DOCKET NO. 70-58

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MARTIN COMPANY

Baltimore, Maryland 21203

Refer to: ACC-516
CWK:845

Nov 11, 1966

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

Attention: Dr. John A. McBride, Director
Division of Materials Licensing

Subject: Application for Specific License for Packaging Radioactive Material for Transport

Reference: (a) Title 10, Code of Federal Regulations Part 71

Gentlemen:

The Martin-Marietta Corporation hereby makes application for a Specific License for the packaging of radioactive material for transport. The attached application is in compliance with the referenced regulation.

Thank you for your effort in reviewing our application and in granting the specific license.

Very truly yours,

Martin Company
MARTIN-MARIETTA CORPORATION
Baltimore, Maryland

C W Keller

C. W. Keller
Nuclear Accountability &
Licensing Representative

CWK:mal

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ACKNOWLEDGED

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A DIVISION OF MARTIN MARIETTA

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APPLICATION FOR SPECIFIC LICENSE
for
THE PACKAGING OF RADIOACTIVE MATERIAL FOR TRANSPORT

TABLE OF CONTENTS

GENERAL INFORMATION

In compliance with Part 71, Title 10, Code of Federal Regulations, "Packaging of Radioactive Material for Transport", the Martin-Marietta Corporation hereby requests that a specific license be issued for the use of the all-purpose Martin shipping containers described in this submission. The two containers which are of very similar design and construction have been approved for use in transport of enriched uranium in any form under the Martin Special Nuclear Material License No. 53. This application establishes the containers as Class II containers with a limit per container of 5000 gms. U-235 in any solid form. Our nuclear safety evaluation has assumed the conservative approach of the very improbable in leakage of water into the containment vessel but in doing so has shown the safety of shipment of up to a maximum of 5000 gms. of solid U-235 in any chemical composition per container considering maximum reactivity and moderation. Dimensions established by a 30 foot drop of the container were used in the criticality calculations. We have established that a maximum of 22 containers may be safely transported at any one time and that the radiation units assigned to each package is 1.8.

PACKAGE DESCRIPTION
Section 71.22

DESCRIPTION OF ALL-PURPOSE CONTAINERS

The all-purpose containers consist of a steel pipe centered and welded in a 55 gallon, 18 gage steel drum. The fuel is contained in a 4 inch I.D. schedule 40 stainless steel pipe centered in the drum with variable lengths of 38 to 42 inches. The container pipe which is sealed by means of a threaded steel cap is the "containment vessel."

The basic steel drums have been reinforced by one of the following designs. The first design consists of a drum that has been reinforced at the top and bottom ends with 1/8 inch thick steel plates welded around and to the circumferential ends of the drums. The central steel pipe is welded to the 1/8 inch steel end plates and geometrically located on the longitudinal axis of the drum. The steel pipe protrudes 9 inches above the drum top surface and has six 3/4 inch nominal steel pipe supports welded each 60° circumferentially from the outboard edge of the upper plate to just below the threaded end of the 4 inch central pipe. These 3/4 inch supports form an approximate 30° angle with the end of the drum when viewed from the side and serve to both reinforce the overall structure and in addition prevent stacking of loaded containers.

The second design consists of a drum that has been reinforced with a 1/8 inch thick plate welded to the bottom of the drum. The plate is hexagonal in shape and 6.5 inches across flats. The central pipe is welded to the 1/8 inch steel bottom end plate and the top of the drum. The pipe is located on the longitudinal axis of the drum and protrudes 5 to 9 inches above the drum top surface.

Figure 1 shows the general construction of these containers which weigh approximately 75 pounds each. There are no non-fissile neutron absorbers, moderators or coolants associated with the container. No valves, sampling ports, lifting devices, or tie down devices are incorporated into the container and the transfer and dissipation of heat is not applicable.

We have established a maximum of 5000 gms. of solid U-235 in any chemical composition for the container. No credit is taken in our calculations for non-fissile neutron absorbers. In addition, optimum reflection by water is considered. The H/X ratio is equal to or greater than 40.

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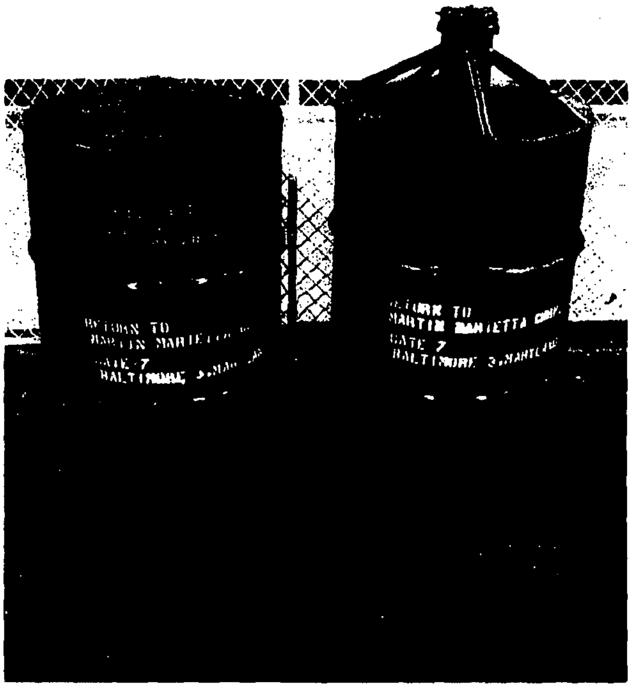


SHIPPING CONTAINER

SECTION 71.22 CHECK LIST

71.22 Package Description

a1	Gross Weight - Maximum 150 pounds includes approximately 75 pound container and 75 pounds contents.
a2	No specific Model Number
a3	18 gage 55 gallon drum, 4 inch I.D. Stainless Steel Schedule 40 pipe, threaded steel cap, 1/8 inch thick steel plate as reinforcement. (See drawing for specific details).
a3i	Containment vessel is 4 inch schedule 40 pipe closed by threaded steel cap.
a3ii	No non-fissile neutron absorbers or moderators.
a3iii	Any reinforcement structures are integral part of container.
a3iv	No valves, sampling ports, lifting devices and tie-down devices incorporated in container.
a3v	Not applicable.
a4	Not applicable
b1	Less than 1 curie Enriched Uranium
b2	Maximum 5000 gms. U-235
b3	Any chemical composition in solid physical form.
b4	No credit taken for absorption. Optimum reflection by water is considered. H/X ratio is equal to or greater than 40.
b5	Weight of contents established as 75 pounds
b6	Not applicable.

PACKAGE EVALUATION
SECTION 71.23

PACKAGE EVALUATION

The evaluation of the Martin all-purpose shipping container was made both by actual drop test and by calculation. The materials of construction preclude any internal reactions and provide the required strength to withstand stress requirements. A 30 foot drop test was performed to define the spacing of damaged containers and the criticality calculations were performed for these defined conditions in the most reactive configurations. It has been determined that 57 damaged containers and 111 undamaged containers will be subcritical in any arrangement. Thus, the number of packages which may be transported together in compliance with Section 71.39 becomes 28 damaged packages and 22 undamaged packages. Thus, the number of packages which may be offered for transport is 22 and the radiation unit assigned to the package is 1.8. The following part of this application discusses the applicable sections of Part 71.

Section 71.31

a. Constructed of iron and stainless steel there are no reactive components in the packaging.

b. The positive closure of the "containment vessel" is by a threaded steel cap on the end of the schedule 40 pipe. No loosening of this cap was evident even after performance of the 30 foot drop test.

c. & d. There are no lifting or tie down devices incorporated in the packaging.

Section 71.33

a. The criticality evaluation performed to define the number of containers per shipment has considered all of these parameters.

b. There will be no solutions or liquids transported in this container, thus these criteria do not apply.

Section 71.34

a.1 & 2 The container has been evaluated under normal and accident conditions and has been shown to meet the required standards.

Section 71.35

a.1 The positive screw cap closure prohibits the release of radioactive material from the "containment vessel." As shown pictorially in the 30 foot drop test the cap remains intact after undergoing these severe conditions.

a.2 Reduction in effective spacing amounts to approximately 0.4 inch or about 2% as a result of a 4 foot drop. Previous use of the containers has shown no significant deformation or decrease in the structural integrity of the container.

a.3, 4, & 5 Not Applicable.

b.1 & 2 As developed in our criticality evaluation the package will be subcritical and nuclear safety is not based on the geometrical form of the package contents.

b.3 Although in leakage of water is highly improbable the criticality evaluation is based on in leakage of water which represents the most reactive condition.

b.4.i Not Applicable.

b.4.ii Calculation of deformation resulting from a 4 foot drop defines the decrease of the effective diameter of the container to be 0.4 inch. This represents a 2% reduction in effective diameter or a 4% reduction from the center of the containment vessel to the outer surface of the packaging.

b.4.iii The evaluation of the puncture criteria shows that only a slight deformation rather than a puncture will occur under the defined conditions.

Section 71.36

a.1 Not applicable since only unirradiated special nuclear material (U-235) will be transported in the container.

a.2 "Containment vessel" is positively sealed by steel screw cap which remained intact when subjected to 30 foot drop test.

b. The criticality evaluation of the container was performed under these parameters.

Section 71.39

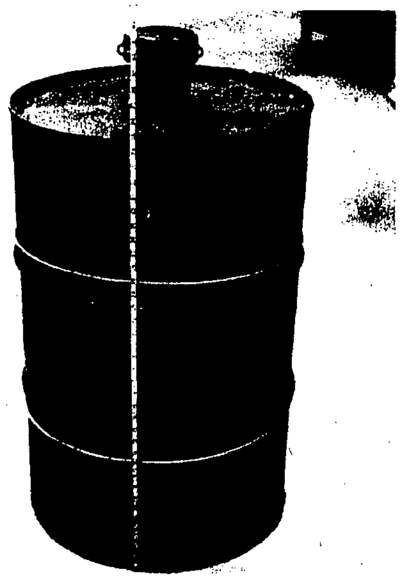
a.1 The criticality analysis for an array has shown that 111 undamaged packages will be subcritical in any arrangement under the most reactive conditions. Thus, the number of containers which may be transported at one time is 111 divided by 5 or 22.

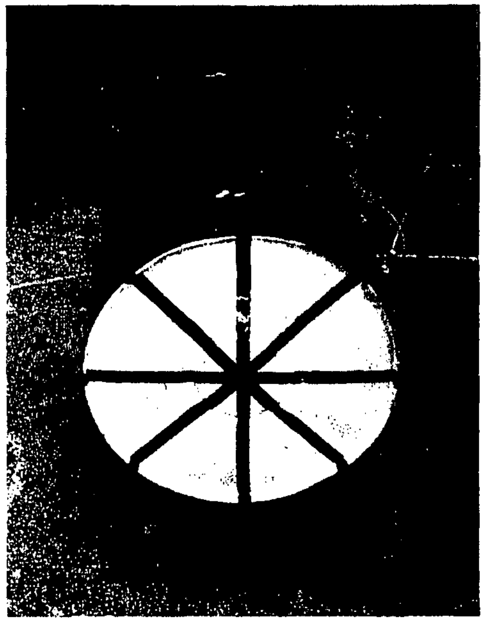
a.2 The criticality analysis has shown that 57 damaged containers will be subcritical in any arrangement under the most reactive conditions. Thus the number of containers which may be transported at one time is .57 divided by 2 or 28.

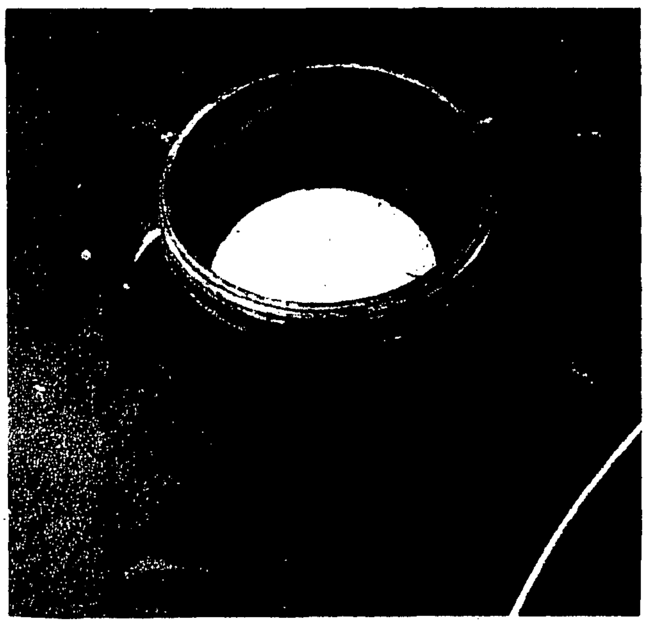
b. The number of radiation units assigned for each container will be 40 divided by 22 or 1.8.

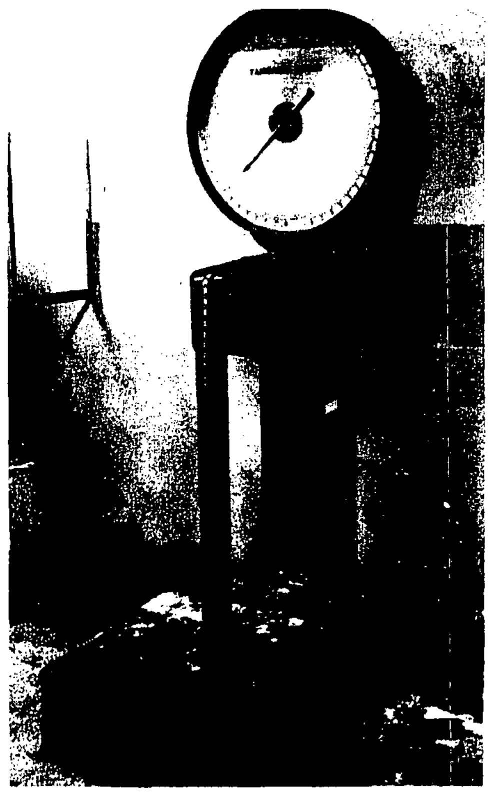
CONTAINER DROP TEST

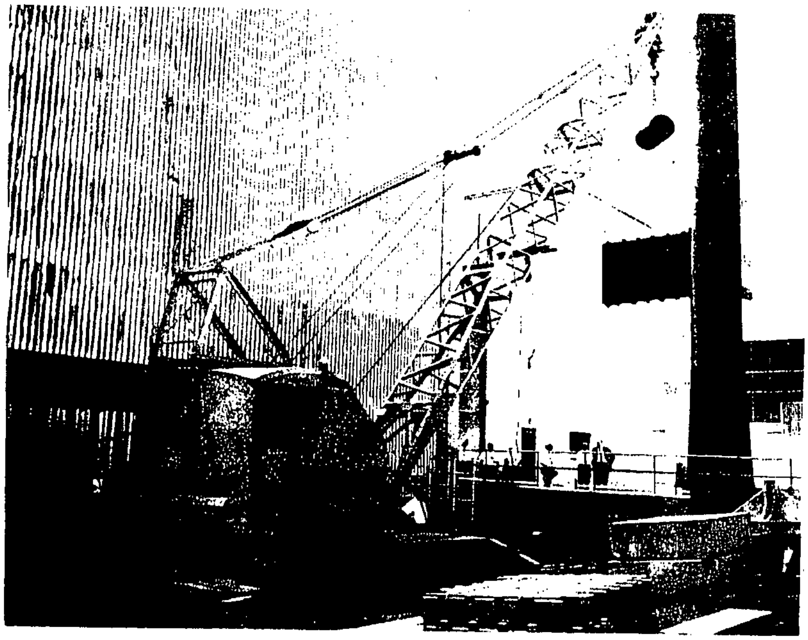
To define the structural integrity of the Martin all-purpose container, a drop test which would simulate possible accident conditions was performed. A steel rod weighing approximately 75 pounds and filling the inner 40 schedule pipe was used to represent the loading of the container with fuel. The first drop was made to provide a side impact on the shipping container from a height of 30 feet measured to the bottom of the drum. The diameter of the drum prior to the drop was 22.75 inches and a deformation of 3.25 inches was determined after the drop. Since the container remained intact another drop on the top was performed in the same manner with the same container. Except for an approximate 2-1/2 inch protrusion from the bottom of the drum, no significant deformation was produced. The dimensions of the container resulting from the drop test are used for any required nuclear safety evaluations.

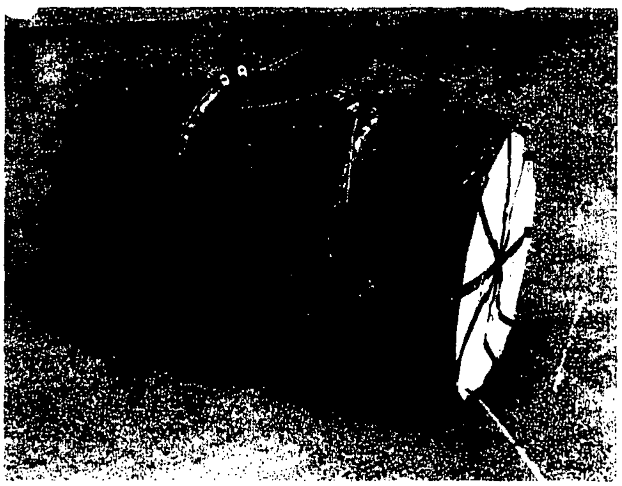


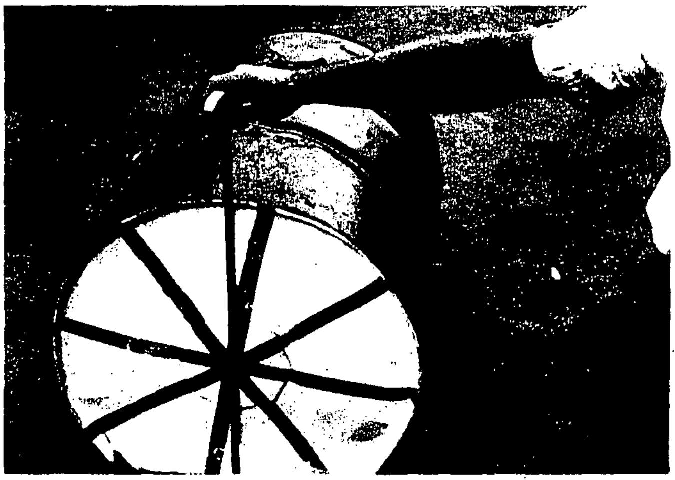


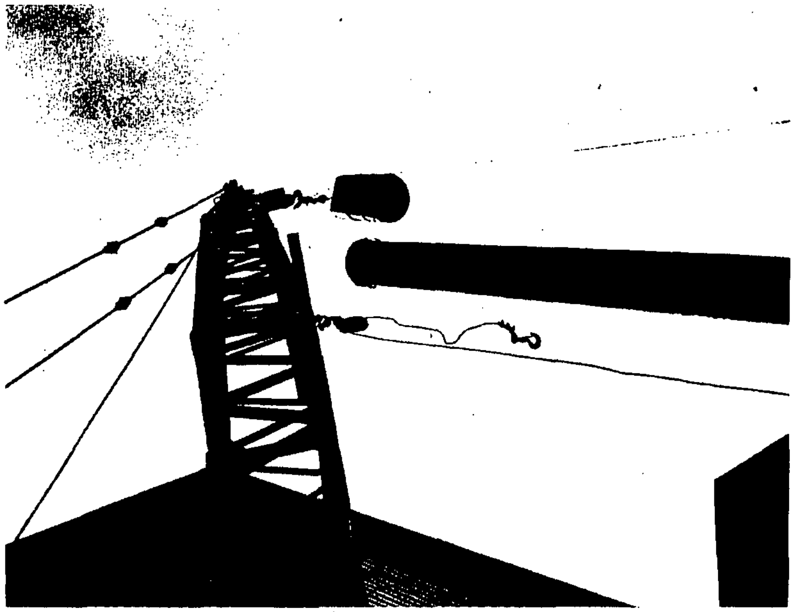












EVALUATION OF DEFORMATION and PENETRATION

The following analysis predicts the structural integrity of the shipping container (outer shell) as a result of a four foot drop on a non-yielding surface. In addition, potential penetration is studied assuming a 40 inch drop of the container on a six inch diameter steel cylinder and the drop of a 13 pound - 1 1/4 inch steel cylinder on the container.

From actual drop tests from a thirty foot height to a concrete surface which were conducted at the Martin Company, the maximum deformation was found to be 3 1/4 inches. To evaluate the potential deformation resulting from a four foot drop, the assumption will be made that the deformation is proportional to the energy available to cause deformation. Thus, for a free fall,

$$v_f^2 = 2ah$$

For the 30' drop,

$$v_f^2 = 2(32)(30) = 1920 \quad (\text{ft./sec.})^2$$

$$K.E. = 1/2\ m\, v_f^2$$

where the weight of container and internals is 150 lbs.

$$K.E. = 1/2\ \frac{150}{32}\ (1920) = 4500 \text{ ft-lbs.}$$

Associated with a four foot drop,

$$v_f^2 = 2\ (32)\ (4) = 256\ (\text{ft./sec.})^2$$

and $$K.E. = 1/2\ \frac{150}{32}\ (256) = 600 \text{ ft-lbs.}$$

Thus, the anticipated deformation for a four foot drop is,

$$3\ 1/4\ \frac{600}{4500} = 0.43 \text{ inches.}$$

Considering a 40 inch drop on a six inch steel cylinder, the following penetration equation is applied.

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Ex4

Considering the 4 foot drop of a 13 lb. -1 1/4" dia. steel cylinder on the container, the energy available is considerably less than the case previously examined whereas the projectile diameter is only about five times smaller than before. Therefore, only a very small local deformation would be expected.

TRANSPORT CONDITIONS CHECK LIST

Normal Conditions of Transport

Heat, Cold, Pressure, Vibration, Water Spray, Compression.

The materials of construction and the fabrication of the component parts into the final shipping container preclude any significant affects from criteria established for these tests.

Free Drop and Penetration

The evaluation of the Martin shipping container under the 4 foot drop and penetration criteria has shown that possible deformation would approximate 0.4 inch and be within the 5% decrease permitted for the 4 foot drop and that only a very small local deformation might occur from the penetration criteria.

Hypothetical Accident Conditions

Free Drop

The performance of the 30 foot drop test has conclusively defined the results obtained from this test. The defined dimensions were used in the criticality evaluation.

Puncture

The evaluation of the puncture test has shown that no puncture would take place under the established criteria.

Thermal

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Water Immersion

The materials of construction preclude any adverse affect on the packaging.

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NUCLEAR SAFETY EVALUATION

All Purpose Container

The all purpose container limits were established by calculating the effective neutron multiplication for a single unit and the solid angle subtended for the remaining units. Calculations were based on a homogeneous system consisting of only U-235 and water.

K_{eff} Calculation

$$\text{Volume (inner Container)} = \frac{d^2}{4} h = \frac{3.14159 \times (4)^2 \times 42}{4} 16.387 =$$

$$8648.8 \text{ cc}$$

$$\text{Volume (U-235)} = \frac{5000}{18.7} = 267.4 \text{ cc}$$

Material	Volume (cc)	Volume Fraction	Σ_a (Cm^{-1})	Σ_a (homogenized) (Cm^{-1})
H_2O	8381.4	.96908	.0221	.0214
U-235	267.4	.03092	32.70	1.0111

$$f = \frac{\Sigma_a^{\ Fuel}}{\Sigma_a^{\ Total}} = \frac{1.0111}{1.0325} = 0.98$$

$$\eta = 2.07$$

$$k_\infty = \eta f = 2.03$$

$$\delta = 2.25 \text{ Cm.} \qquad \text{(Reference TID-7028)}$$

$$B^2 = \left(\frac{2.405}{R+\delta}\right)^2 + \left(\frac{\pi}{H+2\delta}\right)^2 = \left(\frac{2.405}{2x2.54+2.25}\right)^2$$

$$\left(\frac{3.1416}{42x2.54+2.25x2}\right)^2$$

$$B^2 = .108 \ cm^{-2}$$

$$L^2 = L_m^2 (1-f) = 0.164 \ cm^2$$

$$L_1^2 = 2.625 \ cm^2$$

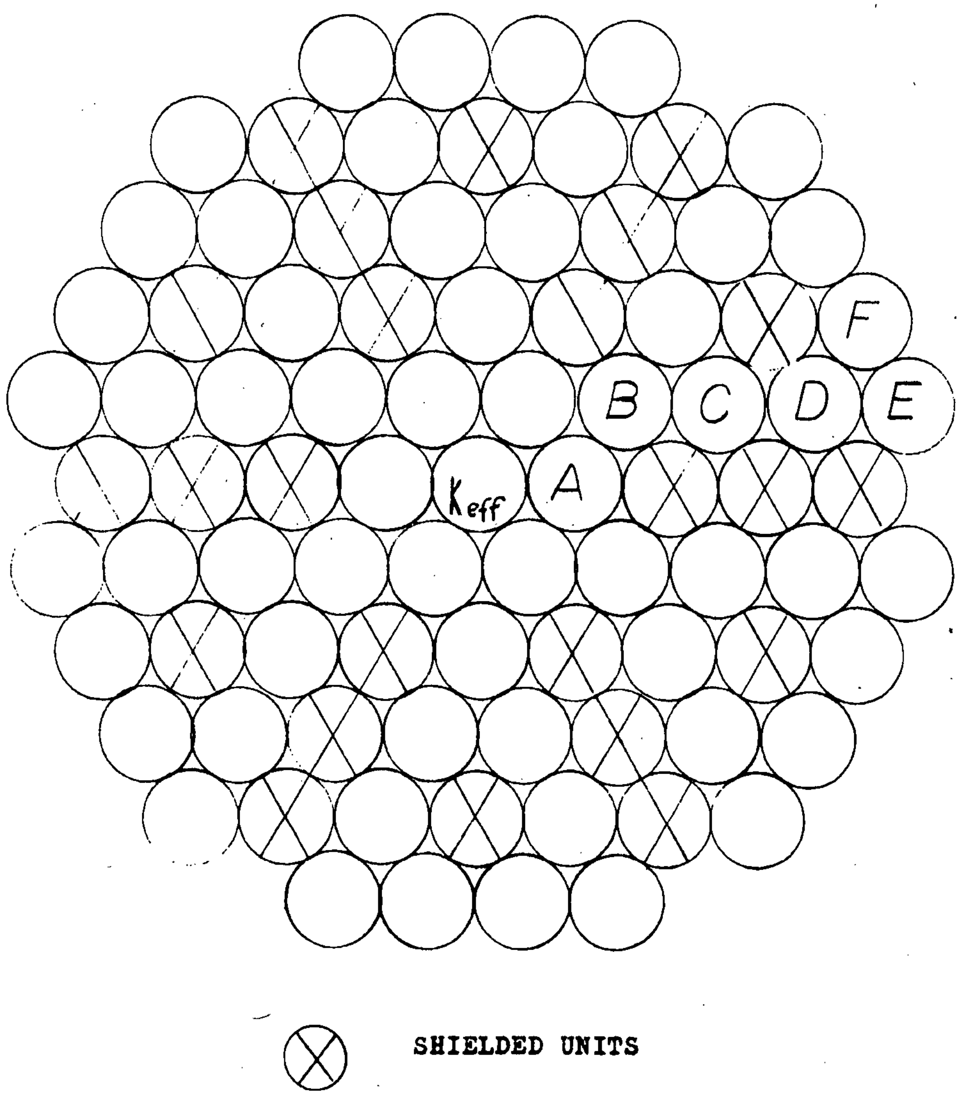
$$L_2^2 = 26.429 \ cm^2$$

$$k_{eff} = \frac{k_\infty}{(1+L_1^2 B^2)(1+L_2^2 B^2)(1+L^2 B^2)} =$$

$$= \frac{2.03}{(1.284)(3.866)(1.018)}$$

$$k_{eff} = \frac{2.03}{5.05} = .40$$

55GALLON DRUM SHIPPING CONTAINERS



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The Nuclear Safety analysis for the all-purpose containers which is based on a K_{eff} value of 0.40 applies to 5 kg of U-235. For quantities less than 5 kg U-235, solid angle calculations made with $K_{eff} = 0.40$ are valid. The following calculation demonstrates the safety of fifty-seven (57) damaged containers in any array.

A most reactive array of fifty-seven (57) containers can be visualized as a close packed array of nineteen (19) units stacked three containers high. The accompanying figure illustrates this arrangement.

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For a 42 inch active container length (conservative assumption) the following table summarizes the solid angle calculation for the three high stack. Container 1 is naturally taken as the most central unit.

$L = 3 \times 42'' = 126''$

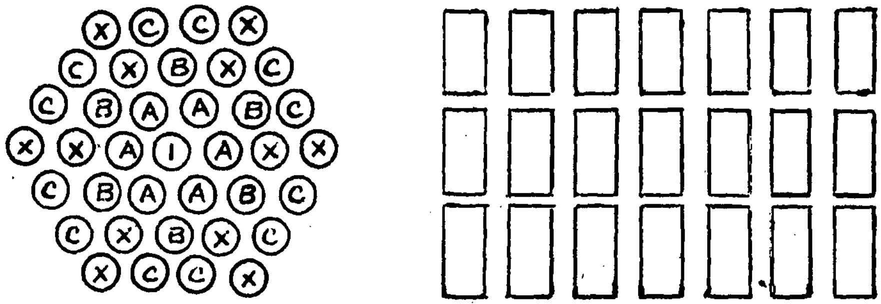
Container	d	h (distance from 1)	$\sqrt{h^2 + (L/2)^2}$	$\sin\theta$	Ω
A	4"	17.5	65.4	.963	.440
B	4"	31.8	70.6	.892	.224

Total Solid angle $= 6\Omega_A + 6\Omega_B$

$= 6(.440) \quad 6\,(.224) = 3.98$

Since the allowable $\Omega = 9 - 10\,K_{eff} = 9 - 10\,(.4) = 5$ is larger than the calculated value for the array, fifty-seven (57) containers are safe. It is interesting to note also, that even on infinite stacking of nineteen (19) containers yields a solid angle of only 4.25. Thus the safety of fifty-seven (57) all purpose containers is assured for any configuration.

In a similar manner the safety of an undamaged array of all-purpose containers is shown in the following table. Again, a three-high stack is assumed. However, because of the greater separation afforded by the undamaged outer drum, the allowable limit is one-hundred eleven (111) containers.



Container	d	h	$\sqrt{h^2+(L/2)^2}$	Ω
A	4"	21.0"	66.4	.361
B	4"	34.4"	71.8	.204
C	4"	54.3	83.2	.112

Total Solid Angle $= 6(.361) + 6(.204) + 12(.112)$

$= 4.73$

Since the allowable $\Omega = 9 - 10\ K_{eff} = 9 - 10\ (.4) = 5$ is larger than the calculated value for the array, one-hundred eleven (111) containers is safe.

It should be noted that although the calculated array is not cubic, the one-hundred eleven limit is safe in any configuration. This conclusion is based on the observation that the solid angle contribution of a drum placed to increase the stack height is less than that if the drum remains in its calculated location (observe the preceding damaged container calculations for infinite stack height compared to calculated array).