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Title: Incidental Reflector Comparison of Containerized Dry Fire Extinguishing Agents

Author(s): Chapman, Bryan Scott
Wysong, Andrew Russell

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To: NCS File
Through: B. Greenfield, NCS, E585
From: A. Wysong, NCS, E585
From: B. Chapman, NCS, E585
Phone: 7-1711
Email: wysong@lanl.gov
Symbol: NCS-TECH-15-009
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1 Summary

This document addresses the incidental reflector reactivity worth of containerized fire extinguishing agents authorized for use in PF-4 at Los Alamos National Laboratory (LANL). The intent of the document is to analyze dry fire extinguishing agent that remains in a container and is not actively being used in a fire emergency. The incidental reflector reactivity worth is determined by comparison to various thicknesses of close fitting water reflection which is commonly used to bound incidental reflectors in criticality safety evaluations. The conclusion is that even in unlimited quantities, when containerized the authorized dry fire extinguishing agents are bound by 0.4 inches of close fitting water.

2 Material Compositions

The fire extinguishing agents analyzed and the composition modeled in MCNP6 are presented in Table 1 below.

Table 1 - Material Information

Material	Composition Weight Fraction (Atom Fraction)	Full Theoretical Density (g/cc)	Bulk Density (g/cc)	Cross Sections
Graphite Powders[1,2,3,4,5,6]	Carbon (1.0)	2.3	1.2	6000.80c grph.20t
Magnesium Oxide[7,8]	Magnesium (0.5) Oxygen (0.5)	3.58	1.9	8016.80c 12024.80c 12025.80c 12026.80c

Material	Composition Weight Fraction (Atom Fraction)		Full Theoretical Density (g/cc)	Bulk Density (g/cc)	Cross Sections
MET-L-X®9,10	Hydrogen Carbon Nitrogen Oxygen Sodium Magnesium Aluminum Silicon Chlorine	0.003 0.032 0.008 0.022 0.346 0.004 0.005 0.010 0.572	N/A	2.067	1001.80c 6000.80c 7014.80c 8016.80c 11023.80c 12024.80c 12025.80c 12026.80c 13027.80c 14028.80c 14029.80c 14030.80c 17035.80c 17037.80c poly.20t lwtr.20t
Water	Hydrogen Oxygen	(0.667) (0.333)	1.0	N/A	1001.80c 8016.80c lwtr.20t
Plutonium	^{239}Pu	(1.0)	19.84	N/A	94239.80c

3 Methodology

Three simple MCNP6 models were constructed to compare the reflection characteristics of the fire extinguishing agents with water. The fissile material considered in the model is a 4.5 kg Pu[0] cylinder with a height to diameter (H/D) ratio equal to 1.0. Material information from Table 1 was used in the models. The calculations were performed using MCNP6 Version 1.0 with ENDF/B-VII.1 (See Table 1) nuclear data on the Moonlight High Performance Computing cluster. This is a verified and validated computational method[11]. Determination of a USL is not considered in this document as it's purpose is to compare the reactivity effects of various reflectors on a Pu metal cylinder.

Table 2 below depicts the color scheme used in the models illustrated in Figures 1-3.

Table 2 – Model Illustration Color Legend

Material	Color
Plutonium	
Water	
Fire Extinguishing Agent	

Model #1 was used to calculate the reactivity based on close fitting water reflection of varying thickness as is shown in Figure 1 below. The reflection was varied from 0-2 inches and was modeled as a close-fitting layer around the Pu metal cylinder.

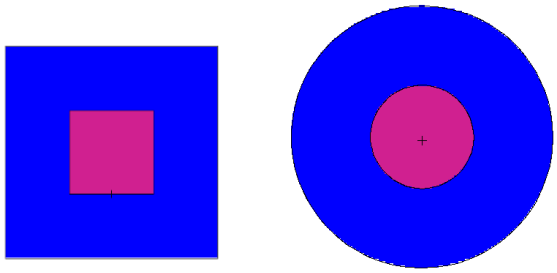

Figure 1 - MCNP6 Model #1 Geometry
Side View (left) & Top View (right)

Model #2 was developed to investigate having an impractically large amount of dry fire extinguishing agent in a single glovebox. The model places the Pu cylinder in contact with a 50 L, H/D=1 cylinder of the three dry fire fighting agents. This configuration is shown in Figure 2 below.

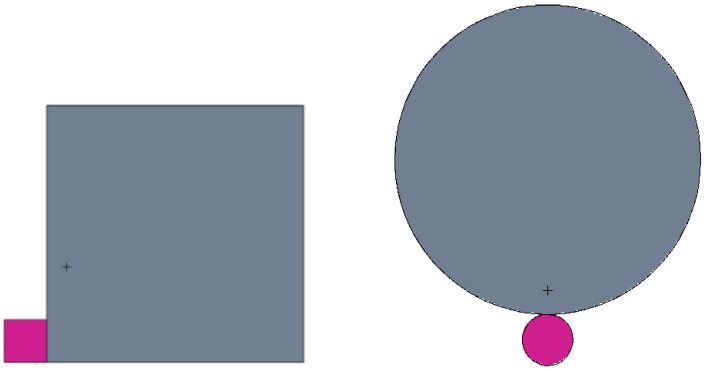

Figure 2 - MCNP6 Model #2 Geometry
Side View (left) & Top View (right)

Model #3 was developed to investigate having multiple small containers of dry fire extinguishing agent in a single glovebox which could allow for closer fitting reflection than one large single container. The model radially surrounds the Pu cylinder with four 1 L, H/D=1 cylinders which is the maximum number of the cylinders that can be physically be placed on contact with the Pu cylinder. This configuration is shown in Figure 3 below.

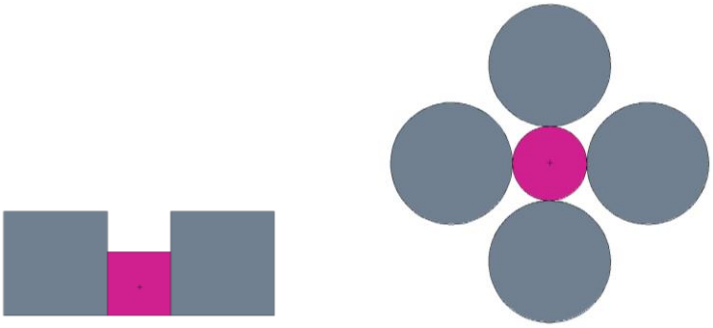

Figure 3 - MCNP6 Model #3 Geometry
Side View (left) & Top View (right)

4 Results

The results of the calculations are shown in Figure 4 and illustrate that the greatest reactivity is achieved when four 1 L containers are placed around the Pu cylinder (blue lines on plot). A single 50 L container placed in contact with the Pu cylinder is less reactive (red lines on plot). The maximum reactivity achieved from the three containerized dry fire extinguishing agents is bounded by a 0.4 inch layer of close fitting water.

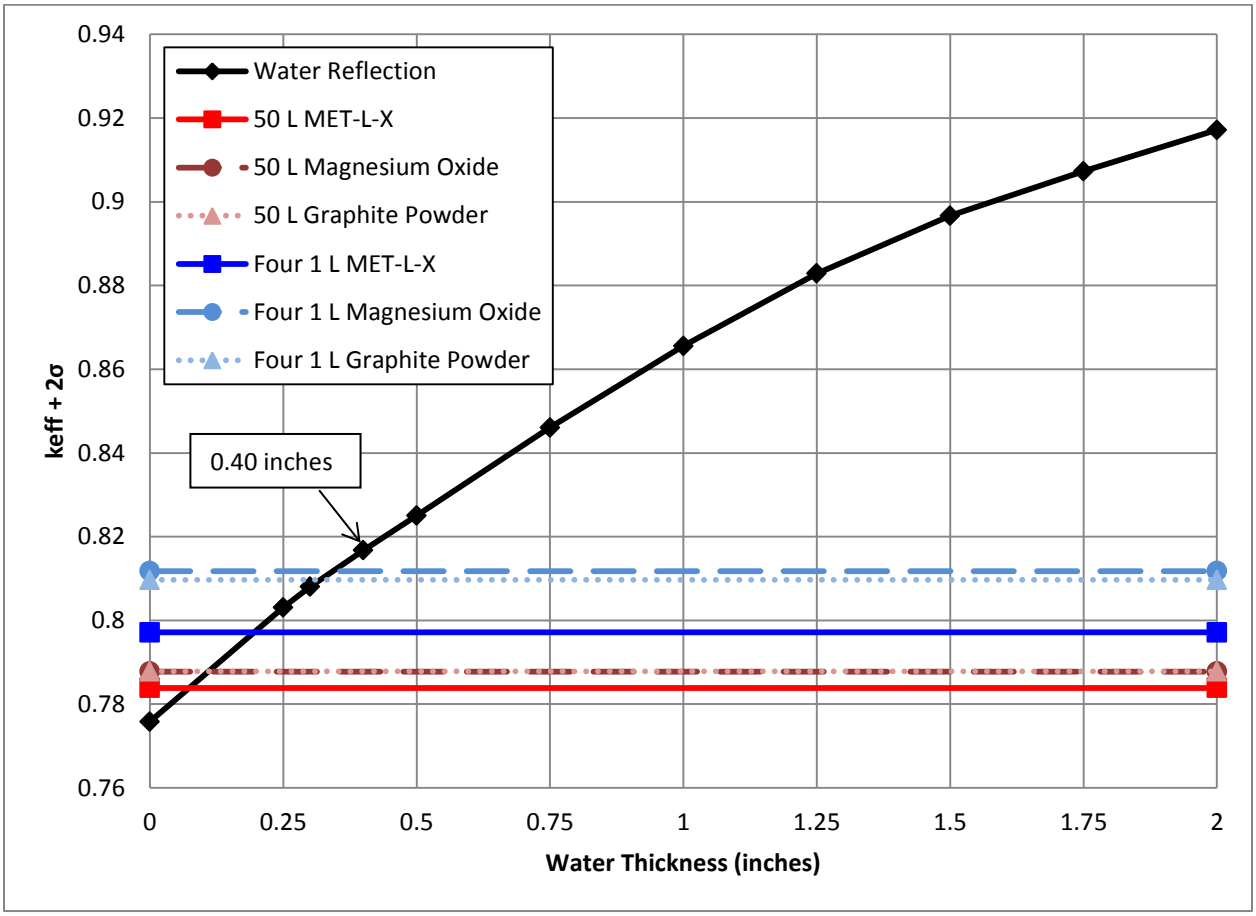

Figure 4 - MCNP6 Results of Containerized Fire Fighting Agent Comparison to Water

5 Conclusion

Based on the MCNP6 analysis performed, the reactivity increase from reflection of the three containerized fire extinguishing agents (graphite powder, magnesium oxide, or Met-L-X® are bound by a 0.4 inch thick layer of close fitting water reflection.

6 References

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