

MALLINCKRODT NUCLEAR CORPORATION

SAINT LOUIS 7, MISSOURI

Central 1-6980

Plant: Hematite, Missouri

March 2, 1960

Mr. J. C. Dolanoy  
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. Dolanoy:

On February 2, 1959, we asked for a revision of our SNM-33 license to include the shipping 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 license 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 is made up of aluminum and is of all welded construction. The lid on the center tube, in which the material is packed, is bolted in place with a gasket to prevent water leakage. In addition, to fulfill Bureau of Explosive requirements, 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 and sealed before being packed in the cage. 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.

B-49

A. Metal Shipments

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  $(\frac{11}{2.3})$  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 (deleted), Los Alamos Scientific Laboratory Report, 4/56, p. 6. Also, the factor 2.3 is the normal safety factor applied to determine safe masses.

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

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

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

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.

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The maximum amount of  $^{235}\text{U}$  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. Dry Compound and Solution Shipments

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. Stacking will be prevented by adding a pyramid frame to the top of the container as shown in the attached sketch. In addition, a sign warning against stacking will be stenciled on the outside of the shipping container. 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  $\text{UO}_2$  is much less than 1%.

Interaction

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

<u>Number of Containers Per Stack</u>	<u>Solid Angle For 12 Container Shipment (Steradians)</u>	<u>Solid Angle With Twin Alongside (teradians)</u>	<u>Solid Angle With Twin Above (Steradians)</u>
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.

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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 and that he will not store our shipment alongside another nuclear shipment at transfer points enroute.

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

cc: AEC (3)

APPENDIX I

SAMPLE SOLID ANGLE CALCULATIONS

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

I. Sketches:

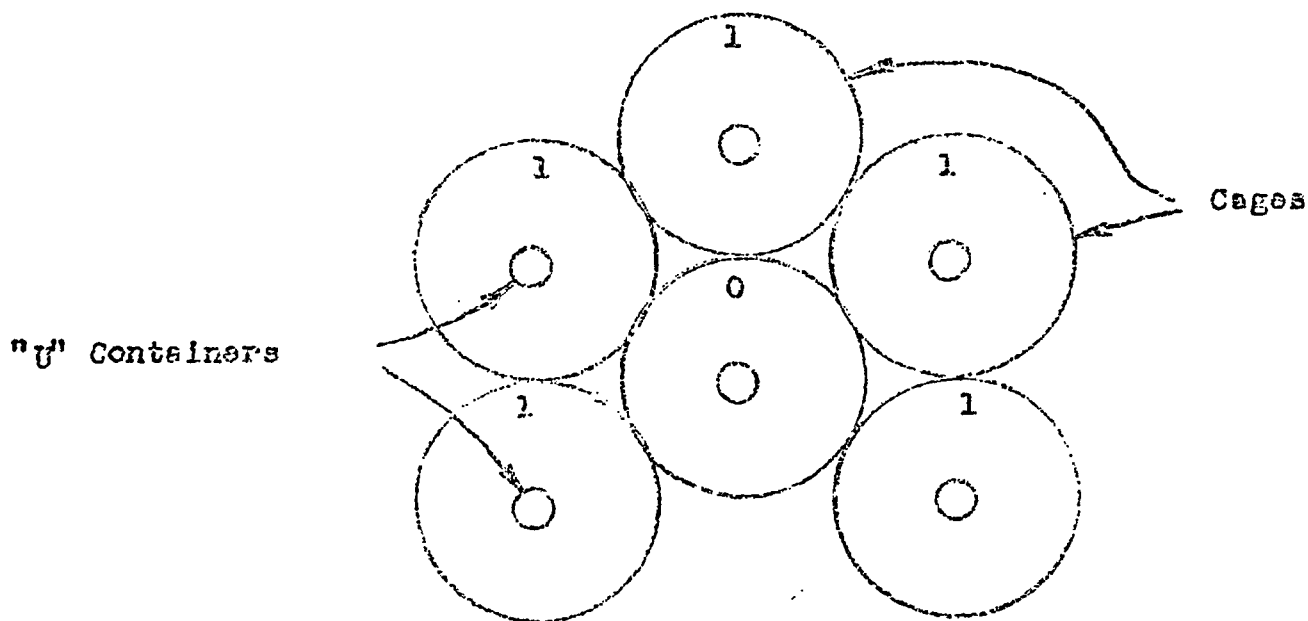
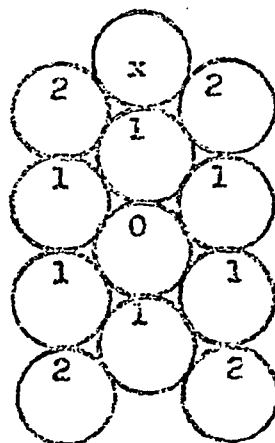


Fig. 1 12 containers in 6 stacks of 2 each, hexagonal (or closest possible) arrangement.



0 = Center Container  
 1 = 1st Neighbor to "0"  
 2 = 2nd Neighbor to "0"  
 X = Container Unseen by "0"

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

## II. Pertinent Data:

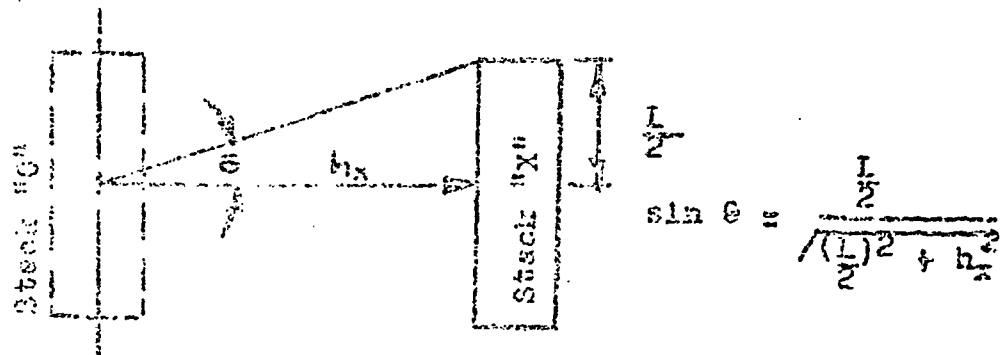
Cage diameter = 30"  
Container I.D. = 5" = d  
Container height = 14.5"  
Stack height taken as 14.5" x 2 or 29" = L

## III. Calculations:

$$\Omega_{\pi} = \frac{2d}{E_{\pi}} \sin \theta \quad (\text{A-1019, Appendix 3, p. 44, Method B 1})$$

Where  $\Omega_{\pi}$  = The solid angle in steradians subtended by any stack;

$\theta$  is defined from the sketch below:



and  $h_x$  is the distance from the center of stack "0" to the edge of any stack for which the solid angle is to be calculated.

$$(a) \Omega_{\text{total}} \text{ (6 stacks of 2 each)} = 5\Omega_1 \quad (\text{see Fig. 1})$$

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

$$h_1 = 30 - 2.5 = 27.5" \quad \checkmark$$

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

.1696 steradians

$$\Omega_{\text{total}} = 5 (.1696) = .848 \text{ steradians}$$

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

$$\Omega_1 = .1696 \text{ steradians}$$

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

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

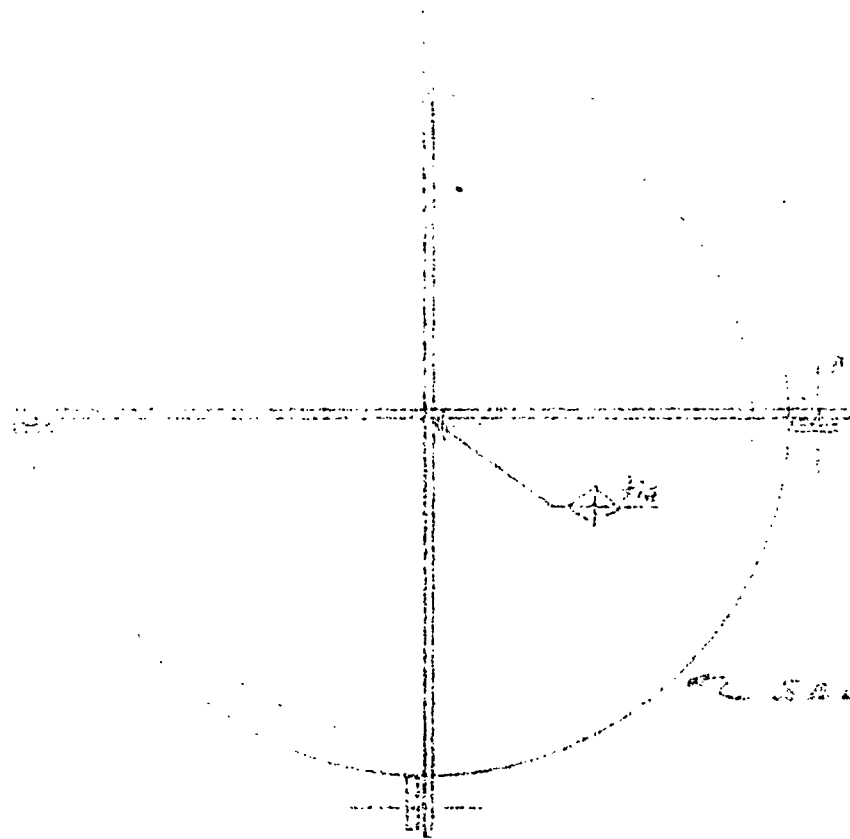
$$\Omega_2 = \frac{145}{(49.5) \sqrt{210 + (49.5)^2}} = \frac{145}{2550} =$$

.0569 Steradians

$$\Omega_{\text{Total}} \text{ (inc. twin)} = 6(.1696) + 4(.0569) =$$

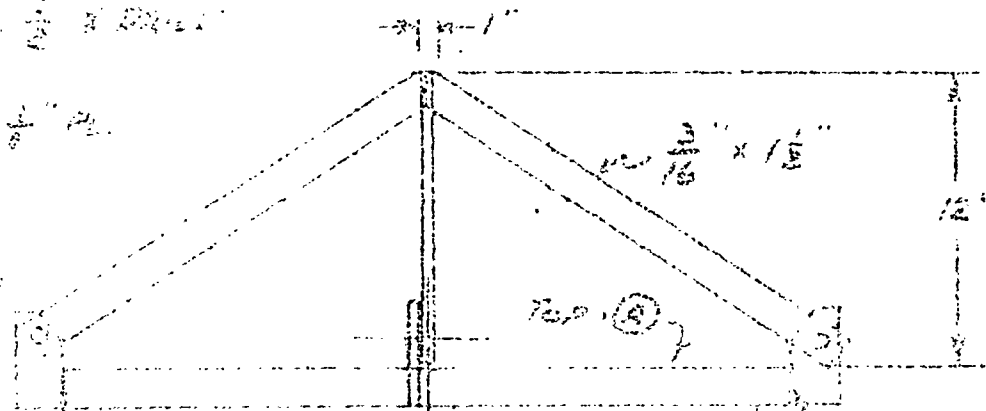
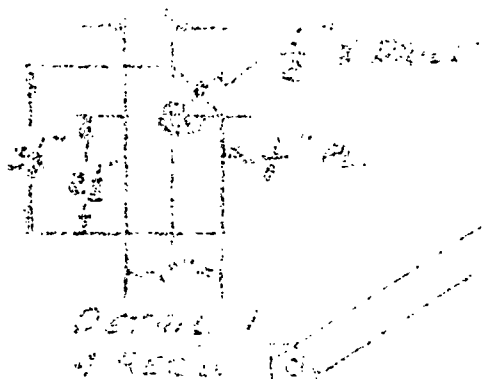
1.247 Steradians





AL - 3/4" DIA. 1/2"  
BOLT WITH  
WASHER & CON-  
WASHER  
1 REF.

SEE SKETCH 6408



SEE SKETCH 6408

SEE SKETCH 6408

M

# KRODT CHEMICAL WORKS ENGINEERING DEPT.

FEB 12 1960

COMPUTATION SHEET

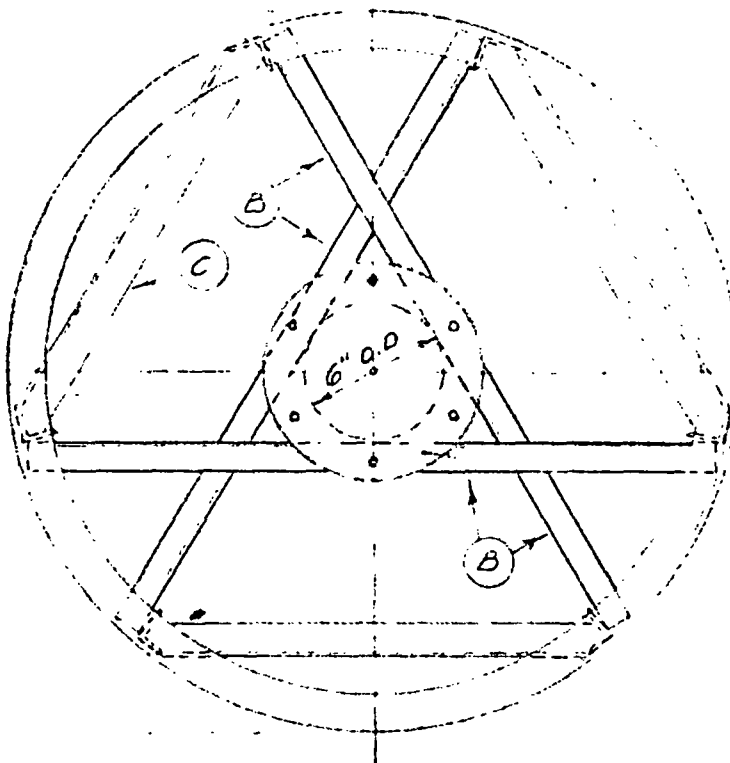
PLANT HANCOCK BLDG.

DATE 9/12/57

SUBJECT PRODUCT SHIPPING CONTAINER

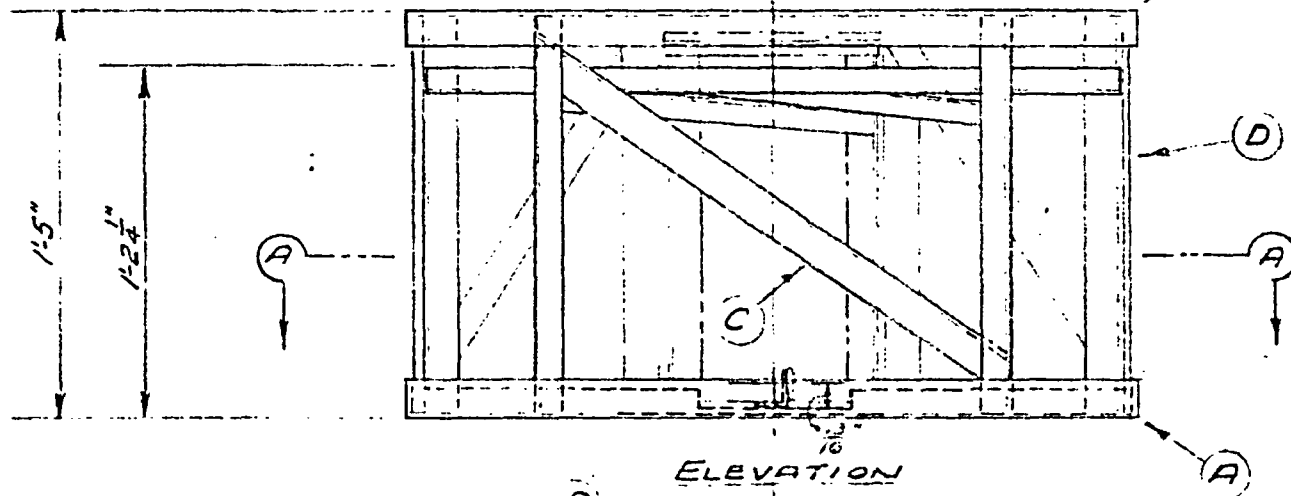
Sketch No. 6448

2'-6" DIA.



SIZES	
ANGLES	ALUM.
(A)	$1\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{4}$
(B)	$1 \times 1 \times \frac{3}{16}$
(C)	$1\frac{1}{2} \times 1\frac{1}{2} \times \frac{3}{16}$
(D)	$1\frac{1}{2} \times 1\frac{1}{2} \times \frac{3}{16}$

PLAN

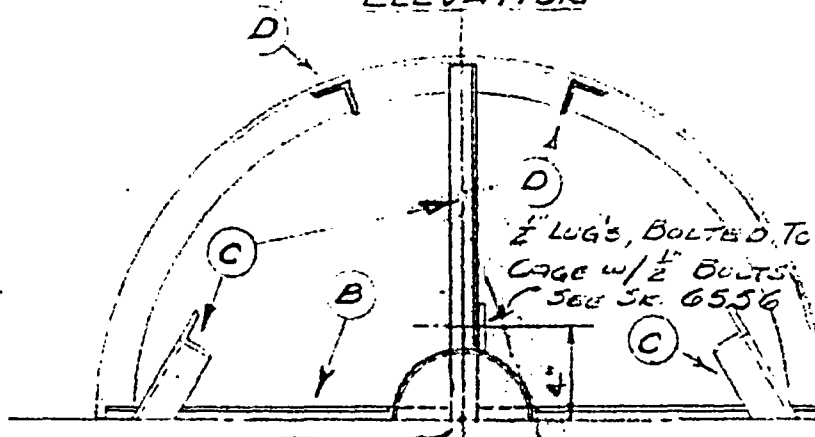


ELEVATION

NET WEIGHT -

ALUM - 27#

ADD 33# (CONTAINER) &  
 20# (GOODS), TOTAL 53#  
 TO OBTAIN GROSS WT.



HALF SECT. "A-A"

NOTE - BOTTOM L (B) IS TO PASS UNDER  
 BOTTOM L (C) AND BE WELDED TO L (C).

Signed I

P No 135

E N. 613

1 1/2 = 1'-0"

6448

## MALINCKRODT CHEMICAL WORKS

COMPUTATION SHEET

ENGINEERING DEPT.

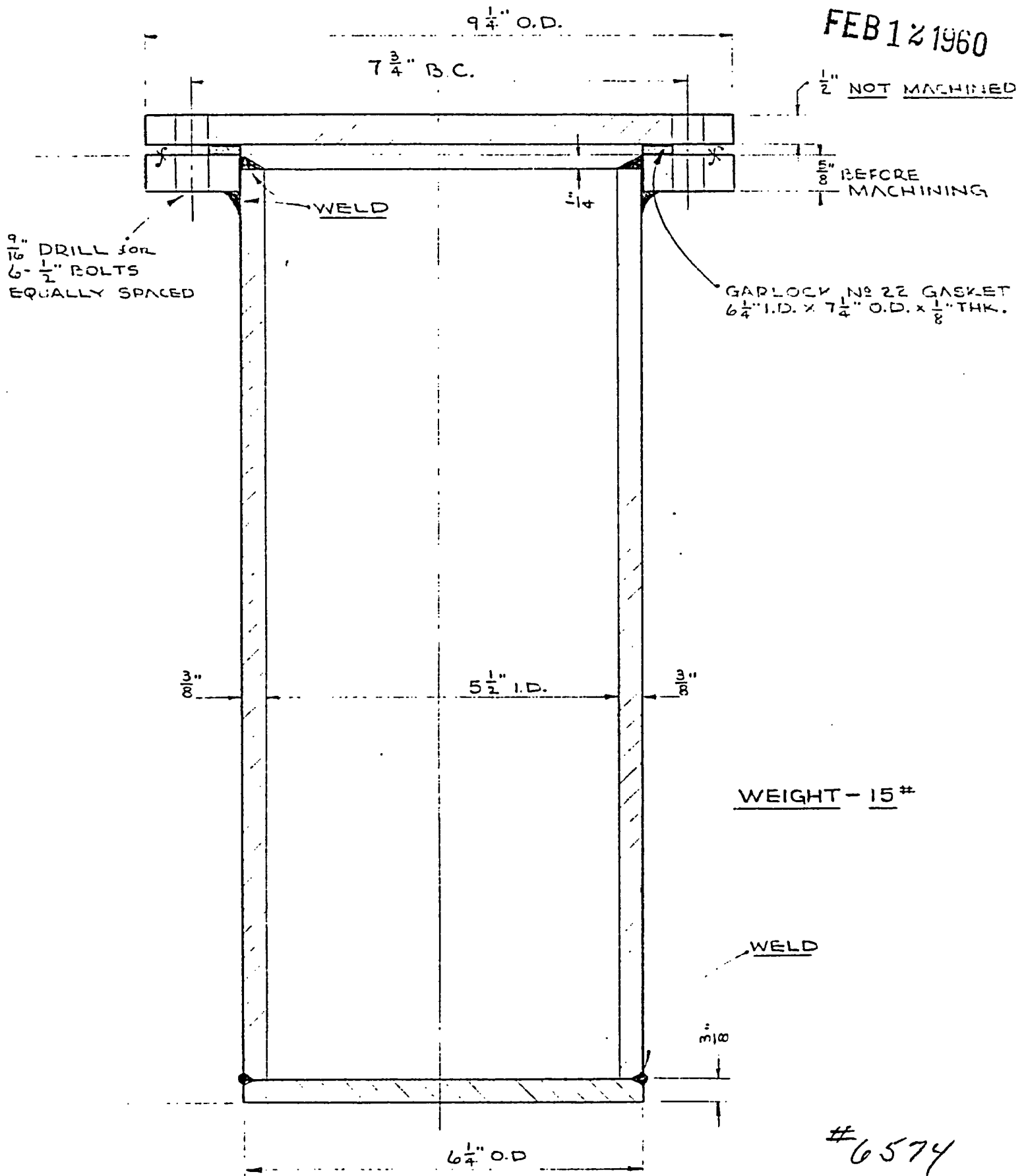
HEMATITE  
PLANT BLDG.

DATE 1-30-58

SUBJECT ALUMINUM PRODUCT CONTAINER

Sketch No. 6574

FEB 12 1960



Signed F.W.

P No. 135

E No. 613

Scale = HALF SIZE

#6574