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**ROCKY FLATS MODEL 2030-1 CONTAINER
(AEC-AL USA/5332/BLF)
SAFETY ANALYSIS REPORT FOR PACKAGING (SARP)**

(This revision supersedes RFP-1867 dated November 16, 1972.)

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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.

**ROCKY FLATS MODEL 2030-1 CONTAINER
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SAFETY ANALYSIS REPORT FOR PACKAGING (SARP)**

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 stainless steel containment vessel(s) of 10-inch diameter. A simple venting system prevents rupture of the outer drum in the event of accidental fire. Approved material limits include 5 kilograms of plutonium or 11 kilograms of enriched uranium. Thermal decay energy is normally limited to 20 watts.

Results of extensive tests show the container will function effectively when exposed to all environment and accident conditions as required. The containment vessel temperature rise will not exceed 140 °F during the thermal test. Internal heating of 20 watts will cause an additional temperature rise of 80 °F.

This document constitutes the Safety Analysis Report for Packaging (SARP) as required by AEC Manual Chapters 0529 and 5201.

INTRODUCTION

Purpose of Report

AEC Manual Chapters 0529 and 5201 require a Safety Analysis Report for Packaging (SARP) be prepared for each container to be used for shipping radioactive material. This report constitutes the required SARP and is the basis for AEC Certificate of Compliance AEC-AL USA/5332/BLF as it applies to the Model 2030-1 Container.

Revision 1 of RFP-1867 has been issued to add an expanded section on quality assurance

procedures and to provide additional information as deemed necessary by Contractor and AEC Field Office (ALO) reviews of the original report.

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.

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 overpack, 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 a very limited number of the containers would be needed. Model 2030-1, however, has found a variety of applications at Rocky Flats and other AEC contractors' plants. Approximately 240 of these containers are in service at Rocky Flats.

Based on Rocky Flats engineering evaluation, the Albuquerque Operations Office of the USAEC approved the Model 2030-1 Container on July 11, 1967, and assigned it the identification number AL-R4. DOT Special Permit 5332 was assigned to Dow Chemical U.S.A. on August 23, 1967.

The permit has subsequently been revised to include several other users and to approve one alternate containment vessel.

This SARP was prepared and reviewed by Rocky Flats and submitted to the Albuquerque Operations Office in August 1973, in compliance with Immediate Action Directive 5201-3. The AEC Certificate of Compliance was issued January 9, 1974.

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 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 the Model 2030-1, and identifies the sections in the text where additional information can be found.

Package Definition

The documents listed below constitute the specifications, acceptance criteria and packaging procedures for the Model 2030-1 Container. The required drawings are a part of CAPE-1657; the referenced drawings and procedures may be requested from the Product Engineering Department at Rocky Flats.

Required Documents —

P12077	Packing, Fiberboard
P12081	Containment Vessel
P12082	RFD Container — Model 2030-1

Referenced Documents —

P12150	RF Inspection Form — Model 2030-1 Container
P12192	General Requirements for Inspection and Packing Rocky Flats Containers
P12346	Procurement Specification for DOT-17H 30-gallon Drum
P12414	Security Clip for Drum Locking Ring
PC777-02	Production Control Packing Procedures for Buildings 707 and 777
Q2000	Radioactive Material Packaging Quality Assurance

Table 1. Important Operating Characteristics and Limitations of the Model 2030-1 Container.

	Text Reference Page
DRUM	
Minimum inside dimensions: 18.12-in. dia by 27.21-in. long	4
Maximum gross weight (18 ga): 300 lb.	6
VENTING	
One 1-in. diameter hole required in drum lid	4, 6
INSULATION	
Celotex industrial board, 2 in. on ends, 3.88 in. on sides	5, 6
Service temperature: 250 °F maximum	8
CONTAINMENT VESSEL	
Material: stainless steel, 12 ga (0.1093 in.)	5
Service Temperature: 400 °F minimum	6
Gross Weight: 160 pounds maximum (total weight in any package)	5, 10
ACCIDENT-CONDITION TEST RESULTS	
Size reduction from 30-ft drop: no effective change	11
Temperature rise of containment vessel(s) during 30-minute fire: 135 °F	12
CONTENTS	
Plutonium metal: 5.0 kg maximum	17
²³⁵ U metal: 11.0 kg maximum	17
Heating: 20 watts	16
Volatility: No pressure rise permitted at 400 °F (Sum of thermal test and internal heating)	12, 15
Pressure: 10 psig maximum when packaged	See engineering drawing and certificate

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

Components

Components of the Model 2030-1 Container have been selected to ensure there will be no significant chemical, galvanic, or other reaction that would be detrimental to the container's performance.

Metal Drum — A 30-gallon DOT-17H open head drum with body and heads of 18-gauge (0.048 inch) steel forms the outside of the container. Methods of fabrication and dimensional limits are controlled by MH2.13, American Standard Specifications for 30-gallon Full-Removable-Head Universal Drum (DOT-17H). Because of the wide variation in diameter and height found in "standard" drums, all 30-gallon drums used at Rocky Flats are purchased to a Dow drawing specifying a minimum inside diameter of 18.12 inches and a minimum inside height of 27.21 inches. These values will assure a proper drum-to-insulation fit. Maximum dimensions are controlled by the DOT specification on allowable volume and by MH2.13. 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

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

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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 has been carefully selected to ensure that all design objectives are met. Test packages used Cerafelt, a Johns-Manville insulation of 0.5-inch thickness and 8 pounds per cubic foot density, and it is strongly 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

Figure 3. Details of Nameplate and Security Seal. Delivery is expected soon on a new nameplate design. 15889-2

identification. The words "Fissile Radioactive Material," and return address are chemically etched approximately 0.001-inch deep to be legible after exposure to a fire. The variable information, such as approval number and serial number, is die-stamped in the spaces provided. The name-plate is rolled to the approximate diameter of the drum and fastened with six spot welds.

Closure — Primary package closure is the drum locking ring. Drop forged lugs welded to the ends of the locking ring are fastened using a $\frac{5}{8}$ -inch bolt and lock nut thereby providing a positive closure. A wire and lead seal may be wrapped around the bolt and lugs to provide a tamper-proof feature. However, 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. The 0.375-inch wide by 0.015-inch thick strapping is then 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 inches minimum) of insulating board is provided at the ends of the container and 3.88 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 inches) 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 at a service

temperature of 400 °F. There are two heights of vessels, approximately 7 and 13 inches, both with a 10-inch diameter; tare weights are 17 and 20 pounds. A quick-connect coupling is provided in the lid for evacuating and back filling the vessel with inert gas or dry air. The compound gauge will indicate internal pressure to 15 psi and vacuum to 30 inches of Hg. Test data show the flange will deform at an internal pressure of 300 psi and allow leakage around the O-ring. Each vessel is marked with the model number (DPV), serial number, and size (A or B).

Lifting and Tie-Down Devices — No lifting or tie-down devices have been provided and none are required. The Model 2030-1 Container is handled and shipped as an ordinary 30-gallon drum. No special handling precautions are necessary.

Shielding — No shielding, neutron absorbers, or moderators are required for the types of material shipped from Rocky Flats in the Model 2030-1 Container, and none have been provided. A bare piece of plutonium weighing 5 kilograms has a radiation dose rate of 187 mrem/hr at 3 feet, well below the 1000 mrem/hr at a distance of 3 feet that is allowed under existing shipping regulations. Uranium has still lower external radiation.

Recommended Design Limits

Most container users other than the originator need to make certain design changes to meet shipping requirements. To make Special Permit 5332 (now AEC-AL USA/5332/BLF) more versatile, testing and evaluation was done on packages that were larger and heavier than we expect to use at Rocky Flats. For example, drop tests were performed using a load of 142 pounds, although we plan not to exceed 25 pounds in actual service. In a similar manner, drums differing only in length (60 inches) were subjected to beam loading, drop, and compression tests to qualify for design variation.

This section of the Safety Analysis Report is provided to define container modifications that may be made without additional testing, and to state design equivalents. Should any user incorporate any of these variations in his container, he must submit the new design to the AEC for an extension of the original approval.

Overall Size and Weight – Criticality calculations are based on the minimum inside dimensions (18.12-inch diameter by 27.21 inches high) of a 30-gallon drum; drums of smaller capacity cannot be used. Table 2 gives various combinations of drum, gross weight, and end insulation that have been proved adequate. Other designs must be proof tested. Note that double height 30-gallon (18 gauge by 60-inch height) and 55-gallon (16 gauge by 68-inch height) drums are acceptable.

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.

Table 2. Drum and Insulation Requirements.

Maximum Gross Weight (lb.)	Maximum Drum Height (in.)	Drum Thickness, Body and Head (in.)	Minimum End Insulation (in.)
300	60	18 ga (0.0428 min.)	2*
550	68	16 ga (0.0533 min.)	3*

*Nominal board size.

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 – The 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 Celotex rings is permissible (to accommodate other sizes of containment vessels), provided the packing thickness is a minimum of 3 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 Tests for Hypothetical Accident Conditions).

Containment Vessel - Any containment vessel used must be the equivalent in strength and leak-tightness to the design tested. (Service pressure = 100 psi, calculated failure pressure = 278 psi, leak rate less than 1×10^{-4} cm³/sec at a pressure differential of 12 to 15 psi). The O-ring must have a service temperature of 400 °F. Any fittings or gauges used must remain leak-tight at 400 °F or else be disconnected from the vessel during shipment using a valve or other suitable means.

PACKAGE STRUCTURAL EVALUATION

General

The design, construction, testing and use of the Model 2030-1 Container is governed by USAEC Manual Chapter 0529 "Safety Standards for the Packaging of Fissile and Other Radioactive Materials," and Chapter 5201 "Transportation and Traffic Management," also by the Code of Federal Regulations, Title 49—Transportation, Parts 170-179, "Hazardous Materials Regulations" of the DOT.

This section, "Package Structural Evaluation," shows by tests performed and by engineering analysis that the Model 2030-1 Container will meet AEC and DOT requirements for shipping Type B, large quantity, and fissile radioactive materials.

Structural Standards for Type B and Large Quantity Packaging

Load Resistance — Regarded as a simple beam supported at its ends along any major axis, packaging shall be capable of withstanding a static load, normal to and uniformly distributed along its length, equal to five times its fully loaded weight, without generating stress in any material of the packaging in excess of its yield strength.

Assuming the package to be loaded as specified above, stress in the drum may be calculated as follows:

Maximum gross weight = 300 pounds
 Total load: $W = 300 \times 5 = 1500$ pounds
 Beam length: $l = 60$ inches
 Drum outside diameter: $D_o = 18.20$ inches
 Drum inside diameter: $D_i = 18.12$ inches
 Maximum moment:

$$\begin{aligned} M \text{ max.} &= \frac{Wl}{8} \\ &= \frac{1500 \times 60}{8} \\ &= 11,250 \text{ inch-pounds} \end{aligned}$$

$$\begin{aligned} \text{Moment of Inertia: } I &= \frac{\pi}{64} (D_o^4 - D_i^4) \\ &= \frac{\pi}{64} (18.20^4 - 18.12^4) \\ &= 94.1 \text{ inches}^4 \end{aligned}$$

Maximum Stress:

$$\begin{aligned} S &= \frac{Mc}{I} \\ &= \frac{11,250 \times 9.1}{94.1} \\ &= 1088 \text{ psi} \end{aligned}$$

Yield strength of hot rolled steel is 35,000 psi, providing a safety factor of over 30. The Model 2030-1, with a height (beam length) of 29 inches has an even greater margin of safety. By similar analysis it can be shown that a 55-gallon drum of 550 pounds gross weight and 68 inches in length will have a maximum stress of 1950 psi.

External Pressure — Packaging shall be adequate to assure that the containment vessel will suffer no loss of contents if subjected to an external pressure of 25 pounds per square inch gauge.

The containment vessel has a rated service pressure of at least 100 psi. This vessel would demonstrate equal or greater strength if the pressure differential were applied in the opposite direction with the greater pressure on the outside.

Tests for Normal Conditions of Transport

When subjected to the environment and test conditions given below, the package must function effectively and there must be no release of radioactive material.

Heat — Direct sunlight at an ambient temperature of 130 °F in still air.

Because of security requirements to protect packages of fissile material, the Model 2030-1 is never stored or transported in open vehicles; nevertheless, the following analysis is presented for information.

Container surface temperature (T_s) is computed following the method given in ORNL-TM-2410*, Section 5, assuming a solar heat load of 144 BTU/hr-ft², and an internal heat load of zero. Projected area of a 30-gallon drum (19-inch diameter and 29-inch height) is 4.6 ft².

Total heat input (Q_T) to the drum is solar heat load times projected area of drum or:

$$\begin{aligned} Q_T &= 144 \text{ BTU/hr-ft}^2 \times 4.6 \text{ ft}^2 \\ &= 662 \text{ BTU/hr} \end{aligned}$$

Assuming the drum is upright and supported on its lower end, heat is transferred from the top and side of the drum to the environment by radiation and natural convection. Total heat transfer from the drum is given by equation 5.2 of the Cask Design Guide:

$$Q_T = h_t A(T_s - T_a)$$

where:

A = Effective surface area of drum (side + one end), 14 ft²

h_t = Overall heat transfer coefficient, BTU/hr-ft² °F

T_a = Ambient air temperature, 130 °F

Since the overall coefficient of heat transfer is equal to the sum of the radiant heat transfer coefficient and the convective heat transfer coefficient we may write:

$$Q_T = (h_r + h_c) A (T_s - T_a)$$

Using 0.94 as the emissivity of a black painted drum and 0.19 as the "C" factor of a vertical cylinder, assume a drum surface temperature and enter the graph, Figure 4, to find h_r and h_c .

Equation 5.2 may now be solved for Q_T . If this value does not equal the previously determined

heat input of 662 BTU/hr, assume a new value of T_s and repeat the calculation. By successive substitution, it can be determined that the container surface temperature is 154 °F.

With a drum surface temperature of 154 °F and assuming an internal heat load of 20 watts, the temperature of the containment vessel (T_c) may be approximated as follows:

$$Q = UA (T_c - T_s)$$

where:

Q = Overall rate of heat transfer, 20 watts or 68.4 BTU/hr

T_s = Temperature of drum surface, 154 °F

UA = 0.88 (determined experimentally and reported in RFP-1696)

$$\begin{aligned} T_c &= \frac{Q}{UA} + T_s \\ &= \frac{68.4}{0.88} + 154 \\ &= 232 \text{ °F} \end{aligned}$$

All container components will function satisfactorily with the containment vessel at temperatures up to 285 °F. Work at Savannah River** shows that Celotex Industrial Board loses its compressive strength above 285 °F, although charring or 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 contents be limited so as not to exceed this value during normal shipment. Because of the many factors involved, shippers should determine their containment vessel temperature during a simulated transportation and storage cycle to ensure that 250 °F will not be exceeded.

Cold — An ambient temperature of -40 °F in still air

*L. B. Shappert, Irradiated Fuel Shipping Cask Design Guide, ORNL-TM-2410, Union Carbide Corporation, Oak Ridge National Laboratory, January, 1969.

**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.

Figure 4. Convective and Radiative Heat Transfer Coefficients as a Function of ΔT when $T_a = 130^\circ\text{F}$. Graph is taken from L. B. Shappert's "Irradiated Fuel Shipping Cask Design Guide," ORNL-TM-2410, Union Carbide Corporation, Oak Ridge National Laboratory, January 1969.

The only package materials affected by cold temperatures are the plastic vent plug in the drum lid, the Viton O-ring seal at the flange of the containment vessel, and the neoprene seal in the disconnect fitting. Manufacturer's data on neoprene and Viton O-rings indicate these materials will be satisfactory for static applications at -65°F . The vent plug will also function satisfactorily at -65°F . Thus, the Model 2030-1 will meet the cold exposure requirement with an ample reserve.

Reduced Pressure – Ambient atmospheric pressure of 0.5 atmosphere (absolute) (7.3 psia).

Each containment vessel is leak tested by placing the assembly in a bell jar and evacuating the jar to less than 0.0001 atmospheres. The drum heads may deform (oil can) a slight amount at a pressure of 0.5 atmospheres until the center of the head rests on the Celotex packing. This would in no way affect the functioning of the package.

Vibration — Vibration normally incident to transportation.

The Model 2030-1 Container has no component that could be damaged by any type of vibration encountered in the transportation cycle. Hundreds of shipments have been made since 1968 without any evidence of damage or leakage.

Water Spray — A water spray sufficiently heavy to keep the entire exposed surface of the package except the bottom continuously wet during a period of 30 minutes.

The steel drum outer jacket of the Model 2030-1 and the plastic vent plug are not susceptible to damage from this test.

Free Drop — . . . a free drop through a distance of 4 feet onto a flat essentially unyielding horizontal surface, striking the surface in a position for which maximum damage is expected.

Many packages of 18-inch diameter with lengths up to 60 inches and weights up to 250 pounds (including the Model 2030-1) have been subjected to the 4-foot drop test at Rocky Flats. Maximum damage resulted in a portion of the lower chime being compressed into the body of the container. (This section of the drum is never considered as part of the effective package length for criticality calculations.)

Corner Drop — A free drop. . . onto each quarter of each rim, from a height of 1 foot onto a flat essentially unyielding horizontal surface.

This test has also been imposed on the various lengths and weights of 18-inch diameter packages subjected to the preceding free drop test.

Results of the corner drops consisted only of minor deformations (flattened spots) on the chime extension at the bottom rims and no visible change to the locking rings. These drops inflicted no apparent internal damage to any of the packages.

Penetration — Impact of the hemispherical end of a vertical steel cylinder 1.25-inches diameter and weighing 13 pounds, dropped from a height of 40 inches onto the exposed surface of the package which is expected to be most vulnerable to puncture.

The nose of the drop bar leaves a small impression about 0.25-inch deep in the 18 gauge steel side and/or covers of the 18-inch diameter drums which have been given this test. There has been no sign of metal rupture.

Compression — A compressive load equal to either 5 times the weight of the package or 2 pounds per square inch multiplied by the maximum horizontal cross section of the packages, whichever is greater. The load shall be applied during a period of 24 hours, uniformly against the top and bottom of the package in the position in which the package would normally be transported.

An empty 60-inch-high drum of 18-inch diameter was loaded with 1500 pounds of steel weights on the upper rim. No measurable change from original height was noted, either with load applied or after the completion of test. On the basis of the load being five times package weight, the test qualifies the package for a gross weight of 300 pounds. A 30-inch-high drum would exhibit equal or better strength for compression loading.

Tests for Hypothetical Accident Conditions

In addition to the preceding tests for normal conditions of transport, Type B packaging must be capable of withstanding the cumulative effect of four hypothetical accident tests without release of radioactive material. The required tests are (1) Free Drop, (2) Puncture, (3) Thermal, and (4) Water Immersion, applied in the sequence numbered.

Test Packages — A package in Configuration "B" (that is, with one 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

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Figure 5. Typical Results of 30-Foot Corner Drop on DOT-17C Drums. These packages, weighing up to 535 pounds, remained intact.

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 AL-R8, Size 2040 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.

Free Drop — A free drop through a distance of 30 feet onto a flat essentially unyielding horizontal surface, striking the surface in a position for which maximum damage is expected.

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

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Figure 6. Celotex Flow Pattern After 30-Foot Drop. Shock of impact is absorbed by compression and flow of Celotex with little tendency to shatter or disintegrate.

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 5 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 6. This same phenomena has also been noted on heavily loaded 10-gallon packages and could be expected to apply equally to 30-gallon drums.

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 nuclear safety evaluation. The resulting permanent reduction (out-of-roundness) in diameter measured less than 0.25 inch for the portion of drum

*Frank E. Adcock, RFD Container Model 55/30 Report 2012-68PE, Rocky Flats Division, Dow Chemical U.S.A., September 1968.

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. Denting at the cover end of drum is shown in Figure 7.

Puncture — A free drop through a distance of 40 inches striking, in a position maximum damage is expected, the top end of a vertical (6-inch diameter) steel bar. . .

The test package was inverted to have the cover end of the drum impact onto the flat end of a 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 7. 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 the free drop and puncture tests, inspection of the package interior showed 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 the package. Checking with helium detector equipment showed the leak-tightness of the containment vessel had not been reduced by the drops.

Thermal — Exposure. . . of the whole package to a radiation environment of 1475 °F for 30 minutes. . . The package shall not be cooled artificially until 3 hours after the test period. . .

Thermal tests were conducted in a 275-kilowatt induction furnace that 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 starting the test run, and represents a temperature rise of about 135 °F above that of the package components at the start of the test.

Figure 8 shows the temperatures recorded during the above test on Model 2030-1, at the containment vessel flange, in the Celotex packing rings adjacent to the flange, and 2 and 3 inches inward from the outside edge of the insulating material. The graph also shows temperatures recorded at the drum surface and at 1 inch in from the surface of the Celotex when the AL-R8 Container was tested under the same conditions.

For the Configuration "A" package, heat-sensitive monitor tabs with increments of 10 or 25 °F were

Figure 7. Drum Opened After Thermal Test. The square pad of Cerafelt prevents ignition of Celotex at the vent location. At left, the flat places on rims of the cover, drum curl, and rolling hoop are the results of the 30-foot drop test; the impression from the puncture test appears below the vent hole in the cover. At right, thermocouple leads are covered with protective wrapping.

15927-4

used to determine the highest temperatures reached at various locations within the package. These peak temperatures occurred within the following ranges.

- Within both upper and lower containment vessels, small steel plates nested in aluminum foil: 150 to 175 °F.
- On exterior surface of upper containment vessel, the rim of the cover (over O-ring) and also the body sidewall: 190 to 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 to 210 °F; and adjacent to the lower vessel: 190 to 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 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 did not exceed 170 °F during two comparable thermal-test runs using AL-R8 packages.

Water Immersion – Immersion in water to the extent that all portions of the package. . . are under at least 3 feet of water for a period of not less than 8 hours.

The purpose of the water immersion test is to check the primary containment vessel for such things as cracks and damaged seals. The overpack of Celotex and the outer drum may be removed from the containment vessel for this part of the test.

Figure 8. Time-Temperature Data Recorded from Thermocouple Stations During Thermal Test Runs.

Figure 9. Time-Pressure Curve for Drum with Vented Lid During Thermal 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 that showed the leak-tightness had remained well above the qualifying (after drop) rating of 1×10^{-4} cm³/sec for 12 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 an AL-R8 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 gauge located outside the furnace.

16001-7

Figure 10. 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.

Figure 9 shows the time-pressure curve. The plastic plug sealing the vent hole melted out in less than one minute. Soon afterwards, the pressure began to rise, probably as the result of gasses emitted by the drum gasket that was burning at the 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 burn-out. The intensity of a hissing noise, which was audible throughout the test, varied with the pressure-gauge 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.

The thermal test on the Model 2030-1 in configuration "A" used a sound drum that 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

14770-5
Figure 11. Model 2030-1 Package Opened at End of a Typical Heat Build-Up Test. The three recorders each monitor two thermocouple channels.

the AL-R8 Container. It was noted 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 10).

The tests demonstrated 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 Celotex must be porous to allow venting, or 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 Build-up — We have investigated the temperature rise caused by 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.

Ten test runs have been conducted on Model 2030-1 packages (Figure 11). These runs used

*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.

14512-9
Figure 12. 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.

heat loads in 5-watt steps up to 20-watts total. This is approximately twice the heat energy produced by decay of 5 kilograms of plutonium-239, the criticality limit for this package.

Heat sources for test runs were electrical resistance elements or plutonium metal, generally fitted in number 3 food cans which were supported in crumpled metal foil within the containment vessels (Figure 12). In all runs, heat sources were placed in a single 7-inch-high containment vessel for minimal surface area to dissipate the heat. In most cases, the single vessel was positioned at about mid-height in the drum.

From the studies on Configuration "B" packages, temperature readings taken at outer surfaces of successive metal enclosures (food can, containment vessel, and drum) are charted in Figure 13. The curves represent average values as adjusted for 70 °F ambient temperature at the test area.

Temperature build-up at the flange area and the adjacent sidewall of containment vessel(s) denotes the service condition for Viton O-ring seal(s), and also for the contacting inside diameters of the Celotex packing rings. Test results show 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 235 °F if a package with the same

Figure 13. Temperature Distribution Throughout Package for Various Internal Energies.

heating load were subjected to the 130 °F ambient heat test, which is listed for "Normal Conditions of Transport."

The test work on heat build-up 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.

Drop and Pressure Test of Containment Vessel –
To simulate the maximum probable damage caused by an accidental drop from the height of a loading table or transfer cart, an assembled containment vessel was subjected to a 40-inch free drop with the gauge impacting onto a concrete floor.

The only part of the assembly affected by the drop was the gauge. It suffered broken glass, a dented

case, and bent stem. Prior to the drop, the vessel showed a helium leak rate of 5.6×10^{-6} cm³/sec at 12 psi pressure differential. After the drop the value was 1.0×10^{-5} for the same helium differential, with weepage occurring at the threaded connection of the gauge stem in the 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 pressure forced the flange to spread apart and deform between bolting points.

PACKAGE CRITICALITY EVALUATION

Method

A modified density analogue method was used to evaluate arrays of these containers as necessary to be in compliance with Fissile 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 with no spacing between containers

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 Part II, Paragraph I, of the Appendix to AEC Chapter 0529.

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 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).

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. Each container must be assumed to be damaged to the same extent as the test package.

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 .

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

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

Material†*	Maximum Material per Containment Vessel (kg)		Maximum Packages per shipment	
	Configuration A††	B	Fissile Class II	Fissile 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 metal is permitted in each containment vessel; however, 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 is permitted. For other combinations of mass and number of pieces, the user must impose the necessary controls to ensure a subcritical condition when water-flooded, per Chapter 0529 Part II, Paragraph C.1.

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

* The material is to be unreflected and unmoderated. This does not preclude the use of aluminum foil, steel wool, etc. as packaging materials.

** Minimum plutonium-240 content is 5 weight percent.

*** Maximum uranium-235 enrichment is 93 weight percent.

Class III Evaluation

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

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

Requirements for accident conditions are that shipments would be subcritical with the containers in any arrangement if fully reflected with moderation considered credible in view of the controls put on the shipments. Each container must be assumed to be damaged to the same extent as the test package.

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

The restrictions of metal only and on the number of pieces of fissile metal, were imposed on the contents to meet the requirements for a single package as specified in Part II, Paragraph C.1 of the Appendix to AEC Manual Chapter 0529.

QUALITY ASSURANCE

Background

AEC Manual Chapter 0529 requires that each AEC contractor establish a quality assurance program for the fabrication, assembly, and testing of offsite shipping containers. The intent of this program is to assure high quality standards are met during the fabrication, assembly, and inspection of each package and that packages in use continue to meet these same standards.

Rocky Flats drawing P12192, originally issued in March 1968, gives general requirements for the design, procurement, and use of shipping containers, and for related inspection and quality control provisions. P12192 has been revised to include the latest AEC quality assurance requirements.

Requirements

Listed below are the AEC's requirements for a packaging quality assurance program, followed by the method used at Rocky Flats to comply with those requirements.

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

At Rocky Flats, responsibilities for assuring container quality are assigned by document Q2000, a quality

control procedure entitled, "Radioactive Packaging Quality Assurance." Primary responsibility is assigned to individuals in Quality Control Engineering who supervise the preliminary determination (receiving inspection) and to Production Control personnel who store, assemble, and pack the containers. All container components are purchased from commercial suppliers or fabricators and assembled at Rocky Flats. Certain key fabricators such as drum manufacturers are subject to a vendor audit conducted by a team consisting of Purchasing, Quality Control, and Product Engineering personnel. This team ensures that the fabricators maintain good manufacturing and quality control methods.

Primary reliance for quality assurance is placed in the receiving inspection conducted at Rocky Flats. All features of package components are readily accessible for inspection and/or testing at this stage. Defective material is returned to the vendor for rework or replacement. Acceptable parts are stocked in the Production Control warehouse. From its supply of components, Production Control assembles new containers as needed and makes routine determinations prior to use.

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

Drawings listed in the section on Package Definition give all necessary dimensions, standards and material specifications to produce an acceptable container. Any special fabrication methods or nondestructive tests required are given on the applicable engineering drawings. A formal system of drawing preparation, control, and distribution is defined by the Rocky Flats Product Engineering Manual. Drawings for the Model 2030-1 Container are prepared, issued, and maintained in accordance with this manual.

Acceptance Requirements — Establish acceptance criteria in terms of measurable characteristics and tests to assure that all package design requirements, including performance tests (such as drop, fire, and immersion), would be met by the assembled container.

Inspection and test requirements for the "preliminary determination before use" are itemized on Product Engineering-controlled forms. These requirements are shown in Figure 14, panels A, B, and C.

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 & 1/8-inch bolt and nut.	
7	Lug weld satisfactory.	
8	.375 minimum convexity, both ends.	
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: SST 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, O-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 1/8 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 14. Inspection Requirements for Preliminary and Routine Determinations of Package Integrity.

Routine Maintenance Inspection – 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 14, 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. These operations are performed in accordance with Production Control Manual PC777-02.

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

Required inspection forms are maintained for the life of the container (or container component) by Production Control, which is the organization that stores, maintains, and controls all containers for radioactive materials. Records applicable to each shipment are retained by the Traffic Department for at least two years.

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 at least semiannually by Dow's Quality Control Department.

Special Processes – Provide for training, testing, and certification of manufacturing and inspection personnel involved in special processes, such as welding and nondestructive testing, and for the certification of equipment and procedures used in the performance of special processes.

Welding and radiographic inspection of the containment vessel are considered “special processes.”

The Model 2030-1 containment vessel is welded in accordance with the ASME Boiler and Pressure Vessel Code that requires the welders and the welding processes be qualified. The radiographic examination at Rocky Flats is performed using certified personnel. These requirements for welding and radiography are specified on drawing P12081-1, beginning with issue H, and the related inspection form P12150-2, beginning with issue C. Vessels made to earlier drawing issues were welded and inspected using high quality commercial practices; however, the qualification requirements of the ASME Code were not applied. The certification of personnel and equipment used in the performance of special processes at Rocky Flats (as applicable to shipping containers) is detailed in Q2000.

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 and 5201 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, and the AEC Certificate of Compliance (Appendix A).

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. Minor dents are repaired periodically, however, 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:

<u>Component</u>	<u>Cost</u>
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 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 attempting 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. BPF-1) —

Protective Closures Company, Inc.
Buffalo, New York

Refractory Insulation (Cerafelt) —

Johns-Manville
Denver, Colorado

APPENDIX A

APPENDIX A - AEC Certificate of Compliance

RFP-1867 Rev. 1

Form AEC-618
(9-72)
AECM 5201U.S. ATOMIC ENERGY COMMISSION
CERTIFICATE OF COMPLIANCE
For Radioactive Materials Packages

1a. Number AEC - AL USA/5332/BLF	1b. Revision No. Original Issue	1c. Page No. 1	1d. Total No. Pages 3

2. Authority

This certificate is issued pursuant to Sections 173.394, 173.395, and 173.396 of the Department of Transportation Hazardous Materials Regulations as amended (49 CFR 170-189 and 14 CFR 103), and AEC Manual Chapters 5201 and 0529.

3. CONDITIONS

3a. This certificate is issued on the basis of SAFETY ANALYSIS REPORT FOR PACKAGING (SARP)

(1) Prepared by

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

(2) Number

RFP-1867, Revision 1

(3) Date Published

February 27, 1974

3b. The packaging described in the SARP and further described in item 4 below, when constructed and assembled as prescribed in the SARP, with the contents as authorized herein, meets the standards prescribed in DOT regulations.

3c. The outside of each package must be plainly and durably marked with the letters and number shown in item 1a. on this form in accordance with the standards for markings in paragraph 173.24(b) of 49 CFR 173.

3d. This certificate does not relieve the consignor from compliance with any requirements of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies.

3e. Each user of packages approved under this certificate shall register his name and address with the issuing office.

4. Description of Packaging and Authorized Contents, Restrictions, and References:

4a. ALO Contractor
Dow Chemical USA
Rocky Flats Division
Box 888
Golden, Colorado 80401

4b. Identification of Shipping Container
RFD Container - Model 2030-1
Metal nameplate spot welded to drum.
Dow drawing Number: P12082-1

TO BE COMPLETED BY AEC

5a. Address (of AEC Approving Official) Albuquerque Operations Office P. O. Box 5400 Albuquerque, New Mexico 87115	5b. Signature (of AEC Approving Official) <i>Jack R. Roeder</i>
	5c. Name and Title (of AEC Approving Official) Jack R. Roeder, Director Operational Safety Division
	6. Expiration Date (if appropriate) -
	7. Date January 9, 1974

U.S. ATOMIC ENERGY COMMISSION
CERTIFICATE OF COMPLIANCE
 For Radioactive Materials Packages

1a. Number AEC - AL	USA/5332/BLF	1b. Revision No. Original Issue	1c. Page No. 2	1d. Total No. Pages 3

4c. General Information Concerning Containers.

1. Outside container is an DOT-17H, or equivalent, 30-gallon metal drum with bolt-type locking ring. Insulation and shock protection is provided by Celotex Industrial Board.
2. 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. Maximum service temperature is 400°F.
3. Criticality Limits:

Material ① ③	Maximum Material per Containment Vessel (Kg)		Maximum Packages per Shipment	
	Conf. A ②	Conf. B	Fissile Class II	Fissile Class III
Pu-239 ⑤ 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 ④ Metal	5.5	11.0	38	96
	3.5	7.0	88	222
	1.7	3.5	316	790

- ① A maximum of two pieces of fissile metal permitted in each containment vessel; except, if the total mass per vessel is less than 450 grams of ²³⁹Pu or ²³³U or less than 725 grams of ²³⁵U, 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 11.C.1.
- ② 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.
- ③ The material is to be unreflected and unmoderated. This does not preclude the use of aluminum foil, steel wool, etc. as packaging materials.
- ④ Maximum uranium-235 enrichment is 93 weight percent.
- ⑤ Minimum plutonium-240 content is 5 weight percent.

4d. Specific Limitations and Restrictions.

1. Authorized for metal shapes only.
2. Containment vessel pressure must not exceed 10 psig of dry air or inert gas when packaged.
3. Vented drum lid required.
4. Maximum gross weight is 300 pounds (See SARP for exception).

U.S. ATOMIC ENERGY COMMISSION
CERTIFICATE OF COMPLIANCE
For Radioactive Materials Packages

1a. Number AEC -AL	USA /5332/BLF	1b. Revision No. Original Issue	1c. Page No. 3	1d. Total No. Pages 3

ROCKY FLATS MODEL 2030-1