Critical Mass Experiment Using U-235 Foils and Lucite Plates

By

Rene Sanchez, Ken Butterfield, Robert Kimpland, Peter Jaegers

Introduction

The main objective of this experiment was to show how the multiplication of the system increases as moderated material is placed between highly enriched uranium foils. In addition, this experiment served to demonstrate the hand-stacking techniques, and approach to criticality by remote operation. This experiment was designed by Tom McLaughlin in the mid seventies as part of the criticality safety course that is taught at Los Alamos Critical Experiment Facility (LACEF). The H/U-235 ratio for this experiment was 215 which is where the minimum critical mass for this configuration occurs.

Description

This experiment was performed on the Planet vertical assembly machine when the hand-stacking limit was exceeded. The configuration was built up of alternating Lucite plates which were approximately 35.6-cm (14'')-square by 1.27-cm (0.5'') thick and highly enriched uranium foils approximately 23-cm (9'')-square by 0.0076-cm (0.003'') thick. The Lucite extended 6.35-cm (2.5'') beyond the foils and there were a 7.62-cm (3'') top and bottom Lucite reflectors. One of the Lucite plates had a central recess where the neutron source was placed. To reduce airborne contamination, the uranium foils were laminated with thin plastic sheets.

The starting configuration contained six foils weighing approximately 420 g, which represents a conservative starting point compared to the approximately 800 g minimum water reflected critical mass of U(93) in water. A l/M approach to critical was performed following the guidelines set forth in the Operating Procedures.

While hand stacking the foils and Lucite plates, two hand-stacking rules were observed. The first rule was the 75% rule, which states that the hand-stacking operations would continue until the next step would exceed 75% of the extrapolated critical number of foils. The second rule was the halfway rule, which simply states that hand-stacking operations would continue as long as the individual steps that are taken do not double the multiplication of the system or the count rate. If we double the multiplication or count rates for a particular step, then the next step of the same size would take us above delayed critical. This assumes that there is a linear relationship between multiplication and the changing parameter; namely, the number of foils or the gap distance.

Once the hand-stacking limit was reached, the assembly was split into two parts. The bottom part of the core contained 10 foils and the neutron source, and was placed on the movable platen of Planet. The top part of the core was placed on the top platform and typically contained two or three foils. Planet was then operated remotely observing only the halfway rule. This approach continued until we were certain of the behavior of the system (see Fig.2). We then made the decision to go above delayed critical and establish a reactor period.

Results

Figure 1 shows the normalized inverse multiplication as a function of the number of foils placed on the assembly. As we can see, the nature of the curve is conservative, that is the curve is convex towards the origin. This is because as we place foils on the top of the assembly, the farther out they are from the center of the core. Therefore, the worth of the foils near the reflector region is less than those at center of the core.

Figure 2 shows the normalized inverse multiplication as function of gap distance for the closure of 20.23 foils. Partial foils were used for the last approach to limit the excess reactivity. It is interesting to note that as we get closer to the critical separation, there is a linear relationship between the inverse multiplication.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

MASTER
DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.
DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.
and the gap spacing. The critical separation was found to be 0.10 in at a temperature of 25.1 °C. There were two partial foils at the top in contact with the Lucite reflector. These foils weigh approximately 16 g and were placed centered 1.5-cm apart. When the stack was fully closed, the reactor period was 35 seconds or 20 cents above delayed critical.

Figure 1. Normalized inverse multiplication vs. number of foils.
Figure 2. Normalized multiplication vs. gap distance.

References