

**Materials Transportation  
Testing & Analysis Program  
at  
Sandia National Laboratories**

**[www.sandia.gov/tp/tp.htm](http://www.sandia.gov/tp/tp.htm)**



Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,  
for the United States Department of Energy's National Nuclear Security Administration  
under contract DE-AC04-94AL85000.



# Who We Are

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- **Sandia's Materials Transportation Testing & Analysis' people** develop innovative solutions to solve transportation and packaging problems for DOE and other federal agencies.
- These solutions cover a broad spectrum of activities ranging from new package design to package testing and from regulatory standard development to transportation risk/safety assessments.
- Our goal is to provide the technology to achieve safe, efficient, and economical packaging and transportation of nuclear and other hazardous materials.

[www.sandia.gov/tp/tp.htm](http://www.sandia.gov/tp/tp.htm)

# What We Do

- Strong talents in two complementary transportation program areas are **Risk Assessment & Packaging** give Sandia unique synergistic capabilities.



# Our Customers

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- **DOE NTP - National Transportation Program**
- **DOE EM - Environmental Management**
- **DOE/AL- Albuquerque Operations Office**
- **DP - Defense Programs**
- **SNL and other laboratories**
- **Work For Others**
  - **ARMY, EONC**
  - **BECHTEL BETTIS**
  - **BNFL - British Nuclear Fuels Limited**
  - **DOT/MARAD - Maritime Administration, DOT**
  - **JNC - Japan Nuclear Cycle Development Institute**
  - **NRC - Nuclear Regulatory Commission**

# Packaging

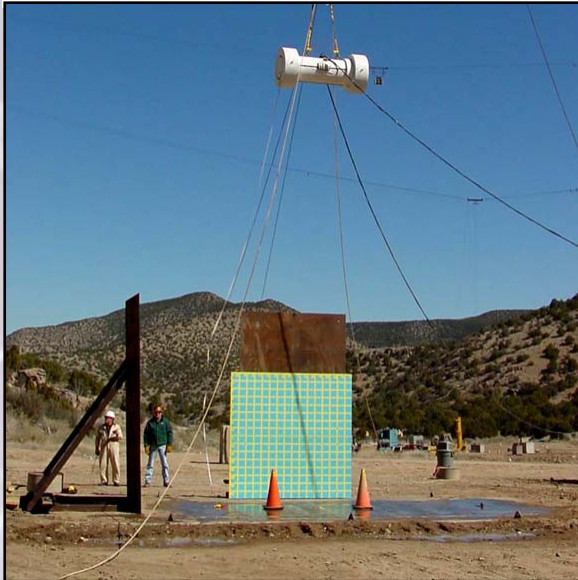
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- **Capabilities include computer modeling and analysis, coupled with physical testing.**
  - **Full-scale testing**
  - **Scale-model testing**
  - **Structural computer analysis**
  - **Thermal computer analysis**
  - **Packaging systems concepts**
  - **Package development**



# Full-Scale Testing

## Free Drop Test



Free dropping a package from 30-feet onto an unyielding target.

The speed on impact is 44-feet per second or 30 miles per hour.

## Puncture Test



Dropping a package from 40-inches onto a 6-inch diameter, welded steel spike that is bolted to the unyielding target.

The speed on impact is 14.6-feet per second or 10 miles per hour.

## Thermal Test



Placing a package 40-inches above a fully engulfing pool of burning fuel for 30-minutes at 800 degrees Celsius or 1475 degrees Fahrenheit..

# Scale-Model Testing



**1/4 scale-model  
free drop test**



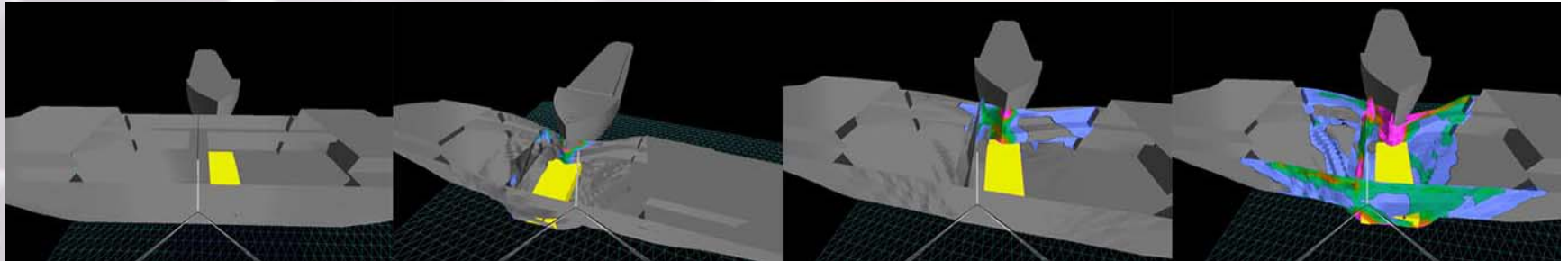
**1/8 scale-model  
highway/railroad  
impact**



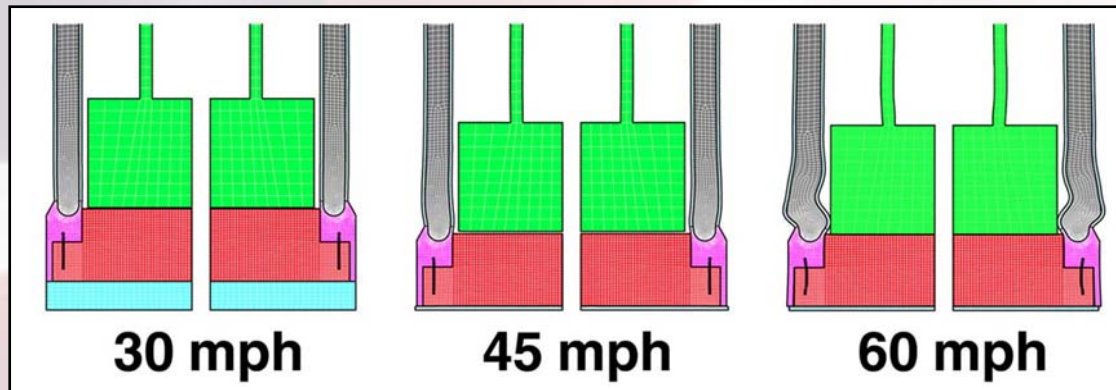
**1/3 scale-model  
puncture test**



# Structural Computer Analysis



Computer analysis was used to determine a ship & package structural response to a ship-to-ship collision. The package (in yellow) gets pushed through the ship hull and drops into the sea. There would be no release of material from the package.

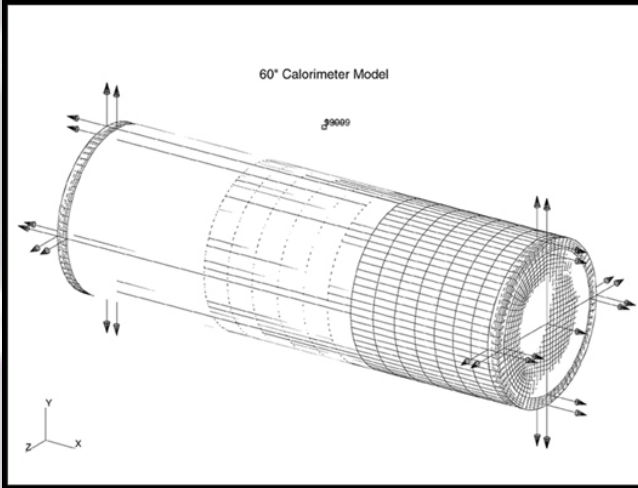


Computer analysis was used to determine a high-speed impact simulation response of a generic spent fuel package in a series of accidents.

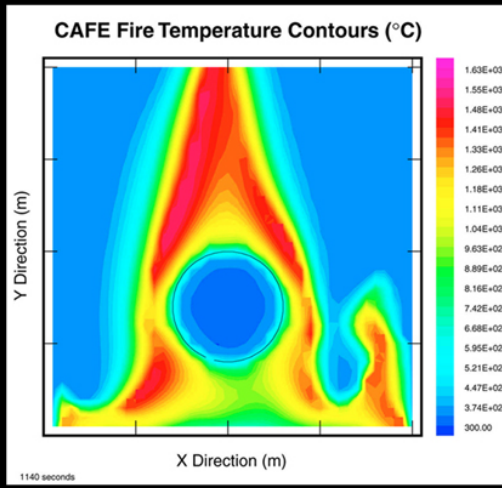


# Thermal Computer Analysis

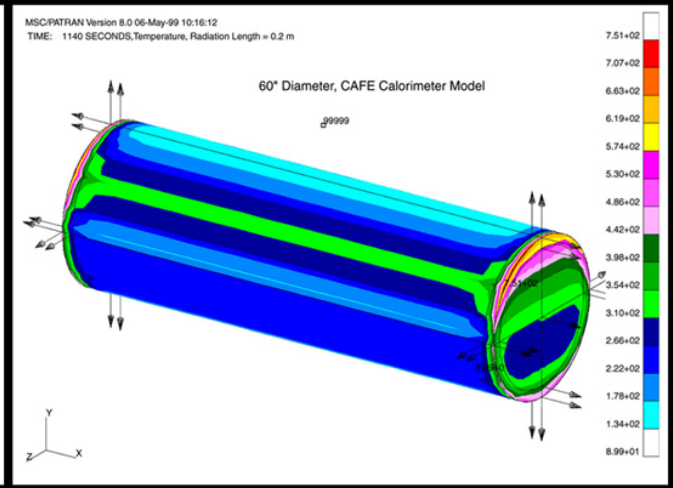
## Model mesh



## Fire model



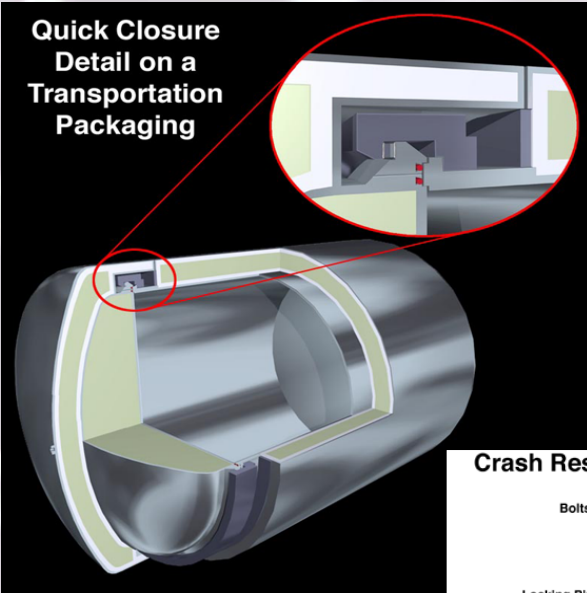
## Results



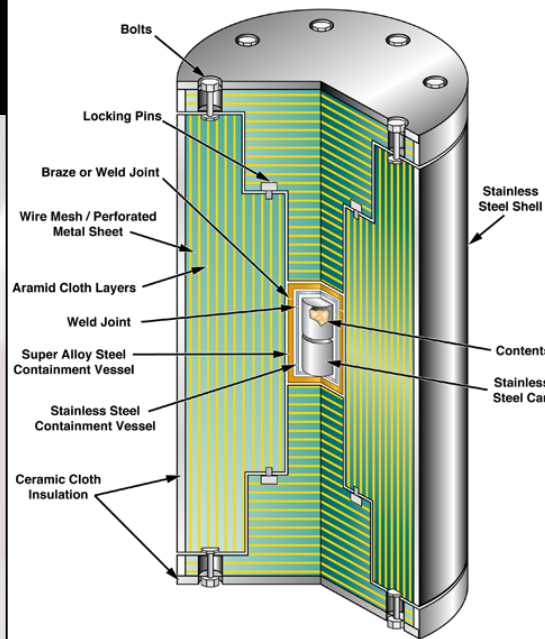
Thermal analysis is used to determine realistic fire boundary conditions, heat transfer, and thermodynamics for package design analysis and risk studies.

# Packaging Systems Concepts

Quick Closure  
Detail on a  
Transportation  
Packaging

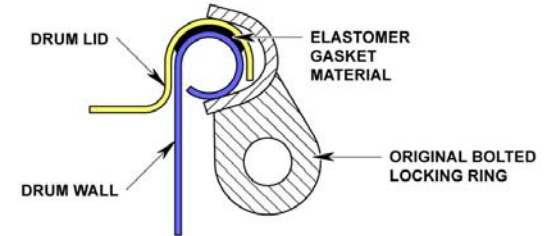


Crash Resistant Container with Wire Mesh



## DOT 17-C DRUM CONTAINMENT WITH NEW **CRIMPED CLOSURE LID**

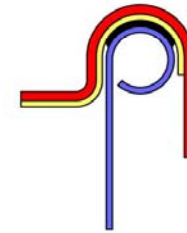
DOT 17-C DRUM CONTAINMENT WITH ORIGINAL BOLTED LOCKING RING



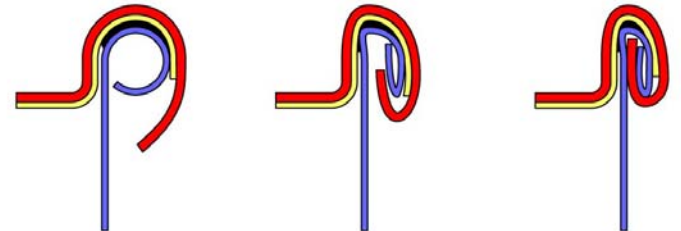
STEP 1. REMOVE ORIGINAL  
BOLTED LOCKING RING



STEP 2. EMPLACE NEW  
**CRIMPED CLOSURE LID**



STEP 3. PERFORM CRIMPING PROCESS WITH NEW **CRIMPED CLOSURE LID**



# Package Development



**BUSS**



**ONC**



**PAT**



# Risk Assessment

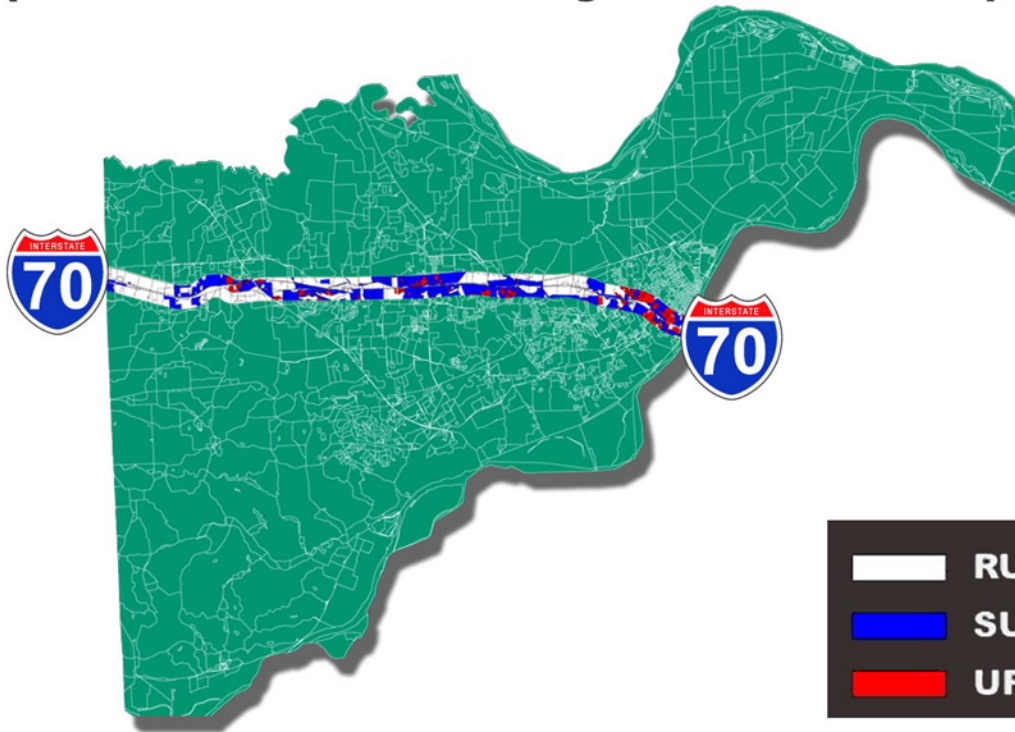
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- **Our capability includes conducting risk assessments of transportation of RAM, risk assessment tools, data development, and applications of the tools and data.**
  - **The Risk Assessment program has supported essentially every transportation environmental impact assessment (EA) and transportation environmental impact statement (EIS) that has been published to date.**
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- **Geographical Information Systems (GIS)**
  - **RADTRAN**
  - **RADCAT**
  - **Transportation Risk Analysis**

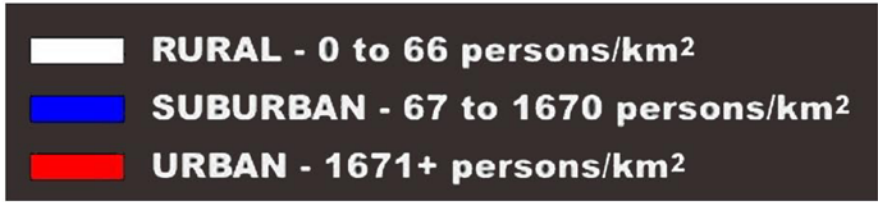


# Geographical Information System (GIS)

## GIS Interstate Route example (St. Charles county in Missouri)



SEGMENT ID	NUMBER OF CENSUS BLOCKS IN SEGMENT	AVERAGE OF BLOCK POPULATION DENSITIES	DENSITY ZONE	CUMULATIVE LINK DISTANCE, KM	LINK AVERAGE POPULATION DENSITY	LINK ID
45	32	3203.3095	U	1.00000		
46	41	2640.8648	U	2.00000		
47	43	1972.2617	U	3.00000	3304.48000	18.00000
48	32	1440.8259	S	1.00000	1440.83000	19.00000
49	69	2182.0791	U	1.00000		
50	40	10221.6649	U	2.00000	6391.87000	20.00000
51	12	483.0361	S	1.00000		
52	32	441.2216	S	2.00000		
53	24	132.7660	S	3.00000	335.67000	21.00000
54	12	39.8747	R	1.00000	39.87000	22.00000
55	11	159.2876	S	1.00000		
56	19	211.7388	S	2.00000		
57	27	604.9139	S	3.00000	325.31000	23.00000
58	49	1894.8421	U	3.00000	1894.84000	24.00000
59	27	927.3278	S	1.00000		
60	23	1307.9285	S	2.00000		
61	12	241.4772	S	3.00000		
62	24	737.8183	S	4.00000		
63	30	1118.3266	S	5.00000		
64	34	973.7500	S	6.00000	884.44000	25.00000
65	28	2188.8605	U	1.00000		
66	15	1857.2638	U	2.00000		
67	13	894.9536	U	3.00000	2695.83000	26.00000
68	25	326.4391	S	1.00000	392.46000	27.00000
69	28	1804.4390	U	1.00000	1804.64000	28.00000
70	27	608.2469	S	1.00000		
71	38	1480.841	S	2.00000		
72	35	828.8787	S	3.00000		
73	32	472.4517	S	4.00000		
74	24	378.2261	S	5.00000		
75	26	707.8907	S	6.00000		
76	43	967.7970	S	7.00000		
77	69	900.6646	S	8.00000		
78	20	833.8605	S	9.00000		
79	10	137.6010	S	10.00000		
80	39	153.8078	S	11.00000		
81	142	142.6053	S	12.00000		
82	22	140.6191	S	13.00000	593.32000	29.00000
83	3	16.9649	R	1.00000		
84	7	8.9563	R	2.00000		
85	53	53.8456	R	3.00000	26.58000	30.00000
86	18	208.2961	S	1.00000		
87	15	98.2569	S	2.00000	153.28000	31.00000



- GIS is used to create graphical & numerical data to represent rural, suburban, and urban population densities within census blocks along any truck/rail routes for risk assessments.

# RADTRAN

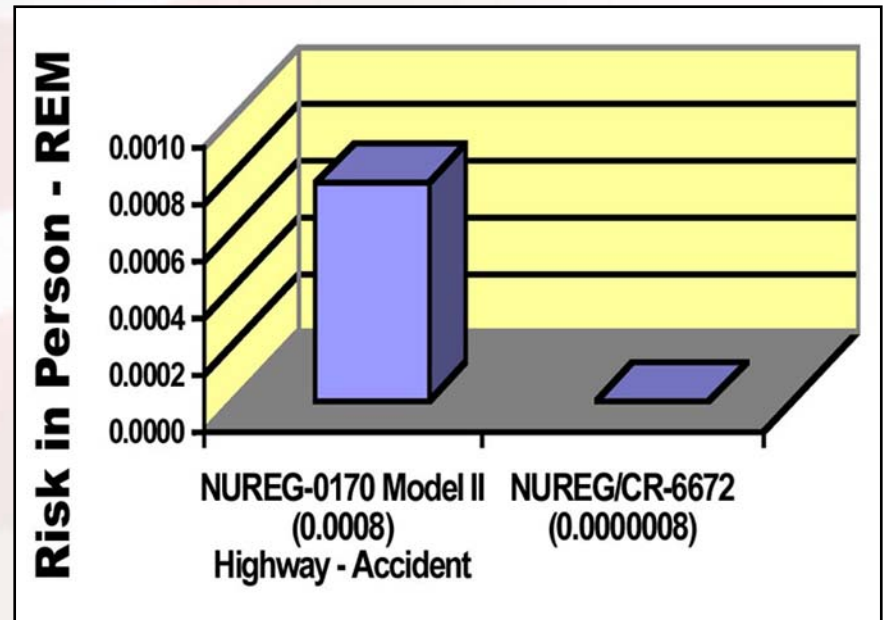
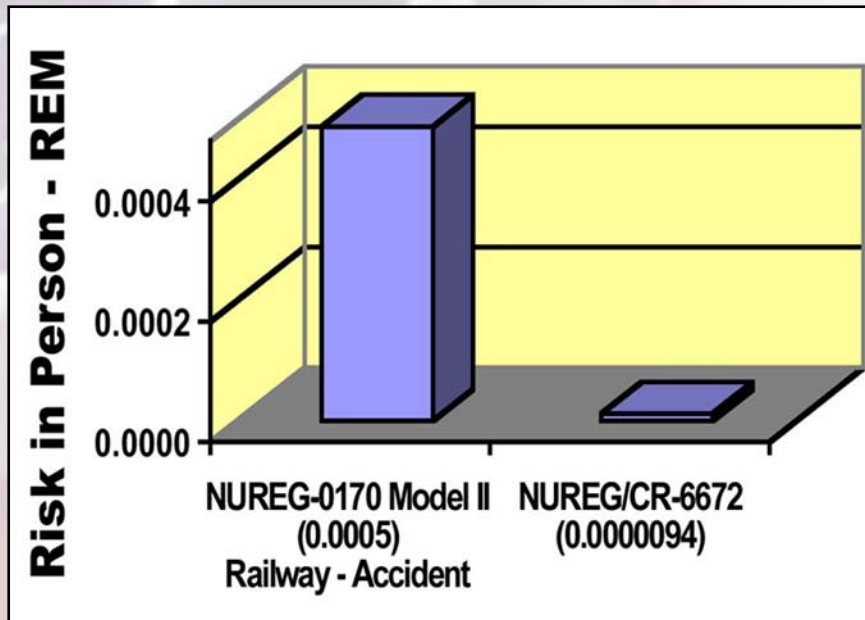
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- **RADTRAN is the world-standard for risk assessment of radioactive material transportation computer code.**
- **It combines user-determined meteorological, demographic, transportation, packaging, and material data with health physics data to calculate the expected radiological consequences and accident risk of transporting radioactive material.**

[www.sandia.gov/tp/risk/radtran.htm](http://www.sandia.gov/tp/risk/radtran.htm)

# Transportation Risk Assessment

- Support for the **FRR** return shipments
- Support for the **Yucca Mountain EIS**.
- Sandia computed **dose risks** for the NRC from impact and thermal accident conditions.
- Calculated risks are orders of magnitude smaller than those computed in **NUREG-0170**



# Facilities Overview

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- **One of the differentiating capabilities of the Transportation Risk & Packaging Program is its ability to provide in-depth **analytical and experimental analysis** to scenarios that could affect the integrity of transportation packages for nuclear and hazardous materials.**
- **Because nuclear weapons remain at the center of the Sandia National Laboratories mission, extensive and unique test facilities are available for regulatory and engineering testing for all perceived accident conditions.**



# Facilities

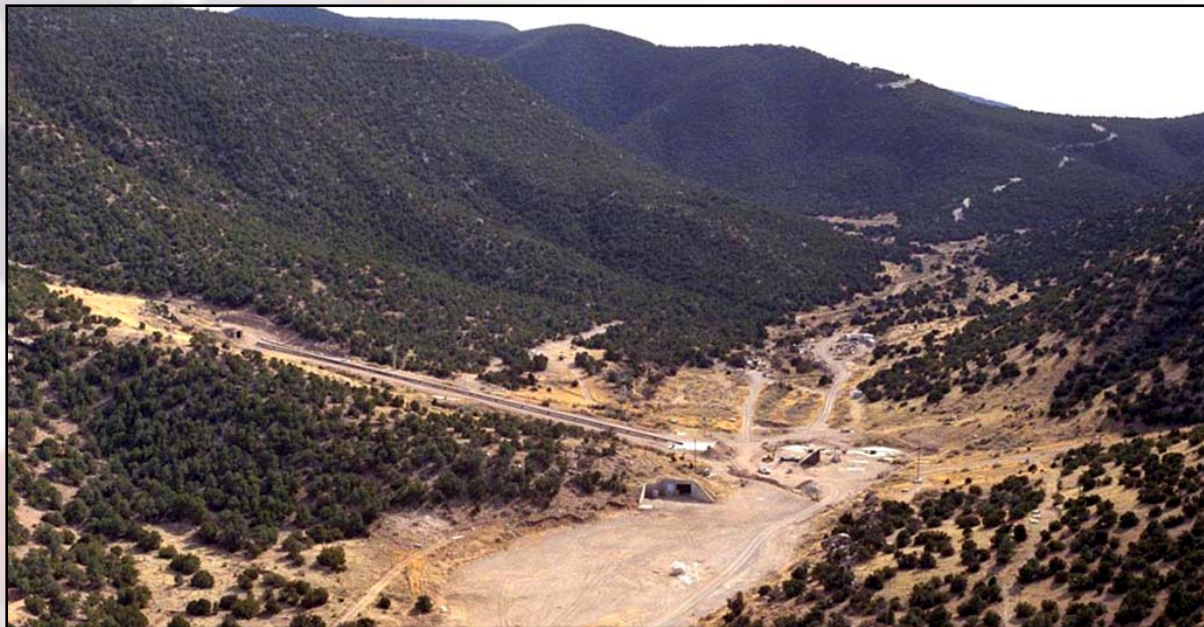
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- **Aerial Cable Facility**
- **1000-ton Armored Unyielding Target**
- **Drop Tower Facility**
- **Burn Test Facility**
- **Radiant Heat Facility**
- **Rocket sled track facility**
- **Mobile Laser Tracker**
- **Photometrics and Ultra-High-Speed Video**
- **Mobile Instrumentation Data Acquisition System (MIDAS)**
- **Seals Laboratory**
- **Visualization Laboratory**

# Aerial Cable Facility

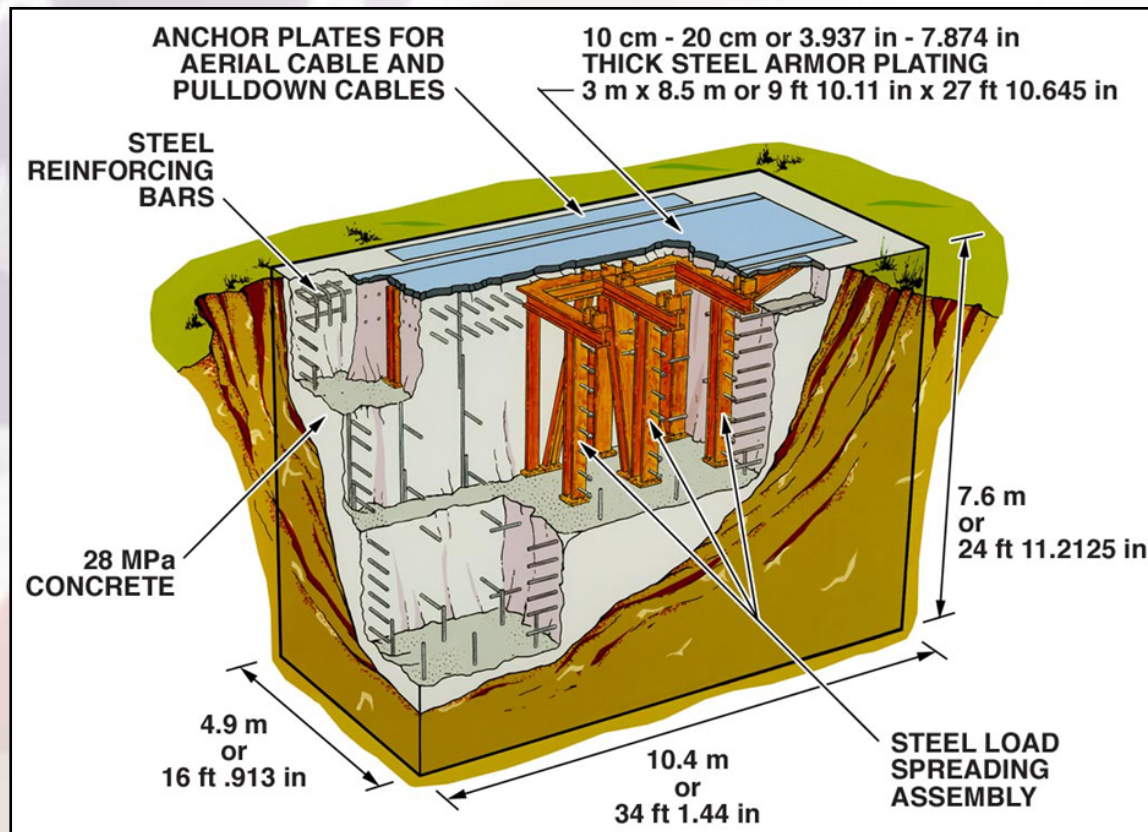
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- The aerial cable facility has **four cable systems that extend 5000-feet between two ridges.**
- The cable can lift, hold, and drop objects weighing **80,000-pounds from 100-feet in the air and smaller objects from 700-feet.**
- Various free drop, guided drop, puncture, and pull-down tests are conducted here.



# 1000-ton Armored Target at the Aerial Cable Facility

- 1000-tons of armored steel and reinforced concrete used to drop, puncture, and pull-down test objects onto.
- The unyielding target will not absorb any energy in an impact which forces all of the deformation to be in the test object, none in the target.





# Drop Tower Facility

- **The drop tower is 185-feet tall with a four inch thick steel plate target on a reinforced concrete block**
- **This photo shows dropping a 1100 pound steel plate from 30-feet onto a 55-gallon drum.**
- **The speed on impact is 44-feet per second or 30 miles per hour.**





# Burn Test Facility

- The burn facility consists of **three sizes of open pools**; 9-meter by 18-meter open pool, an enclosed pool, a small wind-shielded enclosure, and a bunker-like structure.
- This photo shows a package in a 7-meters in diameter pool, 1-meter above burning fuel for 30 minutes at 800 degrees Celsius or 1475 degrees Fahrenheit.



# Radiant Heat Facility

- The radiant heat facility provides a controlled environment to test the performance of components and assemblies under various temperatures.
- These temperatures can be up to **2200 degrees centigrade** and determine failure levels, demonstrate system integrity, and to develop and validate thermal numerical models.





# Rocket Sled Track Facility

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- The rocket sled track provides high-velocity impact, aerodynamic, acceleration testing of small and large test objects.
- This facility has a **10,000-foot track** for very high-speed tests and a **2000-foot railroad track** for very large object tests.





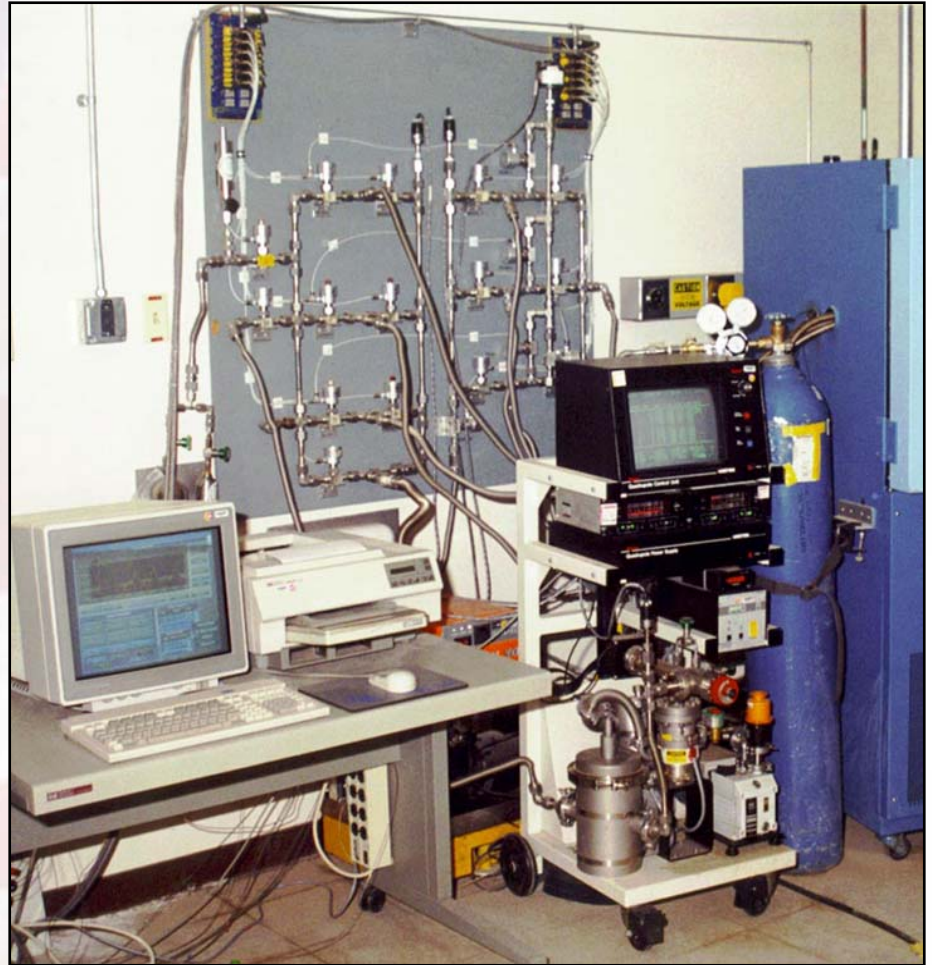
# Mobile Instrumentation Data Acquisition System (MIDAS)

- MIDAS was developed by Sandia for the U.S. Department of Energy.
- This self-contained facility is built within a 44-foot trailer, and is equipped with structural and thermal data acquisition systems to provide **on-site data acquisition** of test objects during drop, crush, puncture, fire, and immersion tests.



# Seals Laboratory

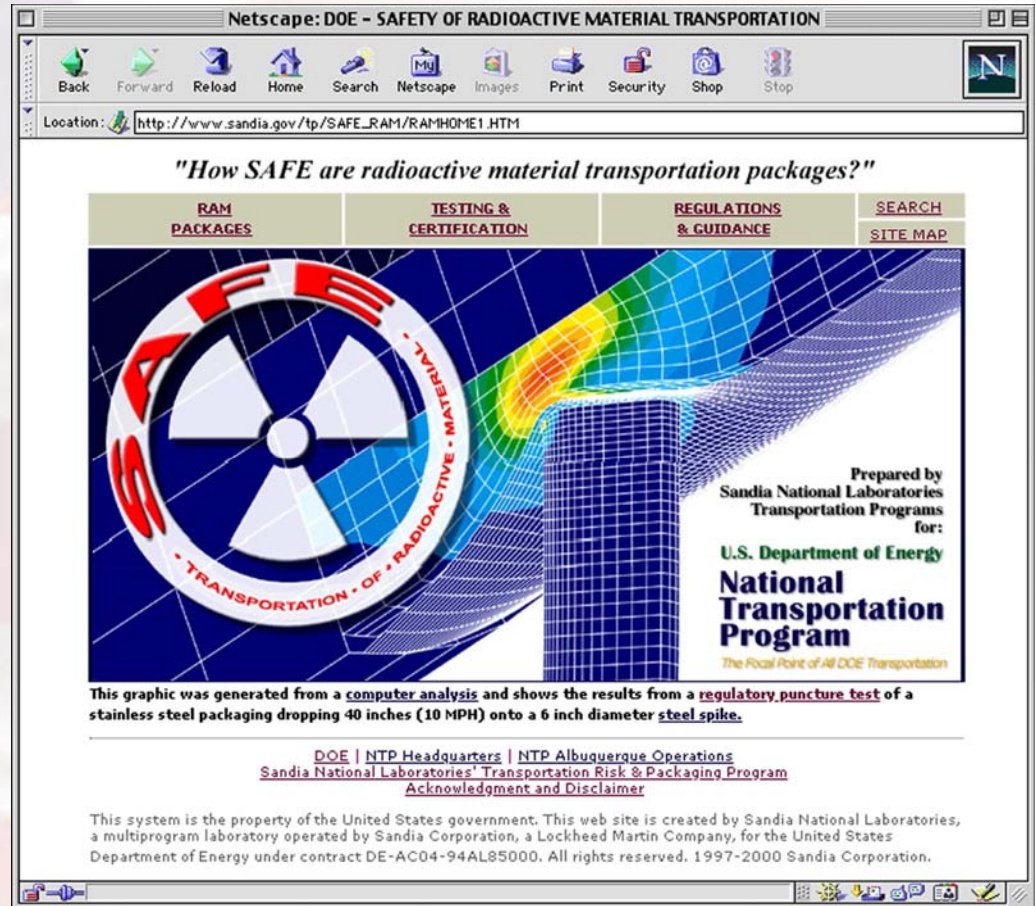
- This laboratory is used to **test the o-rings** that are used to provide a leak-tight seal between the package lid and the package body of a RAM transportation package.
- Testing includes high and low temperatures and relative displacement of the the sealing surfaces.





# Visualization Laboratory

- This lab is equipped with state-of-the-art visualization tools that are used to explain and demonstrate the safety of RAM transportation packagings using computer analysis, full-scale testing, and scale-model testing to assure SAFE cask performance in the transportation of RAM for DOE, Sandia, press, public, and stakeholders.



[www.sandia.gov/tp/SAFE\\_RAM/RAMHOME1.HTM](http://www.sandia.gov/tp/SAFE_RAM/RAMHOME1.HTM)



# Extra-Regulatory Testing

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- **Sandia conducted extra-regulatory tests on transport casks for the Department of Energy in the mid 70's. These tests were intended to verify mathematical models, but also mimicked the kinds of accident scenarios people had expressed concern about.**
- **These were not certification tests. Large-scale cask response was evaluated to investigate the potential for any catastrophic behavior.**
- **The extensive instrumentation and data analyses needed for certification was not conducted, but results indicated the casks did not fail catastrophically for accident environments typical of very severe accidents.**

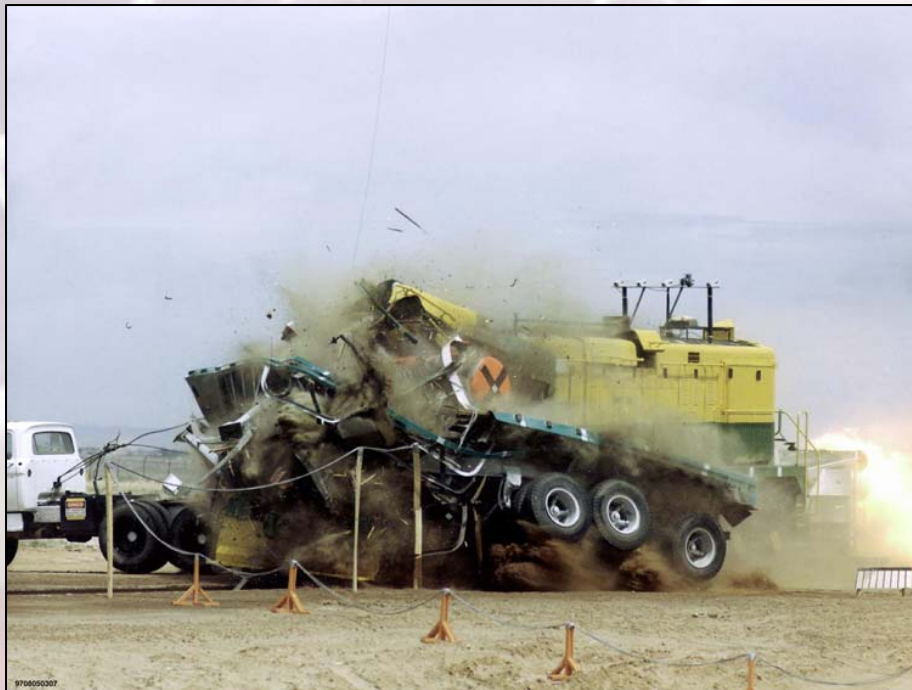
# Extra-Regulatory Testing

- **Full-Scale Rail Test at SNL**
  - A 74-ton cask on a railcar crashed into a 690-ton concrete block at 81 mph



# Extra-Regulatory Testing

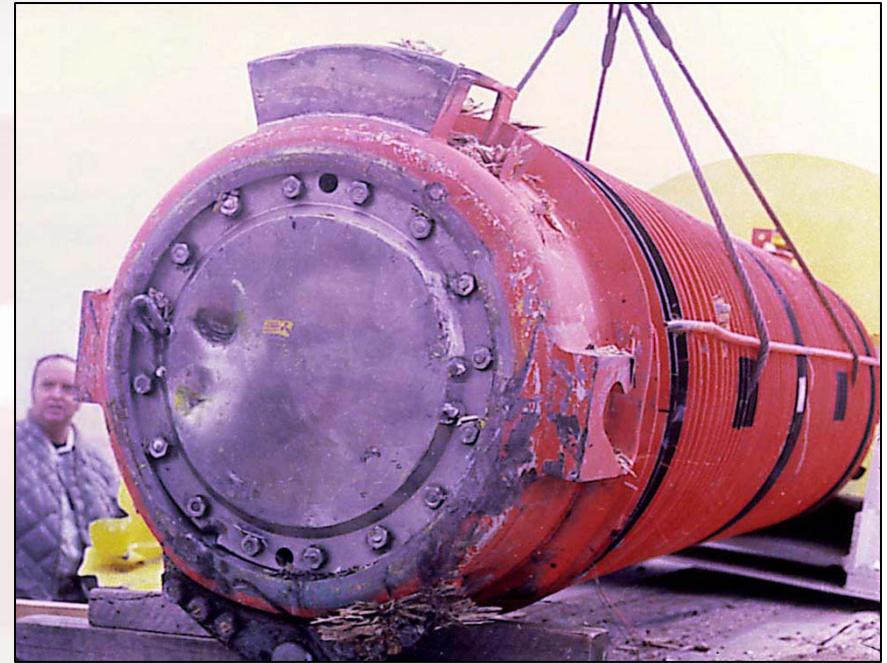
- **Full-Scale Railroad Grade Crossing Test at SNL**
  - A 24-ton cask on a semi-trailer was struck by a 150-ton diesel locomotive traveling at 81 mph





# Extra-Regulatory Testing

- **Full-Scale Truck Testing at SNL**
  - A 22- ton cask on a flatbed semi-trailer crashed into a 690-ton concrete block at 60 mph



# Extra-Regulatory Testing

- **Full-Scale Rail Testing at SNL**
  - A rail car with a 74-ton Type B on it burning in a pool fire for 90-minutes at 1800-degrees Fahrenheit

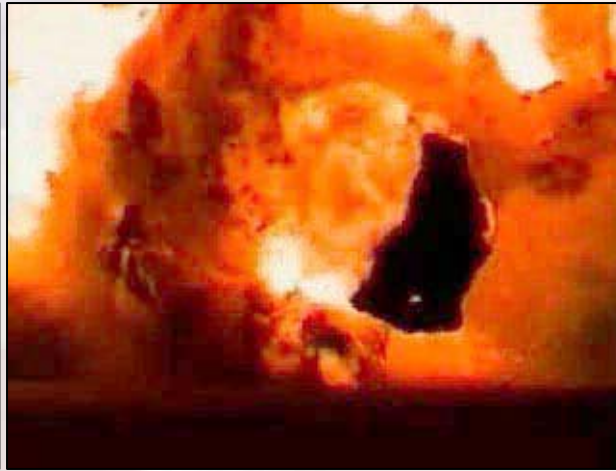




# Extra-Regulatory Testing

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- **Propane Tank Explosion Test (BAM, Germany)**
  - A propane rail tank car and a transport cask were co-located in a pool fire.
  - The propane tank exploded and the cask was thrown 33-feet



**RESULT:** There was no damage to the cask containment boundary.