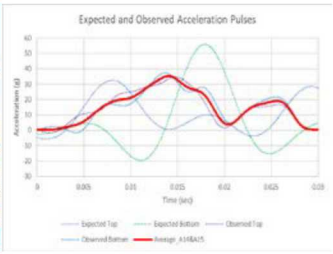
SAND2019-12327C

Sandia National Laboratories

Full-Scale Assembly 30 cm Drop Test



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PRESENTED BY

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MRS
43rd Symposium on the Scientific Basis for Nuclear Waste Management

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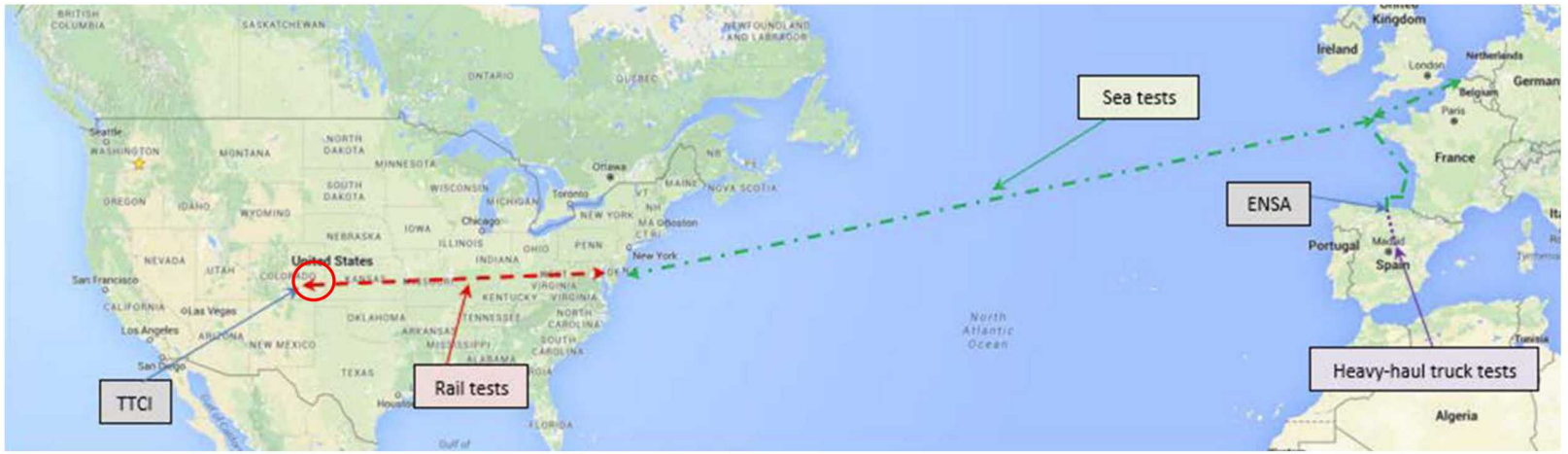
Introduction

- The 30 cm drop test was a follow-on to the 2017 US/Spanish/Korean Multi-Modal Transportation Test (MMTT): 8-month, 9,400-mile transportation of spent nuclear fuel (SNF) test.
- The test purpose was to quantify the shocks and vibration environments during heavy-haul, rail, and ship transport.
- For the first time, strains and accelerations were measured on the surrogate assemblies within the ENUN 32P dual purpose rail cask.

ENUN 32P Cask



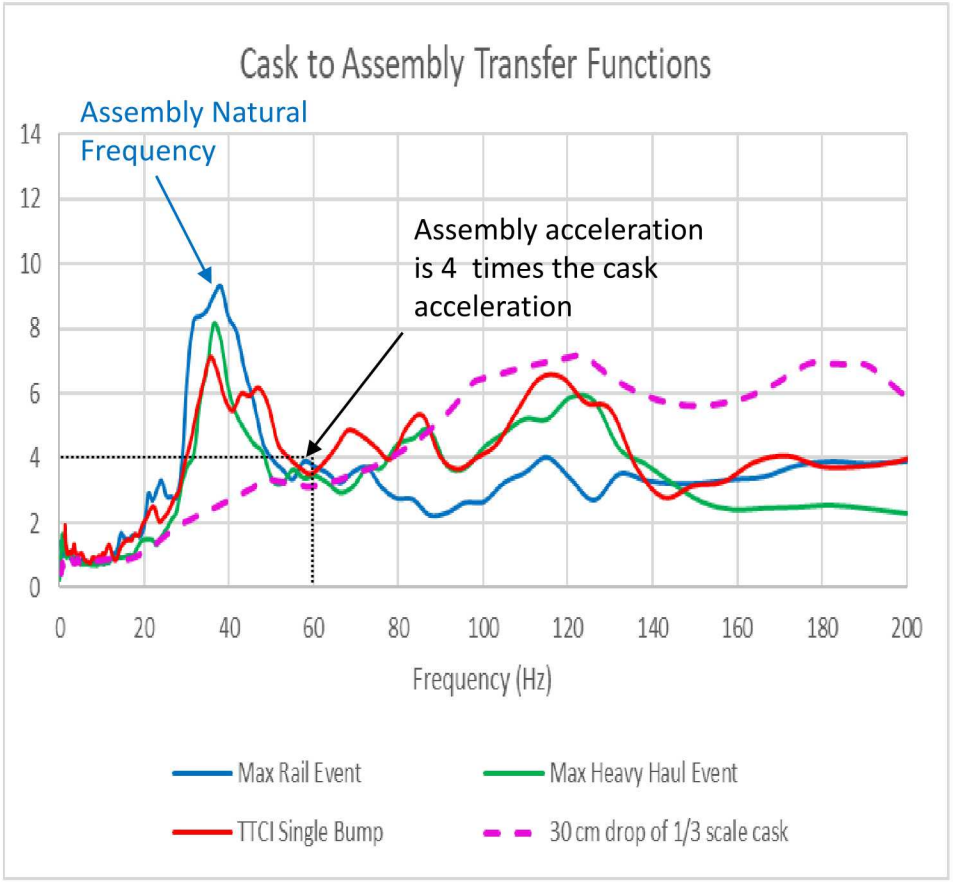
MMTT video is available on YouTube: *https://www.youtube.com/watch?v=wGKtgrozrGM&feature=youtu.be*

MMTT data analysis report is available at: *https://www.osti.gov/biblio/1532526-data-analysis-ensa-doe-rail-cask-tests*

Motivation for 30 cm Drop Test

- The common assumption is that the cask content experiences the same accelerations as the cask itself.
- The data from the MMTT demonstrated that the accelerations were amplified from the cask to the surrogate assemblies during transport.
- The peaks at 40 Hz were due to assembly natural frequency.

What accelerations and strains will fuel rods experience inside the cask when dropped from a height of 30 cm?



The transfer function is the relationship between accelerometers on the cask and on the fuel assemblies.

30 cm Drop Test: Purpose, Incentive, Goals, and Implementation

Purpose:

Measure accelerations and strains on a surrogate 17x17 PWR fuel assembly

Incentive

- ❑ The 30 cm drop is the NRC normal conditions of transportation (NCT) regulatory requirement (10 CFR 71.71)
- ❑ There are no data on the actual surrogate fuel for the 30 cm drop.
- ❑ Obtaining these data is not a direct requirement, but it allows for:

Goals

- ➢ Completing the NCT mechanical testing environment
- ➢ Better understanding the potential implications of handling incidents
- ➢ Quantifying the risk of fuel breakage under the 30 cm drop conditions
- ➢ Defining transfer function from the cask to the fuel for more severe impacts

Implementation

- ❖ Ideally, the 30 cm drop test would be conducted with the full-scale cask containing full-scale surrogate assemblies.
- ❖ The cost of a full-scale cask and impact limiters make this test impractical.
- ❖ The accelerations and strains on a full-scale surrogate fuel assembly will be obtained by implementing 3 consecutive steps.
- ❖ This presentation describes Step 2.

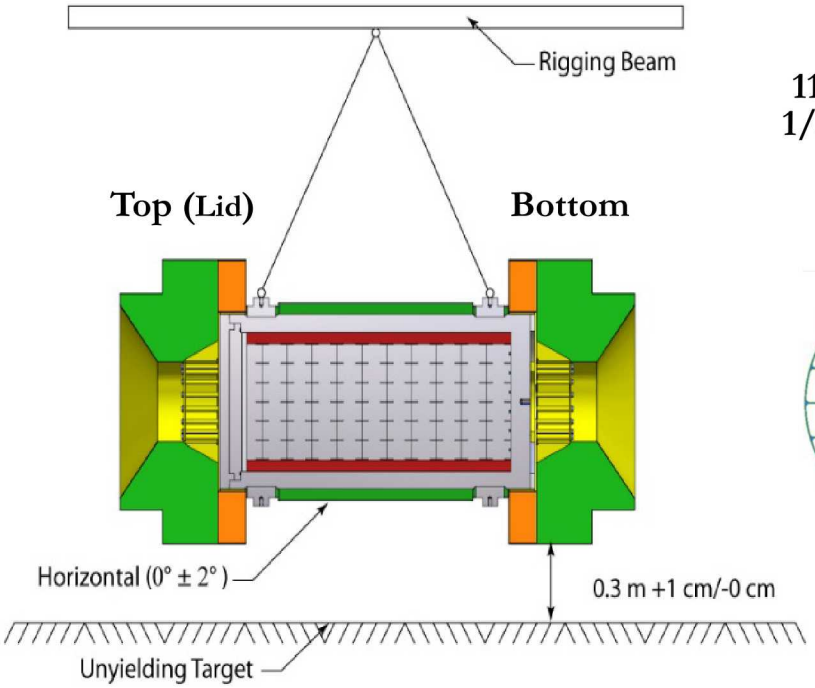
STEP 1 – 30 cm Drop of 1/3 Scale ENUN 32P Cask with Dummy Assemblies

BAM Facility in Berlin (Germany), December 2018

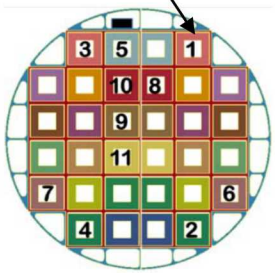
Details in PATRAM-2019 paper by Kalinina et al.

Dummy assembly

Drop Test Setup



11 instrumented 1/3 scale dummy assemblies

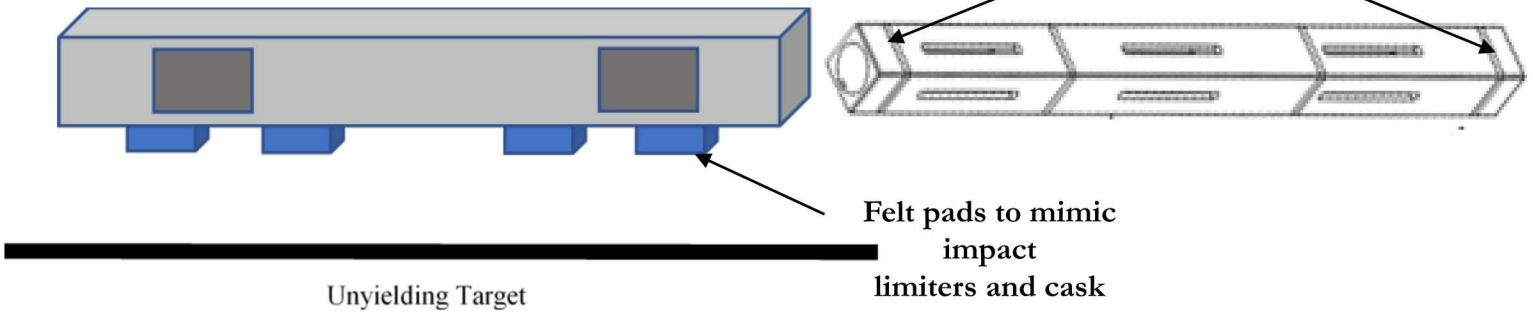


Obtain maximum acceleration pulses on 1/3 scale dummy assemblies (top and bottom)

STEP 2 – 30 cm Drop of the Full-Scale Dummy Assembly

SNL Facility in Albuquerque (NM), June 2019

Drop Test Setup



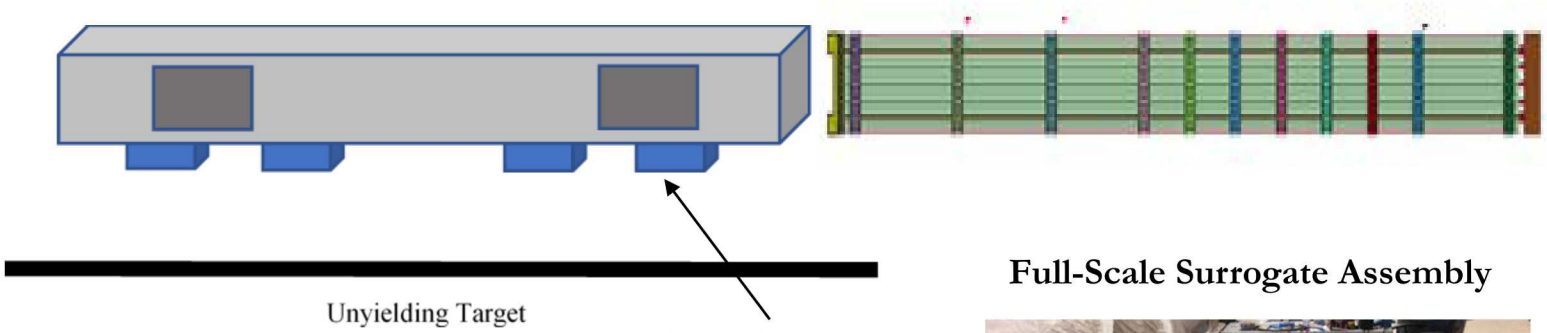
Full-Scale Basket Tube

Full-Scale Dummy Assembly

STEP 3 - 30 cm Drop of Full-Scale Surrogate Fuel Assemblies

To Be Conducted at SNL Facility in Albuquerque (NM) in Spring 2020

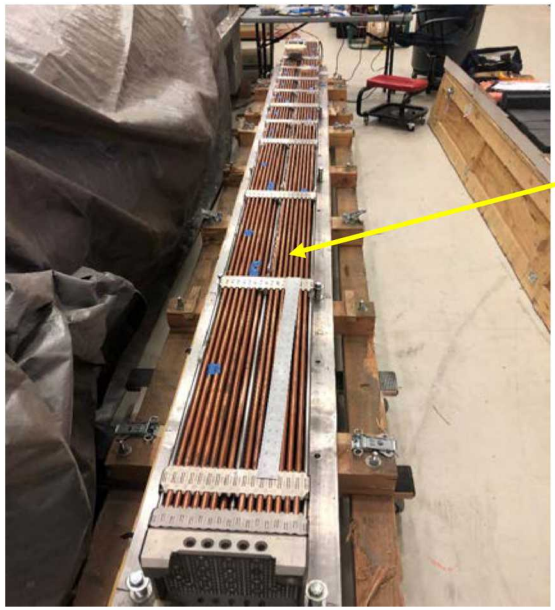
Drop Test Setup



Obtain strain and accelerations on the surrogate fuel rods at multiple locations

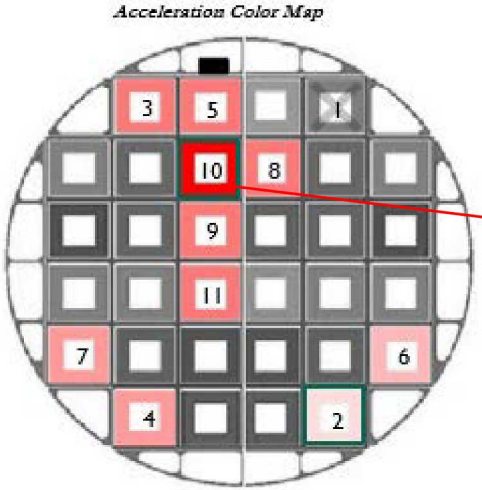
Will the fuel rods maintain their integrity inside a cask when dropped from a height of 30 cm?

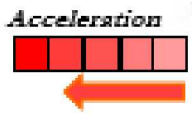
Full-Scale Surrogate Assembly



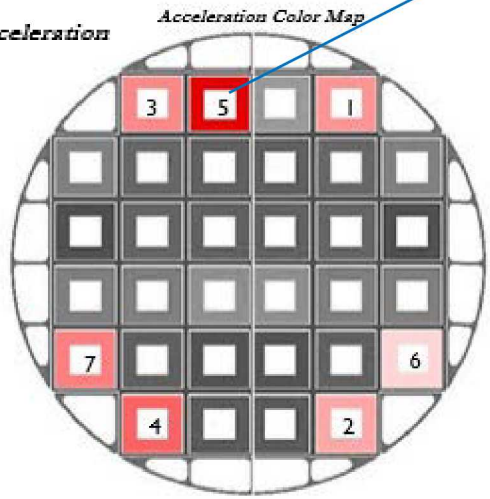
STEP 1 Maximum Acceleration Pulses on 1/3 Scale Dummy Assemblies in 30 cm Drop of 1/3 Scale Cask

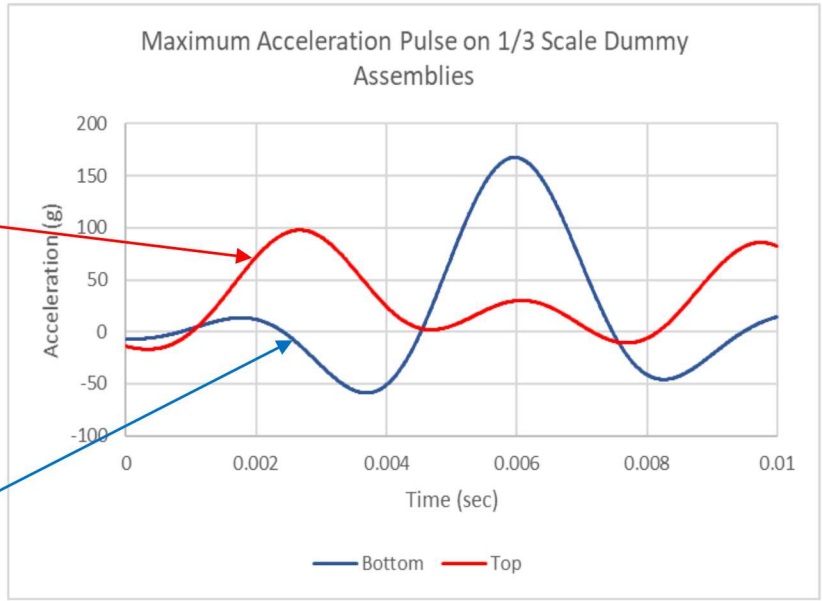
Top (Lid)





Bottom





- The pulses at the top and bottom locations are different because the horizontal drop is never truly horizontal.
- In this test the cask hit the target with its lid side first.

STEP 2: Full-Scale Dummy Assembly 30 cm Drop Test

The drop tests were conducted at the SNL drop tower in Albuquerque (NM) in June, 2019.

Goal: recreate a full-scale acceleration pulses on the dummy assembly that corresponds to the measured pulses on the 1/3-scale dummies (from STEP 1).

Hardware and Materials

- ❑ PNNL/SNL designed and ENSA manufactured a full-scale dummy assembly.
- ❑ The dummy assembly was dropped within an actual basket tube from the ENUN-32P cask.
- ❑ Felt programming material was used to create tailored shock inputs.

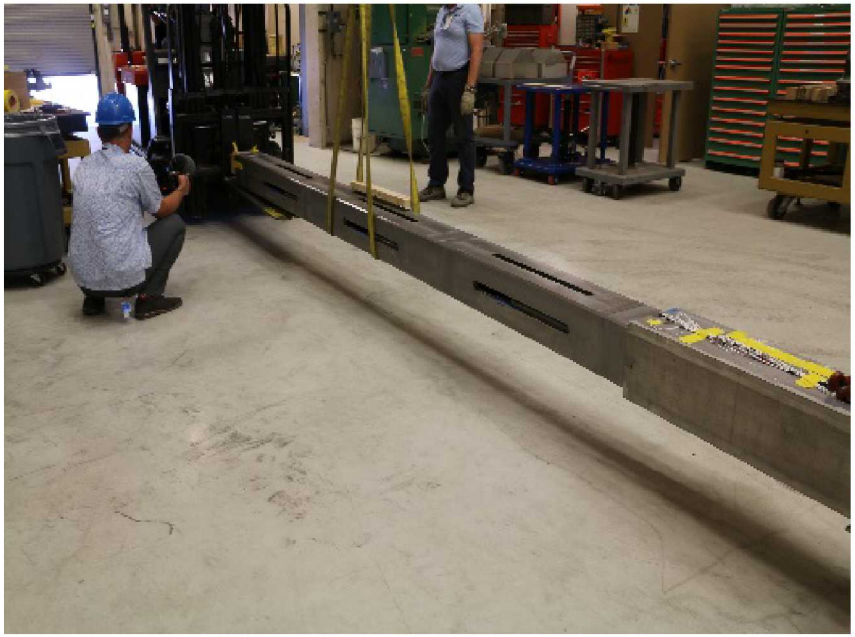
Procedure

- ➢ Multiple tests were performed to get the desired acceleration pulse.
- ➢ After each test the pulse amplitude, duration, and shape were examined and the felt programming material was adjusted.

SNL Drop Tower Facility

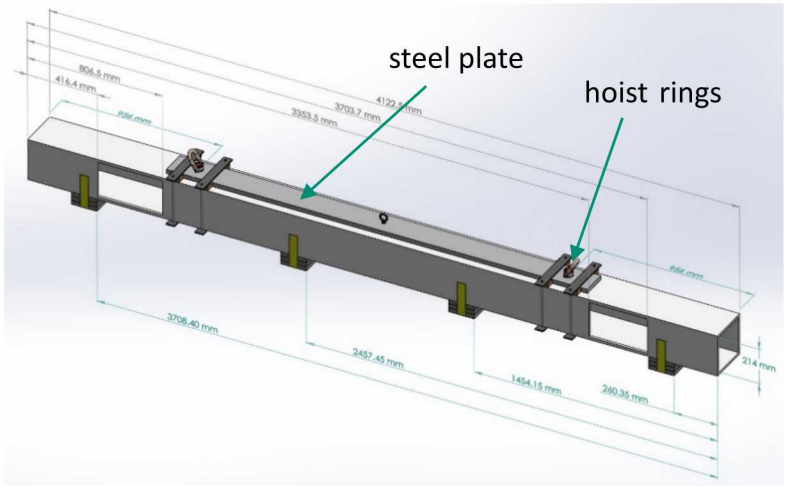
Preparation for The Drop Test and Handling

Inserting Dummy Assembly in the Basket Tube



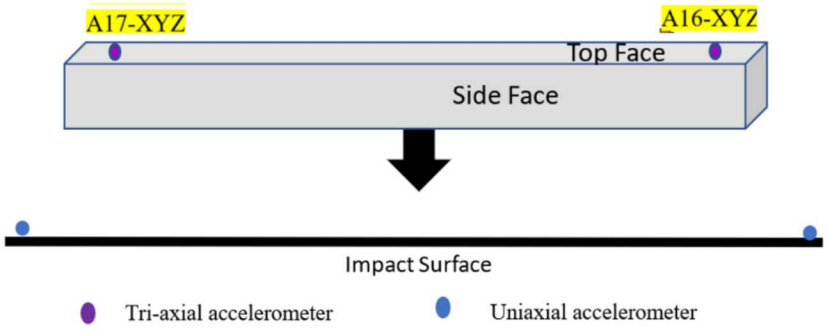
Bringing the Test Unit to the Test Facility

- To handle the basket tube, a steel plate was manufactured and attached to the basket tube by steel clamps.
- Two hoist rings were installed in the steel plate to allow for lifting and handling.

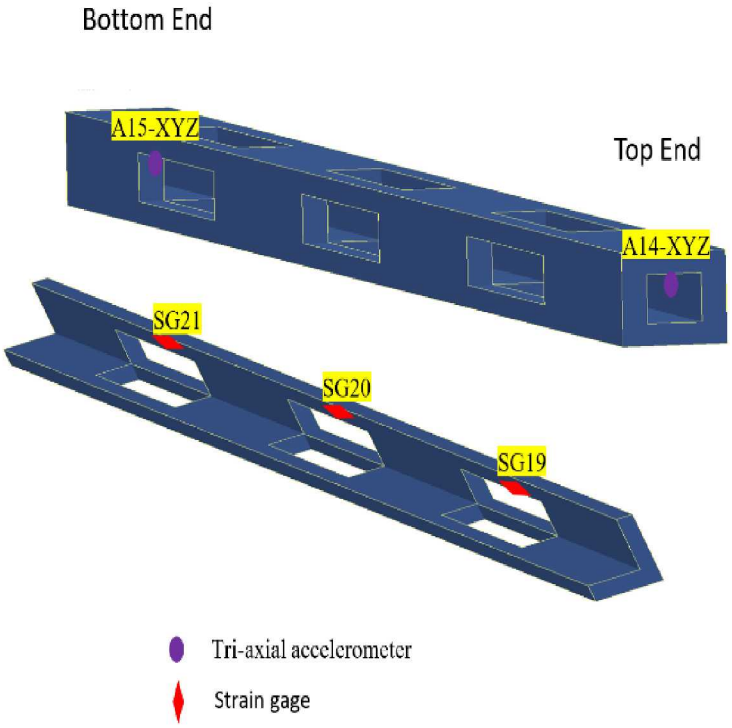


Instrumentation and Test Setup

Full-scale basket tube and target surface instrumentation



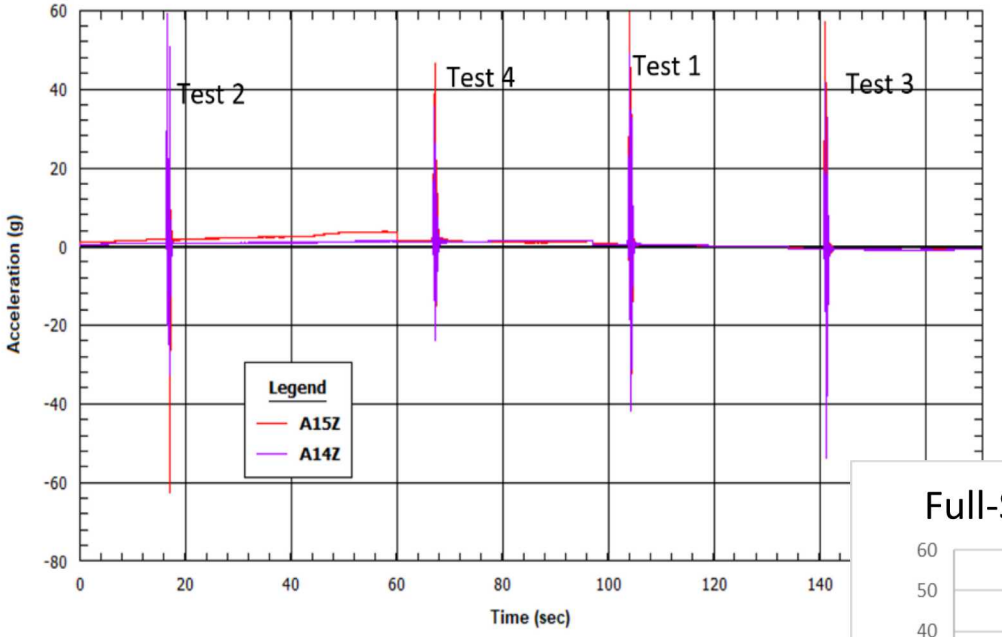
Full-scale dummy assembly instrumentation.



Test Setup

Results of the 30 cm Full-Scale Dummy Assembly Drop Tests

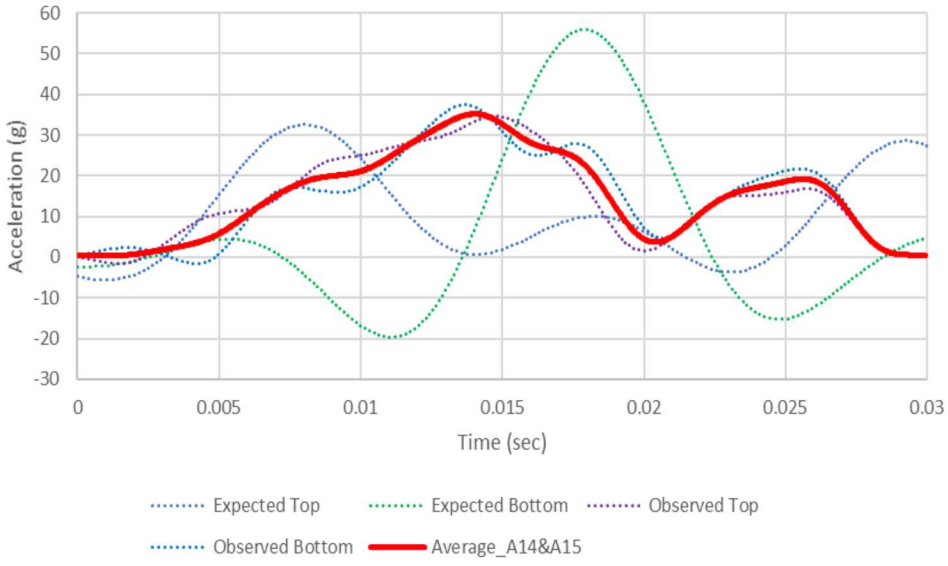
Acceleration Time Histories in Four Drop Tests



The full-scale acceleration pulses in Test 4 showed good agreement with the 1/3 scale acceleration pulses

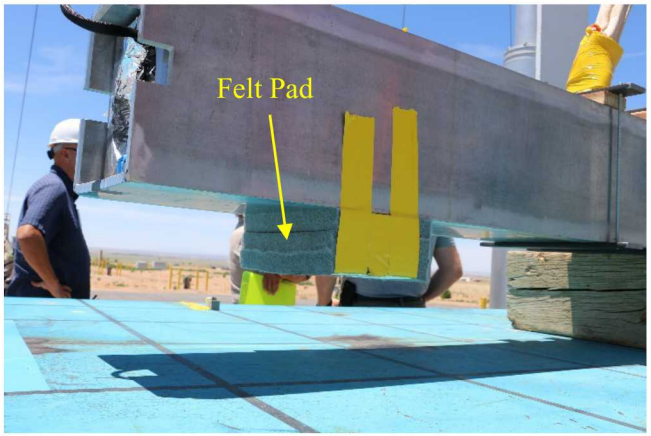
- The full-scale assembly drop was virtually horizontal and the accelerations on the to[p and bottom are very similar.

Full-Scale (Test 4) and 1/3 Scale Acceleration Pulses



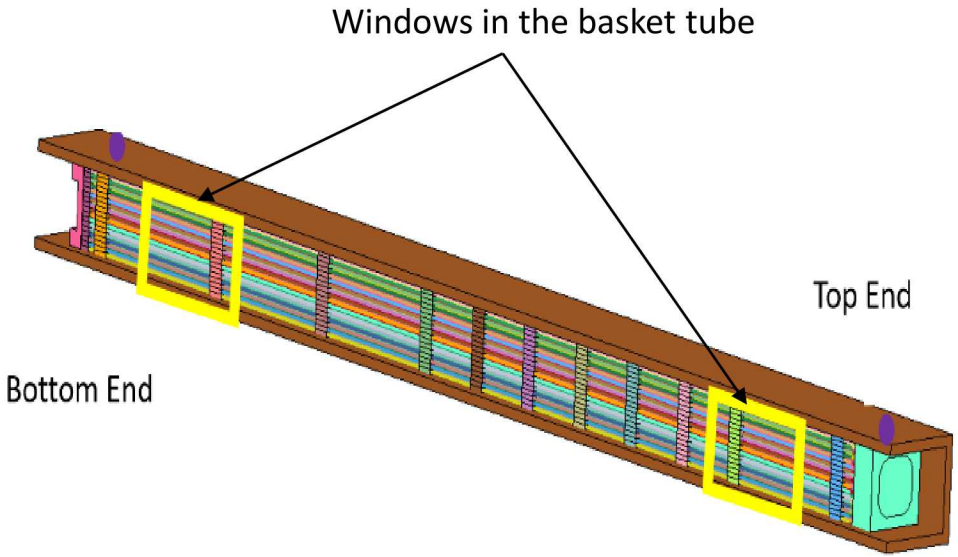
Conducting 30 cm Drop Test 4

Felt pad configuration in Test 4



Conclusions

- The felt pad design in Test 4 adequately represents the effect of the cask and the impact limiters.
- This design will be used in STEP 3 - the 30 cm drop of the full-scale surrogate assembly.
- The surrogate assembly will be instrumented with multiple accelerometers and strain gauges to obtain the data at the different locations on the rods.
- Two windows in the basket tube will allow for recording the behaviour of the fuel rods using high-speed video cameras.
- These data will help to determine whether or not the fuel rods can maintain their integrity inside a cask when dropped from a height of 30 cm



Full-Scale Surrogate Assembly in the Basket Tube

Questions?