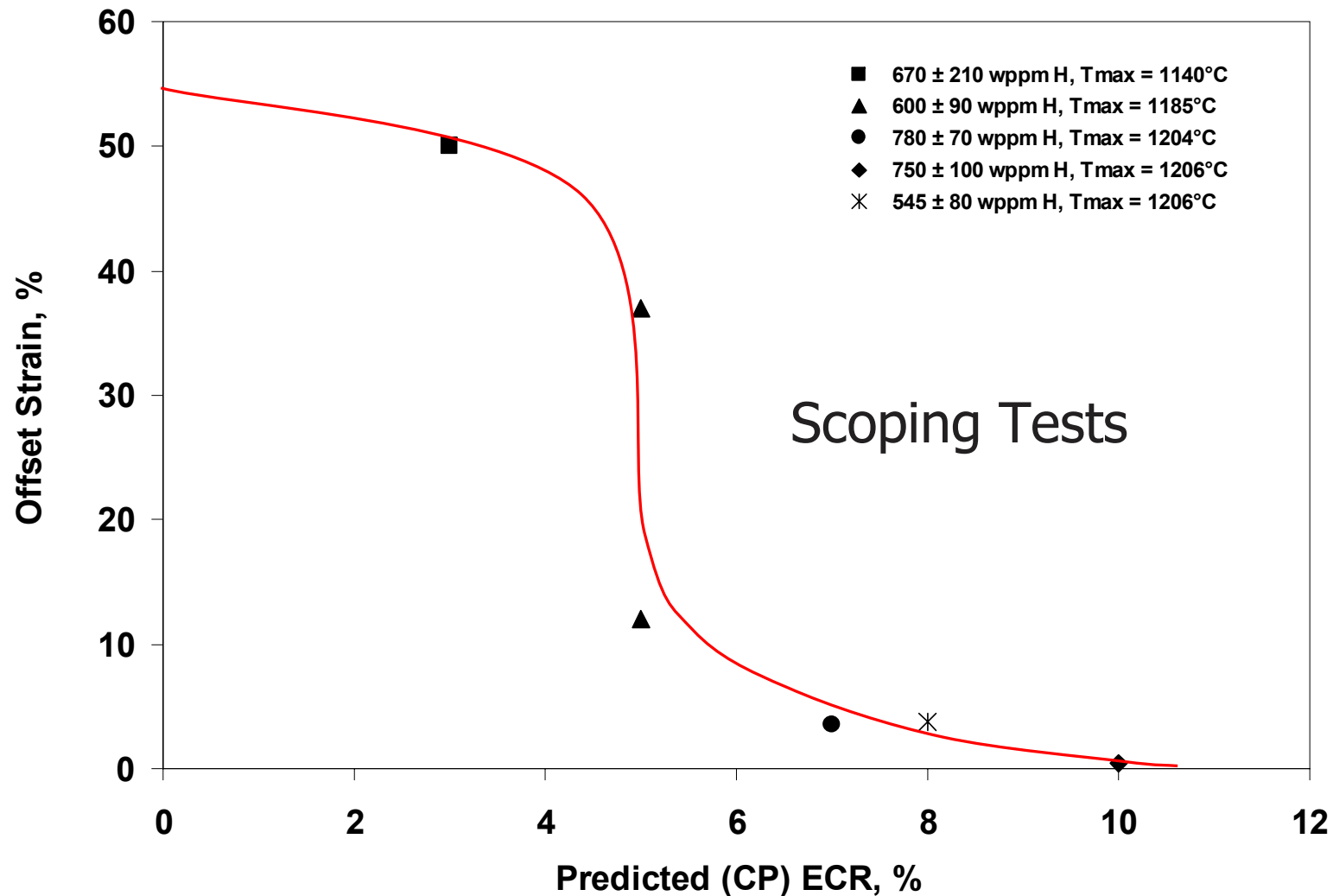


# COMPARISON OF PRELIMINARY RESULTS WITH CURRENT EMBRITTLEMENT CRITERIA

- H. B. Robinson rod F07. 15x15 Zircaloy. 63.8 GWd/t average. 70 microns oxide on specimen tested.
- Oxidation temperatures 1140-1206°C (2084-2203°F). Ring test temperature 135°C.
- 70 microns oxide on 15x15 cladding is 5.3% oxidation.
- 13% oxidation (17% Baker-Just) minus 5.3% = 7.7%.
- Preliminary results (next presentation) show ductile-to-brittle transition ~8% oxidation for non-ballooned specimen.

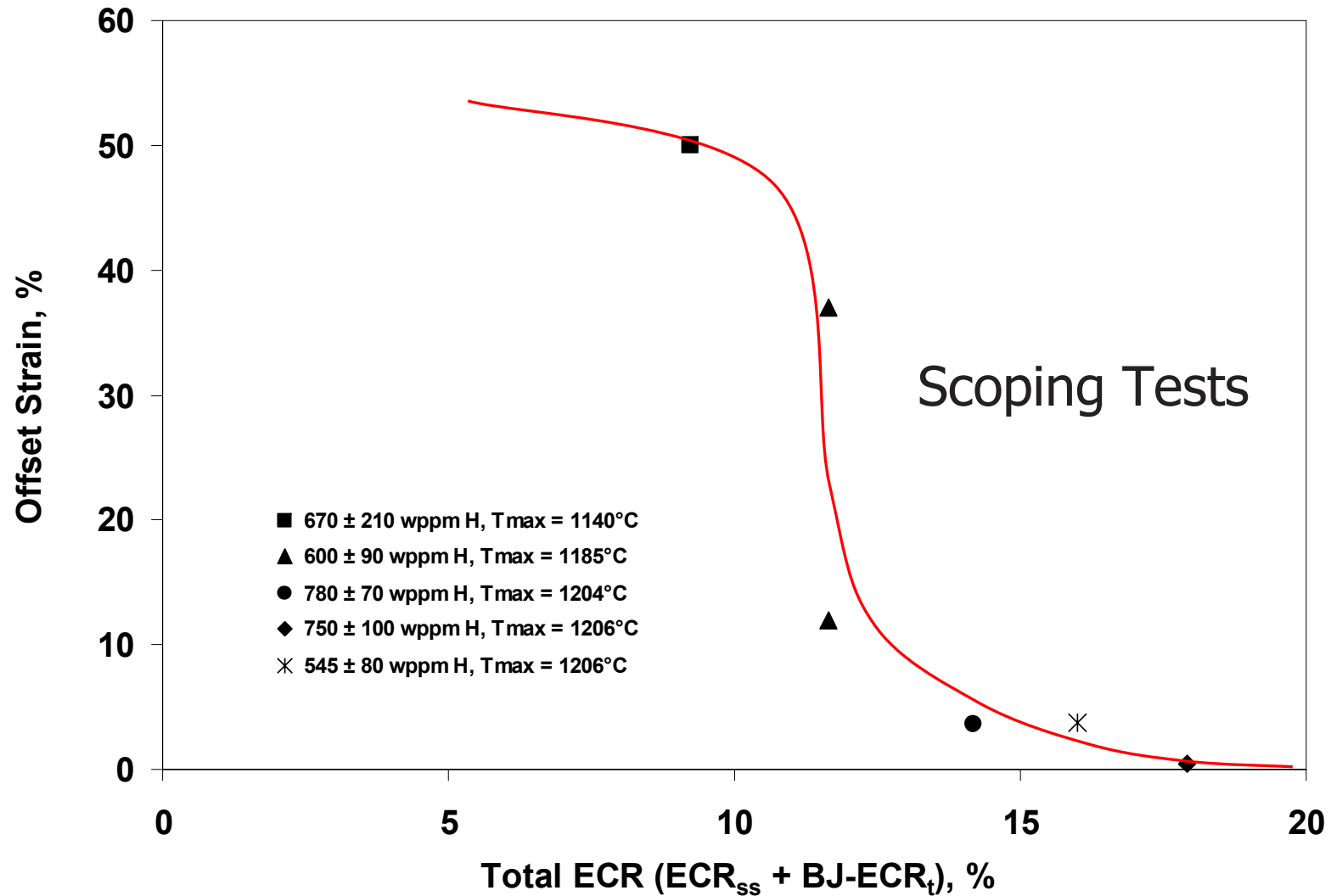


## Summary of Post-Oxidation Ductility (Offset Strain) at 135°C vs. CP-ECR for High-Burnup Zry-4 Cladding





## High-Burnup Zry-4 Post-Oxidation Ductility at 135°C vs. "Total" ECR (Corrosion + BJ Transient ECR)







# IMPLICATIONS AND SCHEDULE

- Test results from ANL indicate that ductility-based embrittlement criteria similar to those in 50.46 can be effective.
- Complete ring tests on irradiated Zircaloy by May 31. Complete benchmark ring tests on irradiated ZIRLO and M5 by June 30. Complete integral tests on irradiated Zircaloy-clad rods by August 31.
- Research Information Letter with confirmatory check of current licensing analysis and technical basis for rulemaking scheduled for September 30, 2005.