

File Copy

NUCLEAR  
DIVISION  
Baltimore,  
Maryland  
21203

**MARTIN COMPANY**

Mail No. 845  
Refer to: ACC-324  
26 August 1964

RECEIVED  
S. A. I.  
REGULATORY  
MAIL SECTION

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

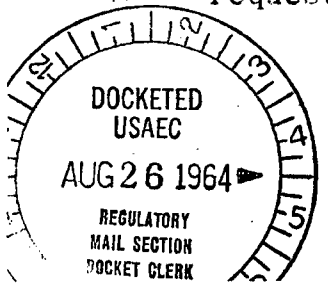
Attention: Mr. Kenneth Lauterbach

Subject: Drop Test of Shipping Container -  
Proposed Amendment No. 21 to SNM-53

Gentlemen:

As a result of our discussion in Bethesda on August 20, 1964 we have conducted a drop test for the container designated A in support of our request for shipment approval for loaded tubular elements containing approximately 5% enriched UO<sub>2</sub> pellets. We selected Container A since it represents the container having the lesser structural strength of the two containers proposed for this shipment. All calculations have been based on the drop test results for Container A. A steel rod weighing approximately 75 pounds and filling the inner 40 schedule pipe was used to simulate 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 2½ inch protrusion from the bottom of the drum no significant deformation was produced.

Our nuclear safety calculation, considering a cubic array of the deformed containers, was performed using the dimensions resulting from the drop test. Since this calculation has shown that the most reactive array of the deformed containers will not produce criticality, we request that your approval of this shipment be made without a requirement for shoring as described in our August 14, 1964 submission. Fuel is ready for shipment at Nuclear Fuel Services and we request immediate approval for shipment of the tubular elements.



104 to CB 8/26/64  
204 to Compliance 8/28/64  
104 to PDR

B/30  
ACKNOWLEDGED

A DIVISION OF  
**MARTIN**  
**MARIETTA**  
4302

Page 2  
Refer to: ACC-324

We appreciate very much the excellent cooperation of all AEC personnel who have reviewed our submissions. Their comments have been very helpful.

Very truly yours,



C. W. Keller  
Nuclear Accountability &  
Licensing Representative

CKK/mc

Nuclear Safety EvaluationDiscussion

Nuclear safety calculations have been completed for the MF-1A shipping container using the dimensions obtained from the 30-foot drop test. The container consists of a 4-inch inside diameter pipe centered in a 55 gallon drum. The maximum deformation of the diameter was 3.25 inches.

The calculations were based on a 19.5 inch center-to-center drum spacing for the most reactive array assuming that the shipping containers were stacked two high as shown in the solid angle calculations.

The calculations assumed that:

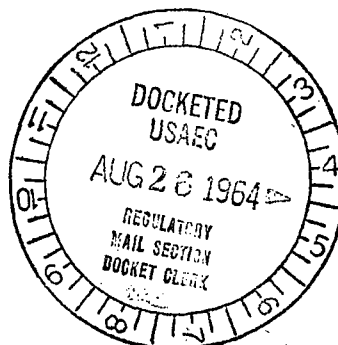
- (1) each container contained a maximum of 27 fuel tubes which limited the U-235 content to 1.11 kilograms
- (2) the active fuel region was a 4 inch cylinder 40 inches in length\*, and
- (3) the container was flooded with water

The effective multiplication factor for the most reactive unit in the array was 0.35. A unit consisted of shipping containers stacked two high.

Conclusions

The total allowable solid angle is equal to 9-10 keff or 5.5 steradians. The total calculated solid angle was 4.7 steradians for the previously described array. Therefore, the use of the shipping containers described in this letter presents no potential hazards from the nuclear safety standpoint.

\*The 4-inch diameter center pipe is actually 42 inches long. However, the active fuel is actually 36 inches long with a 2 inch end-cap welded onto each fuel tube.



File Copy

EFFECTIVE NEUTRON MULTIPLICATION CALCULATIONS

MATERIAL	VOLUME (CM <sup>3</sup> )	VOL. FRACTION	$\Sigma_a$	$\Sigma_a$ (WGT. AVG)
H <sub>2</sub> O	10,350.333	.63010	.0321	.01592
347 SS	1,072.872	.06512	.237	.01745
U-238	2,447.722	.14872	.128	.01703
U-235	113.783	.00692	31.90	.22625
NEUTRON MODERATORS	2,456.927	.14917	∞	∞

THERMAL UTILIZATION

$$f = \frac{\Sigma_a^{mod}}{\Sigma_a^{mod} + \Sigma_a^{238} + \Sigma_a^{235}} = \frac{.01592}{.01592 + .01703 + .22625} = .057$$

FAST FISSION FACTOR

$$C = 1 + \frac{\Sigma_{f2}^{238}}{\Sigma_a^{238} + \Sigma_a^{235}} = 1 + \frac{.01592}{.01703 + .22625} = 1.072$$

RESONANCE ESCAPE

$$p(E) = \exp\left(-\frac{E_0}{1 - E_0}\right)$$

$$\frac{1}{p} = 1.237$$

$$\Sigma_{a0} = \frac{\Sigma_a(E_0)}{\Sigma_a(E_0/2)} = \frac{.0321}{.0321}$$

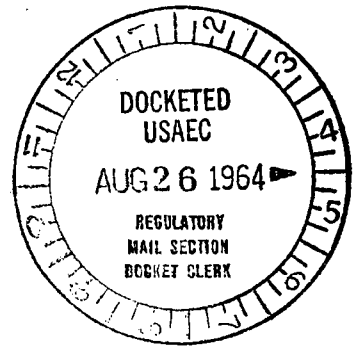
$$\Sigma_{a0} = \frac{\Sigma_a(E_0 + 1/E_0)}{\Sigma_a(E_0/2)} = \frac{.0321(1 + 1/10)}{.0321(1/10)} = 1.105$$

$$k = 1 + \frac{(k_0 E_0)^2}{1 - E_0} = 1.006$$

WHERE:  $k_0 = 21 \text{ cm}^{-1}$   
 $E_0 = 580 \text{ eV}$

$$F_2 = 1 + \frac{(k_0 E_0)^2}{2} \left[ \frac{\Sigma_{a0}}{\Sigma_a(E_0)} \frac{1}{E_0} + \frac{1}{2} \left( \frac{E_0}{E_0} \right)^2 - 1 \right]$$

$$F_2 = 1 + .174 [3.099 \cdot 1.105 + 4(1.072) - 2] = 1.015$$



WHERE:  $k_0$  = PRODUCT  
 $E_0$  = MODERATOR

$$\frac{1}{f} = 1 + \frac{1}{\beta} \frac{E_{a1}}{E_{a0}} F_{a1} + (F_{a1} - 1) = 1 + (1.231)(2.919)(1.004) - (1.005 - 1)$$

$$\frac{1}{f} = 12.550$$

$$f_{a1} = .0733$$

$$p(E) = 247 \left( -\frac{.0733}{2.919} \right) = 923$$

NEUTRONS LIBERATED PER THERMAL NEUTRON ABSORBED IN FUEL

$$\eta = 1.923$$

INFINITE MULTIPLICATION FACTOR

$$k_{\infty} = \epsilon \eta f p = (1.042)(1.923)(.071)(923) = 1.645$$

BUCKLING

$$B^2 = \left( \frac{2.500}{L} \right)^2 + \left( \frac{2.0}{R} \right)^2 = .07710 + .00000 = .07710$$

$$\text{WHERE: } H = 50 = 2.00 + 47 = 210.51$$

$$R = 2 = 2.00 + 0.00 = 2.00$$

EFFECTIVE MULTIPLICATION FACTOR

$$k_{eff} = \frac{k_{\infty}}{(1 + L^2 B^2)(1 + R^2 B^2)(1.042)} = \frac{1.645}{1.755} = .936$$

WHERE:

$$L^2 = 2.625$$

$$R^2 = 26.529$$

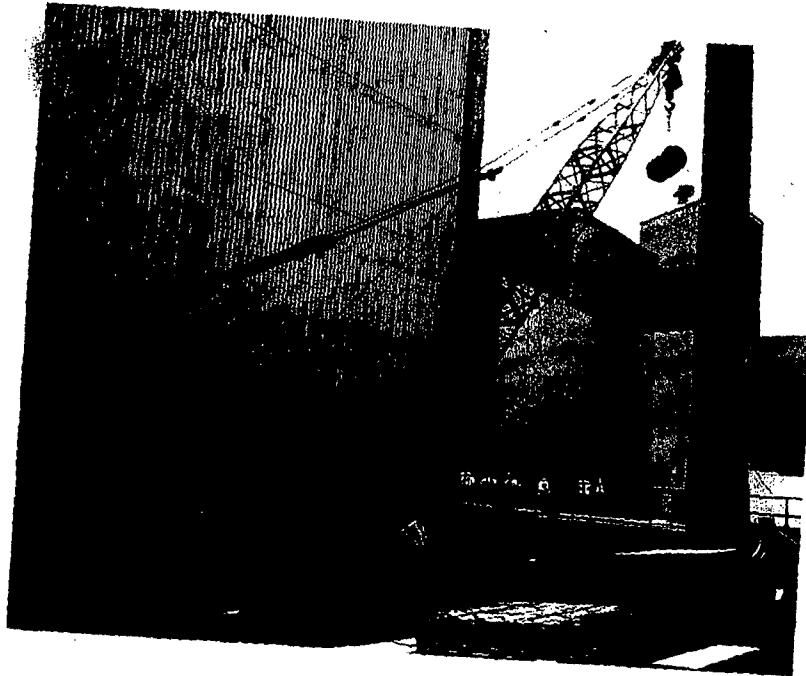
$$L^2 B^2 = L^2 (1 - f) = 2.625(1 - .071) = .245$$

$$(1 + L^2 B^2) = (1 + 2.625(.07710)) = 1.4195$$

$$(1 + R^2 B^2) = (1 + 26.529(.07710)) = 2.0621$$

Pages 6 through 7 redacted for the following reasons:

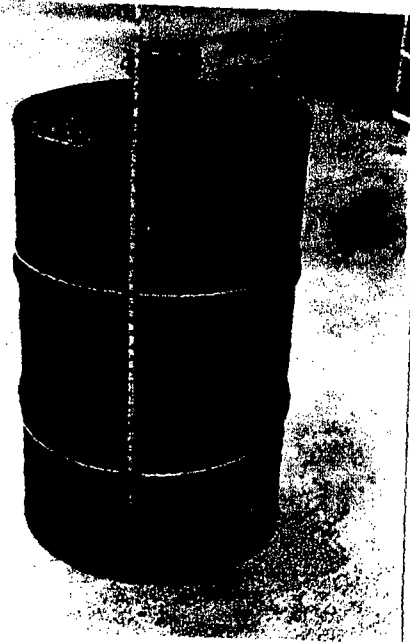
-----  
(b)(4)



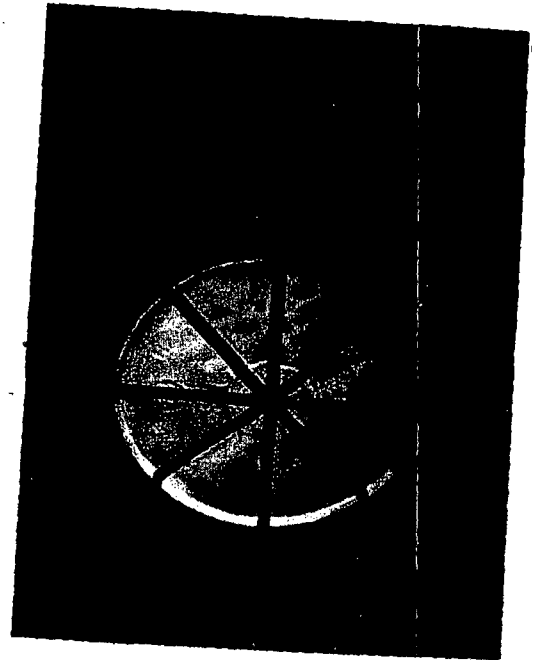
Shipping Container 30 Feet  
Above Ground Level.



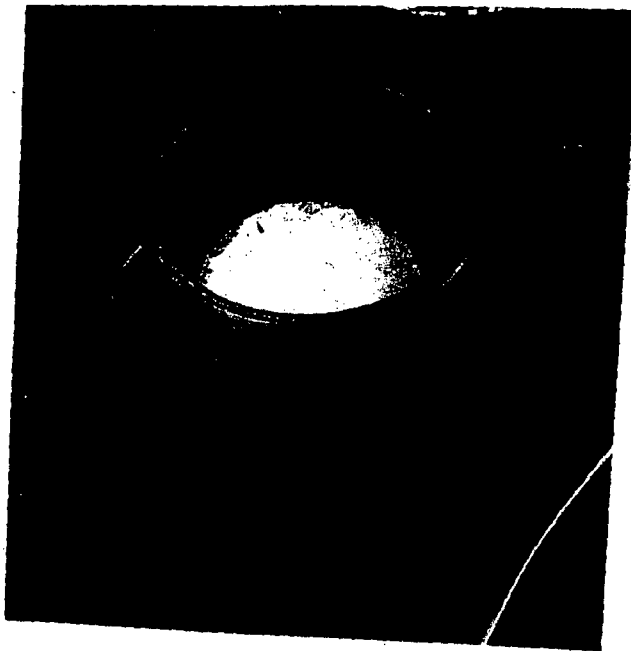
Top View of Shipping Container  
After 30 Foot Drop Test  
(Max. Deformation 3 1/2 Inches)



Side View of Shipping Container  
Overall Length 45 inches



End View of Shipping Container  
Overall Diameter 30 inches

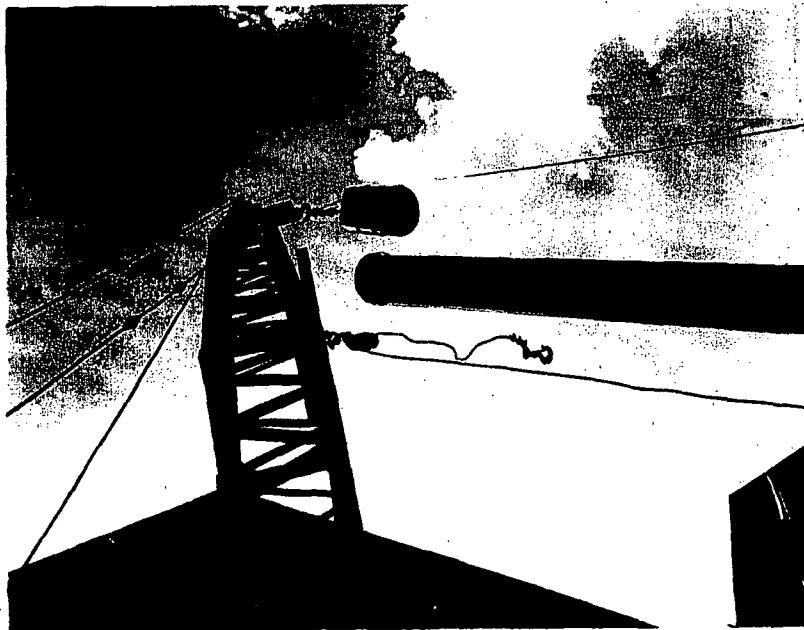


Top View of Shipping Container  
and 3 inch Diameter Steel Rod



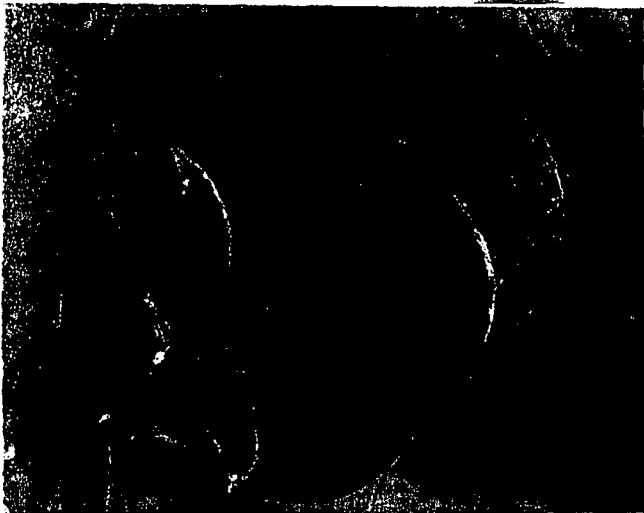
3 inch Diameter Steel Rod  
35 inches in Length  
Weighting 20 grams





Shipping  
Container Prior  
to Second 30  
Foot Drop Test

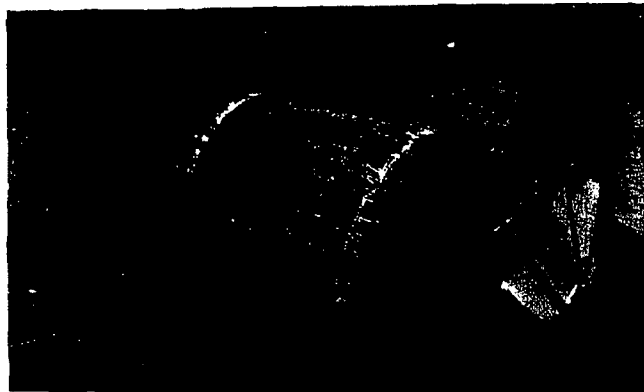
(Container  
dropped from  
vertical  
position with  
top facing  
downward)



Top View After Second 30  
Foot Drop Test



Side View After Second 30  
Foot Drop Test

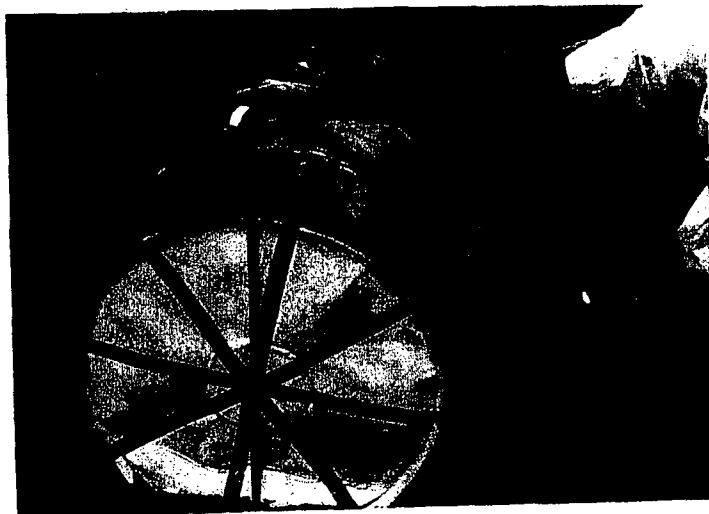


Side View After  
Second 30 Foot  
Drop Test

(Note: Refer to  
27. 10/1/54)



Side View of Shipping Container  
After 30 Foot Drop Test



End View of Shipping Container  
After 30 Foot Drop Test

