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BNWL-2288
UC-71

Plutonium Transport Package Closure Survey

by
S. W. Heaberlin

April 1978

Prepared for the
U.S. Department of Energy
under Contract EY-76-C-06-1830

Battelle
Pacific Northwest Laboratories

BNWL-2288

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PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE
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UNITED STATES DEPARTMENT OF ENERGY
Under Contract EY-76-C-06-1830

Printed in the United States of America
Available from
National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22151

Price: Printed Copy $____*; Microfiche $3.00

*Pages	NTIS Selling Price
001-025	$4.50
026-050	$5.00
051-075	$5.50
076-100	$6.00
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RICHLAND, WASHINGTON 99352

ACKNOWLEDGMENT

The author would like to acknowledge those PNL staff members who conducted the survey: L. C. Davenport, D. E. Friar, M. A. Lewallen, R. A. Libby and D. R. Oden. The author would also like to collectively thank all those who provided data for the survey. Their cooperation made this document possible.

SUMMARY

In the fall of 1976, Battelle, Pacific Northwest Laboratories conducted a survey of eight facilities receiving plutonium shipments to determine the condition of plutonium shipping packages during shipment. This survey followed a similar survey conducted by PNL in early 1974.

The package types considered were the L-10, 6M and LLD-1 packages. A total of 6,700 packages were included in the survey. Compared to the earlier survey, a marked reduction was observed in nonstandard package closure conditions. One exception was an increase in the occurrence of extremely tight pipe plugs in the 2R inner container for the 6M package. This is not felt to be a significant safety problem.

The reduction in nonstandard package closure conditions was apparently due to the improved quality assurance in packing procedures.

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PLUTONIUM TRANSPORT PACKAGE CLOSURE SURVEY

1.0 INTRODUCTION

In February of 1974, PNL surveyed nine receivers of plutonium. Information was obtained on the frequency of nonstandard package closure conditions for three common plutonium shipping packages, the L-10, 6M and LLD-1.[a] This survey covered the period from 1970 to early 1974. The results were presented in "Importance of Quality Control in Plutonium Packaging Loading" by C. L. Brown and S. W. Heaberlin at the 4th International Symposium on Packaging and Transportation of Radioactive Materials. The results were also used as the basis for Chapter 7 - Condition of Packages During Transport - of BNWL-1846, "An Assessment of the Risk of Transporting Plutonium Oxide and Liquid Plutonium Nitrate by Truck."

The information from this 1974 survey generated continued interest in the question of package closure errors. A second survey was authorized to determine the current state of packages in transport and to compare this with the results from the earlier survey. This report describes the second survey and gives its results.

2.0 SURVEY METHOD

The survey was conducted in four steps: 1) establish a facility contact, 2) provide a survey questionnaire, 3) visit the facility; and 4) prepare a site report. The first step was to establish a contact at the receiver facility.[b] The starting point was most often the individual or group contacted in the 1974 survey. In most cases staff and responsibilities had changed. Therefore new contacts were made. It was important that the facility contact be close to the operations staff (i.e., those handling the packages) while staying at a responsible management level. Where appropriate, the local Energy Research and Development Administration (ERDA) officials were also contacted to inform them of our activities. Often they became the main source of information.

a. The packages are described in Appendix B.
b. The facilities included in the survey are listed in Section 3.1.

After a contact was identified at the facility and agreed to participate in the survey, a questionnaire was sent. The questionnaire is shown in Appendix A. It is based on the form used in the 1974 survey with improvements and additions based on experience from the first survey.

A date to visit the facility was established during the initial contact. This date allowed the contact a reasonable amount of time to examine the questionnaire. During the visit, the questionnaire was discussed and questions were answered. If possible, the questionnaire was completed and given to the survey team. Additional information was also gained on events, experiences, opinions and suggestions covering a variety of transportation related items.

After the facility visit the survey team summarized the information acquired in a site report which was then given to the original facility contact for comment. This follow up was eigher by phone or letter.

These steps were generally followed but deviations from the procedure did occur. For example, in one instance, the facility was not visited. The site interview was conducted entirely by phone.

Two important elements were incorporated into the survey method. First, each facility was surveyed as a receiver of plutonium packages because package closure problems are most readily observable at the time of unpacking. This also allows observation of package integrity problems which may originate during transport. Reports of closure problems were therefore, a reporting of someone else's problem rather than their own. Second, to assure the anonymity of the individual site report, the results are for all sites collectively.

3.0 SURVEY RESULTS

The results of the survey are described in this section. The results from the 1974 survey, which covered the period from 1970 to early 1974, will be compared to that of the 1976 survey, which covered the period from early 1974 to the fall of 1976.

3.1 PARTICIPATING FACILITIES

The 1974 survey was conducted at nine facilities. Between 1974 and 1976 two of these facilities terminated their plutonium activities. One site not surveyed in 1974 was added in the 1976 survey. The facilities included in the two surveys are listed in Table 3.1.

TABLE 3.1 Facilities Surveyed

1974 Survey	1976 Survey
Argonne National Laboratory Argonne, Illinois	Argonne National Laboratory Argonne, Illinois
E. I. duPont deNemours Savannah River Plant Aiken, South Carolina	E. I. duPont deNemours Savannah River Plant Aiken, South Carolina
Union Carbide Corporation Oak Ridge National Laboratory Oak Ridge, Tennessee	Union Carbide Corporation Oak Ridge National Laboratory Oak Ridge, Tennessee
Los Alamos Scientific Laboratory Los Alamos, New Mexico	Los Alamos Scientific Laboratory Los Alamos, New Mexico
NUMEC Babcock and Wilcox Company Apollo,Pennsylvania	NUMEC Babcock and Wilcox Company Apollo, Pennsylvania
Atlantic Richfield Hanford Company Richland, Washington	Atlantic Richfield Hanford Company Richland, Washington
Rocky Flats Plant The Dow Chemical Company Golden, Colorado	Rocky Flats Plant The Dow Chemical Company Golden, Colorado
New York State Atomic and Space Development Authority New York, New York	Mound Laboratory Monsanto Research Corporation Miamisburg, Ohio
Kerr-McGee Nuclear Corporation Oklahoma City, Oklahoma	

3.2 SURVEY QUESTIONNAIRE SUMMARY

Each of the eight facilities contacted in 1976 filled out a survey questionnaire. The questionnnaire used is shown in Appendix A. The facilities surveyed in 1974 filled out a similar form. The results obtained from these forms are summarized in Tables 3.2 and 3.3. Table 3.2 gives the total number of received packages covered in the survey by package type for the two periods. Table 3.3 summarizes the frequency of nonstandard package closure conditions observed. The frequency is given in observations per package shipped.

TABLE 3.2 Estimated Number of Packages Included in the Surveys

Package[a]	Number 1974 Survey[b]	1976 Survey[c]
L-10, L-3	2130[d]	219[f]
6M	1243	∿3080[g]
LLD-1	2700-3000[e]	∿3400[g]

a. The packages are described in Appendix B.

b. Period of 1970 to early 1974.

c. Period of early 1974 to fall 1976.

d. Includes some ^{233}U shipped in the same manner as liquid plutonium nitrate.

e. Includes some plutonium metal shipments.

f. Eight were L-3's, all others L-10's.

g. Includes some $^{233}UO_2/ThO_2$ shipments.

TABLE 3.3 Frequency of Observed Nonstandard Package Closure Conditions

Observation	Estimated Observation Frequency (per container received) 1974 Survey	1976 Survey[a]
Part I - L-3 and L-10 Packages		
Outside Primary Containment Vessel		
1. Bolt ring on outer drum turned upward	2.2×10^{-2}	0.0
2. Vermiculite level low	9.4×10^{-2}	0.0
3. Vermiculite contaminated	1.9×10^{-3}	0.0
4. Vermiculite waterlogged	5.0×10^{-4}	0.0
5. No cap on vent line	6.1×10^{-3}	0.0
6. Vent cap loose	1.4×10^{-3}	0.0
7. Valve on vent line not closed	7.5×10^{-3}	0.0
8. Flange bolts too tight (over 80-ft lb torque)	2.4×10^{-2}	0.0
9. Gasket missing	9.4×10^{-4}	0.0
10. Improper gasket material	NA[b]	7.8×10^{-2}
Inside Primary Containment Vessel		
1. Plastic bag pressurized	2.4×10^{-3}	0.0
2. Plastic bottle cap loose	4.7×10^{-4}	0.0
3. Plutonium solution in plastic bag	7.0×10^{-2}	0.0
4. Contamination outside plastic bag	1.2×10^{-2}	0.0
5. Plutonium solution outside plastic bag	5.2×10^{-3}	0.0
6. Plastic bottle gasket in "figure eight"	1.9×10^{-3}	0.0
7. Plastic bag broken	9.4×10^{-4}	0.0
8. Low acid molarity	NA[b]	7.8×10^{-2}

a. The 1976 survey included only 219 L-10/L-3 type packages. Frequencies of 5×10^{-3} or less would not appear. For this reason, direct comparison between the 1974 and 1976 surveys may not be valid.

b. Not Applicable, this item was not included in the 1974 survey.

TABLE 3.3 (Continued)

Obervation	Estimated Observation Frequency (per container received) 1974 Survey	1976 Survey
Part II - Plutonium Oxide Shipments in 6M Packages		
Outside Primary Containment Vessel		
1. Hole in outer drum	1.6×10^{-3}	0.0
2. Bolt rings turned upward	5.3×10^{-2}	0.0
3. Bolt ring bolt loose (finger tight)	1.2×10^{-1}	0.0
4. Bolt ring bolt broke off while tightening	2.0×10^{-2}	0.0
5. Tamper indication seal broken	NA[a]	1.6×10^{-3}[b]
6. Plug in 2R containment vessel not tight	2.2×10^{-1}	0.0
7. Threads damaged	0.0	3.2×10^{-4}
8. Plug extremely tight	0.0	5.7×10^{-2}[c]
Inside Primary Containment Vessel		
1. Can bulged due to internal pressure	5×10^{-4}	0.0
2. Contamination outside of can	0.0	3.2×10^{-4}
3. Contamination of plastic bag	0.0	0.0
Part III - Plutonium Oxide Shipments in LLD-1 Packages		
Outside Primary Containment Vessel		
1. Locking cover loose	4×10^{-4}	2.9×10^{-3}
2. Tamper indication seal broken	NA[a]	0.0
3. Plug in 2R containment vessel not tight	0.18	0.0
4. Threads damaged	2.4×10^{-4}	0.0
5. Plug extremely tight	2.4×10^{-4}	6.2×10^{-3}[d]
6. O ring missing	3.9×10^{-3}	2.6×10^{-3}

a. NA - Not asked in this survey.
b. Not all packages have tamper seals.
c. Approximately 6% of these are pipe caps, others are pipe plugs, also 93% of these occurrences were reported by a single receiver.
d. Approximately 10% of these are flanged 2R containers.

TABLE 3.3 (Continued)

Observation	Estimated Observation Frequency (per container received) 1974 Survey	1976 Survey
Inside Primary Containment Vessel		
1. Can bulged due to internal pressure	4.9×10^{-4}	0.0
2. Can breached or not completely sealed upon arrival	1.1×10^{-3}	0.0
3. Contamination outside can but not outside containment vessel	1.1×10^{-3}	$\sim 1.8 \times 10^{-2}$

3.3 INDUSTRY OBSERVATIONS ON PACKAGING AND TRANSPORTATION

During the facility visit, much additional information was gained in conversations with the facility staff. This information consisted of opinions, theories, suggestions and general comments. Although the validity of the statements was not researched, they are listed here to indicate the current thinking of some members of the industry. The following list summarizes the most significant of these.

1. More stringent QA in package closure procedures were introduced in the period 1972-1974.

2. Most facilities felt their own closure procedures had improved somewhat but packages received had improved significantly.

3. Documentation, records control and training had improved.

4. Concern was expressed on the ban of nitrate shipments. It was felt that nitrate spills would be easier to contain than oxide spills. Use of the foam glass package in place of the vermiculite insulation of the L-10 would reduce or remove the present safety disadvantage of the nitrate form.

5. The first PNL survey report suggested the use of luting material such as teflon tape on 2R threads. In cases where teflon tape was used on machined threads, rather than pipe thread, binding and excessive tightness resulted. It should be noted that not all of the extremely tight plugs listed in Table 3.3 suffered this fate.

6. Some incidence of the over zealous use of fluid luting/lubricant was reported. This resulted in the product cans being smeared with lubricant.

7. Criticism of the 12-31-74 amendment to the 6M certificate were made. Some of the new requirements were felt to be excessive and not to contribute to safety. In particular the venting requirement was thought to possibly weaken the containment.

8. Better documentation to accompany the packages was suggested. In some cases, especially scrap, contents are ill defined. Also the nature of the package might be better defined, for instance, the addition of an exploded parts figure.

9. Training for drivers and transport handlers could be improved. Instances of sloppy handling indicate a lack of understanding of the package and material being transported.

10. A few instances of careless handling of empty packages were also reported. Loss of control of the package and severe damage both were noted.

3.4 CONCLUSIONS

The conclusions from this survey are determined by comparing the 1974 survey and the 1976 survey. The conclusions are drawn from both the questionnaire data and industry observations.

- Although both surveys indicated some level of package integrity insult, there were no reported instances of complete package containment failure or leakage of any plutonium for either period.
- The frequency of package closure problems for the period 1974 to 1976 is significantly less than that for 1970 to 1974.*
- The quality assurance for package closure procedures increased at the same time as improvements in package conditions. The better quality assurance is most likely responsible for that improvement.
- While the total number of packages included in both surveys was nearly equal, there was a marked reduction in the use of L-10, L-3 nitrate solution shipments. The majority of the difference seemed to be taken up by an increased use of the 6M package.

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*The greatest exception is the increase in frequency of extremely tight 2R plugs. While there was an increase for LLD-1 packages the most dramatic increase was in the 6M packages. The 2R container used in the 6M generally does not contain an O-ring seal, using rather a tapered plug to provide leak tightness. Therefore an overtight plug, while an inconvenience to the receiver, does not significantly affect the integrity of the package during shipment. 2R containers using O-ring seals, such as those used in LLD-1 packages, are affected by over tightening. This would result in an over compressed O-ring and possibly a bad seal.

APPENDIX A

1976 SURVEY QUESTIONNAIRE

Survey Questions I - Receivers of $Pu(NO_3)_4$

A. Shipments

Year	No. of Shipments	No. of L-10 Packages	No. of L-3 Packages
1974			
1975			
1976			

B. Outside Primary Containment Vessel

	Occurrence	Number of Occurrences
1.	Visible external damage	_____
2.	Puncture in outer drum	_____
3.	Packages having tamper indication seal	_____
4.	Tamper indication seals broken	_____
5.	Bolt ring on outer drum turned upward	_____
6.	Packages using vermiculite as packing/ insulating material	_____
7.	Low vermiculite level	_____
8.	Inner vessel exposed by low vermiculite level	_____
9.	Vermiculite contaminated	_____
10.	Vermiculite waterlogged	_____
11.	No cap on vent line	_____
12.	Vent cap loose	_____
13.	Valve on vent line not closed	_____
14.	Flange bolts loose or missing	_____
15.	Flange bolts too tight (over 80 ft. lb torque)	_____
16.	Flange gasket missing	_____

C. Inside Primary Containment Vessel

Occurrence	No. of Occurrences
1. Plastic bag pressurized	
2. Contamination outside plastic bag	
3. Plutonium solution outside plastic bag	
4. Plastic bag broken	
5. Plutonium solution in plastic bag	
6. Plastic bottle cap loose	
7. Plastic bottle gasket in "figure eight"	
8. Plastic bottle ruptured	

D. Reusability of Packages

Occurrence	No. of Occurrences
1. Outer drum not reusable (reason for rejection)	
2. Outer drum reusable after repair (specify-weld, paint, etc.)	
3. Inner steel vessel not reusable (reason for rejection)	

Occurrence	No. of Occurrences
4. Inner steel vessel reusable after repair (specify-weld, new flange bolts, venting repair, etc.)	_____
5. Plastic bottle reused (specify repaired need for reuse-cleaning, seam sealing, new cap, etc.)	_____

Survey Questions II - Receivers of PuO_2 6M Packages

A. Shipments

Year	No. of Shipments	No. of Packages
1974		
1975		
1976		

B. Outside Primary Containment Vessel

Occurrence	No. of Occurrences
1. Visable external damage	_____
2. Puncture in outer drum	_____
3. Packages with tamper indication seal	_____
4. Tamper indication seals broken	_____
5. Bolt ring on outer drum turned upward	_____
6. Bolt ring bolt loose (finger tight)	_____
7. Bolt ring bolt broke off while tightening	_____
8. Insulating disks missing	_____
9. Contamination outside of 2R containment vessel	_____
10. Plug in 2R containment vessel not tight	_____
11. 2R plug extremely tight	_____

C. Inside Primary Containment Vessel

Occurrence	No. of Occurrences
1. 2R's designed for O-ring	_____
2. For 2R's normally having O-ring, O-ring missing	_____

Occurrence	No. of Occurences
3. For 2R's normally without O-ring, no luting (sealant) on threads	_____
4. Threads on plug or 2R pipe damaged	_____
5. Can breached or not completely sealed	_____
6. Contamination outside of can	_____
7. Can bulged due to internal pressure	_____
8. Contamination outside plastic bag	_____

D. Reusability of Packages

Occurrence	No. of Occurrences
1. Outer drum not reusable (reason for rejection)	_____
2. Outer drum reusable after repair (specify-weld, paint, etc.)	_____

Occurrence	No. of Occurrences
3. 2R container not reusable (reason for rejection)	_____
4. 2R container reusable after repair (specify - weld, rethread, etc.)	_____

Survey Questions III - Receivers of PuO_2 LLD-1 Packages

A. Shipments

Year	No. of Shipments	No. of Packages
1974		
1975		
1976		

B. Outside Primary Containment Vessel

Occurrence	No. of Occurrences
1. Visable external damage	_____
2. Locking cover loose	_____
3. Packages with tamper indication seals	_____
4. Tamper indication seals broken	_____
5. Padding material missing	_____
6. Contamination outside of 2R containment vessel	_____
7. Plug in 2R containment vessel not tight	_____
8. 2R plug extremely tight	_____

C. Inside Primary Containment Vessel

Occurrence	No. of Occurrences
1. 2R's designed for O-ring	_____
2. For 2R's normally having O-ring, O-ring missing	_____
3. For 2R's normally without O-ring, no luting (sealant) on threads	_____
4. Threads on plug or 2R pipe damaged	_____

Occurrence	No. of Occurrences
5. Can breached or not completely sealed	_____
6. Contamination outside of can	_____
7. Can bulged due to internal pressure	_____
8. Contamination outside plastic bag	_____

D. Reusability of Package

Occurrence	No. of Occurrences
1. Outer package not reusable (reason for rejection)	_____
2. Outer package reusable after repair (specify - straighten birdcage, weld outer vessel, paint, etc.)	_____

Occurrence	No. of Occurrences
3. 2R container not reusable (reason for rejection)	_____
4. 2R container reusable after repair (specify – weld, rethread, etc.)	_____

APPENDIX B

DESCRIPTION OF PLUTONIUM TRANSPORT PACKAGES

APPENDIX B

PACKAGE DESCRIPTION

Three plutonium transport packages were covered in this survey. Two packages, the 6M and LLD-1, are used primarily in the transport of solid plutonium compounds. The third package, the L-10, is used to ship liquid plutonium usually in the form of plutonium nitrate. Some data was also obtained for the L-3 package. The package is very similar to the L-10 but reduced in capacity. The L-10 data presented is the combination of L-10 and L-3 data collected. Each of the packages is described below.

B.1 PLUTONIUM NITRATE PACKAGES L-10, L-3

The form of the plutonium product is plutonium nitrate [$Pu(NO_3)_4$] in 3 - 6 molar nitric acid. Plutonium nitrate solution is normally shipped at a concentration of about 250 g Pu/liter. The most commonly used containers for $Pu(NO_3)_4$ are the L-3 and L-10. These hold 3 liters and 10 liters of solution, respectively. The outer container of the L-3 container is a 208 ℓ (55 gallon) drum and the outer container of the L-10 is two 208 ℓ drums welded end-to-end.

A single shipment is limited by criticality safety considerations to 68 bottles, or a total of 170 kg of plutonium. A diagram of the L-10 container is shown in Figure B.1. Details taken from the "Directory of Packagings for Transportation of Radioactive Materials" WASH 1279, USAEC, 1973 are summarized below:

Authorized Contents

Up to 10.5 liters per package UHN solutions having concentration of ^{235}U not exceeding 350 g/liter, or having a combined concentration of ^{233}U and ^{235}U not exceeding 250 g/liter; or plutonium nitrate solutions of concentration not exceeding 250 g ^{239}Pu/liter; or 4.5 kg dry Pu-U compounds and mixtures.

Interior and Exterior Dimensions

Pressure vessel - 12.2 cm ID x 132.6 cm deep inside; Drum - 61 cm diam. x 169 cm in. high outside x 18 ga. wall.

L-10 CONTAINER

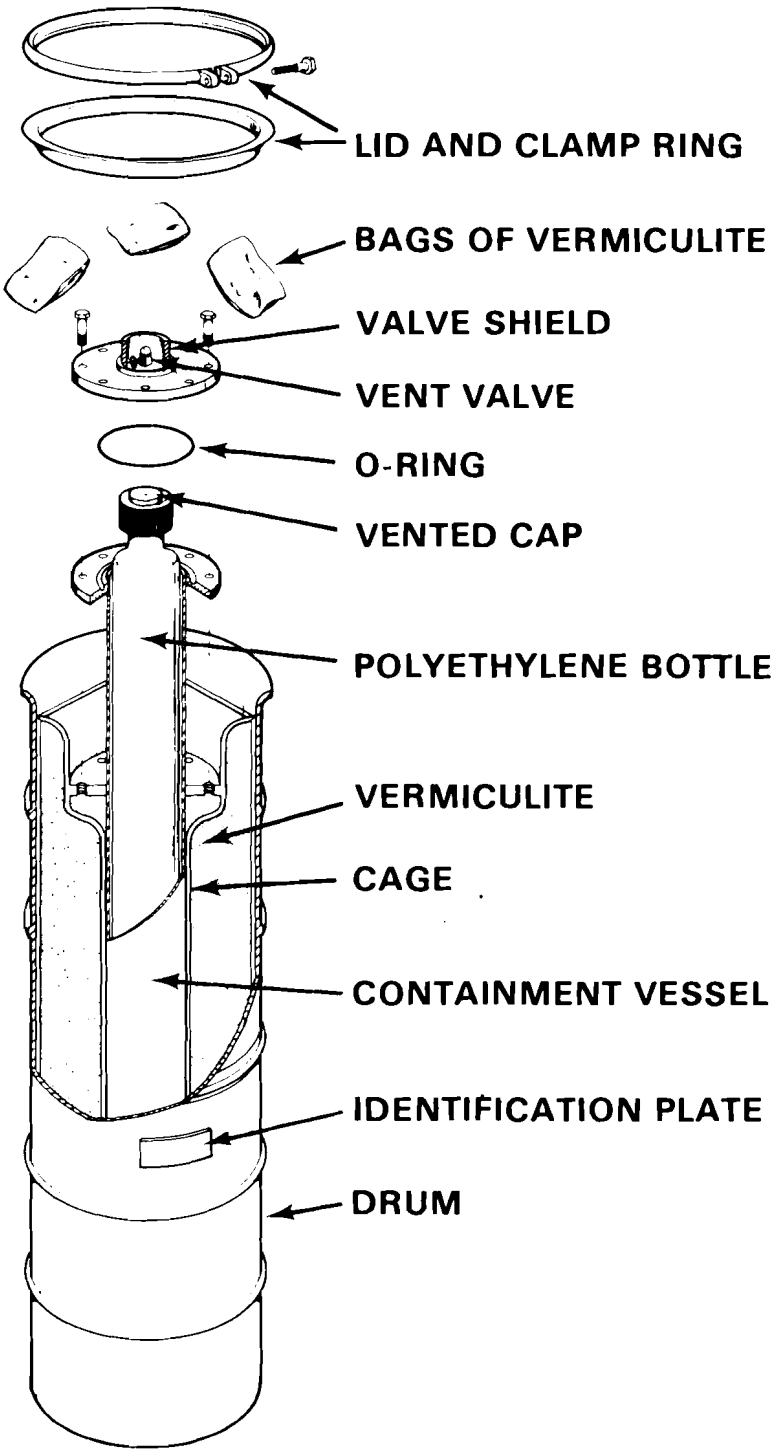

FIGURE B.1 L-10 Package

Description of Container

Outer container consists of two 208 ℓ DOT Spec. 17H drums end-to-end. Inner container is a stainless steel pressure vessel (200 Atm at 300°C) supported inside the drum by a tubular steel frame. Annular space is filled with vermiculite for thermal insulation. The product solution is contained in a 10-liter polyethylene bottle sealed in a polyvinylchloride bag and then inserted into the pressure vessel, with a thin neoprene pad to cushion the bottom of the bottle. Weight: 231 kg, total; 206 kg without bottle.

Type and Thickness of Shielding

23 cm vermiculite insulation.

Heat Removal Capacity

Not applicable.

Authorized Modes of Transport

Cargo-only aircraft, motor vehicle, rail and vessel. May be used for fissile Class II or Class III.

B.2 PLUTONIUM OXIDE PACKAGES - 6M, LLD-1

Two licensed plutonium oxide containers are described here. These are the 6M and LLD-1 containers. Both of these packages can be used to transport a variety of fissile compounds in addition to plutonium oxide.

DOT Specification 6M Containers

The 6M designation represents a class of containers which have been approved for radioactive material transport. The general set of design criteria are found in 49CFR 178.104. The outer drum must conform to Spec. 6C and 17C as defined under paragraph 178.99 and 178.115, respectively. The inner container design must meet or exceed the 2R specification presented in paragraph 178.34.

The outer container of the 6M can vary from a 38 to 416 liter capacity. The following description is based on the 57 liter size. This size 6M was used throughout the report and is shown in Figure B.2. Much of the information shown below was taken from WASH-1279. Other information has been obtained from actual container measurements.

6M CONTAINER

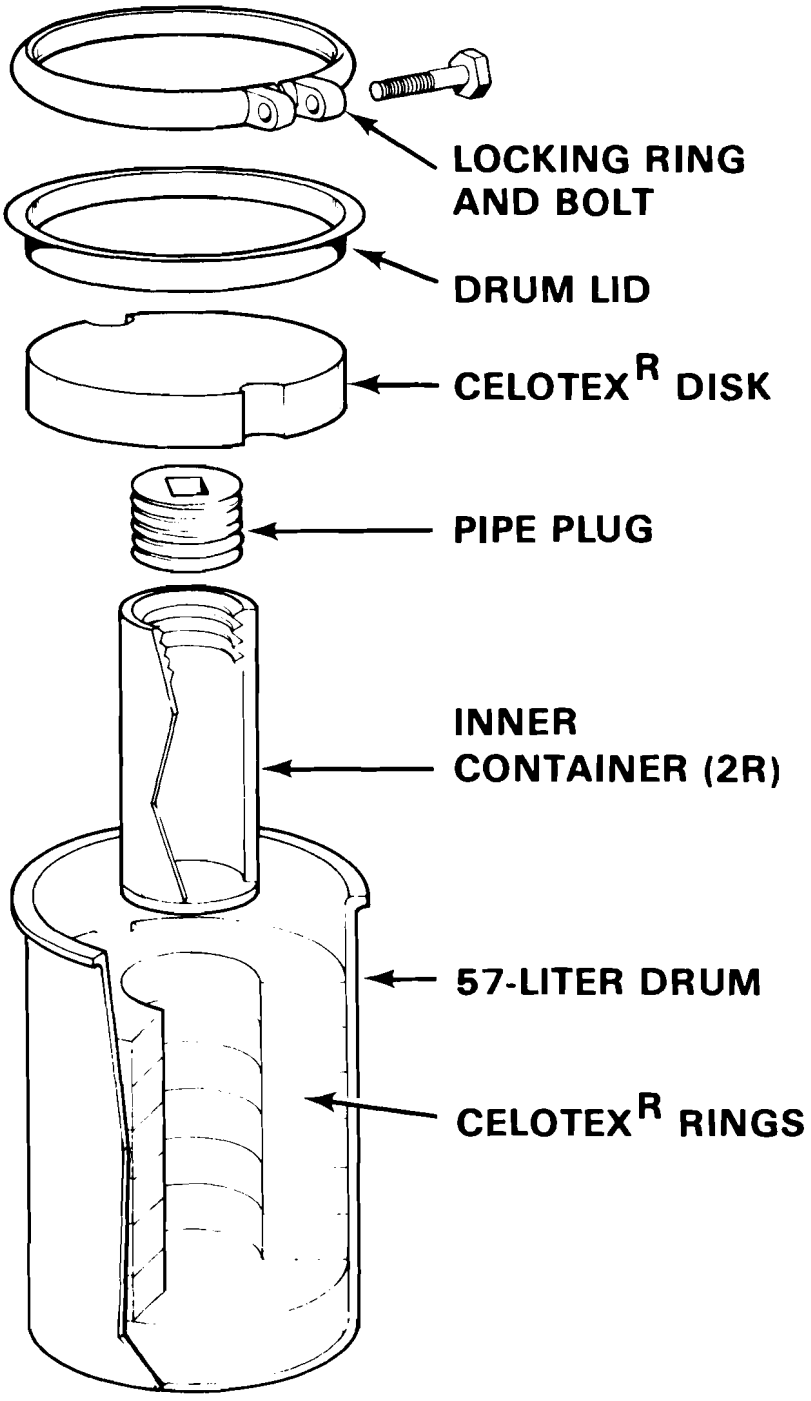

FIGURE B.2 6M Package (57-Liter)

Authorized Contents

Up to 4.5 kg of plutonium metal, alloy or compound or up to 13.5 kg of uranium 235 metal or alloy. Additional details and restrictions are provided in 49CFR 173.396.

Interior and Exterior Dimensions

Interior 13.3 cm ID x 26.7 in. deep inside; Drum - 39.6 cm diam. x 54 cm high outside with 18 ga. wall.

Description of Container

The outer container is a 57 liter DOT Spec. 17C drum. The inner container is a steel pipe with an inner diameter of 12.2 cm and 0.95 cm wall thickness (5 in. Sch 80). It has a threaded plug. The bottom end is closed by a welded steel cap. The plutonium product is contained in two sealed No. 8 steel cans which are placed inside the inner container. The inner container is lined with padding to minimize damage to the steel cans during a shipment.

Type and Thickness of Insulation

The inner container is insulated by Celotex® Industrial Board with a minimum thickness of 7.6 cm.

Shielding

None provided, may be added within the containment vessel when required.

Heat Removal Capacity

Normal licensed limit of 10 watts. Special permits have been issued for designs which allow for up to 50 watts. The 10 watt limit results in a containment vessel temperature limit of 68°C for a 21°C ambient temperature. Special handling requirements are required when materials that generate more than 10 watts are shipped.

Authorized Modes of Transport

Vessel, cargo or passenger-carrying aircraft, motor vehicle, rail freight, and rail express.

LLD-1 Package

A diagram of the LLD package is shown in Figure B.3. The following specifications taken from WASH-1279 summarizes the container design characteristics.

Authorized Contents

Up to 7 kg of Pu metal, or Pu-U alloy containing 7 kg of fissile uranium or up to 4.5 kg of Pu oxide.

Interior and Exterior Dimensions

Interior - 11.4 cm ID x 26.0 cm high. Exterior - 42 cm x 42 cm x 66 cm high.

Description of Container

A cylindrical outer container is supported in a cage of 1.9 cm OD x 0.16 cm wall seamless steel tubing. This outer container is closed by engaging the closing lugs on the bird. Seal is effected by tightening the lid against a gas-filled O-ring using the hex head bolts on the lid assembly. The inner container is a DOT-2R container, fabricated of steel pipe with an inner diameter of 12.2 cm and 0.45 cm wall thickness (5 in Sch 80). It is closed with a threaded plug and a gas-filled O-ring seal. The product is contained in two No. 8 steel cans which are placed inside the inner container. The inner container is lined with padding to minimize damage to the steel cans during transport.

Type of Shielding

None.

Heat Removal Capacity

By convection only.

Authorized Modes of Transport

Air, highway, rail, water. Fissile Class II or III by cargo only aircraft.

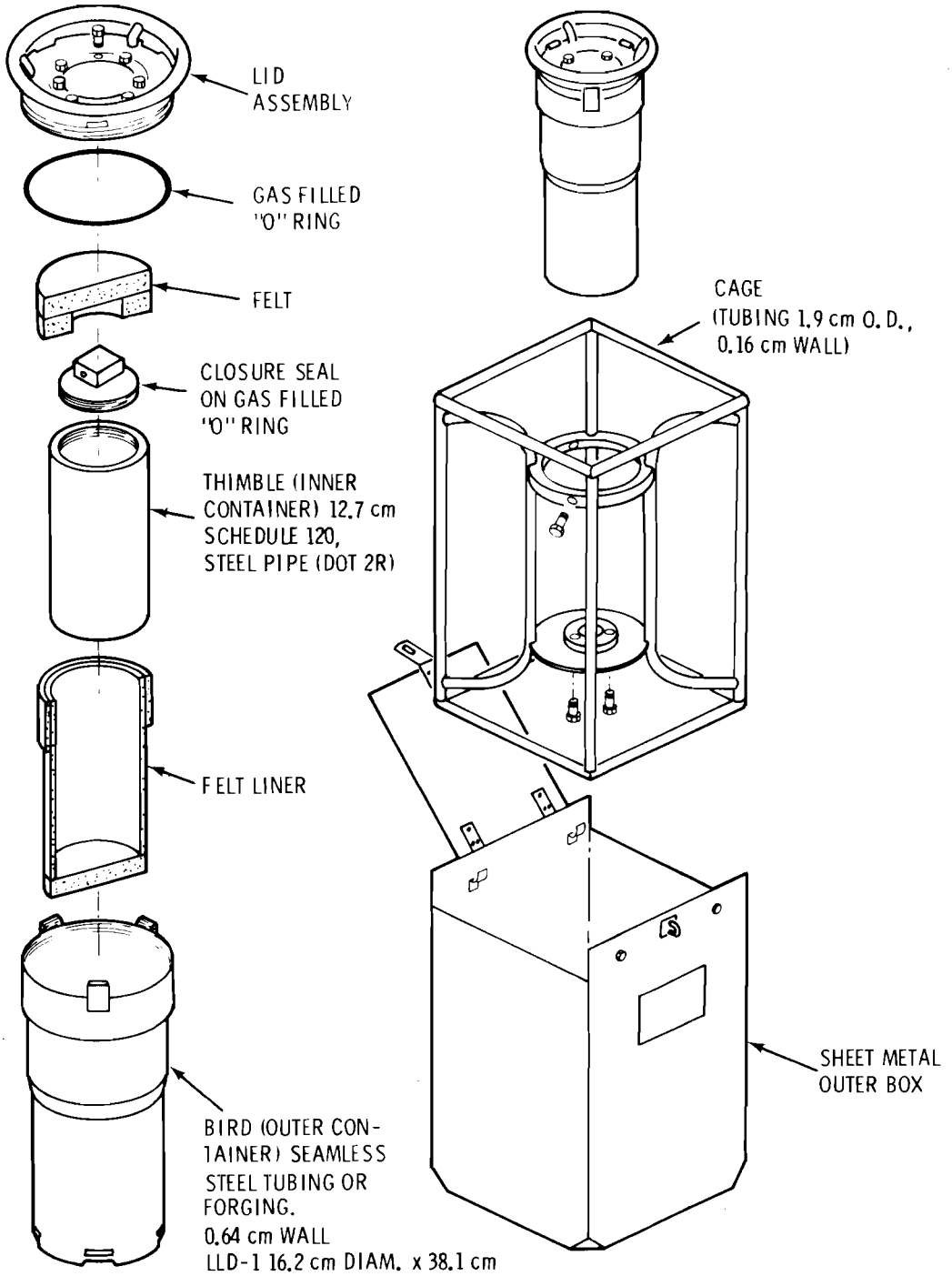

FIGURE B.3 LLD-1 Package

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