Simulation of Spent Fuel PWR Assembly Behavior under Normal Conditions of Transport

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Normal Conditions of Transport

Regulatory Requirements (10 CFR 71)

0.3-m Drop of a Transport Cask onto an Un-yielding Horizontal Surface, Unprotected by Impact Limiters, in Maximum-Damage Orientation

- Package Contents "Not Substantially Altered"
- No Loss or Dispersal of Spent Fuel
- No "Significant Increase" in External Surface Radiation Levels
- No "Substantial Reduction" in Effectiveness of Package

Presentation Outline

Analytical Approach: Two-Step Process

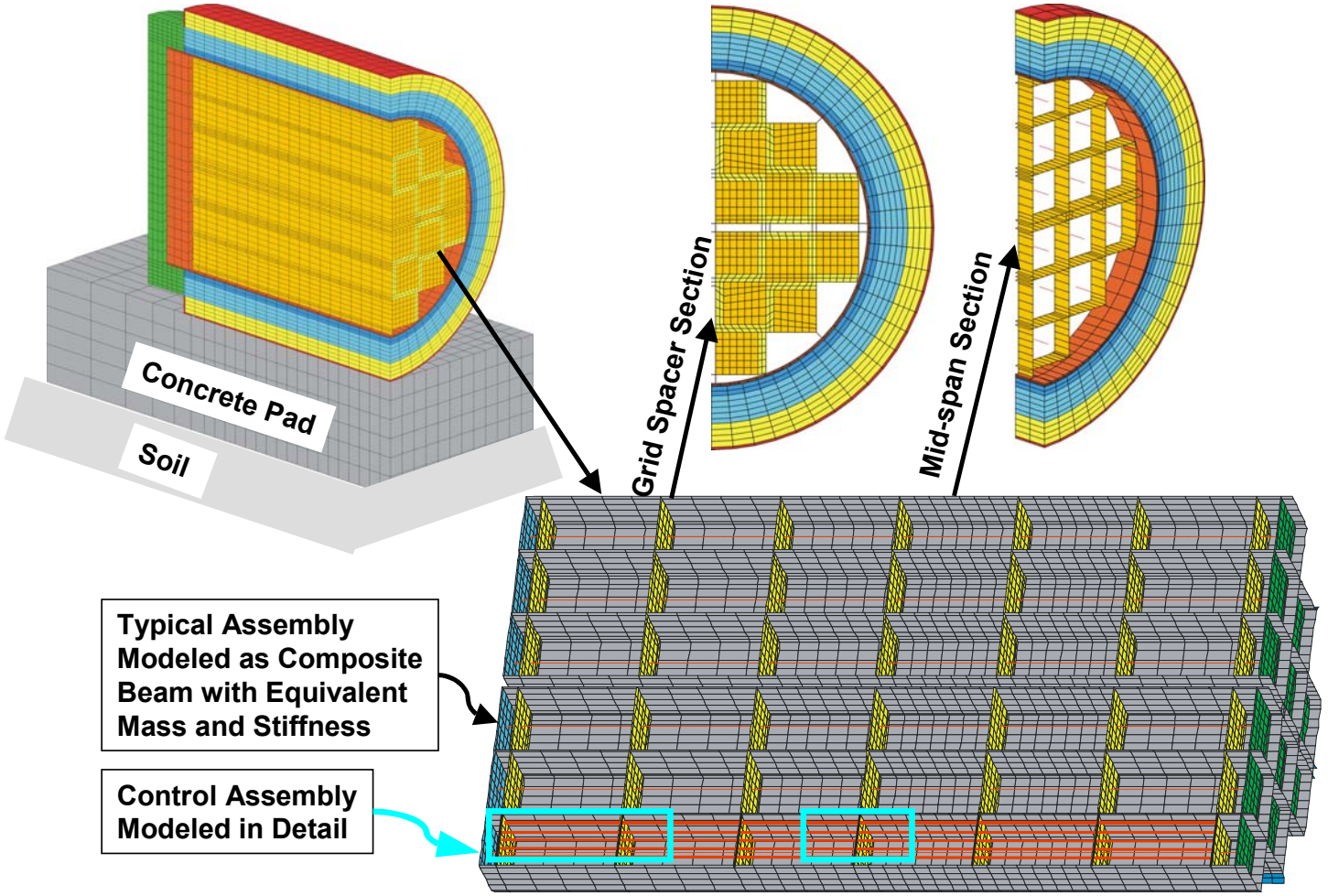
- Global Modeling and Explicit-Dynamics Analysis
- Local Modeling and Failure Analysis

Results

- Global Forces Acting on Fuel Rods
- Spacer Grid / Assembly Distortions
- Fuel Rods and Guide Tube Failure

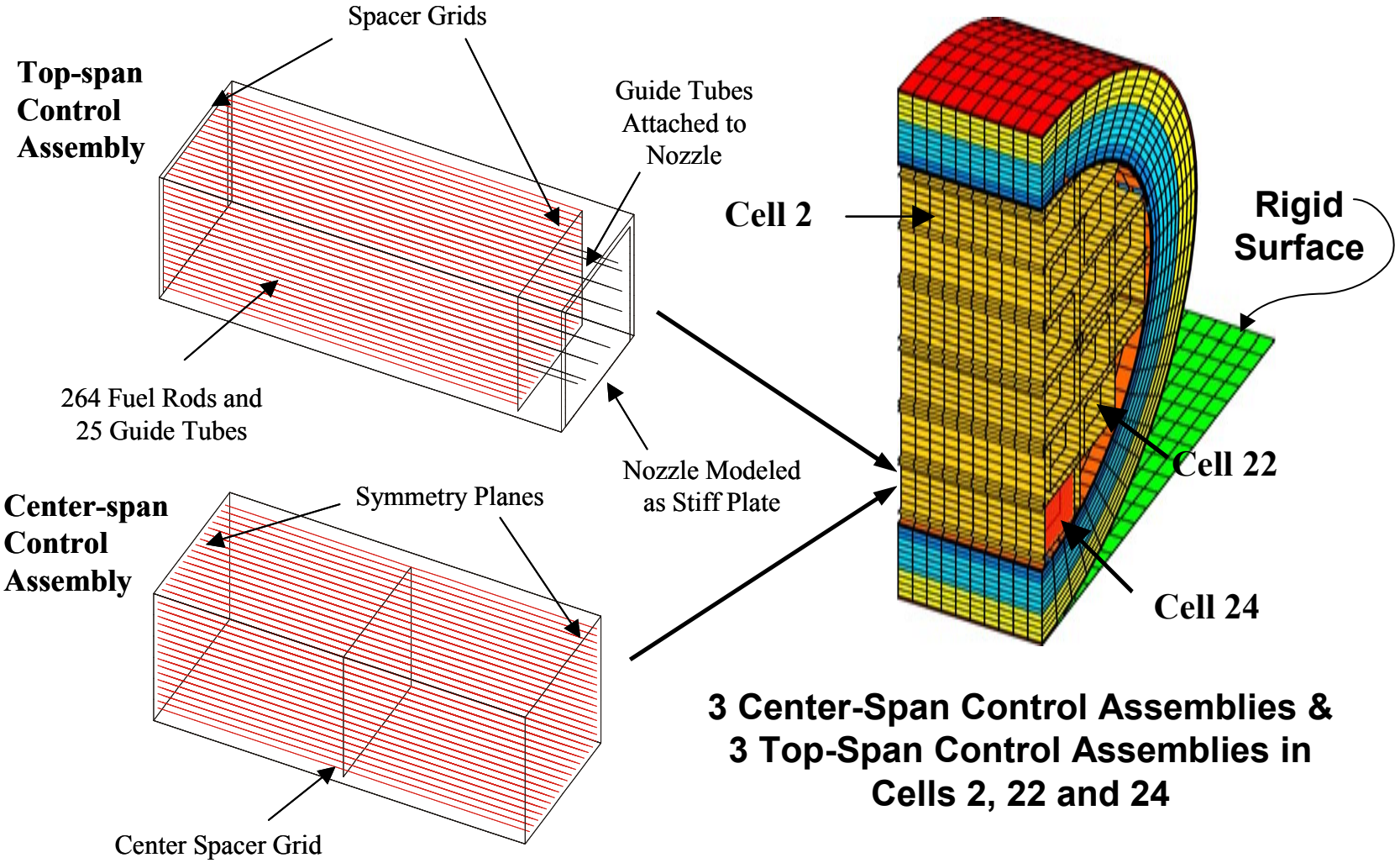
Conclusions

Global Modeling and Analysis



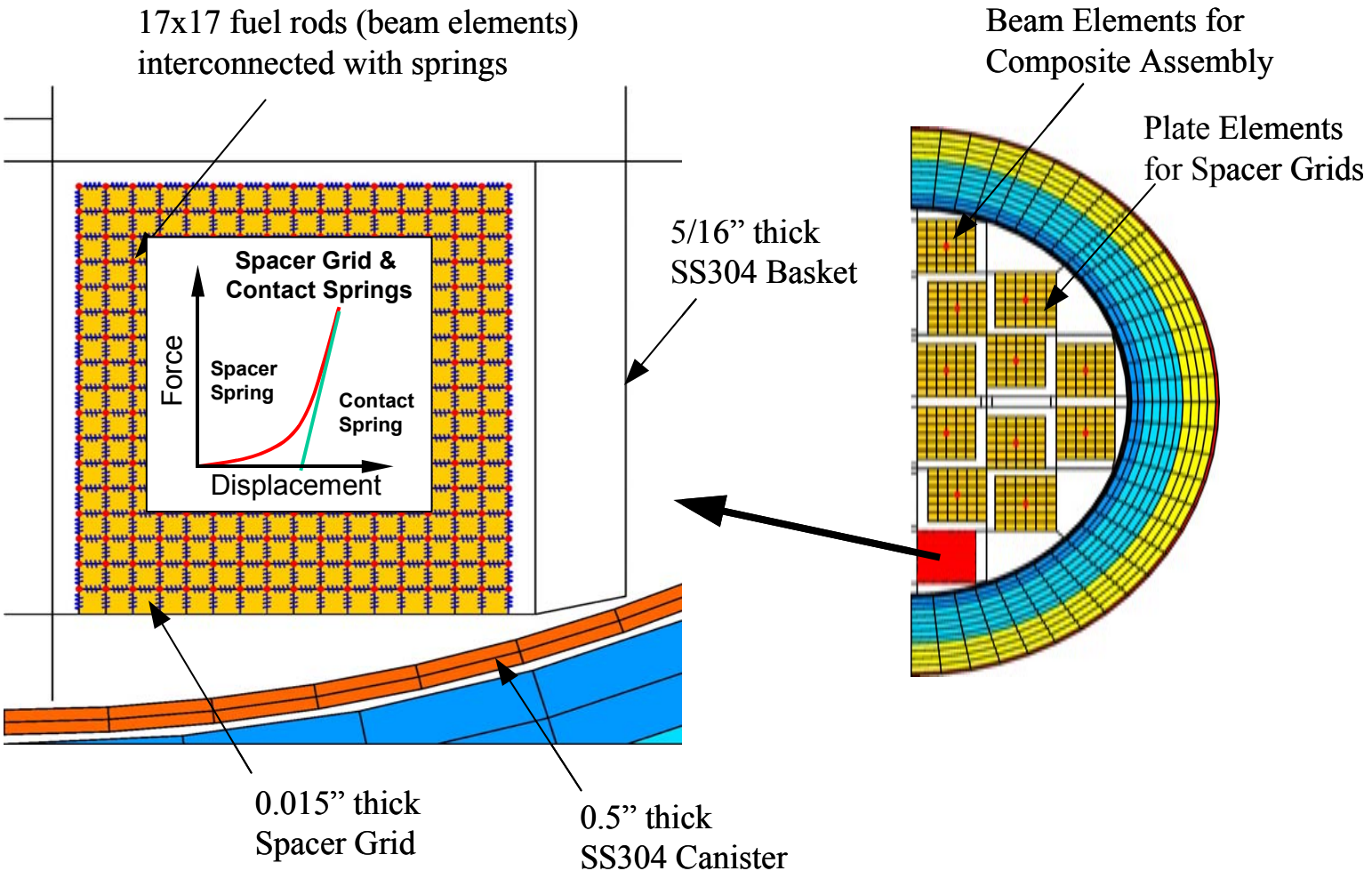
Finite Element Model for Dynamics Analysis

Global Modeling & Analysis – cont.

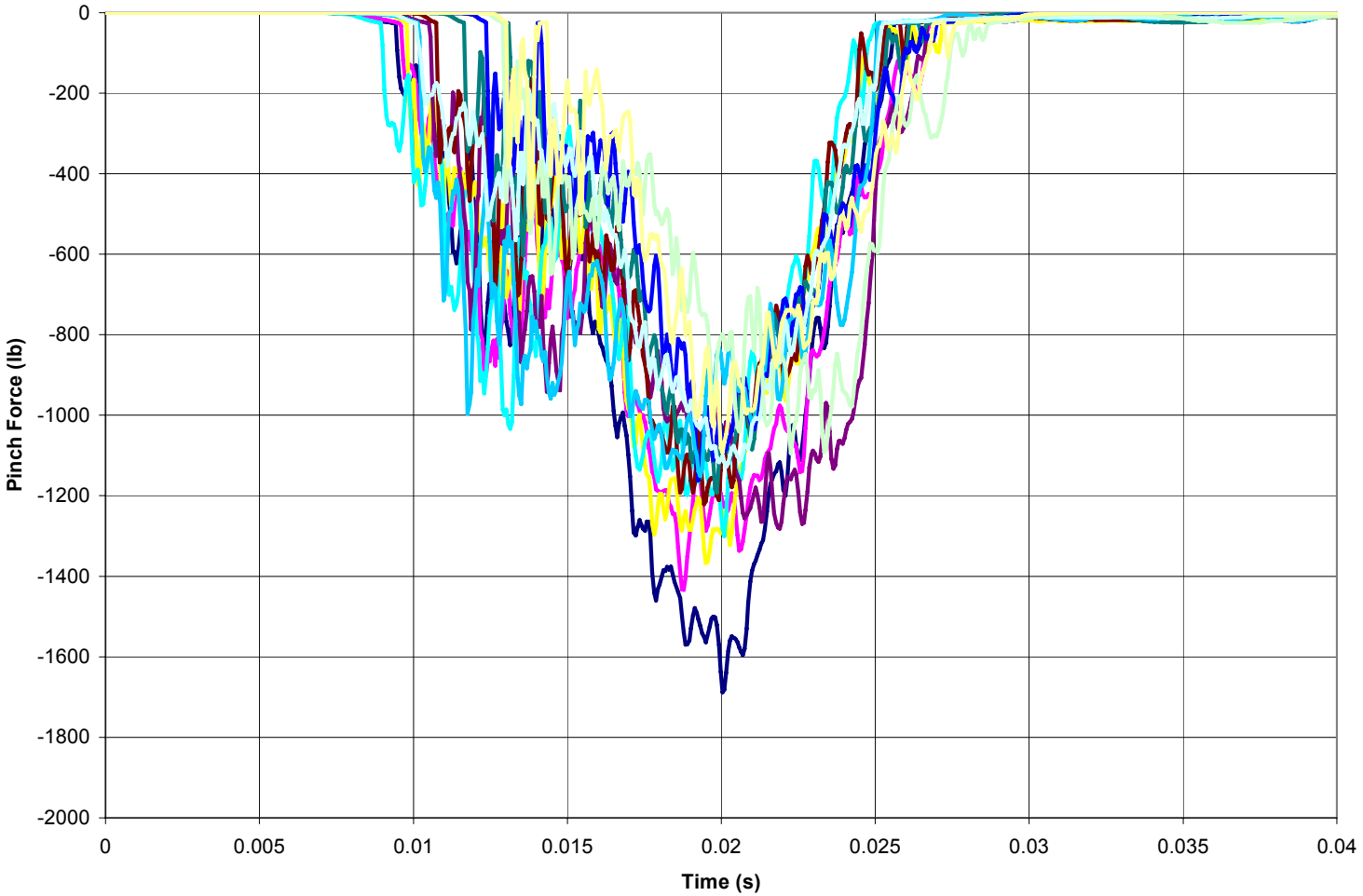


3 Center-Span Control Assemblies & 3 Top-Span Control Assemblies in Cells 2, 22 and 24

Global Modeling & Analysis – cont.



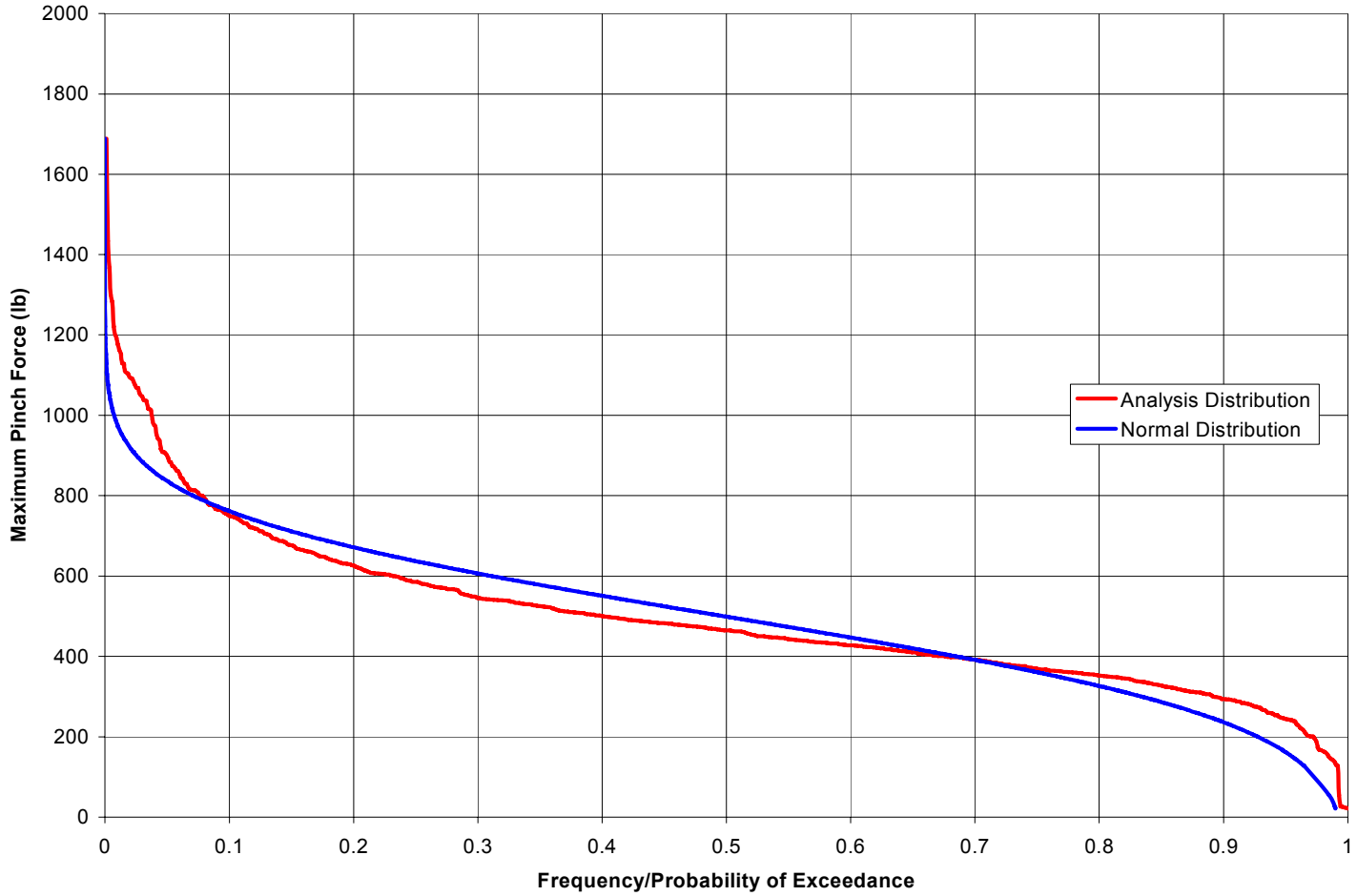
Dynamic Forces Acting on Fuel Rods



Assembly 22 Maximum Pinch Force Time Histories at Spacer Grid

Dynamic Forces Acting on Fuel Rods

Maximum Pinch Force Frequency/Probability Distribution – Spacer Grid



Local Modeling & Failure Analysis

Failure Modes during Drop Accidents

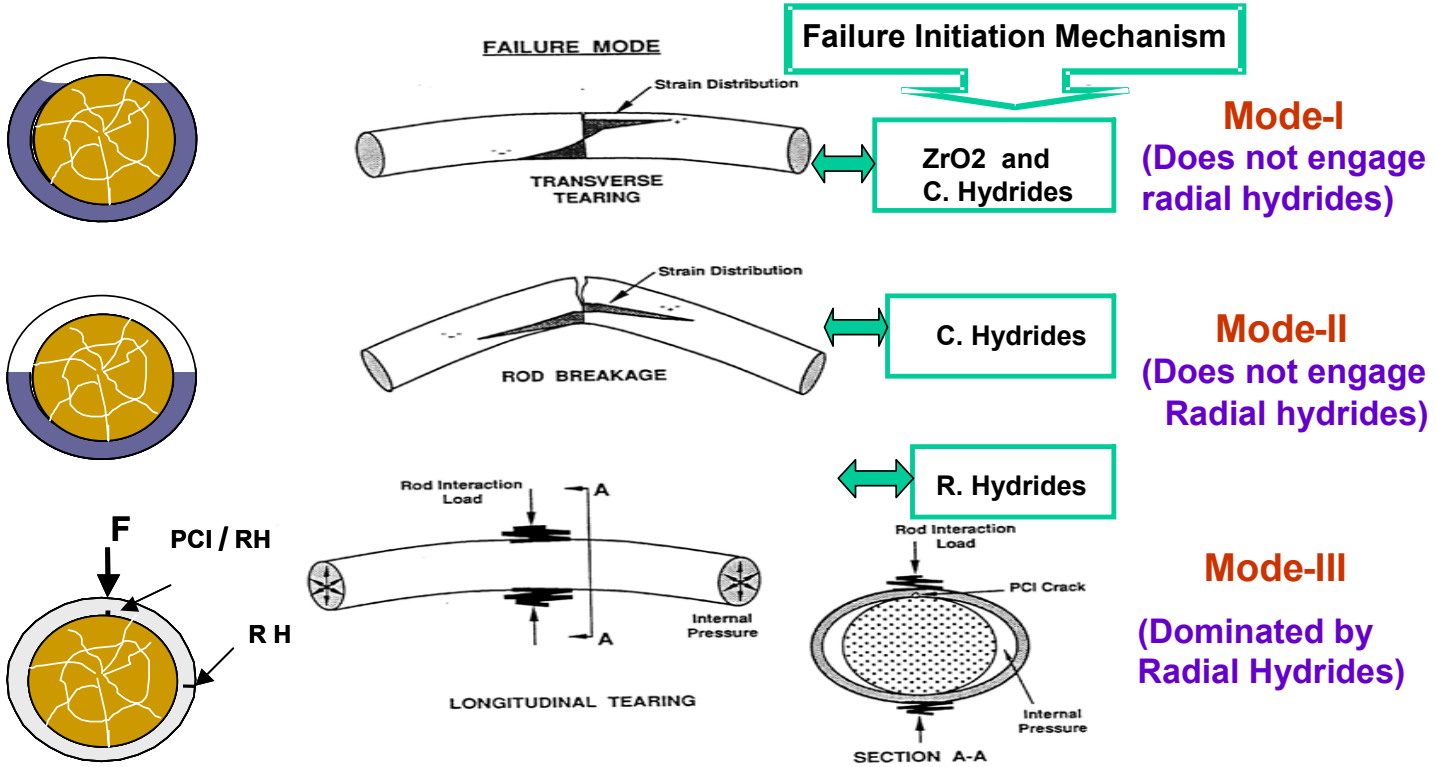
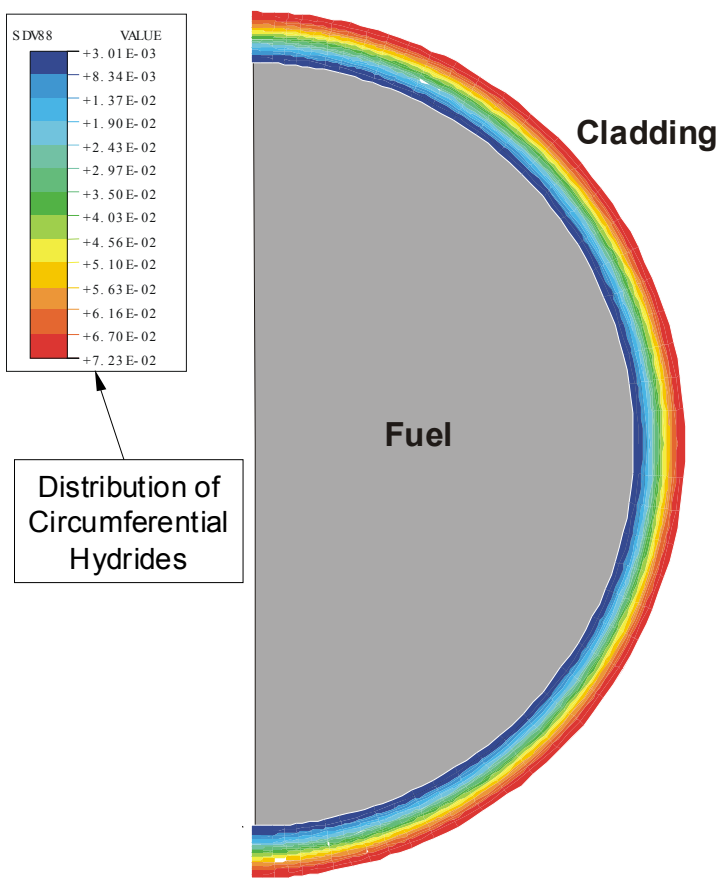


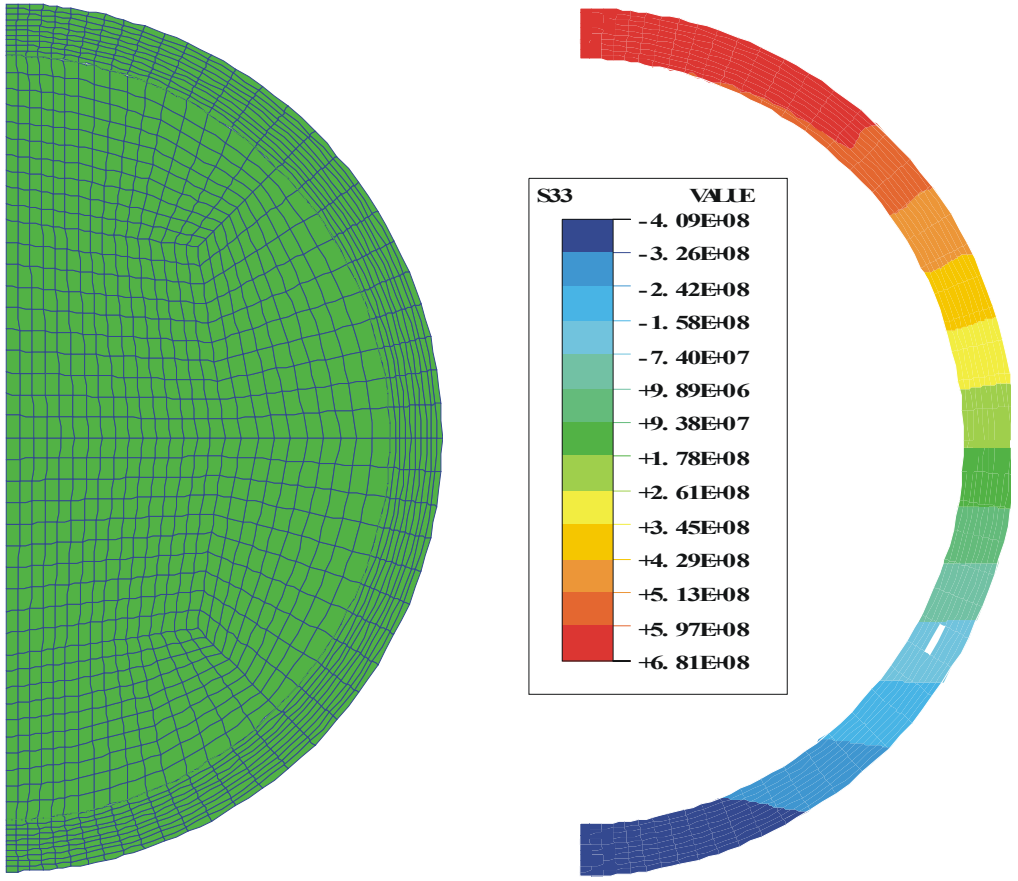
Figure III-29. Fuel Rod Failure Modes

Mode-I/II Damage in Fuel Rods

Axial Stress is at the Limit Of Mode-I Damage Initiation, but No Failure

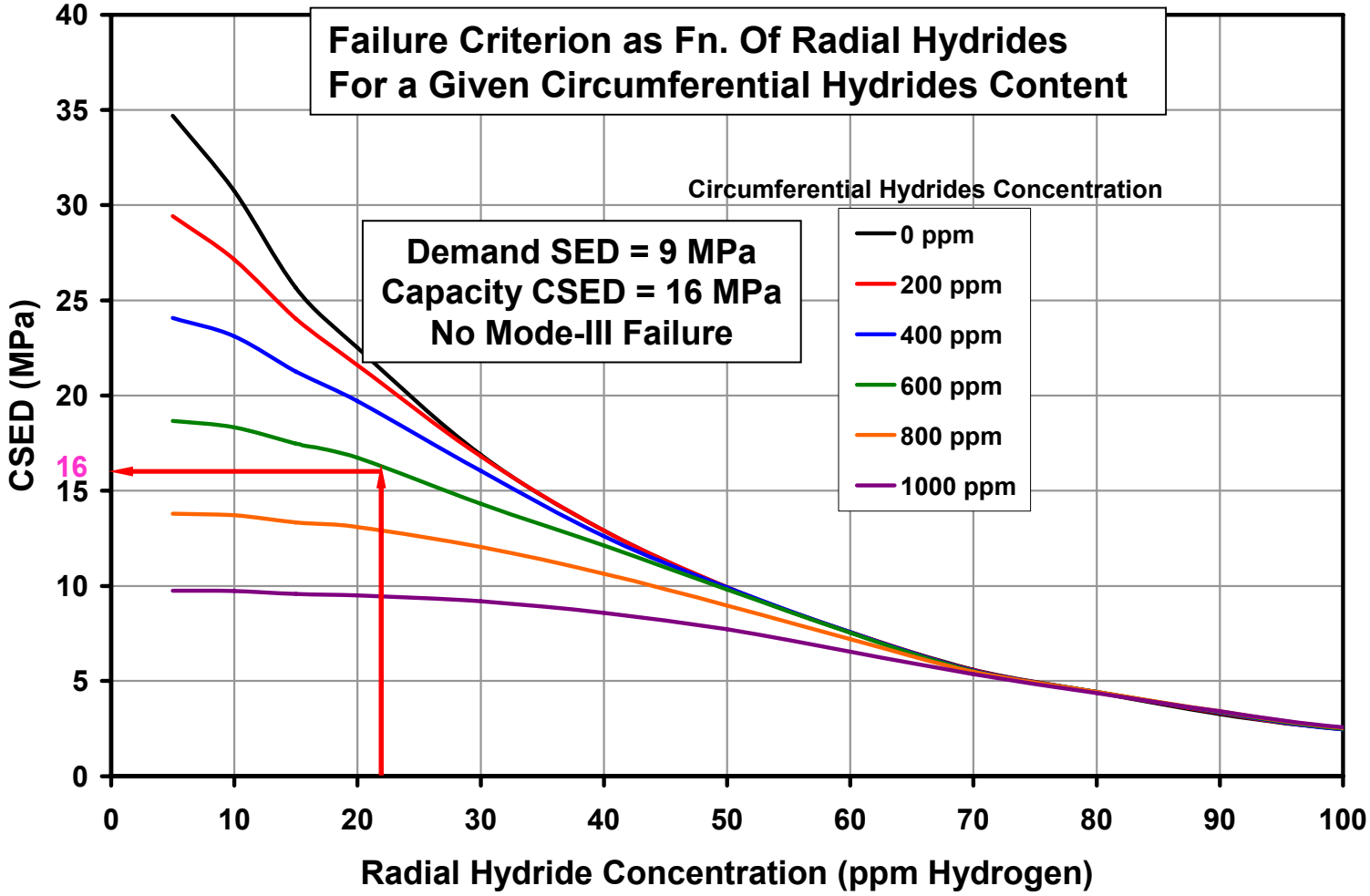


Hydrides distribution & FE Model

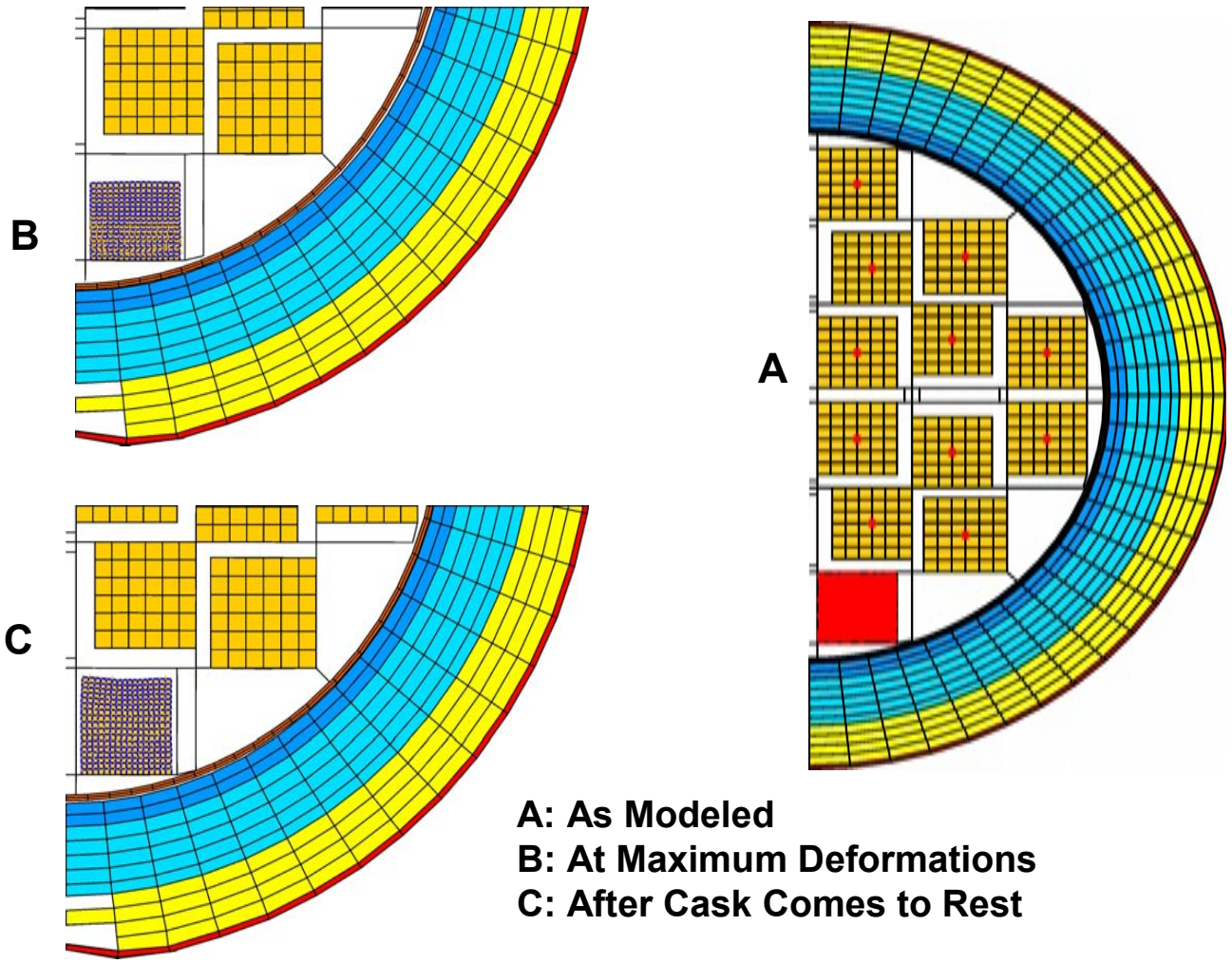


Maximum Axial Stress

Mode-III Damage in Fuel Rods

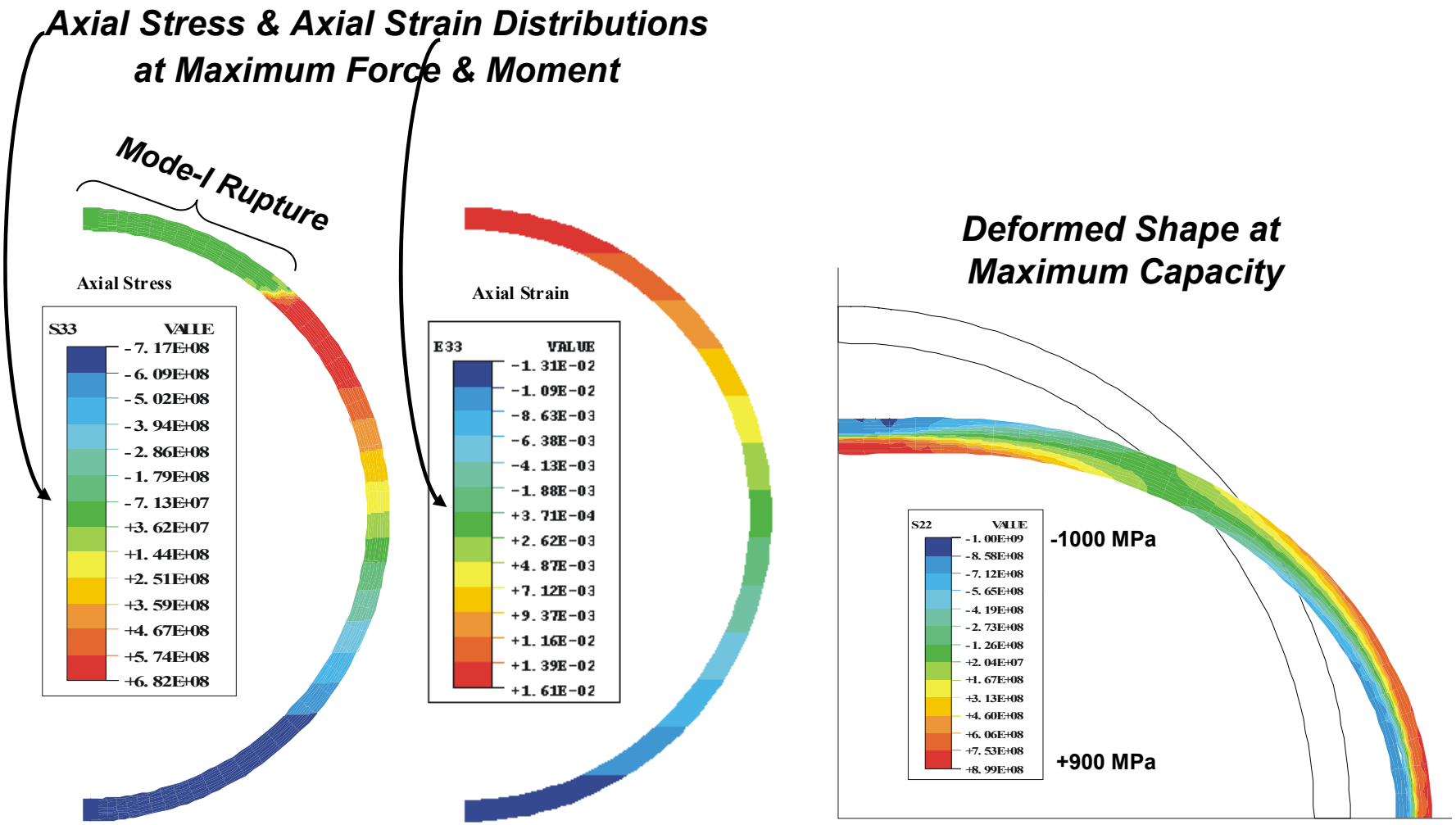


Damage Evaluation of Fuel Assembly



A: As Modeled
B: At Maximum Deformations
C: After Cask Comes to Rest

Damage Evaluation of Guide Tubes



Conclusions: Compliance with 10 CFR 71 ?

- **Package Contents "Not Substantially Altered"**
  - **Assembly Geometry is Restored to Near Original Shape**
- **No Loss or Dispersal of Spent Fuel**
  - **No Fuel Rod Failures**
- **No "Significant Increase" in External Surface Radiation Levels**
  - **Minor Damage in Shielding Material**
- **No "Substantial Reduction" in Effectiveness of Package**
  - **Guide Tubes may Experience Partial Rupture or Plastic Distortion, but Assemblies Remain Intact**