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NUCLEAR  
DIVISION  
Baltimore,  
Maryland  
21203

**MARTIN COMPANY**

Refer to: ACC-347  
Mail No. 845  
November 23, 1964

U. S. Atomic Energy Commission  
Division of Material Licensing  
Washington, D. C. 20545

Attention: Mr. Kenneth Lauterbach

Subject: Interim Storage of Fuel Rods Containing Slightly  
Enriched Uranium Oxide Pellets - Martin  
Marietta SNM License No. 53

Gentlemen:

In previous submissions in connection with Amendment No. 21 to Special Nuclear Material License No. 53 we have described the fabrication and storage of fuel tubes and finished fuel elements for a nuclear core of tubular design employing slightly enriched uranium oxide pellets. We have now completed processing of all tubes containing the higher (4.65%) enrichment of UO<sub>2</sub> pellets but because of a delay in the supply of base plates we will not be able to assemble the rods into finished fuel elements at this time. We, therefore, plan to store the completed tubes in the nuclear storage area to permit completion of the lower enriched (4.07%) tubes in the fabrication shop. Our planned storage array is detailed in the enclosed nuclear safety evaluation.

We will appreciate receiving approval of this storage arrangement by December 4, 1964. Thank you for your usual efficient processing of our request.

Very truly yours,

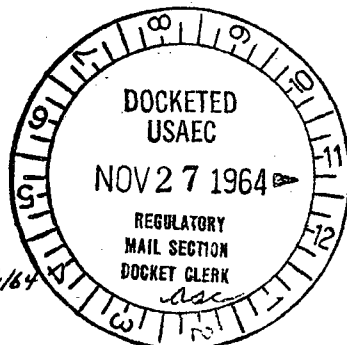
C. W. Keller  
Nuclear Accountability  
& Licensing Representative

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**ACKNOWLEDGED**

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NUCLEAR SAFETY EVALUATION

The nuclear safety analysis has been completed for the storage of the 4.63 percent enriched M2-1A fuel tubes. These tubes are to be stored in Area E of D Building. The fuel tubes are ready to be assembled into fuel elements. However, a problem has arisen with the alignment of the grid plates and the core barrel. This problem must be resolved before assembling the fuel elements.

In order for manufacturing to start fabrication of the 4.07 percent enriched M2-1A fuel, it was decided to store the finished high enriched fuel tubes in Bay 2 of Area E. The fuel tubes are to be stored in the M2 storage containers. Fifty-two tubes are to be loaded into each storage container. A typical storage container is shown in Figure 1. Four containers are to be strapped onto a 48-inch by 48-inch pallet. The containers on each pallet are separated by a 4-inch spacer. The four containers are strapped to the pallet with steel strips which are 5/8 inch wide and 20 mils thick. The storage array showing the containers, spacers and pallets are shown in Figure 2.

The nuclear safety of the array shown in Figure 2 was determined by calculating the effective neutron multiplication factor ( $k_{eff}$ ) for the most centrally located container and the total solid angle subtended by the remaining containers in the array. The  $k_{eff}$  calculations and the solid angle ( $\Omega$ ) calculations are shown below.

Effective Neutron Multiplication Calculations

Volume of container =  $6.1466(3.837)(6.16)(.387) = 29,617.36 \text{ cm}^3$

Volume of 52 fuel tubes =  $52(3.14159)(.2385)^2 \times 37.16(3.87) = 6,365.27 \text{ cm}^3$

Volume of water =  $29,617.36 - 6,365.27 = 19,252.11 \text{ cm}^3$

Volume of Stainless Steel =  $52 \left[ 3.14159(3.837)^2 \times 37.16(3.87) - 3.14159(2.385)^2 \times 37.16(3.87) \right] = 1102.64 \text{ cm}^3$

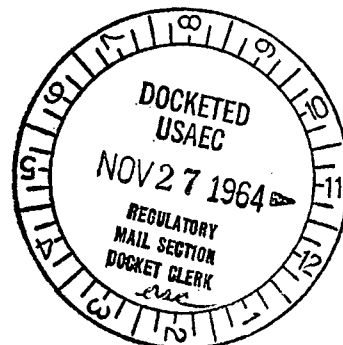
Volume of  $\text{UO}_2$  pellets for 52 fuel tubes =  $52 \left[ 3.14159(3.837)^2 \times 37.16(3.87) \right] = 3,000.92 \text{ cm}^3$

Volume of void =  $19,252.11 - 1102.64 - 3,000.92 = 15,148.55 \text{ cm}^3$

Volume of U-235 for 52 fuel tubes =  $\frac{3,000.92}{15.7} = 190.94 \text{ cm}^3$

Volume of U-238 for 52 fuel tubes =  $\frac{19,252.11 - 3,000.92}{15.7} = 2,315.01 \text{ cm}^3$

Volume of Oxygen + Boron =  $29,617.36 \text{ cm}^3$



Effective Stiffness of Composite Plate Section

- U-235 gas tube            10.928 inches
- Active shell length        16.00 inches
- Shell tube length         37.00 inches
- Length of top end fitting   1.25 inches
- Length of bottom end fitting 1.50 inches

Material	Volume fraction	$\frac{E_i}{E_c}$	Formal $\frac{E_i}{E_c}$
Steel	.7515	.0221	.01951
Nickel alloy steel	.0831	.0530	.01351
U-235	.0075	92.70	.14572
U-238	.0012	12.40	.01367
Oxygen + Argon filler	.1000	~ 0	~ 0
Void	.0557	~ 0	~ 0

$$F = \frac{\sum E_i A_i}{\sum E_i A_i + \sum E_i B_i + \sum E_i C_i} = .848$$

$$U = 1.928 \text{ (Int. Eq. - 6.273)}$$

$$U(E) \approx \left[ \frac{r}{1-r} \right]$$

$$\frac{1}{r} = 1 + \frac{1}{U} \frac{\sum E_i}{E_c} \quad (6-1)$$

$$r \approx 1 - \frac{(\sum E_i)^2}{E_c^2} - \frac{(E_c r_0)^2}{E_c^2}$$

$$r \approx 1.004$$

$$r_0 = .97975 \text{ cm}$$

$$K_0 = 0.31 \text{ cm}^{-1}$$

$$r \approx 1 + \frac{(K_0 r_0)^2}{2} \left[ \frac{1}{r_1^2} - \frac{1}{r_0^2} \right] \ln \frac{r_1}{r_0} - \frac{1}{2} (K_0 r_0)^2$$

1. The value of  $\sin^{-1}(\sin \frac{2\pi}{3})$  is

(a)  $\frac{2\pi}{3}$

(b)  $\frac{\pi}{3}$

(c)  $\frac{4\pi}{3}$

(d)  $\frac{5\pi}{3}$

2. The value of  $\cos^{-1}(\cos \frac{7\pi}{6})$  is

(a)  $\frac{7\pi}{6}$

(b)  $\frac{5\pi}{6}$

(c)  $\frac{11\pi}{6}$

(d)  $\frac{13\pi}{6}$

3.  $\sin^{-1}(\sin \frac{5\pi}{6}) =$

(a)  $\frac{5\pi}{6}$

(b)  $\frac{7\pi}{6}$

(c)  $\frac{11\pi}{6}$

(d)  $\frac{13\pi}{6}$

4.  $\cos^{-1}(\cos \frac{7\pi}{6}) =$

(a)  $\frac{7\pi}{6}$

(b)  $\frac{5\pi}{6}$

(c)  $\frac{11\pi}{6}$

(d)  $\frac{13\pi}{6}$

Example 2: The Application Calculations (cont'd)

12-20

- 1.  $L_1 = 2.0$
- 2.  $L_2 = 2.0$
- 3.  $L_3 = 2.0$
- 4.  $L_4 = 2.0$
- 5.  $L_5 = 2.0$
- 6.  $L_6 = 2.0$
- 7.  $L_7 = 2.0$
- 8.  $L_8 = 2.0$
- 9.  $L_9 = 2.0$
- 10.  $L_{10} = 2.0$

$$1 + \frac{L_1}{L_2} + \frac{L_2}{L_3} + \frac{L_3}{L_4} + \frac{L_4}{L_5} + \frac{L_5}{L_6} + \frac{L_6}{L_7} + \frac{L_7}{L_8} + \frac{L_8}{L_9} + \frac{L_9}{L_{10}}$$

Example 2: The Application Calculations

<u>Year</u>	<u>Q (in \$)</u>	<u>P (in \$)</u>	<u>Q (in \$)</u>	<u>P (in \$)</u>
1	7.1	9.45	10.75	.0000
2	7.2		10.50	.0010
3	7.3		10.25	.0020
4	7.4		10.00	.0030
5	7.5		9.75	.0040
6	7.5		9.50	.0050
7	7.6		9.25	.0060
8	7.6		9.00	.0070
9	7.7		8.75	.0080
10	7.6		8.50	.0090
11	7.6		8.25	.0100
12	7.5		8.00	.0110
13	7.5		7.75	.0120
14	7.4		7.50	.0130
15	7.4		7.25	.0140
16	7.2		7.00	.0150
17	7.2		6.75	.0160
18	7.0		6.50	.0170
19	7.0		6.25	.0180



Pages 8 through 10 redacted for the following reasons:

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(b)(4)