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Nuclear
Criticality
Safety Division

Document: NCS-TECH-23-014, R0

(U) Parametric Study for Glovebox Limit for Puck Pressing

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NCS-TECH-23-014, R0	See cover page	New document	New document

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1.0 SUMMARY

This document aims to demonstrate the results of various parametric studies which may be applied for gloveboxes whose primary purpose is puck pressing and metal cutting. It is the responsibility of any criticality safety analyst utilizing this study to ensure the applicability of the models presented to the scenario analyzed. This technical document is written according to the requirements of NCS-AP-005 [Ref. (1)].

The calculations and analysis within this technical document analyze the results of several conditions. Practical application of this study is at the discretion of the analyst and CSED writing team. Each model should be thoroughly considered to ensure it may be applied. Note that the un-containerized turnings are a subset of the bulk metal limit.

Several proposed limit sets are presented in Table 1 below. The parametric studies throughout the body of this document attempt to analyze these limit sets when under conditions anticipated at puck pressing locations.

Table 1. Proposed limit sets for parametric study.

Material Limits	
^{239}Pu in Metal (excluding pressed pucks)	≤4.0 kg
AND	
^{239}Pu in Pressed Metal Pucks	≤0.5 kg
Additional Restrictions	
• Uncontainerized ^{239}Pu metal turnings shall be ≤ 0.5 kg	
Material Limits	
^{239}Pu in Metal (excluding pressed pucks)	≤3.5 kg
AND	
^{239}Pu in Pressed Metal Pucks	≤2.0 kg
Additional Restrictions	
• Uncontainerized ^{239}Pu metal turnings shall be ≤ 0.5 kg	
Material Limits	
^{239}Pu in Metal (excluding pressed pucks)	≤3.0 kg
AND	
^{239}Pu in Pressed Metal Pucks	≤3.0 kg
Additional Restrictions	
• Uncontainerized ^{239}Pu metal turnings shall be ≤ 0.5 kg	

2.0 DESCRIPTION

The Nuclear Criticality Safety (NCS) Division aims to evaluate a broad range of activities to standardize the knowledge of gloveboxes. This study evaluates gloveboxes which house a puck press which is used in the compression of plutonium turnings, along with a manual stand cutter for metal cutting. While not the gloveboxes' primary purpose, fissionable material may also be stored within the glovebox as needed.

The evaluated data was derived from information modeled from a machining room which is equipped with an overhead water-based fire suppression system, and fissionable material may be conveyed outside of the glovebox line. This evaluation bounds the evaluated space within the glovebox and is not inclusive of the transition piece, as the transition piece is greater than 6 inches long and thus neutronically isolates the glovebox from the trunk line.

The glovebox's environment is inert and maintains negative pressure to prevent spontaneous combustion as ^{239}Pu is pyrophoric. Various facility systems are plumbed to it, including Zone 1 ventilation, house dry vacuum, and nitrogen. There are no connected water lines.

3.0 METHODOLOGY

MCNP6 calculations were performed using ENDF B/VII cross section sets on the high-performance computing cluster Blowfish, with code and validation information as stated in NCS-TECH-21-001 [Ref. (2)].

Although this document is not a CSE, it aims to support future documents which compare the reactivity of various configurations against an upper subcritical limit. As such a USL is considered for future use. The USL is derived from the validation for Pu, the calculations may be considered subcritical if:

$$k_{eff} = k_{calc} + 2\sigma \ \leq 0.970 - AoA$$

As seen below from the comparison of the Area of Applicability (AoA) to the modeled parameters within these parametric studies, there is no need for an additional AoA margin. This is a direct result of the parameters falling within the margin. Thus, the USL is considered 0.97.

Materials are modeled according to the definitions of NCS-TECH-18-024 [Ref. (3)]. A comparison of the areas of applicability defined in NCS-TECH-15-005 [Ref. (4)] and the calculations reported herein are presented in Table 2.

Table 2. Validation Area of Applicability

Parameter	Validation AoA	Calculation AoA
Fissile Material	^{239}Pu	^{239}Pu
Fissile Material Form	Pu Metal, PuO_2, & $Pu(NO_3)_4$	*Pu Metal*
$H/^{239}Pu$	$0 \leq H/^{239}Pu \leq 2807$	$0 \leq H/^{239}Pu \leq 104$
Average Neutron Energy Causing Fission (MeV)	$0 \leq ANECF \leq 1.935$	$0.371 \leq ANECF \leq 1.83$
^{240}Pu	$0 \leq {}^{240}Pu \leq 42.9wt\%$	$0\ wt\%\ {}^{240}Pu$
Moderating Materials	*none, water, graphite, polystrene*	*water*
Reflecting Materials	*none, water, steel, oil, Plexiglass, Polyethylene, graphite, W, Cu, U Th, Al, Ni, Fe, Pb, Cd, Mo, Be, BeO*	*water, steel, Be*
Other Materials	*Concrete, PVC, Ga, B, Gd, Ta*	*concrete*
Geometry	*cylinder array, cylinder, slab, sphere, hemisphere, cuboid, stacked discs, annular*	*cylinder*

3.1 Material Definitions

Materials are defined according to NCS-TECH-18-024 [Ref. (3)]. The following were used in the calculations:

- Plutonium metal
- Beryllium metal
- Water
- Stainless steel 304
- PF-4 concrete

The density of the Pu metal in pressed pucks is less than that of solid metal. In dry conditions that highest density will be most reactive. For calculations with flooding, a homogenous Pu metal-water mixture of varying concentration was used. The concentration was varied based on varying Pu metal density in pucks and in turnings.

3.2 MCNP Calculations

At least 10,000 neutrons per cycle, and at least 200 active cycles were used for each reported result. The convergence of the fission source was verified via Shannon entropy test and relevant statistical checks.

4.0 ANALYSIS

The following parametric studies consider various configurations that may be anticipated to support both normal and abnormal conditions analysis. The analyses cover a broad scope of considerations for this and other similar locations. Appropriate recommendations and criticality safety controls may be derived from the analyses.

4.1 Base Model

A model was constructed which is based on the normal operation of puck pressing to study the effect of mass on reactivity. It serves as a base for all other variations in credible abnormal conditions. In this model two cylinders of ^{239}Pu are modeled; the plutonium metal turnings are modeled as full density metal while the plutonium pressed pucks are modeled at 10 g/cm^3. The pressed pucks produced vary in density from 3 g/cm^3 to 10 g/cm^3 PT-2-20-35 [Ref. (4)]. However, under normal and dry conditions the highest density will be most reactive thus for all dry conditions only the 10 g/cm^3 was modeled. Dry/unmoderated turnings are bounded by considerations for metal. If moderation beyond limited volumes of maintenance fluids is not credible, turnings may simply be analyzed as metal per NCS-TECH-21-001 [Ref. (2)]

The glovebox floors, ceilings, and side walls are constructed with 3/16” thick stainless steel. There are false floors (1/4” thick steel) which are used for convenience in housekeeping and in placing items.

Present in the glove box is a metal cutter attached to a metal base such that it is free-standing. Its use is to manually reduce metal size and is represented below in Figure 1.

Figure 1. Representative metal cutter present in the glovebox.

To facilitate puck pressing within the glovebox, an electric pump powered puck press is present alongside a half-gallon oil reservoir. The puck press is not secured to any one place in the glovebox, and if needed, the press can be operated manually. The diameter of the tube where the turnings are placed is ~2.95”. The tube walls are stainless steel, ¼” thick. The puck press within the glovebox is represented in Figure 2 below.

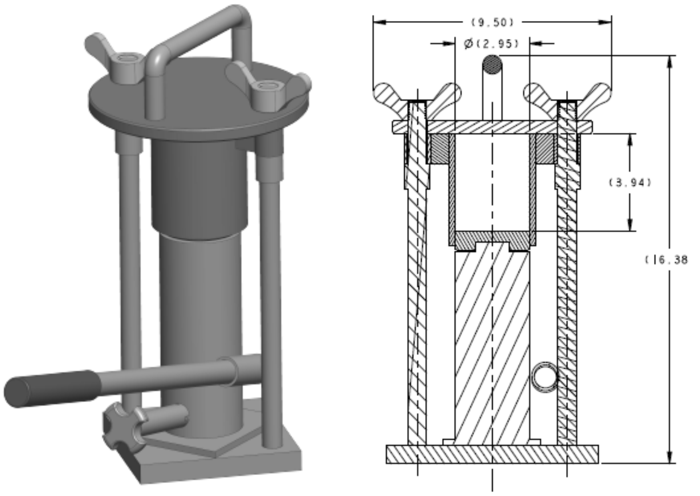

Figure 2 . Representative puck press present in the glovebox.

The glovebox floor, windows, tools, containers, machinery, bottles of cleaning fluid, firefighting agents, the oil reservoir for the pump, and any other item present, such as items stored in the subfloor, all act as incidental neutron reflectors. This also includes operators’ hands during handling. This reflection can adequately be represented by 1 cm of tight-fitting, contiguous water around the fissionable material, per NCS-TECH-19-021 [Ref (5)], provided any large reflectors are explicitly accounted for. The puck press tube, where turnings are placed to be compressed, is made of ¼” (0.635 cm) stainless steel. There is also a drill press in the glovebox that is no longer used. Being large and firmly secured, it will not be removed at this time. Although not active, the drill press is still considered in the analysis as it is a thick neutron reflector. The drill press is ~2” steel, and there is no restriction against placing fissionable material on it. To be conservative, the drill press is modeled as 3” thick with a radius of 50 cm.

To evaluate varied amounts of pucks and arrangements the height to diameter ratio was varied.

For a single 4.5 kg metal ingot of density 19.84 g/cm^3 adjacent to 3.0 kg of pressed pucks of density 10 g/cm^3, with incidental neutron reflection the highest reactivity occurred at k_{eff} = 0.871 with a mass ratio of 4.5/3.0 kg of ^{239}Pu metal turnings to ^{239}Pu metal pucks. This configuration is shown in Figure 3 below; red is full density ^{239}Pu metal, green is the pressed pucks, gray is steel, and blue is water, representing incidental reflection. This color arrangement holds for all future figures. To increase conservatism the drill press is modeled as 4″ thick. The k_{eff} is plotted as a function of both the height to diameter ratio and the mass ratio for the bulk metal to pressed pucks.

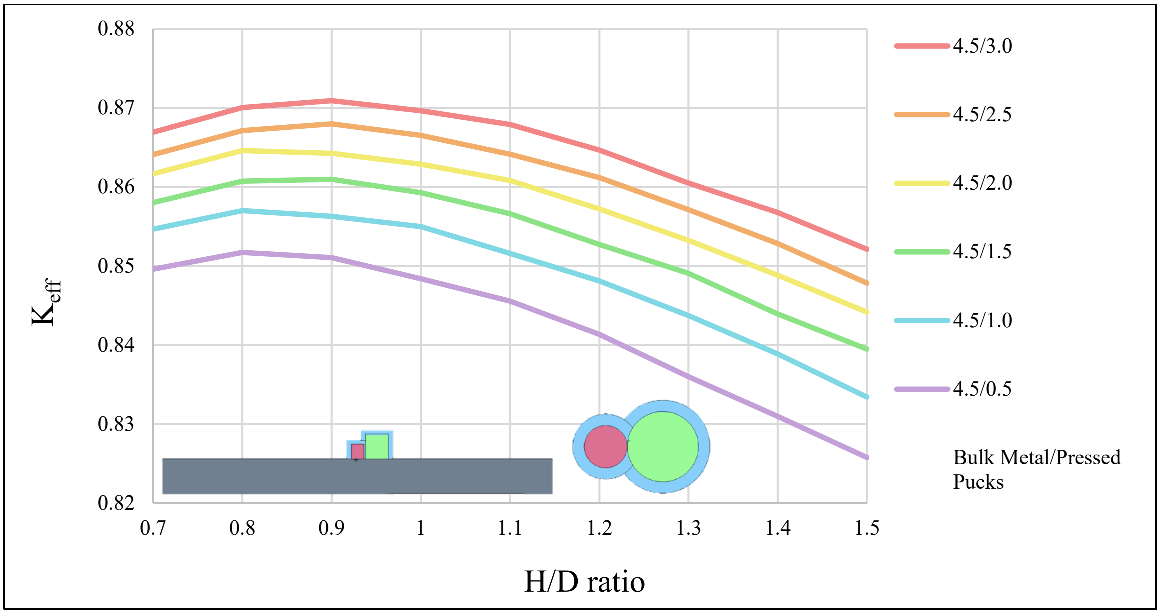

Figure 3. Keff for normal conditions without shielding as a function of the H/D ratio.

Since container shielding of up to ¾ ″ is permitted by PA-RD-01009 [Ref. (6)], it was modeled to determine its effect on reactivity. The model is equivalent to the previous normal condition apart from an additional steel shielding component displayed in grey and modeled around the ^{239}Pu metal turnings and ^{239}Pu metal pucks. To increase conservatism the drill press is modeled as 4″ thick. An evaluation of the results leads to the determination that the addition of shielding for the normal condition increases reactivity by 0.02 with the peak $k_{eff} = 0.893$ occurring at a mass ratio of 4.5/3.0 kg of ^{239}Pu metal turnings to ^{239}Pu metal pucks with a H/D = 0.9 as shown in Figure 4.

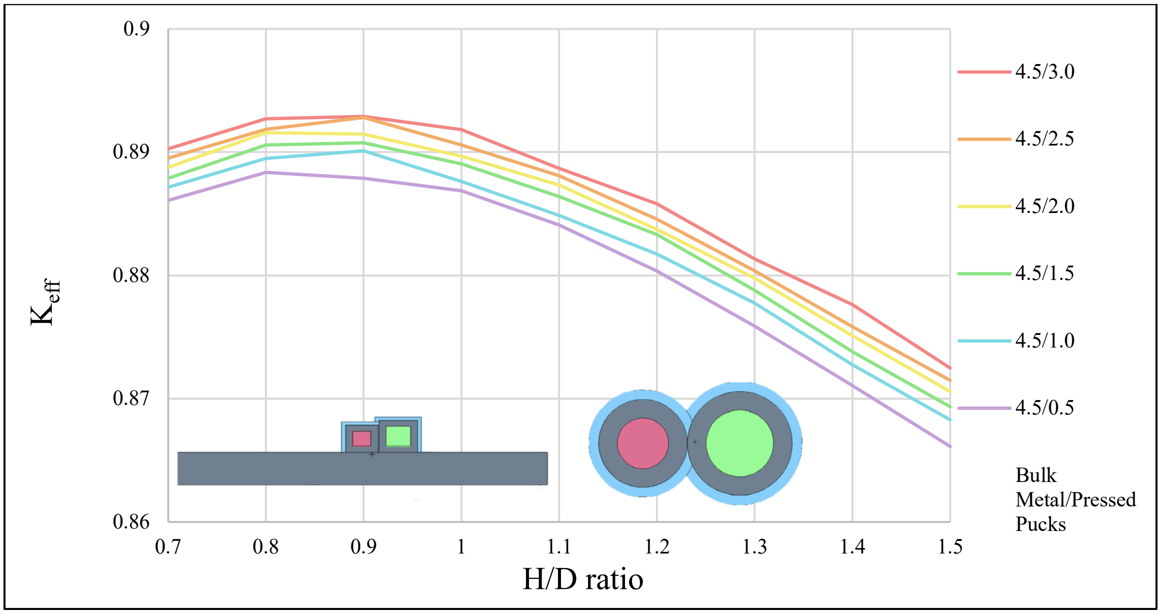

Figure 4. Keff for normal conditions with shielding as a function of the H/D ratio.

4.2 Leak of Water Through Zone 1 Ventilation

Water has previously entered gloveboxes through Zone 1 ventilation. However, ingress of water to gloveboxes via Zone 1 ventilation is no longer credible per NCS-TECH-21-001 [Ref. (2)].

4.3 Overmass Analysis for a 3.0 Kg Double Batch

A parametric study was performed to analyze potential mass configurations during an overmass upset condition. This model considered an additional 3.0 kg of ^{239}Pu metal. Since the density of ^{239}Pu metal varies within the box due to the presence of pressed pucks, the additional mass is modeled as full density metal to bound both turnings and pressed pucks. The model is derived from the normal condition with the addition of the overmass modeled as a singular cylinder with a varying H/D ratio. The placement of the overmass was dictated by the law of cosines. By holding both puck and bulk metal location constant the ideal location for peak reactivity could be calculated. The law of cosines was utilized to place the upset metal item so that it was in contact with both the pressed pucks and bulk metal. Models were created both with and without shielding to determine the effect shielding may have on the system's reactivity. The results are modeled below in Figure 5 and Figure 6, without and with shielding respectively.

The model's calculated reactivity peaked at $k_{eff} = 0.967$ for the system modeled without shielding. It can be inferred from the graphs that any mass ratio beneath a mass ratio of 4.5/3.0 kg of ^{239}Pu metal turnings to ^{239}Pu metal pucks, in dry conditions will be less reactive. Thus, lower mass ratios are not presented. In the models below the previous color arrangement holds however the upset item is modeled as the purple cylinder.

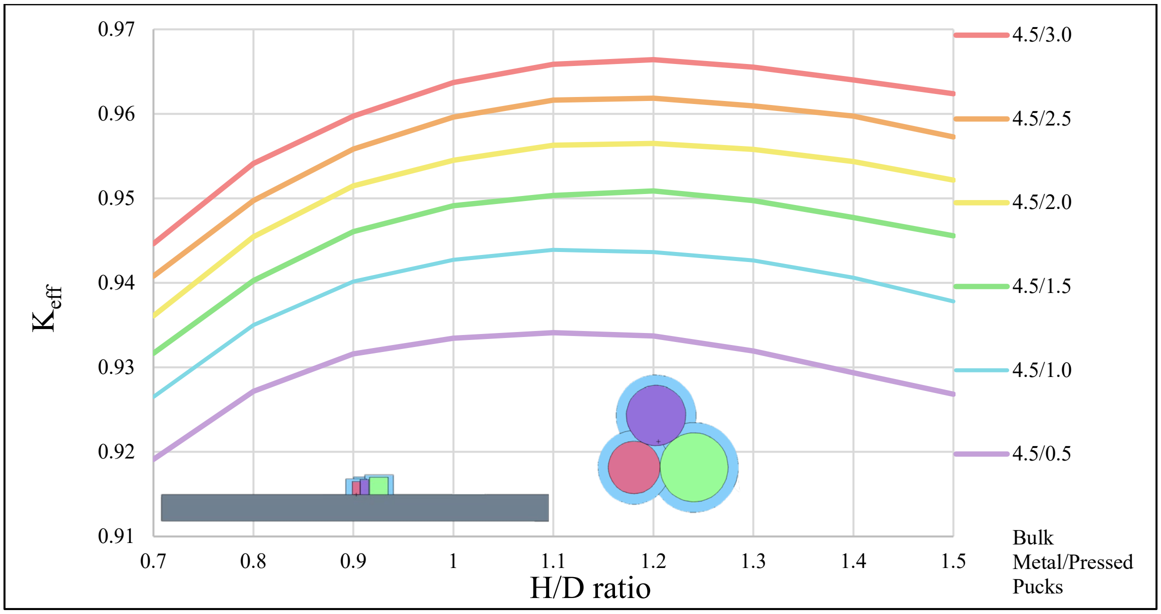

Figure 5. K_{eff} for a 3.0 kg double batch without shielding as a function of the H/D ratio.

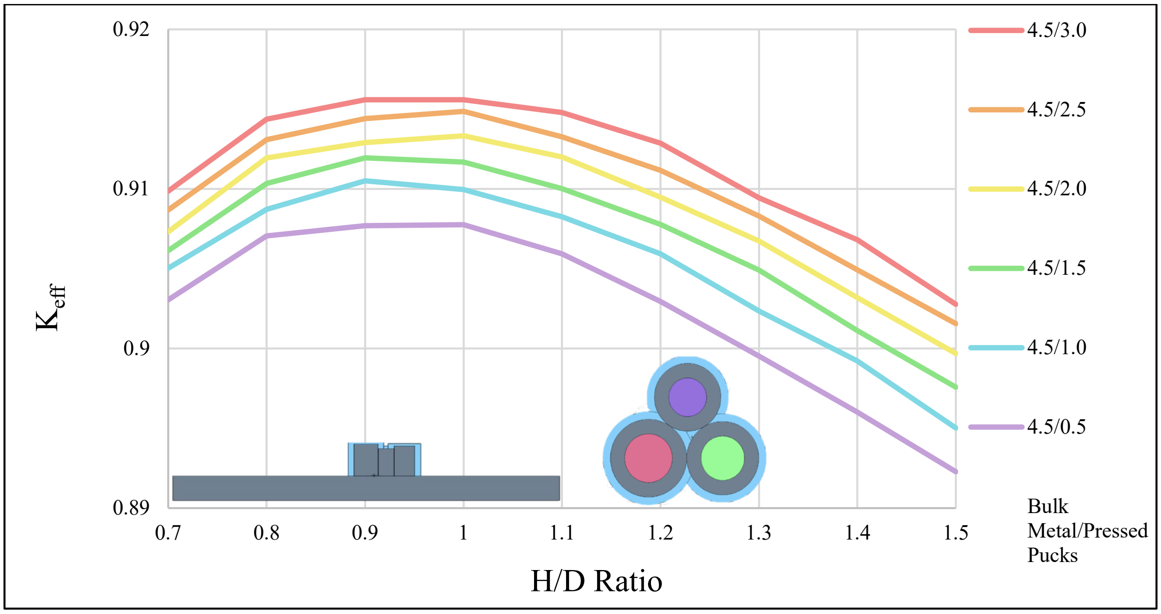

Figure 6. K_{eff} for a 3.0 kg double batch with shielding as a function of the H/D ratio.

Analysis of the calculational results indicates that the presence of shielding decreases reactivity for this upset condition which contrasts the normal condition results. This results from the interaction differences between the normal and credible abnormal condition. The normal condition's only interaction is between one full density ^{239}Pu ingot, and one stack of pressed pucks at 10 g/cm^3. Whereas the interactions caused by the 3.0 kg upset condition include one extra full theoretical density metal item. These results show that between two full density ingots, the decreased interaction provided by shielding has more of an effect that the increased reflection on individual items. The model's calculated reactivity peaked at $k_{eff} = 0.916$ for the system modeled with shielding of ¾″. It can be inferred from the graphs that any mass ratio beneath a mass ratio of 4.5/3.0 kg of ^{239}Pu metal turnings to ^{239}Pu metal pucks, in dry conditions will be less reactive. Thus, lower mass ratios are not presented.

4.4 Overmass Analysis for a 4.5 Kg Double Batch with Spacer

A parametric study was performed to analyze potential mass configurations during an overmass upset condition. This model considered an additional 4.5 kg ingot of ^{239}Pu metal and spacer. The model is derived from the normal condition with the addition of the overmass modeled as a singular cylinder with a varying H/D ratio and considered to be full density ^{239}Pu. Per PA-RD-01009 [Ref (6)] a 1 cm spacer is required for the transport of collections of Pu in metal greater than 3 kg. The spacer was modeled as a void surrounding the circumference of ingot. The placement of the overmass was dictated by the law of cosines to determine the ideal location for peak reactivity. Models were created both with and without shielding to determine the effect shielding may have on the system's reactivity. The results are modeled below in Figure 7 and Figure 8, without and with shielding respectively. Peak reactivity occurs at a mass ratio of 4.5/3.0 kg of ^{239}Pu metal turnings to ^{239}Pu metal pucks where $k_{eff} = 0.961$. Calculated k_{eff} for the study displays reactivity is heavily dependent on mass. It can be inferred that any mass combination below 4.5/3.0 kg of ^{239}Pu metal turnings to ^{239}Pu metal pucks in dry conditions will be less reactive. In the model below the previous color arrangement holds however the ^{239}Pu ingot item is modeled as the purple cylinder. Also, a spacer modeled as a void solely in the radial direction as required by NCS-TECH-21-001 [Ref (2)]. To increase conservatism the drill press is modeled as 4″ thick.

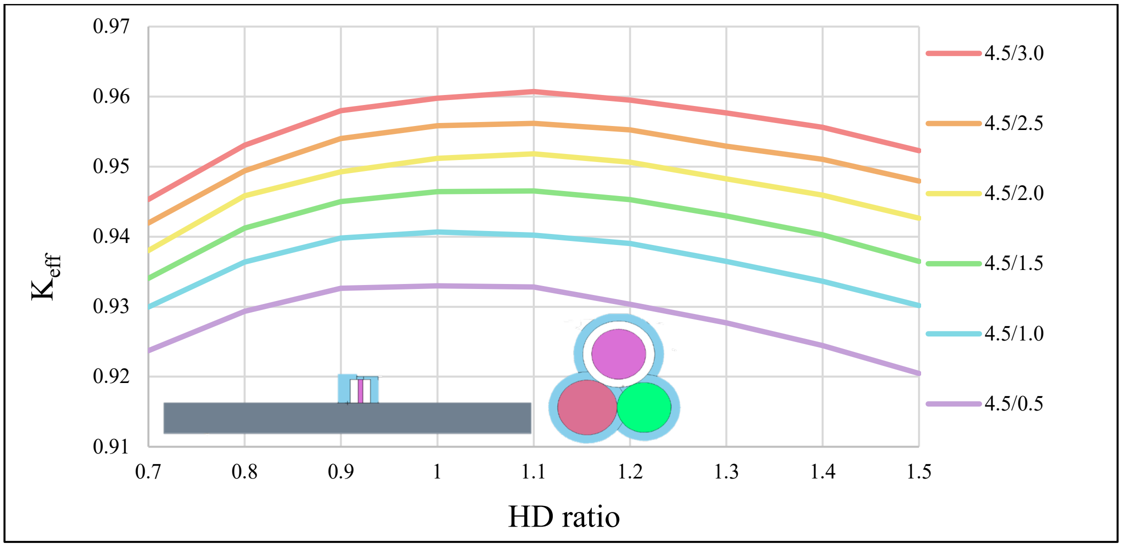

Figure 7. K_{eff} for a 4.5 kg double batch without shielding as a function of the H/D ratio.

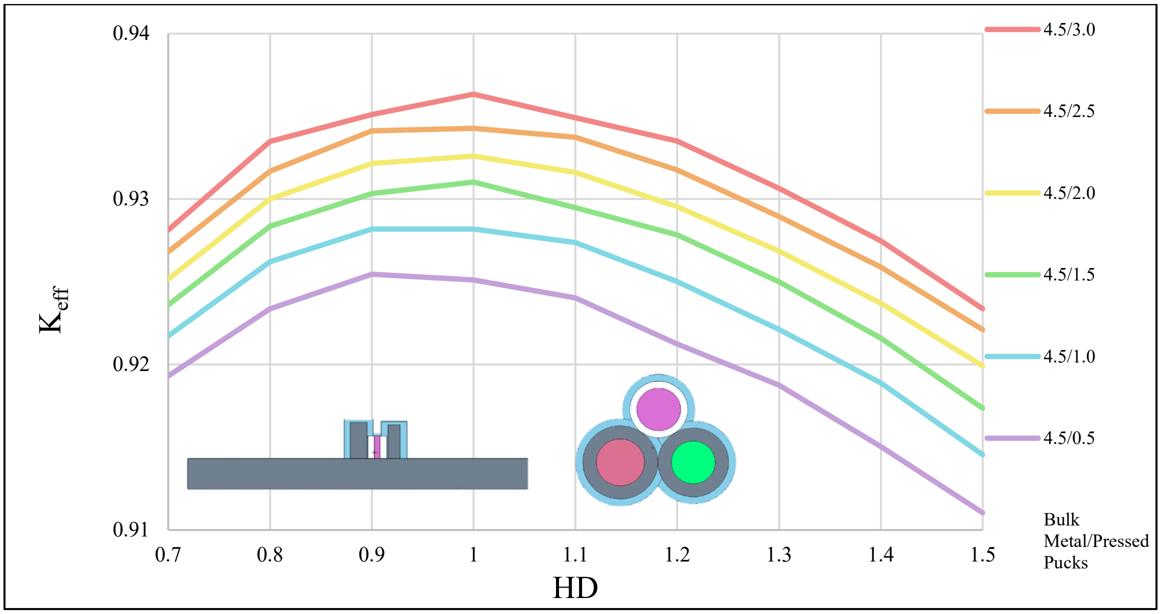

Figure 8 Keff for a 4.5 kg double batch with shielding as a function of the H/D ratio.

Analysis of the calculational results indicates that the presence of shielding decreases reactivity for this upset condition which contrasts the normal condition results. This results from the interaction differences between the normal and credible abnormal condition. The normal condition's only interaction is between one full density ^{239}Pu ingot, and one stack of pressed pucks at 10 g/cm^3. Whereas the interactions caused by the upset condition include one extra full theoretical density metal item. These results show that between two full density ingots, the decreased interaction provided by shielding has more of an effect that the increased reflection on individual items. The effect is opposite when the pressed pucks are an interacting item. The model's calculated reactivity peaked at $k_{eff} = 0.937$ for the system modeled with shielding as seen in Figure 8. It can be inferred from Figure 7 and Figure 8 that any mass ratio beneath a mass ratio of 4.5/3.0 kg of ^{239}Pu metal turnings to ^{239}Pu metal pucks, in dry conditions will be less reactive. Thus, lower mass ratios are not presented.

4.5 Overmass Analysis for a 6.0 Kg Hemishell

A parametric study was performed to analyze potential mass configurations during an overmass upset condition. This model considered an additional 6.0 kg of ^{239}Pu metal in the form of a hemishell. The model is derived from the normal condition with the addition of the overmass modeled as a hemishell with a varying H/D ratio and is modeled at full density. The placement of the overmass was dictated by the law of cosines to determine the ideal location for peak reactivity. The effect of beryllium cladding was assessed upon reactivity. The study determined that 2-cm of cladding was most reactive and modeled the upset condition consistently with 2-cm of cladding throughout. The effect of beryllium cladding peaked at $k_{eff} = 0.967$ as seen in Figure 9. In the model below the previous color arrangement holds however the ^{239}Pu hemishell item is modeled as the purple hemisphere. In the figures below cladding is modeled as brown.

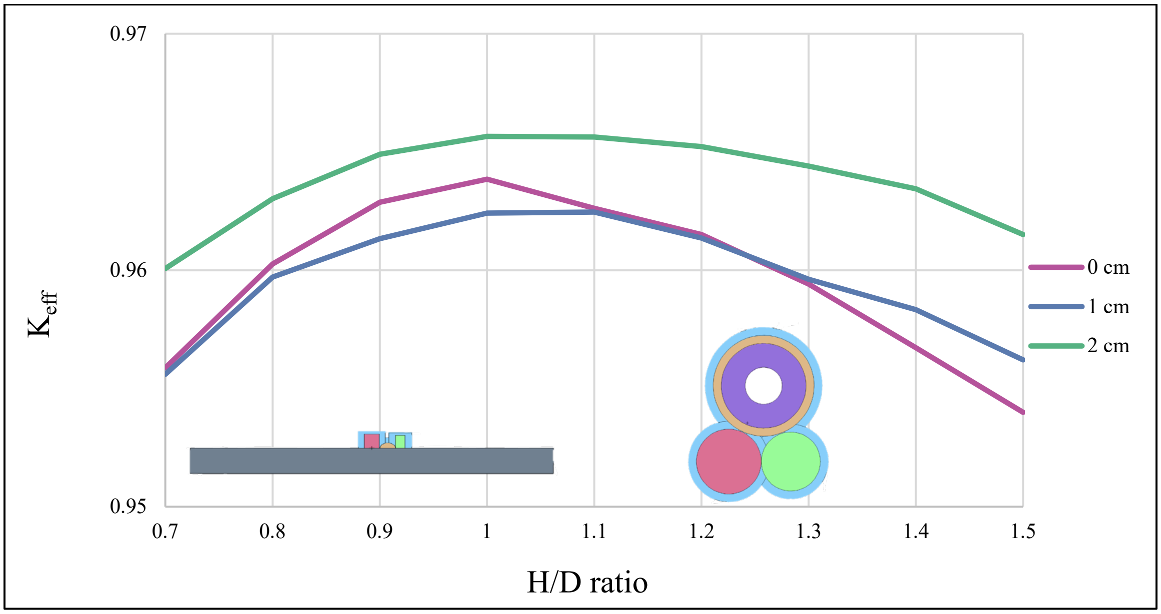

Figure 9. Cladding's affect on K_{eff} as a function of the H/D ratio.

Models were created both with and without shielding to determine the effect shielding may have on the system's reactivity. The results are modeled below in Figure 10 and Figure 11, without and with shielding respectively. Peak reactivity occurs at a mass ratio of 4.5/3.0 kg of ^{239}Pu metal turnings to ^{239}Pu metal pucks where $k_{eff} = 0.967$. It can also be inferred that any mass combination below 4.5/3.0 kg of ^{239}Pu metal turnings to ^{239}Pu metal pucks in dry conditions will be less reactive, thus is not presented. In the figures below cladding is modeled as brown.

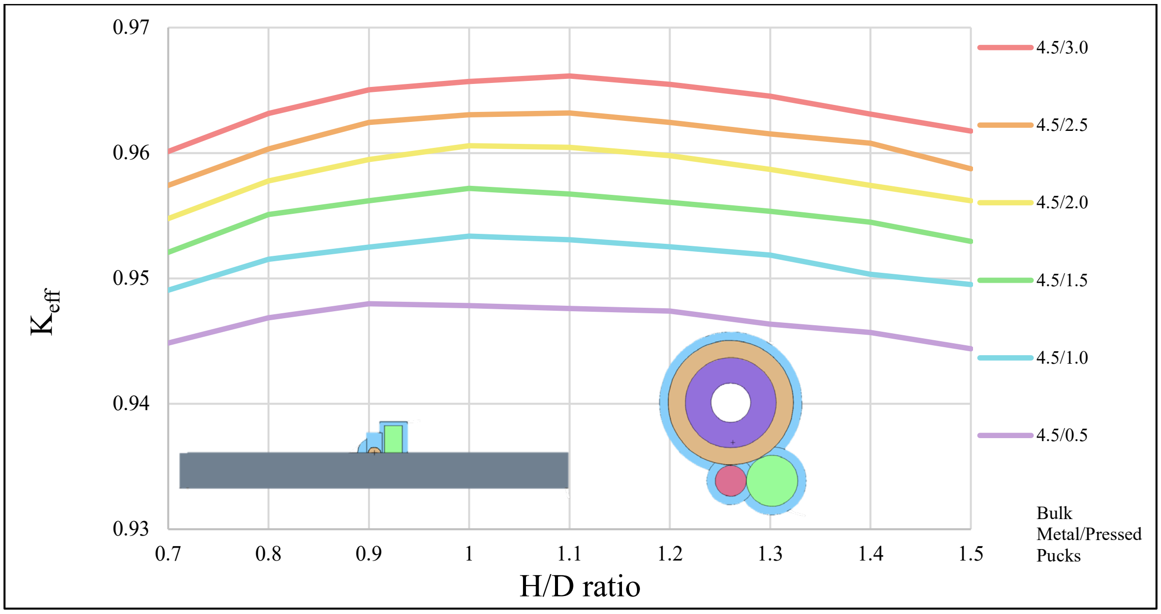

Figure 10. K_{eff} for a 6.0 kg Hemishell overmass without shielding as a function of the H/D ratio.

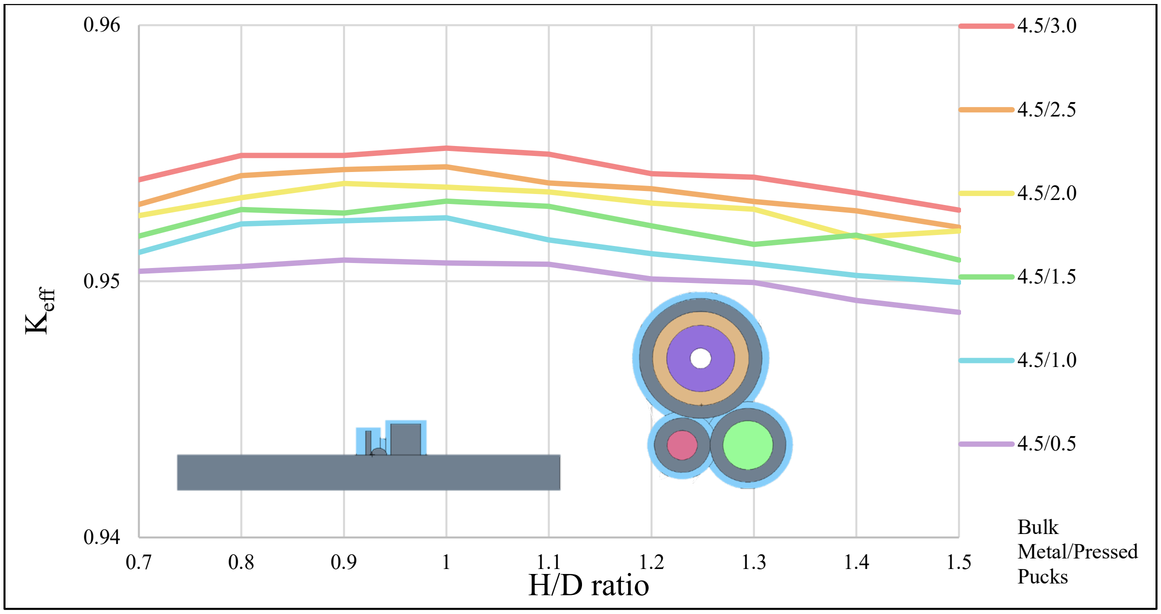

Figure 11. K_{eff} for a 6.0 kg Hemishell overmass with shielding as a function of the H/D ratio.

Analysis of the calculational results indicates that the presence of shielding decreases reactivity for this upset condition which contrasts the normal condition results. This results from the interaction differences between the normal and credible abnormal condition. The normal condition's only interaction is between one full density ^{239}Pu ingot, and one stack of pressed pucks at 10 g/cm^3. Whereas the interactions caused by the 3.0 kg upset condition include one extra full theoretical density metal item. These results show that between two full density ingots, the decreased interaction provided by shielding has more of an effect that the increased reflection on individual items. The model's calculated reactivity peaked at k_{eff} = 0.956 for the system modeled with shielding seen in Figure 11. It can be inferred from the graphs that any mass ratio beneath a mass ratio of 4.5/3.0 kg of ^{239}Pu metal turnings to ^{239}Pu metal pucks, in dry conditions will be less reactive. Thus, lower mass ratios are not presented.

4.6 Design Basis Events

4.6.1 Seismic event with Water Ingress into Box

A parametric study was performed to analyze potential mass configurations during a design basis upset. For a glovebox which not seismically stable, it is assumed to topple to the floor during a seismic event. Should this occur it is also assumed that the windows break as a result. If the seismic event also causes nearby pipes to break, a volume of water to If the seismic event also causes nearby pipes to break, a volume of water to a depth of 4.45″ could then ingress into the glovebox. This flood depth was determined with reference to the anticipated location of puck pressing operations and with reference to NCS-TECH-21-003 [Ref. (7)]. This study does not evaluate other depths of water accumulation.

As this upset addresses the influence of water on reactivity, density is varied. The calculations for this upset vary the density of the pucks from 3-10 g/cm^3 per NCS-TECH-15-024 [Ref. (8)]. Due to the presence of significant interstitial moderation, resulting from room and glovebox flooding, the most reactive puck density is unknown. The overall reactivity of the system is greatly dependent on the effective concentration of the SNM. Additionally, 0.5 kg of un-containerized turnings were explicitly modeled under seismic flooding conditions to account for the increased reactivity that can be anticipated to result from un-containerized material readily intermixing with water.

In situations where turnings can become moderated through normal or upset conditions, the fissionable material should be analyzed as being homogenized into a metal+moderator "solution" mixture. For unconstrained turnings, fissionable metal concentrations ranging from 0.252 – 0.42 g/cm^3 (252 – 420 g/L) should be analyzed based on the turnings packing experiments in LA-UR-16-28017 [Ref. (9)]. For constrained (containerized) moderated turnings, the same reference states that an effective metal density of up to 0.5 g/cm^3 (500 g/L) can be reached for a given limited volume, and thus should be analyzed.

While the loose turnings could take any number of shapes, here, they are modeled as a cylinder whose H/D ratio is varied and which surrounds the pucks and portions of the bulk metal. Modeling the turnings as a cylinder which encompasses the remaining fissionable material increases neutron interaction between the other cylindrical items and addresses the possibility of the uncontainerized turnings forming a mound surrounding the ^{239}Pu pressed pucks and ^{239}Pu bulk metal. The concrete is modeled as 30" thick, which is essentially infinite. The water is modeled as an x-plane with a height of 4.45″ per NCS-TECH-21-003 [Ref. (7)].

The parametric study evaluated several mass ratios all of which varied greatly in reactivity. These results are presented below. It is of note that any mass ratio over 4.0/3.0 kg of ^{239}Pu metal turnings to ^{239}Pu metal pucks is not evaluated in this study. While any mass ratio under 4.0/3.0 kg of ^{239}Pu metal turnings to ^{239}Pu metal pucks is evaluated in this study not all graphs are presented. It is of note that a majority of the cases for any ratio involving 4.0 kg of ^{239}Pu metal turnings resulted in a k_{eff} above the USL and thus the only ratios presented are the highest mass ratio, Figure 12, and the first one whose calculations yielded a k_{eff} under the USL, Figure 13. This occurred at a mass ratio of 4.0/0.5 kg of ^{239}Pu metal turnings to ^{239}Pu metal pucks where peak reactivity remained under the USL at k_{eff} = 0.964, as seen in Figure 13.

In the model below the previous color arrangement holds however the 0.5 kg of containerized ^{239}Pu turnings modeled as homogenous mixture of ^{239}Pu and water is modeled as the purple cylinder which completely encompasses the pressed pucks and partially encompasses the bulk metal turnings. For conservatism and to comply with the conservation of mass, the volume of the cylinder of containerized tunings always considers the entire volume of both the ^{239}Pu pucks and bulk metal turnings. In the figures below, cement is modeled as a brown cylinder.

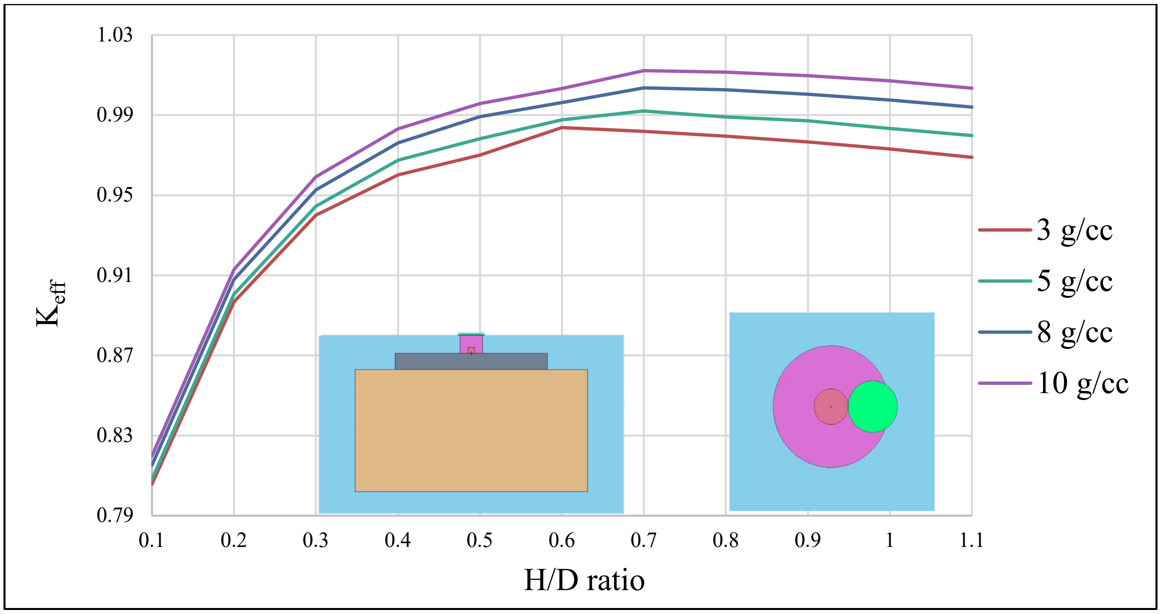

Figure 12. K_{eff} vs H/D ratio at varied density given 4.0kg of Bulk Metal Turnings (500 g un-containerized) and 3.0kg of Pressed Pucks.

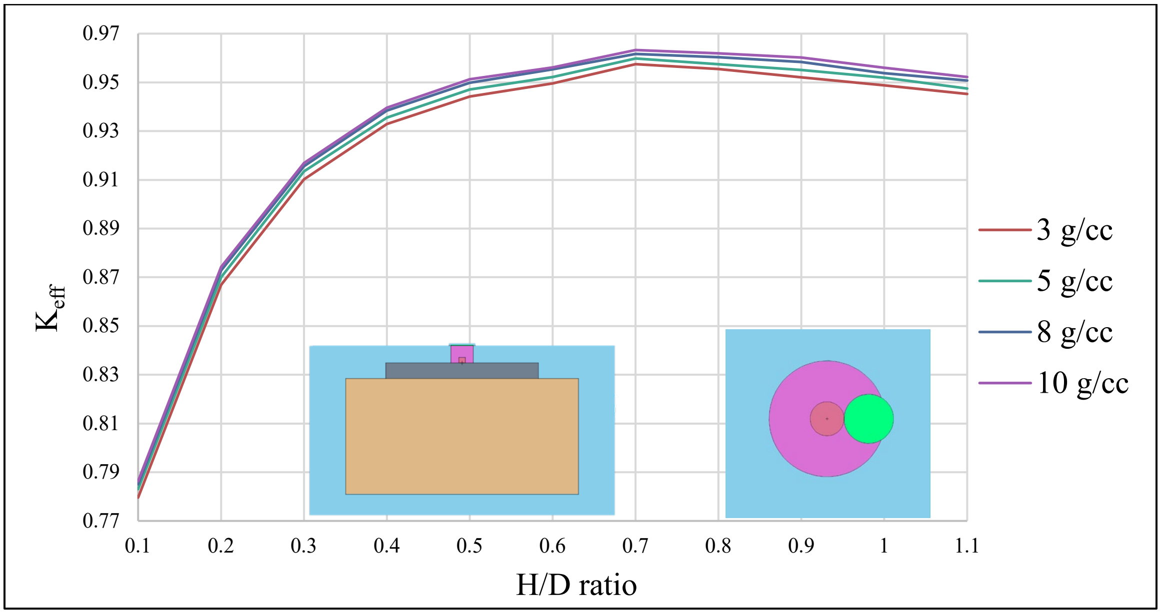

Figure 13. K_{eff} vs H/D ratio at varied density given 4.0kg of Bulk Metal Turnings (500 g un-containerized) and 0.5kg of Pressed Pucks.

For mass ratios of 3.5 kg of ^{239}Pu metal turnings, several of the cases resulted in a k_{eff} above the USL. Thus the only ratios presented are the highest mass ratio, Figure 14, and the first ratio whose calculations yielded a k_{eff} under the USL, Figure 15. This occurred at a mass ratio of 3.5/2.0 kg of ^{239}Pu metal turnings to ^{239}Pu metal pucks where peak reactivity remained under the USL at $k_{eff} = 0.968$, as seen in Figure 15. Subsequently, any mass ratios beneath 3.5/2.0 kg of ^{239}Pu metal turnings to ^{239}Pu metal pucks also fell beneath the USL.

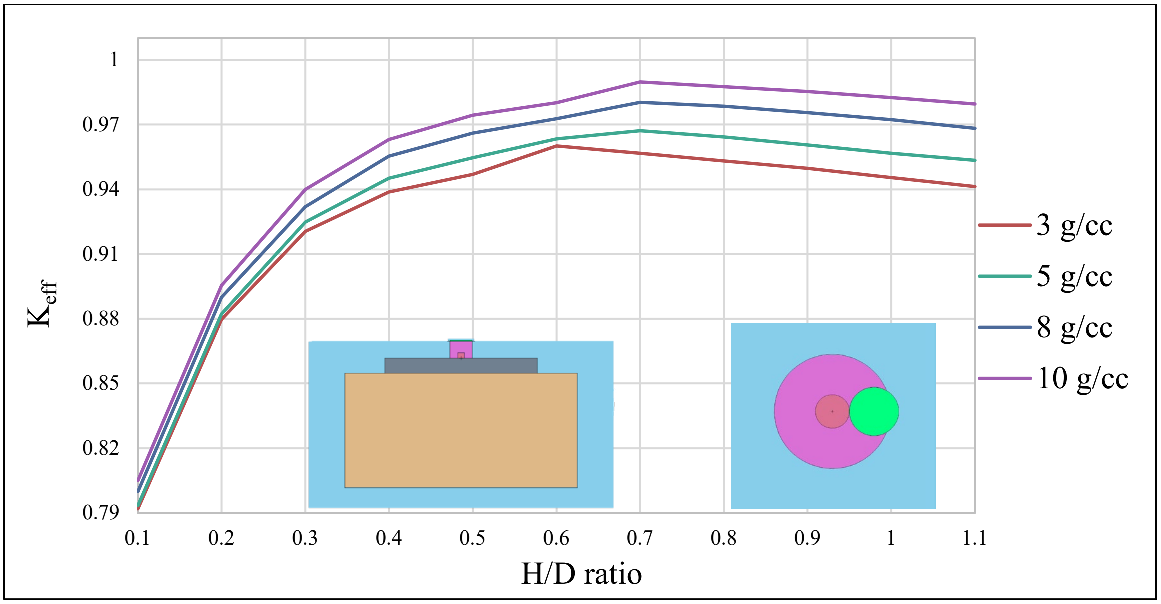

Figure 14. K_{eff} vs H/D ratio at varied density given 3.5kg of Bulk Metal Turnings (500 g un-containerized) and 3.0kg of Pressed Pucks.

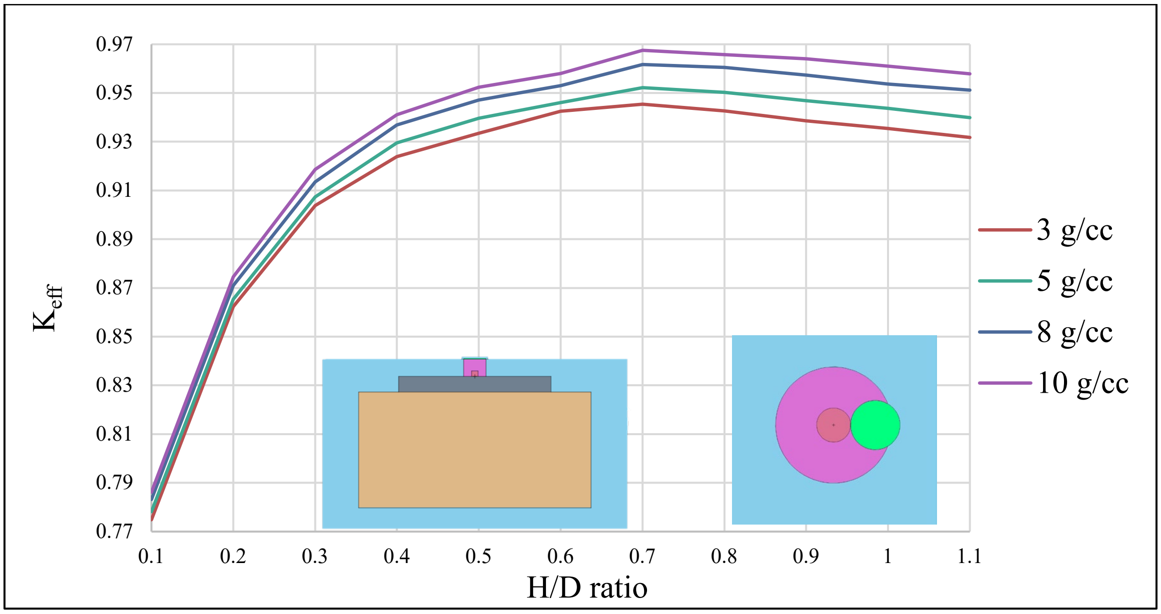

Figure 15. K_{eff} vs H/D ratio at varied density given 3.5kg of Bulk Metal Turnings (500 g un-containerized) and 2.0kg of Pressed Pucks.

For mass ratios of 3.0 kg of ^{239}Pu metal turnings all the cases resulted in a k_{eff} below the USL. Thus, the only ratio presented is the highest mass ratio, Figure 16. Peak reactivity remained under the USL at k_{eff} = 0.967, as seen in Figure 16.

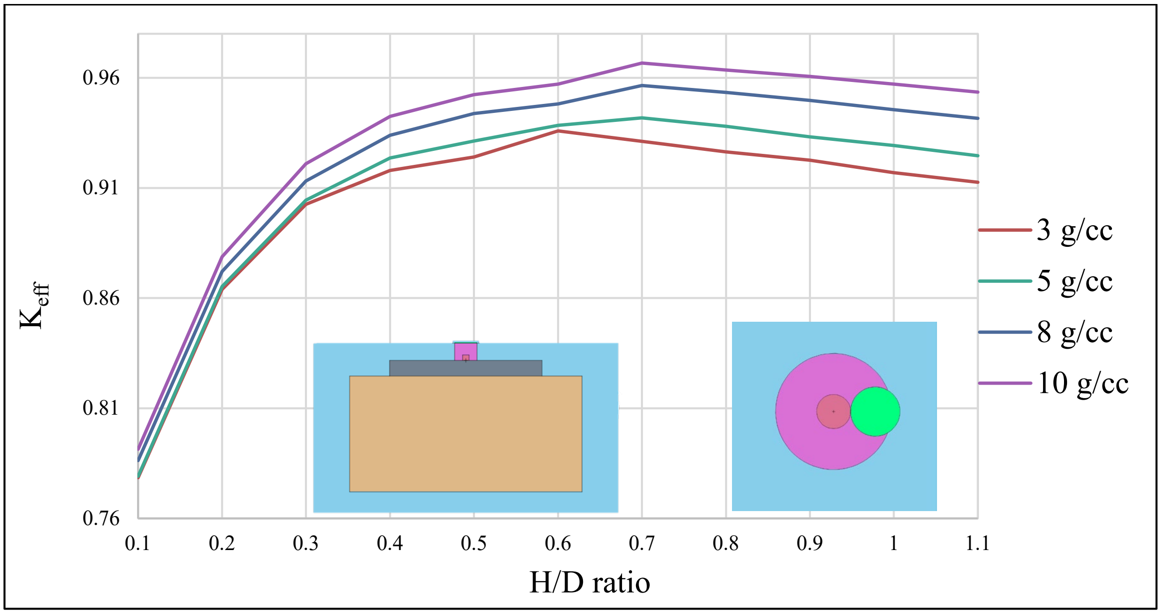

Figure 16. K_{eff} vs H/D ratio at varied density given 3.0kg of Bulk Metal Turnings (500 g un-containerized) and 3.0kg of Pressed Pucks.

While a container of fissionable material may have shielded around it, thus study considers that shielding would only serve to separate the fissionable material from each other decreasing reactivity. This would differ from dry conditions as it would be without the same increase in reactivity that is found in normal dry conditions.

4.6.2 Fire Event with Subsequent Introduction of Water

4.6.2.1 Fire External to the Glovebox

There are two types of fires to consider. The first is a fire external to the glovebox. Room fires affecting fissionable operations within gloveboxes through water intrusion due to glove burning are discussed in the PF-4 DSA, Table 4-29 [Ref. (10)]. For glovebox locations where the normal working level is at standard height, the DSA determined that the fire progression and water intrusion will be limited to < 2 gallons for a two-hour fire event. Further, the DSA discusses that such a low volume and the physical realities of the water spray impinging upon an open glove port will limit the water to collection on the floor of the glovebox; preferential collection in containers of fissionable material is not realistic and such collection in containers will be incidental and therefore insufficient to create a moderation or reflection state capable of achieving criticality.

4.6.2.2 Fire Internal to the Glovebox with Dry Firefighting Agent Applied

It is credible, that a fire initiates in the glovebox, which may then require the use of dry firefighting agents to extinguish. This is unlikely because facility practices greatly reduce the likelihood of a fire starting in a glovebox. NCS-TECH-14-027 [Ref. (10)] compares several dry fire extinguishing agents where it is shown that water is bounding of all of them as a reflector. Therefore, this upset is bounded by the analysis for full water flooding in Section 4.6.1.

5.0 CONCLUSION

This document shows a series of parametric studies which may be applied to allow for new mass limits to be enacted at applicable locations. Practical application of this analysis is at the discretion of the analyst. The analyst should specifically analyze the credible upsets to ensure the applicability of the models utilized in these parametric studies prior to applying them to any location within LANL facilities.

6.0 REFERENCES

1. **NCS-AP-005, R2.** *Technical Documents.*
2. **NCS-TECH-21-001, R3.** *Criticality Safety General Techincal Bases and Guidance.*
3. **NCS-TECH-18-024, R2.** *Materials Definitions Library for Criticality Safety Calculations.*
4. **NCS-TECH-15-005.** *Validation of MCNP6 Version 1.0 with the ENDF/B.VII.1 Cross Section Library for Plutonium Metals, Oxides, and Solutions on the High Performance Computing Platform Moonlight.*
5. **NCS-TECH-19-021.** *Incidental Reflection as Applicable to Criticality Safety.*
6. **PA-RD-01009, R15.** *TA55 Criticality Safety Requirements.*
7. **NCS-TECH-21-003, R0.** *Documentation and Analysis of Credible Water Accumulation Depth in PF-4 Lab Rooms.*
8. **NCS-TECH-15-024.** *Parametric Studies of Plutonium Metal, Compounds, and Mixtures.*
9. **LA-UR-16-28017.** *Density of Plutonium Turnings Generated from Machining Activities.*
10. **NCS-TECH-14-027.** *Reflector Worth of Dry Chemical and Powder Fire Extinguishing Agents.*