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June 27, 1979

License SNM-1067
Docket 70-1100

U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. L. C. Rouse, Chief
Fuel Processing & Fabrication Branch
Division of Fuel Cycle & Material Safety

Gentlemen:

This is in response to your request for additional information to support our amendment application dated April 23, 1979. Resolution of NRC comments agreed to by Mr. N. Ketzlach of your staff and Mr. G. J. Bakevich of my staff are forwarded as revised license pages. Please make the following page changes to our orignal amendment application:

Delete Pages	Add Pages
II-1, Rev. 2, 3/15/74	
XIX-3, Rev. 0, 3/22/79	XIX-3, Rev. 1, 6/27/79
XIX-6, Rev. 0, 3/22/79	XIX-6, Rev. 1, 6/27/79
C-5, Rev. 0, 3/22/79	C-5, Rev. 1, 6/27/79
C-6, Rev. 0, 3/22/79	C-6, Rev. 1, 6/27/79
C-10, Rev. 0, 3/22/79	C-10, Rev. 1, 6/27/79
C-18, Rev. 0, 3/22/79	C-18, Rev. 1, 6/27/79
C-19, Rev. 0, 3/22/79	C-19, Rev. 1, 6/27/79
	C-19a, Rev. 0, 6/27/79
D-2, Rev. 0, 3/22/79	D-2, Rev. 1, 6/27/79
	D-20, Rev. 0, 6/27/79
	D-21, Rev. 0, 6/27/79
	D-43 thru D-50, Rev. 0, 6/27/79

Very truly yours,

HV Lichtenberger
H. V. Lichtenberger
Vice President-Nuclear Fuel
Nuclear Power Systems-Manufacturing

HVL/GJB/ssb
Enclosures

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TABLE 19.1

Safe Individual Unit Limits for ≤ 4.1% enriched UO_2 at optimum moderation. All Mass and Volume limits adjusted to provide constant spacing areas for the enrichment shown. Heterogeneous limits have been developed with optimum rod sizes (up to 0.4" diameter) taken to allow for pellet chips, etc.

	HOMOGENEOUS		HETEROGENEOUS	
	Limit	f*	Limit	f*
Mass (Kg UO_2)				
<2.5 % U^{235}	54	.19	50	.26
2.5-3.0 "	41	.23	38	.29
3.0-3.2 "	36	.23	36	.29
3.2-3.4 "	35	.25	33	.29
3.4-3.6 "	32	.26	30	.30
3.6-3.8 "	28	.26	27	.29
3.8-4.1	24	.25	24	.27
Volume (liters)**				
<3.5%	31	.39	22	.40
3.5-4.1	25	.38	18	.38
Cylinder Diameter (inches)				
<3.5%	10.7	.34	9.5	.36
3.5-4.1	9.8	.33	8.9	.34
Slab Thickness (inches)				
<3.5%	5.1	.23	4.1	.14
3.5-4.1	4.6	.21	3.7	.13

* Fraction of the equivalent unreflected critical spherical volume or mass.

** Includes all available container volumes.

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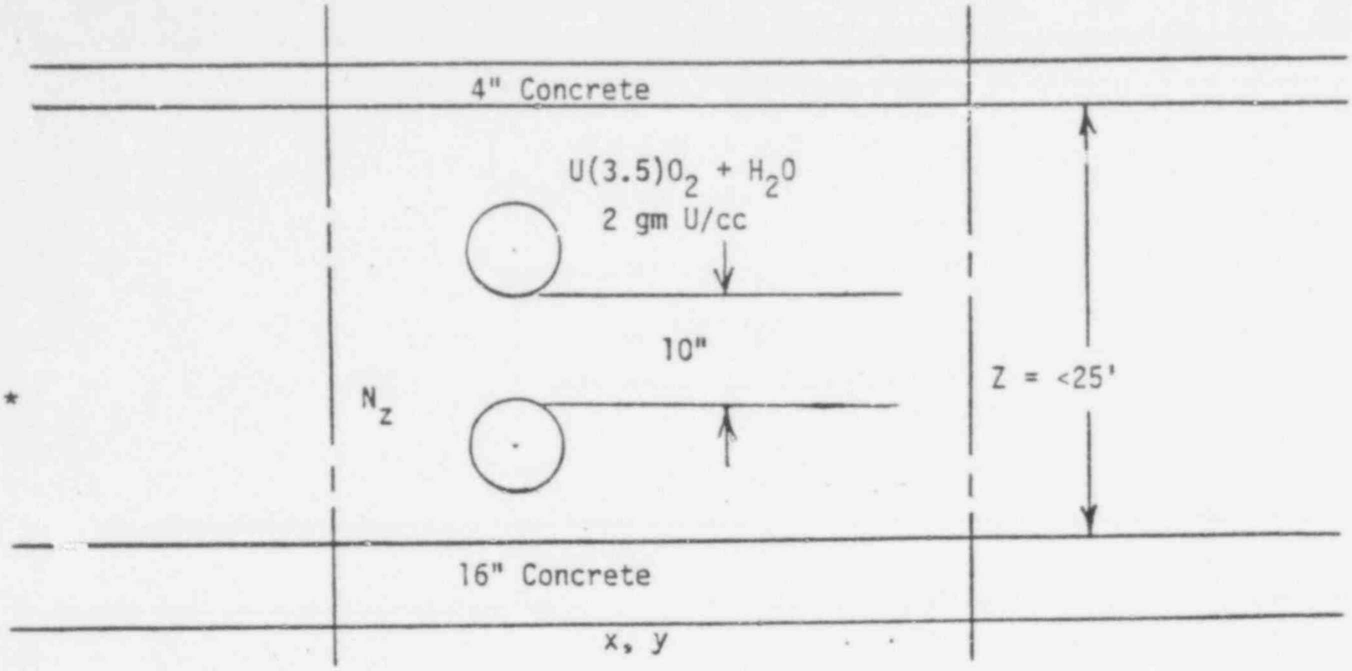

This configuration has been evaluated using KENO with 16 group Hansen-Roach cross sections with the following critical parameters:

N_z	x,y (cm)	ℓ/ft^2
1	59.6	8.1
2	86.0	7.8
3	114.0	6.6
4	122.6	7.1
5	145.8	7.3

Accordingly, stacked units with at least 10 inch vertical separation, and no column exceeding 5 units, can be spaced with the area being increased by a multiple equal to the number of units in the stack. To provide additional safety, stacked units will be limited to a maximum volume of 20 liters.

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Criticality Safety Analysis

The following conservative assumptions were incorporated into the calculational model of the Virgin Powder Storage Area:

1) All steel structural materials were neglected.
2) The fuel was assumed to be a homogeneous mixture of UO_2 containing 7.0 wt.% H_2O.
3) The rack was filled to capacity (330 cans of UO_2 powder) and each individual can was assumed to be full.
4) Effects of interspersed water moderation and flooding were not addressed.

The KENO-IV Code with sixteen group Hansen-Roach cross sections was used to determine the reactivity of the Virgin Powder Storage Area under the conditions noted above. Dimensional details of the model are provided in Section
* 1.1 of the demonstration section of this license. A k_{eff} of 0.9338 ± 0.0077 was obtained for an infinite system in the horizontal direction.

3.3 Batch Make-Up

Powder containers are removed from the virgin powder storage area and placed on a conveyor (W.S. P-2) (safe cylinder limit) for transfer to the Batch Make-Up Hood (W.S. P-3). A maximum of three powder containers are clamped to fixtures in the hood, where an appropriate batch of less than 35 Kg UO_2 is weighed out and put into 5-gallon pails..The batch weights and enrichment are recorded on the container. A water tight cover is secured to these batch containers and they are then conveyed (W.S. P-4) to a lift (W.S. P-5) for transfer to the blender hoods (W.S. P-6). The batch make-up operation is enclosed in a ventilated hood. Sufficient negative pressure is provided to assure a minimum face velocity of 100 fpm.

Criticality Safety Analysis

The following conservative assumptions were incorporated into the calculational model of the Batch Make-Up Hood and associated conveyors (W.S. P-3 and P-4):

* 1) The 3 stainless steel UO_2 powder cans (safe cylinders) inside the hood were considered to be full at optimum moderation and maximum enrichment (4.1% wt.% U^{235}).
2) The 5-gallon batch make-up bucket inside the hood was assumed to contain UO_2 powder at optimum moderation and maximum enrichment (4.1 wt.% U^{235}).

3) All structural steel in the hood was neglected.

4) All sealed containers of UO_2 on conveyors (W.S. P-2 and P-4) adjacent to the hood were assumed to contain 7.0 wt.% H_2O.

The KENO-IV Code with 16 group Hansen-Roach cross sections was used to determine the reactivity of the system under various conditions of moderation.

Optimum moderation of the fuel containers within the hood occurred at a fuel concentration of 1.8 gm U/cc in water, assuming no external mist. The highest reactivity of 0.7934 ± 0.0070 for an infinite system (at 1.8 gm U/cc in water) occurred for the full flood case. Additional calculations for the external full flood condition were run for various concentrations of fuel in water ranging from 1.2 - 3.5 gm U/cc. The peak system reactivity of 0.8595 ± 0.0117 for the flooded cases occurred at a fuel concentration of 2.6 gm U/cc in water. Dimensional details of the calculational model and results of the calculations are discussed in Section 1.2 of the demonstration section of this license.

3.4 Powder Preparation and Blending

* UO_2 powder from one sealed batch container (moderation control assurred) is transferred to a blender where it is mixed with a binder (W.S. P-6). Two separate blenders feed a common powder spread funnel by means of individual powder transfer pipes entering at a 45° angle. An identical powder prep line runs parallel to this one at a centerline distance of 13 feet.

The blending operation is enclosed in a ventilated hood. Sufficient negative pressure is provided to assure a minimum face velocity of 100 fpm.

3.4.1 Drying

Agglomerated UO_2 powder is spread onto the dryer belt (W.S. P-7) from the powder spread funnel to a controlled depth of 1/2". A complete enclosure is provided around the dryer belt assembly and this enclosure is maintained at a slight negative pressure. The discharge end of the dryer belt utilizes a wiper blade to prevent the flow of significant amounts of material to the plenum under the belt. Nevertheless, this plenum shall be inspected once per week and cleaned as necessary.

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For the second case, the system was analyzed at 3.5 wt.% U^{235} with the 11" diameter, 40" long press feed hopper. The maximum k_{eff} in the absence of external water mist occurred at 2.2 gm U/cc in water. This result was derived from calculations at 2.0, 2.2, and 2.4 gm U/cc with associated k_{eff} values of 0.800 ± 0.010, 0.833 ± 0.014, and 0.804 ± 0.014 respectively. Variable density external water mist was then introduced to determine peak reactivity of the system with the 11" hopper. The highest k_{eff} of 0.934 ± 0.017 occurred for the full flood case. This result was derived from calculations at 0.001, 0.01, 0.05, 0.10, and 1.0 gm/cc of H_2O with associated k_{eff} values of 0.825 ± 0.016, 0.821 ± 0.020, 0.805 ± 0.012, 0.850 ± 0.014, and 0.934 ± 0.017 respectively.

* Dimensional details of both calculational models and the results obtained for the 4.1% cases are discussed in Section 1.4 of the demonstration section of this license.

3.5 Final Mixing

Filled press feed hoppers may be rolled to assure complete blending of the die lubricant (W.S. P-10).

3.6 Pressing

The filled portable hoppers are transferred to the pelletizing presses (W.S. P-11) and secured to assure their stability and the containment of powder. Powder is gravity fed to the press, and compacted to green pellets which are placed into furnace boats. The boats have a maximum height of 3.7 inches. Only one boat shall be at each press at any one time. Each press is provided a spacing area of at least 20 ft^2.

The press is provided with enclosures which assure adequate ventilation at the opening face, and at the junction of the portable hopper with the press. Air flow rates are sufficient to assure face velocities of at least 100 fpm.

Two work benches (W.S. P-12) are provided for inspection of pellets. These stations are limited to one safe mass each.

3.7 Dewaxing and Sintering

Furnace boats containing green pellets are charged in a single line to a

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7.0 PRETREATMENT OF LOW LEVEL LIQUID WASTES

In order to effect a reduction in the quantities of UO_2 released to the retention tanks in Building #6, low level liquid wastes, consisting primarily of floor mop water will be pumped into a 10 inch diameter, 11 foot long settling tank with a release line located 18 inches from its lowest point. The water is then passed through a high efficiency closed loop centrifuge system, sampled to verify acceptable discharge levels, and transferred to the retention tanks in Building #6. The settling tank is located in the rod loading area, and is shown as W.S. P-113 in Figure C-1.

Based on past experience, wash water may contain up to 10^{-3} μCi/cc (~0.5 gm U/ℓ). Much of this activity quickly settles to the bottom of the tank. Accordingly, criticality considerations are applied only to the lower 18 inches of the tank, with the balance of the tank considered to have a sufficiently low uranium concentration to preclude further criticality considerations.

Although the diameter of the tank (10 inches) slightly exceeds the Section 19 limit (9.8 inches), it is well below the minimum critical diameter (10.8 inches) for a fully reflected infinite cylinder. In addition, the optimum concentration necessary to achieve criticality in a 10.8 inch cylinder is between 2000 and 2500 gm U/ℓ, a factor of 4000 higher than the uranium concentrations observed in the mop water handled. The volume of the settling tank is 23.2 liters. The allowable surface density (ta) is taken as 25% of
* the critical infinite slab thickness (tc). Accordingly, ta = 1.38" or 3.26
* liters/ft^2. The required spacing area for the tank is therefore 7.11 ft^2.

Sludge and other uranium bearing solids will be collected in volume limited SIU's. This material may be subsequently loaded into trays to a maximum depth of 3.7 inches, dried in an oven (W.S. P-23 or 24) and stored in authorized packages awaiting final disposition.

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8.0 ROD LOADING AND ASSEMBLY FABRICATION

8.1 Pellet Alignment and Drying

Pellets from the pellet fabrication facility, or from outside vendors are placed on a downdraft table (W.S. 100) where they are loaded for placement into drying furnaces (W.S. 101 and 102). On the table, the pellet configuration is limited to a 3.7 inch slab thickness. The UO_2 pellets are placed on aluminum troughs in approximately 12 foot lengths before being loaded into the furnaces. The inside diameter of the furnaces is 20", and the overall length is 13 feet.

The furnaces are dry and about 12 inches above the floor level. Water entry is possible only when the doors at either end are open; however, under this condition, free drainage will occur. With the doors closed, the furnace is a sealed chamber and moderation control is assured.

Criticality Safety Analysis

The following conservative assumptions were incorporated into the calculational model of the pellet drying furnaces:

* 1) It was assumed that the 200 pellet storage positions were fully loaded with maximum diameter pellets (0.3765") at maximum enrichment (4.1 wt.% U^{235}).

* 2) The remaining 16 furnace locations contain B_4C powder clad in SS tubes and fixed in place. It was assumed that this powder was 45% of theoretical density (although it "pours" to a greater T.D.). The SS tubes have an O. D. of 0.625 inch and a wall thickness of 0.035 inch. All SS tubes were omitted in the calculations for additional conservatism.

3) The furnaces were assumed to be infinitely long and spaced 36.5" on center. An infinite array was assumed, although there are only two furnaces.

4) Variable density water mist was introduced to determine peak reactivity of the system.

5) All aluminum pellet troughs were omitted and the variable density mist was substituted in their place.

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* 6) Four group cross sections were generated using the CEPAK Code for the fuel and poison regions of the model and for the concrete floor and ceiling.

* The KENO-IV Code was used to determine the reactivity of the Pellet Drying Furnaces under various external mist conditions with and without the fixed B_4C poison rods in place. The peak reactivity of the furnaces, $k_{eff} = 0.8693 \pm 0.0057$, occurred for the full density water condition. Additional calculations were performed assuming loss of all poison. The margin of safety is unacceptable only for mist densities exceeding 50%. These conditions were not considered credible since the furnaces would drain freely to the floor and could not retain this amount of water. Dimensional details of the calculational model and results obtained are presented in Section 1.7 of the demonstration section of this license.

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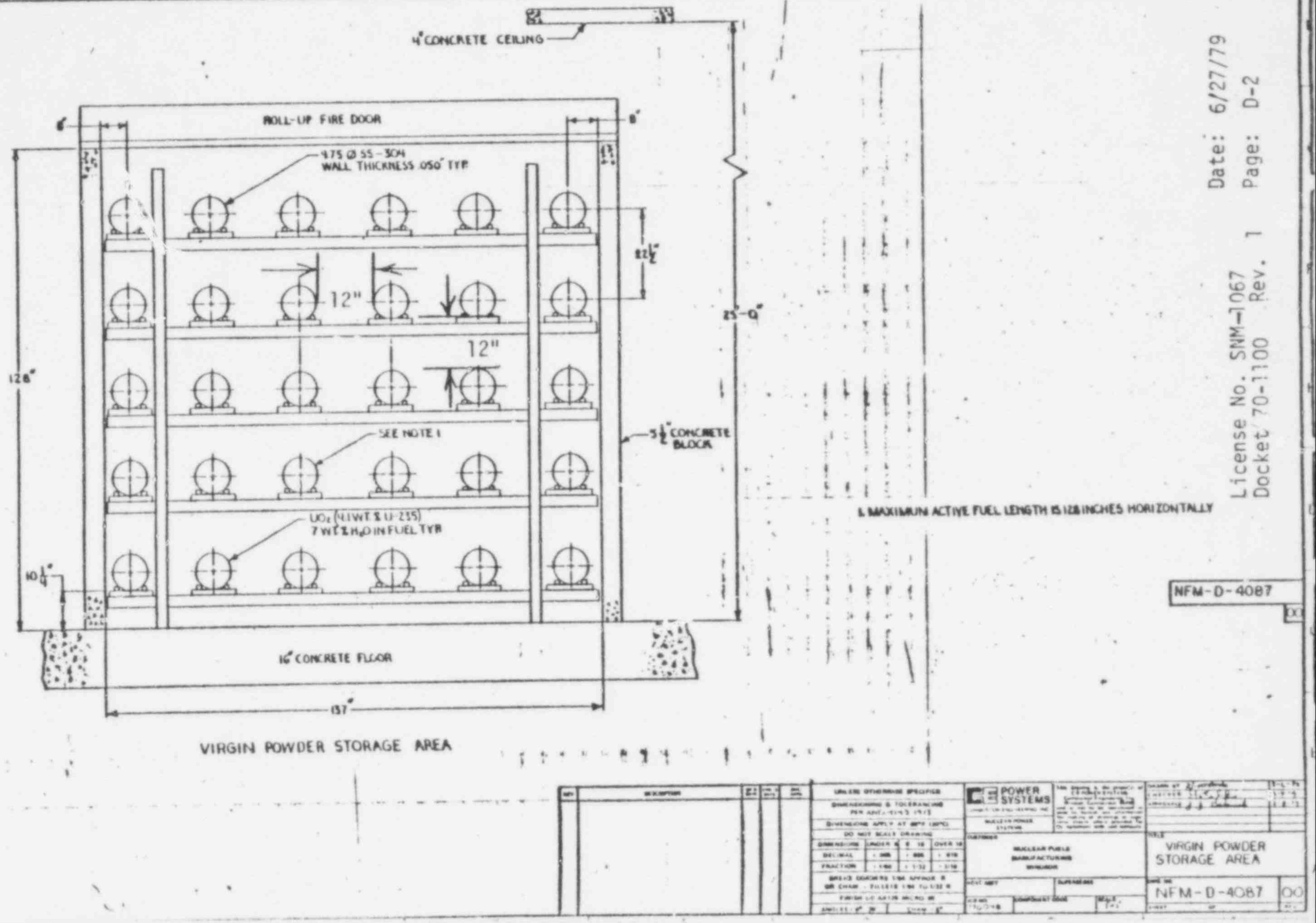
1.1 Virgin Powder Storage Area



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1.7 Pellet Drying Furnaces

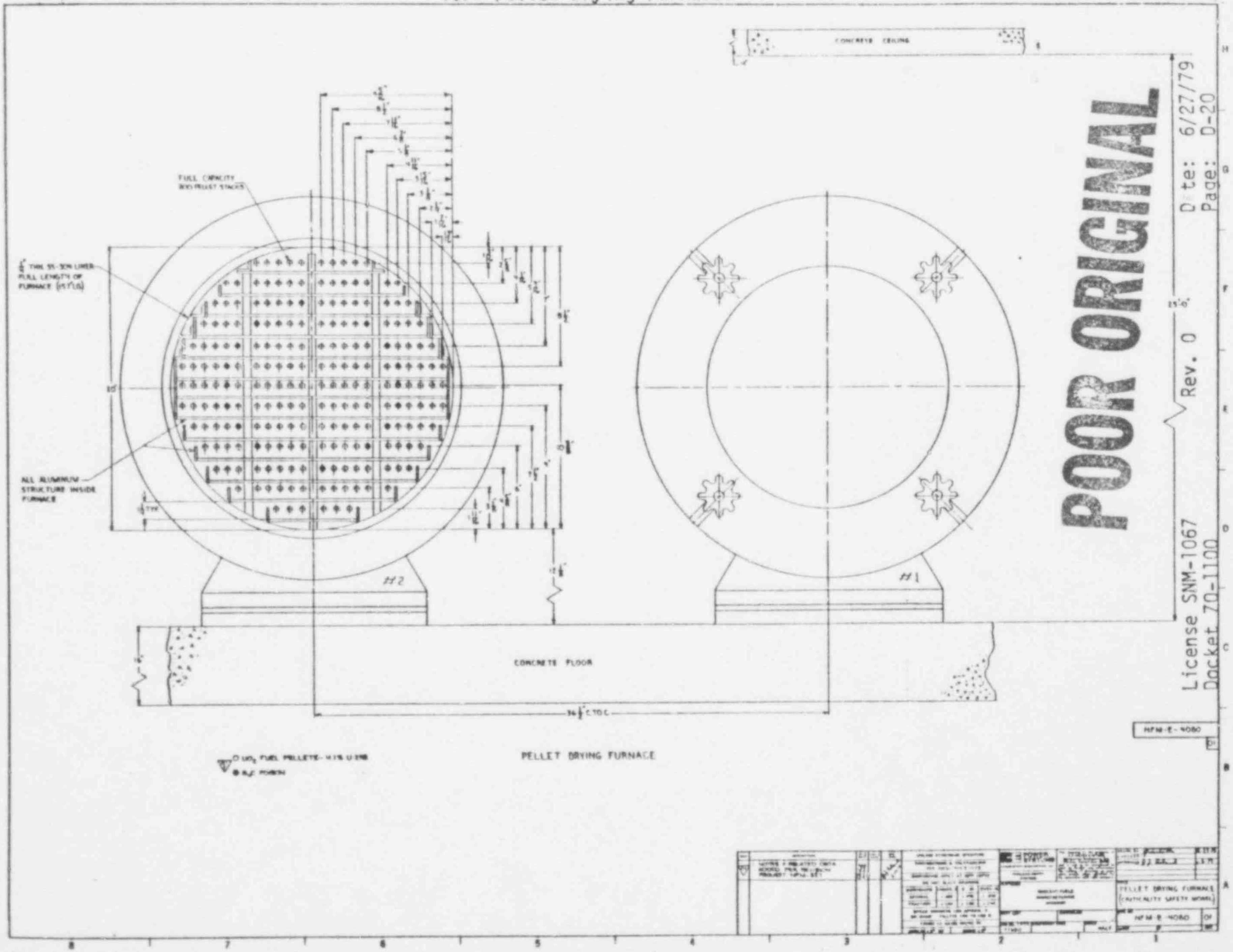

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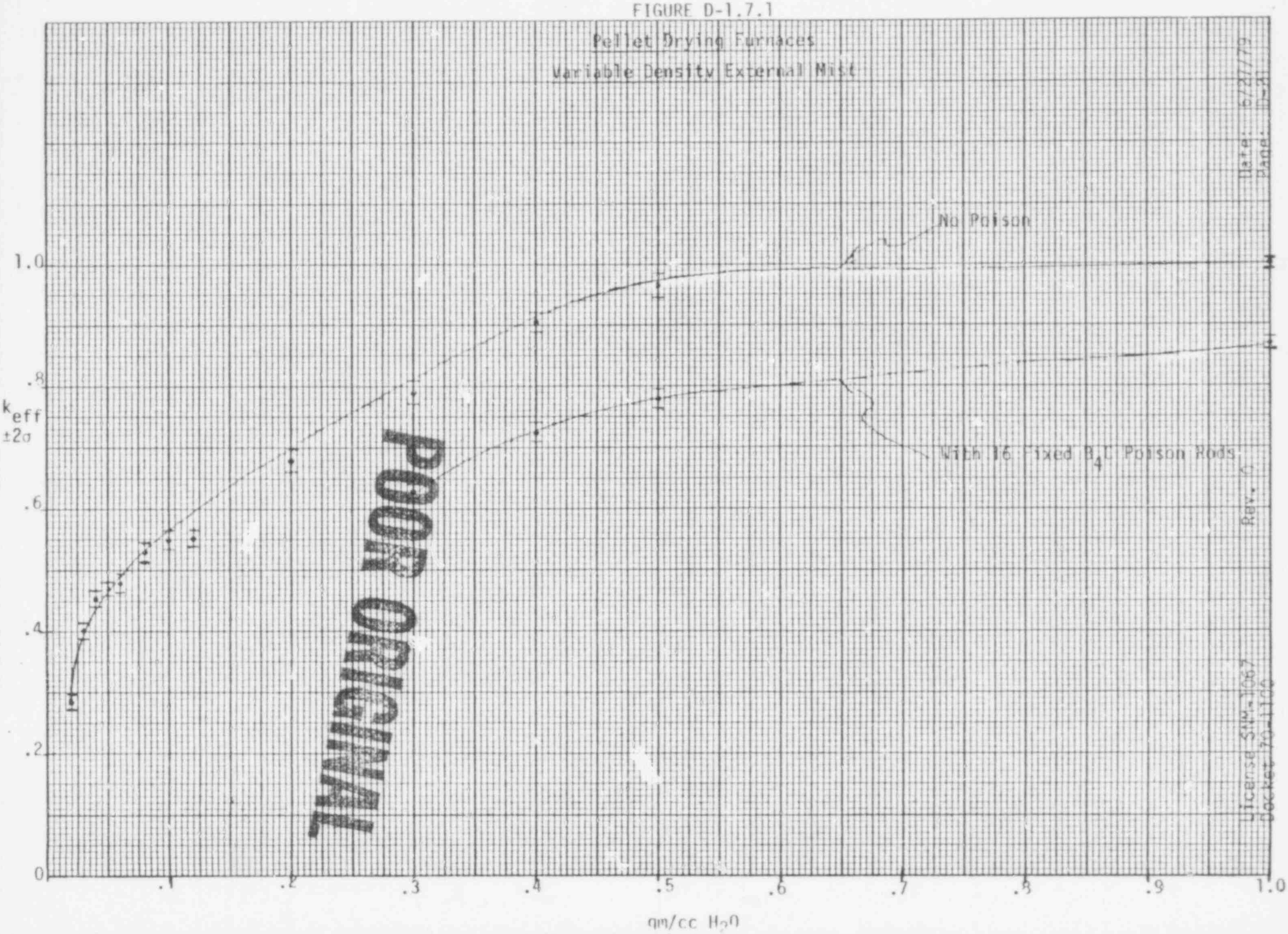
FIGURE D-1.7.1

Pellet Drying Furnaces

Variable Density External Mist



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3.0 VALIDATION OF CALCULATIONAL METHODS FOR NUCLEAR CRITICALITY SAFETY

To validate the methods used in criticality analysis of fuel manufacturing processes, the 2.35 w/o U^{235} UO_2 critical separation experiments by Battelle (Reference 1) were analyzed in three dimensions. The mean k_{eff} value of these nineteen experiments was 1.00157 with a standard deviation of .00419.

The experiments are concerned with the critical separation between water-flooded subcritical clusters of fuel rods in the presence of various fixed neutron poisons. The experiments were carried out in a 1.8m x 3m x 2.1m deep tank provided with features specifically designed and built for these experiments. These experiments involved aluminum-clad 2.35 wt% ^{235}U enriched UO_2 rods about 12mm in diameter by 914mm in length. The critical separation between three subcritical clusters of these rods aligned in a row was determined and analyzed with and without the following neutron absorber materials (neutron poisons) located between the clusters: 304L Steel with 0, 1.1, and 1.6 wt% boron; and boral.

3.1 Description of Experiments

The experiments analyzed each consisted of three assembly-like configurations separated by water and/or poison plates with the spacing adjusted to criticality. Figure I illustrates typical top and end view of the arrangements. The 914mm length fuel rods 11.176mm in diameter of 2.35 w/o U^{235} in UO_2 were clad with 6061 aluminum having an O.D. of 62.7mm and 0.762mm thick with different alloys of aluminum for top and bottom plugs. A fixed square center-to-center pin pitch of 20.32mm was maintained. The number of pins in the width of the cluster varied (in different experiments) between 14 and 17 and the length from 20 to 24 pins. The experimental data on experiments analyzed are given in Tables 1, 2 and 3.

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3.2 Method of Calculation

The calculation methods which are essentially those used to determine reactivity for fuel rack storage, fuel shipping containers plus other fuel configurations found in fuel manufacturing areas are based on CEPAK (Reference 2) cross sections. Using an appropriate buckling value and taking proper account of resonance absorption, three fast groups are collapsed from 55 fine energy mesh groups in FORM and the one thermal group is collapsed from 29 thermal emergy groups in THERMOS. Fast cross sections for certain trace elements such as sodium and zinc were obtained from GGC-3 (Reference 3). In addition, each component such as water gap, end plug, or poison plate has its thermal cross section determined by a slab THERMOS calculation employing the proper fuel environment.

Normally, for two dimensional representations, the transport Code DOT-IIW (Reference 4) is used. Since, however, the short fuel length made necessary a three dimensional treatment, the Monte Carlo Code KENO IV (Reference 5) was used with six axial levels. Batches of one hundred neutron histories were used with the first four discarded. Calculated K_{eff} values are shown in Table 4. For economy, about 150 batches were run for most cases, however, because of their greater use in fuel storage analyses, about 500 batches were employed for plain stainless steel and boral.

The mean value of the calculated k_{effs} is 1.00157 with a standard deviation of .00419; thus at a 95/95 confidence level using a σ multiplier of 2.423, the k_{eff} values are between 1.012 and 0.991.

3.3 References:

1. S. R. Bierman, E. D. Clayton and B. M. Durst, "Critical Separation Between Subcritical Clusters of 2.35 w/o U^{235} Enriched UO_2 Rods in Water with Fixed Neutron Poisons", PNL-2438, October 1977.

2. CEPAK--A Synthesis of the following computer codes:

FORM - A Fourier Transform Fast Spectrum Code for the IBM-7090, McGoff, D. J., NAA-SR-Memo 5766 (September 1960).

THERMOS- A Thermalization Transport Theory Code for Reactor Lattice Calculations, Honeck, H., BNL-5816 (July 1961).

3.3 References (Cont'd)

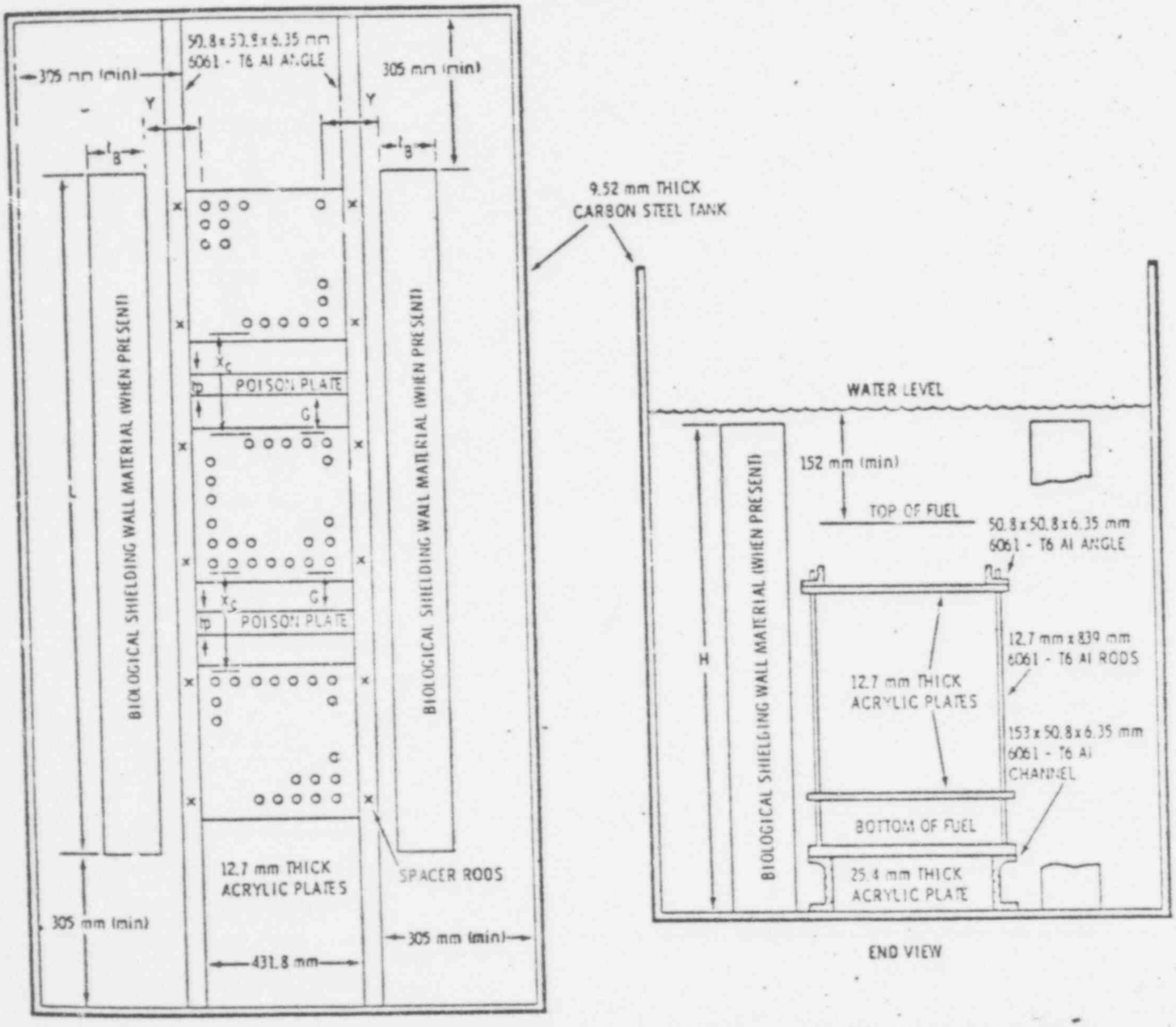
CINDER - A One-Point Depletion and Fission Product Program, England, T. R., WAPD-TM-334 (Revised June 1964).

3. J. Adir, S. Clarke, R. Forelich, and L. Tody, "Users and Programmers Manual for the GGC-3 Miltigroup Cross Section Code", GA-7157, July 25, 1967.

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

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

GRAPHICAL ARRANGEMENT OF SIMULATED SHIPPING PACKAGE CRITICAL EXPERIMENTS



PLAN VIEW

END VIEW

POOR ORIGINAL

FIGURE 1

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TABLE 1

EXPERIMENTAL DATA ON CLUSTERS OF 2.35 wt% ^{235}U ENRICHED UO_2 RODS IN WATER

FUEL CLUSTERS		
LENGTH x WIDTH 20.32mm SQ. PITCH (FUEL RODS)	CRITICAL SEPARATION BETWEEN FUEL CLUSTERS (1) (Xc, mm)	EXPERIMENT NUMBER
20 x 17	119.2 ± 0.4	015
20 x 16	83.9 ± 0.5	005
20 x 16	84.4 ± 0.5	049 (2)
22 x 16 (3)	100.5 ± 0.5	018
20 x 14	44.6 ± 1.0	021

(1) PERPENDICULAR DISTANCE BETWEEN THE CELL BOUNDARIES OF THE FUEL CLUSTERS. ERROR LIMITS ARE ONE STANDARD DEVIATION

(2) RERUN OF EXPERIMENT 005

(3) CENTER FUEL CLUSTER AT 20 x 16 RODS. TWO OUTER FUEL CLUSTERS AT 22 x 16 RODS EACH

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TABLE 2

EXPERIMENTAL DATA ON CLUSTERS OF 2.35 wt% ^{235}U ENRICHED UO_2 RODS IN WATER WITH 304L STEEL PLATES BETWEEN FUEL CLUSTERS (1)

FUEL CLUSTERS	304L STEEL PLATES (2)				
LENGTH x WIDTH 20.32mm SQ. PITCH (FUEL RODS)	BORON CONTENT wt%	THICKNESS (Tp, mm)	DISTANCE TO FUEL CLUSTER (3) (G, mm)	CRITICAL SEPARATION BETWEEN FUEL CLUSTERS (4) (Xc, mm)	EXPERIMENT NUMBER
20 x 16	0	4.85 ± 0.15	6.45 ± 0.06	68.8 ± 0.2	028
20 x 16	0	4.85 ± 0.15	27.32 ± 0.50	76.4 ± 0.4	005*
20 x 16	0	4.85 ± 0.15	40.42 ± 0.70	75.1 ± 0.3	029
20 x 16	0	3.02 ± 0.13	6.45 ± 0.06	74.2 ± 0.2	027
20 x 16	0	3.02 ± 0.13	40.42 ± 0.70	77.6 ± 0.3	026
20 x 17	0	3.02 ± 0.13	6.45 ± 0.06	104.4 ± 0.3	034
20 x 17	0	3.02 ± 0.13	40.42 ± 0.70	114.7 ± 0.3	035
20 x 17	1.05	2.98 ± 0.06	6.45 ± 0.06	75.6 ± 0.2	032
20 x 17	1.05	2.98 ± 0.06	40.42 ± 0.70	96.2 ± 0.3	033
20 x 17	1.62	2.98 ± 0.05	6.45 ± 0.06	73.6 ± 0.3	038
20 x 17	1.62	2.98 ± 0.05	40.42 ± 0.70	95.2 ± 0.3	039

(1) ERROR LIMITS SHOWN ARE ONE STANDARD DEVIATION

(2) PLATES ARE 356mm WIDE BY 915mm LONG.

(3) PERPENDICULAR DISTANCE BETWEEN THE CELL BOUNDARY OF THE CENTER FUEL CLUSTER AND THE NEAR SURFACE OF THE STEEL PLATE

(4) PERPENDICULAR DISTANCE BETWEEN THE CELL BOUNDARIES OF THE FUEL CLUSTERS

*To distinguish from experiment #005 of Table 1.

TABLE 3

EXPERIMENTAL DATA ON CLUSTERS OF 2.35 wt% ^{235}U ENRICHED UO_2 RODS IN WATER WITH BORAL PLATES BETWEEN FUEL CLUSTERS (1)

FUEL CLUSTERS	BORAL PLATES			
LENGTH x WIDTH 20.32mm SQ. PITCH (FUEL RODS)	THICKNESS(2) (tp, mm)	DISTANCE TO FUEL CLUSTER (3) (G, mm)	CRITICAL SEPARATION BETWEEN FUEL CLUSTERS (4) (Xc, mm)	EXPERIMENT NUMBER
20 x 17	7.13 ± 0.11	6.45 x 0.06	63.4 ± 0.2	020
20 x 17	7.13 ± 0.11	44.42 ± 0.60	90.3 ± 0.5	016
22 x 16 (5)	7.13 ± 0.11	6.45 ± 0.06	50.5 ± 0.3	017

(1) ERROR LIMITS SHOWN ARE ONE STANDARD DEVIATION

(2) INCLUDES 1.02 mm THICK CLADDING OF TYPE 1100 Al ON EITHER SIDE OF THE B_4C-Al CORE MATERIAL. PLATES 365mm WIDE BY 915 mm LONG.

(3) PERPENDICULAR DISTANCE BETWEEN THE CELL BOUNDARY OF THE CENTER FUEL CLUSTER AND THE NEAR SURFACE OF THE BORAL PLATE

(4) PERPENDICULAR DISTANCE BETWEEN THE CELL BOUNDARIES OF THE FUEL CLUSTERS

(5) CENTER FUEL CLUSTER AT 20 x 16 RODS. TWO OUTER FUEL CLUSTERS AT 22 x 16 RODS EACH

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TABLE 4

Calculated k_{eff} Values

Expt #	Type Poison Plate	K_{eff}	Monte Carlo σ(STD Deviation)
15	None	1.00227	.00534
04	None	0.99912	.00540
49	None	1.00221	.00473
18	None	1.00813	.00489
21	None	0.99589	.00461
28	304 S Steel 0.0 w/o Boron	1.00393	.00308
05*	304 S Steel 0.0 w/o Boron	1.00329	.00303
29	304 S Steel 0.0 w/o Boron	1.00271	.00302
27	304 S Steel 0.0 w/o Boron	1.00418	.00273
26	304 S Steel 0.0 w/o Boron	0.99811	.00279
34	304 S Steel 0.0 w/o Boron	0.99793	.00297
35	304 S Steel 0.0 w/o Boron	1.00436	.00290
32	304 S Steel 1.05 w/o Boron	0.99970	.00524
33	304 S Steel 1.05 w/o Boron	1.01173	.00491
38	304 S Steel 1.62 w/o Boron	1.00289	.00512
39	304 S Steel 1.62 w/o Boron	1.00208	.00506
20	Boral	0.99585	.00301
16	Boral	1.00020	.00288
17	Boral	0.99519	.00286

Mean K_{eff} Value 1.00157

Std. deviation .00419

432 285