INVESTIGATION OF REACTIVITY DIFFERENCES IN CYLINDER ARRAYS USING VARIOUS FILL GEOMETRIES WITH CONSTANT MASS

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Introduction

- Ensuring systems stay subcritical is of utmost importance to the safe operation of a facility.
- Relatively straight forward for simple or isolated systems.
- Array configurations can be challenging and present hidden complications not seen in simpler systems.
  - Competing effects between interaction, moderation, and reflection
    - Characterization to any one given factor more difficult
    - Effects can lead to unanticipated trends in array systems

Introduction

- Investigating different modeling configurations is vital to ensuring subcritical configurations.
  - Also helps capture the peak reactivity of the system
- The reactivity differences in cylinder arrays with constant mass using three different modeling techniques is investigated herein.
- Outcome helps demonstrate the capabilities of stacking UF_6 cylinders – increased storage options, reduced storage footprint, thus reduced facility cost.

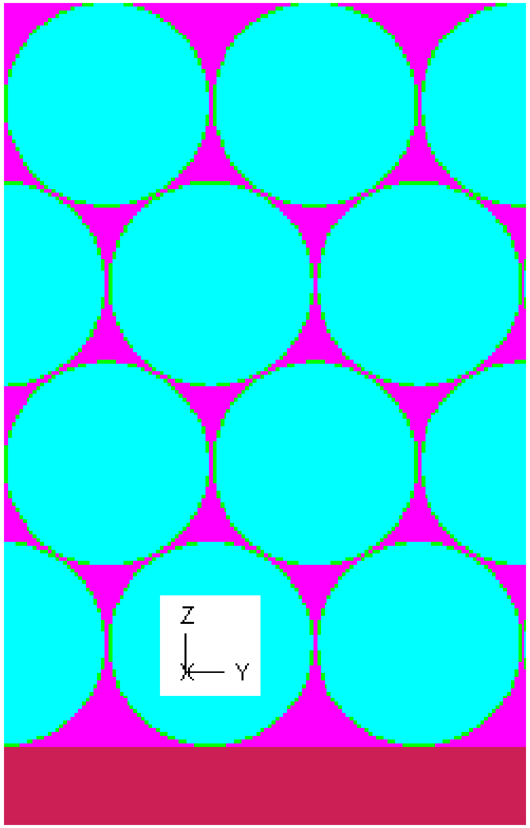
Methodology

- Monte Carlo computer code MONK8A along with JEF2.2 cross section library was utilized.
  - 30 skipped cycles; 1,000 active cycles; 4,000 neutrons per cycle; 0.0005 standard deviation
- 30B cylinders were modeled with the following dimensions:
  - Diameter = 30 in.; Length = 76 in.; Nominal wall thickness = 0.5 in.
- Cylinders filled with 2,300kg of UF_6 at 6 wt% with an H/U=0.088.

Methodology

- Various UF_6 fill geometries considered.
  - Completely filled cylinder (reduced density)
  - Normally filled cylinder – material in bottom of cylinder (density=5.075 g/cm^3)
  - Completely filled cylinder mixed with void space (density=5.075 g/cm^3)
- Cylinders evaluated in a semi-infinite (infinite x and y, four cylinders high in z) triangular pitch array.
  - Cylinder pitch inside array was varied between 0 and 20 cm
  - Mist density of 0.01 g/cm^3 surrounding array

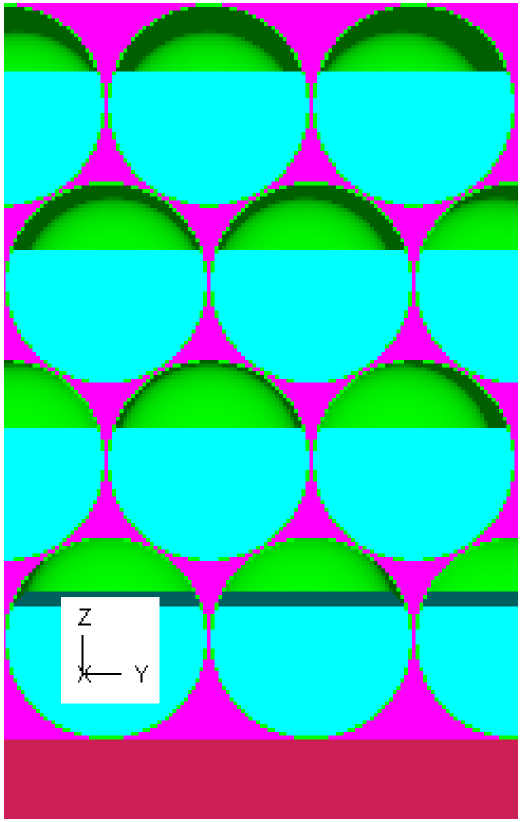
Modeling Scenarios



Completely Filled Cylinder Model

Scenario 1

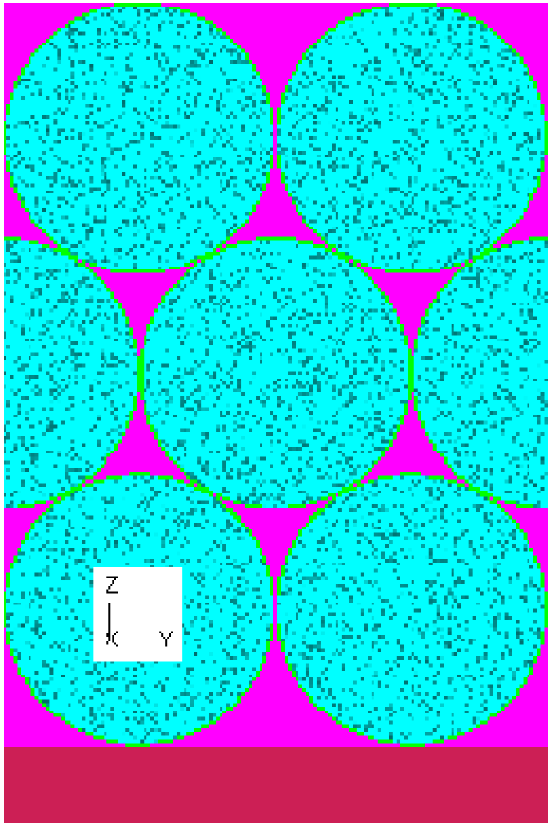
Bounding case for 30B cylinder arrays



Nominally Filled Cylinder Model

Scenario 2

Represents homogenization (after heating UF_6 cylinder)



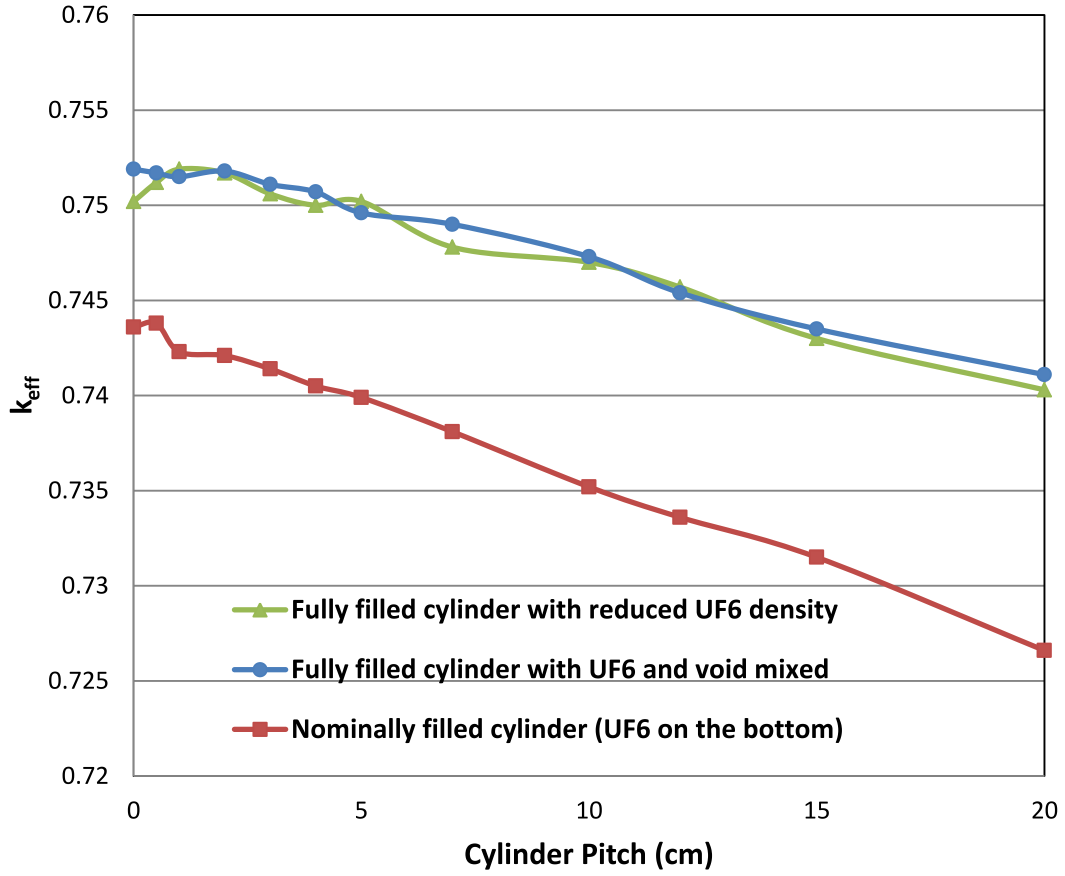
Completely Filled Cylinder Model with Void Space

Scenario 3

Test case

Results –30B Cylinder Array Models

Reactivity Results of Various UF_6 Cylinder Array Models
Mist Density of 0.01 g/cm³



Results

- Results indicate that Scenario 1 (completely filled cylinders) and Scenario 3 (completely filled cylinder; UF_6 mixed with void space) in an array configuration are statistically equivalent.
- Scenarios 1 and 3 produce higher reactivity compared to Scenario 2 (bottom filled cylinder).
  - Approximately Δk_{eff} = 0.008

Conclusions

- Three different modeling scenarios have been investigated:
  1. Completely filled cylinders with reduced density
  2. UF_6 on the bottom of cylinder at nominal density
  3. Completely filled cylinder mixed with void space at nominal density
- Highest reactivity of the 30B array system is produced when the UF_6 mass completely fills the cylinder (Scenarios 1 and 3).
  - Trend consistent with previous studies performed by ORNL (ORNL/TM-11947)
  - Additional studies performed by authors show that uniform, completely filled, modeling approach in an array configuration most reactive

Future Work

- Note that results herein are only for a cylinder fill mass of 2,300 kg (represents ANSI-N14.1 transportation fill limit) and one mist density/reflection condition.
  - Future work should determine if same trends exist with various mass and/or reflection conditions

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