Progress on NCSP Training and Education Programs at Sandia

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Sandia National Laboratories
SAND2013 - XXXX
SNL Hands on Criticality Safety Training Course

- Course Attendance
- Course Content
- Experiments
  - Approach on Fuel
  - Approach on Moderator Height
  - Approach on Separation
  - Approach on Removal of Fuel
# Course Attendance

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<td>Light Water Reactor (LWR) Design</td>
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Classroom discussions are interspersed through the experiments

- The basics of criticality safety
- Criticality safety data and limits
- Historic critical experiments
- Subcritical multiplication
- Reactor theory and kinetics
- Description of selected critical mass accidents
- The design and operation of critical experiments at Sandia
- Radiation detection in the experiments
- Results of Sandia critical experiments
- The development and use of critical experiment benchmarks
- Light water reactor concepts as applied to the Sandia experiments
Hands-On Training

- Sort Fuel
- Hand Fuel to Load into Experiment
- Load Fuel into Experiment
Experiment 1 Overview

- Approach-to-critical experiment by loading fuel into the fully-reflected assembly
- Same process that is performed for experiments
- Criticality safety parameters that are in play:
  - Mass
  - Moderation
  - Reflection
  - Absorption

- Application to criticality safety:
  - What happens when the number of fuel lumps in an array increases?
Core Loading Experiment
Configuration 1

Fuel Rods: 836

k ~ 0.95
Core Loading Experiment
Configuration 2

Fuel Rods: 895
k ~ 0.97
~Critical Core Loading

Fuel Rods: 1060

k ~ 1.00 (at 1059.6 rods)
Experiment 2 Overview

- Approach-to-critical experiment by increasing the moderator height in the assembly with a constant fuel loading

- Criticality safety parameters that are in play:
  - Moderation
  - Geometry
  - Mass

- Application to criticality safety:
  - What happens to an array that becomes flooded?
The Fuel Rod Configuration

1137 fuel rods

The blue rods are the difference from the fully-reflected critical array in the first experiment.

This configuration goes critical with the moderator at about 95% of the fuel height.

Source (at the midplane of the fuel)
Moderator Height Experiment
Configuration 1

Fuel Rods: 1137
\( k_{\text{eff}}: \sim 0.90 \)
Water Depth: 271.6 mm
Moderator Height Experiment
Configuration 2

Fuel Rods: 1137
\( k_{\text{eff}} \): \( \sim 0.95 \)
Water Depth: 341.3 mm
Moderator Height Experiment at DC

Fuel Rods: 1137
\[ k_{\text{eff}}: \sim 1.0 \]
Water Depth: 461 mm
Experiment 3 Overview

- Approach-to-critical experiment by moving two roughly equal (and unchanging) fuel lumps toward each other
- This simulates experiments done with a horizontal split table machine
- Criticality safety parameters that were in play:
  - Interaction
  - Moderation

Application to criticality safety:
- What happens as two fuel masses are moved progressively closer to one another?
- What happens when two neighboring fuel masses are moved apart?
- This experiment is applicable to many accident configurations.
Core Separation Experiment
Configurations

Fuel Rods: 477 (left) + 444 (right) = 921 (total)
Separation: 5.130 cm
Core Separation Experiment
Configurations

Fuel Rods: 477 (left) + 444 (right) = 921 (total)
Separation: 4.275 cm
Fuel Rods: 477 (left) + 444 (right) = 921 (total)
Separation: 3.420 cm
Core Separation Experiment
Configurations

Fuel Rods: 477 (left) + 444 (right) = 921 (total)
Separation: 2.565 cm
Core Separation Experiment

Configurations

Fuel Rods: 477 (left) + 444 (right) = 921 (total)

Separation: 1.710 cm
Core Separation Experiment
Configurations

Fuel Rods: 477 (left) + 444 (right) = 921 (total)
Separation: 0.855 cm
Core Separation Experiment
Configurations

Fuel Rods: 921
Fuel Separation Experiment

This experiment demonstrates the trade-off between increasing interaction between the core halves as they come together and decreasing moderation as the water is squeezed from between the core halves.
Experiment 4 Overview

- Effect of removing fuel rods from the interior of the fuel array
- Replacing fuel rods with water
- Criticality safety parameters that are in play:
  - Mass
  - Moderation
  - Reflection
  - Absorption

- Application to criticality safety:
  - What happens to a compact array of fuel lumps if the array becomes more spread out?
Fuel Replacement with Water
Configuration 0

1032 Fuel Rods
0 Water Holes (the source doesn’t count)

Remember that this core is critical with about 1060 rods (first experiment)
Fuel Replacement with Water
Configuration 1

1028 Fuel Rods
4 Water Holes
Fuel Replacement with Water Configuration 2

1024 Fuel Rods
8 Water Holes
Fuel Replacement with Water Configuration 3

1020 Fuel Rods
12 Water Holes
Fuel Replacement with Water
Configuration 4

1016 Fuel Rods
16 Water Holes
Approach on Water Holes
Concluding Remarks

- Hands-on criticality experiments class
  - Second week in the NCSP T&EP course for Nuclear Criticality Safety Engineers
  - Conducted Five Classes
- The class consists of four experiments, all using a different approach variable
- The experiments are accompanied by a series of lectures intended to supplement the experiments