Spent Fuel Transportation Risk Assessment (SFTRA) Draft NUREG-2125

Overview for
National Transportation Stakeholders Forum

John Cook
Division of Spent Fuel Storage and Transportation
SFTRA Overview Contents

• Project and review teams
• Purpose and goals
• Basic methodology
• Improvements relative to previous studies
• Draft NUREG structure and format
• Routine shipment analysis and results
• Accident condition analysis and results
• Findings and conclusions
• Schedule
SFTRA Research and Review Teams

• Sandia National Laboratory Research Team [$1.8M; 9/06-9/12]
  – Doug Ammerman – principal investigator
  – Carlos Lopez – thermal
  – Ruth Weiner – RADTRAN

• NRC’s SFTRA Technical Review Team
  – Gordon Bjorkman – structural
  – Chris Bajwa – thermal and overall content
  – Bob Einziger – fuels, source term
  – Anita Gray – health physics

• Oak Ridge National Laboratories External Peer Review Team [$125K; 9/10-3/12]
  – Matt Feldman
  – Cecil Parks
SFTRA Purpose and Goals

- **Continuing review**
  - Final Environmental Statement (NUREG-0170, 1977)
  - “Modal Study” (NUREG/CR-4829, 1987)
  - Reexamination of Spent Shipment Risk Estimates (NUREG/CR-6672, 2000)

- **NRC’s safety mission**
  - Considering public comment, provide updated basis for NRC’s safety regulations applicable to spent fuel transportation

- **Outreach responsibilities**
  - Reassure public regarding spent fuel shipments
    - Basic message: Risks are low, so safety is high
    - Improve public understanding and acceptance of spent fuel shipments

- **Update benchmark for environmental assessments**

- **Potential shipments**
  - Significant issue when study began (2006) – much less so now (post Yucca Mtn curtailment)
  - Applicable to future shipments

- **SFTRA is not**
  - Driven by any external requirement or commitment
  - An EIS or major federal action
  - Required for any licensing action, nor does it contain any regulatory proposals
  - An analysis of transport security
SFTRA Basic Methodology

• Radiological impacts of spent nuclear fuel (SNF) shipments
  – Routine conditions
    • Determine doses to various populations from cask during routine transport
  – Accident conditions
    • Perform finite element analysis of cask response to impact and thermal accident conditions
    • Use “event trees” developed by U.S. DOT to estimate probabilities of accident conditions

• Use RADTRAN to calculate routine doses and accident dose risks for representative truck and rail shipments

• Approach similar to that in NUREG-0170 and NUREG/CR-6672
SFTRA Enhancements Over Previous NRC Spent Fuel Risk Studies

- New rail and truck event trees
- RADTRAN new Version 6:
  - Elevated (plume) releases
  - New loss of shielding analysis
- Updated population data (2000 Census; trying to revise to 2010 Census pending WebTRAGIS update)
- Updated traffic density and accident data for truck and rail
- High-fidelity cask finite element models of NRC-certified casks
  - NAC-STC (26 PWR, 130 ton rail-lead)
  - HI-STAR 100 (24 PWR, 140 ton rail-steel)
- Direct loaded fuel and welded inner canister fuel
- More precise structural (e.g., bolt model) and thermal (e.g., 3-D) analyses
  - improved estimate of cask-to-environment release fractions
SFTRA Report Structure and Format

- **Audience**
  - Public, media, industry, state and tribal governments, elected officials, and federal agencies

- **Graded structure and content**

- **Executive Summary and Public Summary [All audiences]**

- **Main body text [informed public, science media]**

- **Appendices [industry, other federal agencies]**

- **Electronic and printed versions of SFTRA**
  - NRC ADAMS Accession Number: **ML12125A218**
  - Printed Draft NUREG in black and white only (CD inside back cover will contain color version)
  - Printed Final NUREG in full color
Sample SFTRA Shipment Routes

Maine Yankee NP Routes

HANFORD
SKULL VALLEY
DEAF SMITH
ORNAL

Highway
Rail
Routine Conditions: Illustration of Truck Route

- Route segment lengths and population densities
- WebTRAGIS
Routine Condition Results:
Illustration for Maine Yankee to ORNL truck shipment

Collective Doses from Background and from a Truck Shipment of Spent Nuclear Fuel (Person-Sv)

- Background, 7.56
- Total shipment dose, 3.7x10^{-3}
- Inspector, 1.6x10^{-3}
- Truck crew and escorts, 6.8x10^{-4}
- Traffic on the route, 4.6x10^{-4}
- Persons sharing stop, 8.6x10^{-4}
- Residents near route, 9.6x10^{-5}
- Residents near truck stops, 1.2x10^{-5}
Rail-Lead Cask Impact Accident

- Rail-Steel cask (welded inner fuel canister) does not form leakpath under any impact conditions analyzed
- Deformed shape of the Rail-Lead cask following the 193 kph (120 mph) impact onto an unyielding target in the corner orientation
  - No leakpath is formed so there is no release of contents
Rail-Lead Cask Impact Accident

- Deformed shape in side orientation following a 145 kph (90 mph) impact onto an unyielding target.
  - Only cask and orientation resulting in a leakpath
  - 60 mph result shows no leakpath, but 60 mph impact into hard rock is assumed to result in a leakpath
  - 115 mph into non-hard rock would be required to result in a leakpath
    - No recorded accidents at this velocity
Rail-Lead Cask Fire Accident

After 3-hour concentric fire:
Rail-Lead Cask Fire Accident

- Rail-Lead cask is capable of protecting the fuel rods from burst rupture and of maintaining containment when exposed to the severe fire environments analyzed.

- Some reduction of gamma shielding is estimated to occur in two cases. Partial loss of lead shielding is expected when the cask is exposed to
  - a concentric fire that burns longer than 65 minutes
  - a fire offset by 3 meters (10 feet) and that burns for longer than 2 hours and 15 minutes.

- No release of radioactive material is expected if this cask was exposed to any of the severe fire environments analyzed because the elastomeric seals did not reach their temperature limit, thus preventing any radioactive material release.
Accident Conditions: U.S. DOT Rail Accident Event Tree Segment

Rail Event Tree

<table>
<thead>
<tr>
<th>ACCIDENT</th>
<th>SPEED DISTRIBUTION</th>
<th>SURFACE STRUCK</th>
<th>PROBABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Derailment no fire: 0.9846</td>
<td>80-113 kph collision: 0.06043</td>
<td>Into slope: 0.0011</td>
<td>4.76e-5</td>
</tr>
<tr>
<td>Derailment: 0.7355</td>
<td>&gt;113 kph collision: 5.01e-5</td>
<td>Embankment: 0.0004</td>
<td>1.73e-5</td>
</tr>
<tr>
<td></td>
<td>Off bridge: 0.9887</td>
<td>Into structure: 0.0077</td>
<td>0.000333</td>
</tr>
<tr>
<td></td>
<td>On bridge: 0.0113</td>
<td>Into tunnel: 0.00801</td>
<td>0.000347</td>
</tr>
<tr>
<td></td>
<td>Off bridge: 0.9887</td>
<td>Other: 0.9828</td>
<td>0.04252</td>
</tr>
<tr>
<td></td>
<td>On bridge: 0.0113</td>
<td></td>
<td>0.00049</td>
</tr>
<tr>
<td></td>
<td>Off bridge: 0.9887</td>
<td>Into slope: 0.0011</td>
<td>3.95e-8</td>
</tr>
<tr>
<td></td>
<td>On bridge: 0.0113</td>
<td>Embankment: 0.0004</td>
<td>1.43e-8</td>
</tr>
<tr>
<td></td>
<td>Off bridge: 0.9887</td>
<td>Into structure: 0.0077</td>
<td>2.76e-7</td>
</tr>
<tr>
<td></td>
<td>On bridge: 0.0113</td>
<td>Into tunnel: 0.00801</td>
<td>2.87e-7</td>
</tr>
<tr>
<td></td>
<td>Off bridge: 0.9887</td>
<td>Other: 0.9828</td>
<td>3.53e-5</td>
</tr>
<tr>
<td></td>
<td>On bridge: 0.0113</td>
<td></td>
<td>4.10e-7</td>
</tr>
</tbody>
</table>
Accident Condition Results:
Accident collective dose risks from release and loss of gamma shielding (LOS) accidents. The LOS bars are not to scale.
SFTRA Findings

- The collective dose risks from routine transportation are vanishingly small. Theses doses are about four to five orders of magnitude less than collective background radiation dose over the same time period and exposed population as the shipment.
- The routes selected for this study adequately represent the routes for spent nuclear fuel transport, and there was relatively little variation in the risks per kilometer over these routes.
- **Radioactive material would not be released in an accident if the fuel is contained in an inner welded canister inside the cask.**
- Only rail casks without inner welded canisters would release radioactive material, and only then in exceptionally severe accidents.
- If there were an accident during a spent fuel shipment with a cask that does not include an inner welded canister, there is only about one in a billion chance the accident would result in a release of radioactive material.
- **If there were a release of radioactive material in a spent fuel shipment accident, the dose to the maximum exposed individual would be non-fatal.**
Based on these findings, **this study reconfirms that estimated radiological impacts from spent fuel transportation conducted in compliance with NRC regulations are low**, in fact generally less than previous, already low, estimates. Accordingly, with respect to spent fuel transportation, the previous NRC conclusion that the **regulations for transportation of radioactive material are adequate to protect the public against unreasonable risk** is also reconfirmed by this study.
# SFTRA Current Schedule

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Publish Notice for comment in Federal Register</td>
<td>5/14/2012 (completed)</td>
</tr>
<tr>
<td>2. Public comments due</td>
<td>7/13/2012</td>
</tr>
<tr>
<td>3. Response to public comments (SFTRA Rev 3.0)</td>
<td>8/15/2012</td>
</tr>
<tr>
<td>4. Final Draft (SFTRA Rev. 4.0)</td>
<td>9/30/2012</td>
</tr>
<tr>
<td>5. NRC publishes Final SFTRA</td>
<td>by 12/31/2012</td>
</tr>
</tbody>
</table>
Comments on Draft Report

- ADAMS Accession Number for Draft NUREG-2125: ML12125A218

- Federal Register Notice: 77 FR 28406, May 14, 2012

- You may submit comments by the following methods:
  - Mail comments to: Cindy Bladey, Chief, Rules, Announcements, and Directives Branch (RADB), Office of Administration, Mail Stop: TWB-05-B01M, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.
  - Fax comments to: RADB at 301-492-3446.