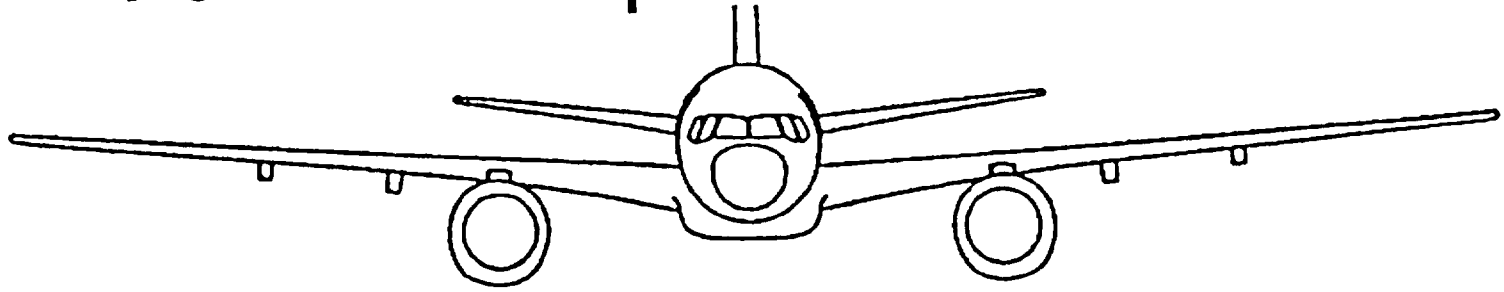


# Aircraft Crash Impact on Spent Fuel Transportation Casks



Presented by

Joe Rashid and Randy James

NEI-NRC Meeting on Plant Security

Washington D C, March 4-5, 2002

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February 2002

Preliminary Results

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# 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

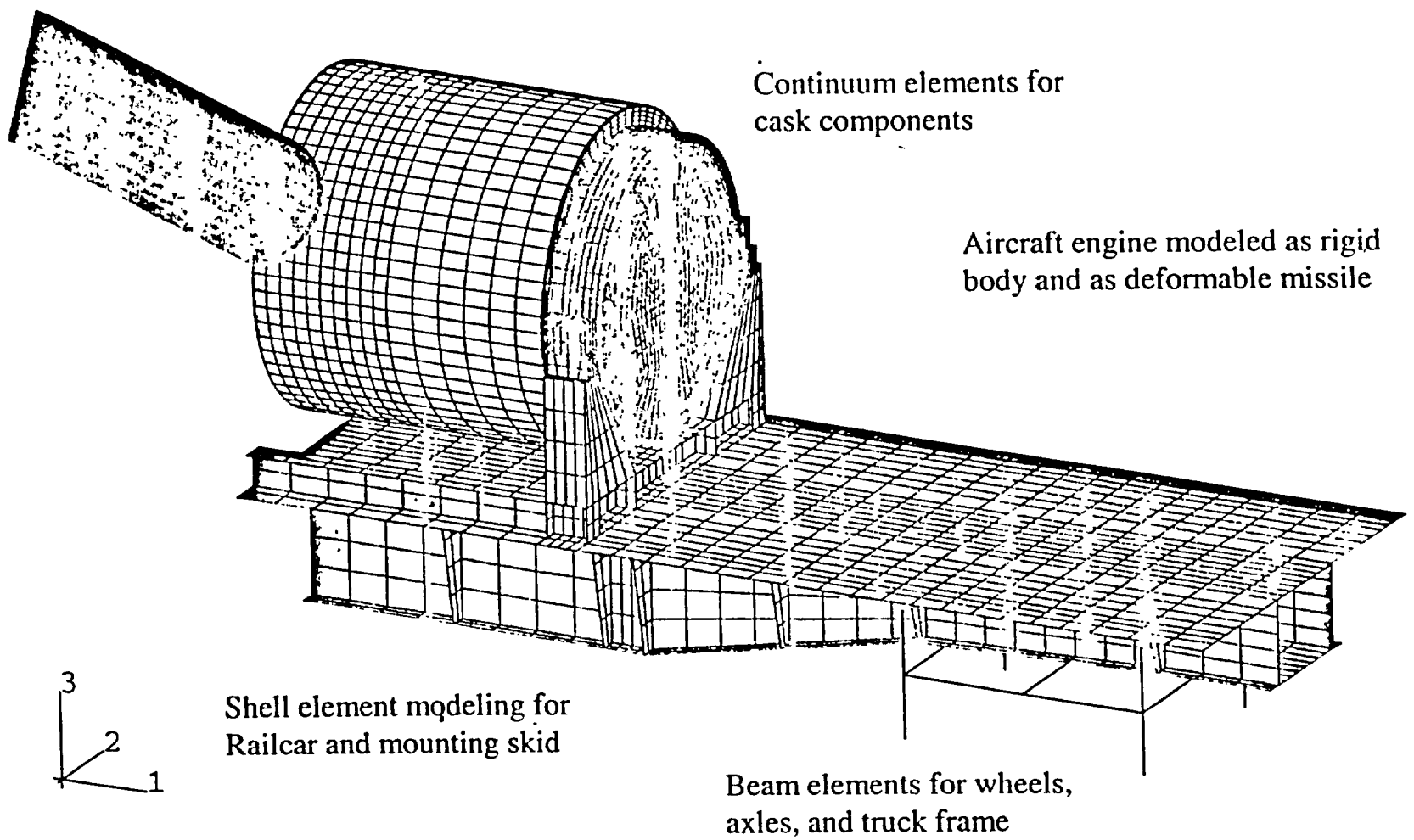
## ± Case 2: Rigid Missile - Impulse Model

- ✓ 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



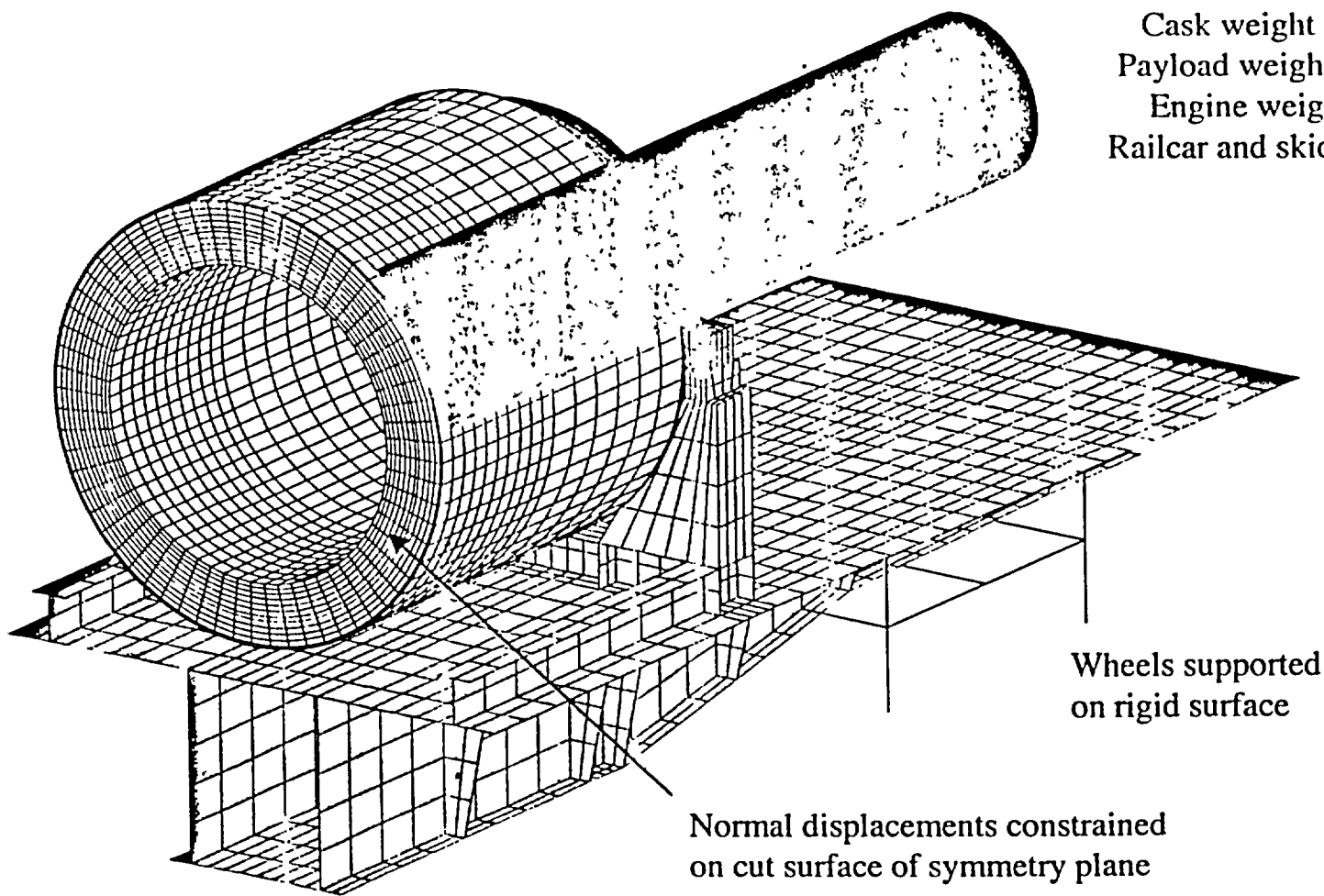
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# Model Assumes Half Symmetry

Cask weight = 158,000#  
Payload weight = 90,000#  
Engine weight = 9,500#  
Railcar and skid = 66,000#



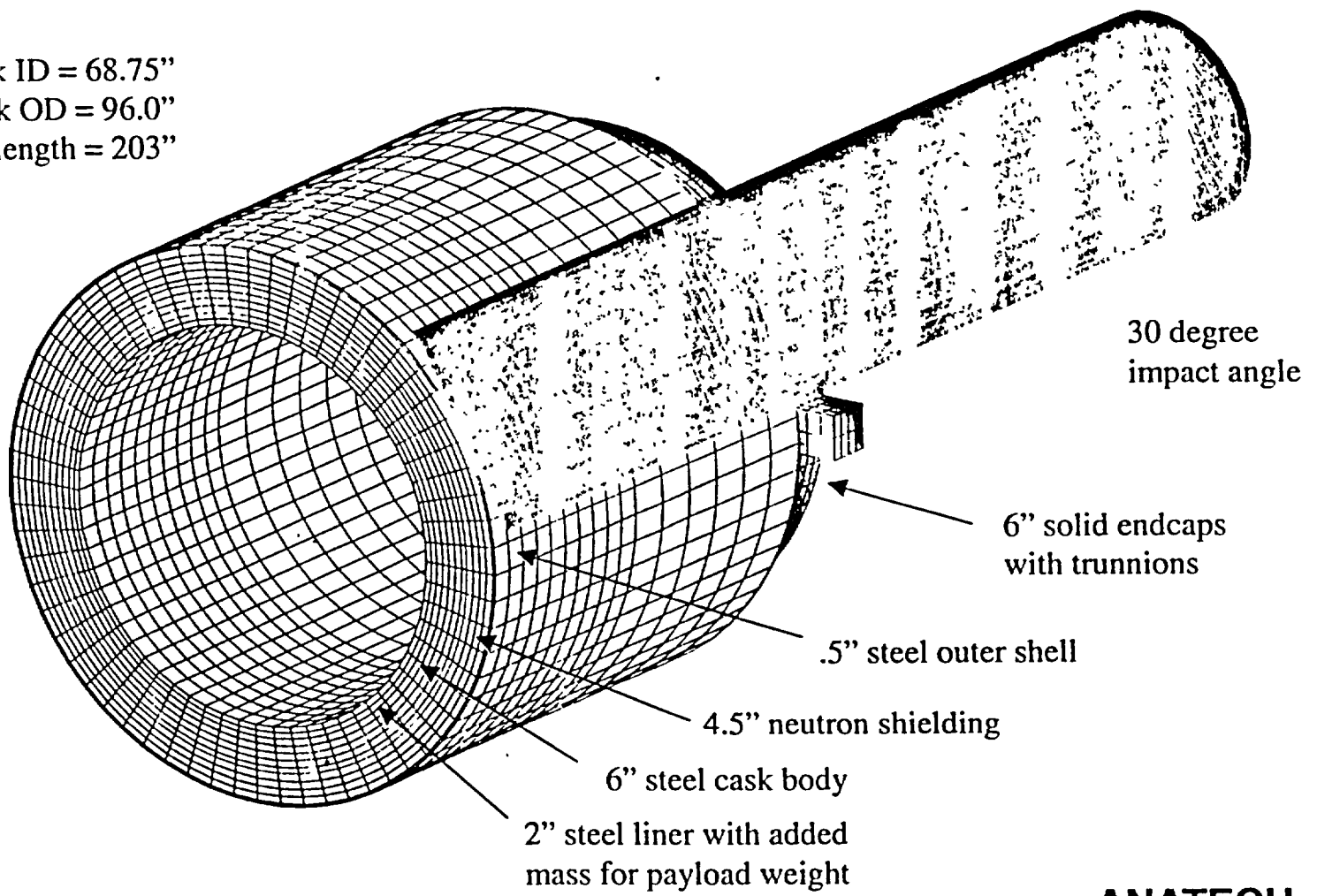
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# Cask Components

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

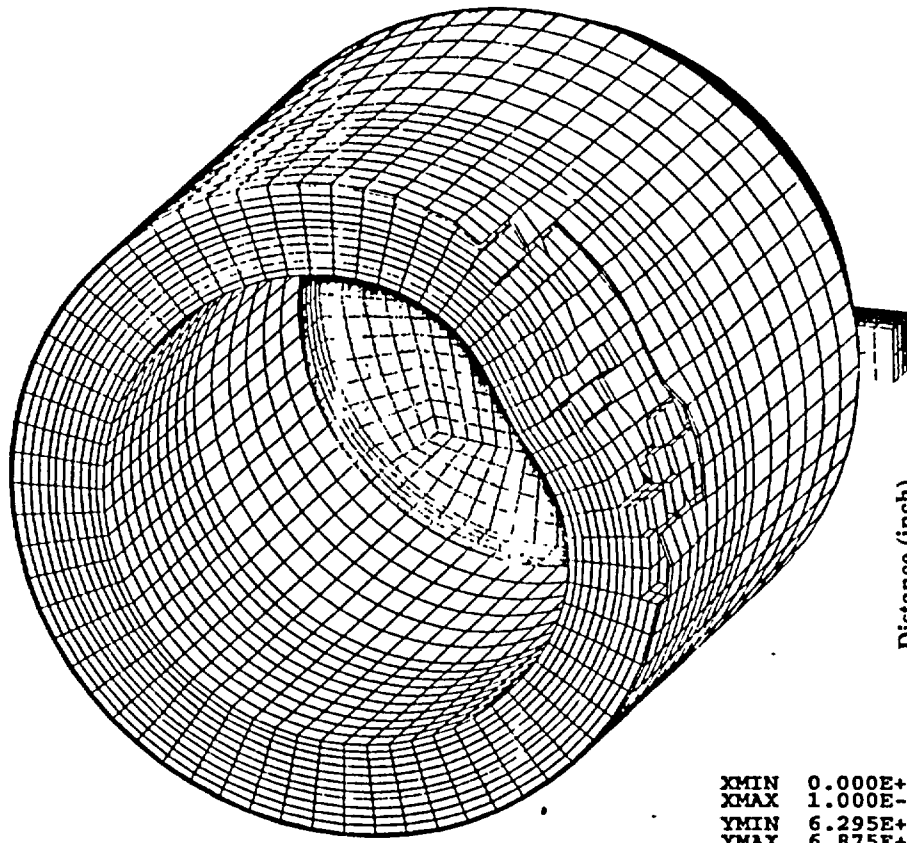


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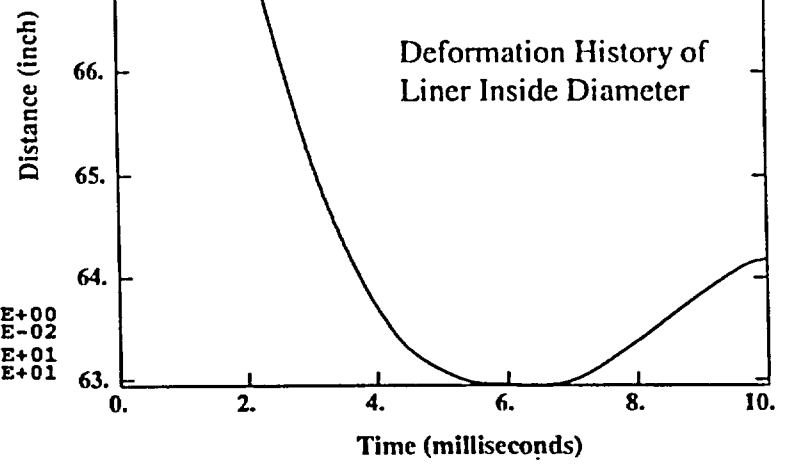
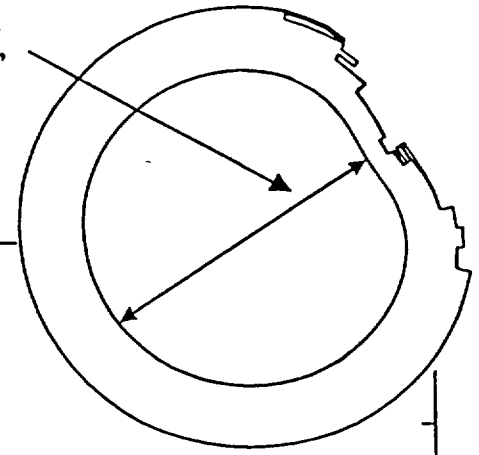
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# Case 1: Cask Damage



Maximum Relative Deformation = 5.8"



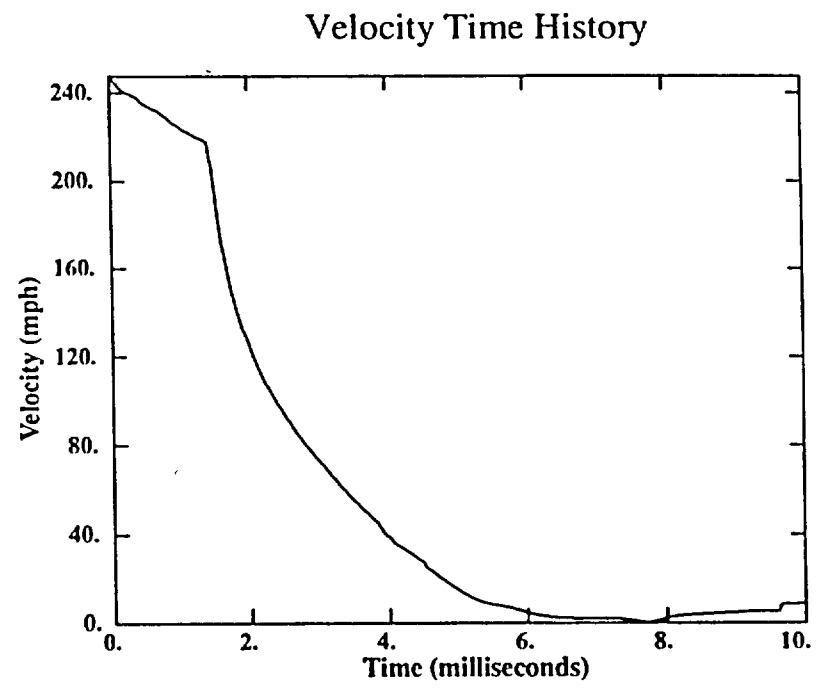
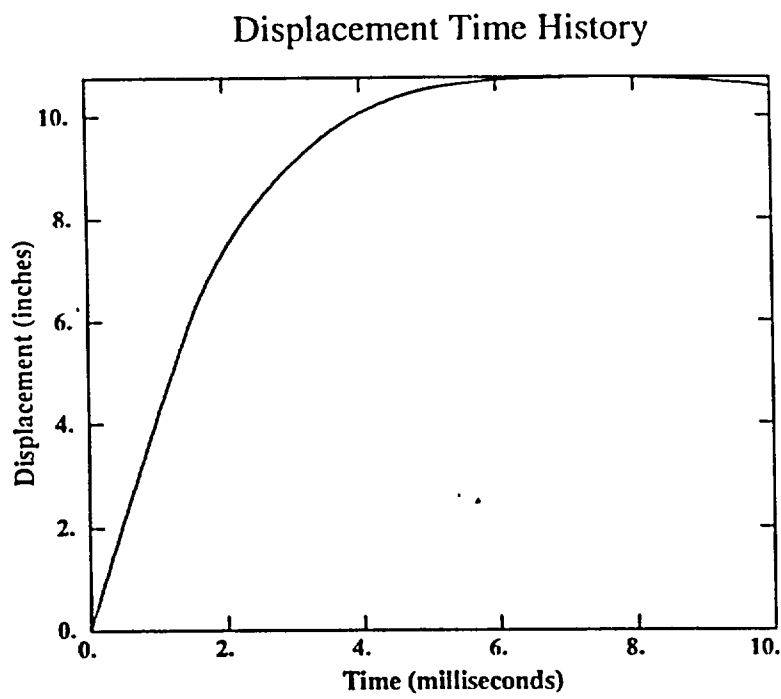
XMIN 0.000E+00  
XMAX 1.000E-02  
YMIN 6.295E+01  
YMAX 6.875E+01

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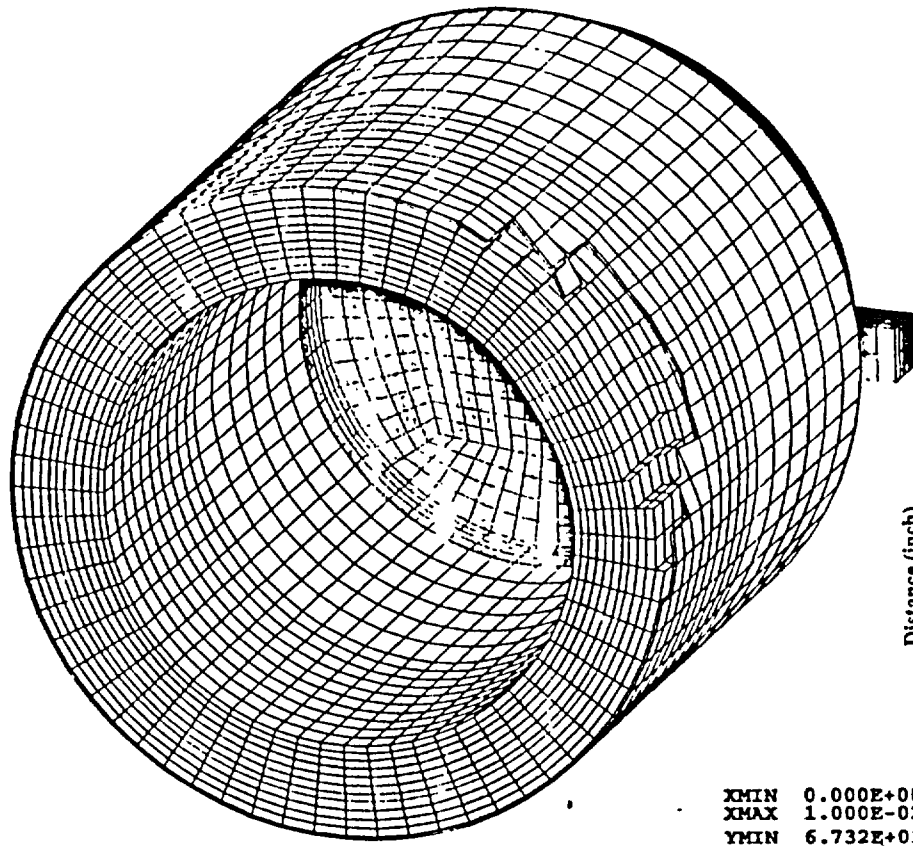
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# Case 1: Rigid Missile Response



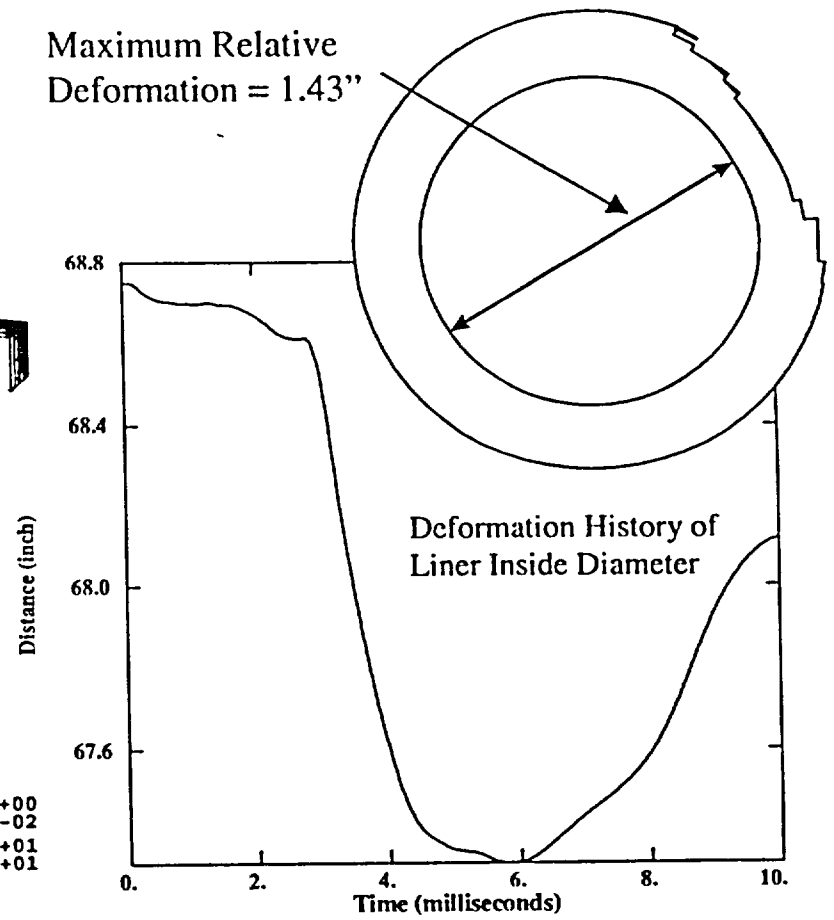


# Case 2: Cask Damage



XMIN 0.000E+00  
XMAX 1.000E-02  
YMIN 6.732E+01  
YMAX 6.875E+01

Maximum Relative Deformation = 1.43"

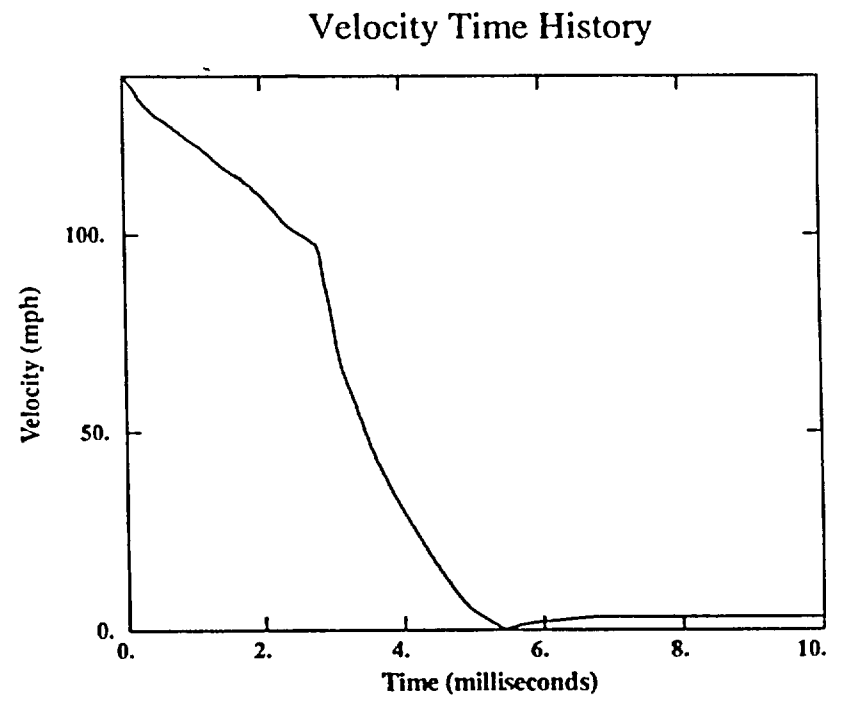
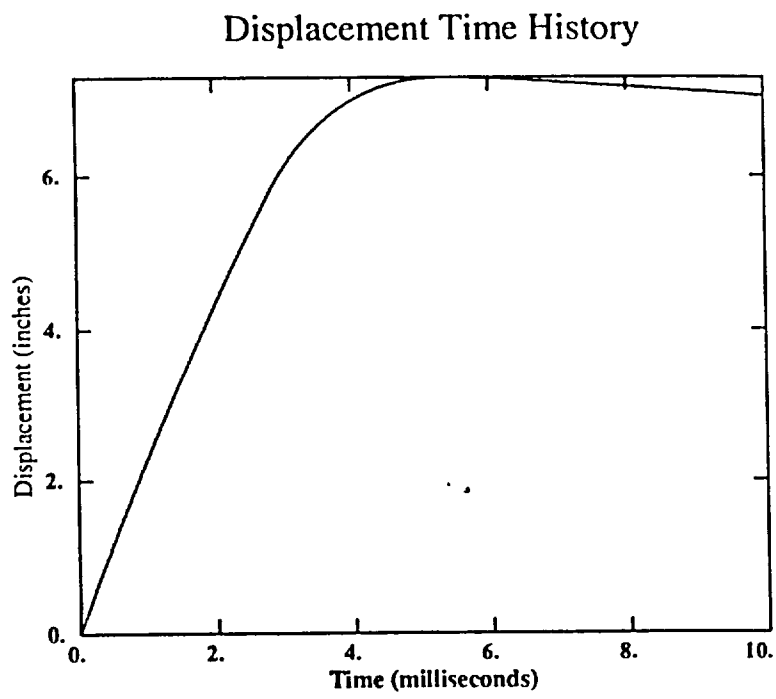


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## Case 2: Rigid Missile Response



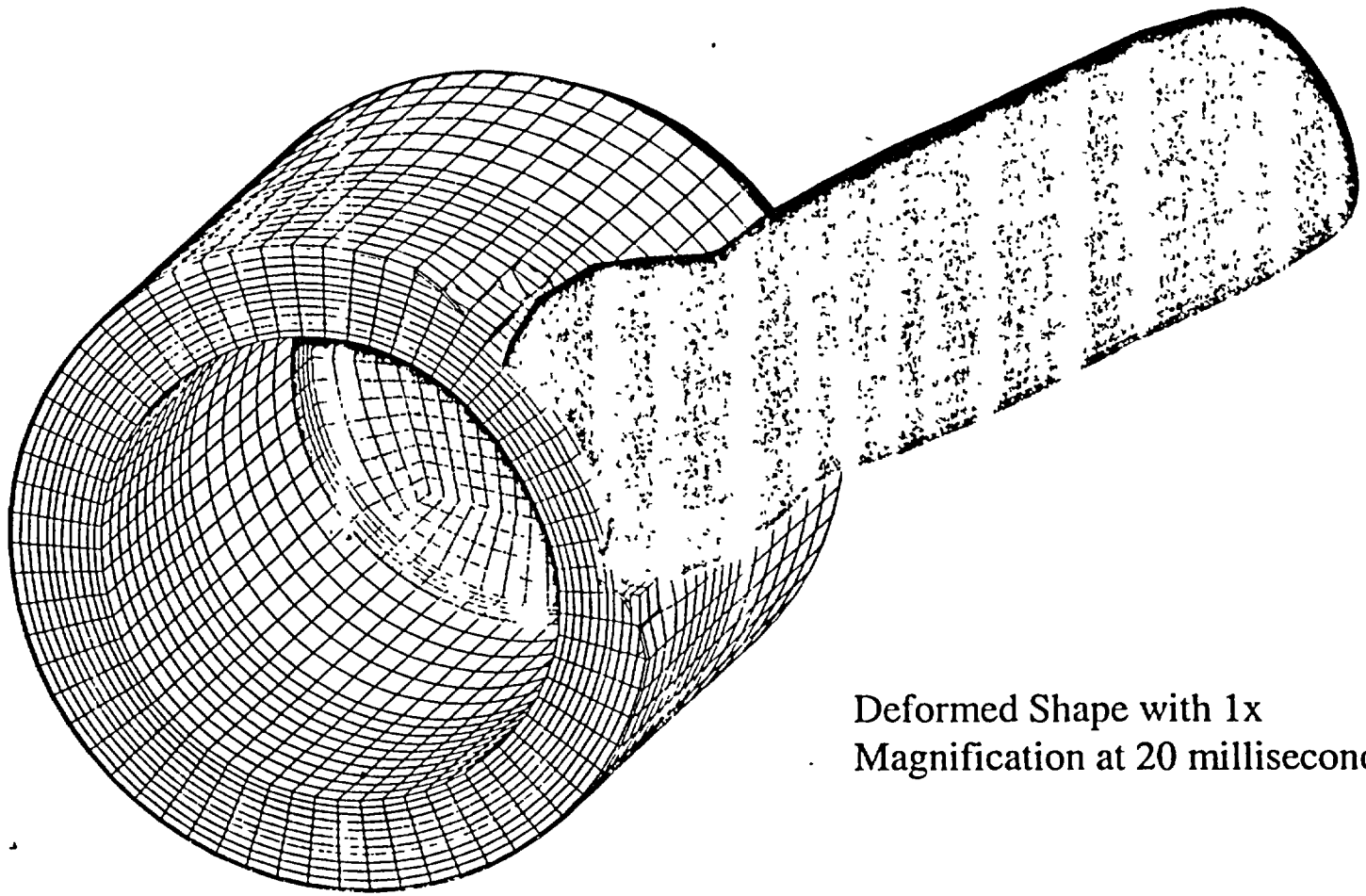
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## Case 3: Deformable Missile



Deformed Shape with 1x  
Magnification at 20 milliseconds

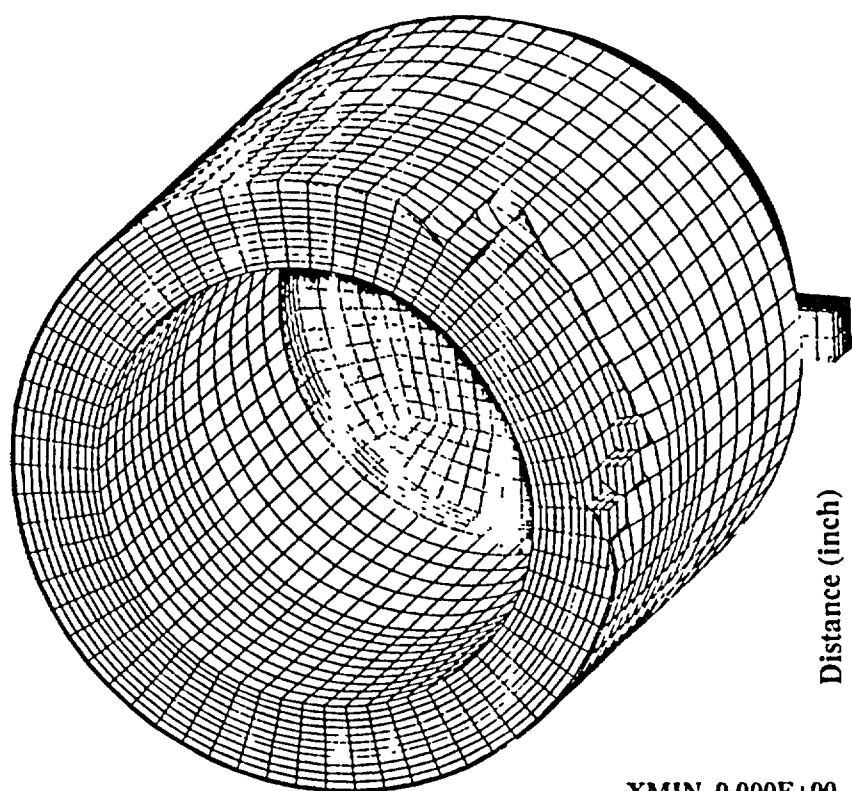
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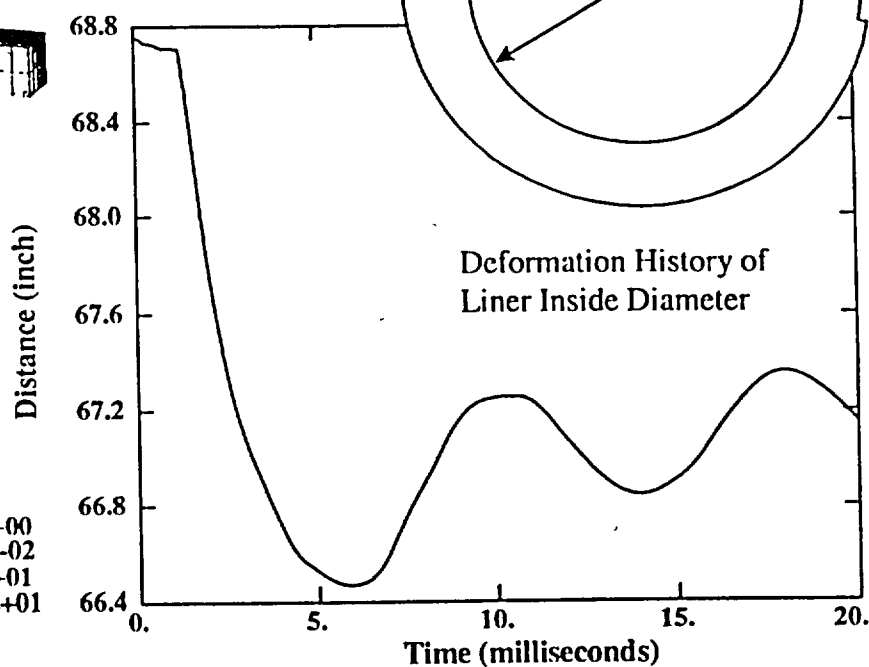
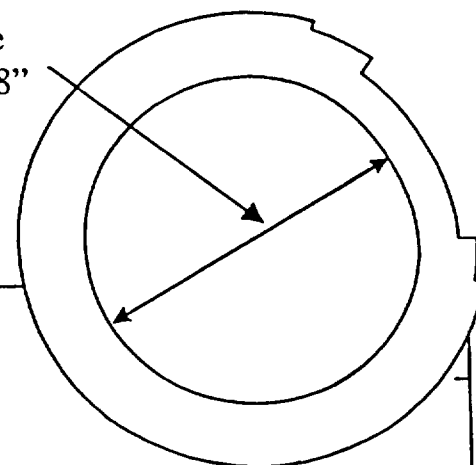
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# Case 3: Cask Damage

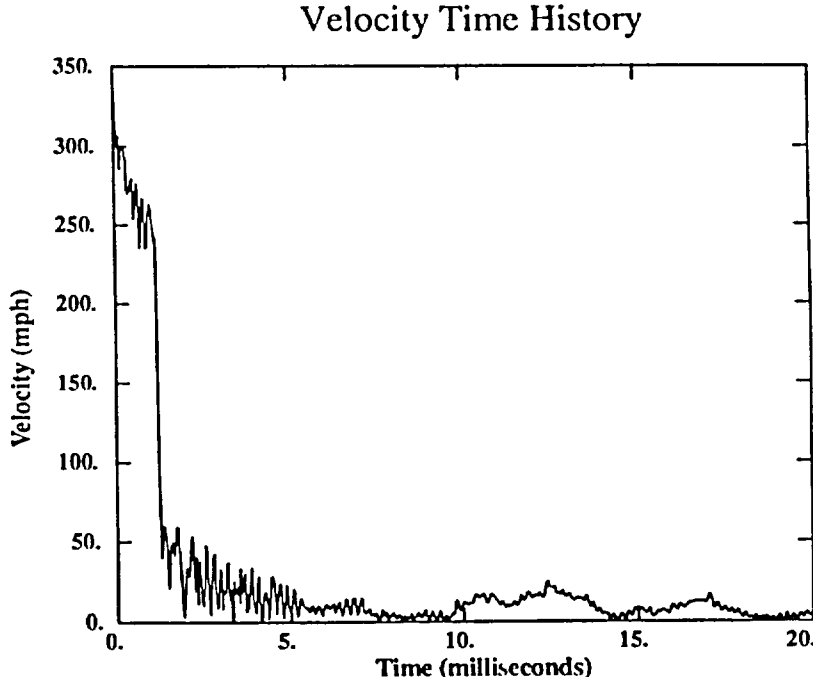
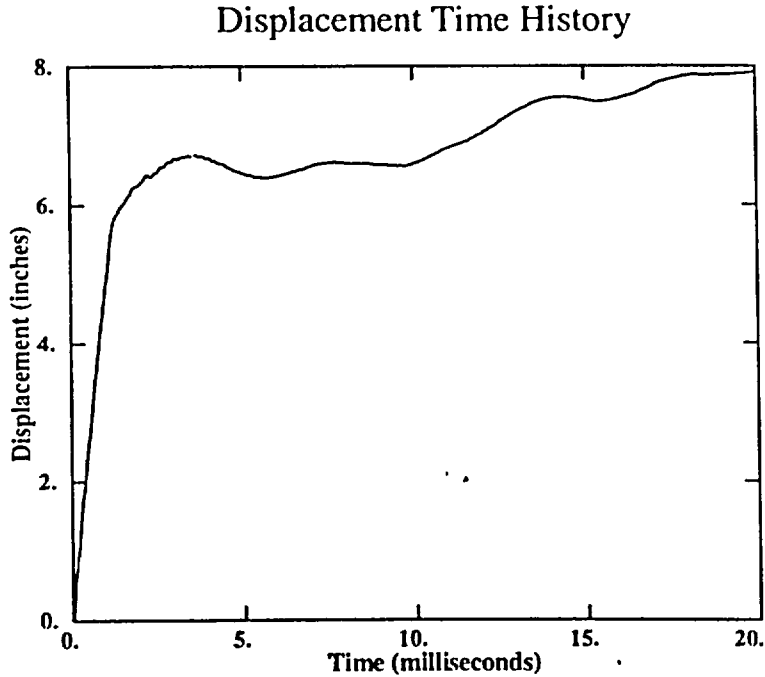


XMIN 0.000E+00  
XMAX 2.000E-02  
YMIN 6.647E+01  
YMAX 6.875E+01

Maximum Relative Deformation = 2.28"



# Case 3: Deformable Missile Response



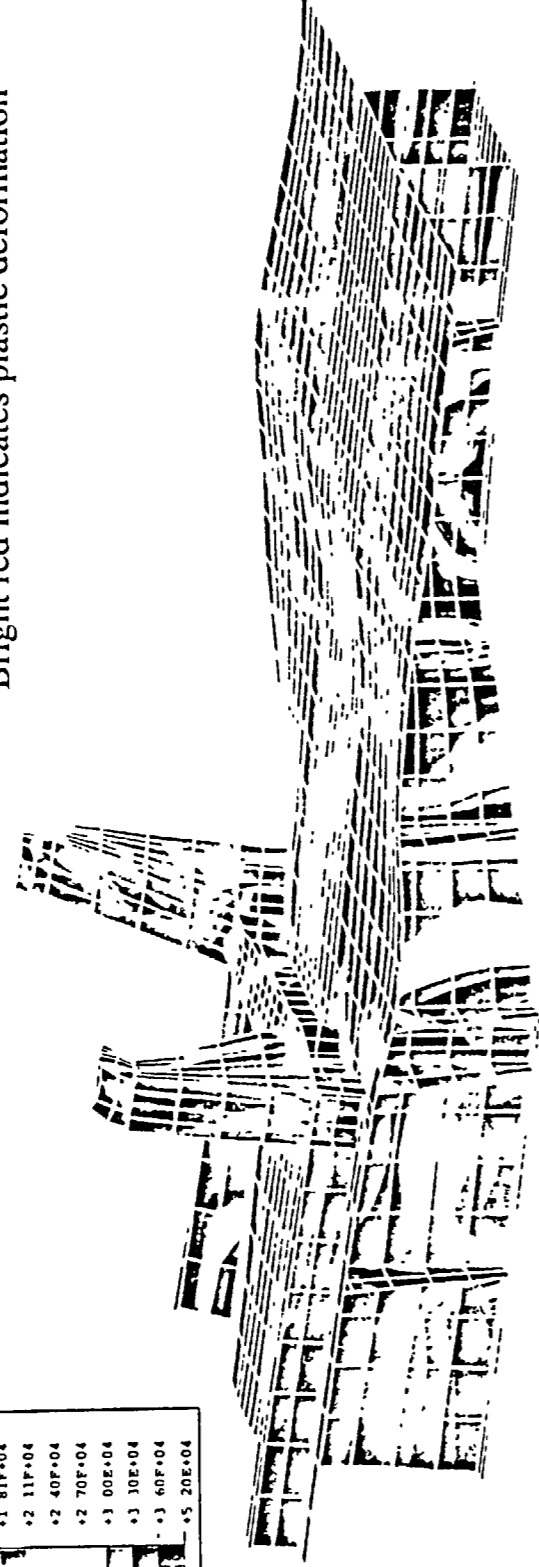
Centerline Point on Missile Impact Face

# Case 3: Railcar and Skid Response

*SECTION POINT 1	
MEFF	VALUE
+1	41F+02
+3	13F+03
+6	12E+03
+9	11F+03
+1	21E+04
+1	51E+04
+1	81F+04
+2	11F+04
+2	40F+04
+2	70F+04
+3	00E+04
+3	30E+04
+3	60F+04
+5	20E+04

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

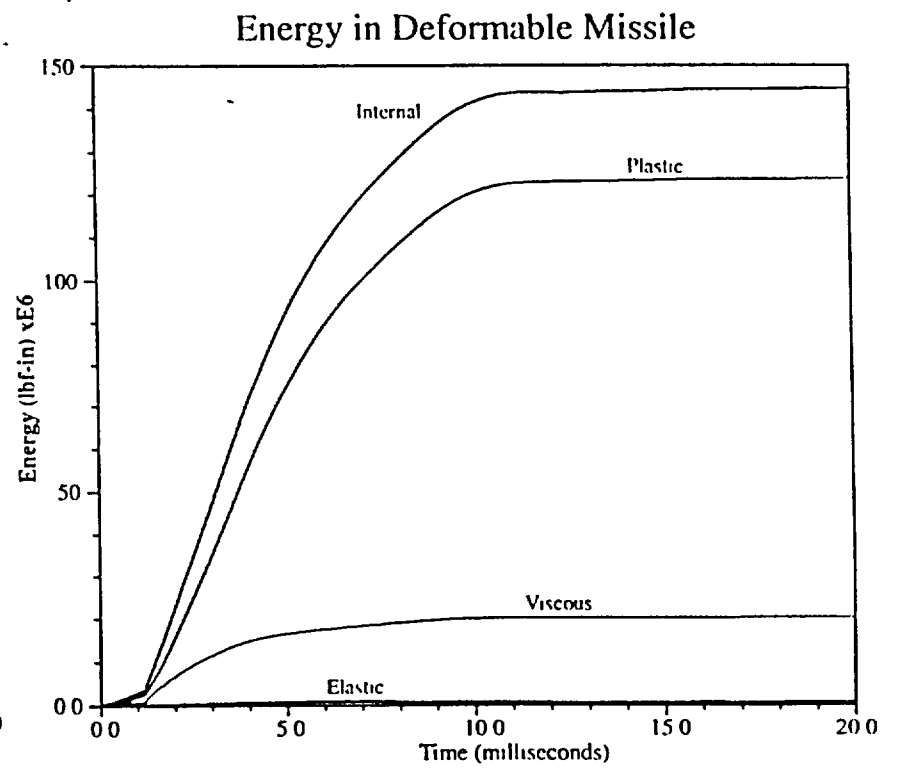
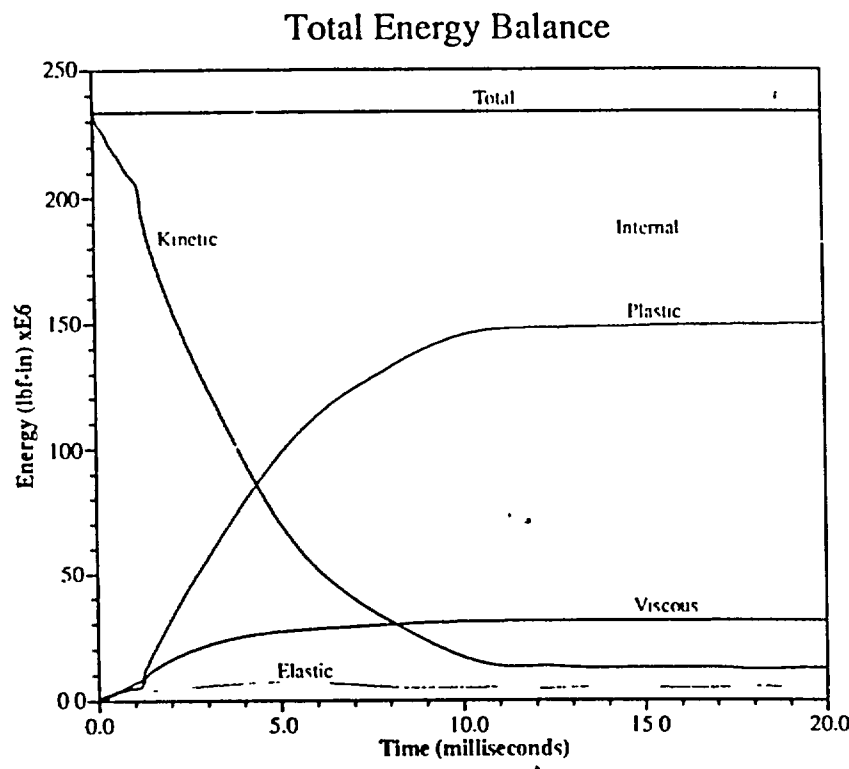
Bright red indicates plastic deformation



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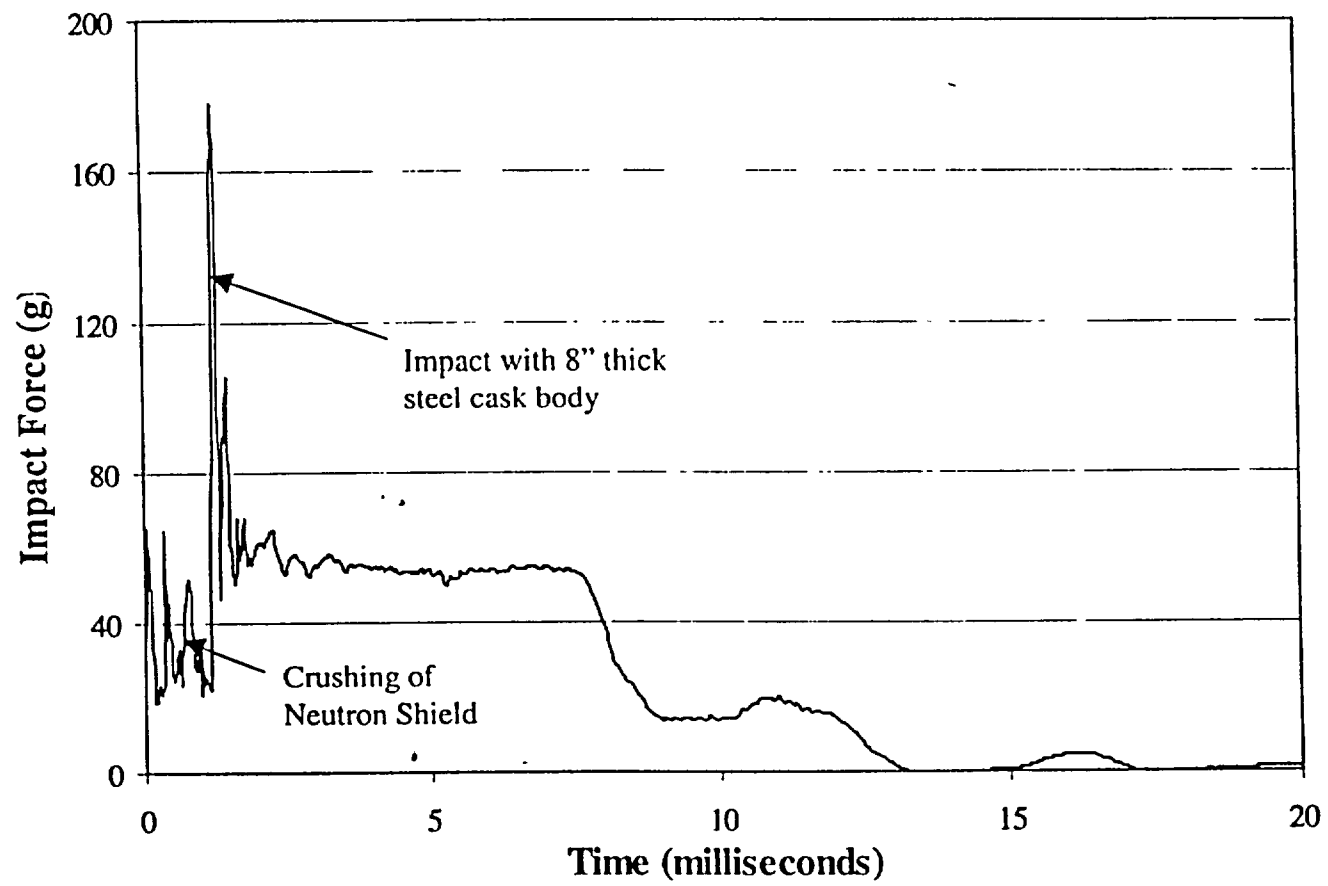
# Case 3: Energy Balance



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



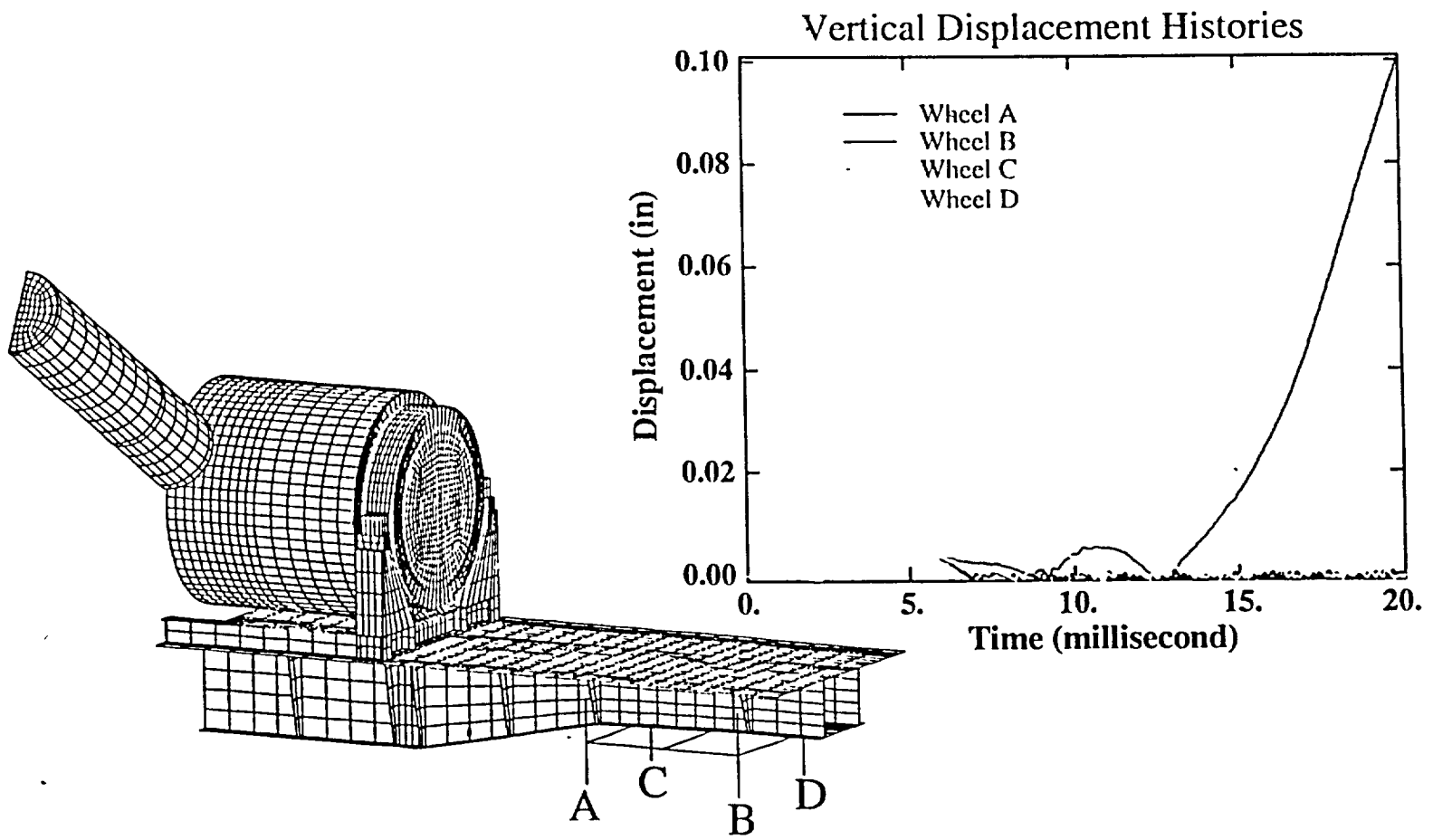
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# Case 3: Uplift on Railcar Wheels



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# 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