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CSER 00-006: Storage of Plutonium Residue Containers in 55-Gallon Drums at the PFP

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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CSER 00-006: Storage of Plutonium Residue Containers in 55-Gallon Drums at the PFP

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Fluor Federal Services

Date Published
May 2000

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CSER 00-006: Storage of Plutonium Residue Containers in 55-Gallon Drums at the PFP

Key Words: 234-5Z, PFP, wagon, 55-Gallon, residue, billet drums, concrete walls

Abstract: This criticality safety evaluation report (CSER) provides the required limit set and controls for safe transit and storage of these drums in the 234-5Z Building at the PFP. A mass limit of 200 g of plutonium or fissile equivalent per drum is acceptable provided that the drums are not stacked and that the general transportation and storage requirements at the PFP are met. However, a wagon is likely to pass by a drum during transit so one wagon is placed next to a drum as one of the base cases. PFP transition and storage spacing requirements are still required to provide consistent facility-wide requirements but a spacing violation between a wagon and a drum does not constitute a violation of double contingency. Waste drums that contain a maximum of 200 g per drum mass limit can be intermixed in the billet drum array. Drums are excluded from Rooms 227, Room 230C, and the vaults. Also, FFTF fuel can be stored in the room 192A, adjacent to billet drums stored in Room 192D, due to the thickness of the concrete walls isolating the drums from the fuel.

**CSER 00-006:
STORAGE OF PLUTONIUM RESIDUE
CONTAINERS IN 55 GALLON DRUMS AT
THE PFP**

May 2000

Prepared by
Fluor Federal Services, Inc.
Richland, Washington

For
Fluor Hanford, Inc.
In Support of
Task Order No. 5204

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Executive Summary

The plutonium stabilization program at the Plutonium Finishing Plant (PFP) involves treatment of the residual inventory of plutonium at the plant by various means, dependent on the material form and makeup, to convert it into forms amenable to long term storage at PFP or for disposition elsewhere. There is a significant quantity of plutonium-bearing residues stored in various vaults and gloveboxes. The residues are in the forms of sand, slag and crucible (SS&C), ash, or oxide and other miscellaneous residues from prior process operations. These materials, along with other fissile residues are to be stabilized by the cementation process as cement billets or direct packaged and stored in 55-gallon drums. The storage of this residual plutonium in these drums at the PFP is addressed by this criticality safety evaluation report (CSER).

This criticality safety evaluation report (CSER) provides the required limit set and controls for safe transit and storage of these drums in the 234-5Z Building at the PFP. A mass limit of 200 g of plutonium or fissile equivalent per drum is acceptable provided that the drums are not stacked and that the general transportation and storage requirements at the PFP are met. However, a wagon is likely to pass by a drum during transit so one wagon is placed next to a drum as one of the base cases. PFP transition and storage spacing requirements are still required to provide consistent facility-wide requirements but a spacing violation between a wagon and a drum does not constitute a violation of double contingency. Waste drums that contain a maximum of 200 g per drum mass limit can be intermixed in the billet drum array. Drums are excluded from Room 227, Room 230C, and the vaults. Also, FFTF fuel can be stored in the room 192A, adjacent to billet drums stored in Room 192D, due to the thickness of the concrete walls isolating the drums from the fuel.

Evaluation of these drums included normal, base cases, and contingencies. The base cases included an array of drums and a single drum passing a wagon in the hallway. Each contingency is evaluated assuming the unlikely event happens to the most conservative base case. A hazards assessment was conducted to assure that each credible unlikely event or set of correlated unlikely events was included in this analysis. This evaluation shows that storage of cemented billets as described in this report meets the double contingency requirement. That is, at least two unlikely, independent, and concurrent changes in process conditions are required before a criticality is possible. Therefore, this CSER meets the requirements for a criticality evaluation contained in the Hanford Site Nuclear Criticality Safety Manuals, HNF-PRO-334 (FDH 2000), HNF-PRO-537 (FDH 1997a), and HNF-PRO-539 (FDH 1997b), ANSI standards (ANSI 1998), and DOE Order 5480.24 (DOE 1992). This CSER also follows Fluor Federal Services, Inc. Practice 134.290.1121 (FFS 1999).

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List of Terms

AIChE	American Institute of Chemical Engineers
ANSI	American National Standards Institute
ANS	American Nuclear Society
CSER	Criticality Safety Evaluation Report
DOE	United States Department of Energy
ID	Identification Number
MCM	Minimum Critical Mass
NC	No Controls
NDA	Nondestructive Analysis
PFP	Plutonium Finishing Plant
PHA	Preliminary Hazards Analysis
PnG	Pipe-and-Go
POC	Pipe Overpack Container
SS&C	Sand, Slag, and Crucible

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1.0 INTRODUCTION AND SUMMARY

1.1 INTRODUCTION

The plutonium stabilization program at the Plutonium Finishing Plant (PFP) involves treatment of the residual inventory of plutonium at the plant by various means, dependent on the material form and makeup, to convert it into forms amenable to long term storage at PFP or for disposition elsewhere. There is a significant quantity of plutonium-bearing residues stored in various vaults and gloveboxes. The residues are in the forms of sand, slag and crucible (SS&C), ash, or oxide and other miscellaneous residues from prior process operations. These materials, along with other fissile residues are to be stabilized by the cementation process as cement billets or direct packaged and stored in 55-gallon drums. The storage of this residual plutonium in these drums at the PFP is addressed by this criticality safety evaluation report (CSER).

SS&C material will be stabilized for storage and ultimate disposal by cementation with portland cement to form concrete billets in Glovebox HA-20MB in Room 235B. The product of that operation is placed in 2.7 L containers containing up to 200 g plutonium or fissile equivalent. The volume of these containers is defined in Section 2.1. They are either bagged out of the HA-20MB glovebox or out of the adjacent HA-28 conveyor glovebox, then placed into 55-gallon drums.

The other residues will either be cemented in Glovebox HA-20MB or directly packaged by the Pipe-and-Go (PnG) process. Irregardless of form, the residue will be loaded into 55-gallon drums and stored in Building 234-5Z. The plutonium or fissile equivalent will be limited to 200 g per drum and drums are excluded from Room 227, Room 230C, and the vaults.

The criticality safety evaluation includes the loading, transport, and storage of these drums in Building 234-5Z. Mass will be controlled to 200 g plutonium or fissile equivalent per drum. Drums will not be stacked, due to the prohibition on stacking throughout the PFP complex. These billet drums can be intermingled with other waste drums that also do not exceed the 200 g plutonium mass limit. The general PFP transition and storage spacing requirements will apply between these drums and other fissile material to provide consistent facility-wide requirements. However, a transport wagon is included in the base calculation so that if a wagon should violate that spacing requirement to a single drum, double contingency would not be compromised. If uranium is present in this scrap, its enrichment must not exceed 50 wt% ^{235}U . Each of these limitations has contingent events analyzed with the exception of the ^{235}U enrichment because it has been determined during the hazards evaluation of CSER 00-001 (Dobbin 2000) that it is not credible to have a uranium enrichment in ^{235}U of greater than 50 wt% in this residue.

The evaluation shows that under the controls specified, assurance of subcriticality under normal and plausible upset conditions is provided which satisfies the double contingency criterion set forth in the Hanford Site Nuclear Criticality Safety Manuals. That is, at least two unlikely, independent, and concurrent changes in process conditions are required before a criticality is possible.

1.2 DOUBLE CONTINGENCY DOCUMENTATION

This section presents a summary description of expected operations, expected normal conditions, and a base case summary of normal conditions plus anticipated off-normal conditions for storage of plutonium residue in 55 gallon drums. Plutonium residue consists of containers of sand, slag, and crucible (SS&C), ash, oxides, and other miscellaneous residues from the cementation or pipe and go processes. These waste drums can be intermixed in storage with other waste drums that are also limited to 200 g of plutonium or fissile equivalent. In effect, this CSER also applies to the other waste drums provided the conditions and assumptions of this criticality safety evaluation are satisfied.

Expected Operation

Plutonium residue from SS&C is cemented in Glovebox HA-20MB, bagged out, and placed into 55 gallon drums. Up to 200 g plutonium or fissile equivalent is placed either unconstrained in each drum or in a Pipe Overpack Container (POC) central tube arrangement. Ash, oxide, and miscellaneous residues are also expected to be loaded into these drums either in cement billets or directly packaged (PnG) in a present storage form. These UN1A2 drums have nominal inner dimensions of 57.15 cm (22.5 inches) and inner heights of 89.54 cm (35.25 inches) and steel thickness of at least 0.15 cm (0.059 inches) for the walls, bottom, and lids. Drums will have a rigid internal polyethylene liner that is 0.23 cm (0.09 inches) thick just on the inside of the drum wall, bottom, and top. Drums may also contain packing material and spider spacing arrangements.

Drums are transported to storage areas such as Rooms 172 and 192D in the 234-5Z building at the PFP. From here, they are moved to a loading dock area at the southwest corner of the building where they are loaded onto trucks and hauled to the Central Waste Complex or other storage locations.

Expected Normal Conditions

Waste material, described above, with up to 200 g of plutonium or fissile equivalent may be loaded into each 55 gallon drum along with packaging and packing material. The drums are transported one at a time from loading locations to storage locations where they are stored one tier high, in double rows (not a criticality limit), with walkways between. During transport, drums are spaced at least 45.7 cm (18 inches) from other fissile material, and stored at least 91.4 cm (36 inches) from such material as required by PFP transition and storage spacing requirements by CPS-Z-165-80100. A six-inch minimum spacing is allowed when moving past the north side of Glovebox HA-20 MB (Dobbin 2000).

Base Case Summary

The base case encompasses the normal and worst-case likely off-normal events. A calculation of an infinite by infinite by one array is a conservative representation of drum storage and movement of waste drums within an array. The array is modeled as a close-packed

arrangement of standing cylinders, each with the optimum arrangement of 200 g of fissile material and optimum moderation and reflection as established in Section 5.2. The k_{eff} for this case is 0.8392 ± 0.0015 (nonpipe_refrotp). A more realistic base case is a 23' x 23', 12 x 12 drum, room-size array with a $k_{\text{eff}} = 0.8357 \pm 0.0015$ (nonpipe_lat1). Storage area contingencies add the unlikely event to those base cases. To analyze drum transport from loading to storage, a drum is modeled adjacent to a wagon in a second alternate base case. A 5-position wagon loaded with 400 g of plutonium with unrestricted moderation per position is used to model the adjacent fissile material. The k_{eff} for this case is 0.7593 ± 0.0014 (nonpipe5_wagon) and transport contingencies are added to this base case.

Table 1-1. Plutonium Residue in 55 Gallon Drums Base Case Summary

Controlled Parameter	Limit	Abnormal but Anticipated Conditions and Conservatism for Analysis
Mass	Maximum 200 g Pu or fissile equivalent	Pu represented as Pu-239
Volume	None	Infinite array of drums for array calculation when actually limited by room size
Moderation	None	Optimized
Interaction	Drum arrays shall be only one tier high; minimum spacing to other fissile material: PFP transition and storage spacing, except other waste drums not exceeding 200 g Pu.	Base case includes likely loss of spacing to wagons during transport through 234-5Z Building hallways
Reflection	None	Optimized for filling of space within drums with polyethylene
Geometry	None	
Enrichment	Uranium enrichment limited to 50wt%	
Density	None	Optimized for 200 g in 55 gallon drum
Concentration	None	
Poisons	None	Steel in the drum reduced by 50% for conservatism

The mass of fissile material in each container is established by nondestructive analysis (NDA) and carefully tracked to its placement into 55 gallon drums. Therefore, it is unlikely that

the mass limits in the table above will be exceeded and subsequently no anticipated abnormal mass conditions are included in the box cases. If during the cementation process, a container with an NDA quantity of fissile material is split into more than one container, then all the resulting containers shall be placed into one 55 gallon drum to maintain an accurate account of the fissile mass.

Contingency Summary

Table 1-2 summarizes the analyses of the unlikely, independent, off-normal events (contingencies). Each event is assumed to occur with the drums configured with the most conservative base case with the contingency added. The resultant computed reactivity is compared to the subcriticality target k_{eff} of 0.942 for MCNP calculations of plutonium systems similar to those in this evaluation, except for the cases involving plutonium billets where the subcriticality target $k_{\text{eff}} = 0.932$. The distinction between the benchmark analysis of plutonium metal versus plutonium in other forms is explained in Section 4.0. This table summarizes the results of the contingency evaluation found in Section 5.0. Specific k_{eff} calculations were not made for contingencies that were bounded by other analyzed contingencies.

There is no contingency associated with the 50 weight percent U-235 enrichment limit because CSER 00-001 analysis (Dobbin 2000) for cementation operations determined that it is not credible to have cemented billets exceeding that limit.

Table 1-2. Plutonium Residue in 55 Gallon Drum Contingency Summary

Contingency Description	Affected Parameter(s)	Barriers that Make Contingency Unlikely	k_{eff} Bounding Contingency (Case ID)¹
Stacking of drums in extra tier	Interaction	Stacking is prohibited at PFP; no mechanical device available to stack drums; weight and size of drum would require two operators to set one on another; entire second tier stacked is unlikely	0.9264 ± 0.0015 (nonpipe_refrot2l)
Fissile mass overload	Mass	Procedure; Operator training; material inventory	0.7944 ± 0.0014 (ovbtch_bot1p) for one drum 22% overbatch; 0.8947 ± 0.0015 (ovbtch_refrotp) for entire array 22% overbatched; 0.8800 ± 0.0017 (dblbtc_bot1p) for one drum with 400 g Pu; 0.9269 ± 0.0017 (nonpipe_lat3) one drum with 400 g in array
Overloaded wagon next to drum	Mass Interaction	Procedure; Operator training; spacing required between drum and wagon	0.7941 ± 0.0014 (nonpipe6_wagon)

Contingency Description	Affected Parameter(s)	Barriers that Make Contingency Unlikely	k_{eff} Bounding Contingency (Case ID) ¹
Overloaded drum next to wagon	Mass Interaction	Procedure; Operator training; spacing required between drum and wagon	0.8919 ± 0.0017 (nonpipe2_wagon)
Wagon next to 12 x 12 drum array	Interaction	Procedure; Operator training; wagons not likely in rooms with arrays of waste drums	0.8268 ± 0.0015 (nonpipe_lat6)
Drums crushed by concrete from floor above or wall collapse	Geometry	Requires unlikely event such as earthquake	Physical effect is the same as second layer

1.2 SUMMARY

This criticality safety evaluation report (CSER) documents the criticality safety of storage of plutonium residues in 55 gallon drums with each drum containing up to 200 g plutonium or fissile equivalent. Some of the residues (i.e., SS&C) will be treated for hazardous characteristics and stabilized by the cementation process in Glovebox HA-20MB. Direct packaging of residues without other stabilization activities, known as the Pipe-and-Go (PnG) alternative, has also been proposed for residues. It is expected that both processes will utilize the Pipe Overpack Container (POC). However, there may be cases when the UNIA2 galvanized drum will be used. This criticality safety evaluation includes loading, transport, and storage of the drums in the PFP 234-5Z building, excluding Room 227, Room 230C, and the vaults.

Evaluation of these billet drums included normal, base case, and contingencies. The base cases included both normal operation and the likely off-normal events, so that each contingency is evaluated upon the worst likely situation. A hazards analysis was conducted to assure that each credible unlikely event or set of correlated unlikely events was included in this analysis.

Demonstrating that each contingency has a calculated k_{eff} less than the subcritical safety limit shows that this operation meets the double contingency requirement. That is, at least two unlikely, independent, and concurrent changes in process conditions are required before a criticality is possible. Therefore, this CSER meets the requirements for a criticality evaluation contained in the Hanford Site Nuclear Criticality Safety Manuals, HNF-PRO-334 (FDH 2000), HNF-PRO-537 (FDH 1997a), and HNF-PRO-539 (FDH 1997b), ANSI/ANS-8 series Standards (ANSI 1998), and DOE Order 5480.24 (DOE 1992). This CSER also follows Fluor Federal Services, Inc. Practice 134.290.1121 (FFS 1999).

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2.0 SYSTEM DESCRIPTION AND NORMAL OPERATIONS

Plutonium residue will be mixed with cement to form billets or directly packaged and stored in 55 gallon drums in the 234-5Z Building at the PFP. The directly-packaged residue will use a PnG. With the exception of Room 227, Room 230C, and the vaults, the remainder of the 234-5Z Building can be used for loading and storage of these drums, as explained in the PHA in Appendix D. The drums will be shipped to another location to be prepared for ultimate disposal.

The following sections present the pertinent data necessary to evaluate the criticality safety of drum storage of this plutonium residue.

2.1 PROCESS DESCRIPTIONS

Plutonium bearing residues at PFP include Sand, Slag and Crucible residue (SS&C), incinerator ash, impure Pu-oxides and other miscellaneous residues as described in CSER 00-001 (Dobbin 2000).

Cementation

SS&C residues contain calcium metal and are mixed with water to react the calcium prior to mixing with cement and pouring into steel cans 14 cm in diameter and 17.8 cm high with a calculated volume of 2.725 L (designated in this report as 2.7 L containers to be consistent with how operations refer to these containers) to form billets that are allowed to harden, and stored in 55-gallon drums analyzed in this CSER. The billets will be formed in Glovebox HA-20MB with an operation that is described in CSER 00-001 (Dobbin 2000).

Pipe and Go

It is proposed that the pipe overpack container (POC) has the capability to accommodate selected residues. In the PnG process, residue is packaged and loaded directly into the POC. Ash is the only residue that is designated for packaging by the PnG method. However, utilization of this alternative for packaging other residue is being considered.

For both processes, each container is labeled with a mass that can be up to 200 g of plutonium or fissile equivalent. The plutonium and other fissile mass are assumed to be ^{239}Pu . This simplification is conservative for the plutonium with more ^{240}Pu than ^{241}Pu , which is the case for the reactor produced plutonium at PFP. The ^{239}Pu assumption also applies to the fissile atoms in depleted or natural uranium or mixed oxides of plutonium and uranium that may be present. For uranium, the ^{235}U enrichment (Marusich 1999) must not exceed 50 wt% in order for the ^{239}Pu to conservatively model this uranium. The carbon content of the feed material may vary. For the materials described in CSER 00-001, Appendices F and G, the carbon could be as high as 33% of the material. For other material, the carbon content is assumed to be 10%, maximum. As described in Section 5.2, the moisture content of the cement waste was selected to provide the maximum reactivity for moderating material in billets in 55 gallon drums.

2.2 DRUM DESCRIPTION

Cemented billet or residue cans are bagged out and placed into one of two types of 55 gallon drums. One has a rigid internal polyethylene liner that is 0.23 cm (0.09 in.) thick. The drums have an inner radius of 28.6 cm, a wall thickness of 0.15 cm (0.06 in.) and an internal height of 84.5 cm. The drum material is standard steel with a bulk density of 7.8 g/cc. Cans are added to the drum up to the drum limit for total plutonium or fissile equivalent mass. There is no specified geometry for these cans inside the drums. The second 55 gallon drum type, called a POC, has a central pipe extending the length of the drum and packing material to center the pipe in the drum.

2.3 STORAGE ARRAY DESCRIPTION

Drums will be loaded, transported, and stored as one-tier arrays in Building 234-5Z, except in Room 227, Room 230C, or the vaults. Normally, the drums are stored in double rows with a 91.6 cm walkway between each set of rows, but this is not a criticality safety requirement. Storage can be in rooms with concrete walls or of other construction. In Room 192D, FFTF fuel is stored on the other side of the concrete wall in Room 192A. In Room 172, there are several adjacent rooms in which there is fissile material. This evaluation will consider that during transport, the drum is likely to pass by wagons transporting fissile material. Also, the drums need to pass by other stored drums in the storage room, so an infinite array is used to model that storage. It is also desired to store drums right up to the wall next to Room 192A. Also, it is desired to intermix the storage of these drums with other waste drums that are limited to 200 g per drum.

The steel in the drums absorbs neutrons and tends to lower the k_{eff} in this analysis. In order to be conservative and not require surveillance of the steel, the steel density is reduced by 50% in the calculations. It is not considered credible for these drums to have manufacturing tolerances that large or for corrosion or other natural phenomena to reduce the steel to less than half of the manufacturer's specifications.

3.0 LIMITS AND CONTROLS

Table 3-1 lists each of the parameters of concern for criticality safety, and discusses whether these parameters are necessary.

Table 3-1. Controls on Parameters Related to Criticality Safety for Plutonium Billets in 55 Gallon Drums

Parameter	Controlled	Discussion (Limit or Process Control if Yes, Reason if No)
Mass	Yes	Maximum mass limit per drum.
Volume	No	Optimum container volume used in analysis
Spacing	Yes	No drum stacking; PFP minimum transition and storage spacing to other fissile material except other waste drums.
Moderator	No	Optimum moderation in analysis.
Reflector	No	Optimum neutron reflection used in analysis
Poisons	No	Poisons were not used in this analysis.
Concentration	No	Worst credible concentrations were analyzed.
Enrichment	Plutonium, no; Uranium, yes	Plutonium was assumed to be 100 wt% ^{239}Pu . This conservatively encompasses all allowed fissionable materials including depleted or natural uranium and uranium enriched to 50 wt% ^{235}U .
Density	No	Optimized for 200 g of Pu in 55 gallon drum.
Geometry	No	Worst-case geometry modeled.

3.1 LIMITS

Storage of fissile-containing cement billets in the 55-gallon drums is described in Section 2. Table 3-2 shows the parameter limits for storage using these drums.

Table 3-2. Limit Set for Storage of Plutonium Residue in 55 Gallon Drums

Mass	Maximum 200 g plutonium or fissile equivalent per drum
Volume	None
Spacing	Drum arrays shall be one tier high; minimum spacing to other fissile material: PFP transition and storage spacing, except other waste drums not exceeding 200 g Pu.
Moderator	None
Reflector	None

Poisons	None
Concentration	None
Enrichment	Plutonium not restricted; Uranium enrichment limited to 50% ^{235}U .
Density	None
Geometry	None

3.2 PROCESS CONTROLS

To assure continued criticality safety during operations, the following process controls are required:

- Drums shall not be stacked.
- Firefighting category B.
- PFP transition and storage spacing requirements between array of these drums and other fissile material (CPS-Z-165-80100 1999) except waste drums.
- Split cementation batches must be placed in the same drum for fissile material accountability.

3.3 ENGINEERED CONTROLS

Engineered controls are the primary means of preventing a criticality for storage of plutonium residue in 55 gallon drums. These controls include the following:

- Structure of drum maintains separation of one drum from another.
- Concrete wall maintains 76.2 cm separation from these drums and FFTF fuel and 30.5 cm from pedestal or shelf stored fissile material.

3.4 ADMINISTRATIVE CONTROL IMPLEMENTATION

Criticality Prevention Specifications (CPS), postings and procedures provide limits and controls for handling fissionable materials, moderators, and other conditions that will assure criticality safety. These controls will address the limit set of Table 3-2 and process controls of Section 3.2.

The criticality analysis in this document demonstrates that a single failure of any administrative control will not result in a k_{eff} that will exceed the criticality prevention criterion.

3.5 SUPPORTING INFORMATION

Storage of plutonium residue in 55 gallon drums require:

Fire Fighting Category: B.

No restrictions on use of water for fire fighting is required. Intermixing these drums with waste drums is allowed. Waste drums were analyzed and reported in CSER 80-021 (Carter 1980) and fire fighting category B was required. In order to intermix, these drums will have the same designation.

3.6 EVALUATION ASSUMPTIONS

The important assumptions of this criticality safety evaluation are:

- Fissile material is conservatively modeled as Pu-239.
- It is not credible to have uranium with enrichment greater than 50% U-235.
- Moderating material within billet is modeled to provide the greatest k-effective for a drum array.
- In the cement model, calcium is replaced by silicon because the amounts of these two elements vary, depending upon the cement, and calcium is conservatively represented by silicon.
- Moderation optimized using polyethylene.
- The billets are loose within the drum and are in a triangular array with equal plutonium loading in each billet to provide the greatest k_{eff} as established in CSER 96-027 (Watson 1997).
- None of the calculations accounted for the iodine constituent of the real SS&C residues, a conservative omission because of the high neutron absorption properties for the element (7 barns at thermal energies, a factor of 20 times the absorption for hydrogen).
- For the cement mix, iron oxide, as sometimes present in concrete, was excluded.
- Drums are excluded from Room 227, Room 230C, and the vaults in Building 234-5Z.
- It is not credible for the drums to have less than half of the 24 kg of steel established by their specifications. Calculations include 12 kg of steel per drum, which acts as a neutron absorber in this lattice arrangement.

- A fully loaded wagon adjacent to drum can create a higher k_{eff} than any other fissile item encountered in Building 234-5Z.

4.0 METHODOLOGY

4.1 ANALYSIS PHILOSOPHY

The computer code, MCNP (Briesmeister 1997), was used to calculate the k-effective of the allowed limit sets and credible upset events. Validation of this code was performed by evaluation of benchmark experiments involving the materials that will be used in this glovebox. As described in Section 4.2, Erickson evaluated plutonium and uranium in systems involving water and concrete as reflectors and water as a moderator. Because the drums contain billets of cement mixed with the fissile material, another benchmark experiment using concrete as a moderator was evaluated as reported in Appendix B of CSER 00-001 (Dobbin 2000).

Nominal dimensions and optimum moderation are used throughout the analyses. Where appropriate, minimum spacing between fissile masses is modeled for conservatism. Only mass and spacing parameters require administrative control for this drum storage. It is not credible to have any uranium enriched to more than 50% ^{235}U .

4.2 MCNP CODE

The Monte Carlo code MCNP Version 4B, was certified (Schwinkendorf 1998) and validated (Erickson 1998 and Lan 1999) for plutonium systems such as the operation in this glovebox. Because that validation did not include concrete or cement as a moderator, an additional validation was performed and reported in CSER 00-001 Appendix B, MCNP 4B Computer Code Validation. Room temperature cross sections were used for the MCNP calculations. In Appendix B, a maximum allowable k_{eff} value of 0.932 was established for calculations of systems dominated by large metal pieces such as plutonium buttons. For this cementation process, the oxide maximum allowable k_{eff} of 0.942 is more appropriate because it more closely matches the benchmarks of lower density fissile material. These values are for calculations with statistical uncertainties ≤ 0.002 and assure subcriticality with an acceptable margin, including the uncertainties in the analytical methods and benchmark experimental data. The oxide target k_{eff} is applicable to other plutonium compounds listed in Greenborg 1999, and uranium up to an enrichment of 50% ^{235}U (Marusich 1999).

4.3 SUBCRITICALITY LIMIT

For the purposes of this report, the principal criticality prevention criterion or parameter is that the effective neutron multiplication (or criticality) factor (k_{eff}) shall not exceed 0.95 (i.e., $k_{\text{eff}} \leq 0.95$) for all permitted normal configurations of materials, containers, etc., and for any credible off-normal event. This criterion is based on implementing the applicable DOE Orders, ANSI standards, and HNF-PROs. The subcriticality criterion is used to judge the acceptability of a calculated k_{eff} value for fissionable material configuration. This criterion accounts for the bias inherent in the code and cross sections used, any uncertainties in the physical problem being

MCNP and Monte Carlo are computer codes developed by Los Alamos National Laboratory.

analyzed, and the uncertainties in both the bias determination (the experimental basis) and the calculational methods.

4.4 APPLICATION OF DOUBLE CONTINGENCY PRINCIPLE

This analysis meets the requirements of HNF-PRO-334, *Criticality Safety General Requirements*, (FDH 2000), HNF-PRO-537, *Criticality Safety Control of Fissionable Material*, (FDH 1997a) and HNF-PRO-539, *Criticality Safety Evaluations* (FDH 1997b). HNF-PRO-539 states that for all new operations and changes pertinent to criticality safety issues in existing operations, the CSER is required to demonstrate that there is an acceptable margin of subcriticality for all normal and credible abnormal conditions. To demonstrate the Double Contingency Principle is satisfied, this CSER must show that there are sufficient factors of safety for plutonium billet storage in 55 gallon drums such that at least two unlikely, independent, and concurrent changes in process conditions are required before a criticality accident is possible.

4.5 HAZARDS ASSESSMENT

Identification of the contingencies for the operation described in Section 2 and evaluated in Section 5 used a hazards assessment technique called a Preliminary Hazard Assessment (PHA). The goal of this effort is to identify deviations from the planned operation that may pose a challenge to criticality safety. Analysis is done as necessary to demonstrate that each identified condition satisfies the criticality safety criteria.

In a PHA, an interdisciplinary team uses a disciplined, systematic approach to identify hazards and deviations that could lead to undesirable consequences. Because the criticality safety concerns usually arise from deviations from the process design, an experienced team leader systematically guides the team through the planned operation. Off-normal events are identified and separated into likely and unlikely to happen during the duration of the operation. The likely events become part of the base case and the unlikely events are the contingencies of Section 5. The detailed results of this assessment are presented in Appendix D.

5.0 EVALUATION AND RESULTS

5.1 NORMAL CASE

Drums are loaded one at a time and transported to one of the storage rooms where they are arranged in double rows with walkways between sets of these double rows. Drums will be transported down these walkways between the rows. Therefore, the value of a calculation of the normal array is questionable. For this evaluation, a normal case calculation is bypassed for the conservative base case of an infinite by infinite by one tier high array calculation described in the next section.

5.2 BASE CASE

This section presents the base case models of the plutonium billets in 55 gallon drums. The results of CSER 96-027 (Watson 1997) were utilized to ascertain the most reactive configuration of billets within the drum. The case where the 200 g allowed in the drum was distributed equally between three billets in a triangular array proved to be the most reactive. For this evaluation, the triangular billet array is located near the edge of the drum adjacent to fissile material either in an adjacent drum or in an adjacent wagon.

The mass of fissile material in each container is established by nondestructive analysis (NDA) and carefully tracked until placed into 55 gallon drums. Therefore, it is unlikely that the mass limits in the table above will be exceeded and subsequently no anticipated abnormal mass conditions are included in the base cases. If during the cementation process, a container with an NDA quantity of fissile material is split into more than one container, then all the resulting containers shall be placed into one 55 gallon drum to maintain an accurate account of the fissile mass.

Cemented containers were modeled as cylinders with a volume of 2.725 L with interior diameter of 14 cm and a height of 17.8 cm. For mixtures of fissile material and cement, the cement acts as a moderator and the most reactive container is one with the most water (Dobbin 2000). So, a mixture of plutonium and water was modeled in each billet container. Drums were modeled as described in Section 2.2. Material densities and weight fractions used in this analysis are shown in Table 5-1.

Infinite arrays, finite room-sized arrays, and single drums were analyzed. Infinite arrays are simple calculations that bound the worst k_{eff} possible from assembling drums. A finite array is required to analyze the contingency of violating the PFP transition and storage minimum spacing requirement. For this evaluation, a transport wagon is modeled adjacent to the room array of drums. A single drum allows other fissile material, that may be encountered in transit within the PFP 234-5Z Building, to be modeled adjacent to the drum.

Table 5-1. Elemental Weight Fractions and Densities of Materials used in Calculations

	Cemented Waste 1.024* g/cm³	Steel 7.83 g/cm³	Air 0.00129 g/cm³	Polyethylene 0.92 g/cm³	Concrete 2.24 g/cm³	Water 1.0 g/cm³	Cemented Waste with 45 wt% Water 1.51 g/cm³
H	0.1092			0.143702	0.009959	0.1119	0.0632
C		0.000293		0.856298	0.000979		
N			0.754918				
O	0.8669		0.231967		0.529069	0.8881	0.6211
F							
Na					0.016003		
Mg					0.002000		
Al					0.034006		
Si		0.007497			0.337036		0.2995
P		0.000447					
S		0.000294					
Ar			0.013115				
K					0.012981		
Ca					0.043965		
Cr		0.200003					
Mn		0.020000					
Fe		0.651464			0.014002		
Ni		0.120002					
Pu	0.0239						0.0162

* For 100% free water in cement.

There is also a possibility that plastic "peanuts" will be packed in the drums with loose billets. Thus the effect of a polyethylene reflector within the drum was investigated with the free water content of the cement at an arbitrary 45 wt%. Figure 2 illustrates that full density polyethylene (Carter 1968) proved to be the most effective moderator/reflector, and the rest of the cases were run with this value. For billets modeled as plutonium and water, the full density polyethylene is still the most effective moderator/reflector. The curves are for one drum, two drums together, and an infinite array of drums. This is a very conservative assumption since the peanuts will have a much higher void fraction than solid polyethylene.

Figure 1: k_{eff} for 200 g in Three Billets in a 55 Gallon Drum Versus Density of Polyethylene Fill.

Since these drums can be intermixed with standard waste drums, the reactivity of a single drum was compared with the most reactive drum analyzed in the CSER for solid fissile material storage in 55-gallon drums (Carter 1980). The model has 200 g of plutonium in the shape of a cylinder ($H/D=1.5$) in a matrix of polyethylene at the most reactive concentration ($H/\text{Pu}=730$). The k_{eff} of a drum with cemented waste was 0.7733 ± 0.0013 (nonpipe_cp), while the k_{eff} of the generic waste drum was 0.4768 ± 0.0010 (cement/odrum_bot1). Thus the addition of other currently approved waste packed in 55-gallon drums will be less reactive than the cemented waste in 55-gallon drums.

In all of the calculations the billets are assumed to be unrestricted within the drum. The use of the pipe overpack drum, which constrains the fissile material to a central pipe region, will be a less reactive situation and so the unrestricted arrangement was used as a limiting case. The base case calculations are presented in the sections below. Details of the base models are summarized in Tables 5-1, 5-2, and 5-4. Results are presented in Tables 5-3 and 5-5.

For all cases the plutonium involved was assumed to be entirely ^{239}Pu . Also, none of the calculations accounted for the iodine constituent of the real SS&C residues, a conservative omission because of the high neutron absorption properties for the element (7 barns at thermal energies, a factor of 20 times the absorption for hydrogen). For the cement mix, iron oxide, as sometimes present in concrete, was excluded.

5.2.1 Infinite Array of Drums

The base case model for an infinite by infinite by one tier high array of drums has a k_{eff} of 0.8357 ± 0.0015 (case nonpipe_lat1). This value is well below the allowable k_{eff} of 0.942. Description of this model is as follows.

Table 5-2. Base Case Model for Infinite Array

Drum Array Assumptions	12 x 12 x 1 or $\infty \times \infty \times 1$
Drum Dimensions	Inner Radius = 28.575 cm Height = 83.998 cm Wall thickness = 0.242 cm
Billet cans	Inner Radius = 6.985 cm Height = 17.780 cm Vol = 2.725 L

Table 5-3. MCNP Calculational Results of Base Case of Infinite Array of Drums

Case	Description	k_{calc}	1σ
Nonpipe_lat1	12 x 12 x 1 array of drums with 200 g Pu/drum distributed in three billets	0.8357	0.0015
Nonpipe_refrotp	$\infty \times \infty \times 1$ array of drums with 200 g Pu/drum distributed in three billets	0.8392	0.0015

5.2.2 Drum with Wagon

The base case model for a drum and wagon with 2.5 kg of metal in each of the wagon's five positions has a k_{eff} of 0.7593 ± 0.0014 (nonpipe5_wagon). This value is well below the allowable k_{eff} for a system with metal buttons of 0.932. Description of this model is presented in Table 5-4. This is the most reactive of the following three wagon loadings:

- 4.5 kg of dry plutonium oxide
- 400 g of plutonium in a can full of water (2.7 L)
- 2.5 kg of metal

A combination of these loadings was not calculated because CSER 87-004 (Ramble 1999) states that intermixing of the 2.5 kg metal and oxide limit sets does not increase the k_{eff} above the all-metal case. There is no reason to believe that the presence of an adjacent drum would alter this conclusion because CSER 87-004 also had adjacent wagons.

Present wagon CSERs do not allow the 4.5 kg of dry plutonium oxide. When the evaluation to alter the higher mass in wagons is performed, the intermixing will again be

addressed. If intermixing the higher fissile mass is found to increase k_{eff} , then this CSER will need to be reviewed prior to allowing the higher mass in the wagons.

Table 5-4. Base Case Model for Drum Next to Wagon

Drum Dimensions	Inner Radius = 28.575 cm Height = 83.998 cm Wall thickness = 0.242 cm
Billet cans	Inner Radius = 6.985 cm Height = 17.780 cm Vol = 2.725 L
Wagon Assumptions	A five position wagon was used with a 2.7 L can at each of the five positions. Each can is filled with the plutonium and moderation described in Table 5-5. The wagon is completely surrounded by full density polyethylene.

Table 5-5. MCNP Calculational Results of Base Case of a Drum Next to a Wagon

Case	Description	k_{calc}	1σ
Nonpipe3_ wagon	Wagon One drum with three unrestricted moderation billets for a total of 200 g Pu in a triangular array in intimate contact with the center of the three position side of a five position wagon with 400 g Pu unrestricted moderation in each position. The fissile material in the drum is raised to be in the same plane as the fissile material in the wagon.	0.7507	0.0016
Nonpipe_ wagon	Same as nonpipe3_wagon except 4.5 kg Pu oxide at theoretical density in each wagon position.	0.7558	0.0014
Nonpipe5_ wagon	Same as nonpipe3_wagon except 2.5 kg Pu metal at theoretical density in each wagon position	0.7593	0.0014

5.2.3 Interaction of Array of Drums with Material in Adjacent Rooms

Fissionable material is stored in rooms adjacent to those in which the drums with cemented waste may be stored. If the drums are stored in room 192-D, the adjacent room is 192-A in which is stored FFTF fuel assemblies. However, the two rooms are separated by a 76.2 cm (2.5 ft) concrete wall which will isolate the fissile material in 192-A from the drums in 192-D.

Room 172, another possible location for the storage of the cemented drums, is adjacent to rooms 173, 175, and 179, and shares a corner with room 174. Rooms 173, 174, and 175 are separated from 172 by 30.5 cm (1 ft) concrete walls. Room 174 is a vault for shelf storage of fissile material in containers with up to 4.4 kg of material inside. Room 175 is a vault for

pedestal storage for similar containers. Room 173 is also a vault, but no fissile material is stored there. The concrete wall will isolate the material in these vaults from the cemented waste drums.

Any approved waste drum stored in adjacent rooms has been shown to be less reactive than the cemented waste container (see page 5-3). Other fissile material containers may be more reactive than a waste drum, therefore, PFP transfer and spacing requirements require a 91.4 cm (3 ft) spacing between an array of cemented drums and other fissile material.

5.3 CONTINGENCY ANALYSIS

The contingency analysis section addresses the effect of various unlikely, off-normal events on the critical parameters and their associated controls to confirm the double contingency criterion has been met.

Mass is controlled administratively. Section 5.3.4 addresses the contingency of exceeding the drum limit of 200 g plutonium or equivalent.

Volume and Geometry are not controlled.

Density is not controlled. The most reactive credible densities were used for all materials.

Moderation is not controlled.

Reflection is not controlled.

Interaction is controlled by a no drum stacking requirement, the general transportation and storage spacing requirements, and isolating walls. Sections 5.3.5 and 5.3.6 address interaction contingencies.

Enrichment, Concentration, and Isotopes are not controlled for plutonium which was assumed to be 100 wt% ^{239}Pu . This conservatively encompasses all allowed fissionable materials including depleted or natural uranium and uranium enrichment which is restricted to 50 wt% ^{235}U . The hazards assessment of CSER 00-001 (Dobbin 2000) states that it isn't credible for this residue to exceed that uranium enrichment.

Neutron Absorption is not controlled.

The following discussions in this section give a description of the off-normal conditions and the calculational results. Each of the unlikely off-normal events results from a loss of one or more controls, and is therefore considered to be a contingency. For each contingency, the model assumed the most limiting allowed conditions for criticality controls shown in Section 3 including likely off-normal events.

5.3.1 Seismic Event

Three dimensional collapse was judged by the HAZOP process to be incredible. However, in a seismic event the drum could be crushed in the vertical dimension. However, this contingency is not limiting for the following reasons.

The drums have been analyzed in their most reactive close packed arrangement. Any disturbance due to a seismic event will tend to lower the reactivity. A one dimensional seismic induced collapse of the building will tend to crush the drums, but would not compress the billets.

With the billets in their most reactive arrangement, fully reflected in all directions, no substantial change in conditions would result from the seismic event. In fact, the two layer array scenario would encompass the seismic scenario since the billets in the lower layer were modeled at the top of the drum while the billets in the upper layer were modeled on the bottom. Thus there are two layers of nine billets each in the most intimate contact possible. The analysis has considered billets in the most reactive arrangement and these contingencies would not result in a more reactive condition. The POC drums will have additional structural integrity provided by the vertical pipe. The analysis has considered maximum polyethylene interspersed moderation and reflection. Therefore, the addition of water between the drums due to a breaching of the fire suppressant system would not add additional reactivity.

5.3.2 Major Fire

The analysis has considered maximum polyethylene reflection. The addition of water between the drums due to an activation of the fire suppressant system would not add additional reactivity.

5.3.3 Stacking Event

The addition of a complete second layer of loaded drums was considered as described in Table 5-6. Both of the layers have the most reactive geometry, water content, and polyethylene reflector. This contingency case model for a double array of drums has a k_{eff} of 0.9264 ± 0.0015 (nonpipe_refrot21), listed in Table 5-7. This value is below the allowable k_{eff} of 0.942. A calculation with an array of drums filling a 700 cm by 700 cm (23' x 23') room with concrete walls with three drums stacked in a second layer produced a k_{eff} of 0.8368 ± 0.0013 (nonpipe_lat4).

Table 5-6. Contingency Case Model for Two Layer Arrays

Drum Array Assumptions	$\infty \times \infty \times 2$ and $12 \times 12 \times 1$
Drum Dimensions	Inner Radius = 28.575 cm Height = 83.998 cm Wall thickness = 0.242 cm
Billet cans	Inner Radius = 6.985 cm Height = 17.780 cm Vol = 2.725 L

Table 5-7. Calculational Results for Two Layer Arrays

Case	Description	k_{calc}	1σ
Nonpipe_refrot2l	Two infinite layers of drums	0.9264	0.0015
Nonpipe_lat4	One 700 cm x 700 cm lower layer of drums with three drums stacked in second layer within a concrete box	0.8368	0.0013

5.3.4 Overbatching

The overbatching of the drums was considered. Considering Safeguards limitations (Watson 1997), the cemented waste may have up to 2 wt% of plutonium. However, if three billets of such material are loaded into a drum, the 200 g limit on the drum will be exceeded. It was assumed that the most probable overbatch event is for three of these billets to be inadvertently loaded into a drum. Therefore, this contingency could result in an infinite layer of drums loaded with three billets of 2 wt% plutonium or a total of 244 g of plutonium in each drum as described in Table 5-8. This event is extremely unlikely. The drums are assumed to have the most reactive geometry, water content, and polyethylene reflector.

In Appendix D, it was considered credible to have 10% of the drums overbatched by 10% or have one drum with 400 g plutonium. Table 5-9 shows the calculated k_{eff} 's of drum overbatches. For a single drum double-batched, $k_{\text{eff}} = 0.8800 \pm 0.0017$ (dblbtch_bot1p). For an entire array of drums containing 244 g plutonium, $k_{\text{eff}} = 0.8947 \pm 0.0015$ (ovbtch_refrotp). For a 400 g plutonium drum in an array of 200 g plutonium drums, $k_{\text{eff}} = 0.9269 \pm 0.0017$ (nonpipe_lat3). These values are below the allowable k_{eff} of 0.942.

Table 5-8. Contingency Case Model for Overbatching

Drum Array Assumptions	$\infty \times \infty \times 1$ and $12 \times 12 \times 1$
Drum Dimensions	Inner Radius = 28.575 cm Height = 83.998 cm Wall thickness = 0.242 cm
Billet cans	Height = 17.780 cm Vol = 2.725 L Inner Radius = 6.985 cm
Cemented Waste	2 wt% plutonium in cement (244 g/drum)

Table 5-9. Calculational Results for Overbatching

Case	Description	k_{calc}	1σ
Ovbtch_bot1p	One drum with 244 g Pu	0.7944	0.0014
Ovbtch_ref2p	Two drums each with 244 g Pu	0.8508	0.0015
Ovbtch_refp	Infinite array with fissile material facing in pairs of drums	0.8786	0.0014
Ovbtch_refrotp	Infinite array with fissile material facing in triads of drums	0.8947	0.0015
Dblbtch_bot1p	One drum with 400 g Pu	0.8800	0.0017
Nonpipe_lat3	One drum with 400 g Pu in 200 g Pu per room drum array	0.9269	0.0017

5.3.5 Interactions with Other Fissile Material

Of the fissile material available at the PFP that could inadvertently be brought next to an array of billet drums, the wagon analyzed in Section 5.2.2 would have the greatest reactivity impact. A wagon with 5 containers each containing various allowed loadings of fissile material and moderation are analyzed adjacent to a normal and overloaded drum and adjacent to an array of drums as described in Table 5-10. Also, an overloaded wagon is analyzed next to a normal drum. Results are shown in table 5-11. The worst overloaded drum, normal wagon arrangement has a k_{eff} of 0.8919 ± 0.0017 (nonpipe4_wagon), listed in Table 5-11 which is lower than the allowable k_{eff} of 0.942. The worst overloaded wagon, normal drum arrangement has a k_{eff} of 0.7941 ± 0.0014 (nonpipe6_wagon) which is lower than the allowable k_{eff} of 0.932 for metal systems. For a wagon next to an array of drums, that k_{eff} of 0.8268 ± 0.0015 (nonpipe_lat6) is lower than the allowable k_{eff} of 0.932 for metal systems.

Table 5-10. Contingency Case Model for Wagon Next to Single Drum or Array

Drum Array Assumptions	12 x 12 x 1 and 1 x 1 x 1
Drum Dimensions	Inner Radius = 28.575 cm Height = 83.998 cm Wall thickness = 0.242 cm
Billet cans	Inner Radius = 6.985 cm Height = 17.780 cm Vol = 2.725 L
Wagon Assumptions	A five position wagon was used with a 2.7 L can in each of the five positions. Each can is filled with either 400 g Pu with unrestricted moderation, 2.5 kg of Pu metal, or 4.5 kg of plutonium oxide at theoretical density. The wagon is completely surrounded by full density polyethylene.

Table 5-11. Calculational Results for Wagon Next to Single Drum or Array

Case	Description	k_{calc}	1σ
Nonpipe4_wagon	wagon with 4.5 kg Pu except 400 g Pu in drum	0.8919	0.0017
Nonpipe2_wagon	Same as nonpipe3_wagon except 400 g Pu in drum	0.8899	0.0018
Nonpipe_lat5	Wagon with 4.5 kg oxide adjacent to array of drums	0.8244	0.0015
Nonpipe_lat6	Wagon with 2.5 kg Pu metal adjacent to an array of drums	0.8268	0.0015
Nonpipe6_wagon	Overloaded wagon of 2.5 kg Pu metal adjacent to single drum	0.7941	0.0014

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APPENDIX A - INDEPENDENT REVIEW COMMENTS AND CHECKLIST

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FLUOR DANIEL NORTHWEST

TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: HNF-6179, Rev. 0
 Title: CSER 00-006: Storage of Cemented Plutonium Residue Containers
 in 55 Gallon Drums at the PFP
 Author: K. D. Dobbin and H. J. Goldberg
 Date: 4/19/00
 Scope of Review:

Yes	No*	NA	
☒	☐	☐	** Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☒	☐	☐	Problem completely defined.
☒	☐	☐	Accident scenarios developed in a clear and logical manner.
☒	☐	☐	Necessary assumptions explicitly stated and supported.
☐	☐	☒	Computer codes and data files documented.
☐	☐	☐	Data used in calculations explicitly stated in document.
☐	☐	☒	Data checked for consistency with original source information as applicable.
☐	☐	☒	Mathematical derivations checked including dimensional consistency of results.
☒	☐	☐	Models appropriate and used within range of validity or use outside range of established validity justified.
☒	☐	☐	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
☐	☐	☐	Software input correct and consistent with document reviewed.
☐	☐	☐	Software output consistent with input and with results reported in document reviewed.
☒	☐	☐	Limits/criteria/guidelines applied to analysis results are appropriate and referenced.
			Limits/criteria/guidelines checked against references.
☒	☐	☐	Safety margins consistent with good engineering practices.
☒	☐	☐	Conclusions consistent with analytical results and applicable limits.
☒	☐	☐	Results and conclusions address all points required in the problem statement.
☒	☐	☐	Format consistent with applicable guides or other standards.
☐		☒	** Review calculations, comments, and/or notes are attached.
☒	☐	☐	Document approved (i.e., the reviewer affirms the technical accuracy of the document).

K. N. Schwinkendorf
 Reviewer: (Printed and Signed)

K. N. Schwinkendorf

Date

4/20/00

* All "NO" responses must be explained below or on an additional page.

** Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

NUCLEAR ENGINEERING

Independent Peer Reviewer Comments: K. N. Schwinkendorf – 04/20/2000

This CSER was independently peer reviewed by K. N. Schwinkendorf, a qualified Criticality Safety Specialist in the Criticality and Shielding group of Fluor Federal Services. This technical review covered all aspects of this CSER with the exception of checking computer code input and output files. This phase of the review was carried out by S. R. Gedeon, also of the Criticality and Shielding group of Fluor Federal Services. As shown in the two Independent Review Checklists, taken together, this CSER has been reviewed with no gaps.

The construction of base case models using bounding, abnormal but credible conditions was well documented and is conservative. The maximum allowable k_{eff} of 0.942 is appropriate for drums of plutonium residue because no large plutonium pieces are anticipated. Although some fine metal phase particles may still be present, they will be well-mixed with other materials such that the system may be considered “non-metal” from a neutronics perspective. For those calculations involving proximately to transport wagons containing metal buttons, this evaluation conservatively uses an allowable k_{eff} of 0.932, for a plutonium metal system.

No single contingency violated the criticality safety criterion, and so this reviewer concurs with the conclusion of this CSER, that storage of plutonium residue in 55 gallon drums satisfies double contingency.

Finally, minor editorial comments were suggested, and were incorporated into the final version of the CSER.

Independent Peer Reviewer Comments: S. R. Gedeon – 04/25/2000

Computer inputs, outputs and were checked for consistency and reasonableness. Densities were checked with data in ARH-600 and found equal or conservative.

Input files were checked for model adequacy, material densities, geometry, and container volume. K_{eff} values given in the report were verified against output files. Output files were reviewed for adequate convergence. Minor typographical errors were corrected.

FLUOR DANIEL NORTHWEST

TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: HNF-6179, Rev. 0
 Title: CSER 00-006: Storage of Cemented Plutonium Residue Containers
 in 55 Gallon Drums at the PFP
 Author: K. D. Dobbin and H. J. Goldberg
 Date: 4/19/00
 Scope of Review: Calculations, computer models, inputs and outputs

Yes	No*	NA	
☐	☐	☒ **	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☐	☐	☒	Problem completely defined.
☐	☐	☒	Accident scenarios developed in a clear and logical manner.
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☒	☐	☐	Software output consistent with input and with results reported in document reviewed.
☐	☐	☒	Limits/criteria/guidelines applied to analysis results are appropriate and referenced.
☐	☐	☒	Limits/criteria/guidelines checked against references.
☐	☐	☒	Safety margins consistent with good engineering practices.
☐	☐	☒	Conclusions consistent with analytical results and applicable limits.
☐	☐	☒	Results and conclusions address all points required in the problem statement.
☐	☐	☒	Format consistent with applicable guides or other standards.
☐	☐	☒ **	Review calculations, comments, and/or notes are attached.
☒	☐	☐	Document approved (i.e., the reviewer affirms the technical accuracy of the document).

S. R. Gedeon
 Reviewer: (Printed and Signed)

25 Apr 2000
 Date

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NUCLEAR ENGINEERING

FLUOR DANIEL NORTHWEST

TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: HNF-6179, Rev. 0
 Title: CSER 00-006: Storage of Cemented Plutonium Residue Containers
 in 55 Gallon Drums at the PFP
 Author: K. D. Dobbin and H. J. Goldberg
 Date: 4/19/00
 Scope of Review:

Yes	No*	NA	
☐	☐	☒	** Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☒	☐	☐	Problem completely defined.
☒	☐	☐	Accident scenarios developed in a clear and logical manner.
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☐	☐	☒	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
☒	☐	☐	Software input correct and consistent with document reviewed.
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☒	☐	☐	Limits/criteria/guidelines applied to analysis results are appropriate and referenced.
		☒	Limits/criteria/guidelines checked against references.
☒	☐	☐	Safety margins consistent with good engineering practices.
☒	☐	☐	Conclusions consistent with analytical results and applicable limits.
☒	☐	☐	Results and conclusions address all points required in the problem statement.
☐	☐	☒	Format consistent with applicable guides or other standards.
☒		☐	** Review calculations, comments, and/or notes are attached.
☒	☐	☐	Document approved (i.e., the reviewer affirms the technical accuracy of the document).

A. D. Wilcox
 Reviewer: (Printed and Signed)

4/20/2000
 Date

* All "NO" responses must be explained below or on an additional page.

** Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

NUCLEAR ENGINEERING

MOHR AND ASSOCIATES
ENGINEERING-ANALYSIS-CONSULTING

1440 AGNES STREET
RICHLAND, WA 99352
509-946-0943
FAX 509-946-4395

April 20, 2000

To: K. D. Dobbin, Criticality and Shielding, Fluor Federal Services, Inc.
From A. D. Wilcox, Mohr and Associates

Subj: Review of CSER 00-006 "STORAGE OF CEMENTED PLUTONIUM RESIDUE
CONTAINERS IN 55 GALLON DRUMS AT THE PFP"

CSER 00-006 was reviewed. The CSER addresses the transport to storage and the storage of 55-gallon drums containing cemented plutonium residue from the PFP. The analyses considered a range of contingencies involving interactions within a drum: interactions between drums; and between a drum or drums and the wagon used to transport plutonium cans. The results of these analyses show that the drums may be safely transported and stored in the PFP. The administrative control of the total amount of plutonium (or equivalent fissile material) allowed in each drum, 200 grams of Pu, is the most important restriction on the whole process.

The input listings that are part of the subject CSER were reviewed and found adequate. The output listings were not reviewed.

CSER 96-027 and CSER 00-001 were used to provide background information pertinent to CSER 00-006. These CSERs describe the cementation of the plutonium bearing waste and the storage of the cemented containers in 55 gallon drums.

Some editorial comments were transmitted orally to you and have been incorporated into the CSER.

After reviewing CSER 00-006, I find that the analysis covers the range of contingencies adequately and demonstrates that the 55 gallon drums may be safely transported and stored in the PFP.

Sincerely,

Archie D. Wilcox

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APPENDIX B - MCNP COMPUTER CODE VALIDATION

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B.1 VALIDATION PROCEDURE

Validation of the computer code methods in this analysis consisted of testing the code and neutron cross sections on calculations of known critical configurations. These benchmark experiments have fissile isotopes in systems similar to that evaluated by this CSER. The computed and measured k_{eff} s for the benchmark configurations were compared to establish a bias that includes the uncertainty in the calculational methods. A bias-adjusted k_{eff} for the benchmark systems was defined to include both the deviations of the calculated from the measured k_{eff} 's, and experimental and calculational uncertainties along with the spread in the ability of the computer code to calculate similar systems. In addition, criticality safety criteria require that the bias-adjusted k_{eff} for CSER analysis calculations not exceed the established k_{eff} safety limit at the 95% confidence level.

This method is illustrated in Figure B.1. Critical is defined as a k_{eff} of unity, adjusted by the bias established from the comparison of calculations with benchmarks. The bias is combined with the safety margin of 0.05 (a safety limit that k_{eff} must be less than or equal to 0.95) to compare with the calculated value and statistical uncertainty of the computer calculated k_{eff} 's of this CSER analysis. The calculated target k_{eff} is established by adding the bias, 0.05, and 1.645 times the one-sigma uncertainty of the calculated k_{eff} for the particular CSER analysis and subtracting that value from 1.0. For the analyses in this CSER, all the computer statistical uncertainties were less than ± 0.002 , so this value was used to set the target k_{eff} 's as described in Section B.2.

Figure B.1. Logic of Validation Procedure

B.2 GENERIC VALIDATION FOR PLUTONIUM SYSTEMS

A report by J. S. Lan, *MCNP Version 4B Approval For Use Documentation & Authorized User List* (Lan 1999), presents the results of calculations to determine a generic bias for plutonium configurations, as encountered in the Plutonium Finishing Plant. One hundred and forty three benchmark experiments were calculated. There were different material types that were considered in the plutonium validation calculations:

- Plutonium metal,
- Plutonium oxide,
- Plutonium solutions,
- Plutonium solutions with cadmium (a neutron poison),
- Water and polystyrene moderators, and
- Water, plexiglass, paraffin, polyethylene, and steel and concrete reflectors

The lower tolerance limit b_L was calculated for the benchmark experiments such that there is 95% confidence that 95% of the benchmark calculated k_{eff} 's is above that limit. This is expressed by the following formula:

$$b_L = k_{avg} - K_b * \sigma_{avg}$$

where: b_L = lower tolerance limit for 95% confidence that 95% of the benchmark calculated k_{eff} 's is above this limit,
 k_{avg} = the average of the k_{eff} 's calculated by MCNP 4B,
 K_b = a multiplier found from statistical tables for non-central t-distribution, and depends on number of degrees of freedom, and
 σ_{avg} = standard deviation of the MCNP k_{eff} 's.

Bias is calculated by the following formula:

$$\text{bias} = b_L - k_{crit}$$

where:

k_{crit} = the average of the k_{eff} 's for the critical experiments; for the plutonium experiments $k_{crit} = 1.000$.

The bias for the plutonium metal group was significantly different than for all other groups. For this reason, it was concluded that separate bias values for metal and non-metal groupings would be appropriate. The lower tolerance limit for the metal group (17 benchmark critical experiments) calculated to be 0.9884. The lower tolerance limit for the non-metal group (126 benchmark critical experiments) calculated to be 0.9991. These lower tolerance limits yielded the bias appropriate for each material category:

- Plutonium metal bias is -0.0116,
- Plutonium non-metal bias is -0.0009.

For conservatism, these calculated biases were recommended to be increased to:

- Plutonium metal recommended bias is -0.0150,
- Plutonium non-metal recommended bias is -0.0050.

The safety criteria for future calculations on undetermined systems requires that the bias-adjusted k_{eff} does not exceed 0.95 at the 95% confidence level. This is expressed by the following formula:

$$k_{\text{eff}} = k_{\text{calc}} - \text{bias} + 1.645 * \sigma_{\text{calc}} \leq k_{\text{limit}}$$

where: k_{calc} = k value given by MCNP 4B calculation for system in question,
 bias = -0.015 for Pu metal, and -0.005 for Pu non-metal systems,
 1.645 = a constant number of standard deviations for .95 of the distribution for a one-sided standard normal distribution
 σ_{calc} = standard deviation given by MCNP 4B calculation for system in question, and
 k_{limit} = 0.95 for plutonium systems, generally.

k_{limit} is generally taken to be 0.95 for plutonium systems.

For a standard deviation (σ_{calc}) of 0.002 or less, the k_{eff} value for plutonium metal systems is:

$$k_{\text{calc}} - (-0.015) + 1.645 * 0.002 \leq 0.95, \text{ or}$$

$$k_{\text{calc}} \leq 0.95 + (-0.015) - 1.645 * 0.002 = 0.932.$$

On this basis, it is determined that the true k_{eff} of an analyzed configuration with plutonium will not exceed 0.95 with a 95% confidence level for plutonium metal systems if the calculated value (k_{calc} , and $\sigma \leq 0.002$) is limited to a maximum value of **0.932**.

Figure B.2. Implementation of Validation Procedure

For a standard deviation (σ_{calc}) of 0.002 or less, the k_{eff} value for non-metal systems is:

$$k_{\text{calc}} - (-0.005) + 1.645 * 0.002 \leq 0.95, \text{ or}$$

$$k_{\text{calc}} \leq 0.95 + (-0.005) - 1.645 * 0.002 = 0.942.$$

On this basis, it is determined that the true k_{eff} of an analyzed configuration with plutonium will not exceed 0.95 with a 95% confidence level for plutonium non-metal systems if the calculated value (k_{calc} , and $\sigma \leq 0.002$) is limited to a maximum value of **0.942**.

Figure B.3 Implementation of Validation Procedure

B.3 VALIDATION OF MCNP 4B

The validation of the MCNP4B code on the new computing system, Intergraph™, 400/450 MHz Pentium II, personal computers was documented in Lan, 1999. The essence of the validation was cross-correlation of calculational results obtained with this code version and results of critical experiments, as reported in *MCNP Version 4B Approval for Use Documentation & Authorized User List* (Lan 1999).

™ Intergraph is a trademark of the Intergraph Corporation of Huntsville, Alabama.
Pentium is a trademark of Intel Corporation, Santa Clara, California.

APPENDIX C - MCNP INPUT FILES

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HNF-6179 Rev. 0

db1btch_botlap										5	p2	-8.893					\$ Bottom of Can	
										6	pz	8.893					\$ Top of Can	
Three Billets in a Non-pipe 55 Gallon Drum										c								
three overpacked Pu billets at the bottom of a 400 g/drum										c					Drum			
Filled with poly										7	cz	28.485					\$ Radius of	
Silicon replaces Calcium										8	pz	-41.999					\$ Bottom of	
Cell Definitions										9	pz	41.999					\$ Top of Interior	
Can Contents - Universe 1										c								
1	1	-1.024	-1	2	-3	imp:n=1	u=1	\$	Cemented Waste	10	cz	28.575					\$ Radius of Liner	
2	3	-0.00129	1	-2	3	imp:n=1	u=1	\$	Steel Can	11	pz	-42.227					\$ Bottom of Liner	
Double Batched Can Contents - Universe 2										12	pz	42.227					\$ Top of Liner	
3	11	-1.049	-1	2	-3	imp:n=1	u=2	\$	Cemented Waste	13	cz	28.727					\$ Radius of Drum	
4	3	-0.00129	1	-2	3	imp:n=1	u=2	\$	Steel Can	14	pz	-42.379					\$ Bottom of Drum	
Can (0,0,0) - Universe 3										15	pz	42.379					\$ Top of Drum	
10	3	-0.00129	-4	5	-6	fill=2	u=3	imp:n=1		16	pz	42.380					\$ Top above Drum	
trcl=(7.0581 4.075 -33.10)										17	pz	-42.380					\$ Bottom below	
\$ Can 1										c								
11	like 10 but	trcl=(14.0295 16.20 -33.10)																
\$ Can 2										c								
12	like 10 but	trcl=(21.0445 4.0498 -33.10)																
\$ Can 3										c								
Can (1,0,0) - Universe 4										20	px	-28.729					\$	
13	3	-0.00129	-4	5	-6	fill=1	u=4	imp:n=1		21	px	28.729					\$	
dx dy dz										c								
trcl=(-7.000 4.00 -33.1)										22	p	0.5	0.8660254	0	28.730			\$
\$ Can 1										23	p	-0.5	0.8660254	0	28.730			\$
14	like 13 but	trcl=(-21.0445 4.0498 -33.1)								24	p	0.5	0.8660254	0	28.730			\$
\$ Can 2										25	p	-0.5	0.8660254	0	-28.730			\$
15	like 13 but	trcl=(-14.0295 16.200 -33.1)								c								
\$ Can 3										36	pz	-42.381					\$ Concrete Floor	
Can (0,1,0) - Universe 5										37	so	200.00					\$ End of the World	
16	3	-0.00129	-4	5	-6	fill=1	u=5	imp:n=1		mode n								
dx dy dz										kcode	3000	1.0	10	100				
trcl=(0.0 -8.15 -33.1)										ksrc	15.	20.	-33.					
17	like 16 but	trcl=(-7.015 -20.25 -33.1)									40.	20.	-33					
\$ Can 2											30.	40.	-33					
18	like 16 but	trcl=(7.015 -20.25 -33.1)								c								
\$ Can 3										c								
Drum - Universe 3										ml								
20	4	-0.92	-7	8	-9	#10 #11 #12	u=3	imp:n=1	\$ Interior									
21	4	-0.92	-10	11	-12	(7:-8:9)	u=3	imp:n=1	\$ Polyethylene									
Liner										mt1								
24	2	-3.92	-13	14	-15	(10:-11:12)	u=3	imp:n=1	\$ Drum	c								
25	3	-0.00129	-14:15:13	u=3						imp:n=1	\$ Air around Drum	c						
Drum - Universe 4										m2								
34	4	-0.92	-7	8	-9	#13 #14 #15	u=4	imp:n=1	\$ Interior									
35	4	-0.92	-10	11	-12	(7:-8:9)	u=4	imp:n=1	\$ Polyethylene									
Liner										c								
36	2	-3.92	-13	14	-15	(10:-11:12)	u=4	imp:n=1	\$ Drum									
37	3	-0.00129	-14:15:13	u=4						imp:n=1	\$ Air around Drum	c						
Drum - Universe 5										m3								
38	4	-0.92	-7	8	-9	#16 #17 #18	u=5	imp:n=1	\$ Interior									
39	4	-0.92	-10	11	-12	(7:-8:9)	u=5	imp:n=1	\$ Polyethylene									
Liner										c								
40	2	-3.92	-13	14	-15	(10:-11:12)	u=5	imp:n=1	\$ Drum									
41	3	-0.00129	-14:15:13	u=5						imp:n=1	\$ Air around Drum	c						
The Hexes										mt4								
42	3	-0.00129	20	-21	-22	-23 24 25 17 -15	fill=3 imp:n=1			\$ (0,0,0) Hex	c							
\$ (0,0,0) Hex										m5								
43	3	-0.00129	20	-21	-22	-23 24 25 17 -15	trcl=(57.5 0.0 0.0)			\$ (1,0,0) Hex	c							
\$ (1,0,0) Hex										c								
44	3	-0.00129	20	-21	-22	-23 24 25 17 -15	trcl=(28.729 50.0 0.0)			\$ (1,0,0) Hex	c							
\$ (1,0,0) Hex										mt5								
The Room										c								
30	3	-0.00129	-37	36	-42	#42 #43 #44	imp:n=1	\$	Air around Drum	c								
31	5	-2.24	-36	-37	imp:n=1					\$ Concrete Floor	m6							
50	0	37	imp:n=0							\$ The Great Void	mt6							
Surface Definitions										c								
Billets										c								
1	cz	6.985	\$ Radius of Waste							mt7								
2	pz	-8.890	\$ Bottom of Waste							c								
3	pz	8.890	\$ Top of Waste							c								
4	cz	6.988	\$ Outside of Can							c								
Cellulose (1.45 g/cc)																		
1001.50c 0.054311														\$ Cellulose Reflector				
8016.50c 0.026949																		
6000.50c 0.03233																		
Polyethylene (0.92 g/cc)																		

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```

m8      6000.50c  0.03952      $ Polyethylene Reflector
        1001.50c  0.07903
mt8     poly.01t
c
c      Water (1.02 g/cc)
m9      1001.50c  -0.1097      $ H
        8016.50c  -0.8703      $ O
        94239.55c -0.0200      $ Pu
mt9     lwtr.01t      $ Light Water
c
c      30 g/l Pu in Water (1.03 g/cc)
m10     94239.55c -0.0292      $ Plutonium
        1001.50c  -0.1086      $ Water Moderator
        8016.50c  -0.8622
mt10    lwtr.01t
c
c      Cemented Waste (1.049 g/cc) 100% Water
m11     1001.50c  -0.1067      $ H
        8016.50c  0.8467      $ O
        94239.55c -0.0467      $ Pu
mt11    poly.01tc
c
totnu
ctme    480
print

```

dblbtch_bot1p

```

Three Billets in a Non-pipe 55 Gallon Drum
c      three overpacked Pu billets at the bottom of a 400 g/drum
c      Filled with poly
c      Silicon replaces Calcium
c
c      Cell Definitions
c
c      Can Contents - Universe 1
1      1 -1.049 -1 2 -3      imp:n=1 u=1      $ Cemented Waste
2      3 -0.00129 1:-2:3      imp:n=1 u=1      $ Steel Can
c
c      Can - Universe 2
10     3 -0.00129 -4 5 -6 fill=1 imp:n=1
        trcl=( 8.150 0.00 -33.100 )
11     like 10 but trcl=( 20.250 7.015 -33.100 )      $ Can 1
12     like 10 but trcl=( 20.250 -7.015 -33.100 )      $ Can 2
c
c      Drum - Universe 2
20     4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1      $ Interior
21     4 -0.92 -10 11 -12 (7:-8:9) imp:n=1      $ Polyethylene
Liner
24     2 -3.92 -13 14 -15 (10:-11:12) imp:n=1      $ Drum
25     3 -0.00129 20 -21 -22 -23 24 25 14 -15 13      imp:n=1      $ Hex around Drum
c
c      The Room
30     3 -0.00129 -37 36 (-20:21:22:23:-24:-25:15:-14)
        imp:n=1      $ Air around Drum
31     5 -2.24 -36 -37      imp:n=1      $ Concrete Floor
c
50     0      37      imp:n=0      $ The Great Void
c
c      Surface Definitions
c
c      Billets
1      cz      6.985      $ Radius of Waste
2      pz      -8.890      $ Bottom of Waste
3      pz      8.890      $ Top of Waste
4      cz      6.988      $ Outside of Can
5      pz      -8.893      $ Bottom of Can
6      pz      8.893      $ Top of Can
c
c      Drum
7      cz      28.485      $ Radius of
8      pz      -41.999      $ Bottom of
Interior
9      pz      41.999      $ Top of Interior
c
10     cz      28.575      $ Radius of Liner
11     pz      -42.227      $ Bottom of Liner
12     pz      42.227      $ Top of Liner
c
13     cz      28.727      $ Radius of Drum
14     pz      -42.379      $ Bottom of Drum
15     pz      42.379      $ Top of Drum
16     pz      42.380      $ Top above Drum
c
c      Hexagonal Surfaces (Ax+By+Cz=D)
20     px      -28.729      $
21     px      28.729      $

```

```

c      A      B      C      D      $
22     p      0.5      0.8660254      0      28.730      $
23     p      -0.5      0.8660254      0      28.730      $
24     p      0.5      0.8660254      0      -28.730      $
25     p      -0.5      0.8660254      0      -28.730      $
c
36     pz      -42.381      $ Concrete Floor
37     so      100.00      $ End of the World

```

```

mode n
kcode   3000 1.0 10 100
ksrc    8.150 0.00 -33.100
c
c      Cemented Waste (1.049 g/cc) 100% Water
m1      1001.50c  -0.1067      $ H
        8016.50c  -0.8467      $ O
        94239.55c -0.0467      $ Pu
mt1     poly.01t
c
c      SS-304 (7.83 g/cc)
m2      6000.50c  -0.000293      $ C
        14000.50c  -0.007497      $ Si
        15031.50c  -0.000447      $ P
        16032.50c  -0.000294      $ S
        24000.50c  -0.200003      $ Cr
        25055.50c  -0.020000      $ Mn
        26000.55c  -0.651464      $ Fe
        28000.50c  -0.120002      $ Ni

```

```

c
c      Air (0.00129 g/cc)
m3      7014.50c  -0.78084      $ N
        8016.50c  -0.20982      $ O
        18000.35c  -0.00934      $ Ar

```

```

c
c      Polyethylene (0.92 g/cc)
m4      6000.50c  0.03952      $ C
        1001.50c  0.07903      $ H
mt4     poly.01t
c

```

```

c
c      Concrete (2.24 g/cc)
m5      1001.50c  -0.009959      $ H
        6000.50c  -0.000979      $ C
        8016.50c  -0.529069      $ O
        11023.50c  0.016003      $ Na
        12000.50c  -0.002000      $ Mg
        13027.50c  -0.034006      $ Al
        14000.50c  -0.337036      $ Si
        19000.50c  -0.012981      $ K
        20000.50c  -0.043965      $ Ca
        26000.55c  -0.014002      $ Fe

```

```

mt5     poly.01t
c
c      Water (1.0 g/cc)
m6      1001.50c  -0.1119      $ H
        8016.50c  -0.8881      $ O
mt6     lwtr.01t      $ Light Water
c

```

```

c
c      Cellulose (1.45 g/cc)
m7      1001.50c  0.054311      $ Cellulose Reflector
        8016.50c  0.076949
        6000.50c  0.03233
mt7     poly.01t
c

```

```

c
c      Polyethylene (0.92 g/cc)
m8      6000.50c  0.03952      $ Polyethylene Reflector
        1001.50c  0.07903
mt8     poly.01t
c
c      Water (1.049 g/cc)
m9      1001.50c  -0.1067      $ H
        8016.50c  -0.8467      $ O
        94239.55c  -0.0467      $ Pu
mt9     lwtr.01t      $ Light Water
c

```

```

totnu
ctme    480
print

```

dblbtch_ref2p

```

Three Billets in a Non-pipe 55 Gallon Drum
c      three Pu billets at the bottom of a 400 g/drum
c      One reflecting boundary (two drums): Poly
c
c      Cell Definitions
c
c      Can Contents - Universe 1
1      1 -1.049 -1 2 -3      imp:n=1 u=1      $ Cemented Waste
2      3 -0.00129 1:-2:3      imp:n=1 u=1      $ Steel Can
c

```

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```

c
10 3 -0.00129 -4 5 -6 fill=1 imp:n=1
    trcl=( 8.150 0.00 -33.100 ) $ Can 1
11 like 10 but trcl=( 20.250 7.015 -33.100 ) $ Can 2
12 like 10 but trcl=( 20.250 -7.015 -33.100 ) $ Can 3
c
c
    Drum - Universe 2
20 4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1 $ Interior
21 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 $ Polyethylene
Liner
24 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 $ Drum
25 3 -0.00129 20 -21 -22 -23 24 25 14 -15 13
    imp:n=1 $ Hex around Drum
c
c
    The Room
30 3 -0.00129 -37 36 (-20:21:22:23:-24:-25:15:-14) -21
    imp:n=1 $ Air around Drum
31 5 -2.24 -36 -37 -21 imp:n=1 $ Concrete Floor
c
50 0 37:21 imp:n=0 $ The Great Void
c
c
    Surface Definitions
c
c
    Billets
1 cz 6.985 $ Radius of Waste
2 pz -8.890 $ Bottom of Waste
3 pz 8.890 $ Top of Waste
4 cz 6.988 $ Outside of Can
5 pz -8.893 $ Bottom of Can
6 pz 8.893 $ Top of Can
c
c
    Drum
7 cz 28.485 $ Radius of
8 pz -41.999 $ Bottom of
Interior
9 pz 41.999 $ Top of Interior
c
10 cz 28.575 $ Radius of Liner
11 pz -42.227 $ Bottom of Liner
12 pz 42.227 $ Top of Liner
c
13 cz 28.727 $ Radius of Drum
14 pz -42.379 $ Bottom of Drum
15 pz 42.379 $ Top of Drum
16 pz 42.380 $ Top above Drum
c
c
    Hexagonal Surfaces (Ax+By+Cz=D)
20 px -28.729 $
*21 px 28.729 $
c
    A B C D
22 p 0.5 0.8660254 0 28.730 $
23 p -0.5 0.8660254 0 28.730 $
24 p 0.5 0.8660254 0 -28.730 $
25 p -0.5 0.8660254 0 -28.730 $
c
36 pz -42.381 $ Concrete Floor
37 so 100.00 $ End of the World
mode n
kcode 3000 1.0 10 100
ksrc 8.150 0.00 -33.100
c
    Cemented Waste (1.049 g/cc) 100% Water
m1 1001.50c -0.1067 $ H
8016.50c -0.8467 $ O
94239.55c -0.0467 $ Pu
mt1 poly.01t
c
c
    SS-304 (7.83 g/cc)
m2 6000.50c -0.000293 $ C
14000.50c -0.007497 $ Si
15031.50c -0.000447 $ P
16032.50c -0.000294 $ S
24000.50c -0.200003 $ Cr
25055.50c -0.020000 $ Mn
26000.55c -0.651464 $ Fe
28000.50c -0.120002 $ Ni
c
    Air (0.00129 g/cc)
m3 7014.50c -0.78084 $ N
8016.50c -0.20946 $ O
18000.35c -0.00934 $ Ar
c
    Polyethylene (0.92 g/cc)
m4 6000.50c 0.03952 $ C
1001.50c 0.07903 $ H
mt4 poly.01t
c
c
    Concrete (2.24 g/cc)
m5 1001.50c -0.009959 $ H
6000.50c -0.009979 $ C
8016.50c -0.529069 $ O
11023.50c -0.016003 $ Na
12000.50c -0.002000 $ Mg
13027.50c -0.034006 $ Al
14000.50c -0.337036 $ Si
19000.50c -0.012981 $ K
20000.50c -0.043965 $ Ca
26000.55c -0.014002 $ Fe
mt5 poly.01t
c
c
    Water (1.0 g/cc)
m6 1001.50c -0.1119 $ H
8016.50c -0.8881 $ O
mt6 lwtr.01t $ Light Water
c
c
    Cellulose (1.45 g/cc)
m7 1001.50c 0.054311 $ Cellulose Reflector
8016.50c 0.026949
6000.50c 0.03233
mt7 poly.01t
c
c
    Polyethylene (0.92 g/cc)
m8 6000.50c 0.03952 $ Polyethylene Reflector
1001.50c 0.07903
mt8 poly.01t
c
c
    Water (1.02 g/cc)
m9 1001.50c -0.1097 $ H
8016.50c -0.8703 $ O
94239.55c -0.0200 $ Pu
mt9 lwtr.01t $ Light Water
c
totnu
ctme 480
print
dblbtch_refp
Three Billets in a Non-pipe 55 Gallon Drum
c three Pu billets at the bottom of a 400 g/drum
c Infinite reflection-Poly
c
c
    Cell Definitions
c
c
    Can Contents - Universe 1
c
1 1 -1.049 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
2 3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can
c
c
    Can - Universe 2
10 3 -0.00129 -4 5 -6 fill=1 imp:n=1
    trcl=( 8.150 0.00 -33.100 ) $ Can 1
11 like 10 but trcl=( 20.250 7.015 -33.100 ) $ Can 2
12 like 10 but trcl=( 20.250 -7.015 -33.100 ) $ Can 3
c
c
    Drum - Universe 2
20 4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1 $ Interior
21 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 $ Polyethylene
Liner
24 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 $ Drum
25 3 -0.00129 20 -21 -22 -23 24 25 14 -15 13
    imp:n=1 $ Hex around Drum
31 5 -2.24 38 -14 20 -21 -22 -23 24 25
    imp:n=1 $ Concrete Floor
32 3 -0.00129 -37 15 20 -21 -22 -23 24 25
    imp:n=1 $ Air Above Drums
c
50 0 (-20:21:22:23:-24:-25:37:-38) imp:n=0 $ The Great Void
c
c
    Surface Definitions
c
c
    Billets
1 cz 6.985 $ Radius of Waste
2 pz -8.890 $ Bottom of Waste
3 pz 8.890 $ Top of Waste
4 cz 6.988 $ Outside of Can
5 pz -8.893 $ Bottom of Can
6 pz 8.893 $ Top of Can
c
c
    Drum
7 cz 28.485 $ Radius of
Interior
8 pz -41.999 $ Bottom of
Interior
9 pz 41.999 $ Top of Interior
c
10 cz 28.575 $ Radius of Liner

```

```

11 pz -42.227 $ Bottom of Liner
12 pz 42.227 $ Top of Liner
c
13 cz 28.727 $ Radius of Drum
14 pz -42.379 $ Bottom of Drum
15 pz 42.379 $ Top of Drum
16 pz 42.380 $ Top above Drum

```

```

c
Hexagonal Surfaces (Ax+By+Cz=D)
*20 px -28.729 $
*21 px 28.729 $
c
A B C D $
*22 p 0.5 0.8660254 0 28.730 $
*23 p -0.5 0.8660254 0 28.730 $
*24 p 0.5 0.8660254 0 -28.730 $
*25 p -0.5 0.8660254 0 -28.730 $
c
36 pz -42.381 $ Concrete Floor
37 pz 100.00 $ Top of the World
38 pz -100.00 $ Bottom of the
World

```

```

mode n
kcode 3000 1.0 10 100
ksrc 8.150 0.00 -33.100
c
Cemented Waste (1.049 g/cc) 100% Water
m1 1001.50c -0.1067 $ H
8016.50c -0.8467 $ O
94239.55c -0.0467 $ Pu
mt1 poly.01t

```

```

c
SS-304 (7.83 g/cc)
m2 6000.50c -0.000293 $ C
14000.50c -0.007497 $ Si
15031.50c -0.000447 $ P
16032.50c -0.000294 $ S
24000.50c -0.200003 $ Cr
25055.50c -0.020000 $ Mn
26000.55c -0.651464 $ Fe
28000.50c -0.120002 $ Ni

```

```

c
Air (0.00129 g/cc)
m3 7014.50c -0.78084 $ H
8016.50c -0.20982 $ O
18000.35c -0.00934 $ Ar

```

```

c
Polyethylene (0.92 g/cc)
m4 6000.50c 0.03952 $ C
1001.50c 0.07903 $ H
mt4 poly.01t

```

```

c
Concrete (2.24 g/cc)
m5 1001.50c -0.009959 $ H
6000.50c -0.000979 $ C
8016.50c -0.529069 $ O
11023.50c -0.016003 $ Na
12000.50c -0.002000 $ Mg
13027.50c -0.034006 $ Al
14000.50c -0.337036 $ Si
19000.50c -0.012981 $ K
20000.50c -0.043965 $ Ca
26000.55c -0.014002 $ Fe
mt5 poly.01t

```

```

c
Water (1.0 g/cc)
m6 1001.50c -0.1119 $ H
8016.50c -0.8881 $ O
mt6 lwtr.01t

```

```

c
Cellulose (1.45 g/cc)
m7 1001.50c 0.054311 $ Cellulose Reflector
8016.50c 0.026949
6000.50c 0.03233
mt7 poly.01t

```

```

c
Polyethylene (0.92 g/cc)
m8 6000.50c 0.03952 $ Polyethylene Reflector
1001.50c 0.07903
mt8 poly.01t

```

```

c
Water (1.049 g/cc)
m9 1001.50c -0.1067 $ H
8016.50c -0.8467 $ O
94239.55c -0.0467 $ Pu
mt9 lwtr.01t

```

```

totnu
ctme 480

```

```
print
```

```

db1btch_refrotp
Three Billets in a Non-pipe 55 Gallon Drum
c three Pu billets at the bottom of a 400 g/drum
c Infinite reflection-Poly
c

```

```

Cell Definitions
c
Can Contents - Universe 1
1 1 -1.049 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
2 3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can
c
Can - Universe 2
10 3 -0.00129 -4 5 -6 fill=1 imp:n=1
c dx dy dz xx' yy' zz' xy' yz' xz' yz' zz' M
trcl*=( 8.15 0.000 33.1 30 60 90 120 30 90 90 90 0 -1)

```

```

11 like 10 but $ Can 1
trcl*=(20.25 7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
12 like 10 but $ Can 2
trcl*=(20.25 -7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
$ Can 3

```

```

c
Drum - Universe 2
20 4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1 $ Interior
21 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 $ Polyethylene
Liner
24 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 $ Drum
25 3 -0.00129 20 -21 -22 -23 24 25 14 -15 13 imp:n=1
31 5 -2.24 38 -14 20 -21 -22 -23 24 25 imp:n=1 $ Hex around Drum
32 3 -0.00129 -37 15 20 -21 -22 -23 24 25 imp:n=1 $ Concrete Floor
50 0 (-20:21:22:23:-24:-25:37:-38) imp:n=0 $ Air Above Drums
$ The Great Void

```

```
Surface Definitions
```

```

c
Billets
1 cz 6.985 $ Radius of Waste
2 pz -8.890 $ Bottom of Waste
3 pz 8.890 $ Top of Waste
4 cz 6.988 $ Outside of Can
5 pz -8.893 $ Bottom of Can
6 pz 8.893 $ Top of Can

```

```

c
Drum
7 cz 28.485 $ Radius of
8 pz -41.999 $ Bottom of
Interior
9 pz 41.999 $ Top of Interior
c
10 cz 28.575 $ Radius of Liner
11 pz -42.227 $ Bottom of Liner
12 pz 42.227 $ Top of Liner

```

```

c
13 cz 28.727 $ Radius of Drum
14 pz -42.379 $ Bottom of Drum
15 pz 42.379 $ Top of Drum
16 pz 42.380 $ Top above Drum

```

```

Hexagonal Surfaces (Ax+By+Cz=D)
*20 px -28.729 $
*21 px 28.729 $
c
A B C D $
*22 p 0.5 0.8660254 0 28.730 $
*23 p -0.5 0.8660254 0 28.730 $
*24 p 0.5 0.8660254 0 -28.730 $
*25 p -0.5 0.8660254 0 -28.730 $

```

```

36 pz -42.381 $ Concrete Floor
37 pz 100.00 $ Top of the World
38 pz -100.00 $ Bottom of the
World

```

```

mode n
kcode 3000 1.0 10 100
ksrc -8.150 0.00 -33.100

```

```

c
Cemented Waste (1.049 g/cc) 100% Water
m1 1001.50c -0.1067 $ H
8016.50c -0.8467 $ O
94239.55c -0.0467 $ Pu

```

```

mt1 poly.01t
c
c
c 55-304 (7.83 g/cc)
m2 6000.50c -0.000293 $ C
14000.50c -0.007497 $ Si
15031.50c -0.000447 $ P
16032.50c -0.000294 $ S
24000.50c -0.200003 $ Cr
25055.50c -0.020000 $ Mn
26000.55c -0.651464 $ Fe
28000.50c -0.120002 $ Ni
c
c Air (0.00129 g/cc)
m3 7014.50c -0.78084 $ N
8016.50c -0.20982 $ O
18000.35c -0.00934 $ Arc
c
c Polyethylene (0.92 g/cc)
m4 6000.50c 0.03952 $ C
1001.50c 0.07903 $ H
mt4 poly.01t
c
c Concrete (2.24 g/cc)
m5 1001.50c -0.009959 $ H
6000.50c -0.000979 $ C
8016.50c -0.529069 $ O
11023.50c -0.016003 $ Na
12000.50c -0.002000 $ Mg
13027.50c -0.034006 $ Al
14000.50c -0.337036 $ Si
19000.50c -0.012981 $ K
20000.50c -0.043965 $ Ca
26000.55c -0.014002 $ Fe
mt5 poly.01t
c
c Water (1.0 g/cc)
m6 1001.50c -0.1119 $ H
8016.50c -0.8881 $ O
mt6 lwtr.01t $ Light Water
c
c Cellulose (1.45 g/cc)
m7 1001.50c 0.054311 $ Cellulose Reflector
8016.50c 0.026949
6000.50c 0.03233
mt7 poly.01t
c
c Polyethylene (0.92 g/cc)
m8 6000.50c 0.03952 $ Polyethylene Reflector
1001.50c 0.07903
mt8 poly.01t
c
c Water (1.02 g/cc)
m9 1001.50c -0.1097 $ H
8016.50c -0.8703 $ O
94239.55c -0.0200 $ Pu
mt9 lwtr.01t $ Light Water
c
totnu
ctme 480
print

```

nonpipe_bot1p.inp

```

Three Billets in a Non-pipe 55 Gallon Drum
c three 66.7 g Pu billets at the bottom of a 200 g/drum
c Silicon replaces Calcium
c
c Cell Definitions
c
c Can Contents - Universe 1
1 1 -2.059 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
2 2 -7.83 1:-2:3 imp:n=1 u=1 $ Steel Can
c
c Can - Universe 2
10 2 -7.83 -4 5 -6 fill=1 imp:n=1
trcl=( 8.150 0.00 -33.100 ) $ Can 1
11 like 10 but trcl=( 20.250 7.015 -33.100 ) $ Can 2
12 like 10 but trcl=( 20.250 -7.015 -33.100 ) $ Can 3
c
c Drum - Universe 2
20 3 -0.00129 -7 8 -9 #10 #11 #12 imp:n=1 $ Interior
21 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 $ Polyethylene
Liner
24 2 -7.83 -13 14 -15 (10:-11:12) imp:n=1 $ Drum
25 3 -0.00129 20 -21 -22 -23 24 25 14 -15 13 imp:n=1 $ Hex around Drum
c

```

```

c The Room
30 3 -0.00129 -37 36 (-20:21:22:23:-24:-25:15:-14) imp:n=1 $ Air around Drum
31 5 -2.24 -36 -37 imp:n=1 $ Concrete Floor
c
50 0 37 imp:n=0 $ The Great Void
c
c Surface Definitions
c
c Billets
1 cz 6.985 $ Radius of Waste
2 pz -8.890 $ Bottom of Waste
3 pz 8.890 $ Top of Waste
4 cz 6.988 $ Outside of Can
5 pz -8.893 $ Bottom of Can
6 pz 8.893 $ Top of Can
c
c Drum
7 cz 28.485 $ Radius of
Interior
8 pz -41.999 $ Bottom of
Interior
9 pz 41.999 $ Top of Interior
c
10 cz 28.575 $ Radius of Liner
11 pz -42.227 $ Bottom of Liner
12 pz 42.227 $ Top of Liner
c
13 cz 28.727 $ Radius of Drum
14 pz -42.379 $ Bottom of Drum
15 pz 42.379 $ Top of Drum
16 pz 42.380 $ Top above Drum
c
c Hexagonal Surfaces (Ax+By+Cz=D)
20 px -28.729 $
21 px 28.729 $
c
22 p 0.5 0.8660254 0 28.730 $
23 p -0.5 0.8660254 0 28.730 $
24 p 0.5 0.8660254 0 -28.730 $
25 p -0.5 0.8660254 0 -28.730 $
c
36 pz -42.381 $ Concrete Floor
37 so 100.00 $ End of the World
mode n
kcode 3000 1.0 10 100
ksrc 8.150 0.00 -33.100
c
c Cemented Waste (2.059 g/cc)
m1 1001.50c -0.0408 $ H
8016.50c -0.4853 $ O
9019.50c -0.0324 $ F
12000.50c -0.0667 $ Mg
14000.50c -0.3629 $ Si
94239.55c -0.0119 $ Pu
mt1 poly.01t
c
c 55-304 (7.83 g/cc)
m2 6000.50c -0.000293 $ C
14000.50c -0.007497 $ Si
15031.50c -0.000447 $ P
16032.50c -0.000294 $ S
24000.50c -0.200003 $ Cr
25055.50c -0.020000 $ Mn
26000.55c -0.651464 $ Fe
28000.50c -0.120002 $ Ni
c
c Air (0.00129 g/cc)
m3 7014.50c -0.754918 $ N
8016.50c -0.231967 $ O
18000.35c -0.013115 $ Arc
c
c Polyethylene (0.92 g/cc)
m4 6000.50c 0.03952 $ C
1001.50c 0.07903 $ H
mt4 poly.01t
c
c Concrete (2.24 g/cc)
m5 1001.50c -0.009959 $ H
6000.50c -0.000979 $ C
8016.50c -0.529069 $ O
11023.50c -0.016003 $ Na
12000.50c -0.002000 $ Mg
13027.50c -0.034006 $ Al
14000.50c -0.337036 $ Si
19000.50c -0.012981 $ K
20000.50c -0.043965 $ Ca
26000.55c -0.014002 $ Fe
mt5 poly.01t

```

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```

c
c      Water (1.0 g/cc)
m6      1001.50c -0.1119      $ H
      8016.50c -0.8881      $ O
mt6      lwtr.01t      $ Light Water
c
c      Cellulose (1.45 g/cc)
m7      1001.50c 0.054311      $ Cellulose Reflector
      8016.50c 0.026949
      6000.50c 0.03233
mt7      poly.01t
c
c      Polyethylene (0.92 g/cc)
m8      6000.50c 0.03952      $ Polyethylene Reflector
      1001.50c 0.07903
mt8      poly.01t
c
c      Water (1.02 g/cc)
m9      1001.50c -0.1097      $ H
      8016.50c -0.8703      $ O
      94239.55c -0.0200      $ Pu
mt9      lwtr.01t      $ Light Water
c
ctotnu
ctme      480
cprint

```

```

nonpipe_bot2p.inp
Three Billets in a Non-pipe 55 Gallon Drum
c      three 66.7 g Pu billets in the bottom of a a 200 g/drum
c      Filled with poly
c
c      Cell Definitions
c
c      Can Contents - Universe 1
1      1 -1.024 -1 2 -3      imp:n=1 u=1      $ Cemented Waste
2      3 -0.00129 1:-2:3      imp:n=1 u=1      $ Steel Can
c
c      Can - Universe 2
10     3 -0.00129 -4 5 -6 fill=1 imp:n=1
      trcl=( 21.49 0.00 -33.1)      $ Can 1
11     like 10 but trcl=( 9.40 7.015 -33.1)      $ Can 2
12     like 10 but trcl=( 9.40 -7.015 -33.1)      $ Can 3
c
c      Drum - Universe 2
20     4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1      $ Interior
21     4 -0.92 -10 11 -12 (7:-8:9) imp:n=1      $ Polyethylene
Liner
24     2 -3.92 -13 14 -15 (10:-11:12) imp:n=1      $ Drum
25     3 -0.00129 20 -21 -22 -23 24 25 14 -15 13
      imp:n=1      $ Hex around Drum
c
c      The Room
30     3 -0.00129 -37 36 (-20:21:22:23:-24:-25:15:-14)
      imp:n=1      $ Air around Drum
31     5 -2.24 -36 -37      imp:n=1      $ Concrete Floor
c
50     0      37      imp:n=0      $ The Great Void

```

```

c
c      Surface Definitions
c
c      Billets
1      cz      6.985      $ Radius of Waste
2      pz      -8.890      $ Bottom of Waste
3      pz      8.890      $ Top of Waste
4      cz      6.988      $ Outside of Can
5      pz      -8.893      $ Bottom of Can
6      pz      8.893      $ Top of Can
c
c      Drum
7      cz      28.485      $ Radius of
8      pz      -41.999      $ Bottom of
9      pz      41.999      $ Top of Interior
c
10     cz      28.575      $ Radius of Liner
11     pz      -42.227      $ Bottom of Liner
12     pz      42.227      $ Top of Liner
c
13     cz      28.727      $ Radius of Drum
14     pz      -42.379      $ Bottom of Drum
15     pz      42.379      $ Top of Drum
16     pz      42.380      $ Top above Drum

```

```

c
c      Hexagonal Surfaces (Ax+By+Cz=D)
20     px      -28.729      $
21     px      28.729      $
c
c      A      B      C      D      $
22     p      0.5      0.8660254      0      28.730      $

```

```

23     p      -0.5      0.8660254      0      28.730      $
24     p      0.5      0.8660254      0      -28.730      $
25     p      -0.5      0.8660254      0      -28.730      $
c
36     pz      -42.381      $ Concrete Floor
37     so      100.00      $ End of the World

```

```

mode n
kcode      3000 1.0 10 100
ksrc      21.49 0.00 -33.1
c
c      Cemented Waste (1.024 g/cc)
m1      1001.50c -0.1092      $ H
      8016.50c -0.8669      $ O
      94239.55c -0.0239      $ Pu
mt1      poly.01t
c
c      SS-304 (7.83 g/cc)
m2      6000.50c -0.000293      $ C
      14000.50c -0.007497      $ Si
      15031.50c -0.000447      $ P
      16032.50c -0.000294      $ S
      24000.50c -0.200003      $ Cr
      25055.50c -0.020000      $ Mn
      26000.55c -0.651464      $ Fe
      28000.50c -0.120002      $ Ni

```

```

c
c      Air (0.00129 g/cc)
m3      7014.50c -0.78084      $ N
      8016.50c -0.20982      $ O
      18000.35c -0.00934      $ Arc
c
c      Polyethylene (0.92 g/cc)
m4      6000.50c 0.03952      $ C
      1001.50c 0.07903      $ H
mt4      poly.01t
c
c      Concrete (2.24 g/cc)
m5      1001.50c -0.009959      $ H
      6000.50c -0.000979      $ C
      8016.50c -0.529069      $ O
      11023.50c -0.016003      $ Na
      12000.50c -0.002000      $ Mg
      13027.50c -0.034006      $ Al
      14000.50c -0.337036      $ Si
      19000.50c -0.012981      $ K
      20000.50c -0.043965      $ Ca
      26000.55c -0.014002      $ Fe
mt5      poly.01t

```

```

c
c      Water (1.0 g/cc)
m6      1001.50c -0.1119      $ H
      8016.50c -0.8881      $ O
mt6      lwtr.01t      $ Light Water
c
c      Cellulose (1.45 g/cc)
m7      1001.50c 0.054311      $ Cellulose Reflector
      8016.50c 0.026949
      6000.50c 0.03233
mt7      poly.01t
c
c      Polyethylene (0.92 g/cc)
m8      6000.50c 0.03952      $ Polyethylene Reflector
      1001.50c 0.07903
mt8      poly.01t
c
c      Water Source (1.02 g/cc)
m9      1001.50c -0.1097      $ H
      8016.50c -0.8703      $ O
      94239.55c -0.0200      $ Pu
mt9      lwtr.01t      $ Light Water
c
ctotnu
ctme      480
cprint

```

```

nonpipe_cp.inp
Three Billets in a Non-pipe 55 Gallon Drum
c      three 66.7 g Pu billets in the center of a a 200 g/drum
c      Filled with poly
c
c      Cell Definitions
c
c      Can Contents - Universe 1
1      1 -1.024 -1 2 -3      imp:n=1 u=1      $ Cemented Waste
2      3 -0.00129 1:-2:3      imp:n=1 u=1      $ Steel Can
c
c      Can - Universe 2

```

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```

10 3 -0.00129 -4 5 -6 fill=1 imp:n=1
    trcl=( 8.35 0.00 0.00 )
11 like 10 but trcl=(-3.80 7.015 0.00 )
12 like 10 but trcl=(-3.80 -7.015 0.00 )
c
c
c      Drum - Universe 2
20 4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1
21 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1
Liner
24 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1
25 3 -0.00129 20 -21 -22 -23 24 25 14 -15 13
    imp:n=1
c
c
c      The Room
30 3 -0.00129 -37 36 (-20:21:22:23:-24:-25:15:-14)
    imp:n=1
31 5 -2.24 -36 -37
    imp:n=1
c
50 0 37
    imp:n=0
c
c      Surface Definitions
c
c      Billets
1  cz 6.985 $ Radius of Waste
2  pz -8.890 $ Bottom of Waste
3  pz 8.890 $ Top of Waste
4  cz 6.988 $ Outside of Can
5  pz -8.893 $ Bottom of Can
6  pz 8.893 $ Top of Can
c
c      Drum
7  cz 28.485 $ Radius of
8  pz -41.999 $ Bottom of
Interior
9  pz 41.999 $ Top of Interior
c
10 cz 28.575 $ Radius of Liner
11 pz -42.227 $ Bottom of Liner
12 pz 42.227 $ Top of Liner
c
13 cz 28.727 $ Radius of Drum
14 pz -42.379 $ Bottom of Drum
15 pz 42.379 $ Top of Drum
16 pz 42.380 $ Top above Drum
c
c      Hexagonal Surfaces (Ax+By+Cz=D)
20 px -28.729 $
21 px 28.729 $
c
c      A B C D
22 p 0.5 0.8660254 0 28.730 $
23 p -0.5 0.8660254 0 28.730 $
24 p 0.5 0.8660254 0 -28.730 $
25 p -0.5 0.8660254 0 -28.730 $
c
36 pz -42.381 $ Concrete Floor
37 so 100.00 $ End of the World
c
mode n
kcode 3000 1.0 10 100
ksrc 8.35 0.00 0.00
c
c      Cemented Waste (1.024 g/cc) 65% Water
ml 1001.50c -0.1092 $ H
8016.50c -0.8669 $ O
94239.55c -0.0239 $ Pu
mt1 poly.01t
c
c
c      SS-304 (7.83 g/cc)
m2 6000.50c -0.000293 $ C
14000.50c -0.007497 $ Si
15031.50c -0.000447 $ P
16032.50c -0.000294 $ S
24000.50c -0.200003 $ Cr
25055.50c -0.020000 $ Mn
26000.55c -0.651464 $ Fe
28000.50c -0.120002 $ Ni
c
c      Air (0.00129 g/cc)
m3 7014.50c -0.78084 $ N
8016.50c -0.20982 $ O
18000.35c -0.00934 $ Arc
c
c      Polyethylene (0.92 g/cc)
m4 6000.50c 0.03952 $ C
1001.50c 0.07903 $ H
mt4 poly.01t
c
c      Concrete (2.24 g/cc)

```

```

m5 1001.50c -0.009959 $ H
6000.50c -0.000979 $ C
8016.50c -0.529069 $ O
11023.50c -0.016003 $ Na
12000.50c -0.002000 $ Mg
13027.50c -0.034006 $ Al
14000.50c -0.337036 $ Si
19000.50c -0.012981 $ K
20000.50c -0.043965 $ Ca
26000.55c -0.014002 $ Fe
mt5 poly.01t
c
c      Water (1.0 g/cc)
m6 1001.50c -0.1119 $ H
8016.50c -0.8881 $ O
mt6 lwtr.01t $ Light Water
c
c      Cellulose (1.45 g/cc)
m7 1001.50c 0.054311 $ Cellulose Reflector
8016.50c 0.026949
6000.50c 0.03233
mt7 poly.01t
c
c      Polyethylene (0.92 g/cc)
m8 6000.50c 0.03952 $ Polyethylene Reflector
1001.50c 0.07903
mt8 poly.01t
c
c      Water (1.02 g/cc)
m9 1001.50c -0.1097 $ H
8016.50c -0.8703 $ O
94239.55c -0.0200 $ Pu
mt9 lwtr.01t $ Light Water
c
totnu
ctme 480
print
c
nonpipe_lat1.inp
c
Three Billets in a Non-pipe 55 Gallon Drum
c three 66.7 g Pu billets in a 200 g/drum
c Lattice Model
c
c      Cell Definitions
c
c      Can Contents - Universe 1
1 1 -1.024 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
2 3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can
c
c      Lower Can (0.0,0) - Universe 2
10 3 -0.00129 -4 5 -6 fill=1 u=2 imp:n=1
c dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
trcl*=( -8.15 0.000 33.1 30 60 90 120 30 90 90 90 0 -1)
c
11 like 10 but
trcl*=( -20.25 7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
c
12 like 10 but
trcl*=( -20.25 -7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
c
c      Lower Can (1.0,0) - Universe 3
13 3 -0.00129 -4 5 -6 fill=1 u=3 imp:n=1
c dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
trcl*=( 8.15 0.000 33.1 30 120 90 60 30 90 90 90 0 -1)
c
14 like 13 but
trcl*=( 20.25 7.015 33.1 30 120 90 60 30 90 90 90 0 -1)
c
15 like 13 but
trcl*=( 20.25 -7.015 33.1 30 120 90 60 30 90 90 90 0 -1)
c
c      Lower Can (0.1,0) - Universe 4
16 3 -0.00129 -4 5 -6 fill=1 u=4 imp:n=1
c dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
trcl*=( -8.15 0.000 33.1 90 180 90 0 90 90 90 90 0 -1)
c
17 like 16 but
trcl*=( -20.25 7.015 33.1 90 180 90 0 90 90 90 90 0 -1)
c
18 like 16 but
trcl*=( -20.25 -7.015 33.1 90 180 90 0 90 90 90 90 0 -1)
c
c

```


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Upper Can (0,0,0) - Universe 5														
c	3	-0.00129	-4	5	-6	fill=1	u=5	imp:n=1						
c		dx	dy	dz	xx'	yx'	zx'	xy'	yy'	zy'	xz'	yz'	zz'	M
		trcl**(-8.15	0.000	33.1	30	60	90	120	30	90	90	90	0	-1)
														\$ Can 1
20		like 19 but												
		trcl**(-20.25	7.015	33.1	30	60	90	120	30	90	90	90	0	-1)
														\$ Can 2
21		like 19 but												
		trcl**(-20.25	-7.015	33.1	30	60	90	120	30	90	90	90	0	-1)
														\$ Can 3
Upper Can (1,0,0) - Universe 6														
c	3	-0.00129	-4	5	-6	fill=1	u=6	imp:n=1						
c		dx	dy	dz	xx'	yx'	zx'	xy'	yy'	zy'	xz'	yz'	zz'	M
		trcl**(-8.15	0.000	33.1	30	120	90	60	30	90	90	90	0	-1)
														\$ Can 1
23		like 22 but												
		trcl**(-20.25	7.015	33.1	30	120	90	60	30	90	90	90	0	-1)
														\$ Can 2
24		like 22 but												
		trcl**(-20.25	-7.015	33.1	30	120	90	60	30	90	90	90	0	-1)
														\$ Can 3
Upper Can (0,1,0) - Universe 7														
c	3	-0.00129	-4	5	-6	fill=1	u=7	imp:n=1						
c		dx	dy	dz	xx'	yx'	zx'	xy'	yy'	zy'	xz'	yz'	zz'	M
		trcl**(-8.15	0.000	33.1	90	180	90	0	90	90	90	90	0	-1)
														\$ Can 1
26		like 25 but												
		trcl**(-20.25	7.015	33.1	90	180	90	0	90	90	90	90	0	-1)
														\$ Can 2
27		like 25 but												
		trcl**(-20.25	-7.015	33.1	90	180	90	0	90	90	90	90	0	-1)
														\$ Can 3
Drum - Universe 2														
c	30	4	-0.92	-7	8	-9	#10	#11	#12	imp:n=1	u=2	\$ Interior		
c	31	4	-0.92	-10	11	-12	(7:-8:9)			imp:n=1	u=2	\$ Polyethylene		
Liner	32	2	-3.92	-13	14	-15	(10:-11:12)			imp:n=1	u=2	\$ Drum		
c	33	3	-0.00129	13:-14:15						imp:n=1	u=2	\$ Air around Drum		
Drum - Universe 3														
c	34	4	-0.92	-7	8	-9	#13	#14	#15	imp:n=1	u=3	\$ Interior		
c	35	4	-0.92	-10	11	-12	(7:-8:9)			imp:n=1	u=3	\$ Polyethylene		
Liner	36	2	-3.92	-13	14	-15	(10:-11:12)							

		z=-1															
c																	
c	x=	-14	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	12	14	
c		-15	-13	-11	-9	-7	-5	-3	-1	1	3	5	7	9	11	13	15
y=-15		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=-14		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=-13		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=-12		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=-11		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=-10		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=-9		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=-8		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=-7		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=-6		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=-5		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=-4		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=-3		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=-2		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=-1		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=0		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=1		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=2		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=3		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=4		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=5		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=6		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=7		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=8		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=9		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=10		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=11		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=12		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=13		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=14		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
y=15		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8

		z=0															
c																	
c	x=	-14	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	12	14	
c		-15	-13	-11	-9	-7	-5	-3	-1	1	3	5	7	9	11	13	

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```

c
c
c
c
c
70 3 -0.00129 -32 31 -34 33 -36 27 imp:n=1 $ Air above array
71 5 -2.24 -35 44 -43 42 -41 40 imp:n=1 $ Concrete Floor
72 5 -2.24 -45 36 -43 42 -41 40 imp:n=1 $ Concrete Ceiling
73 5 -2.24 -36 35 -43 42 -41 32 imp:n=1 $ Right Concrete
Wall
74 5 -2.24 -36 35 -43 42 -31 40 imp:n=1 $ Left Concrete
Wall
75 5 -2.24 -36 35 -33 42 -32 31 imp:n=1 $ Front Concrete
Wall
76 5 -2.24 -36 35 -32 31 -43 34 imp:n=1 $ Back Concrete
Wall
c
80 0 41:-40:43:-42:45:-44 imp:n=0 $ The Great Void

c
c
c
c
c
1 cz 6.985 $ Radius of Waste
2 pz -8.890 $ Bottom of Waste
3 pz 8.890 $ Top of Waste
4 cz 6.988 $ Outside of Can
5 pz -8.893 $ Bottom of Can
6 pz 8.893 $ Top of Can

c
c
c
7 cz 28.485 $ Radius of
Interior pz -41.999 $ Bottom of
Interior pz 41.999 $ Top of Interior
c
10 cz 28.575 $ Radius of Liner
11 pz -42.227 $ Bottom of Liner
12 pz 42.227 $ Top of Liner
c
13 cz 28.727 $ Radius of Drum
14 pz -42.379 $ Bottom of Drum
15 pz 42.379 $ Top of Drum
16 pz 42.380 $ Top above Drum
c
17 so 15.00 $ Pu in other drum

c
c
c
20 px 28.729 $
21 px 28.729 $
c
22 p 0.5 0.8660254 0 28.730 $
23 p 0.5 0.8660254 0 -28.730 $
24 p -0.5 0.8660254 0 28.730 $
25 p -0.5 0.8660254 0 -28.730 $

c
c
c
26 pz -42.380 $ Bottom of Bottom
Layer pz 127.140 $ Top of Top Layer
28 pz -42.3795 $ Bottom of Fill
Volume pz 42.3795 $ Top of Fill
Volume
c
c
c
31 px -350.00 $ Left Side of
Room px 350.00 $ Right Side of
Room py -350.00 $ Front of Room
34 py 350.00 $ Back of Room
35 pz -42.88 $ Floor of Room
36 pz 150.00 $ Ceiling of Room

c
c
c
40 px -380.48 $ Left Wall
41 px 380.48 $ Right Wall
42 py -380.48 $ Front Wall
43 py 380.48 $ Back Wall
44 pz -100.00 $ Floor
45 pz 200.00 $ Ceiling

mode n
kcode 3000 1.0 10 100
ksrc 0.0 -10.0 -33.0
-12.0 -35.0 -33.0
12.0 -35.0 -33.0

c
c
c
ml 1001.50c -0.1092 $ H
8016.50c -0.8669 $ O

```

```

94239.55c -0.0239 $ Pu
poly.01t

mt1
c
c
c
c
SS-304 (7.83 g/cc)
6000.50c -0.000293 $ C
14000.50c -0.007497 $ Si
15031.50c -0.000447 $ P
16032.50c -0.000294 $ S
24000.50c -0.200003 $ Cr
25055.50c -0.020000 $ Mn
26000.55c -0.651464 $ Fe
28000.50c -0.120002 $ Ni

c
c
c
Air (0.00129 g/cc)
7014.50c -0.78084 $ N
8016.50c -0.20946 $ O
18000.35c -0.00934 $ Arc

c
c
c
Polyethylene (0.92 g/cc)
6000.50c 0.03952 $ C
1001.50c 0.07903 $ H

mt4
c
c
Concrete (2.24 g/cc)
1001.50c -0.009959 $ H
6000.50c -0.000979 $ C
8016.50c -0.529069 $ O
11023.50c -0.016003 $ Na
12000.50c -0.002000 $ Mg
13027.50c -0.034006 $ Al
14000.50c -0.337036 $ Si
19000.50c -0.012981 $ K
20000.50c -0.043965 $ Ca
26000.55c -0.014002 $ Fe

mt5
c
c
Water (1.0 g/cc)
1001.50c -0.1119 $ H
8016.50c -0.8881 $ O
lwtr.01t $ Light Water

c
c
Cellulose (1.45 g/cc)
1001.50c 0.054311 $ Cellulose Reflector
8016.50c 0.026949
6000.50c 0.03233

mt7
c
c
Polyethylene (0.92 g/cc)
6000.50c 0.03952 $ Polyethylene Reflector
1001.50c 0.07903

mt8
c
c
Water (1.02 g/cc)
1001.50c -0.1097 $ H
8016.50c -0.8703 $ O
94239.55c -0.0200 $ Pu
lwtr.01t $ Light Water

mt9
c
c
30 g/l Pu in Water (1.03 g/cc)
94239.55c -0.0292 $ Plutonium
1001.50c -0.1086 $ Water Moderator
8016.50c -0.8622

mt10
c
c
totnu 480
ctme
print

nonpipe_lat2.inp

Three Billets in a Non-pipe 55 Gallon Drum
c three 66.7 g Pu billets in a 200 g/drum
c Lattice Model

c
c
c
Cell Definitions

c
c
Can Contents - Universe 1
1 1 -1.024 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
2 3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can

c
c
Over Batched Can Contents - Universe 9
3 11 -1.04 -1 2 -3 imp:n=1 u=9 $ Cemented Waste
4 3 -0.00129 1:-2:3 imp:n=1 u=9 $ Steel Can

c
c
c
Lower Can (0,0,0) - Universe 2
10 3 -0.00129 -4 5 -6 fill=1 u=2 imp:n=1
c dx dy dz xx' yy' zz' M

```

C-13

[illegible]

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[illegible][illegible]

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[illegible]

C-16

```

Three Billets in a Non-pipe 55 Gallon Drum
three 66.7 g Pu billets in a 200 g/drum
Lattice Model

Cell Definitions

Can Contents - Universe 1
1 1 -1.024 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
2 3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can

Double Batched Can Contents - Universe 9
3 11 -1.049 -1 2 -3 imp:n=1 u=9 $ Cemented Waste
4 3 -0.00129 1:-2:3 imp:n=1 u=9 $ Steel Can

Lower Can (0.0,0) - Universe 2
10 3 -0.00129 -4 5 -6 fill=1 u=2 imp:n=1
C dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
C trcl*=( -8.15 0.000 33.1 30 60 90 120 30 90 90 90 0 -1)
$ Can 1
11 like 10 but
trcl*=(-20.25 7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
$ Can 2
12 like 10 but
trcl*=(-20.25 -7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
$ Can 3

Lower Can (1.0,0) - Universe 3
13 3 -0.00129 -4 5 -6 fill=1 u=3 imp:n=1
C dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
C trcl*=( 8.15 0.000 33.1 30 120 90 60 30 90 90 90 0 -1)
$ Can 1
14 like 13 but
trcl*=(20.25 7.015 33.1 30 120 90 60 30 90 90 90 0 -1)
$ Can 2
15 like 13 but
trcl*=(20.25 -7.015 33.1 30 120 90 60 30 90 90 90 0 -1)
$ Can 3

Lower Can (0.1,0) - Universe 4
16 3 -0.00129 -4 5 -6 fill=1 u=4 imp:n=1
C dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
C trcl*=( -8.15 0.000 33.1 90 180 90 0 90 90 90 90 0 -1)
$ Can 1
17 like 16 but
trcl*=(-20.25 7.015 33.1 90 180 90 0 90 90 90 90 0 -1)
$ Can 2
18 like 16 but
trcl*=(-20.25 -7.015 33.1 90 180 90 0 90 90 90 90 0 -1)
$ Can 3

Upper Can (0.0,0) - Universe 5
19 3 -0.00129 -4 5 -6 fill=9 u=5 imp:n=1
C dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
C trcl*=( -8.15 0.000 33.1 30 60 90 120 30 90 90 90 0 -1)
$ Can 1
20 like 19 but
trcl*=(-20.25 7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
$ Can 2
21 like 19 but
trcl*=(-20.25 -7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
$ Can 3

```

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[illegible]

```

28000.50c -0.120002 $ Ni
c
c Air (0.00129 g/cc)
m3 7014.50c -0.78084 $ N
8016.50c -0.20946 $ O
18000.35c -0.00934 $ Arc
c
c Polyethylene (0.92 g/cc)
m4 6000.50c -0.03952 $ C
1001.50c 0.07903 $ H
mt4 poly.01t
c
c Concrete (2.24 g/cc)
m5 1001.50c -0.009959 $ H
6000.50c -0.000979 $ C
8016.50c -0.529069 $ O
11023.50c -0.016003 $ Na
12000.50c -0.002000 $ Mg
13027.50c -0.034006 $ Al
14000.50c -0.337036 $ Si
19000.50c -0.012981 $ K
20000.50c -0.043965 $ Ca
26000.55c -0.014002 $ Fe
mt5 poly.01t
c
c Water (1.0 g/cc)
m6 1001.50c -0.1119 $ H
8016.50c -0.8881 $ O
mt6 lwtr.01t $ Light Water
c
c Cellulose (1.45 g/cc)
m7 1001.50c 0.054311 $ Cellulose Reflector
8016.50c 0.026949
6000.50c 0.03233
mt7 poly.01t
c
c Polyethylene (0.92 g/cc)
m8 6000.50c 0.03952 $ Polyethylene Reflector
1001.50c 0.07903
mt8 poly.01t
c
c Water (1.02 g/cc)
m9 1001.50c -0.1097 $ H
8016.50c -0.8703 $ O
94239.55c -0.0200 $ Pu
mt9 lwtr.01t $ Light Water
c
c 30 g/l Pu in Water (1.03 g/cc)
m10 94239.55c -0.0292 $ Plutonium
1001.50c -0.1086 $ Water Moderator
8016.50c -0.8622
mt10 lwtr.01t
c
c Cemented Waste (1.049 g/cc) 100% Water
m11 1001.50c -0.1067 $ H
8016.50c -0.8467 $ O
94239.55c -0.0467 $ Pu
mt11 poly.01t
c
totnu
ctme 480
print

```

nonpipe_lat3a.inp

Three Billets in a Non-pipe 55 Gallon Drum

```

c three 66.7 g Pu billets in a 200 g/drum
c Lattice Model
c
c
c
c

```

Cell Definitions

```

c
c Can Contents - Universe 1
1 1 -1.024 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
2 3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can
c
c Double Batched Can Contents - Universe 9
3 11 -1.049 -1 2 -3 imp:n=1 u=9 $ Cemented Waste
4 3 -0.00129 1:-2:3 imp:n=1 u=9 $ Steel Can
c
c Lower Can (0.0,0) - Universe 2
10 3 -0.00129 -4 5 -6 fill=1 u=2 imp:n=1
c dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
trcl*=( -8.15 0.000 -33.1 30 60 90 120 30 90 90 90 0 -1)
c
c $ Can 1
11 like 10 but
trcl*=( -20.25 7.015 -33.1 30 60 90 120 30 90 90 90 0 -1)
c
c $ Can 2

```

```

12 like 10 but
trcl*=( -20.25 -7.015 -33.1 30 60 90 120 30 90 90 90 0 -1)
c
c $ Can 3
c
c Lower Can (1.0,0) - Universe 3
13 3 -0.00129 -4 5 -6 fill=1 u=3 imp:n=1
c dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
trcl*=( 8.15 0.000 -33.1 30 120 90 60 30 90 90 90 0 -1)
c
c $ Can 1
14 like 13 but
trcl*=(20.25 7.015 -33.1 30 120 90 60 30 90 90 90 0 -1)
c
c $ Can 2
15 like 13 but
trcl*=(20.25 -7.015 -33.1 30 120 90 60 30 90 90 90 0 -1)
c
c $ Can 3
c
c Lower Can (0.1,0) - Universe 4
16 3 -0.00129 -4 5 -6 fill=1 u=4 imp:n=1
c dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
trcl*=( -8.15 0.000 -33.1 90 180 90 0 90 90 90 90 0 -1)
c
c $ Can 1
17 like 16 but
trcl*=( -20.25 7.015 -33.1 90 180 90 0 90 90 90 90 0 -1)
c
c $ Can 2
18 like 16 but
trcl*=( -20.25 -7.015 -33.1 90 180 90 0 90 90 90 90 0 -1)
c
c $ Can 3
c
c Upper Can (0.0,0) - Universe 5
19 3 -0.00129 -4 5 -6 fill=9 u=5 imp:n=1
c dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
trcl*=( -8.15 0.000 -33.1 30 60 90 120 30 90 90 90 0 -1)
c
c $ Can 1
20 like 19 but
trcl*=( -20.25 7.015 -33.1 30 60 90 120 30 90 90 90 0 -1)
c
c $ Can 2
21 like 19 but
trcl*=( -20.25 -7.015 -33.1 30 60 90 120 30 90 90 90 0 -1)
c
c $ Can 3
c
c Upper Can (1.0,0) - Universe 6
22 3 -0.00129 -4 5 -6 fill=9 u=6 imp:n=1
c dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
trcl*=( 8.15 0.000 -33.1 30 120 90 60 30 90 90 90 0 -1)
c
c $ Can 1
23 like 22 but
trcl*=(20.25 7.015 -33.1 30 120 90 60 30 90 90 90 0 -1)
c
c $ Can 2
24 like 22 but
trcl*=(20.25 -7.015 -33.1 30 120 90 60 30 90 90 90 0 -1)
c
c $ Can 3
c
c Upper Can (0.1,0) - Universe 7
25 3 -0.00129 -4 5 -6 fill=9 u=7 imp:n=1
c dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
trcl*=( -8.15 0.000 -33.1 90 180 90 0 90 90 90 90 0 -1)
c
c $ Can 1
26 like 25 but
trcl*=( -20.25 7.015 -33.1 90 180 90 0 90 90 90 90 0 -1)
c
c $ Can 2
27 like 25 but
trcl*=( -20.25 -7.015 -33.1 90 180 90 0 90 90 90 90 0 -1)
c
c $ Can 3
c
c Drum - Universe 2
30 4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1 u=2 $ Interior
31 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 u=2 $ Polyethylene
Liner
32 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 u=2 $ Drum
33 3 -0.00129 13:-14:15 imp:n=1 u=2 $ Air around Drum
c
c Drum - Universe 3
34 4 -0.92 -7 8 -9 #13 #14 #15 imp:n=1 u=3 $ Interior
35 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 u=3 $ Polyethylene
Liner
36 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 u=3 $ Drum
37 3 -0.00129 13:-14:15 imp:n=1 u=3 $ Air around Drum
c
c Drum - Universe 4
38 4 -0.92 -7 8 -9 #16 #17 #18 imp:n=1 u=4 $ Interior
39 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 u=4 $ Polyethylene
Liner

```

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[illegible][illegible]

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27	pz	127.140	\$ Top of Top Layer
28	pz	-42.3795	\$ Bottom of Fill
29	pz	42.3795	\$ Top of Fill
The Room			
31	px	350.00	\$ Left Side of
32	px	350.00	\$ Right Side of
33	py	-350.00	\$ Front of Room
34	py	350.00	\$ Back of Room
35	pz	-42.88	\$ Floor of Room
36	pz	150.00	\$ Ceiling of Room
Walls, Ceiling, Floor			
40	px	-380.48	\$ Left Wall
41	px	380.48	\$ Right Wall
42	py	-380.48	\$ Front Wall
43	py	380.48	\$ Back Wall
44	pz	-100.00	\$ Floor
45	pz	200.00	\$ Ceiling

```
mode n
kcode    3000  1.0 10 100
ksrc      0.0 -10.0 33.0
          -12.0 -35.0 33.0
          12.0 -35.0 33.0
```

c	Cemented	Waste (1.024 g/cc)	100% Water
ml	1001.50c	-0.1092	\$ H
	8016.50c	-0.8669	\$ O
	94239.55c	-0.0239	\$ Pu
mt1	poly. 01t		
c			
c			
c	55.304 (7.83 g/cc)		
m2	6000.50c	-0.000293	\$ C
	14000.50c	-0.007497	\$ Si
	15031.50c	-0.000447	\$ P
	16032.50c	-0.000294	\$ S
	24000.50c	-0.200003	\$ Cr
	25055.50c	-0.020000	\$ Mn
	26000.55c	-0.651464	\$ Fe
	28030.50c	-0.120002	\$ Ni

C	Air (0.00129 g/cc)	
C	7014.50c	-0.78084
m3	8016.50c	-0.20946
	18000.35c	-0.00934
		\$ N
		\$ O
		\$ Arc

C			
C	Polyethylene (0.92 g/cc)		
mt4	6000.50c	0.03952	\$ C
	1001.50c	0.07903	\$ H
mt4	poly. 01t		

C	Concrete (2.24 g/cc)	
1001.50c	-0.009959	\$ H
6000.50c	-0.000979	\$ C
8016.50c	-0.529069	\$ O
11023.50c	-0.016003	\$ Na
12000.50c	-0.002000	\$ Mg
13027.50c	-0.034006	\$ Al
14000.50c	-0.337036	\$ Si
19000.50c	-0.012981	\$ K
20000.50c	-0.043965	\$ Ca
26000.55c	-0.014002	\$ Fe

mt5	poly.01t		
c			
c	Water (1.0 g/cc)		
m6	1001.50c	-0.1119	\$ H
	8016.50c	-0.8881	\$ O
mt6	Watr.01t		\$ Light Water

c	Cellulose (1.45 g/cc)	
c	1001.50c	0.054311
m7	8016.50c	0.026949
	6000.50c	0.03233
mt7	poly. 01t	

C			
C	Polyethylene (0.92 g/cc)		
m8	6000.50c	0.03952	\$ Polyethylene Reflector
	1001.50c	0.07903	

mt8	poly.01t		
c			
c	Water (1.02 g/cc)		
m9	1001.50c	-0.1097	\$ H
	8016.50c	-0.8703	\$ O
	94239.55c	-0.0200	\$ Pu

```

mt9      lwtr.01t                $ Light Water
C
C      30 g/l Pu in Water (1.03 g/cc)
m10      94239.55c -0.0292      $ Plutonium
      1001.50c -0.1086      $ Water Moderator
      8016.50c -0.8622
mt10     lwtr.01t
C
C      Cemented Waste (1.049 g/cc) 100% Water
m11      1001.50c -0.1067      $ H
      8016.50c -0.8467      $ O
      94239.55c -0.0467      $ Pu
mt11     poly.01t
C
totnu
ctme     480
print

```

nonpipe_1at3b.inp

Three Billets in a Non-pipe 55 Gallon Drum
c three 66.7 g Pu billets in a 200 g/drum
c Lattice Model

Cell Definitions

```

c          Can Contents - Universe 1
1  1 -1.024 -1 2 -3      imp:n=1 u=1  $ Cemented Waste
2  3 -0.00129 1:-2:3    imp:n=1 u=1  $ Steel Can

```

```

C
c      Double Batched Can Contents - Universe 9
3      11 -1.049 -1 2 -3      imp:n=1 u=9      $ Cemented Waste
4      3 -0.00129 1:-2:3      imp:n=1 u=9      $ Steel Can

```

```

c
c                                     Lower Can (0,0,0) - Universe 2
10  3 -0.00129 -4 5 -6 fill=1 u=2 imp:n=1
c      dx      dy      dz
   trcl=( 7.0581 4.075 -33.1)          $ Can 1
11  like 10 but
   trcl=(14.0295 16.200 -33.1)          $ Can 2
12  like 10 but
   trcl=(21.0445 4.0498 33.1)          $ Can 3

```

```

c                                     Lower Can (1,0,0) - Universe 3
c
13  3 -0.00129 -4 5 -6 fill=1 u=3 imp:n=1
c      dx dy dz
c      trcl=(-7.000 4.00 -33.1) $ Can 1
14  like 13 but
c      trcl=(-21.0445 4.0498 -33.1) $ Can 2
15  like 13 but
c      trcl=(-14.0295 16.200 -33.1) $ Can 3

```

```

c
16 3 -0.00129 -4 5 -6 fill=1 u=4 imp:n=1
    dx dy dz
    trcl=(- 0.0 -8.15 -33.1 ) $ Can 1
    like 16 but
    trcl=(- 7.015 -20.25 -33.1) $ Can 2
18 like 16 but
    trcl=(- 7.015 -20.25 -33.1) $ Can 3

```

```

c
c                                     Upper Can (0.0,0) - Universe 5
19  3 -0.00129 -4      5      -6      f11)=9      u5      imp:n=1
c      dx      dy      dz
c      trcl=( 7.0581  4.075 -33.1)      $ Can 1
20      like 19 but
c      trcl=(14.0295 16.200 -33.1)      $ Can 2
21      like 19 but
c      trcl=(21.0445  4.0498 -33.1)      $ Can 3

```

```

c
c      3 -0.00129 -4 -5 -6      Upper Can (1.0,0) - Universe 6
c      dx      dy      dz      fill=9 u=6 imp:n=1
23      trcl=(- 4.075  7.0581 -33.1)      $ Can 1
      like 22 but
      trcl=(- 21.0445 4.0498 -33.1)      $ Can 2
24      like 22 but
      trcl=(- 14.0295 16.200 -33.1)      $ Can 3

```

```

c      Upper Can (0.1,0) - Universe 7
25    3 -0.00129 -4 5 -6 fill=9 u=7 imp=n=1
      dx dy dz
      trcl=( 0.0 -8.15 -33.1 ) $ Can 1
26    like 25 but
      trcl=(-7.015 -20.25 -33.1) $ Can 2
27    like 25 but
      trcl=( 7.015 -20.25 -33.1 ) $ Can 3

```

C-23

[illegible]

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[illegible][illegible]

HNF-6179 Rev. 0

14	pz	-42.379		\$ Bottom of Drum
15	pz	42.379		\$ Top of Drum
16	pz	42.380		\$ Top above Drum
c				
17	so	15.00		\$ Pu in other drum
c				
			Hexagonal Surfaces (Ax*By+Cz=D)	
20	px	-28.729		\$
21	px	28.729		\$
c		A	B	C
22	p	0.5	0.8660254	0 28.730 \$
23	p	0.5	0.8660254	0 -28.730 \$
24	p	-0.5	0.8660254	0 28.730 \$
25	p	-0.5	0.8660254	0 -28.730 \$
c				
			The Array Boundaries	
26	pz	-42.380		\$ Bottom of Bottom
Layer				
27	pz	127.140		\$ Top of Top Layer
28	pz	-42.3795		\$ Bottom of Fill
Volume				
29	pz	42.3795		\$ Top of Fill
Volume				
c				
			The Room	
31	px	-350.00		\$ Left Side of
Room				
32	px	350.00		\$ Right Side of
Room				
33	py	-350.00		\$ Front of Room
34	py	350.00		\$ Back of Room
35	pz	-42.88		\$ Floor of Room
36	pz	150.00		\$ Ceiling of Room
c				
			Walls, Ceiling, Floor	
40	px	-380.48		\$ Left Wall
41	px	380.48		\$ Right Wall
42	py	-380.48		\$ Front Wall
43	py	380.48		\$ Back Wall
44	pz	-100.00		\$ Floor
45	pz	200.00		\$ Ceiling

mode	n				
kc	code	3000	1.0	10	100
ks	rc	0.0	-10.0	-33.0	
		-12.0	-35.0	-33.0	
		12.0	-35.0	-33.0	
c					
c		Cemented Waste	(1.024 g/cc)	100%	Water
m1		1001.50c	-0.1092		\$ H
		8016.50c	-0.8669		\$ O
		94239.55c	-0.0239		\$ Pu
mt1		poly.01t			
c					
c					
c		SS-304	(7.83 g/cc)		
m2		6000.50c	-0.000293		\$ C
		14000.50c	-0.007497		\$ Si
		15031.50c	-0.000447		\$ P
		16032.50c	-0.000294		\$ S
		24000.50c	-0.200003		\$ Cr
		25055.50c	-0.020000		\$ Mn
		26000.55c	-0.651464		\$ Fe
		28000.50c	-0.120002		\$ Ni
c					
c		Air	(0.00129 g/cc)		
m3		7014.50c	-0.78084		\$ N
		8016.50c	-0.20946		\$ O
		18000.35c	-0.00934		\$ Arc
c					
c		Polyethylene	(0.92 g/cc)		
m4		6000.50c	0.03952		\$ C
		1001.50c	0.07903		\$ H
mt4		poly.01t			
c					
c		Concrete	(2.24 g/cc)		
m5		1001.50c	-0.009959		\$ H
		6000.50c	-0.000979		\$ C
		8016.50c	-0.529069		\$ O
		11023.50c	-0.016003		\$ Na
		12000.50c	-0.002000		\$ Mg
		13027.50c	-0.034006		\$ Al
		14000.50c	-0.337036		\$ Si
		19000.50c	-0.012981		\$ K
		20000.50c	-0.043965		\$ Ca
		26000.55c	-0.014002		\$ Fe
mt5		poly.01t			
c					
c		Water	(1.0 g/cc)		
m6		1001.50c	-0.1119		\$ H

```

8016.50c      -0.8881      $ O
mt6            lwtr.01t      $ Light Water
c
c      Cellulose (1.45 g/cc)
m7            1001.50c      0.054311      $ Cellulose Reflector
            8016.50c      0.026949
            6000.50c      0.03233
mt7            poly.01t
c
c      Polyethylene (0.92 g/cc)
m8            6000.50c      0.03952      $ Polyethylene Reflector
            1001.50c      0.07903
mt8            poly.01t
c
c      Water (1.02 g/cc)
m9            1001.50c      -0.1097      $ H
            8016.50c      -0.8703      $ O
            94239.55c      -0.0200      $ Pu
mt9            lwtr.01t      $ Light Water
c
c      30 g/l Pu in Water (1.03 g/cc)
m10           94239.55c      0.0292      $ Plutonium
            1001.50c      -0.1086      $ Water Moderator
            8016.50c      -0.8622
mt10           lwtr.01t
c
c      Cemented Waste (1.049 g/cc) 100% Water
m11           1001.50c      -0.1067      $ H
            8016.50c      -0.8467      $ O
            94239.55c      -0.0467      $ Pu
mt11           poly.01t
c
totnu
ctme      480
print

nonpipe_1at3c.inp

Three Billets in a Non-pipe 55 Gallon Drum
c      three 66.7 g Pu billets in a 200 g/drum
c      Lattice Model
c
c      Cell Definitions
c
c      Can Contents - Universe 1
c      1 -1.024 -1 2 -3      imp:n=1 u=1      $ Cemented Waste
c      2 -0.00129 1:-2:3      imp:n=1 u=1      $ Steel Can
c
c      Double Batched Can Contents - Universe 9
c      3 11 -1.049 -1 2 -3      imp:n=1 u=9      $ Cemented Waste
c      4 3 -0.00129 1:-2:3      imp:n=1 u=9      $ Steel Can
c
c      Lower Can (0.0,0) - Universe 2
c      10 3 -0.00129 -4 5 -6 fill=1 u=2 imp:n=1
c      dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
c      trcl*=( -8.15 0.000 33.1 30 60 90 120 30 90 90 90 0 -1)
c
c      $ Can 1
11      like 10 but
c      trcl*=( -20.25 7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
c
c      $ Can 2
12      like 10 but
c      trcl*=( -20.25 -7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
c
c      $ Can 3
c
c      Lower Can (1.0,0) - Universe 3
c      13 3 -0.00129 -4 5 -6 fill=1 u=3 imp:n=1
c      dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
c      trcl*=( 8.15 0.000 33.1 30 120 90 60 30 90 90 90 0 -1)
c
c      $ Can 1
14      like 13 but
c      trcl*=(20.25 7.015 33.1 30 120 90 60 30 90 90 90 0 -1)
c
c      $ Can 2
15      like 13 but
c      trcl*=(20.25 -7.015 33.1 30 120 90 60 30 90 90 90 0 -1)
c
c      $ Can 3
c
c      Lower Can (0.1,0) - Universe 4
c      16 3 -0.00129 -4 5 -6 fill=1 u=4 imp:n=1
c      dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
c      trcl*=( -8.15 0.000 33.1 90 180 90 0 90 90 90 90 0 -1)
c
c      $ Can 1
17      like 16 but
c      trcl*=( -20.25 7.015 33.1 90 180 90 0 90 90 90 90 0 -1)
c
c      $ Can 2
18      like 16 but

```


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	u=8	lat=2 fil =15:15	-15:15	-1:2	imp:n=1	\$ Hex around Drum
C						
C						
C						
C	x=-	-14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14				
C		-15 -13 -11 -9 -7 -5 -3 -1 1 3 5 7 9 11 13 15				
y=-15		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-14		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-13		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-12		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-11		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-10		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-9		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-8		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-7		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-6		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-5		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-4		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-3		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-2		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-1		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=0		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=1		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=2		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=3		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=4		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=5		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=6		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=7		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=8		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=9		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=10		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=11		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=12		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=13		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=14		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=15		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
C						
C						
C						
C	x=-	-14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14				
C		-15 -13 -11 -9 -7 -5 -3 -1 1 3 5 7 9 11 13 15				
y=-15		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-14		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-13		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-12		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-11		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-10		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				
y=-9		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 \$				

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[illegible][illegible]

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[illegible]

	12.0	-35.0	-33.0	
C				
C				
m1	Cemented Waste (1.024 g/cc) 100% Water			
	1001.50c	-0.1092		\$ H
	8016.50c	-0.8669		\$ O
	94239.55c	-0.0239		\$ Pu
mt1	poly.01t			
C				
C				
C				
m2	SS-304 (7.83 g/cc)			
	6000.50c	-0.000293		\$ C
	14000.50c	-0.007497		\$ Si
	15031.50c	-0.000447		\$ P
	16032.50c	-0.000294		\$ S
	24000.50c	-0.200003		\$ Cr
	25055.50c	-0.020000		\$ Mn
	26000.55c	-0.651464		\$ Fe
	28000.50c	-0.120002		\$ Ni
C				
C				
m3	Air (0.00129 g/cc)			
	7014.50c	-0.78084		\$ N
	8016.50c	-0.20946		\$ O
	18000.35c	-0.00934		\$ Arc
C				
C				
m4	Polyethylene (0.92 g/cc)			
	6000.50c	0.03952		\$ C
	1001.50c	0.07903		\$ H
mt4	poly.01t			
C				
C				
m5	Concrete (2.24 g/cc)			
	1001.50c	-0.009959		\$ H
	6000.50c	-0.000979		\$ C
	8016.50c	-0.529069		\$ O
	11023.50c	-0.016003		\$ Na
	12000.50c	-0.002000		\$ Mg
	13027.50c	-0.034006		\$ Al
	14000.50c	-0.337036		\$ Si
	19000.50c	-0.012981		\$ K
	20000.50c	-0.043965		\$ Ca
	26000.55c	-0.014002		\$ Fe
mt5	poly.01t			
C				
C				
m6	Water (1.0 g/cc)			
	1001.50c	-0.1119		\$ H
	8016.50c	-0.8881		\$ O
mt6	lwtr.01t			\$ Light Water
C				
C				
m7	Cellulose (1.45 g/cc)			
	1001.50c	0.054311		\$ Cellulose Reflector
	8016.50c	0.026949		
	6000.50c	0.03233		
mt7	poly.01t			
C				
C				
m8	Polyethylene (0.92 g/cc)			
	6000.50c	0.03952		\$ Polyethylene Reflector
	1001.50c	0.07903		
mt8	poly.01t			
C				
C				
m9	Water (1.02 g/cc)			
	1001.50c	-0.1097		\$ H
	8016.50c	-0.8703		\$ O
	94239.55c	-0.0200		\$ Pu
mt9	lwtr.01t			\$ Light Water
C				
C				
m10	30 g/l Pu in Water (1.03 g/cc)			
	94239.55c	-0.0292		\$ Plutonium
	1001.50c	-0.1086		\$ Water Moderator
	8016.50c	-0.8622		
mt10	lwtr.01t			
C				
C				
m11	Cemented Waste (1.049 g/cc) 100% Water			
	1001.50c	-0.1067		\$ H
	8016.50c	-0.8467		\$ O
	94239.55c	-0.0467		\$ Pu
mt11	poly.01t			
C				
totru				
ctme	480			
print				

nonpipe_lat3d.inp

Three Billets in a Non-pipe 55 Gallon Drum
 three 66.7 g Pu billets in a 200 g/drum
 Lattice Model

Cell Definitions

Can Contents - Universe 1

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[illegible][illegible]

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[illegible]

			Hexagonal Surfaces (Ax+By+Cz=D)		
20	px	-28.729			\$
21	px	28.729			\$
c			A	B	D
22	p	0.5	0.8660254	0	28.730
23	p	0.5	0.8660254	0	-28.730
24	p	-0.5	0.8660254	0	28.730
25	p	-0.5	0.8660254	0	-28.730
c			The Array Boundaries		
26	pz	-42.380			\$ Bottom of Bottom
Layer					
27	pz	127.140			\$ Top of Top Layer
28	pz	-42.3795			\$ Bottom of Fill
Volume					
29	pz	42.3795			\$ Top of Fill
Volume					
c			The Room		
31	px	-350.00			\$ Left Side of
Room					
32	px	350.00			\$ Right Side of
Room					
33	py	-350.00			\$ Front of Room
34	py	350.00			\$ Back of Room
35	pz	-42.88			\$ Floor of Room
36	pz	150.00			\$ Ceiling of Room
c			Walls, Ceiling, Floor		
40	px	-380.48			\$ Left Wall
41	px	380.48			\$ Right Wall
42	py	-380.48			\$ Front Wall
43	py	380.48			\$ Back Wall
44	pz	-100.00			\$ Floor
45	pz	200.00			\$ Ceiling
mode n					
kcode	3000	1.0 10 500			
ksrc	0.0	-10.0 -33.0			
	-12.0	-35.0 -33.0			
	12.0	-35.0 -33.0			
c					
c			Cemented Waste (1.024 g/cc) 100% Water		
m1	1001.50c	-0.1092			\$ H
	8016.50c	-0.8669			\$ O
	94239.55c	-0.0239			\$ Pu
mt1	poly.01t				
c					
c					
c			SS-304 (7.83 g/cc)		
m2	6000.50c	-0.000293			\$ C
	14000.50c	-0.007497			\$ Si
	15031.50c	-0.000447			\$ P
	16032.50c	-0.000294			\$ S
	24000.50c	-0.200003			\$ Cr
	25055.50c	-0.020000			\$ Mn
	26000.55c	-0.651464			\$ Fe
	28000.50c	-0.120002			\$ Ni
c					
c			Air (0.00129 g/cc)		
m3	7014.50c	-0.78084			\$ N
	8016.50c	-0.20946			\$ O
	18000.35c	-0.00934			\$ Arc
c					
c			Polyethylene (0.92 g/cc)		
m4	6000.50c	-0.03952			\$ C
	1001.50c	-0.07903			\$ H
mt4	poly.01t				
c					
c			Concrete (2.24 g/cc)		
m5	1001.50c	-0.009959			\$ H
	6000.50c	-0.000979			\$ C
	8016.50c	-0.529069			\$ O
	11023.50c	-0.016003			\$ Na
	12000.50c	-0.002000			\$ Mg
	13027.50c	-0.034006			\$ Al
	14000.50c	-0.337036			\$ Si
	19000.50c	-0.012981			\$ K
	20000.50c	-0.043965			\$ Ca
	26000.55c	-0.014002			\$ Fe
mt5	poly.01t				
c					
c			Water (1.0 g/cc)		
m6	1001.50c	-0.1119			\$ H
	8016.50c	-0.88			

```

6000.50c 0.03233
mt7 poly.01t
c
c Polyethylene (0.92 g/cc)
m8 6000.50c 0.03952 $ Polyethylene Reflector
    1001.50c 0.07903
mt8 poly.01t
c
c Water (1.02 g/cc)
m9 1001.50c -0.1097 $ H
    8016.50c -0.8703 $ O
    94239.55c -0.0200 $ Pu
mt9 lwtr.01t $ Light Water
c
c 30 g/l Pu in Water (1.03 g/cc)
m10 94239.55c -0.0292 $ Plutonium
    1001.50c -0.1086 $ Water Moderator
    8016.50c -0.8622
mt10 lwtr.01t
c
c Cemented Waste (1.049 g/cc) 65% Water
m11 1001.50c -0.1067 $ H
    8016.50c -0.8467 $ O
    94239.55c -0.0467 $ Pu
mt11 poly.01t
c
totnu
ctme 480
print

```

nonpipe_lat3e.inp

```

Three Billets in a Non-pipe 55 Gallon Drum
c three 66.7 g Pu billets in a 200 g/drum
c Lattice Model
c
c Cell Definitions
c
c Can Contents - Universe 1
1 1 -1.024 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
2 3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can
c
c Double Batched Can Contents - Universe 9
3 11 -1.049 -1 2 -3 imp:n=1 u=9 $ Cemented Waste
4 3 -0.00129 1:-2:3 imp:n=1 u=9 $ Steel Can
c
c Lower Can (0,0,0) - Universe 2
10 3 -0.00129 -4 5 -6 fill=1 u=2 imp:n=1
    dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
    trcl*=( -8.15 0.000 33.1 30 60 90 120 30 90 90 90 0 -1)
c
c $ Can 1
11 like 10 but
    trcl*=(20.25 7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
c
c $ Can 2
12 like 10 but
    trcl*=(20.25 -7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
c
c $ Can 3
c
c Lower Can (1,0,0) - Universe 3
13 3 -0.00129 -4 5 -6 fill=1 u=3 imp:n=1
    dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
    trcl*=( 8.15 0.000 33.1 30 120 90 60 30 90 90 90 0 -1)
c
c $ Can 1
14 like 13 but
    trcl*=(20.25 7.015 33.1 30 120 90 60 30 90 90 90 0 -1)
c
c $ Can 2
15 like 13 but
    trcl*=(20.25 -7.015 33.1 30 120 90 60 30 90 90 90 0 -1)
c
c $ Can 3
c
c Lower Can (0,1,0) - Universe 4
16 3 -0.00129 -4 5 -6 fill=1 u=4 imp:n=1
    dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
    trcl*=( -8.15 0.000 33.1 90 180 90 0 90 90 90 90 0 -1)
c
c $ Can 1
17 like 16 but
    trcl*=(20.25 7.015 33.1 90 180 90 0 90 90 90 90 0 -1)
c
c $ Can 2
18 like 16 but
    trcl*=(20.25 -7.015 33.1 90 180 90 0 90 90 90 90 0 -1)
c
c $ Can 3
c
c Upper Can (0,0,0) - Universe 5
19 3 -0.00129 -4 5 -6 fill=9 u=5 imp:n=1
    dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M

```

```

trcl*=( -8.15 0.000 33.1 30 60 90 120 30 90 90 90 0 -1)
c
c $ Can 1
20 like 19 but
    trcl*=(20.25 7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
c
c $ Can 2
21 like 19 but
    trcl*=(20.25 -7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
c
c $ Can 3
c
c Upper Can (1,0,0) - Universe 6
22 3 -0.00129 -4 5 -6 fill=9 u=6 imp:n=1
    dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
    trcl*=( 8.15 0.000 33.1 30 120 90 60 30 90 90 90 0 -1)
c
c $ Can 1
23 like 22 but
    trcl*=(20.25 7.015 33.1 30 120 90 60 30 90 90 90 0 -1)
c
c $ Can 2
24 like 22 but
    trcl*=(20.25 -7.015 33.1 30 120 90 60 30 90 90 90 0 -1)
c
c $ Can 3
c
c Upper Can (0,1,0) - Universe 7
25 3 -0.00129 -4 5 -6 fill=9 u=7 imp:n=1
    dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
    trcl*=( -8.15 0.000 33.1 90 180 90 0 90 90 90 90 0 -1)
c
c $ Can 1
26 like 25 but
    trcl*=(20.25 7.015 33.1 90 180 90 0 90 90 90 90 0 -1)
c
c $ Can 2
27 like 25 but
    trcl*=(20.25 -7.015 33.1 90 180 90 0 90 90 90 90 0 -1)
c
c $ Can 3
c
c Drum - Universe 2
30 4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1 u=2 $ Interior
31 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 u=2 $ Polyethylene
Liner
32 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 u=2 $ Drum
33 3 -0.00129 13:-14:15 imp:n=1 u=2 $ Air around Drum
c
c Drum - Universe 3
34 4 -0.92 -7 8 -9 #13 #14 #15 imp:n=1 u=3 $ Interior
35 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 u=3 $ Polyethylene
Liner
36 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 u=3 $ Drum
37 3 -0.00129 13:-14:15 imp:n=1 u=3 $ Air around Drum
c
c Drum - Universe 4
38 4 -0.92 -7 8 -9 #16 #17 #18 imp:n=1 u=4 $ Interior
39 4 -0.92 -10 11 -12 (7: 8:9) imp:n=1 u=4 $ Polyethylene
Liner
40 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 u=4 $ Drum
41 3 -0.00129 13:-14:15 imp:n=1 u=4 $ Air around Drum
c
c Drum - Universe 5
42 4 -0.92 -7 8 -9 #19 #20 #21 imp:n=1 u=5 $ Interior
43 4 -0.92 -10 11 -12 (7: 8:9) imp:n=1 u=5 $ Polyethylene
Liner
44 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 u=5 $ Drum
45 3 -0.00129 13:-14:15 imp:n=1 u=5 $ Air around Drum
c
c Drum - Universe 6
46 4 -0.92 -7 8 -9 #22 #23 #24 imp:n=1 u=6 $ Interior
47 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 u=6 $ Polyethylene
Liner
48 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 u=6 $ Drum
49 3 -0.00129 13:-14:15 imp:n=1 u=6 $ Air around Drum
c
c Drum - Universe 7
50 4 -0.92 -7 8 -9 #25 #26 #27 imp:n=1 u=7 $ Interior
51 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 u=7 $ Polyethylene
Liner
52 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 u=7 $ Drum
53 3 -0.00129 13:-14:15 imp:n=1 u=7 $ Air around Drum
c
c The Array
60 3 -0.00129 -27 35 -32 31 -34 33 fill=8 imp:n=1 $ The Array to be
filled
c
c Hexagonal Universe - Universe 8
61 3 -0.00129 -21 20 -22 23 -24 25 -29 28
    u=8 lat=2 imp:n=1 $ Hex around Drum
    fill=-15:15 -15:15 -1:2
c
c z=-1
c
c x= -14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14

```

C-33

[illegible]

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[illegible]

```

C
C
C      55-304 (7.83 g/cc)
m2      6000.50c -0.000293 $ C
      14000.50c -0.007497 $ Si
      15031.50c -0.000447 $ P
      16032.50c -0.000294 $ S
      24000.50c -0.200003 $ Cr
      25055.50c -0.020000 $ Mn
      26000.55c -0.651464 $ Fe
      28000.50c -0.120002 $ Ni
C
C      Air (0.00129 g/cc)
m3      7014.50c -0.78084 $ N
      8016.50c -0.20946 $ O
      18000.35c -0.00934 $ Arc
C
C      Polyethylene (0.92 g/cc)
m4      6000.50c 0.03952 $ C
      1001.50c 0.07903 $ H
mt4      poly.01t
C
C      Concrete (2.24 g/cc)
m5      1001.50c -0.009959 $ H
      6000.50c -0.000979 $ C
      8016.50c -0.529069 $ O
      11023.50c -0.016003 $ Na
      12000.50c -0.002000 $ Mg
      13027.50c -0.034006 $ Al
      14000.50c -0.337036 $ Si
      19000.50c -0.012981 $ K
      20000.50c -0.043965 $ Ca
      26000.55c -0.014002 $ Fe
mt5      poly.01t
C
C      Water (1.0 g/cc)
m6      1001.50c -0.1119 $ H
      8016.50c -0.8881 $ O
mt6      lwtr.01t $ Light Water
C
C      Cellulose (1.45 g/cc)
m7      1001.50c 0.054311 $ Cellulose Reflector
      8016.50c 0.026949
      6000.50c 0.03233
mt7      poly.01t
C
C      Polyethylene (0.92 g/cc)
m8      6000.50c 0.03952 $ Polyethylene Reflector
      1001.50c 0.07903
mt8      poly.01t
C
C      Water (1.02 g/cc)
m9      1001.50c -0.1097 $ H
      8016.50c -0.8703 $ O
      94239.55c -0.0200 $ Pu
mt9      lwtr.01t $ Light Water
C
C      30 g/l Pu in Water (1.03 g/cc)
m10     94239.55c -0.0292 $ Plutonium
      1001.50c -0.1086 $ Water Moderator
      8016.50c -0.8622
mt10     lwtr.01t
C
C      Cemented Waste (1.049 g/cc) 100% Water
m11     1001.50c -0.1067 $ H
      8016.50c -0.8467 $ O
      94239.55c -0.0467 $ Pu
mt11     poly.01t
C
totnu
ctme 480
print

```

nonpipe_1at4.inp

Three Billets in a Non-pipe 55 Gallon Drum
three 66.7 g Pu billets in a 200 g/drum
Lattice Model

Cell Definitions

Can Contents - Universe 1

```

1 1 -1.024 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
2 3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can

```

Over Batched Can Contents - Universe 9

```

3 1 -1.024 -1 2 -3 imp:n=1 u=9 $ Cemented Waste
4 3 -0.00129 1:-2:3 imp:n=1 u=9 $ Steel Can

```

```

C
C      Lower Can (0.0,0) - Universe 2
10 3 -0.00129 -4 5 -6 fill=1 u=2 imp:n=1
    dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
    trcl*=( -8.15 0.000 33.1 30 60 90 120 30 90 90 90 0 -1)
C
C      $ Can 1
11 like 10 but
    trcl*=( -20.25 7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
C
C      $ Can 2
12 like 10 but
    trcl*=( -20.25 -7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
C
C      $ Can 3
C
C      Lower Can (1.0,0) - Universe 3
13 3 -0.00129 -4 5 -6 fill=1 u=3 imp:n=1
    dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
    trcl*=( 8.15 0.000 33.1 30 120 90 60 30 90 90 90 0 -1)
C
C      $ Can 1
14 like 13 but
    trcl*=(20.25 7.015 33.1 30 120 90 60 30 90 90 90 0 -1)
C
C      $ Can 2
15 like 13 but
    trcl*=(20.25 -7.015 33.1 30 120 90 60 30 90 90 90 0 -1)
C
C      $ Can 3
C
C      Lower Can (0.1,0) - Universe 4
16 3 -0.00129 -4 5 -6 fill=1 u=4 imp:n=1
    dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
    trcl*=( -8.15 0.000 33.1 90 180 90 0 90 90 90 90 0 -1)
C
C      $ Can 1
17 like 16 but
    trcl*=( -20.25 7.015 33.1 90 180 90 0 90 90 90 90 0 -1)
C
C      $ Can 2
18 like 16 but
    trcl*=( -20.25 -7.015 33.1 90 180 90 0 90 90 90 90 0 -1)
C
C      $ Can 3
C
C      Upper Can (0.0,0) - Universe 5
19 3 -0.00129 -4 5 -6 fill=9 u=5 imp:n=1
    dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
    trcl*=( -8.15 0.000 33.1 30 60 90 120 30 90 90 90 0 -1)
C
C      $ Can 1
20 like 19 but
    trcl*=( -20.25 7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
C
C      $ Can 2
21 like 19 but
    trcl*=( -20.25 -7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
C
C      $ Can 3
C
C      Upper Can (1.0,0) - Universe 6
22 3 -0.00129 -4 5 -6 fill=9 u=6 imp:n=1
    dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
    trcl*=( 8.15 0.000 33.1 30 120 90 60 30 90 90 90 0 -1)
C
C      $ Can 1
23 like 22 but
    trcl*=(20.25 7.015 33.1 30 120 90 60 30 90 90 90 0 -1)
C
C      $ Can 2
24 like 22 but
    trcl*=(20.25 -7.015 33.1 30 120 90 60 30 90 90 90 0 -1)
C
C      $ Can 3
C
C      Upper Can (0.1,0) - Universe 7
25 3 -0.00129 -4 5 -6 fill=9 u=7 imp:n=1
    dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
    trcl*=( -8.15 0.000 33.1 90 180 90 0 90 90 90 90 0 -1)
C
C      $ Can 1
26 like 25 but
    trcl*=( -20.25 7.015 33.1 90 180 90 0 90 90 90 90 0 -1)
C
C      $ Can 2
27 like 25 but
    trcl*=( -20.25 -7.015 33.1 90 180 90 0 90 90 90 90 0 -1)
C
C      $ Can 3
C
C      Drum - Universe 2
30 4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1 u=2 $ Interior
31 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 u=2 $ Polyethylene
    Liner
32 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 u=2 $ Drum
33 3 -0.00129 13:-14:15 imp:n=1 u=2 $ Air around Drum
C
C      Drum - Universe 3
34 4 -0.92 -7 8 -9 #13 #14 #15 imp:n=1 u=3 $ Interior

```

HNF-6179 Rev. 0

[illegible][illegible]

HNF-6179 Rev. 0

[illegible][illegible]

```

22 p 0.5 0.8660254 0 28.730 $
23 p 0.5 0.8660254 0 -28.730 $
24 p -0.5 0.8660254 0 28.730 $
25 p -0.5 0.8660254 0 -28.730 $
c
c The Array Boundaries
26 pz -42.380 $ Bottom of Bottom
Layer
27 pz 127.140 $ Top of Top Layer
28 pz -42.3795 $ Bottom of Fill
Volume
29 pz 42.3795 $ Top of Fill
Volume
c
c The Room
31 px -350.00 $ Left Side of
Room
32 px 350.00 $ Right Side of
Room
33 py -350.00 $ Front of Room
34 py 350.00 $ Back of Room
35 pz -42.88 $ Floor of Room
36 pz 150.00 $ Ceiling of Room
c
c Walls, Ceiling, Floor
40 px -380.48 $ Left Wall
41 px 380.48 $ Right Wall
42 py -380.48 $ Front Wall
43 py 380.48 $ Back Wall
44 pz -100.00 $ Floor
45 pz 200.00 $ Ceiling

```

```

mode n
kcode 3000 1.0 10 100
ksrc 0.0 -10.0 -33.0
-12.0 -35.0 -33.0
12.0 -35.0 -33.0
c
c Cemented Waste (1.024 g/cc) 65% Water
m1 1001.50c -0.1092 $ H
8016.50c -0.8669 $ O
94239.55c -0.0239 $ Pu
mt1 poly.01t
c
c SS-304 (7.83 g/cc)
m2 6000.50c -0.000293 $ C
14000.50c -0.007497 $ Si
15031.50c -0.000447 $ P
16032.50c -0.000294 $ S
24000.50c -0.200003 $ Cr
25055.50c -0.020000 $ Mn
26000.55c -0.651464 $ Fe
28000.50c -0.120002 $ Ni
c
c Air (0.00129 g/cc)
m3 7014.50c -0.78084 $ N
8016.50c -0.20946 $ O
18000.35c -0.00934 $ Arc
c
c Polyethylene (0.92 g/cc)
m4 6000.50c 0.03952 $ C
1001.50c 0.07903 $ H
mt4 poly.01t
c
c Concrete (2.24 g/cc)
m5 1001.50c -0.009959 $ H
6000.50c -0.000979 $ C
8016.50c -0.529069 $ O
11023.50c -0.016003 $ Na
12000.50c -0.002000 $ Mg
13027.50c -0.034006 $ Al
14000.50c -0.337036 $ Si
19000.50c -0.012981 $ K
20000.50c -0.043965 $ Ca
26000.55c -0.014002 $ Fe
mt5 poly.01t
c
c Water (1.0 g/cc)
m6 1001.50c -0.1119 $ H
8016.50c -0.8881 $ O
mt6 twtr.01t $ Light Water
c
c Cellulose (1.45 g/cc)
m7 1001.50c 0.054311 $ Cellulose Reflector
8016.50c 0.026949
6000.50c 0.03233
mt7 poly.01t
c
c Polyethylene (0.92 g/cc)

```

```

m8 6000.50c 0.03952 $ Polyethylene Reflector
1001.50c 0.07903
mt8 poly.01t
c
c Water (1.02 g/cc)
m9 1001.50c -0.1097 $ H
8016.50c -0.8703 $ O
94239.55c -0.0200 $ Pu
mt9 twtr.01t $ Light Water
c
c 30 g/l Pu in Water (1.03 g/cc)
m10 94239.55c -0.0292 $ Plutonium
1001.50c 0.1086 $ Water Moderator
8016.50c -0.8622
mt10 twtr.01t
c
c Cemented Waste (1.041 g/cc) 65% Water
m11 1001.50c -0.1101 $ H
8016.50c -0.8738 $ O
94239.55c -0.0162 $ Pu
mt11 poly.01t
c
totru
ctme 480
print

```

nonpipe_1at5.inp

```

Three Billets in a Non-pipe 55 Gallon Drum
c three 66.7 g Pu billets in a 200 g/drum
Lattice Model with Wagon
c
c Cell Definitions
c
c Can Contents - Universe 1
1 1 -1.024 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
2 3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can
c
c Over Batched Can Contents - Universe 9
3 11 -1.041 -1 2 -3 imp:n=1 u=9 $ Cemented Waste
4 3 -0.00129 1:-2:3 imp:n=1 u=9 $ Steel Can
c
c Wagon Can Contents - Universe 10
5 8 -11.46 -208 204 -205 u=10 imp:n=1 $ Plutonium Oxide
6 3 -0.00129 201:-204:206 u=10 imp:n=1 $ Can
7 3 -0.00129 -201 204 -206 #5 u=10 imp:n=1 $ Air above Oxide
c
c Lower Can (0.0,0) - Universe 2
10 3 -0.00129 -4 5 -6 fill=1 u=2 imp:n=1
dx dy dz xx' yy' zz' M
trcl*=( -8.15 0.000 20.1 30 60 90 120 30 90 90 90 0 -1)
$ Can 1
11 like 10 but
trcl*=( -20.25 7.015 20.1 30 60 90 120 30 90 90 90 0 -1)
$ Can 2
12 like 10 but
trcl*=( -20.25 -7.015 20.1 30 60 90 120 30 90 90 90 0 -1)
$ Can 3
c
c Lower Can (1.0,0) - Universe 3
13 3 -0.00129 -4 5 -6 fill=1 u=3 imp:n=1
dx dy dz xx' yy' zz' M
trcl*=( 8.15 0.000 20.1 30 120 90 60 30 90 90 90 0 -1)
$ Can 1
14 like 13 but
trcl*=( 20.25 7.015 20.1 30 120 90 60 30 90 90 90 0 -1)
$ Can 2
15 like 13 but
trcl*=( 20.25 -7.015 20.1 30 120 90 60 30 90 90 90 0 -1)
$ Can 3
c
c Lower Can (0.1,0) - Universe 4
16 3 -0.00129 -4 5 -6 fill=1 u=4 imp:n=1
dx dy dz xx' yy' zz' M
trcl*=( -8.15 0.000 20.1 90 180 90 0 90 90 90 90 0 -1)
$ Can 1
17 like 16 but
trcl*=( -20.25 7.015 20.1 90 180 90 0 90 90 90 90 0 -1)
$ Can 2
18 like 16 but
trcl*=( -20.25 -7.015 20.1 90 180 90 0 90 90 90 90 0 -1)
$ Can 3
c
c Upper Can (0.0,0) - Universe 5
19 3 -0.00129 -4 5 -6 fill=9 u=5 imp:n=1
dx dy dz xx' yy' zz' M

```

```

trcl*=( -8.15 0.000 20.1 30 60 90 120 30 90 90 90 0 -1)
% Can 1
20 like 19 but
trcl*=( -20.25 7.015 20.1 30 60 90 120 30 90 90 90 0 -1)
% Can 2
21 like 19 but
trcl*=( -20.25 -7.015 20.1 30 60 90 120 30 90 90 90 0 -1)
% Can 3
c
c
c
22 Upper Can (1,0,0) - Universe 6
3 -0.00129 -4 5 -6 fill=9 u=6 imp:n=1
dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
trcl*=( 8.15 0.000 20.1 30 120 90 60 30 90 90 90 0 -1)
% Can 1
23 like 22 but
trcl*=(20.25 7.015 20.1 30 120 90 60 30 90 90 90 0 -1)
% Can 2
24 like 22 but
trcl*=(20.25 -7.015 20.1 30 120 90 60 30 90 90 90 0 -1)
% Can 3
c
c
c
25 Upper Can (0,1,0) - Universe 7
3 -0.00129 -4 5 -6 fill=9 u=7 imp:n=1
dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
trcl*=( -8.15 0.000 20.1 90 180 90 0 90 90 90 90 0 -1)
% Can 1
26 like 25 but
trcl*=( -20.25 7.015 20.1 90 180 90 0 90 90 90 90 0 -1)
% Can 2
27 like 25 but
trcl*=( -20.25 -7.015 20.1 90 180 90 0 90 90 90 90 0 -1)
% Can 3
c
c
c
30 Drum - Universe 2
4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1 u=2 $ Interior
31 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 u=2 $ Polyethylene
Liner
32 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 u=2 $ Drum
33 3 -0.00129 13:-14:15 imp:n=1 u=2 $ Air around Drum
c
c
c
34 Drum - Universe 3
4 -0.92 -7 8 -9 #13 #14 #15 imp:n=1 u=3 $ Interior
35 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 u=3 $ Polyethylene
Liner
36 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 u=3 $ Drum
37 3 -0.00129 13:-14:15 imp:n=1 u=3 $ Air around Drum
c
c
c
38 Drum - Universe 4
4 -0.92 -7 8 -9 #16 #17 #18 imp:n=1 u=4 $ Interior
39 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 u=4 $ Polyethylene
Liner
40 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 u=4 $ Drum
41 3 -0.00129 13:-14:15 imp:n=1 u=4 $ Air around Drum
c
c
c
42 Drum - Universe 5
4 -0.92 -7 8 -9 #19 #20 #21 imp:n=1 u=5 $ Interior
43 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 u=5 $ Polyethylene
Liner
44 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 u=5 $ Drum
45 3 -0.00129 13:-14:15 imp:n=1 u=5 $ Air around Drum
c
c
c
46 Drum - Universe 6
4 -0.92 -7 8 -9 #22 #23 #24 imp:n=1 u=6 $ Interior
47 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 u=6 $ Polyethylene
Liner
48 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 u=6 $ Drum
49 3 -0.00129 13:-14:15 imp:n=1 u=6 $ Air around Drum
c
c
c
50 Drum - Universe 7
4 -0.92 -7 8 -9 #25 #26 #27 imp:n=1 u=7 $ Interior
51 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 u=7 $ Polyethylene
Liner
52 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 u=7 $ Drum
53 3 -0.00129 13:-14:15 imp:n=1 u=7 $ Air around Drum
c
c
c
54 The Array
3 -0.00129 -27 35 -32 31 -34 33 fill=8 imp:n=1 $ The Array to be
filled
c
c
c
55 Hexagonal Universe - Universe 8
3 -0.00129 -21 20 -22 23 -24 25 -29 28
u=8 lat=2 imp:n=1 $ Hex around Drum
fill=-15:15 -15:15 -1:2
c
c
c
c
z=-1
c
c
c
x= -14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14
-15 -13 -11 -9 -7 -5 -3 -1 1 3 5 7 9 11 13 15

```

[illegible]

P	IN	B	END OF LINE
-	-	-	-

[illegible]

57	like 56 but trcl=(-12.079 -375.884 -19.200)	\$ Wagon Can #2	20	px	-28.729			\$
58	like 56 but trcl=(0.0 -360.529 -19.200)	\$ Wagon Can #3	21	px	28.729			\$
59	like 56 but trcl=(12.079 -375.884 -19.200)	\$ Wagon Can #4	c		A	B	C	D
60	like 56 but trcl=(24.158 -360.529 -19.200)	\$ Wagon Can #5	22	p	0.5	0.8660254	0	28.730
c			23	p	0.5	0.8660254	0	-28.730
c			24	p	-0.5	0.8660254	0	28.730
c			25	p	-0.5	0.8660254	0	-28.730
c			c					
61	2 -7.83 109 -110 104 -101 105 -108 imp:n=1	\$ Wagon Bed	c					
62	2 -7.83 110 -111 102 -101 105 -108 imp:n=1	\$ Near Wagon Wall	c					
63	2 -7.83 110 -111 104 -103 105 -108 imp:n=1	\$ Far Wagon Wall	26	pz	-42.380			\$ Bottom of Bottom
64	2 -7.83 110 -111 105 -106 103 -102 imp:n=1	\$ Front Wagon Wall	Layer					
65	2 -7.83 110 -111 107 -108 103 -102 imp:n=1	\$ Back Wagon Wall	27	pz	127.140			\$ Top of Top Layer
66	2 -7.83 110 -112 113 -114 imp:n=1	\$ Receptacle #1	28	pz	-42.3795			\$ Bottom of Fill
67	2 -7.83 110 -112 115 -116 imp:n=1	\$ Receptacle #2	Volume					
68	2 -7.83 110 -112 117 -118 imp:n=1	\$ Receptacle #3	29	pz	42.3795			\$ Top of Fill
69	2 -7.83 110 -112 119 -120 imp:n=1	\$ Receptacle #4	Volume					
70	2 -7.83 110 -112 121 -122 imp:n=1	\$ Receptacle #5	c					
71	3 -0.00129 110 -112 -113 #56 imp:n=1	\$ Air in	c					
Receptacle #1			31	px	-350.00			\$ Left Side of
72	3 -0.00129 110 -112 -115 #57 imp:n=1	\$ Air in	Room					
Receptacle #2			32	px	350.00			\$ Right Side of
73	3 -0.00129 110 -112 -117 #58 imp:n=1	\$ Air in	Room					
Receptacle #3			33	py	-351.50			\$ Front of Room
74	3 -0.00129 110 -112 -119 #59 imp:n=1	\$ Air in	34	py	350.00			\$ Back of Room
Receptacle #4			35	pz	-42.88			\$ Floor of Room
75	3 -0.00129 110 -112 -121 #60 imp:n=1	\$ Air in	36	pz	150.00			\$ Ceiling of Room
Receptacle #5			c					
76	3 -0.00129 110 -111 103 -102 106 -107 imp:n=1	\$ Air in Wagon	c					
77	3 -0.00129 111 -112 -101 105 104 -108 imp:n=1	\$ Air around Can	40	px	-380.48			\$ Left Wall
Tops			41	px	380.48			\$ Right Wall
78	2 -7.83 -125 127 -101 imp:n=1	\$ Near Front Wheel	42	py	-500.00			\$ Front Wall
79	2 -7.83 -125 104 -128 imp:n=1	\$ Far Front Wheel	43	py	380.48			\$ Back Wall
80	2 -7.83 -123 127 -101 imp:n=1	\$ Near Back Wheel	44	pz	-100.00			\$ Floor
81	2 -7.83 -123 104 -128 imp:n=1	\$ Far Back Wheel	45	pz	200.00			\$ Ceiling
82	10 -2.4 -126 125 127 -101 imp:n=1	\$ Near Front Tire	c					
83	10 -2.4 -126 125 104 -128 imp:n=1	\$ Far Front Tire	c					
84	10 -2.4 -124 123 127 -101 imp:n=1	\$ Near Back Tire	c					
85	10 -2.4 -124 123 104 -128 imp:n=1	\$ Far Back Tire	c					
c			101	py	-352.050			\$ Outside of Near Wagon
c			102	py	-352.263			\$ Inside of Near Wagon
c			103	py	-383.887			\$ Inside of Far Wagon
86	3 -0.00129 -32 31 -34 33 -36 27 imp:n=1	\$ Air above array	104	py	-384.150			\$ Outside of Far Wagon
87	5 -2.24 -35 44 -43 42 -41 40 imp:n=1	\$ Concrete Floor	105	px	-35.430			\$ Outside of Front Wagon
88	5 -2.24 -45 36 -43 42 -41 40 imp:n=1	\$ Concrete Ceiling	106	px	-35.167			\$ Inside of Front Wagon
89	5 -2.24 -36 35 -43 42 -41 32 imp:n=1	\$ Right Concrete	107	px	35.167			\$ Inside of Back Wagon
Wall			108	px	35.430			\$ Outside of Back Wagon
90	5 -2.24 -36 35 -43 42 -31 40 imp:n=1	\$ Left Concrete	109	pz	-19.521			\$ Bottom of Wagon
Wall			110	pz	-19.258			\$ Floor of Wagon
91	3 -0.00129 112 -129 104 -101 -108 105 imp:n=1	\$ Air Above Cans	111	pz	-6.558			\$ Top of Wagon Walls
92	3 -0.00129 -109 35 104 -101 -108 105 imp:n=1	\$ Air Under Wagon	112	pz	-4.018			\$ Top of Receptacle
93	5 -2.24 -36 35 -32 31 -43 34 imp:n=1	\$ Back Concrete	c					
Wall			113	c/z	-24.158	-360.529	6.724	\$ Receptacle #1 Inner
94	4 -0.92 -36 35 -33 42 -32 31 imp:n=1	\$ Front Poly Wall	Radius					
c			114	c/z	-24.158	-360.529	7.065	\$ Receptacle #1 Outer
95	0 41:-40:43:-42:45:-44 imp:n=0	\$ The Great Void	Radius					
c			115	c/z	-12.079	-375.884	6.724	\$ Receptacle #2 Inner
c			116	c/z	-12.079	-375.884	7.065	\$ Receptacle #2 Outer
c			117	c/z	0.000	-360.529	6.724	\$ Receptacle #3 Inner
1	cz 6.985	\$ Radius of Waste	Radius					
2	pz -8.890	\$ Bottom of Waste	118	c/z	0.000	-360.529	7.065	\$ Receptacle #3 Outer
3	pz 8.890	\$ Top of Waste	Radius					
4	cz 6.988	\$ Outside of Can	119	c/z	12.079	-375.884	6.725	\$ Receptacle #4 Inner
5	pz -8.893	\$ Bottom of Can	Radius					
6	pz 8.893	\$ Top of Can	120	c/z	12.079	-375.884	7.065	\$ Receptacle #4 Outer
c			Radius					
c			121	c/z	24.158	-360.529	6.725	\$ Receptacle #5 Inner
7	cz 28.485	\$ Radius of	Radius					
Interior			122	c/z	24.158	-360.529	7.065	\$ Receptacle #5 Outer
8	pz -41.999	\$ Bottom of	c					
Interior			123	c/y	23.980	-30.951	10.420	\$ Back Wheel Radius
9	pz 41.999	\$ Top of Interior	124	c/y	23.980	-30.951	11.420	\$ Back Tire Radius
c			125	c/y	-23.980	-30.951	10.420	\$ Front Wheel Radius
10	cz 28.575	\$ Radius of Liner	126	c/y	-23.980	-30.951	11.420	\$ Front Tire Radius
11	pz -42.227	\$ Bottom of Liner	c					
12	pz 42.227	\$ Top of Liner	127	py	-353.260			\$ Inside of Near Wheels
c			128	py	-382.940			\$ Inside of Far Wheels
13	cz 28.727	\$ Radius of Drum	129	pz	10.000			\$ Top of Air Above Wagon
14	pz -42.379	\$ Bottom of Drum	c					
15	pz 42.379	\$ Top of Drum						
16	pz 42.380	\$ Top above Drum						
c								
17	so 15.00	\$ Pu in other drum						
c								
c								
c								
	Hexagonal Surfaces (Ax+By+Cz=D)							

c	Can in Wagon			8016.50c	-0.8738	\$ O
c				94239.55c	-0.0162	\$ Pu
201	cz	6.327	\$ Inside of Wagon Can	mt11	poly.01t	
202	cz	6.350	\$ Outside of Wagon Can	c		
203	pz	0.0	\$ Bottom of Wagon Can	totru		
204	pz	0.023	\$ Bottom of Plutonium	ctme	480	
205	pz	3.991	\$ Top of Plutonium	print		
206	pz	21.291	\$ Inside of Top of Wagon			
Can						
207	pz	21.314	\$ Outside of Top of	nonpipe_lat6.inp		
Wagon Can				Three Billets in a Non-pipe 55 Gallon Drum		
208	cz	3.968	\$ Radius of Plutonium	three 66.7 g Pu billets in a 200 g/drum		
				Lattice Model with Wagon		
mode n				Cell Definitions		
kcode	3000	1.0 10 100		Can Contents - Universe 1		
ksrc	0.0	-360.0 -15.0		1	-1.024 -1 2 -3	imp:n=1 u=1 \$ Cemented Waste
	10.0	-345.0 -15.0		2	3 -0.00129 1:-2:3	imp:n=1 u=1 \$ Steel Can
	-10.0	-345.0 -15.0		Over Batched Can Contents - Universe 9		
	15.0	-335.0 -15.0		3	-1.024 -1 2 -3	imp:n=1 u=9 \$ Cemented Waste
	-15.0	-335.0 -15.0		4	3 -0.00129 1:-2:3	imp:n=1 u=9 \$ Steel Can
c				Wagon Can Contents - Universe 10		
c				5	11 -19.6 -208 204 -205	u=10 imp:n=1 \$ Plutonium Oxide
c				6	3 -0.00129 201:-204:206	u=10 imp:n=1 \$ Can
c				7	3 -0.00129 -201 204 -206 #5	u=10 imp:n=1 \$ Air above Oxide
c				Lower Can (0.0,0) - Universe 2		
c				10	3 -0.00129 -4 5 -6	fill=1 u=2 imp:n=1
c					dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M	
c					trcl*=(-8.15 0.000 20.1 30 60 90 120 30 90 90 90 0 -1)	
c						\$ Can 1
c				11	like 10 but	
c					trcl*=(-20.25 7.015 20.1 30 60 90 120 30 90 90 90 0 -1)	
c						\$ Can 2
c				12	like 10 but	
c					trcl*=(-20.25 -7.015 20.1 30 60 90 120 30 90 90 90 0 -1)	
c						\$ Can 3
c				Lower Can (1.0,0) - Universe 3		
c				13	3 -0.00129 -4 5 -6	fill=1 u=3 imp:n=1
c					dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M	
c					trcl*=(8.15 0.000 20.1 30 120 90 60 30 90 90 90 0 -1)	
c						\$ Can 1
c				14	like 13 but	
c					trcl*=(-20.25 7.015 20.1 30 120 90 60 30 90 90 90 0 -1)	
c						\$ Can 2
c				15	like 13 but	
c					trcl*=(-20.25 -7.015 20.1 30 120 90 60 30 90 90 90 0 -1)	
c						\$ Can 3
c				Lower Can (0.1,0) - Universe 4		
c				16	3 -0.00129 -4 5 -6	fill=1 u=4 imp:n=1
c					dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M	
c					trcl*=(-8.15 0.000 20.1 90 180 90 0 90 90 90 90 0 -1)	
c						\$ Can 1
c				17	like 16 but	
c					trcl*=(-20.25 7.015 20.1 90 180 90 0 90 90 90 90 0 -1)	
c						\$ Can 2
c				18	like 16 but	
c					trcl*=(-20.25 -7.015 20.1 90 180 90 0 90 90 90 90 0 -1)	
c						\$ Can 3
c				Upper Can (0.0,0) - Universe 5		
c				19	3 -0.00129 -4 5 -6	fill=9 u=5 imp:n=1
c					dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M	
c					trcl*=(-8.15 0.000 20.1 30 60 90 120 30 90 90 90 0 -1)	
c						\$ Can 1
c				20	like 19 but	
c					trcl*=(-20.25 7.015 20.1 30 60 90 120 30 90 90 90 0 -1)	
c						\$ Can 2
c				21	like 19 but	
c					trcl*=(-20.25 -7.015 20.1 30 60 90 120 30 90 90 90 0 -1)	
c						\$ Can 3
c				Upper Can (1.0,0) - Universe 6		
c				22	3 -0.00129 -4 5 -6	fill=9 u=6 imp:n=1
c					dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M	
c					trcl*=(8.15 0.000 20.1 30 120 90 60 30 90 90 90 0 -1)	
c						\$ Can 1
c				23	like 22 but	
c					trcl*=(-20.25 7.015 20.1 30 120 90 60 30 90 90 90 0 -1)	

m2	SS-304 (7.83 g/cc)		
	6000.50c	-0.000293	\$ C
	14000.50c	-0.007497	\$ Si
	15031.50c	-0.000447	\$ P
	16032.50c	-0.000294	\$ S
	24000.50c	-0.200003	\$ Cr
	25055.50c	-0.020000	\$ Mn
	26000.55c	-0.651464	\$ Fe
	28000.50c	-0.120002	\$ Ni
m3	Air (0.00129 g/cc)		
	7014.50c	-0.78084	\$ N
	8016.50c	-0.20946	\$ O
	18000.35c	-0.00934	\$ Arc
m4	Polyethylene (0.92 g/cc)		
	6000.50c	0.03952	\$ C
	1001.50c	0.07903	\$ H
mt4	poly.01t		
m5	Concrete (2.24 g/cc)		
	1001.50c	-0.009959	\$ H
	6000.50c	-0.000979	\$ C
	8016.50c	-0.529069	\$ O
	11023.50c	-0.016003	\$ Na
	12000.50c	-0.002000	\$ Mg
	13027.50c	-0.034006	\$ Al
	14000.50c	-0.337036	\$ Si
	19000.50c	-0.012981	\$ K
	20000.50c	-0.043965	\$ Ca
	26000.55c	-0.014002	\$ Fe
mt5	poly.01t		
m6	Water (1.0 g/cc)		
	1001.50c	-0.1119	\$ H
	8016.50c	-0.8881	\$ O
mt6	lwtr.01t		\$ Light Water
m7	Cellulose (1.45 g/cc)		
	1001.50c	0.054311	\$ Cellulose Reflector
	8016.50c	0.026949	
	6000.50c	0.03233	
mt7	poly.01t		
m8	Polyethylene (0.92 g/cc)		
	6000.50c	0.03952	\$ Polyethylene Reflector
	1001.50c	0.07903	
mt8	poly.01t		
m9	Water (1.1468 g/cc)		
	1001.50c	-0.1097	\$ H
	8016.50c	-0.8703	\$ O
	94239.55c	-0.1468	\$ Pu
mt9	lwtr.01t		\$ Light Water
m10	Rubber (2.4 g/cc)		
	1001.50c	0.66667	\$ H
	6012.50c	0.33333	\$ C
mt10	poly.01t		
m11	Cemented Waste (1.041 g/cc) 65% Water		
	1001.50c	-0.1101	\$ H

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[illegible]

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[illegible]

		z=2																
		x=	-14	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	12	14	
			-15	-13	-11	-9	-7	-5	-3	-1	1	3	5	7	9	11	13	15
y=-15			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=-14			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=-13			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=-12			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=-11			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=-10			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=-9			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=-8			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=-7			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=-6			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=-5			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=-4			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=-3			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=-2			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=-1			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=0			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=1			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=2			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=3			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=4			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=5			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=6			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=7			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=8			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=9			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=10			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=11			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=12			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=13			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=14			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
y=15			\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
C																		
C																		
C																		
56		3	-0.00129	-202	203	-207	fill=10											
							trcl=(-24.158	-360.529	-19.200)									
57		like 56 but	trcl=(-12.079	-375.884	-19.200)													
58		like 56 but	trcl=(0.0	-36														

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72	3	-0.00129	110	-112	-115	#57	imp:n=1	\$ Air in	31	px	-350.00	\$ Left Side of
Receptacle #2									Room			
73	3	-0.00129	110	-112	-117	#58	imp:n=1	\$ Air in	32	px	350.00	\$ Right Side of
Receptacle #3									Room			
74	3	-0.00129	110	-112	-119	#59	imp:n=1	\$ Air in	33	py	-351.50	\$ Front of Room
Receptacle #4									34	py	350.00	\$ Back of Room
75	3	-0.00129	110	-112	-121	#60	imp:n=1	\$ Air in	35	pz	-42.88	\$ Floor of Room
Receptacle #5									36	pz	150.00	\$ Ceiling of Room
76	3	-0.00129	110	-111	103	-102 106 -107			c			
			114	116	118	120 122	imp:n=1	\$ Air in Wagon	c			Walls, Ceiling, Floor
77	3	-0.00129	111	-112	-101	105 104 -108			40	px	-380.48	\$ Left Wall
			114	116	118	120 122	imp:n=1	\$ Air around Can	41	px	380.48	\$ Right Wall
Tops									42	py	-500.00	\$ Front Wall
78	2	-7.83	-125	127	-101		imp:n=1	\$ Near Front Wheel	43	py	380.48	\$ Back Wall
79	2	-7.83	-125	104	-128		imp:n=1	\$ Far Front Wheel				
80	2	-7.83	-123	127	-101		imp:n=1	\$ Near Back Wheel				
81	2	-7.83	-123	104	-128		imp:n=1	\$ Far Back Wheel	44	pz	-100.00	\$ Floor
82	10	-2.4	-126	125	127	-101	imp:n=1	\$ Near Front Tire	45	pz	200.00	\$ Ceiling
83	10	-2.4	-126	125	104	-128	imp:n=1	\$ Far Front Tire	c			
84	10	-2.4	-124	123	127	-101	imp:n=1	\$ Near Back Tire	c			Wagon
85	10	-2.4	-124	123	104	-128	imp:n=1	\$ Far Back Tire	c			
c									101	py	-352.050	\$ Outside of Near Wagon
c									Wall			
c									102	py	-352.263	\$ Inside of Near Wagon
86	3	-0.00129	-32	31	-34	33 -36 27	imp:n=1	\$ Air above array	Wall			
87	5	-2.24	-35	44	-43	42 -41 40	imp:n=1	\$ Concrete Floor	103	py	-383.887	\$ Inside of Far Wagon
88	5	-2.24	-45	36	-43	42 -41 40	imp:n=1	\$ Concrete Ceiling	Wall			
89	5	-2.24	-36	35	-43	42 -41 32	imp:n=1	\$ Right Concrete	104	py	-384.150	\$ Outside of Far Wagon
Wall									Wall			
90	5	-2.24	-36	35	-43	42 -31 40	imp:n=1	\$ Left Concrete	105	px	-35.430	\$ Outside of Front Wagon
Wall									Wall			
91	3	-0.00129	112	-129	104	-101 -108 105			106	px	-35.167	\$ Inside of Front Wagon
						#56 #57 #58 #59 #60	imp:n=1	\$ Air Above Cans	Wall			
92	3	-0.00129	-109	35	104	-101 -108 105			107	px	35.167	\$ Inside of Back Wagon
						#78 #79 #80 #81 #82 #83 #84 #85	imp:n=1	\$ Air Under Wagon	Wall			
93	5	-2.24	-36	35	-32	31 -43 34	imp:n=1	\$ Back Concrete	108	px	35.430	\$ Outside of Back Wagon
Wall									Wall			
94	4	-0.92		36	35	-33 42 -32 31			109	pz	-19.521	\$ Bottom of Wagon
						(129:101:-105:108:-104)	imp:n=1	\$ Front Poly Wall	110	pz	-19.258	\$ Floor of Wagon
c									111	pz	-6.558	\$ Top of Wagon Walls
95	0	41:-40:43:-42:45:-44					imp:n=0	\$ The Great Void	112	pz	-4.018	\$ Top of Receptacle
c									c			
c									113	c/z	-24.158	\$ Receptacle #1 Inner
c									Radius			
1	cz	6.985						\$ Radius of Waste	114	c/z	-24.158	\$ Receptacle #1 Outer
2	pz	-8.890						\$ Bottom of Waste	Radius			
3	pz	8.890						\$ Top of Waste	115	c/z	-12.079	\$ Receptacle #2 Inner
4	cz	6.988						\$ Outside of Can	Radius			
5	pz	-8.893						\$ Bottom of Can	116	c/z	-12.079	\$ Receptacle #2 Outer
6	pz	8.893						\$ Top of Can	Radius			
c									117	c/z	0.000	\$ Receptacle #3 Inner
c									Radius			
7	cz	28.485						\$ Radius of	118	c/z	0.000	\$ Receptacle #3 Outer
Interior									Radius			
8	pz	-41.999						\$ Bottom of	119	c/z	12.079	\$ Receptacle #4 Inner
Interior									Radius			
9	pz	41.999						\$ Top of Interior	120	c/z	12.079	\$ Receptacle #4 Outer
c									Radius			
10	cz	28.575						\$ Radius of Liner	121	c/z	24.158	\$ Receptacle #5 Inner
11	pz	-42.227						\$ Bottom of Liner	Radius			
12	pz	42.227						\$ Top of Liner	122	c/z	24.158	\$ Receptacle #5 Outer
c									Radius			
13	cz	28.727						\$ Radius of Drum	c			
14	pz	-42.379						\$ Bottom of Drum	123	c/y	23.980	\$ Back Wheel Radius
15	pz	42.379						\$ Top of Drum	124	c/y	23.980	\$ Back Tire Radius
16	pz	42.380						\$ Top above Drum	125	c/y	-23.980	\$ Front Wheel Radius
c									126	c/y	-23.980	\$ Front Tire Radius
17	so	15.00						\$ Pu in other drum	c			
c									127	py	-353.260	\$ Inside of Near Wheels
c									128	py	-382.940	\$ Inside of Far Wheels
c									129	pz	10.000	\$ Top of Air Above Wagon
20	px	-28.729							c			
21	px	28.729							c			
c									c			Can in Wagon
22	p	0.5	0.8660254	0	28.730	\$			201	cz	6.327	\$ Inside of Wagon Can
23	p	0.5	0.8660254	0	-28.730	\$			202	cz	6.350	\$ Outside of Wagon Can
24	p	-0.5	0.8660254	0	28.730	\$			203	pz	0.0	\$ Bottom of Wagon Can
25	p	-0.5	0.8660254	0	-28.730	\$			204	pz	0.023	\$ Bottom of Plutonium
c									205	pz	5.502	\$ Top of Plutonium
c									206	pz	21.291	\$ Inside of Top of Wagon
26	pz	-42.380						\$ Bottom of Bottom	Can			
Layer									207	pz	21.314	\$ Outside of Top of
27	pz	127.140						\$ Top of Top Layer	Wagon			
28	pz	-42.3795						\$ Bottom of Fill	Can			
Volume									208	cz	2.728	\$ Radius of Plutonium
29	pz	42.3795						\$ Top of Fill	mode n			
Volume									kcode	3000	1.0	10 100
c									ksrc		0.0	-360.0 -15.0
c											10.0	-345.0 -15.0
											-10.0	-345.0 -15.0

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```

15.0 -335.0 -15.0
15.0 -335.0 -15.0
c
c Cemented Waste (1.024 g/cc) 65% Water
m1 1001.50c -0.1092 $ H
8016.50c -0.8669 $ O
94239.55c -0.0239 $ Pu
mt1 poly.01t
c
c
c SS-304 (7.83 g/cc)
m2 6000.50c -0.000293 $ C
14000.50c -0.007497 $ Si
15031.50c -0.000447 $ P
16032.50c -0.000294 $ S
24000.50c -0.200003 $ Cr
25055.50c -0.020000 $ Mn
26000.55c -0.651464 $ Fe
28000.50c -0.120002 $ Ni
c
c Air (0.00129 g/cc)
m3 7014.50c -0.78084 $ N
8016.50c -0.20946 $ O
18000.35c -0.00934 $ Arc
c
c Polyethylene (0.92 g/cc)
m4 6000.50c 0.03952 $ C
1001.50c 0.07903 $ H
mt4 poly.01t
c
c Concrete (2.24 g/cc)
m5 1001.50c -0.009959 $ H
6000.50c -0.000979 $ C
8016.50c -0.529069 $ O
11023.50c -0.016003 $ Na
12000.50c -0.002000 $ Mg
13027.50c -0.034006 $ Al
14000.50c -0.337036 $ Si
19000.50c -0.012981 $ K
20000.50c -0.043965 $ Ca
26000.55c -0.014002 $ Fe
mt5 poly.01t
c
c Water (1.0 g/cc)
m6 1001.50c -0.1119 $ H
8016.50c -0.8881 $ O
mt6 lwtr.01t $ Light Water
c
c Cellulose (1.45 g/cc)
m7 1001.50c 0.054311 $ Cellulose Reflector
8016.50c 0.026949
6000.50c 0.03233
mt7 poly.01t
c
c Polyethylene (0.92 g/cc)
m8 6000.50c 0.03952 $ Polyethylene Reflector
1001.50c 0.07903
mt8 poly.01t
c
c Water (1.1468 g/cc)
m9 1001.50c -0.1097 $ H
8016.50c -0.8703 $ O
94239.55c -0.1468 $ Pu
mt9 lwtr.01t $ Light Water
c
c Rubber (2.4 g/cc)
m10 1001.50c 0.66667 $ H
6012.50c 0.33333 $ C
mt10 poly.01t
c
c Pu Metal (19.6 g/cc)
m11 94239.55c -1.000 $ Pu-239
c
totnu
ctme 480
print

```

nonpipe_ref21.inp

```

Three Billets in a Non-pipe 55 Gallon Drum
c three 66.7 g Pu billets at the bottom of a 200 g/drum
c Infinite relection -Two Layers
c Silicon replaces Calcium
c
c Cell Definitions
c
c Can Contents - Universe 1
1 1 -1.024 -1 2 -3 imp:n=1 u=1 $ Cemented Waste

```

```

2 3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can
c
c Bottom Can - Universe 2
10 3 -0.00129 -4 5 -6 fill=1 imp:n=1
trcl=( 8.150 0.00 33.100 ) $ Can 18
11 like 10 but trcl=( 20.250 7.015 33.100 ) $ Can 28
12 like 10 but trcl=( 20.250 -7.015 33.100 ) $ Can 38
c
c Top Can - Universe 3
15 like 10 but trcl=( 8.150 0.00 54.460 ) $ Can 17
16 like 10 but trcl=( 20.250 7.015 54.460 ) $ Can 27
17 like 10 but trcl=( 20.250 -7.015 54.460 ) $ Can 37
c
c Bottom Drum - Universe 4
20 4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1 $ Interior
21 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 $ Polyethylene
Liner
22 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 $ Drum
c
c Top Drum - Universe 5
25 4 -0.92 -7 8 -9 #15 #16 #17 imp:n=1
trcl=( 0.0 0.0 87.56 ) $ Interior
26 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1
trcl=( 0.0 0.0 87.56 ) $ Polyethylene
Liner
27 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1
trcl=( 0.0 0.0 87.56 ) $ Drum
c
30 3 -0.00129 20 -21 -22 -23 24 25 #10 #11 #12 #15 #16 #17 -17 18
#20 #21 #22 #25 #26 #27 imp:n=1 $ Hex around Drum
31 5 -2.24 38 -18 20 -21 -22 -23 24 25 imp:n=1 $ Concrete Floor
32 3 -0.00129 -37 17 20 -21 -22 -23 24 25 imp:n=1 $ Air Above Drums
c
50 0 (-20:21:22:23:-24:-25:37:-38) imp:n=0 $ The Great Void
c
c Surface Definitions
c
c Billets
1 cz 6.985 $ Radius of Waste
2 pz -8.890 $ Bottom of Waste
3 pz 8.890 $ Top of Waste
4 cz 6.988 $ Outside of Can
5 pz -8.893 $ Bottom of Can
6 pz 8.893 $ Top of Can
c
c Drum
7 cz 28.485 $ Radius of
8 pz -41.999 $ Bottom of
9 pz 41.999 $ Top of Interior
c
10 cz 28.575 $ Radius of Liner
11 pz -42.227 $ Bottom of Liner
12 pz 42.227 $ Top of Liner
c
13 cz 28.727 $ Radius of Drum
14 pz -42.379 $ Bottom of Drum
15 pz 42.379 $ Top of Drum
16 pz 42.380 $ Top above Drum
17 pz 130.0 $ Top above Top
Drum
18 pz -42.380 $ Floor
c
c Hexagonal Surfaces (Ax+By+Cz=D)
*20 px -28.729 $
*21 px 28.729 $
c
*22 p 0.5 0.8660254 0 28.730 $
*23 p -0.5 0.8660254 0 28.730 $
*24 p 0.5 0.8660254 0 -28.730 $
*25 p -0.5 0.8660254 0 -28.730 $
c
36 pz -42.381 $ Concrete Floor
37 pz 200.00 $ Top of the World
38 pz -100.00 $ Bottom of the
World

```

```

mode n
kcode 3000 1.0 10 100
ksrc 8.150 0.00 33.100
c
c Cemented Waste (1.029 g/cc) 65% Water
m1 1001.50c -0.1092 $ H
8016.50c -0.8669 $ O
94239.55c -0.0239 $ Pu
mt1 poly.01t
c

```

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```

c
c      SS-304 (7.83 g/cc)
m2      6000.50c -0.000293 $ C
          14000.50c -0.007497 $ Si
          15031.50c -0.000447 $ P
          16032.50c -0.000294 $ S
          24000.50c -0.200003 $ Cr
          25055.50c -0.020000 $ Mn
          26000.55c -0.651464 $ Fe
          28000.50c -0.120002 $ Ni
c
c      Air (0.00129 g/cc)
m3      7014.50c -0.78084 $ N
          8016.50c -0.20982 $ O
          18000.35c -0.00934 $ Arc
c
c      Polyethylene (0.92 g/cc)
m4      6000.50c 0.03952 $ C
          1001.50c 0.07903 $ H
mt4      poly.01t
c
c      Concrete (2.24 g/cc)
m5      1001.50c -0.009959 $ H
          6000.50c -0.000979 $ C
          8016.50c -0.529069 $ O
          11023.50c -0.016003 $ Na
          12000.50c -0.002000 $ Mg
          13027.50c -0.034006 $ Al
          14000.50c -0.337036 $ Si
          19000.50c -0.012981 $ K
          20000.50c -0.043965 $ Ca
          26000.55c -0.014002 $ Fe
mt5      poly.01t
c
c      Water (1.0 g/cc)
m6      1001.50c -0.1119 $ H
          8016.50c -0.8881 $ O
mt6      1wtr.01t $ Light Water
c
c      Cellulose (1.45 g/cc)
m7      1001.50c 0.054311 $ Cellulose Reflector
          8016.50c 0.026949
          6000.50c 0.03233
mt7      poly.01t
c
c      Polyethylene (0.92 g/cc)
m8      6000.50c 0.03952 $ Polyethylene Reflector
          1001.50c 0.07903
mt8      poly.01t
c
c      Water (1.02 g/cc)
m9      1001.50c -0.1097 $ H
          8016.50c -0.8703 $ O
          94239.55c -0.0200 $ Pu
mt9      1wtr.01t $ Light Water
c
totnu
ctme 480
print

```

nonpipe.ref2p.inp

```

Three Billets in a Non-pipe 55 Gallon Drum
c      three 66.7 g Pu billets at the bottom of a 200 g/drum
c      One reflecting boundary (two drums)-Poly
c
c      Cell Definitions
c
c      Can Contents - Universe 1
1      1 -1.024 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
2      3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can
c
c      Can - Universe 2
10     3 -0.00129 -4 5 -6 fill=1 imp:n=1
          trcl=( 8.150 0.00 -33.100 ) $ Can 1
11     like 10 but trcl=( 20.250 7.015 -33.100 ) $ Can 2
12     like 10 but trcl=( 20.250 -7.015 -33.100 ) $ Can 3
c
c      Drum - Universe 2
20     4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1 $ Interior
21     4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 $ Polyethylene
Liner
24     2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 $ Drum
25     3 -0.00129 20 -21 -22 -23 24 25 14 -15 13
          imp:n=1 $ Hex around Drum
c
c      The Room
30     3 -0.00129 -37 36 (-20:21:22:23:-24:-25:15:-14) -21

```

```

31     5 -2.24 -36 -37 -21 imp:n=1 $ Air around Drum
c      imp:n=1 $ Concrete Floor
50     0 37:21 imp:n=0 $ The Great Void
c
c      Surface Definitions
c
c      Billets
1      cz 6.985 $ Radius of Waste
2      pz 8.890 $ Bottom of Waste
3      pz 8.890 $ Top of Waste
4      cz 6.988 $ Outside of Can
5      pz -8.893 $ Bottom of Can
6      pz 8.893 $ Top of Can
c
c      Drum
7      cz 28.485 $ Radius of
Interior
8      pz -41.999 $ Bottom of
Interior
9      pz 41.999 $ Top of Interior
10     cz 28.575 $ Radius of Liner
11     pz -42.227 $ Bottom of Liner
12     pz 42.227 $ Top of Liner
13     cz 28.727 $ Radius of Drum
14     pz -42.379 $ Bottom of Drum
15     pz 42.379 $ Top of Drum
16     pz 42.380 $ Top above Drum
c
c      Hexagonal Surfaces (Ax+By+Cz=D)
20     px -28.729 $
*21    px 28.729 $
c
22     p 0.5 0.8660254 0 28.730 $
23     p -0.5 0.8660254 0 28.730 $
24     p 0.5 0.8660254 0 -28.730 $
25     p -0.5 0.8660254 0 -28.730 $
c
36     pz -42.381 $ Concrete Floor
37     so 100.00 $ End of the World
c
mode n
kcode 3000 1.0 10 100
ksrc 8.150 0.00 -33.100
c
c      Cemented Waste (1.024 g/cc) 65% Water
m1     1001.50c -0.1092 $ H
          8016.50c -0.8669 $ O
          94239.55c -0.0239 $ Pu
mt1    poly.01t
c
c      SS-304 (7.83 g/cc)
m2     6000.50c -0.000293 $ C
          14000.50c -0.007497 $ Si
          15031.50c -0.000447 $ P
          16032.50c -0.000294 $ S
          24000.50c -0.200003 $ Cr
          25055.50c -0.020000 $ Mn
          26000.55c -0.651464 $ Fe
          28000.50c -0.120002 $ Ni
c
c      Air (0.00129 g/cc)
m3     7014.50c -0.78084 $ N
          8016.50c -0.20946 $ O
          18000.35c -0.00934 $ Ar
c
c      Polyethylene (0.92 g/cc)
m4     6000.50c 0.03952 $ C
          1001.50c 0.07903 $ H
mt4     poly.01t
c
c      Concrete (2.24 g/cc)
m5     1001.50c -0.009959 $ H
          6000.50c -0.000979 $ C
          8016.50c -0.529069 $ O
          11023.50c -0.016003 $ Na
          12000.50c -0.002000 $ Mg
          13027.50c -0.034006 $ Al
          14000.50c -0.337036 $ Si
          19000.50c -0.012981 $ K
          20000.50c -0.043965 $ Ca
          26000.55c -0.014002 $ Fe
mt5     poly.01t
c
c      Water (1.0 g/cc)
m6     1001.50c -0.1119 $ H
          8016.50c -0.8881 $ O

```

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```

mt6 lwtr.01t $ Light Water
c
c Cellulose (1.45 g/cc)
m7 1001.50c 0.054311 $ Cellulose Reflector
    8016.50c 0.026949
    6000.50c 0.03233
mt7 poly.01t
c
c Polyethylene (0.92 g/cc)
m8 6000.50c 0.03952 $ Polyethylene Reflector
    1001.50c 0.07903
mt8 poly.01t
c
c Water (1.02 g/cc)
m9 1001.50c -0.1097 $ H
    8016.50c -0.8703 $ O
    94239.55c -0.0200 $ Pu
mt9 lwtr.01t $ Light Water
c
totnu
ctme 480
print

```

nonpipe.refp.inp

```

Three Billets in a Non-pipe 55 Gallon Drum
c three 66.7 g Pu billets at the bottom of a 200 g/drum
c Infinite reflection-Poly
c
c Cell Definitions
c
c Can Contents - Universe 1
1 1 -1.024 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
2 3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can
c
c Can - Universe 2
10 3 -0.00129 -4 5 -6 fill=1 imp:n=1
    trcl=( 8.150 0.00 -33.100 ) $ Can 1
11 like 10 but trcl=( 20.250 7.015 -33.100 ) $ Can 2
12 like 10 but trcl=( 20.250 -7.015 -33.100 ) $ Can 3
c
c Drum - Universe 2
20 4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1 $ Interior
21 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 $ Polyethylene
Liner
24 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 $ Drum
25 3 -0.00129 20 -21 -22 -23 24 25 14 -15 13
    imp:n=1 $ Hex around Drum
31 5 -2.24 38 -14 20 -21 -22 -23 24 25
    imp:n=1 $ Concrete Floor
32 3 -0.00129 -37 15 20 -21 -22 -23 24 25
    imp:n=1 $ Air Above Drums
c
50 0 (-20:21:22:23:-24:-25:37:-38) imp:n=0 $ The Great Void
c
c Surface Definitions
c
c Billets
1 cz 6.985 $ Radius of Waste
2 pz -8.890 $ Bottom of Waste
3 pz 8.890 $ Top of Waste
4 cz 6.988 $ Outside of Can
5 pz -8.893 $ Bottom of Can
6 pz 8.893 $ Top of Can
c
c Drum
7 cz 28.485 $ Radius of
8 pz -41.999 $ Bottom of
Interior pz 41.999 $ Top of Interior
c
10 cz 28.575 $ Radius of Liner
11 pz -42.227 $ Bottom of Liner
12 pz 42.227 $ Top of Liner
c
13 cz 28.727 $ Radius of Drum
14 pz -42.379 $ Bottom of Drum
15 pz 42.379 $ Top of Drum
16 pz 42.380 $ Top above Drum
c
c Hexagonal Surfaces (Ax+By+Cz=D)
*20 px -28.729 $
*21 px 28.729 $
c
A B C D $
*22 p 0.5 0.8660254 0 28.730 $
*23 p -0.5 0.8660254 0 28.730 $
*24 p 0.5 0.8660254 0 -28.730 $
*25 p -0.5 0.8660254 0 -28.730 $

```

```

c
36 pz -42.381 $ Concrete Floor
37 pz 100.00 $ Top of the World
38 pz -100.00 $ Bottom of the
World
mode n
kcode 3000 1.0 10 100
ksrc 8.150 0.00 -33.100
c
c Cemented Waste (1.024 g/cc) 65% Water
m1 1001.50c -0.1092 $ H
    8016.50c -0.8669 $ O
    94239.55c -0.0239 $ Pu
mt1 poly.01t
c
c
c SS-304 (7.83 g/cc)
m2 6000.50c -0.000293 $ C
    14000.50c -0.007497 $ Si
    15031.50c -0.000447 $ P
    16032.50c -0.000294 $ S
    24000.50c -0.200003 $ Cr
    25055.50c 0.020000 $ Mn
    26000.55c -0.651464 $ Fe
    28000.50c -0.120002 $ Ni
c
c Air (0.00129 g/cc)
m3 7014.50c -0.78084 $ N
    8016.50c -0.20982 $ O
    18000.35c -0.00934 $ Ar
c
c Polyethylene (0.92 g/cc)
m4 6000.50c 0.03952 $ C
    1001.50c 0.07903 $ H
mt4 poly.01t
c
c Concrete (2.24 g/cc)
m5 1001.50c -0.009959 $ H
    6000.50c -0.000979 $ C
    8016.50c -0.529069 $ O
    11023.50c -0.016003 $ Na
    12000.50c -0.002000 $ Mg
    13027.50c -0.034006 $ Al
    14000.50c -0.337036 $ Si
    19000.50c -0.012981 $ K
    20000.50c -0.043965 $ Ca
    26000.55c -0.014002 $ Fe
mt5 poly.01t
c
c Water (1.0 g/cc)
m6 1001.50c -0.1119 $ H
    8016.50c -0.8881 $ O
mt6 lwtr.01t $ Light Water
c
c Cellulose (1.45 g/cc)
m7 1001.50c 0.054311 $ Cellulose Reflector
    8016.50c 0.026949
    6000.50c 0.03233
mt7 poly.01t
c
c Polyethylene (0.92 g/cc)
m8 6000.50c 0.03952 $ Polyethylene Reflector
    1001.50c 0.07903
mt8 poly.01t
c
c Water (1.02 g/cc)
m9 1001.50c -0.1097 $ H
    8016.50c -0.8703 $ O
    94239.55c -0.0200 $ Pu
mt9 lwtr.01t $ Light Water
c
totnu
ctme 480
print

```

nonpipe.refrot21.inp

```

Three Billets in a Non-pipe 55 Gallon Drum
c three 66.7 g Pu billets at the bottom of a 200 g/drum
c Infinite reflection -Two Layers
c Silicon replaces Calcium
c
c Cell Definitions
c
c Can Contents - Universe 1
1 1 -1.024 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
2 3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can

```

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```

c
c      Bottom Can - Universe 2
10 3 -0.00129 -4 5 -6 fill=1 imp:n=1
c      dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
      trcl*=( 8.15 0.000 -33.1 30 60 90 120 30 90 90 90 0 -1)

11 like 10 but
      trcl*=(20.25 7.015 -33.1 30 60 90 120 30 90 90 90 0 -1)
12 like 10 but
      trcl*=(20.25 -7.015 -33.1 30 60 90 120 30 90 90 90 0 -1)
c
c      Top Can - Universe 3
15 3 -0.00129 -4 5 -6 fill=1 imp:n=1
c      dx dy dz xx' yx' zx' xy' yy' zy' xz' yz' zz' M
      trcl*=( 8.15 0.000 -54.46 30 60 90 120 30 90 90 90 0 -1)

16 like 10 but
      trcl*=(20.25 7.015 -54.46 30 60 90 120 30 90 90 90 0 -1)
17 like 10 but
      trcl*=(20.25 -7.015 -54.46 30 60 90 120 30 90 90 90 0 -1)
c
c      Bottom Drum - Universe 4
20 4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1 $ Interior
21 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 $ Polyethylene
Liner
22 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 $ Drum
c
c      Top Drum - Universe 5
25 4 -0.92 -7 8 -9 #15 #16 #17 imp:n=1
      trcl=( 0.0 0.0 87.56 ) $ Interior
26 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 $ Polyethylene
      trcl=( 0.0 0.0 87.56 )
Liner
27 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 $ Drum
      trcl=( 0.0 0.0 87.56 )
c
30 3 -0.00129 20 -21 -22 -23 24 25 #10 #11 #12 #15 #16 #17 -17 18
      #20 #21 #22 #25 #26 #27 imp:n=1 $ Hex around Drum
31 5 -2.24 38 -18 20 -21 -22 -23 24 25
      imp:n=1 $ Concrete Floor
32 3 -0.00129 -37 17 20 -21 -22 -23 24 25
      imp:n=1 $ Air Above Drums
c
50 0 (-20:21:22:23:-24:-25:37:-38) imp:n=0 $ The Great Void

c
c      Surface Definitions
c
c      Billets
1 cz 6.985 $ Radius of Waste
2 pz -8.890 $ Bottom of Waste
3 pz 8.890 $ Top of Waste
4 cz 6.988 $ Outside of Can
5 pz -8.893 $ Bottom of Can
6 pz 8.893 $ Top of Can

c
c      Drum
7 cz 28.485 $ Radius of
8 pz -41.999 $ Bottom of
9 pz 41.999 $ Top of Interior
10 cz 28.575 $ Radius of Liner
11 pz -42.227 $ Bottom of Liner
12 pz 42.227 $ Top of Liner

13 cz 28.727 $ Radius of Drum
14 pz -42.379 $ Bottom of Drum
15 pz 42.379 $ Top of Drum
16 pz 42.380 $ Top above Drum
17 pz 130.0 $ Top above Top
Drum
18 pz -42.380 $ Floor

c
c      Hexagonal Surfaces (Ax+By+Cz=0)
*20 px -28.729 $
*21 px 28.729 $
c      A B C D $
*22 p 0.5 0.8660254 0 28.730 $
*23 p -0.5 0.8660254 0 28.730 $
*24 p 0.5 0.8660254 0 -28.730 $
*25 p -0.5 0.8660254 0 -28.730 $
c
36 pz -42.381 $ Concrete Floor

37 pz 200.00 $ Top of the World
38 pz -100.00 $ Bottom of the World

mode n
kcode 3000 1.0 10 100
ksrc -8.150 0.00 33.100
-8.15 0.0 54.46

c
c      Cemented Waste (1.024 g/cc) 65% Water
m1 1001.50c -0.1092 $ H
8016.50c -0.8669 $ O
94239.55c -0.0239 $ Pu
mt1 poly.01t

c
c      SS-304 (7.83 g/cc)
m2 6000.50c -0.000293 $ C
14000.50c -0.007497 $ Si
15031.50c -0.000447 $ P
16032.50c -0.000294 $ S
24000.50c -0.200003 $ Cr
25055.50c -0.020000 $ Mn
26000.55c -0.651464 $ Fe
28000.50c -0.120002 $ Ni

c
c      Air (0.00129 g/cc)
m3 7014.50c -0.78084 $ N
8016.50c -0.20982 $ O
18000.35c -0.00934 $ Arc

c
c      Polyethylene (0.92 g/cc)
m4 6000.50c 0.03952 $ C
1001.50c 0.07903 $ H
mt4 poly.01t

c
c      Concrete (2.24 g/cc)
m5 1001.50c -0.009959 $ H
6000.50c -0.000979 $ C
8016.50c -0.529069 $ O
11023.50c -0.016003 $ Na
12000.50c -0.002000 $ Mg
13027.50c -0.034006 $ Al
14000.50c -0.337036 $ Si
19000.50c -0.012981 $ K
20000.50c -0.043965 $ Ca
26000.55c -0.014002 $ Fe
mt5 poly.01t

c
c      Water (1.0 g/cc)
m6 1001.50c -0.1119 $ H
8016.50c -0.8881 $ O
mt6 lwtr.01t $ Light Water

c
c      Cellulose (1.45 g/cc)
m7 1001.50c 0.054311 $ Cellulose Reflector
8016.50c 0.026949
6000.50c 0.03233
mt7 poly.01t

c
c      Polyethylene (0.92 g/cc)
m8 6000.50c 0.03952 $ Polyethylene Reflector
1001.50c 0.07903
mt8 poly.01t

c
c      Water (1.02 g/cc)
m9 1001.50c -0.1097 $ H
8016.50c -0.8703 $ O
94239.55c -0.0200 $ Pu
mt9 lwtr.01t $ Light Water

c
totnu
ctme 480
print

nonpipe_refrotp.inp

Three Billets in a Non-pipe 55 Gallon Drum
c three 66.7 g Pu billets at the bottom of a 200 g/drum
c Infinite reflection-Poly
c
c      Cell Definitions
c
c      Can Contents - Universe 1
1 -1.024 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
2 3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can
c
c      Can - Universe 2

```



```

10 3 -0.00129 -4 5 -6 fill=1 imp:n=1
c dx dy dz xx' yy' zz' M
trcl*=( 8.15 0.000 33.1 30 60 90 120 30 90 90 90 0 -1)

11 like 10 but
trcl*=(20.25 7.015 33.1 30 60 90 120 30 90 90 90 0 -1)

12 like 10 but
trcl*=(20.25 -7.015 33.1 30 60 90 120 30 90 90 90 0 -1)

c
c
c
20 4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1 $ Interior
21 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 $ Polyethylene
Liner
24 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 $ Drum
25 3 -0.00129 20 21 22 23 24 25 14 -15 13 imp:n=1 $ Hex around Drum
31 5 -2.24 38 -14 20 21 22 23 24 25 imp:n=1 $ Concrete Floor
32 3 -0.00129 -37 15 20 21 22 23 24 25 imp:n=1 $ Air Above Drums
c
50 0 (-20:21:22:23:-24:-25:37:-38) imp:n=0 $ The Great Void

c
c
c
c
c
1 cz 6.985 $ Radius of Waste
2 pz -8.890 $ Bottom of Waste
3 pz 8.890 $ Top of Waste
4 cz 6.988 $ Outside of Can
5 pz -8.893 $ Bottom of Can
6 pz 8.893 $ Top of Can

c
c
c
7 cz 28.485 $ Radius of
Interior pz -41.999 $ Bottom of
Interior pz 41.999 $ Top of Interior
c
10 cz 28.575 $ Radius of Liner
11 pz -42.227 $ Bottom of Liner
12 pz 42.227 $ Top of Liner
c
13 cz 28.727 $ Radius of Drum
14 pz -42.379 $ Bottom of Drum
15 pz 42.379 $ Top of Drum
16 pz 42.380 $ Top above Drum

c
c
c
*20 px -28.729 Hexagonal Surfaces (Ax+By+Cz=D) $
*21 px 28.729 $
c
*22 p 0.5 0.8660254 0 28.730 $
*23 p -0.5 0.8660254 0 28.730 $
*24 p 0.5 0.8660254 0 -28.730 $
*25 p -0.5 0.8660254 0 -28.730 $
c
36 pz -42.381 $ Concrete Floor
37 pz 100.00 $ Top of the World
38 pz -100.00 $ Bottom of the
World

mode n
kcode 3000 1.0 10 100
ksrc -8.150 0.00 -33.100
c
c
c
m1 1001.50c -0.1092 $ H
8016.50c -0.8669 $ O
94239.55c -0.0239 $ Pu
mt1 poly.01t
c
c
c
m2 SS-304 (7.83 g/cc)
6000.50c -0.000293 $ C
14000.50c -0.007497 $ Si
15031.50c -0.000447 $ P
16032.50c -0.000294 $ S
24000.50c -0.200003 $ Cr
25055.50c -0.020000 $ Mn
26000.55c -0.651464 $ Fe
28000.50c -0.120002 $ Ni
c
c
c
m3 Air (0.00129 g/cc)
7014.50c -0.78084 $ N
8016.50c -0.20982 $ O

```

```

18000.35c -0.00934 $ Arc
c
c
c
m4 Polyethylene (0.92 g/cc)
6000.50c 0.03952 $ C
1001.50c 0.07903 $ H
mt4 poly.01t
c
c
c
m5 Concrete (2.24 g/cc)
1001.50c -0.009959 $ H
6000.50c -0.000979 $ C
8016.50c -0.529069 $ O
11023.50c -0.016003 $ Na
12000.50c -0.002000 $ Mg
13027.50c -0.034006 $ Al
14000.50c -0.337036 $ Si
19000.50c -0.012981 $ K
20000.50c -0.043965 $ Ca
26000.55c -0.014002 $ Fe
mt5 poly.01t
c
c
c
m6 Water (1.0 g/cc)
1001.50c -0.1119 $ H
8016.50c -0.8881 $ O
mt6 lwtr.01t $ Light Water
c
c
c
m7 Cellulose (1.45 g/cc)
1001.50c 0.054311 $ Cellulose Reflector
8016.50c 0.026949
6000.50c 0.03233
mt7 poly.01t
c
c
c
m8 Polyethylene (0.92 g/cc)
6000.50c 0.03952 $ Polyethylene Reflector
1001.50c 0.07903
mt8 poly.01t
c
c
c
m9 Water (1.02 g/cc)
1001.50c -0.1097 $ H
8016.50c -0.8703 $ O
94239.55c -0.0200 $ Pu
mt9 lwtr.01t $ Light Water
c
totnu
ctme 480
print

nonpipe_wagon.inp

Three Billets in a Non-pipe 55 Gallon Drum
c three 66.7 g Pu billets at the bottom of a 200 g/drum
c Filled with poly Silicon replaces Calcium
c 4.5 kg of Pu as dry oxide (H/Pu=0) at theoretical density in cans
(H/D=1)
c Five cans are in a five position wagon with poly around it
c
c
c
c
c
c
Cell Definitions
c
c
c
c
Cemented Can Contents - Universe 1
1 1 -1.024 -1 2 -3 u=1 imp:n=1 $ Cemented Waste
2 3 -0.00129 1:-2:3 u=1 imp:n=1 $ Steel Can
c
c
c
c
Wagon Can Contents - Universe 2
3 8 -11.46 -208 204 -205 u=2 imp:n=1 $ Plutonium Oxide
4 3 -0.00129 201:-204:206 u=2 imp:n=1 $ Can
5 3 -0.00129 -201 204 -206 #3 u=2 imp:n=1 $ Air above Oxide
c
c
c
c
Cemented Cans in Drum
10 3 -0.00129 -4 5 -6 fill=1 imp:n=1
trcl=( 8.150 0.00 -20.100 ) $ Cement Can #1
11 like 10 but trcl=( 20.250 7.015 -20.100 ) $ Cement Can #2
12 like 10 but trcl=( 20.250 -7.015 -20.100 ) $ Cement Can #3
c
c
c
c
Cans in Wagon
13 3 -0.00129 -202 203 -207 fill=2 imp:n=1
trcl=(37.259 -24.158 -19.200) $ Wagon Can #1
14 like 13 but trcl=(52.614 -12.079 -19.200) $ Wagon Can #2
15 like 13 but trcl=(37.259 0.0 -19.200) $ Wagon Can #3
16 like 13 but trcl=(52.614 12.079 -19.200) $ Wagon Can #4
17 like 13 but trcl=(37.259 24.158 -19.200) $ Wagon Can #5
c
c
c
c
Drum
20 4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1 $ Interior

```

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Liner	4	-0.92	-10	11	-12	(7:-8:9)	imp:n=1	\$ Polyethylene	20	px	-28.729				\$					
24	2	-3.92	-13	14	-15	(10:-11:12)	imp:n=1	\$ Drum	21	px	28.729				\$					
25	3	-0.00129	20	-21	-22	-23	24	25	14	-15	13	imp:n=1	\$ Hex around	22	p	0.5	0.8660254	0	28.730	\$
Drum														23	p	-0.5	0.8660254	0	28.730	\$
c														24	p	0.5	0.8660254	0	-28.730	\$
c														25	p	-0.5	0.8660254	0	-28.730	\$
c														c						
29	2	-7.83	109	-110	101	-104	105	-108	imp:n=1	\$ Wagon Bed	36	pz	-42.381							\$ Concrete Floor
30	2	-7.83	110	-111	101	-102	105	-108	imp:n=1	\$ Near Wagon Wall	37	so	100.00							\$ End of the World
31	2	-7.83	110	-111	103	-104	105	-108	imp:n=1	\$ Far Wagon Wall	c									
32	2	-7.83	110	-111	105	-106	102	-103	imp:n=1	\$ Front Wagon Wall	c									
33	2	-7.83	110	-111	107	-108	102	-103	imp:n=1	\$ Back Wagon Wall	c									
34	2	-7.83	110	-112	113	-114			imp:n=1	\$ Receptacle #1	101	px	28.730							\$ Outside of Near Wagon
35	2	-7.83	110	-112	115	-116			imp:n=1	\$ Receptacle #2	Wall									
36	2	-7.83	110	-112	117	-118			imp:n=1	\$ Receptacle #3	102	px	28.993							\$ Inside of Near Wagon
37	2	-7.83	110	-112	119	-120			imp:n=1	\$ Receptacle #4	Wall									
38	2	-7.83	110	-112	121	-122			imp:n=1	\$ Receptacle #5	103	px	60.881							\$ Inside of Far Wagon
39	3	-0.00129	110	-112	-113	#13			imp:n=1	\$ Air in	Wall									
Receptacle #1											104	px	61.144							\$ Outside of Far Wagon
40	3	-0.00129	110	-112	-115	#14			imp:n=1	\$ Air in	Wall									
Receptacle #2											105	py	-35.430							\$ Outside of Front Wagon
41	3	-0.00129	110	-112	-117	#15			imp:n=1	\$ Air in	Wall									
Receptacle #3											106	py	-35.167							\$ Inside of Front Wagon
42	3	-0.00129	110	-112	-119	#16			imp:n=1	\$ Air in	Wall									
Receptacle #4											107	py	35.167							\$ Inside of Back Wagon
43	3	-0.00129	110	-112	-121	#17			imp:n=1	\$ Air in	Wall									
Receptacle #5											108	py	35.430							\$ Outside of Back Wagon
44	3	-0.00129	110	-111	102	-103	106	-107			Wall									
											109	pz	-19.521							\$ Bottom of Wagon
45	3	-0.00129	111	-112	101	-104	105	-108			110	pz	-19.258							\$ Floor of Wagon
											111	pz	-6.558							\$ Top of Wagon Walls
Tops											112	pz	-4.018							\$ Top of Receptacle
46	2	-7.83	-125	101	-127				imp:n=1	\$ Near Front Wheel	113	c/z								

```

c
c
c      55-304 (7.83 g/cc)
m2      6000.50c -0.000293 $ C
      14000.50c -0.007497 $ Si
      15031.50c -0.000447 $ P
      16032.50c -0.000294 $ S
      24000.50c -0.200003 $ Cr
      25055.50c -0.020000 $ Mn
      26000.55c -0.651464 $ Fe
      28000.50c -0.120002 $ Ni
c
c      Air (0.00129 g/cc)
m3      7014.50c -0.78084 $ N
      8016.50c -0.20982 $ O
      18000.35c -0.00934 $ Arc
c
c      Polyethylene (0.92 g/cc)
m4      6000.50c 0.03952 $ C
      1001.50c 0.07903 $ H
mt4      poly.01t
c
c      Concrete (2.24 g/cc)
m5      1001.50c -0.009959 $ H
      6000.50c -0.000979 $ C
      8016.50c -0.529069 $ O
      11023.50c -0.016003 $ Na
      12000.50c -0.002000 $ Mg
      13027.50c -0.034006 $ Al
      14000.50c -0.337036 $ Si
      19000.50c -0.012981 $ K
      20000.50c -0.043965 $ Ca
      26000.55c -0.014002 $ Fe
mt5      poly.01t
c
c      Water (1.0 g/cc)
m6      1001.50c -0.1119 $ H
      8016.50c -0.8861 $ O
mt6      lwtr.01t
c
c      Cellulose (1.45 g/cc)
m7      1001.50c 0.054311 $ Cellulose Reflector
      8016.50c 0.026949
      6000.50c 0.03233
mt7      poly.01t
c
c      Plutonium Dioxide (11.46 g/cc)
m8      94239.55c -0.881 $ Plutonium
      8016.50c -0.219 $ Oxygen
c
c      Water (1.02 g/cc)
m9      1001.50c -0.1097 $ H
      8016.50c -0.8703 $ O
      94239.55c -0.0200 $ Pu
mt9      lwtr.01t
c
c      Rubber (2.4 g/cc)
m10     1001.50c 0.66667 $ H
      6012.50c 0.33333 $ C
mt10     poly.01t
c
ctotnu
ctme 480
print

nonpipe2_wagon.inp

Three Billets in a Non-pipe 55 Gallon Drum
c three 66.7 g Pu billets at the bottom of a 400 g/drum
c Filled with poly Silicon replaces Calcium
c 400 g of Pu as wet oxide in cans (H/D=1)
c Five cans are in a five position wagon with poly around it
c
c      Cell Definitions
c
c      Cemented Can Contents - Universe 1
c
c      1 1 -1.049 -1 2 -3 u=1 imp:n=1 $ Cemented Waste
c      2 3 -0.00129 1:-2:3 u=1 imp:n=1 $ Steel Can
c
c      Wagon Can Contents - Universe 2
c
c      3 9 -1.1468 -208 204 -205 u=2 imp:n=1 $ Plutonium Oxide
c      4 3 -0.00129 201:-204:206 u=2 imp:n=1 $ Can
c      5 3 -0.00129 -201 204 -206 #3 u=2 imp:n=1 $ Air above Oxide
c
c      Cemented Cans in Drum
c
c      10 3 -0.00129 -4 5 -6 fill=1 imp:n=1

11      trcl=( 8.150 0.00 -20.100 ) $ Cement Can #1
12      like 10 but trcl=( 20.250 7.015 -20.100 ) $ Cement Can #2
12      like 10 but trcl=( 20.250 -7.015 -20.100 ) $ Cement Can #3
c
c      Cans in Wagon
c
c      13 3 -0.00129 -202 203 -207 fill=2 imp:n=1
c      trcl=(37.259 -24.158 -19.200) $ Wagon Can #1
c      14 like 13 but trcl=(52.614 -12.079 -19.200) $ Wagon Can #2
c      15 like 13 but trcl=(37.259 0.0 -19.200) $ Wagon Can #3
c      16 like 13 but trcl=(52.614 12.079 -19.200) $ Wagon Can #4
c      17 like 13 but trcl=(37.259 24.158 -19.200) $ Wagon Can #5
c
c      Drum
c
c      20 4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1 $ Interior
c      21 4 -0.92 -10 11 -12 (-8:9) imp:n=1 $ Polyethylene
c
c      Liner
c
c      24 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 $ Drum
c      25 3 -0.00129 20 -21 -22 -23 24 25 14 -15 13 imp:n=1 $ Hex around
c
c      Drum
c
c      Wagon
c
c      29 2 -7.83 109 -110 101 -104 105 -108 imp:n=1 $ Wagon Bed
c      30 2 -7.83 110 -111 101 -102 105 -108 imp:n=1 $ Near Wagon Wall
c      31 2 -7.83 110 -111 103 -104 105 -108 imp:n=1 $ Far Wagon Wall
c      32 2 -7.83 110 -111 105 -106 102 -103 imp:n=1 $ Front Wagon Wall
c      33 2 -7.83 110 -111 107 -108 102 103 imp:n=1 $ Back Wagon Wall
c      34 2 -7.83 110 -112 113 -114 imp:n=1 $ Receptacle #1
c      35 2 -7.83 110 -112 115 -116 imp:n=1 $ Receptacle #2
c      36 2 -7.83 110 -112 117 -118 imp:n=1 $ Receptacle #3
c      37 2 -7.83 110 -112 119 -120 imp:n=1 $ Receptacle #4
c      38 2 -7.83 110 -112 121 -122 imp:n=1 $ Receptacle #5
c      39 3 -0.00129 110 -112 -113 #13 imp:n=1 $ Air in
c
c      Receptacle #1
c      40 3 -0.00129 110 -112 -115 #14 imp:n=1 $ Air in
c
c      Receptacle #2
c      41 3 -0.00129 110 -112 -117 #15 imp:n=1 $ Air in
c
c      Receptacle #3
c      42 3 -0.00129 110 -112 -119 #16 imp:n=1 $ Air in
c
c      Receptacle #4
c      43 3 -0.00129 110 -112 -121 #17 imp:n=1 $ Air in
c
c      Receptacle #5
c      44 3 -0.00129 110 -111 102 -103 106 -107
c      114 116 118 120 122 imp:n=1 $ Air in Wagon
c      45 3 -0.00129 111 -112 101 -104 105 108
c      114 116 118 120 122 imp:n=1 $ Air around Can
c
c      Tops
c
c      46 2 -7.83 -125 101 -127 imp:n=1 $ Near Front Wheel
c      47 2 -7.83 -125 128 -104 imp:n=1 $ Far Front Wheel
c      48 2 -7.83 -123 101 -127 imp:n=1 $ Near Back Wheel
c      49 2 -7.83 -123 128 -104 imp:n=1 $ Far Back Wheel
c      50 10 -2.4 -126 125 101 -127 imp:n=1 $ Near Front Tire
c      51 10 -2.4 -126 125 128 -104 imp:n=1 $ Far Front Tire
c      52 10 -2.4 -124 123 101 -127 imp:n=1 $ Near Back Tire
c      53 10 -2.4 -124 123 128 -104 imp:n=1 $ Far Back Tire
c
c      The Room
c
c
c      60 3 -0.00129 112 -129 -104 101 -108 105
c      #13 #14 #15 #16 #17 imp:n=1 $ Air Above Cans
c      61 3 -0.00129 -109 36 -104 101 -108 105
c      #46 #47 #48 #49 #50 #51 #52 #53 imp:n=1 $ Air Under Wagon
c      62 4 -0.95 -37 36 (-20:21:22:23:-24:-25:15:-14)
c      (129:104:-101:108:-105) imp:n=1 $ Air around Drum
c
c      63 5 -2.24 -36 -37 imp:n=1 $ Concrete Floor
c
c      70 0 37 imp:n=0 $ The Great Void
c
c      Surface Definitions
c
c      Billets
c
c      1 cz 6.985 $ Radius of Cemented
c
c      Waste
c      2 pz -8.890 $ Bottom of Cemented
c
c      Waste
c      3 pz 8.890 $ Top of Waste
c      4 cz 6.988 $ Outside of Billet
c
c      Can
c      5 pz -8.893 $ Bottom of Billet
c
c      Can
c      6 pz 8.893 $ Top of Billet Can
c
c      Drum
c

```

C-53

7	c	28.485	\$ Radius of	mode n
8	pz	-41.999	\$ Bottom of	kcode 3000 1.0 10 100
9	pz	41.999	\$ Top of Interior	ksrc 8.15 0.0 -17.0
10	c			20.25 7.015 -17.0
11	c			20.25 -7.015 -17.0
12	c			37.259 -24.159 -17.0
13	c			32.614 -12.079 -17.0
14	c			37.259 0.0 -17.0
15	c			52.614 12.079 -17.0
16	c			37.259 24.159 -17.0
17	c			
18	c			
19	c			
20	px	-28.729	\$	c Cemented Waste (1.049 g/cc) 100% Water
21	px	28.729	\$	m1 1001.50c -0.1067 \$ H
22	p	0.5	\$	8016.50c -0.8467 \$ O
23	p	-0.5	\$	94239.55c -0.0467 \$ Pu
24	p	0.5	\$	poly.01t
25	p	-0.5	\$	mt1
26	pz	-42.381	\$ Concrete Floor	c
27	so	100.00	\$ End of the World	c
28	c			c
29	c			c
30	px	28.730	\$ Outside of Near Wagon	m3 55-304 (7.83 g/cc)
31	px	28.993	\$ Inside of Near Wagon	m2 6000.50c -0.000293 \$ C
32	px	60.881	\$ Inside of Far Wagon	14000.50c -0.007497 \$ Si
33	px	61.144	\$ Outside of Far Wagon	15031.50c -0.000447 \$ P
34	py	-35.430	\$ Outside of Front Wagon	16032.50c -0.000294 \$ S
35	py	-35.167	\$ Inside of Front Wagon	24000.50c -0.200003 \$ Cr
36	py	35.167	\$ Inside of Back Wagon	25055.50c -0.020000 \$ Mn
37	py	35.430	\$ Outside of Back Wagon	26000.55c -0.651464 \$ Fe
38	pz	-19.521	\$ Bottom of Wagon	28000.50c -0.120002 \$ Ni
39	pz	-19.258	\$ Floor of Wagon	
40	pz	-6.558	\$ Top of Wagon Walls	
41	pz	-4.018	\$ Top of Receptacle	
42	c/z	37.259	\$ Receptacle #1 Inner	c Air (0.00129 g/cc)
43	c/z	37.259	\$ Receptacle #1 Outer	m3 7014.50c -0.78084 \$ N
44	c/z	52.614	\$ Receptacle #2 Inner	8016.50c -0.20982 \$ O
45	c/z	52.614	\$ Receptacle #2 Outer	18000.35c -0.00934 \$ Arc
46	c/z	37.259	\$ Receptacle #3 Inner	c Polyethylene (0.92 g/cc)
47	c/z	37.259	\$ Receptacle #3 Outer	m4 6000.50c 0.03952 \$ C
48	c/z	52.614	\$ Receptacle #4 Inner	1001.50c 0.07903 \$ H
49	c/z	52.614	\$ Receptacle #4 Outer	poly.01t
50	c/z	37.259	\$ Receptacle #5 Inner	c Concrete (2.24 g/cc)
51	c/z	37.259	\$ Receptacle #5 Outer	m5 1001.50c -0.009959 \$ H
52	c/x	23.980	\$ Back Wheel Radius	6000.50c -0.000979 \$ C
53	c/x	23.980	\$ Back Tire Radius	8016.50c -0.529069 \$ O
54	c/x	23.980	\$ Front Wheel Radius	11023.50c -0.016003 \$ Na
55	c/x	23.980	\$ Front Tire Radius	12000.50c -0.002000 \$ Mg
56	px	29.200	\$ Inside of Near Wheels	13027.50c -0.034006 \$ Al
57	px	60.670	\$ Inside of Far Wheels	14000.50c -0.337036 \$ Si
58	pz	10.000	\$ Top of Air Above Wagon	19000.50c -0.012981 \$ K
59	c			20000.50c -0.043965 \$ Ca
60	c			26000.55c -0.014002 \$ Fe
61	c			poly.01t
62	c			c
63	c			c
64	c			c
65	c			c
66	c			c
67	c			c
68	c			c
69	c			c
70	c			c
71	c			c
72	c			c
73	c			c
74	c			c
75	c			c
76	c			c
77	c			c
78	c			c
79	c			c
80	c			c
81	c			c
82	c			c
83	c			c
84	c			c
85	c			c
86	c			c
87	c			c
88	c			c
89	c			c
90	c			c
91	c			c
92	c			c
93	c			c
94	c			c
95	c			c
96	c			c
97	c			c
98	c			c

Cell Definitions										Billets											
Cemented Can Contents - Universe 1																					
1	1	-1.024	-1	2	-3	u=1	imp:n=1	\$	Cemented Waste	1	cz	6.985						\$	Radius of Cemented		
2	3	-0.00129	1	-2	3	u=1	imp:n=1	\$	Steel Can	2	pz	-8.890						\$	Bottom of Cemented		
Wagon Can Contents - Universe 2																					
3	9	-1.1468	-208	204	-205	u=2	imp:n=1	\$	Plutonium Oxide	3	pz	8.890						\$	Top of Waste		
4	3	-0.00129	201	-204	206	u=2	imp:n=1	\$	Can	4	cz	6.988						\$	Outside of Billet		
5	3	-0.00129	201	204	-206	#3	u=2	imp:n=1	\$	Air above Oxide	5	pz	-8.893						\$	Bottom of Billet	
Cemented Cans in Drum										Drum											
10	3	-0.00129	-4	5	-6	fill=1	imp:n=1			7	cz	28.485						\$	Radius of		
						trcl=(	8.150	0.00	-20.100)		Interior										
11	like 10	but	trcl=(	20.250	7.015	-20.100)			\$	Cement Can #2	8	pz	-41.999						\$	Bottom of	
12	like 10	but	trcl=(	20.250	-7.015	-20.100)			\$	Cement Can #3	9	pz	41.999						\$	Top of Interior	
Cans in Wagon																					
13	3	-0.00129	-202	203	-207	fill=2	imp:n=1			10	cz	28.575						\$	Radius of Liner		
						trcl=(	37.259	-24.158	-19.200)			11	pz	-42.227					\$	Bottom of Liner	
14	like 13	but	trcl=(	52.614	-12.079	-19.200)			\$	Wagon Can #1	12	pz	42.227						\$	Top of Liner	
15	like 13	but	trcl=(	37.259	0.0	-19.200)			\$	Wagon Can #3	13	cz	28.727						\$	Radius of Drum	
16	like 13	but	trcl=(	52.614	12.079	-19.200)			\$	Wagon Can #4	14	pz	-42.379						\$	Bottom of Drum	
17	like 13	but	trcl=(	37.259	24.158	-19.200)			\$	Wagon Can #5	15	pz	42.379						\$	Top of Drum	
Drum																					
20	4	-0.92	-7	8	-9	#10 #11 #12	imp:n=1	\$	Interior	16	pz	42.380							\$	Top above Drum	
21	4	-0.92	-10	11	-12	(7:-8:9)	imp:n=1	\$	Polyethylene	Hexagonal Surfaces (Ax+By+Cz=D)											
Liner	2	-3.92	-13	14	-15	(10:-11:12)	imp:n=1	\$	Drum	20	px	-28.729							\$		
25	3	-0.00129	20	-21	-22	-23	24	25	14	-15	13	imp:n=1	\$	Hex around	21	px	28.729		\$		
Drum																					
Wagon																					
29	2	-7.83	109	-110	101	-104	105	-108	imp:n=1	\$	Wagon Bed	22	p	0.5	0.8660254	0	28.730		\$		
30	2	-7.83	110	-111	101	-102	105	-108	imp:n=1	\$	Near Wagon Wall	23	p	-0.5	0.8660254	0	28.730		\$		
31	2	-7.83	110	-111	103	-104	105	-108	imp:n=1	\$	Far Wagon Wall	24	p	0.5	0.8660254	0	-28.730		\$		
32	2	-7.83	110	-111	105	-106	102	-103	imp:n=1	\$	Front Wagon Wall	25	p	-0.5	0.8660254	0	-28.730		\$		
33	2	-7.83	110	-111	107	-108	102	-103	imp:n=1	\$	Back Wagon Wall	Wagon									
34	2	-7.83	110	-112	113	-114			imp:n=1	\$	Receptacle #1	101	px	28.730					\$	Outside of Near Wagon	
35	2	-7.83	110	-112	115	-116			imp:n=1	\$	Receptacle #2	Wall									
36	2	-7.83	110	-112	117	-118			imp:n=1	\$	Receptacle #3	102	px	28.993					\$	Inside of Near Wagon	
37	2	-7.83	110	-112	119	-120			imp:n=1	\$	Receptacle #4	Wall									
38	2	-7.83	110	-112	121	-122			imp:n=1	\$	Receptacle #5	103	px	60.881					\$	Inside of Far Wagon	
39	3	-0.00129	110	-112	-113	#13			imp:n=1	\$	Air in	Wall									
Receptacle #1	40	3	-0.00129	110	-112	-115	#14		imp:n=1	\$	Air in	104	px	61.144					\$	Outside of Far Wagon	
Receptacle #2	41	3	-0.00129	110	-112	-117	#15		imp:n=1	\$	Air in	Wall									
Receptacle #3	42	3	-0.00129	110	-112	-119	#16		imp:n=1	\$	Air in	105	py	-35.430					\$	Outside of Front Wagon	
Receptacle #4	43	3	-0.00129	110	-112	-121	#17		imp:n=1	\$	Air in	106	py	-35.167					\$	Inside of Front Wagon	
Receptacle #5	44	3	-0.00129	110	-111	102	-103	106	-107			107	py	35.167					\$	Inside of Back Wagon	
												108	py	35.430					\$	Outside of Back Wagon	
												Wall									
												109	pz	-19.521					\$	Bottom of Wagon	
												110	pz	-19.258					\$	Floor of Wagon	
												111	pz	-6.558					\$	Top of Wagon Walls	
												112	pz	-4.018					\$	Top of Receptacle	
												113	c/z	37.259	-24.158	6.724		\$	Receptacle #1 Inner		
												Radius									
												114	c/z	37.259	-24.158	7.065		\$	Receptacle #1 Outer		
												Radius									
												115	c/z	52.614	-12.079	6.724		\$	Receptacle #2 Inner		
												Radius									
												116	c/z	52.614	-12.079	7.065		\$	Receptacle #2 Outer		
												Radius									
												117	c/z	37.259	0.0	6.724		\$	Receptacle #3 Inner		
												Radius									
												118	c/z	37.259	0.0	7.065		\$	Receptacle #3 Outer		
												Radius									
												119	c/z	52.614	12.079	6.725		\$	Receptacle #4 Inner		
												Radius									
												120	c/z	52.614	12.079	7.065		\$	Receptacle #4 Outer		
												Radius									
												121	c/z	37.259	24.158	6.725		\$	Receptacle #5 Inner		
												Radius									
												122	c/z	37.259	24.158	7.065		\$	Receptacle #5 Outer		
												Radius									
												123	c/x	23.980	-30.951	10.420		\$	Back Wheel Radius		
												124	c/x	23.980	-30.951	11.420		\$	Back Tire Radius		
												125	c/x	-23.980	-30.951	10.420		\$	Front Wheel Radius		
												126	c/x	-23.980	-30.951	11.420		\$	Front Tire Radius		
The Room																					
60	3	-0.00129	112	-129	-104	101	-108	105													
						#13 #14 #15 #16 #17	imp:n=1	\$	Air Above Cans												
61	3	-0.00129	-109	36	-104	101	-108	105													
						#46 #47 #48 #49 #50 #51 #52 #53	imp:n=1	\$	Air Under Wagon												
62	4	-0.95	-37	36	(-20:21:22:23:-24:-25:15:-14)																
						(129:104:-101:108:-105)	imp:n=1	\$	Air around Drum												
63	5	-2.24	-36	-37			imp:n=1	\$	Concrete Floor												
70	0	37					imp:n=0	\$	The Great Void												
Surface Definitions																					

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127	px	29.200	\$ Inside of Near Wheels
128	px	60.670	\$ Inside of Far Wheels
129	pz	10.000	\$ Top of Air Above Wagon
c			
c			
			Can
201	cz	6.327	\$ Inside of Wagon Can
202	cz	6.350	\$ Outside of Wagon Can
203	pz	0.0	\$ Bottom of Wagon Can
204	pz	0.023	\$ Bottom of Plutonium
205	pz	3.991	\$ Top of Plutonium
206	pz	21.291	\$ Inside of Top of Wagon
Can			
207	pz	21.314	\$ Outside of Top of
Wagon Can			
208	cz	3.968	\$ Radius of Plutonium

mode n			
kcode	3000	1.0 10 100	
ksrc	8.15	0.0	-17.0
	20.25	7.015	-17.0
	20.25	-7.015	-17.0
	37.259	-24.159	-17.0
	32.614	-12.079	-17.0
	37.259	0.0	-17.0
	52.614	12.079	-17.0
	37.259	24.159	-17.0

C	Cemented Waste (1.024 g/cc) 65% Water	
C	1001.50c	-0.1092 \$ H
ml	8016.50c	-0.8669 \$ O
	94239.55c	-0.0239 \$ Pu

mt1	poly.01t	
c		
c		
c	55-304	(7.83 g/cc)
m2	6000.50c	-0.000293
	14000.50c	-0.007497
	15031.50c	-0.000447
	16032.50c	-0.000294
	24000.50c	-0.200003
	25055.50c	-0.020000
	26000.55c	-0.651464
	28000.55c	-0.120002

C	Air (0.00129 g/cc)	
C		
m3	7014.50c	-0.78084 \$ N
	8016.50c	-0.20982 \$ O
	18000.35c	-0.00934 \$ Arc

c	Polyethylene (0.92 g/cc)	
m4	6000.50c	0.03952
	1001.50c	0.07903
mt4	poly.01t	

C	Concrete (2.24 g/cc)	
m5	1001.50c	-0.009959 \$ H
	6000.50c	-0.000979 \$ C
	8016.50c	-0.529069 \$ O
	11023.50c	-0.016003 \$ Na
	12000.50c	-0.002000 \$ Mg
	13027.50c	-0.034006 \$ Al
	14000.50c	-0.337036 \$ Si
	19000.50c	-0.012981 \$ K
	20000.50c	-0.043965 \$ Ca
	26000.55c	-0.014002 \$ Fe

```

mt5    poly.01t
C
C      Water (1.0 g/cc)
m6     1001.50c    -0.1119    $ H
      8016.50c    -0.8881    $ O
mt6     \wtr.01t    $ Light Water

```

c	Cellulose (1.45 g/cc)	
c	1001.50c	0.054311
m7	8016.50c	0.026949
	6000.50c	0.03233
mt7	poly.01t	

C		
C	Plutonium Dioxide (11.46 g/cc)	
m8	94239.55c	-0.881
	8016.50c	-0.219

C	Water (1.1468 g/cc)		
C			
m9	1001.50c	-0.1097	\$ H
	8016.50c	-0.8703	\$ O
	94239.55c	-0.1468	\$ Pu
mt9	lwtr 01t		\$ Light Water

C Rubber (2.4 g/cc)

```

ml0      1001.50c      0.66667      $ H
          6012.50c      0.33333      $ C
mt10
c
totnu
ctme      480
print

```

nonpipe4 wagon.inp

- c Three Billets in a Non-pipe 55 Gallon Drum
- c three 66.7 g Pu billets at the bottom of a 400 g/drum
- c Filled with poly Silicon replaces Calcium
- c 400 g of Pu as wet oxide in cans (H/D=1)
- c Five cans are in a five position wagon with poly around it

Cell Definitions

Cemented Can Contents - Universe 1

1	1	-1.049	-1	2	-3	u=1	imp:n=1	\$ Cemented Waste
2	3	-0.00129	1	-2	3	u=1	imp:n=1	\$ Steel Can

Wagon Can Contents - Universe 2

3	8	-11.46	-208	204	-205	u=2	imp:n=1	\$ Plutonium Oxide
4	3	-0.00129	201	-204	206	u=2	imp:n=1	\$ Can
5	3	-0.00129	-201	204	-206 #3	u=2	imp:n=1	\$ Air above Oxide

Cemented Cars in Drum

```

10 3 -0.00129 -4 5 -6 fill=1 imp:n=1
    trcl=( 8.150 0.00 -20.100 ) $ Cement Can #1
11 like 10 but trcl=( 20.250 7.015 -20.100 ) $ Cement Can #2
12 like 10 but trcl=( 20.250 -7.015 -20.100 ) $ Cement Can #3

```

Cans in Wagon

```

13 3 -0.00129 -202 203 -207 fill=2 imp=n=1          $ Wagon Can #1
      trcl=(37.259 -24.158 -19.200)
14 like 13 but trcl=(52.614 -12.079 -19.200)          $ Wagon Can #2
15 like 13 but trcl=(37.259 0.0 -19.200)              $ Wagon Can #3
16 like 13 but trcl=(52.614 12.079 -19.200)           $ Wagon Can #4
17 like 13 but trcl=(37.259 24.158 -19.200)           $ Wagon Can #5

```

Drum

20	4	-0.92	-7	8	-9	#10	#11	#12	imp:n=1	\$ Interior
21	4	-0.92	-10	11	-12	(7:-8:9)			imp:n=1	\$ Polyethylene

```

Liner
24 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 $ Drum
25 3 -0.00129 20 -21 -22 -23 24 25 14 -15 13 imp:n=1 $ Hex around

```

Wagon

29	2	-7.83	109	-110	101	-104	105	-108	imp:n=1	\$ Wagon Bed	
30	2	-7.83	110	-111	101	-102	105	-108	imp:n=1	\$ Near Wagon Wall	
31	2	-7.83	110	-111	103	-104	105	-108	imp:n=1	\$ Far Wagon Wall	
32	2	-7.83	110	-111	105	-106	102	-103	imp:n=1	\$ Front Wagon Wall	
33	2	-7.83	110	-111	107	-108	102	-103	imp:n=1	\$ Back Wagon Wall	
34	2	-7.83	110	-112	113	-114			imp:n=1	\$ Receptacle #1	
35	2	-7.83	110	-112	115	-116			imp:n=1	\$ Receptacle #2	
36	2	-7.83	110	-112	117	-118			imp:n=1	\$ Receptacle #3	
37	2	-7.83	110	-112	119	-120			imp:n=1	\$ Receptacle #4	
38	2	-7.83	110	-112	121	-122			imp:n=1	\$ Receptacle #5	
39	3	-0.00129	110	-112	-113	#13			imp:n=1	\$ Air in	
Receptacle #1											
40	3	-0.00129	110	-112	-115	#14			imp:n=1	\$ Air in	
Receptacle #2											
41	3	-0.00129	110	-112	-117	#15			imp:n=1	\$ Air in	
Receptacle #3											
42	3	-0.00129	110	-112	-119	#16			imp:n=1	\$ Air in	
Receptacle #4											
43	3	-0.00129	110	-112	-121	#17			imp:n=1	\$ Air in	
Receptacle #5											
44	3	-0.00129	110	-111	102	-103	106	-107			
					114	116	118	120	122	imp:n=1	\$ Air in Wagon
45	3	-0.00129	111	-112	101	-104	105	-108			
					114	116	118	120	122	imp:n=1	\$ Air around Can

Tops								
46	2	-7.83	-125	101	-127	imp:n=1	\$ Near Front Wheel	
47	2	-7.83	-125	128	-104	imp:n=1	\$ Far Front Wheel	
48	2	-7.83	-123	101	-127	imp:n=1	\$ Near Back Wheel	
49	2	-7.83	-123	128	-104	imp:n=1	\$ Far Back Wheel	
50	10	-2.4	-126	125	101	-127	imp:n=1	\$ Near Front Tire
51	10	-2.4	-126	125	128	-104	imp:n=1	\$ Far Front Tire
52	10	-2.4	-124	123	101	-127	imp:n=1	\$ Near Back Tire
53	10	-2.4	-124	123	128	-104	imp:n=1	\$ Far Back Tire

C-56

[illegible]

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```

m7      1001.50c 0.054311      $ Cellulose Reflector
      8016.50c 0.026949
      6000.50c 0.03233
mt7     poly.01t
c
c      Plutonium Dioxide (11.46 g/cc)
m8      94239.55c -0.881      $ Plutonium
      8016.50c -0.219      $ Oxygen
c
c      Water (1.1468 g/cc)
m9      1001.50c -0.1097      $ H
      8016.50c -0.8703      $ O
      94239.55c -0.1468      $ Pu
mt9     lwtr.01t      $ Light Water
c
c      Rubber (2.4 g/cc)
m10     1001.50c 0.66667      $ H
      6012.50c 0.33333      $ C
mt10    poly.01t
c
c      totpu
c      ctme 480
c      print

```

nonpipe5_wagon.inp

```

Three Billets in a Non-pipe 55 Gallon Drum
c three 66.7 g Pu billets at the bottom of a 200 g/drum
c Filled with poly Silicon replaces Calcium
c 2.5 kg of Pu as metal (H/Pu=0) in cans (H/D=1)
c Five cans are in a five position wagon with poly around it
c
c      Cell Definitions
c
c      Cemented Can Contents - Universe 1
c
c      1 1 -1.024 -1 2 -3      u=1      imp:n=1      $ Cemented Waste
c      2 3 -0.00129 1:-2:3      u=1      imp:n=1      $ Steel Can
c
c      Wagon Can Contents - Universe 2
c
c      3 11 -19.6 -208 204 -205      u=2      imp:n=1      $ Plutonium Oxide
c      4 3 -0.00129 201:-204:206      u=2      imp:n=1      $ Can
c      5 3 -0.00129 -201 204 -206 #3      u=2      imp:n=1      $ Air above Oxide
c
c      Cemented Cans in Drum
c
c      10 3 -0.00129 -4 5 -6 fill=1      imp:n=1
c      trcl=( 8.150 0.00 -20.100 )      $ Cement Can #1
c      11 like 10 but trcl=( 20.250 7.015 -20.100 )      $ Cement Can #2
c      12 like 10 but trcl=( 20.250 -7.015 -20.100 )      $ Cement Can #3
c
c      Cans in Wagon
c
c      13 3 -0.00129 -202 203 -207 fill=2      imp:n=1
c      trcl=(37.259 -24.158 -19.200)      $ Wagon Can #1
c      14 like 13 but trcl=(52.614 -12.079 -19.200)      $ Wagon Can #2
c      15 like 13 but trcl=(37.259 0.0 -19.200)      $ Wagon Can #3
c      16 like 13 but trcl=(52.614 12.079 -19.200)      $ Wagon Can #4
c      17 like 13 but trcl=(37.259 24.158 -19.200)      $ Wagon Can #5
c
c      Drum
c
c      20 4 -0.92 -7 8 -9 #10 #11 #12      imp:n=1      $ Interior
c      21 4 -0.92 -10 11 -12 (7:-8:9)      imp:n=1      $ Polyethylene
Liner
c
c      24 2 -3.92 -13 14 -15 (10:-11:12)      imp:n=1      $ Drum
c      25 3 -0.00129 20 -21 -22 -23 24 25 14 -15 13 imp:n=1 $ Hex around
Drum
c
c      Wagon
c
c      29 2 -7.83 109 -110 101 -104 105 -108 imp:n=1      $ Wagon Bed
c      30 2 -7.83 110 -111 101 -102 105 -108 imp:n=1      $ Near Wagon Wall
c      31 2 -7.83 110 -111 103 -104 105 -108 imp:n=1      $ Far Wagon Wall
c      32 2 -7.83 110 -111 105 -106 102 -103 imp:n=1      $ Front Wagon Wall
c      33 2 -7.83 110 -111 107 -108 102 -103 imp:n=1      $ Back Wagon Wall
c      34 2 -7.83 110 -112 113 -114      imp:n=1      $ Receptacle #1
c      35 2 -7.83 110 -112 115 -116      imp:n=1      $ Receptacle #2
c      36 2 -7.83 110 -112 117 -118      imp:n=1      $ Receptacle #3
c      37 2 -7.83 110 -112 119 -120      imp:n=1      $ Receptacle #4
c      38 2 -7.83 110 -112 121 -122      imp:n=1      $ Receptacle #5
c      39 3 -0.00129 110 -112 -113 #13      imp:n=1      $ Air in
Receptacle #1
c
c      40 3 -0.00129 110 -112 -115 #14      imp:n=1      $ Air in
Receptacle #2
c
c      41 3 -0.00129 110 -112 -117 #15      imp:n=1      $ Air in
Receptacle #3

```

```

42 3 -0.00129 110 -112 -119 #16      imp:n=1      $ Air in
Receptacle #4
43 3 -0.00129 110 -112 -121 #17      imp:n=1      $ Air in
Receptacle #5
44 3 -0.00129 110 -111 102 -103 106 -107      imp:n=1      $ Air in Wagon
      114 116 118 120 122
45 3 -0.00129 111 -112 101 -104 105 -108      imp:n=1      $ Air around Can
      114 116 118 120 122
Tops
46 2 -7.83 -125 101 -127      imp:n=1      $ Near Front Wheel
47 2 -7.83 -125 128 -104      imp:n=1      $ Far Front Wheel
48 2 -7.83 -123 101 -127      imp:n=1      $ Near Back Wheel
49 2 -7.83 -123 128 -104      imp:n=1      $ Far Back Wheel
50 10 -2.4 -126 125 101 -127      imp:n=1      $ Near Front Tire
51 10 -2.4 -126 125 128 -104      imp:n=1      $ Far Front Tire
52 10 -2.4 -124 123 101 -127      imp:n=1      $ Near Back Tire
53 10 -2.4 -124 123 128 -104      imp:n=1      $ Far Back Tire
c
c      The Room
c
c
60 3 -0.00129 112 -129 -104 101 -108 105      imp:n=1      $ Air Above Cans
      #13 #14 #15 #16 #17
61 3 -0.00129 -109 36 -104 101 -108 105      imp:n=1      $ Air Under Wagon
      #46 #47 #48 #49 #50 #51 #52 #53
62 4 -0.95 -37 36 (-20:21:22:23:-24:-25:15:-14)      imp:n=1      $ Air around Drum
      (129:104:-101:108:-105)
c
63 5 -2 24 -36 -37      imp:n=1      $ Concrete Floor
c
70 0 37      imp:n=0      $ The Great Void
c
c      Surface Definitions
c
c      Billets
c
c      1 cz 6.985      $ Radius of Cemented
Waste
c      2 pz -8.890      $ Bottom of Cemented
Waste
c      3 pz 8.890      $ Top of Waste
c      4 cz 6.988      $ Outside of Billet
Can
c      5 pz -8.893      $ Bottom of Billet
Can
c      6 pz 8.893      $ Top of Billet Can
c
c      Drum
c
c      7 cz 28.485      $ Radius of
Interior
c      8 pz -41.999      $ Bottom of
Interior
c      9 pz 41.999      $ Top of Interior
c
c      10 cz 28.575      $ Radius of Liner
c      11 pz -42.227      $ Bottom of Liner
c      12 pz 42.227      $ Top of Liner
c
c      13 cz 28.727      $ Radius of Drum
c      14 pz -42.379      $ Bottom of Drum
c      15 pz 42.379      $ Top of Drum
c      16 pz 42.380      $ Top above Drum
c
c      Hexagonal Surfaces (Ax+By+Cz=D)
c
c      20 px -28.729      $
c      21 px 28.729      $
c
c      22 p 0.5 0.8660254 0 28.730      $
c      23 p -0.5 0.8660254 0 28.730      $
c      24 p 0.5 0.8660254 0 -28.730      $
c      25 p -0.5 0.8660254 0 -28.730      $
c
c      36 pz -42.381      $ Concrete Floor
c      37 so 100.00      $ End of the World
c
c      Wagon
c
c      101 px 28.730      $ Outside of Near Wagon
Wall
c      102 px 28.993      $ Inside of Near Wagon
Wall
c      103 px 60.881      $ Inside of Far Wagon
Wall
c      104 px 61.144      $ Outside of Far Wagon
Wall
c      105 py -35.430      $ Outside of Front Wagon
Wall

```


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106					\$ Inside of Front Wagon	m5	1001.50c	-0.009959	\$ H
Wall							6000.50c	-0.000979	\$ C
107	py	35.167			\$ Inside of Back Wagon		8016.50c	-0.529069	\$ O
Wall							11023.50c	-0.016003	\$ Na
108	py	35.430			\$ Outside of Back Wagon		12000.50c	-0.002000	\$ Mg
Wall							13027.50c	-0.034006	\$ Al
109	pz	-19.521			\$ Bottom of Wagon		14000.50c	-0.337036	\$ Si
110	pz	-19.258			\$ Floor of Wagon		19000.50c	-0.012981	\$ K
111	pz	-6.558			\$ Top of Wagon Walls		20000.50c	-0.043965	\$ Ca
112	pz	-4.018			\$ Top of Receptacle		26000.55c	-0.014002	\$ Fe
113	c/z	37.259	-24.158	6.724	\$ Receptacle #1 Inner	mt5	poly.01t		
Radius						c			
114	c/z	37.259	-24.158	7.065	\$ Receptacle #1 Outer	c	Water (1.0 g/cc)		
Radius						m6	1001.50c	-0.1119	\$ H
115	c/z	52.614	-12.079	6.724	\$ Receptacle #2 Inner		8016.50c	-0.8881	\$ O
Radius						mt6	lwtr.01t		\$ Light Water
116	c/z	52.614	-12.079	7.065	\$ Receptacle #2 Outer	c			
Radius						c	Cellulose (1.45 g/cc)		
117	c/z	37.259	0.0	6.724	\$ Receptacle #3 Inner	m7	1001.50c	0.054311	\$ Cellulose Reflector
Radius							8016.50c	0.026949	
118	c/z	37.259	0.0	7.065	\$ Receptacle #3 Outer		6000.50c	0.03233	
Radius						mt7	poly.01t		
119	c/z	52.614	12.079	6.725	\$ Receptacle #4 Inner	c			
Radius						c	Plutonium Dioxide (11.46 g/cc)		
120	c/z	52.614	12.079	7.065	\$ Receptacle #4 Outer	m8	94239.55c	-0.881	\$ Plutonium
Radius							8016.50c	-0.219	\$ Oxygen
121	c/z	37.259	24.158	6.725	\$ Receptacle #5 Inner	c			
Radius						c	Water (1.02 g/cc)		
122	c/z	37.259	24.158	7.065	\$ Receptacle #5 Outer	m9	1001.50c	-0.1097	\$ H
Radius							8016.50c	-0.8703	\$ O
123	c/x	23.980	-30.951	10.420	\$ Back Wheel Radius		94239.55c	-0.0200	\$ Pu
124	c/x	23.980	-30.951	11.420	\$ Back Tire Radius	mt9	lwtr.01t		\$ Light Water
125	c/x	-23.980	-30.951	10.420	\$ Front Wheel Radius	c			
126	c/x	-23.980	-30.951	11.420	\$ Front Tire Radius	c	Rubber (2.4 g/cc)		
127	px	29.200			\$ Inside of Near Wheels	m10	1001.50c	0.66667	\$ H
128	px	60.670			\$ Inside of Far Wheels		6012.50c	0.33333	\$ C
129	pz	10.000			\$ Top of Air Above Wagon	mt10	poly.01t		
c						c	Pu Metal (19.6 g/cc)		
c			Can			m11	94239.55c	-1.000	\$ Pu-239
c						c			
201	cz	6.327			\$ Inside of Wagon Can	totnu			
202	cz	6.350			\$ Outside of Wagon Can	ctme	480		
203	pz	0.0			\$ Bottom of Wagon Can	print			
204	pz	0.023			\$ Bottom of Plutonium				
205	pz	5.502			\$ Top of Plutonium				
206	pz	21.291			\$ Inside of Top of Wagon				nonpipe6_wagon.inp
Can									
207	pz	21.314			\$ Outside of Top of				
Wagon Can									Three Billets in a Non-pipe 55 Gallon Drum
208	cz	2.728			\$ Radius of Plutonium				c three 66.7 g Pu billets at the bottom of a 200 g/drum
									c Filled with poly Silicon replaces Calcium
									c 2.5 kg of Pu as metal (H/Pu=0) in cans (H/D=1)
									c Five cans are in a five position wagon with poly around it
									c One can overbatched
mode n									
kcode	3000	1.0	10	100					
ksrc	8.15	0.0	-17.0						
	20.25	7.015	-17.0						

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17	like 13 but trcl=(37.259 24.158 -19.200)		\$ Wagon Can #5	15	pz	42.379		\$ Top of Drum
c				16	pz	42.380		\$ Top above Drum
c				c				
c				c				
20	4 -0.92 -7.8 -9 #10 #11 #12	imp:n=1	\$ Interior	c				Hexagonal Surfaces (Ax+By+Cz=0)
21	4 -0.92 -10.11 -12 (7:-8:9)	imp:n=1	\$ Polyethylene	20	px	-28.729		\$
Liner				21	px	28.729		\$
24	2 -3.92 -13.14 -15 (10:-11:12)	imp:n=1	\$ Drum	c				\$
25	3 -0.00129 20 -21 -22 -23 24 25 14 -15 13	imp:n=1	\$ Hex around	22	p	0.5	0.8660254	0 28.730 \$
Drum				23	p	-0.5	0.8660254	0 28.730 \$
c				24	p	0.5	0.8660254	0 -28.730 \$
c				25	p	-0.5	0.8660254	0 -28.730 \$
c				c				
29	2 -7.83 109 -110 101 -104 105 -108	imp:n=1	\$ Wagon Bed	36	pz	-42.381		\$ Concrete Floor
30	2 -7.83 110 -111 101 -102 105 -108	imp:n=1	\$ Near Wagon Wall	37	so	100.00		\$ End of the World
31	2 -7.83 110 -111 103 -104 105 -108	imp:n=1	\$ Far Wagon Wall	c				
32	2 -7.83 110 -111 105 -106 102 -103	imp:n=1	\$ Front Wagon Wall	c				
33	2 -7.83 110 -111 107 -108 102 -103	imp:n=1	\$ Back Wagon Wall	c				
34	2 -7.83 110 -112 113 -114	imp:n=1	\$ Receptacle #1	101	px	28.730		\$ Outside of Near Wagon
35	2 -7.83 110 -112 115 -116	imp:n=1	\$ Receptacle #2	Wall				
36	2 -7.83 110 -112 117 -118	imp:n=1	\$ Receptacle #3	102	px	28.993		\$ Inside of Near Wagon
37	2 -7.83 110 -112 119 -120	imp:n=1	\$ Receptacle #4	Wall				
38	2 -7.83 110 -112 121 -122	imp:n=1	\$ Receptacle #5	103	px	60.881		\$ Inside of Far Wagon
39	3 -0.00129 110 -112 -113 #13	imp:n=1	\$ Air in	Wall				
Receptacle #1				104	px	61.144		\$ Outside of Far Wagon
40	3 -0.00129 110 -112 -115 #14	imp:n=1	\$ Air in	Wall				
Receptacle #2				105	py	-35.430		\$ Outside of Front Wagon
41	3 -0.00129 110 -112 -117 #15	imp:n=1	\$ Air in	Wall				
Receptacle #3				106	py	-35.167		\$ Inside of Front Wagon
42	3 -0.00129 110 -112 -119 #16	imp:n=1	\$ Air in	Wall				
Receptacle #4				107	py	35.167		\$ Inside of Back Wagon
43	3 -0.00129 110 -112 -121 #17	imp:n=1	\$ Air in	Wall				
Receptacle #5				108	py	35.430		\$ Outside of Back Wagon
44	3 -0.00129 110 -111 102 -103 106 -107	imp:n=1	\$ Air in Wagon	Wall				
	114 116 118 120 122	imp:n=1	\$ Air around Can	109	pz	-19.521		\$ Bottom of Wagon
45	3 -0.00129 111 -112 101 -104 105 -108	imp:n=1	\$ Air around Can	110	pz	-19.258		\$ Floor of Wagon
	114 116 118 120 122	imp:n=1	\$ Air around Can	111	pz	-6.558		\$ Top of Wagon Walls
Tops				112	pz	-4.018		\$ Top of Receptacle
46	2 -7.83 -125 101 -127	imp:n=1	\$ Near Front Wheel	113	c/z	37.259	-24.158 6.724	\$ Receptacle #1 Inner
47	2 -7.83 -125 128 -104	imp:n=1	\$ Far Front Wheel	Radius				
48	2 -7.83 -123 101 -127	imp:n=1	\$ Near Back Wheel	114	c/z	37.259	-24.158 7.065	\$ Receptacle #1 Outer
49	2 -7.83 -123 128 -104	imp:n=1	\$ Far Back Wheel	Radius				
50	10 -2.4 -126 125 101 -127	imp:n=1	\$ Near Front Tire	115	c/z	52.614	-12.079 6.724	\$ Receptacle #2 Inner
51	10 -2.4 -126 125 128 -104	imp:n=1	\$ Far Front Tire	Radius				
52	10 -2.4 -124 123 101 -127	imp:n=1	\$ Near Back Tire	116	c/z	52.614	-12.079 7.065	\$ Receptacle #2 Outer
53	10 -2.4 -124 123 128 -104	imp:n=1	\$ Far Back Tire	Radius				
c				117	c/z	37.259	0.0 6.724	\$ Receptacle #3 Inner
c				Radius				
c				118	c/z	37.259	0.0 7.065	\$ Receptacle #3 Outer
c				Radius				
60	3 -0.00129 112 -129 -104 101 -108 105	imp:n=1	\$ Air Above Cans	119	c/z	52.614	12.079 6.725	\$ Receptacle #4 Inner
	#13 #14 #15 #16 #17	imp:n=1	\$ Air Above Cans	Radius				
61	3 -0.00129 -109 36 -104 101 -108 105	imp:n=1	\$ Air Under Wagon	120	c/z	52.614	12.079 7.065	\$ Receptacle #4 Outer
	#46 #47 #48 #49 #50 #51 #52 #53	imp:n=1	\$ Air Under Wagon	Radius				
62	4 -0.95 -37.36 (-20:21:22:23:-24:-25:15:-14)	imp:n=1	\$ Air around Drum	121	c/z	37.259	24.158 6.725	\$ Receptacle #5 Inner
	(129:104:-101:108:-105)	imp:n=1	\$ Air around Drum	Radius				
c				122	c/z	37.259	24.158 7.065	\$ Receptacle #5 Outer
63	5 -2.24 -36 -37	imp:n=1	\$ Concrete Floor	Radius				
c				123	c/x	23.980	-30.951 10.420	\$ Back Wheel Radius
c				124	c/x	23.980	-30.951 11.420	\$ Back Tire Radius
70	0 37	imp:n=0	\$ The Great Void	125	c/x	-23.980	-30.951 10.420	\$ Front Wheel Radius
				126	c/x	-23.980	-30.951 11.420	\$ Front Tire Radius
c				127	px	29.200		\$ Inside of Near Wheels
c				128	px	60.670		\$ Inside of Far Wheels
c				129	pz	10.000		\$ Top of Air Above Wagon
c				c				
1	cz	6.985	\$ Radius of Cemented	c				
Waste				c				
2	pz	-8.890	\$ Bottom of Cemented	c				
Waste				c				
3	pz	8.890	\$ Top of Waste	201	cz	6.327		\$ Inside of Wagon Can
4	cz	6.988	\$ Outside of Billet	202	cz	6.350		\$ Outside of Wagon Can
Can				203	pz	0.0		\$ Bottom of Wagon Can
5	pz	-8.893	\$ Bottom of Billet	204	pz	0.023		\$ Bottom of Plutonium
Can				205	pz	5.502		\$ Top of Plutonium
6	pz	8.893	\$ Top of Billet Can	206	pz	21.291		\$ Inside of Top of Wagon
c				Can				
c				207	pz	21.314		\$ Outside of Top of
c				Wagon Can				
7	cz	28.485	\$ Radius of	208	cz	2.728		\$ Radius of Plutonium
Interior				209	pz	10.981		\$ Top of Double Batched
8	pz	-41.999	\$ Bottom of	Pu				
Interior				mode n				
9	pz	41.999	\$ Top of Interior	kcode	3000	1.0 10 100		
c				ksrc	8.15	0.0 -17.0		
10	cz	28.575	\$ Radius of Liner		20.25	7.015 -17.0		
11	pz	-42.227	\$ Bottom of Liner		20.25	-7.015 -17.0		
12	pz	42.227	\$ Top of Liner		37.259	-24.159 -17.0		
c					32.614	-12.079 -17.0		
13	cz	28.727	\$ Radius of Drum		37.259	0.0 -17.0		
14	pz	-42.379	\$ Bottom of Drum		52.614	12.079 -17.0		

```

37.259   24.159   -17.0
c
c      Cemented Waste (1.024 g/cc) 65% Water
ml      1001.50c    -0.1092          $ H
        8016.50c    -0.8669          $ O
        94239.55c   -0.0239          $ Pu
mt1     poly.01t
c
c
c      SS-304 (7.83 g/cc)
m2      6000.50c    -0.000293         $ C
        14000.50c   -0.007497         $ Si
        15031.50c   -0.000447         $ P
        16032.50c   -0.000294         $ S
        24000.50c   -0.200003         $ Cr
        25055.50c   -0.020000         $ Mn
        26000.55c   -0.651464         $ Fe
        28000.50c   -0.120002         $ Ni
c
c      Air (0.00129 g/cc)
m3      7014.50c    -0.78084          $ N
        8016.50c    -0.20982          $ O
        18000.35c   -0.00934          $ Arc
c
c      Polyethylene (0.92 g/cc)
m4      6000.50c    0.03952           $ C
        1001.50c    0.07903           $ H
mt4     poly.01t
c
c      Concrete (2.24 g/cc)
m5      1001.50c    -0.009959         $ H
        6000.50c    -0.000979         $ C
        8016.50c    -0.529069         $ O
        11023.50c   -0.016003         $ Na
        12000.50c   -0.002000         $ Mg
        13027.50c   -0.034006         $ Al
        14000.50c   -0.337036         $ Si
        19000.50c   -0.012981         $ K
        20000.50c   -0.043965         $ Ca
        26000.55c   -0.014002         $ Fe
mt5     poly.01t
c
c      Water (1.0 g/cc)
m6      1001.50c    -0.1119           $ H
        8016.50c    -0.8881           $ O
mt6     lwtr.01t
c      $ Light Water
c
c      Cellulose (1.45 g/cc)
m7      1001.50c    0.054311          $ Cellulose Reflector
        8016.50c    0.026949
        6000.50c    0.03233
mt7     poly.01t
c
c      Plutonium Dioxide (11.46 g/cc)
m8      94239.55c   -0.881            $ Plutonium
        8016.50c    -0.219            $ Oxygen
c
c      Water (1.02 g/cc)
m9      1001.50c    -0.1097           $ H
        8016.50c    -0.8703           $ O
        94239.55c   -0.0200           $ Pu
mt9     lwtr.01t
c      $ Light Water
c
c      Rubber (2.4 g/cc)
m10     1001.50c    0.66667            $ H
        6012.50c    0.33333            $ C
mt10    poly.01t
c      Pu Metal (19.6 g/cc)
m11     94239.55c   -1.000            $ Pu-239
c
ctnu
ctme
print

odrum_bot1.inp

200 g of Pu with Polyethylene in a 55 Gallon Drum
H/D = 1.5 : H/Pu = 730
Rest of drum filled with poly

Cell Definitions

Can Contents
4 -0.963 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can

Can
3 -0.00129 -4 5 -6 fill=1 imp:n=1
trcl=( 20.565 0.00 -33.100 ) $ Can

Drum - Universe 2
20 4 -0.92 -7 8 -9 #10 imp:n=1 $ Interior
21 4 -0.92 -10 11 -12 (-8:9) imp:n=1 $ Polyethylene
Liner
24 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 $ Drum
25 3 -0.00129 20 -21 -22 -23 24 25 14 -15 13 imp:n=1 $ Hex around Drum
The Room
30 3 -0.00129 -37 36 (-20:21:22:23:-24:-25:15:-14) imp:n=1 $ Air around Drum
31 5 -2.24 -36 -37 imp:n=1 $ Concrete Floor
50 0 37 imp:n=0 $ The Great Void

Surface Definitions

Can
1 cz 7.904 $ Radius of Waste
2 pz -8.890 $ Bottom of Waste
3 pz 14.817 $ Top of Waste
4 cz 7.907 $ Outside of Can
5 pz -8.893 $ Bottom of Can
6 pz 14.820 $ Top of Can

Drum
7 cz 28.485 $ Radius of
8 pz -41.999 $ Bottom of
9 pz 41.999 $ Top of Interior
10 cz 28.575 $ Radius of Liner
11 pz -42.227 $ Bottom of Liner
12 pz 42.227 $ Top of Liner
13 cz 28.727 $ Radius of Drum
14 pz -42.379 $ Bottom of Drum
15 pz 42.379 $ Top of Drum
16 pz 42.380 $ Top above Drum

Hexagonal Surfaces (Ax+By+Cz=D)
20 px -28.729 $
21 px 28.729 $
22 p A 0.5 0.8660254 0 28.730 $
23 p B -0.5 0.8660254 0 28.730 $
24 p C 0.5 0.8660254 0 -28.730 $
25 p D -0.5 0.8660254 0 -28.730 $
36 pz -42.381 $ Concrete Floor
37 so 100.00 $ End of the World

mode n
kcode 3000 1.0 10 100
ksrc 20.5 0.00 -33.100
c
c      Cemented Waste (2.059 g/cc) 45% Water
ml      1001.50c    -0.0604          $ H
        8016.50c    -0.5955          $ O
        9019.50c    -0.0233          $ F
        12000.50c   -0.0480          $ Mg
        14000.50c   -0.2609          $ Si
        94239.55c   -0.0119          $ Pu
mt1     poly.01t
c
c      SS-304 (7.83 g/cc)
m2      6000.50c    -0.000293         $ C
        14000.50c   -0.007497         $ Si
        15031.50c   -0.000447         $ P
        16032.50c   -0.000294         $ S
        24000.50c   -0.200003         $ Cr
        25055.50c   -0.020000         $ Mn
        26000.55c   -0.651464         $ Fe
        28000.50c   -0.120002         $ Ni
c
c      Air (0.00129 g/cc)
m3      7014.50c    -0.78084          $ N
        8016.50c    -0.20982          $ O
        18000.35c   -0.00934          $ Arc
c
c      Polyethylene (0.92 g/cc)
m4      6000.50c    0.03952           $ C
        1001.50c    0.07903           $ H
        94239.55c    0.04297          $ Pu
mt4     poly.01t
c
c      Concrete (2.24 g/cc)
m5      1001.50c    -0.009959         $ H

```

```

6000.50c -0.000979 $ C
8016.50c -0.529069 $ O
11023.50c -0.016003 $ Na
12000.50c -0.002000 $ Mg
13027.50c -0.034006 $ Al
14000.50c -0.337036 $ Si
19000.50c -0.012981 $ K
20000.50c -0.043965 $ Ca
26000.55c -0.014002 $ Fe
mt5 poly.01t
c
c Water (1.0 g/cc)
m6 1001.50c -0.1119 $ H
8016.50c -0.8881 $ O
mt6 lwtr.01t $ Light Water
c
c Cellulose (1.45 g/cc)
m7 1001.50c 0.054311 $ Cellulose Reflector
8016.50c 0.026949
6000.50c 0.03233
mt7 poly.01t
c
c Polyethylene (0.92 g/cc)
m8 6000.50c 0.03952 $ Polyethylene Reflector
1001.50c 0.07903
mt8 poly.01t
c
c Water (1.02 g/cc)
m9 1001.50c -0.1097 $ H
8016.50c -0.8703 $ O
94239.55c -0.0200 $ Pu
mt9 lwtr.01t $ Light Water
c
totnu
ctme 480
print

```

odrum_c.inp

```

200 g of Pu with Polyethylene in a 55 Gallon Drum
c H/D = 1.5 ; H/Pu = 730
c Rest of drum filled with poly
c
c Cell Definitions
c
c Can Contents
l 4 -0.963 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
2 3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can
c
c Can
l0 3 -0.00129 -4 5 -6 fill=1 imp:n=1
trcl=( 0.00 0.00 0.0100 ) $ Can
c
c Drum - Universe 2
20 4 -0.92 -7 8 -9 #10 imp:n=1 $ Interior
21 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 $ Polyethylene
Liner
24 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 $ Drum
25 3 -0.00129 20 -21 -22 -23 24 25 14 -15 13 imp:n=1 $ Hex around Drum
c
c The Room
30 3 -0.00129 -37 36 (-20:21:22:23:-24:-25:15:-14) imp:n=1 $ Air around Drum
31 5 -2.24 -36 -37 imp:n=1 $ Concrete Floor
c
50 0 37 imp:n=0 $ The Great Void
c
c Surface Definitions
c
c Can
1 cz 7.904 $ Radius of Waste
2 pz -8.890 $ Bottom of Waste
3 pz 14.817 $ Top of Waste
4 cz 7.907 $ Outside of Can
5 pz -8.893 $ Bottom of Can
6 pz 14.820 $ Top of Can
c
c Drum
7 cz 28.485 $ Radius of
8 pz -41.999 $ Bottom of
9 pz 41.999 $ Top of Interior
c

```

```

10 cz 28.575 $ Radius of Liner
11 pz -42.227 $ Bottom of Liner
12 pz 42.227 $ Top of Liner
c
13 cz 28.727 $ Radius of Drum
14 pz -42.379 $ Bottom of Drum
15 pz 42.379 $ Top of Drum
16 pz 42.380 $ Top above Drum
c
c Hexagonal Surfaces (Ax+By+Cz=D)
20 px -28.729 $
21 px 28.729 $
c A B C D $
22 p 0.5 0.8660254 0 28.730 $
23 p -0.5 0.8660254 0 28.730 $
24 p 0.5 0.8660254 0 -28.730 $
25 p -0.5 0.8660254 0 -28.730 $
c
36 pz -42.381 $ Concrete Floor
37 so 100.00 $ End of the World
mode n
kcode 3000 1.0 10 100
ksrc 20.5 0.00 -33.100
c
c Cemented Waste (2.069 g/cc) 45% Water
m1 1001.50c -0.0604 $ H
8016.50c -0.5955 $ O
9019.50c -0.0233 $ F
12000.50c -0.0480 $ Mg
14000.50c -0.2609 $ Si
94239.55c -0.0119 $ Pu
mt1 poly.01t
c
c SS-304 (7.83 g/cc)
m2 6000.50c -0.000293 $ C
14000.50c -0.007497 $ Si
15031.50c -0.000447 $ P
16032.50c -0.000294 $ S
24000.50c -0.200003 $ Cr
25055.50c -0.020000 $ Mn
26000.55c -0.651464 $ Fe
28000.50c -0.120002 $ Ni
c
c Air (0.00129 g/cc)
m3 7014.50c -0.78084 $ N
8016.50c -0.20982 $ O
18000.35c -0.00934 $ Arc
c
c Polyethylene (0.92 g/cc)
m4 6000.50c 0.03952 $ C
1001.50c 0.07903 $ H
94239.55c 0.04297 $ Pu
mt4 poly.01t
c
c Concrete (2.24 g/cc)
m5 1001.50c -0.009959 $ H
6000.50c -0.000979 $ C
8016.50c -0.529069 $ O
11023.50c -0.016003 $ Na
12000.50c -0.002000 $ Mg
13027.50c -0.034006 $ Al
14000.50c -0.337036 $ Si
19000.50c -0.012981 $ K
20000.50c -0.043965 $ Ca
26000.55c -0.014002 $ Fe
mt5 poly.01t
c
c Water (1.0 g/cc)
m6 1001.50c -0.1119 $ H
8016.50c -0.8881 $ O
mt6 lwtr.01t $ Light Water
c
c Cellulose (1.45 g/cc)
m7 1001.50c 0.054311 $ Cellulose Reflector
8016.50c 0.026949
6000.50c 0.03233
mt7 poly.01t
c
c Polyethylene (0.92 g/cc)
m8 6000.50c 0.03952 $ Polyethylene Reflector
1001.50c 0.07903
mt8 poly.01t
c
c Water (1.02 g/cc)
m9 1001.50c -0.1097 $ H
8016.50c -0.8703 $ O
94239.55c -0.0200 $ Pu
mt9 lwtr.01t $ Light Water
c

```

totnu
ctme 480
print

ovbtch_botlp.inp

Three Billets in a Non-pipe 55 Gallon Drum
 c three overpacked Pu billets at the bottom of a 400 g/drum
 c Filled with poly
 c Silicon replaces Calcium
 c
 c Cell Definitions
 c
 c Can Contents - Universe 1
 1 1 -1.04 -1 2 -3 imp:n=1 u=1 \$ Cemented Waste
 2 3 -0.00129 1: -2:3 imp:n=1 u=1 \$ Steel Can
 c
 c Can - Universe 2
 10 3 -0.00129 -4 5 -6 fill=1 imp:n=1
 trcl=(8.150 0.00 -33.100) \$ Can 1
 11 like 10 but trcl=(20.250 7.015 -33.100) \$ Can 2
 12 like 10 but trcl=(20.250 -7.015 -33.100) \$ Can 3
 c
 c Drum - Universe 2
 20 4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1 \$ Interior
 21 4 -0.92 -10 11 -12 (7: -8:9) imp:n=1 \$ Polyethylene
 c
 c Liner
 24 2 -3.92 -13 14 -15 (10: -11:12) imp:n=1 \$ Drum
 25 3 -0.00129 20 -21 -22 -23 24 25 14 -15 13
 imp:n=1 \$ Hex around Drum
 c
 c The Room
 30 3 -0.00129 -37 36 (-20:21:22:23: -24: -25:15: -14)
 imp:n=1 \$ Air around Drum
 31 5 -2.24 -36 -37 imp:n=1 \$ Concrete Floor
 c
 50 0 37 imp:n=0 \$ The Great Void
 c
 c Surface Definitions
 c
 c Billets
 1 cz 6.985 \$ Radius of Waste
 2 pz -8.890 \$ Bottom of Waste
 3 pz 8.890 \$ Top of Waste
 4 cz 6.988 \$ Outside of Can
 5 pz -8.893 \$ Bottom of Can
 6 pz 8.893 \$ Top of Can
 c
 c Drum
 7 cz 28.485 \$ Radius of
 8 pz -41.999 \$ Bottom of
 9 pz 41.999 \$ Top of Interior
 c
 10 cz 28.575 \$ Radius of Liner
 11 pz -42.227 \$ Bottom of Liner
 12 pz 42.227 \$ Top of Liner
 c
 13 cz 28.727 \$ Radius of Drum
 14 pz -42.379 \$ Bottom of Drum
 15 pz 42.379 \$ Top of Drum
 16 pz 42.380 \$ Top above Drum
 c
 c Hexagonal Surfaces (Ax+By+Cz=D)
 20 px -28.729 \$
 21 px 28.729 \$
 c
 A B C D \$
 22 p 0.5 0.8660254 0 28.730 \$
 23 p -0.5 0.8660254 0 28.730 \$
 24 p 0.5 0.8660254 0 -28.730 \$
 25 p -0.5 0.8660254 0 -28.730 \$
 c
 36 pz -42.381 \$ Concrete Floor
 37 so 100.00 \$ End of the World
 c
 mode n
 kcode 3000 1.0 10 100
 ksrc 8.150 0.00 -33.100
 c
 c Cemented Waste (1.041 g/cc) 100% Water
 m1 1001.50c -0.1086 \$ H
 8016.50c -0.8623 \$ O
 94239.55c -0.0289 \$ Pu
 mt1 poly.01t
 c
 c SS-304 (7.83 g/cc)
 m2 6000.50c -0.000293 \$ C

14000.50c -0.007497 \$ Si
 15031.50c -0.000447 \$ P
 16032.50c -0.000294 \$ S
 24000.50c -0.200003 \$ Cr
 25055.50c -0.020000 \$ Mn
 26000.55c -0.651464 \$ Fe
 28000.50c -0.120002 \$ Ni

c
 c Air (0.00129 g/cc)
 m3 7014.50c -0.78084 \$ N
 8016.50c -0.20982 \$ O
 18000.35c -0.00934 \$ Ar
 c
 c Polyethylene (0.92 g/cc)
 m4 6000.50c 0.03952 \$ C
 1001.50c 0.07903 \$ H
 mt4 poly.01t
 c
 c Concrete (2.24 g/cc)
 m5 1001.50c -0.009959 \$ H
 6000.50c -0.000979 \$ C
 8016.50c -0.529069 \$ O
 11023.50c -0.016003 \$ Na
 12000.50c -0.002000 \$ Mg
 13027.50c -0.034006 \$ Al
 14000.50c -0.337036 \$ Si
 19000.50c -0.012981 \$ K
 20000.50c -0.043965 \$ Ca
 26000.55c -0.014002 \$ Fe
 mt5 poly.01t
 c
 c Water (1.0 g/cc)
 m6 1001.50c -0.1119 \$ H
 8016.50c -0.8881 \$ O
 mt6 lwtr.01t \$ Light Water
 c
 c Cellulose (1.45 g/cc)
 m7 1001.50c 0.054311 \$ Cellulose Reflector
 8016.50c 0.026949
 6000.50c 0.03233
 mt7 poly.01t
 c
 c Polyethylene (0.92 g/cc)
 m8 6000.50c 0.03952 \$ Polyethylene Reflector
 1001.50c 0.07903
 mt8 poly.01t
 c
 c Water (1.02 g/cc)
 m9 1001.50c -0.1097 \$ H
 8016.50c -0.8703 \$ O
 94239.55c -0.0200 \$ Pu
 mt9 lwtr.01t \$ Light Water
 c
 totnu
ctme 480
print

ovbtch_ref2p.inp

Three Billets in a Non-pipe 55 Gallon Drum
 c three Pu billets at the bottom of a 400 g/drum
 c One reflecting boundary (two drums)-Poly
 c
 c Cell Definitions
 c
 c Can Contents - Universe 1
 1 1 -1.04 -1 2 -3 imp:n=1 u=1 \$ Cemented Waste
 2 3 -0.00129 1: -2:3 imp:n=1 u=1 \$ Steel Can
 c
 c Can - Universe 2
 10 3 -0.00129 -4 5 -6 fill=1 imp:n=1
 trcl=(8.150 0.00 -33.100) \$ Can 1
 11 like 10 but trcl=(20.250 7.015 -33.100) \$ Can 2
 12 like 10 but trcl=(20.250 -7.015 -33.100) \$ Can 3
 c
 c Drum - Universe 2
 20 4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1 \$ Interior
 21 4 -0.92 -10 11 -12 (7: -8:9) imp:n=1 \$ Polyethylene
 c
 c Liner
 24 2 -3.92 -13 14 -15 (10: -11:12) imp:n=1 \$ Drum
 25 3 -0.00129 20 -21 -22 -23 24 25 14 -15 13
 imp:n=1 \$ Hex around Drum
 c
 c The Room
 30 3 -0.00129 -37 36 (-20:21:22:23: -24: -25:15: -14) -21
 imp:n=1 \$ Air around Drum
 31 5 -2.24 -36 -37 -21 imp:n=1 \$ Concrete Floor
 c

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```

50 0 37:21 imp:n=0 $ The Great Void
c Surface Definitions
c
c Billets
1 cz 6.985 $ Radius of Waste
2 pz -8.890 $ Bottom of Waste
3 pz 8.890 $ Top of Waste
4 cz 6.988 $ Outside of Can
5 pz -8.893 $ Bottom of Can
6 pz 8.893 $ Top of Can
c
c Drum
7 cz 28.485 $ Radius of
8 pz -41.999 $ Bottom of
9 pz 41.999 $ Top of Interior
10 cz 28.575 $ Radius of Liner
11 pz -42.227 $ Bottom of Liner
12 pz 42.227 $ Top of Liner
13 cz 28.727 $ Radius of Drum
14 pz -42.379 $ Bottom of Drum
15 pz 42.379 $ Top of Drum
16 pz 42.380 $ Top above Drum
c
c Hexagonal Surfaces (Ax+By+Cz=D)
20 px -28.729 $
*21 px 28.729 $
c
c A B C D $
22 p 0.5 0.8660254 0 28.730 $
23 p -0.5 0.8660254 0 28.730 $
24 p 0.5 0.8660254 0 -28.730 $
25 p -0.5 0.8660254 0 -28.730 $
c
36 pz -42.381 $ Concrete Floor
37 so 100.00 $ End of the World

mode n
kcode 3000 1.0 10 100
ksrc 8.150 0.00 -33.100
c
c Cemented Waste (1.495 g/cc) 100% Water
m1 1001.50c -0.1086 $ H
8016.50c -0.8623 $ O
94239.55c -0.0289 $ Pu
mt1 poly.01t
c
c SS-304 (7.83 g/cc)
m2 6000.50c -0.000293 $ C
14000.50c -0.007497 $ Si
15031.50c -0.000447 $ P
16032.50c -0.000294 $ S
24000.50c -0.200003 $ Cr
25065.50c -0.020000 $ Mn
26000.55c -0.651464 $ Fe
28000.50c -0.120002 $ Ni
c
c Air (0.00129 g/cc)
m3 7014.50c -0.78084 $ N
8016.50c -0.20946 $ O
18000.35c -0.00934 $ Ar
c
c Polyethylene (0.92 g/cc)
m4 6000.50c 0.03952 $ C
1001.50c 0.07903 $ H
mt4 poly.01t
c
c Concrete (2.24 g/cc)
m5 1001.50c -0.009959 $ H
6000.50c -0.000979 $ C
8016.50c -0.529069 $ O
11023.50c -0.016003 $ Na
12000.50c -0.002000 $ Mg
13027.50c -0.034006 $ Al
14000.50c -0.337036 $ Si
19000.50c -0.012981 $ K
20000.50c -0.043966 $ Ca
26000.55c -0.014002 $ Fe
mt5 poly.01t
c
c Water (1.0 g/cc)
m6 1001.50c -0.1119 $ H
8016.50c -0.8881 $ O
mt6 lwtr.01t $ Light Water
c
c Cellulose (1.45 g/cc)

```

```

m7 1001.50c 0.054311 $ Cellulose Reflector
8016.50c 0.026949
6000.50c 0.03233
mt7 poly.01t
c
c Polyethylene (0.92 g/cc)
m8 6000.50c 0.03952 $ Polyethylene Reflector
1001.50c 0.07903
mt8 poly.01t
c
c Water (1.02 g/cc)
m9 1001.50c -0.1097 $ H
8016.50c -0.8703 $ O
94239.55c -0.0200 $ Pu
mt9 lwtr.01t $ Light Water
c
totnu
ctme 480
print

ovbtch_refp.inp
Three Billets in a Non-pipe 55 Gallon Drum
c three Pu billets at the bottom of a 400 g/drum
c Infinite reflection-Poly
c
c Cell Definitions
c
c Can Contents - Universe 1
1 1 -1.04 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
2 3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can
c
c Can - Universe 2
10 3 -0.00129 -4 5 -6 fill=1 imp:n=1
trcl=( 8.150 0.00 -33.100 ) $ Can 1
11 like 10 but trcl=( 20.250 7.015 -33.100 ) $ Can 2
12 like 10 but trcl=( 20.250 -7.015 -33.100 ) $ Can 3
c
c Drum - Universe 2
20 4 -0.92 -7 8 -9 #10 #12 imp:n=1 $ Interior
21 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 $ Polyethylene
Liner
24 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 $ Drum
25 3 -0.00129 20 -21 -22 -23 24 25 14 -15 13
imp:n=1 $ Hex around Drum
31 5 -2.24 38 -14 20 -21 -22 -23 24 25
imp:n=1 $ Concrete Floor
32 3 -0.00129 -37 15 20 -21 -22 -23 24 25
imp:n=1 $ Air Above Drums
c
50 0 (-20:21:22:23:-24:-25:37:-38) imp:n=0 $ The Great Void
c
c Surface Definitions
c
c Billets
1 cz 6.985 $ Radius of Waste
2 pz -8.890 $ Bottom of Waste
3 pz 8.890 $ Top of Waste
4 cz 6.988 $ Outside of Can
5 pz -8.893 $ Bottom of Can
6 pz 8.893 $ Top of Can
c
c Drum
7 cz 28.485 $ Radius of
8 pz -41.999 $ Bottom of
9 pz 41.999 $ Top of Interior
10 cz 28.575 $ Radius of Liner
11 pz -42.227 $ Bottom of Liner
12 pz 42.227 $ Top of Liner
13 cz 28.727 $ Radius of Drum
14 pz -42.379 $ Bottom of Drum
15 pz 42.379 $ Top of Drum
16 pz 42.380 $ Top above Drum
c
c Hexagonal Surfaces (Ax+By+Cz=D)
*20 px -28.729 $
*21 px 28.729 $
c
c A B C D $
*22 p 0.5 0.8660254 0 28.730 $
*23 p -0.5 0.8660254 0 28.730 $
*24 p 0.5 0.8660254 0 -28.730 $
*25 p -0.5 0.8660254 0 -28.730 $
c
36 pz -42.381 $ Concrete Floor
37 pz 100.00 $ Top of the World
38 pz -100.00 $ Bottom of the
World

```

```

mode n
kcode 3000 1.0 10 100
ksrc 8.150 0.00 -33.100
c
c Cemented Waste (1.04 g/cc) 100% Water
m1 1001.50c -0.1086 $ H
8016.50c -0.8623 $ O
94239.55c -0.0289 $ Pu
mt1 poly.01t
c
c
c SS-304 (7.83 g/cc)
m2 6000.50c -0.000293 $ C
14000.50c -0.007497 $ Si
15031.50c -0.000447 $ P
16032.50c -0.000294 $ S
24000.50c -0.200003 $ Cr
25055.50c -0.020000 $ Mn
26000.55c -0.651464 $ Fe
28000.50c -0.120002 $ Ni
c
c
c Air (0.00129 g/cc)
m3 7014.50c -0.78084 $ N
8016.50c -0.20982 $ O
18000.35c -0.00934 $ Ar
c
c
c Polyethylene (0.92 g/cc)
m4 6000.50c 0.03952 $ C
1001.50c 0.07903 $ H
mt4 poly.01t
c
c
c Concrete (2.24 g/cc)
m5 1001.50c -0.009959 $ H
6000.50c -0.000979 $ C
8016.50c -0.529069 $ O
11023.50c -0.016003 $ Na
12000.50c -0.002000 $ Mg
13027.50c -0.034006 $ Al
14000.50c -0.337036 $ Si
19000.50c -0.012981 $ K
20000.50c -0.043965 $ Ca
26000.55c -0.014002 $ Fe
mt5 poly.01t
c
c
c Water (1.0 g/cc)
m6 1001.50c -0.1119 $ H
8016.50c -0.8881 $ O
mt6 lwtr.01t $ Light Water
c
c
c Cellulose (1.45 g/cc)
m7 1001.50c 0.054311 $ Cellulose Reflector
8016.50c 0.026949
6000.50c 0.03233
mt7 poly.01t
c
c
c Polyethylene (0.92 g/cc)
m8 6000.50c 0.03952 $ Polyethylene Reflector
1001.50c 0.07903
mt8 poly.01t
c
c
c Water (1.02 g/cc)
m9 1001.50c -0.1097 $ H
8016.50c -0.8703 $ O
94239.55c -0.0200 $ Pu
mt9 lwtr.01t $ Light Water
c
totnu
ctme 480
print

```

ovbtchrefrotp.inp

Three Billets in a Non-pipe 55 Gallon Drum
three Pu billets at the bottom of a 400 g/drum
Infinite reflection-Poly

Cell Definitions

```

c
c Can Contents - Universe 1
1 1 -1.04 -1 2 -3 imp:n=1 u=1 $ Cemented Waste
2 3 -0.00129 1:-2:3 imp:n=1 u=1 $ Steel Can
c
c Can - Universe 2
10 3 -0.00129 -4 5 -6 fill=1 imp:n=1
c dx dy dz xx' yy' zz' xy' yz' xz' yz' zz' M
trcl*=( 8.15 0.000 33.1 30 60 90 120 30 90 90 90 0 -1)

```

```

$ Can 1
11 like 10 but
trcl*=(20.25 7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
$ Can 2
12 like 10 but
trcl*=(20.25 -7.015 33.1 30 60 90 120 30 90 90 90 0 -1)
$ Can 3
c
c Drum - Universe 2
20 4 -0.92 -7 8 -9 #10 #11 #12 imp:n=1 $ Interior
21 4 -0.92 -10 11 -12 (7:-8:9) imp:n=1 $ Polyethylene
Liner
24 2 -3.92 -13 14 -15 (10:-11:12) imp:n=1 $ Drum
25 3 -0.00129 20 -21 -22 -23 24 25 14 -15 13 imp:n=1 $ Hex around Drum
31 5 -2.24 38 -14 20 -21 -22 -23 24 25 imp:n=1 $ Concrete Floor
32 3 -0.00129 -37 15 20 -21 -22 -23 24 25 imp:n=1 $ Air Above Drums
c
50 0 (-20:21:22:23:-24:-25:37:-38) imp:n=0 $ The Great Void
c
c Surface Definitions
c
c Billets
1 cz 6.985 $ Radius of Waste
2 pz -8.890 $ Bottom of Waste
3 pz 8.890 $ Top of Waste
4 cz 6.988 $ Outside of Can
5 pz -8.893 $ Bottom of Can
6 pz 8.893 $ Top of Can
c
c Drum
7 cz 28.485 $ Radius of
8 pz -41.999 $ Bottom of
Interior
9 pz 41.999 $ Top of Interior
c
10 cz 28.575 $ Radius of Liner
11 pz -42.227 $ Bottom of Liner
12 pz 42.227 $ Top of Liner
c
13 cz 28.727 $ Radius of Drum
14 pz -42.379 $ Bottom of Drum
15 pz 42.379 $ Top of Drum
16 pz 42.380 $ Top above Drum
c
c Hexagonal Surfaces (Ax+By+Cz=0)
*20 px -28.729 $
*21 px 28.729 $
c A B C D $
*22 p 0.5 0.8660254 0 28.730 $
*23 p -0.5 0.8660254 0 28.730 $
*24 p 0.5 0.8660254 0 -28.730 $
*25 p -0.5 0.8660254 0 -28.730 $
c
36 pz -42.381 $ Concrete Floor
37 pz 100.00 $ Top of the World
38 pz -100.00 $ Bottom of the
World

```

```

mode n
kcode 3000 1.0 10 100
ksrc -8.150 0.00 -33.100
c
c Cemented Waste (1.041 g/cc) 100% Water
m1 1001.50c -0.1086 $ H
8016.50c -0.8623 $ O
94239.55c -0.0289 $ Pu
mt1 poly.01t
c
c
c SS-304 (7.83 g/cc)
m2 6000.50c -0.000293 $ C
14000.50c -0.007497 $ Si
15031.50c -0.000447 $ P
16032.50c -0.000294 $ S
24000.50c -0.200003 $ Cr
25055.50c -0.020000 $ Mn
26000.55c -0.651464 $ Fe
28000.50c -0.120002 $ Ni
c
c
c Air (0.00129 g/cc)
m3 7014.50c -0.78084 $ N
8016.50c -0.20982 $ O
18000.35c -0.00934 $ Arc
c
c
c Polyethylene (0.92 g/cc)
m4 6000.50c 0.03952 $ C

```

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mt4	1001.50c	0.07903	\$ H
c	poly.01t		
c	Concrete (2.24 g/cc)		
m5	1001.50c	-0.009959	\$ H
	6000.50c	-0.000979	\$ C
	8016.50c	-0.529069	\$ O
	11023.50c	-0.016003	\$ Na
	12000.50c	-0.002000	\$ Mg
	13027.50c	-0.034006	\$ Al
	14000.50c	-0.337036	\$ Si
	19000.50c	-0.012981	\$ K
	20000.50c	-0.043965	\$ Ca
	26000.55c	-0.014002	\$ Fe
mt5	poly.01t		
c			
c	Water (1.0 g/cc)		
m6	1001.50c	-0.1119	\$ H
	8016.50c	-0.8881	\$ O
mt6	lwtr.01t		\$ Light Water
c			

c	Cellulose (1.45 g/cc)		
m7	1001.50c	0.054311	\$ Cellulose Reflector
	8016.50c	0.026949	
	6000.50c	0.03233	
mt7	poly.01t		
c			
c	Polyethylene (0.92 g/cc)		
m8	6000.50c	0.03952	\$ Polyethylene Reflector
	1001.50c	0.07903	
mt8	poly.01t		
c			
c	Water (1.02 g/cc)		
m9	1001.50c	-0.1097	\$ H
	8016.50c	-0.8703	\$ O
	94239.55c	-0.0200	\$ Pu
mt9	lwtr.01t		\$ Light Water
c			
totnu			
ctme	480		
print			

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APPENDIX D - PRELIMINARY HAZARDS ANALYSIS

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List of Terms

AIChE	American Institute of Chemical Engineers
CSER	Criticality Safety Evaluation Report
CWC	Central Waste Complex
GB	glovebox
ID	Identification Number
NC	no controls
PHA	Preliminary Hazards Analysis

List of Definitions

Container - Any vessel that is in a position to hold solids or liquids (e.g., a pan turned upside down is not a container).

Contingency - A possible but unlikely change in a condition/control important to the nuclear criticality safety of a fissionable material operation that would, if it occurred, reduce the number of barriers (either administrative or physical) that are intended to prevent an accidental nuclear criticality.

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PLUTONIUM RESIDUE IN 55-GALLON DRUM CRITICALITY PRELIMINARY HAZARDS ANALYSIS

1.0 PURPOSE

The purpose of this Preliminary Hazard Analysis (PHA) is to identify potential events and conditions that could lead to a nuclear criticality in the cemented Sand, Slag, and Crucible (SS&C), ash, oxide or other miscellaneous residues stored within 55-gallon drums at the Plutonium Finishing Plant (PFP). The results of this PHA will be used for input into the Plutonium Residue in 55-Gallon Drum Criticality Safety Evaluation Report (CSER).

This PHA was conducted in two stages. At the beginning of CSER preparation, drum loading in Building 234-5Z was assumed to be in Room 235B with storage in Rooms 172 and 192D as described in Section 2.0. The areas of the facility assessed at that meeting are illustrated in Figure 1 with the results summarized in Table A1. After the CSER was completed, a second PHA meeting was conducted to identify to what extent the CSER would apply to loading drums and storing them in the balance of Building 234-5Z. In addition, the dropped billet and drum tipping/rolling events were reevaluated as likely rather than unlikely events. Results of the second PHA meeting are described in Section 6.0.

2.0 PROCESS DESCRIPTION USED IN CSER PREPARATION

The cementation process will take place within the Plutonium Finishing Plant (PFP). Billet cans of cemented Sand, Slag, and Crucible (SS&C) scrap are removed from the HA-28 conveyor belt in room 235B through a 12-inch sealout port, individually bagged, and loaded into 55-gallon steel drums with rigid polyethylene liners. The billet cans bagged out of HA-28 may also be placed into 55-gallon drums containing pipe overpack containers (POC). One drum at a time will be loaded within a containment structure. The drums from either cementation or other processing activities will be sealed, loaded onto a transfer cart, and moved to a temporary storage location within the PFP to await shipment to offsite disposal. The transfer cart will maintain at least 18 inches of clearance from any other fissile material. Relief from the 18-inch rule may be needed for the passage between HA-20MB, HA-21I and the 235B stairway.

If the temporary storage location is room 192D, the drum will move down room 235B, through rooms 235C and 235D, through the room 193 airlock, into room 192, and from there into room 192D. It will be removed through corridor 192 and door 133 to the West Pad for loading onto a transport truck for shipment to the Central Waste Complex (CWC) (see Figure 1). If the temporary storage location is room 172, the drum will move down room 235B, through room 235C and room 245 to Corridor 6, and into room 172. It will be removed through corridors 6, 7, and 7A and door 131 to the West Pad for loading onto a transport truck for shipment to the CWC.

A PHA is a hazards identification/evaluation technique derived from the U.S. Military Standard System Safety Program Requirements (MIL-STD-882). A PHA is a structured

discovery process involving a multi-disciplinary team and focuses on the hazardous materials and major process areas of a facility. The results of the PHA are recorded using a tabular format. Because of its military heritage, the PHA technique is useful for reviewing process areas where energy can be released in an uncontrolled manner. In general, the PHA formulates a list of hazards and hazardous situations by considering the following process characteristics:

- Raw materials, intermediate and final products, and their reactivity
- Plant equipment
- Facility layout
- Operating environment
- Operational activities (testing, maintenance, etc.)
- Interfaces among system components.

The American Institute of Chemical Engineers (AIChE) recognizes the PHA process as a creditable method of hazard evaluation. AIChE describes this process in their publication titled "Guidelines for Hazard Evaluation Procedures" (AIChE 1992).

The depth of a PHA is directly related to the experience and knowledge of the participants. A short resume of each team member is included (Section 3.0) to document the experience and knowledge of the PHA team.

3.0 PHA EVALUATION STRUCTURE

The hazardous condition of concern for this PHA is a nuclear criticality. Criticality events are prevented by establishing limits for specific parameters. These parameters are referred to as controlled parameters. This PHA was structured to address the following controlled parameters:

Mass
Volume
Geometry
Moderation
Reflection
Interaction
Enrichment
Density
Concentration
Poisons

The process occurring involves loading the cans containing the SSC scrap into a 55-gallon drum, transferring the drum to a storage location, and transferring the drum to the truck loading dock. It is conservatively assumed that all cans are unconstrained in position inside the drum. The PHA was structured as follows to evaluate the controlled parameters associated with process steps and conditions:

1. Processes Occurring in Containment Envelope

- Removal of billet can from conveyor
- Billet can seal out
- Drum loading

2. Processes Occurring Outside Containment Envelope

- Move drum to storage
- Drum storage
- Move drum to loading dock

External Events

Fire

Flood

Seismic

High winds

4.0 PHA TABLE DESCRIPTION

The PHA table (Table A1) was structured to ensure a systematic and thorough evaluation of the controlled parameters. The PHA table captured the following information:

ID: Item identification used to record a unique identifier for the hazardous condition.

Process Condition or Step: The process step or condition being evaluated for potential situations which can result in changes in the controlled parameters that could cause a criticality during cementation drum loading.

Event and Detailed Causes: Specific events and causes that have the potential to result in a criticality. This column is used to capture details that may be important in the analysis that will define the controls to prevent a criticality.

Controlled Parameter: Parameters that are controlled to prevent the occurrence of criticality events. Ten parameters are used: **mass, volume, moderation, interaction, reflection, geometry, enrichment, density, concentration, and poisons.**

Engineered Safety Features: Hardware items that are identified by the PHA team that have the potential to mitigate or prevent the hazardous condition of concern.

Administrative Safety Features: Administrative controls such as facility worker training and safety procedures identified by the PHA team that have the potential to mitigate or prevent the hazardous condition.

Freq Cat NC: Frequency Category, No controls – The frequency ranking is a qualitative estimate of whether the hazardous condition is considered credible (C) or not credible (NC). Conditions considered NC will not be evaluated further. Credible conditions considered likely (L) are considered in the base case analysis. Credible conditions considered unlikely (U) are considered as contingencies to the base case.

Remarks: Miscellaneous observations or clarifying comments provided for a given item. This column is also used to capture criticality analysis requirement decisions of the PHA team.

5.0 PHA RESULTS

The results of this PHA are in the form of information to be considered as part of the Criticality Safety Evaluation Report (CSER). The raw data are presented in Table A1. The information contained in the PHA table is used to ensure that the CSER analysis addresses the appropriate conditions that may contribute to a criticality in the HC-20MB glovebox. The following assumptions that are important to the CSER analysis were extracted from Table A1 and discussions during the PHA.

Plutonium Residue in 55-Gallon Drum PHA Assumptions and Dispositions Derived from the PHA:

1. Analysis scope covers the following process steps: seal out billet, load billet in drum, move drum to storage location, and store the drum. SARP covers shipment of drum to CWC.
2. CSER 96-027 is to be replaced via this analysis.
3. This analysis assumes that loading more than one drum at a time with cemented billets is not credible, based on the anticipated size of the containment enclosure.
4. Each billet (2.7 L, 5.5" dia x 7" high) is sealed out one at a time in a plastic bag. Sealout of more than one billet per bag is a contingency considered in ID #1 of Table A1.
5. Drums will be transported to Room 192D or other location for storage (see Section 2.0 of this Appendix). This analysis is intended to be flexible enough to accommodate several possible storage locations.
6. The mass limit evaluated in this analysis is a maximum of 200 g Pu or fissile equivalent for the unconstrained drum or 6-inch or 12-inch pipe overpack.
7. The current minimum distance allowed between the edge of the container and any other fissile material over 100 g is 18 inches during transit. Drums passing by HA-20MB and HA-21I may require an exception to the 18-inch rule. The analysis will evaluate this condition.
8. This analysis assumes that drums will pass by HA-23S at a minimum of 3 feet. The analysis will evaluate closer distances as a contingency.

9. Preferred storage of drums in 192 D is 2 x infinite arrays, 1 high, butted up against concrete walls and directly on floor. The analysis assumes an infinite array (1 high) in the horizontal plane. The drums are to be arranged in a square array, but the analysis will consider arrangement in a hexagonal array.
10. Drums weigh from 120 to 300 lbs. The analysis will consider the weight of the drum and wagon.
11. Intermixing of other types of waste drums in an infinite array is considered likely and will be evaluated in the analysis. This condition is listed in ID #16 of Table A1.
12. The analysis assumes unrestricted moderation.
13. The analysis assumes that drums have heads and bolt rings on during transit and storage. Transporting an open drum is considered "unlikely" in ID #15 of Table A1 and will be evaluated as a contingency.
14. The analysis assumes that only one drum will be transported at a time.
15. The drum will be latched to a carrier for moving. Failure of the latch is considered credible but unlikely. It is not credible for a tipped and rolling drum to damage a "wagon" or to roll under a glovebox. See ID #13 of Table A1.
16. The analysis assumes that the drum array can only be crushed vertically. See ID #18 of Table A1.
17. Cans may be loaded either in drums with a center pipe, or in unconstrained drums.
18. In addition to cemented SSC scrap, the drum may be loaded with cans containing uncemented ash and/or oxide.

6.0 EXTENSION OF PHA TO LOAD AND STORE DRUMS IN OTHER ROOMS OF BUILDING 234-5Z

As a second stage to the PHA, the team members listed in Section 7.0 reconvened to evaluate the applicability of the CSER, based upon the hazards review of the process described in Section 2.0, to other rooms in the PFP Building 234-5Z. PFP operations would like to extend the CSER analysis for loading and storing drums for processing activities other than cementation in as much of the building as possible.

The worst mass overload analyzed was 400 g plutonium with unrestricted moderation. Therefore, areas of the building where an overbatch contingency greater than 400 g was credible need to be excluded. Because the scrap and billet containers are larger and physically different

from those containing metal or oxide, it was concluded that operator training and procedure would preclude accidental loading of greater mass containers into these drums.

In a seismic event, either end of the plutonium nitrate transfer piping from Room 227 to Room 230C could be a source of liquid fissile material not analyzed in this CSER. The pipe conduit is seismically qualified for the rest of its length, so the drums need to be excluded from these rooms at the source and destination of the piping but not in between. It is not possible to get plutonium nitrate in these drums elsewhere in 234-5Z. Open drums are not stored at the PFP, which precludes an accidental accumulation of other forms of fissile material in these drums. The PHA team concludes that it is not credible to get more than 400 g of plutonium into these drums anywhere else in Building 234-5Z.

The worst interaction effect analyzed was a five-position wagon loaded with 2.5 kg plutonium as metal or 4.5 kg plutonium as oxide in each position. Vaults, with their greater fissile mass loading, are outside of this analysis and are excluded from allowed locations for loading and storing these drums. The PHA team reviewed the fissile mass inventory of gloveboxes, transfer containers, and storage arrays for possible interaction with these drums throughout the balance of Building 234-5Z. The team concluded that the fully-loaded wagon, already analyzed in the CSER, was the worst interaction event. Interaction with glovebox contents, drums with plutonium nitrate, or isolated transport containers are bounded by the wagon/drum analysis.

The CSER includes a single drum/wagon interaction as a likely event in one of the base cases. The dropped billet and drum tipping/rolling events are bounded by the wagon interaction and there is no need to consider them as contingencies. Initially, the PHA team concluded that a dropped billet and drum tipping/rolling were unlikely events. However, upon reconsideration, it was agreed that these could be considered likely, that they are bounded by the base case, and that they could be removed from the contingency table in the CSER. Table A1 is therefore changed to indicate dropped billets and drum tipping/rolling as likely.

7.0 PHA TEAM MEMBER BIOGRAPHIES

David J. Braun, Fluor Federal Services, Inc., Engineer, Safety Analysis and Risk Assessment. Mr. Braun has over 21 years experience at Hanford working primarily in Safety Analysis. His experience includes Probabilistic Risk Analysis of nuclear reactors, tank farm activities, and hazards identification and evaluation of various Hanford site operations and facilities. He was one of the lead engineers on the hazards identification and evaluation team for the current TWRS BIO and FSAR. He has facilitated numerous PHA and HAZOP studies for projects at the Hanford site. Mr. Braun has a Master of Science Degree in Mechanical Engineering from the University of California at Davis. He is a registered Professional Engineer in Mechanical Engineering (Washington State).

Lane Cunningham, Parsons Engineering, Project Engineer. Mr. Cunningham has 9 years experience working at the Hanford site. The last 7 years were spent working on stabilization and baseline projects for the Plutonium Finishing Plant (PFP). While a direct employee at the PFP, he served as a shift technical adviser and held various cognizant engineer positions in support of stabilization activities, including cementation. His primary responsibilities included installation, start-up, and operational support for the Thermal Stabilization process, cementation process, Vertical Denitration process, and the Low Level Waste Treatment Facility (LLWTF). He has both undergraduate and master degrees in chemical engineering from the University of North Dakota. Mr. Cunningham is currently serving as the Acting Project Manager for the cementation project.

LaPriel Dayley, Project Enhancement Corporation, Project Engineer. Ms. Dayley has 15 years of experience working at the Hanford Site. She spent about 4 years as technical support for N Reactor and 7 years as Process Engineer at PFP. She was the Cementation process cog engineer for initial process start up in 1996. Her experience includes specifying equipment, acting as PIC for equipment installation, developing procedures and technical basis documents and shift technical support. Ms. Dayley has a Bachelor of Science degree in Chemical Engineering from the University of Washington.

Ken Dobbin, Fluor Federal Services, Inc, Criticality Safety Engineer. Mr. Dobbin has 25 years experience as a nuclear engineer, 20 of these years analyzing reactor physics and fuel management and 5 years in criticality safety. He is qualified as a Criticality Safety Engineer at the Plutonium Finishing Plant and has 20 months experience with PFP systems. During his PFP tenure, he contributed criticality safety expertise for the successful completion of an Operational Readiness Review to resume thermal stabilization of plutonium. Mr. Dobbin has both undergraduate and masters degrees in nuclear engineering.

David G. Erickson, Fluor Federal Services, Criticality Safety Engineer. Mr. Erickson has a B. S. in Physics, and has been at the Hanford Site for 16 years performing analysis in the fields of reactor physics and 13 years in criticality safety. He is familiar with the codes used in criticality analysis and has performed analysis and reviews of other PFP operations. He is a qualified Criticality Safety Specialist with FFS.

Harvey J. Goldberg, Fluor Federal Services, Inc., Engineer. Dr. Goldberg has 21 years at the Hanford Site. His experience has been in PFP, WRAP, BWIP, HWVP, and packaging and shipping. This experience has been in the field of safety concerned with shielding, criticality, operational procedures, source development, and facility siting, design, and regulatory approval. Dr. Goldberg has a B. S. from the University of Rhode Island, and an M. S. and Ph. D. from Kansas State University as well as certification from the American Academy of Health Physics.

Brit E. Hey, Fluor Federal Services, Inc., Safety Analysis and Risk Assessment. Mr. Brit Hey has over 18 years of combined engineering and management experience in the commercial and DOE nuclear industries. For the last 10 years Mr. Hey has performed safety analysis for numerous Hanford facilities and activities including tank farms, the waste encapsulation and storage facility, B-Plant, and the plutonium finishing plant. Mr. Hey has successfully completed the process hazard analysis leader training course offered by the ABS Group, Inc. Mr. Hey has both undergraduate and masters degrees in nuclear engineering from North Carolina State University.

James R. Hilliard, Fluor Hanford, PFP Solid Waste Operations, Team Leader. Mr. Hilliard has 16 years of waste management and fissile material handling experience at the Hanford Site including nuclear fuel fabrication, reactor operations, hazardous and radioactive waste packaging and shipping. He was the PUREX Solid Waste Cognizant Engineer and Team Leader for the PUREX Waste Team through the PUREX deactivation. Jim currently is the Team Leader for the PFP Solid Waste Operations Team, which manages all containerized wastes at the PFP.

James R. Hilliard, Fluor Hanford, PFP Solid Waste Operations, Team Leader. Mr. Hilliard has 16 years of waste management and fissile material handling experience at the Hanford Site including nuclear fuel fabrication, reactor operations, hazardous and radioactive waste packaging and shipping. He was the PUREX Solid Waste Cognizant Engineer and Team Leader for the PUREX Waste Team through the PUREX deactivation. Jim currently is the Team Leader for the PFP Solid Waste Operations Team, which manages all containerized wastes at the PFP.

Robert F. Richard, Fluor Federal Services, Inc., Criticality Safety Engineer. B. S. Nuclear Engineering. Thirteen years experience at Hanford performing nuclear engineering analyses in fuel management, reactor physics, radiation shielding, and seven years in criticality safety.

Maria E. Shaw, B&W Federal Services, PFP Nuclear Criticality Safety Representative, Nuclear Engineer. Ms. Shaw has worked as an engineer since 1991 and has been at the Hanford site since 1998. She has worked at the Plutonium Finishing Plant as a criticality safety representative and is plant certified as a Criticality Safety Representative. She has worked on the PFP thermal stabilization project. Ms. Shaw holds a B. S. in Math from Idaho State and an M. S. in Chemistry from Univ. of Idaho. Prior to Hanford, she worked in the criticality safety field at Idaho National Engineering Laboratory and at the Naval Nuclear Fuel Facility (Lynchburg, VA.)

Blaise S. Mo, Fluor Hanford Company, Criticality Safety Representative for PFP. B. S. Physics and M. S. Environmental Science and Engineering. Over seventeen years experience in various

assignments at the Rocky Flats Environmental Technology Site, including eleven years as a criticality safety engineer and six years in managing analytical laboratories, training programs, and facility operations. Recently assigned as a CSR at PFP.

Brian D. Skeels, Fluor Hanford Company, PFP Stabilization Operations, Thermal Stabilization Support Team Leader. Mr. Skeels has 15 years experience at the Hanford Site. His experience has been at 100-KE/KW basins, 100N and PFP. Mr. Skeels has been at PFP for 12 years with 9 years as a First Line Supervisor/Manager. Mr. Skeels is currently the Team Leader for the Thermal Stabilization Support Team (TSST). Prior to being assigned as the TSST Team Leader, Mr. Skeels was a Shift Manager in charge of both the Cementation and Thermal Stabilization Processes during their operating campaigns. Mr. Skeels is currently qualified on the Cementation process as it was operated during the last campaign.

Hans Toffer, Fluor Federal Services, Inc., Criticality and Shielding. Managed technical organizations and projects with emphasis on criticality safety, reactor physics and nuclear engineering. Background includes: Criticality safety of plutonium, high enriched uranium, low enriched uranium processing, storage and handling, thermal reactor core analysis and measurements, neutronic, ultrasonic and vibration measurement technology development, isotope production, reactor design analysis, computer code software quality assurance, organizing national technical meetings and participating in American National Standards development. Responsibilities included: Technical management and direction technical team leadership, coordination of multi-discretionary teams, served as classification officer, chairman of American National Standards working group ANS 8.21, chaired and organized national/international technical meetings, and served on special assessment teams at different Department of Energy contractor sites.

James C. Williams, Fluor Federal Services, Inc., Safety Analysis and Risk Assessment. Mr. Williams has fourteen years of experience in the nuclear industry, including five years at the Hanford site. At Hanford, he has worked on waste tank characterization, vadose zone characterization, and safety analysis for tank farms operations. Mr. Williams has a bachelor of science degree in nuclear engineering from the Pennsylvania State University.

8.0 References

AICHE, 1992, *Guidelines for Hazard Evaluation Procedures*, American Institute of Chemical Engineers, New York, New York.

MIL-STD-882B, 1977, *System Safety Program Requirements*, Department of Defense, Washington, DC

FIGURE 1

TABLE A1. CEMENTATION DRUM LOADING PRELIMINARY HAZARDS ANALYSIS

Total Pages: 2

Date: January 19, 2000

ID	PROCESS CONDITION STEP	OR	EVENT AND DETAILED CAUSES ¹	CONTROLLED PARAMETER ²	ENGINEERED SAFETY FEATURES	ADMINISTRATIVE SAFETY FEATURES	FREQ CAT ³	REMARKS
1	Seal out billet		Seal out more than one billet can at a time in the same bag.	Mass	None	Procedures, training	C, U	More than 2 billets in 1 bag is not credible, due to physical weight limitations.
2	Seal out billet		More than 200 gm Pu in billet can.	Mass	None	Procedures, training, inventory control	C, U	400 gm is maximum credible overbatch.
3	Seal out billet		Container from other process sealed out (e.g., 400-gm unrestricted moderation).	Interaction	Billet container is visually different from other containers	Procedures, training	C, U	Wrong container will have different appearance on conveyor. Could affect maximum mass loaded into drum (see below).
4	Seal out billet		Dropped billet.	Interaction	Containment tent	Procedures, training	C, L	Dropped can will roll around within the tent.
5	Load billet in drum		Less than 16 kg steel in drum.	Poison	Drum specs	Acceptance criteria	NC	Drums usually weigh approximately 28 kg. without internals
6	Load billet in drum		Missing drum liner.	Poison	None	Procedures, training	C, U	None
7	Load billet in drum		Container from other process (not a billet) inadvertently loaded into drum.	Interaction, mass, spacing	Billet container is visually different from other containers	Procedures, training	C, U	See #3; see CPS for HA-28 conveyor
8	Load billet in drum		Water introduced into drum.	Moderation, reflection	Containment tent	Procedures, training	C, U	Possibly caused by fire suppression system.
9	Load billet in drum		Overloading drum with Pu.	Mass	None	Procedures, training	C, U	None
10	Move drum to storage		Properly loaded drum closer than allowed to other fissile material.	Interaction	None	Procedures, training	C, L	Worst case is boat in HA-211.
11	Move drum to storage		Improperly loaded drum closer than allowed to other fissile material.	Mass, interaction	None	Procedures, training	C, U	Worst case is fully loaded 5-position fixed array wagon.
12	Move drum to storage		Properly loaded drum closer than allowed to other fissile material.	Mass, interaction	None	Procedures, training	C, L	Worst case is fully loaded 5-position fixed array wagon.
13	Move drum to storage		Drum tips and rolls.	Interaction	Drum cart has hold-down clamp	Procedures, training	C, L	A tipped drum cannot crush the wagon.
14	Drum storage		Hexagonal packing.	Interaction	None	None	C, L	Drum diameter (24") determines spacing.
15	Drum storage		Water spray from fire suppression system.	Moderation	None	None	C, U	Drums are covered per Assumptions.
16	Drum storage		Intermixing of other types of waste drums (properly loaded).	Interaction	None	None	C, L	NDA assures other waste is OK.

TABLE A1. CEMENTATION DRUM LOADING PRELIMINARY HAZARDS ANALYSIS

Total Pages: 2

Date: January 19, 2000

ID	PROCESS CONDITION OR STEP	EVENT AND DETAILED CAUSES ¹	CONTROLLED PARAMETER ²	ENGINEERED SAFETY FEATURES	ADMINISTRATIVE SAFETY FEATURES	FREQ CAT ³	REMARKS
17	Drum storage	10% of drums are overloaded with Pu (by 10%).	Mass	None	Procedures, training	C, U	None
18	Drum storage	Drum crushed by falling roof or walls.	Spacing	None	None	C, U	Only one-dimensional collapse of building is credible.
19	Drum storage	Drums are stored in 192D, adjacent to room 192A with FFTF fuel.	Interaction	None	None	C, L	Concrete wall on West side of building, standard construction on the other three walls.
20	Drum storage	Drums are stored in 172, adjacent to room 174 (cabinet storage), 175 (pedestal storage), and 179 (PPSL).	Interaction	None	None	C, L	Concrete walls are between 172 and 174, between 172 and 175, but not between 172 and 179.
21	Drum storage	Drums are stacked.	Interaction, geometry	None	Procedures, training	C, U	None
22	Drum storage	Fire, seismic.	N/A	N/A	N/A	N/A	Addressed above in items 15 and 18.
23	Drum storage	Tornado and other natural phenomena.	N/A	N/A	N/A	N/A	Would reduce reactivity by spreading fissile material in the building.

1 - Variation: MORE, LESS, NO, AS WELL AS, PART OF, REVERSE, OTHER THAN

2 - Controlled Parameters: MASS, VOLUME, MODERATION, INTERACTION, REFLECTION, GEOMETRY, ENRICHMENT, DENSITY, CONCENTRATION, POISONS

3 - Freq. Cat.: C - Credible, NC - Not Credible, U - Unlikely, L - Likely

Note: Fissile material is assumed to be present for all controlled parameters

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APPENDIX E - MCNP MODEL FIGURES

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Figure E-1. Wagon Next to Single Drum - Plan.

Figure E-2. Wagon Next to Single Drum - Elevation
(Note that only one billet is in the plane of this cut)

Figure E-3. Wagon Next to Room Array of Drums - Plan

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