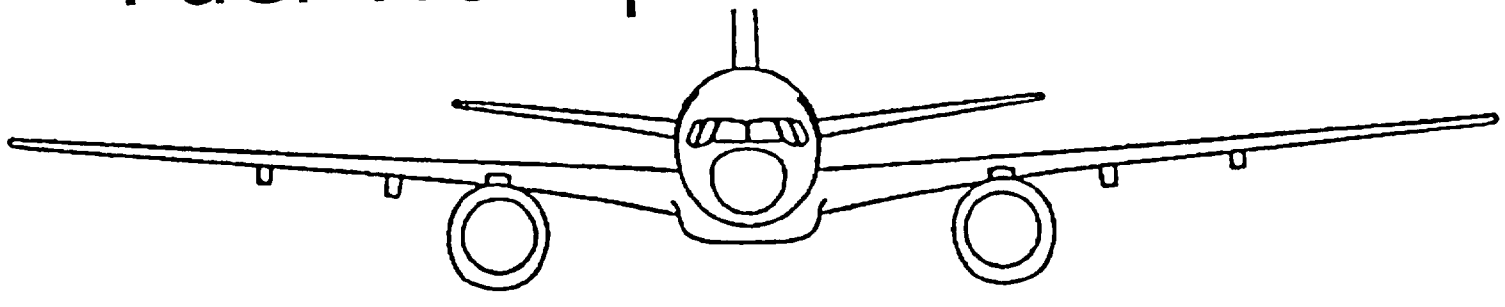
Aircraft Crash Impact on Spent Fuel Transportation Casks



Presented by

Joe Rashid and Randy James

NEI-NRC Meeting on Plant Security

Washington D C, March 4-5, 2002

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Linking Theory and Practice

B/3

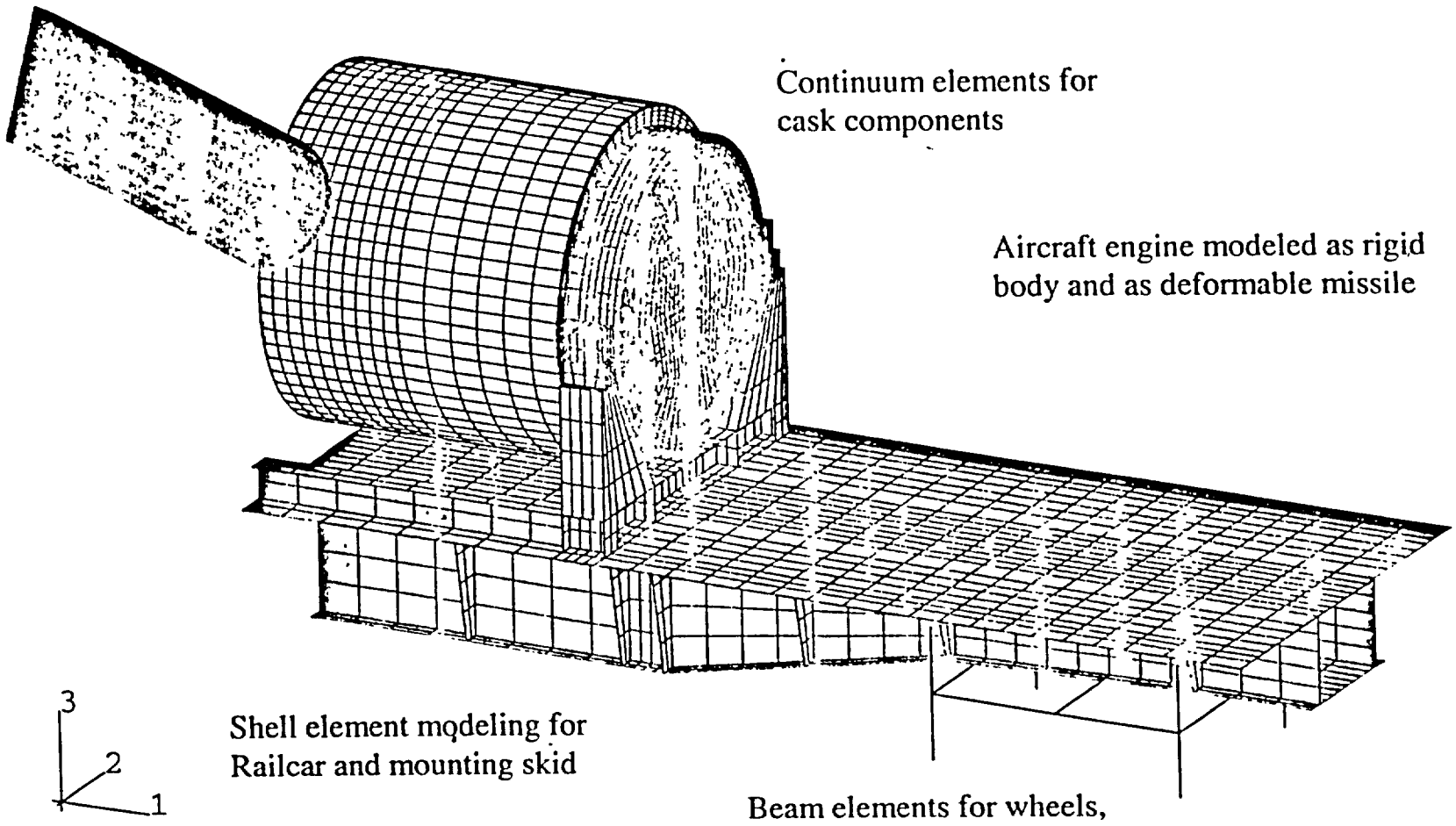
Basic Assumptions

- Commercial Wide Body Aircraft
  - ✓350 mph Velocity
  - ✓30 Degree Impact Angle
- Spent Fuel Transportation Cask
  - ✓125 Ton Steel Cask
  - ✓Mounted on Rail Car
- Current Study Considers Engine Impact
  - ✓9500 lb Turbofan Engine
  - ✓36" Diameter Impact Area

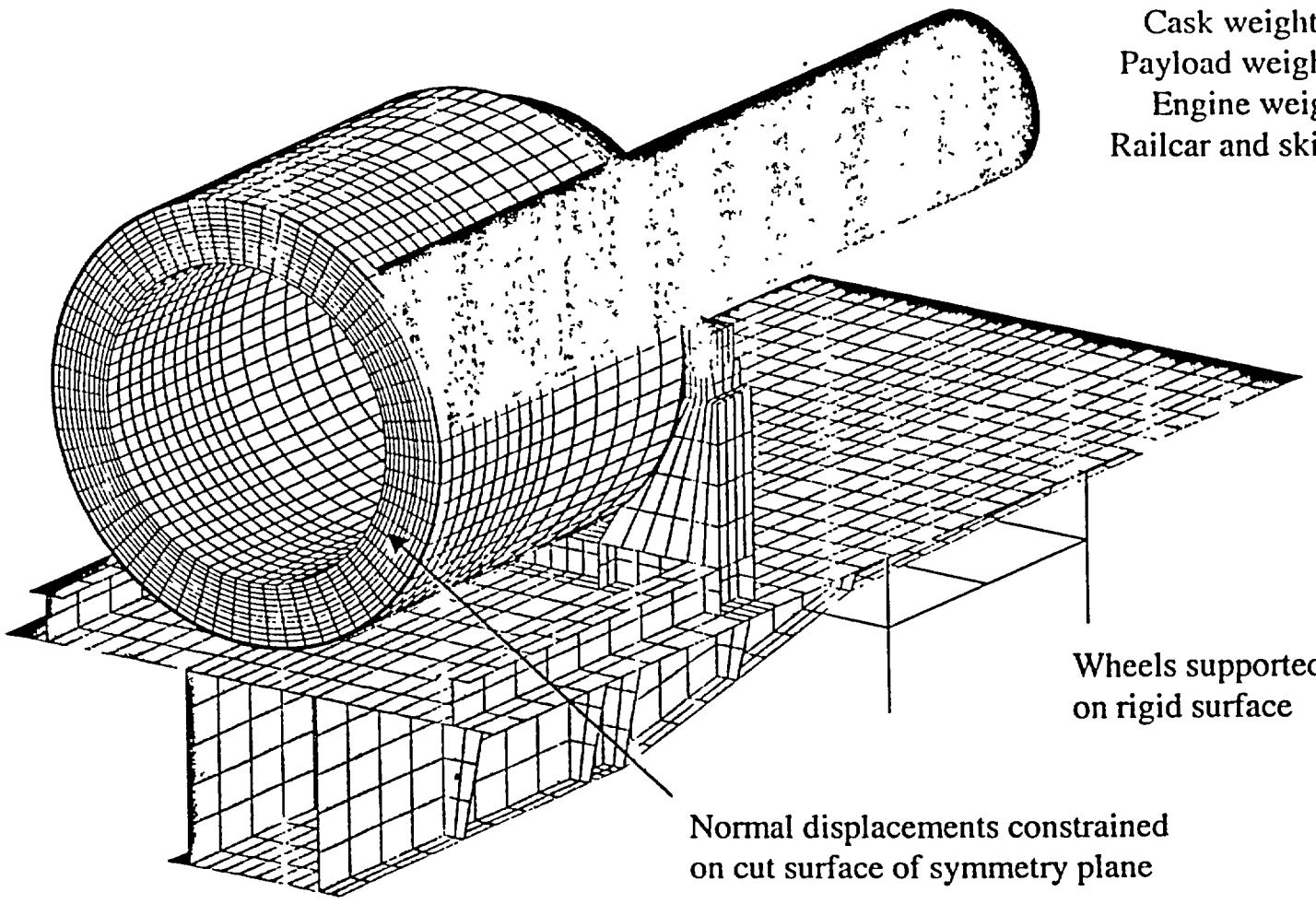
Case Studies and Assumptions

- Case 1: Rigid Missile - Kinetic Energy Model
  - ✓Engine absorbs 50% of kinetic energy
  - ✓Set impact velocity = 247.5 mph
- Case 2: Rigid Missile - Impulse Model
  - ✓Engine absorbs 60% of impulse
  - ✓Set impact velocity = 140 mph
- Case 3: Deformable Missile
  - ✓Engine stiffness based on SNL test data
  - ✓Impose full 350 mph impact velocity

Finite Element Modeling

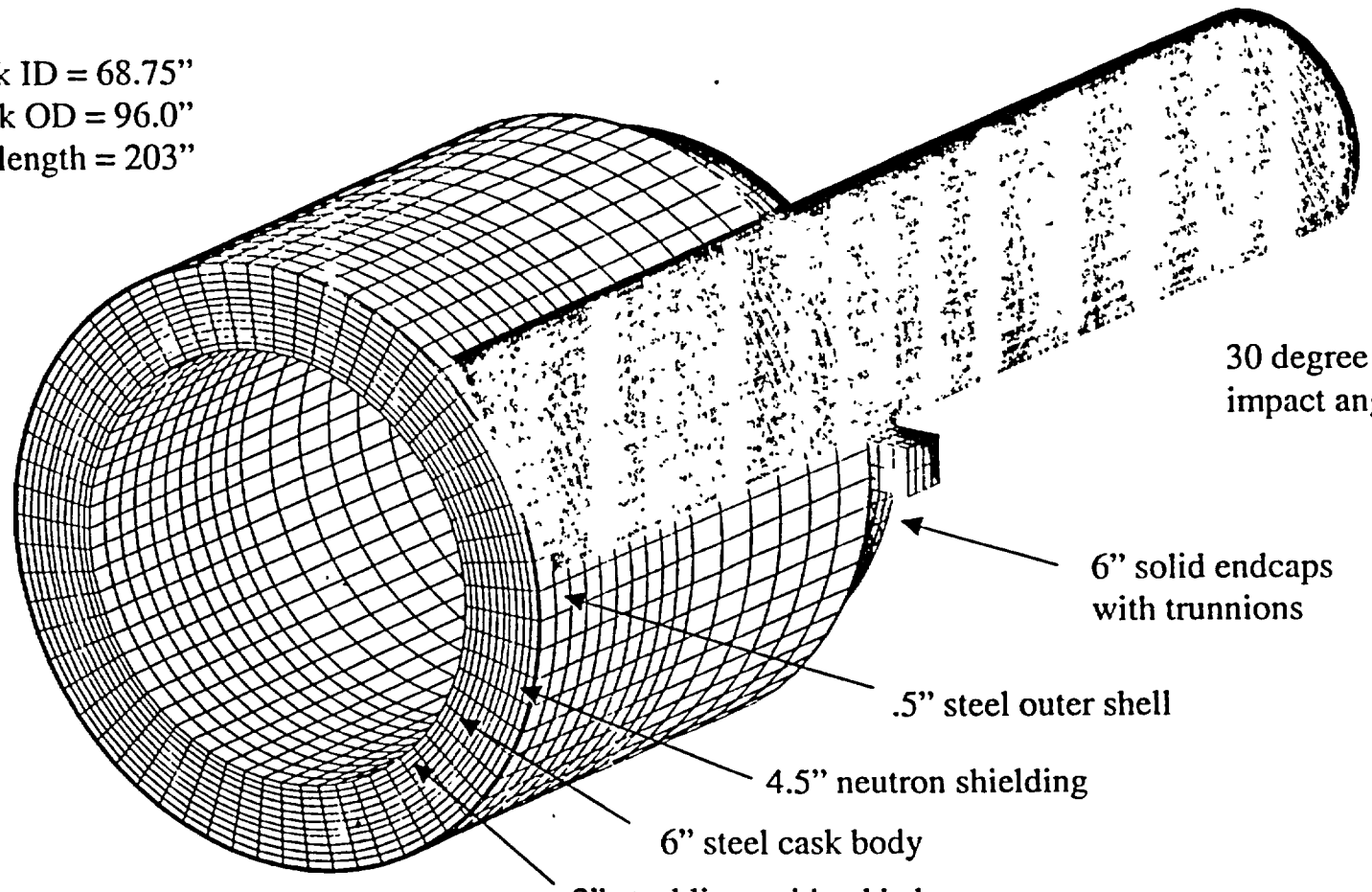


Model Assumes Half Symmetry

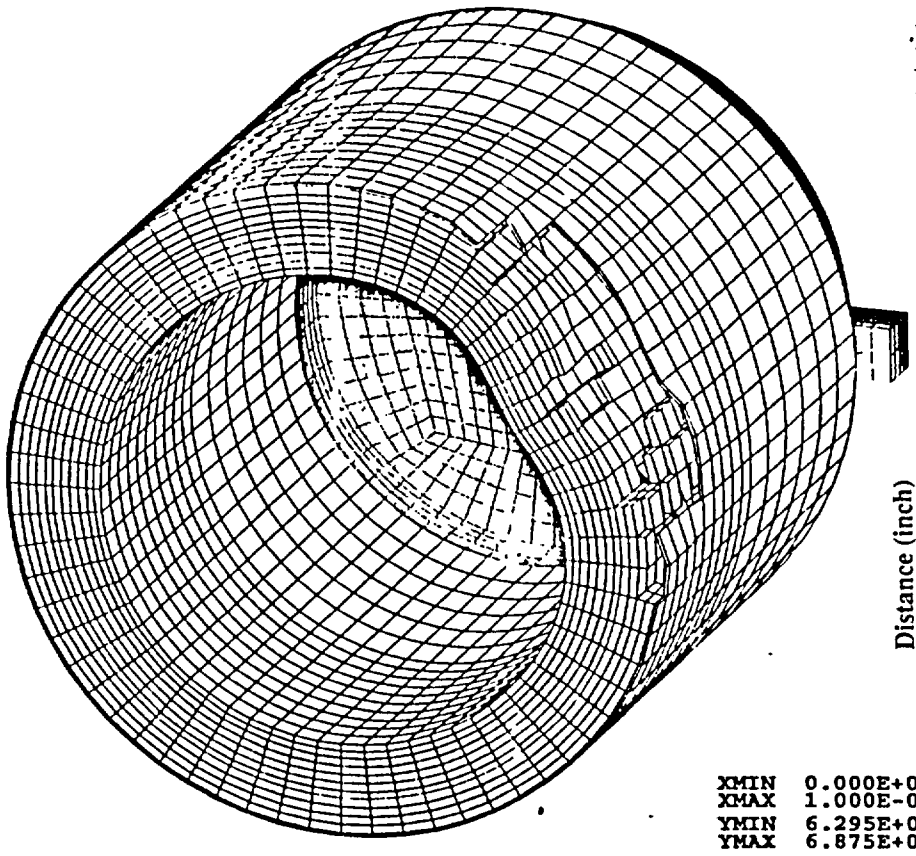


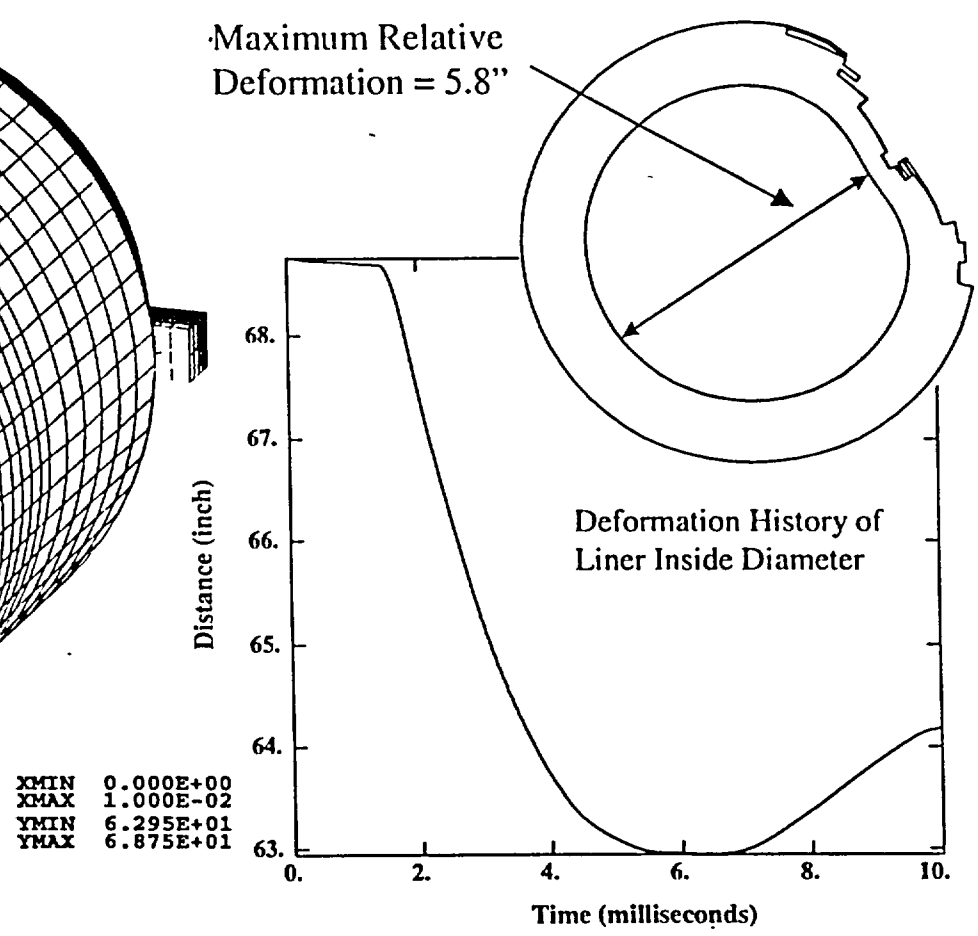
Cask Components

Cask ID = 68.75"
Cask OD = 96.0"
Total length = 203"



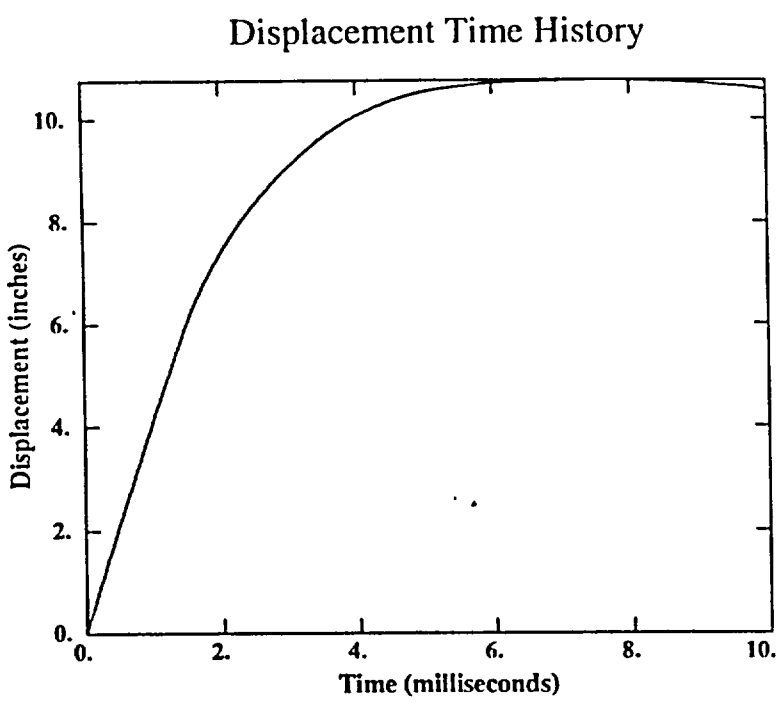
Case 1: Cask Damage

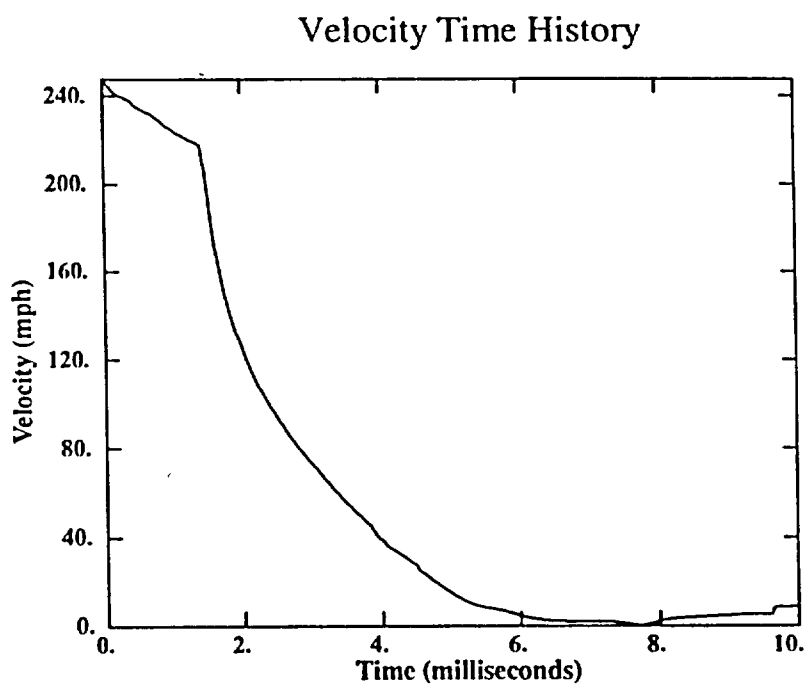




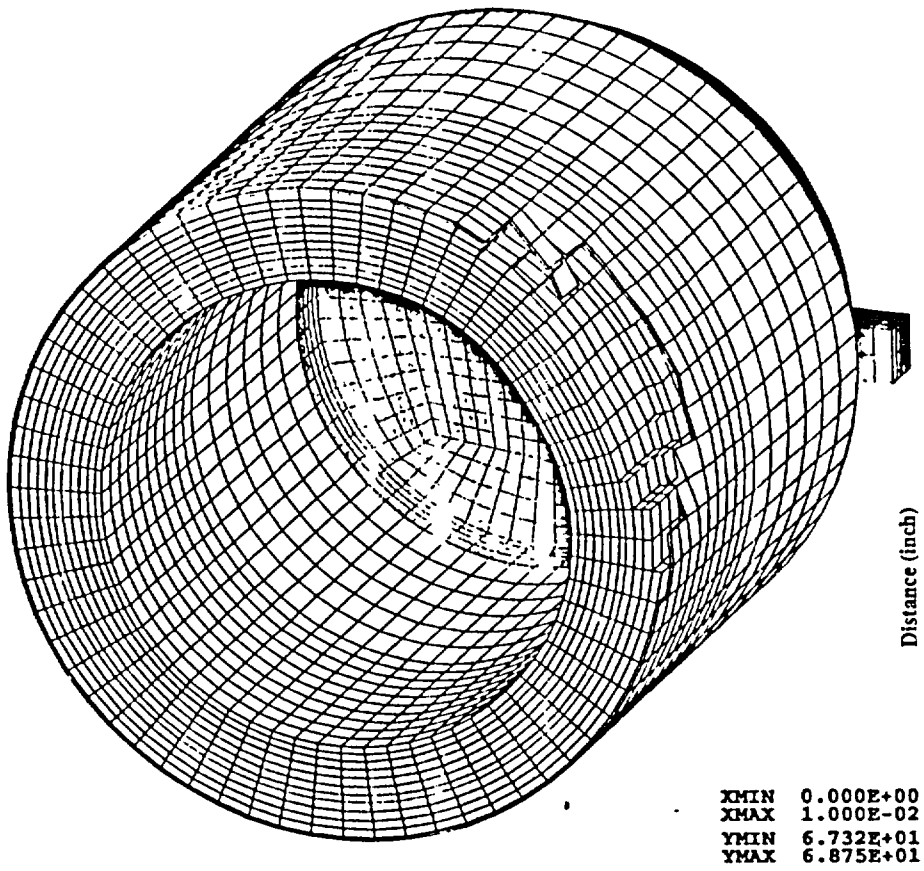
XMIN 0.000E+00
XMAX 1.000E-02
YMIN 6.295E+01
YMAX 6.875E+01

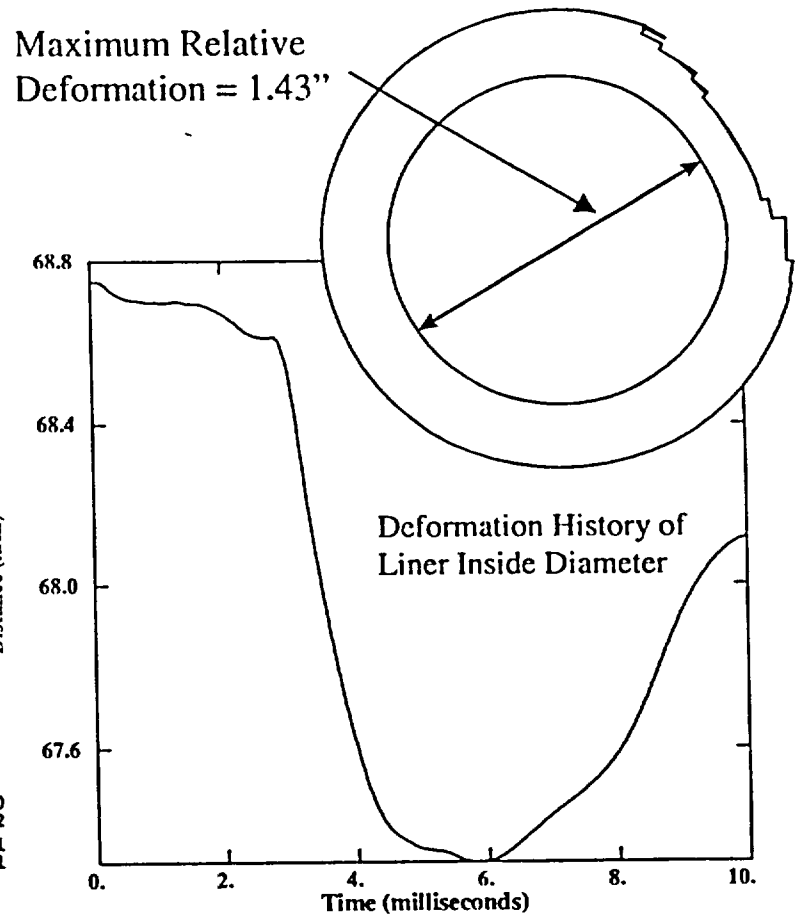
Case 1: Rigid Missile Response





Case 2: Cask Damage





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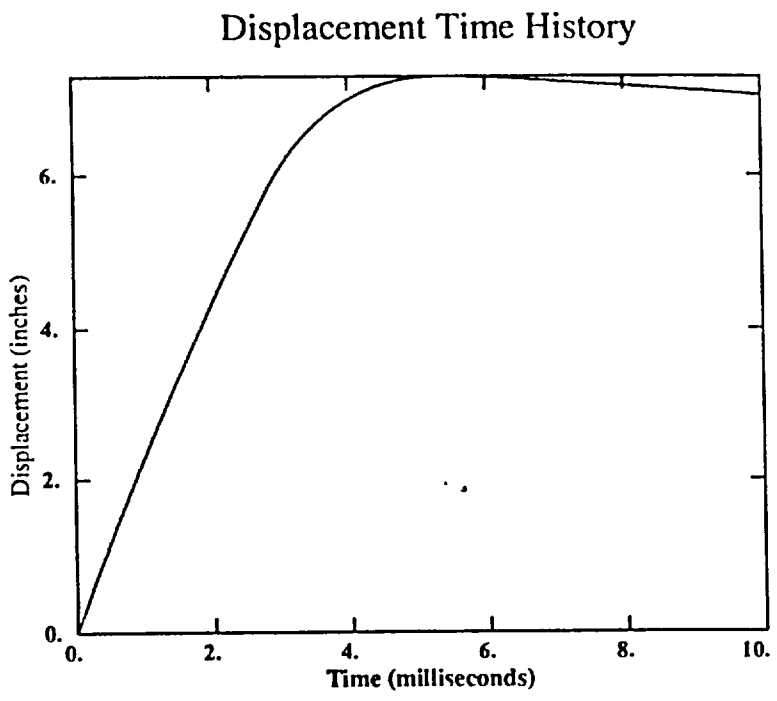
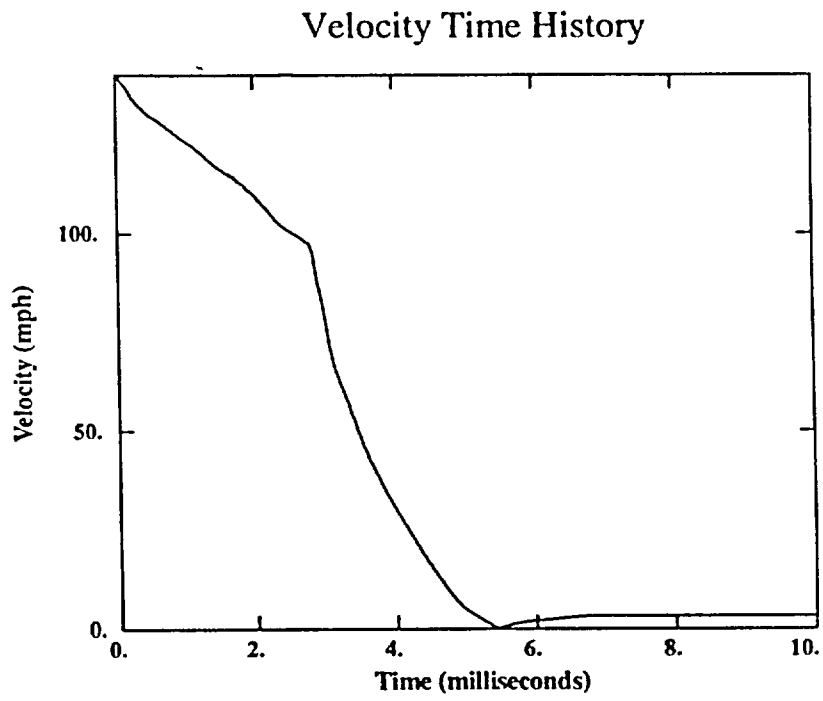
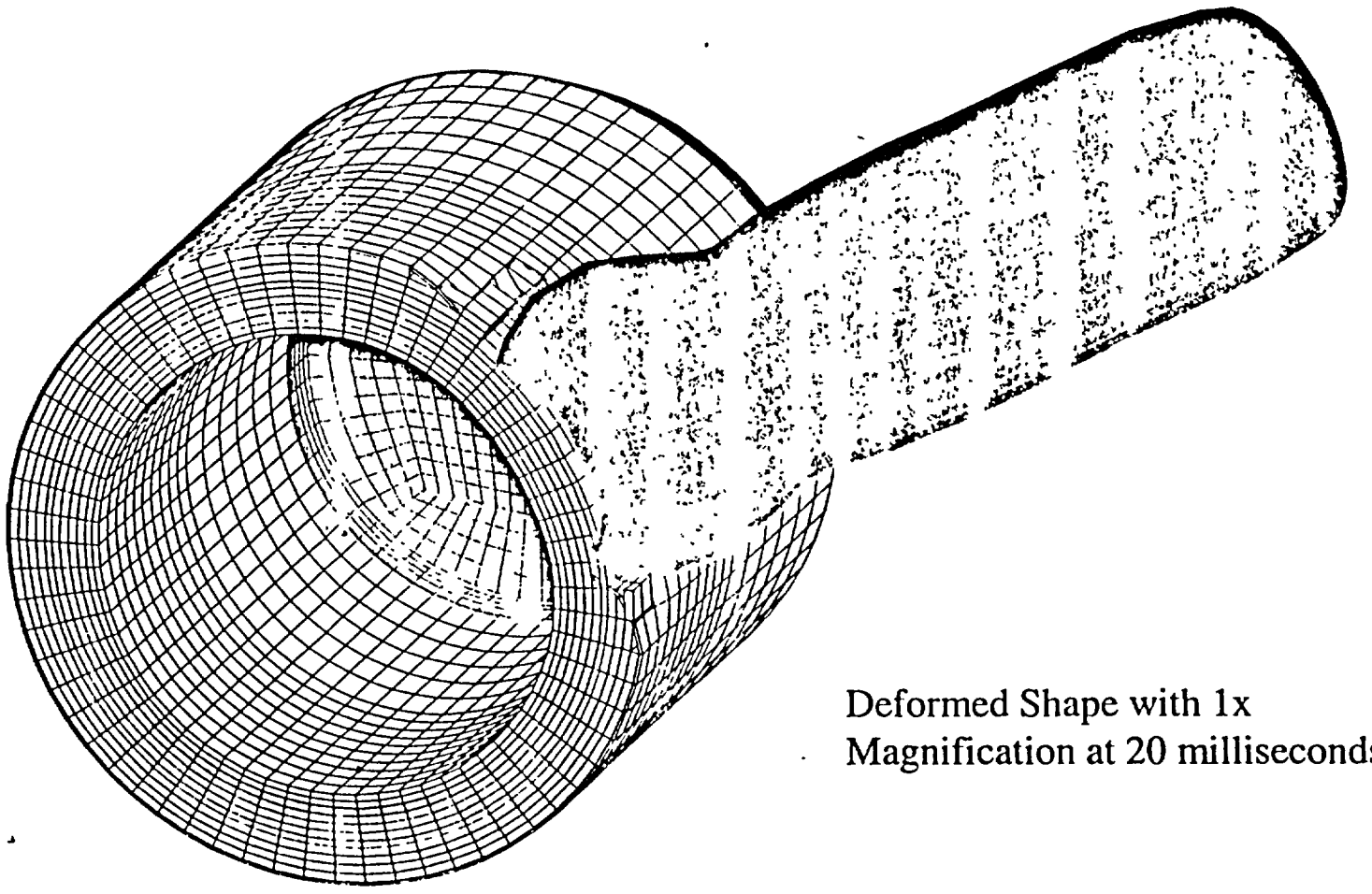
Case 2: Rigid Missile Response



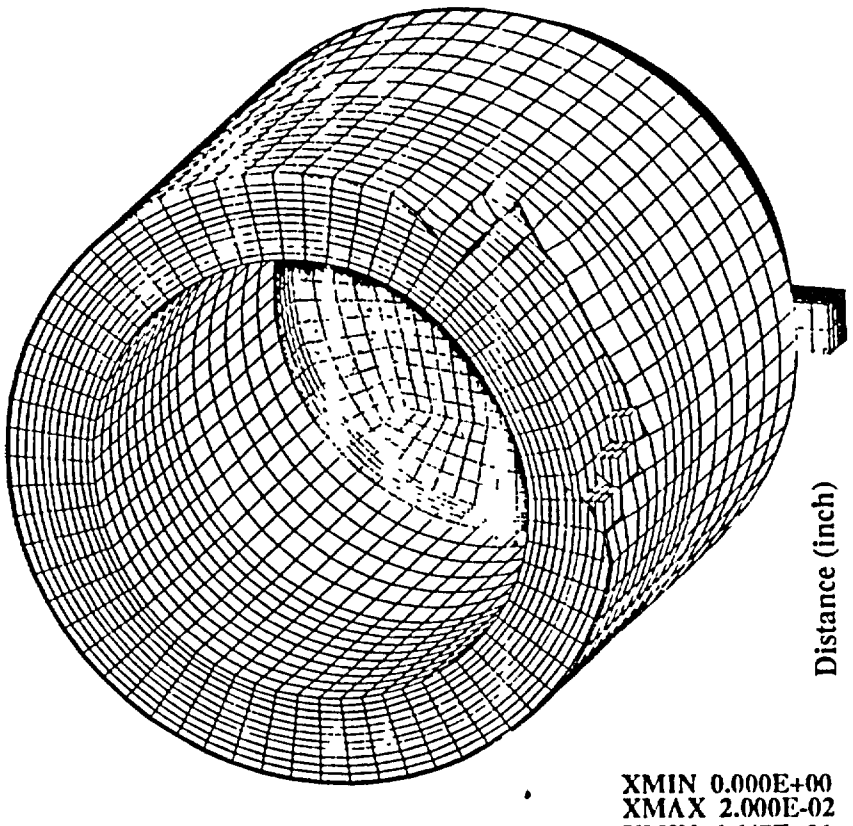


Case 3: Deformable Missile

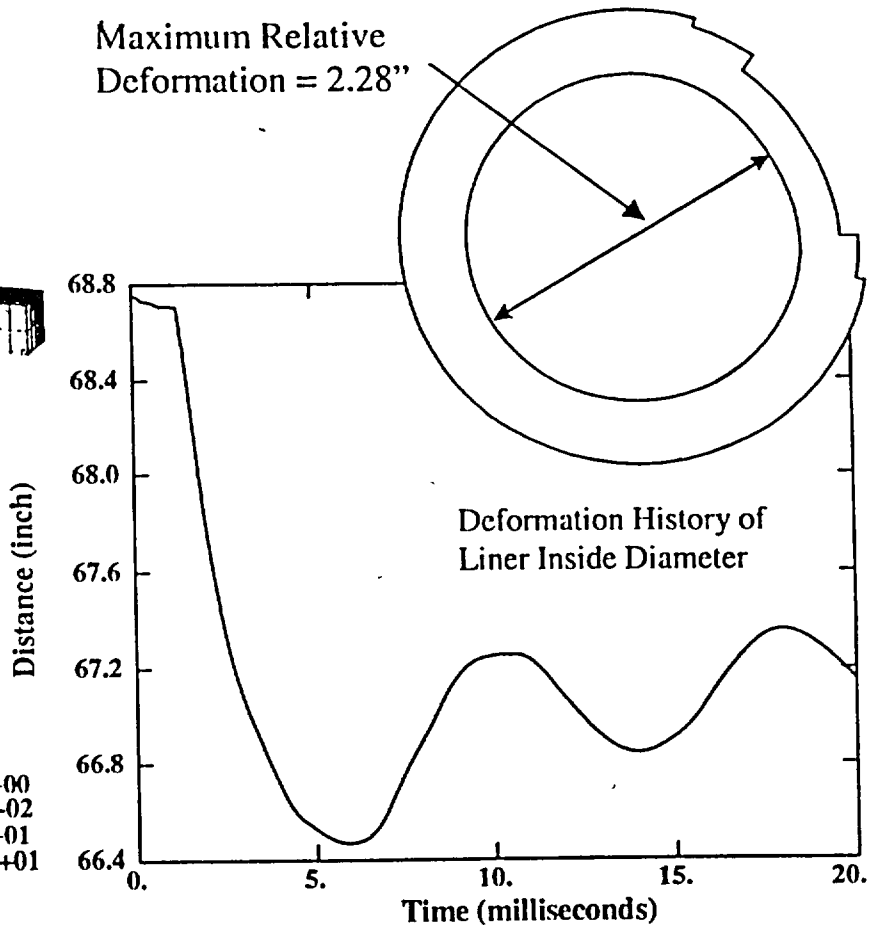


Deformed Shape with 1x
Magnification at 20 milliseconds

Case 3: Cask Damage



XMIN 0.000E+00
XMAX 2.000E-02
YMIN 6.647E+01
YMAX 6.875E+01



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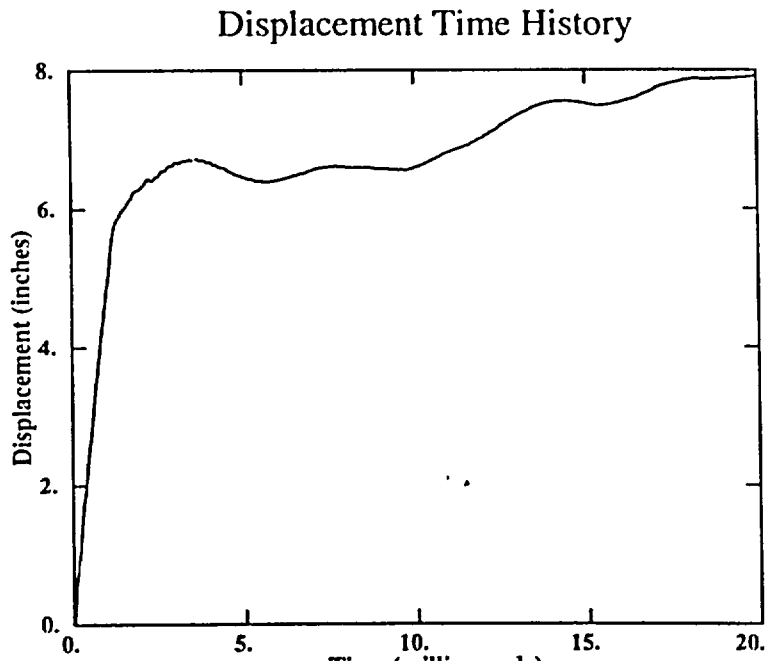
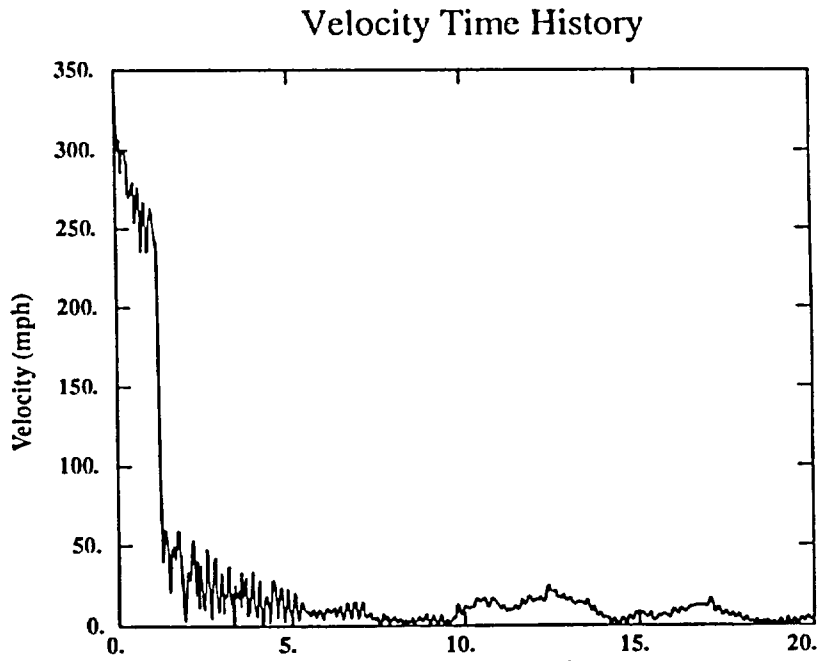
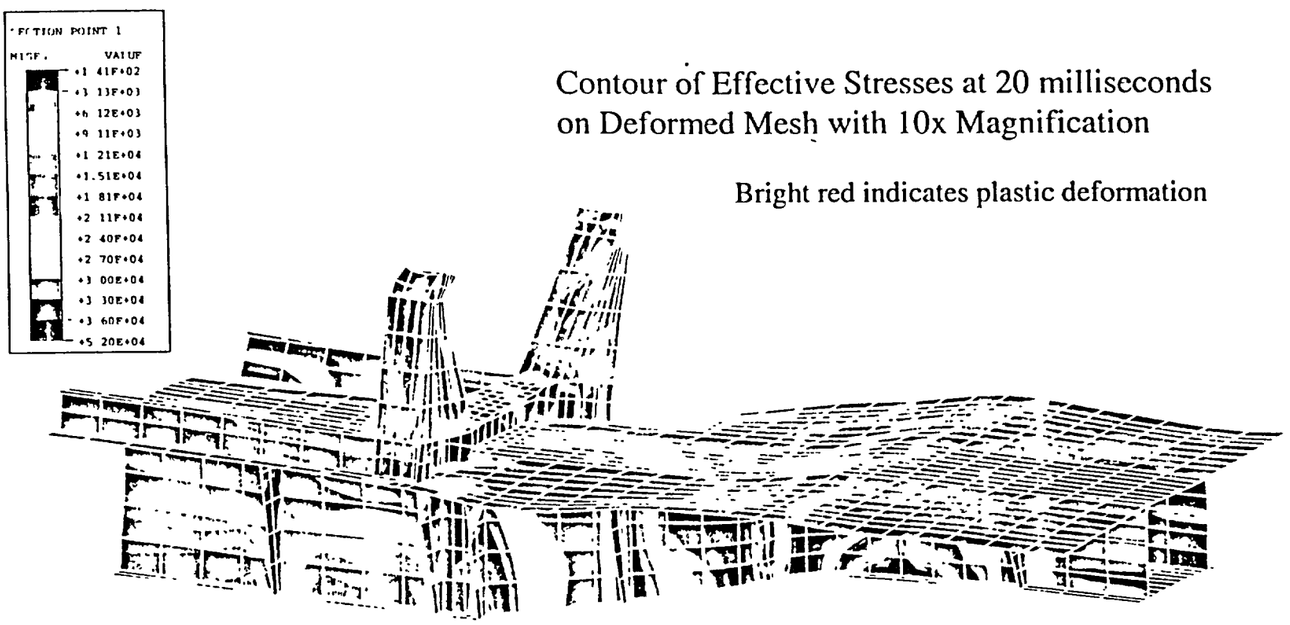
Case 3: Deformable Missile Response





Centerline Point on Missile Impact Face

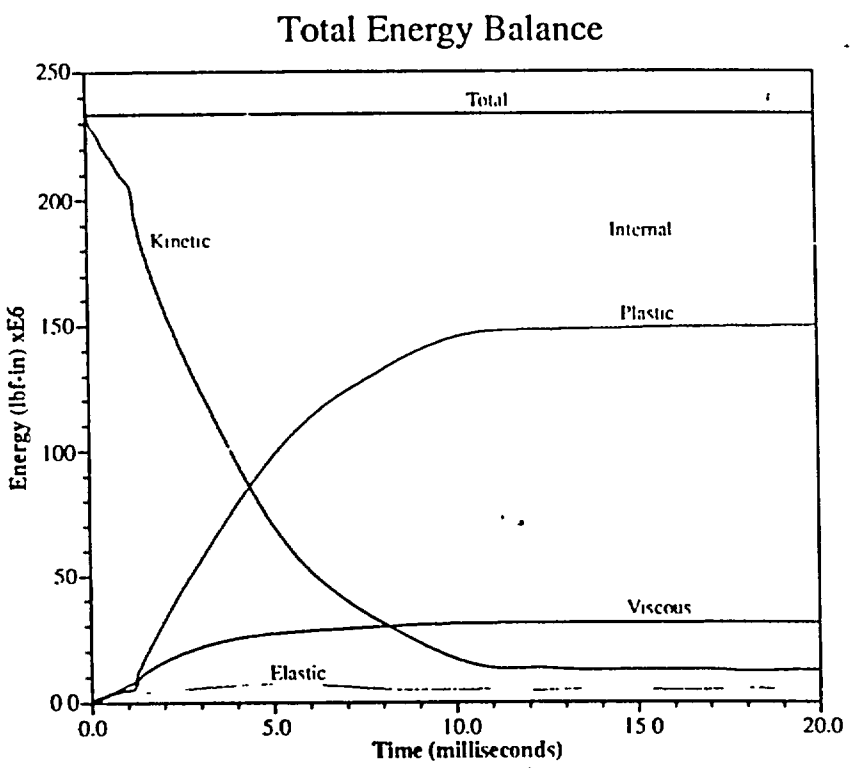
Case 3: Railcar and Skid Response

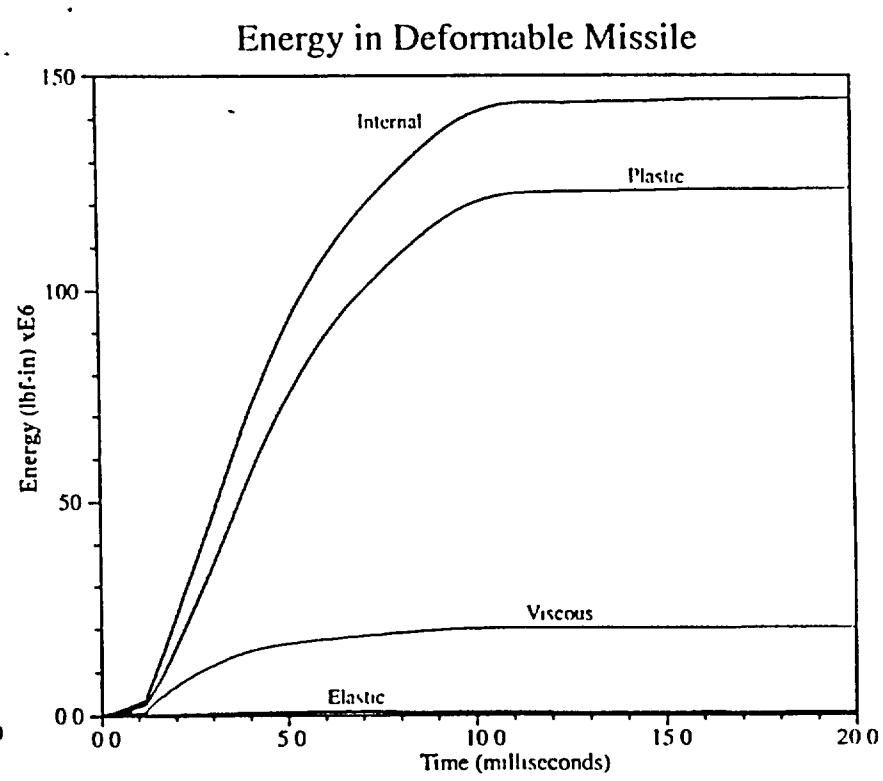


Contour of Effective Stresses at 20 milliseconds on Deformed Mesh with 10x Magnification

Bright red indicates plastic deformation

Case 3: Energy Balance

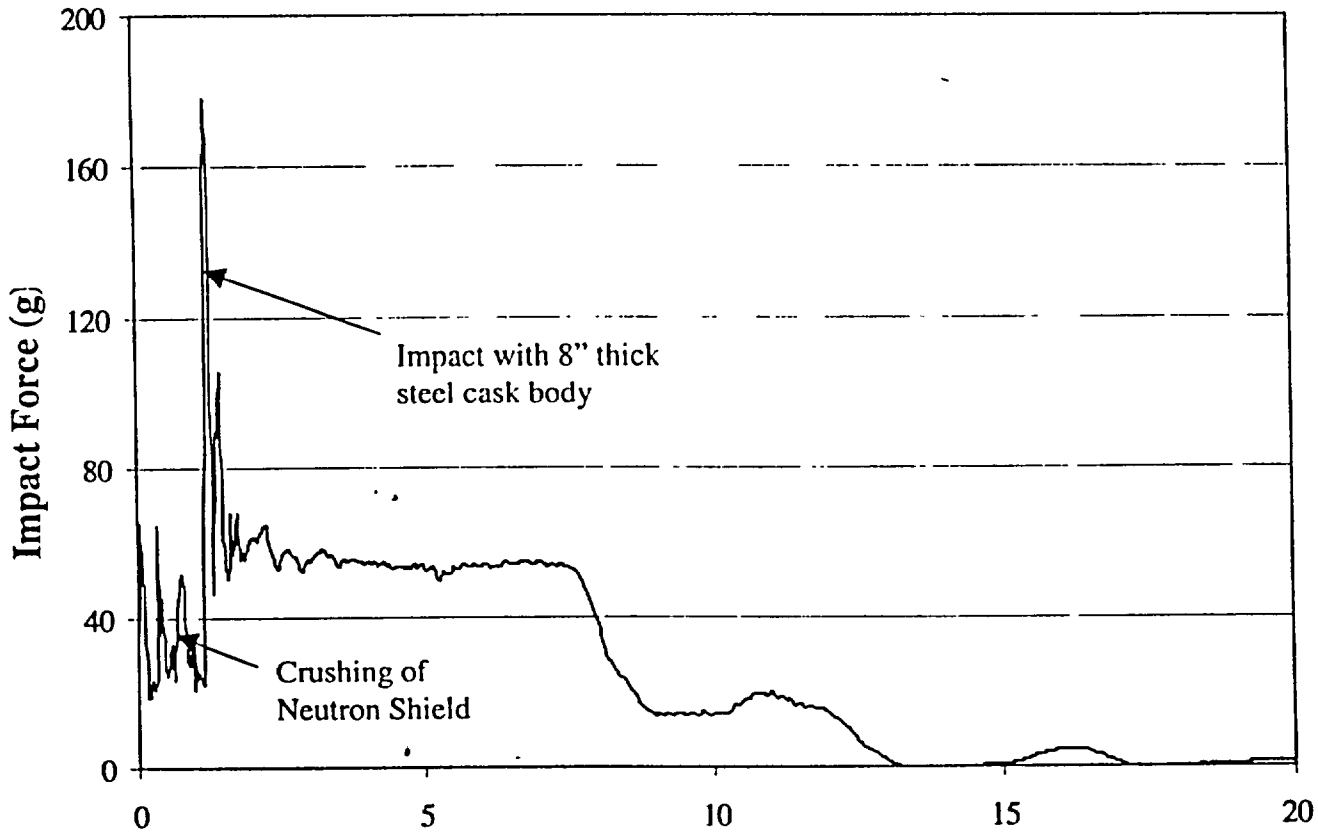




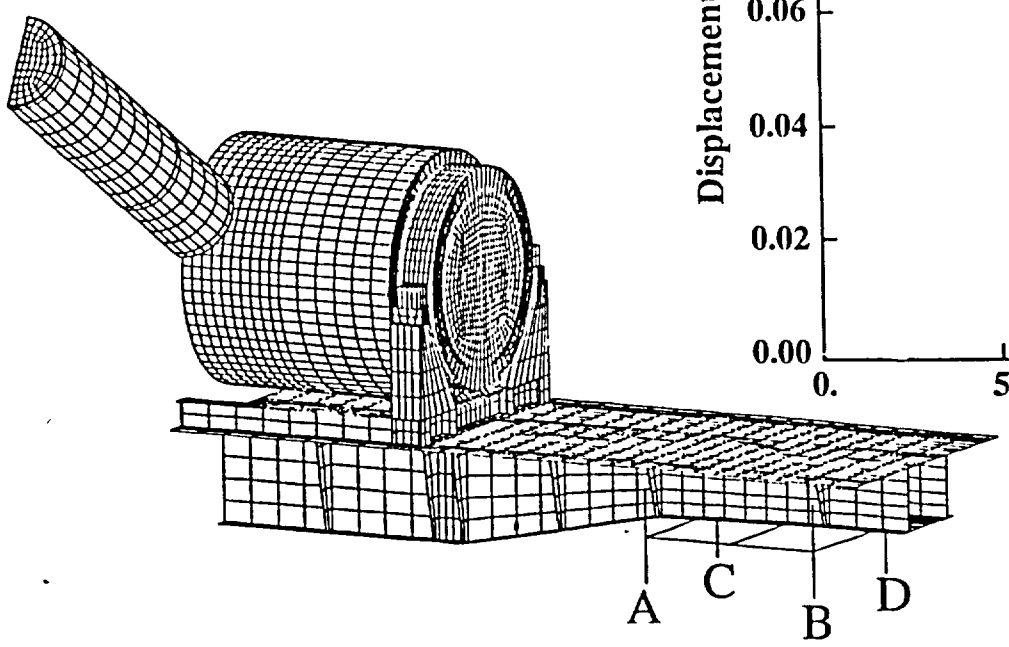
Energy Absorbed by Deformable Missile = 62%

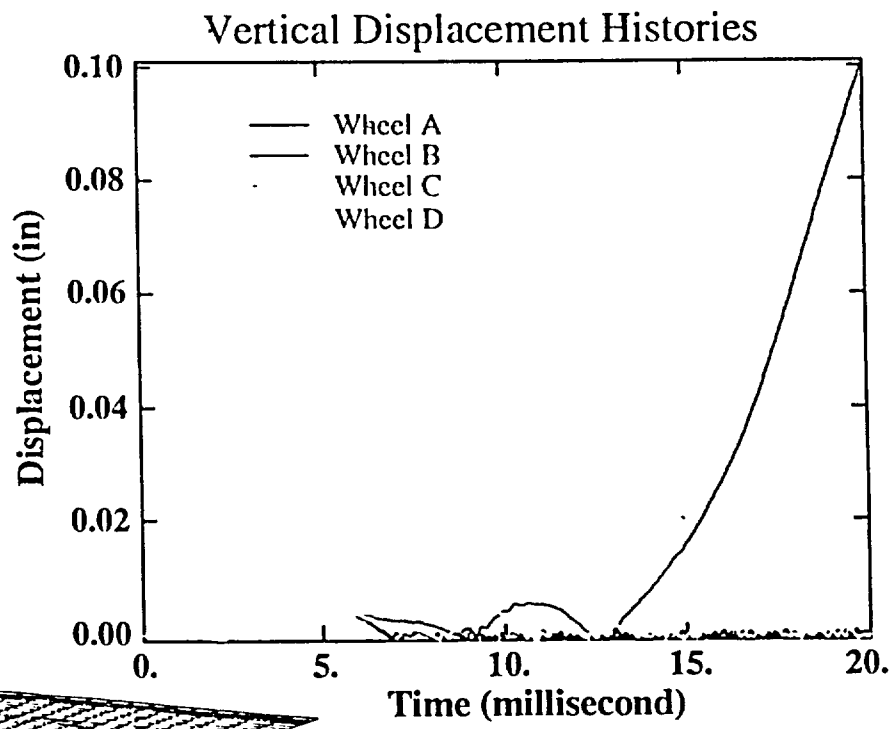
Case 3: Impact Force

Force calculated from normal stresses in missile impact face
and normalized by the total cask weight



Case 3: Uplift on Railcar Wheels





Preliminary Conclusions

- Cask Body Withstands Impact From Direct Hit Without Breaching
- G-loads are comparable to design basis cask drop events
- No Secondary Impact Consequences
  - ✓Cask stays attached to rail car
  - ✓Rail car does not tip over