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NEUTRON MULTIPLICATION BY EXPERIMENTAL GAS COOLED REACTOR FUEL ASSEMBLIES

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Abstract

Experiments were conducted to determine the source neutron multiplication of EGCR fuel assemblies under conditions which might exist in transportation and storage. Twenty-eight fuel assemblies were arranged to yield maximum nuclear reactivity under conditions which might be expected for out-of-reactor environments. It was found that these 28 assemblies cannot be made critical when water moderated and reflected.

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Establishment of the specifications for storage and transport of the fuel assemblies for the Experimental Gas Cooled Reactor (EGCR) has required some measure of the source neutron multiplication by the limited number of assemblies made available to the Laboratory for experimentation at this time. The conditions of the experiment were purposely made those which might be practically expected in an out-of-reactor environment yielding maximum nuclear reactivity. The assemblies were, therefore, submerged in water as they might accidently be in transport or in storage. In one variation water was excluded from within each assembly as it may be by packing materials of low hydrogen density. Only twenty-eight EGCR assemblies were available for these experiments.

The fuel assembly for the EGCR has been described by Samuels[1] and is shown schematically in Fig. 1. The fuel consists of 2.46%-U^{235}-enriched UO_2 hollow pellets 0.707 in. O.D., 0.323 in. I.D. and about 0.75 in. long. The minimum density of the UO_2 is specified[2] as 10.3 g/cm^3. An element contains 36 of these pellets sealed in seamless type 304 stainless steel tubing (20 mil wall thickness) with 3/16-in.-long MgO pellets at the top and bottom of the fuel column. A cluster of seven fuel elements welded to a top spider is supported within a 1-in.-thick, 29.4-in.-long graphite sleeve having an outside diameter of 5.0 in. The separation between elements in the cluster and between elements and the graphite sleeve is maintained by midplane spacers and by a bottom spider to which alternate peripheral elements are welded. The minimum spacing between the peripheral elements and the graphite sleeve is specified[2] as 0.110 in., and that between adjacent elements as 0.233 in. The average UO_2 content of the assemblies available for these experiments was 9895 g of which 214 g was U^{235}.

In these experiments fuel assemblies were arranged vertically in triangular lattices on a perforated plastic table set on the floor of a 6-ft-cubical stainless steel lined tank to which water for moderator and reflector could be added remotely. A 0.25-in.-dia cylindrical Po-Be neutron source was placed between fuel elements in the center assembly. A typical arrangement is shown in Fig. 2.

With 19 assemblies in a regular hexagon the spacing between adjacent graphite sleeves was made 0.0, 0.5 and 0.8 in. in three tests in order to investigate the dependence of activity upon moderation of the array. It was determined that arrays were most reactive with the assemblies in contact.

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1. G. Samuels, Nuclear Science and Engineering 14, 37 (1962).
2. J. H. Coobs, E. A. Wick and R. M. Evans, "Specifications for Fuel Assemblies for Core I of the Experimental Gas-Cooled Reactor" ORNL-CF-60-11-90 (Dec. 9, 1960).

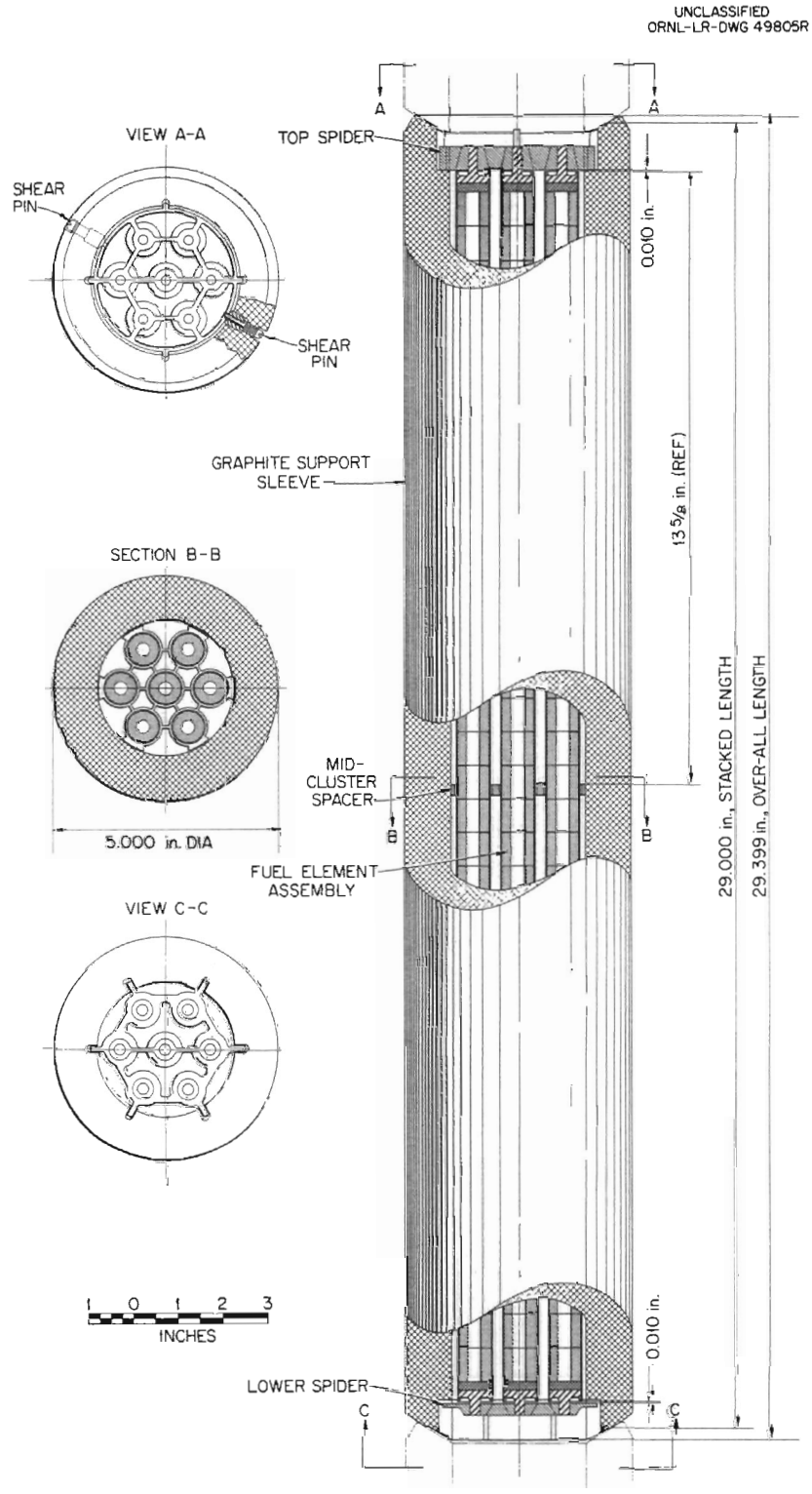

Fig. 1. Fuel Assembly for EGCR.

Fig. 2. Typical Fuel Element Arrangement

A close packed array of 28 assemblies had an apparent source neutron multiplication of no more than five. Extrapolation of the inverse neutron multiplication curve, Fig. 3, indicates that as few as 40 assemblies might be critical when moderated and reflected by water. It should be emphasized, however, that this number is uncertain because of the long extrapolation.

In order to determine the effect of the moderator water within the graphite sleeves, each assembly in a 19 unit close-packed hexagonal array was encased in a plastic bag. The neutron multiplication was not significantly different from that observed with the assemblies filled with water although the measurement of multiplications, by standard techniques, of highly subcritical arrays is quite uncertain.

It is, therefore, concluded that 28 EGCR fuel assemblies can not be made critical when water moderated and reflected.

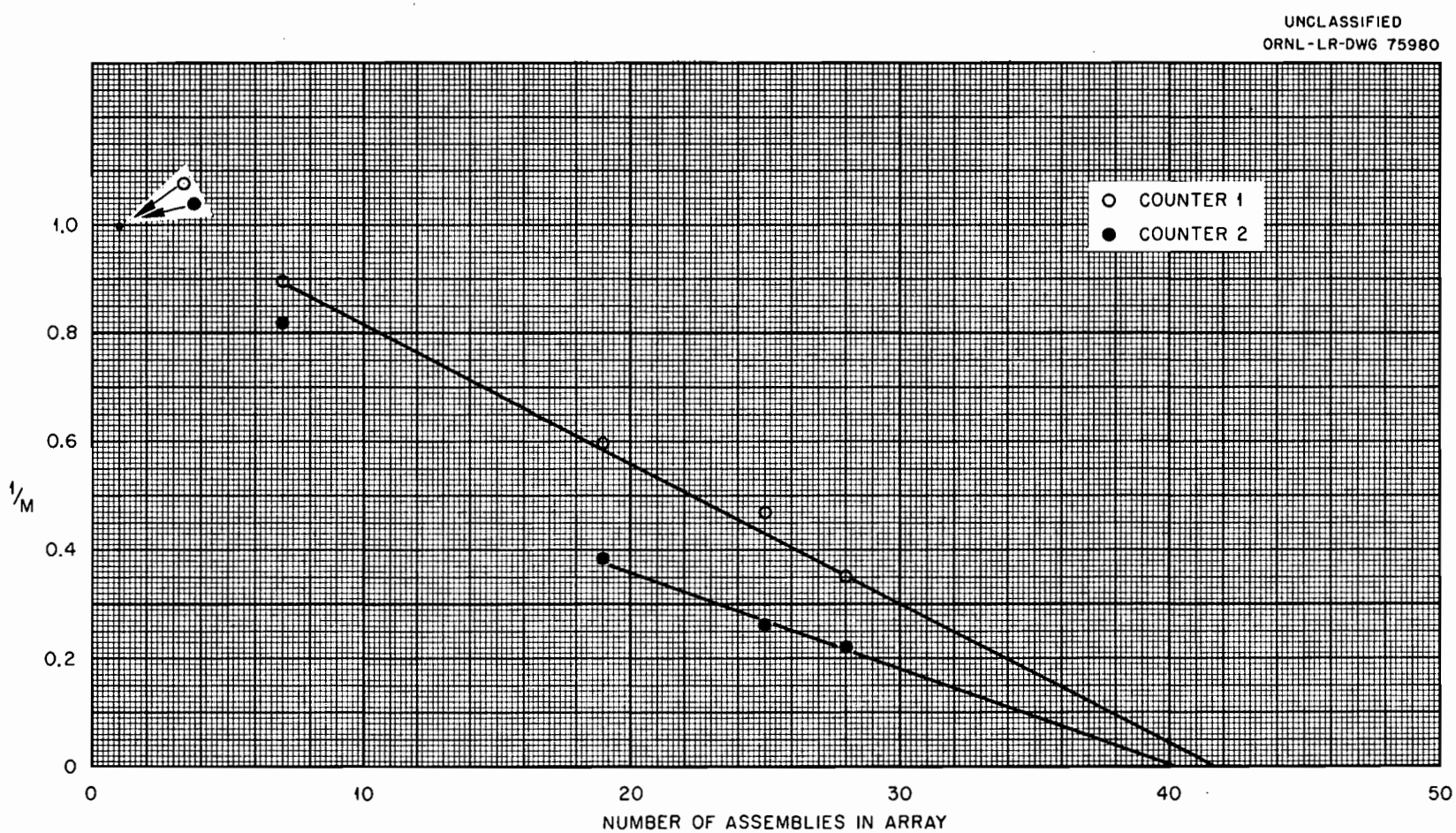

Fig. 3. Reciprocal Neutron Multiplication Curve for EGCR Fuel Assemblies in Close-Packed Triangular Lattice, Water-Moderated and -Reflected.

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