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TECHNICAL DOCUMENTATION FOR
MODEL 2030-1 SHIPPING CONTAINER
(DOT SPECIAL PERMIT 5332)

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DOW CHEMICAL U.S.A.
ROCKY FLATS DIVISION
P. O. BOX 888
GOLDEN, COLORADO 80401

U. S. ATOMIC ENERGY COMMISSION
CONTRACT AT(29-1)-1106

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for the

**Albuquerque Operations Office
U. S. Atomic Energy Commission**

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Plutonium Packaging

Shipping Containers

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Model 2030-1 Container Being Loaded for Shipment. The "Routine Determination" of Package Integrity is Made Following a Written Procedure and Check List.

TECHNICAL DOCUMENTATION FOR MODEL 2030-1 SHIPPING CONTAINER (DOT SPECIAL PERMIT 5332)

Frank E. Adcock, John D. McCarthy, and William F. Wackler

Abstract. The Model 2030-1 container is used by Rocky Flats Division, Dow Chemical U.S.A., for shipping unirradiated fissile material in solid form. Components consist of a 30-gallon steel drum, Celotex insulation, and a stainless steel containment vessel of 10-inch diameter. Approved material limits include 5-kilograms of plutonium or 11-kilograms of enriched uranium. Thermal decay energy is normally limited to 20-watts. Higher values are permissible by modifying the design and observing certain restrictions.

AEC Approval (AL-R4) and DOT Special Permit 5332 were issued in 1967, based on the engineering evaluation by Rocky Flats. Results of recently conducted tests show the containment vessel temperature rise will not exceed 140°F during the thermal test. A unique and simple venting system to prevent container rupture is described and time/pressure data determined during a 30-minute furnace test at 1475°F are given.

All technical data for the package are provided, as required by an Immediate Action Directive (IAD 0529-24) change to AEC Manual Chapter 0529.

A similar vessel with a bolted flange, Viton O-ring seal, and quick-coupling fitting was used for in-plant storage of plutonium parts. Offering more strength and reliability than the modified pressure cookers, the flanged container more adequately met the new regulations and was selected as the containment vessel to use for shipping parts. An over-pack, consisting of machined Celotex rings and disks within a 30-gallon DOT-17H steel drum outer jacket, was designed to accommodate two heights of the flanged vessel.

At that time, it was thought that a very limited number of the containers would be needed. However, the Model 2030-1 has found a variety of applications both at Rocky Flats and at other AEC contractor's plants. Approximately 240 of these containers are in service at Rocky Flats.

Based on Rocky Flat's engineering evaluation, the Albuquerque Operations Office of the USAEC approved the Model 2030-1 container on July 11, 1967, and assigned an identification number AL-R4. DOT Special Permit 5332 was assigned to Dow Chemical U.S.A., August 23, 1967. The permit has subsequently been revised to include several other users.

DESCRIPTION OF CONTAINER

General

Figure 1 shows a cross section of the Model 2030-1 Container. The outer skin is a standard DOT-17H drum of approximately 20-inches diameter and 30-inches height. The version using two 7-inch high containment vessels is known as Configuration "A." The 14 Celotex rings and disks may be rearranged to accept one 13-inch-high vessel of identical design. This version is called Configuration "B." All the components are commercially available or can be easily fabricated by a general machine shop.

Engineering drawings are available from the United States Atomic Energy Commission, Division of Technical Information Extension, Post Office Box 62, Oak Ridge, Tennessee, reference number CAPE-1657.

Table 1 gives a summary of the important characteristics of Model 2030-1, and identifies the sections in the text where additional information can be found.

INTRODUCTION

Purpose of Report

This report has been prepared to familiarize users and potential users with the capabilities and limitations of the Dow Model 2030-1 (DOT Special Permit 5332) Container. The report fulfills the AEC's requirements for a bound document listing all pertinent information for each container design.

Background

Prior to July 1, 1968; when the present AEC and DOT shipping regulations were implemented, Rocky Flats shipped fissile material parts in modified household-type pressure cookers overpacked with a steel drum and vermiculite insulation.

Figure 1. Cross Section of the Model 2030-1 Container Showing Both Lengths of the Containment Vessels.

Table 1. Important Operating Characteristics and Limitations

	Text Reference Page
DRUM	
Minimum size: 18.12-in. dia. by 27.21-in. long	3,5
Maximum size: Limited only by gross weight	5
Maximum gross weight 18 ga: 250 pounds	5
16 ga: 400	
14 ga: 600	
VENTING	
One 1-in.-diameter hole required in drum lid	3,5,8
INSULATION	
Celotex industrial board, 2-in. on ends, 3 ⁷ / ₈ -in. on sides, (see text for exceptions)	4,5
Service temperature: 250° F maximum	5,10
CONTAINMENT VESSEL	
Material: stainless steel, 12 ga (0.1093 in.)	4
Pressure rating: 300 psi	4
Temperature rating: 400° F	5
Shielding: none provided	4
ACCIDENT-CONDITION TEST RESULTS	
Size reduction from 30-foot drop: no effective change	6
Temperature rise of containment vessel(s) during 30-minute fire: 140° F	7
CONTENTS	
Plutonium metal: 5.0 kilograms maximum	
U ₂₃₅ metal: 11.0 kilograms maximum	11,20
Heating: 20-watts w/exceptions to about 47-watts (contingent on users data)	9,10
Volatility: No pressure rise permitted at 400° F (Sum of thermal test and internal heating)	20
Pressure: 10-psig maximum when packaged	20

Components

METAL DRUM — A 30-gallon DOT-17H full-open-head drum with head and body of 18-gauge (0.048 in.) steel forms the outside of the container. Because of the wide variation in diameter and height found in “standard” drums, all 30-gallon drums are purchased to Dow drawings specifying a minimum inside diameter of 18.12-inches and a minimum inside height of 27.21-inches. Maximum dimensions are controlled by the DOT specification on allowable volume. These dimensional limits should not impose a cost penalty since they are less restrictive than the applicable industry standard, MH2.13, American Standard Specifications for 30-Gallon Full-Removable-Head Universal Drum (DOT-17H). However, both the drum manufacturer and the user’s receiving inspectors are alerted to conditions that would affect the fit between drum and insulation. After inspection, but prior to use, drums are modified by drilling a hole in the lid (see discussion on Vented Lid), by welding on a nameplate, and by adding security clips to the locking ring.

VENTED LID — A one-inch diameter hole is placed in the drum lid to prevent package rupture from internal pressure during an accidental fire. This hole is sealed weather tight by inserting a molded plastic plug (Figure 2). A 12-inch square of porous refractory fiber insulation is placed between the vent hole and the Celotex. This pad is the key to proper functioning of the vent and must be carefully selected to ensure that all the design objectives are met. Test packages used Cerafelt, a Johns-Manville insulation, of 1/2-inch thickness and 8-pound per cubic foot density, and it is strongly

Figure 2. Molded Plastic Button Plugs, in Free State and After Placement in Vent Hole.

Package Definition

The drawings listed below define the Model 2030-1 Container. Drawings preceded by an asterisk are for reference only and are not a part of CAPE 1657. These may be requested from the Product Engineering Department at Rocky Flats.

Number	Title
*P11997	DOT Special Permit Identification Tag
P12077	Packing, Fiberboard
P12081	Parts Storage Container
P12082	RFD Container — Model 2030-1
*P12150	RFD Container — Model 2030-1 Packing Check List
*P12346	Procurement Specification for DOT-17H 30-Gallon Drum
*P12414	Security Clip for Drum Locking Ring

recommended that no substitute be used without prior testing. The refractory fiber insulation performs the following functions:

- Protects the Celotex from direct exposure to flame.
- Allows venting of internal pressure.
- Limits in-flow of air to the drum to prevent smoldering of packing after exposure to fire.
- Prevents separation of the Celotex components by eliminating drum-to-Celotex gap.

NAMEPLATE — A stainless steel nameplate (Figure 3), 3 by 7 by 0.03-inches thick, provides all necessary identification. The words "Fissile Radioactive Material," "DOT Special Permit Number," and return address are all chemically etched approximately 0.001-inch deep to be legible after exposure to a fire. The variable information, such as permit number and serial number, is die-stamped in the spaces provided. The nameplate is rolled to the approximate diameter of the drum and fastened with six spot welds.

Figure 3. Details of Nameplate and Security Seal.

SECURITY SEAL — The Albuquerque Operations Office requires their contractors to use flat steel strapping and seal, instead of the more common wire and lead seal, for packages shipped via common carrier. To use this type of seal, a steel clip is welded to each lug of the locking ring.

Then the $\frac{3}{8}$ -inch wide by 0.015-inch thick strapping is passed through the slots under these clips and crimped in place using a seal printed with a distinctive pattern (Figure 3).

INSULATION — Celotex Industrial Board provides thermal insulation, shock protection, and a means of centering the containment vessels within the drum. Celotex, with a density of 15-pounds per cubic foot, is factory laminated into 4- by 8-foot boards 2-inches thick. The required rings and disks are cut from these boards by one of several commercial shops which stock Celotex. A nominal 2-inches (1.95-in. minimum) of insulating board is provided at the ends of the container and $3\frac{7}{8}$ inches around the sides, except where a relief for the flange of the containment vessel reduces the thickness to 3 inches.

CONTAINMENT VESSEL — The containment vessel is constructed of 12-gauge (0.109 in.) stainless steel with a flange and lid 0.25-inches thick. Closure is made by bolting the flange using twelve $\frac{5}{16}$ -inch cap screws. A Viton O-ring provides an adequate seal up to a service temperature of 400°F. There are two heights of vessels, approximately 7- and 13-inches, both with a 10-inch diameter. A quick-connect coupling is provided in the lid for evacuating and back filling the vessel with inert gas or dry air. The compound gage will indicate internal pressure to 15-psi and vacuum to 30 inches of Hg. Test data show that the flange will deform at an internal pressure of 300-psi and allow leakage around the O-ring. This provides a safety factor of 10 above the maximum pressure resulting from the accident condition tests.

SHIELDING — No shielding is necessary for the types of material shipped from Rocky Flats in the Model 2030-1 Container, and none has been provided.

Permissible Design Variations

Most container users other than the originator need to make minor design changes to meet their special requirements. This section is provided to define authorized modifications and design equivalents.

OVERALL SIZE AND WEIGHT — Criticality calculations are based on the minimum inside dimensions (18.12 diameter by 27.21 high) of a 30-gallon drum. Drums of smaller capacity cannot be used; however, larger sizes are acceptable. Table 2 gives various combinations of drum, gross weight, and end insulation that have proved adequate. Other designs must be proof tested.

Table 2. Drum and Insulation Requirements.

Maximum Gross Weight (lb)	Drum Thickness, Body and Head (in.)	Minimum End Insulation (in.)
300	18 ga (0.0428 min.)	2*
550	16 ga (0.0533 min.)	3*

*Nominal board size.

METAL DRUM — To be an acceptable equivalent, a drum must meet the following requirements:

- Gauge of metal per Table 2.
- 12-gauge locking ring with drop forged lugs and $\frac{5}{8}$ -inch bolt.
- Drop, hydrostatic, and leak tests per DOT Specification 17H, paragraph 178.118.
- Drums of 55-gallon capacity, or larger, must be at least 16-gauge and must have 3 rolling hoops, one of which is near the top curl.

VENTED LID — Tests have shown that two or more vent holes can result in continued smoldering and burning of the Celotex for periods in excess of 24 hours after removal of the package from a fire. If more than one vent hole is provided, extreme care must be taken to limit the in-flow of oxygen during the post-fire period. Alternative designs must be proof-tested for adequacy.

INSULATION — Any Celotex used must be "Industrial Board" made of cane fiber and must be at least 15 pounds per cubic foot density. Military Grade is preferable but not required. Care must be taken not to use Celotex building insulation or related products. Other types of insulation, such as plywood, may be used in accordance with DOT Specification 6M, paragraph 178.104-3(c).

Dimensional variations of the Celotex rings is permissible (to accommodate other sizes of containment vessels), provided the packing thickness is a minimum of three-inches around the sides. With all rings at this minimum, the temperature rise of the vessel will be under 170°F during the thermal test (see Accident Condition Tests).

CONTAINMENT VESSEL — Any containment vessel used should be equivalent in strength and leak-tightness to the design tested. Gaskets and fittings used must have a service temperature of 400°F, or higher. This value is based on the sum of the maximum heat rise during the thermal test (140°F) and maximum containment vessel temperature at the specified maximum heat load (250°F).

TESTING

General

The shipping safety and effectiveness of the Model 2030-1 Container is governed by USAEC Manual Chapter 0529 "Safety Standards for Packaging of Radioactive and Fissile Materials"; and the comparable standards for Type B packagings published in "Hazardous Materials Regulations of the Department of Transportation." The standards prescribe tests to simulate 'Normal Conditions of Transport' and 'Hypothetical Accident Conditions.'

Normal conditions of transport are not evaluated in this report because drum-type Celotex insulated shipping containers of comparable size and gross weight ratings have repeatedly demonstrated compliance with the applicable test requirements. The design has been approved in DOT Specification 6M, and several special permits.

The Model 2030-1 passes the tests for Hypothetical Accident Conditions without exposure, release, or malfunction of the inner components. The four test parts (Free Drop, Puncture, Thermal, and Water Immersion) are described herein.

In addition to the requirements for package standards, the following safety and performance investigations, which pertain to the Model 2030-1, have been conducted at Rocky Flats:

- Venting of drum (outer jacket) during accidental fire.
- Heat build-up caused by thermal emission of contents.
- Drop and pressure tests on containment vessel.

Accident Condition Tests

TEST PACKAGES — A package in Configuration "B" (that is, with 13-inch high containment vessel) was subjected to the four accident condition tests. For the Free Drop and the Puncture drop, a steel cylinder weighing 142 pounds was placed in the containment vessel to give a total package weight of 250 pounds. To avoid the "heat-sink" influence of this heavy piece of steel, it was replaced with two, small, steel rings weighing about 1-pound each for the Thermal test, reducing total package weight to 110 pounds.

The Thermal test part was also run on a Model 2030-1 package in Configuration "A." This configuration uses two containment vessels about 7-inches high, each loaded with a small piece of steel. Total package weight was 132 pounds.

In the sections on Thermal Test and Venting, results are given for test work done on the Model 2040 (AL-R8)

container. This size has essentially the same drum-type overpack as the Model 2030-1, with the variation being 10-inches more height, and 3-inch nominal wall thickness for the Celotex rings.

DROP AND PUNCTURE TESTS — Criteria for these tests stipulate that the package be dropped in a position for which maximum damage is expected. For the 30-foot Free Drop, packages similar to the Model 2030-1 are most likely to break open if impact is on the rim of the cover at the locking ring joint. A number of drop tests have been made at Rocky Flats with the drums oriented in this way. We have never had a rupture or opening of the outer drum. Figure 4 shows four 55-gallon packages with weights ranging from 400 to 535-pounds, all have successfully passed a 30-foot drop on the locking ring. These outer drums are Specification 17C with 16-gauge wall thickness. Typical Celotex flow pattern is shown in Figure 5. This same phenomena has also been noted on heavily loaded 10-gallon packages and could be expected to apply equally to 30-gallon drums.

Figure 4. Typical Results of 30-Foot Corner Drop on DOT-17C Drums. These packages weighing up to 535-pounds all remained intact.

Having already demonstrated the adequacy of the package on a corner drop, the Model 2030-1 was impacted in a horizontal position to obtain the maximum flattening or loss of spacing as used in the nuclear safety evaluation. The resulting permanent reduction (out-of-roundness) in diameter measured less than one-fourth inch for the portion of drum body between the rolling hoops. More pronounced denting was evident near each end of the drum and on each rolling hoop, but these are not considered to decrease the effective spacing radius for criticality evaluation. The denting at the cover end of drum shows in Figure 6.

Figure 5. Celotex Flow Pattern After 30-Foot Drop. Shock of impact is absorbed by compression and flow of Celotex with very little tendency to shatter or disintegrate.

Figure 6. Drum Opened After Thermal Test. Thermocouple leads are covered with protective wrapping.

For the 40-inch Puncture drop, the package was inverted to have the cover end of the drum impact onto the flat end of the 6-inch-diameter steel cylinder. The resulting circular impression in the domed cover was about 1 inch below normal contour at the deepest part, and tapered out to almost no indentation at the shallow part. Interior view of the impression is shown in Figure 6. There was no rupture or tearing of the sheet metal, and the plastic vent plug remained in place at the center of the cover.

After these two tests, inspection of the package interior showed that there had been no functional impairment to any of the components. There was some flow of Celotex fibers where the packing adjusted to the dented areas on the drum, but the containment vessel with the 142-pound load remained undamaged in the center of package. Checking with helium detector equipment showed that the leak-tightness of the containment vessel had not been reduced by the drops.

THERMAL TEST — These tests were conducted in a 275-kilowatt induction furnace which was preheated to about 1525°F (830°C) prior to the 30-minute test runs at 1475°F (800°C).

The Configuration "B" package was instrumented with three thermocouples to continuously record interior temperatures during the test. The outer surface of the containment vessel, at bolt flange of body portion, reached peak temperature of 205°F (95°C). This occurred approximately 2 hours after start of test run, and represents a temperature rise of about 135°F above that of the package components at the start of the test.

Figure 7 shows the temperatures recorded (during the above test on Model 2030-1) at the containment vessel flange, and in the Celotex packing rings adjacent to the flange 2- and 3-inches inward from the outside edge of the insulating material. The graph also shows curves recorded at the drum surface and at 1-inch in from the surface of the Celotex when the Model 2040 Container was tested under the same conditions.

For the Configuration "A" package, heat-sensitive monitor tabs with increments of 10° or 25°F were used to determine the highest temperatures reached at various locations within the package. These peak temperatures occurred within the ranges shown:

Figure 7. Time-Temperature Data Recorded from Thermocouple Stations During Thermal Test Runs.

- Within both upper and lower containment vessels, small steel plates nested in aluminum foil: 150-175°F.
- On exterior surface of upper containment vessel, the rim of the cover (over O-ring) and also the body sidewall: 190-200°F.
- On the lower containment vessel, no part of the exterior surface reached 190°F (the lowest rating of tabs attached to it).
- At 3-inches inward from the outside edge, the Celotex packing adjacent to the upper containment vessel: 200-210°F; and adjacent to the lower vessel: 190-200°F.

During the thermal-test runs on both package configurations, the temperature rise on the outer surfaces of the containment vessels was less than 140°F for the Model 2030-1 packages which have only two of the Celotex rings at the minimum recommended wall thickness of 3-inches.

With all the packing rings at 3-inch wall thickness, the interior temperature rise was less than 170°F during two comparable thermal-test runs on Model 2040 packages.

LEAK TEST — The regulations require that the thermal test be followed by the Water Immersion Test of 3-foot-minimum submergence for at least 8 hours. This is a leak test to check the primary containment vessel for cracks, damaged seals, etc. The overpack of Celotex and the outer drum may be removed from the vessel for this part of the test.

The 13-inch vessel and the two 7-inch vessels (from the thermal-test packages) were water tight under the required test conditions. The vessels were given a more stringent check with helium leak detector equipment which showed that the leak-tightness had remained well above the qualifying (after drop) rating of 1×10^{-4} cm³/sec for 18 psi helium differential.

Other Tests

VENTING — Thermal tests conducted at Mound Laboratory and at Savannah River (DuPont) indicate that Celotex insulated drums over 30-gallon capacity should be vented to prevent rupture from internal pressure. There has been much speculation on how many and what size holes are required. A spectacular jet of flame can be seen issuing from vent holes during a typical thermal test, but no data were available on the actual internal pressure of the drums. In January 1971, a thermal test was conducted using a Model 2040 container to check the adequacy of a single

one-inch diameter vent hole in the drum lid, and to measure internal pressure. A tube fitted to the drum led to a pressure gage located outside the furnace.

Figure 8 shows the time-pressure curve. The plastic plug sealing the vent hole melted out in less than one-minute. Soon after that the pressure began to rise probably as the result of gasses emitted by the drum gasket which was burning at that time. The peak pressure of 3.5 psi was reached about 8 minutes after start-up. Thereafter the pressure began to drop because of increased venting as the result of gasket burnout. The intensity of a hissing noise, which was audible throughout the test, varied with the pressure-gage readings. When the container was removed from the furnace, a conical-shaped portion of the insulation was protruding through the vent hole and completely blocked the opening. After the internal pressure decreased to zero, the insulation dropped back to its original place. A slight doming of the lid was also noted, but the soundness of the drum was not impaired.

Figure 8. Time-Pressure Curve for Drum with Vented Lid During Thermal Test.

The thermal test on the Model 2030-1 in configuration "A" used a sound drum which had not been dented by drop tests; therefore, it was also a proof test for the venting feature. Observations through the furnace view port showed the same pattern of gas flaring that had been seen with the Model 2040. It was noted that there was no apparent increase of doming on the lid for the Model 2030-1 indicating good venting efficiency with very slight pressure build-up (Figure 9).

Figure 9. Flames Showing Venting Action at Center Hole and Rim of Drum Lid. Photograph taken when furnace was opened after 30-minute heat run of Thermal Test.

The tests demonstrated that the one-inch-diameter vent hole is ample for these shipping packages. It is important to note that the high temperature insulation placed between the vent hole and the Celotex must be porous to allow venting, or else the vent must be designed to physically prevent the insulation from restricting the opening.

The venting arrangement should also restrict the amount of air entering the drum after the package is removed from the flame. This prevents continued smoldering of the Celotex. Our tests showed no indication of excessive smoldering.

HEAT BUILDUP — We have been pursuing a study program to investigate the temperature rise caused by the thermal emission of contents within Celotex insulated containers. USAEC RFP-1696* reports on test work done prior to early 1971, and additional studies have followed.

To date, ten test runs have been conducted on Model 2030-1 packages (Figure 10). These runs used heat loads in 5-watt steps up to 20-watts total. This is approximately twice the heat energy produced by decay of 5 kg of plutonium-239, the criticality limit for this package.

Heat sources for test runs were electric resistance elements or plutonium metal; generally fitted in number 3 food cans which were supported in crumpled metal foil within the containment vessels. All but two of the runs were on

Figure 10. Model 2030-1 Package Opened at End of a Typical Heat Build-Up Test. The three recorders each monitor two thermocouple channels.

the configuration "B" packages having one containment vessel. All runs have used 7-inch-high containment vessels for minimal surface area to dissipate the heat (Figure 11).

Figure 11. Temperature Monitor Tabs and Thermocouples Attached to Containment Vessel Prior to Heat Build-Up Study. "C" shaped band in foreground is electric resistance element for heat source.

From the studies on configuration "B" packages, temperature readings taken at outer surfaces of the successive metal enclosures (food can, containment vessel, and drum) are charted in Figure 12. The curves represent average values as adjusted for 70°F ambient temperature at test area.

Temperature buildup at the flange area and the adjacent sidewall of containment vessel(s) denotes the service

*Frank E. Adcock, Heat Buildup in Insulated Shipping Containers for Plutonium, USAEC RFP-1696, Rocky Flats Division, Dow Chemical U.S.A., May 19, 1971.

Figure 12. Temperature Distribution Throughout Package for Various Internal Energies.

condition for Viton O-ring seal(s), and also for the contacting inside diameters of the Celotex packing rings. Test results show that this part of the vessel stabilizes at about 150°F for a 20-watt heating load and 70°F room temperature; or would be at about 210°F if a package with the same heating load were subjected to the 130°F ambient heat test, which is listed for 'Normal Conditions of Transport.'

The test work on heat buildup has demonstrated the reliability of Model 2030-1 packaging for thermal emissive loads up to 20-watts energy. This may be used as a safe, practical limit without further qualification.

Heating loads over 20-watts are permissible, provided the containment vessel is properly designed and the insulation service temperature is not exceeded. Work at Savannah River** shows that Celotex Industrial Board loses its compressive strength above 285°F, although charring or

**E. E. Lewallen, "Celotex" Insulated Shipping Containers, BNWL-SA-3906, proceedings of the Third International Symposium on Packaging and Transportation of Radioactive Materials, August 16, 1971.

burning does not take place until about 400°F. We recommend the use of 250°F as the maximum service temperature of the containment vessel and suggest that the contents be limited so as not to exceed this value during normal shipment. There is a sufficient safety reserve (35°F) in the 250° limit to provide for ambient shipping temperature up to 105°F. Because of the many factors involved, any shipper who exceeds the 20-watt limit should determine their containment vessel temperature during a simulated transportation and storage cycle to ensure that 250°F will not be exceeded.

DROP AND PRESSURE TEST OF CONTAINMENT

VESSEL — To simulate the maximum probable damage caused by an accidental drop from height of loading table or transfer cart, an assembled containment vessel was given a 40-inch free drop with the gage impacting onto a concrete floor.

The only part of the assembly affected by the drop was the gage, which suffered broken glass, dented case, and bent stem. Prior to the drop, the vessel showed a helium leak rate value of 5.6×10^{-6} cm³/sec at 18 psi pressure differential. After the drop the value was 1.0×10^{-5} for same helium differential, with the weepage occurring at threaded connection of gage stem into cover plate.

The same vessel (with the gage replaced by a hydraulic line connection) was pressure tested to failure. At 300 psi, leakage occurred along the O-ring seal, where the pressure forced the flange to spread apart and deform between bolting points.

CRITICALITY EVALUATION

In order to use the Model 2030-1 Shipping Container for shipment of fissile material, a criticality evaluation is necessary to ensure that the container meets the AEC requirements as specified in the Appendix to AEC Manual Chapter 0529.

Method

A modified density analogue method was used to evaluate arrays of these containers as necessary to be in compliance with Class II and Class III requirements.

The basic equation for this method and the definitions of terms are as follows:

$$N_c = \frac{M}{M_e} \left(\frac{\rho}{\rho_1} \right)^x$$

where:

- N_c = critical number of containers
 M = critical mass of a solid water reflected sphere of the fissile material being considered
 ρ = density of M
 M_e = equivalent or actual mass of the fissile material in the individual containers
 ρ_1 = density of fissile material in the array
 x = density exponent as derived from experimental data

Class II Evaluation

The number of containers that meet the requirements for Fissile Class II shipments must meet the requirements for both normal and accident conditions as specified in Section II.I of the Appendix to AEC Chapter 0529.

The requirements for normal conditions are that five times the permitted number of undamaged containers would be subcritical in any arrangement if fully reflected by water.

In the analysis of the normal conditions, the above described density analogue method was used with the following assumptions:

1. Optimum moderation between containers.
2. Array is fully reflected.
3. Undamaged containers.
4. Approved contents in one containment vessel (Conf B) or one-half the approved contents in each of two containment vessels* (Conf A).

The requirements for accident conditions must also be met. These requirements are that twice the permitted number of containers to be in one shipment would be subcritical in any arrangement with full reflection and optimum moderation, unless greater than optimum moderation is in the packaging. The assumed condition of each container must be the condition after subjected to the hypothetical accident conditions.

*5 kg ^{239}Pu or ^{233}U approved for Configuration A, not Configuration B.

In the analysis for the accident conditions, the following was assumed:

1. Optimum moderation between containers.
2. Array is fully reflected.
3. Effective diameter of drum is decreased by 0.5 inch.
4. Approved contents in one containment vessel (Conf B) or one-half the approved contents in each of two containment vessels (Conf A).

The results of this evaluation that meet the normal and accident conditions for Fissile Class II shipments are summarized in Table 3. This table is a compilation of the permitted number of containers with the respective masses of ^{239}Pu , ^{233}U , and ^{235}U .

Table 3. Criticality Limits for Model 2030-1 Container.

Material*	Maximum Material per Containment Vessel (kg)		Maximum Packages per Shipment	
	Configuration		Fissile	Fissile
	A**	B	Class II	Class III
^{239}Pu or ^{233}U	2.5	—	10	27
Metal	2.0	4.0	17	42
	1.5	3.0	25	63
	1.0	2.0	49	124
	0.5	1.0	148	370
^{235}U Metal	5.5	11.0	38	96
	3.5	7.0	88	222
	1.7	3.5	316	790

*A maximum of two pieces of fissile material permitted in each containment vessel; except, if the total mass per vessel is less than 450 grams of ^{239}Pu or ^{233}U or less than 725 grams of ^{235}U , any number of pieces permitted. For other combinations of mass and number of pieces, the user must impose the necessary controls to ensure a sub-critical condition when water-flooded per Chapter 0529 paragraph II.C.1.

**When two containment vessels with unequal quantities of material are shipped in one Model 2030-1, use higher quantity and this table to find allowable packages.

Class III Evaluation

The same method and assumptions used for the evaluation for the normal and accident conditions for Fissile Class II were also used for the evaluation of arrays of these containers under normal and accident conditions for Fissile Class III requirements as specified in Section II.J of the Appendix to AEC Manual Chapter 0529.

The requirements for normal conditions for Fissile Class III are that two identical shipments of undamaged containers are subcritical if fully reflected by water.

The requirements for accident conditions are that the shipment would be subcritical with the containers in any arrangement if fully reflected with moderation considered credible in view of the controls put on the shipment. The assumed condition of each container must be the condition after the container is subjected to the hypothetical accident conditions.

The number of containers that meet the normal and accident conditions for Fissile Class III requirements are summarized in Table 3.

The restriction of metal only, and the restriction on the number of pieces of fissile metal were imposed on the contents to meet the requirements for a single package as specified in Section II.C.1.

QUALITY ASSURANCE

Recently the AEC has revised Manual Chapter 0529 to more fully define the required quality assurance program for shipping containers. These requirements are listed below, along with the method used at Rocky Flats to comply with the requirements.

Rocky Flats has been meeting the intent of the new regulations. Rocky Flats Drawing P12192, issued in March 1968, gives the general requirements for inspection and use of shipping containers and for the related record keeping.

Responsibilities

Assign specific responsibilities to the user, vendors and fabricators, to assure specified quality at all stages of construction.

Responsibility for container quality assurance is assigned to two organizations at Rocky Flats; Quality Assurance, who performs the preliminary determination, (receiving inspection); and Production Control, who stores, assembles and packs the containers. All container components are purchased from private suppliers or fabricators. In-process inspection is not necessary, because when the parts are received at Rocky Flats, their features are readily accessible for inspection and/or testing. Acceptable parts are stocked in the Production Control warehouse. As new

containers are needed, Production Control assembles them from their supply of components and makes the routine determination prior to use.

Specifications

Designate standards, material specifications, fabrication methods, testing and performance requirements.

The drawings listed in the section on Package Definition give all necessary dimensions, standards, and materials to produce an acceptable container. Tests, such as leak rate determination and radiographic examination of the containment vessel, are also given. A formal system of drawing preparation, control, and distribution is defined by the Rocky Flats Product Engineering Manual. The drawings for the Model 2030-1 Container are prepared, issued, and maintained in accordance with this manual.

Acceptance Criteria

Establish acceptance criteria to assure that all package design requirements, including performance tests (such as drop, fire, and immersion) would be met by the assembled contained.

Inspection and test requirements for the "preliminary determination before first use" are itemized on Product-Engineering-controlled forms. These requirements are shown in Figure 13, panels A, B, and C.

Packaging and Use

Provide for the routine inspection prior to the reuse of any container to ensure that all applicable design standards have been met.

Packaging and "routine determination before each use" is accomplished by following a written procedure. A packaging check list, Figure 13, panel D, is completed for each container to be shipped. This check also serves as a routine maintenance inspection, since any component found to be defective is replaced from an inventory of spare parts.

Records

Provide that quality assurance records are maintained in an auditable file during the service life of the container.

The required inspection forms are maintained for the life of the container (or container component) by Production

MODEL 2030-1 DRUM AND PACKING ROCKY FLATS INSPECTION FORM*		
*This form gives the minimum requirements for "Preliminary determination" required prior to first use of any package component as specified in AEC Manual, Chapter 0529.		
ITEM	REQUIREMENTS	REMARKS
1	Quantity in lot.	
2	Record container serial numbers.	
3	Identification tag welded to drum. Special Permit Number 5332, Model 2030-1, and serial number stamped or engraved.	
4	Drum Inspected per P12346.	
5	1-inch diameter hole thru, approximately centered in lid.	
6	Celotex rings and disks visually checked for defects: Size B1, 3 req'd. Size B2, 8 req'd. Size B3, 2 req'd. Size B4, 1 req'd. Size B5, as req'd.	
7	All parts assembled without visible gaps; drum-to-Celotex gap 0.5 maximum per P12082.	
A		DWG. NUMBER

DOT-17H 30-GAL. DRUM (P12346) ROCKY FLATS INSPECTION FORM*		
*This form gives the minimum requirements for "Preliminary determination" required prior to first use of any package component as specified in AEC Manual, Chapter 0529.		
ITEM	REQUIREMENTS	REMARKS
1	Quantity in lot. Record lot number.	
2	Identification embossed in lower head per DOT-17H.	
3	.0428 minimum thickness, body & heads.	
4	18.12 minimum inside diameter.	
5	27.21 minimum inside height w/cover on.	
6	.0946 minimum closure ring w/drop forged lugs & 5/8-inch bolt and nut.	
7	Lug weld satisfactory.	
8	.375 minimum convexity, both heads.	
9	Gasket satisfactory.	
10	Workmanship & painting satisfactory.	
11	Leak test w/cover in place.	
B		DWG. NUMBER

CONTAINMENT VESSEL (P1208) ROCKY FLATS INSPECTION FORM*		
*This form gives the minimum requirements for "Preliminary determination" required prior to first use of any package component as specified in AEC Manual, Chapter 0529.		
ITEM	REQUIREMENTS	REMARKS
1	Quantity in lot.	
2	Record serial numbers and other identification.	
3	O-ring groove free of burrs and defects.	
4	Mating surfaces of flange and lid free of burrs and defects.	
5	Threads smooth and free of burrs.	
6	Body and lid cleaned by electro-polishing.	
7	Welds full penetration and free of voids and defects.	
8	Leak rate determination satisfactory.	
9	Serial number marked.	
10	Correct hardware installed: SS1 Cap Screws Viton O-ring Coupling w/Viton washer Compound Gage	
11	Overall leak rate $\leq 1 \times 10^{-4}$ std cc/sec. Record measured leak rate.	
NOTES: Two vessels from each lot to have 100% inspection; remainder may be given a functional inspection consisting of the eleven items listed.		
C		DWG. NUMBER

MODEL 2030-1 (SP 5332) PACKING CHECK LIST*		
*This form gives the minimum requirements for "routine determinations prior to each use" as specified in AEC Manual, Chapter 0529.		
ITEM	REQUIREMENTS	REMARKS
1	Nameplate welded in place, all marking legible. Record serial number.	
2	Contents of containment vessel packed per user's written procedure.	
3	Contents limited per P12082-1 or other applicable criticality limits.	
4	Flanges clean, U-ring groove free of defects.	
5	O-ring serviceable.	
6	Containment vessel(s) sealed and filled to 10-psig maximum with dry air or inert gas.	
7	Radioactive material caution label on containment vessel(s).	
8	Drum, lid and locking ring visually checked for defects affecting function of container.	
9	Celotex components visually checked for defects, 0.50 maximum gap per P12082-1.	
10	Porous refractory fiber insulation in place per P12082-1.	
11	Plastic plug installed.	
12	Lid secured with locking ring and 5/8 diameter bolt and lock nut.	
13	Security seal applied.	
14	Radioactive material label, 2 pieces, transport index marked (when applicable).	
15	Containment vessel leak rate $\leq 1 \times 10^{-4}$ std cc/sec. Record vessel serial number and measured leak rate.	
D		DWG. NUMBER

Figure 13. Inspection Requirements for Preliminary and Routine Determinations of Package Integrity.

Control, which is the organization that stores, maintains, and controls all containers for radioactive materials. The records applicable to each shipment are retained for at least 2 years after the date of shipment.

Audits

Perform an audit of each AEC contractor at least annually as required by Manual Chapter 0504.

Rocky Flats is audited annually by the Operational Safety Division of the Albuquerque Operations Office to ensure satisfactory performance in the areas of radiation safety, criticality, and packaging. In addition, internal audits are conducted by Dow's Quality Control Department.

Personnel and Equipment

Provide for training, testing, and certification of manufacturing and inspection personnel involved in special processes such as welding and nondestructive examination, and for the certification of equipment such as gages and testing apparatus.

Container components are all supplied by reputable fabricators. Certain key suppliers are subjected to a vendor audit conducted by a team consisting of Purchasing, Quality Control, and Product Engineering personnel. This team ensures that the fabricator maintains good manufacturing and quality control methods.

At Rocky Flats, the inspection and nondestructive test personnel are all highly trained, although they are not "certified" as such. They are subject to regular audits under the AEC's Quality Assurance Program for weapons contractors.

Rocky Flat's Quality Control Manual Q1000, entitled "Policy and Definitions," is the basic document defining the plant's quality control program. Section 1 of the manual assigns specific quality responsibilities for each production-related activity. Section 2 defines the requirements for product definition, material control, process control, and gage control and calibration. Each of these activities is in turn controlled by a detailed procedure which is listed in Q1000.

Use of Package by Other Contractors

Provide data to other AEC contractors or licensees who may use the Model 2030-1 container to assure that all requirements of Manual Chapter 0529 are met.

This document has been furnished expressly to provide all information needed to convey package design intent, provide data on accident condition tests, and to define the requirements for fabrication, inspection, and use of the Model 2030-1 container. Before any user ships radioactive material in this container he should have a copy of this document, the engineering drawings listed herein, DOT Special Permit 5332, and the applicable nuclear safety evaluation.

EXPERIENCE

Shipping and Maintenance

The Model 2030-1 container has been in routine service at Rocky Flats since 1967. It has never been involved in an accident, contamination spill, or other incident. There has been no experience of damage during normal handling. However, minor dents are repaired periodically and the drums are spot painted to restore their original appearance.

Cost

Container components are purchased from private firms on a competitive bid basis. The latest costs, based on material purchased in 1971, are given below:

Component	Cost
Containment Vessel (for two)	\$220.00
Celotex Rings and Disks	19.35
DOT-17H Drum	7.25
Nameplate	.75
Refractory Fiber Insulation	1.00
Security Clip and Vent Plug	.21
Total	\$248.56

There are no data available on the cost of the receiving inspection, or the assembly of components at Rocky Flats.

Suggested Suppliers

As an aid to other contractors who may wish to purchase components for the Model 2030-1, the following list of vendors has been prepared. These firms are in no way "approved," however, they have all bid on, and in some cases supplied, container components. Since the only assembly operations consist of drilling a hole in the lid, and welding the nameplate and security clips to the drum,

we suggest the purchase of individual parts rather than attempt to find a supplier for a complete container.

Celotex Rings and Disks:

Cadillac Products, Inc.
Warren, Michigan

Duro Flex Products Co.
Foristell, Missouri

Industrial Wood and Packaging Products
Jersey City, New Jersey

Containment Vessel:

Precision Beam Welding
Boulder, Colorado

Process Equipment Co.
Brockton, Massachusetts

Stainless Equipment Co.
Englewood, Colorado

Nameplates:

Miller Dial and Nameplate Co.
El Monte, California

Plastic Vent Plug (CAPLUG No. PBF-1)

Protective Closures Company, Inc.
Buffalo, New York

Refractory Insulation (Cerafelt):

Johns-Manville
New York, New York

AEC APPROVAL AL-R4

CERTIFICATION OF APPROVAL FOR FISSILE-LARGE QUANTITY SHIPPING CONTAINERS
ALBUQUERQUE OPERATIONS OFFICE, USAEC

Approved - 7-11-67
 *Revision 1 - 6-7-71

I. <u>ALO Contractor</u> The Dow Chemical Company Rocky Flats Division Box 888 Golden, Colorado 80401 Contact: Frank E. Adcock	II. <u>Identification of Shipping Container</u> RFD Container - Model 2030-1 Metal nameplates spot welded to drum. Dow drawing Number: P12082-1 ALO designation: AL-R4 DOT Special Permit: No. 5332
---	--

III. General Information Concerning Container.

- * A. Outside container is an DOT-17H¹, or equivalent, 30-gallon metal drum with bolt-type locking ring and 3/8" bolt. Insulation and shock protection is provided by machined Celotex fiberboard disks.
- B. Containment vessel is a stainless steel vessel with .062 minimum wall thickness, 10-inches diameter and in either of two lengths: approximately 7- and 13-inches. Closure is a bolted flange and Viton o-ring seal. O-ring seal fails at 300 psig due to deformation of the flange.
- C. Package weight, empty: 120 pounds.
- * D. Criticality Limits:

Material ②	Maximum Material per Containment Vessel (Kg)		Maximum Packages per Shipment	
	Conf. A ①	Conf. B	Fissile Class II	Fissile Class III
Pu-239 or U-233 Metal	2.5	----	10	27
	2.0	4.0	17	42
	1.5	3.0	25	63
	1.0	2.0	49	124
	0.5	1.0	148	370
U-235 Metal	5.5	11.0	38	96
	3.5	7.0	88	222
	1.7	3.5	316	790

① When two containment vessels (Configuration A, dwg. P12082-1) with unequal quantities of material are shipped in one Model 2030-1, use higher quantity and this table to find allowable packages.

② A maximum of two pieces of fissile material permitted in each containment vessel, except if the total mass per vessel is less than 450 grams of Pu-239 or U-233 or less than 725 grams of U-235, any number of pieces permitted. For other combinations of mass and number of pieces, the user must impose the necessary controls to assure a sub-critical condition when water-flooded per Chapter 0529 paragraph 11.C.1. Under no circumstances may the values in the table be exceeded.

- E. An engineering evaluation has been presented relating this container to the RFD Container, Model 1518, and to other test data previously published.

AEC APPROVAL AL-R4 (continued)

IV. Specific Limitations and Restrictions.

1. Container for metal shapes only.
2. Inner container pressure must not exceed 10 psig of dry air or inert gas when packaged.
- * 3. Vented drum lid required.

V. Additional Information and/or Limitations.

- * Fire test with vented lid (dwg. P12082-1, issue E or later) showed inner container will remain under 240°F.

VI. Certification of Approval.

Pursuant to Chapter AEC 0529, this container is approved subject to the limitations described above. This certification does not relieve the shipper of his responsibility to obtain a DOT Special Permit and to comply with the requirements of other Federal Regulations as appropriate.

Date: 2 June 1971

Certification Official
Albuquerque Operations
U. S. Atomic Energy Commission

DOT SPECIAL PERMIT 5332

DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS REGULATIONS BOARD
WASHINGTON, D.C. 20590

SPECIAL PERMIT NO. 5332
SEVENTH REVISION

Pursuant to 49 CFR 170.15 of the Department of Transportation (DOT) Hazardous Materials Regulations, as amended, and on the basis of the March 6, 1972, petition by the Union Carbide Corporation, Nuclear Division, Oak Ridge, Tennessee.

Special Permit No. 5332 is hereby amended as follows:

1. Paragraph (3) is changed so as to authorize a one-time shipment with alternate contents in the form of Aberdeen Pulse Reactor Fuel plates, fused together to form a cylinder 8.9" in diameter by 3.36" high, with a center hole 4.16" diameter 12 other holes varying from 0.709" to 1.116" diameter. The total mass is 35.845 Kg containing 30.06 Kg of U-235. Shipment shall be Fissile Class III by motor vehicle between Aberdeen, Maryland and Oak Ridge, Tennessee. Shipment must be in accordance with the provisions of USAEC, Oak Ridge Operations Office certificate of approval no. 72-002, dated February 18, 1972. This revision expires upon completion of the single shipment authorized herein.

All other terms of this permit, as revised, remain unchanged. The complete permit currently in effect consists of the Sixth and Seventh Revisions.

Issued at Washington, D.C.:

for *B. J. Milster*
W.R. Fiste
For the Administrator
Federal Highway Administration

28 MAR 1972
(DATE)

Address all inquiries to: Secretary, Hazardous Materials Regulations Board, U.S. Department of Transportation, Washington, D.C. 20590.
Attention: Special Permits.

Dist: a, c, d, e, h, i
Dow Chemical Company, Golden, Colorado
U.S. Atomic Energy Commission, Richland, Washington
Lawrence Radiation Laboratory, Berkely, California

DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS REGULATIONS BOARD
WASHINGTON, D.C. 20590

SPECIAL PERMIT NO. 5332
SIXTH REVISION
(COMPLETE)

This special permit is reissued pursuant to 49 CFR 170.15 of the Department of Transportation (DOT) Hazardous Materials Regulations, as amended, and on the basis of the July 12, 1971, petition by the Dow Chemical Company, Golden, Colorado, and the June 4, 1971, petition by Union Carbide Corporation, Oak Ridge, Tennessee, and the previous petition on file with this Board.

1. Shipments of fissile and large quantities of radioactive materials, n.o.s., are hereby authorized in the packaging as described in this special permit. This packaging, when constructed and assembled as prescribed herein, with the contents as authorized herein meets the standards prescribed in the DOT Regulations, Sections 173.395(c)(2), 173.396(c)(3), and 173.398(c). Shipments must be in accordance with the provisions of the U.S. Atomic Energy Commission (USAEC), Albuquerque Operations Office approval number AL-R4 dated June 7, 1971, and as further provided for herein.

2. Each shipper, under this permit, other than the petitioner named above, and the other previously identified petitioners shall register his identity with this Board prior to his first shipment, and shall have a copy of this permit in his possession before making any shipment.

3. The packaging authorized by this permit consists of the RFD Model 2030-1, which is a metal, drum-type "birdcage," utilizing an outer DOT Specification 17H, or equivalent, steel drum (with a 5/8" steel bolt and locking ring), and either one or two inner vessels, which are centered and supported within the outer drum by means of stacked rings and discs of machined Celotex, filling the void space between containers. The inner vessels are either one 13" long or two 7" long stainless steel pressure vessels, each having 0.062" wall thickness and a 10" diameter (approx.), with closure by means of bolted flange and a Viton o-ring seal (rated to 300 psig). The package tare weight is about 120 pounds, and is described on Dow Chemical Company's Drawings No. P-12082, Rev. G and 12634 (inner container) and Union Carbide Corporation's Drawing No. E-T-69975 (alternate version of inner container). The drum lid is equipped with a vent hole and fusible plug.

4. The contents of each package authorized by this permit consist of fissile radioactive material, including large quantity, in the form of metallic plutonium or uranium; with the Pu-239, U-233, or U-235 limited as indicated in the Appendix hereto. The inner container pressure must not exceed 10 psig of dry air or inert gas before shipment.

5. The packaging authorized by this permit meets the requirements for shipment as Fissile Class II, with the appropriate transport index as indicated in the Appendix to be assigned to each package (unless, however, external radiation levels dictate a higher assignment).

6. The packaging authorized by this permit meets the requirements for shipment as Fissile Class III, with not more than the number of packages as indicated in the Appendix, per transport vehicle or stowage area. Shipments by cargo-only aircraft must conform to §173.396(g)(1).

7. The authorized package described herein is hereby certified as meeting the specific requirements of the International Atomic Energy Agency's (IAEA) "Regulations for the Safe Transport of Radioactive Material," Safety Series No. 6, 1967 edition, as follows:

a. Marginal C-6.2.2 - The package design meets the requirements for Type B packaging for radioactive materials.

b. Marginal C-6.2.4 - The package design meets the requirements for Fissile Class II and III shipments.

8. The outside of each package must be plainly and durably marked "USA DOT SP 5332" and "TYPE B," in connection with and in addition to the other markings and labels prescribed by the DOT Regulations. Each chipping paper issued in connection with shipments made under this permit must bear the notation "DOT SPECIAL PERMIT NO. 5332," in connection with the commodity description thereon.

9. Each package must have its gross weight plainly and durably marked on the outside of the package.

10. This permit authorizes shipments only by cargo-only aircraft, motor vehicle and rail. ~~For shipments by air, a copy of this permit, kept current, must be carried aboard each aircraft transporting radioactive material under these terms.~~

11. Prior to each shipment authorized by this permit, the shipper shall notify the consignee and, for export shipments, the competent authority of any country into or through which the package will pass, of the dates of shipment and expected arrival.

12. Any incident involving loss of contents of the package must be reported to this Board at the earliest feasible moment following the incident.

13. The permit does not relieve the shipper or carrier from compliance with any requirement of either the DOT Regulations, except as specifically provided for herein, or the regulations of any foreign government into or through which the package will be carried.

Continuation of 6th Rev. SP 5332

Page 3

14. This permit expires on August 31, 1973.

Issued at Washington, D.C.:

W.R. Fiste
for W.R. Fiste
For the Administrator
Federal Highway Administration

27 AUG 1971
(DATE)

Mac E. Rogers
Mac E. Rogers
For the Administrator
Federal Railroad Administration

AUG 31 1971
(DATE)

Ellis C. Langford
Ellis C. Langford
For the Administrator
Federal Aviation Administration

3 SEP 1971
(DATE)

Address all inquiries to: Secretary, Hazardous Materials Regulations Board, U.S. Department of Transportation, Washington, D.C. 20590.
Attention: Special Permits.

Dist: a, c, d, e, h, i
Dow Chemical Company, Golden, Colorado
Union Carbide Corporation, Oak Ridge, Tennessee
U.S. Atomic Energy Commission, Washington, D.C.
U.S. Atomic Energy Commission, Richland, Washington
Lawrence Radiation Laboratory, Livermore, California

Continuation of 6th Rev. SP 5332

Page 4

APPENDIXTABLE OF PACKAGE LOADING LIMITS

Fissile Material**	Maximum Material Per Inner Container (kg)		Minimum Transport Index Per Package For Fissile Class II	Maximum Packages Per Vehicle For Fissile Class III
	Two Inner Containers*	One Inner Container		
Pu-239 or U-233	2.5	---	5.0	27
	2.0	4.0	2.9	42
	1.5	3.0	2.0	63
	1.0	2.0	1.1	124
	0.5	1.0	0.4	370
U-235	5.5	11.0	1.3	96
	3.5	7.0	0.6	222
	1.7	3.5	0.2	790

* When the two inner containers bear unequal quantities of material, apply the value for the higher of the two quantities against this column.

** A maximum of two pieces of fissile material is permitted in each inner container, except if the total mass per inner container is less than 450 grams Pu-239 or U-233, or less than 725 grams U-235, any number of pieces is permitted.