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ORNL/TM-8340

**OAK
RIDGE
NATIONAL
LABORATORY**

**Safety Analysis Report for
Packaging: The ORNL DOT
Specification 6M—Special
Form Package**

R. W. Schaich

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OPERATIONS DIVISION

SAFETY ANALYSIS REPORT FOR PACKAGING: THE ORNL
DOT SPECIFICATION 6M - SPECIAL FORM PACKAGE

R. W. Schaich

Date Published - July 1982

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SAFETY ANALYSIS REPORT FOR PACKAGING:
THE ORNL DOT SPECIFICATION 6M - SPECIAL
FORM PACKAGE

R. W. Schaich

Operations Division
Oak Ridge National Laboratory

ABSTRACT

The ORNL DOT Specification 6M - Special Form Package was fabricated at the Oak Ridge National Laboratory (ORNL) for the transport of Type B solid non-fissile radioactive materials and exempt quantities of solid fissile materials in special form. The package was evaluated on the basis of tests performed by the Dow Chemical Company, Rocky Flats Division, on the DOT-6M container and special form tests performed on a variety of stainless steel capsules at ORNL by Operations Division personnel. The results of these evaluations demonstrate that the package is in compliance with the applicable regulations for the special form transport of Type B quantities of solid non-fissile radioactive materials and of exempt quantities of fissile material.

1.0 INTRODUCTION

The ORNL DOT Specification 6M - Special Form Package (Figure 1.0) was fabricated at the Oak Ridge National Laboratory (ORNL) to meet the transport requirements of the Safety Series No. 6, "Regulations for Safe Transport of Radioactive Materials." 1973 Revised Edition, International Atomic Energy Agency (IAEA). The package is designed to ship Type B quantities of solid non-fissile radioactive materials in special form, as well as exempt quantities of solid fissile materials in special form containers. The package was analyzed on the following basis: 1) Special form tests performed by ORNL on a variety of stainless steel capsules which have been

Figure 1. ORNL DOT Specification 6M - Special Form Package
(Typical Assembly Detail)

issued IAEA Certificates of Competent Authority, and 2) Tests performed by the Dow Chemical Company, Rocky Flats Division, on the DOT-6M container.

The primary use of the package is to provide impact and thermal resistance for its contents during transport for both normal and hypothetical accident conditions. The package is amenable to rail, highway, air, and water transport of quantities of Type B radioactive material in special form. It complies with the regulations contained in Title 10, Code of Federal Regulations, Part 71;¹ DOE Manual Chapter 5480.1;² and all Immediate Action Directives (IAD) in effect as of this report date. The package also complies with U.S. Department of Transportation (DOT) regulations published in Title 49, Code of Federal Regulations, Part 173;³ and the IAEA regulations found in Safety Series No. 6, "Regulations for the Safe Transport of Radioactive Materials," 1973 Revised Edition.⁴

Calculations, engineering logic, and all related documents which demonstrate compliance with specifications are presented in Appendices A and B of this report. Copies of the approval documents are reproduced in Appendix C.

2.0 PACKAGE DESCRIPTION

2.1 Container Description

The outer packaging consists of a 10 gallon DOT Specification 6M metal package (49 CFR 178.104) which is approved by the DOT for the shipment of Type B quantities of radioactive material in special form. This packaging concept was tested and approved by the DOW Chemical Company, Report RFP-1042, RFD Container Model 1518 (Appendix A). The maximum quantity of radioactive material is limited to a radioactive thermal decay energy of 10 watts. Fissile material is further limited to a maximum of 15 grams. Special form capsules containing cobalt-60, iridium-192, cesium-137, and

strontium-90 cannot be shipped in this package due to shielding limitations. Appendix D contains the ORNL procedures for the inspection and packaging of Type B packages prior to shipment.

2.2 Special Form Capsule

The encapsulation consists of two concentric cans, both constructed of Type 304L stainless steel, which has a melting point of approximately 1375°C (2000°F) and meets all requirements listed in References 1-4. The IAEA Certificates of Competent Authority (USA/0156/S, USA/0198/S, USA/0202/S, and USA/0206/S) (Appendix B) give the detailed dimensions of the parts before assembly. For shipment of fissile and non-fissile radioactive materials, a weighed quantity of the dry radioactive material is introduced into the liner, then the interference-fit plug is pressed into the liner until the upper surface of the plug is flush with the lip of the liner. The plugged liner is then wiped to remove gross contamination. The liner is inserted into the containment capsule and the capsule plug is pressed in until the upper surface of the plug is flush with the lip of the capsule. The capsule is then seal-welded by gas tungsten-arc (GTA) method. The procedures used for welding the capsule were developed by welding and destructively examining units of identical design and material. The completed capsule is leak-tested by the ethylene glycol-vacuum technique (American National Standard N542, A2.2.1) then cleaned to a contamination level of less than 0.005 microcuries per 100 cm² before insertion into the DOT Specification 6M container. Appendix D contains the ORNL procedures for leak testing special form capsules prior to shipment.

3.0 RADIOACTIVE MATERIALS

The maximum quantities of solid non-fissile radioactive materials to be shipped are listed in the attached IAEA Certificates of Competent Authority (Appendix B). The maximum quantity of solid fissile radioactive materials is limited to 15 grams. Only one of the listed materials will be shipped in a given capsule. In each case the radionuclide is in a relatively inert chemical form which will not melt, sublime, oxidize, or decompose at the temperatures and conditions normally encountered during shipment. The materials will be in either powder or pelletized form. The radiochemical purity of the radionuclides will be such that contributions from other radionuclides, except daughter products, will be insignificant.

4.0 SPECIAL FORM CAPSULE TESTING

Prototype capsules, identical to those described in Section 2.2, except for the radioactive material content, were fabricated and subjected to the tests prescribed in References 1-4. The same capsule was used for each series of tests. Before and after each test the capsule was examined by microscope and leak-tested by both the ethylene glycol-vacuum and a helium leak test sensitive to leak rate $<1.0 \times 10^{-7}$ STD cm³/sec. No leakage or other evidence of release of contents was detected after any of the tests. Test records are on file at Oak Ridge National Laboratory.

5.0 SHIELDING

This section is not applicable, since the container will be used to transport fissile and non-fissile radioactive materials emitting weak alpha and beta particles.

6.0 CRITICALITY

Since no fissile materials are to be transported, a criticality evaluation is not necessary for this package.

7.0 QUALITY ASSURANCE

The regulations¹⁻⁴ require packaging to be designed, fabricated, and operated in conformance with an established formal quality assurance program. Compliance with this requirement is discussed in the following subsections.

7.1 Fabrication, Inspection, and Acceptance Tests

The fabrication, inspection, and acceptance tests for a typical special form capsule are specified on the drawing, C-SK 1719. The welds will be made and inspected according to the drawing. The ferrous materials to be used in the container are specified on the data sheets to ASTM standards. Dimensional inspection and inspection of finishes shall be performed to ensure that they are within the specified tolerances. A certificate of compliance with the drawings will be issued to the owner. DOT-6M drums are purchased through commercial fabricators and are certified to meet the requirements of 49 CFR 178.104.³

7.2 Routine Operating and Inspection Procedures

The ORNL Operations Division has established routine operating and inspection procedures and standard check lists to ensure that all shipments are safe, comply with the regulations,¹⁻⁴ and comply with all ORNL procedures

and regulations. Copies of the procedures and the checklists are presented in Appendix D.

7.3 Periodic Maintenance and Inspections

Prior to each shipment, routine inspections are performed with the owners' procedures and checklists. The ORNL procedures are presented in Appendix D as an example. Maintenance is required only when routine inspections indicate damage. There are no time-degradable materials used in the construction of the package except for celotex rings, and DOT-6C drums used in the construction of containers. Any damage or degradation to these would be detected during routine inspection and replacement effected.

7.4 Records

It is the responsibility of the owner to assure that the containers are fabricated to the specifications on the drawings and data sheets. In addition, the owner shall maintain fabrication and inspection records in an auditable form for the life of the container.

8.0 CONCLUSIONS

Based on the Dow Chemical Company report (Appendix A) on the testing of the DOT-6M drums and the IAEA Special Form Certificates of Competent Authority (Appendix B), it is concluded that the ORNL Specification 6M - Special Form Package meets all pertinent regulations concerning the shipment of Type B quantities of solid non-fissile radioactive material in special form and the shipment of limited quantities of solid fissile material in special form.

REFERENCES

1. Title 10, *Code of Federal Regulations*, Part 71, "Packaging of Radioactive Material for Transport and Transportation of Radioactive Materials Under Certain Conditions".
2. U. S. Department of Energy, Environmental Protection, Safety and Health Protection Program for DOE Operations, DOE 5480.1.
3. Title 49, *Code of Federal Regulations*, Part 173, "Transportation".
4. International Atomic Energy Agency, Safety Series No. 6, "Regulations for the Safe Transport of Radioactive Materials", 1973 Revised Edition.

APPENDIX A

THE DOW CHEMICAL COMPANY

ROCKY FLATS DIVISION

RFP-1042

RFD CONTAINER - MODEL 1518

FOR FISSILE CLASS II AND CLASS III SHIPMENTS

RFD CONTAINER - MODEL 1518
FOR FISSILE CLASS II AND CLASS III SHIPMENTS

THE DOW CHEMICAL COMPANY
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CONTRACT AT(29-1)-1106

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RFD Container -- Model 1518 for Fissile Class II and Class III Shipments

F. E. Adcock and W. F. Wackler

ABSTRACT

The Model 1518 container has been developed for shipping radioactive and fissile materials in either solid or powder form. Radioactive materials with up to eight-watts thermal energy may be shipped in each package. Plutonium is limited to 4.5 kg; fully enriched uranium to 11.0 kg.

Basic components are a ten-gallon steel drum, Celotex fiberboard insulation, and a steel inner-container with a four-inch pipe plug closure. Total cost is about \$26.

The container easily passed all of the tests required by the AEC, including a 30-foot free drop and a half-hour fire at 1475°F. Package contents remained under 200°F during the thermal test.

Numerous AEC contractors and licensees have expressed an interest in the Model 1518. Because of the potential of this container, the Department of Transportation (DOT) Specification 6M, based on the Model 1518 design, will be published in the near future.

INTRODUCTION

In January 1967, the Rocky Flats Division of The Dow Chemical Company, began a program to design and test product-containers for shipping fissile materials under existing AEC¹ and DOT² regulations. The general design concept called for a family of similar containers to ship a variety of products ranging from a few grams of chip samples to large fabricated shapes.

The smallest container that would provide sufficient thermal insulation was a 5-gallon drum; however, its useful load was rather limited. To minimize the number of different drums in the family, the 5-gallon drum was not considered, and the 10-gallon drum was chosen as the smallest basic size.

¹U. S. Atomic Energy Commission, AEC Manual Chapter 0529, "Safety Standards for the Packaging of Radioactive and Fissile Material," August 22, 1966.

²Department of Transportation Regulations, Agent T. C. George's Tariff No. 19, August 5, 1966.

Development and testing of this 10-gallon package and the details of two optional inner containers are included in this report.

PACKAGE DESCRIPTION

General: The prototype Model 1518 container used for the tests described in this report is shown in Figure 1. Each part is available commercially or can be fabricated by a machine shop.

Figure 1. Prototype Model 1518 Container Showing All Components and Dummy Load.

Engineering drawings of the RFD Container, Model 1518 (Dow drawing P11993), are available from the United States Atomic Energy Commission, Division of Technical Information Extension, Post Office Box 62, Oak Ridge, Tennessee. The drawing set is listed in the AEC's Engineering Materials List, TID-4100, and has been assigned an identification number CAPE-1546.

Metal Drum: The outer container is a standard DOT Specification ICC-6C openhead steel drum with a 16-gauge bolt-type locking ring and $\frac{3}{8}$ -inch diameter bolt and nut. No modifications are required; however, a metal identification plate must be welded to the outside of the drum.

Since Specification 6C lists only drum volume, the limits of diameter and inside height, as given on the engineering drawing, must be specified when ordering drums to ensure a proper fit with the

insulation, and to provide the spacing required for nuclear safety.

Insulation: Two-inch-thick disks of Celotex industrial fiberboard provide thermal insulation, shock protection, and a means for centering the inner container. The British had reported earlier³ that Celotex was an ideal packaging material, and that 2 inches of insulation at the ends and 3 inches on the sides would limit the temperature rise of the inner container to 120°C (248°F) during the fire test. Our choice of material was based primarily on this report.

The cushioning properties exhibited by fiberboard disks were surprising. Fiberboard appears to be a hard, rigid material; yet, it tends to flow or extrude under load rather than to split or shatter. Figure 2 shows the top disk rolling to match the deformed drum contour after a 30-foot free drop.

³F. E. Dixon and A. E. Partridge, Experimental Work at AERE on the Development of Packaging for Radioactive Materials which will meet the IAEA Regulations, as published in the "Proceedings - International Symposium for Packaging and Transportation of Radioactive Materials," Sandia Corporation report SC-RR-65-98, June 1965.

Figure 2. Celotex Insulation and Drum After 30-Foot Drop Test.

The fabricated metal spacers and loose vermiculite, formerly used for most Fissile Class II designs (Figure 3), are no longer necessary. This results in a simpler, easier-to-use container, and eliminates the "messy" handling problem associated with vermiculite.

Figure 3. Early Class II Container Showing Tubular Metal Spacers and Loose Vermiculite Insulation.

Fiberboard has better insulating properties than most types of wood and is far cheaper to fabricate than laminated wood shapes. Density is approximately 15 pounds per cubic foot, compared with 48 pounds for white oak and 27 pounds for white pine. Some of the more important properties of Celotex industrial fiberboard are tabulated below:⁴

Thermal Conductivity — 0.33-0.37 Btu/hr/ft²/
("K" factor) °F/inch at 75°F

Density — 13-17 lb/ft³

Compressive Strength — 91 psi
(perpendicular to
surface)

Linear Expansion — 0.4% maximum at 0%-
93% relative humidity

⁴As given by Technical Bulletin No. 6003, The Celotex Corp., August 26, 1963.

Resilience

Pressure (psi)	Reduction in Thickness (%)	
	Under Load	After Removing Load
5	1.14	0.62
10	2.44	1.09
20	4.30	1.76
40	8.86	3.16
100	19.22	7.82

Inner Container: The Model 1518 Inner Container was designed to hold two No. 2½ cans (4⅜-dia. by 4⅜-inches high). When properly marked, this container will meet the requirements of DOT Specification 2R.

Overall dimensions and other useful data are summarized below:

Overall height	— 11.750 inches (maximum)
Outside diameter	— 4.770 inches (maximum)
Usable inside height w/lid on	— 10.000 inches (minimum)
Inside diameter	— 4.180 inches (minimum)
Weight (empty)	— 17 pounds
Cost	— \$15.45

The inner container has a straight outside diameter without any projections that would complicate the insulation or centering device. Since the empty weight is only 17 pounds, no handle was provided. The best combination of standard materials that would meet our size limitations was a 4-inch pipe plug and a section of 4⅜-inch OD by ¼-inch wall steel tubing.

Tape of Teflon, which has a temperature rating of 500°F, is applied to the threads of the pipe plug to ensure a tight seal. No in-leakage of water was noted during the 24-hour immersion test.

A cloth adhesive-backed radioactive material caution label was neither scorched nor loosened during the tests, and will provide adequate warning and identification under all anticipated conditions.

The 2-inch-square key, or wrench, required to remove the pipe plug is not readily available. A sketch of a suitable wrench (Appendix IV) is provided for those users who wish to fabricate their own. A strap wrench is the only other tool necessary for use with the Model 1518 Inner Container.

Cost: Based on one lot of 200 containers purchased in May 1967, the cost of individual components is as follows:

Drum	— \$ 2.64
Celotex (2 disks + 6 rings)	— 7.52
Inner Container	— 15.45
Nameplate (3-inch x 7-inch etched stainless steel)	— .49
Radioactive Material Caution Label	— .25
TOTAL	— \$26.35

All components are reusable and no spare parts should be necessary.

The buyer's before-use inspection of components, and the cost of welding the nameplates, must be included as an additional expense.

TESTING

Objective: The Model 1518 Container was tested to ensure that there would be no release of radioactive materials or any other danger to life, or property, due to transportation mishaps. This portion of the test was in compliance with AEC Manual, Chapter 0529.⁵ Secondary objectives were to determine if the package contents would be damaged in any manner, and to determine the extent of internal heating that could be expected when shipping materials that exhibit a heat build-up due to radioactive decay such as plutonium or polonium.

Test Package: Full-scale containers meeting the requirements of Dow drawing P11993 were used for all tests. A dummy load of about 4 pounds was placed in the inner container. This load consisted of two food cans 3.75-inches in diameter and 4.50 inches high, each containing a plastic bag of dry sand. Steel wool was used to separate the cans and to cushion each end.

Measured weights of the packages tested were as follows:

Total package weight	— 54 pounds
Inner container	— 16 pounds, empty 20 pounds, loaded

⁵ Reference cited elsewhere.

A typical test set-up (Figure 4) shows the major items of equipment used for the drop and puncture tests. These items are:

1. Steel plate 5 feet x 4 feet x 4 inches thick.
2. Steel bar 1 1/4-inches in diameter x 13 pounds weight.
3. Steel cylinder 6-inches in diameter x 12 inches high.
4. Quick-release hook.

Figure 4. Typical Drop and Puncture Test Setup.

TESTS SIMULATING NORMAL HANDLING CONDITIONS

Free Drop:

REQUIREMENT — 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.

RESULT — The crimped chime which extends beyond the bottom head was distorted for an arc length of 6 inches (Figure 5). There was no damage to the usable portion of the drum.

Figure 5. Results of Eight 1-Foot and One 4-Foot Drop.

Corner Drop:

REQUIREMENT — Free drop onto each quarter of each rim, from a height of one foot.

RESULT — Three of the drops on the bottom end caused flats about 4 inches long with no visible distortion on the interior of the drum. The fourth drop was coincident with the flat caused by the 4-foot drop, and resulted in no measurable increase in deformation (Figure 5). The drops on the top caused slight dents in the locking ring and the cover curl. The flatted spots were so shallow that the lid gasket adjusted to the variance.

Penetration:

REQUIREMENT — Impact of the flat circular end of a vertical steel cylinder 1½-inches in diameter and weighing 13 pounds, dropped from a height of 4 feet normally onto the exposed surface of the package which is expected to be most vulnerable to puncture.

RESULT — Two drops were made striking the lid (Figure 6) and side (Figure 7). Each impact resulted in a depression about 3/16-inch deep with no penetration or rupture of the drum skin.

Compression:

REQUIREMENT — A compressive load equal to either five times the package weight (270 pounds) or a 2 psi load on the maximum horizontal cross section (354 pounds), 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.

Figure 6. Package Exterior after 30-Foot Corner Drop.

Figure 7. Interior of Package after Two 30-Foot Drops.

RESULT — A 390-pound load was applied to an assembled, but empty, upright drum with no measurable effect.

TESTS SIMULATING HYPOTHETICAL ACCIDENT CONDITIONS

Free Drop:

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

RESULTS — The package was dropped, striking the area of the bolt and locking ring. A corner of the package was deformed about 3½-inches by 2½-inches (Figure 6). However, the locking ring continued to clamp the lid securely and no insulation was exposed. There was no loss in effective package-to-package spacing.

When the locking ring was opened, it was found that the drum and lid had interlocked so the cover could not be removed until the deformed area had

been straightened. The top Celotex disk had also been moulded into the deformed drum, thereby holding all of the insulation and the inner container in place. These results all testify to the reliability of this type of drum and closure.

A second 30-foot drop was made striking along one element of the container in an attempt to cause the maximum deformation. The resulting flat caused a 0.20-inch decrease in effective radius (Figure 7). This value was used in the nuclear safety evaluation.

Puncture:

REQUIREMENT — A free drop through a distance of 40 inches striking, in a position where maximum damage is expected, the top end of a steel bar mounted on an essentially unyielding horizontal surface. The bar shall be 6 inches in diameter, with the top horizontal and its edge rounded to a radius of not more than $\frac{1}{4}$ -inches, and of such a length as to cause maximum damage to the package, but not less than 8 inches long. The long axis of the bar shall be normal to the package surface.

RESULTS — An irregular depression less than $\frac{1}{2}$ -inch deep was formed in the bottom of the drum with no rupture of the skin. A second drop,

striking the side of the drum, caused the slight dent shown in Figure 7.

At this point the package was opened and the contents examined. There was no visible damage to the inside diameter of the Celotex insulation, to the inner container, or to the food cans inside.

Thermal:

REQUIREMENT — Exposure for 30 minutes within a source of radiant heat having a temperature of 1475°F and an emissivity coefficient of 0.9, or equivalent. The package shall not be cooled artificially until after the 30-minute test period has expired and the temperature at the center of the package has begun to fall.

DISCUSSION — We intended to add thermocouples for this test, but since the Celotex rings were crimped in place by the deformation of the drum, this was not possible. The use of a second package seemed valid, since the previous tests had not caused a loss or exposure of the insulation or any other damage that would affect package performance.

RESULTS — The package was placed in a preheated induction furnace and exposed for 30 minutes. (See Figures 8 and 9.) The thermocouples shorted

Figure 8. Model 1518 Thermal-Test Furnace Temperature.

out during the first 5 minutes of exposure, and since the internal temperatures could not be monitored, the entire package was allowed to come to room temperature without any artificial cooling. Temperature-sensitive pellets (Figure 10) placed on the inner container and on the tin cans recorded the maximum temperatures reached. The 200°F pellets on the side and bottom of the inner container had started to turn from yellow to black, indicating that 200°F had just been reached. The pellets on the cans indicated 150°F had been exceeded, but that 175°F had not been reached. There was no scorching of the paint or radiation label and no swelling of the the tin cans. Figure 11 shows the top Celotex disk (right), the top ring section (left), and the remaining ring sections and inner container in place. The depth of char was 1.5 inches or less on each of the rings.

Figure 9. Package Being Removed from Furnace after Thermal Test.

Water Immersion:

REQUIREMENT — Immersion in water for 24 hours to a depth of at least 3 feet.

RESULTS — Only the inner container was subjected to the test. No in-leakage of water was observed and the radiation caution label remained firmly attached.

SPECIAL TESTS

Thermal Test of Unvented Container: Since the first package had been vented to allow the passage of

Figure 10. Inner Container after Thermal Test.

thermocouple wires, it was not known if the production containers would require venting. At this same time, it became desirable to decrease the end insulation from 1.92-inches minimum to 1.87-inches minimum to allow for a better fit between the various package components. A second package with the thinner end insulation, and no venting of any kind, was subjected to the half-hour thermal test previously described.

Figure 11. Drum and Celotex Insulation after Thermal Test.

Temperature-sensitive pellets showed the inner container remained under 250°F and the contents under 200°F, an increase of 50 degrees over the first test. This may have been caused by the reduction in insulation, by the increase in furnace temperature (Figure 8), or both.

Both ends of the steel drum bowed out slightly (Figure 12); however, no other damage was observed. It appeared that the rubber lid gasket burns out almost immediately and allows any overpressure to vent.

Figure 12. Unvented Drum after Thermal Test.

The final production container was not vented and the thinner (1.87 inch minimum) end insulation was specified.

Heat Buildup Due to Plutonium Radioactive Decay:

TEST — The package was loaded with short-#401 (4 $\frac{1}{8}$ -inch dia.) cans each containing a 2.1 kg plutonium button. These cans in turn were cushioned with steel wool, which conducts heat from the cans to the inner container. Maximum can temperatures were determined using temperature-sensitive pellets; inner container temperatures were monitored using a thermocouple and recording chart.

RESULTS — The 4.2 kg's of plutonium produced about 8 watts of thermal energy, and resulted in equilibrium temperatures of 200°F in the can and 135°F on the surface of the inner container (Figure 13). This seemed like a practical working temperature and 8 watts has been taken as a specification limit.

Figure 13. Plutonium Radioactive-Decay Heat Buildup.

CRITICALITY EVALUATION AND MATERIAL LIMITS*

Group IV Fissile Materials: A nuclear safety evaluation for Fissile Class II and Class III shipments was performed by J. D. McCarthy of our Nuclear Safety Department and reported elsewhere.⁵ Calculations were made for those fissile materials most commonly shipped by AEC contractors. Results of Mr. McCarthy's work are summarized below. The table lists varying quantities of material (where applicable) to provide the shipper with the widest choice of mass-per-container and number of containers per vehicle.

Allowable number of packages was computed for both damaged and undamaged containers. In each case, the allowable number of undamaged containers proved to be the most restrictive. Criteria for these calculations can be found in AEC Chapter 0529.⁶

Transport Group I, II, III, IV Radioactive Materials: The Model 1518 Container has been approved for any Transport Group I, II, III, and IV radioactive material

*Limits shown are pending approval by DOT.

⁵ J. D. McCarthy — Criticality Analysis of Model 1518, Class II and Class III Container, revision dated February 1968. Rocky Flats Division, The Dow Chemical Company, Golden, Colorado.

⁶ Reference cited elsewhere.

Material	Maximum Package Contents (kg)	Maximum Packages per Shipment	
		Fissile Class II	Fissile Class III
²³⁹ Pu, ²³⁵ U, except oxides	4.5 ^a	15	39
	3.0	20	52
	2.5	28	70
	1.0	133	333
²³⁹ Pu, ²³⁵ U oxides	6.0	71	179
²³⁵ U except oxides	11.0	15	37
	7.0	34	85
	3.5	119	296
²³⁵ U oxide	6.0	397	992
Pa Alloy Fuel Elements w/SST Cladding, Pa content	4.1	63	157

^a Divided into two parts of 2.25 kg maximum and separated at least 2.750-inches.

in solid form. Allowable quantities per package are limited by two factors:

1. The penetrating radiation must comply with DOT regulations. If shielding is used to meet this requirement, it must be placed within the inner container to provide thermal protection.
2. Aggregate thermal energy per package must not exceed eight watts. This requirement is based on the results of special tests included in this report. About 74 grams of americium-241 or 0.057 grams of polonium-210 could be shipped under the 8-watt limitation.

OPTIONAL INNER CONTAINERS

Designs of two additional inner containers are available to interested contractors. These have not been submitted for AEC approval; however, both should be approved on the basis of earlier tests and on the data published for the basic Model 1518 Container.

5-Inch Pipe Plug Closure: This design is similar to the original inner container except that a 5½-inch OD × ¼-inch wall tube is used and the closure is a 5-inch pipe plug. Useful inside dimensions are 5.200-inch minimum diameter for 8.360-inch minimum length. The Celotex rings must be modified to accept this 5.800-inch maximum outside diameter container. Thermal test results should not be affected, since there is still more than the required 3 inches of side insulation.

The original nuclear safety evaluation has been extended to cover this larger inner container; no modifications to the approved material limits are necessary.

O-Ring Seal and Valve: A valve has been incorporated into this design to allow venting any over-pressure before removing the lid, or for purging the inner container and filling with an inert atmosphere when necessary to protect the contents. The cutaway drawing (Figure 14) shows the steel retaining ring used to hold the lid in place. Useful inside dimensions are 4.320-inch minimum diameter for 8.320-inch minimum height. Test pressure is 300 psi. The container fails through leakage in the area of the O-ring at 1200 psi. A description and the results of testing of a similar, but longer, inner container are reported in RFP-501.⁷

⁷ F. E. Adcock, et al, Plutonium Oxide Shipping Packages, RFP-501. Rocky Flats Division, The Dow Chemical Company, April 28, 1965.

Figure 14. Optional Inner Container. Weight - 12 lb, usable inside height - 8.320-in. minimum, inside diameter 4.320-in. minimum.

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

(Revised: 2-8-68)

I. ALO Contractor The Dow Chemical Company Rocky Flats Division Box 888 Golden, Colorado 80401 Contact: Engr. - Frank E. Adcock Traffic - W. F. Romine	II. Identification of Shipping Container RFD Container - Model 1518 Metal nameplate spot welded to drum Dow Drawing Number: FI1993 ALO Designation: AL-R2 DOT Special Permit: No. 5000
---	--

III. General Information Concerning Container.

- A. Outside container is a 10-gallon ICC-6C open-head metal pail 15" diameter and 18" high. The inner container is 4.77" O.D. and 11.75" high. Usable inside dimensions are 4.180" diameter by 10.000" high (for use with #401 cans). Insulation is provided by machined Celotex rings.
- B. Empty weight: 51 pounds.
- C. The tests prescribed by AEC Chapter 0529 were met; temperature of the package contents remained under 200°F during the fire test.
- D. Material Limits:

1. Group IV Fissile Radioactive Material

Material Description	Max. Packages	Max. Packages
	Class II	Class III
Pu 239, U233 except oxides - 4.5 kg*	15	39
. . . do . . . - 3.0 kg	20	52
. . . do . . . - 2.5 kg	28	70
. . . do . . . - 1.0 kg	133	333
Pu 239, U233 oxides - 6.0 kg	71	179
U235 except oxides - 11.0 kg	15	37
. . . do . . . - 7.0 kg	34	85
. . . do . . . - 3.5 kg	119	296
U235 oxide - 6.0 kg	397	992
Pu alloy fuel elements, Pu content - 4.1 kg	63	157

*Separated into two parts per Dow drawing FI1993-1.

2. Transport Group I, II, III, IV Radioactive Material.

Solid form only, quantity limited such that:

- a. Penetrating radiation complies with para. 173.393 of the DOT regulations.
- b. Aggregate thermal energy per package does not exceed 8 watts.

IV. Specific Limitations and Restrictions.

Not approved for liquids. Material within the inner container must not decompose below 250°F.

V. Additional Information.

4.2 kg of Pu producing 8 watts results in inner container temperature of 135°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: 2-20-68

 Certification Official
 Albuquerque Operations
 U. S. Atomic Energy Commission

6M SHIPPING CONTAINER

April 19, 1967

SP #5000

Mr. William F. Romine
Traffic Manager
The Dow Chemical Company
Rocky Flats Division
Post Office Box 388
Golden, Colorado 80401

Dear Mr. Romine:

In accordance with your request of April 4, attached is Special Permit No. 5000 authorizing shipment of certain fissile radioactive materials. Shipments are authorized as Fissile Class II or III.

Inquiries concerning the provisions of this permit should be addressed to Mr. W. A. Brobst or to me.

Sincerely,

G. Rousseau
Special Permits Officer
Office of Hazardous
Materials

cc:
U. S. Coast Guard
Bureau of Explosives, AAR
Atomic Energy Control Board, Canada
Atomic Energy Commission, Mr. Robert A. Kaye
Federal Highway Administration
Federal Railroad Administration

SPECIAL PERMIT NO. 5000

This special permit is issued pursuant to the authority of §173.22(a)(1), Department of Transportation Regulations for the Transportation of Explosives and Other Dangerous Articles, 49 CFR Parts 171-190, as amended.

1. The DOW CHEMICAL COMPANY, Golden, Colorado, is hereby authorized to ship fissile radioactive material, n.o.s., further described as plutonium and uranium metal and oxides, under the provisions of §173.393(g)(2) and §173.393(m) of the DOT regulations, in accordance with the provisions of Atomic Energy Commission, Albuquerque Operations Office approval dated March 28, 1967, and as further provided for herein.

2. The authorized packaging shall consist of a 10 gallon DOT Specification ICC-6C open head metal drum, 15 inches in diameter, 18 inches high, with an inner DOT Specification ICC-2R steel container. The void space between the inner and outer container is filled with machined celotex rings. The packaging is identified as RFD Model 1518, and meets the IAEA Type B tests. The package is described on Dow drawing numbers P-11993-1, -2 and -3.

3. The closure device must have affixed to it a tamper-proof lock wire and seal adequate to prevent inadvertent opening of the container, and of a type that must be broken if the package is opened.

4. The authorized contents of each package shall consist of not more than 6.0 kilograms of plutonium or uranium-233, or 11.0 kilograms of uranium-235, in the form of oxide or metal (liquids not authorized), and not more than 20 curies of any transport Group I material, as defined in 10 CFR Part 71, U. S. Atomic Energy Commission Regulations.

5. Packages are authorized for shipment as Fissile Class II, with radiation units to be assigned to each package as outlined below (unless, however, external radiation levels dictate a higher assignment). Shipments are also authorized as Fissile Class III, with not more than the following number of packages per vehicle:

Continuation of SP #5000

Page 2

fissile Material	Maximum Package Contents	Radiation Units (Class II)	Maximum No. of Packages per Transport Vehicle (Class III)
1. Plutonium or U-233			
a. Metal	4.5 kg.	2.9	35
	2.5 kg	2.3	45
	1.0 kg.	0.5	Not authorized
b. Oxide	6.0 kg.	0.5	Not authorized
c. Pu/U-238 Fuel	4.1 kg.	0.5	200
2. Uranium-235	11.0 kg.	2.4	42
a. Metal	7.0 kg.	1.0	97
	3.5 kg.	0.3	Not authorized
b. Oxide	6.0 kg.	0.1	Not authorized

6. The outside of each package shall be plainly and durably marked "DOT SP 5000" and "FISSILE RADIOACTIVE MATERIAL", in connection with and in addition to the other markings and labels prescribed by the DOT regulations. In accordance with §173.9(c) of the DOT regulations, the special permit identification may be by either tag or label securely affixed to each package. Each bill of lading, shipping order or other shipping paper issued in connection with shipments made under this permit must bear the notation "DOT SPECIAL PERMIT NO. 5000" in connection with the commodity description and label notation thereon.

7. This permit does not relieve the shipper from compliance with any requirement of the DOT regulations, except as specifically provided for herein.

Continuation of SP #5000

Page 3

8. Shipments are authorized by rail and highway only.

9. This permit shall expire April 30, 1969.

Issued at Washington, D. C., this 13th day of April, 1967.

W. K. Byrd
Acting Director
Office of Hazardous
Materials

Approved:

E. G. Cox
For the Administrator
Federal Highway Administration

W. K. Byrd
For the Administrator
Federal Railroad Administration

OFFICE OF THE SECRETARY OF TRANSPORTATION
WASHINGTON, D. C. 20590

N O T I C E

On April 1, 1967, the safety functions of the Interstate Commerce Commission were transferred to the new Department of Transportation. The activities of the former Section of Explosives and Other Dangerous Articles are now performed by the Office of Hazardous Materials in the Office of the Assistant Secretary for Research and Technology. Beginning April 22, 1967, all correspondence relating to explosives and other dangerous articles functions should be addressed to:

Mr. William K. Byrd
Director
Office of Hazardous Materials
Department of Transportation
6th and D Streets, S. W.
Washington, D. C. 20590

To reach this office by telephone dial: (Area Code 202) 962-5545.

The current regulations covering the transportation of explosives and other dangerous articles, "Code of Federal Regulations, Title 49-Transportation, Parts 71 to 90," effective January 1, 1966, and the volume soon to be released, effective January 1, 1967, will be continued in use by the new Department of Transportation. Amendments, additions, deletions, etc., to the regulations will be coordinated by the Office of Hazardous Materials, Department of Transportation. Parts 71 to 90 will now be referred to as Parts 171 to 190 and all sections thereof will have "100" added preceding the current number, e.g., Part 73 becomes 173 and Part 197 becomes 297. All numbered Parts and sections referred to in the future will carry the new numbering system.

The directive establishing the new numbering system was published in the Federal Register on April 5, 1967 (32 F.R. 5606).

May 22, 1967

REV
SP #5000

Mr. William F. Romine
Traffic Manager
The Dow Chemical Company
Rocky Flats Division
Post Office Box 888
Golden, Colorado 80401

Dear Mr. Romine:

In accordance with your request of May 5, attached is Revised Special Permit No. 5000 authorizing shipment of various radioactive materials under certain conditions. Shipments are authorized as Fissile Class II or Class III.

We are in the process of taking the necessary steps to have the permit amended for shipments by air. You may expect a further amendment covering this particular facet.

Any inquiries concerning the provisions of this permit should be addressed to Mr. W. A. Brobst or to me.

Sincerely,

G. Rousseau
Special Permits Officer
Office of Hazardous
Materials

cc:

U. S. Coast Guard
Bureau of Explosives, AAR
Atomic Energy Control Board, Canada
U. S. Atomic Energy Commission, Mr. Robert A. Kaye
Federal Highway Administration
Federal Railroad Administration

REVISED SPECIAL PERMIT NO. 5000

This special permit is issued pursuant to the authority of SI73.22(a)(1), Department of Transportation Regulations for the Transportation of Explosives and Other Dangerous Articles, 49 CFR Parts 171-190, as amended.

1. The DOW CHEMICAL COMPANY, Golden, Colorado, is hereby authorized to ship radioactive material, n.o.s., and fissile radioactive material, n.o.s., under the provisions of SI73.393(g)(2) and SI73.393(m) of the DOT regulations, in accordance with the provisions of Atomic Energy Commission, Albuquerque Operations Office approval dated March 28, 1967, and as further provided for herein.

2. The authorized packaging shall consist of a 10 gallon, 20 gauge DOT Specification ICC-6D open head metal drum, 15 inches in diameter, 18 inches high, with an inner DOT Specification ICC-2R steel container. The void space between the inner and outer containers is filled with machined rings of at least 2 inch thick non-flammable fiberboard solid multipurpose insulating board. The sides of the inner container shall be protected by at least 4 inches of such material, and the ends by at least 2 inches of such material. The outer container closure shall be at least 16-gauge bolted ring with drop-forged lugs, one of which is threaded, and having at least a 5/16 inch bolt and a lock nut equivalent device. The packaging is identified as RFD Model 1518, and meets the IAEA tests for a large source container. The packaging is described on Dow drawing numbers P-11993-1, -2 and -3.

3. The closure device must have affixed to it a tamper-proof lock wire and seal adequate to prevent inadvertent opening of the container, and of a type that must be broken if the package is opened.

Continuation of REV SP #5000

Page 2

4. The authorized contents of each package shall consist of not more than 6.0 kilograms of plutonium-233, or 11.0 kilograms of uranium-235, in the form of oxide or metal (liquids not authorized); or not more than 100 grams (325 curies) of americium-241, 30 grams (135,000 curies) of polonium-210, or not more than 20 curies of any Transport Group I material, as defined in 10 CFR Part 71, U. S. Atomic Energy Commission Regulations.

5. Packages are authorized for shipment as Fissile Class II, with radiation units to be assigned to each package as outlined below (unless, however, external radiation levels dictate a higher assignment). Shipments are also authorized as Fissile Class III, with not more than the following number of packages per vehicle:

Fissile Material	Maximum Package Contents	Radiation Units (Class II)	Maximum No. of Packages per Transport Vehicle (Class III)
1. Plutonium or U-233			
a. Metal	4.5 kg.	2.9	35
	2.5 kg.	2.3	45
	1.0 kg.	0.5	Not authorized
b. Oxide	6.0 kg.	0.5	Not authorized
c. Pu/U-238 Fuel	4.1 kg.	0.5	200
2. Uranium-235	11.0 kg.	2.4	42
a. Metal	7.0 kg.	1.0	97
	3.5 kg.	0.3	Not authorized
b. Oxide	6.0 kg.	0.1	Not authorized

Continuation of REV SP #5000

Page 3

6. The outside of each package shall be plainly and durably marked "DOT SP 5000" and either "RADIO-ACTIVE MATERIAL" or "FISSILE RADIOACTIVE MATERIAL", as appropriate in connection with and in addition to the other markings and labels prescribed by the DOT regulations. In accordance with SI73.9(c) of the DOT regulations, the special permit identification may be by either tag or label securely affixed to each package. Each bill of lading, shipping order or other shipping paper issued in connection with shipments made under this permit must bear the notation "DOT SPECIAL PERMIT NO. 5000" in connection with the commodity description and label notation thereon.

7. This permit does not relieve the shipper or carrier from compliance with any requirement of the DOT regulations, except as specifically provided for herein.

8. Shipments are authorized by rail and highway only.

9. This permit shall expire April 30, 1969.

Issued at Washington, D. C., this 18th day of May, 1967.

W. K. Byrd
Acting Director
Office of Hazardous
Materials

Approved:

E. G. Cox
For the Administrator
Federal Highway
Administration

W. K. Byrd
For the Administrator
Federal Railroad
Administration

June 29, 1967

2nd Rev
SP 5000

Mr. William F. Romine
Traffic Manager
The Dow Chemical Company
Post Office Box 888
Golden, Colorado 80401.

Dear Mr. Romine:

On the basis of your June 21 letter, attached is Second Revised Special Permit No. 5000. Please note that the permit has not been completely amended to the degree you requested.

Inquiries concerning the provisions of this permit should be addressed to Mr. W. A. Brobst or to me.

Sincerely,

G. Rousseau
Special Permits Officer
Office of Hazardous
Materials

att.

cc: .

U.S. Coast Guard
Bureau of Explosives, AAR
Atomic Energy Control Board, Canada
U.S. Atomic Energy Commission, Mr. Robert A. Kaye
Federal Highway Administration
Federal Railroad Administration

SECOND REVISED SPECIAL PERMIT NO. 5000

Pursuant to the authority of S173.22(a)(1), Department of Transportation Regulations for the Transportation of Explosives and Other Dangerous Articles, 49 CFR Parts 171-190, as amended:

1. The DOW CHEMICAL COMPANY, Golden, Colorado, is hereby authorized to ship radioactive material, n.o.s., and fissile radioactive material, n.o.s., under the provisions of S173.393(g)(2) and S173.393(m) of the DOT Regulations, in accordance with the provisions of Atomic Energy Commission, Albuquerque Operations Office approval dated March 28, 1967, and as further provided for herein.
2. The authorized packaging shall consist of a 10 gallon, 20 gauge DOT Specification ICC-6C open head metal drum, 15 inches in diameter, 18 inches high, with an inner DOT Specification ICC-2R steel container. The void space between the inner and outer containers is filled with machined rings of at least 2 inch thick non-flammable fiberboard solid multipurpose insulating board. The sides of the inner container shall be protected by at least 4 inches of such material, and the ends by 2 inches (nominal) of such material. The outer container closure shall be at least 16-gauge bolted ring with drop-forged lugs, one of which is threaded, and having at least a 5/16 inch bolt and a lock nut equivalent device. The packaging is identified as RFD Model 1518, and meets the IAEA tests for a large source container. The packaging is described on Dow drawing numbers P-11993-1, -2 and -3.
3. The closure device must have affixed to it a tamper-proof lock wire and seal adequate to prevent inadvertent opening of the container, and of a type that must be broken if the package is opened.

Continuation of 2nd Rev SP 5000

Page 2

4. The authorized contents of each package shall consist of plutonium, uranium-235 or uranium-233 as shown herein, in the form of metal or oxide (liquids not authorized); or not more than 100 grams of americium-241, 30 grams of polonium, or not more than 20 curies of any Transport Group I material, as defined in 10 CFR Part 71, U.S. Atomic Energy Commission Regulations.

5. Packages are authorized for shipment as Fissile Class II, with radiation units to be assigned to each package as outlined below (unless, however, external radiation levels dictate a higher assignment). Shipments are also authorized as Fissile Class III, with not more than the following number of packages per vehicle:

Fissile Material	Maximum Package Contents	Radiation Units (Class II)	Maximum No. of Packages per Transport Vehicle (Class III)
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1. Pu or U-233

a. Metal	4.5 kg.	2.9	35
	2.5 kg.	2.3	45
	1.0 kg.	0.5	202

b. Oxide	6.0 kg.	0.5	195
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c. Pu/U-238	4.1 kg.	0.5	200
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2. U-235

	11.0 kg.	2.4	42
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a. Metal	7.0 kg.	1.0	97
	3.5 kg.	0.3	358

b. Oxide	6.0 kg.	0.1	3415
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Continuation of 2nd Rev SP 5000

Page 3

6. The outside of each package shall be plainly and durably marked "DOT SP 5000" and either "RADIOACTIVE MATERIAL" or "FISSILE RADIOACTIVE MATERIAL", as appropriate in connection with and in addition to the other markings and labels prescribed by the DOT Regulations. In accordance with S173.9 (c) of the DOT Regulations, the special permit identification may be by either tag or label securely affixed to each package. Each bill of lading, shipping order or other shipping paper issued in connection with shipments made under this permit must bear the notation "DOT SPECIAL PERMIT NO. 5000" in connection with the commodity description and label notation thereon.

7. This permit does not relieve the shipper or carrier from compliance with any requirement of the DOT Regulations including 14 CFR Part 103, except as specifically provided for herein.

8. This permit authorizes shipments only by rail freight, rail express, motor vehicle and cargo aircraft.

Issued at Washington, D.C., this 28th day of June 1967.

W. K. Byrd

Acting Director
Office of Hazardous Materials

Approved:

E. G. Cox
For the Administrator
Federal Highway Administration

W. K. Byrd
For the Administrator
Federal Railroad Administration

July 28, 1967

3rd REV
SP 5000

Mr. William F. Romine
Traffic Manager
The Dow Chemical Company
Post Office Box 888
Golden, Colorado 80401

Dear Mr. Romine:

In accordance with Nuclear Materials and Equipment Corporation's telegram of July 12, Special Permit No. 5000 has been amended to also cover that company as an authorized shipper. Please note that two other changes have been made regarding closures and the amount of polonium authorized to be shipped.

Any inquiries concerning the provisions of this permit should be addressed to Mr. W. A. Brobst or to me.

Sincerely,

G. Rousseau
G. Rousseau
Special Permits Officer
Office of Hazardous
Materials

cc:
U. S. Coast Guard
Bureau of Explosives, AAR
Atomic Energy Control Board, Canada
U. S. Atomic Energy Commission, Mr. Kaye
Nuclear Materials & Equipment Corporation
Federal Highway Administration
Federal Railroad Administration

THIRD REVISED SPECIAL PERMIT NO. 5000

Pursuant to the authority of S173.22(a)(1), Department of Transportation Regulations for the Transportation of Explosives and Other Dangerous Articles, 49 CFR Parts 171-190, as amended:

Special Permit No. 5000, authorizing shipment of certain radioactive materials in the RFD Model 1518 container, is hereby amended by adding the NUCLEAR MATERIALS AND EQUIPMENT CORPORATION, Apollo, Pennsylvania, as an authorized shipper under its terms. It is further amended by changing paragraphs (2) and (4) to read as follows:

2. The authorized packaging shall consist of a 10 gallon, 20 gauge DOT Specification ICC-6C open head metal drum, 15 inches in diameter, 18 inches high, with an inner DOT Specification ICC-2R steel container. The void space between the inner and outer containers is filled with machined rings of at least 2 inch thick non-flammable fiberboard solid multipurpose insulating board. The sides of the inner container shall be protected by at least 4 inches of such material, and the ends by 2 inches (nominal) of such material. The outer container closure shall be at least 16-gauge bolted ring having at least a 5/16 inch bolt and a lock nut or equivalent device. The packaging is identified as RFD Model 1518, and meets the IAEA tests for a large source container. The packaging is described on DOW drawing numbers P-11993-1, -2 and -3.
4. The authorized contents of each package shall consist of plutonium, uranium-235 or uranium-233 as shown herein, in the form of metal or oxide (liquids not authorized); or not more than 100 grams of americium-241, or not more than 20 curies of any other Transport Group I material, as defined in 10 CFR Part 71, U. S. Atomic Energy Commission Regulations.

Continuation of 3rd REV
SP #5000

Page 2

All other conditions remain unchanged.

Issued at Washington, D. C., this 25th day of
July, 1967.

W. K. Byrd
Acting Director
Office of Hazardous
Materials

Approved:

E. G. Cox
For the Administrator
Federal Highway Administration

W. K. Byrd
For the Administrator
Federal Railroad Administration

OFFICE OF THE SECRETARY OF TRANSPORTATION
Washington, D.C. 20590

DEC 15 1967

4th Rev
SP 5000

Mr. C. H. Perry,
Acting Chief
Transportation Engineering Division
Department of the Army
Headquarters
Military Traffic Management &
Terminal Service
Washington, D.C. 20315

Dear Mr. Perry:

Attached is Fourth Revised Special Permit No. 5000 which has been rewritten to editorially coincide with the pending radioactive material regulations revision. It has been broadened to cover more shippers.

Sincerely,

for W. K. Byrd
Acting Director
Office of Hazardous Materials

att.

cc:
U.S. Coast Guard
Bureau of Explosives, AAR
Federal Highway Administration
Federal Railroad Administration
Federal Aviation Administration
Atomic Energy Control Board, Canada
USAEC, Operations Office, Mr. S. Braiden
USAEC, Mr. Seath Woodruff, Jr.
USAEC, Mr. C. F. Goodner
USAEC, Mr. R. A. Kaye
Battelle Memorial Institute, Mr. Homer Laust
Lawrence Radiation Laboratory, Mr. Stephen Chin
Nuclear Material and Equipment Corporation, Mr. Thomas Gutman
The Dow Chemical Company, Mr. William F. Romine

OFFICE OF THE SECRETARY OF TRANSPORTATION

WASHINGTON, D.C. 20590

FOURTH REVISED SPECIAL PERMIT NO. 5000

Pursuant to the authority of 46 CFR 146.05-4 of the Coast Guard Dangerous Cargo Regulations, and 49 CFR 173.22(a)(1) Department of Transportation Hazardous Materials Regulations, as amended:

1. The DEPARTMENT OF DEFENSE, and its prime contractors, the U. S. ATOMIC ENERGY COMMISSION (USAEC), and its prime contractors and licensees, and licensees of "agreement states" as approved by the USAEC, are hereby authorized to ship radioactive material, n.o.s., either fissile or nonfissile, under the provisions of 46 CFR 146.25-30 and 146.25-400 of the Coast Guard Dangerous Cargo Regulations, and 49 CFR 173.393(f)(9), 173.393(g)(2), and 173.393(m) of the DOT Regulations, in accordance with the provisions of the U. S. Atomic Energy Commission (USAEC), Albuquerque Operations Office, approval dated August 15, 1967, and as further provided for herein. Each user of this permit shall register his identity with the Department prior to the first shipment by that user.
2. The authorized packaging shall consist of the following:
 - (a) Outside container must conform to Specification 6C, 6J, 17C, or 17H (S178.99, 178.100, 178.115, 178.116) steel drum, or equivalent, except as otherwise specified herein. Inside dimensions must be at least 15 inches in diameter and 10 inches in height.
 - (b) Inner container must conform to Specification 2R (S178.34) or equivalent, with maximum usable inside diameter of 4 1/4 inches and minimum wall thickness of 1/8 inch. Material shall be Schedule 40 steel pipe or other material having equivalent physical strength and fire resistance. Pipe threads must be luted with an appropriate nonhardening compound to prevent leakage of water or loosening of the cap due to vibration or heat.
 - (c) Inner container must be fixed within the outer container with appropriate centering devices of adequate physical strength and fire resistance to be able to withstand the accident test conditions prescribed in S173.398 without a displacement of the inner container of more than 2 inches in any direction. The following types of centering mechanisms shall be deemed to meet this requirement. Any other type of centering device must be specifically approved by the Office of Hazardous Materials.

Continuation of 4th Rev SP 5000

Page 2

(1) Machined discs and rings of wood, plywood, or nonflammable solid fiberboard multipurpose insulating material or other nonflammable material having an equivalent thermal and shock absorbing effect. The sides of the inner container shall be protected by at least $3 \frac{3}{4}$ inches of such material, and the ends by $1 \frac{7}{8}$ inches of such material. There must be no gap or direct heat path to the inner container.

(d) Any radiation shielding material used must be placed within the inner container, and must be protected in all directions by at least 4 inches of the thermal insulating material described in this paragraph. Each such shielded package must be able to withstand the fire test conditions prescribed in Appendix B of 10 CFR Part 71, USAEC Regulations.

(e) Gross weight shall conform to the limits prescribed in SI78.99-5.

(f) The outer container closure must be at least a 12-gauge bolted ring with drop-forged lugs, one of which is threaded, and having at least a $\frac{5}{16}$ inch steel bolt for drum sizes not over 30 gallons or a $\frac{3}{8}$ inch steel bolt for drum sizes over 30 gallons, and having a lock nut or equivalent device.

3. The closure device must have affixed to it a tamperproof lock wire and seal adequate to prevent inadvertent opening of the container, and of a type that must be broken if the package is opened.

4. The authorized contents of each package shall consist of not more than the following solid radioactive materials which will not decompose at temperatures up to 250° F.:

(a) Fissile radioactive materials as shown in the table that follows. The atomic ratio of hydrogen to fissile material shall not exceed three (3), all sources of hydrogen within the inside container being considered. Packages are authorized as Fissile Class II, with the transport index to be assigned as shown in the table. Shipments are authorized as Fissile Class III, with not more than the listed number of packages per transport vehicle.

Continuation of 4th Rev SP 5000

Page 3

TABLE

	Maximum Package % Contents (kilograms)	Transport Index (Fissile Class II)	Maximum number of packages per transport vehicle (Fissile Class III)
(1) Plutonium or uranium-233			
a. Oxide	6.0	0.7	195
b. Metal, alloys or other compounds	4.5 ^{1/} 3.0 2.5 1.0	3.6 3.6 2.8 0.7	35 35 45 202
(2) Uranium-235			
a. Oxide	6.0	0.1	3415
b. Metal, alloy or other compounds	11.0 7.0 3.5	3.0 1.3 0.4	42 97 358

^{1/} Divided into two parts of not more than 2.25 kilograms each, and each part separated by at least 2 3/4 inches by an appropriate divider mechanism.

(b) Other solid radioactive materials. Thermal decay energy output shall not exceed 8 watts. Radiation levels shall not exceed those prescribed in SI73.393.

5. The authorized package meets the criteria of the International Atomic Energy Agency for Type B packaging for large quantity and fissile radioactive materials.

6. Prior to each shipment authorized by this permit, the consignee shall be notified of the dates of shipment and expected arrival.

7. The outside of each package shall be plainly and durably marked "DOT SP 5000" and "FISSILE RADIOACTIVE MATERIAL" or "RADIOACTIVE MATERIAL", as appropriate, in connection with and in addition to the other markings and labels prescribed by the DOT Regulations. Each shipping paper issued in connection with shipments made under this permit must bear the notation "DOT SPECIAL PERMIT NO. 5000" in connection with the commodity description thereon. In accordance with SI73.9(c) of the DOT Regulations, the special permit identification may be either tag or label securely affixed to each package. For export shipments, the outside of each package shall be also marked "TYPE B."

Continuation of 4th Rev SP 5000

Page 4

8. The permit does not relieve the shipper from compliance with any requirement of the DOT Regulations, including 46 CFR Parts 146 to 149 of the Coast Guard Regulations, except as specifically provided for herein.

9. Shipments are authorized only by vessel, cargo aircraft, passenger-carrying aircraft, motor vehicle, rail freight, and rail express.

10. For shipments by water, the shipper or agent shall notify the U. S. Coast Guard Captain of the Port in the port area through which the shipment is to be made, of the name of the vessel on which the shipment is to be made, and of the time, date, and place of loading. When the initial notification is given in a port area, it shall be accompanied by a copy of this permit, addressed to the attention of that Captain of the Port.

11. This permit shall expire November 30, 1969.

Issued at Washington, D.C., this 24th day of November 1967.

E. G. Grundy, Capt.
For the Commandant
U.S. Coast Guard

W. R. Fiste
For the Administrator
Federal Highway Administration

H. R. Longhurst
For the Administrator
Federal Railroad Administration

Address all inquiries to: Director, Office of Hazardous Materials, U.S. Department of Transportation, Washington, D.C. 20590. Attention: Special Permits Branch.

PROPOSED DOT SPECIFICATION
FOR FISSILE RADIOACTIVE MATERIAL CONTAINER
SUBMITTED BY THE DOW CHEMICAL COMPANY - ROCKY FLATS DIVISION

July 14, 1967
(Revised February 8, 1968)

SPECIFICATION 6 ____: metal container for fissile and other radioactive materials.

1. Compliance.

(a) Required in all details.

2. Rated Capacity.

(a) Authorized for fissile and other radioactive materials in solid form as listed below. Any material within the inner container, including packing, must not decompose or cause a buildup of pressure below a temperature of 250°F. Gross weight not to exceed that of Specification 6C, paragraph 178.99-5.

(1) Fissile radioactive materials in the form of metal, compounds, or alloys, quantity of material per package and number of packages per shipment shall be limited as follows:

Material	Maximum Package Contents (kg)	Allowable Packages per shipment	
		Fissile Class II	Fissile Class III
Pu or U-233, except oxides	4.5*	15	39
...do...	3.0	20	52
...do...	2.5	28	70
...do...	1.0	133	333
Pu or U-233 Oxides	6.0	71	179
U-235, except oxide	11.0	15	37
...do...	7.0	34	85
...do...	3.5	119	296
U-235 Oxide	6.0	397	992

*Divided into two parts of not more than 2.25 kg each, and separated at least 2.75 inches by a strong wood or metal divider.

- (2) Other solid radioactive materials, aggregate thermal energy per package must not exceed eight (8) watts. Penetrating radiation must comply with paragraph 173.393.

3. Outer Container.

- (a) Full removable head steel barrel or drum and conforming to Specification 6C (paragraph 178.99) or equivalent. Inside dimensions must be at least 13.87 inch diameter and 15.50 inch height.
- (b) Drum closure shall be at least 16-gauge bolted ring having at least a 5/16 inch bolt and nut for drums of not over 30-gallon capacity, and a 3/8 inch bolt and nut for drums of over 30-gallon capacity. A tamper-proof seal shall be applied to prevent inadvertent opening of the container.

4. Inner Container.

- (a) Steel tube or pipe of at least .12 inch wall thickness. Inside diameter not to exceed 5.25 inches.
- (b) Ends must be closed with a plug or cap using American Standard taper pipe threads or equivalent with an engagement of at least 5 threads, except one or both ends may be closed by a welded plate.
- (c) Threads shall be luted with an appropriate sealant to prevent in-leakage of water or loosening of closure due to vibration. The luting material used must remain serviceable when subjected to a temperature of 300°F. for one hour.

5. Radiation Shielding.

- (a) Any radiation shielding used must be placed within the inner container or must be provided with equivalent thermal protection.

6. Insulation.

- (a) The void between the outer and inner containers shall be filled with Celotex Industrial Board, cane fiber, or an approved equivalent in a manner to prevent shifting of the inner container and to prevent a gap or direct heat path to the inner container.
- (b) The inner container must have at least 1.87 inches of insulation at each end and at least 3.75 inches around the sides.

7. Marking.

(a) The side of each outer container shall be conspicuously marked with the following:

- (1) "ICC-6 ____". These marks shall be understood to certify that the container complies with all specification requirements.
- (2) "RADIOACTIVE MATERIALS" or "FISSILE RADIOACTIVE MATERIALS," as appropriate.
- (3) The name and address of the user assuming responsibility for compliance with specification requirements.

Marking shall be by raised or indented letters applied directly to the outer container or to a steel plate welded to the outer container, or by other means to assure that the words will be legible after exposure to a temperature of 1475°F. for one-half hour.

- (b) Each inner container shall be conspicuously marked with the words "RADIOACTIVE MATERIAL." Marking to be by securely affixed tag or label, or by other means to assure that the words will be legible after exposure to a temperature of 300°F. for one hour.

Sketch of 2-Inch-Square Wrench.

APPENDIX B

DEPARTMENT OF TRANSPORTATION
IAEA CERTIFICATES OF COMPETENT AUTHORITY
SPECIAL FORM

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
WASHINGTON, D.C. 20390

IAEA CERTIFICATE OF COMPETENT AUTHORITY

Special Form Radioactive Material Encapsulation

REFER TO:

Certificate Number USA/0156/S

This certifies that the encapsulated source, as described, when loaded with the authorized radioactive contents, has been demonstrated to meet the regulatory requirements for special form radioactive material as prescribed in IAEA ¹ and USA ² regulations for the transport of radioactive materials.

I. Source Description - The source described by this certificate is identified as the Type I Powder Shipping Can which is a 304-L stainless steel welded encapsulation measuring 0.75 inches in diameter by 3.0 inches in length constructed as described in Union Carbide Nuclear Division drawing B-RD 3092.

II. Radioactive Contents - The authorized radioactive contents of this source consist of not more than:

<u>Radionuclide</u>	<u>Form</u>	<u>Maximum Content, Curies per Capsule</u>
Americium-241	Oxide, AmO ₂	50
Americium-243	Oxide, AmO ₂	3
Cesium-137	Chloride, CsCl	375
Cobalt-60	Metal	5,000
Curium-244	Oxide, CmO ₂	1,000
Iridium-192	Metal	5,000
Neptunium-237	Oxide, NpO ₂	0.01
Plutonium-238	Oxide, PuO ₂	250
Plutonium-239	Oxide, PuO ₂	0.90
Plutonium-240	Oxide, PuO ₂	3.40
Plutonium-241	Oxide, PuO ₂	1,500
Plutonium-242	Oxide, PuO ₂	0.06
Promethium-147	Oxide, Pm ₂ O ₃	5,000
Strontium-90	Fluoride, SrF ₂	450
Strontium-90	Oxide, SrO	450
Strontium-90	Titanate, SrO·(TiO ₂) _x where x ≥ 0.5	450
Thorium-230	Oxide, ThO ₂	0.30
Uranium-233	Oxide, U ₃ O ₈	0.14
Uranium-233	Metal	0.14
Uranium-234	Oxide, U ₃ O ₈	0.09

Certificate Number USA/0156/S Revision 1

III. This certificate, unless renewed, expires February 28, 1983.

This certificate is issued in accordance with paragraph 803 of the IAEA Regulations ¹, and in response to the October 24, 1980, petition by the Oak Ridge National Laboratory, and in consideration of the associated information therein.

Certified by:

F. R. Rawl,
Chief, Radioactive Materials Branch
Office of Hazardous Materials Regulations
Materials Transportation Bureau

J. M. Jones, 21, 1981
(date)

¹ "Safety Series No. 6, Regulations for the Safe Transport of Radioactive Materials, 1967 Edition", published by the International Atomic Energy Agency (IAEA), Vienna, Austria.

² Title 49, Code of Federal Regulations, Part 170-178, USA.

Revision 1 issued to amend contents, reflect conformance with 1973 IAEA regulations and extend expiration date.

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
WASHINGTON, D.C. 20590

IAEA CERTIFICATE OF COMPETENT AUTHORITY

Special Form Radioactive Material Encapsulation

REFER TO:

Certificate Number USA/0198/S

This certifies that the encapsulated source, as described, when loaded with the authorized radioactive contents, has been demonstrated to meet the regulatory requirements for special form radioactive materials as prescribed in IAEA 1/ and USA 2/ regulations for the transport of radioactive materials.

I. Source Description - The source described by this certificate is identified as Oak Ridge National Laboratory Capsule Am-1 which is a double cylindrical encapsulation constructed of 304L stainless steel with the outer capsule closed and sealed by welding. The outer capsule measures 1.25" in outside diameter by 7.0" in length.

II. Radioactive Contents - The authorized radioactive contents of this source consist of:

<u>Radionuclide</u>	<u>Form</u>	<u>Maximum Content, Curies per Capsule</u>
Americium-241	Oxide, AmO ₂	130
Americium-243	Oxide, AmO ₂	8
Curium-244	Oxide, CmO ₂	3,000
Neptunium-237	Oxide, NpO ₂	0.03
Plutonium-238	Oxide, PuO ₂	680
Plutonium-239	Oxide, PuO ₂	2.50
Plutonium-240	Oxide, PuO ₂	10.0
Plutonium-241	Oxide, PuO ₂	4,000
Plutonium-242	Oxide, PuO ₂	0.15
Promethium-147	Oxide, Pm ₂ O ₃	5,000
Strontium-90	Fluoride, SrF ₂	1,200
Strontium-90	Oxide, SrO	1,200
Strontium-90	Titanate, SrO·(TiO ₂) _x where $x \geq 0.5$	1,200
Thorium-230	Oxide, ThO ₂	0.80
Uranium-233	Oxide, U ₃ O ₈	0.40
Uranium-233	Metal	0.40
Uranium-234	Oxide, U ₃ O ₈	0.25

Certificate Number USA/0198/S

Page 2

III. This certificate, unless renewed, expires January 31, 1983.

This certificate is issued in accordance with paragraph 803 of the IAEA Regulations 1/, and in response to the October 24, 1980 petition by Oak Ridge National Laboratory and in consideration of the associated information therein.

Certified by:

R. R. Rawl
Chief, Radioactive Materials Branch
Office of Hazardous Materials Regulation
Materials Transportation Bureau

Date

1/ "Safety Series No. 6, Regulations for the Safe Transport of Radioactive Materials, 1973 Revised Edition", published by the International Atomic Energy Agency (IAEA), Vienna, Austria.

2/ Title 49, Code of Federal Regulations, Part 170-178, USA.

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
WASHINGTON, D.C. 20590

IAEA CERTIFICATE OF COMPETENT AUTHORITY

Special Form Radioactive Materials Encapsulation

REFER TO:

Certificate Number USA/0202/S

This certifies that the encapsulated source, as described, when loaded with the authorized radioactive contents, has been demonstrated to meet the regulatory requirements for special form radioactive material as prescribed in IAEA/ and USA2/ regulations for the transport of radioactive materials.

I. Source Description - The source described by this certificate is identified as Oak Ridge National Laboratory (ORNL) Powder Shipping Can Type 2 which is a tungsten-inert gas welded double encapsulation constructed of stainless steel. The capsule is cylindrical with external dimensions of 5" in length by 1.25" in diameter.

II. Radioactive Contents - The authorized radioactive contents of this source consist of not more than the following:

<u>Radionuclide</u>	<u>Form</u>	<u>Maximum Content, Curies per Capsule</u>
Americium-241	Oxide AmO_2	200
Americium-243	Oxide, AmO_2	12
Cesium-137	Chloride, CsCl	1,500
Cobalt-60	Metal	5,000
Curium-244	Oxide, CmO_2	4,000
Iridium-192	Metal	5,000
Neptunium-237	Oxide, NpO_2	0.04
Plutonium-238	Oxide, PuO_2	1,000
Plutonium-239	Oxide, PuO_2	3.6
Plutonium-240	Oxide, PuO_2	14.0
Plutonium-241	Oxide, PuO_2	5,000
Plutonium-242	Oxide, PuO_2	0.25
Promethium-147	Oxide, Pm_2O_3	5,000
Strontium-90	Fluoride, SrF_2	2,000
Strontium-90	Oxide, SrO	2,000
Strontium-90	Titanate, $\text{SrO} \cdot (\text{TiO}_2)_x$ where $x \geq 0.5$	2,000
Thorium-230	Oxide, ThO_2	1.2
Uranium-233	Oxide, U_3O_8	0.6
Uranium-233	Metal	0.6

Certificate Number USA/0202/S

Page 2

III. This certificate, unless renewed, expires on February 1, 1984.

This certificate is issued in accordance with paragraph 803 of the IAEA Regulations^{1/}, ... in response to the October 21, 1980 petition by Oak Ridge National Laboratory and in consideration of the associated information therein.

Certified by:

R. R. Pawl
Chief, Radioactive Materials Branch
Office of Hazardous Materials Regulation
Materials Transportation Bureau

(Date)

1/ "Safety Series No. 6 Regulations for the Safe Transport of Radioactive Materials 1973 Revised Edition", published by the International Atomic Energy Agency (IAEA), Vienna, Austria.

2/ Title 49, Code of Federal Regulations, Part 170-178, USA.

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
WASHINGTON, D.C. 20570

IAEA CERTIFICATE OF COMPETENT AUTHORITY

Special Form Radioactive Materials Encapsulation

REFER TO:

Certificate Number USA/0206/S

This certifies that the encapsulated source, as described, when loaded with the authorized radioactive contents, has been demonstrated to meet the regulatory requirements for special form radioactive material as prescribed in IAEA/and USA2/ regulations for the transport of radioactive materials.

I. Source Description - The source described by this certificate is identified as Oak Ridge National Laboratory (ORNL) Capsule Pm-1 which is a tungsten-inert gas welded double encapsulation constructed of stainless steel. The source is cylindrical with external dimensions of 3" in length by 1.25" in diameter.

II. Radioactive Contents - The authorized radioactive contents of this source consist of not more than:

<u>Radionuclide</u>	<u>Form</u>	<u>Maximum Content, Curies per Capsule</u>
Americium-241	Oxide, AmO ₂	30
Americium-243	Oxide, AmO ₂	2
Curium-244	Oxide, CmO ₂	700
Neptunium-237	Oxide, NpO ₂	0.01
Plutonium-238	Oxide, PuO ₂	155
Plutonium-239	Oxide, PuO ₂	0.60
Plutonium-240	Oxide, PuO ₂	2.20
Plutonium-241	Oxide, PuO ₂	1,000
Plutonium-242	Oxide, PuO ₂	0.04
Promethium-147	Oxide, Pm ₂ O ₃	5,000
Strontium-90	Fluoride, SrF ₂	300
Strontium-90	Oxide, SrO	300
Strontium-90	Titanate, SrO·(TiO ₂) _x where $x \geq 0.5$	300
Thorium-230	Oxide, ThO ₂	0.20
Uranium-233	Oxide, U ₃ O ₈	0.10
Uranium-233	Metal	0.10
Uranium-234	Oxide, U ₃ O ₈	0.06

Certificate Number USA/0206/S

Page 2

III. This certificate, unless renewed, expires on February 1, 1984,

This certificate is issued in accordance with paragraph 803 of the IAEA Regulations^{1/}, and in response to the October 24, 1980 petition by Oak Ridge National Laboratory and in consideration of the associated information therein.

Certified by:

R. R. Pawl
U. S. Department of Transportation
Office of Hazardous Materials Regulation
Washington, D.C. 20590

January 23, 1981
(Date)

1/ "Safety Series No. 6, Regulations for the Safe Transport of Radioactive Materials, 1973 Revised Edition", published by the International Atomic Energy Agency (IAEA), Vienna, Austria.

2/ Title 49, Code of Federal Regulations, Part 170-178, USA.

APPENDIX C

APPROVAL DOCUMENTS

(Transportation Committee Approval)

(Certificate of Compliance)

NUCLEAR DIVISION

INTERNAL CORRESPONDENCE

April 20, 1982

TC 82-1

To: R. W. Schaich

From: Transportation Committee

Subject: Approval of ORNL DOT Specification 6-M Special Form Radioactive
Materials Packaging

The Transportation Committee has reviewed your submission dated March 3, 1982 of the subject packaging. The package including the capsule, the capsule testing, and the DOT Specification 6M metal package were reviewed.

The review concludes that the container provides for the safe shipment of the materials listed in the IAEA Certificates of Competent Authority as included in your submission.

E.M. King

E. M. King, Chairman
Transportation Committee

EMK:jr

cc: G. H. Burger

DOE Form EV-618
(11-77)
10 CFR 71

U.S. DEPARTMENT OF ENERGY
CERTIFICATE OF COMPLIANCE
For Radioactive Materials Packages

1a. Certificate Number 9855	1b. Revision No. 1	1c. Package Identification No. USA/9855/B(U)(DOE-OR)	1d. Page No. 1	1e. Total No. Pages. 2
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2. PREAMBLE

- 2a. This certificate is issued to satisfy Sections 173.393a, 173.394, 173.395, and 173.396 of the Department of Transportation Hazardous Materials Regulations (49 CFR 170-189).
- 2b. The packaging and contents described in item 5 below, meets the safety standards set forth in Subpart C of Title 10, Code of Federal Regulations, Part 71, "Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions."
- 2c. This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.

3. This certificate is issued on the basis of a safety analysis report of the package design or application--

(1) Prepared by (Name and address):

(2) Title and identification of report or application:

(3) Date: July 1982

Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, TN 37830

Safety Analysis Report for Packaging:
The ORNL DOT-6M Type B
Special Form Packaging
Report ORNL/TM-8340

4. CONDITIONS

This certificate is conditional upon the fulfilling of the requirements of Subpart D of 10 CFR 71, as applicable, and the conditions specified in item 5 below.

5. Description of Packaging and Authorized Contents, Model Number, Frangible Class, Other Conditions, and References:

a. Packaging

(1) Model No.: DOT-6M Type B-Special Form

(2) Description

Metal packaging as described and constructed in accordance with DOT Specification 6M (49 CFR 178.104), 10-gallon size.

b. Contents:

(1) Type and Form of Material:

(a) Fissile and nonfissile, solid radioactive materials which will not decompose at temperatures up to 250°F.

(b) Radioactive material is encapsulated in a metal capsule meeting the special form definitions of:

1 U.S. Department of Transportation Regulations, 49 CFR 173.403(z) and

5a. Date of Issuance: April 12, 1957

5b. Expiration Date: April 30, 1989

FOR THE U.S. DEPARTMENT OF ENERGY

7a. Address (of DOE Issuing Office)

U.S. Department of Energy
P.O. Box E
Oak Ridge, Tennessee 37830

7b. Signature, Name, and Title (of DOE Approving Official)

William A. Pryor
William A. Pryor
Safety & Environmental Control Division

- 2 International Atomic Energy Agency Safety Series No. 6, Regulations for the Safe Transport of Radioactive Materials, 1973 Revised Edition (As Amended), Part 135.

Capsules are individually leak tested during fabrication per ANSI N542, procedure A2.2.1 (ethylene glycol-vacuum technique) or equivalent.

(2) Maximum quantity of material per package:

The maximum quantity of radioactive material is a Type B quantity for special form which is limited to:

- (a) Up to 10 watts of thermal decay energy,
- (b) Fissile materials are further limited to 15 g, and
- (c) The authorized external radiation levels specified within the regulations of the U.S. Department of Transportation 49 CFR 173.441.

(3) Restrictions

Due to the lack of radiation shielding, the following radionuclides are excluded:

^{60}Co , ^{192}Ir , ^{137}Cs , ^{90}Sr , and other radionuclides emitting similar levels of penetrating radiation.

APPENDIX D

OAK RIDGE NATIONAL LABORATORY

OPERATIONS DIVISION

PROCEDURES FOR PACKAGING AND LEAK TESTING

SPECIAL FORM CAPSULES AND TYPE B PACKAGES

OPERATIONS DIVISION RADIOISOTOPE DEPARTMENT

BUILDING 3038
RADIOISOTOPE PACKING AND SHIPPING
OAK RIDGE NATIONAL LABORATORY
RADIOISOTOPE PACKAGING AND SHIPPING PROCEDURE
OPERATIONS DIVISION

PROC. NO. 1
PAGE 1 OF 3
DATE 6/30/80

PROCEDURE FOR APPROVAL TO SHIP RADIOACTIVE MATERIAL

1. All requests to ship radioactive material are first referred to the SS Materials Management Department or to the Isotopes Sales Office for approval [reference: *Isotopes Sales Operating Manual* and the *Nuclear Materials Management Manual*, ORNL-2800 (Revised)].
2. Radioactive Materials Packaging Form (UCN-12301) is completed by the requester and attached to the Special Works data sheet (UCN-1784) or the SS Accountability document (UCN-2681). The supervisor of the Radioisotope Packing and Shipping operation reviews the information provided and flags all shipping documents for shipments requiring Type "B" shipping containers.
3. Documentation of requests for shipping radioactive materials with half-lives >14 days is submitted two full working days before the scheduled shipping date to give adequate time for review of package documentation and approval of the shipment.
4. Documentation of requests for shipment of radioactive material with a half-life of <14 days must be submitted by 1:00 p.m. on the day before the scheduled shipping date.
5. The review of packaging documentation follows the procedure established in *ORNL Guide for the Packaging of Radioactive Materials for Transport*, and *Nuclear Materials Management Manual*, ORNL-2800 (Revised).
6. A Radioactive Materials Packaging Form (UCN-12301) is required for all returnable container shipments (empty or full) and for all shipments containing >1 mCi alpha or >3 Ci beta/gamma.

PACKING AND SHIPPING PROCEDURE

1. The supervisor of the Radioisotope Packing and Shipping Operation (RPSO) receives approved shipping documents UCN-2775 (3 3-79) from the SS Materials Management and Isotopes Sales Group by 1:00 p.m. on the day before the shipment is scheduled to leave ORNL.
2. The RPSO supervisor reviews each shipping document and the Radioactive Materials Packaging Form and reports any discrepancies to the Process Group Leader for action. In the absence of the Group Leader, discrepancies in the documentation are reported to the Radioisotope Department Superintendent for action.

APPROVED.

SUPERVISOR
R. D. Johnston

PROCESS GROUP LEADER

G. W. Schuch

DATE
6/30/80

OPERATIONS DIVISION
RADIOISOTOPE DEPARTMENT
BUILDING 3038

PROC. NO. 1
PAGE 2 OF 3
DATE 6/30/80

RADIOISOTOPE PACKING AND SHIPPING
OAK RIDGE NATIONAL LABORATORY
RADIOISOTOPE PACKAGING AND SHIPPING PROCEDURE
OPERATIONS DIVISION

3. All shipping documents flagged as Type "B" are separated by the RPSO supervisor and handled on a personal basis until the unit is properly loaded on the transporting vehicle. He then signs the Radioactive Materials Packaging Form (UCN-12301) and immediately returns all completed documents to the Process Group Leader for a final review.
4. In the absence of the RPSO supervisor, the relief supervisor brings all shipping documents to the Process Group Leader for review and identification of shipments that require special attention of the relief supervisor.

GENERAL REGULATIONS

1. Short half-life materials (<14 days) are shipped on Tuesday and Friday of each week. Special schedules can be arranged for holiday weeks. Medical isotopes are shipped when required.
2. Long half-life materials (>14 days) are shipped on Wednesday and Thursday of each week. Shipments weighing greater than 300 lb are shipped on Friday unless special arrangements are made.
3. All packages received at Building 3038 Packing and Shipping Room must meet ORNL *Health Physics Manual* Chapter 4.2 requirements concerning internal transfers of radioactive materials and must meet DOT shipping regulations for external radiation (<200 mrem/hr at the surface and 10 mrem/hr at 3 feet). The RPSO supervisor must be notified by the originator of the shipment when he delivers his package to Building 3038.
4. For each package, bottle of product, source, target, or other form of radioactive material taken to Radioisotope Packing and Shipping, a copy of the Special Work Order or a note must be attached to the container with the following information:
 - A. Quantity of radioactivity actually being shipped.¹
 - B. Chemical form.
 - C. Concentration of radionuclide in solution, mCi/ml.
 - D. Volume or product weight.
 - E. Specific activity¹ (list as "C.F." for carrier free where applicable).
 - F. Assay date and time.¹

APPROVED

SUPERVISOR

PROCESS GROUP LEADER

DATE

6/30/80

OPERATIONS DIVISION
RADIOISOTOPE DEPARTMENT
BUILDING 3038

RADIOISOTOPE PACKING AND SHIPPING
OAK RIDGE NATIONAL LABORATORY
RADIOISOTOPE PACKAGING AND SHIPPING PROCEDURE
OPERATIONS DIVISION

PROC. NO. 1
PAGE 3 OF 3
DATE 6/30/80

G. Normality of solutions of acids and bases.

H. Radiochemical purity.²

¹Unprocessed reactor and cyclotron targets are not assayed; therefore, quantity of radioactivity is calculated in these cases. Cyclotron target strip solutions should be analyzed for quantity of product radioisotope prior to shipment.

²In the case of short-lived radioisotopes, radiochemical purity assay results may be furnished after the shipment is made.

In the case of partial shipments of products listed on the Special Work Order a copy of the Special Work Order must be furnished with each partial shipment, and the items on the Special Work Order not being shipped must be marked out.

An Isotope Product Card (UCN-6216) must be filled out for every radioisotope product solution. In the case of product solutions loaded in shipping containers outside of Radioisotope Packing and Shipping, a completed copy of this form must be submitted with the product container to the Packing Supervisor with a copy to the Isotopes Sales Office.

5. The packaging and shipment of radioisotopes shall follow the *Procedures for Packaging and Shipment of Radioactive Materials Building 3038* and *ORNL Guide for the Packaging of Radioactive Materials for Transport*.

APPROVED:

SUPERVISOR

PROJECT GROUP LEADER

DATE
6/30/80

OAK RIDGE NATIONAL LABORATORY RADIOACTIVE MATERIALS PACKAGING CERTIFICATION

THIS FORM IS REQUIRED FOR ALL RADIOACTIVE SHIPMENTS AND ALL EMPTY RETURNABLE CONTAINERS

(Routine Type A Shipments Packaged by Process Group Personnel are Exempt)

GENERAL INFORMATION

1. Origin (Division)	2. Destination
3. Method of Transport	4. Weight
5. Special Instructions	

Special Instructions Complied by

RADIOACTIVE CONTENTS

1. All major activities in curies and/or grams	
2. ☐ Analyzed?	☐ Calculated?
3. Specify (a) ☐ Normal Form (b) ☐ Special Form (c) ☐ Fissile (d) ☐ Non-Fissile	
4. Radioactive Material Form: ☐ Solid ☐ Liquid ☐ Gas	
5. Heat Load (watts): Calculated _____ Estimated _____ By _____	

INTERNAL CONTAINER

1. Internal Containment: ☐ Glass Bottle ☐ Plastic Bottle ☐ "2R" ☐ Conoseal ☐ Welded Capsule (specify capsule material) _____ ☐ Other (explain) _____	
2. Contamination level on internal container: Estimated _____	Smeared _____
3. Radiation level from internal container: Measured _____	Calculated _____
4. Gaskets or seals (valves) properly installed _____	By _____
5. Leak tests of internal container _____	By _____
6. Packaging schematic attached _____	By _____

EXTERNAL CONTAINER

1. Moderator and neutron absorber present for fissile materials?	☐ Yes	By _____
2. External container examination	☐ Yes	By _____
3. Gaskets or seals properly installed	☐ Yes	By _____
4. Leak test	☐ Yes	By _____
5. Bolts torqued to _____ ft. lbs.		By _____
6. Tie down to skid checked	☐ Yes	By _____
7. Tamper seal installed	☐ Yes	By _____
8. Lid eye bolt removed and wire to the outside of the carrier	☐ Yes	By _____
9. Packaging schematic attached	☐ Yes	By _____

SHIPPING CONTAINER

1. Certificate of Compliance No. USA-
2. DOT Specification No.

RADIATION SURVEY

1. Surface contamination level: Alpha _____ dpm; Beta/Gamma _____ dpm
2. External radiation level _____ mrem/hr @ contact
3. Domestic shipments _____ mrem/hr @ 3 ft. from surface
4. Foreign shipments _____ mrem/hr @ 1 meter from center
5. Health Physics Surveyor _____ Date _____

TRUCK TIE-DOWN AND SHORING

1. Tie-down in accordance with SARP and Designed Layout checked by _____ (Inspection Engineering)
2. Shoring check by (if required) _____

Certifies Packaging Data is Correct for Shipment

Date

OPERATIONS DIVISION
RADIOISOTOPE DEPARTMENT
BUILDING 3029

SOURCE DEVELOPMENT LABORATORY
LEAK TESTING PROCEDURE FOR RADIOACTIVE MATERIALS
CONTAINED IN SPECIAL FORM CAPSULES

PROC. NO. 31
PAGE 1 OF 3
DATE 2/26/82

I. Leak Testing

A. General

All radioactive materials contained in Special Form or DOT 2R capsules are leak tested before shipment. The method used is the air bubble, vacuum, and glycol as described in ANSI Standard N14.5 A3.6.

B. Equipment

1. The leak test equipment consists of a glass test chamber with a removable sealable top. A line penetrates the top and is connected to an in-cell vacuum pump. The size and shape of the test chamber may vary with the design of the piece being tested; and must be large enough that the piece can be completely immersed in the test liquid, leaving at least one inch of test liquid above the weld area.
2. Racks, suspension assemblies, or similar positioning devices may be required for some radioactive sources. These will be designed so as not to interfere with observation of the weld area during testing.
3. Unless otherwise specified, the test liquid for liners is distilled water. The final test liquid for radioactive sources is ethylene glycol. The final leak test has a sensitivity greater than 1×10^{-6} at.cm³/sec.

C. Procedure

1. The test chamber is filled with test liquid to a depth sufficient to cover the piece being tested and leave at least one inch, but not more than three inches, of test liquid above the weld area when the piece is in the test position.
2. The top is placed on the test chamber and a vacuum of at least 20 inches Hg is imposed.
3. The piece, and especially the weld area, is observed for 30 seconds while the vacuum is maintained. A leak is indicated by a steady stream of air bubbles coming from a fixed point on the source.
4. After the 30-second observation the vacuum is relieved; then the piece is removed from the test chamber.

APPROVED:

SUPERVISOR

PROCESS GROUP LEADER

DATE

2/26/82

OPERATIONS DIVISION
RADIOISOTOPE DEPARTMENT
BUILDING 3029

PROC. NO. 31
PAGE 2 OF 3
DATE 2/26/82

SOURCE DEVELOPMENT LABORATORY
LEAK TESTING PROCEDURE FOR RADIOACTIVE MATERIALS
CONTAINED IN SPECIAL FORM CAPSULES

-
-
- a. Leaking pieces are rejected and defueled.
- b. Non-leaking pieces are transferred to the furnace testing area.

APPROVED:

SUPERVISOR

J. H. Moore

PROCESS GROUP LEADER

R. W. Schuch

DATE

2/26/82

OPERATIONS DIVISION
RADIOISOTOPE DEPARTMENT

BUILDING 3029

SOURCE DEVELOPMENT LABORATORY

QUALITY ASSURANCE PROCEDURE FOR TYPE B SHIPPING CONTAINERS

PROC. NO. 24
PAGE 1 OF 7
DATE 4/19/82

Incoming Type B Containers

1. Container is opened under the supervision of the Packing Foreman and a representative of the Health Physics Division. Radiation readings and smear levels on the external and internal surfaces are recorded. These records are stored in the auditable Quality Assurance (QA) file in Building 3029.
2. If container is contaminated externally or internally, it is cleaned to ORNL smear tolerance of 500 dis/min beta-gamma or 30 dis/min alpha. The final smear level is recorded by Health Physics and placed in the container's QA file.
3. If the radiation level internally or externally is greater than 1 mr/hr beta-gamma or 500 dis/min alpha, the container is to be decontaminated to the above tolerance. If decontamination efforts fail, the container is tagged out of service and the Department Head is notified in writing of the status. A copy of the notification is placed in the container's QA file. EXCEPTION: Uranium carriers may read up to 10 mrem/hr internally or externally.

4. Fire Shields

The RSPO Foreman will visually inspect all fire shields for cracks in the wood, protective coatings, foam glass, and/or steel covers. Defects in these items are to be recorded in the container's QA file and a blanket work order issued immediately to repair same. A copy of the blanket work order and the copy of the completed work order are to be placed in the container's QA file. An inspection of the repair work is to be made by the RSPO Foreman and a record of acceptance placed in the container's QA file.

Outgoing Type B Containers

1. Shielded Containers

- a. A soap bubble test will be performed by operating personnel and recorded in the container's QA file in Building 3029 before the container can be used for loading encapsulated radioactive material.
- b. An Inspection Engineering report on the internal weld dye penetrant inspection is valid for 6 months prior to shipment. If inspection is over 6 months old, a new dye penetrant inspection of the internal welds must be made and the results recorded in the QA file. All repairs will be inspected and approved by Inspection Engineering and recorded in the QA file.

APPROVED:

SUPERVISOR

UCN-12530A (3 4-77)

PROCESS GROUP LEADER

DATE

4/19/82

OPERATIONS DIVISION
RADIOISOTOPE DEPARTMENT
BUILDING 3029

PROC. NO. 24
PAGE 2 OF 2
DATE 2/26/82

SOURCE DEVELOPMENT LABORATORY
QUALITY ASSURANCE PROCEDURE FOR TYPE B SHIPPING CONTAINERS

- c. Gaskets will be changed every 6 months and recorded in the container's QA file. Gasket material from stores stock must be verified by the store stock number.

2. Fire Shields

Fire shield lids and bolting devices will be inspected before shipment by the Packing Foreman to insure proper fit of the locking mechanism to hold the lid securely in place during transit. A record of this inspection is to be placed in the container's QA file. All repairs are to be made before shipment and the blanket work order with its completed form is to be filed in the container's QA file.

APPROVED

SUPERVISOR

PROCESS GROUP LEADER

DATE

2/26/82

**OPERATIONS DIVISION
RADIOISOTOPE DEPARTMENT**
BUILDING 3029

PROC. NO. 24
PAGE 6 OF 7
DATE 4/16/82

SOURCE DEVELOPMENT LABORATORY
QUALITY ASSURANCE PROCEDURE FOR TYPE B SHIPPING CONTAINERS

CONTAINER INSPECTION SHEET

Date _____ Container Number _____

EXTERNAL INSPECTION

By _____

Smeared _____ dpm $\beta\gamma$; _____ dpm alpha

Condition Good Fair Poor

Repairs Needed _____

Action Taken _____

INTERNAL INSPECTION

By _____

Smeared _____ dpm $\beta\gamma$; _____ dpm alpha

Decontaminated: Yes No By _____

CONTAINER TESTING

Soap Bubble Test _____ Gaskets _____

Weld Dye Check _____ Bolts & Lock Washers _____

Repairs Made _____

RE-TESTING

Soap Bubble Test _____

Weld Dye Check _____

CONTAINER CERTIFIED FOR SHIPMENT - Date _____

By _____

APPROVED:

SUPERVISOR

J. H. Moore

PROCESS GROUP LEADER

R. W. Schuch

DATE

4/16/82

APPENDIX E

DRAWINGS AND SPECIFICATIONS

A

NO REPRESENTATION OR WARRANTY EXPRESSED OR IMPLIED IS MADE THAT THE USE OR DISCLOSURE OF ANY INFORMATION APPARATUS METHOD OR PROCESS DISCLOSED IN THESE DRAWINGS MAY NOT INFRINGE PRIVATE RIGHTS OF OTHERS. NO LIABILITY IS ASSUMED WITH RESPECT TO THE USE OF OR FOR DAMAGES RESULTING FROM THE USE OF ANY INFORMATION APPARATUS METHOD OR PROCESS DISCLOSED IN THESE DRAWINGS. THE DRAWINGS ARE TO BE MADE AVAILABLE FOR INFORMATION TO BIDDER AND ARE NOT TO BE USED FOR OTHER PURPOSES. THEY ARE TO BE RETURNED UPON REQUEST OF THE FORWARDING CONTRACTOR.

§ 178.104 Specification 6M; metal packaging.

§ 178.104-1 General requirements. (a) Each package must meet the applicable requirements of § 173.24

§ 178.104-2 Rated capacity. (a) Rated capacity as marked (see § 178.104-5) Not less than 10 gallons nor more than 110 gallons for the outer steel drum. Not less than 124 liters for the inner containment vessel

§ 178.104-3 General construction requirements. (a) The outer shell must be of straight-sided steel, with welded body seams, and may be either a single sheet of steel, or may be fabricated by welding together two appropriate lengths of drums, such as a DOT Specification 6C or 17C, with each length to contain 3 swedged or rolled rolling hoops as prescribed for either of these specifications. A removable head for a packaging of 210 liters (55 gallons) or larger volume must have one or more corrugations in the cover near the periphery. For a packaging exceeding 57 liters (55 gallons) volume, the head must be crowned (convexed), not extending beyond the level of the chime, with a minimum convexity of 1 centimeter ($\frac{3}{8}$ -inch).

(1) The maximum authorized gross weight, metal thickness, and minimum end insulation thickness for the marked volume is as follows:

Marked capacity		Maximum authorized gross weight		Minimum thickness of uncoated sheets and heads (gauge)	Minimum thickness of end insulation	
Gallons not over	Liters	Pounds	Kilograms		Inches	Centimeters
15	57	160	73	20	1.88	4.7
30	114	480	219	18	3.75	9.5
55	210	640	292	16	3.75	9.5
110	420	640	292	16	3.75	9.5

(2) Each drum must have at least four 1.2 centimeter (0.5-inch) diameter vents near the top, each covered with a weatherproof tape or fusible plug, or equivalent device.

(b) Inner containment vessel must conform to specification 2R or equivalent (cast iron or brass are prohibited), with maximum usable inside diameter of 13.3 centimeters (5.25 inches), minimum usable inside diameter of 10 centimeters (4 inches), and minimum height of 15 centimeters (6 inches).

(c) Inner containment vessel must be fixed within the outer shell by one of the following types of solid centering media, with the sides of the inner vessel protected by at least 9.5 centimeters (3.75 inches) of insulation media, and the ends with at least the thickness as prescribed in § 178.104-3(a)(1).

(1) Machined discs and rings made of solid industrial cane fiberboard having a density of at least 0.24 g/cc (15 pounds per cubic foot) fitted such that the radial clearances between the fiberboard, inner vessel, and shell do not exceed 6 millimeters ($\frac{1}{4}$ -inch), or

(2) Hardwood or plywood at least 1.2 centimeter ($\frac{1}{2}$ -inch) thick, having a density of at least 0.45 g/cc (28 pounds per cubic foot). There must be no gap or direct heat path from the shell to the inner vessel.

(d) Any radiation shielding material used must be placed within the inner containment vessel or must be protected in all directions by at least the thickness of the thermal insulating material prescribed in paragraph (a) of this section.

(e) For a packaging having an authorized gross weight in excess of 219kg (480 pounds), a steel bearing plate, at least 6 millimeters (0.25-inch) thick or a plywood disc, at least 2.5 centimeters (1 inch) thick, and at least 25 centimeters (10 inches) in diameter must be provided at both ends and adjacent to the specification 2R inner containment vessel, to provide additional load-bearing surface against the insulation-centering medium.

§ 178.104-4 Closure. (a) The outer drum closure must be at least 16-gauge bolt-type locking ring having at least a $\frac{5}{16}$ -inch steel bolt for drum sizes not over 15 gallons, or a 12-gauge bolted ring with drop-forged lugs, one of which is threaded, and a $\frac{5}{8}$ -inch steel bolt for drum sizes over 15 gallons. Each bolt must be provided with a lock nut or equivalent device.

(b) The closure device must have means for the attachment of a tamperproof lock wire and seal, or equivalent.

§ 178.104-5 Markings. (a) Marking must be as prescribed in § 173.24.

(b) Marking on the outside of each package must be as follows: "DOT-6M Type B," "Radioactive Materials," or "Fissile Radioactive Materials," as appropriate, and the gauge of metal of the outer drum in the thinnest part, rated capacity of the outer drum in gallons, and year of manufacture (for example, 18-30-69). When the gauge of the metal in the drum wall differs from that in the head, both must be indicated with a slanting line between, and with the gauge of the body indicated first (e.g., 18/16-55-69 for 18-gauge body and 16-gauge head).

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