Presentation to ACRS

Spent Fuel Pool Studies

September 10, 2003

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SFP Analysis

- SFP Background
- Analysis - Summary
  - CFD
  - MELCOR Results
    - Separate Effects Model
    - Whole Pool Model
- Modeling Issues/Uncertainties
- Testing

SFP Analysis Background

- NRC Vulnerability Project
  - Past work primarily limited to "early phase" heat-up calculations, no integrated severe accident analysis performed
  - Most codes only analyzed potential for zirconium fire using "ignition temp" criteria

    - **No Severe Accident Models**
    - **Historical Tools Also Criticized for Modeling Limitations**
      - **Damage propagation**
      - **Oxidant depletion**
      - **FP release and transport modeling**
      - **Heat transfer modeling**
      - **Flow Mixing**
    - **Shortcomings can be overcome with severe accident modeling (MELCOR) + detailed T/H support (CFD)**

Spent Fuel Pool Analyses

- Analyses will address scenario characteristics (from different threats)
  - Partial Pool Drainage (Water Boildown)
  - Complete Pool Drainage (Air Natural Circulation)

Ex. 5
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  -

- CFD Used to Evaluate
  - Details of Single Assembly in Air Circulation and Heat Flows

Ex. 5
  -
  - Flow and Mixing Behavior in Pool and Building
  - Provide Boundary Conditions for MELCOR Analyses
- MELCOR Will Analyze
  - Global Response of Pool and Assemblies,
  - Fuel Damage, Steam and Air Oxidation
  - Fission Product Source Term
  - Mitigation or Recovery Actions

MELCOR Modeling Approach

- 2 Model Approach - Separate Effects and Whole Pool/Reactor Building Models
  - Subdivided into 2 Types of Scenarios
    - **Complete Loss-of-Inventory** Ex 5
    - **Partial Loss-of Inventory** Ex 5

- Separate Effects Model
  - Developed First to Guide Full SFP Model Development
  - Fast Running + Controlled Boundary Conditions
  - Ex. 5
  - Ex. 5
    - **Use Separate Effects Model to Develop Appropriate Modeling Approach**
    - **Identify Sensitivities and Uncertainties**
    - **Recommend Code Development**

- Full SFP + Building Model
  - Integral Effects
  - Whole SFP Source Term

Testing

- Testing performed at ANL to confirm MELCOR air oxidation kinetics
  - For Zircalloy and Zirlo testing confirmed general adequacy of correlationa at low temp(<600 C)
  - Breakaway phenomena seen f (temp, time)
  - Testing underway to examine effect of hydriding on oxidation behavior for Zirlo

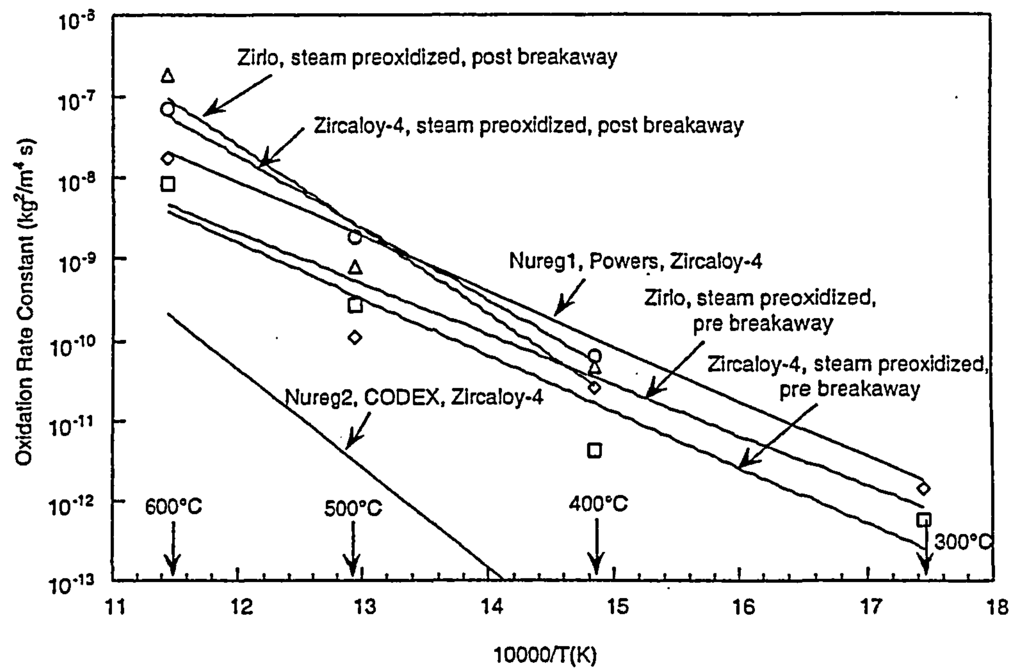

Figure 19. A comparison of the temperature dependence of the oxidation rate constant for air oxidation of steam-preoxidized Zircaloy-4 and Zirlo at 300-600°C derived from this project with those for Zircaloy-4. based on Nuregl (Powers). NuregII. and CODEX.

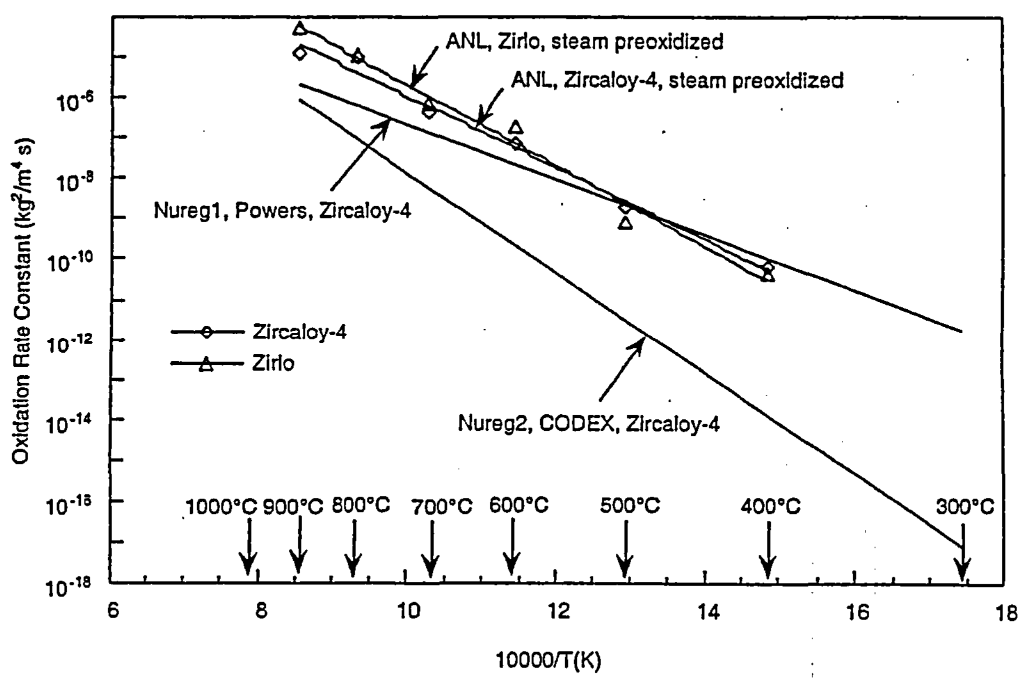

Figure 20. A comparison of the temperature dependence of the oxidation rate constant (in post-breakaway region) for air oxidation of steam-preoxidized Zircaloy-4 and Zirlo at 400-900°C derived from this project with those for Zircaloy-4, based on Nuregl (Powers), NuregII, and CODEX.

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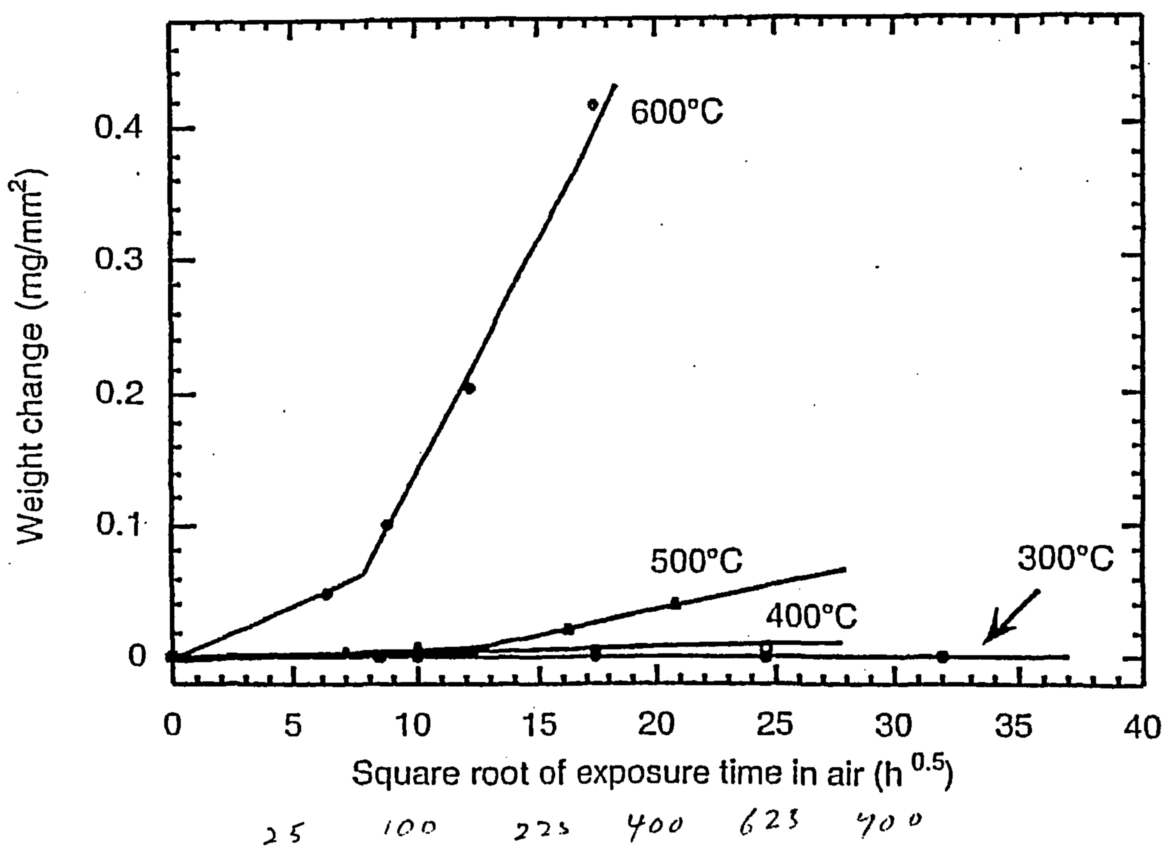

Figure 5. Weight change data during air oxidation of steam-preoxidized Zirlo capsule specimens.

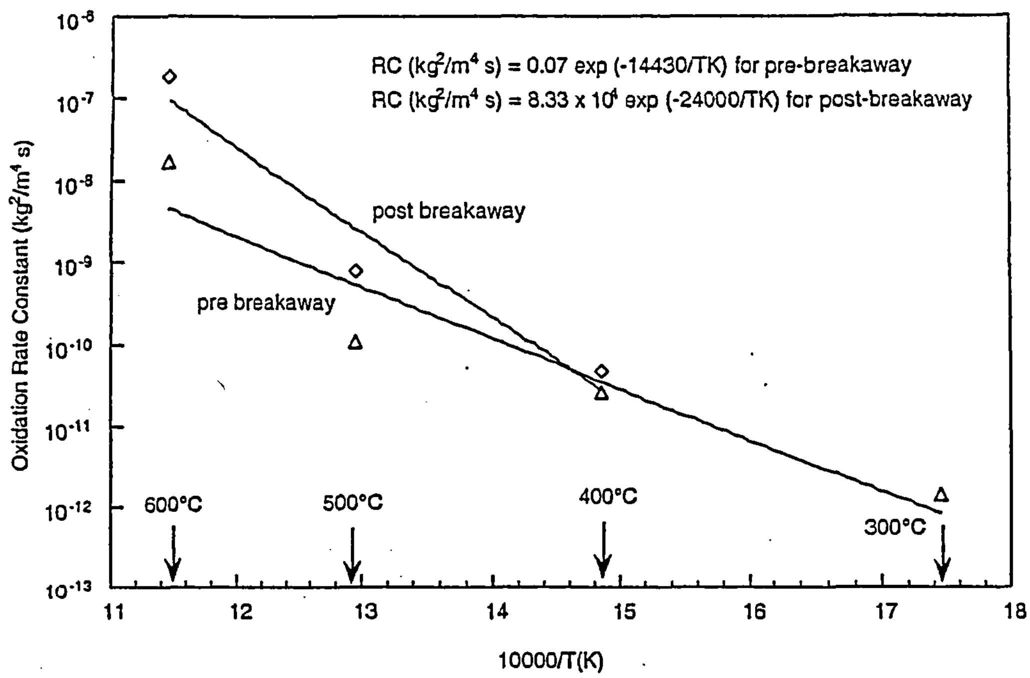

Figure 13. Temperature dependence of rate constant for the air oxidation of steam-preoxidized Zirlo capsule specimens in the temperature range of 300-600°C.

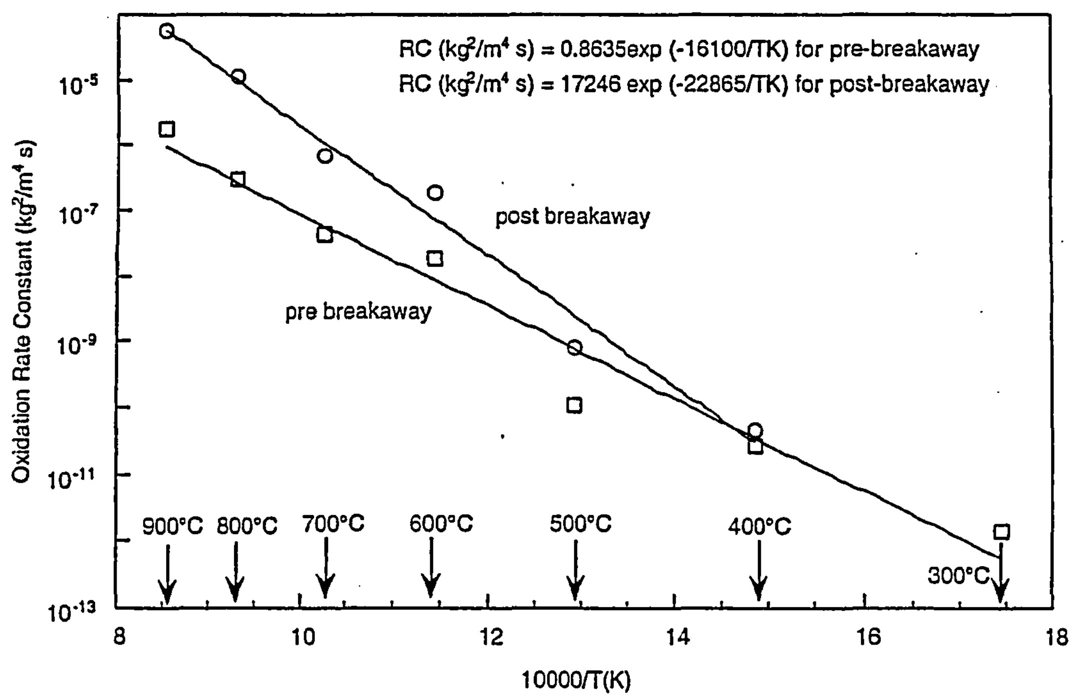

Figure 14. Temperature dependence of rate constant for the air oxidation of steam-preoxidized Zirlo capsule specimens in the temperature range of 300-900°C.

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Testing

- New testing proposed for confirming spent fuel pool modeling of T/H and accident progression
- Confirmation of modeling adequacy
  - Natural circulation flow – air flow case
    - **Laminar flow losses (initial and degrading fuel conditions)**
    - **Base plate and bypass region modeling**
    - **Convective heat transfer**
    - **Radiation heat transfer**
  - Transient oxidation behavior