

Exceptional service in the national interest



ENSA

Sandia National Laboratories

Pacific Northwest National Laboratory

Collaboration Meeting for the Full-scale ENUN-32P Cask

Normal Conditions of Transport Rail Test

Santander, Spain

June 20-21, 2016

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UFD Storage and Transportation R&D: Full-scale Rail Cask Test

Goal:

Obtain a library of shock and vibration data from a series of comprehensive Normal Condition of Transport full-scale rail cask tests

Objectives:

- 1. Conduct a series of full-scale rail cask tests with surrogate PWR assemblies**
- 2. Obtain data for the following modes of transport**
 - Normal rail
 - Heavy-haul truck
 - Coastal shipment
 - Open ocean transport
 - Transfer operations
- 3. Envelop all track conditions and train speeds to bound representative loadings expected for rail Normal Conditions of Transport**

Opportunity

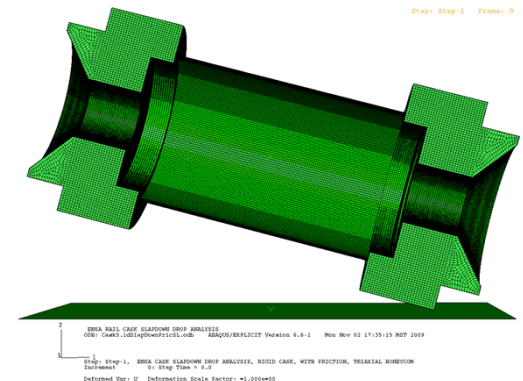
We look forward to extending our collaborative relationship with ENSA with this unique opportunity to conduct full-scale rail tests in 2017:

1. Under the DOE program, Sandia, PNNL, and SRNL have collaborated to conduct Normal Conditions of Transport truck shock and vibration tests to determine loads on surrogate spent fuel assemblies.
2. Tests were conducted on two different shaker tables and one over the road truck test.
3. A limited set of rail shock and vibration data have been obtained from one shaker table test. Shock and vibration loading for this test was developed in collaboration with TTCL.
4. Measured maximum strains are significantly below elastic, fracture mechanics, and fatigue failure criteria for Zircaloy cladding.
5. This full-scale test program will provide a unique set of data for rail transport loadings on spent fuel.

Initial ENSA/SNL contract
April 2009

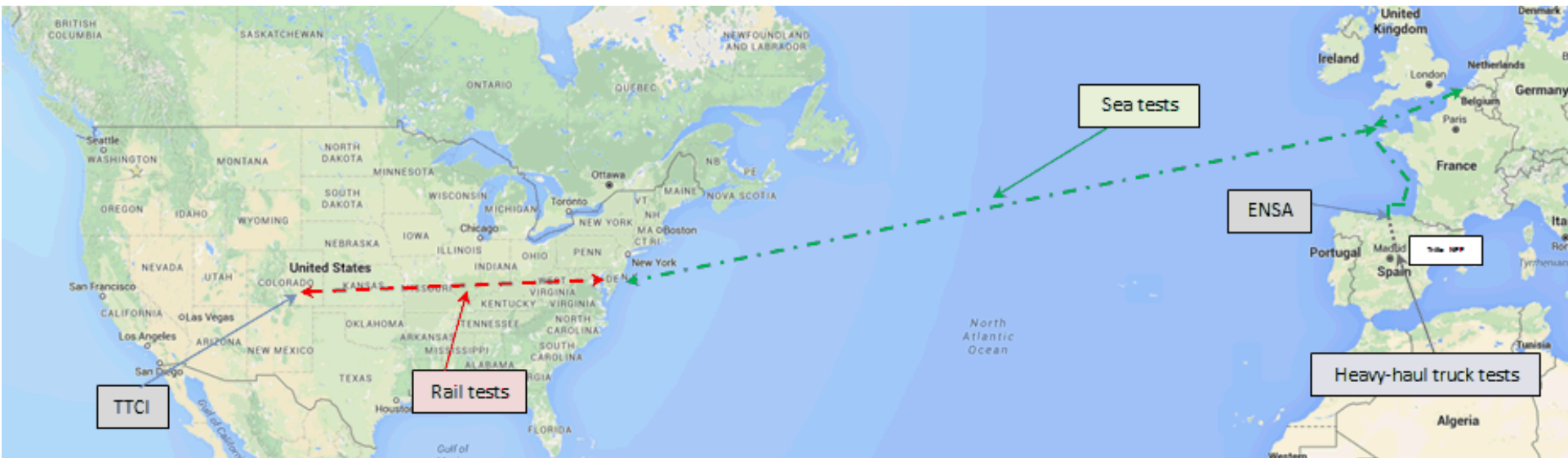


1/3-scale ENUN-32 test
@ SNL
November 2010



Full-scale ENUN-32
certification analysis @ SNL
Jan 2012

Proposed Routing of the Cask to Support these Tests



1. Heavy-haul truck from Santander, Spain to a site near Madrid and back (ENSA)
2. Coastal sea shipment from Santander to a large European port: e.g., Zeebrugge, Belgium (ENSA)
3. Ocean transport from Zeebrugge to an Eastern U.S. port (e.g., Baltimore) (ENSA)
4. Commercial rail shipment from U.S. Eastern port (e.g., Baltimore) to Pueblo (ENSA or DOE)
5. Testing at TTCI in Pueblo (DOE)
6. Return trip will be the same. The heavy-haul truck tests will not be repeated.

- Test time ~ 3 weeks
- Will instrument surrogate assemblies
- Will be a round trip test (~ 1160 km)
- Strain and vibration data will be collected during the trip
- Vibration testing will be conducted at by ENSA



- Shipment time ~ 3 days
- ENSA will use a Roll on – Roll off vessel (RoRo). Cask will be on the heavy-haul trailer with pneumatic tires. This will make the ride similar to any barge shipment that may be made in the U.S.
- Strain and vibration data will be collected during the trip

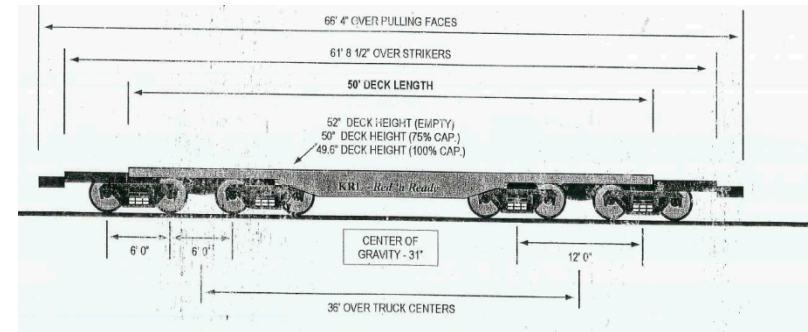
- Shipment time ~ 2 weeks via RoRo vessel
- Cask/cradle will be loaded onto a 30' Mafi with solid rubber tires on one end and metal support on the other
- Strain and vibration data will be collected



Specifics of Modal Tests (cont.)

4. Commercial rail shipment from Baltimore to Pueblo

- Transit time ~ 3 weeks
- Data collection during transit
- Rail car will be rented
- Rail car will be instrumented



Typical commercial flat deck rail car

5. Testing at TTCI

- 2 weeks for all testing
- Specific tests being considered include:
 - Instrumented wheel set
 - Dynamic curving test
 - Hunting test

6. Return trip

- Sandia assembly will be removed at ENSA and shipped back to Sandia
- Data collection for the entire return trip is being considered (the same route will have different track, weather conditions, etc.)



PFS 2043 rail car with mass loading @ TTCI

Transportation Technology Center, Inc.

TTCI

Pictures and details from TTCI website: <http://www.aar.com>

TTCI is a wholly-owned subsidiary of the Association of American Railroads

Vision: “To be the provider of choice for advancing railway safety and technology”

Mission: “To provide our customers highly effective and efficient railway research, consulting, testing, system engineering, inspections, training, and technical support for standards in a safe manner, ensuring the highest level of integrity while providing our employees a challenging and sustainable work environment.”



52-square mile facility 21 miles
Northeast of Pueblo, Colorado

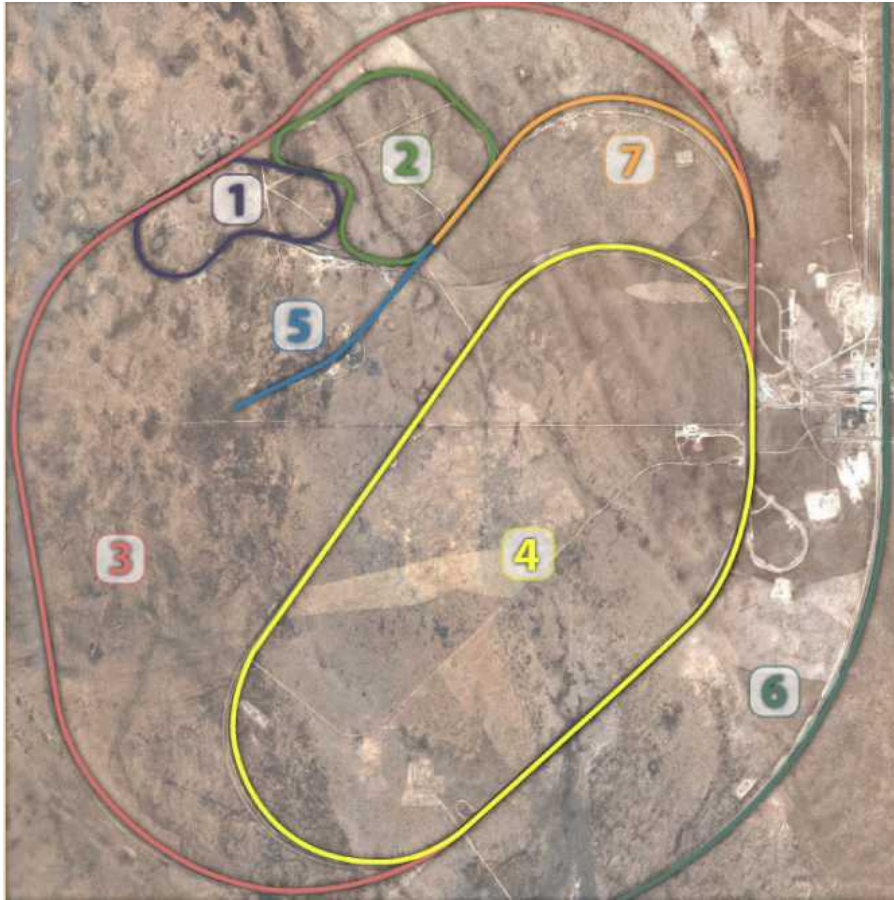
48 miles of railroad track available
for testing



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Picture and details from TTCI website: <http://www.aar.com>



Test track lay-out

1. High tonnage loop
 - Heavy axle load tests
2. Wheel Rail Mechanism
 - 3.5-mile loop
 - Smooth and perturbed track conditions
3. Railroad Test Track
 - 13.5-mile loop
 - < 165 mph
 - Stability and endurance tests
4. Transit Test Track
 - 9.1-mile oval track
 - < 80 mph
 - Vehicle performance and specification compliance
5. Impact Track
 - 0.75-mile track
 - Destructive impact tests
6. Precision Test Track
 - 6.2-mile track
 - Vehicle dynamic behavior and impact tests
7. Train Dynamics Track

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Picture from TTCI website: <http://www.aar.com>



PNNL is currently working with TTCI to develop a detailed test plan, complete with cost and schedule. Potential identified tests include:

- Crossing diamond
- Twist and Roll
- Pitch and bounce
- Dynamic curving
- Coupling impact
- Loaded hunting

Conclusions

- This collaborative full-scale rail test is a unique opportunity for obtaining important data on loads imparted to spent nuclear fuel during normal conditions of rail transport
- Much of this data will be first-of-a-kind
- All data will be in the open literature so that organizations from around the world will have access
- Other programs within DOE have also expressed interest that will expand the visibility in the U.S. for this test
- This data and follow-on benchmarking analysis will provide added confidence that rail transport of spent nuclear fuel is safe