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Structural Evaluation of a Shielded Transfer Cask System for Intra Plant Spent Fuel Transfer

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Abstract 409

Introduction

- Shielded transfer cask is an essential component for processing fuel for dry storage
  - Protects personnel during canister handling
- The cask can also be used to move spent fuel between reactor units at a site
- For movement between units, the cask is attached to the trailer by a system of cables and displacement limiting restraints

Typical transfer cask

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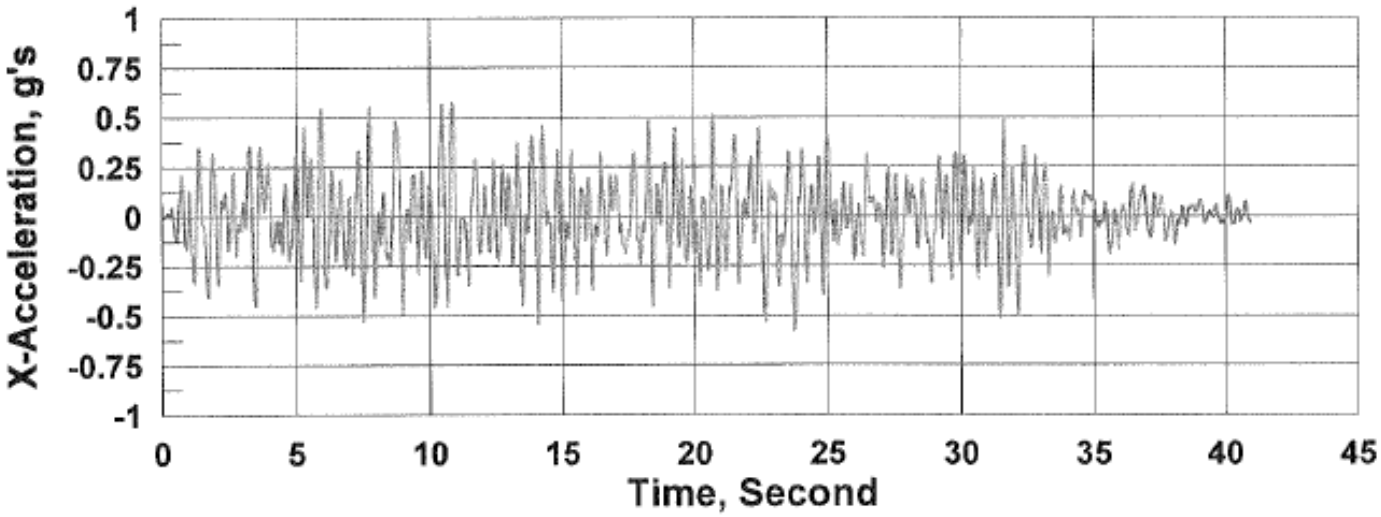
System Description

- Transfer cask is comprised of series of shells: steel-lead-NS4FR-steel
  - Primarily intended for lifting
  - Loaded cask mass:82,000 kg
- Stainless steel canister is the confinement boundary for the contents
  - Lid is bolted to the canister flange
- Structural basket maintains the fuel assembly positions
  - Basket is comprised of a series of high strength carbon steel disks.

Design Conditions/Criteria

- Using site specific seismic time histories the loaded cask must remain upright

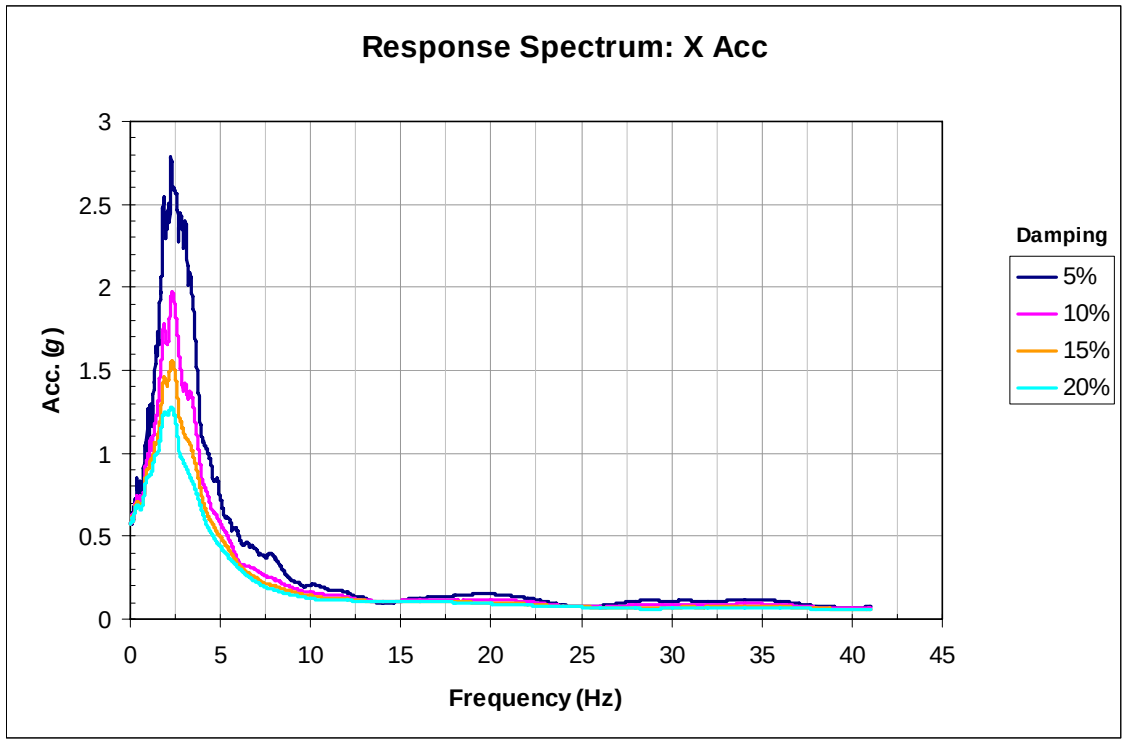


- Canister maintains confinement due to a non-mechanistic tip over of the cask
- The effort is limited to the cask and its attachments

Seismic Evaluations

- Response spectrum of time history identifies frequency which would result in maximum loads to the system
- Cask modal frequencies are above 40 Hz

- Trailer modal frequencies are in the 1-6 Hz range
- Tire stiffnesses was provided as design input



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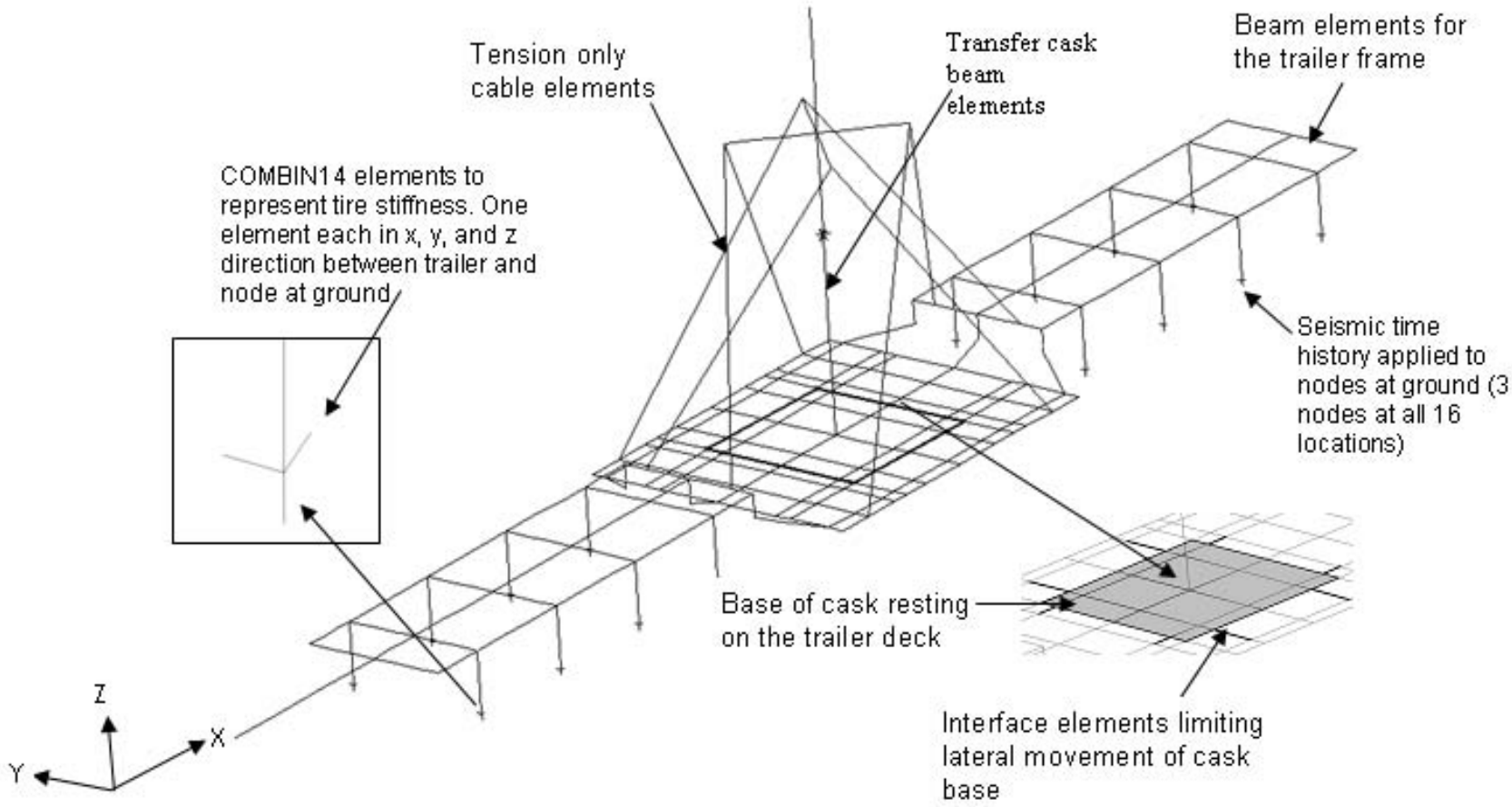
Trailer Model

•ANSYS model is comprised of beam elements, tension only elements, shell elements and springs



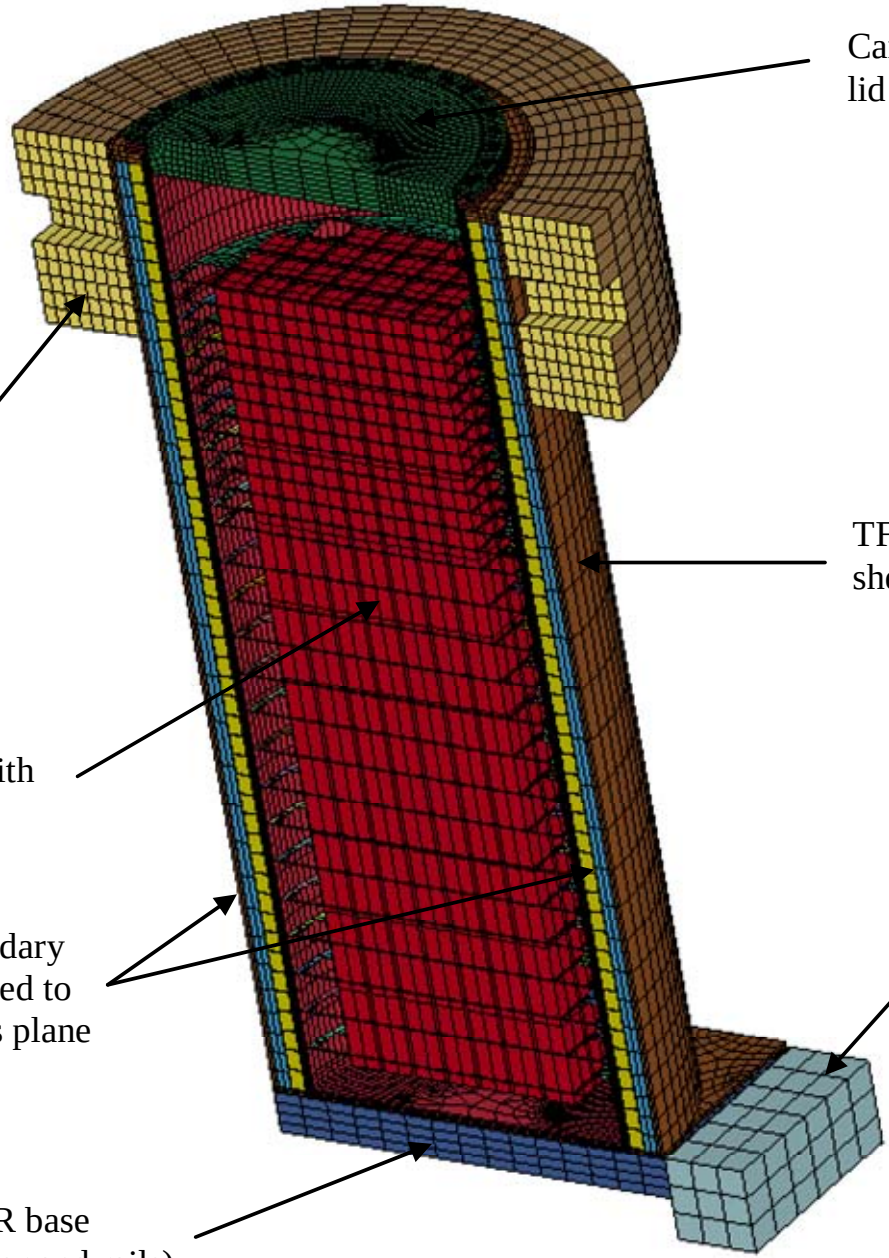
Definition/Results of Seismic Analysis Cases

Case	Description	Comment	Cask Tip Angle(°)
1	Tire stiffness K = 900 N/mm, 7% damping	Use provided tire properties	1.6°
2	Tire stiffness K = 900 N/mm, 3.5% damping	Reduce damping by 50%	2.6°
3	Tire stiffness K = 720 N/mm, 7% damping	Reduce tire stiffness by 20%	1.8°
4	Tire stiffness K = 1080 N/mm, 7% damping	Increase tire stiffness by 20%	1.5°
5	Tire stiffness K = 900 N/mm, 7% damping, interchange seismic excitation X and Y axis	Considers case with trailer-cask system rotated 90°	2.0°
6	Tire stiffness K = 900 N/mm, 7% damping, seismic excitation directions rotated 45°	Considers case with trailer-cask system rotated 45°	1.6°
7	Tire stiffness K = 900 N/mm, 7% damping apply excitation in the Y and Z directions	Trailer-cask system to freely move in X	1.6°

Non-mechanistic Cask Tip Over Evaluation

- Model for this evaluation includes
  - Transfer cask
  - Canister with the bolted lid
  - Basket maintaining fuel position
  - Impact limiter
  - Fuel
- Detailed modeling of the basket provides the most accurate definition of the forces applied to the transfer cask
- Analyses initial condition is the angular velocity at the instant of impact of the system with the rigid surface
- Gravity is also applied

Cask System Model



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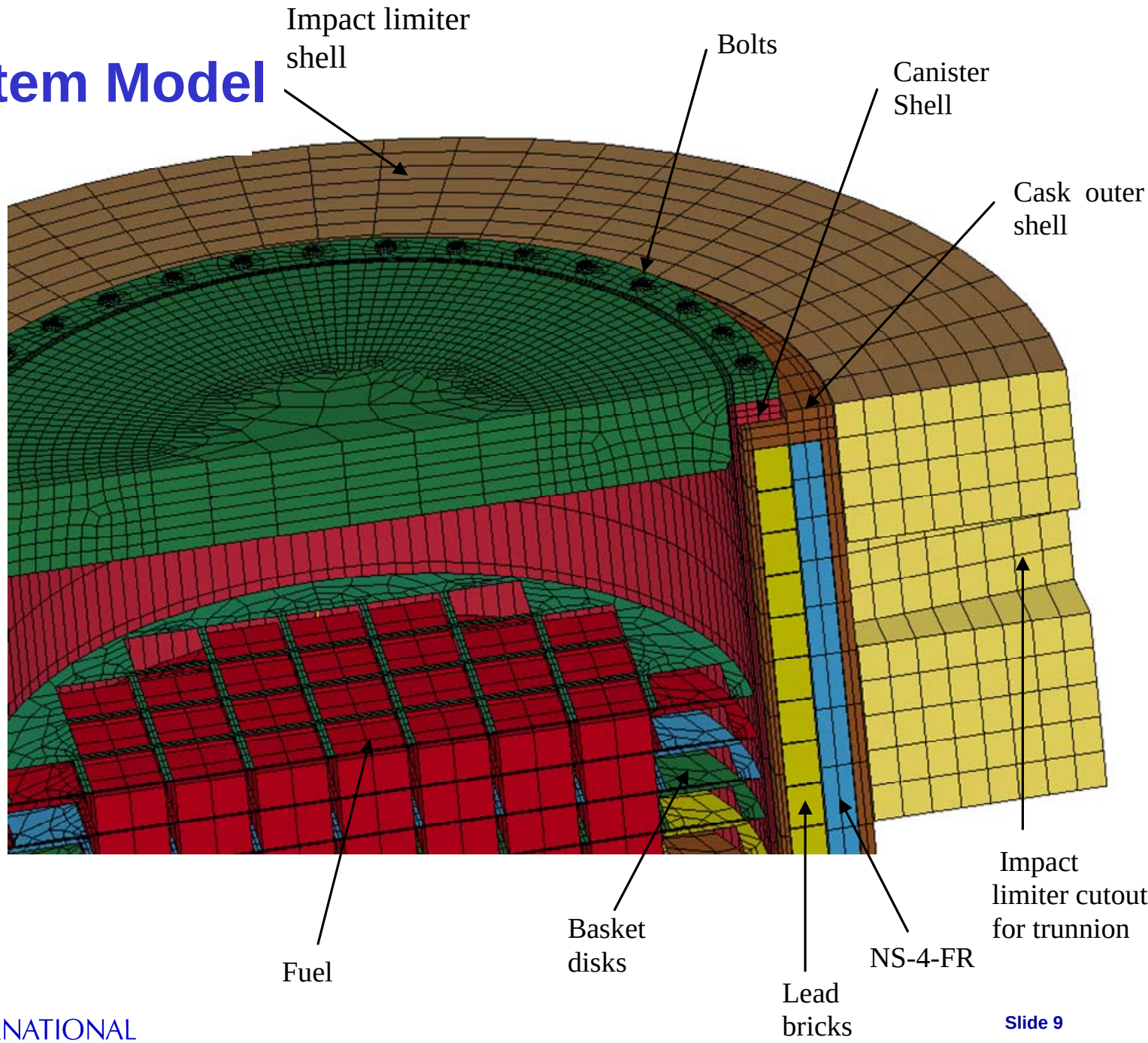
System Model



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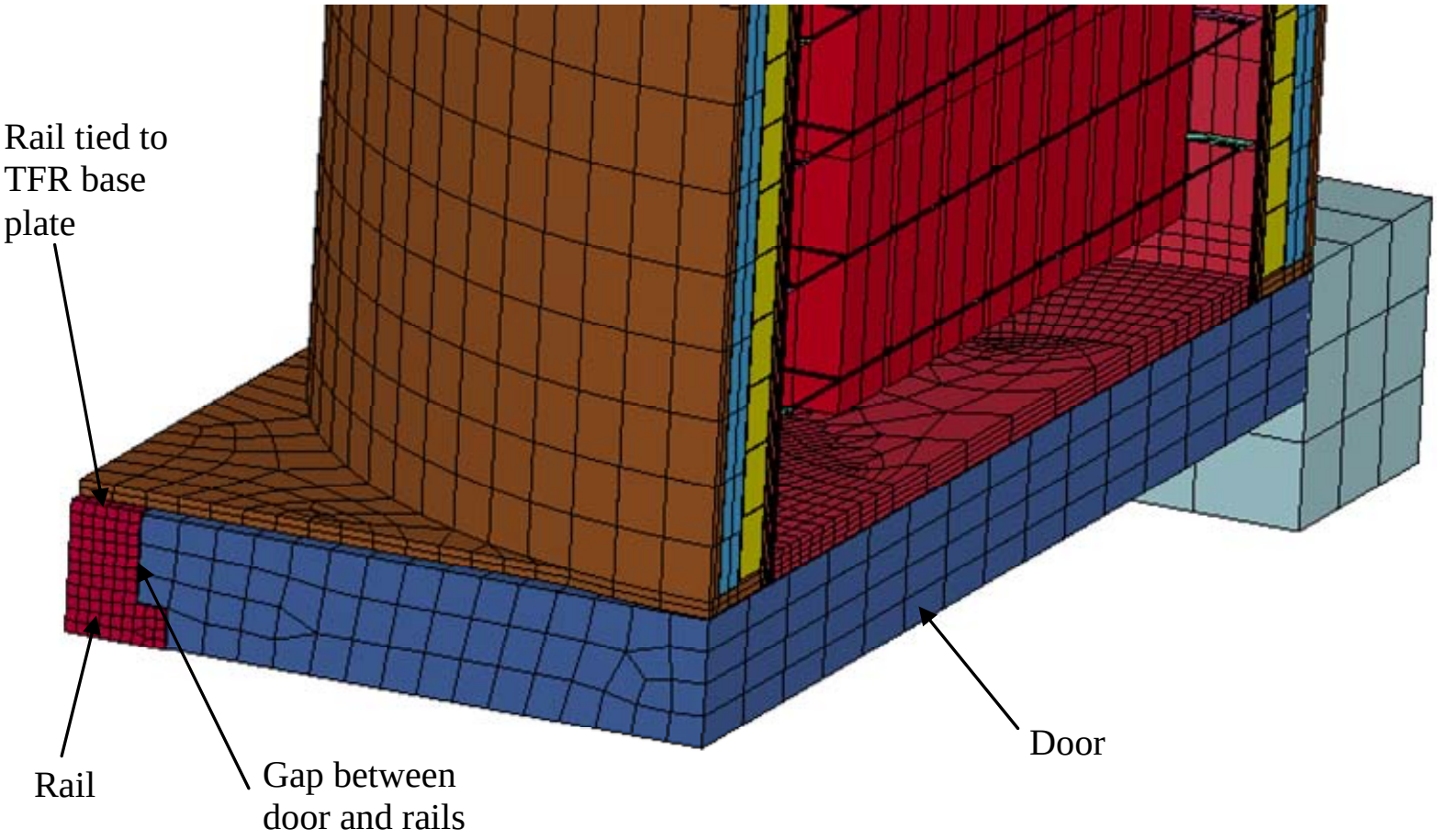
Model Base


Rail tied to TFR base plate
Rail
Gap between door and rails
Door

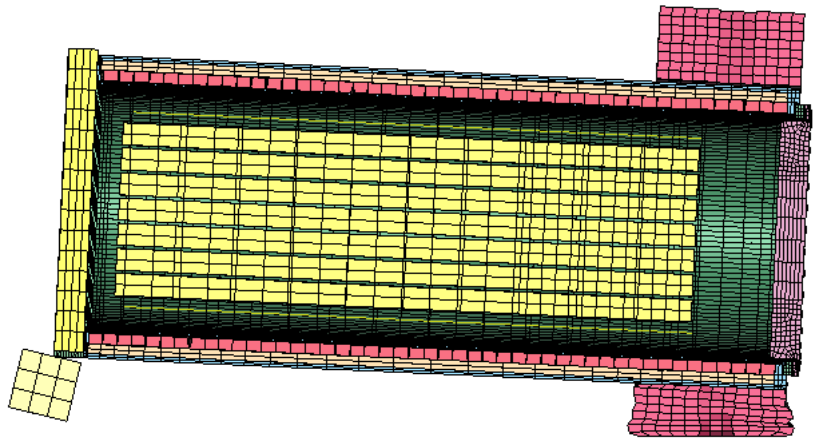
Material Properties

- Carbon steel/stainless steel are modeled with inelastic properties
  - Static properties are conservatively used
- Impact limiter uses foam properties accounting for
  - Temperature dependence
  - Foam pour direction
  - Strain rate sensitivity
  - Fabrication tolerances
- Two cases are required
  - Minimal foam properties occur at the maximum temperatures resulting in maximum foam crushing
  - Maximum foam properties occur at the minimum system temperatures resulting in maximum accelerations
- Fuel is modeled as an elastic component

System Performance

- Foam crush for the hot condition was limited to 60%
- Basket accelerations were bounded by a previous licensed system
- Accelerations were used to perform the evaluation of the seal performance to confirm that the seal confinement is maintained

Deformation at last time step



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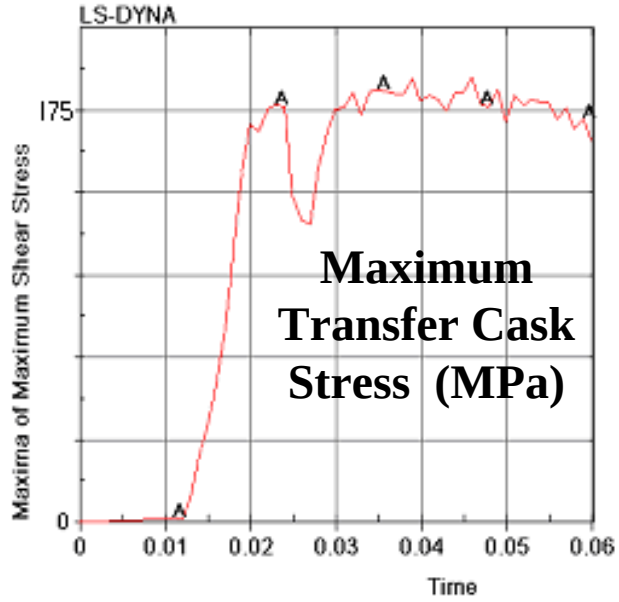
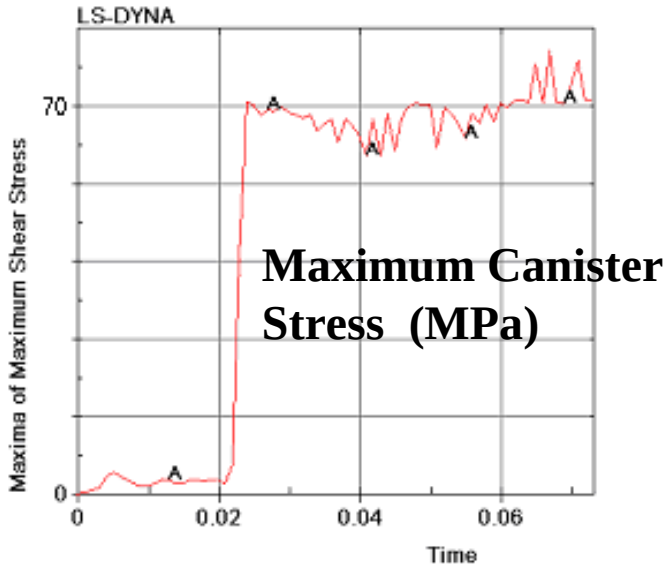
Maximum Stresses in Cask and Canister

- Maximum stress in cask occurs for the cold condition. Factor of safety is 1.6
- Maximum stress in the canister occurs for the hot condition. Factor of safety is 2.2





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Conclusions

- Methodology has been described to evaluate the seismic performance of the trailer system with a loaded transfer cask
  - Cask is shown to remain upright during the design basis seismic condition
- A detailed model of the cask, canister, basket, fuel and impact limiter was developed for the evaluation for the non-mechanistic cask tip over.
- Confinement boundary as well as the cask remains intact after the tip over condition