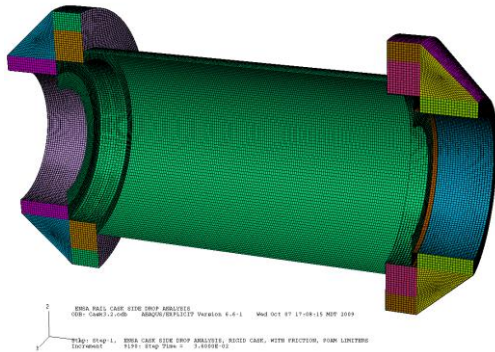


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# Nuclear Material Containers Design/Certification

INERI Euratom Visit

July 8, 2015

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Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

# Package Regulations

- Packages for the transportation of large quantities of radioactive material must be accident resistant.
- Hypothetical accident environments include:
  - 9-m free drop onto an essentially unyielding target in the orientation that provides the most damage, or (and in the U.S.)
  - Dynamic crush from a 500-kg steel plate dropped from 9 meters
  - 1-m free drop onto a 15-cm diameter mild steel puncture probe
  - 30-minute exposure to an engulfing pool fire
  - Immersion
    - Fissile material packages 0.9 meter after the above tests
    - All packages 15 meter on a separate package
    - Greater than 100,000 A<sub>2</sub> to a pressure of 2 MPa on a separate package

# Measures of Acceptance

- Following the hypothetical accident tests the package must be demonstrated to:
  - Have sufficient radiation shielding to limit the dose rate to 10 mSv/hr at a distance of 1 meter from the package surface
  - Contain the radioactive contents to prevent release of more than 1 A<sub>2</sub> in a week (this is usually done by demonstrating the package is leak tight)
  - Remain subcritical (for fissile material packages)

# Design Guidance

- Packages must be designed following established codes and standards.
- In the U.S., and much of the rest of the world, the ASME Boiler and Pressure Vessel Code is used.
- The Code limits the materials of construction, the fabrication processes, and the calculated levels of stress/strain.
- There is a big push to modernize the Code to make it more compatible with finite element analyses.

# Design Analyses

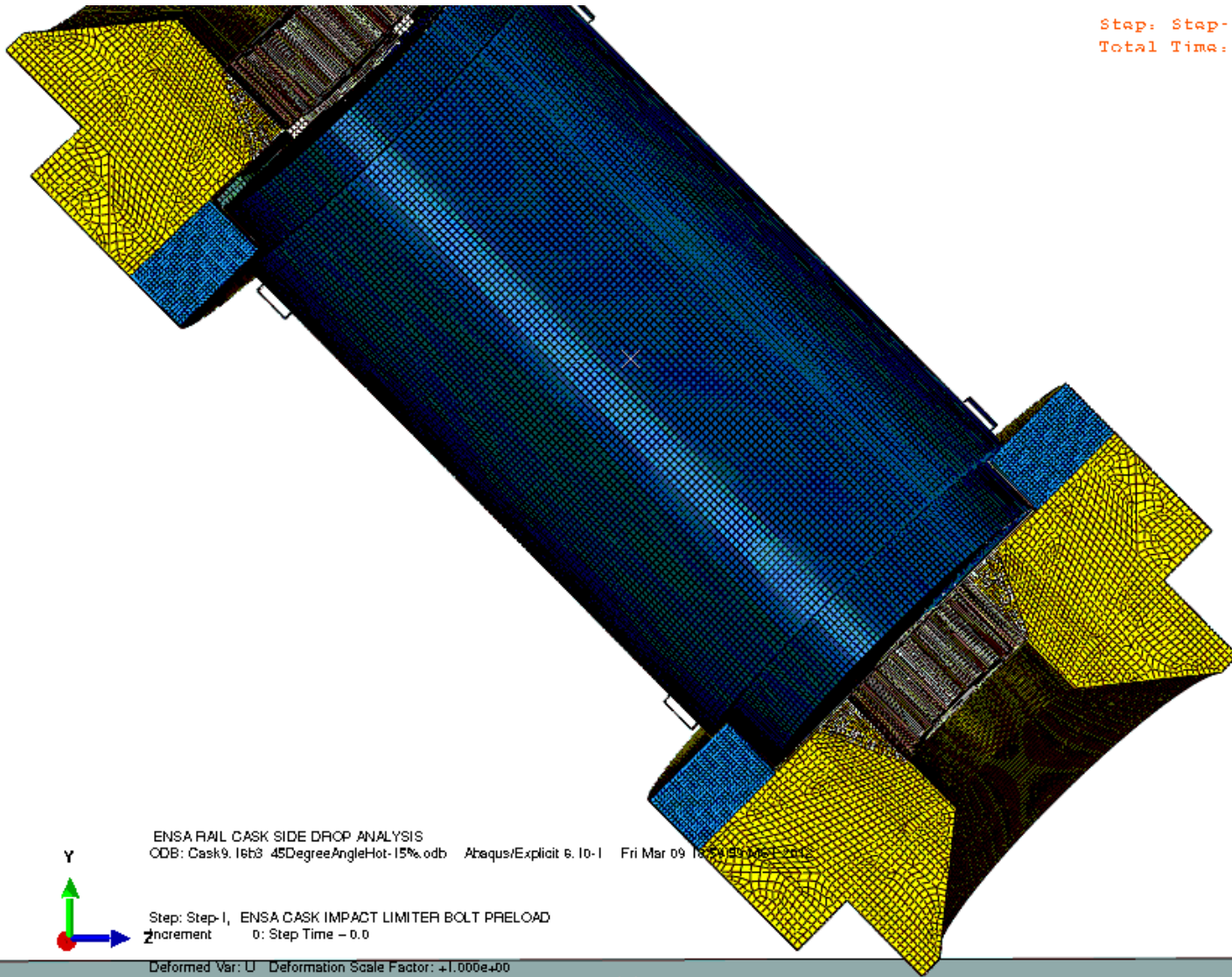
- Preliminary design analyses are used to size the various components of the package.
  - Containment vessel body and lid
  - Closure bolts
  - Shielding
  - Shells that contain the shielding
  - Energy absorber(s)
  - Attachment bolts
  - Etc.
- These analyses can be relatively unrefined, and may consist of hand calculations, comparisons to other design, finite element analyses, or a combination of these.

# Certification Analyses

- These analyses have to be conducted under a full QA plan.
- Even for packages that will be certified by tests, analyses are required to define the “worst case” for testing.
- The analyses may be coupled or uncoupled.
- Cumulative damage from the entire hypothetical accident sequence needs to be considered.
- Outputs:
  - Stresses/strains
  - Amount of crush
  - Loss of shielding
  - Accelerations
  - Temperatures

# Sample Finite Element Analysis

Step: Step-1 Frame: 0  
Total Time: 0.000000

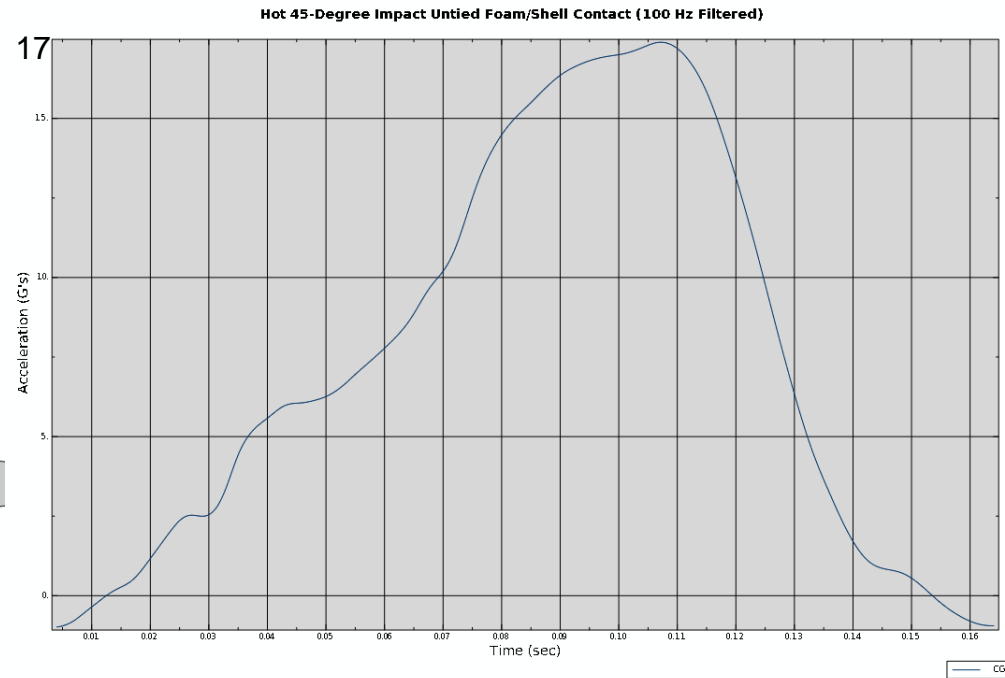
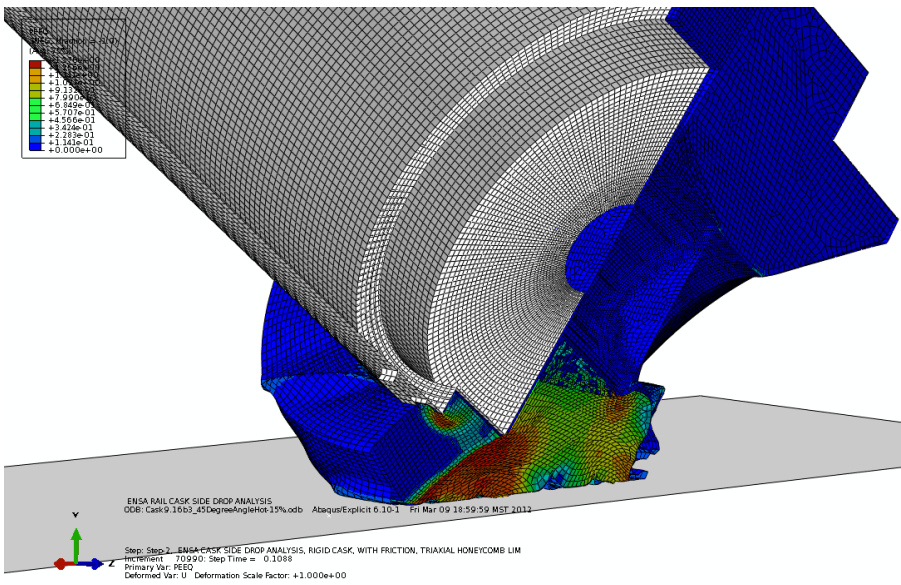


ENSA RAIL CASK SIDE DROP ANALYSIS  
ODB: Cask9.16b3\_45DegreeAngleHot-15%.odb Abaqus/Explicit 6.10-1 Fri Mar 09 18:24:59 MDT 2012

Step: Step-1, ENSA CASK IMPACT LIMITER BOLT PRELOAD  
Increment: 0; Step Time = 0.0

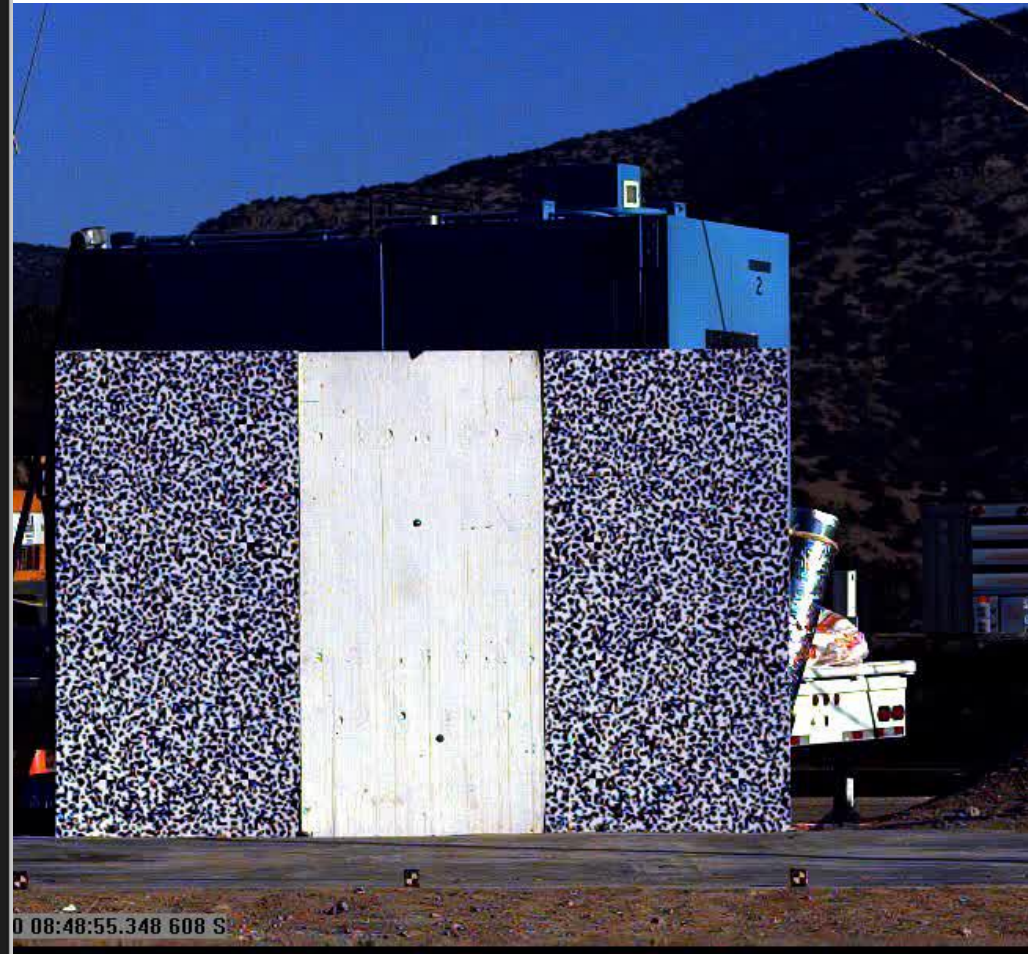
Deformed Var: U Deformation Scale Factor: 1.000e+00

# Analysis Results



# Certification Testing – 9-meter drop

ENSA Slapdown Drop  
Test 4 - 9 m Cold  
South East  
11.12.2010



# Certification Testing – Punch Test

ENSA Side Puncture Drop  
Test 7 - 1m  
South East  
11.19.2010



# Certification Testing - Thermal



# Certification Testing - Immersion



# Conclusion

- The rigorous requirements placed on radioactive material transportation packages provide for a high level of assurance that there will be no release even if a package is involved in an accident.
- There has never been a release from a properly loaded Type B package anywhere in the world.
- The U.S. Nuclear Regulatory Commission recently published a Spent Fuel Transportation Risk Assessment (NUREG-2125) that reaffirms that current regulations are adequate to protect the public and the environment.