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INVESTIGATION OF REACTIVITY DIFFERENCES IN UF_6 CYLINDER ARRAYS WITH DIFFERENT MASSES AT VARIOUS MIST CONDITIONS

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Introduction

- All systems must stay subcritical for the safe operation of a facility.
- Array configurations can be challenging and present hidden complications not seen in simpler systems.
  - Arrays can introduce competing effects
    - Effects can lead to unanticipated trends in array systems
- Factors influencing reactivity in UF_6 cylinder arrays include cylinder mass, cylinder pitch (interaction), moderation and reflection – specifically mist (water vapor) investigated.
- Reactivity differences in cylinder arrays investigated herein:
  - Function of mass and mist density with a fixed cylinder pitch
  - Function of cylinder pitch and mist density with fixed mass

Introduction/Purpose of Study

- Even though arrays of UF_6 product cylinders are known to remain subcritical provided material inside cylinder remains dry (i.e., un-moderated), at most facilities the UF_6 product cylinder arrays are not in a stacked configuration.
- The results presented herein help demonstrate capabilities of stacking UF_6 product cylinders in arrays inside or outside buildings.
  - Thus allowing facilities increased storage options, one of which is the ability to reduce facility's cylinder storage foot print, thereby reducing overall facility costs

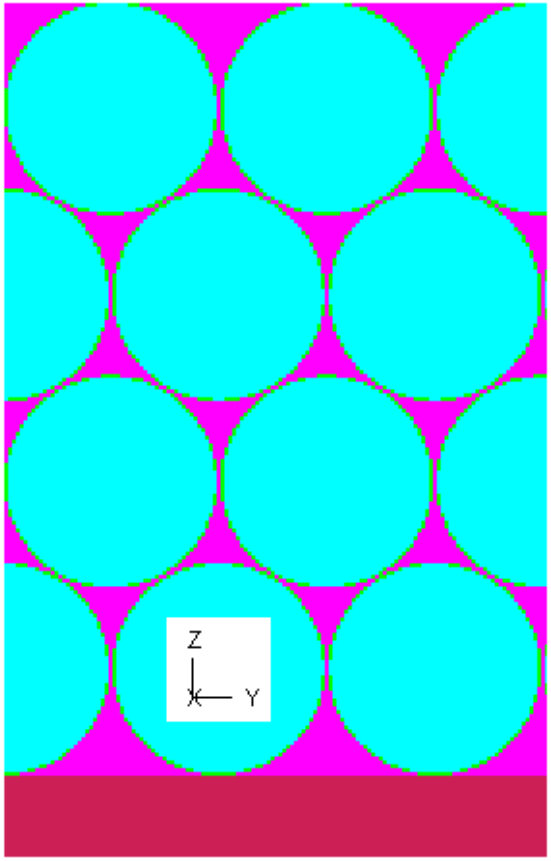
Methodology

- 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, 2,700kg, or 3,100kg of UF_6 at 6 wt% with an H/U=0.088.
  - 2,300 kg – represents ANSI-N14.1 transportation fill limit
  - 2,700 kg and 3,100 kg – represent overfill scenarios

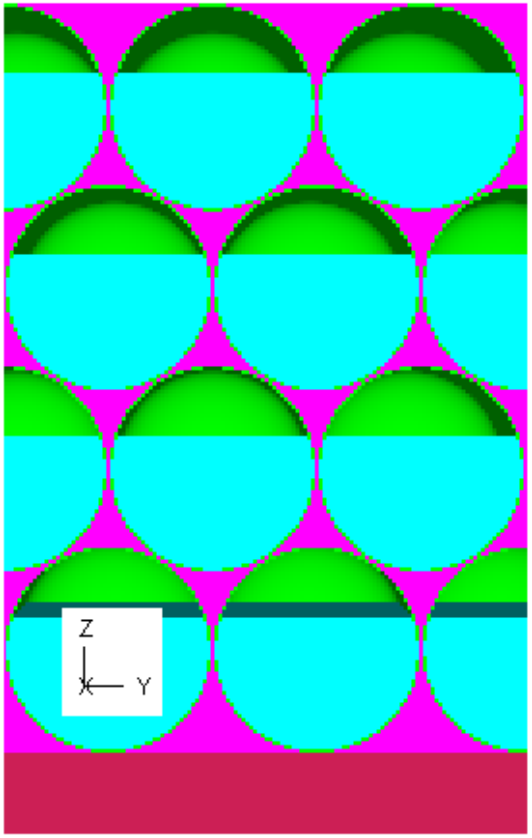
Methodology

- Two different modeling scenarios were considered:
  1. Completely filled cylinders with reduced density
  2. Nominally filled cylinders – material in bottom – with nominal density (5.075 g/cm^3)
     - Same mass between geometry configurations
- 30B cylinders evaluated in a semi-infinite (infinite x and y, four cylinders high in z) triangular pitch array configuration.
  - 1.0 cm cylinder pitch inside array
    - Cylinder pitch varied between 0.5 to 15 cm for fixed mass model test
  - Mist range of 0.001 to 1g/cm^3
  - One 30B cylinder modeled dry with optimally moderated UO_2F_2 sphere representing an upset condition

Modeling Scenarios



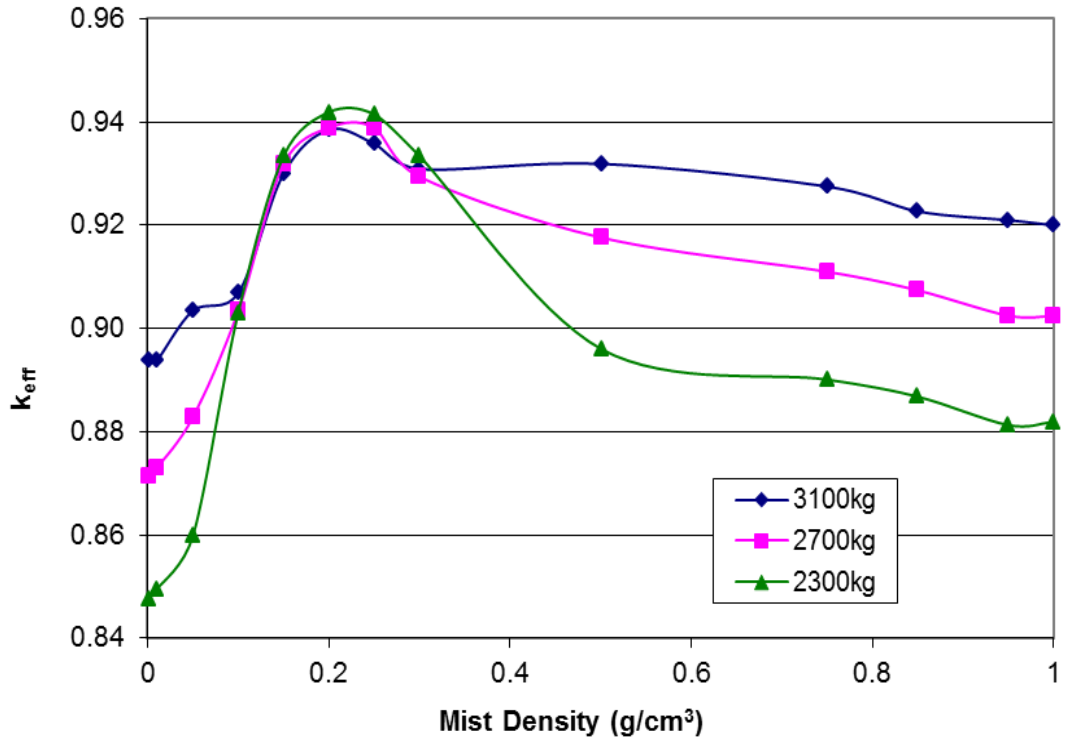
Completely Filled Cylinder Model



Nominally Filled Cylinder Model

Results – Filled 30B Cylinders

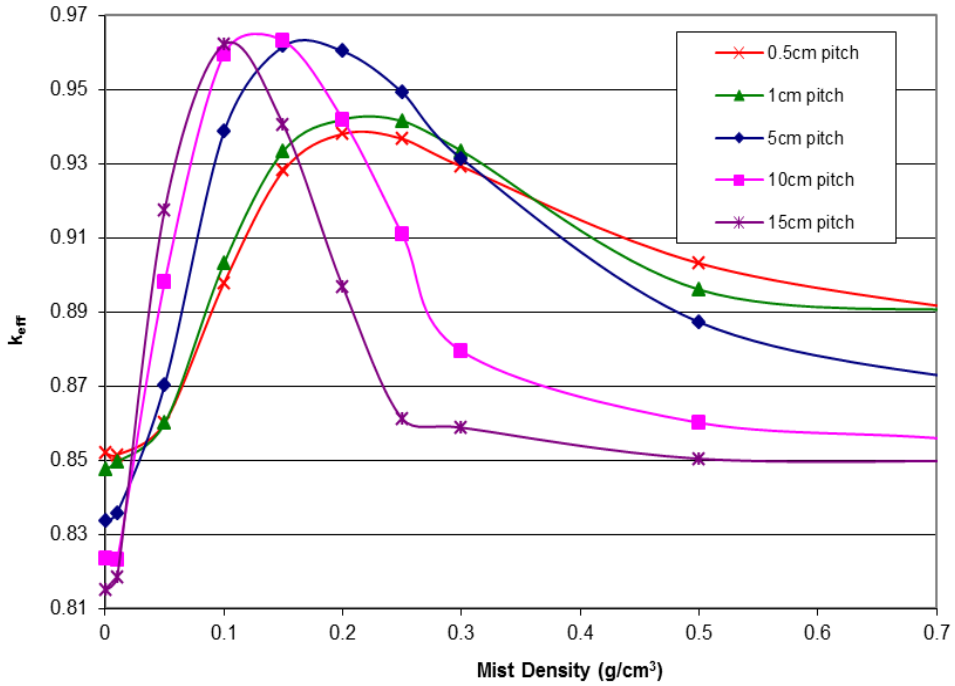
Reactivity Effects of Completely Filled 30B Cylinders with Varied UF_6 Masses as a Function of Water/Mist Density



- Note area of interest is between 0.1 – 0.3 g/cm^3

Results – Filled 30B Cylinders

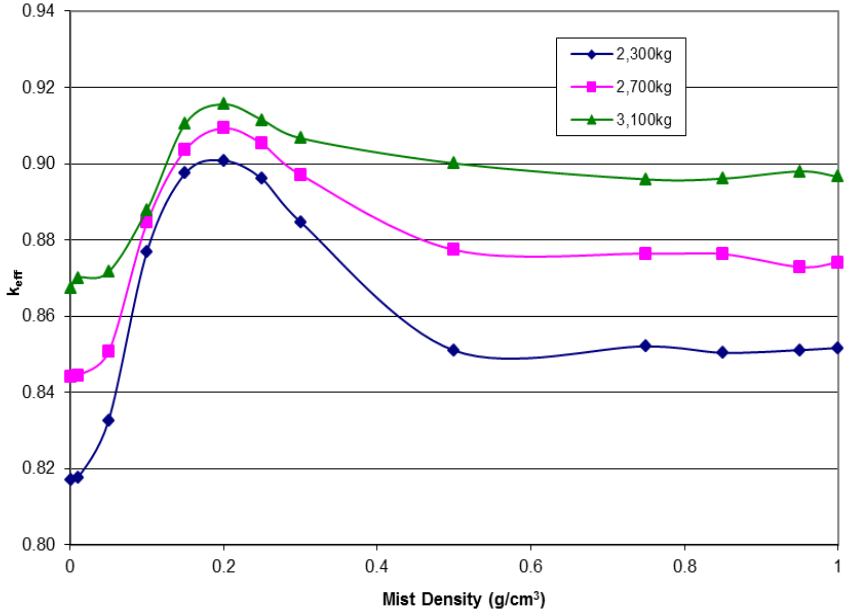
Reactivity Effects of Completely Filled 30B Cylinders with a Mass of 2,300 kg UF_6 and Varied Cylinder Pitch/Spacing Distance as a Function of Water/Mist Density



- Further investigation performed to evaluate any dependence on cylinder pitch/spacing
  - Pitch varied from 0.5 – 15 cm
  - Peak reactivity shifts to lower mist densities as pitch increases

Results – Partially Filled 30B Cylinders

Reactivity Effects of Partially Filled 30B Cylinders with Varied UF_6 Masses as a Function of Water/Mist Density



- Different fill heights to achieve same mass as in completely filled cylinder; nominal UF_6 density of 5.075 g/cm^3.
- Similar trends observed between completely filled cylinders and nominally/partially filled cylinders:
  - Higher mass generally yields higher reactivity
  - Peak reactivity occurs with mist densities between 0.1 – 0.3 g/cm^3

Conclusions

- Differences between fully filled cylinders and nominally filled 30B cylinders in an array configuration were investigated.
  - Important to model all aspects of array systems
    - Ensure effects from geometry, spacing, moderation/reflection conditions are captured
- Highest reactivity of 30B cylinder arrays produced when UF_6 mass modeled completely filling 30B cylinder compared to partially filled cylinder.
- Peak reactivity value as a function of mist density varied both in occurrence (i.e., mist density) and magnitude (i.e., k_{eff} value) depending on cylinder pitch inside array.

Acknowledgement

The authors wish to thank URENCO USA for their support in performing this work