ENCLOSURE (1)

CRITICALITY SAFETY STUDY OF CALVERT CLIFFS FRESH FUEL STORAGE FACILITY

by

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I. INTRODUCTION

The criticality safety of the Calvert Cliffs fresh fuel storage facilities has been reevaluated to determine whether adequate margin exists to permit storage of fuel assemblies having enrichments of up to 4.1 $^{w}/o$ U-235. The safety evaluation for the normally dry fresh fuel storage facility included the innundation of the fresh fuel rack in H_2O having effective densities in the range of 0.04 to 1.0 gram/cm^3. Such conditions of moderation by low density water could conceivably arise, for example, during fire-fighting operations through the use of fire hoses, fog nozzles, or foam generators. While the possibility of such conditions occurring is considered to be remote, such occurrences cannot be categorically ruled out as not credible. The purpose of this report is to describe the results of the studies and provide information necessary to revise the license for the existing fresh fuel storage facilities.

II. SUMMARY AND CONCLUSIONS

The fresh fuel storage rack consists of a two by six array of storage modules, each of which consists of a two by six array of fuel assemblies. The modules are separated by aisles that are two to three feet wide, and the center-to-center spacing of assemblies within each module is about 17 inches. One-quarter inch thick full-length stainless steel angles 2" by 2" are at the corner of each assembly. This facility was assumed to be filled to capacity with equilibrium cycle UO_2 fuel having an enrichment of 4.1 wt % U-235. Densities of nonborated water ranging from 1.0 to 0.04 gm/cm^3, both within and between assemblies, were considered. Transport theory calcuations performed with the DOT-2W code and the Monte Carlo code KENO-IV yielded a K_{eff} value of 0.89 for full density water and in the low water density range yielded a K_{eff} value of 0.75 for a secondary peak, at a water density of about 0.08 gm/cm^3. This value of K_{eff} provides 10% margin to the limiting value of 0.98 recommended in the applicable standard, Reference 3. This margin was judged adequate to warrant the conclusion that the fuel rack can safely accommodate 4.1 ^{w}/o enriched 14 x 14 fuel assemblies and should be licensable under existing criteria.

III. CONDITIONS OF SAFETY

The conclusions of safety of these storage facilities are predicated on certain assumptions and conditions which are listed below. Violation of these conditions may seriously compromise the safety of these storage facilities.

1. It is assumed that the fresh fuel storage facility is loaded from the top, and that it is impossible, by virtue of rack structure and/or administrative controls, to place one or more fuel assemblies within the storage array between designated storage locations. This specifically includes the aisles of the fresh fuel facility, and the movement or placement of assemblies within these aisles must be prevented.

2. Plastic bags or other dust covers placed around fresh fuel assemblies must be removed or rendered incapable of holding water (e.g., by cutting holes, or cutting off the lower ends) prior to inserting the assemblies into the fresh fuel storage facility. The possibility of having an array of assemblies where each assembly is internally flooded with water but the assemblies are separated by air must be avoided, since a very small array of this type could become critical.

3. The safety of these storage facilities has been examined only for UO_2 fuel; plutonium recycle fuel has not been considered. The criticality safety of the storage facilities must be reexamined should Pu recycle be contemplated.

IV. ANALYSIS OF FRESH FUEL STORAGE FACILITY

A. Facility Description

The fresh fuel storage facility is described in detail by Bechtel Associates drawings (Reference 4) transmitted to CE by Baltimore Gas and Electric Company. A simplified schematic plan review of the storage arrangement is shown in Figure I. The facility consists of two rows of storage modules, each of which consists of a double row of six storage locations. Fuel assemblies are centered in each storage location. Pertinent distances between storage location centers within each storage module (as obtained from Drawing C-512, Section D) and between storage modules are shown in Figure I. A total of 144 assemblies may be stored in this facility. The storage facility is enclosed by a concrete wall that is one foot thick. The floor is of concrete, but there is no concrete structure immediately above the facility.

B. Conservative Assumptions Used in Safety Analysis

In performing the criticality safety analysis, care was taken to avoid assumptions and methods application techniques that are known to lead to nonconservative results (underpredictions of K_{eff}), and a number of clearly conservative assumptions have been made as discussed below.

1. The facility was assumed to be filled to capacity with fresh UO_2 fuel assemblies having an enrichment of 4.1 wt % U-235. This is higher than the presently anticipated maximum enrichment for reload fuel in the eighteen month cylce.
2. Thick, close-fitting concrete reflectors were assumed to be present both

above and below the active fuel region of the storage facility. This is a realistic representation of the lower reflector, but is a conservative representation of the upper reflector. The latter consists of air and some steel which is part of the fuel assembly upper fitting and the rack structure. There are no massive metal or concrete structures above the fuel. Previous calcuations of the types performed in this analysis have indicated that thick concrete reflectors lead to higher values of the effective multiplication factor than thick, full density water reflectors.

3. All water, regardless of density, was assumed to be pure (i.e., contain no nuclear poisons).

C. Methods of Analysis and Results

Four-group cross-section data for both fuel assembly regions and surrounding water and concrete regions were computed as a function of water density using the CEPAK code, which embodies the MUFT and THERMOS codes as described in Section 3.4.9.1 of the Calvert Cliffs Plant FSAR. The accuracy of this CEPAK model for water moderated lattices is established in the FSAR. Different buckling values for each density were used in CEPAK that were representative of the buckling values of the lattice. To obtain thermal cross-sections, slab THERMOS cases were run that provided the proper fuel environment and just a position of water, steel and concrete components.

The storage module rack is shown in Figure I; the inset portion is represented by a DOT-IIW cell including fuel pin cells, water holes, steel angles and water reflector as shown in Figure II. The flux volume weighted cross-sections for the DOT cell were used in a three dimensional KENO IV calculations having one foot concrete walls immediately surrounding all six sides of the fresh fuel storage area. The KENO's were run in batches of 100 neutron histories with the first four batches discarded. Sufficient numbers of batches were run to reduce the statistical standard deviation to less than 0.003.

Figure III shows as a function of water mist density the infinite lattice DOT cell eigenvalues with a peak of about 1.11 at a water density of 0.08 gm/cm^3 and the finite concrete reflected complete storage rack KENO results. These KENO K effective values have a high of 0.89 at full density water and a secondary peak of about 0.75 at a water density of about 0.08 gm/cm^3.

V. REFERENCES:

1. R. G. Sottesy, R. J. Disney. A. Collier, "User's Manual for the DOT-IIW Discrete Ordinates Transport Computer Code," WANL-TME-1982, December 1969.

2. L. M. Petrie and N. F. Cross, "KENO IV, An improved Monte Carlo Criticality Program," ORNL-4938, November 1975.

3. ANS Standards Committee Working Group, ANS-57.2, "American National Standard Design Objectives for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Station," ANSI-N210-1976 approved April 12, 1976.

4. Bechtel Associates Drawings

Bechtel Dwg. No.	C-511, or BG&E Dwg. No.	63-512-E, Rev. 2, 3/9/72
	C-512	63-513-E, Rev. 1, 3/9/72
	C-513	63-514-E, Rev. 2, 3/9/72

FIGURE I

SCHEMATIC VIEW OF FRESH FUEL STORAGE RACK

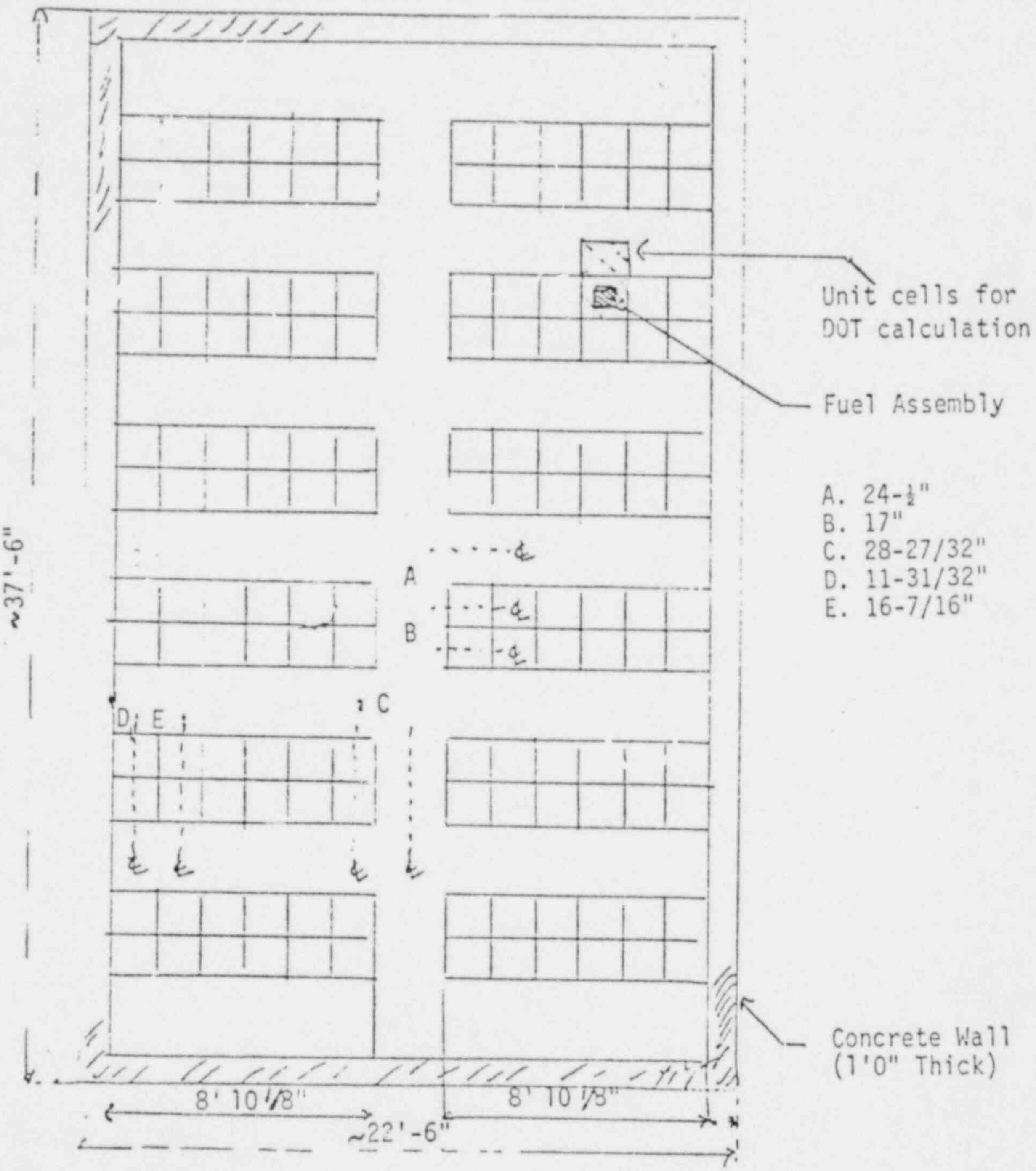
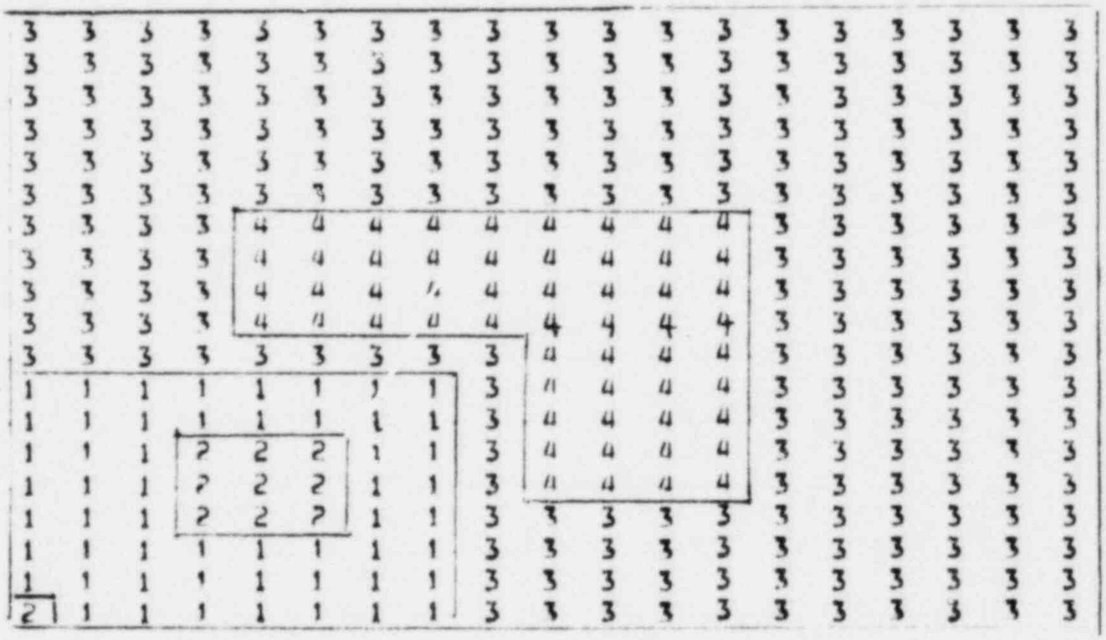


FIGURE II

DOT REPRESENTATION OF FUEL STORAGE LATTICE



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2	1	1	1	1	1	1	1	3	3	3	3	3	3	3	3	3	3	3

Material Description

1. Fuel Pin Cell
2. Waterhole
3. Water Reflector
4. Steel Angle

Not to Scale

Neutron Reflection on all Exterior Boundaries

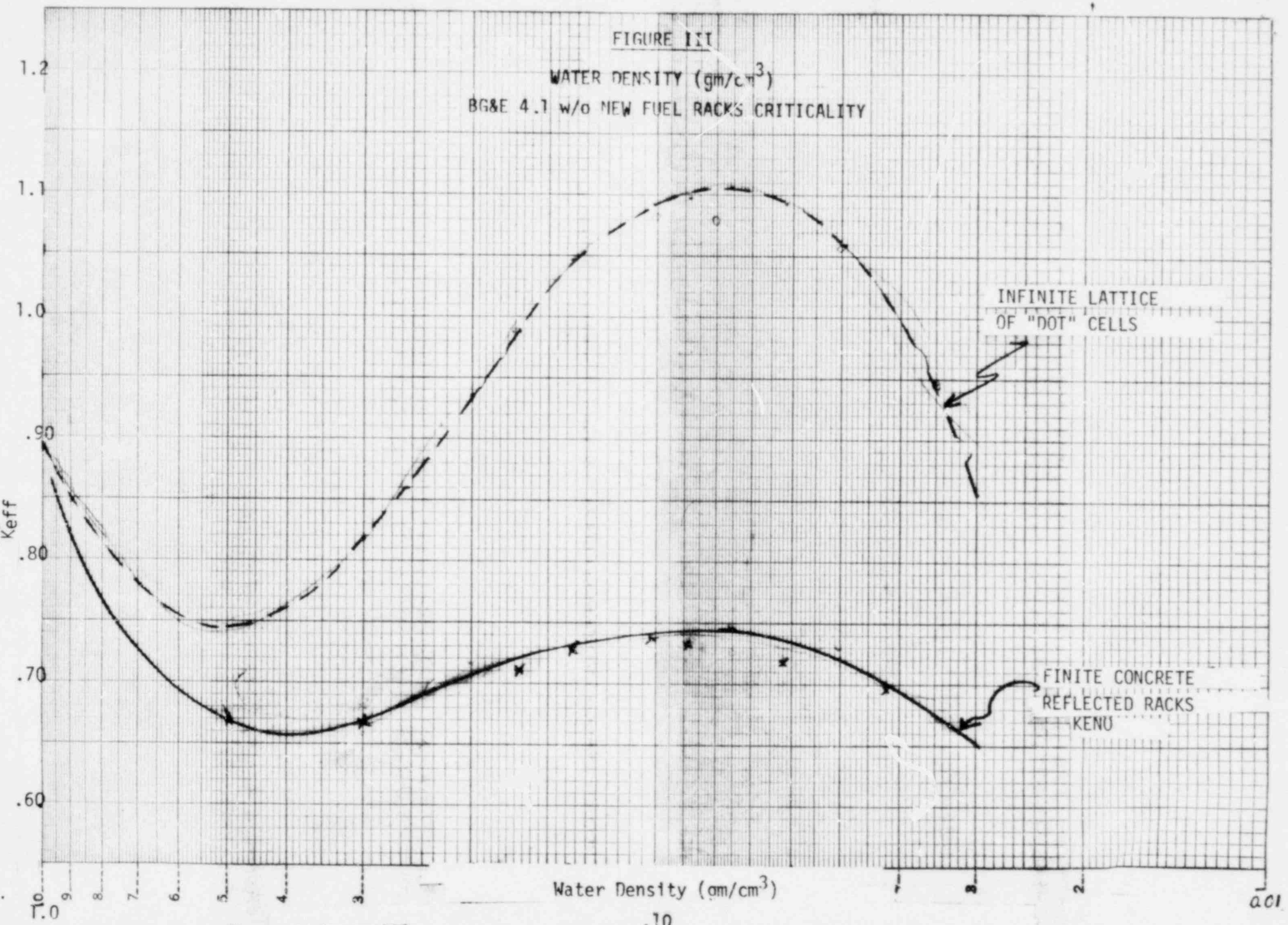

FIGURE III

WATER DENSITY (gm/cm^3)

BG&E 4.1 w/o NEW FUEL RACKS CRITICALITY