



## Department of Energy

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March 27, 1998

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DNF SAFETY BOARD

The Honorable John T. Conway  
Chairman  
Defense Nuclear Facilities Safety Board  
625 Indiana Avenue, N.W., Suite 700  
Washington, D. C. 20004

Dear Mr. Chairman:

**DEFENSE NUCLEAR FACILITIES SAFETY BOARD (DNFSB) 97-1  
DELIVERABLE - OAK RIDGE NATIONAL LABORATORY (ORNL) INITIAL  
SITE ASSESSMENT REPORT**

Enclosed is the ORNL Initial Site Assessment Report which summarizes information developed from initial inspections and assessments of material containing uranium-233 at ORNL. This report is the deliverable for Commitment 5 of the Department's Implementation Plan for addressing the DNFSB Recommendation 97-1, concerning the safe storage of uranium-233 material.

The report describes the types of uranium-233 material in inventory at ORNL, the facilities where the material is stored, and the actions completed to date to determine any remediation efforts required as work continues in response to the recommendations in 97-1. The report will continue to be updated as inspections and assessments progress with the final report planned to be completed in June 1999.

The actions identified under this milestone (Commitment 5) have been completed and we propose closure of this commitment. If there are any questions, please contact Harold Clark at (423) 576-0823 or Jim Rushton of ORNL at (423) 576-7000.

Sincerely,

Edward G. Cymesty  
ORNL Site Manager

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98-0666

**INITIAL ORNL SITE ASSESSMENT REPORT  
ON THE STORAGE OF <sup>233</sup>U**

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## ACRONYMS AND ABBREVIATIONS

ALARA	as low as reasonably achievable
BIO	Basis for Interim Operations
CAAS	Criticality Accident Alarm System
CEUSP	Consolidated Edison Uranium Solidification Project
CFR	Code of Federal Regulations
COG	Cell Off-Gas
DAC	Design & Analysis Calculation
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
ES&H	Environmental Safety & Health
FAB	Facility Authorization Basis
FY	fiscal year
GBOG	Glove Box Off-Gas
HEPA	High-Efficiency Particulate Air
HEU	highly enriched uranium
IP	Implementation Plan
LOG	Laboratory Off-Gas
MCCs	Motor Control Centers
MSRE	Molten Salt Reactor Experiment
NCSA	Nuclear Criticality Safety Assessment
NPH	natural phenomena hazards
ORNL	Oak Ridge National Laboratory
OSR	Operational Safety Requirements
ppm	parts per million
RCV	Radiation Confinement Ventilation
RTR	real-time radiography
SAR	Safety Analysis Report
SS	stainless steel
TSR	Technical Safety Requirements
USQD	Unreviewed Safety Question Determination
VA	Vulnerability Assessment
VOG	Vessel Off-Gas

## EXECUTIVE SUMMARY

This initial assessment characterizes the  $^{233}\text{U}$  inventories and storage facility at Oak Ridge National Laboratory (ORNL). This assessment is a commitment in the U.S. Department of Energy (DOE) Implementation Plan (IP), "Safe Storage of Uranium-233", in response to the Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 97-1.

The  $^{233}\text{U}$  storage facility at ORNL is Building 3019. The inventory stored in Building 3019 consists of 426.5 kg of  $^{233}\text{U}$  contained in 1387.1 kg of total uranium. The inventory is primarily in the form of uranium oxides; however, uranium metal and other compounds are also stored. Over 99% of the inventory is contained in 1007 packages stored in tube vaults within the facility. A tank of thorium nitrate solution, the P-24 Tank, contains 0.13 kg of  $^{233}\text{U}$  in ~4000 gal. of solution. The facility is receiving additional  $^{233}\text{U}$  for storage from the remediation of the Molten Salt Reactor Experiment (MSRE) at ORNL. Consolidation of material from sites with small holdings is also adding to the  $^{233}\text{U}$  inventory. Additionally, small quantities (< 50 g total) of  $^{233}\text{U}$  are in other research facilities at ORNL.

A risk assessment process was chosen to evaluate the stored material and packages based on available package records. The risk scenario was considered the failure of a package (or a group of similar packages) in the Building 3019 inventory. The probability of such a failure depends on packaging factors such as the age and material of construction of the containers. The consequence of such a failure depends on the amount and form of the material within the packages. One thousand seven packages were categorized with this methodology resulting in 859 low-risk packages, 147 medium-risk packages, and 1 high-risk package.

Based on this risk categorization, a sample of  $^{233}\text{U}$  containers in Building 3019 will be inspected (a) to characterize the inventory's material condition, quantity, and type and (b) to assess the condition of each type of storage container. The inspection plan is currently being developed. The results of records investigation and characterization will be used to plan the order in which containers should be removed from the storage tube vaults for inspection. As the contents of each storage tube vault are accessed, the inventory data for each tube vault will be verified. Inspection of the containers may include smear sampling, weighing, radiography, calorimetric non-destructive assay, and gamma scanning.

The inspection results will be compared with the requirements of the  $^{233}\text{U}$  storage standard, which is being developed as a part of the IP. If the material and container characteristics meets the standard, no destructive analysis will be performed, and the container will be returned to the Building 3019 storage tube vaults. Corrective actions will be taken on containers that show degradation or do not meet the storage standard. Corrective actions may include overpackaging, repackaging, or complete processing and repackaging as is appropriate to meet the storage standard.

This initial assessment also documents the status of the evaluation of the Building 3019 and its systems for safe storage of  $^{233}\text{U}$ . The properties of  $^{233}\text{U}$  impose unique ventilation and shielding requirements on the storage facility. Uranium-232, which is present at 1 to 200 parts per million (ppm) concentrations in  $^{233}\text{U}$ , has a decay product,  $^{208}\text{Tl}$ , which emits a highly penetrating 2.6-MeV gamma ray. Because of this emission,  $^{233}\text{U}$  requires special shielding and remote handling for most of the inventory.

The  $^{233}\text{U}$  material can also require special ventilation considerations imposed by the decay chain of its associated isotope,  $^{232}\text{U}$ . Part of the  $^{232}\text{U}$  decay chain includes  $^{220}\text{Rn}$ . Thus, storage and processing facilities for  $^{233}\text{U}$  must consider the presence of this gas so that the radon is retained until it decays into a particulate form that may be filtered.

Nuclear criticality safety in Building 3019 is maintained by a combination of (a) passive and active systems and (b) administrative controls. While  $^{233}\text{U}$  is in storage, criticality is prevented by controlling geometry,  $^{233}\text{U}$  loading densities, moderation, and container-stacking configuration. The facility is equipped with a Criticality Accident Alarm System (CAAS) based on neutron detection. Cell 4, which contains the largest array of concrete shielded tube vaults, has a sump area that is continuously monitored for water. A recent video inspection of the Cell 4 floor area verified that there were no visible signs of water or condensation. Visual inspection of empty tube vaults in the Cell 4 tubes and in the walls between Cell 2 and Cell 3 also verified the absence of water.

The concrete cell walls and the shielding designed into the storage tube vaults serve to protect personnel from the radiation hazards associated with  $^{233}\text{U}$ . Administrative procedures and personnel training are used to limit exposure and identify changes to existing conditions. The condition of the outer concrete walls appears to be excellent as evidenced by a remote video inspection.

Smear samples were analyzed from the inside surfaces of the Vessel Off-Gas (VOG) piping which ventilates the storage tube vaults. Additionally, smear samples were taken from the headers of the empty tube vaults to check for cross contamination between vaults. No detectable contamination was found on the smear samples. A comprehensive radiation (gross beta-gamma) scan survey of selected areas around the storage tube vaults and VOG piping was also performed. No indication of a material breach in the stored packaging was found. Sampling of the off-gas lines from the storage tube vaults showed no contamination and no evidence of package breach. The sampling provides a baseline for future trending of off-gas conditions.

When the Building 3019 storage tube vaults are accessed for physical inspection of the material, the following activities will take place: (1) vapor space sampling, (2) hydrogen sampling, (3) measurement of available storage space height, (4) smear sampling of tube vault interiors, and (5) measurement of the penetrating radiation field. These measurements can give advanced warning of potential problems with containers that have been stored for extended periods before the containers are removed from the tube vaults.

As a part of the IP, additional capability is being installed in Building 3019 to stabilize and repackage multikilogram quantities of  $^{233}\text{U}$ . These capabilities are required to implement the inspection and repackaging of material within the tube vaults. Commercial hot cell modules have been procured and are being installed in Cell 2 of Building 3019. The hot cells will be ventilated by an upgraded Glove-Box Off-Gas (GBOG) system. In addition, an analysis is being prepared to document the design, functional performance, and regulatory requirements for the Building 3019 ventilation systems.

Building 3019 has initiated an update of its Facility Authorization Basis (FAB). The result of this update will be a Safety Analysis Report (SAR) and Technical Safety Requirements (TSR) that



are compliant with DOE Orders. These two documents are scheduled to be submitted to DOE for approval by September 30, 1999.

The DOE Environmental Safety & Health Highly Enriched Uranium (HEU) Vulnerability Assessment (VA) identified six vulnerabilities associated with  $^{233}\text{U}$  storage at Building 3019. Three of these vulnerabilities were linked to natural phenomena. Two other vulnerabilities address potential failure of cans of  $^{233}\text{U}$  in the tube vaults. The final vulnerability involves potential release from Tank P-24. A complete natural phenomena hazard analysis is being performed as part of the FAB update. One of the vulnerabilities linked to possible can failure will be corrected by performing a physical inspection of the material. The other will be corrected by addressing, in the Building 3019 safety basis, a potential failure of cans during handling. A procedure requirement for periodic monitoring during material transfer from the P-24 tank has mitigated the third potential vulnerability.

The final assessment report for ORNL storage of  $^{233}\text{U}$  is scheduled for June 1999. The report will document the facility assessments, the specific package inspection plan, and the results of initial package inspections.

# 1. INTRODUCTION

## 1.1 PURPOSE AND SCOPE

The purpose of this initial assessment is to characterize the  $^{233}\text{U}$  currently stored within Oak Ridge National Laboratory (ORNL) Building 3019 (Fig. 1.1) and provide information on the condition of the facilities in which this material is housed. This assessment was identified as a commitment in the Department of Energy (DOE) Implementation Plan (DOE 1997), "Safe Storage of Uranium-233," in response to the Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 97-1 (DNFSB 1997a). This recommendation, which addresses the safe storage of  $^{233}\text{U}$ -bearing material, was issued by the DNFSB on March 3, 1997. The U.S. Secretary of Energy accepted the DNFSB's Recommendation on April 25, 1997.

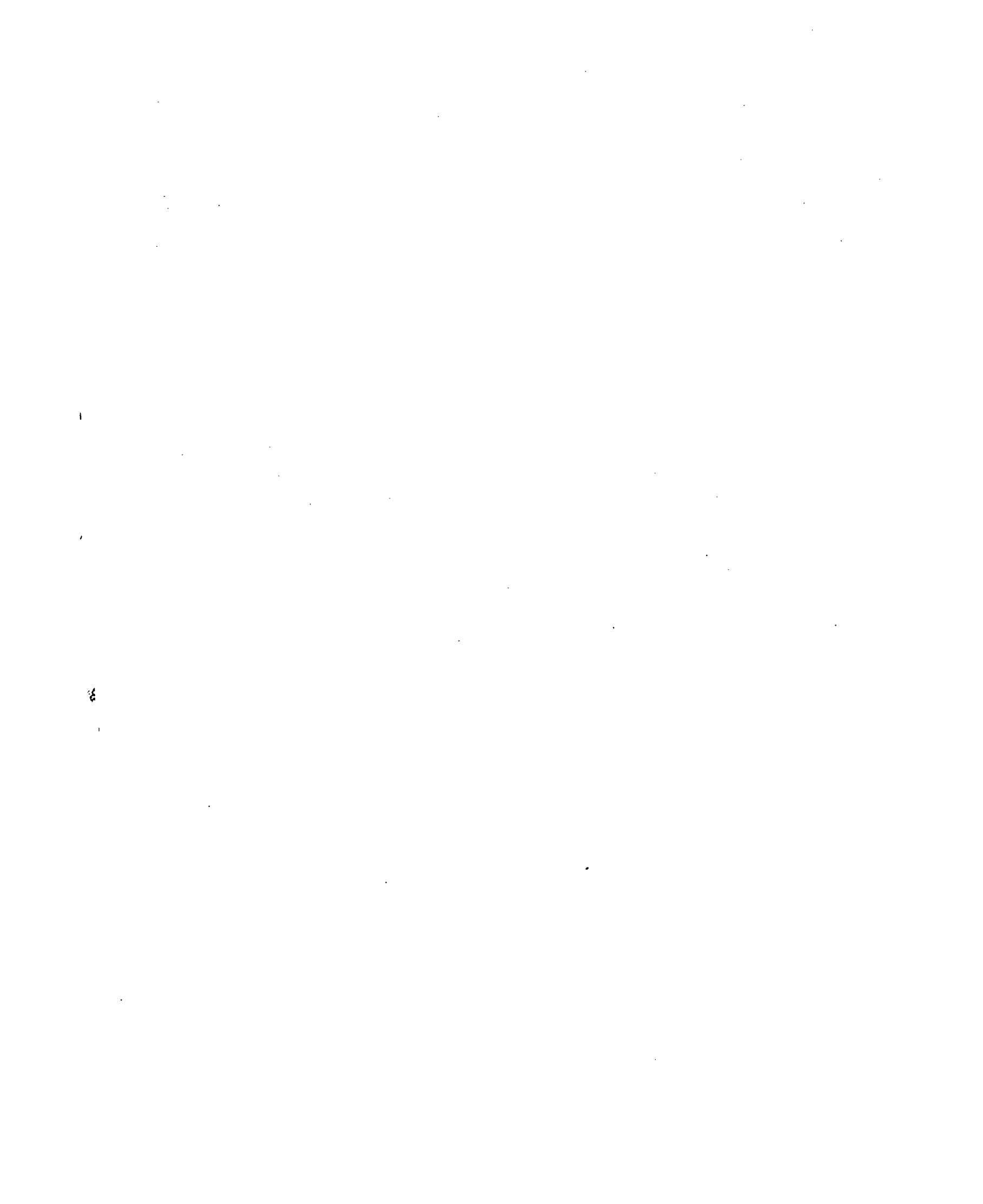
Recommendation 97-1 describes actions that the DNFSB considers necessary to ensure the safe storage of  $^{233}\text{U}$ -bearing materials in the interim and the longer term. Those actions are detailed in eight subrecommendations. The initial site assessment addresses two of the eight subrecommendations:

Subrecommendation 3: Characterize the items of  $^{233}\text{U}$  presently in storage in the Department of Energy's (DOE) defense nuclear facilities as to material, quantity, type and condition of storage container.

Subrecommendation 4: Evaluate the conditions and appropriateness of the vaults and other storage systems used for the  $^{233}\text{U}$  at the Department's defense nuclear facilities.

In the current report, where documented information is available, it will be used in the assessment; where information is lacking, actions will be identified and initiated to acquire information needed for a final assessment. The final site assessment will also address additional subrecommendations by using the results of the initial inspections to evaluate the adequacy of storage.

Recommendation 97-1 was based on a DNFSB technical report in which the safety of  $^{233}\text{U}$  stored at various sites in the DOE complex was evaluated (DNFSB 1997b). Both the Recommendation and the report acknowledged the Highly Enriched Uranium (HEU) Vulnerability Assessment (VA) conducted for DOE's Office of Environmental Safety and Health (ES&H) (DOE 1996). Because of the VA, the DOE was aware of the legacy issues surrounding the storage of  $^{233}\text{U}$ -bearing materials. In addition, at the time Recommendation 97-1 was issued, the DOE was developing the HEU Vulnerability Management Plan to correct the vulnerabilities identified in the VA (DOE 1997b). The corrective actions identified in the Vulnerability Management Plan are incorporated in this initial assessment.





## 2. BACKGROUND

Building 3019 was built during the Manhattan Project to separate plutonium from irradiated reactor fuel and to demonstrate other nuclear fuel processes on a pilot scale (Brooksbank et al. 1994). The current mission of Building 3019 is to serve as the DOE National Repository for  $^{233}\text{U}$ . This mission requires Building 3019 to be able to handle, store, and process multikilogram quantities of  $^{233}\text{U}$ . ORNL has been storing  $^{233}\text{U}$ -bearing materials since 1962 and has been operating Building 3019 in compliance with an approved Facility Authorization Basis (FAB), nuclear criticality safety program, and radiation protection program.

### 2.1 INVENTORY

The inventory at Building 3019 currently consists of 426.5 kg of  $^{233}\text{U}$  in 1387.1 kg of total uranium. Almost all of this material is stored in 1007 outer packages located in the Building 3019 storage tube vaults (described in the following). In some instances, these outer packages contain multiple inner packages. The material exists in a variety of chemical and physical forms and in a variety of packages, as is summarized in Table 2.1. Drawings of the prevalent packaging forms are provided in Appendix A.

Tank P-24 stores 0.13 kg of  $^{233}\text{U}$  diluted in ~4000 gal of thorium nitrate solution. Small quantities of  $^{233}\text{U}$  (< 2 kg) for research are stored or are in process in other areas of Building 3019. A small amount of residual contamination is in historical processing equipment. The Building 3019 inventory is increasing as  $^{233}\text{U}$  is recovered from the remediation of the Molten Salt Reactor Experiment (MSRE). Consolidation of material from sites with small holdings will also increase the inventory.

In addition to the material being recovered from the MSRE, there are other small quantities of  $^{233}\text{U}$  at ORNL that are not in Building 3019. The Building 3027 vault is currently holding 16 g of very high-quality (very low  $^{232}\text{U}$ )  $^{233}\text{U}$ . Research quantities (< 1 g) of  $^{233}\text{U}$  are contained in Buildings 3525 and 4501. Additionally, 12 kg of  $^{233}\text{U}$  are managed as waste and are tracked in the ORNL Waste Management and Remedial Action Division waste tracking system. This material is stored in over 5000 packages consisting of vaults, drums, and boxes.

The entire DOE inventory of  $^{233}\text{U}$  currently is being evaluated as part of the Material Disposition Program. A strategy is being developed to determine which  $^{233}\text{U}$  materials are surplus to DOE's needs and which materials have a potential programmatic application (Forsberg and Krichinsky 1998). Surplus material will be disposed as feasible. Remaining material in excess of defense needs will be retained as a "national treasure."

### 2.2 STORAGE TUBE VAULTS

In Building 3019,  $^{233}\text{U}$  is stored in four sets of tube vaults. One set is located in Cell 4; and the other three sets are located in the shield walls between Cells 2 and 3, Cells 3 and 4, and Cells 4 and 5, respectively. All tube vaults are top-loaded, shielded, ventilated, and accessible from the "Penthouse" (Room 201) of Building 3019 (Fig. 2.1). The head space of the tube vaults are vented through a manifold to the Vessel Off-Gas (VOG) System and provide negative pressure to the

Table 2.1 Uranium-233 in Building 3019 storage tube vaults <sup>a</sup>

Reference Figure	Material Form	Package Assembly	Package Configuration	No. of Outer Packages	<sup>233</sup> U (kg)	<sup>232</sup> U (ppm)	Total U (kg)
Fig. A.1	U Metal	LANL	Unique SST	2	5.9	40	6.0
Fig. A.2	U Oxide Powder	Savannah River SRO-9	Welded Al in Welded Al	6	3.0	7	3.0
Fig. A.3	U Oxide Powder	Savannah River LZB	Welded Al in Welded Al	6	2.9	4.5	3.0
Fig. A.4	U Oxide Powder	ORNL-RDF	Tin-plated steel over plastic bagged glass sample vials	1	0.01	7	0.01
Fig. A.5	UF <sub>4</sub> ·LIF	RCP-04	Welded Ni in Al	2	1.1	220	1.2
Fig. A.6	UF <sub>4</sub> ·LIF	RCP-04	Welded Al in welded Al	1	1.55	220	1.7
Fig. A.7	UF <sub>4</sub> ·LIF	RCP-04	SST in welded Al	1	0.3	220	0.3
Fig. A.8	U <sub>3</sub> O <sub>8</sub> Monolith	CEUSP	Tin-plated steel over welded SST	403	101.1	140	1042.6
Fig. A.8	U <sub>3</sub> O <sub>8</sub> Monolith	RCP-06	Tin-plated steel over welded SST	27	60.3	20	65.2
Fig. A.9	U Oxide Powder	Savannah River aluminum (RCP-02)	Welded Al in welded Al	27	10.7	38	11.1
Fig. A.9	U Oxide Powder	Savannah River aluminum (RCP-03)	Welded Al in welded Al	140	61.6	220	67.4
Fig. A.10	U Oxide Powder	Short oxide-product can (PZA BPL)	Tin-plated steel over plastic-bagged SST	22	15	6	15.4
Fig. A.10	U Oxide Powder	Short oxide-product can	Tin-plated steel over plastic-bagged SST	68	54.6	6.5 - 10	58.9
Fig. A.11	U Oxide Powder	Tall oxide-product can	Tin-plated steel over plastic-bagged SST	71	33.5	6 - 8.3	34.4
Fig. A.12	U Oxide Powder	Mound	Glass within SST within SST	20	3.5	2 - 16	3.6
Fig. A.13	U <sub>3</sub> O <sub>8</sub> Powder	ANL-ZPR (5 Packet)	Ni plated SST packets within tin-plated steel	2	0.3	7	0.3
Fig. A.14	U <sub>3</sub> O <sub>8</sub> Powder	ANL-ZPR (12 Packet)	Ni plated SST packets within tin-plated steel	101	32.9	7	33.6
Fig. A.15	U <sub>3</sub> O <sub>8</sub> Powder	ANL-ZPR (16 Packet)	Ni plated SST packets within tin-plated steel	27	11.8	7	12.1
Fig. A.16	U Metal	ANL-ZPR (Metal)	Ni plated SST packets within tin-plated steel	1	0.6	5	0.6
Fig. A.17	U Oxide Powder	Oxide	Tin-plated steel over plastic bagged tin-plated steel	6	1.5	7 - 10.8	1.5
Fig. A.18	U Oxide Powder	Oxide scrap	Tin-plated steel over plastic bagged tin-plated steel	6	3.8	6 - 42	3.9
Fig. A.19	U Metal	RCP-20(#2&#3)	Tin-plated steel over plastic bagged tin-plated steel	2	4	5 - 42	4
Fig. A.19	U Metal	Metal scrap	Tin-plated steel over plastic bagged tin-plated steel	3	0.5	5 - 42	0.6
Fig. A.20	Ammonium Diuranate Powder	ADU scrap	Tin-plated steel over plastic bagged tin-plated steel	1	0.1	7	0.1
Fig. A.21	U Oxide Powder	Hanford HUA-2	SST in welded SST	6	0.3	8 - 38	0.4
Fig. A.22	U Metal	LANL AUA-84	Welded SST in welded SST	3	0.5	8	0.5
Fig. A.23	U Oxide Microspheres	ORNL-RDF misc. samples	Plastic-bagged glass in cardboard within tin-plated steel	3	0.4	7	0.4
Fig. A.24	U Oxide Powder	ORNL-RDF archive samples	Tin-plated steel over plastic bagged plastic sample vials	9	0.7	6 - 10	0.7
Fig. A.25	Ammonium Diuranate Powder		Tin-plated steel over tin-plated steel	1	0.1	7	0.1
None	Various	Miscellaneous	Various	39	13.9	<1 - 220	14.5
			Totals	1007	426.5		1387.1

<sup>a</sup> as of 3/10/98. Does not include material recovered from MSRE. This material will become part of the scope of Recommendation 97-1 when it is stabilized.

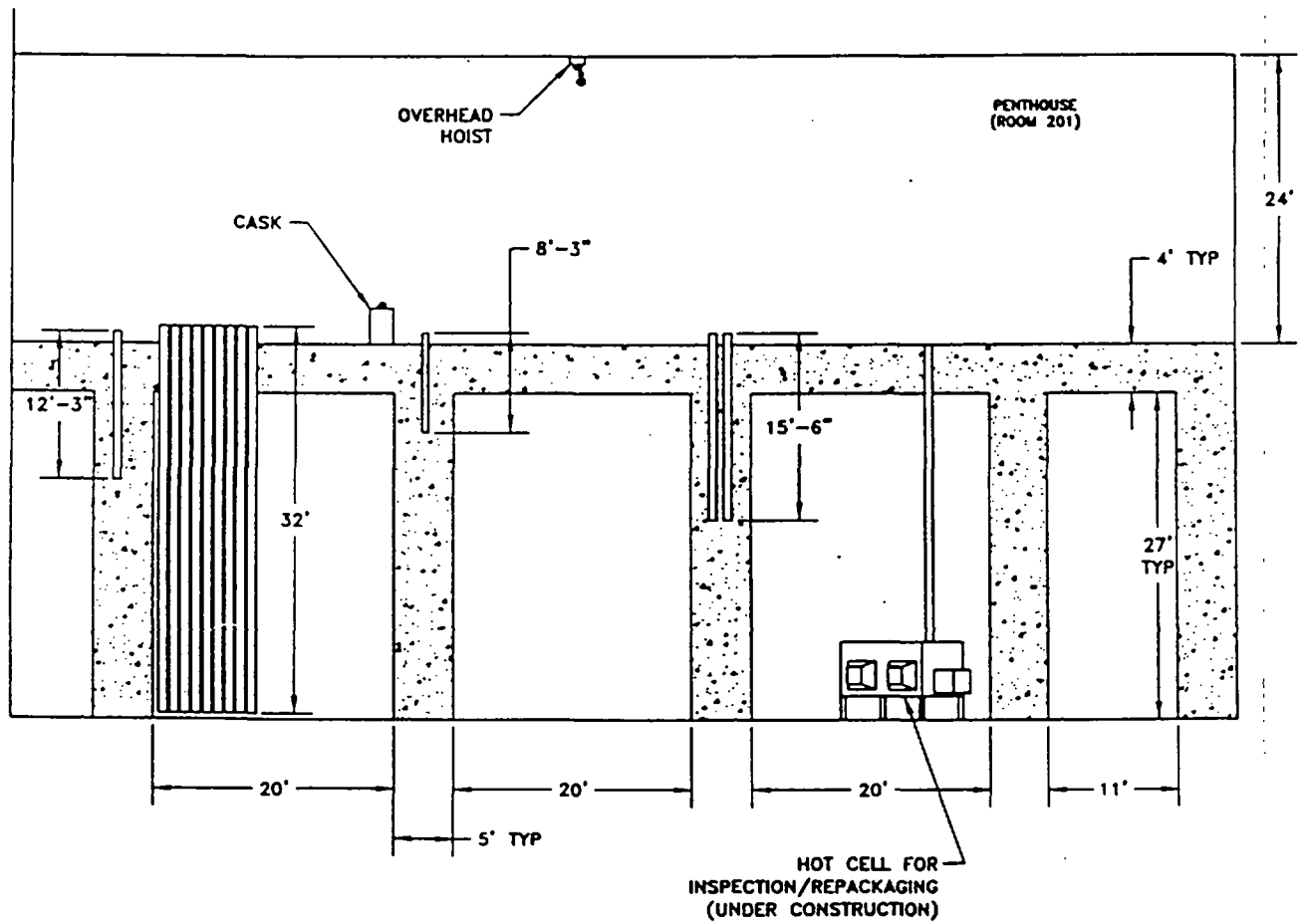
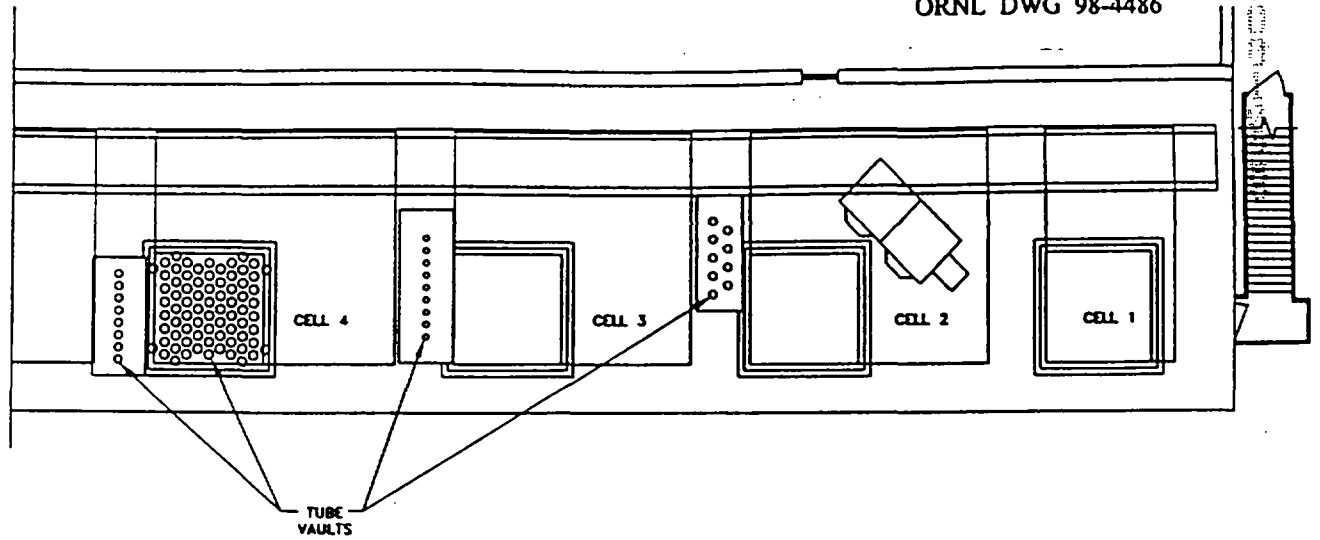


Fig. 2.1. Building 3019 storage configuration.

storage tube below (i.e., not flow-through ventilation). The top of each vault is shielded with a removable plug made of stainless steel (SS) and lead.

One set, an array of 68 tube vaults, is installed in the southwestern corner of Cell 4. These tube vaults extend up into a 9-ft. by 9-ft. former equipment hatch in the cell ceiling. The tube vaults extend from the cell floor to ~1 ft above the former hatch opening. Thus, each pipe is ~32 ft long with the top 6 ft being a 6-in.-diam expanded head section for shield plugs, ventilation connections, and locking devices, which allow each tube to be secured (and accessed) individually. These tube vaults are arranged in a triangular pattern, and each consists of a carbon steel pipe that is encased in a hexagonal concrete structure (Fig. 2.2). The pipes inside 45 of the tube vaults are constructed from 4-in.-diam, schedule 40 pipe. The pipes inside the other 23 tube vaults are constructed from 5-in.-diam (outside), 0.25-in.-thick tubing.

There are 26 tube vaults in the three sets of in-wall vaults, each consisting of a 4-in.-diam., schedule 40 SS pipe, which serves as the storage tube. There are nine 15-ft-long tube vaults between Cells 2 and 3, nine 8.25-ft-long tube vaults between Cells 3 and 4, and eight 12.25-ft-long tube vaults between Cells 4 and 5. These three sets of tube vaults have locking devices that secure or allow access to all tubes in the set. Currently, the tube vaults between Cells 2 and 3 are empty and are being modified to allow individual vault securing (and accessing). The current inventory of  $^{233}\text{U}$  occupies ~54% of the available storage capacity of Building 3019.

The tube vaults between Cells 3 and 4 and between Cells 4 and 5 are single rows of tube vaults positioned ~3 in. from the center plane of the between-cell shield walls (avoiding a construction joint located in the center plane of the concrete wall that is equidistant from the cell interiors). The tube vaults between Cells 2 and 3 are oriented in two rows in a nominal 18-in. triangular pattern, with each row being closer to the adjacent cell interior (Fig. 2.3). Therefore, for this positioning, the concrete walls did not provide shielding sufficient for high gamma radiation. Thus, larger holes were drilled, and lead shot was added to the annulus surrounding the storage tubes to augment shielding.

Cans containing  $^{233}\text{U}$ -bearing materials are placed into or retrieved from the storage tube vaults by one of several types of lifting or handling devices that are actuated by vacuum, electromagnet, or mechanical linkage (or a combination of actuators). These devices can be used also to transfer cans to a shielded transfer cask. A 10-ton crane provides the means for moving the shielded transfer cask within the Penthouse.

### 2.3 P-24 TANK

In addition to the tube vaults, which store  $^{233}\text{U}$  in solid form, a small amount of  $^{233}\text{U}$  is stored in thorium nitrate solution in tank P-24. This 9-ft-diam. tank with ellipsoidal heads has a capacity of 10,000 gal and is oriented horizontally below ground level. The tank currently contains ~4,000 gal of thorium nitrate solution contaminated with 0.1 kg of  $^{233}\text{U}$ . It is recognized that solutions are an unacceptable form for long-term storage.



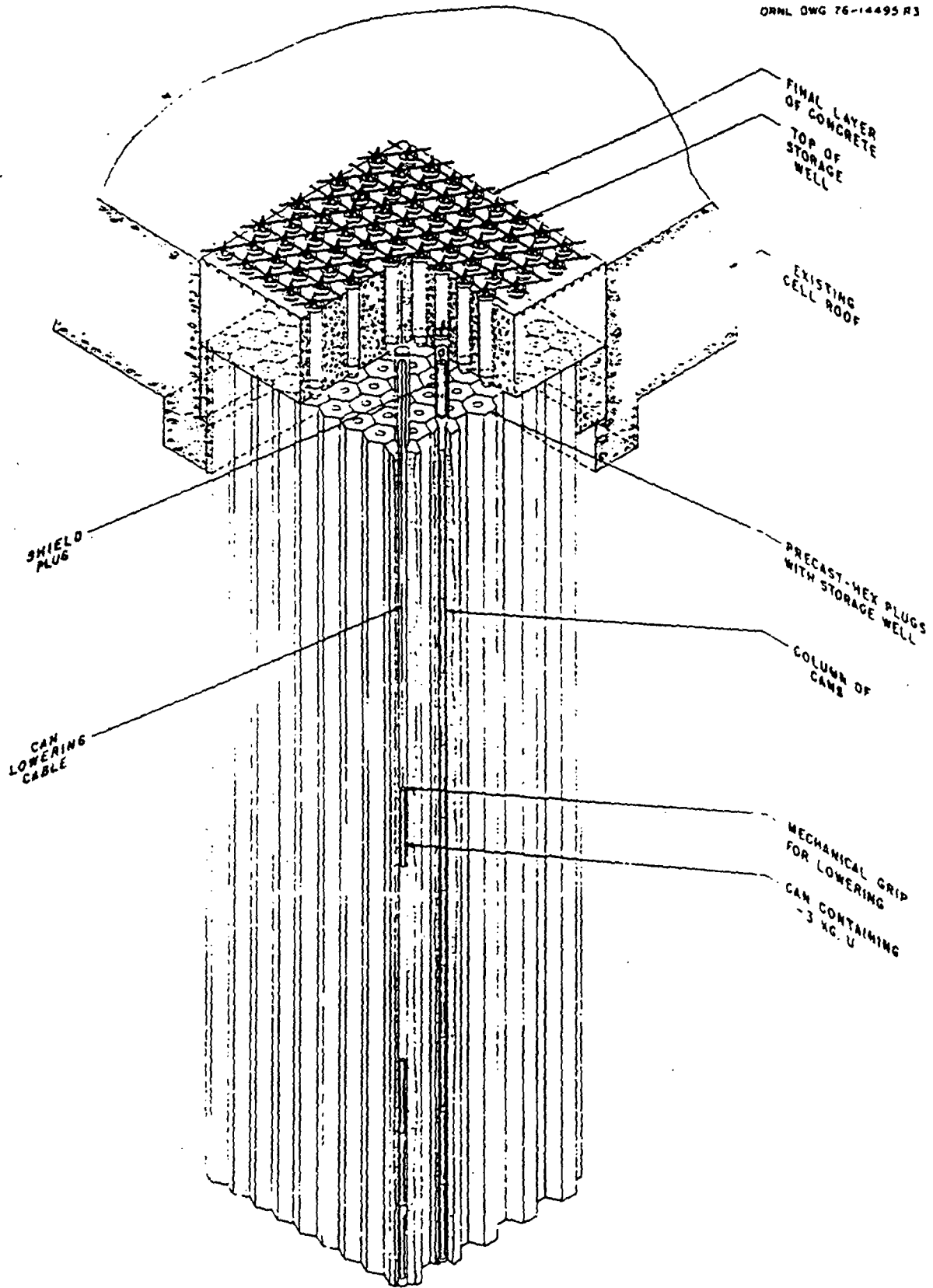


Fig. 2.2. Cell 4 storage tube vaults.

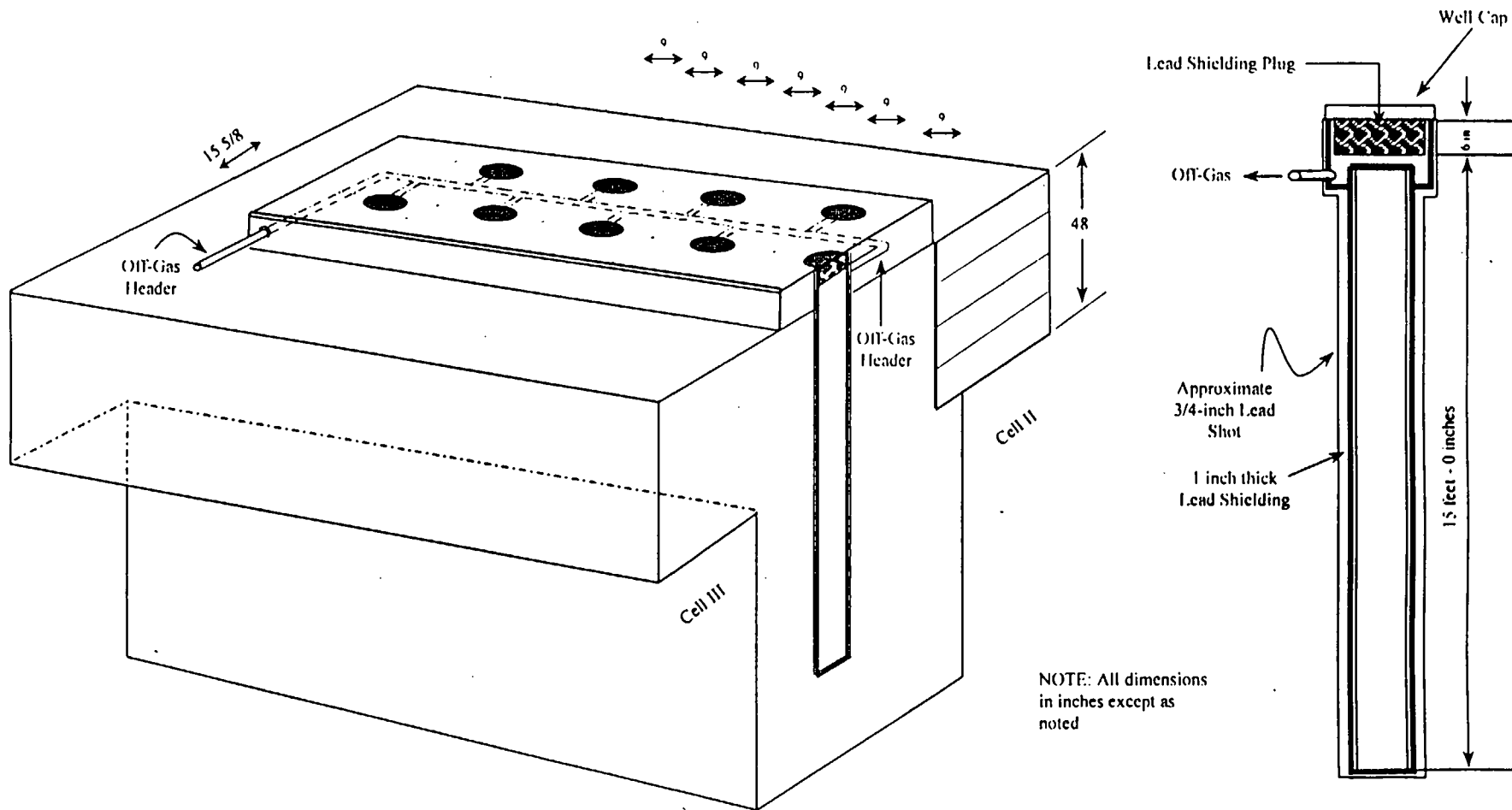


Fig. 2.3. Cells 2 and 3 storage tube vaults.

(Redrawn referencing ORNL Dwg. 70-3682R)  
(Not to Scale)

Tank P-24 is located in a bunker external to Building 3019 (Fig 2.4). The bunker consists of 16-in.-thick concrete walls and 12-in.-thick roof plugs. Two spare tanks, P-23 (10,000 gal) and P-25 (5,000 gal) also occupy the bunker and are available for backup storage. The bunker is equipped with a sump and is vented through the VOG system.

## 2.4 VENTILATION SYSTEMS

Building 3019 is ventilated by four off-gas systems designated as the *ventilation confinement network* (Fig. 2.5): (1) Laboratory Off-Gas system (LOG) (2) Cell Off-Gas system (COG) (3) Glove Box Off-Gas system (GBOG) (4) VOG. This network is designed to confine radioactive materials within the radiochemical laboratories, hot cells, glove boxes, process cells, vessels, and storage tube vaults. Only the GBOG is considered a candidate safety class system.

In high specific-alpha-activity nuclear facilities, it is a customary and safe practice to maintain reliable ventilation that causes air to flow from areas of low (potential) contamination to areas of higher (potential) contamination before high-efficiency particulate air (HEPA) filtration, ES&H monitoring, and discharge to the environment. At Building 3019, air is continuously drawn from outdoors into the building's secondary confinement structure and on through primary confinement boundaries. Air is exhausted through the network of ventilation systems composed of ductwork headers, HEPA filters, ES&H monitors, and discharged primarily to Stack 3020.

### 2.4.1 LOG System

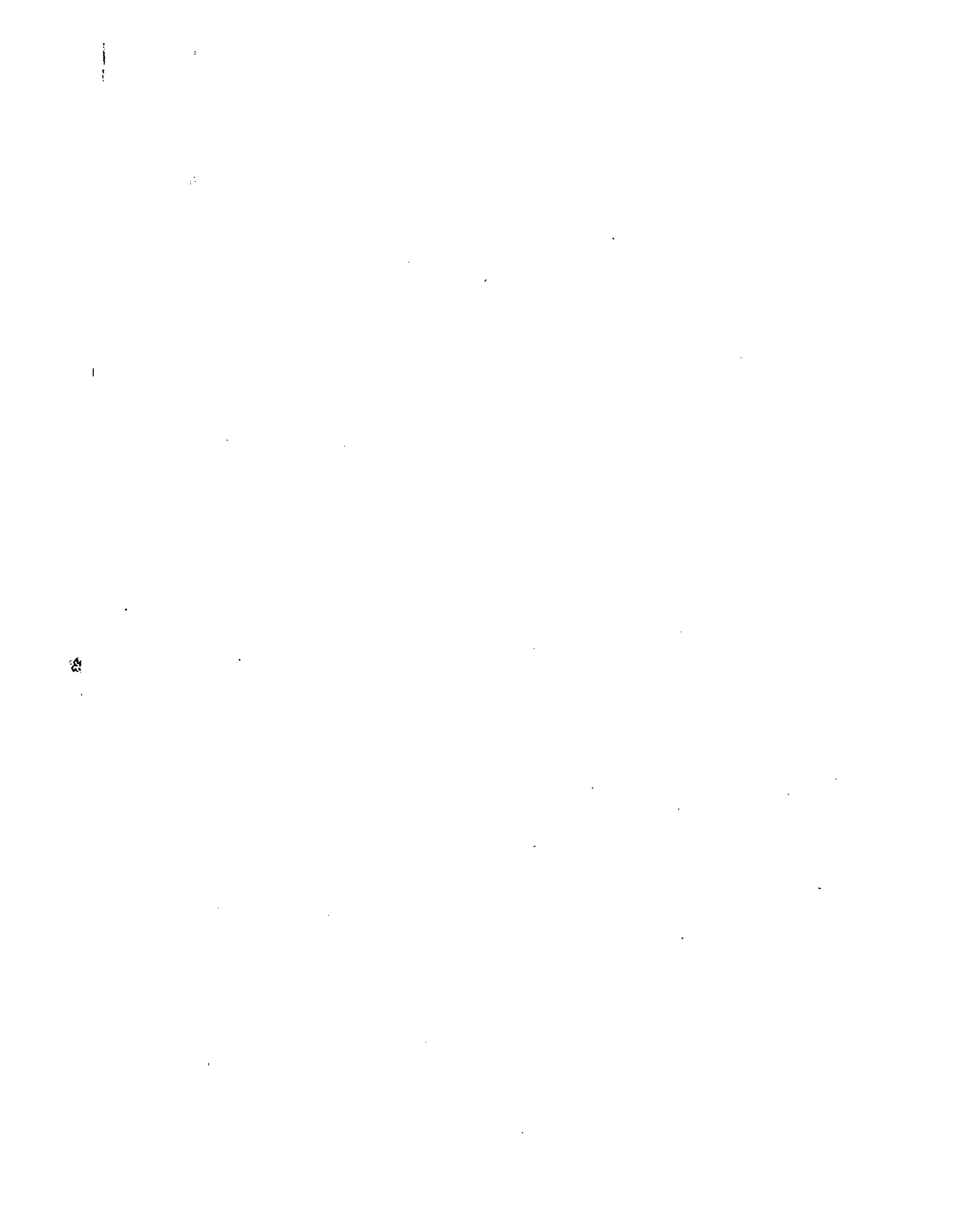
The LOG system primarily routes exhaust from the Building 3019 laboratory hoods to the inlet of Filter House 3108. The LOG System parallels and is connected to the COG system (see the following) at about the mid-roof point. This connection was originally installed to allow the COG system to provide exhaust ventilation service to the areas normally served by the LOG system while the replacement of the LOG fans and ductwork was performed as part of the Stack 3020 Improvement Project, which was completed in 1985. The cross-connect duct now serves permanently as the normal and emergency cross-connect duct between the two systems.

### 2.4.2 COG System

The COG system is located at the middle and east end of Building 3019 and serves as the central collection for the process cell effluent. This service begins with a rectangular concrete duct that serves as an exhaust plenum for the seven remote process cells in the building. The concrete duct is formed on the top the process cells and runs from the west end of Cell 7 to just east of Cell 1. The concrete duct is connected to a carbon steel duct that directs exhaust to the east side of Stack 3020 via HEPA filters located in Filter House 3091.

As cited above, the COG and LOG systems are connected at the mid-cell location. Although these two systems are distinct in their physical locations and discharge paths, many common areas are essentially served by both the LOG and COG systems because of the infiltration occurring between adjacent areas within Building 3019.

Two electrically driven fans, installed in parallel for redundancy, are located in each of these two systems downstream of their respective filter houses. One fan in the COG system and one fan in the LOG system are normally operated, and the second fan in each system serves as a backup.





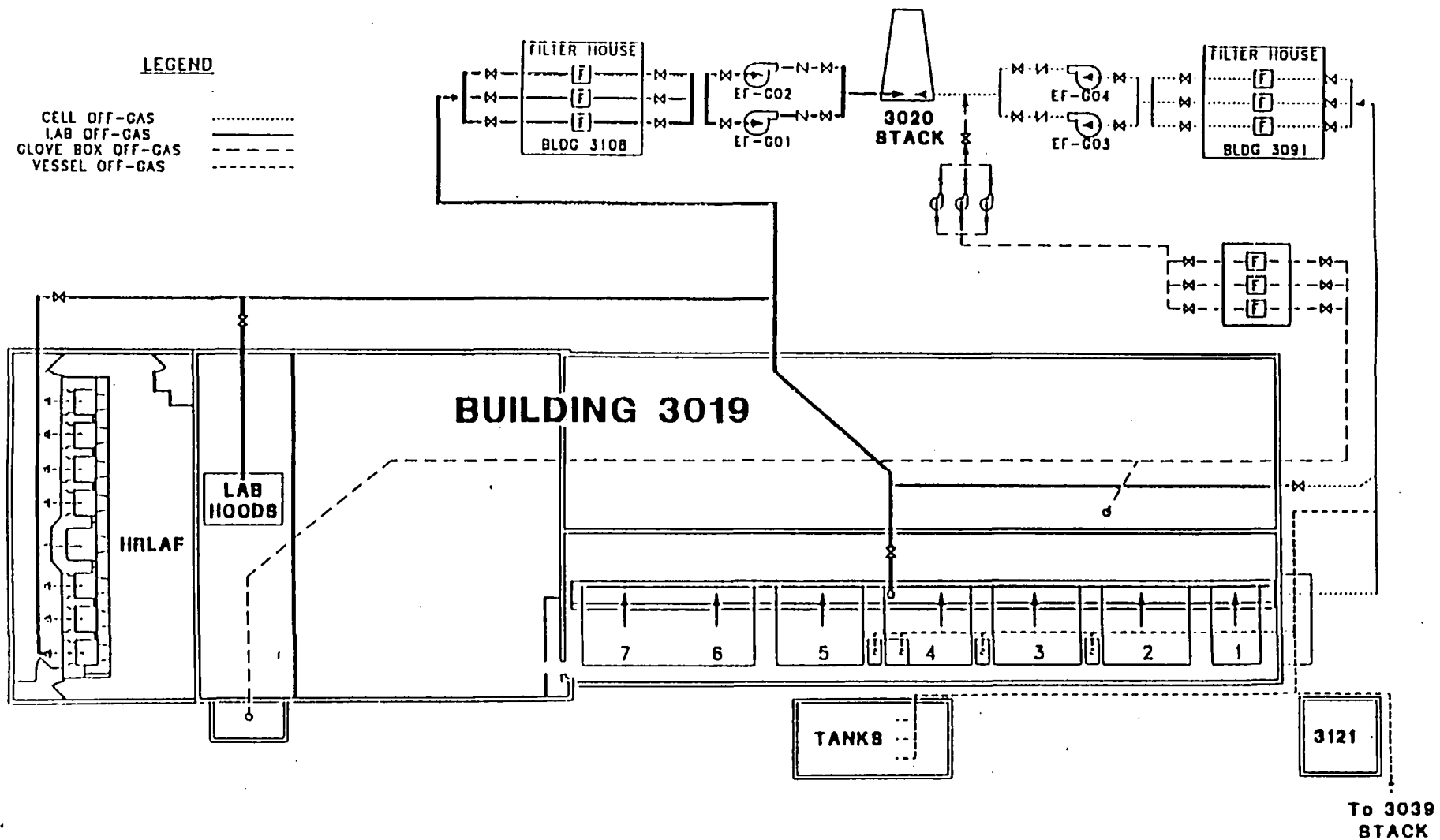


Fig. 2.5. Building 3019 ventilation systems.

ORNL-CONF-98-100

### 2.4.3 GBOG System

The GBOG system was installed in Building 3019 during the early 1970s to provide HEPA-filtered exhaust ventilation from the glove boxes in which radioactive materials were processed in preparation for storage or shipment to other DOE facilities. The GBOG system consists of ductwork, valves, dampers, filters, and fans that provide exhaust ventilation from glove boxes located throughout the Building 3019 complex and discharges to Stack 3020. The main GBOG header, on the roof of Building 3019, directs the flow from two branch headers to the GBOG final filter. In addition, a connection from the Building 3100 branch header joins the main header. However, no glove boxes are currently connected to this branch. Installed in the main header is a steam-heating coil, which is no longer connected to a steam supply and does not function.

HEPA filters, located at each glove box outlet, provide initial filtration of the air leaving the glove boxes. Dampers installed throughout the system provide manual shutoff and volume adjustment capability in all major portions of the system to allow a diverse array of operating and maintenance configurations. Back-pressure dampers are provided in the discharge duct of each fan discharge to minimize flow reversals in case of improper pressure differentials or upset conditions. The GBOG system provides vacuum relief to the glove boxes via two vacuum relief valves installed between the first and final stage of HEPA filtration. Should the header vacuum exceed the set-point value, the relief valve lifts off its seat and allows the inflow of air, thus relieving the high vacuum condition. Inlet air to the relief valves is HEPA-filtered. A fire barrier is installed in each of the final filter housing inlet ducts. These fire barriers provide flame-arresting capability to prevent damage to the final HEPA filter media in case of a fire or explosion in the GBOG system.

Three fans service the GBOG. One fan operates, one fan is in standby mode, and one fan is off-line. The functionality of the three fans is rotated on a monthly basis.

### 2.4.4 VOG System

The VOG system provides exhaust ventilation for facility operating, process, and storage areas. The primary purpose of this system is to ensure confinement of contamination in process vessels, tanks, and storage tube vaults. The system accomplishes this by maintaining confinement areas at a negative pressure with regard to surrounding areas. The system also has the capability of discharging to the COG system as an alternate discharge path.

The VOG system is normally directed to Stack 3039, which provides the actual ventilating resources (electric-driven fans providing ~30 in. water gauge vacuum) necessary for the normal operation of the VOG system. A diesel generator provides standby power for the fans and a steam-powered fan is used as backup. The function of the VOG can alternatively be provided by the COG system (~5 in. water gauge vacuum) as a backup. The VOG system is a relatively low-flow, high-vacuum system in contrast to the higher flow, lower vacuum COG system. The main header and numerous branch headers provide service to many areas of Building 3019.

Various process vessels throughout the facility are provided with ventilation from the VOG system. The system is maintained at negative pressure (with respect to the rooms in which the VOG service is used), to ensure contaminants are captured and discharged to a safe path. The Thorium Reactor Uranium Storage Tank (P-25), Bulk Thorium Storage Tanks (P-23 and P-24),

and the Building 3019 laboratories (Rooms 110,112,113, and 114) and Room 15 are served by the VOG system.

## **2.5 POWER AND ELECTRICAL**

Normal power is supplied to Building 3019 from ORNL's 2.4 kV distribution system through four substations. Major loads on the system are the Radiation Confinement Ventilation (RCV) Control Board and two Motor Control Centers (MCCs). The MCCs provide power to and control operation of the four COG/LOG fans and three GBOG fans. The VOG is backed up by a steam-powered fan.

Two diesel generators provide standby power. These generators start automatically upon loss of power. General alarm and status information about both generators are reported to an annunciator on the RCV panel in Building 3019. Remote alarms are fed to ORNL's Waste Operations Control Center, which is attended 24 h per day, 7 days per week.

## **2.6 FACILITY AUTHORIZATION BASIS**

### **2.6.1 Current Facility Authorization Basis**

The current FAB consists of the Basis for Interim Operations (BIO) (Chemical Technology Division 1996a) and the Operational Safety Requirements (OSR) (Chemical Technology Division 1996b). The BIO includes the relevant operational history of Building 3019, safety management, safety analysis, and safety envelope. The OSR covers operating limits, surveillance requirements, and administrative controls in place at Building 3019. Both documents were approved by DOE in 1996. These documents are reviewed on an annual basis to and updated as necessary incorporate changes to the facility configuration or operations. The 1997 revisions currently are going through the comment resolution cycle. Changes are evaluated by safety implications and subjected to the Unreviewed Safety Question Determination (USQD) process as they occur.

### **2.6.2 FAB Update**

Since the BIO is intended as an interim document, Building 3019 has initiated an update of its FAB. The result of this update will be a Safety Analysis Report (SAR) that is compliant with DOE Order 5480.23 and Technical Safety Requirements (TSR) that are compliant with DOE Order 5480.22. These two documents are scheduled to be submitted to DOE for approval by September 30, 1999.

## **2.7 VULNERABILITIES**

The DOE ES&H Highly Enriched Uranium Vulnerability Assessment identified six vulnerabilities in the Building 3019 complex (DOE 1996). Three of the vulnerabilities focus on potential failures caused by natural phenomena. Two additional vulnerabilities address potential failures of packages storing <sup>233</sup>U. The remaining vulnerability is potential leakage from Tank P-24 during transfer of material. Each vulnerability is relevant to the material, containers, or the storage system. The details and planned corrective actions for the natural phenomena vulnerabilities are



discussed in the facility evaluation (Sect. 4). The other three vulnerabilities and their corrective actions are described in the material and packaging assessment (Sect. 3).

### 3. MATERIAL AND PACKAGING ASSESSMENT

The third subrecommendation from the DNFSB is to characterize the items of  $^{233}\text{U}$  currently in storage in DOE's defense nuclear facilities in terms of material, quantity, and type and condition of storage. At ORNL, a two-pronged approach is being taken to this characterization: (1) analysis of risk scenarios and investigation of material and packaging records and (2) physical inspection of the material in the tube vaults.

The first portion of the assessment has been completed. An analysis of risk scenarios has been done as a part of the corrective actions identified in the DOE Vulnerability Management Plan (DOE 1997b). Investigation of material receipts and inventory records was used to rank the relative risk of each can in storage. This information will be used as input to the planning for physical inspections.

The physical inspections will consist of opening the Building 3019 storage tube vaults and examining a sampling of the stored packages. The package conditions will be evaluated, compared to a storage standard, and repackaged, as required.

#### 3.1 VULNERABILITIES

Three vulnerabilities were identified in the DOE VA where  $^{233}\text{U}$  could be released from its place in storage by methods not involving natural phenomena. Two vulnerabilities address failure of cans of  $^{233}\text{U}$  in the tube vaults. The third involves release from Tank P-24.

The first vulnerability is a potential container failure within a storage tube vault. This might be caused by corrosion from long periods of storage or by overpressurization resulting from radiation effects on the materials inside the can. Because of the lack of inspection capabilities, most packages have not been removed since being placed in the tube vaults. The longest residence time is 33 years. The average is 15 years. The physical inspection of material will be the corrective action to this vulnerability.

The other vulnerability associated with containers of  $^{233}\text{U}$  is that a possibly aged or corroded container fails while being handled. The most likely scenario for such an event could occur if the container was dropped because of a failure in the can lift device. This vulnerability is more of an operational issue than a storage issue, which is being addressed in the Building 3019 safety basis and inspection preparations.

A vulnerability associated with the P-24 tank is the potential of a spill during the transfer of material. During the storage of liquids in the P-24 tank, it may be necessary to pump the entire inventory into an adjoining tank or even into a nearby temporary tank. If the transfer were to be performed unattended and a leak in the line developed, the entire contents could be released to the environment as they are pumped. This vulnerability is being addressed through procedural controls discussed in the next section to ensure technician attention during transfers.

## 3.2 COMPLETED ACTIONS

### 3.2.1 Analysis of Dropped Container Accident Scenario

The dropped container accident scenario was examined in the USQD (Chemical Technology Division 1996c) for the  $^{233}\text{U}$  shipment from EG&G Mound Applied Technologies in Ohio. Two separate scenarios were examined. In the first, a container of powder was dropped ~5 ft to the floor of the Penthouse. In the other, the container was dropped ~35 ft down a storage tube vault impacting the can(s) below it. Both cases were bounded by accidents analyzed in the Building 3019 BIO. Consequences either to an on-site worker or to the public were deemed minor.

Because there were no unresolved safety questions, this USQD is being incorporated into the BIO and should be applicable to any material consolidated from small-holdings sites. However, this analysis may not apply to material already located in the tube vaults because (a) the material examined in the USQD for the Mound material does not bound the material in some stored packages and (b) the condition of the cans was known to be good. For material already in the storage tube vaults, the container condition is unknown. Therefore, the damage factor (the fraction of material at risk that is released in an accident scenario) may be higher.

For the planned inspections of containers currently in the tube vaults, the dropped container scenario will be addressed by confinement augmentation. This will be an engineered system that will provide confinement of the material in the case of a failed can, thus protecting workers and preventing release of material to the environment.

### 3.2.2 Analysis of Transfers from Tank P-24

An analysis of the transfer process for Tank P-24 has shown that it would take 14 h of pumping at the maximum flow rate before the minimum dose limit requiring corrective action would be reached (Webb 1996). Therefore, by monitoring transfers more frequently than once every 14 h this accident scenario could be prevented. A procedure requirement for periodic monitoring during these transfers eliminates this potential vulnerability.

### 3.2.3 Storage Tube Vault Video Examination

The possibility of inserting a small (~8-mm-diam) camera into the annulus between the storage tube vault wall and the side of storage canisters was investigated. The mockup tube vault in the Building 3019 complex was set up to demonstrate a commercially available camera. The tube vault was filled with dummy cans and spacers. The storage tube vault spacers consist of 0.25- to 0.5-in.-thick aluminum disks in a variety of configurations.

A demonstration of what could be seen using an end-viewing lens vs. a right-angle-viewing lens was conducted with good results. Video clarity was excellent with either lens, and the right angle lens gave the best view of a canister side wall. However, the 8-mm camera encased in a contamination-resistant sleeve was too large to clear the gap between the canister spacers and the side wall of the tube vault. Although this demonstration was conducted in a 4-in.-diam tube vault, the 4.5-in.-diam tube vaults have a similar clearance problem between spacer and tube vault side wall and the larger canisters emplaced in these larger diameter tubes. In almost all the tube vaults,

the arrangement consists of a canister followed by spacers followed by another canister and spacers. The only exception to this arrangement is with the CEUSP canisters. Because of this configuration in most tube vaults, no useful information can be obtained from this type of video examination.

In order to use this technique in the storage tube vaults where the CEUSP material is stored, each and every canister would need to be forced to the same side of the tube vault in order to provide a straight-path off-centered annulus for the camera. Because the CEUSP canisters are quite heavy (~30 kg), it would be very difficult to position more than two or three canisters to insert the camera. Furthermore, such a tight configuration would result in the camera lens virtually touching the canister sides.

In conclusion, the camera provided a good view of the cans in testing. However, difficulty was encountered in sliding the camera past spacers in the tube vaults. The only tube vaults without spacers contain cans that will be difficult to move in order to allow the camera to view deeply into the well. Therefore, the effort to perform an in-place video examination of the storage canisters will not be pursued further.

### 3.2.4 Risk-Based Characterization

A process analogous to risk assessment was chosen as the approach to material and packaging characterization. The "accident" scenario was considered the failure of a package (or a group of similar packages) in the Building 3019 inventory. The probability of such a failure was related to packaging factors such as the age and material of construction of the cans. The consequence of such a failure was related to the amount and form of the material within the packages.

Each group of packages was assigned a material score and a packaging score as the principal, first-order, components to risk. Other factors may contribute to risk, but are considered of lesser importance. These two scores were then combined to give the risk of each packaging group. The intention was not to assign an absolute risk factor to each group of packages, but to establish a relative risk ranking of the cans. This information will be input for decisions regarding inspection, repackaging, and storage of the material.

#### 3.2.4.1 Material Factor

The material factor was based on four items: quantity of material, amount of  $^{232}\text{U}$  impurity, chemical form, and physical form. All items were given scores, which were then combined to give a material factor for each package group. Low factors correspond to low consequence. Scoring was calculated as follows

- Quantity of  $^{233}\text{U}$  per can = mass in kilograms. For groups of similar packages, the average quantity per can was used.
- Amount of  $^{232}\text{U}$  impurity =  $(\text{ppm } ^{232}\text{U}/25) + 1$ . The basis for this expression was that at 25 ppm the inhalation hazard from  $^{232}\text{U}$  and its decay products is roughly equal to that of  $^{233}\text{U}$  and its decay products. Thus, multiplying this factor by the amount of  $^{233}\text{U}$  gave the total equivalent inhalation hazard in terms of kg of  $^{233}\text{U}$ .

- Chemical and physical forms. Scoring for the physical and chemical forms are summarized in Table 3.1. The chemical form scores were based on relative stability, while the physical form scores were based on relative mobility.

**Table 3.1. Scoring of chemical and physical forms**

Form	1	2	3
Chemical Form	U <sub>3</sub> O <sub>8</sub>	other oxides, metal	salts, UF <sub>x</sub>
Physical Form	monolith, metal pieces	powders, foils	liquid, gas, unknown

The combining rule for the inputs to the material factor is given as follows:

$$\text{Material factor} = \text{quantity / can(kg)} \times \left[ \frac{\text{ppm}^{232}\text{U}}{25} + 1 \right] \times (\text{chem. form score} + \text{phys. form score})$$

### 3.2.4.2 Packaging Factor

The packaging factor was judged on four items: two based on age and two based on the materials of construction of the inner and outer packages. Age was scored by a simple linear formula that equates older cans with higher risk. Two ages were scored: the package age and the time since last inspection. In both cases, the score equaled the age in decades.

The scoring methodology for the material of construction is given in Table 3.2. Robust corrosion-resistant materials, such as SS and nickel, were given low scores thereby indicating a low contribution to failure probability. More vulnerable materials (e.g., plastic and glass), were given higher scores. A welded closure was considered favorable, so packages that were welded had their packaging risk lowered by one point.

**Table 3.2. Scoring of packaging material**

Factor	1	2	3	4	5
Inner Packaging	Welded SS or welded Ni	SS, Ni or welded Al	Al	Tinplate or carbon steel	Plastic, glass, unknown or none
Outer Packaging	Welded SS or welded Ni	SS, Ni or welded Al	Al	Tinplate or carbon steel	Plastic, glass, or unknown

The combining rule for the inputs to the packaging factor is given as follows:

$$\text{Packaging factor} = (\text{package age} \times \text{inner score}) + (\text{time from last inspection} \times \text{outer score})$$

where times are in decades

### 3.2.4.3 Risk-Based Characterization Results

Figure 3.1 shows the results of evaluating 1007 packages in the Building 3019 storage tube vaults. Numbers are not included on this figure to emphasize the qualitative nature of the results. Each point on the figure represents a group of similar packages ranging from several single packages to 403 packages for the CEUSP material. The graph is broken into three regions where those in the bottom left portion of the graph are deemed low risk (low material score and low package score) while those in the upper right are deemed higher risk. The lines delimiting regions of risk represent the product of the material and packaging factors equaling arbitrarily selected constants.

The single package in the higher risk group is one of the four assemblies labeled RCP-04 (Fig. A.6). Unlike the other RCP-04 packages this package is doubly contained in unwelded aluminum canisters, which have been deemed to be less robust than SS or nickel containers. This material has been in storage for 30 years, which ranks among the oldest material in storage. In addition to these packaging factors, the material in this package is in an undesirable form (fluoride salt) with 220 ppm  $^{232}\text{U}$  (162 ppm in 1998). Finally, the amount of material in this package (1.6 kg) is more than three times the amount in any of the other RCP-04 packages.

The other three RCP-04 assemblies are in the medium risk category (Figs. A.5 and A.7). They all have the undesirable, fluoride salt material form with 162 ppm  $^{232}\text{U}$  in 1998. However, unlike the high-risk package, the amount of  $^{233}\text{U}$  in each of these packages is less than 0.5 kg. Also, all of these assemblies have at least one packaging layer constructed of SS or nickel.

Another group in the medium risk category are the two LANL assemblies (Fig. A.1). These are the only packages in the inventory which have only one packaging layer. Each package contains ~3 kg of  $^{233}\text{U}$  metal, the two largest quantities in the ORNL inventory. These materials also have an above average  $^{232}\text{U}$  content (33 ppm in 1998).

The two metal scrap assemblies labeled RCP-20(#2&#3) (Fig. A.19) are also in the medium risk category. Each package contains ~2 kg of  $^{233}\text{U}$  metal in two layers of tinplated packaging. This material also has a large amount of  $^{232}\text{U}$  impurity (29 ppm in 1998).

The largest batch of packages in the medium group are the 140 Savannah River aluminum assemblies labeled RCP-03 (Fig. A.9). Like the high-risk RCP-04 material, this material is doubly contained in aluminum cans, the packages have been in storage for over 30 years, and the  $^{232}\text{U}$  content is 158 ppm in 1998. The reasons for this material not being in the high risk category are that both layers of cans are welded shut and the material is oxide powder rather than fluoride salt.

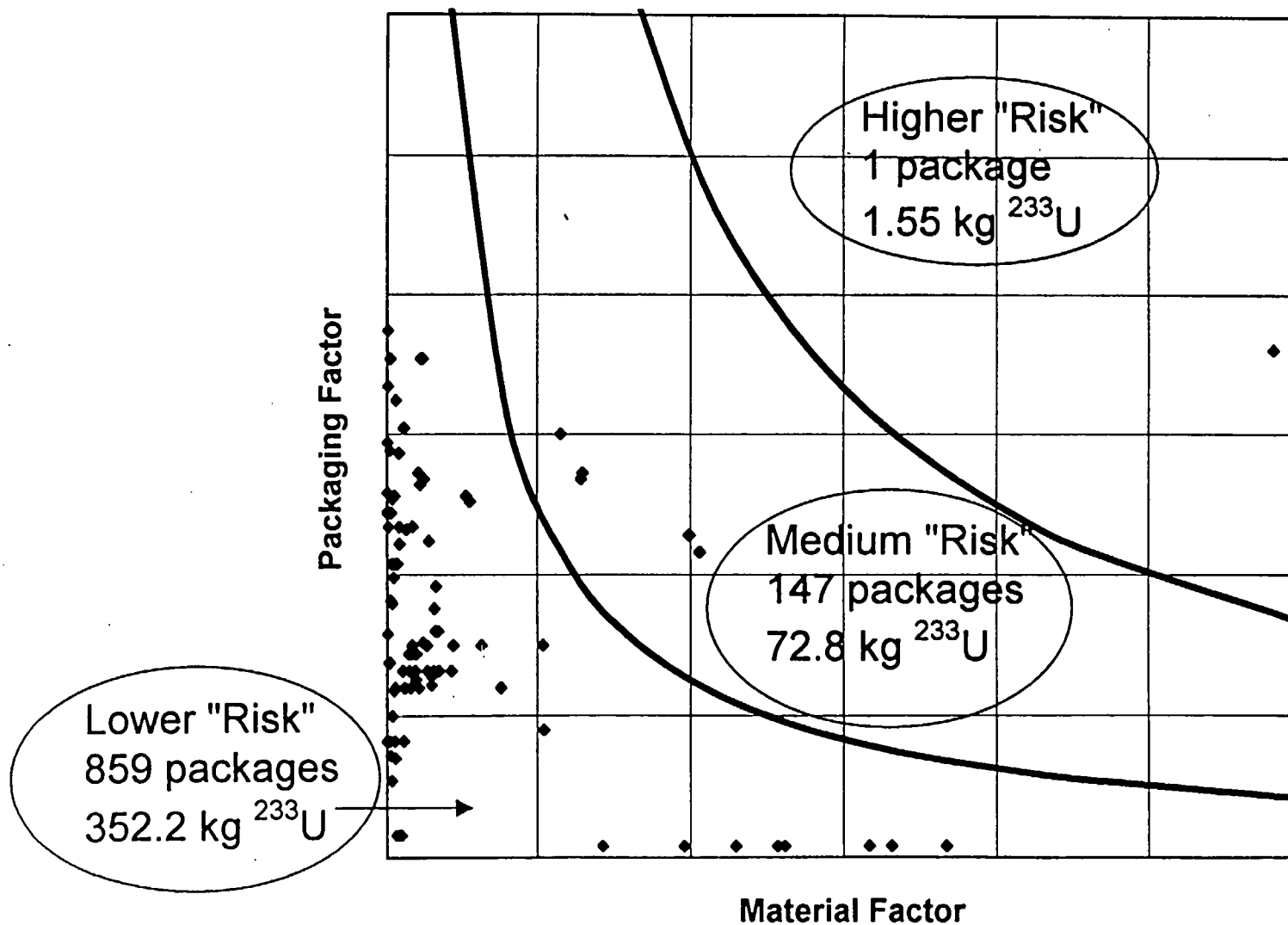


Fig. 3.1. Results of risk model of cans in Building 3019 storage tube vaults.

### 3.3 PLANNED INSPECTION AND REPACKAGING ACTIVITIES

A safe storage standard for  $^{233}\text{U}$  currently is being developed. A sampling of  $^{233}\text{U}$  containers in Building 3019 will be inspected and repackaged as necessary to meet this standard. Other  $^{233}\text{U}$  containers may be added to the sample as a result of these inspections. The inspections will also characterize the inventory's material condition, quantity, and type as well as to assess the condition of each type of storage container and to initiate corrective measures. The inspection plan is currently being developed. The sections below give an outline of the items being considered. Details of the inspection plan will be provided in the final site assessment report.

#### 3.3.1 Container and Material Evaluation Strategy

The results of records investigation and characterization will be used to establish the order in which containers should be removed from the storage tube vaults for inspection. As the contents of each storage tube vault are accessed, the packaging data for each tube vault will be verified and corrected, if necessary.

Analysis of inventory records has been used to identify packages that do not meet the standard with respect to material form or packaging construction. Eighteen packages containing a total of 9.4 kg of  $^{233}\text{U}$  are in an undesirable material form (salt or thin metal foil). Another fifty-three packages containing 24.1 kg  $^{233}\text{U}$  have problems with the construction of the inner package (plastic, glass, tinplate, or none). A statistical approach is being developed to determine which other packages will be examined and a technical approach will be used to determine the order in which to examine them. Consideration will be given to risk, accessibility, and the potential for combining several packages containing small amounts of material into one.

Inspection of the containers may include smear sampling, weighing, real-time radiography (RTR), calorimetric measurement, and gamma scanning. The gross weight of the container can be compared with inventory records. Information from RTR analysis can be used to verify container integrity and, to verify the internal configurations of the primary container(s). Information from the RTR evaluation may also spot potential problems, such as bulging from pressurization. For low  $^{232}\text{U}$ -content material, calorimeter data may be used as a non-destructive analysis to verify  $^{233}\text{U}$  content. Non-destructive methods for high  $^{232}\text{U}$ -content material are still being investigated. A collimated gamma scan may determine the radionuclides present in the container. Quantitative measurements of the  $^{233}\text{U}$  and  $^{232}\text{U}$  will be made and compared with inventory data.

#### 3.3.2 Container Evaluation

If there are no immediate problems detected (e.g., leaks detected, corrosion, or other signs of container degradation), each container will be evaluated as to whether its present design and material form meets the storage standard. If the container meets the standard, no destructive analysis will be performed and the container will be returned into the Building 3019 storage tube vaults. All package conditions will be documented.



Corrective actions will be taken on containers that show degradation or do not meet the storage standard. This corrective action may include overpackaging or complete repackaging as appropriate to meet the storage standard.

### 3.3.3 Stabilization

If it is determined that the material must be stabilized, the inner container will be opened and a sample withdrawn for chemical and isotopic analysis as needed. A sample of the  $^{233}\text{U}$  material will be removed for chemical and isotopic analysis. A portion of the sample may be prepared for analysis to determine the moisture content of the material. The opened container will be stored under controlled conditions until the results of the moisture analysis are known. If the results indicate excessive moisture content, the  $^{233}\text{U}$  will be calcined and resampled for moisture analysis.

### 3.3.4 Repackaging

This section describes the process for repackaging both the inner and outer container. In some cases, it may be determined that the material and inner packaging is suitable for storage and only the outer packaging will need to be replaced.

The contents of the opened container will be transferred to one or more approved storage cans, depending on the amount in the original container. Transfer operations may include simple pouring or may require mechanical means to remove the material. After the transfer of material is complete, the new container will be sealed, weighed, and the ID number of the can recorded with the corresponding weight. Decontamination of the new outer container will be performed as needed to comply with the storage standard.

### 3.3.5 Personnel

The personnel requirements for accessing the tube vaults, removing and inspecting the packages, and performing any necessary repackaging are as follows: 3 fissile material handlers (2 technicians and 1 supervisor), 1 millwright, 2 radiation control technicians, 1 gamma spectroscopy operator, 1 Material Balance Area representative, 1 Nuclear Materials Control and Accountability auditor, fire department personnel, and security guards. It is preferable, but not necessary that all personnel involved in the operations have Q security clearances. The current Building 3019 staffing is adequate for daily operations. Should the decision be made to perform the inspection and repackaging on an around-the-clock basis, additional operational and security personnel would have to be recruited and trained.

## 4. STORAGE SYSTEM EVALUATION

The storage systems in Building 3019 are being evaluated as to their appropriateness for the storage of  $^{233}\text{U}$ . Because of its unique characteristics,  $^{233}\text{U}$  requires special handling and storage (Bereolos et al. 1997). The basic facility requirements for storage of fissile materials are criticality control, shielding, ventilation, and safeguards. Additionally, resistance to natural phenomena has an impact on criticality control, ventilation and shielding. A specialized facility for  $^{233}\text{U}$  is needed because of the differences from the other special nuclear materials (i.e., Pu and HEU), especially with regards to ventilation and shielding.

Uranium-232 is almost always present with  $^{233}\text{U}$  and has as part of its decay chain  $^{208}\text{Tl}$ , which emits a highly penetrating 2.6-MeV gamma-ray accompanying its beta decay to stable  $^{208}\text{Pb}$ . Because of this emission,  $^{233}\text{U}$  requires special shielding and remote handling.

Ventilation is used as a means of physical confinement. In terms of alpha specific activity,  $^{233}\text{U}$  is more active than HEU, but less active than most Pu isotopes. However,  $^{233}\text{U}$  also has a unique ventilation requirement imposed by the decay chain of its associated isotope,  $^{232}\text{U}$ . Part of the  $^{232}\text{U}$  decay chain includes  $^{220}\text{Rn}$  which normally exists as a gas. Thus, storage facilities for  $^{233}\text{U}$  must consider the presence of this gas, so that the radon is retained (prior to final filtration) until it decays back into a particulate form that may be filtered. The retention time should be on the order of ten minutes based on the 55-second half-life of  $^{220}\text{Rn}$ .

In this section, the current condition for each storage attribute is described with a focus on any areas of concern. Next, the results of inspections to address these concerns are described followed by the planned future activities.

### 4.1 NUCLEAR CRITICALITY SAFETY

#### 4.1.1 Description

Nuclear criticality safety in Building 3019 is maintained by a combination of passive and active systems as well as administrative controls. Criticality safety analysis is an integral part of operations and is based on the approved Nuclear Criticality Safety Assessment (NCSA), ORNL procedures, and criticality safety studies (Primm 1992, Primm 1993). As part of the criticality safety program, ORNL continually reviews potential accident and operational scenarios for their impact on criticality safety.

NCSAs are used to prescribe moderation, loading, and handling controls for criticality prevention. Several moderation controls can be applied when accessing wells. The fire header is always isolated and drained in the Penthouse when accessing loaded wells. Only a limited number of wells are opened at the same time. Limits may be placed on the size of containers and presence of moderating liquids in the Penthouse. Careful bounding calculations are used to determine the spacing of containers in the wells to preserve at least two independent safety contingencies against an in-well criticality. Material or container limits, as well as other factors, are imposed to prevent an out-of-well criticality.

A Criticality Accident Alarm System (CAAS) monitors for neutrons and can detect a criticality accident during the handling and movement of  $^{233}\text{U}$ . The CAAS consists of neutron monitors located around the Penthouse to detect a criticality accident and the associated electronics to process the signals and activate alarms in the control room and throughout the building. If two monitors in the same coincidence circuit alarm simultaneously, the CAAS alarms are automatically actuated, and the building is evacuated. Under the ORNL preventive maintenance program, the monitors are routinely calibrated with a known source, the electronics are routinely checked and the system sirens are routinely actuated.

#### 4.1.2 Inspections

The sump area of Cell 4 is continuously monitored. Additionally, a video inspection of the Cell 4 floor area determined that no visible signs of water or condensation were present. Visual inspection of the empty tube vaults (between Cell 2 and Cell 3) determined no water was present. The lack of evidence of water also reduces concerns about corrosion of cans.

### 4.2 RADIATION AND SHIELDING

#### 4.2.1 Description

The concrete cell walls, and the shielding designed into the storage tube vaults, described in Section 2.2 (e.g., the shield plugs and the lead shot surrounding the storage tube vaults located in the wall between Cells 2 and 3) serve to protect personnel from the radiation hazards associated with  $^{233}\text{U}$ . Administrative procedures and personnel training are used to limit exposure and identify changes to existing conditions. Radiological protection procedures control access and exposures. Periodic radiation surveys to verify conditions and identify potentially unacceptable radiation levels. Periodic smear sampling is done to determine transferable contamination levels.

ORNL radiation protection personnel routinely survey and sample the  $^{233}\text{U}$  storage areas and systems to verify the continuing adequacy of the shielding, to identify any changes in  $^{233}\text{U}$  container integrity, and to identify the level of contamination. Gamma surveys are conducted in the storage areas to search for and quantify gamma radiation fields, which may change if shielding degrades. Only one elevated reading (70 mR/hr on contact) is attributed to  $^{233}\text{U}$  in storage. This occurs at the south end of the tube vaults between cells 4 and 5. The elevated reading at this point has been stable over the decades and is attributed to the original shielding design and not due to legacy contamination or a weakness in the structure. This area is posted in accordance with radiation procedures to alert workers of the radiation fields.

#### 4.2.2 Inspections

Recent video inspection of Cell 4 allowed full view of the east face of the eastern-most row of concrete columns from top to bottom. The floor area did display indications that paint, possibly from the cell wall and ceiling areas, has begun to separate and flake off from upper surfaces. This paint is not associated with the tube vaults, which are embedded in unpainted concrete. The condition of the concrete appeared to be excellent from this video inspection. Overall, no evidence of concrete deterioration was indicated.

### 4.2.3 Personnel Exposure

From 1996 through February 1998, the total exposure to personnel in Building 3019 from routine surveillance and maintenance was 1579 mR for 22846 person-hours of work (0.069 mR/h). Prior to the inspection and repackaging campaign, the estimated personnel exposures will be detailed in a plan to keep exposures as low as reasonably achievable (ALARA).

For comparison, activities similar to those that will be performed during the inspection took place during material receipt in 1996, material shipment in 1991, and tube vault transfers and material shipment in 1988. For the 1996 material receipt, the collective exposure to all workers involved was 73 mR for 110 person-hours of work (0.66 mR/h). For the 1991 material shipment, the total exposure was 312 mR for 60.5 person-hours of work (5.16 mR/h). The 1988 transfers and shipment resulted in an exposure of 284 mR in 163 person-hours (1.74 mR/h). These exposure rates were well within standard limits.

During future operations, exposures may be decidedly higher because material will not only be accessed and handled, but also examined and processed. Control factors will include a rigorous ALARA approach and upgrades of handling and processing equipment, as discussed elsewhere. Statistical sampling of the inventory, rather than a complete inspection, will also serve to limit exposures.

## 4.3 VENTILATION

### 4.3.1 Description

The ventilation systems, as described in Sect. 2.2.3, are used in Building 3019 as contamination control during the processing, handling, and repackaging of  $^{233}\text{U}$ . In the Building 3019 BIO, no credit is given for the ventilation systems in the safety analyses of stored material. However, these systems contribute to defense-in-depth by providing containment should a can be breached within the storage tube vault. During most accessing, handling, and processing activities a HEPA filter and accompanying ductwork are required in the GBOG system for the protection of the public.

### 4.3.2 Completed Activities

An increasing level of radiation detected in the off-gas, for example, might indicate leakage of the  $^{233}\text{U}$  containers within the storage tube vaults. This possibility was examined by smearing the VOG piping, gamma surveying the VOG piping, and trend analysis of off-gas monitoring data.

#### 4.3.2.1 Smear sampling and gamma survey of VOG piping

Smear samples of the inside surfaces of the VOG piping were performed on the pipes of the VOG manifold, which are connected to the storage tube vaults (Fig. 4.1). Additionally, smear samples were taken from the headers of the empty tube vaults to check for cross contamination between vaults (Fig. 4.2). The smear samples were analyzed, and no detectable contamination was found. A comprehensive radiation (gross beta-gamma) scan survey of selected areas around the storage tube vaults and VOG piping was also performed. Again, no indication of a container breach was found.





#### **4.3.2.2 Sampling of tube vault off-gas line**

Because of the lack of sampling data from the off-gas lines, a system for residual gas sampling has been put in place (Fig. 4.3). Residual gas sampling is accomplished by attaching a sampling apparatus to selected points in the VOG lines that serve to maintain a negative pressure

on the storage tube vaults. The sampling apparatus consists of a mass flowmeter with flow totalizer capability, a hydrogen detector, a HEPA filter, and a vent valve for venting the storage tube vaults to atmospheric pressure in a controlled manner. Air is pumped out in a controlled manner and passed through the HEPA filter. The HEPA filter is arranged in such a way that isolation valves can be closed and the filter element can be removed for analysis. Existence of activity on the HEPA filter could be an indication of a leaking storage container.

Sample of the off-gas lines from the storage tube vaults showed no contamination and no evidence of package breach. The sampling provides a baseline for future trending of off-gas conditions. If contamination is discovered in the future, package integrity in the area contaminated will come into question.

#### **4.3.3 Planned Activities**

##### **4.3.3.1 Inspection of Building 3019 tube vault headers**

When the Building 3019 storage tube vaults are accessed for physical inspection of the material, the following activities will take place: (1) vapor-space sampling, (2) hydrogen analysis, (3) measurement of available storage space height, (4) smear sampling of tube vault interiors, and (5) measurement of the penetrating radiation field. These measurements can give advanced warning of potential problems with containers before the containers are removed from the tube vaults.

Over the decades of material storage and occasional storage tube vault accesses, only two adjacent contaminated tubes have been encountered. One of these appears to be the source of the contamination. The other tube indicated much lower levels of contamination than the first tube. Upon initial investigation, it became apparent that the contamination came from external surface contamination – not a release from a breached container.

##### **4.3.3.2 Ventilation Requirements Analysis**

The historical mission of Building 3019 has involved the development of radiochemical processing of nuclear materials for various fuel cycles. To accommodate these programs, and to address evolving ES&H requirements, the original ventilation network has been modified numerous times. Today, some portions of the ventilation network are original Manhattan Project vintage, and some portions have been added or replaced as recently as this current year (e.g., filters and instruments). An analysis is being prepared to document the design, functional, performance, interface, and regulatory requirements for the Building 3019 ventilation system. The ventilation systems will be designed to function to meet the specific performance requirements for particular systems, to interface those systems with other interdependent systems, and to meet modern regulatory requirements. The design criteria will be based on DOE Orders and the Building 3019 FAB.









Design requirements depend on the type of system required, such as Supply Air Systems, LOG, COG, GBOG, VOG, or General Room Exhaust Systems. Specific guidelines for the design of each ventilation system in this type of building, a non-reactor nuclear facility, formerly were found in "General Design Criteria, DOE Order 6430.1A" and in references listed in this criteria. DOE Orders 430.1 and 420.1 cancel 6430.1A. However, some portions of 6430.1A are useful to Building 3019. Additionally, the draft DOE handbook for design considerations (DOE 1998) retains many good parts of 6430.1A. The current Work Smart Standards for Building 3019 do not include the DOE handbook or 6430.1A, but will probably incorporate the design handbook in the future. Therefore, the ventilation requirements will include appropriate sections of 6430.1A

The Building 3019 OSR provides information concerning the functional requirements of the building safety class ventilation systems (i.e., GBOG). The OSR, with guidance from DOE Order 5480.22, defines the controls to ensure that the facility remains within the safe operating envelope, as defined in the Building 3019 BIO. The OSR formally documents the requirements in the following sections: (1) "Use and Application"; (b) "Safety Limits and their Bases"; (c) "Operating Limits", which include limiting control settings, limiting conditions for operation, surveillance requirements and their bases; (d) "Administrative Controls"; (e) "Design Features" (if required).

The BIO states performance requirements and functions for the main ventilation system, LOG, COG, GBOG, and VOG Systems. In addition, figures indicating air flows of the main ventilation system, GBOG, VOG, and filter pits are shown.

Both the BIO and the OSR provide interface requirements. The BIO in Sect. 2.5, facility ventilation systems, and the associated figures provide descriptions of how a ventilation system interfaces with the other ventilation systems in the building. The OSR provides additional interface information on the GBOG, which is a safety class system.

The BIO, OSR, and DOE 6430.1A contain references to sections of the Code of Federal Regulations (CFR) that are the bases of these documents and guidance for design, construction, operation, and maintenance of the ventilation systems in Building 3019.

#### 4.3.3.3 Ventilation Upgrades

As a part of its current mission, Building 3019 needs the capability to process multi-kilogram quantities of  $^{233}\text{U}$ . These capabilities will be necessary during the inspection and repackaging of material stored within the tube vaults. Upgrades are currently being performed to enable such capability on a routine basis.

A hot cell has been procured and is currently being installed in Cell 2 of Building 3019 (Fig. 4.4). After installation, it will be connected to an upgraded GBOG system. The upgrades to the GBOG have been designed and are ready for construction.



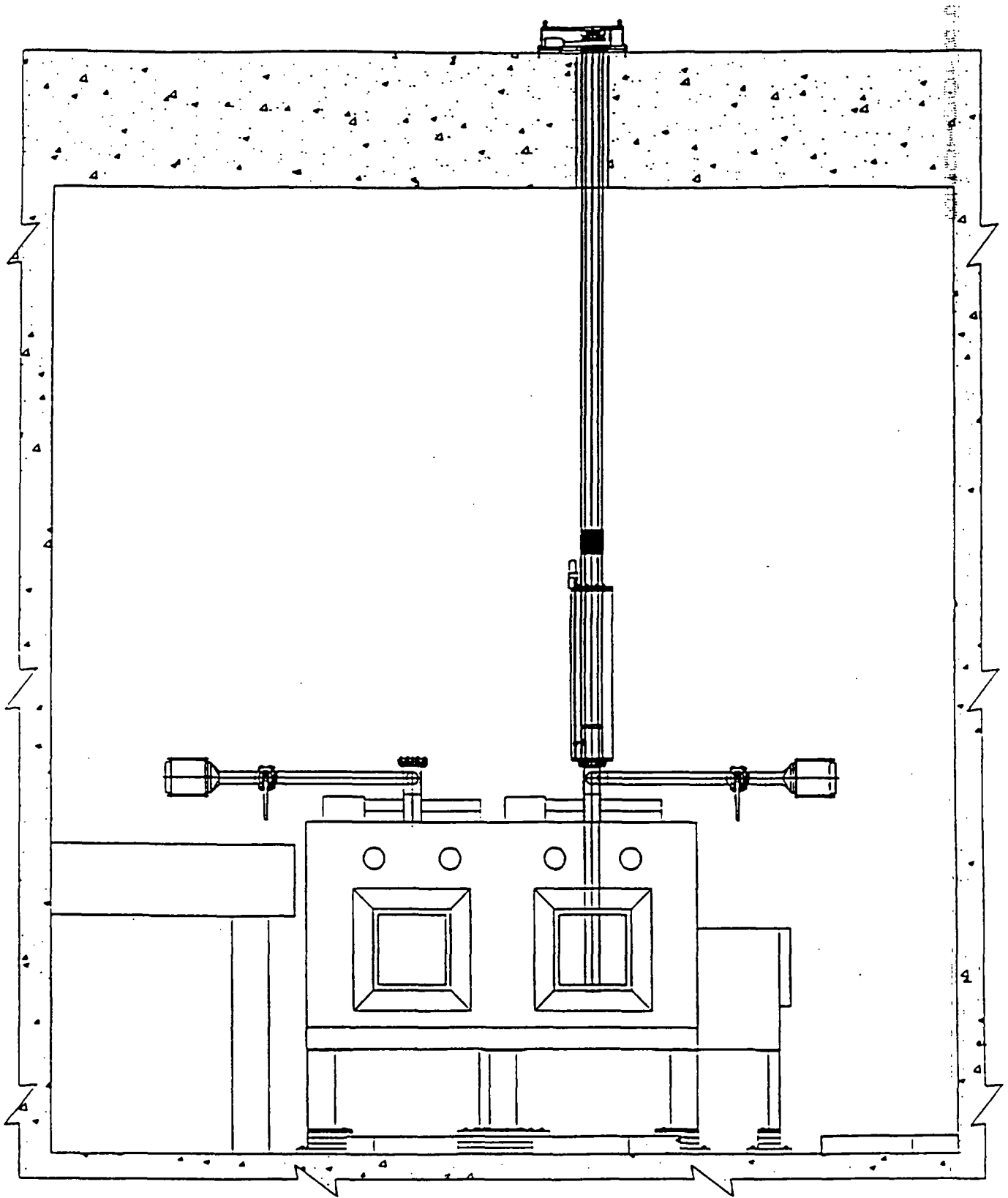


Fig. 4.4. Schematic of hot cell in cell 2.

## 4.4 RESISTANCE TO NATURAL PHENOMENA

### 4.4.1 Description and Concerns

Accidents caused by natural phenomena (e.g., earthquakes, tornadoes, or floods) can impact criticality control, radiation protection, and confinement. At Building 3019, these are of concern since three vulnerabilities due to natural phenomena have been identified.

The first vulnerability is a generic vulnerability for the ORNL site that the seismic and wind capacity of many of the buildings has not been evaluated per current DOE requirements. For Building 3019 this vulnerability applies to the areas outside of the storage tube vaults. This vulnerability does not indicate a lack of qualification, only a lack of evaluation.

The second vulnerability dealing with natural phenomena is a failure of HEPA filter equipment during an earthquake or tornado. For example, tornado missiles could cause substantial damage to off-gas equipment that remains above ground outside of Building 3019.

The final natural event vulnerability pertains to failure of Tank P-24 during an earthquake event. Tank P-24 is located in a concrete bunker next to Building 3019 and stores uranium and thorium nitrate solutions.

### 4.4.2 Natural Phenomena Hazards (NPH) Analysis

Analysis of resistance to natural phenomena was first performed for Building 3019 in 1977 (Parsons 1977). In that report, the integrity of the cell structure was analyzed and determined to be adequate. This analysis was most recently updated for the tube vaults in 1994 (Hammond 1994). At that time, the tube vaults met all DOE requirements for new "moderate hazard" facilities in Oak Ridge. Since that evaluation, the DOE has refined hazard classification and evaluation methodology. The seismic hazard for Oak Ridge has been revised as well (DOE 1994).

Currently, the storage tube vaults are classified as "Performance Category 3", but evaluation requirements are essentially the same as those for the superceded, moderate hazard classification. The recommended methodology for evaluation of the storage tube vaults has not changed. The evaluation-basis earthquake has changed, but the peak ground acceleration was reduced from 0.19 times the acceleration of gravity,  $g$ , to 0.16 $g$ . Although the most highly amplified portion of the earthquake response spectrum is broader now than in 1994, the evaluation performed in 1994 was conservatively independent of response frequency. The evaluation of the storage wells will be revised as a part of the current facility evaluation discussed in the following, but it is clear that the storage tube vaults meet the latest, appropriate DOE requirements for natural phenomena resistance.

A complete natural phenomena hazards analysis for the Building 3019 complex is being performed in conjunction with the preparation of the Building 3019 SAR and TSR. This evaluation is scheduled for completion in fiscal year (FY) 1999. The analysis is studying the hazards posed by the occurrence of natural phenomena events. The NPH analysis requires: (1) an initial walk-down of all structural and safety significant components and equipment at Building 3019, (2) soil

characterization and liquefaction studies, (3) building evaluations, (4) stack evaluations, (5) vault evaluations, and (6) ventilation system evaluations. As an aid for the analyses that have to be performed, a computer model of the building is being developed. Design & Analysis Calculation (DAC) packages will document the results of the analysis. Completion of the first DAC for the storage tube vaults is scheduled for April 1998.

The results of the NPH analysis will determine if the areas in question from the DOE VA are seismically qualified. Measures will need to be taken to address any areas that do not meet the seismic qualifications. This vulnerability to seismic events of the HEPA filter system is already being addressed in an active project that will harden this section of the VOG. Additional upgrades to the ventilation system will be defined at a future date. With regard to Tank P-24, solidifying the material in grout would reduce the likelihood of release during a natural disaster. However, no schedule for such a plan has been made, to date, because the material contained in Tank P-24 has potential usefulness as a neutron poison.

## **4.5 SAFEGUARDS AND SECURITY**

### **4.5.1 Description**

Security in Building 3019 is provided in real time by alarms and surveillance systems. Perimeter control prevents unauthorized access to material. Time-delay features in the storage system further enhance security. During access of the storage tube vaults, security guards provide necessary protection.





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## APPENDIX A: CAN DRAWINGS

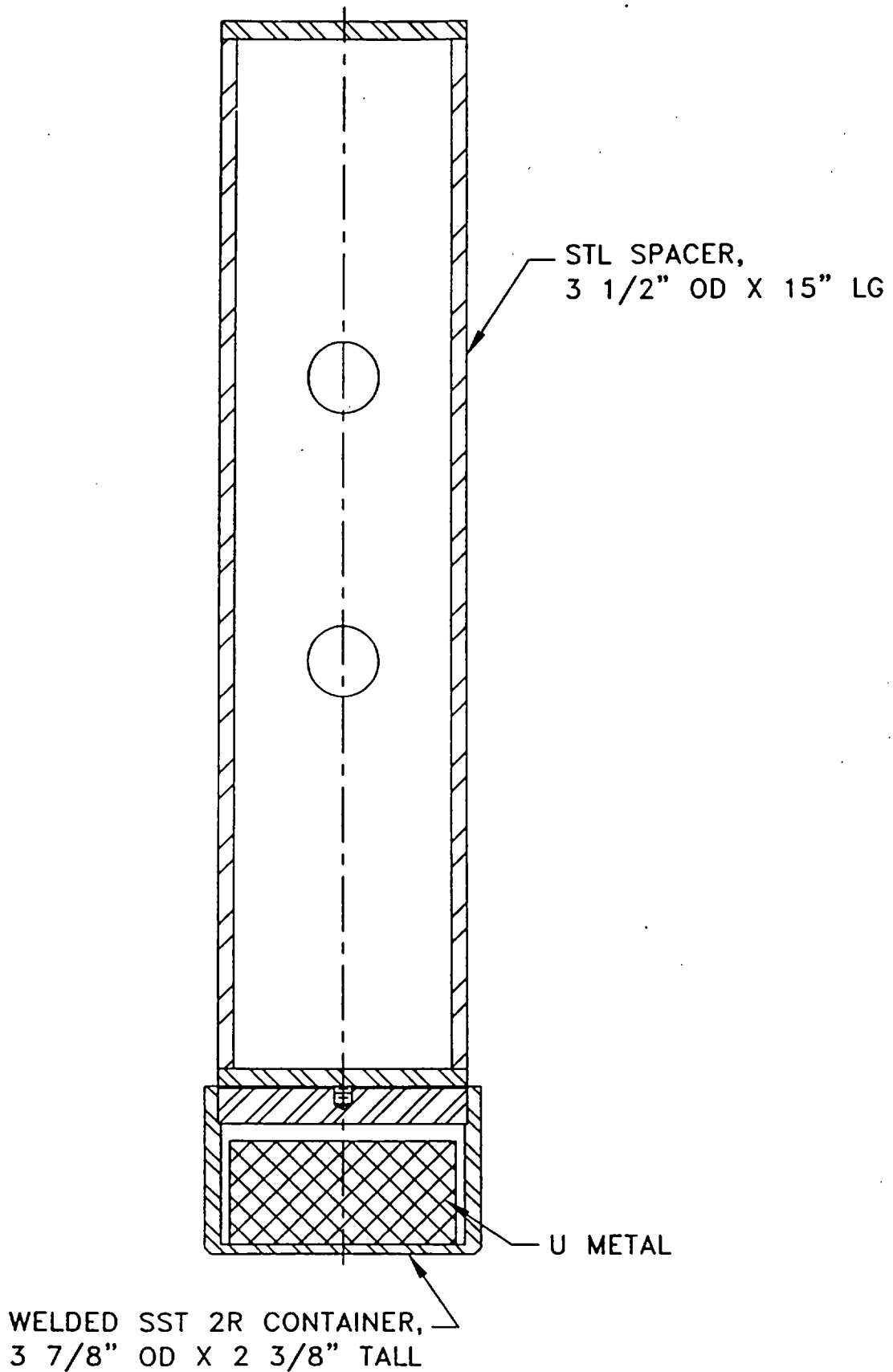
This appendix contains drawings of the packaging configuration for the majority (> 90%) of the packages stored in the Building 3019 tube vaults. The configurations that are not provided are one-of-a-kind assemblies, which hold small amounts of material.



# LANL PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO AUA-67 & AUA-70 ONLY.

APPLIES TO 2 OUTER PACKAGES CONTAINING A TOTAL OF 5.9 KG <sup>235</sup>U.



(ALL DIMENSIONS ARE NOMINAL)

FIG. A-1

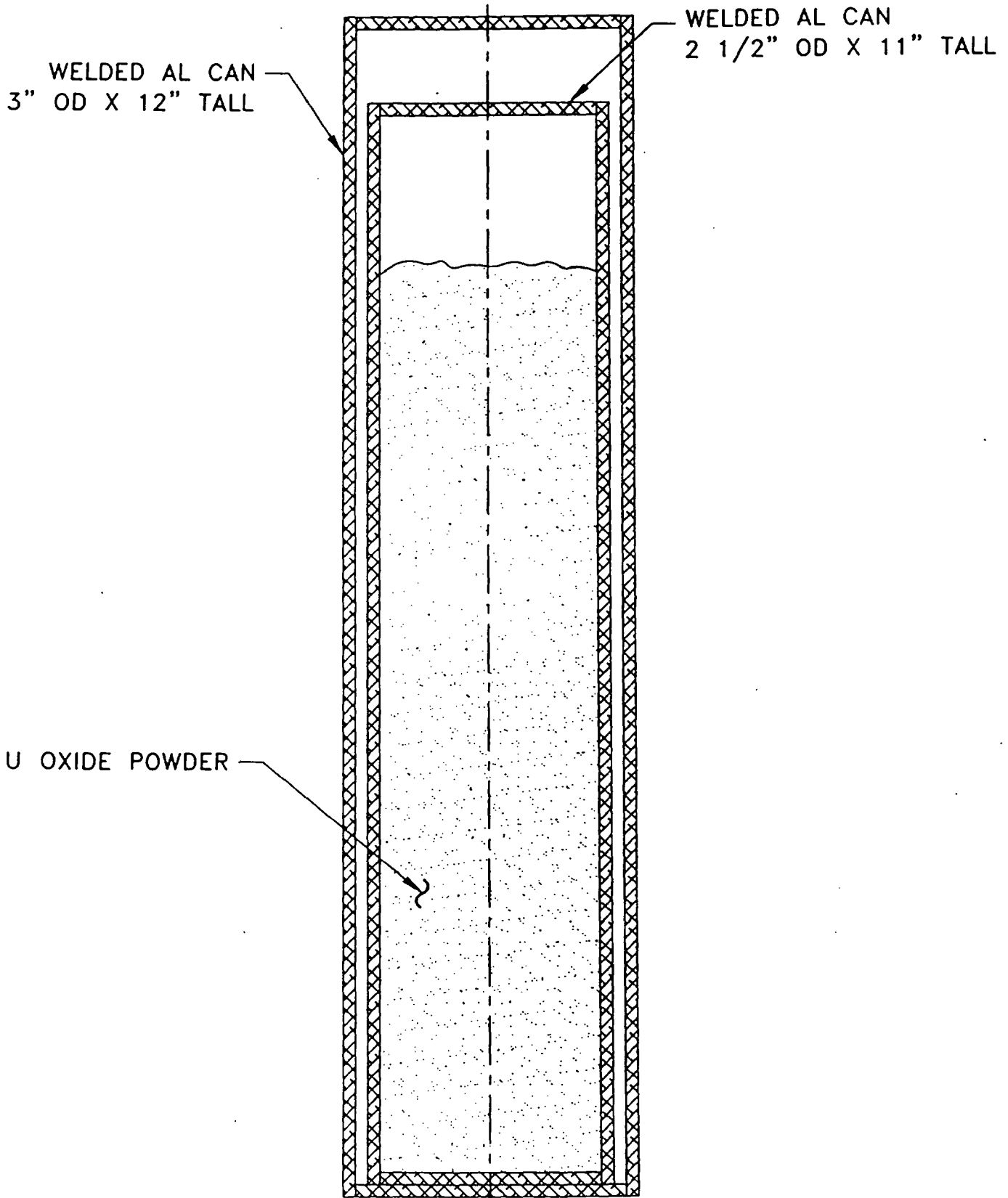
# SAVANNAH RIVER SRO-9 PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO SRO-9 ONLY.

THIS REPRESENTS THE PRESUMED CONFIGURATION.

DETAILS OF ACTUAL ASSEMBLY NOT AVAILABLE.

APPLIES TO 6 OUTER PACKAGES CONTAINING A TOTAL OF 3.0 KG <sup>233</sup>U.



(ALL DIMENSIONS ARE NOMINAL & INFERRED FROM DESCRIPTIONS)

FIG. A-2

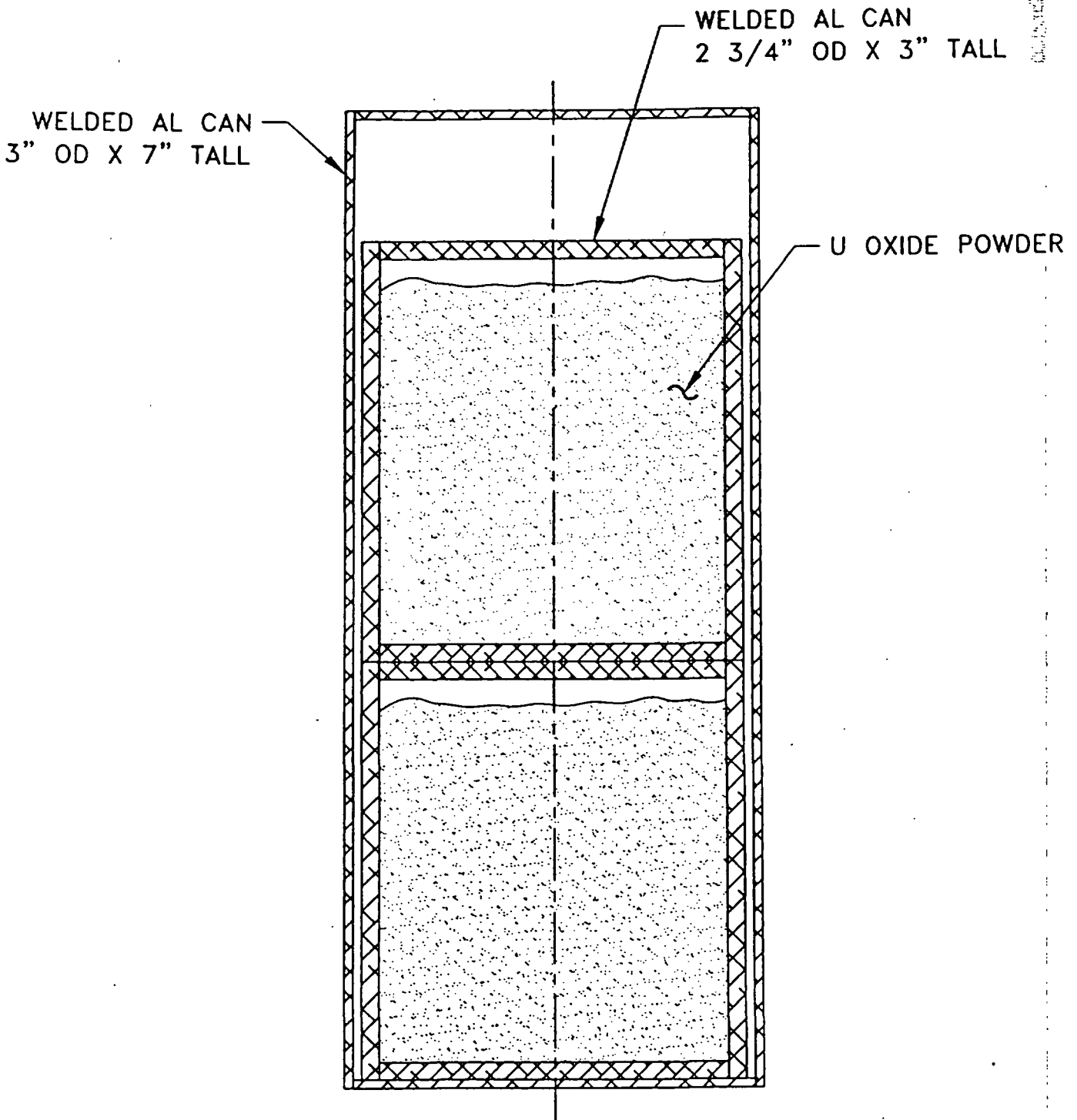
# SAVANNAH RIVER LZB PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO LZB-22 & LZB-22-1 ONLY.

THIS REPRESENTS THE PRESUMED CONFIGURATION.

DETAILS OF ACTUAL ASSEMBLY NOT AVAILABLE.

APPLIES TO 6 OUTER PACKAGES CONTAINING A TOTAL OF 2.9 KG <sup>233</sup>U.



(ALL DIMENSIONS ARE NOMINAL & INFERRED FROM DESCRIPTIONS)

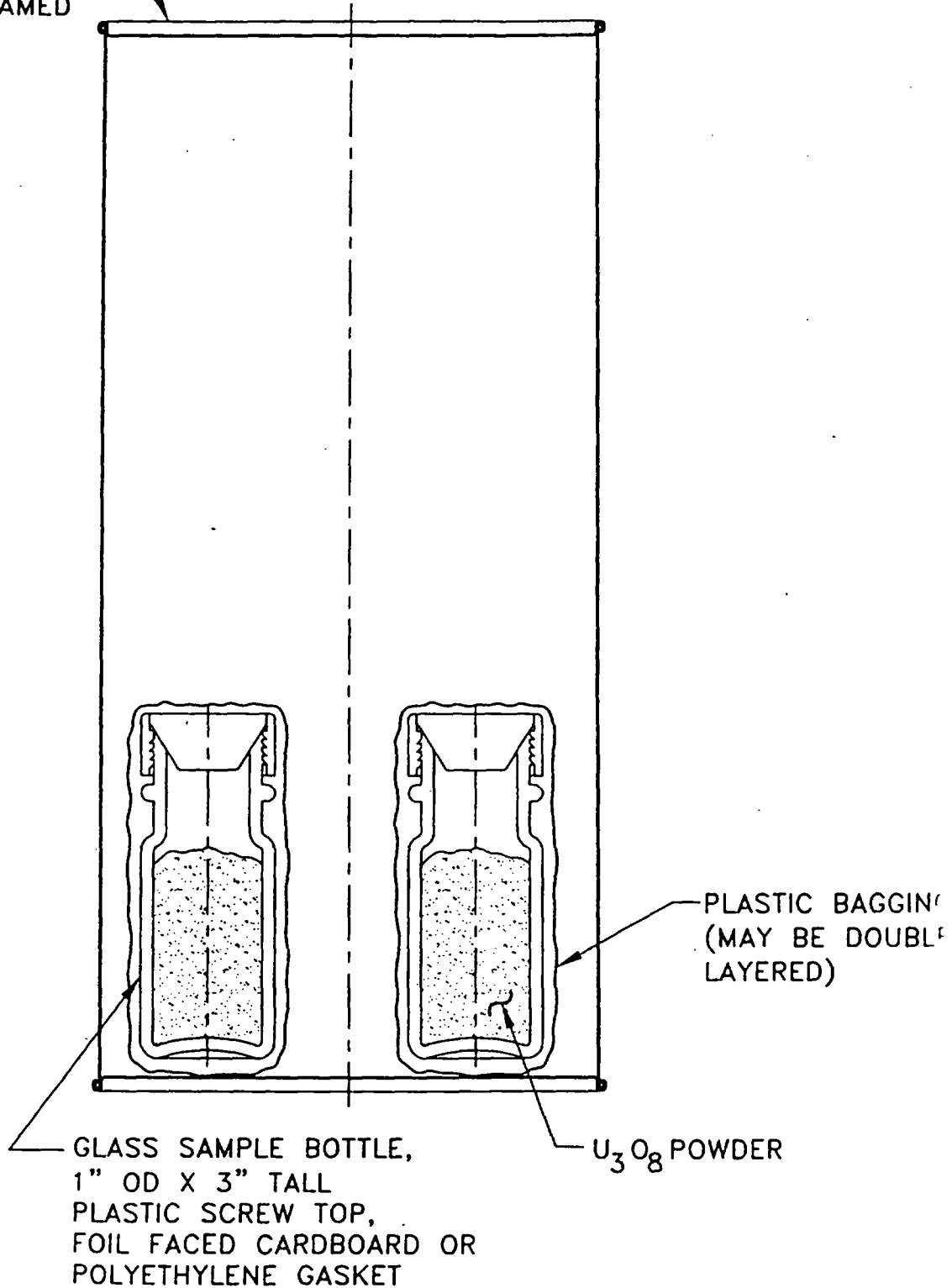
FIG. A-3

# ORNL-RDF OX-222-BOP PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO OX-222-BOP ONLY.

APPLIES TO 1 OUTER PACKAGE CONTAINING A TOTAL OF 0.01 KG <sup>233</sup>U.

ISOTOPE CAN  
3 7/8" OD X 8" TALL  
TINPLATED STL  
DOUBLE SEAMED



(ALL DIMENSIONS ARE NOMINAL)

FIG. A-4

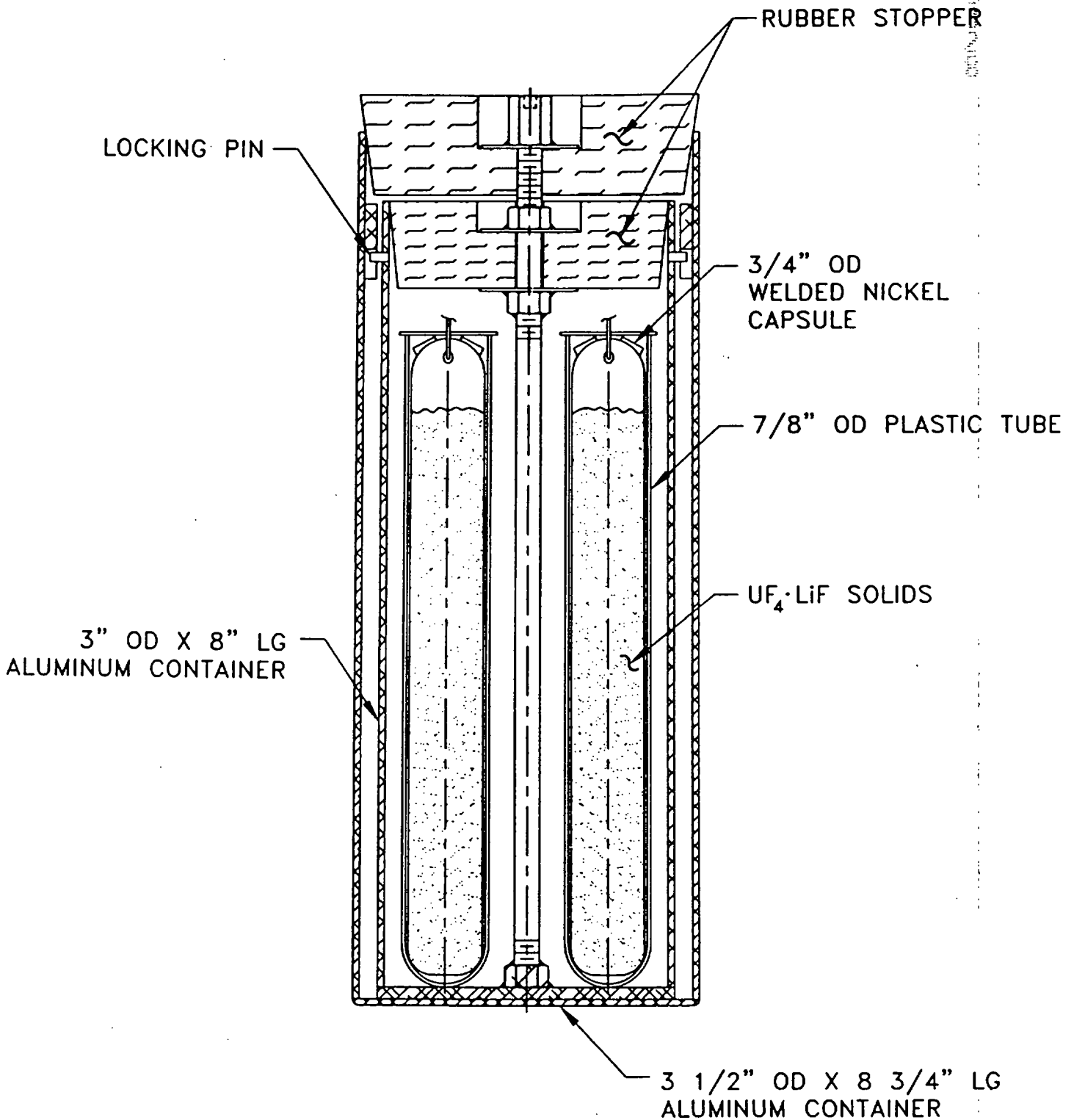


# RCP-04 (ENRICHMENT CAPSULE) PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO ENRICHMENT CAPSULES ONLY.

PACKAGE CONTAINS 6 CAPSULES.

APPLIES TO 2 OUTER PACKAGES CONTAINING A TOTAL OF 1.1 KG <sup>233</sup>U.



(ALL DIMENSIONS ARE NOMINAL)

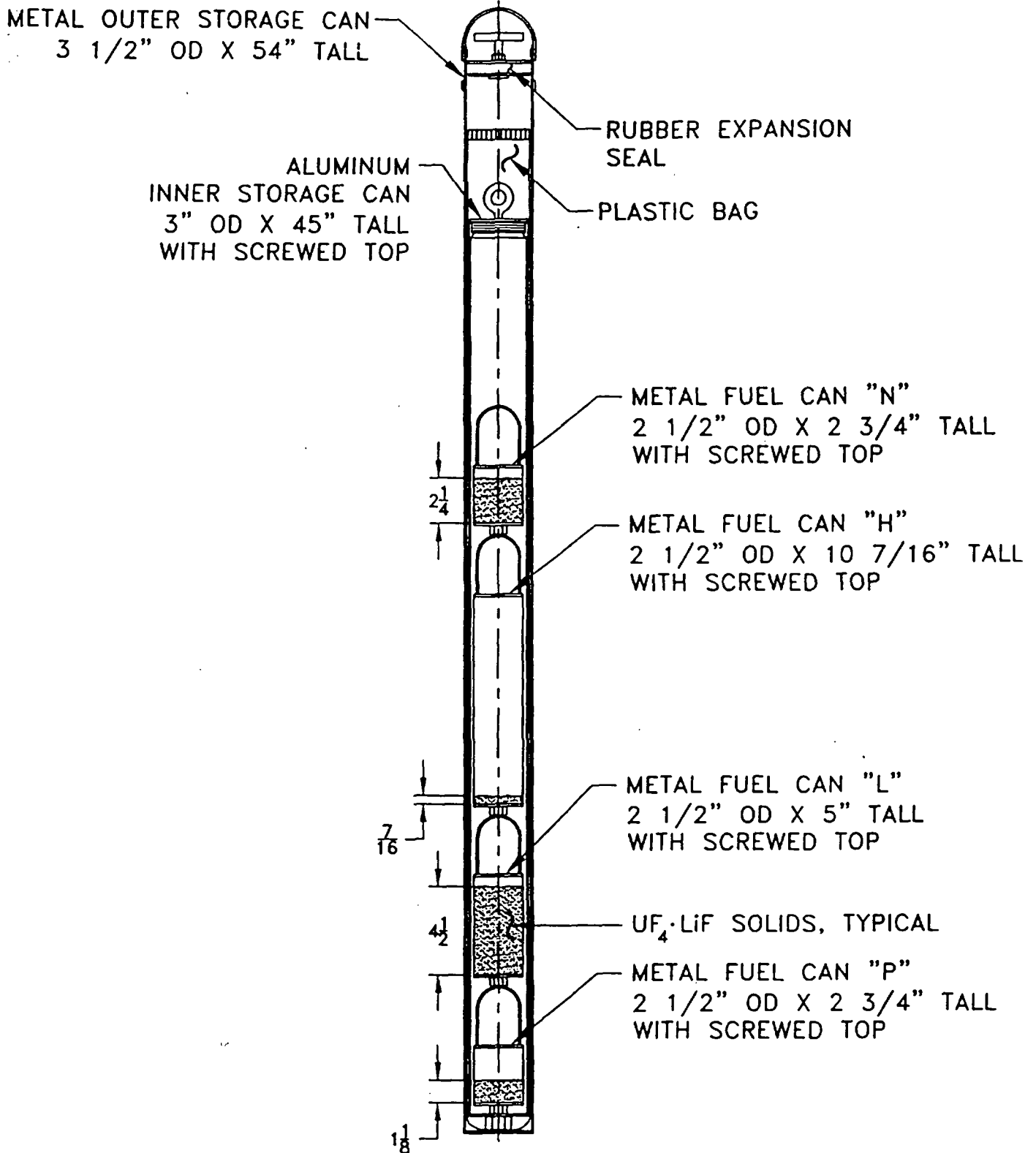
FIG. A-5

# RCP-04 (MSRE FUEL CAN) PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO MSRE FUEL CANS ONLY.

PACKAGE CONTAINS 4 FUEL CANS.

APPLIES TO 1 OUTER PACKAGE CONTAINING A TOTAL OF 1.6 KG <sup>233</sup>U.



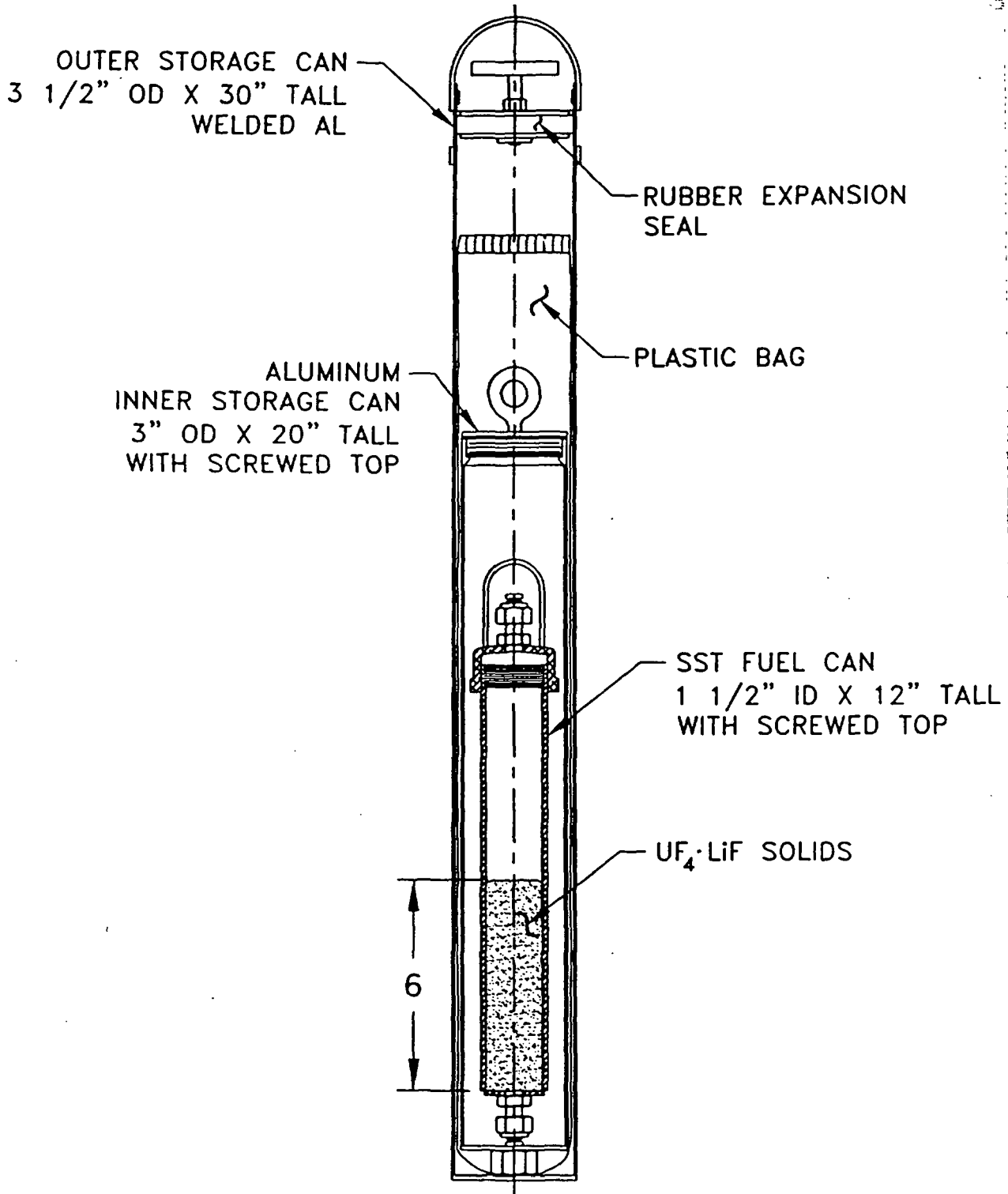
(ALL DIMENSIONS ARE NOMINAL)

FIG. A-6

# RCP-04 (T-2 VESSEL HEEL) PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO T-2 VESSEL HEEL ONLY.

APPLIES TO 1 OUTER PACKAGE CONTAINING A TOTAL OF 0.3 KG <sup>233</sup>U



(ALL DIMENSIONS ARE NOMINAL)

FIG. A-7

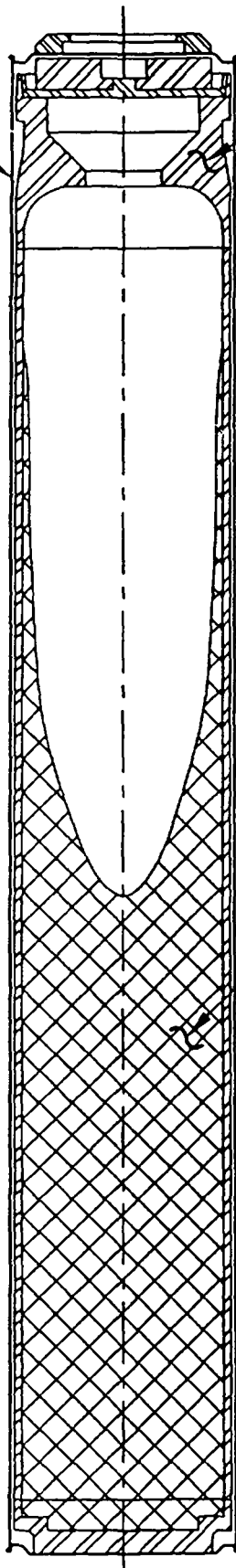
# CEUSP PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO CEUSP & RCP-06 ONLY.

APPLIES TO 430 OUTER PACKAGES CONTAINING A TOTAL OF 161.4 KG <sup>235</sup>U.

OUTER CANISTER  
3 9/16" O.D. X  
24 3/4" TALL  
TINPLATED STL  
DOUBLE SEAMED

PRIMARY CAN  
3 1/2" OD X  
24 3/16" TALL  
WELDED SST



$U_3O_8$  MONOLITH

(ALL DIMENSIONS ARE NOMINAL)

FIG. A-8

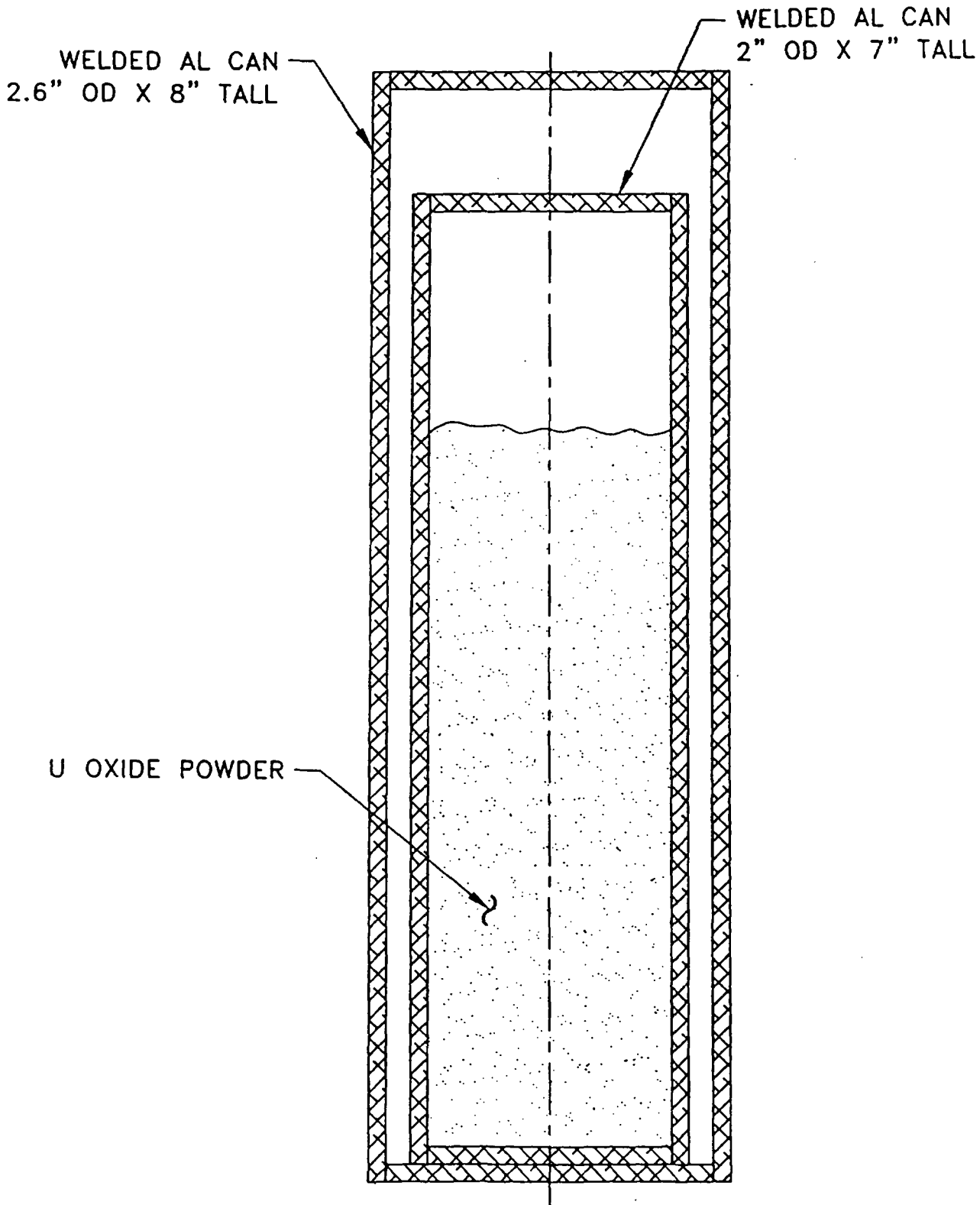
# SAVANNAH RIVER ALUMINUM PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO RCP-02 & RCP-03 ONLY.

THIS REPRESENTS THE PRESUMED CONFIGURATION.

DETAILS OF ACTUAL ASSEMBLY NOT AVAILABLE.

APPLIES TO 167 OUTER PACKAGES CONTAINING A TOTAL OF 72.3 KG <sup>235</sup>U.



(ALL DIMENSIONS ARE NOMINAL & INFERRED FROM DESCRIPTIONS)

FIG. A-9

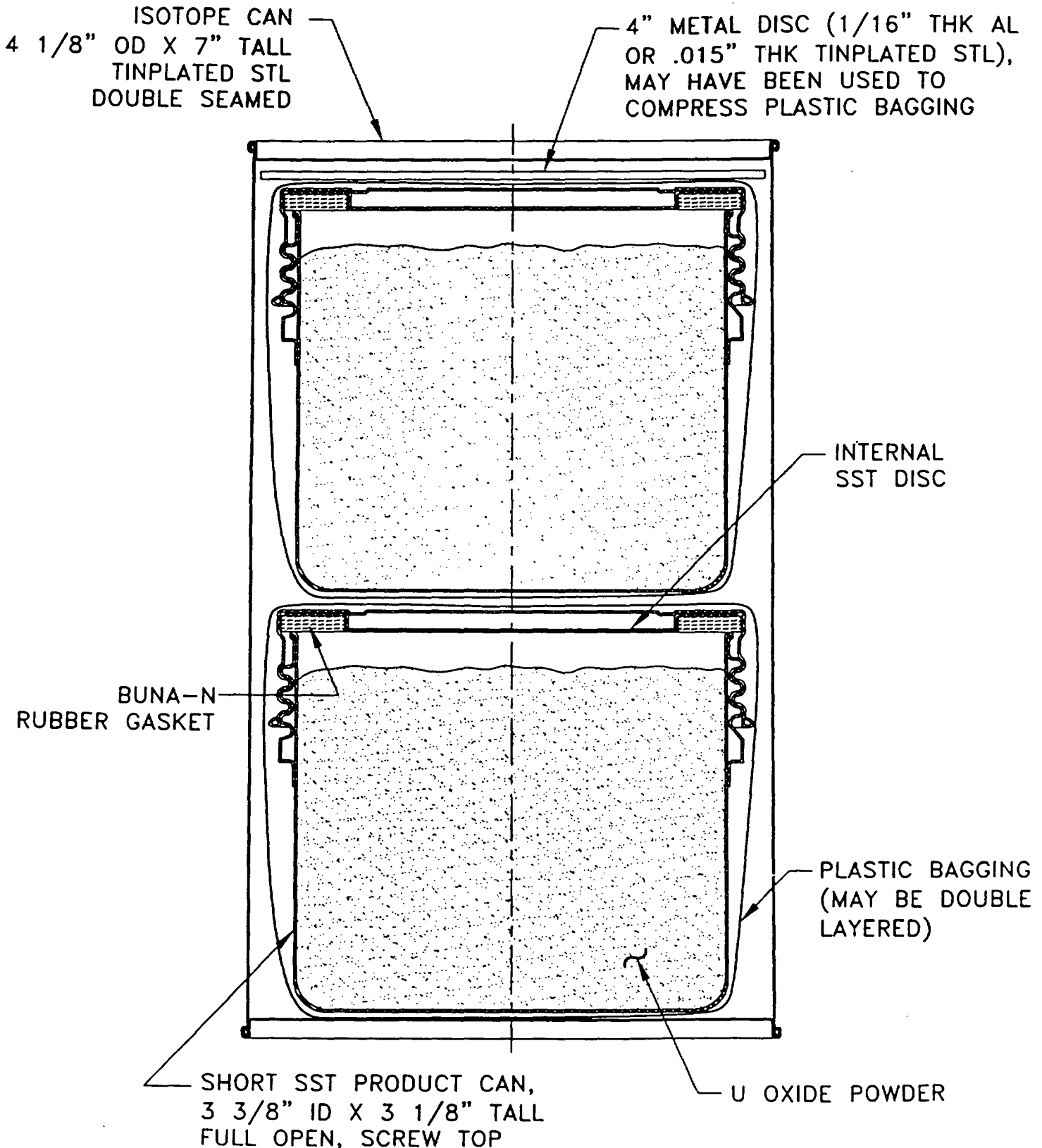
# SHORT OXIDE-PRODUCT CAN PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO OX-222, -301, -302,

-310 THRU -316, OX-SCRAP, & PZA-BPL ONLY.

PACKAGE MAY CONTAIN ONE OR TWO PRODUCT CANS.

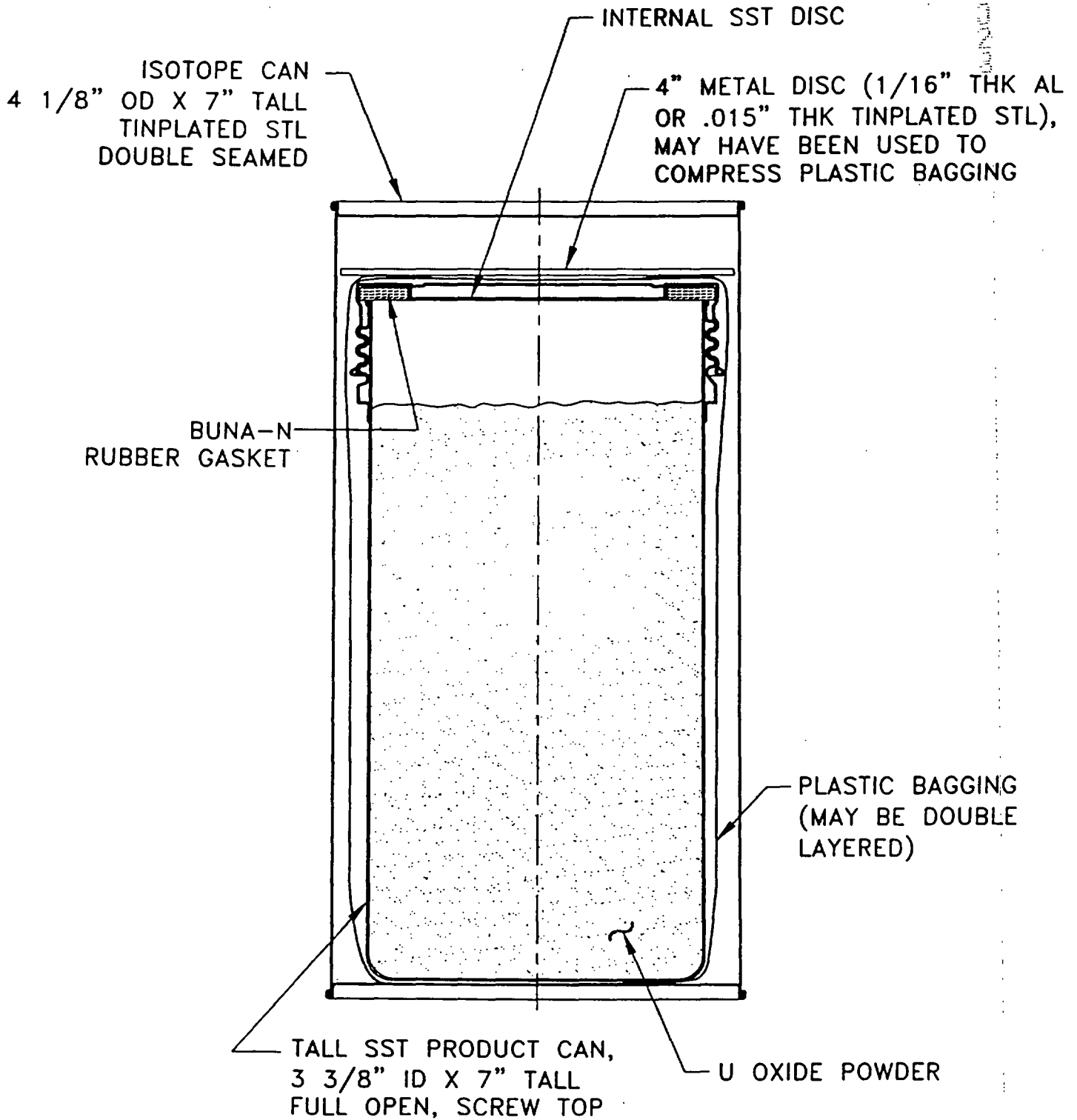
APPLIES TO 90 OUTER PACKAGES CONTAINING A TOTAL OF 69.7 KG <sup>235</sup>U.



(ALL DIMENSIONS ARE NOMINAL)

FIG. A-10

TALL OXIDE-PRODUCT CAN PACKAGE ASSEMBLY  
CONFIGURATION APPLIES TO OX-305, -306(-1), -306(-2), -307, & -309 ONLY.  
APPLIES TO 71 OUTER PACKAGES CONTAINING A TOTAL OF 33.5 KG <sup>235</sup>U.



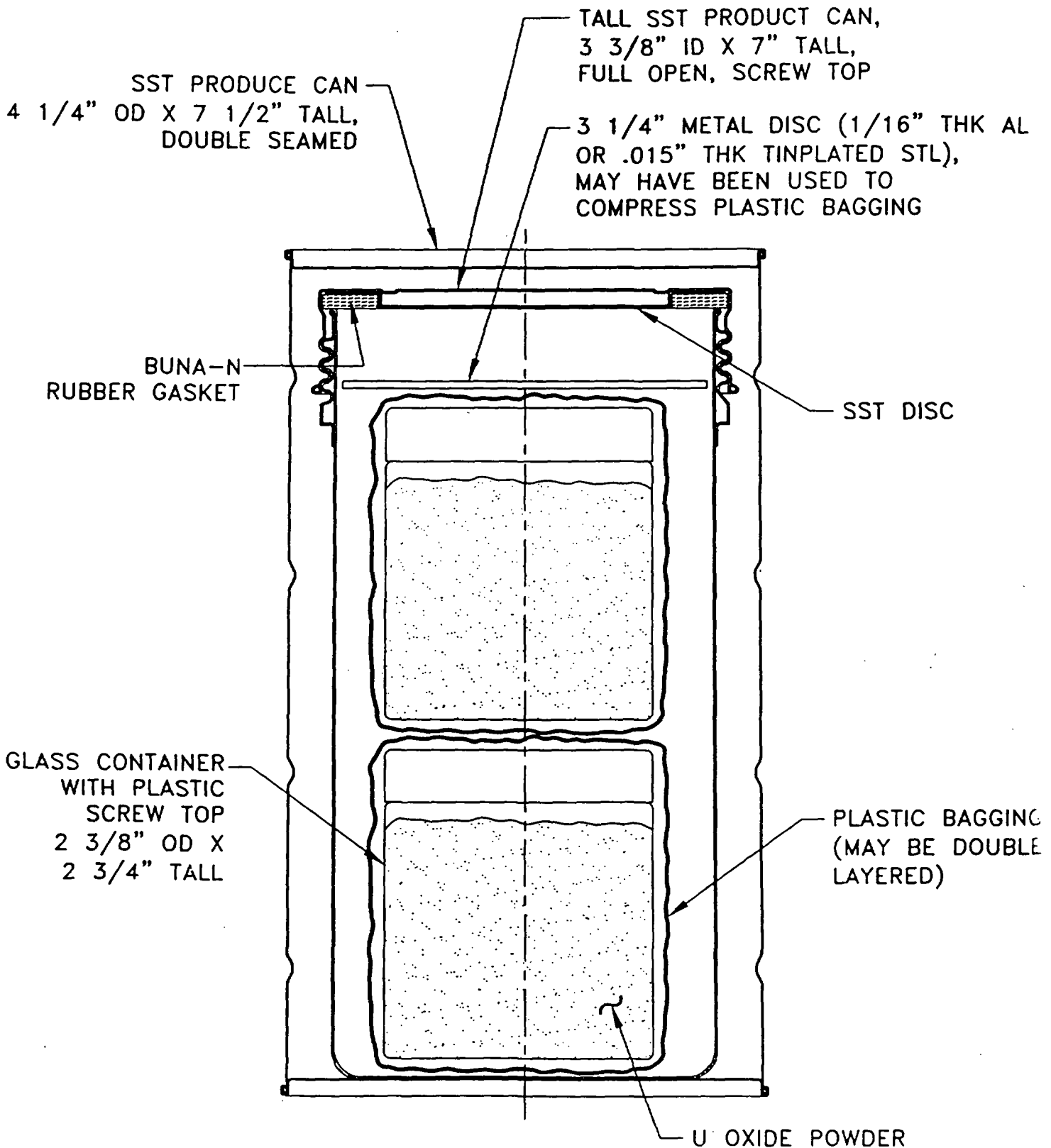
(ALL DIMENSIONS ARE NOMINAL)  
FIG. A-11

# MOUND PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO GVB-02 & GVB-03.

CONFIGURATION MAY HAVE ONE OR TWO  
GLASS CONTAINERS PER PRODUCT CAN.

APPLIES TO 20 OUTER PACKAGES CONTAINING A TOTAL OF 3.5 KG <sup>233</sup>U.



(ALL DIMENSIONS ARE NOMINAL)

FIG. A-12



# ANL-ZPR (5 PACKET) PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO ANL-10B & ANL-10D ONLY.

(5 PACKETS PER OUTER ISOTOPE CAN)

APPLIES TO 2 OUTER PACKAGES CONTAINING A TOTAL OF 0.3 KG <sup>235</sup>U

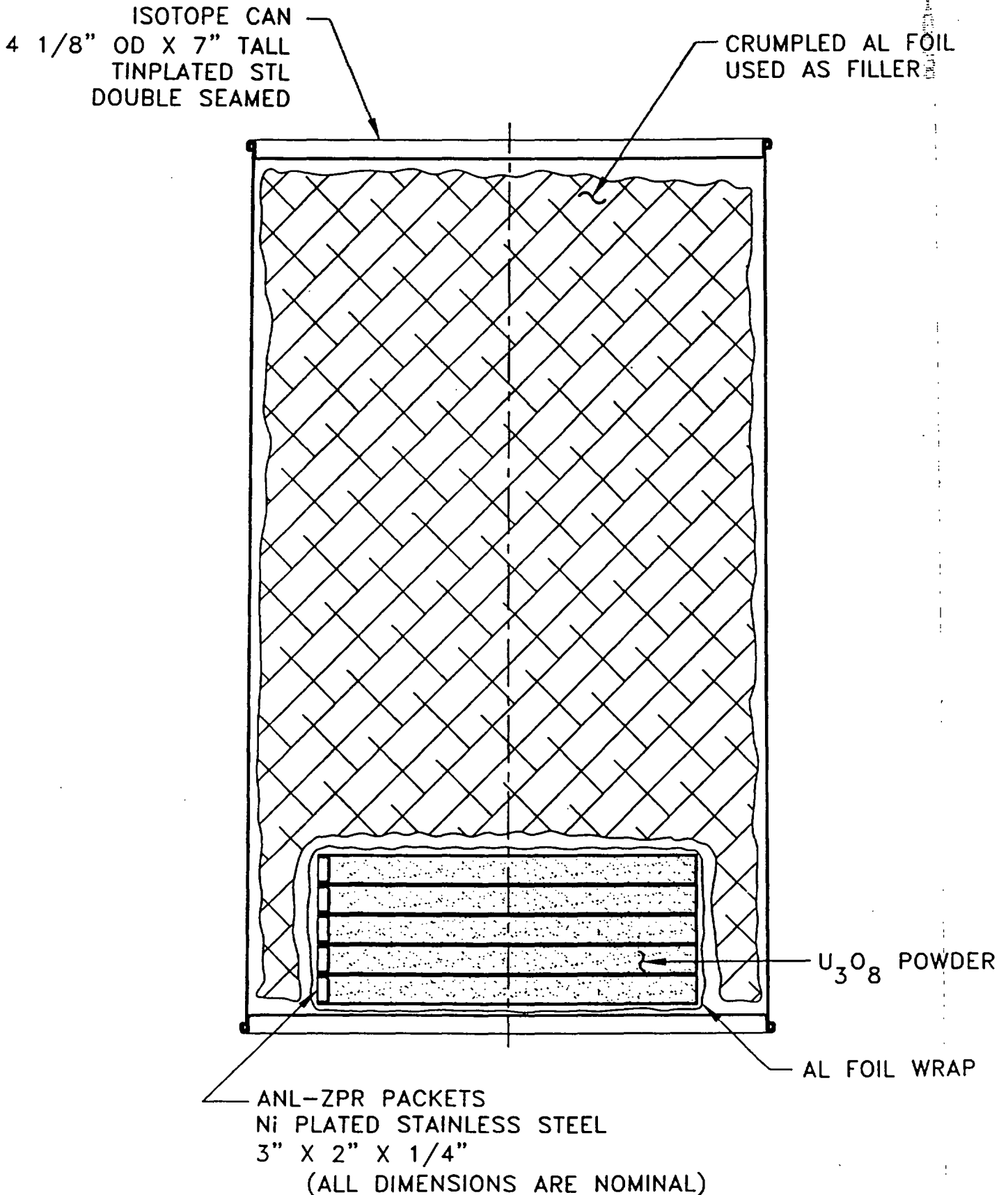


FIG. A-13

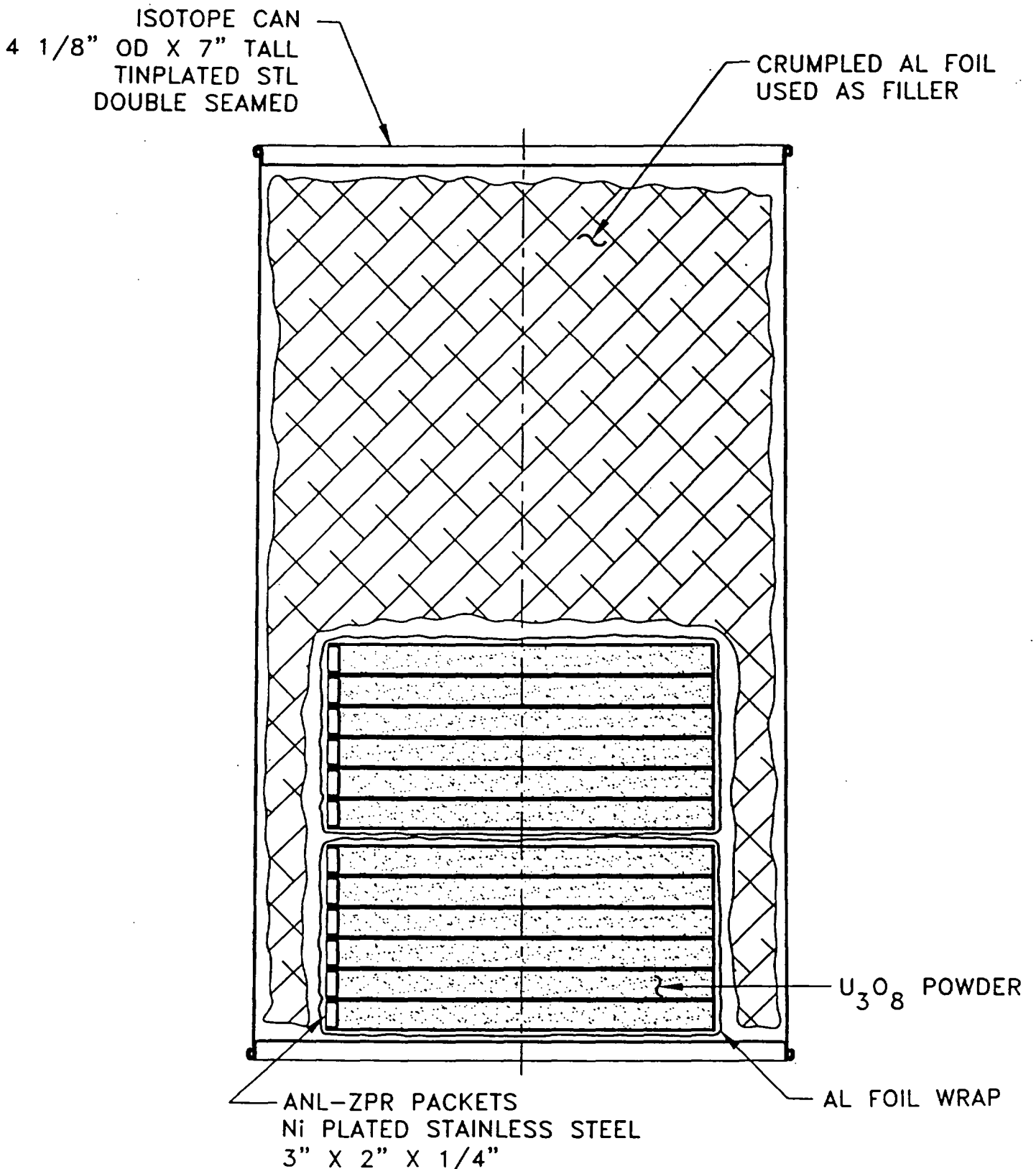
# ANL-ZPR (12 PACKET) PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO CZC-9A, -11, -12, & -13 ONLY.

TYPICAL CONFIGURATION INCLUDES 12 PACKETS PER OUTER ISOTOPE CAN.

ONE CAN IN GROUP MAY HAVE FEWER PACKETS.

APPLIES TO 101 OUTER PACKAGES CONTAINING A TOTAL OF 32.9 KG <sup>235</sup>U.



(ALL DIMENSIONS ARE NOMINAL)

FIG. A-14

# ANL-ZPR (16 PACKET) PACKAGE ASSEMBLY

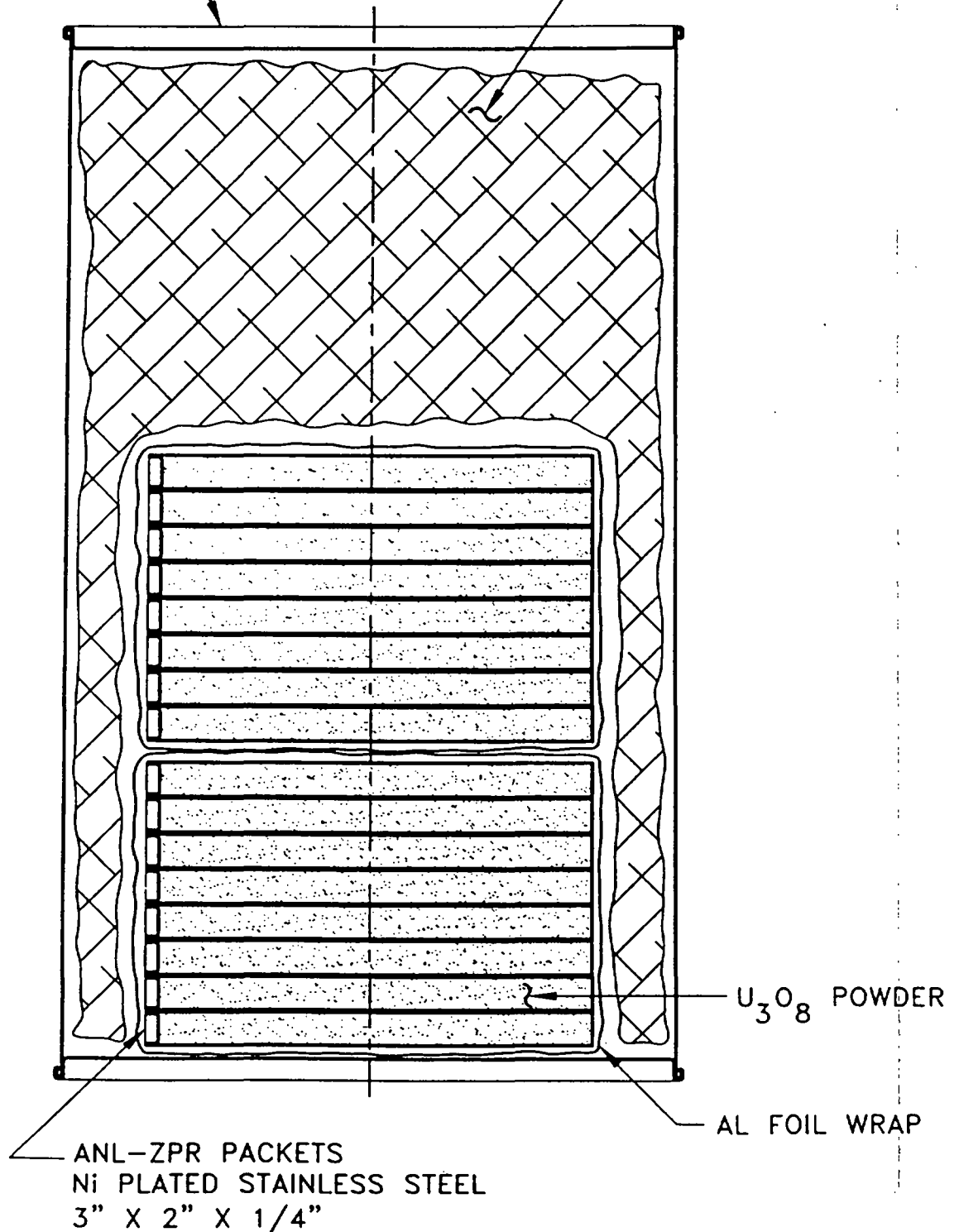
CONFIGURATION APPLIES TO CZC-7A ONLY.

(16 PACKETS PER OUTER ISOTOPE CAN)

APPLIES TO 27 OUTER PACKAGES CONTAINING A TOTAL OF 11.8 KG <sup>235</sup>U

ISOTOPE CAN  
4 1/8" OD X 7" TALL  
TINPLATED STL  
DOUBLE SEAMED

CRUMPLED AL FOIL  
USED AS FILLER



ANL-ZPR PACKETS  
Ni PLATED STAINLESS STEEL  
3" X 2" X 1/4"

U<sub>3</sub>O<sub>8</sub> POWDER

AL FOIL WRAP

(ALL DIMENSIONS ARE NOMINAL)

FIG. A-15

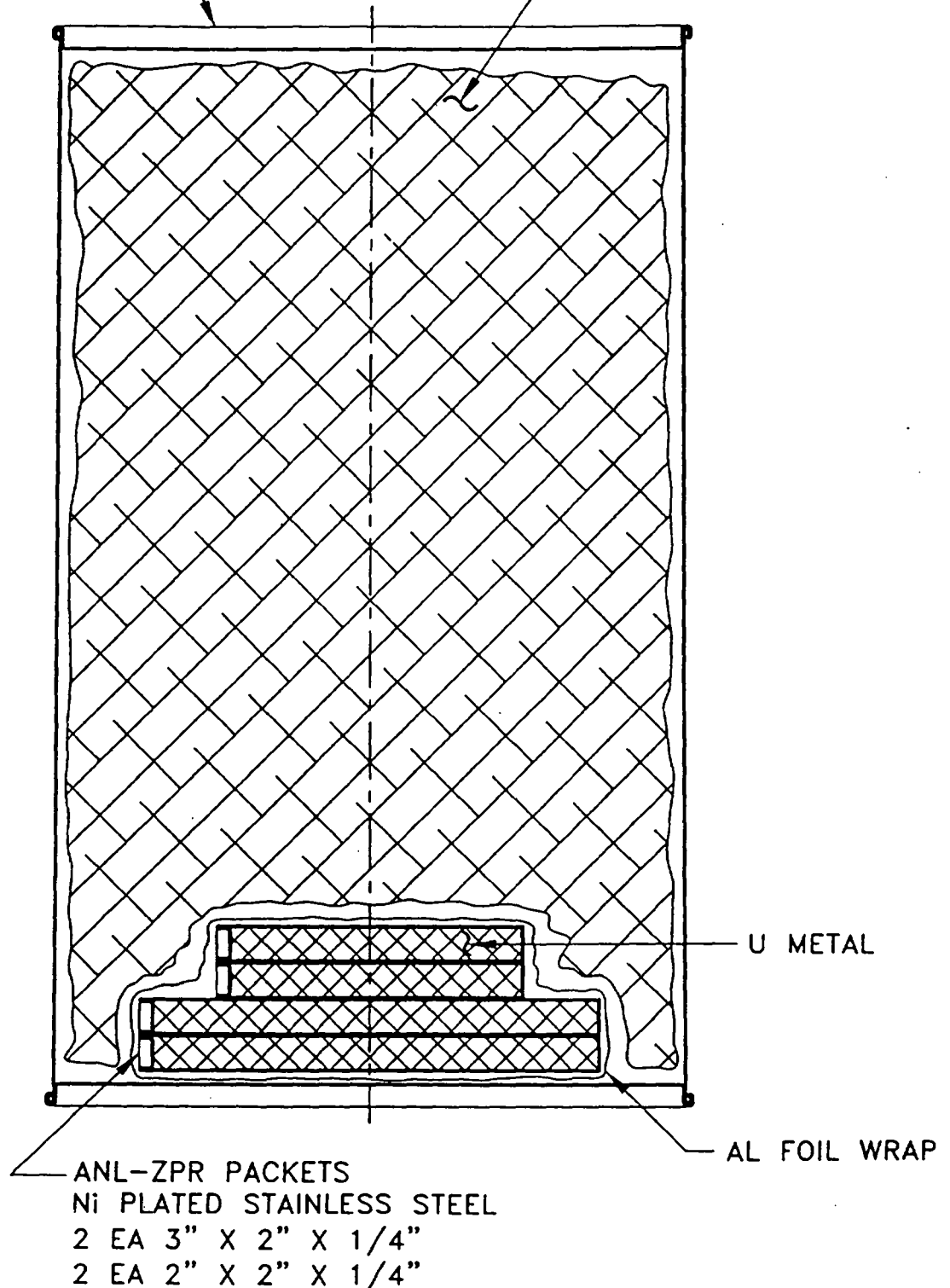
# ANL-ZPR (METAL) PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO CZC-7B ONLY.

APPLIES TO 1 OUTER PACKAGE CONTAINING A TOTAL OF 0.6 KG <sup>235</sup>U.

ISOTOPE CAN  
4 1/8" OD X 7" TALL  
TINPLATED STL  
DOUBLE SEAMED

CRUMPLED AL FOIL  
USED AS FILLER



(ALL DIMENSIONS ARE NOMINAL)

FIG. A-16

# OXIDE PACKAGE ASSEMBLY

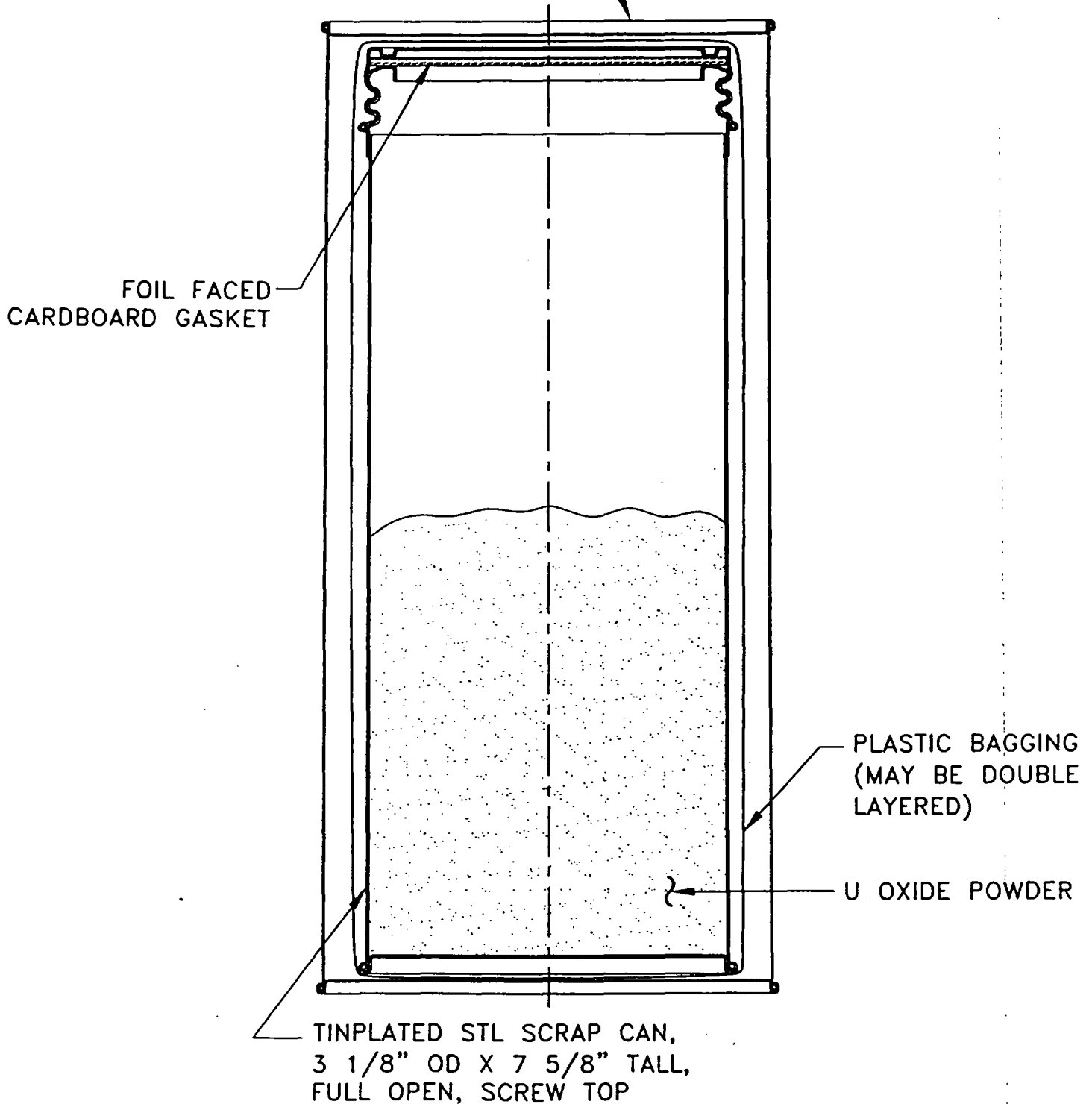
CONFIGURATION APPLIES TO Y-12 POOL, & ARF-35 ONLY.

THIS REPRESENTS THE PRESUMED CONFIGURATION.

DETAILS OF ACTUAL ASSEMBLY NOT AVAILABLE.

APPLIES TO 6 OUTER PACKAGES CONTAINING A TOTAL OF 1.5 KG <sup>235</sup>U.

TALL, THIN ISOTOPE CAN,  
3 3/4" OD X 8" TALL,  
TIN PLATED STL, DOUBLE SEAMED



(ALL DIMENSIONS ARE NOMINAL & INFERRED FROM DESCRIPTIONS)

FIG. A-17

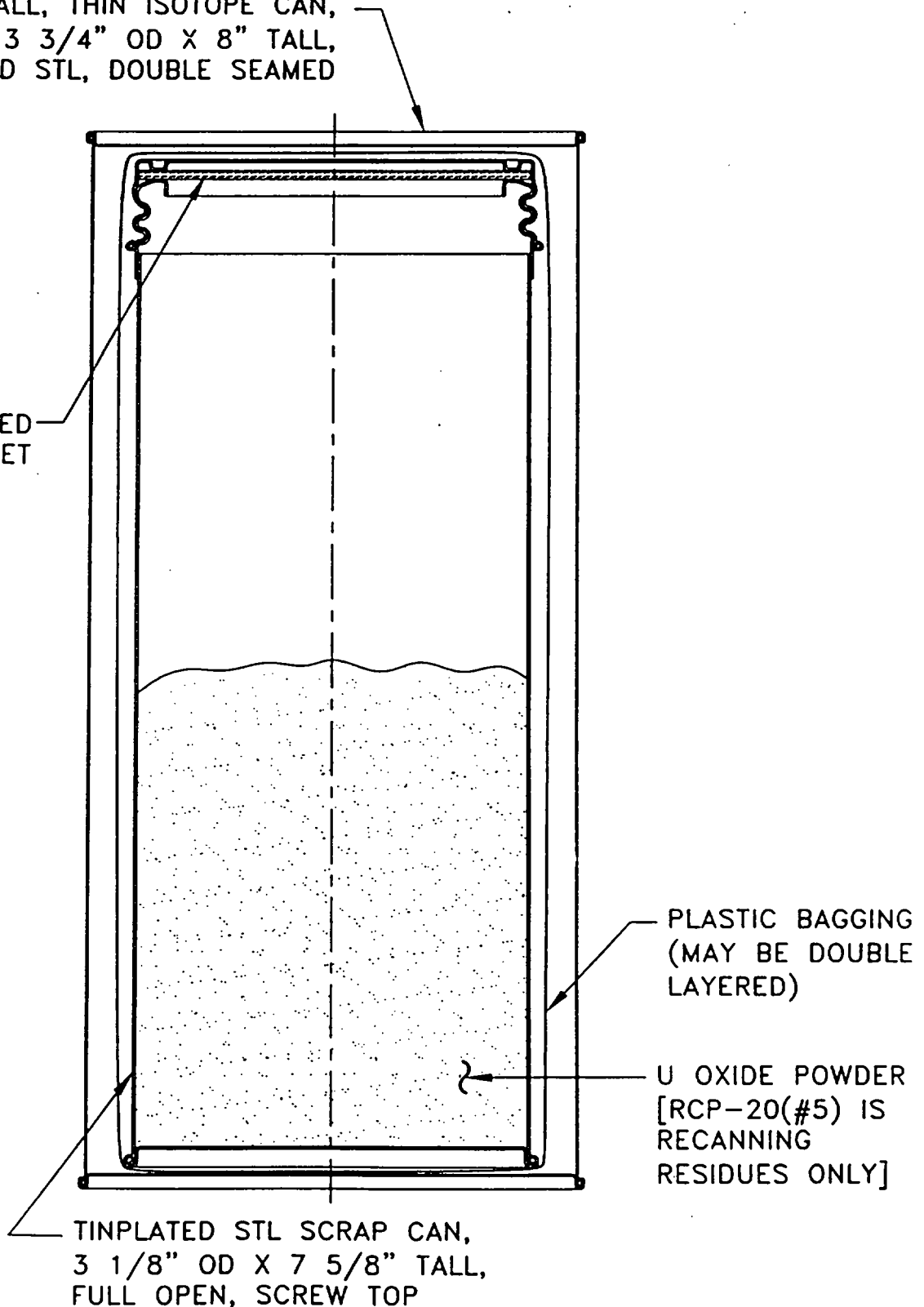
# OXIDE SCRAP PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO OX-225(-1 THRU -4),  
OX-225-BOX G, RCP-20(#4 & #5) ONLY.

APPLIES TO 7 OUTER PACKAGES CONTAINING A TOTAL OF 3.8 KG <sup>233</sup>U.

TALL, THIN ISOTOPE CAN,  
3 3/4" OD X 8" TALL,  
TIN PLATED STL, DOUBLE SEAMED

FOIL FACED  
CARDBOARD GASKET



(ALL DIMENSIONS ARE NOMINAL)

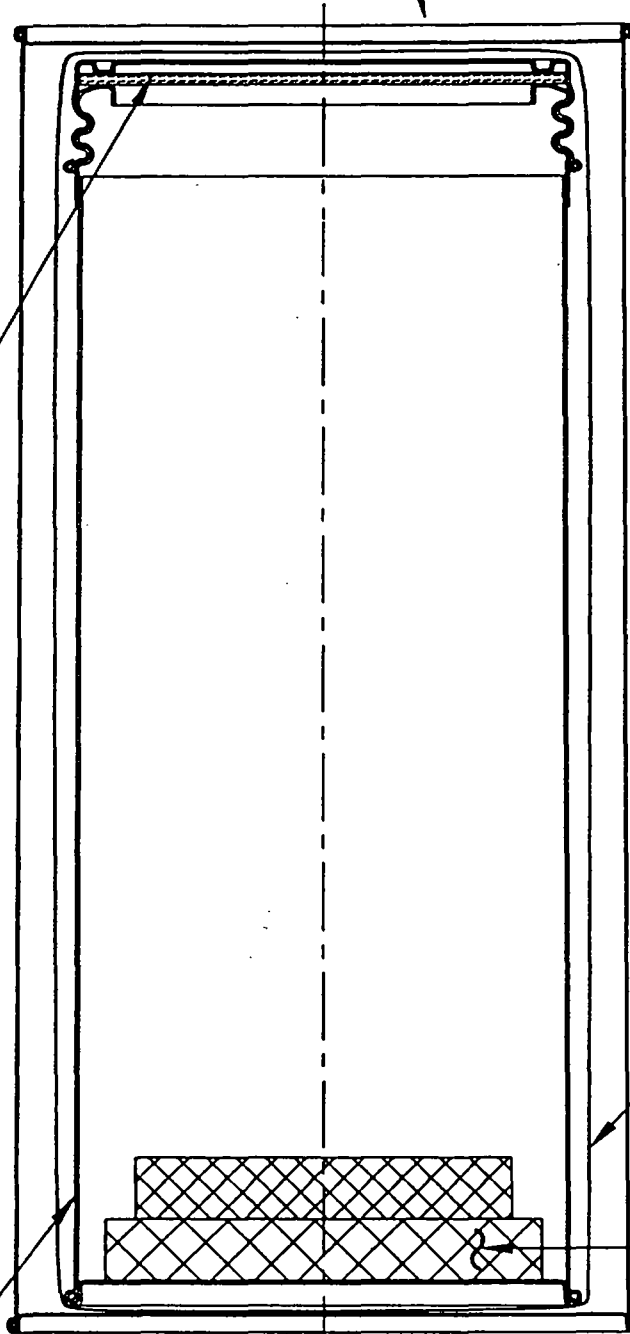
FIG. A-18

# METAL SCRAP PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO RCP-20(#1, 2, & 3), Y-12 METAL, & JZBL ONLY.  
MAY CONTAIN ONE OR MORE PIECES OR DISCS PER CAN.  
APPLIES TO 5 OUTER PACKAGES CONTAINING A TOTAL OF 4.5 KG <sup>233</sup>U.

TALL, THIN ISOTOPE CAN,  
3 3/4" OD X 8" TALL,  
TIN PLATED STL, DOUBLE SEAMED

FOIL FACED  
CARDBOARD GASKET



PLASTIC BAGGING  
(MAY BE DOUBLE  
LAYERED)

U METAL PIECE(S)

TIN PLATED STL SCRAP CAN,  
3 1/8" OD X 7 5/8" TALL,  
FULL OPEN, SCREW TOP

(ALL DIMENSIONS ARE NOMINAL)

FIG. A-19

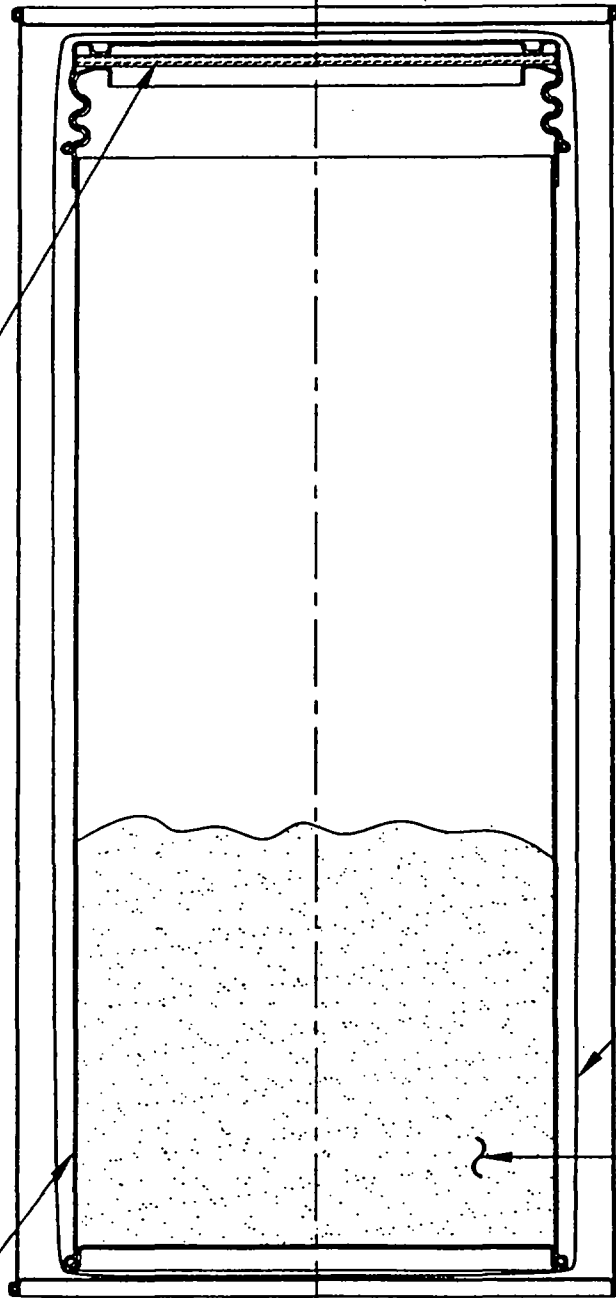
# ADU SCRAP PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO ANL-10C ONLY.

APPLIES TO 1 OUTER PACKAGE CONTAINING A TOTAL OF 0.1 KG <sup>235</sup>U.

TALL, THIN ISOTOPE CAN,  
3 3/4" OD X 8" TALL,  
TIN PLATED STL, DOUBLE SEAMED

FOIL FACED  
CARDBOARD GASKET



PLASTIC BAGGING  
(MAY BE DOUBLE  
LAYERED)

AMMONIUM DIURANATE  
POWDER

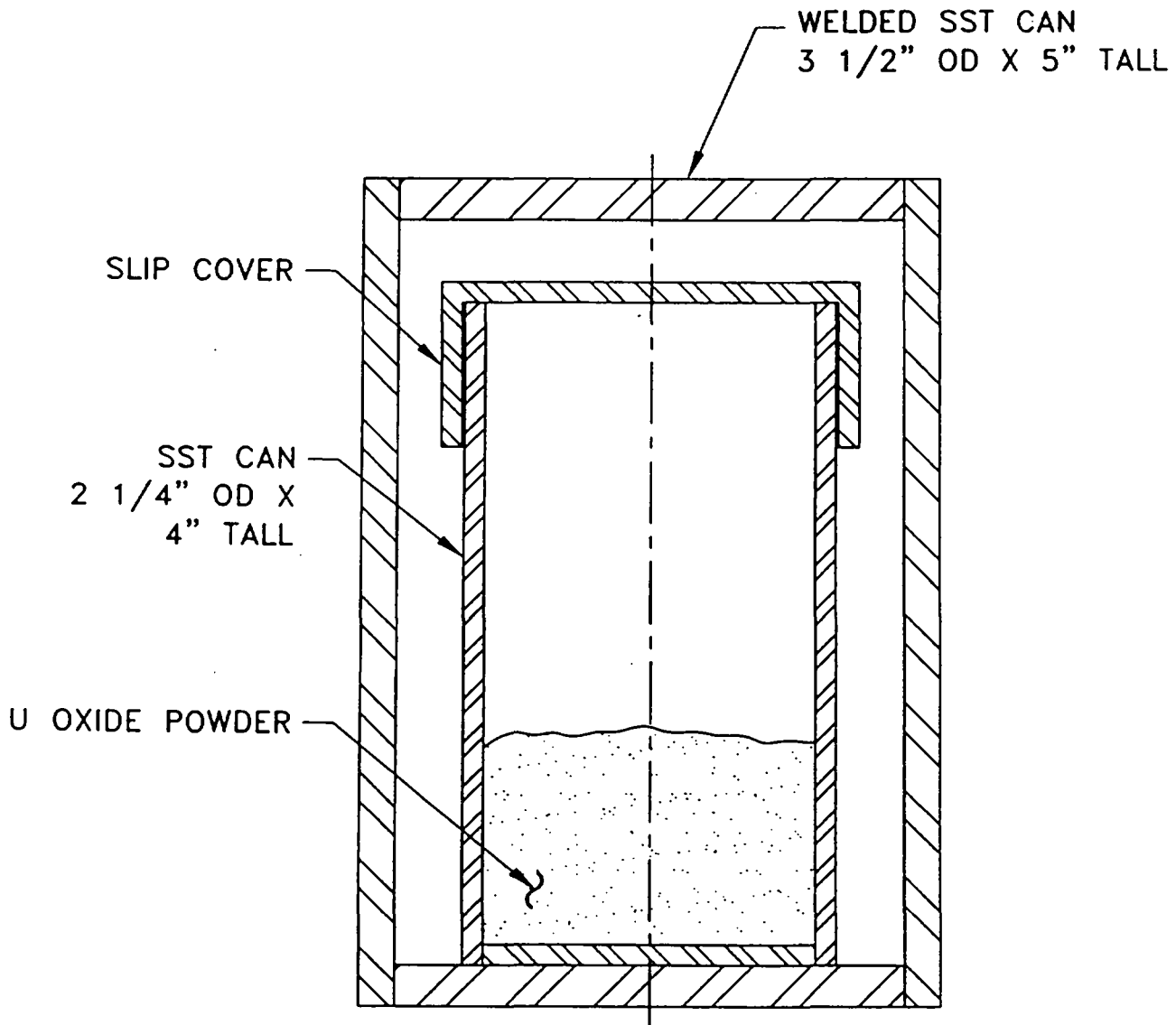
TINPLATED STL SCRAP CAN,  
3 1/8" OD X 7 5/8" TALL,  
FULL OPEN, SCREW TOP

(ALL DIMENSIONS ARE NOMINAL)

FIG. A-20



HANFORD HUA-2 PACKAGE ASSEMBLY  
CONFIGURATION APPLIES TO HUA-2A & HUA-2B ONLY.  
THIS REPRESENTS THE PRESUMED CONFIGURATION.  
DETAILS OF ACTUAL ASSEMBLY NOT AVAILABLE.  
APPLIES TO 6 OUTER PACKAGES CONTAINING A TOTAL OF 0.3 KG <sup>235</sup>U



(ALL DIMENSIONS ARE NOMINAL & INFERRED FROM DESCRIPTIONS.)

FIG. A-21

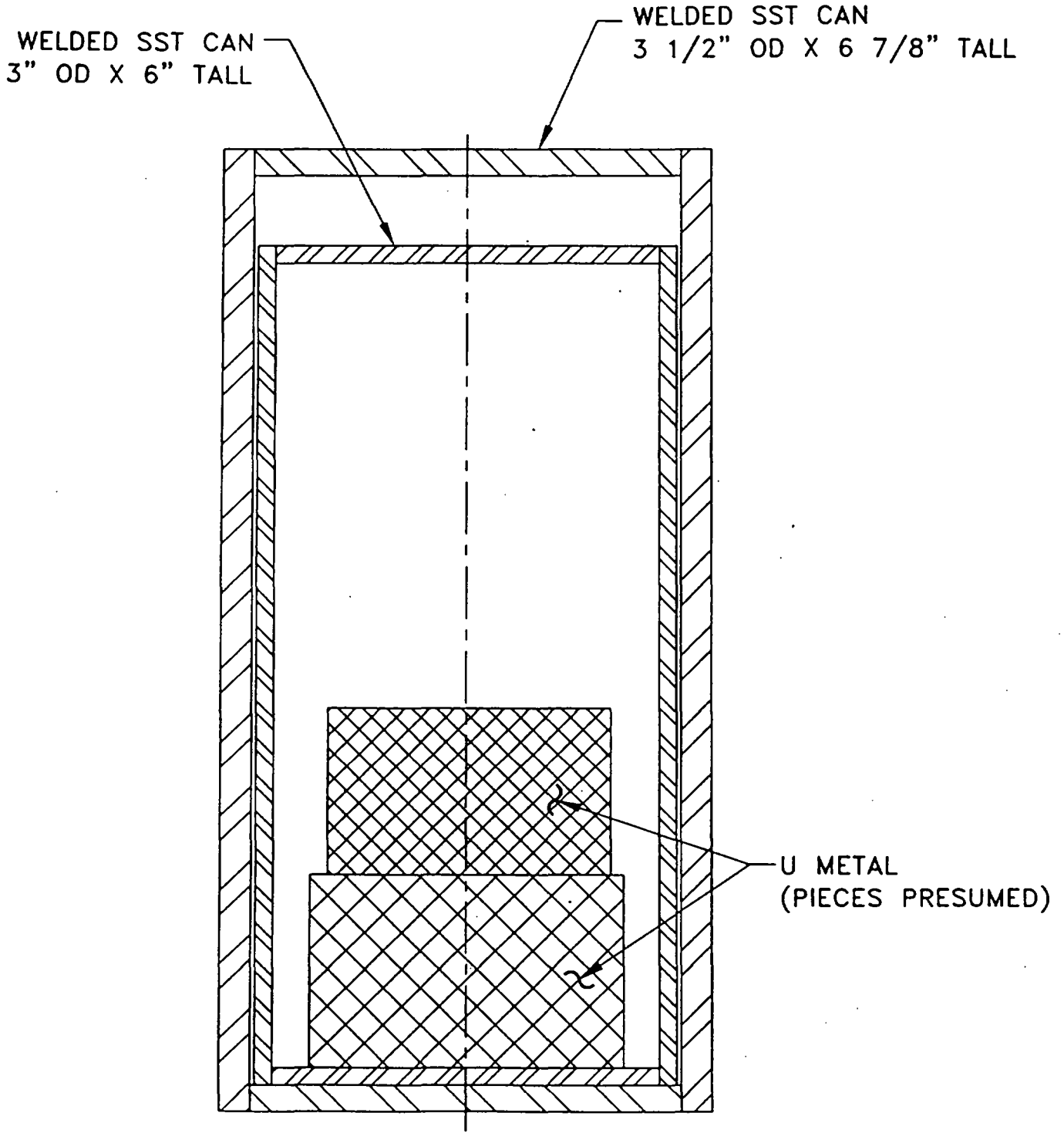
# LANL AUA-84 PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO AUA-84(SS) ONLY.

THIS REPRESENTS THE PRESUMED CONFIGURATION.

DETAILS OF ACTUAL ASSEMBLY NOT AVAILABLE.

APPLIES TO 3 OUTER PACKAGES CONTAINING A TOTAL OF 0.5 KG <sup>233</sup>U.



(ALL DIMENSIONS ARE NOMINAL & INFERRED FROM DESCRIPTIONS)

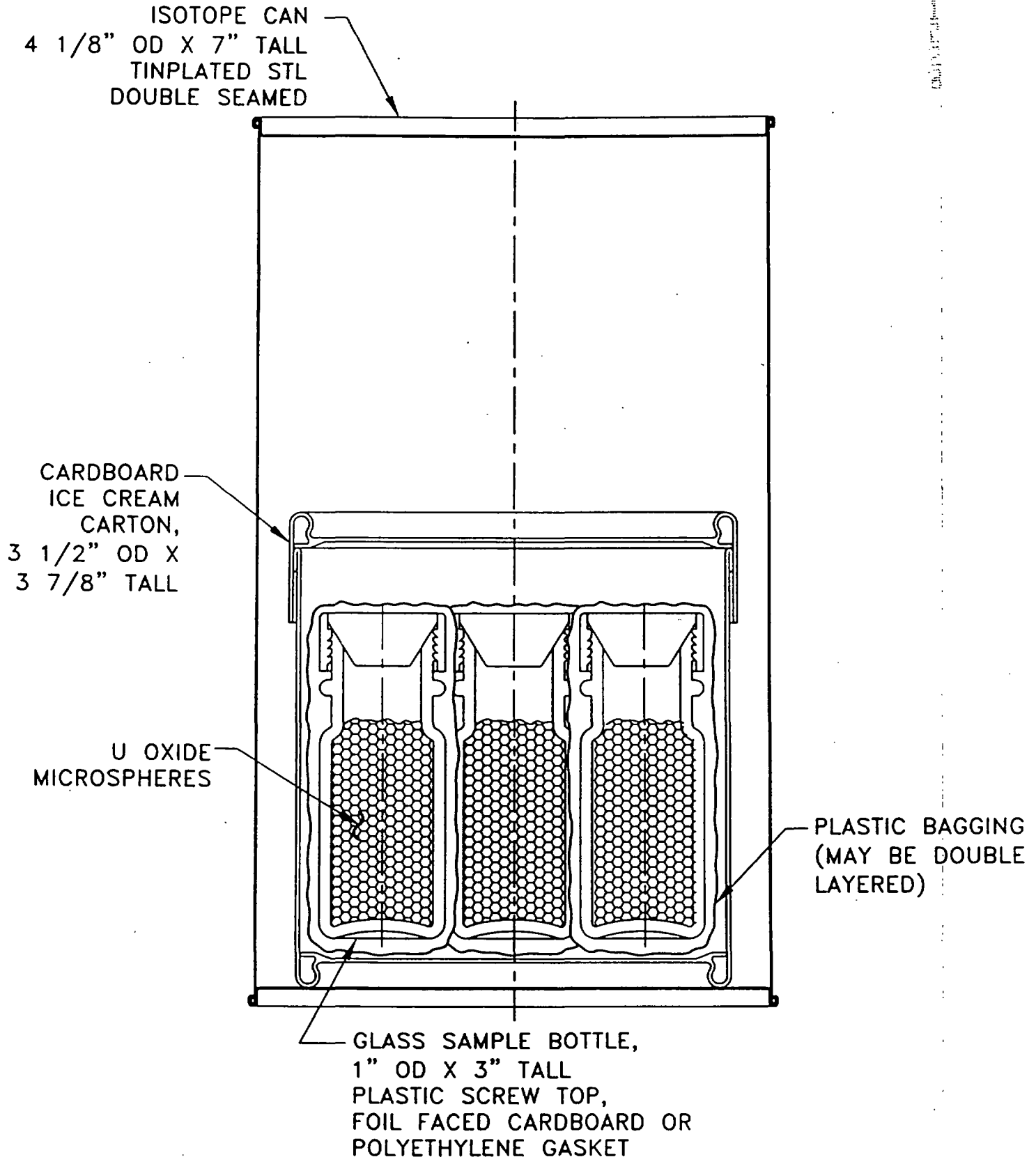
FIG. A-22

# ORNL-RDF MISC. SAMPLES PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO U-TH-SPH, & RCP-18 ONLY.

PACKAGE MAY CONTAIN THREE OR MORE SAMPLE BOTTLES.

APPLIES TO 3 OUTER PACKAGES CONTAINING A TOTAL OF 0.4 KG <sup>235</sup>U



(ALL DIMENSIONS ARE NOMINAL)

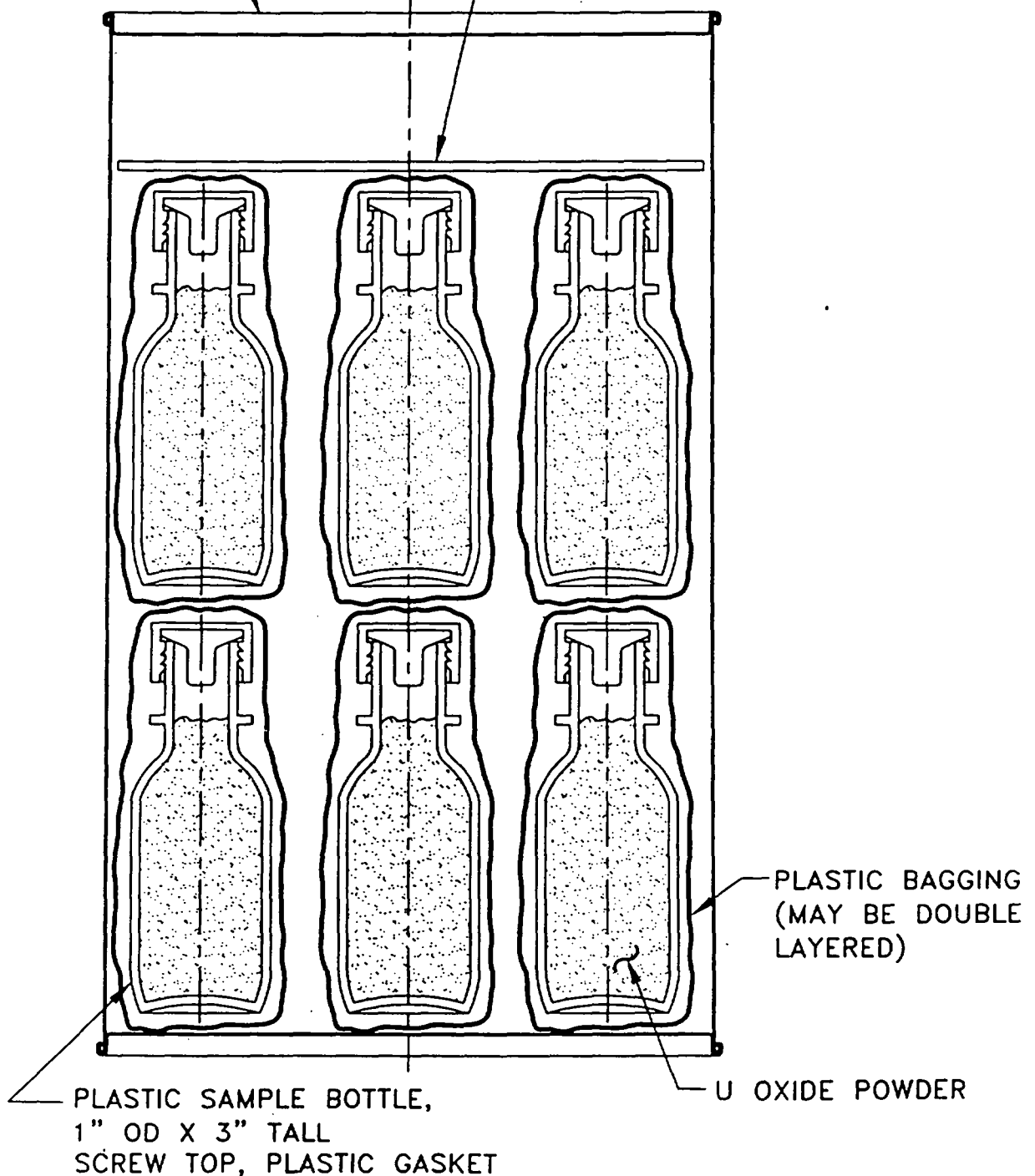
FIG. A-23

# ORNL-RDF ARCHIVE SAMPLES PACKAGE ASSEMBLY

CONFIGURATION APPLIES TO COMPOSITE 1, 2, & 3,  
OX-ARCH CANS 1, 2, & 3, OX-225-LOP(aka OX-225-3), ANL-10E, & ANL-10F.  
PACKAGE MAY CONTAIN THREE TO TWELVE SAMPLE BOTTLES.  
APPLIES TO 9 OUTER PACKAGES CONTAINING A TOTAL OF 0.7 KG <sup>233</sup>U.

ISOTOPE CAN  
4 1/8" OD X 7" TALL  
TINPLATED STL  
DOUBLE SEAMED

4" METAL DISC (1/16" THK AL  
OR .015" THK TINPLATED STL),  
MAY HAVE BEEN USED TO  
COMPRESS PLASTIC BAGGING

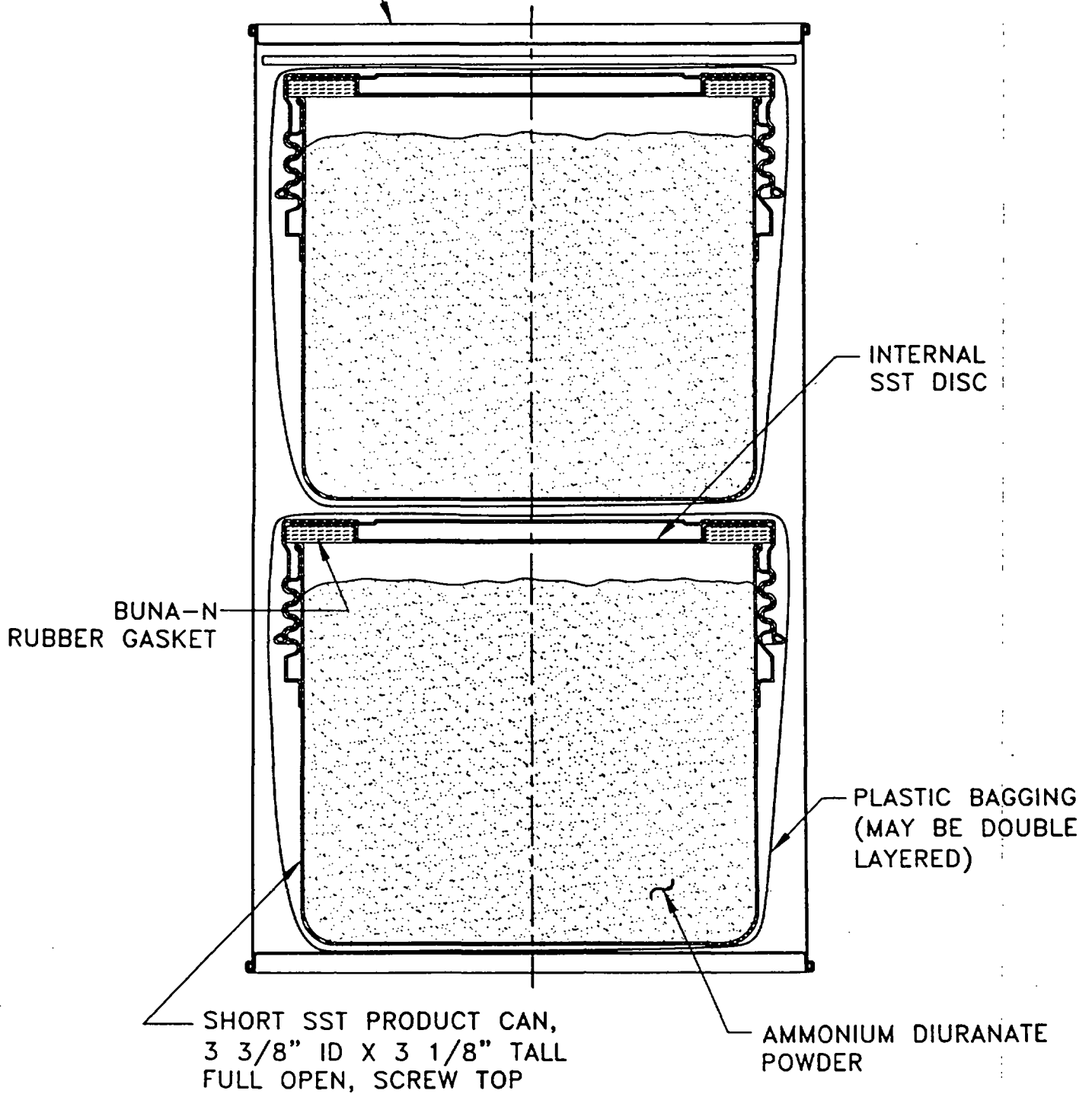


(ALL DIMENSIONS ARE NOMINAL)

FIG. A-24

ADU PRODUCT PACKAGE ASSEMBLY  
CONFIGURATION APPLIES TO ADU-SCRAP ONLY.  
APPLIES TO 1 OUTER PACKAGE CONTAINING A TOTAL OF 0.1 KG <sup>235</sup>U.

ISOTOPE CAN  
4 1/8" OD X 7" TALL  
TINPLATED STL  
DOUBLE SEAMED



(ALL DIMENSIONS ARE NOMINAL)

FIG. A-25