RFP-290

THE DOW CHEMICAL COMPANY
ROCKY FLATS DIVISION
DENVER, COLORADO

U. S. Atomic Energy Commission Contract AT(29-1)-1106

For Presentation at the

AEC SYMPOSIUM ON PACKAGING AND REGULATION STANDARDS

FOR

SHIPPING RADIOACTIVE MATERIALS

December 3-5, 1962

DESCRIPTION OF A PLUTONIUM AND ENRICHED URANIUM SHIPPING CONTAINER AND INTEGRITY TESTS ON THIS CONTAINER

by

C. L. Schuske

J. G. Epp - Technical Service Director

Distribution Date: November 16, 1962

Facsimile Price $ 1.10

Microfilm Price $ .80

Available from the
Office of Technical Services
Department of Commerce
Washington 25, D. C.

DISCLAIMER

DISCLAIMER

ABSTRACT

The M-101 (an all steel) shipping container and safety cage has been in use for about 15 years for transporting and storage of enriched uranium. With slight modifications and the addition of an inner container, the M-101 can be used to ship plutonium metal. This paper describes various physical tests performed on the M-101 and inner container and also discusses critical array sizes under various conditions of spacing and flooding.

INTRODUCTION

Although the M-101 has been used for 15 years without incident in the transport of enriched uranium, we recommend various modifications to this container for the handling of plutonium metal. Because of the toxicity of plutonium, better containment is desirable.

The suggested modifications to the M-101 consist basically of replacing a Neoprene gasket with a stainless steel "O" ring and removing a gauge and stopcock from the container lid. These changes result in a very fire resistant carrier. In addition, extra safety for plutonium is accomplished by adding an inner container. This inner container will retain plutonium metal or oxides under the adverse conditions that might be expected in a transport accident and resulting fire.

Figures 1 and 2 are exploded views of the modified M-101 and inner container.

Dow Drawing 2-7552-76A defines M-101 modifications and inner container design. Other points of interest are:

1. The M-101 and inner container are of all steel construction. Containment of contents is accomplished by the use of pressurized stainless steel "O" rings in both the M-101 and inner container.

2. The M-101's approximate weight is 85 lbs. The inner container is approximately 50 lbs. The total weight is 135 lbs.

3. The cost of the M-101 is $126.00. The inner container cost is approximately $100.00. The total cost is approximately $226.00.

INTEGRITY TESTS

Although the M-101 container was designed more than 15 years ago, very few physical tests were performed to determine the integrity of this container under serious accident conditions. The tests previously performed were vibration tests. These tests fairly well established the strength of welds and construction under conditions which would lead to fatigue of its components.

The M-101 has held up well over the many years of its use. Recent thought was given to certain required changes to this system that would extend its possible use to plutonium as well as enriched uranium.

Due to the toxicity of plutonium, it was felt that containment under a serious transport accident such as collision and fire would be necessary.

The modification to the M-101 and the inner container addition are given in Dow Drawing 2-7552-76A.

The requirements were as follows: Containment be maintained under the following contingencies, severe collision, impact velocity of the M-101 case and contents of approximately 130 ft/sec, followed by an oil fire.

The tests were conducted on the modified M-101 and inner container that contained a simulated load (in this case, lead.)

TESTS PERFORMED ON MODIFIED M-101 AND INNER CONTAINER

Drop Tests (1)

Drop tests were performed on a modified M-101 and inner container. The container with store was dropped onto a concrete pad on the cage corner from a height of 13 feet, and again from 19 feet. Peak accelerations recorded along the direction of impact were 310 and 350 g respectively. A third and final drop of 250 feet from a tower onto a concrete pad was performed. The M-101 was dropped lid down for maximum damage.

The outer framework of the cage was bent, however, the overall volume defined by the framework was compressed less than 20%. The central container and inner container were only slightly scarred and no leaks occurred in these containers as a result of these tests. The tests revealed that the container could have survived a considerably more severe drop test.

---

(1) W. M. Sigmon, J. E. Bear, R. S. Hooper, "Drop Test of an M-101 Carry Case and Simulated Store". T-18725, 5-22-62.

Fire Test [2]

An ignited pool of fuel oil was used to determine the fire resistance of the M-101 and inner container. The maximum temperature developed in the inner container during a 30-minute fire was 1600 F or 870 C. The M-101 and inner container were not damaged in this test.

The Metallurgical studies (reported elsewhere in this report), indicate that the 0.5 in. thick steel inner container is sufficiently durable to withstand an oil fire that could occur as a result of an accident. In addition, the outer container of the M-101 will add a second line of containment.

Molten Plutonium Penetration Study on Steel Inner Container [3]

Since molten plutonium readily forms low melting eutectics with iron, it was desirable to test materials out of which the inner steel container was manufactured. This study consisted of using a steel thimble 4 in. long and 2 in. in diameter with 0.5 in. thick walls as the test vessel. Plutonium metal was placed into the thimble and heated in an induction furnace to arrive at the temperature that could be expected from an oil fire which is about 870 C or 1600 F. Molten plutonium held for 30-minutes at 900 C and molten for approximately one hour will penetrate the steel inner

---

(2) J. Q. Lilly, J. E. Bear, R. S. Hooper, "Simulated Aircraft Fire Test on a M-101 Carrying Case and Store". T-18710, 5-16-62.

(3) C. E. Wickland, "Investigation of Steel as a Shipping Container for Plutonium". Metallurgy Group Memo 41. The Dow Chemical Co., Rocky Flats Division, Denver, Colorado.

container an average of 1/8 in. with a maximum penetration of 3/16 in. as determined by sectioning the test vessel and making metallographic determination on these test sections. These conditions exceeded the test requirements (inner container temperature of 860 C for 30-minutes) and indicate that the 0.50 in. walled inner container will retain plutonium as per the test requirements.

Equilibrium Temperature of Plutonium in Shipping Container (under normal conditions) [4]

Due to alpha heating of plutonium, some care should be observed in the packaging of plutonium for storage and transportation. It is desirable that the packaging have a minimum of thermal insulation. Heat build up can present operational problems in the removal of the material from the package. It was thus felt desirable to study this effect for the M-101 arrangement. Experimental and Theoretical studies performed on 4 kg of plutonium buttons indicated that the equilibrium temperature of plutonium in the M-101 and inner container will not exceed 50 C.

These tests indicate that the heat build up under normal operating conditions will not present any additional handling hazards.

CRITICALITY CONSIDERATIONS

The following contingencies were considered in arriving at a safe number of containers (plutonium) for shipment.

---

(4) G. D. Hartert, "Equilibrium Temperature of Plutonium in Shipping Containers". May 11, 1962.

1. Assumed accident sufficiently severe to strip outer cage from the M-101 central container which in turn contains the inner container. (Drop tests indicate that this assumption is grossly conservative.)
2. An array of central containers come together to form a pseudo-cylinder.
3. The array of these containers will be moderated with an optimum amount of water.
4. The array of central containers will be infinitely reflected with water or earth.

Results of the calculations indicate that under the above conditions more than 100 containers, each containing 4 kg of plutonium or 18 kg of uranium would be required to become critical. We recommend 50 containers as a conservative number per shipment.

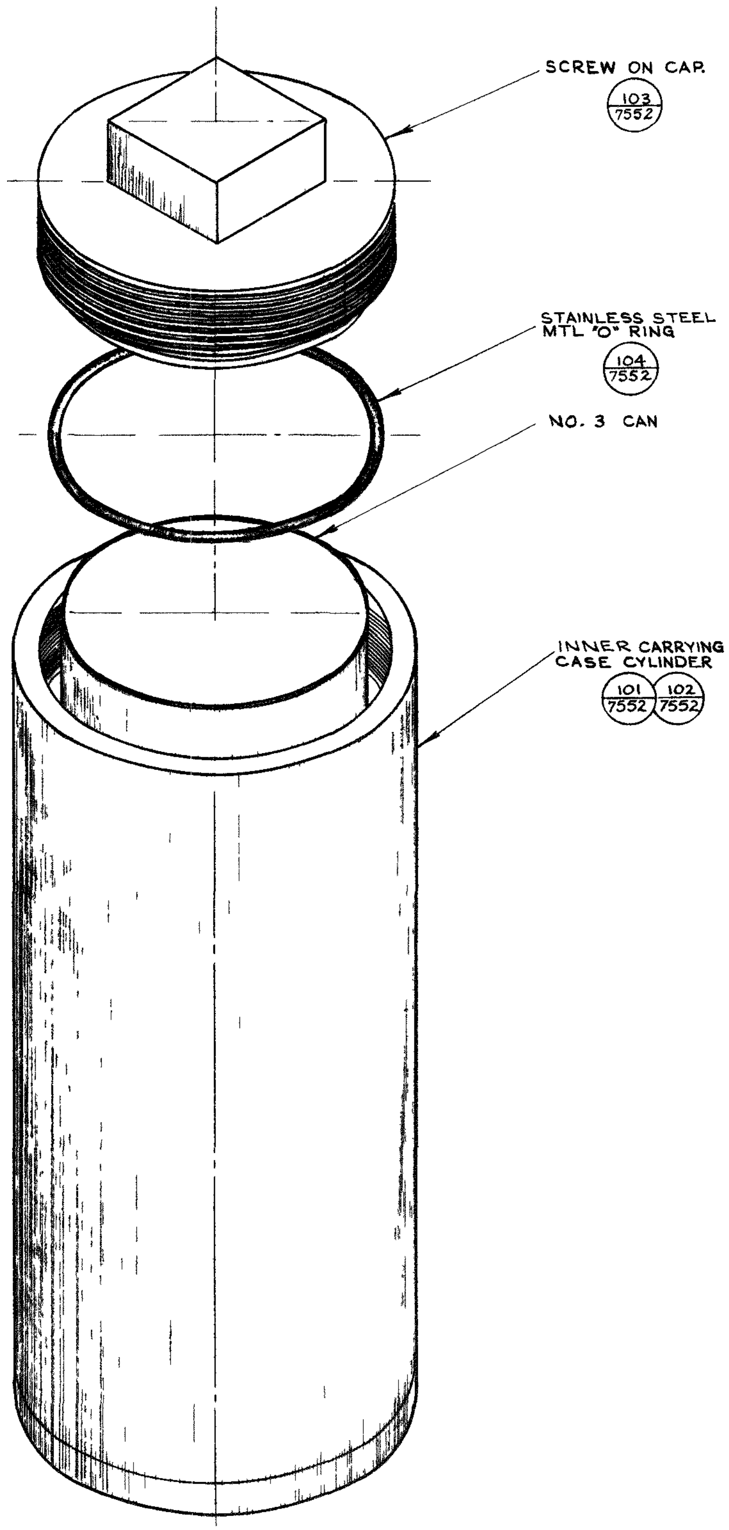
The drop tests indicate that the actual array lattice resulting from a serious collision would be considerably greater than that assumed in the above analysis, thus the critical number of containers would be several times greater than 100.

CONCLUSIONS

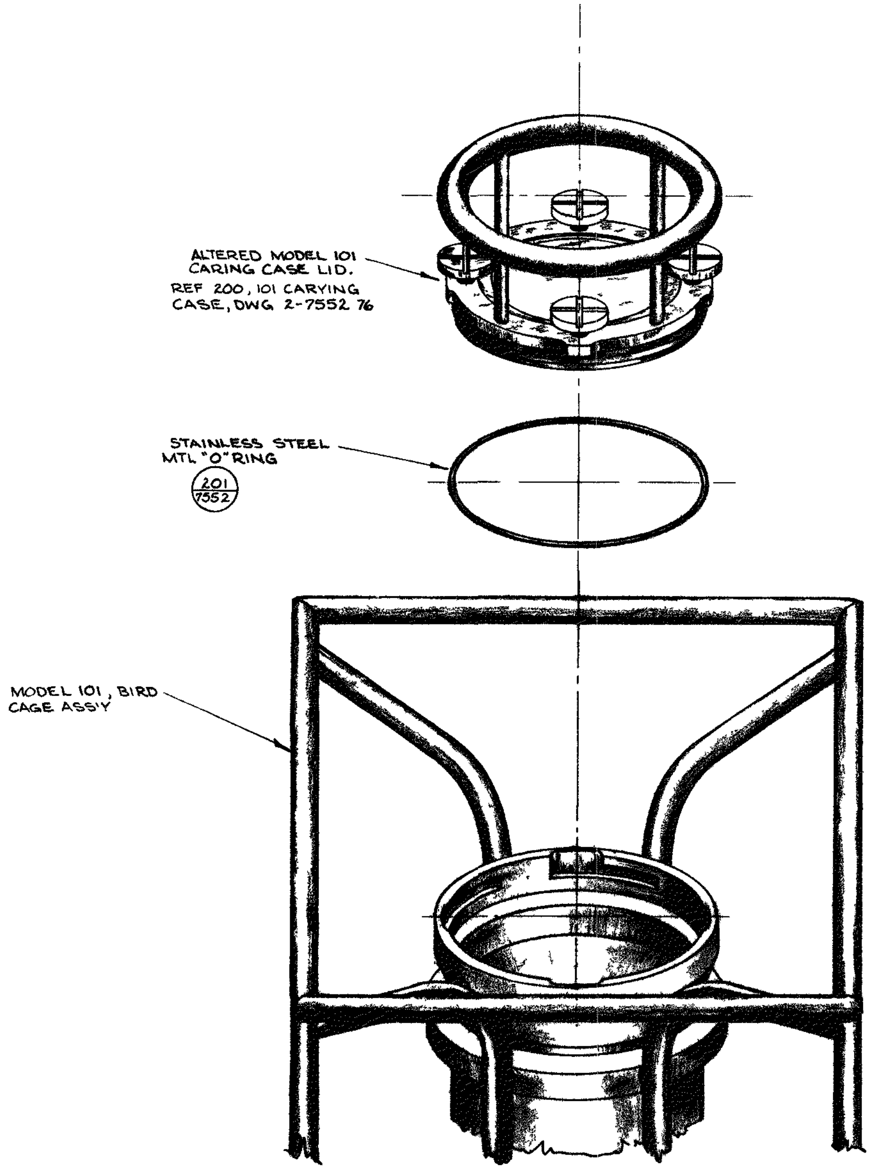
The results of the tests indicate that the modified M-101 and inner container are more than adequate to ship plutonium and enriched uranium metal safely.

ACKNOWLEDGMENT

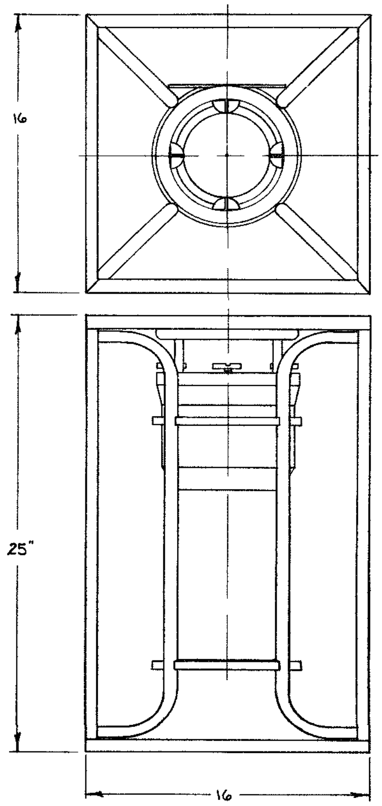
The author acknowledges the contributions to this report of work and results provided by the Sandia Corporation, Albuquerque, New Mexico, and Rocky Flats personnel from the Chemical Engineering, Metallurgy Technical Staff Groups, and Mr. D. W. Park of Technical Staff Engineering.



EXPLODED ASSEMBLY
FIGURE 1



EXPLODED ASSEMBLY
FIGURE 2



REF DETAIL OF ASS'Y
SHOWING OVER-ALL DIM'S.
SCALE 1/4 1'

REF DWG'S
2Y51409
1P20070
2-7552 76
1 7745-76