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Initial Experimental Results from Zeus, an Intermediate Energy Neutron Spectrum Experiment

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I. INTRODUCTION

The Zeus experiment is intended to provide nuclear criticality benchmark data for a wide variety of fissile and non-fissile materials in both fast and intermediate neutron energy spectra systems. In this paper, we will present a brief description of the Zeus assembly. We will then go on to present experimental results, from three configurations, produced during the initial core loading and approach to critical.

II. ZEUS

The Zeus critical experiment has been constructed at the Los Alamos Critical Experiments Facility (LACEF). In general, the critical assembly consists of a core region that is 26.67 cm in radius, and can have a maximum height to diameter ratio of 1.75. This core is reflected with a parallelepiped copper reflector. The reflector is approximately 17.35 cm thick on each side and 14.43 cm thick on the top and bottom. This reflector serves several purposes. The first is to minimize the critical core volume, this is necessary since intermediate energy systems are physically large. The second purpose is to reduce the effects of room return on the system being studied. The copper has a nominal impurity content of 0.04 % oxygen and 22 ppm metal impurities, most of which is silver. Figure 1, shows the Zeus experiment on the general-purpose assembly machine Comet. The core is split into two portions. The top portion is supported on a 0.264 cm thick stainless steel membrane, while the lower portion rides on the lower movable reflector.

For the first series of Zeus experiments, the core consists of graphite and uranium plates. The purpose of the initial experiments is to provide a base line measurement for testing the ^{235}U cross sections in an intermediate spectrum; thus limiting the number of uncertainties in subsequent experiments, which will use other moderating materials. The uranium fuel plates are nominally 93.3% enriched, and measure 26.67 cm in radius and 0.32 cm thick. Stacked between each fuel plate are graphite plates, which also have a radius of 26.67 cm. By varying the number of graphite plates between each fuel plate the neutron energy spectrum of the assembly may be regulated. The graphite plates have been manufactured from high purity graphite with an average ash content of approximately 0.4 ppm. It should be noted that approximately half of the fuel and graphite plates have a 3.175 cm radius hole in the center. This is to accommodate an alignment spindle located on the bottom portion of the core.

III. FIRST CORE LOADING

For the initial core loading, a unit cell consisting of 4 cm of graphite, a fuel plate, and 4 cm of graphite was chosen. This core configuration was chosen since it was estimated that the resulting core would be near the maximum height to diameter ratio for the assembly. An incremental approach to critical, a 1/M, was used during the fuel loading. Figure 2 shows the results of the incremental approach to critical during which successive units were added to the assembly.

During the approach to critical, two sub-critical configurations, consisting of 10 units, were obtained. Configuration 1 consisted of 5 units on the bottom portion of the assembly, each with a 3.175 cm radius hole, and 5 units on the top portion of the core, 4 with no hole and one with a 3.175 cm radius hole in only the fuel. The extrapolated critical number of units for this case was determined to be 10.32 units. In an effort to obtain a critical configuration, a second sub-critical configuration was obtained. Configuration 2 consisted of 4 units, on the bottom portion of the assembly, with a 3.175 cm radius hole and 6 units, on the top portion of the core, 5 with no hole and one with a 3.175 cm radius hole in only the fuel. This configuration was again sub-critical with an extrapolated critical number of units now approximately 10.10 units.

On April 26, 1999 a critical configuration was finally achieved. This configuration essentially consisted of the above configuration 2 with the exception that the forth unit from the bottom of the assembly had been modified. This forth unit consisted of 4 cm of graphite, a fuel plate, 1.5 cm of graphite, 0.152 cm of aluminum, and 1 cm of graphite. This configuration was arrived at by incrementally removing graphite from the system. The reactor period for the assembly on full closure was determined to be approximately 1100 sec. It is of interest to note that there were two competing effects that the removal of graphite from the forth unit had on the system. The first was to produce a geometrically favorable condition, since the forth and fifth fuel plates were closer together. The competing effect was to change the uranium to graphite ratio in a high worth cell, which drove the critical mass of the overall system up.

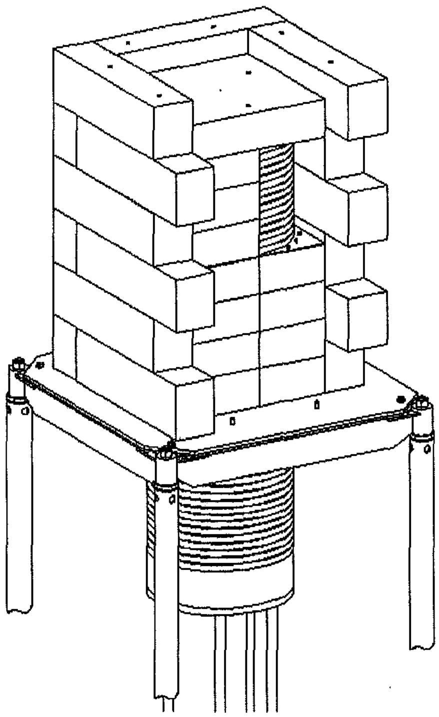

Figure 1. Cut Away View of Zeus

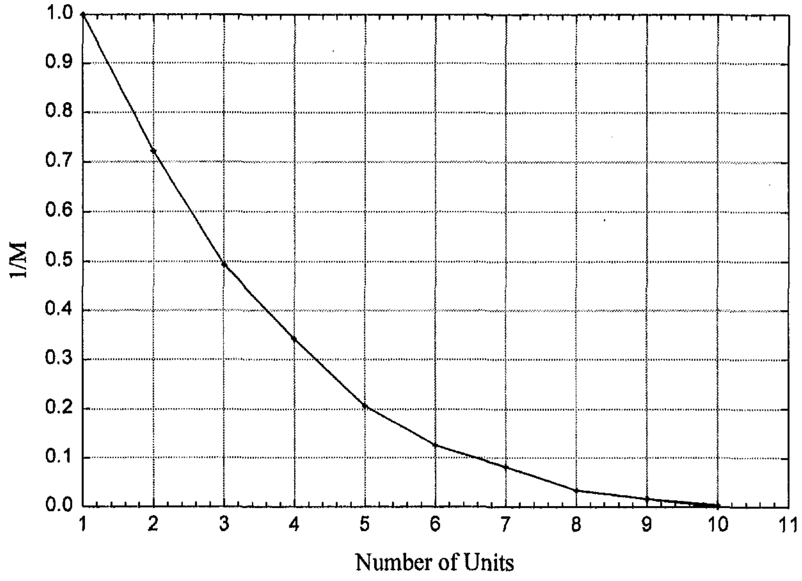

Figure 2. One Over Multiplication Approach to Critical