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**INSPECTION, TESTING, AND OPERATING
REQUIREMENTS FOR THE PACKAGING AND
SHIPPING OF URANIUM TRIOXIDE IN 55-GALLON
DEPARTMENT OF TRANSPORTATION (DOT)
SPECIFICATION 6M SHIPPING PACKAGINGS**

D. V. TOOMER

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IDAHO NATIONAL ENGINEERING LABORATORY

Managed by the U.S. Department of Energy

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*Prepared for the
U.S. Department of Energy
Idaho Operations Office
Under DOE Contract No. DE-AC07-84ID12435*

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TABLE OF CONTENTS

1.	INTRODUCTION	1
2.	SUMMARY	2
3.	DOT SPECIFICATION 6M SHIPPING PACKAGING LEAKAGE EVALUATION	3
4.	QUALITY CONTROL REQUIREMENTS	6
4.1	Inspection Requirements for Packagings with Full Documentation .	6
4.2	Inspection and Testing Requirements for Packagings without Full Documentation	7
4.3	Periodic Inspection Requirements	8
4.3.1	Preloading Inspections	8
4.3.2	Annual Inspections	8
5.	OPERATING REQUIREMENTS	9
6.	BASIC OPERATING PROCEDURES	14
6.1	Loading of UO_3 Material into Primary Containers	14
6.2	Loading of the 2R Inner Container and 6M Packaging	14
6.3	Shipping of Loaded 6M Packages	16
6.4	Receipt and Unloading of 6M Packages	16
7.	REFERENCES	17

FIGURES

1.	PACKAGING ARRANGEMENT OF 2R INNER CONTAINER	11
2.	CENTER SPACER PLATE	12
3.	END SPACER PLATE	13

TABLES

1. SUMMARY OF CALCULATIONS	5

APPENDIXES

A. RELATIONSHIP BETWEEN SAND88-3005 REQUIREMENTS AND IMPLEMENTING SECTION/STEP OF THIS DOCUMENT	A-1
B. CASES ANALYZED	B-1
C. MINIMUM INSPECTION REQUIREMENTS FOR 6M SHIPPING PACKAGINGS	C-1
D. UNIAXIAL STATIC FORCE AND LEAK TESTS FOR 2R INNER CONTAINERS	D-1

INSPECTION, TESTING, AND OPERATING REQUIREMENTS
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1. INTRODUCTION

This document identifies the inspection, testing and operating requirements for the packaging, loading, and shipping of uranium trioxide (UO_3) in 55-gallon DOT Specification 6M shipping packagings from the Idaho Chemical Processing Plant (ICPP).

Compliance with this document assures established controls for the purchasing, packaging, loading, and shipping of DOT Specification 6M shipping packagings are maintained in strict accordance with applicable Code of Federal Regulations (CFRs) and Department of Energy (DOE) Orders.

This document also implements the requirements for the use of DOT Specification 6M packagings as identified by Troy E. Wade II Memorandum, "Resolution of Issues Regarding the Department of Transportation (DOT) Specification 6M Package and 2R Inner Vessel", dated January 24, 1989¹; and Thomas B. Hindman, Jr. Memorandum, "Clarification of Issues About the Department of Transportation (DOT) Specification 6M Package and 2R Inner Vessel", dated February 21, 1989². These memorandums require all Type B radioactive material shipments in 6M packagings be packaged in accordance with the applicable requirements of Sandia report SAND88-3005, "A Review of the Safety Features of 6M Packagings for DOE Programs," September 1988³. The applicable requirements include the Operating Procedures (Chapter 7, Modules 7.4, 7.5, and 7.6), Acceptance Tests and Maintenance Program (Chapter 8), and Quality Assurance (Chapter 9) of SAND88-3005.

If it is not possible for a specific facility to implement the requirements of SAND88-3005, the memorandums require the facility to document an approach that provides equivalent protection in order to make Type B radioactive material shipments in DOT Specification 6M packagings. This document identifies an approach that provides equivalent protection to that described in SAND88-3005 for the packaging of UO_3 in DOT Specification 6M packagings from the ICPP. Appendix A is a tabulation of the SAND88-3005 requirements and identifies the section of this document that implements them.

Compliance with this document is ensured by the performance of audits and/or inspections by the WINCO Quality Assurance (QA) Department and control of materials, equipment, and processes as required by the WINCO Quality Assurance Program Manual (QAPM), developed in accordance with ANSI/ASME NQA-1 and DOE Order 5700.6C.

2. SUMMARY

The packaging array identified in this document meets all DOT and DOE regulations and requirements for the shipping of uranium trioxide (UO_3) from the Idaho Chemical Processing Plant (ICPP) in DOT Specification 6M packagings. The packaging array and the requirements of this document also meet the applicable SAND88-3005 requirements with the following exceptions:

1. SAND88-3005 requires a leak test be performed on a loaded 2R inner container.

Leak testing of a 2R inner container containing the packaging array identified in this document is not required. Calculations demonstrate that the Maximum Permissible Leakage Rates and the Reference Air Leakage Rates, during both normal and accident conditions of transport, (as defined in ANSI N14.5-1987 Section 5) of the packaging array are such that ANSI N14.5 exempts the package from leak testing.

In addition to the calculations, 30-foot drop and puncture tests, as described in 10 CFR 71.73, were also performed on the packaging array to provide additional data. These tests showed⁴ that, although some damage did occur to the bottles and cans containing the material, no detectable material was released to the inside of the 2R inner container.

2. SAND88-3005 requires that "G. E. Silicone Hi-Temp Gasket Material" be used as a luting compound, and that the luting compound be allowed to cure for approximately 10 to 12 hours prior to performing leak tests of a loaded 2R inner container.

This document allows the use of other luting compounds or vacuum grease as long as they meet applicable DOT requirements. A curing time is not specified since leak testing of a loaded 2R inner container is not required (item #1 above).

3. SAND88-3005 requires the cap/plug of a loaded 2R inner container be torqued to 100 foot-pounds.

This document requires the cap/plug of a loaded 2R inner container be torqued to 15 foot-pounds. This requirement, along with requiring that at least five threads of the 2R inner container be engaged when the cap/plug is securely tightened as required by DOT requirements, ensures adequate sealing of the 2R inner container. Since leak testing of a loaded 2R inner container is not required (item #1 above), torquing of the cap/plug to 100 foot-pounds is not necessary.

The Quality Control Requirements identified in this document ensure that DOT Specification 6M shipping packagings are designed and fabricated in accordance with applicable regulations and are maintained in good condition. These requirements, along with the identified Operating Requirements (Section 5 of this document) and Basic Operating Procedures (Section 6 of this document) which are incorporated into the formal operating procedures, ensure that the shipping of UO_3 in DOT Specification 6M packagings is performed safely and successfully.

3. DOT SPECIFICATION 6M SHIPPING PACKAGING LEAKAGE EVALUATION

Radioactive material shipping packagings are required to retain their contents during both normal and accident conditions of transport. To ensure this, ANSI N14.5 Section 5, "Package Containment Requirements and Maximum Permissible Leakage Rates", and Section 6, "Containment System Test Requirements", are used to determine the maximum permissible leakage rates and testing requirements for a containment system. The containment system for the shipping of ICPP uranium trioxide (UO_3) in a DOT Specification 6M shipping packaging (hereafter called the ICPP packaging array) is considered to be the components of a UO_3 package (i.e. product can consisting of a polyethylene bottle, bag, and outer can) and the 2R inner container of a 6M packaging.

In order to identify the testing requirements of a containment system, as required by ANSI N14.5 Section 6, the Maximum Permissible Leakage Rates and the Reference Air Leakage Rates for both normal and accident conditions of transport, as identified by ANSI N14.5 Section 5.3 and Section 5.4 respectively, of the containment system must be determined. To determine these rates, ANSI N14.5 Section 5.3.1 requires the "activity in the medium that could escape from the containment system", in Ci/cm^3 , (designated "Cn" for normal conditions of transport and "Ca" for accident conditions of transport) be determined first. Ca and Cn can be determined through calculation.

Once Cn and Ca are determined, the Maximum Permissible Leakage Rates for normal (Ln) and accident (La) conditions of transport, in cm^3/s , are calculated using formulas specified in ANSI N14.5 Section 5.3.2. The formula for calculating Ln cm^3/s is: $\text{Ln} = \text{Rn}/\text{Cn} \times 1/3600$, where "Rn" is the Maximum Permissible Release Rate for normal conditions of transport. Table 1, "Containment Requirements for Type B Packages", of ANSI N14.5 specifies Rn to be A_2E-6 per hour where " A_2 " is a value specified in 10 CFR 71 Table A-1. The formula for calculating La cm^3/s is: $\text{La} = \text{Ra}/\text{Ca} \times 1.65E-6$, where "Ra" is the Maximum Permissible Release Rate for accident conditions of transport. Table 1 of ANSI N14.5 specifies Ra to be A_2 in one week.

Once Ln and La are determined, the Reference Air Leakage Rate (Lr) is determined. ANSI N14.5 Section 5.4 specifies that Lr is "equivalent to the maximum of Ln or La". Lr is used to determine the testing requirements of a containment system. ANSI N14.5 Section 6.1 states that packages determined to have an Lr that is equal to or greater than 10 $\text{std cm}^3/\text{s}$, for both normal and accident conditions of transport, are exempt from the testing requirements of ANSI N14.5 Section 6, "Containment System Test Requirements".

A Lotus 1-2-3 spreadsheet model was used to conservatively calculate Cn and Ca for the ICPP packaging array⁵. The powder concentration, g/cm^3 , in the 2R inner container ("powder concentration, 2R, g/cm^3 " of the model) was assumed to be the amount of material that could escape from the containment system. Cn and Ca, for their respective conditions, were obtained by converting g/cm^3 to Ci/cm^3 by multiplying the g/cm^3 by $9.1E-5 \text{ Ci}/\text{g}$. This conversion factor is specified by 10 CFR 71 Table A-4 for 95% enriched uranium. 93.5% enrichment is the maximum allowed in a DOT Specification 6M packaging and is conservative for all of the ICPP UO_3 that will be shipped in DOT Specification 6M shipping packagings. Using the conversion factor for 95% enriched uranium in the calculations helps ensure the results are conservative. The Rn and Ra values used in the spreadsheet were based on the A_2 value of 0.1 Ci (for greater than 20% U-235) as identified in 10 CFR 71 Table A-1.

While calculating the Cn and Ca values, the spreadsheet model considered the geometrical arrangement of the ICPP packaging array and its content; an assumed initial temperature of the material and the rise in temperature due to the hypothetical accident event; and the assumption of a broken inner poly bottle(s) due to the hypothetical accident event. The uranium powder transfer function, used to determine the mass of UO_3 which mixes with the air in the package, was selected as $1.4E-6$ g/cm³ of air. This is based on report NUREG/CR-1302 PNL-3278, "Study of Plutonium Oxide Powder Emissions from Simulated Shipping Container Leaks," by Pacific Northwest Laboratory⁶. Since the particle size of the ICPP UO_3 is larger than that of the Plutonium Oxide powder used in the study, the powder transfer function is conservative for the ICPP UO_3 .

The calculations considered an array where the material was contained within a polyethylene bottle, which was enclosed in a single plastic bag and then enclosed in a metal can. One or two of these packages were then enclosed in the 2R inner container of the 6M shipping packaging. No allowance was made for the inclusion of spacers or cushioning material, which would limit the volume of available air in the 2R inner container, nor for the sealing of any of the containers (i.e. no credit was taken for reduced leakage through the containers caused by pore sizes or other restrictions. Airborne material was assumed to flow freely from one container to the other). Additional containment provided by the outer drum was also not considered in the calculations. To ensure that all probable loading arrangements were enveloped; the cases analyzed considered both accident and normal conditions of transport for 2R inner containers containing either one or two poly bottles loaded to ten or ninety percent of capacity.

The ambient air temperature of the material and packaging at time of loading was assumed to be 70 degrees Fahrenheit. The transport condition material centerline temperature was assumed to be either 150 degrees Fahrenheit for normal conditions or 270 degrees Fahrenheit (250 degrees centerline temperature plus a 20 degree temperature increase in the bottle) for accident conditions. The elevated temperature of the material was assumed to provide the driving force for the expansion of air and transport of material from the packaging. Air was assumed to be an ideal gas in the calculations.

Once the Cn and Ca values were calculated, the Ln/La and Lr values were calculated for the cases analyzed using the formulas specified in ANSI N14.5 Section 5.3.2.

In all cases (Appendix B), the Reference Air Leakage Rate (L_r) for the ICPP packaging array was determined to be greater than 10 std cm³/s and therefore the packaging array is exempt from the leak testing requirements of ANSI N14.5 Section 6 as allowed by that section. Results of the calculations are summarized in Table 1.

In addition to the calculations, the packaging array was subjected to 30-foot drop and puncture tests, as described in 10 CFR 71.73, to provide additional data. The tests were performed by Westinghouse Hanford Co. and showed⁴ that, although some damage did occur to the bottles and cans containing the material, no detectable material was released to the inside of the 2R inner container; and the packaging array is safe for shipping.

TABLE 1. SUMMARY OF CALCULATIONS

ACCIDENT CONDITIONS - BREACHED POLY BOTTLE(S)

Case #	Configuration	Container % Full	Uranium Wt. grams	Material Temp. F	Curies Leaking Through			Max. Permissible Leak Rate cm ³ /s
					Bag	Can	2R Vessel	
1	2 Poly Bottles	10	1,000	250	9.98E-08	2.90E-08	4.83E-09	2.68E+04
2	2 Poly Bottles	90	10,000	250	3.17E-08	2.93E-09	1.55E-10	2.65E+05
3	1 Poly Bottle	10	500	250	4.99E-08	1.45E-08	9.38E-10	6.89E+04
4	1 Poly Bottle	90	5,000	250	1.59E-08	1.47E-09	3.02E-11	6.81E+05

NORMAL CONDITIONS - INTACT POLY BOTTLE(S)

Case #	Configuration	Container % Full	Uranium Wt. grams	Material Temp. F	Curies Leaking Through				Max. Permissible Leak Rate cm ³ /s
					Bottle	Bag	Can	2R Vessel	
5	2 Poly Bottles	10	1,000	150	3.32E-08	1.54E-08	1.49E-09	8.25E-11	8.77E+01
6	2 Poly Bottles	90	10,000	150	3.69E-09	1.91E-10	2.04E-12	1.26E-14	6.39E+04
7	1 Poly Bottle	10	500	150	1.66E-08	7.72E-09	7.45E-10	1.60E-11	2.26E+02
8	1 Poly Bottle	90	5,000	150	1.84E-09	9.53E-11	1.02E-12	2.44E-15	1.64E+05

All cases considered uranium oxide powder as the material being shipped

The Maximum Permissible Leakage Rate (cm³/s) must be greater than or equal to 10 cm³/s for both normal and accident conditions for the package to be exempt from leak testing (ANSI N14.5-1987 Sec. 5.4 and 6.1)

4. QUALITY CONTROL REQUIREMENTS

Quality control of DOT Specification 6M shipping packagings must be maintained to ensure that a packaging used for the shipping of UO_3 from the ICPP is; properly designed and fabricated, will operate safely and successfully, and is maintained in its original condition. In order to ensure these items, each 6M packaging used for shipping must meet the Inspection Requirements for Packagings with Full Documentation (Section 4.1) or the Inspection and Testing Requirements for Packagings without Full Documentation (Section 4.2).

All inspections shall be conducted and documented in accordance with the applicable Quality Method and Procedure (QMP) of the WINCO Quality Assurance Program Manual (QAPM) and applicable sections of the WINCO Transportation of Hazardous Materials Requirements Manual (THM).

4.1 INSPECTION REQUIREMENTS FOR PACKAGINGS WITH FULL DOCUMENTATION

Each DOT Specification 6M shipping packaging shall be designed and built in strict accordance with 49 CFR 178.104 (Specification 6M) and 49 CFR 178.34 (Specification 2R). The following documentation (as a minimum) is required for each packaging:

- A certification of compliance by the manufacturer stating that the packaging was manufactured in strict accordance with applicable specifications and regulations.
- Certified Material Test Reports for: 2R tube, 2R cap, and 2R bottom plate
- Weld rod material certifications
- Welder certifications
- Weld procedure qualifications
- Certification for bearing plate material
- Certification for cane fiberboard/plywood
- Manufacturer's inspection checkoff sheets
- Manufacturer's certification of inspection

Each DOT Specification 6M shipping packaging shall be inspected by Quality Assurance inspectors to ensure that it is designed and built in strict accordance with 49 CFR 178.104 (Specification 6M) and 49 CFR 178.34 (Specification 2R). Appendix C of this document, "Minimum Inspection Requirements for DOT Specification 6M Shipping Packagings", shall be used to assist in the development of inspection plans for DOT Specification 6M shipping packagings.

The 2R inner containers of packagings that have successfully passed the inspections shall be marked as indicated below to indicate their acceptance.

DESIGN AND FABRICATION OF THIS CONTAINER IS FULLY DOCUMENTED
DATE - (Month/Year container passed inspection)

Packagings that successfully pass the inspections shall also be tagged to indicate their acceptance.

4.2 INSPECTION AND TESTING REQUIREMENTS FOR PACKAGINGS WITHOUT FULL DOCUMENTATION

Each DOT Specification 6M shipping packaging not meeting the documentation requirements of Section 4.1 of this document shall be inspected, prior to its initial use, by Quality Assurance inspectors to ensure that it is designed and built in strict accordance with 49 CFR 178.104 (Specification 6M) and 49 CFR 178.34 (Specification 2R). Appendix C, "Minimum Inspection Requirements for DOT Specification 6M Shipping Packagings", shall be used to assist in the development of inspection plans for each used DOT Specification 6M shipping packaging. A packaging with nonconforming items may be repaired, if possible, and reinspected as necessary to bring it into compliance with the requirements.

Packagings that fail the inspections, and cannot be repaired, shall be tagged to indicate their failure and shall be disposed of.

After successfully passing the inspections identified above, each packaging's 2R inner container must successfully pass a one-time-only uniaxial static force test and soap bubble leak test (Appendix D) as recommended in the DOE Container Weld Advisory Committee's final report prior to its initial use. These tests will be witnessed by Quality Assurance inspectors who will document their success/failure.

2R containers that fail either of the above tests shall be tagged to indicate their failure and shall be disposed of.

2R containers that successfully pass all of the tests shall be marked as indicated below to indicate their acceptance.

24,400 LBS. FORCE TEST - PASSED
LEAK TEST - PASSED
DATE (Month/Year container passed tests)

Packagings that successfully pass all of the inspections and tests shall be tagged to indicate their acceptance.

4.3 PERIODIC INSPECTION REQUIREMENTS

4.3.1 Preloading Inspections

Each DOT Specification 6M shipping packaging shall be visually inspected, by Production Department personnel trained on the inspection of 6M packagings, prior to loading to ensure the following:

1. The packaging has successfully passed the inspections/tests required by Section 4.1 or 4.2.
2. The packaging contains all the required components and that each component is in proper working order and has not deteriorated such that the intent of the component is compromised.

Those packagings not passing the above inspections shall be tagged out-of-service and shall not be used for shipping until the nonconforming items are corrected .

4.3.2 Annual Inspections

Each DOT Specification 6M shipping packaging shall be inspected, by Quality Assurance Inspectors, at least once annually to ensure the following:

1. The packaging has successfully passed the inspections/tests required by Section 4.1 or 4.2.
2. The packaging contains all the required components and that each component is in proper working order and has not deteriorated such that the intent of the component is compromised.

The annual inspections shall consist (where practical) of those items identified in Appendix C.

Nonconforming items discovered during the inspections shall be documented and those packagings with nonconforming items shall not be used for shipping until all nonconforming items are repaired or replaced.

If an annual inspection cannot be performed on a packaging when the inspection is due or it is deferred to an anticipated established length of time before the drums are to be used, the packaging shall be marked "ANNUAL INSPECTION NOT PERFORMED - DO NOT USE FOR SHIPPING" (or equivalent) and shall not be used for shipping until the inspection is performed.

5. OPERATING REQUIREMENTS

Operating controls for the packaging and shipping of UO_3 from the ICPP in DOT Specification 6M shipping packagings must be maintained to ensure that a packaging is properly loaded prior to shipment and is shipped in accordance with applicable regulations.

1. Only qualified personnel, whom are trained in the following activities, or personnel under the direct supervision of qualified personnel, shall perform the following activities:
  - A. Loading UO_3 into primary containers in preparation for shipment.
  - B. Loading of the 2R inner containers and reassembling a 6M packaging.
  - C. Shipping of loaded 6M packagings
  - D. Unloading of 6M packagings
2. Personnel shall wear the appropriate protective clothing, as determined by Health Physics personnel, during the 1) loading of UO_3 into primary containers, 2) loading of 2R inner containers and reassembling of 6M packaging, and 3) unloading of 6M packagings and 2R inner containers.
3. Each DOT Specification 6M shipping packaging shall be loaded in accordance with 49 CFR 173.417.
4. Only those packagings that have successfully passed the required inspections and tests, as described in Sections 4.1/4.2 and 4.3 of this document, shall be used for the shipping of UO_3 from the ICPP.
5. A nonhardening thread luting compound or vacuum grease, which is capable of withstanding a temperature of 149 degrees Centigrade (300 degrees F) without loss of efficiency, shall be used to seal the threads of the 2R inner container and its closure cap/plug.
6. At least five threads of the 2R inner container shall be engaged when the closure cap/plug is securely tightened. The closure cap/plug shall be torqued to a minimum of 15 foot-pounds.
7. Personnel loading the shipping container shall ensure that the 0.25-inch thick steel or 1-inch thick plywood bearing plate is at both ends and adjacent to the 2R inner container prior to closing the loaded drum.
8. The 6M packaging's closure ring shall have drop forged lugs, one of which is threaded, and shall be bolted closed with a 5/8-in steel bolt that is equipped with a lock nut.

9. A Tamper Indicating Device (TID) shall be accommodated at the drum closure.
10. The UO_3 material to be shipped shall be packaged in a 1 Qt. (3.5" x 6.5") polyethylene bottle and the lid of the bottle shall be taped closed to prevent the lid from inadvertently coming off. The bottle shall be placed in a plastic bag and heat sealed. The sealed bag and bottle shall be placed in a standard "Tall No. 3" (4.25" x 7") metal food can. The loaded can shall then be sealed with a mechanical can sealer. A UO_3 package (i.e. product can) contains approximately 5 kg of UO_3 .
11. A loaded 2R inner container shall not be loaded with more than two product cans stacked end-to-end.
12. Product cans shall be loaded into a 2R inner container as indicated in Figure 1. Silicone sponge material and aluminum spacer plates (Figures 2 & 3) shall be used to cushion the product cans inside the 2R inner container.
13. If only one product can is to be shipped, then an empty "Tall No. 3" metal food can shall be used as a spacer in place of the other normally loaded product can.

Figure 1.
Packaging Arrangement of 2R Container

ICPP A 17429
(5 91)

Figure 2.
Center Spacer Plate

ICPP A 17430
(5 91)

Figure 3.
End Spacer Plate

6. BASIC OPERATING PROCEDURES

The following "Basic Operating Procedures" are to be used as a guide for the development of formal operating procedures that direct 1) the loading of UO_3 into primary containers, 2) the loading of a 2R inner container and reassembly of a 6M packaging, 3) the shipping of a loaded 6M package and, 4) the receipt and unloading of 6M packages.

The loading and shipping of 6M packages containing UO_3 shall be in accordance with applicable CFRs, the "WINCO Transportation of Hazardous Material Requirements/Information Manual", and applicable procedures.

Verifications required in these basic procedures are required in the formal procedures.

6.1 LOADING OF UO_3 MATERIAL INTO PRIMARY CONTAINERS

1. The UO_3 material is packaged into a 1 Qt. polyethylene bottle. The lid of the bottle is screwed on and secured with tape. Proper loading and closing of the bottle is verified.
2. The can and lid to be used is inspected to ensure they are not damaged. Inspection of the can and lid are verified.
3. The loaded 1 Qt. bottle is "bagged out" of the glove box, where it was loaded, and is placed into the product can.
4. The lid of the can is sealed onto the can using a mechanical can sealer. Proper loading of the can is verified.
5. The can is visually inspected and proper sealing is verified. The can is surveyed and cleaned as necessary until no detectable radioactive contamination is present.
6. The loaded can is weighed and marked with a unique identifying number, the contents of the can, and other pertinent information.

6.2 LOADING OF THE 2R INNER CONTAINER AND 6M PACKAGING

1. The 6M packaging to be used is identified. Appropriate markings (name plate) and a current annual inspection of the packaging are verified.
2. All superfluous labels are removed from the packaging and the packaging is opened and the 2R inner container is removed. Appropriate markings on the 2R container (as identified in Section 4.1 or 4.2) are verified.
3. The vent holes and insulating rings of the packaging are inspected and are verified to be functional. The presence of the bottom steel/plywood bearing plate in the packaging is verified.

4. The 2R inner container is opened and loaded as shown in Figure 1. A maximum of two product cans are placed inside the 2R inner container. Proper loading of the 2R inner container is verified.
5. The threads of the 2R inner container and its cap/plug are visually inspected and verified to be undamaged.
6. An approved luting compound or vacuum grease is applied to the threads of the 2R inner container and its cap/plug in accordance with the manufacturer's instructions. The type of compound used is recorded and proper application of the compound is verified.
7. The cap/plug of the 2R inner container is installed and torqued to a minimum of 15-ft pounds. The 2R inner container is secured in a vise or other holding device if necessary to prevent it from slipping. Excess luting compound/vacuum grease is removed, and engagement of at least five threads and proper torque is verified.
8. The loaded 2R inner container is placed back in the packaging. Insulation rings and the top steel/plywood bearing plate are installed. Verifications that the 2R inner container is below the insulation rings and correct placement of the top bearing plate are performed.
9. The remaining insulation rings and lid are installed. An insulation-lid gap of less than 0.5" and proper assembly of the packaging is verified.
10. The lid closure ring is installed and secured with a 5/8" closure bolt.
11. The closure ring is tapped around its circumference with a rubber mallet several times while securing the closure bolt to ensure the ring is properly seated, and then the closure bolt is torqued to 45 - 50 ft pounds. Proper torquing of the bolt is verified. The closure bolt lock nut is installed and set.
12. A security seal (tamper indicating device) is installed on the closure ring/bolt.
13. The loaded package is surveyed for contamination and radiation. All detectable contamination is removed.
14. The Fissile Class II Transport Index (TI) is determined in accordance with 49 CFR 173.417.
15. The package is marked and labeled for storage and stored in an approved storage area.

6.3 SHIPPING OF LOADED 6M PACKAGES

1. The 6M package to be shipped is identified and its loading is rechecked and verified to be within the limits for a DOT Specification 6M packaging.
2. The Radiation Index (RI) for the package is determined and then the Transport Index (TI) for shipping the package is determined based upon the RI or the Fissile Class II TI, whichever is higher.
3. All superfluous labels are removed and the package is marked and labeled for shipment in accordance with applicable DOT requirements.
4. The package is shipped from the ICPP in accordance with the WINCO Transportation of Hazardous Material Requirements Manual and appropriate shipping procedures.

6.4 RECEIPT AND UNLOADING OF 6M PACKAGES

1. ICPP interdepartmental reviews and approvals of proposed shipments of material to the ICPP are performed prior to authorizing shipment of material to the ICPP.
2. Prior to shipping the material, the shipper provides the ICPP with an itemized listing which includes serial numbers of shipping packagings used, the security seal (tamper indicating device) number that was installed on each package, and the contents of each package.
3. Upon receipt of the shipment at the ICPP, radiation and contamination surveys of each package and the shipping vehicle are performed.
4. The packaging serial number, security seal number, and package contents are compared with the appropriate shipping papers and verified.
5. The locking ring and lid of a package is removed and the interior of the package and lid are surveyed for contamination.
6. The insulating rings are removed to allow access to the 2R inner container. Monitoring for contamination is performed during removal of the rings.
7. The 2R inner container is opened and radiation and contamination surveys of the container are performed.
8. The cans/bottles are removed from the 2R inner container and stored in the appropriate storage area. Radiation and contamination surveys of the can/bottles are performed during removal from the 2R.
9. The empty 2R inner container and packaging are surveyed and decontaminated as necessary. The entire packaging is reassembled and the appropriate empty tag is affixed to the packaging.

7. REFERENCES

1. Troy E. Wade II Memorandum, "Resolution of Issues Regarding the Department of Transportation (DOT) Specification 6M Package and 2R Inner Vessel", dated January 24, 1989
2. Thomas B. Hindman, Jr. Memorandum, "Clarification of Issues About the Department of Transportation (DOT) Specification 6M Package and 2R Inner Vessel", dated February 21, 1989
3. SAND88-3005, "A Review of the Safety Features of 6M Packagings for DOE Programs," Sandia National Laboratories, September 1988
4. WHC-SD-CP-TRP-043 Rev. 0, "Test Report for the 30 Foot Drop and Puncture Test of the Westinghouse Idaho Nuclear Co. DOT 6M Packaging," Westinghouse Hanford Co., July 1990
5. Letter, A. B. Christensen to D. V. Toomer, ABC-08-90, "UO₃ Release Estimates from 2R Containers", dated June 13, 1990
6. NUREG/CR-1302 PNL-3278, "Study of Plutonium Oxide Powder Emissions from Simulated Shipping Container Leaks," Pacific Northwest Laboratory, August 1980
7. Terrance M. Pierce Memorandum, "DOE Container Weld Advisory Committee Final Report", dated May 31, 1989

APPENDIX A

RELATIONSHIP BETWEEN SAND88-3005
REQUIREMENTS AND IMPLEMENTING SECTION/STEP OF THIS DOCUMENT

RELATIONSHIP BETWEEN SAND88-3005
REQUIREMENTS AND IMPLEMENTING SECTION/STEP OF THIS DOCUMENT

Loading of 2R Inner Container		
SAND88-3005 Reference	Requirement	Implementing Section/Step
7.4.1	Visually inspect 2R threads	6.2.5
7.4.2	Provide centering and cushioning for cans	6.2.4
7.4.3	Apply luting compound	6.2.6
7.4.4	Secure 2R in vise	6.2.7
7.4.5	Torque cap	6.2.7
7.4.6	Remove excess luting compound	6.2.7
7.4.7	Perform leak test	N/R

Final Assembly of 6M Package		
SAND88-3005 Reference	Requirement	Implementing Section/Step
7.5.1	Verify payload is within 6M limits	6.2.4
7.5.2	Inner pkg is metal can or polyethylene bottle	6.1
7.5.3	Visually inspect 2R threads	6.2.5
7.5.4	Verify luting compound is applied	6.2.4
7.5.5	Ensure cap is torqued	6.2.7
7.5.5	Ensure 2R is leak tested	N/R
7.5.6	Visually inspect drum	6.2.3
7.5.7	Verify vent holes are functional	6.2.3
7.5.8	Visually inspect celotex	6.2.3
7.5.9	Install 2R in celotex	6.2.8
7.5.10	Verify 2R is below celotex rings	6.2.8
7.5.11	Verify celotex-lid gap is less than 0.5"	6.2.9
7.5.12	Install and torque locking ring	6.2.11
7.5.13	Insure locking ring has lock nut	6.2.11
7.5.14	Install security seal	6.2.13
7.5.15	Verify correct name plate	6.2.1
7.5.16	Attach radioactive label and check TI is appropriate	6.3.2

Unpacking Procedures for the 6M Package		
SAND88-3005 Reference	Requirement	Implementing Section/Step
7.6.1	Verify package contents with shipping papers and serial number	6.4.5
7.6.2	Conduct radiation survey	6.4.3
7.6.3	Verify presence of security seal	6.4.5
7.6.4	Put on protective clothing	5.2
7.6.5	Remove locking ring	6.4.6
7.6.6	Perform survey on inside of drum lid	6.4.6
7.6.7	Remove some celotex rings, check for contam.	6.4.7
7.6.8	Remove 2R, check for contam. and radiation	6.4.8
7.6.9	Open 2R, remove cans or bottles, check for contamination and radiation	6.4.9
7.6.10	Reassemble and affix empty label	6.4.10

Acceptance Tests and Maintenance Program		
SAND88-3005 Reference	Requirement	Implementing Section/Step
Chapter 8	Acceptance tests ensure the packaging complies with design intent and federal regulations	Sect. 4

Quality Assurance		
SAND88-3005 Reference	Requirement	Implementing Section/Step
Chapter 9	A formal Quality Assurance (QA) organization and program must be established and QA oversight must be independent of operational organizations	Sect. 1 & 4

APPENDIX B
CASES ANALYZED

CASE #1

6M LEAKAGE CALCULATIONS - ACCIDENT CONDITIONS

PACKAGING CONFIGURATION = Two Breached Poly Bottles - 10% Full
MATERIAL BEING SHIPPED = Uranium Oxide Powder

		[-----CONFINEMENT DIMENSIONS-----]			
		1st	2nd	3rd	4th
		Bottle	Bag	Can	2R
DESCRIPTION OF CONFINEMENT BARRIER:	DIAMETER, INCHES	3.5	3.875	4.25	5
HEIGHT OF INNER CONTAINERS WHEN STACKED, INCHES		13	13.5	14	23
	% FULL OF POWDER	10	*	*	*
CALCULATED GAS VOLUMES, CM ³		1844.65	559.36	2695.24	4705.23
MATERIAL CENTERLINE TEMPERATURE, F		250			
AMBIENT AIR TEMPERATURE, F		70			
AIR TEMPERATURE INCREASE IN BAG AFTER FIRE, F		20			
AMOUNT OF MATERIAL LOADED, G		1,000			
MATERIAL A ₂ VALUE, CURIES		0.1			
MATERIAL SPECIFIC ACTIVITY, Ci/G		9.10E-05			
POWDER TRANSFER FUNCTION, G/CM ³ AIR		1.40E-06			
FRACTION OF A ₂ LEAKING THROUGH BAG AFTER FIRE		9.98E-07			
FRACTION OF A ₂ LEAKING THROUGH CAN AFTER FIRE		2.90E-07			
FRACTION OF A ₂ LEAKING THROUGH 2R AFTER FIRE		4.83E-08			
AIR IN BAG & BROKEN POLY BOTTLE, STEADY STATE, # MOLES		2.20E-04			
AIR IN BAG & BROKEN POLY BOTTLE, AFTER FIRE, # MOLES		1.59E-04			
AIR LEAKING FROM BAG, AFTER FIRE, # MOLES		6.02E-05			
AVERAGE AIR SPECIFIC VOLUME, CM ³ /# MOLE		1.30E+07			
AIR LEAKING FROM BAG, AFTER FIRE, CM ³		7.83E+02			
POWDER CONCENTRATION, BAG, AFTER FIRE, G/CM ³ AIR		4.16E-01			
POWDER LEAKING THROUGH BAG, AFTER FIRE, G		1.10E-03			
POWDER LEAKING THROUGH BAG, AFTER FIRE, Ci		9.98E-08			
POWDER CONCENTRATION, CAN, AFTER FIRE, G/CM ³ AIR		4.07E-07			
POWDER LEAKING THROUGH CAN, AFTER FIRE, G		3.19E-04			
POWDER LEAKING THROUGH CAN, AFTER FIRE, Ci		2.90E-08			
POWDER CONCENTRATION, 2R, AFTER FIRE, G/CM ³ AIR		6.77E-08			
POWDER LEAKING THROUGH 2R, AFTER FIRE, G		5.31E-05			
POWDER LEAKING THROUGH 2R, AFTER FIRE, Ci		4.83E-09			

PACKAGE CONTAINMENT REQUIREMENTS AND MAXIMUM PERMISSIBLE LEAKAGE RATES (per ANSI N14.5-1987)

(Ra) Criterion for accident conditions (Ci)	1.00E-01
(Ca) Activity/unit volume that could escape (Ci/cm ³)	6.16E-12
(La) Maximum permissible leak rate cm ³ /s (Ra/Ca)*1.65E-6	2.68E+04

CASE #2

6M LEAKAGE CALCULATIONS - ACCIDENT CONDITIONS

PACKAGING CONFIGURATION = Two Breached Poly Bottles - 90% Full
 MATERIAL BEING SHIPPED = Uranium Oxide Powder

		[-----CONFINEMENT DIMENSIONS-----]			
		1st	2nd	3rd	4th
		Bottle	Bag	Can	2R
DESCRIPTION OF CONFINEMENT BARRIER:	DIAMETER, INCHES	3.5	3.875	4.25	5
HEIGHT OF INNER CONTAINERS WHEN STACKED, INCHES		13	13.5	14	23
	% FULL OF POWDER	90	*	*	*
CALCULATED GAS VOLUMES, CM ³		204.96	559.36	2695.24	4705.23
MATERIAL CENTERLINE TEMPERATURE, F		250			
AMBIENT AIR TEMPERATURE, F		70			
AIR TEMPERATURE INCREASE IN BAG AFTER FIRE, F		20			
AMOUNT OF MATERIAL LOADED, G		10,000			
MATERIAL A ₂ VALUE, CURIES		0.1			
MATERIAL SPECIFIC ACTIVITY, Ci/G		9.10E-05			
POWDER TRANSFER FUNCTION, G/CM ³ AIR		1.40E-06			
FRACTION OF A ₂ LEAKING THROUGH BAG AFTER FIRE		3.17E-07			
FRACTION OF A ₂ LEAKING THROUGH CAN AFTER FIRE		2.93E-08			
FRACTION OF A ₂ LEAKING THROUGH 2R AFTER FIRE		1.55E-09			
AIR IN BAG & BROKEN POLY BOTTLE, STEADY STATE, # MOLES		6.98E-05			
AIR IN BAG & BROKEN POLY BOTTLE, AFTER FIRE, # MOLES		5.07E-05			
AIR LEAKING FROM BAG, AFTER FIRE, # MOLES		1.91E-05			
AVERAGE AIR SPECIFIC VOLUME, CM ³ /# MOLE		1.30E+07			
AIR LEAKING FROM BAG, AFTER FIRE, CM ³		2.49E+02			
POWDER CONCENTRATION, BAG, AFTER FIRE, G/CM ³ AIR		1.31E+01			
POWDER LEAKING THROUGH BAG, AFTER FIRE, G		3.49E-04			
POWDER LEAKING THROUGH BAG, AFTER FIRE, Ci		3.17E-08			
POWDER CONCENTRATION, CAN, AFTER FIRE, G/CM ³ AIR		1.29E-07			
POWDER LEAKING THROUGH CAN, AFTER FIRE, G		3.22E-05			
POWDER LEAKING THROUGH CAN, AFTER FIRE, Ci		2.93E-09			
POWDER CONCENTRATION, 2R, AFTER FIRE, G/CM ³ AIR		6.85E-09			
POWDER LEAKING THROUGH 2R, AFTER FIRE, G		1.71E-06			
POWDER LEAKING THROUGH 2R, AFTER FIRE, Ci		1.55E-10			

PACKAGE CONTAINMENT REQUIREMENTS AND MAXIMUM PERMISSIBLE LEAKAGE RATES (per ANSI N14.5-1987)

(Ra) Criterion for accident conditions (Ci)	1.00E-01
(Ca) Activity/unit volume that could escape (Ci/cm ³)	6.23E-13
(La) Maximum permissible leak rate cm ³ /s (Ra/Ca)*1.65E-6	2.65E+05

CASE #3

6M LEAKAGE CALCULATIONS - ACCIDENT CONDITIONS

PACKAGING CONFIGURATION = One Breached Poly Bottle - 10% Full
MATERIAL BEING SHIPPED = Uranium Oxide Powder

		[----CONFINEMENT DIMENSIONS----]			
		1st	2nd	3rd	4th
		Bottle	Bag	Can	2R
DESCRIPTION OF CONFINEMENT BARRIER:	DIAMETER, INCHES	3.5	3.875	4.25	5
	HEIGHT OF INNER CONTAINER, INCHES	6.5	6.75	7	23
	% FULL OF POWDER	10	*	*	*
CALCULATED GAS VOLUMES, CM ³		922.32	279.68	1347.62	6052.84
MATERIAL CENTERLINE TEMPERATURE, F		250			
AMBIENT AIR TEMPERATURE, F		70			
AIR TEMPERATURE INCREASE IN BAG AFTER FIRE, F		20			
AMOUNT OF MATERIAL LOADED, G		500			
MATERIAL A ₂ VALUE, Curies		0.1			
MATERIAL SPECIFIC ACTIVITY, Ci/G		9.10E-05			
POWDER TRANSFER FUNCTION, G/CM ³ AIR		1.40E-06			
FRACTION OF A ₂ LEAKING THROUGH BAG AFTER FIRE		4.99E-07			
FRACTION OF A ₂ LEAKING THROUGH CAN AFTER FIRE		1.45E-07			
FRACTION OF A ₂ LEAKING THROUGH 2R AFTER FIRE		9.38E-09			
AIR IN BAG & BROKEN POLY BOTTLE, STEADY STATE, # MOLES		1.10E-04			
AIR IN BAG & BROKEN POLY BOTTLE, AFTER FIRE, # MOLES		7.97E-05			
AIR LEAKING FROM BAG, AFTER FIRE, # MOLES		3.01E-05			
AVERAGE AIR SPECIFIC VOLUME, CM ³ /# MOLE		1.30E+07			
AIR LEAKING FROM BAG, AFTER FIRE, CM ³		3.92E+02			
POWDER CONCENTRATION, BAG, AFTER FIRE, G/CM ³ AIR		4.16E-01			
POWDER LEAKING THROUGH BAG, AFTER FIRE, G		5.48E-04			
POWDER LEAKING THROUGH BAG, AFTER FIRE, Ci		4.99E-08			
POWDER CONCENTRATION, CAN, AFTER FIRE, G/CM ³ AIR		4.07E-07			
POWDER LEAKING THROUGH CAN, AFTER FIRE, G		1.59E-04			
POWDER LEAKING THROUGH CAN, AFTER FIRE, Ci		1.45E-08			
POWDER CONCENTRATION, 2R, AFTER FIRE, G/CM ³ AIR		2.63E-08			
POWDER LEAKING THROUGH 2R, AFTER FIRE, G		1.03E-05			
POWDER LEAKING THROUGH 2R, AFTER FIRE, Ci		9.38E-10			

PACKAGE CONTAINMENT REQUIREMENTS AND MAXIMUM PERMISSIBLE LEAKAGE RATES (per ANSI N14.5-1987)

(Ra) Criterion for accident conditions (Ci)	1.00E-01
(Ca) Activity/unit volume that could escape (Ci/cm ³)	2.40E-12
(La) Maximum permissible leak rate cm ³ /s (Ra/Ca)*1.65E-6	6.89E+04

CASE #4

6M LEAKAGE CALCULATIONS - ACCIDENT CONDITIONS

PACKAGING CONFIGURATION = One Breached Poly Bottle - 90% Full
 MATERIAL BEING SHIPPED = Uranium Oxide Powder

DESCRIPTION OF CONFINEMENT BARRIER:	[----CONFINEMENT DIMENSIONS----]			
	1st Bottle	2nd Bag	3rd Can	4th 2R
DIAMETER, INCHES	3.5	3.875	4.25	5
HEIGHT OF INNER CONTAINER, INCHES	6.5	6.75	7	23
% FULL OF POWDER	90	*	*	*
CALCULATED GAS VOLUMES, CM ³	102.48	279.68	1347.62	6052.84
MATERIAL CENTERLINE TEMPERATURE, F	250			
AMBIENT AIR TEMPERATURE, F	70			
AIR TEMPERATURE INCREASE IN BAG AFTER FIRE, F	20			
AMOUNT OF MATERIAL LOADED, G	5,000			
MATERIAL A ₂ VALUE, CURIES	0.1			
MATERIAL SPECIFIC ACTIVITY, Ci/G	9.10E-05			
POWDER TRANSFER FUNCTION, G/CM ³ AIR	1.40E-06			
FRACTION OF A ₂ LEAKING THROUGH BAG AFTER FIRE	1.59E-07			
FRACTION OF A ₂ LEAKING THROUGH CAN AFTER FIRE	1.47E-08			
FRACTION OF A ₂ LEAKING THROUGH 2R AFTER FIRE	3.02E-10			
AIR IN BAG & BROKEN POLY BOTTLE, STEADY STATE, # MOLES	3.49E-05			
AIR IN BAG & BROKEN POLY BOTTLE, AFTER FIRE, # MOLES	2.53E-05			
AIR LEAKING FROM BAG, AFTER FIRE, # MOLES	9.56E-06			
AVERAGE AIR SPECIFIC VOLUME, CM ³ /# MOLE	1.30E+07			
AIR LEAKING FROM BAG, AFTER FIRE, CM ³	1.25E+02			
POWDER CONCENTRATION, BAG, AFTER FIRE, G/CM ³ AIR	1.31E+01			
POWDER LEAKING THROUGH BAG, AFTER FIRE, G	1.74E-04			
POWDER LEAKING THROUGH BAG, AFTER FIRE, Ci	1.59E-08			
POWDER CONCENTRATION, CAN, AFTER FIRE, G/CM ³ AIR	1.29E-07			
POWDER LEAKING THROUGH CAN, AFTER FIRE, G	1.61E-05			
POWDER LEAKING THROUGH CAN, AFTER FIRE, Ci	1.47E-09			
POWDER CONCENTRATION, 2R, AFTER FIRE, G/CM ³ AIR	2.66E-09			
POWDER LEAKING THROUGH 2R, AFTER FIRE, G	3.31E-07			
POWDER LEAKING THROUGH 2R, AFTER FIRE, Ci	3.02E-11			

PACKAGE CONTAINMENT REQUIREMENTS AND MAXIMUM PERMISSIBLE LEAKAGE RATES
 (per ANSI N14.5-1987)

(Ra) Criterion for accident conditions (Ci)	1.00E-01
(Ca) Activity/unit volume that could escape (Ci/cm ³)	2.42E-13
(La) Maximum permissible leak rate cm ³ /s (Ra/Ca)*1.65E-6	6.81E+05

CASE #5

6M LEAKAGE CALCULATIONS - NORMAL CONDITIONS

PACKAGING CONFIGURATION = Two Poly Bottles - 10% Full
MATERIAL BEING SHIPPED = Uranium Oxide Powder

		[----CONFINEMENT DIMENSIONS----]			
		1st	2nd	3rd	4th
DESCRIPTION OF CONFINEMENT BARRIER:		Bottle	Bag	Can	2R
DIAMETER, INCHES		3.5	3.875	4.25	5
HEIGHT OF INNER CONTAINERS WHEN STACKED, INCHES		13	13.5	14	23
% FULL OF POWDER		10	*	*	*
CALCULATED GAS VOLUMES, CM ³		1844.65	559.36	2695.24	4705.23
MATERIAL CENTERLINE TEMPERATURE, F		150			
AMBIENT AIR TEMPERATURE, F		70			
AMOUNT OF MATERIAL LOADED, G		1,000			
MATERIAL A ₂ VALUE, Curies		0.1			
MATERIAL SPECIFIC ACTIVITY, Ci/G		9.10E-05			
POWDER TRANSFER FUNCTION, G/CM ³ AIR		1.40E-06			
FRACTION OF A ₂ LEAKING THROUGH BOTTLE		3.32E-07			
FRACTION OF A ₂ LEAKING THROUGH BAG		1.54E-07			
FRACTION OF A ₂ LEAKING THROUGH CAN		1.49E-08			
FRACTION OF A ₂ LEAKING THROUGH 2R		8.25E-10			
AIR IN POLY BOTTLE, AMBIENT, # MOLES		1.68E-04			
AIR IN POLY BOTTLE, STEADY STATE, # MOLES		1.46E-04			
AIR LEAKING FROM POLY BOTTLE, # MOLES		2.21E-05			
AVERAGE AIR SPECIFIC VOLUME, CM ³ /# MOLE		1.18E+07			
AIR LEAKING FROM POLY BOTTLE, CM ³		2.60E+02			
POWDER CONCENTRATION, POLY BOTTLE, G/CM ³ AIR		5.42E-01			
POWDER LEAKING THROUGH POLY BOTTLE, G		3.64E-04			
POWDER LEAKING THROUGH POLY BOTTLE, Ci		3.32E-08			
POWDER CONCENTRATION, BAG, G/CM ³ AIR		6.52E-07			
POWDER LEAKING THROUGH BAG, G		1.70E-04			
POWDER LEAKING THROUGH BAG, Ci		1.54E-08			
POWDER CONCENTRATION, CAN, G/CM ³ AIR		6.29E-08			
POWDER LEAKING THROUGH CAN, G		1.64E-05			
POWDER LEAKING THROUGH CAN, Ci		1.49E-09			
POWDER CONCENTRATION, 2R, G/CM ³ AIR		3.48E-09			
POWDER LEAKING THROUGH 2R, G		9.06E-07			
POWDER LEAKING THROUGH 2R, Ci		8.25E-11			

PACKAGE CONTAINMENT REQUIREMENTS AND MAXIMUM PERMISSIBLE LEAKAGE RATES (per ANSI N14.5-1987)

(Rn) Criterion for normal conditions (Ci)	1.00E-07
(Cn) Activity/unit volume that could escape (Ci/cm ³)	3.17E-13
(Ln) Maximum permissible leak rate cm ³ /s (Rn/Cn)/3600	8.77E+01

CASE #6

6M LEAKAGE CALCULATIONS - NORMAL CONDITIONS

PACKAGING CONFIGURATION = Two Poly Bottles - 90% Full
 MATERIAL BEING SHIPPED = Uranium Oxide Powder

DESCRIPTION OF CONFINEMENT BARRIER:	[----CONFINEMENT DIMENSIONS----			
	1st Bottle	2nd Bag	3rd Can	4th 2R
DIAMETER, INCHES	3.5	3.875	4.25	5
HEIGHT OF INNER CONTAINERS WHEN STACKED, INCHES	13	13.5	14	23
% FULL OF POWDER	90	*	*	*
CALCULATED GAS VOLUMES, CM ³	204.96	559.36	2695.24	4705.23
MATERIAL CENTERLINE TEMPERATURE, F	150			
AMBIENT AIR TEMPERATURE, F	70			
AMOUNT OF MATERIAL LOADED, G	10,000			
MATERIAL A ₂ VALUE, CURIES	0.1			
MATERIAL SPECIFIC ACTIVITY, Ci/G	9.10E-05			
POWDER TRANSFER FUNCTION, G/CM ³ AIR	1.40E-06			
FRACTION OF A ₂ LEAKING THROUGH BOTTLE	3.69E-08			
FRACTION OF A ₂ LEAKING THROUGH BAG	1.91E-09			
FRACTION OF A ₂ LEAKING THROUGH CAN	2.04E-11			
FRACTION OF A ₂ LEAKING THROUGH 2R	1.26E-13			
AIR IN POLY BOTTLE, AMBIENT, # MOLES	1.87E-05			
AIR IN POLY BOTTLE, STEADY STATE, # MOLES	1.63E-05			
AIR LEAKING FROM POLY BOTTLE, # MOLES	2.46E-06			
AVERAGE AIR SPECIFIC VOLUME, CM ³ /# MOLE	1.18E+07			
AIR LEAKING FROM POLY BOTTLE, CM ³	2.89E+01			
POWDER CONCENTRATION, POLY BOTTLE, G/CM ³ AIR	4.88E+01			
POWDER LEAKING THROUGH POLY BOTTLE, G	4.05E-05			
POWDER LEAKING THROUGH POLY BOTTLE, Ci	3.69E-09			
POWDER CONCENTRATION, BAG, G/CM ³ AIR	7.24E-08			
POWDER LEAKING THROUGH BAG, G	2.09E-06			
POWDER LEAKING THROUGH BAG, Ci	1.91E-10			
POWDER CONCENTRATION, CAN, G/CM ³ AIR	7.77E-10			
POWDER LEAKING THROUGH CAN, G	2.25E-08			
POWDER LEAKING THROUGH CAN, Ci	2.04E-12			
POWDER CONCENTRATION, 2R, G/CM ³ AIR	4.78E-12			
POWDER LEAKING THROUGH 2R, G	1.38E-10			
POWDER LEAKING THROUGH 2R, Ci	1.26E-14			

PACKAGE CONTAINMENT REQUIREMENTS AND MAXIMUM PERMISSIBLE LEAKAGE RATES
 (per ANSI N14.5-1987)

(Rn) Criterion for normal conditions (Ci)	1.00E-07
(Cn) Activity/unit volume that could escape (Ci/cm ³)	4.35E-16
(Ln) Maximum permissible leak rate cm ³ /s (Rn/Cn)/3600	6.39E+04

CASE #7

6M LEAKAGE CALCULATIONS - NORMAL CONDITIONS

PACKAGING CONFIGURATION = One Poly Bottle - 10% Full
MATERIAL BEING SHIPPED = Uranium Oxide Powder

		[----CONFINEMENT DIMENSIONS----]			
		1st	2nd	3rd	4th
DESCRIPTION OF CONFINEMENT BARRIER:		Bottle	Bag	Can	2R
	DIAMETER, INCHES	3.5	3.875	4.25	5
	HEIGHT OF INNER CONTAINER, INCHES	6.5	6.75	7	23
	% FULL OF POWDER	10	*	*	*
CALCULATED GAS VOLUMES, CM ³		922.32	279.68	1347.62	6052.84
MATERIAL CENTERLINE TEMPERATURE, F		150			
AMBIENT AIR TEMPERATURE, F		70			
AMOUNT OF MATERIAL LOADED, G		500			
MATERIAL A ₂ VALUE, Curies		0.1			
MATERIAL SPECIFIC ACTIVITY, Ci/G		9.10E-05			
POWDER TRANSFER FUNCTION, G/CM ³ AIR		1.40E-06			
FRACTION OF A ₂ LEAKING THROUGH BOTTLE		1.66E-07			
FRACTION OF A ₂ LEAKING THROUGH BAG		7.72E-08			
FRACTION OF A ₂ LEAKING THROUGH CAN		7.45E-09			
FRACTION OF A ₂ LEAKING THROUGH 2R		1.60E-10			
AIR IN POLY BOTTLE, AMBIENT, # MOLES		8.42E-05			
AIR IN POLY BOTTLE, STEADY STATE, # MOLES		7.32E-05			
AIR LEAKING FROM POLY BOTTLE, # MOLES		1.11E-05			
AVERAGE AIR SPECIFIC VOLUME, CM ³ /# MOLE		1.18E+07			
AIR LEAKING FROM POLY BOTTLE, CM ³		1.30E+02			
POWDER CONCENTRATION, POLY BOTTLE, G/CM ³ AIR		5.42E-01			
POWDER LEAKING THROUGH POLY BOTTLE, G		1.82E-04			
POWDER LEAKING THROUGH POLY BOTTLE, Ci		1.66E-08			
POWDER CONCENTRATION, BAG, G/CM ³ AIR		6.52E-07			
POWDER LEAKING THROUGH BAG, G		8.48E-05			
POWDER LEAKING THROUGH BAG, Ci		7.72E-09			
POWDER CONCENTRATION, CAN, G/CM ³ AIR		6.29E-08			
POWDER LEAKING THROUGH CAN, G		8.19E-06			
POWDER LEAKING THROUGH CAN, Ci		7.45E-10			
POWDER CONCENTRATION, 2R, G/CM ³ AIR		1.35E-09			
POWDER LEAKING THROUGH 2R, G		1.76E-07			
POWDER LEAKING THROUGH 2R, Ci		1.60E-11			

PACKAGE CONTAINMENT REQUIREMENTS AND MAXIMUM PERMISSIBLE LEAKAGE RATES
(per ANSI N14.5-1987)

(Rn) Criterion for normal conditions (Ci)	1.00E-07
(Cn) Activity/unit volume that could escape (Ci/cm ³)	1.23E-13
(Ln) Maximum permissible leak rate cm ³ /s (Rn/Cn)/3600	2.26E+02

CASE #8

6M LEAKAGE CALCULATIONS - NORMAL CONDITIONS

PACKAGING CONFIGURATION = One Poly Bottle - 90% Full
 MATERIAL BEING SHIPPED = Uranium Oxide Powder

		[----CONFINEMENT DIMENSIONS----]			
		1st	2nd	3rd	4th
DESCRIPTION OF CONFINEMENT BARRIER:		Bottle	Bag	Can	2R
	DIAMETER, INCHES	3.5	3.875	4.25	5
	HEIGHT OF INNER CONTAINER, INCHES	6.5	6.75	7	23
	% FULL OF POWDER	90	*	*	*
CALCULATED GAS VOLUMES, CM ³		102.48	279.68	1347.62	6052.84
MATERIAL CENTERLINE TEMPERATURE, F		150			
AMBIENT AIR TEMPERATURE, F		70			
AMOUNT OF MATERIAL LOADED, G		5,000			
MATERIAL A ₂ VALUE, CURIES		0.1			
MATERIAL SPECIFIC ACTIVITY, Ci/G		9.10E-05			
POWDER TRANSFER FUNCTION, G/CM ³ AIR		1.40E-06			
FRACTION OF A ₂ LEAKING THROUGH BOTTLE		1.84E-08			
FRACTION OF A ₂ LEAKING THROUGH BAG		9.53E-10			
FRACTION OF A ₂ LEAKING THROUGH CAN		1.02E-11			
FRACTION OF A ₂ LEAKING THROUGH 2R		2.44E-14			
AIR IN POLY BOTTLE, AMBIENT, # MOLES		9.36E-06			
AIR IN POLY BOTTLE, STEADY STATE, # MOLES		8.13E-06			
AIR LEAKING FROM POLY BOTTLE, # MOLES		1.23E-06			
AVERAGE AIR SPECIFIC VOLUME, CM ³ /# MOLE		1.18E+07			
AIR LEAKING FROM POLY BOTTLE, CM ³		1.45E+01			
POWDER CONCENTRATION, POLY BOTTLE, G/CM ³ AIR		4.88E+01			
POWDER LEAKING THROUGH POLY BOTTLE, G		2.02E-05			
POWDER LEAKING THROUGH POLY BOTTLE, Ci		1.84E-09			
POWDER CONCENTRATION, BAG, G/CM ³ AIR		7.24E-08			
POWDER LEAKING THROUGH BAG, G		1.05E-06			
POWDER LEAKING THROUGH BAG, Ci		9.53E-11			
POWDER CONCENTRATION, CAN, G/CM ³ AIR		7.77E-10			
POWDER LEAKING THROUGH CAN, G		1.12E-08			
POWDER LEAKING THROUGH CAN, Ci		1.02E-12			
POWDER CONCENTRATION, 2R, G/CM ³ AIR		1.86E-12			
POWDER LEAKING THROUGH 2R, G		2.68E-11			
POWDER LEAKING THROUGH 2R, Ci		2.44E-15			

PACKAGE CONTAINMENT REQUIREMENTS AND MAXIMUM PERMISSIBLE LEAKAGE RATES
 (per ANSI N14.5-1987)

(Rn) Criterion for normal conditions (Ci)	1.00E-07
(Cn) Activity/unit volume that could escape (Ci/cm ³)	1.69E-16
(Ln) Maximum permissible leak rate cm ³ /s (Rn/Cn)/3600	1.64E+05

APPENDIX C

**MINIMUM INSPECTION REQUIREMENTS FOR 55-GALLON
DOT SPECIFICATION 6M SHIPPING PACKAGINGS**

MINIMUM INSPECTION REQUIREMENTS FOR 55-GALLON
DOT SPECIFICATION 6M SHIPPING PACKAGINGS
(All references are to Title 49 Code of Federal Regulations)

Outer Drum and Insulating Components

1. Verify correct markings on the drum (letters at least 1/2 inch high).
  - "DOT 6M Type B" and "Radioactive Material" or "Fissile Radioactive Material"
  - Drum Serial Number
  - Rated capacity of drum in gallons
  - Year of manufacture
  - Name and address or registered symbol of manufacturer.
2. Visually inspect the welding on the drum to verify workmanship as specified in 173.24(c)(4)
3. Visually inspect for galvanic corrosion between the drum, the insulation and the inner container as specified in 173.24(c)(5).
4. Visually inspect the gasket material for efficiency and compatibility as specified in 173.24(c)(6).
5. Visually inspect the convexity of the head (must be between 1 cm and the amount of the chime).
6. Verify that the construction of the outer shell is of straight side steel, all welded.
7. Verify the drum has 4 or more, 1/2 inch vents near the top, each covered with a waterproof tape or fusible plug as defined in 178.104-3(a)(2).
8. Drum closure bolt locking ring must 1) be at least 12 gauge, 2) use a 5/8 inch bolt, 3) have drop forged lugs one of which is threaded and, 4) use a lock nut.
9. Verify the drum has provisions for a Tamper Indicating Device (TID) at the drum closure. Holes of at least 3/32 inch diameter exist on each side of the locking ring closure or in the bolt end to accommodate a TID wire.
10. Verify that inner container is fixed in place within the drum by either cane fiberboard or wooden disks. At least 3.75 inches of thermal insulation must be provided on the sides of the inner container.
11. Verify that cane fiberboard disks have a density greater than 15 pounds per cubic foot.
12. Verify that disks fit such that radial clearances between the fiberboard, inner container, and shell do not exceed 1/4 inch.

13. Verify that any wooden disks are:
  - 1) either hardwood or plywood,
  - 2) at least 1/2 inch thick,
  - 3) have a density greater than 28 pounds per cubic foot.
14. Verify that bearing plates are used in packaging. The plates must be glued in place embedded in fiberboard as per 178.104-3(e).
  - 1) Bearing plates must be at least 1 inch thick plywood or 0.25 inch thick steel
  - 2) at least 10 inch in diameter
  - 3) located at both drum ends and adjacent to the 2R container

2R Inner Container

1. Verify that 2R inner container is made of stainless steel, malleable steel or equivalent as per 178.34-1(a).
2. Verify markings on 2R inner container are at least 1/2 inch high and include the following as per 178.34-1(b) and 173.24.
  - Name and address or registered trade mark of manufacturer.
3. Verify that dimensions of the 2R inner container are within limits set by 178.104-3(b).
4. Verify that galvanic corrosion does not exist within the 2R inner container per 173.24(c)(5).
5. Verify the thread type on the closure cap (8 NPT). Assure that threads are not damaged and match up to the 2R inner container and engage at least 5 complete threads.
6. Visually inspect the welding on the 2R inner container to verify workmanship as specified in 173.24(c)(4).

APPENDIX D

UNIAXIAL STATIC FORCE TEST AND
SOAP BUBBLE LEAK TEST FOR 2R INNER CONTAINERS

UNIAXIAL STATIC FORCE TEST AND SOAP BUBBLE LEAK TEST FOR 2R INNER CONTAINERS

PURPOSE

The following tests are required to ensure the bottom welds of 2R inner containers that do not have complete manufacturing documentation are strong enough to survive the stress levels reached during a 30-ft drop. The one-time-only tests are performed as recommended in Appendix B of the DOE Container Weld Advisory Committee's Final Report (May 1989).

UNIAXIAL STATIC FORCE TEST

1. Paint the weld of the 2R container with a brittle coating that will flake off the weld if plastic deformation occurs. Ensure the coating has completely cured before proceeding with the following steps. QA shall verify that the coating has completely cured.
2. Attach the 2R container to a ridged support under a hydraulic press. The press must be capable of exerting a minimum of 25,000 lbs. and must have a calibrated force gauge. Calibration of the gauge shall be current and traceable to the National Institute of Standards Technology. QA shall verify and document calibration of the gauge for each 2R container tested.
3. Place the test ram and ram head in the 2R container. The ram head shall be of the largest diameter which will easily slip inside the container and not interfere with any irregularities of the container interior and shall be strong enough not to deform or buckle upon repeated use. QA shall verify and document that the ram head is appropriately placed on the bottom of the 2R container and that it is not deformed before and after each use.
4. Using hydraulic press and ram, apply 24,400 lbs. (+1000 lbs, -0 lbs) of force on the weld of the container. QA shall verify and document the amount of force applied.
5. QA shall inspect the weld of the container for any flaking of the coating. If any flaking of the coating occurs, the container has failed the test and shall not be used for shipping. QA shall document the results of the test.

UNIAXIAL STATIC FORCE TEST AND
SOAP BUBBLE LEAK TEST FOR 2R INNER CONTAINERS (cont.)

SOAP BUBBLE LEAK TEST

1. After successfully passing the uniaxial static force test, remove all coating material from the container's weld and prepare the container for the leak test. The leak test shall be performed in accordance with ANSI N14.5 Appendix 3.4, "Soap Bubble Test". A calibrated pressure gauge shall be installed on the pressurizing equipment used to perform the test. Calibration of the gauge shall be current and traceable to the National Institute of Standards Technology. QA shall verify and document calibration of the gauge for each 2R container tested.
2. When the container is ready to be leak tested, pressurize the container to 14 psig and hold the pressure for 15 minutes. QA shall verify the pressure and time pressurized.
3. While the container is still pressurized, all weld areas shall be coated with the soap solution. If any bubbling of the solution occurs, the container has failed the test and shall not be used for shipping. QA shall document the results of the test.