8898

Hand Carried in by Swallow on 2/17/60 - formal

**MALLINCKRODT NUCLEAR CORPORATION**

SAINT LOUIS 7, MISSOURI • U.S.A. • CENTRAL 1-8980

PLANT
HEMATITE, MISSOURI

About same as 3/2/60 Appl.

~~February 12, 1960~~

appl will follow - check wall th. of 5" inner cont, and general all around mech. integ. of cont & b.c.

Mr. J. C. Delaney
Chief, Nuclear Materials Section
Licensing Branch
Division of Licensing and Regulation
U. S. Atomic Energy Commission
Washington 25, D. C.

SUBJECT: Special Nuclear Material License No. SNM-33

Dear Mr. Delaney:

On February 2, 1959, we asked for a revision of our SNM-33 license to include the shippin container shown in the attached sketches numbered 6448 and 6574. This was denied by your letter of March 11, 1959. Please reconsider our request for extension of our SNM-33 locense to include this shipping container for LTL, LCL, railway express, air freight or air express shipments of uranium compounds, solutions, and metal of any enrichment and moderation subject to the following considerations and safety limitations.

The container shown on the attached sketches, as noted in our earlier letter, is made up of aluminum sheet and angles, and is of all welded construction. In addition, the outside frame will be covered with aluminum sheet or grill to prevent other containers from telescoping with this container.

The material to be shipped will be packaged in tin cans or polyethylene bottles sealed against water inleakage before being inserted into the cage containers shown on Sketch 6574. This cage container will also be sealed against water inleakage during shipment. If tin cans are used, a polyethylene bag will be used as a liner. Maximum inside dimensions of the cans or bottles will be: Diameter 5" Height 14.5". Vermiculite will be packed around the bottle or can to hold it firmly in place in the cage container.

B-47

A. <u>Metal Shipments</u>

For single mass metal shipments, no more than 11 kilograms of $U^{235}$ will be placed in each container (TID-7019, p. 21, Table XI). For shipments of metal chips, cubes, slugs, etc., container quantities will be determined by dividing by 2.3 values obtained from Fig. 12, p. F-17, K-1380. For example, no more than $(\frac{15.5}{2.3})$ or 6.73 kilograms of metal pieces having effective diameters* of .8" will be placed in each container. This, and quantities determined in like fashion, should be conservatively safe since we will not intentionally be optimizing the orientation of the pieces for highest reactivity see K-1380, p. F-16, last paragraph and LA-1958 (depleted), Los Alamos Scientific Laboratory Report, 4/56, p. 6 . Also, the factor 2.3 is the normal safety factor applied to determine safe masses.

Note

A maximum of 12 containers would be shipped in a single layer. Double stacking will be prevented by adding a pyramid to the top of the container as shown in the attached sketch. In addition, a sign warning against double stacking will be mounted on this pyramid. The pyramid would be bolted to the top of the framework so as to be removable for loading and unloading the container.

When the maximum amount of $U^{235}$--11 kilograms--is placed in a container, the $U^{235}$ density per unit shipping container volume is:

$$\frac{11 \text{ kilograms}}{\pi r^2 h} = \frac{11}{(\pi)(1.25)^2 \left(\frac{17}{12}\right)} = 1.59 \text{ kg/ft}^3$$

which is permissible (TID-7019, Table XI, p.21).

* The effective diameter used will be the diameter of a circle having a cross sectional area equal to the cross sectional area of the individual pieces in a container.

The maximum amount of $U^{235}$ metal that will be shipped in any one shipment is 132 kilograms, which is also less than the maximum amount allowed (TID-7019, Table XI, p. 21).

B. <u>Dry Compound and Solution Shipments</u>

For compounds and solutions having uranium densities no greater than 3.2 grams milliliter, the five inch diameter (maximum) container is safe for any quantity of material at any moderation, and any enrichment (see Table IV, p. 15, TID-7019). A maximum of 12 containers would be shipped at any one time. In this case no restriction would be placed on stacking the containers. The lugs shown on the sketch of the pyramid would serve to keep the containers nested together in the event they are stacked.

For compounds and solutions having uranium densities greater than 3.2 grams per milliliter, the basis for determining the maximum quantities of material that will be shipped in each container will be the safe volumes shown in Table II, p. 13, TID-7019, corrected for uranium densities higher than 3.2 grams per milliliter by the procedure outlined in TID-7019, Section 3.2, paragraph 6b. A maximum of 12 containers would be shipped in a single layer. Double stacking will be prevented by adding a pyramid to the top of the container as shown in the attached sketch. In addition, a sign warning against double stacking will be mounted on this pyramid. The pyramid would be bolted to the top of the framework so as to be removable for loading and unloading the container.

The criteria listed in TID-7019, Table XI, p. 21, will be conformed to in all cases. It should be noted that the water content of material such as $UO_2$ is much less than 1%.

<u>Interaction</u>

Interaction calculations we have performed indicate that 12 containers, plus a twin of 12 containers, are safe. Table I, summarizing our calculations, follows. A sample set of the calculations is appended to the end of this letter.

TABLE I

| Number of Containers Per Stack | Solid Angle For 12 Container Shipment (Steradians) | Solid Angle With Twin Along Side (Steradians) | Solid Angle With Twin Above Steradians) |
|---|---|---|---|
| 1 | .70 | .97* | 1.25 |
| 2 | .85 | 1.25 | 1.16 |
| 3 | .53 | 1.07 | .92 |
| 4 | .53 | 1.16 | **** |
| 5** | .56 | 1.18 | **** |
| 6 | .31 | .92 | **** |
| 7*** | .32 | .92 | **** |

* For infinite one layer hexagonal array

** Two stacks of 5, one stack of 2

*** One stack of 7, one stack of 5

**** Stack over 10-1/2' high, the height of the highest railway car.

Based on a K value of .58, which is applicable for a 5" diameter cylinder, (Note 6, Table X, TID-7019), a total interaction angle of 3.2 steradians is allowed. For a K value of .65, which is permitted for nuclearly safe mass quantities (Note 6, Table X, TID-7019) a solid angle of 2.5 steradians is allowed. In the case of uranium compounds and solutions having a uranium density greater than 3.2 g/cc, the nuclear safety control reverts to volume, the K value of .8 is applicable (Note 6, Table X, TID-7019) and a total solid angle of 1.0 steradians is permitted. By comparison of the allowable solid angles to the actual solid angles listed in Table I above, it can be seen that interaction requirements are met for the shipping conditions described.

To supplement the above safety considerations, we will also obtain certification from the carrier that he will not place our shipment on the same vehicle with another shipment of nuclear material.

Please let us know if you require additional information in order to process this request.

Respectfully yours,

MALLINCKRODT NUCLEAR CORPORATION

L. J. Swallow
Hematite Plant

LJS/jrt

# APPENDIX I

## SAMPLE SOLID ANGLE CALCULATIONS

For the case when 12 containers are placed in stacks 2 high:

I. Sketches:

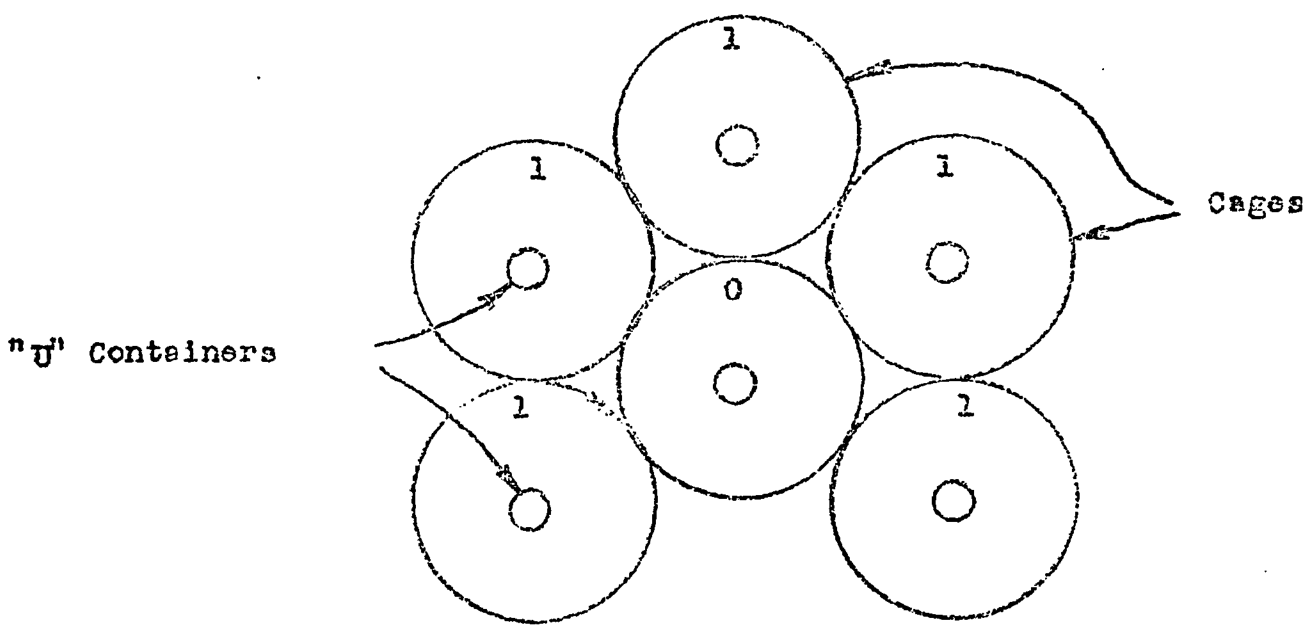



Fig. 1 12 containers in 6 stacks of 2 each, hexagonal (or closest possible) arrangement.

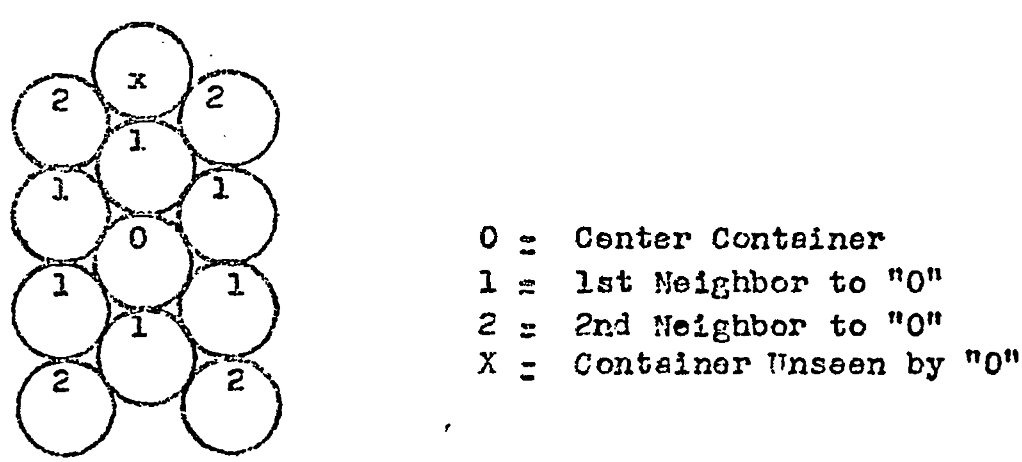



Fig. 2 Cages in Fig. 1, plus a twin.

II. Pertinent Data:

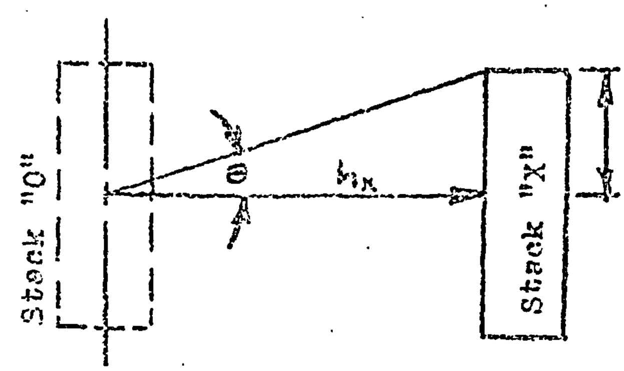
Cage diameter = 30"
Container I.D. = 5" = d
Container height = 14.5"
Stack height taken as 14.5" x 2 or 29" = $L$

III. Calculations:

$$\Omega_x = \frac{2d}{h_x} \sin \theta$$ (K-1019, Appendix 3, p. 44, Method B 1)

Where $\Omega_x$ = The solid angle in steradians subtended by any stack;

$\theta$ is defined from the sketch below:




$$\sin \theta = \frac{\frac{L}{2}}{\sqrt{(\frac{L}{2})^2 + h_x^2}}$$

and $h_x$ is the distance from the center of stack "O" to the edge of any stack for which the solid angle is to be calculated.

(a) $\Omega$ total (6 stacks of 2 each) = $5\Omega_1$ (see Fig. 1)

$$\Omega_1 = \frac{2\ (5)}{h_1} \times \frac{14.5}{\sqrt{(14.5)^2 + h_1^2}}$$

$$h_1 = 30 - 2.5 = 27.5"$$

$$\Omega_1 = \frac{10}{27.5} \times \frac{14.5}{\sqrt{210 + (27.5)^2}} =$$

.1696 steradians

$\Omega$ total = 5 (.1696) = .848 steradians

(b) $\Omega$ total (inc. twin; 12 stacks of 2 each) $= 6\Omega_1 + 4\Omega_2$
(see Fig. 2)

$\Omega_1 =$ .1696 steradians

$$\Omega_2 = \frac{(10)\ (14.5)}{h_2\sqrt{210 + h_2^2}}$$

Where $h_2 = 2 \times 30 \sin 60^\circ - 2.5 = 49.5"$

$$\Omega_2 = \frac{145}{(49.5)\sqrt{210 + (49.5)^2}} = \frac{145}{2550} =$$

.0569 Steradians

$\Omega$ Total (inc. twin) $= 6(.1696) + 4(.0569) =$

1.247 Steradians