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Title: Importance of Plutonium Turnings in Criticality Safety

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Importance of Plutonium Turnings in Criticality Safety

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INTRODUCTION

In criticality safety, turnings are a concern due to the fact that they leave interstitial space in which a moderator can ingress and reduce the critical mass for a fissile material. As turnings are produced when a Plutonium (Pu) items are machined, they are commonly encountered in facilities that process Pu. The intent of this paper is to establish minimum subcritical mass data points for Pu turnings based on the minimum density achievable as measured in a turnings experiment performed at Los Alamos National Laboratory (LANL) [1]. Further discussion will cover the implications of these results with concern to criticality safety during normal operations and during a glovebox fire scenario.

SUMMARY

The experiment in Reference 1 was performed in order to determine the density of birds-nest turnings produced during the machining of a Pu part. The density of these birds-nest turnings is of import as they are the least dense material build-up when machining a part and thereby having the greatest space for allowed moderator.

Our study is aimed at taking the results of the turnings experiment and determining the location of the birds-nest density on the LA-10860-MS [2] Pu Spherical Critical Mass curve. This study will be conducted with moderation by water and by hydrogenous oil since machining is often performed with oil as a cutting fluid.

The results of this study will be used to provide criticality safety guidance in evaluations for operations involving turnings in situations of loss of moderator control.

RESULTS

The results of the study show that a bare homogeneous Pu turnings (at 0.252 kg/L) and water mixture has a spherical critical mass of 3.80 kg, while the fully water reflected spherical critical mass of the same Pu turnings and water mixture has a critical mass of 1.65 kg. These results have been superimposed on Figure 31 from LA-10860 [2] with green dots and shown in Figure 1.

When mixed with an idealized hydrocarbon oil rather than water, the spherical critical mass is reduced. In this case, the bare critical mass of the homogeneous Pu turnings and oil mixture is 2.57 kg while the fully water reflected spherical critical mass of the Pu turnings and oil mixture is 1.17 kg. These results are superimposed on Figure 31 from LA-10860 [2] with red dots and are also shown in Figure 1.

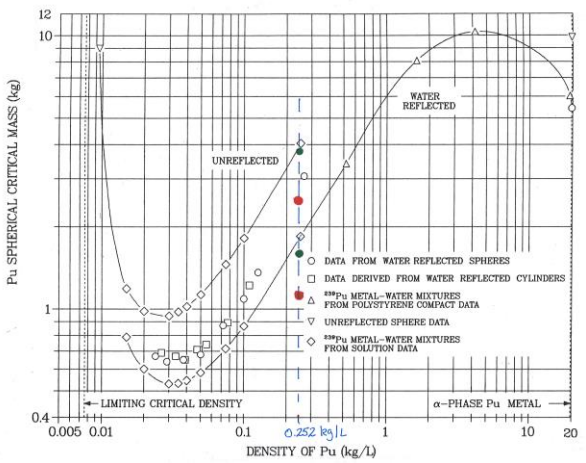

Fig. 1. LA-10860 Figure 31 superimposed with results from this study.

The results of this study show that up to approximately 1000 g of Pu turnings even if mixed with an ideal hydrocarbon and flooded would not be a criticality concern during firefighting activities.

REFERENCES

1. J.R. GONZALES, D.M. VIGIL, T.A. JACHIMOWSKI, G.J. ARELLANO, "Turnings Experiment, TA-55," LA-UR-15-21077, LANL (2015)

2. H.C. PAXTON, N.L. PRUVOST, "Critical Dimensions of Systems Containing ^{235}U, ^{238}Pu, and ^{233}U", LA-10860-MS, LANL (1986)