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Low-Level Waste Vitrification Contact Maintenance Viability Study

C. E. Leach

Westinghouse Hanford Company, Richland, WA 99352
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LOW-LEVEL WASTE VITRIFICATION CONTACT MAINTENANCE VIABILITY STUDY

1.0 INTRODUCTION

This study investigates the economic viability of contact maintenance in the Low-Level Waste Vitrification Facility, which is part of the Hanford Site Tank Waste Remediation System (TWRS). This document was prepared by Fluor Daniel, Inc., and transmitted to Westinghouse Hanford Company in September 1995.

The attached report is divided into the following main sections:

- 1.0 Introduction
- 2.0 Method and Approach
- 3.0 Source Terms
 - Tank Waste Source Terms Selection
 - Process Flow Stream Term Derivation
 - Source Term Evaluation for Maintenance
- 4.0 Maintenance Cases (Examples)
- 5.0 Non-Radioactive Glass Plant Evaluation
- 6.0 Conclusions

The appendices to the report contain supporting data:

- A - Process Flow Diagrams for Option 4C
- B - Facility Layout Drawings for Option 2C
- C - ASPEN¹ Runs for Seven Tank Wastes
- D - Shielding Source Spreadsheets for Seven Sources and Selected Process Streams
- E - Beta Spectra for Selected Sources/Streams

¹ASPEN is a trademark of Aspen Technology.

- F - Example Source Analysis for the High Blend Waste Source
- G - Selected Equipment Specifications from Equipment List SORs
- H - Location of Expected Cesium Accumulation Locations in a Combustion Melter
- I - Offgas Recirculation and Associated Bremsstrahlung Factor Analysis
- J - Specifics for the Various Maintenance Radiation Dose Rate Calculations for the High Blend Waste Streams
- K - Facility Layout Drawings for Non-Radioactive Glass Plant

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ATTACHMENT

Final Report
CONTACT MAINTENANCE VIABILITY STUDY

CHSS 2024 A & B

Prepared for
Westinghouse Hanford Company
Richland, Washington

Prepared by
Fluor Daniel, Inc.
Richland, Washington

September 28, 1995

LIGHTSBL.RPT

Attachment-1

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- IN3. Maintenance Data Sheet for Mist Eliminator
- IN4. Maintenance Data Sheet for Melter Feed Pump
- IN5. Maintenance Data Sheet for Offgas Pipe

DF Optimized Maintenance Data Sheets (NCAW Source):

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- DF2. Maintenance Data Sheet for Evaporator Heat Exchanger
- DF3. Maintenance Data Sheet for Mist Eliminator
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EXECUTIVE SUMMARY

INTRODUCTION

The purpose of this study is to investigate the economic viability of contact maintenance in the Low-Level Waste (LLW) vitrification facility which is part of the Hanford Tank Waste Remediation System (TWRS). The capital cost of a LLW vitrification facility can be broken down into four components:

1. The basic cost of the building and equipment without any allowance for radioactive material. This is represented by the cost of a 200 MT/day commercial glass plant which is estimated to be \$196 million.
2. The additional cost of meeting the Federal Acquisition Requirements (FARs) and using Hanford labor rates. This additional cost is estimated to be \$74 million for a total of \$270 million.
3. The additional cost of handling low source term radioactive material in a LLW vitrification facility. This includes the cost of basic shielding to meet radiological control guidelines and the cost of building confinement systems to control the release of airborne contamination. This additional cost is estimated to be \$636 million resulting in a total cost of \$906 million for a contact maintained facility.
4. The additional cost of remote handling equipment and support facilities to allow the processing of higher source term radioactive material in a remotely maintained LLW vitrification facility. This additional cost is variable, and depends on the degree of remote operations required. The maximum is estimated to be \$444 million resulting in a total cost of \$1,350 million for a mostly remote maintained facility.

The first three components are not controllable within the scope of this study. Only the last component, the degree of remote maintenance, is variable. The degree of remote maintenance required is dependent on the radiation intensity of the waste being vitrified. The radiation characteristics of the waste is, in turn, dependent on the amount of pretreatment processing performed (removing highly radioactive nuclides from the LLW stream and adding them to the high-level waste stream).

To estimate the cost variation as a function of remote maintenance requirements, five maintenance scenarios were identified. Each scenario represents groups of maintenance tasks

with similar radiation exposures. Moving from a low exposure scenario to a higher one either requires additional pretreatment of the waste to allow for contact maintenance or additional remote handling equipment to perform the task. The scenarios were selected so that the step from one scenario to the next represents approximately 25 percent of the costs associated with remote handling equipment.

Additional pretreatment processing to allow more contact maintenance is expensive. Two pretreatment facility designs were prepared and their costs estimated. The first design removed 99 percent of the cesium from the LLW stream, which is a decontamination factor (DF) of 100 and is used throughout the study as the "base case." This defines the high source term LLW stream which requires a mostly remote maintained vitrification facility. The capital cost of this pretreatment facility design was estimated to be \$426 million. The second design removed 99.99 percent (DF of 10,000) of the cesium and 99 percent (DF of 100) the strontium. This defined the low source term LLW stream which, at the time, was assumed to allow for complete contact maintenance. (Further investigation later showed that additional pretreatment is required to allow complete contact maintenance.) The capital cost of this pretreatment facility design was estimated to be \$701 million.

CONCLUSIONS

Figure E.1 shows the capital costs of the pretreatment facility, the LLW vitrification facility, and the combined total as a function of the dose rate ratio (DRR). DRR is the ratio of the dose rate resulting from a higher DF (more radioisotopes removed in the pretreatment facility) to the dose rate of the base case (high source term, cesium DF=100). As can be seen, the cost of additional pretreatment is greater than the savings from less remote maintenance in the LLW vitrification facility. It should also be noted from the curve that considerable reduction in radiation dose rate is required before any meaningful reduction in capital cost is realized. The single greatest cost driver of those identified is the need to provide radiation shielding and contamination confinement when handling radioactive materials.

Two important byproducts of this study are the development and documentation of a methodology for assessing the viability of contact maintenance for specific waste activities, and the utilization of this assessment to define the required pretreatment processing steps. The linking of reductions in radiation source strength to specific pretreatment processing steps achieves an important integration of the overall TWRS waste treatment processes.

BASIS

In order to determine the sensitivity of the radiation fields to waste type (the composition of the waste), seven different tank wastes are studied. Some are current best estimates of actual tank wastes, treated and untreated, and some are simulated combinations/blends ranging from a nominal blend case, to a high blend case, to a maximum theoretical case using the maximum possible radioisotopic concentrations from a number of tanks. The unit radiation fields (mrem/h per gallon) from these tank wastes are compared and ranked from a radiation intensity perspective.

In order to correctly identify the DFs needed to achieve contact maintenance for specific maintenance activities, each contact maintenance activity is analyzed separately. The maintenance activities are analyzed by means of the Maintenance Data Sheets (MDS) developed for this study. Using the radiation dose rate data obtained by shielding analysis, the highest radiation dose rate can be determined. If this dose rate is less than the maximum allowed (50 mrem/h per the Hanford Site Radiological Control Manual), then the total exposure for the entire job for any individual maintenance crew member must be determined. Total exposure must be less than the maximum allowable (assumed to be 300 mrem for this study) to qualify for contact maintenance. If either of these tests fail then pretreatment DFs can be indirectly established that would allow contact maintenance.

The maintenance activity DF analysis is performed indirectly since there are potentially several combinations of waste source constituent DFs which could lead to the same overall dose rate reduction, i.e., there is not necessarily a unique solution to the DF requirement. The approach is to work with the dose rate reduction factors. Any combination of DFs that will produce a dose rate reduction less than that needed for contact maintenance will be acceptable for the purposes of achieving contact maintenance for the specific maintenance activity.

This approach is applied to the five maintenance scenarios discussed in the report. Using the five MDSs, the dose rate reductions were iteratively changed by manual trial and error until the maintenance activity just qualified to be contact, based on both the 50 mrem/h and the 300 mrem/job criteria. These results are summarized in Table E.1 for the NCAW source.

Figure E.1: Summary of Capital Costs Versus Dose Rate Ratio

Table E.1: Summary of Dose Rates for Five Maintenance Scenarios

Maintenance Scenario	Initial Dose Rates		Req'd Dose Rates		DR Ratio
	30 cm	100 cm	30 cm	100 cm	
Rotary Feeder	3043	1531	42.6	21.4	0.014
Evaporator	265	301	32.9	37.4	0.124
Mist Eliminator	6.85	7.60	6.85*	7.60*	1.000
Feed Pump	5404	4163	37.8	29.1	0.007
Offgas Pipe	74.8	59.2	49.9	39.5	0.667

* Note: Initial dose rates already qualify for contact maintenance

Using a generic DF table for the NCAW source and the above DF Ratios, the approximate DRRs, as shown in Table E.2, would allow contact maintenance for the five maintenance scenarios.

Table E.2: Contact Maintenance Possible DF Combinations for HCAN Source

Maintenance Scenario	Combination #1				Combination #2				Combination #3			
	Cs	Ba	Co	Sr	Cs	Ba	Co	Sr	Cs	Ba	Co	Sr
Rotary Feeder	10k	100	10	100	10k	1k	1	100	10k	100	1	1k
Evaporator	10k	10	1	1	1k	10	1	10				
Mist Eliminator	100	1	1	1	Base Case							
Feed Pump	>10k	>1k	>100	>1k	Not Feasible							
Offgas Pipe	1000	1	1	1								

Note that these DF combinations are only approximately minimum since only whole factors of 10 were used for DFs for any individual constituent.

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this Contact Maintenance Viability Study is to determine the degree of contact maintenance that is feasible for the LLW vitrification facility. A secondary goal is to define the Decontamination Factors (DF) for the Pretreatment process that will lead to the maximum practical use of contact maintenance in the vitrification facility.

1.2 SCOPE OF WORK

The scope of work involves four primary activities:

- A. Analysis of seven potential tank waste sources to determine their ranking.
- B. Evaluation of the radiation fields near five candidate equipment maintenance scenarios using the most representative of the seven potential sources.
- C. Development of maintenance data sheets that will assess the radiation dose received by the maintenance crew during the equipment maintenance operation.
- D. Optimization evaluation of the pretreatment DFs that will potentially allow the use of contact maintenance for the five candidate equipment maintenance scenarios.

The results of the above work can be transmitted to the pretreatment design contractor to determine the cost of providing any increased DFs. The increased pretreatment costs would, of course, tend to be offset by the LLW facility costs due to the ability to contact maintain certain equipment rather than providing remote maintenance specialized equipment.

1.3 GENERAL CONSIDERATIONS

1.3.1 Approaches to Contact Maintenance

In order to be able to provide a facility that incorporates contact maintenance into operations, there are several options that can be used to increase the ability to effectively use contact maintenance:

- A. Use outside contract labor for the infrequent maintenance operations that involve higher than normal radiation exposures. This will reduce the exposure to the full time staff that accumulate dose through normal operations of the facility. Even though this option satisfies the "site personnel" accumulated dose

problem, since "people" (outside contract labor) are being exposed this approach violates the spirit of ALARA (only shifts the exposure from one group to another group).

- B. Higher Decontamination Factors (DFs) can be used in the input feed to the facility during the Pretreatment stages of the overall process. This will lower the radioisotope concentrations in the facility and result in lower dose rate fields in general.
- C. The use of temporary shadow shields during the short-term maintenance operations will reduce the exposure to the maintenance crew. Specialized wheeled/portable shields can effectively be used to "shadow" the close-in maintenance crew from the direct "line-of-sight" radiation from near-by equipment which can produce intense radiation fields.
- D. The use of greater than minimum required facility operating staff can lower the dose incurred by any individual within the staff. This option is the least desirable of the four since the overall "person-rem" will be the same, or even higher due to the inefficiencies associated with multiple people performing the same task. In addition, exposing multiple personnel to maintain individual doses is not considered to be within the spirit of ALARA. This option can be considered in extreme circumstances where the addition of outside contract labor (option 1.3.1 A) is not feasible.

1.3.2 Consideration of Risk Problem

There is an associated risk with designing a facility, or parts of a facility, for contact maintenance. Given that residual radioisotopes (crud) tends to buildup and pockets of solid material accumulate, there is some finite probability that radiation fields will be higher than calculated for the purposes of contact maintenance.

Prudent facility design dictates that some reasonable approaches shall be incorporated into the facility design to minimize the risk of over-exposure to maintenance personnel, or in the extreme, shutting down of the facility due to the inability to replace or maintain important pieces of equipment. The following are the main ways that the long-term risk can be controlled (note that each of these involves higher costs than the normal facility, but the costs must be weighed against the risk of loss of production):

- A. Providing redundancy of equipment will allow the failed equipment to be taken off-line and keep the facility operations on-line. The maintenance of the off-line equipment can then be handled over a longer time period with possibilities of solving specific radiation exposure problems.
- B. Remote maintenance equipment and provisions should be incorporated into the facility design. This allows equipment to be handled with a significant reduction in radiation exposure to the maintenance crews.
- C. Selective shielding can be incorporated into the facility design to assure that jeopardized maintenance personnel are adequately protected from identified potentially high radiation sources.

The following report provides a potential methodology for determining contact/remote maintenance requirements in accordance with contemporary regulations.

1.4 ORGANIZATION OF REPORT

This Contact Maintenance Viability Study Report is divided into the following main sections:

- Part 1 Introduction
- Part 2 Method and Approach
- Part 3 Source Terms
 - Tank Waste Source Terms Selection
 - Process Flow Stream Term Derivation
 - Source Term Evaluation for Maintenance
- Part 4 Maintenance Cases (Examples)
- Part 5 Non-Radioactive Glass Plant Evaluation
- Part 6 Conclusions

The following documents the Contact Maintenance Study which deals primarily with the radiation sources and resulting radiation fields to which maintenance crew members would be exposed during several typical example maintenance operations/activities. Based on these examples, proposed increases in pretreatment decontamination factors (DF) for important source constituents (Cs, Eu, Co and Sr) are identified. The methodology for accomplishing the analysis leading to the proposed DF increases, if any, is developed and documented in this report.

2.0 METHOD AND APPROACH

2.1 METHOD

2.1.1 Radiation Dose Limit Considerations

It is well recognized that DOE Order 5480.11, *Radiation Protection For Occupational Workers*, specifies a maximum yearly Effective Dose Equivalent (EDE) of 5 rem. However, 5480.11 does not mention a quarterly dose. In addition, 10CFR20 stipulates a maximum yearly dose of 5 rem and it is also silent on the question of a quarterly dose. It should be noted that these limits are not considered to be ALARA. However, in the past, the NRC did specify a quarterly dose of 3 rem so long as the yearly dose did not exceed 5 rem. This quarterly dose was specified in earlier versions of 10CFR20 and it was applied to reactor operations. Reactor operators generally applied this quarterly dose to contract labor and not to permanent employees. One could speculate that the DOE never used the quarterly dose system because, the DOE and its' prime contractors rarely use contract labor. However, the use of contract workers could dramatically increase in the future if the DOE changes its' mode of operations and actuates new schemes such as "privatization". It is even conceivable that the annual dose could revert back to 5 rem with a "privatization" work force. However, speculation of this nature is beyond the scope of this study. Suffice it to say, that this study must be tied to the current DOE annual dose limits. The methodology, shown below, for contract maintenance is applicable regardless of the annual or quarterly dose limits. In 1989 the DOE 6430.1A, *General Design Criteria*, stated "personnel exposure shall be maintained ALARA. The projected dose rates based on occupancy, time, and frequency of exposure shall not exceed 1 rem/yr." In 1992, the DOE/EN-0256T, *Radiological Control Manual*, stated "Individual worker dose should be ALARA and less than 500 mrem/yr." Consequently, the Westinghouse Hanford Company (WHC) issued HSR-CM-1, *Hanford Site Radiological Manual*, and WHC-CM-1-6, *Radiological Control Manual*. The WHC *Radiological Control Manual* adopted an initial goal of 500 mrem/yr for employees. Finally, in April of 1994, Revision 1 of DOE/EN-0256T, *Radiological Control Manual*, stated "Individual worker dose shall be ALARA and should be less than 500 mrem/yr." It is apparent in this revision that ALARA goes from a suggestion to a directive. Thus, specifying the change from "should" to "shall".

It is obvious from the data shown above, that the DOE trend in annual dose limits for radiation workers has continuously declined. Thus, it is unlikely that any new contract approaches will alter the current trend in declining annual dose limits will so long as the DOE has jurisdiction over the contracts.

However, these new annual limits which are ten times lower than they have been in the recent past, place an enormous burden on the Operations and Maintenance (O&M) contractors to comply with them. In addition, designers of new facilities and major alterations to existing facilities must find new ways to meet these new lower specified dose limits. The only tools available to designers are "source", "shielding", "time", "distance" and whether the operation is contact or remote. These new limits have also caused the O&M contractors to redefine the radiation dose rate limits in areas that radiation workers may enter. These problems are further exacerbated by the fact that existing DOE and local regulations have not been altered since the new annual dose limits have been specified, and they consistently conflict.

In order to meet the criteria shown above, WHC has been required to redesignate Radiation Access Zones (RAZs) as follows:

RADIATION ACCESS ZONE	OCCUPANCY GUIDELINES	RADIATION LEVEL
Uncontrolled	Full Time	0.5 μ Sv/h (0.05 mrem/h)
1	40 hours per week	2.5 μ Sv/h (0.25 mrem/hr)
2	1 hour per day maximum	0.02 mSv/h (2.0 mrem/hr)
3	1 hour per week maximum	0.1 mSv/h (10 mrem/hr)
4	10 hours per year	0.5 mSv/h (50 mrem/hr)
5	No normal access	> 0.5 mSv/h (>50 mrem/hr)

It can be seen that while these zone designations are sufficient to meet the criteria shown above, for annual dose limits, these RAZs practically eliminate maintenance activities in anything except in RAZ 1 and uncontrolled areas. Thus, they would practically eliminate a contact maintained facility. In addition, there is the question of conflicting regulations. For example, WHC-EF-0063-3, the Hanford Solid Waste Acceptance Criteria, permits contact maintenance of solid waste drums with surface dose rates up to 300 mrem/h. However, this drum would create a RAZ 5, which does not permit entrance into an area with a dose rate above 50 mrem/h. Thus, this contact maintainable drum could never have anyone in the same room with it. There are many other conflicts that have been created because new

regulations seem to be generated without regard to existing criteria and there doesn't seem to be any regulatory body that brings existing criteria into compliance with existing regulations

The situation described above calls for a new look at an old solution. Fluor Daniel, Inc. (FDI) Health Physics (HP) suggests that one possible and defensible solution to contact maintenance is to return to the concept of a quarterly dose. However, since the new yearly dose is 500 mrem, then the quarterly dose should be 300 mrem. Please note that a maintenance worker who receives 300 mrem in one quarter cannot receive more than 200 mrem in the next three quarters. This will mean additional workers on a project but that seems to be the cost of these lower dose rate criteria at least as far as contact maintenance is concerned.

Thus, for the purposes of this study, the contact maintenance operations are evaluated as follows:

- 1) In order to perform an initial analysis in a radioactive waste treatment facility, it will be assumed that all maintenance in RAZ 2 and above will be performed in a full face respirator with HEPA filters so that the internal dose is limited to radioactive gases such as radon, thoron (^{220}Th) or iodine. It is further assumed that the internal dose will not exceed more than ten percent of the external, whole body dose.
- 2) If the sum of the direct and indirect radiation fields exceeds a whole body dose rate of 50 mrem/h, then the operation must be remote maintained.
- 3) If the sum of the direct and indirect dose rates multiplied by the number of hours of the maximum exposed individual worker exceeds 300 mrem, then the operation must be remote maintained.
- 4) If the whole body dose rate from all possible sources does not exceed 50 mrem/h and if the sum of the direct and indirect dose rates multiplied by the number of hours of the maximum exposed individual worker is less than or equal to 300 mrem, then the operation can be contact maintained.

The four steps shown above will be used as the determining factor as to whether an operation is contact or remote maintained.

2.1.2 Radiation Access Zone Designations:

There is an apparent conflict between the internal and external dose limits. Based on the need to include internal dose

contribution (primarily inhalation), the RAZ designation dose rate limits were interpreted to be total Committed Effective Dose Equivalents (CEDE) values. The following table is offered as a possible RAZ summary table which addresses both the internal and external dose limit considerations:

RAZ DESIGNATION	TOTAL CEDE DOSE RATE	OCCUPANCY GUIDELINES	DESCRIPTION	NOTES
Uncontrolled	0.05 mrem/h	Full Time	No Posting	0.0 DAC***
RAZ 1	0.15 mrem/h	40 hours per week	No Posting 40 % External 60 % Internal	< 0.1 DAC
RAZ 2	2.0 mrem/h	1 hour per day maximum	Case-By-Case**	Respirator for E-1 DAC
RAZ 3	10.0 mrem/h	10 hours per week maximum	Case-By-Case**	Respirator for E-1 DAC
RAZ 4	50.0 mrem/h	10 hours per year maximum	Case-By-Case**	Respirator for E-1 DAC
RAZ 5	>50.0 mrem/h	No normal access	No Access	Respirator for Emergency Only

- * Note: 40% external implies 0.1 mrem/h and 60% internal implies 0.15 mrem/h.
 ** Note: Total dose (external + internal) for one year shall not exceed 500 mrem
 *** DAC = Derived Air Concentration

2.2 APPROACH

The following describes the approach to be taken to accomplish the above four main radiation analysis activities described in Section 1.1.1.

2.2.1 Basin

The Hanford TWRS has a variety of wastes stored in the tanks in the 200 East and 200 West area. Definition of consistent tank wastes is difficult for the following reasons: 1) Part of the differences in the tank wastes comes from the derived process source for the fuel element reprocessing; 2) although similar processes should result in the same stored wastes, different stored wastes evolve due to differences in subsequent additives to the individual tanks; and 3) different processing campaigns

for the same purpose are changed over time as different process approaches are used.

In addition to the tank sources, the candidate equipment maintenance scenarios needed to be selected in order to define the important facility layout areas and the associated process streams for the relevant sources.

2.2.2 Unit Operations:

In order to select a representative spectrum of unit operations for the methodology, the following parameters for the maintenance activity should be represented:

- A. Frequency of Activity
- B. Duration of Activity
- C. Contamination Level of Activity
- D. Number of Maintenance Crew Required to Perform Activity

The following candidate equipment items were selected for the contact maintenance scenarios:

- 1. Rotary feeders at the cullet storage tanks.
- 2. Evaporator
- 3. Mist eliminator
- 4. Feed pump at the melter feed tank
- 5. Offgas Line at the top of the melter separator

The process streams associated with each of these pieces of equipment can be determined from the appropriate Process Flow Diagram (PFD), in this case for option 4C for the pretreatment and 200 ton-per-day LLW combination vitrification process. The 4C PFD (13 Sheets) is given Appendix A for reference.

The procedure rationale for selecting the above candidate/representative equipment items is as follows:

Maintenance will occur most frequently on the mechanized/motorized equipment such as pumps, agitators, feeders as well as equipment that tends to foul or clog with use such as filters, evaporators, mist eliminators, etc. Thus, representative equipment items associated with these generic subsystems were selected for the contact maintenance study methodology examples. An attempt was also made at selecting items with differing degrees of difficulty in performing the maintenance tasks (i.e., variety of crafts as well as the time required to perform the maintenance operation).

The change out of the entire melter was not selected due to the multiple equipment removal operations and the complicated process required for the maintenance scenario.

Another reason is that the type of LLW melter to be used in the LLW vitrification process has not been selected at the time of this contact maintenance study.

Of the equipment items, pumps/feeders are a primary maintenance concern. Thus, two typical type "pumps"/"feeders" were selected; a melter feed tank pump, and a cullet rotary feeder at the cullet storage tanks (a liquid and a solid pump).

Based on the full equipment list, there are 147 pumps (47 of which are pneumatic cement recycling pumps) and 12 feeders in the LLW vitrification facility. Representative equipment was desired in the areas of potentially high radiation fields to be used as a basis for establishing DF's to reduce the remote maintenance operations. Thus, the melter cell, melter feed preparation room, and the cullet storage room were picked as key areas for review.

The equipment items selected in the melter cell are the mist eliminator and the offgas pipe above the melter glass separator. The melter feed preparation consists of the evaporator feed tank, the evaporator, the melter feed adjustment tank and the melter feed tank. The equipment items selected were the evaporator and the feed pump at the melter feed tank.

The last item selected was the cullet rotary feeder at the bottom of the cullet storage tanks.

2.2.3 Related Equipment Process Flow Streams

By reviewing the facility and equipment layout for option 2C (given in Appendix B, for reference), the other potential radiation sources from equipment in the vicinity of the above equipment items can be identified. The following Table 2.1 gives the streams that are associated with each of the above equipment maintenance scenarios:

TABLE 2.1: Maintenance Related Equipment and Associated PFD Streams

No.	Main Equipment	Vicinity Equipment	Associated Stream No.
1.	Rotary Feeder		406-Cullet
1.1		Cullet Storage Tank	406-Cullet
2.	Evaporator Reboiler		404
2.1		Evaporator	404
2.2		Evaporator Feed Tank	400
3.	Mist Eliminator		628
3.1		Melter CRV	406-Glass
3.2		Melter Cyclone	406-Glass
3.3		Separator Plenum	406-Glass
3.4		Separator Pool	406-Glass
3.5		Offgas Pipe/Line	406-Glass
3.6		Cullet Catch Tank	406-Cullet (411 & 414)
3.7		Cooler	631
3.8		Chiller	624
3.9		Scrub Solution Tank	620
3.10		Quench Tower	620
4.	Feed Pump		406
4.1		Melter Feed Tank	406
4.2		Melter Feed Adjustment Tank	405
5.	Offgas Line		410
5.1		Melter CRV	406
5.2		Melter Cyclone	406
5.3		Separator Plenum	410
5.4		Separator Pool	406-Glass
5.5		Mist Eliminator	628

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5.6		Cullet Catch Tank	406-Cullet (411 & 414)
5.7		Cooler	631
5.8		Chiller	624
5.9		Scrub Solution Tank	620
5.10		Quench Tower	620

The equipment items in the above table are listed in more detail from the excerpted Equipment List found in Appendix G.

3.0 SOURCE TERMS

3.1 TANK SOURCES

The following seven tank sources are used as the basis for the Lightly-Shielded Low-Level Waste (LS-LLW) study (note that these tank sources represent the potential major tank campaigns for the TWRS, except for source numbers 8 and 7):

1. NCAW (Neutralized Current Acid Waste)
2. PFP (Plutonium Finishing Plant) Waste
3. CC (Complexant Concentrate) Waste
4. Nominal Waste (Based on an assumed blending of selected tank wastes)
5. High Bland Waste (Based on the "worst-of-the-worst" concentrations of selected chemical and radioisotope species)
6. DSSF (Double Shell Slurry Feed, which is assumed to have no pretreatment, i.e., Cs DF = 1, unlike the other sources with Cs DF = 100)
7. Max Theoretical (An ultra-conservative simulated tank source that is developed for the purposes of bounding analysis)

Note that the tank sources 1, 2, 3, 4, 5 and 7 assume pretreatment with a DF of 100 for $^{137}\text{Cs}/^{131}\text{Ba}$, whereas source 6 (DSSF) assumes no pretreatment with the input feed flowing directly from the double shelled tanks.

3.2 PROCESS FLOW STREAM SOURCE TERMS

WHC performed a series of ASPEN computer program calculations which identify the concentrations of the chemical and radioisotope species for the various processing streams throughout the pretreatment and subsequent LLW vitrification processes. The stream numbers are tied to the definitive Process Flow Diagram (PFD) for the processes. This study is based on the PFD for the 4C option for the pretreatment and the 200 ton-per-day LLW combination vitrification processing (Drawing No. ES-OP4C-400, 13 Sheets as shown in Appendix A).

The results of the ASPEN calculations for selected pertinent streams as identified in Table 1.1 are presented in Appendix C for each of the seven sources. One source cannot be easily transformed into another source, nor can radiation fields from

one source be easily extrapolated for another source. Each source must be explicitly calculated due to the complex nature of the multi-element (multi-radioisotope) sources. In particular, shielding thicknesses for various shield materials are not a simple linear relationship, unlike some release dispersion models that give inhalation dose for off-site personnel.

3.3 COMPARISON OF TANK WASTE SOURCES

3.3.1 Reduced ASPEN Data for Radioisotopes

The results as directly presented in the output from the ASPEN runs are not in an ideal form to be used for radiation and shielding analysis. The two computer programs used for radiation and shielding analysis (the monte carlo program MCNP-4A and the point kernel program MicroShield 4.10) require either the energy spectra (beta or gamma-ray), or the activity in Ci for each of the radioisotopes present in the source, respectively.

Based on the above, a further reduction of the ASPEN data was needed to translate it into a usable form for the radiation and shielding programs. MicroShield 4.10 (MS4.10) requires the Ci activity for each radioisotope for the gamma-ray analysis. A simple spreadsheet was used to translate the ASPEN radioisotope data into a usable form. The results of the spreadsheet analysis for the seven sources and the pertinent streams (#400, #404, #405, #406, #410, #437 and #628) are presented in Appendix D.

3.3.2 Beta Spectra for Sources and Bremsstrahlung Radiation

Based on the individual radioisotope activity in Ci/l from the reduced ASPEN run spreadsheets, the beta spectra for the beta emitters can be obtained from another spreadsheet. The beta spectra are needed in order to calculate the dose rate due to bremsstrahlung radiation using the MCNP-4A code. The beta spectra spreadsheets for each of the PFD process streams #404 and #406 for the seven tank waste sources are shown in Appendix E.

The bremsstrahlung radiation and the associated dose rate are obtained from the monte carlo code MCNP-4A. The combined beta spectrum obtained from the spreadsheet and the spectrum energy-dependent weighting factors from the spreadsheets are input to the MCNP-4A code and the resulting photon radiation energy-dependent dose rate is obtained at distances of 1 cm, 30 cm and 100 cm from the surface of the source. For the purposes of source comparison, the source was taken as a generic 3.7853 L (1.0 gal) source of the stream #404 for each of the seven tank wastes (NCAW, PFD, CC, Nominal, High Blend, DSSF and Max Theoretical). The two main purposes of these beta analyses were 1) to obtain the relative contribution of the beta radiation to the total dose rate, and 2) to obtain the relative radiation dose

rates of the seven tank wastes at the three distances of interest (1, 30 and 100 cm).

3.3.3 Beta Equivalent Photon Sources

Based on the MCNP-4A printouts, the bremsstrahlung (photon) energy-dependent dose rate is obtained. An equivalent photon source can be obtained in MicroShield 4.10 (MS4.10) by adjusting the energy dependent source to arrive at the same photon energy dependent dose rate at the same distance for the same source geometry. A spreadsheet has been used to obtain the relation between the bremsstrahlung equivalent photon input spectrum and the energy dependent dose rate from MS4.10.

The total (gamma + beta equivalent) source can be obtained by first running the actual quantities/concentrations of radioisotopes in the MS4.10 code based on the reduced data spreadsheets of Appendix D. MS4.10 provides the gamma source spectrum directly. This gamma source spectrum is then added/combined with the equivalent bremsstrahlung photon source spectrum by a procedure described in the next section. The total photon source spectrum can then be run in MS4.10 to obtain the dose rate at various locations for the particular source/geometry of interest.

3.3.4 Combined Gamma and Beta Photon Source for Survey Calculations

In order to provide an efficient means of performing a wide range of survey calculations for the purposes of the Contact Maintenance Trade Study, it was decided to convert the MCNP-4A code beta-induced photon source to an equivalent photon source for use in the MS4.10 code. This equivalent photon source would be superimposed (added to by specific energy groups) the direct gamma-ray source to arrive at a combined photon source representing both the gamma-ray and beta radioisotope components of each LLW tank waste source. This single/combined photon source for each of the tank wastes would then allow the faster running point kernel MicroShield code to be used with a reasonable degree of confidence that the results would be close to what they would be if the potentially long running time MCNP-4A code were used for the beta source and added to the MS4.10 gamma-ray results for each source-dose point configuration.

The objective is to determine the equivalent photon source in the LLW 3.7853 L (1.0 gal) source that will produce the same energy dependent dose rate spectrum at the surface of a 3/4" thick steel container. The photon attenuation that then takes place in the shielding should be the same as if the actual source were composed of separate beta and gamma-ray sources added together.

The procedure to obtain an equivalent beta (bremsstrahlung) source and combined gamma-ray and equivalent beta photon spectrum source for use in the Contact Maintenance Trade Study is as follows:

- Step 1. In MS4.10, input a known energy dependent source (arbitrary) and calculate the resulting dose rate for each energy group at the 30 cm (distance from the container outer surface) dose point.
- Step 2. Divide the resulting dose rate output by the arbitrary input and multiply this ratio by the desired beta-derived photon dose rate for each photon energy group. This was accomplished using a simple Lotus 1-2-3 Spreadsheet to provide easy modification and manipulation of the numbers (and to check totals).
- Step 3. Re-input the new adjusted (equivalent) photon source resulting from Step 2. Check the resulting photon group dose rates and total dose rate to ensure that they are near the same as the MCNP-4A code beta-particle resulting Bremsstrahlung dose rates at the same 30 cm distance dose point.
- Step 4. Run the gamma source for the same 30 cm distance dose point using MS4.10 as before.
- Step 5. Add the two dose rates to see that the total dose rate is similar to the previous MCNP-4A beta + MS4.10 gamma-ray separate runs.
- Step 6. Use Lotus 1-2-3 to superimpose the two photon spectra (beta plus gamma-ray) and add groups together so that the total number of groups does not exceed 25 (maximum allowed by MS4.10). Note that each source photon energy group is treated as a "line" source at that energy, so the gamma and beta spectra can be "interleaved" to arrive at a combined photon source energy spectrum. Also "lump" all photon source energies below 0.015 MeV into the lowest MS4.10 allowed group of 0.015 MeV.
- Step 7. Repeat step 4 with the combined gamma and beta source spectrum to obtain a total equivalent total photon (gamma and beta equivalent) dose rate to compare with the results of Step 5. Note that the photon cross sections in MS4.10 are obtained by an energy "band" averaging, so changing the group structure by "interleaving" the separate gamma and beta photon spectra will result in slightly different answers than adding the two separate

results (they generally agree to within less than 1 percent error).

3.3.5 Summary of Tank Waste Source Comparisons

The above procedure was repeated for each of the tanks waste sources for stream #404 and the 3.7853 L (1.0 gal) source. The dose rates at 1 cm, 30 cm and 100 cm were calculated. Figures 3.1 through 3.7 give the dose rates for the various tank wastes in the standard source configuration as a function of distance from the surface (three data points calculated). These curves provide a basis for comparison of the relative radiation and dose rates from the seven sources. A summary of the results, using the 30 cm distance and PPD stream #404 as the basis, is given in Table 3.1. This table shows that the Max Theoretical waste is the "hottest" waste over the next "hottest" tank waste/source, which was the DSSF (no pretreatment).

Figure 2.1: NCAW Source Radiation Dose Rates (Gamma Only)

Figure 2.3: CC Source Radiation Dose Rates (Gamma Only)

Figure 2.3: PFP Source Radiation Dose Rates (Gamma Only)

Figure 2.4: NOMINAL Source Radiation Dose Rates (Gamma Only)

Figure 2.5: HIGH BLEND Source Radiation Dose Rates

Figure 2.6: DSSF Source Radiation Dose Rates

Figure 2.7: MAXIMUM THEORETICAL Source Radiation Dose Rates

Table 3.1: Comparison of Low-Level Waste Sources for Stream #404 (LLW Evaporator)

BASIS: 3.7853 l (1.0 gal) of Source in 1/4 in. Thick Steel Can (PF = Base, i.e., C ₀ = 100, Except for DSEP which has No Pretreatment)									
WASTE SOURCE	SOURCE DENSITY g/cm ³	WASTE SOURCE GL/4	Activity @ .66 MeV Ph/sec	Dose Rate @ 1 cm mR/h	Dose Rate @ 30 cm mR/h	Dose Rate @ 100 cm mR/h	% From* of Total Dose Rate	SHEK No.	COMMENTS
WCM**	1.48	9.52E-2	2.720E+09	2388.	156.	20.5	0.47%	4	Hottest Actual Source
FFP**	1.40	8.61E-4	5.194E+07	38.1	2.74	0.38	0.02%	7	Least Hot Source
CC**	1.45	1.29E-1	2.940E+07	310.1	22.4	2.77	7.98%	5	High c/e due to β
Nominal**	1.47	1.15E-1	8.836E+07	59.8	4.34	0.54	1.52%	6	Blended Nominal Source
High	1.50	5.86E+0	3.279E+09	4929.	364.4	44.92	25.83%	3	Blended High Source
DSEP	1.55	8.04E-1	4.927E+10	32710.	2390.	294.6	0.02%	1	Assumes No Pretreat.
Maximum Theoretical	1.49	1.07E+0	5.751E+09	18880.	1389.	164.4	1.09%	2	Theoretical Radium Bar Concentration
* Note: % From = 100 x (Fromstgblung Dose Rate) / (Total Dose Rate) @ 30 cm Distance. ** Note: Gamma Source Only for the First Four Sources Due to Revised Tank Sources.									

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3.4 POTENTIAL FOR STORING LLW IN 55-GALLON BARREL

In addition to the five contact maintenance scenarios an investigation was undertaken to determine the possibility of contact handling vitrified glass waste contained in 55-gallon barrels. The investigation included the determination of the source strength of the NCAW LLW vitrified glass for a standard 55-gallon volume along with the barrel-container shielding requirements to allow contact handling. The PFD Stream #406 for NCAW was used and scaled for radioisotopes, in Ci, based on the total glass in the barrel, in kg, from stream #437. Based on the previous tank source comparison analysis, the bremsstrahlung contribution to the total dose rate can be ignored for NCAW in glass (should be less than 0.5% -- i.e., less than 1/2 of 1%) for a Cs DF of 100 (Base Case). The 55-gallon barrel was assumed to have a 22 inch inside diameter with 20 gauge steel walls. The analysis consisted of determining the shielding thicknesses required for concrete, steel and tungsten placed around the outside of the standard 55-gallon barrel.

The following unshielded dose rates (DR) were obtained at standard distances of 1.0 cm, 30 cm and 100 cm distances from the surface of the drum at the mid-height level for total Cs DF's of 100 (base case), 1000 (10 times base case), and 10,000 (100 times base case).

CASE	Distance = 1.0 cm		Distance = 30 cm		Distance = 100 cm	
Cs DF = 100 (Base)	DR = 10,870 mR/h	Base Ratio = 1.00	DR = 3,189 mR/h	Base Ratio = 1.00	DR = 674.5 mR/h	Base Ratio = 1.00
Cs DF = 1000	DR = 3,114 mR/h	Base Ratio = 0.238	DR = 910.1 mR/h	Base Ratio = 0.285	DR = 192.7 mR/h	Base Ratio = 0.286
Cs DF = 10,000	DR = 2,338 mR/h	Base Ratio = 0.215	DR = 682.2 mR/h	Base Ratio = 0.214	DR = 144.4 mR/h	Base Ratio = 0.214

The shielding analysis was performed for the three candidate shield materials (concrete, steel and the relatively more efficient gamma radiation shield material tungsten). The following three shield curves (Figures 3.8, 3.9 and 3.10) show the resulting near contact dose rate as a function of the shield material thickness for the intermediate case Cs DF of 1000 (10 x base case). The acceptable dose rate for short-term handling of the waste barrels is on the order of 10 mR/h. Using the three

shielding curves for the three materials, the respective thicknesses required to reduce the dose rate to less than 10 mR/h are:

<u>Material</u>	<u>Thickness</u>
Concrete	30 cm
Steel	12 cm
Tungsten	3.5 cm

The weight associated with each of these shields, including an equivalent thickness top and bottom shields, plus the approximate weight of the glass filled 55-gallon barrel (549.45 kg) are as follows:

<u>Material</u>	<u>Shield Weight</u>	<u>Total Weight</u>
Concrete	6,839.09 kg	7,388.74 kg
Steel	5,102.31 kg	5,651.95 kg
Tungsten	2,525.01 kg	3,074.66 kg

Thus, by using the more efficient gamma shield material and accounting for the r^2 -effect for the cylindrical shape, a tungsten shield would weigh about 94% of a steel shield and about 42% of a concrete shield.

Figure 2.9: Steel Shield for 55-Gallon Drum of NCAW Glass

Figure 2.10: Tungsten Shield for 55-Gallon Drum of NCAW Glass

Figure 2.10: Tungsten Shield for 55-Gallon Drum of NCAW Glass

4.0 MAINTENANCE CASES

4.1 SELECTED MAINTENANCE EXAMPLES

As indicated in Section 2.2.2 previously, the five equipment items selected for the maintenance methodology development and the primary process stream numbers are:

1. LLW Evaporator (Stream #404)
2. LLW Melter Feed Tank (Stream #406)
3. Rotary Feeder (Cullet Storage Tank, Stream # 406 - Glass)
4. Mist Eliminator (Stream #828)
5. Offgas Line (Stream #410)

It is interesting to note that, in assessing the effective sources for the related process streams, the highest radiation around the equipment often comes from nearby equipment and not necessarily from the equipment being repaired/maintained.

4.2 UNIT OPERATION MAINTENANCE EXAMPLE:

As an example of how the methodology/approach might be applied to the 2C LLW facility, a typical maintenance operation is outlined below:

<u>Equipment:</u>	Melter Feed Evaporator
<u>Activity:</u>	Replace Heat Exchanger due to Tube Failure
<u>Crew:</u>	Pipe Fitters (2) Operators (2) Electrician (0) Riggers (2) Crane Operator (1) Health Physicist (1) Instrument Technician (1) Other (0) (Total Crew = 9, see sequence of maintenance tasks below for distribution of crew by task)
<u>Frequency:</u>	MTBF = 10 years, three heat exchangers per evaporator, therefore frequency is 10/3 or about every 3 years (3.33 yrs).
<u>Duration:</u>	The duration of the tasks is determined for the maintenance operation conditions of with respirator as indicated in the following sequence of maintenance tasks:

Sequence:

SHIFT NO.	DESCRIPTION OF TASK	TASK HOURS
1	Flush and Drain Evaporator	1.0
1	Decontaminate Equipment	2.0
1	Remove Instrumentation and Wiring	1.0
1	Remove Piping	4.0
2	Remove Heat Exchanger (Reboiler)	3.0
2	Place Heat Exchanger in Box, Wrap and Smear Test	2.0
2	Install New Heat Exchanger (Reboiler)	4.0
3	Reconnect Piping	4.0
3	Reconnect Instrumentation	1.0
3	Hydro Test Inspection of Completed Unit	1.0
	TOTAL	23.0

Considerations:

- Liquid Spills
- Surface Contamination
- Shine from Evaporator Components
- Shine from Nearby Equipment Items

4.3 MAINTENANCE OPERATIONS EVALUATION

The following detailed aspects of the analysis/evaluation should be considered:

- A. For the intact operating system (prior to starting the maintenance operation) -
 - Calculate the worker dose
 - Assign Rad Zone
 - Estimate Associated Surface Contamination Level
- B. Radiation Source Issues -
 - How much liquid might be spilled?
 - How much of the spilled source might be re-suspended?
 - How much surface contamination exists?
 - How much component residual source remains (1 percent - 10 percent which will vary by type of equipment and flush/decon ability)?

- What other equipment is in the vicinity (shine), need to study layout drawing?

C. Need to Calculate -

- Inhalation/Ingestion (Internal Dose), if respirators are not used
- External Dose Rate (shine)
- Contact/Skin Dose rate can be ignored due to assumed SWP clothing on maintenance crew.

4.4 HIGH BLEND WASTE SOURCE RADIATION CALCULATIONS

Based on the fact that the High Blend waste was initially intended to envelope the other sources and therefore was the source assumed to give the highest radiation fields and resulting dose rates (DSSF and Max Theoretical sources were provided late in the study), the High Blend waste source was used to initially evaluate the maintenance scenarios. An approximate scaling factor is used to convert the High Blend source dose rates to the more realistic NCAN results.

As an example of the methodology, the Evaporator is used to illustrate the approach for analyzing the radiation fields (dose rates) encountered during the equipment maintenance scenario.

Based on the LLW preliminary facility drawing (Drawing Number ES-ALT2C-01) sheet 1 of 6, the Evaporator Room contains the Evaporator (EV-402-2) and the Evaporator Feed Tank (TK-400-2). An enlarged plan view of the Evaporator Room is shown in Figure 4.1. Using Figure 4.1 and the size of the equipment from the Equipment List (see Appendix G for selected equipment specifications from equipment list sorts), the relative locations of the equipment and their sizes are obtained.

Since there is little information on the actual evaporator reboiler, the entire evaporator is used for the primary source. Based on the Equipment List in Appendix G, the Evaporator is 10'W x 32'L x 38'H. This entire volume is assumed to be flushed so that only 1 percent of the full volume remains during the time of maintenance. Thus, 1 percent of the evaporator volume is calculated to be 3.44×10^3 l of source (stream #404).

The Evaporator Feed Tank has dimensions of 12' ID x 19' H with a normal operating capacity of 35,581.82 l (9400 gal) based on the Equipment List in Appendix G. Using the 12' ID, the cylindrical height to contain 9400 gal is 338.65 cm. For the purposes of radiation analysis, both the Evaporator and the Evaporator Feed Tank are assumed to have 3.27 cm (0.5") thick steel (316 SS) walls. In addition with the absence of an elevation section drawing through the Evaporator Room, the mid-

height of the Evaporator Feed Tank is assumed to be at the mid-height of the Evaporator (worst case for radiation analysis).

According to the PFD's in Appendix A (Sheet 2 of 13), the Evaporator source is characterized by the process flow stream #404 and the Evaporator Feed Tank is characterized by stream #400. These streams are shown in Appendix C (see High Blend waste source for streams #400 and 404, both solid and liquid components). Note that for stream #400, the Ci content for the solid component radionuclides are the same for as for stream #404, but the radionuclide concentration, in Ci/l, is less due to the higher liquid volume of the Evaporator Feed Tank (prior to evaporation of a portion of the water from the evaporator feed stream).

Based on the above geometries and source conditions, the results of the radiation analysis for the Evaporator and the Evaporator Feed Tank with the High Blend waste source are as follows (Gamma radiation only using MS4.10):

Distance From Evaporator Surface	CALCULATED DOSE RATES (without BREMSSTRAHLUNG)		
	Evaporator	Evap. Feed tank	TOTAL
	(mR/h)	(mR/h)	(mR/h)
1 cm	66.34	222.1	288.44
30 cm	61.99	243.6	307.59
100 cm	63.18	308.7	371.88

Note that the dose rates for the Evaporator decrease with increasing distance from the Evaporator surface (as expected) and the dose rates attributed to the Evaporator Feed Tank increase with increasing distance from the Evaporator Surface (decreasing distance from the Evaporator Feed Tank). As seen from the above total values, the vicinity full Evaporator Feed Tank dominates the maintenance dose rates.

As will be shown in the next section (Section 4.5), the bremsstrahlung factor for 0 percent offgas recirculation is 1.348 (ratio of radiation dose rate with both bremsstrahlung and gamma radiation to dose rate with only gamma radiation) for the High Blend source. Using only this factor of 1.348, the radiation dose rates are as follows:

Figure 3.1: Evaporator Room from 2C Layout Drawing

Distance From Evaporator Surface	CALCULATED DOSE RATES (with BREMSSTRAHLUNG)		
	Evaporator	Evaporator Feed Tank	TOTAL
	(mR/h)	(mR/h)	(mR/h)
1 cm	89.43	299.39	388.82
30 cm	86.26	328.37	414.63
100 cm	85.16	416.13	501.29

4.3 MELTER OFFGAS RECIRCULATION

A parametric analysis is conducted to estimate the impact on the resulting calculated dose rates due to the recirculation of critical radioisotopes through the offgas system. Review of the PFD (ES-ALT2C-01, sheet 1 of 6) shows that the return of the offgas system re-enters the main feed flow at the LLW Evaporator Feed Tank (Stream #400). The re-entering flow impacts this tank and the equipment between this tank and the melter, namely the LLW Feed Evaporator (Stream #404), LLW Melter Feed Adjustment Tank (Stream #405), LLW Melter Feed Tank (Stream #406), and the LLW Melter (vaporized glass in the Combustion Melter, cyclone and the plenum space above the glass in the separator, but not the glass in the separator).

Figure 4.2 shows the relationship between the main feed stream, indicated as (1) in Figure 4.2, the glass product stream (4) and the offgas recirculation stream (3) to the equipment between the LLW Evaporator Feed Tank (Stream #400) and the melter (2). WHC has estimated the recirculation fractions (ranges and average) for three main radioisotopes/elements as follows:

Radioisotope/ Element	Recirculation Range, R	Average of Range	$m_1/m_2 = 1/(1-R)$ Low, Avg, High
¹³⁷ Cs/Ba	30% - 80%	55%	1.429, 2.222, 5.00
⁶⁰ Co	30%	30%	1.429
¹⁴⁴ Eu	2%	2%	1.020

Based on the relationships in Figure 4.2, the fourth column above gives the ratio of the main input stream (1) to the combined stream (2) for each of the radioisotopes/elements. Table 4.1 shows how these ratios impact the radioisotope Ci per gallon of the stream #404, as typical of the combined stream (2).

Figure 4.2: Offgas Flow Recirculation Relationships

RELATIONSHIPS:

$$m_1 = m_4 \quad (m = \text{QUANTITY OF RADIOISOTOPE, Ci})$$

i = Stream Leg Number, Above

$$m_2 = m_3 + m_4$$

$$m_3 = Rm_2 \quad (R = \text{RECIRCULATION FRACTION})$$

$$m_4 = (1-R)m_2$$

$$m_2 = \frac{m_3}{(1-R)} = \frac{m_4}{(1-R)}$$

$$\left. \begin{aligned} \frac{m_3}{m_4} &= \frac{1}{(1-R)} \end{aligned} \right\}$$

Table 4.1: Helter Offgas Recirculation Fractions Impact on Stream #404 Cs Ci Content

Element	1/(1-R) Factor (Ratio)	Original Per Gallon (Ci)	Recirc. Value Per Gallon (Ci)	Run No.
¹³⁷ Cs/Ba	1.429	0.102/0.0978	0.1458/0.1398	R1
¹³⁷ Cs/Ba	2.222	0.102/0.0978	0.2266/0.2173	R2
¹³⁷ Cs/Ba	5.000	0.102/0.0978	0.5100/0.4890	R3
⁶⁰ Co	1.429	0.00377	0.005387	*
¹⁴⁴ Sr	1.020	0.0262	0.02672	*

* Note: Co and Sr are added to each of the above runs, thus only 3 runs.

The radioisotope values, shown in column four of Table 4.1 above, are used in the MS4.10 code to obtain the gamma-ray dose rate at 1 cm, 30 cm and 100 cm for 1.0 gal of the stream #404 feed based on the base-case High Blend source (Cs DF=100). The gamma-ray dose rates are then added to the beta dose rates for the three distances to obtain a total dose rate for the three runs above (R1, R2 & R3). Table 4.2, on the next page, shows the results of the MS4.10 calculations giving the total dose rates and the ratio of these dose rates to the un-recirculated values (i.e., R=0). These ratios can then be used to multiply the original un-recirculated dose rates for the low, average and high values of estimated recirculation fractions for the significant radioisotopes.

Using the average recirculation factors obtained from Table 4.2 (column 8), different bremsstrahlung factors are required (see Appendix I for bremsstrahlung factor analysis) that modify the 0 percent recirculation bremsstrahlung factor of 1.348. The following factors are required to account for both the offgas recirculation and the bremsstrahlung contribution to the dose rate (note that the glass is not affected by the offgas recirculation and is only impacted by the bremsstrahlung contribution to the gamma radiation dose rate):

Cs Recirc	Old Brn Factor (No Recirc)	Recirc Factor	New Brn Factor (w/Recirc)	Combined/Total Base Gamma Factor
0%	1.348	1.00	1.348	1.348
30%	1.348	1.23	1.263	1.579
55%	1.348	1.59	1.220	1.928
80%	1.348	2.81	1.124	3.258
Glass	1.133	1.00	1.133	1.133

Using these last recirculation and new bremsstrahlung factors, the following four summary tables (Tables 4.3, 4.4, 4.5 and 4.6) are obtained for each of the five equipment maintenance scenarios and for the four offgas recirculation conditions (0 percent, 30 percent, 55 percent and 80 percent), respectively.

4.6 CESIUM CONCENTRATION IN GLASS PLATE OUT

Based on the information provided in Appendix E, the combustion melter has the following approximate inside surface areas (including the offgas pipe):

COMPONENT	SURFACE AREA (m ²)
CRV	35
Cyclone	40
Separator (Glass Pool)	20
Separator (Plenum)	50
Offgas Pipe (0.6 m ID x 3 m L)	7.5

Various estimates on drained melter residual glass thickness have been offered. These range from 0.254 cm to 2.54 cm (0.1" to 1.0"). An average parametric value of 1.0 cm would seem reasonable. This 1.0 cm, thus, is used to calculate the volume of glass in each component listed above (if the glass thickness turns out to be something other than the assumed 1.0 cm, then the calculated volumes will be directly proportional to the glass thickness in cm). The glass volumes therefore represent "base" glass sources.

Table 4.2: Base MS4.10 Gamma Radiation Factors to Account for Offgas Recirculation

Run No.	Total Dose Rate (mR/h)			Ratio to Base (Gamma) Total			Ratio	Recirc
	@ 1 cm	@ 30 cm	@ 100 cm	@ 1 cm	@ 30 cm	@ 100 cm	Average	Values
Base	4881.1	164.926	44.107	1.000	1.000	1.000	1.00	0 %
R1	5994.1	445.726	54.077	1.228	1.271	1.226	1.23	30%
R2	7725.1	572.016	69.647	1.583	1.568	1.579	1.58	55%
R3	13,788.1	1014.26	124.227	2.825	2.779	2.816	2.81	80%

Attachment-51

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TABLE 4-1: SUMMARY TABLE FOR THE LS-LLW CONTACT MAINTENANCE STUDY, RECIRCULATION = 0%
HIGH BLEND SOURCE (Base Case = 0% Off-Gas Recirculation), RF = 1.00, Near Brem Factor = 1.348

Equipment Name / Description	Distance From Equip.	DOSE RATES (mR/h)								Approx. Min DF Increase (Total/50)
		Main Source	Vicinity #1 Source	Vicinity #2 Source	Vicinity #3 Source	Vicinity #4 Source	Vicinity #5 Source	Vicinity #6 Source	TOTAL (mR/h)	
1: Rotary Feeder @ Cullet Storage Tank (Brem Factor = x1.133)	1 cm	10,821	1,364	1,364	N/A	N/A	N/A	N/A	13,550	271
	30 cm	4,223	1,292	1,292	N/A	N/A	N/A	N/A	6,806	136
	100 cm	1,098	1,164	1,164	N/A	N/A	N/A	N/A	3,425	69
2: Evaporator Reboiler On Melter Feed Evap. (Brem Factor = x1.348)	1 cm	89.4	299.4	N/A	N/A	N/A	N/A	N/A	388.8	8
	30 cm	26.3	326.4	N/A	N/A	N/A	N/A	N/A	414.7	8
	100 cm	8.52	416.1	N/A	N/A	N/A	N/A	N/A	501.3	10
3: Mist Eliminator in Melter Room (Brem Factor = x1.133)	TOP-ME	N/A	0.617	0.915	2.868	19.24	0.319	6.508	32.057	1
	MID-ME	N/A	1.148	0.290	0.248	20.96	0.375	10.497	35.046	1
	BOT-ME	N/A	1.480	0.192	3.570	22.68	0.424	11.489	40.055	1
4: Melter Feed Pump @ Melter Feed Tank (Brem Factor = x1.348)	1 cm	7,992.0	432.7	432.7	N/A	N/A	N/A	N/A	8,547.4	171
	30 cm	7,589.0	432.7	432.7	N/A	N/A	N/A	N/A	8,454.4	169
	100 cm	5,846.0	432.7	432.7	N/A	N/A	N/A	N/A	6,513.4	130
5: Off-Gas Line @ Top of Separator (Brem Factor = x1.133)	1 cm	78.56	2.14	2.34	20.17	58.01	21.14	N/A	210.4	4
	30 cm	49.98	2.22	2.39	19.17	74.00	20.64	N/A	167.4	3
	100 cm	25.02	2.48	2.48	17.00	66.03	19.47	N/A	132.5	3

SOURCES (Stream #, G = Cullet Glass, G = Solid Glass):

1 - Main (#406C) = Cullet Storage Tank (Bottom), 5%	1 - Vicinity #1 (#406C) = Adjacent Cullet Storage Tank (Full)	1 - Vicinity #2 (#406C) = Adjacent Cullet Storage Tank (Full)
2 - Main (#404) = Evaporator, Drained/Flushed to 1% Residual	2 - Vicinity #1 (#400) = Evaporator Feed Tank (Full)	
3 - Main (#628) = Mist Eliminator (N/A)	3 - Vicinity #1 (#406G) = Melter Vortex Combustor (Residual Glass)	3 - Vicinity #2 (#406G) = Melter Cyclone (Residual Glass)
3 - Vicinity #3 (#406G) = Melter Separator (Plenum Residual Glass)	3 - Vicinity #4 (#406G) = Melter Separator (Full Glass Pool)	3 - Vicinity #5 (#410) = Off Gas Pipe/Line (Residual Glass)
3 - Vicinity #6 (#406G) = Cullet Catch Tank (Full, with Water)		

BREM FACTORS: Glass/Cullet = 1.133; Stream Solutions = 1.348

4 - Main (#406) = Melter Feed Tank (Bottom), Drained to 5%	4 - Vicinity #1 (#406) = Adjacent Melter Feed Tank (Full)	4 - Vicinity #2 (#406) = Adjacent Melter Feed Adjustment Tank (Full)
5 - Main (#410) = Off Gas Pipe/Line (Residual Glass)	5 - Vicinity #1 (#406G) = Melter Vortex Combustor (Residual Glass)	5 - Vicinity #2 (#406G) = Melter Cyclone (Residual Glass)
5 - Vicinity #3 (#406G) = Melter Separator (Plenum Residual Glass)	5 - Vicinity #4 (#406G) = Melter Separator (Full Glass Pool)	5 - Vicinity #5 (#406C) = Cullet Catch Tank (Full, with Water)
5 - Vicinity #6+ = Quench Tower, Filter Wash Tank (N/A)		

TABLE - SUMMARY TABLE FOR THE LS-LLW CONTACT MAINTENANCE STUDY, RECIRCULATION = 30%

HIGH BLEND SOURCE (Low Case = 30% Off-Gas Recirculation), RF = 1.23 New Beam Factor = 1.283

Equipment Name / Description	Distance From Equip.	DOSE RATES (mR/h)								Approx. Max OF Increase (Total)
		Main Source	Vicinity #1 Source	Vicinity #2 Source	Vicinity #3 Source	Vicinity #4 Source	Vicinity #5 Source	Vicinity #6 Source	TOTAL (mR/h)	
1: Rotary Feeder @ Cullet Storage Tank (Beam Factor = x1.133)	1 cm 30 cm 100 cm	10,821 4,223 1,089	1,364 1,292 1,164	1,364 1,292 1,164	N/A N/A N/A	N/A N/A N/A	N/A N/A N/A	N/A N/A N/A	13,550 5,806 3,426	27 136 69
2: Evaporator Reboiler On Melter Feed Evap. (Beam Factor = x1.348)	1 cm 30 cm 100 cm	104.7 101.0 59.7	350.5 384.8 487.1	N/A N/A N/A	N/A N/A N/A	N/A N/A N/A	N/A N/A N/A	N/A N/A N/A	455.2 485.8 586.9	9 10 12
3: Mist Eliminator in Melter Room (Beam Factor = x1.133)	TOP-ME MID-ME BOT-ME	N/A N/A N/A	0.617 1.148 1.480	0.315 0.250 0.192	2.988 3.248 3.570	18.24 20.38 22.89	0.319 0.375 0.424	9.508 10.437 11.489	32.067 33.848 40.055	1 1 1
4: Melter Feed Pump @ Melter Feed Tank (Beam Factor = x1.348)	1 cm 30 cm 100 cm	9,993.2 8,884.4 6,612.1	506.6 506.6 506.6	506.6 506.6 506.6	N/A N/A N/A	N/A N/A N/A	N/A N/A N/A	N/A N/A N/A	10,006.4 9,897.5 7,622.2	200 186 153
5: Off-Gas Line @ Top of Separator (Beam Factor = x1.133)	1 cm 30 cm 100 cm	76.56 48.98 25.02	2.14 2.22 2.48	2.34 2.39 2.48	20.17 19.17 17.03	88.01 74.00 58.03	21.14 20.64 19.47	N/A N/A N/A	210.4 187.4 132.5	4 3 3

SOURCES (S) (Green S, G = Cullet Glass, G = Solid Glass):

1-Main (#406C) = Cullet Storage Tank (Bottom), 6%	2-Main (#404) = Evaporator, Drained/Flushed to 1% Residual	3-Main (#408) = Mist Eliminator (N/A)
1-Vicinity #1 (#406C) = Adjacent Cullet Storage Tank (Full)	2-Vicinity #1 (#400) = Evaporator Feed Tank (Full)	3-Vicinity #1 (#406G) = Melter Vortex Combustor (Residual Glass)
1-Vicinity #2 (#406C) = Adjacent Cullet Storage Tank (Full)		3-Vicinity #2 (#406G) = Melter Cyclone (Residual Glass)
		3-Vicinity #3 (#406G) = Melter Separator (Plenum Residual Glass)
		3-Vicinity #4 (#406G) = Melter Separator (Full Glass Pool)
		3-Vicinity #5 (#410) = Off Gas Pipe/Line (Residual Glass)
		3-Vicinity #6 (#406G) = Cullet Catch Tank (Full, with Water)

BEAM FACTORS: Glass/Cullet = 1.133; Stream Solutions = 1.283

4-Main (#406) = Melter Feed Tank (Bottom), Drained to 6%	5-Main (#410) = Off Gas Pipe/Line (Residual Glass)
4-Vicinity #1 (#406) = Adjacent Melter Feed Tank (Full)	5-Vicinity #1 (#406G) = Melter Vortex Combustor (Residual Glass)
4-Vicinity #2 (#406) = Adjacent Melter Feed Adjustment Tank (Full)	5-Vicinity #2 (#406G) = Melter Cyclone (Residual Glass)
	5-Vicinity #3 (#406G) = Melter Separator (Plenum Residual Glass)
	5-Vicinity #4 (#406G) = Melter Separator (Full Glass Pool)
	5-Vicinity #5 (#406G) = Cullet Catch Tank (Full, with Water)
	5-Vicinity #6+ = Quench Tower, Filter Wash Tank (N/A)

TABLE 4-2 SUMMARY TABLE FOR THE LS-LLW CONTACT MAINTENANCE STUDY, RECIRCULATION = 65%
HIGH BLEND SOURCE (Mean Case = 65% Oil-Gas Recirculation), RF = 1.58 New Brem Factor = 1.220

Equipment Name / Description		Distance From Equip.	Main Source	Vicinity #1 Source	Vicinity #2 Source	Vicinity #3 Source	Vicinity #4 Source	Vicinity #5 Source	Vicinity #6 Source	TOTAL (mR/h)	Approx. Mfr OF Increase (Total/50)
1: Rotary Feeder @ Cullet Storage Tank (Brem Factor = x1.133)		1 cm 30 cm 100 cm	10,821 4,223 1,098	1,364 1,292 1,164	1,364 1,292 1,164	N/A N/A N/A	N/A N/A N/A	N/A N/A N/A	N/A N/A N/A	13,550 6,806 3,426	271 136 69
2: Evaporator Reboiler On Melt Feed Evap. (Brem Factor = x1.348)		1 cm 30 cm 100 cm	127.6 123.4 121.6	426.1 409.6 395.0	N/A N/A N/A	N/A N/A N/A	N/A N/A N/A	N/A N/A N/A	N/A N/A N/A	588.0 593.0 718.6	11 12 14
3: Mist Eliminator In Melt Room (Brem Factor = x1.133)		TOP-ME MID-ME BOT-ME	N/A N/A N/A	0.617 1.148 1.460	0.316 0.260 0.192	2.866 3.246 3.670	18.24 20.38 22.88	0.318 0.375 0.424	0.508 10.437 11.489	32.087 35.848 40.053	1 1 1
4: Melt Feed Pump @ Melt Feed Tank (Brem Factor = x1.348)		1 cm 30 cm 100 cm	10,365.0 10,862.0 3,076.5	618.7 618.7 618.7	618.7 618.7 618.7	N/A N/A N/A	N/A N/A N/A	N/A N/A N/A	N/A N/A N/A	12,232.5 12,989.5 8,314.0	244 242 165
5: Oil-Gas Line @ Top of Separator (Brem Factor = x1.133)		1 cm 30 cm 100 cm	76.56 48.98 25.02	2.14 2.22 2.48	2.34 2.39 2.48	20.17 19.17 17.03	88.01 74.00 66.03	21.14 20.64 19.47	N/A N/A N/A	210.4 167.4 132.5	4 3 3

SOURCES (Stream #, C = Cullet Glass, S = Solid Glass):

1-Main (#406C) = Cullet Storage Tank (Bottom), 5%	1-Vicinity#1 (#406C) = Adjacent Cullet Storage Tank (Full)	1-Vicinity#2 (#406C) = Adjacent Cullet Storage Tank (Full)
2-Main (#404) = Evaporator, Drained/Flushed to 1% Residual	2-Vicinity#1 (#404) = Evaporator Feed Tank (Full)	
3-Main (#626) = Mist Eliminator (N/A)	3-Vicinity#1 (#406G) = Melt Vortex Combustor (Residual Glass)	3-Vicinity#2 (#406G) = Melt Cyclone (Residual Glass)
3-Vicinity#3 (#406G) = Melt Separator (Plenum Residual Glass)	3-Vicinity#4 (#406G) = Melt Separator (Full Glass Pool)	3-Vicinity#5 (#410) = Oil Gas Pipe/Line (Residual Glass)
3-Vicinity#6 (#406C) = Cullet Catch Tank (Full, with Water)		

BREM FACTORS: Glass/Cullet = 1.133; Stream Solutions = 1.220

4-Main (#406) = Melt Feed Tank (Bottom), Drained to 5%	4-Vicinity#1 (#406) = Adjacent Melt Feed Tank (Full)	4-Vicinity#2 (#406) = Adjacent Melt Feed Adjustment Tank (Full)
5-Main (#410) = Oil Gas Pipe/Line (Residual Glass)	5-Vicinity#1 (#406G) = Melt Vortex Combustor (Residual Glass)	5-Vicinity#2 (#406G) = Melt Cyclone (Residual Glass)
5-Vicinity#3 (#406G) = Melt Separator (Plenum Residual Glass)	5-Vicinity#4 (#406G) = Melt Separator (Full Glass Pool)	5-Vicinity#5 (#406C) = Cullet Catch Tank (Full, with Water)
5-Vicinity#6 = Quench Tower, Filter Wash Tank (N/A)		

TABLE 4-1: SUMMARY TABLE FOR THE LS-LW CONTACT MAINTENANCE STUDY, RECIRCULATION = 50%

HIGH BLEND SOURCE (High Gas = 50% Oil-Gas Recirculation), RF = 2.81 New Brem Factor = 1.124

Equipment Name / Description		Distance From Equip.	Main Source	Vicinity #1 Source	Vicinity #2 Source	Vicinity #3 Source	Vicinity #4 Source	Vicinity #5 Source	Vicinity #6 Source	TOTAL (mR/h)	Approx. Min DF Increase (Total/50)
DOSE RATES (mR/h)											
1: Rotary Feeder @ Cullet Storage Tank (Brem Factor = x1.133)	1 cm	10,621	1,364	1,364	N/A	N/A	N/A	N/A	N/A	13,550	271
	30 cm	4,223	1,292	1,292	N/A	N/A	N/A	N/A	N/A	6,806	136
	100 cm	1,099	1,164	1,164	N/A	N/A	N/A	N/A	N/A	3,428	69
2: Evaporator Reboiler On Melt Feed Evap. (Brem Factor = x1.348)	1 cm	209.5	701.5	N/A	N/A	N/A	N/A	N/A	N/A	911.0	18
	30 cm	202.2	769.5	N/A	N/A	N/A	N/A	N/A	N/A	971.7	19
	100 cm	199.6	974.8	N/A	N/A	N/A	N/A	N/A	N/A	1,174.6	23
3: Mist Eliminator In Melt Floor (Brem Factor = x1.133)	TOP-ME	N/A	0.917	0.315	2.856	18.24	0.315	9.508		32.067	1
	MID-ME	N/A	1.140	0.280	3.248	20.38	0.375	10.437		35.648	1
	BOT-ME	N/A	1.490	0.192	3.570	22.89	0.424	11.469		40.055	1
4: Melt Feed Pump @ Melt Feed Tank (Brem Factor = x1.348)	1 cm	17,999.4	1,013.9	1,013.9	N/A	N/A	N/A	N/A	N/A	20,027.0	401
	30 cm	17,781.5	1,013.8	1,013.8	N/A	N/A	N/A	N/A	N/A	19,809.1	396
	100 cm	13,233.8	1,013.8	1,013.8	N/A	N/A	N/A	N/A	N/A	15,261.3	305
5: Oil-Gas Line @ Top of Separator (Brem Factor = x1.133)	1 cm	78.58	2.14	2.34	20.17	85.01	21.14	N/A		210.4	4
	30 cm	48.99	2.22	2.39	19.17	74.00	20.64	N/A		187.4	3
	100 cm	25.02	2.48	2.48	17.03	56.03	19.47	N/A		132.5	3

SOURCES (Brem F. C = Cullet Glass, G = Solid Glass):

1-Main (#409C) = Cullet Storage Tank (Bottom), 5%	
1-Vicinity #1 (#409C) = Adjacent Cullet Storage Tank (Full)	
1-Vicinity #2 (#409C) = Adjacent Cullet Storage Tank (Full)	
2-Main (#404) = Evaporator, Drained/Flushed to 1% Residual	
2-Vicinity #1 (#400) = Evaporator Feed Tank (Full)	
3-Main (#628) = Mist Eliminator (N/A)	
3-Vicinity #1 (#406G) = Melt Vortex Combustor (Residual Glass)	
3-Vicinity #2 (#406G) = Melt Cyclone (Residual Glass)	
3-Vicinity #3 (#406G) = Melt Separator (Plenum Residual Glass)	
3-Vicinity #4 (#406G) = Melt Separator (Full Glass Pool)	
3-Vicinity #5 (#410) = Oil Gas Pipe/Line (Residual Glass)	
3-Vicinity #6 (#406C) = Cullet Catch Tank (Full, with Water)	

BREM FACTORS: Glass/Cullet = 1.133; Stream Solutions = 1.124

4-Main (#408) = Melt Feed Tank (Bottom), Drained to 5%	
4-Vicinity #1 (#408) = Adjacent Melt Feed Tank (Full)	
4-Vicinity #2 (#405) = Adjacent Melt Feed Adjustment Tank (Full)	
5-Main (#410) = Oil Gas Pipe/Line (Residual Glass)	
5-Vicinity #1 (#408G) = Melt Vortex Combustor (Residual Glass)	
5-Vicinity #2 (#406G) = Melt Cyclone (Residual Glass)	
5-Vicinity #3 (#406G) = Melt Separator (Plenum Residual Glass)	
5-Vicinity #4 (#406G) = Melt Separator (Full Glass Pool)	
5-Vicinity #5 (#406C) = Cullet Catch Tank (Full, with Water)	
5-Vicinity #6 = Quench Tower, Filter Wash Tank (N/A)	

These potential "base" glass sources must be modified by a factor that accounts for the preferred volatilizing of Cs at the combustion melter operating temperatures (~1300 °C). The potential plateau of Cs within the glass on the above surfaces (excluding the glass pool in the separator) could range in factor of five to 1000. Four parametric values of 1, 10, 100 and 1000 are used to assess the radiation dose impacts for contact maintenance. The critical value will then be identified which just permits the contact maintenance of equipment items near the melter and offgas pipe.

Multiplying the above surface areas by the 1.0 cm glass thickness gives the following associated residual glass volumes:

COMPONENT	AREA (m ²)	AREA (cm ²)	VOLUME (cm ³)	VOLUME (m ³)
CRV	35.0	3.5×10^5	3.5×10^5	0.35
Cyclone	40.0	4.0×10^5	4.0×10^5	0.40
Separator Pool*	20.0	2.0×10^5	2.0×10^5	0.20
Separator Plenum	50.0	5.0×10^5	5.0×10^5	0.50
Offgas Pipe	7.5	7.5×10^4	7.5×10^4	0.075

* Note that it has been previously estimated that the separator pool could be 8" to 16" thick/deep. Based on previous information, the operating separator (undrained glass pool) would contain about 5.748×10^5 cm³ of LLW glass. It should be further noted that neither the drained glass pool or full pool of glass in the separator will have a Cs concentration factor applied since this is relevant only for the "gaseous" plateau areas of the combustion and offgas pipe.

The application of the above Cs plateau considerations is accomplished by using the "base" glass sources for the assumed 1.0 cm thickness. The radiation dose rates attributable to these sources can then be modified by two factors as appropriate:

FACTOR	RANGE OF VALUES
Glass Thickness	0.254 cm to 2.54 cm (0.1" to 1.0")
Cs Concentration	1, 10, 100 or 1000

To a reasonable first approximation, neglecting self absorption, these factors can be directly applied (multiplied) to the "base" dose rates obtained for the 1.0 cm residual glass sources.

4.7 MAINTENANCE DATA SHEETS

In order to accurately determine the dose received by the maintenance crew, the time required to perform the maintenance tasks and the number of each craft required to perform the work must be defined/estimated. The maintenance specific information is developed and included on maintenance data sheets for each of the maintenance scenarios. The maintenance data sheets for the five example maintenance scenarios are given on the following pages. The dose rates provided on each of these particular maintenance data sheets are for the NCAW waste source and the base case DF of $Cs/Ba = 100$. The NCAW dose rates are obtained using the initially calculated dose rates from the High Blend waste sources and multiplying them by the ratio of NCAW-to-High Blend dose rates from Table 2.1 (or 0.447). In addition, an offgas recirculation of 35 percent (median of the low estimate of 30 percent and the high estimate of 40 percent) is assumed for the calculations. A Cs plateau factor of 1.0 and a residual glass thickness of 1.0 cm is used for these five maintenance data sheets. A more detailed future maintenance analysis would use Cs plateau concentration factors of from 10 to 1000, depending on specific combustion melter data (the maintenance dose rate data for these other Cs plateau factors are available from Table 4.3). As an example, the total radiation in Maintenance Data Sheet #1 is 100 mR is obtained from Table 4.3 (1426 mR/h) $\times$ (0.447) = 1531 mR/h.

The important parameters identified on the maintenance data sheets are:

- A. Breakdown of tasks
- B. Times required for each task
- C. Breakdown by number of each main craft and by shift
- D. Maximum time per single person by craft
- E. Total dose received for the job (person-rem)
- F. Average distances/dose rates by craft
- G. Resulting radiation access zone
- H. Decision as to ability to Contact or Remote maintain

Note that the decision to contact maintain is based on either the limit of 50 mrem per hour or 300 mrem for the job for any one individual. Section 1.1.1 gives the rationale for the 300 mrem per job as a decision criteria.

A summary of the results of the equipment maintenance radiation dose rates used in the maintenance data sheets is given in summary Table 4.7. This table shows that, for the base DF case of $Cs/Ba = 100$, at least two of the equipment repair/maintenance must be remote maintained based on the criteria that the dose rate shall not exceed 50 mrem per hour. The issue of decreasing the radiation fields by increasing the pretreatment DFs for selected radioisotopes is discussed later (see Section 4).

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MAINTENANCE DATA SHEET

Equipment: (#1)	Curtel Storage Tank Rotary Feeder M-433	PFD: E3-CP2-200
Scenario:	Rotary Feeder Freezes with a Full Bin	
Activity:	Replace Rotary Feeder	

Max No.	Craft Designation	Avg Dist (cm)	Dose Rate (mrem/h)
1	Plaster (P)	30	3043
2	Operator (O)	30	3043
1	Electrician (E)	30	3043
	Helpers (H)		0
	Crane Operator (C)		0
1	Health Physics Tech (H)	100	1551
	Instrument Tech (I)		0
	Other (#1)		0
5	Total Crew Members		

Radiation Source				
Waste	NCAW			
DF Class	Class 1 (500 Ci)			
Stream #	85 % Radio			
Cont'd/Qty	Actual Equip			
Radiation Analysis Results				
Dist (cm)	Other No.	Dose Rate, mrem/h		
		Direct	Other	Total
1	2			0
30	2	1867.7	1158	3043
100	2	490.8	1640.6	1551

SHIFT No.	Description of Task	Task hours	CRAFT									
			P	O	E	A	C	R	I	#1		
1	Erect Temporary Shielding	4.0		2					1			
1	Open Equipment	2.0		1					1			
1	Disconnect Electrical	1.0			1							
2	Remove Feeder	2.0	1	1					1			
2	Piece in Box, Wrap, & Smear	1.0		1					1			
2	Install New Feeder	2.0	1	1					1			
2	Reconnect Electrical	1.0			1							
2	Remove Temporary Shielding	2.0		2					1			

Total Collective Dose By Craft (person-mrem):	91281	59982	0	0	0	35222	0	0			
Total Collective Dose For Total Job =	196485	person-mrem									
BASIS:											
Max Radiation Dose, for 1 Person (hrs x field = max mrem):	7	3043	=	21299	71						
(Based on limit of 300 mrem for per person for the total job)	Max Field	30 mrem/hr									
Max Dose Rate Field Compared to Max RAZ & ISD mrem/hr:	3043	RAZ:	0	50.9							
Based on Controlling Max Dose Rate/Max Allow (50) =	3043	7	0	80854	2=	1,000					

CONCLUSION: Maintenance Activity	will be REMOTE Maintained	DF Risk =	1,000
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CONCLUSION: Maintenance Activity must be REMOTE Maintained DF Ratio = 1.000

MAINTENANCE DATA SHEET

Equipment (#3)	Max Eliminator DE-818	PFD	ES-OP2-300
Scenario	Max Eliminator Candles Become Fouled		
Activity	Replace Candles		

Max No	Craft Designation	Avg Dose (mrem)	Dose Rate (mrem/h)
1	Pipetter (P)	30	18.02
2	Operators (O)	30	18.02
	Electrician (E)		0
1	Riggers (R)	100	17.9
1	Crane Operator (C)	100	17.9
1	Health Physics Tech (H)	100	17.9
	Instrument Tech (I)		0
	Other (#1)		0
8	Total Crew Members		

Radon Source				
Waste	NCAW			
DF Case	Base (100 Cs)			
Stream #	18 W Reactor			
Config/Qty	Actual Equip			
Radon Analysis Results				
Dist (cm)	Other No	Dose Rate (mrem/h)		Total
1	0	Direct	Other	0
30	0	N/A	18.02	18
100	0	N/A	17.9	17.9

SHIFT No	Description of Task	Task hours	CRAFT									
			P	O	E	R	C	H	I	Other	#1	
1	Detach Top of Max Elim	30		2					1			
1	Remove Top	20	1	1		1	1					
1	Remove Candles	10		1				1				
1	Box Wrap & Smear Candles	10		1				1				
2	Replace Candles	10		1				1				
2	Replace Lid	20	1	1								
Total Job Hrs & Man/hr per 1 Person		100	2	2			2	2	5			

Total Collective Dose By Craft (person-mrem)	480 E	350 E	0	280 E	280 E	411.7	0
Total Collective Dose For Total Job =	1770.8 person-mrem						
	BASIS						
Max Radon Dose for 1 Person (hrs x field = max mrem)	71	18.02	=	1271		112.1	0.3
(Based on limit of 300 mrem for one person for the total job)	Max Field 50 mrem/h						
Max Dose Rate Field Compared to Max PAZ (4.150 mrem/h)	17.9			PAZ	4.1	0.3	
Based on Controlling Max Dose/Max Allowable (300) =	112.1			300	=	0.374	< 1.000

REVISION: Maintenance Activity can be CONTACT Maintained DF Ratio = 1.000

MAINTENANCE DATA SHEET

Equipment:	Melter Feed Pump P-407	PFD: ES-OP2-200
Geosmarker:	Pump Motor Fails	
Activity:	Replace Motor	

Man No.	Craft Designation	Avg Dist (cm)	Dose Rate (mrem/h)
1	Planner (P)	30	5404
2	Operators (O)	30	5404
1	Electrician (E)	30	5404
2	Riggers (R)	100	4183
1	Crane Operator (C)	100	4183
1	Health Physics Tech (H)	100	4183
1	Maintenance Tech (M)	30	5404
	Other (#1)		0
9	Total Crew Members		

Radiation Source			
Waste	NCAW		
DF Case	Base (100 Cg)		
Percent #	55 % Proport		
Condn/Qty	Actual Expts		
Radiation Analysis Results			
Dist (cm)	Other No.	Dose Rate	Other Total
1	2		0
30	2	495.1	8424
100	2	3610	4183

[illegible]

Total Collective Dose By Craft (person-mrem)	25+05/15+05	0/31263	62447	56761	10868	0
Total Collective Dose For Total Job =	31309/	person-mrem				
BASIS:						
Max Radiation Dose, for 1 person (hrs x field = max mrem)	hrs x field	=	300mrem/job			
(Based on limit of 300 mrem for one person for the total job)	7/	5004	=	37225	1.24	
Max Field	Max Field			50 mrem/hr		
Max Dose Rate Field Compared to Max RAD (50 mrem/hr)			5004	RA2	=	1.08
Based on Controlling Max Dose Rate, Max Allow	= 240	50	=	108	=	1.08

CONCLUSION: Maintenance Activity must be REMOTELY Maintained OF Ratio = 1.000

TABLE 7: NCAW BASED MAINTENANCE DOSE RATES SUMMARY OF RESULTS

HIGH BLEND Source (Base DF, C _s = 100)											
Basis		Total Dose Rate at Indicated Distance from all Associated Sources (Equipment + Vicinity)									
Cesium Plateout Factor	Recirc. %	Equip #1		Equip #2		Equip #3		Equip #4		Equip #5	
		@ 30cm (mR/h)	@ 100cm (mR/h)	@ 30cm (mR/h)	@ 100cm (mR/h)	@ 30cm (mR/h)	@ 100cm (mR/h)	@ 30cm (mR/h)	@ 100cm (mR/h)	@ 30cm (mR/h)	@ 100cm (mR/h)
x1	0%	5.608E+03	3.426E+03	4.147E+02	5.013E+02	3.585E+01	4.006E+01	8.454E+03	5.513E+03	1.674E+02	1.325E+02
x1	30%	5.608E+03	3.426E+03	4.855E+02	5.889E+02	3.585E+01	4.006E+01	8.888E+03	7.825E+03	1.674E+02	1.325E+02
x1	55%	5.608E+03	3.426E+03	5.930E+02	7.188E+02	3.585E+01	4.006E+01	1.209E+04	9.314E+03	1.674E+02	1.325E+02
x1	80%	5.608E+03	3.426E+03	6.717E+02	8.175E+02	3.585E+01	4.006E+01	1.961E+04	1.528E+04	1.674E+02	1.325E+02
x10	0%	5.608E+04	3.426E+04	4.147E+02	5.013E+02	3.585E+02	4.006E+02	8.454E+03	5.513E+03	1.674E+03	1.325E+03
x10	30%	5.608E+04	3.426E+04	4.855E+02	5.889E+02	3.585E+02	4.006E+02	8.888E+03	7.825E+03	1.674E+03	1.325E+03
x10	55%	5.608E+04	3.426E+04	5.930E+02	7.188E+02	3.585E+02	4.006E+02	1.209E+04	9.314E+03	1.674E+03	1.325E+03
x10	80%	5.608E+04	3.426E+04	6.717E+02	8.175E+02	3.585E+02	4.006E+02	1.961E+04	1.528E+04	1.674E+03	1.325E+03
x100	0%	5.608E+05	3.426E+05	4.147E+02	5.013E+02	3.585E+03	4.006E+03	8.454E+03	5.513E+03	1.674E+04	1.325E+04
x100	30%	5.608E+05	3.426E+05	4.855E+02	5.889E+02	3.585E+03	4.006E+03	8.888E+03	7.825E+03	1.674E+04	1.325E+04
x100	55%	5.608E+05	3.426E+05	5.930E+02	7.188E+02	3.585E+03	4.006E+03	1.209E+04	9.314E+03	1.674E+04	1.325E+04
x100	80%	5.608E+05	3.426E+05	6.717E+02	8.175E+02	3.585E+03	4.006E+03	1.961E+04	1.528E+04	1.674E+04	1.325E+04
x1000	0%	5.608E+06	3.426E+06	4.147E+02	5.013E+02	3.585E+04	4.006E+04	8.454E+03	5.513E+03	1.674E+05	1.325E+05
x1000	30%	5.608E+06	3.426E+06	4.855E+02	5.889E+02	3.585E+04	4.006E+04	8.888E+03	7.825E+03	1.674E+05	1.325E+05
x1000	55%	5.608E+06	3.426E+06	5.930E+02	7.188E+02	3.585E+04	4.006E+04	1.209E+04	9.314E+03	1.674E+05	1.325E+05
x1000	80%	5.608E+06	3.426E+06	6.717E+02	8.175E+02	3.585E+04	4.006E+04	1.961E+04	1.528E+04	1.674E+05	1.325E+05

NCAW Source (Base DF, C _s = 100) NCAW/HIGH BLEND Ratio = 0.447											
Basis		Total Dose Rate at Indicated Distance from all Associated Sources (Equipment + Vicinity)									
Cesium Plateout Factor	Recirc. %	Equip #1		Equip #2		Equip #3		Equip #4		Equip #5	
		@ 30cm (mR/h)	@ 100cm (mR/h)	@ 30cm (mR/h)	@ 100cm (mR/h)	@ 30cm (mR/h)	@ 100cm (mR/h)	@ 30cm (mR/h)	@ 100cm (mR/h)	@ 30cm (mR/h)	@ 100cm (mR/h)
x1	0%	3.042E+03	1.531E+03	1.854E+02	2.241E+02	1.602E+01	1.790E+01	3.779E+03	2.911E+03	7.483E+01	5.923E+01
x1	30%	3.042E+03	1.531E+03	2.170E+02	2.623E+02	1.602E+01	1.790E+01	4.424E+03	3.408E+03	7.483E+01	5.923E+01
x1	55%	3.042E+03	1.531E+03	2.851E+02	3.204E+02	1.602E+01	1.790E+01	5.404E+03	4.163E+03	7.483E+01	5.923E+01
x1	80%	3.042E+03	1.531E+03	3.435E+02	3.550E+02	1.602E+01	1.790E+01	8.855E+03	5.822E+03	7.483E+01	5.923E+01
x10	0%	3.042E+04	1.531E+04	1.854E+02	2.241E+02	1.602E+02	1.790E+02	3.779E+03	2.911E+03	7.483E+02	5.923E+02
x10	30%	3.042E+04	1.531E+04	2.170E+02	2.623E+02	1.602E+02	1.790E+02	4.424E+03	3.408E+03	7.483E+02	5.923E+02
x10	55%	3.042E+04	1.531E+04	2.851E+02	3.204E+02	1.602E+02	1.790E+02	5.404E+03	4.163E+03	7.483E+02	5.923E+02
x10	80%	3.042E+04	1.531E+04	3.435E+02	3.550E+02	1.602E+02	1.790E+02	8.855E+03	5.822E+03	7.483E+02	5.923E+02
x100	0%	3.042E+05	1.531E+05	1.854E+02	2.241E+02	1.602E+03	1.790E+03	3.779E+03	2.911E+03	7.483E+03	5.923E+03
x100	30%	3.042E+05	1.531E+05	2.170E+02	2.623E+02	1.602E+03	1.790E+03	4.424E+03	3.408E+03	7.483E+03	5.923E+03
x100	55%	3.042E+05	1.531E+05	2.851E+02	3.204E+02	1.602E+03	1.790E+03	5.404E+03	4.163E+03	7.483E+03	5.923E+03
x100	80%	3.042E+05	1.531E+05	3.435E+02	3.550E+02	1.602E+03	1.790E+03	8.855E+03	5.822E+03	7.483E+03	5.923E+03
x1000	0%	3.042E+06	1.531E+06	1.854E+02	2.241E+02	1.602E+04	1.790E+04	3.779E+03	2.911E+03	7.483E+04	5.923E+04
x1000	30%	3.042E+06	1.531E+06	2.170E+02	2.623E+02	1.602E+04	1.790E+04	4.424E+03	3.408E+03	7.483E+04	5.923E+04
x1000	55%	3.042E+06	1.531E+06	2.851E+02	3.204E+02	1.602E+04	1.790E+04	5.404E+03	4.163E+03	7.483E+04	5.923E+04
x1000	80%	3.042E+06	1.531E+06	3.435E+02	3.550E+02	1.602E+04	1.790E+04	8.855E+03	5.822E+03	7.483E+04	5.923E+04

4.6 GENERIC DF ANALYSIS BASIS

Since the important aspect of the DF analysis is the relative concentrations of the various radioisotope constituents, a preliminary analysis can be performed on a 2.7853 L (1.0 gal) sample of the tank waste and the dose rates calculated for each DF selected for the major dose rate contributor. Based on a subjective analysis of the High Blend waste, the DF changes were limited to the three radioisotope constituents of ^{137}Cs , ^{241}Am and the ^{60}Co for the tank sources, except for High Blend and NCAW, which also included ^{90}Sr .

The results of the DF analysis for six of the seven tank sources are summarized in summary Tables 4.6 to 4.13 (a generic DF analysis was not performed for the Max Theoretical waste source). These tables show that for the High Blend and NCAW sources, it is probably optimum (greatest radiation dose rate reduction for the lowest DF increase) for the following DFs (note that the Base Case has a DF of 100 for the Cs):

CONSTITUENT	HIGH BLEND	NCAW
^{137}Cs	DF = 10,000 (base case x 100)	10,000
^{241}Am	DF = 100	100
^{60}Co	DF = 10	1
^{90}Sr	DF = 100	100

Using these DFs will reduce the base case radiation dose rates by about a factor of 0.022 for the High Blend source and by about 0.015 for the NCAW source. It remains to be seen if the pretreatment contractor can technically and economically achieve close to these DFs for the desired radioisotopes.

4.9 DF ANALYSIS (SPECIFIC MAINTENANCE ACTIVITIES)

In order to correctly identify the DFs needed to achieve contact maintenance for specific maintenance activities, each specific contact maintenance activity must be analyzed separately. The maintenance activities are analyzed by means of the Maintenance Data Sheets (MDS) previously discussed in Section 4.8. Using the radiation dose rate data obtained in Section 4.6 and as summarized in Tables 4.3 through 4.6, the highest radiation dose rate for an individual maintenance crew member can be determined. If this dose rate is less than 50 mrem/h, then the total time for the entire maintenance job for any individual crew member must be less than 300 mrem to qualify for possible contact maintenance. If both of these tests fail (i.e., > 50 mrem/h and/or > 300 mrem/job), then the DFs can be indirectly established that would allow contact maintenance.

The specific maintenance activity DF analysis is performed indirectly since there are potentially several combinations of waste source constituent DF which could lead to the same overall dose rate reduction, i.e., there is not necessarily a unique solution to the DF requirement (see Tables 4.8 through 4.13). The approach is to work with the dose rate (DR) reduction factors (called DF Ratio on the MDS, but more correctly DRR for Dose Rate Ratio) that are listed in the last column on Tables 4.8 through 4.13. Any combination of DFs that will produce a dose rate reduction factor (DF Ratio or DRR) less than that needed for contact maintenance will be acceptable for the purposes of achieving contact maintenance for the specific maintenance activity.

This approach is applied to the five example maintenance scenarios discussed in the report and for which initial MDSs were provided in Section 4.8. Using these five MDSs, the DF Ratio (shown in the lower right-hand corner of the MDS) was iteratively changed by manual trial and error until the maintenance activity just qualified to be contact maintainable based on the 50 mrem/h and the 300 mrem/job criteria. The DF Ratio (or DRR) is implemented in the MDS by multiplying the total dose rate in mrem/h on the MDS by the manually input DF Ratio (note that the dose rates from "Direct" and "Other" as shown on the revised MDS do not add to the total dose rates except for an initial DF Ratio or DRR of 1.000). The results of these DRR manipulations are shown on the five corresponding MDS on the following pages. These results are summarized as follows for the NCAW source:

Table 4.14: Maintenance Scenario Dose Rate Ratio Results for the NCAW Source

Maintenance Scenario	Initial Dose Rates		Req'd Dose Rates		DR Ratio
	30 cm	100cm	30 cm	100 cm	
Rotary Feeder	3043	1631	42.6	21.4	0.014
Evaporator	265	320	30.9	37.3	0.117
Mist Eliminator	16.0	17.9	16.0*	17.9*	1.000
Feed Pump	5404	4163	37.8	29.1	0.007
Offgas Pipe	74.8	59.2	49.9	39.5	0.667

* Note: Initial dose rates already qualify for contact maintenance

Using the generic DF Table 4.9 for the NCAW source and the above DR Ratios, the approximate DF factors, as shown in Table 4.13, would allow contact maintenance for the five maintenance scenarios:

TABLE 4.3: Summary of DF Cases for 80 Combinations (NGAW, Stream #454, 1.0 gal)

Case DF	Ex DF	Co DF	B/T DF	DF (300cm mPh)	Gamma Dose Rate	Beta Dose Rate	Rad Dose
100	1	1	1	181.017	185.200	14.817	1.000
1000	1	1	1	50.137	45.320	14.817	0.332
10000	1	1	1	48.417	33.800	14.817	0.287
100	10	1	1	148.917	134.100	14.817	0.823
1000	10	1	1	31.807	18.390	14.817	0.178
10000	10	1	1	20.989	5.272	14.817	0.111
100	100	1	1	148.117	131.300	14.817	0.807
1000	100	1	1	28.977	14.180	14.817	0.160
10000	100	1	1	17.257	2.440	14.817	0.065
10000	100	10	1	18.567	1.750	14.817	0.092
10000	100	100	1	18.488	1.881	14.817	0.081
10000	1000	1	1	16.973	2.150	14.817	0.084
10000	1000	10	1	16.283	1.486	14.817	0.080
10000	1000	100	1	16.214	1.397	14.817	0.080
100	1	1	10	187.891	185.200	1.4907	0.989
1000	1	1	10	48.811	45.320	1.4907	0.289
10000	1	1	10	38.091	33.800	1.4907	0.194
100	10	1	10	133.581	134.100	1.4907	0.745
1000	10	1	10	18.437	18.690	1.4907	0.102
10000	10	1	10	6.763	5.272	1.4907	0.037
100	100	1	10	132.791	131.300	1.4907	0.734
1000	100	1	10	18.581	14.180	1.4907	0.088
10000	100	1	10	8.931	2.440	1.4907	0.022
10000	100	10	10	3.241	1.750	1.4907	0.018
10000	100	100	10	3.172	1.881	1.4907	0.016
10000	1000	1	10	3.847	2.155	1.4907	0.020
10000	1000	10	10	2.857	1.486	1.4907	0.016
10000	1000	100	10	2.889	1.397	1.4907	0.016
100	1	1	100	188.388	188.200	0.1877	0.818
1000	1	1	100	45.508	45.320	0.1877	0.251
10000	1	1	100	39.789	33.800	0.1877	0.187
100	10	1	100	134.288	134.100	0.1877	0.742
1000	10	1	100	17.178	18.990	0.1877	0.088
10000	10	1	100	6.480	5.272	0.1877	0.030
100	100	1	100	131.488	131.300	0.1877	0.728
1000	100	1	100	14.349	14.180	0.1877	0.078
10000	100	1	100	2.828	2.440	0.1877	0.015
10000	100	10	100	1.898	1.750	0.1877	0.011
10000	100	100	100	1.869	1.681	0.1877	0.010
10000	1000	1	100	2.344	2.155	0.1877	0.013
10000	1000	10	100	1.684	1.486	0.1877	0.008
10000	1000	100	100	1.585	1.397	0.1877	0.008
100	1	1	1000	188.243	188.200	0.0432	0.818
1000	1	1	1000	45.289	45.320	0.0432	0.251
10000	1	1	1000	38.843	33.800	0.0432	0.186
100	10	1	1000	134.143	134.100	0.0432	0.741
1000	10	1	1000	17.083	18.980	0.0432	0.084
10000	10	1	1000	6.515	5.272	0.0432	0.029
100	100	1	1000	131.243	131.300	0.0432	0.726
1000	100	1	1000	14.208	14.180	0.0432	0.079
10000	100	1	1000	2.483	2.440	0.0432	0.014
10000	100	10	1000	1.783	1.750	0.0432	0.010
10000	100	100	1000	1.724	1.681	0.0432	0.010
10000	1000	1	1000	2.199	2.155	0.0432	0.012
10000	1000	10	1000	1.809	1.486	0.0432	0.008
10000	1000	100	1000	1.440	1.397	0.0432	0.008

--- Base Case

TABLE 4-9 Summary of DF Cases for EC Combinations (HIGH BLEND, Stream #404, 1.0 gpd)

Case DF	So DF	Co DF	S/W DF	DF @ 300m m/s	Gamma Dose Rate	Beta Dose Rate	Fiber Ci Base	
100	1	1	1	204 828	270 800	94 126	1 000	--- Base Case
1000	1	1	1	221 828	127 400	94 126	0 807	
10000	1	1	1	207 126	113 000	94 126	0 568	
100	10	1	1	209 028	194 900	94 126	0 792	
1000	10	1	1	145 808	51 480	94 126	0 399	
10000	10	1	1	131 288	37 140	94 126	0 380	
100	100	1	1	281 428	187 300	94 126	0 771	
1000	100	1	1	138 016	43 890	94 126	0 375	
10000	100	1	1	123 678	29 550	94 126	0 339	
10000	100	10	1	101 126	6 999	94 126	0 277	
10000	100	100	1	98 670	4 744	94 126	0 271	
10000	1000	1	1	122 816	28 790	94 126	0 337	
10000	1000	10	1	100 868	6 240	94 126	0 276	
10000	1000	100	1	96 111	3 985	94 126	0 269	
100	1	1	10	204 828	270 8	9 783	0 788	
1000	1	1	10	137 183	127 400	9 783	0 376	
10000	1	1	10	122 743	113 000	9 783	0 338	
100	10	1	10	204 828	194 900	9 783	0 581	
1000	10	1	10	51 263	51 480	9 783	0 168	
10000	10	1	10	46 923	37 140	9 783	0 129	
100	100	1	10	197 083	187 300	9 783	0 540	
1000	100	1	10	53 673	43 890	9 783	0 147	
10000	100	1	10	38 333	29 550	9 783	0 109	
10000	100	10	10	16 782	6 999	9 783	0 048	
10000	100	100	10	14 527	4 744	9 783	0 040	
10000	1000	1	10	38 673	28 790	9 783	0 105	
10000	1000	10	10	16 023	6 240	9 783	0 044	
10000	1000	100	10	13 768	3 985	9 783	0 038	
100	1	1	100	271 777	270 8	0 9773	0 745	
1000	1	1	100	129 377	127 400	0 9773	0 352	
10000	1	1	100	113 977	113 000	0 9773	0 312	
100	10	1	100	195 877	194 900	0 9773	0 537	
1000	10	1	100	53 457	51 480	0 9773	0 144	
10000	10	1	100	38 117	37 140	0 9773	0 104	
100	100	1	100	198 277	187 300	0 9773	0 516	
1000	100	1	100	44 807	43 890	0 9773	0 123	
10000	100	1	100	30 627	29 550	0 9773	0 084	
10000	100	10	100	7 576	6 999	0 9773	0 022	
10000	100	100	100	5 721	4 744	0 9773	0 016	
10000	1000	1	100	29 787	28 790	0 9773	0 082	
10000	1000	10	100	7 217	6 240	0 9773	0 020	
10000	1000	100	100	4 892	3 985	0 9773	0 014	
100	1	1	1000	270 898	270 8	0 0978	0 742	
1000	1	1	1000	127 496	127 400	0 0978	0 349	
10000	1	1	1000	113 098	113 000	0 0978	0 310	
100	10	1	1000	194 908	194 900	0 0978	0 534	
1000	10	1	1000	51 574	51 480	0 0978	0 141	
10000	10	1	1000	37 238	37 140	0 0978	0 102	
100	100	1	1000	187 398	187 300	0 0978	0 514	
1000	100	1	1000	43 888	43 890	0 0978	0 121	
10000	100	1	1000	29 548	29 550	0 0978	0 081	
10000	100	10	1000	7 097	6 999	0 0978	0 019	
10000	100	100	1000	4 642	4 744	0 0978	0 013	
10000	1000	1	1000	28 888	28 790	0 0978	0 079	
10000	1000	10	1000	6 338	6 240	0 0978	0 017	
10000	1000	100	1000	4 093	3 985	0 0978	0 011	

TABLE 4.10: Summary of DF Cases for 9 Combinations (Nominal, Stream #404, 1.0 gal)

Cs/Ba DF	Eu DF	Co DF	Sr/Y DF	DR @30cm mR/h	Gamma Dose Rate	Beta Dose Rate	Ratio Of Base	
100	1	No Co	1	4.380	4.353	0	1.000	--- Base Case
1000	1	No Co	1	2.185	2.185	0	0.501	
10000	1	No Co	1	1.811	1.811	0	0.418	
100	10	No Co	1	4.339	4.339	0	0.995	
1000	10	No Co	1	0.553	0.553	0	0.136	
10000	10	No Co	1	0.219	0.219	0	0.050	
100	100	No Co	1	4.180	4.180	0	0.585	
1000	100	No Co	1	0.434	0.434	0	0.100	
10000	100	No Co	1	0.059	0.059	0	0.014	
		No Co						
		No Co						
		No Co						
		No Co						

TABLE 4.11: Summary of DF Cases for 9 Combinations (CC Waste, Stream #404, 1.0 gal)

Cs/Re DF	Fu DF	Co DF	Si/Y DF	DR @30cm mR/h	Gamma Dose Rate	Beta Dose Rate	Ratio Of Base	
100	1	No Co	1	22.400	22.400	0	1.000	← -- Base Case
1000	1	No Co	1	11.690	11.690	0	0.522	
10000	1	No Co	1	10.600	10.600	0	0.473	
100	10	No Co	1	13.150	13.150	0	0.587	
1000	10	No Co	1	2.259	2.259	0	0.101	
10000	10	No Co	1	1.169	1.169	0	0.052	
100	100	No Co	1	12.210	12.210	0	0.545	
1000	100	No Co	1	1.315	1.315	0	0.059	
10000	100	No Co	1	0.226	0.226	0	0.010	
		No Co						
		No Co						
		No Co						
		No Co						
		No Co						

TABLE 4.12: Summary of DF Cases for 9 Combinations (PFP Waste, Stream #404, 1.0 gal)

Cs/Ba DF	Est DF	Co DF	Sr/Y DF	DR 404 mL/h	Gamma Dose Rate	Beta Dose Rate	Ratio Of Base	
100	1	No Co	1	2.740	2.740	0	1.000	← - Base Case
1000	1	No Co	1	0.168	0.168	0	0.061	
10000	1	No Co	1	0.036	0.036	0	0.014	
100	10	No Co	1	1.450	1.450	0	0.829	
1000	10	No Co	1	0.147	0.147	0	0.084	
10000	10	No Co	1	0.017	0.017	0	0.008	
100	100	No Co	1	1.448	1.448	0	0.828	
1000	100	No Co	1	0.145	0.145	0	0.083	
10000	100	No Co	1	0.015	0.015	0	0.008	
		No Co						
		No Co						
		No Co						
		No Co						

TABLE 4.13: Summary of DF Cases for 14 Combinations (DS6F, Stream #404, 1.0 gal)

Cs/BA DF	ED DF	Co DF	Sr/Y DF	DR @ 30cm mS/h	Gamma Dose Rate	Beta Dose Rate	Ratio Of Beta Of Gamma	
100	1	1	1	2389.000	2389.000	0	1.000	←--Base Case
1000	1	1	1	240.100	240.100	0	0.101	
10000	1	1	1	25.150	25.150	0	0.011	
100	10	1	1	2389.000	2389.000	0	1.000	
1000	10	1	1	240.100	240.100	0	0.101	
10000	10	1	1	25.150	25.150	0	0.011	
100	100	1	1	2389.000	2389.000	0	1.000	
1000	100	1	1	240.000	240.000	0	0.100	
10000	100	1	1	25.080	25.080	0	0.010	
10000	100	10	1	24.470	24.470	0	0.010	
10000	100	100	1	24.410	24.410	0	0.010	
10000	1000	1	1	25.060	25.060	0	0.010	
10000	1000	10	1	24.480	24.480	0	0.010	
10000	1000	100	1	24.400	24.400	0	0.010	

MAINTENANCE DATA SHEET

Equipment: (#2)	Evaporator EV-402	FFD: ES-OP2-209/13
Scenario:	Heat Exchanger Failure	
Activity:	Replace Heat Exchanger	

Max No	Craft Designation	Avg Dist (cm)	Dose Rate (mrem/h)
2	Picofitter (P)	30	30.56
2	Operators (O)	30	30.56
0	Electrician (E)		0
2	Riggers (R)	100	37.32
1	Crane Operator (C)	100	37.32
1	Health Physics Tech (H)	100	37.32
1	Instrument Tech (I)	30	30.56
0	Other (#1)		0
8	Total Crew Members		

Radiation Source			
Waste	NCAW		
DF Case	Base (100 Ci)		
Stream #	55 % Recirc		
Contig/Qty	Actual Equip		
Radiation Analysis Results			
Dist (cm)	Other No.	Dose Rate (mrem/h)	
		Direct	Other Total
30	1	66.2	210
100	1	64.4	265

SHIFT No.	Description of Task	Task hours	CRAFT								
			P	O	E	R	C	H	I	#1	
1	Flush & Drain	1.0		1					1		
1	Decon Equipment	2.0		2					1		
1	Remove Instrumentation	1.0							1	1	
1	Remove Piping	4.0	2	1			1	1			
2	Remove Heat Exchanger	3.0	2	1		2	1	1			
2	Place HX in Box, Wrap, & Secure	2.0		1		2		1			
2	Install New HX	4.0	2	1		1	1	1			
3	Reconnect Piping	4.0	2	1			1	1			
3	Reconnect Instruments	1.0							1	1	
3	Hydro Test Inspection	1.0		1					1		
Total Job Hrs & Max Hr per 1 Person:											
23.0											

Total Collective Dose By Craft (person-mrem):	828.4	750.2	0	623	550	459	51.8	0
Total Collective Dose For Total Job =	3.639 person-mrem							
BASIS: hrs x field = 300mrem/job Rating								
Max Radiation Dose, for 1 Person (hrs x field = max mrem):	8	37.3	=	298				1
(Based on limit of 300 mrem for one person for the total job)	Max Field		50 mrem/hr					
Max Dose Rate Field Compared to Max RAD 4 (50 mrem/hr):	37.3				RAD: 4		0.75	
Based on Controlling Max Dose/ Max Allowable (300) =	298.6	/	300	=	1	<	1.000	

CONCLUSION: Maintenance Activity can be CONTACT Maintained DF Ratio = 0.117

MAINTENANCE DATA SHEET

Equipment: (#4)	Melter Feed Pump P-407	PFD: ES-OP2-200
Scenario:	Pump Motor Falls	
Activity:	Replace Motor	

No.	Craft Designation	Avg Dist (cm)	Dose Rate (mrem/h)
1	Pipefitter (P)	30	37.83
2	Operator (O)	30	37.83
1	Electrician (E)	30	37.83
2	Rigger (R)	100	28.14
1	Crane Operator (C)	100	28.14
1	Health Physics Tech (H)	100	28.14
1	Instrument Tech (I)	30	37.83
	Other (#1)		0
6	Total Craft Members		

Radiation Source			
Waste	NCAW		
DF Case	Base (100 Cs)		
Stream #	55 % Radio		
Config/Dn	Actual Equip		
Radiation Analysis Results			
Craft (cm)	Other No.	Dose Rate, mrem/h	
1	2	4851	683 37.8
100	2	3510	553 28.1

SHIFT No.	Description of Task	Task hours	CRAFT								
			P	O	E	R	C	H	I	#1	
1	Install Portable Shielding	2.0		2					1		
1	Open Pump and Motor	2.0		1					1		
1	Disconnect Electrical and Inst.	1.0			1					1	
2	Remove Motor	3.0	1	2		2	1	1			
2	Box, Wrap, & Grease Motor	1.0		1					1		
2	Install New Motor	3.0	1	2		2	1	1			
3	Reconnect Elect. and Inst.	1.0			1					1	
3	Verify Rotation	1.0		1							
3	Remove Portable Shielding	1.0		2					1		

Total Collective Dose By Craft (person-mrem)	1135	870	0	408	437	870	75.7	0
Total Collective Dose For Total Job =	3595.9	person-mrem						
BASIS:	hrs x field	300 mrem/job	Ratio					
Max Radiation Dose, for 1 Person (hrs x field = max mrem):	71 37.8	=	265	0.88				
(Based on limit of 300 mrem for one person for the total job)	Max Field	50 mrem/h						
Max Dose Rate Field Compared to Max RAZ 4 (50 mrem/h):	37.8	RAZ:	4	0.76				
Based on Controlling Max Dose/ Max Allowable (500) =	264.5	/ 500	=	0.53	<	1,000		

CONCLUSION: Maintenance Activity can be CONTACT Maintained	DF Ratio = 0.067
--	------------------

Table 4.15: Contact Maintenance Possible DF Combinations for HCAN Source

Maintenance Scenario	Combination #1				Combination #2				Combination #3			
	Cv	Eu	Co	Sr	Cv	Eu	Co	Sr	Cv	Eu	Co	Sr
Rotary Feeder	10k	100	10	100	10k	1k	1	100	10k	100	1	1k
Evaporator	10k	10	1	1	1k	10	1	10				
Mist Eliminator	100	1	1	1	Base Case							
Feed Pump	>10k	>1k	>100	>1k	Not Feasible							
Offgas Pipe	1000	1	1	1								

Note that these DF combinations are only approximately minimum since only whole factors of 10 were used for DFs for any individual constituent.

4.10 CONTACT MAINTENANCE INTEGRATED COST IMPACTS

Based on 1) the dose rate ratios summarized in Table 4.14 for the NCAW source and 2) the assumption that the five maintenance scenarios represent approximately 1/5 each of the total maintenance operations within the LLW vitrification facility (remote plus contact), then a curve of degree-of-remote-maintenance (i.e., percent of remote maintenance to total maintenance) versus dose-rate ratio can be created. Given the acknowledged approximate nature of the degree of remote maintenance, an error bar of about ± 10 percent is attributed to the values at each of the respective dose rate ratios from Table 4.14. The resulting curve is shown in Figure 4.3.

These assumptions further imply 1) that total maintenance = contact + remote, and 2) that each of the four changes from remote to contact maintenance represents about 25 percent of the cost savings of the facility costs from essentially all-remote maintenance to all-contact maintenance. This linear assumption is valid in that all pretreatment is via ion exchange (for Cs, Sr, Co and Eu) and thus the technology implies that additional pretreatment requires, to a first order approximation, more of the same types of equipment and support facilities. This total cost savings (from all remote to all contact maintenance) has been shown in the phase I studies to be \$1350M - \$906M = \$444M. Therefore, based on the above assumptions, each of the four changes saves about \$111M. The facility costs for pretreatment processes have also been developed for the base DF case, or the High Source Term (Cs DF = 100, others = 1), at \$426M, and a second pretreatment case, or Low Source Term (Cs DF = 10,000 and Sr = 100, others = 1), at \$701M. Assuming a linear relationship between these pretreatment facility capital costs as well as an extrapolated linear relationship for even larger DF values (lower source terms), Figure 4.4 can be generated for the total integrated capital costs for both pretreatment and LLW vitrification facilities. Note that the pretreatment Low Source Term corresponds to a degree of remote maintenance of about 55 percent based on the Table 4.3 value of 0.19 for the respective Low Source Term DF values for NCAW. If it is assumed that the total combined capital costs for pretreatment and LLW vitrification is approximately linear for the pretreatment beyond the Low Source Term Values (even higher pretreatment DFs), then the linear pretreatment curve in Figure 4.3 is obtained.

It should be emphasized that the costs in Figure 4.4 are capital costs only and that life-cycle costs, including annual operating costs could be an important factor in the cost curves for the complete picture. No attempt was made at developing the operating costs for the pretreatment and LLW vitrification facilities since, at this point in the design, not enough detailed design information is available. Given the high uncertainty in the design, the operating costs would have little

meaning. The accuracy of the total costs are probably within the difference of the mostly remote and the total contact maintenance facilities, so one could conclude that there appears to be little overall capital cost advantage of contact maintenance versus remote maintenance.

The results shown in Figures 4.3 and 4.4 can be combined to approximate the facility capital costs as a function of dose rate ratio (which, in turn is reliable to pretreatment DF values through Tables (4.8 through 4.13)). The combined results from Figures 4.3 and 4.4 results in Figure 4.5 which summarizes the main results of this LLW contact maintenance viability study (Figure 4.5 plots the capital costs against the dose-rate ratio rather than the assumed linear degree of remote maintenance. The primary result is that the total integrated capital costs do not change significantly from remote maintenance requirements (based on high dose rates) to contact maintenance requirements (based on low dose rates). The lower LLW vitrification facility costs with increased contact maintenance are more or less offset by the higher costs required to attain increased pretreatment DFs.

Figure 4.3: Assumed Degree of Remote Maintenance Versus Dose Rate Ratio

Figure 4.4: Capital Costs Versus Degree of Remote Maintenance

Figure 4.5: Capital Costs Versus Dose Rate Ratio

5.0 NON-RADIOACTIVE GLASS PLANT EVALUATION**5.1 INTRODUCTION**

The capital cost of a contact maintained LLW vitrification facility (\$906 M) is lower than that of a remotely maintained facility (\$1350 M) but did not approach that of a commercial glass plant (\$150 M - \$200 M), as was initially expected. The purpose of this task is to evaluate the differences between a contact maintained LLW vitrification facility and a non-radioactive glass facility (commercial plant) in order to identify the major cost drivers.

Process designs and facility layouts were prepared for both alternatives, then cost estimates were compiled. The differences in design requirements were then compared.

5.2 NON-RADIOACTIVE GLASS PLANT DESIGN

A 200 MT/day commercial-type glass plant was designed as part of this study with the assistance of Bud Cartz, a retired plant manager from the glass industry. Since over 90 percent of all glass produced in the commercial glass industry is plate, a plate glass facility was selected to most closely represent the cost of a commercial plant. However, since optical quality is not a factor, a less sophisticated and cheaper rolling process was selected rather than the more expensive float glass process as is normally used today. A block flow diagram of this process is shown in Figure 5.1 and the facility layout is shown in Appendix K.

The commercial plant utilizes a Low-NO_x kerosene fired combustion melter (furnace) with a glass content of about 1200 Mg. The NO_x content of the offgas is reduced by reducing the use of kerosene. Glass formers are preheated by the furnace offgas after it has passed through the regenerator, which is used to heat the combustion air. Molten glass is poured onto the glass forming roller mill which forms a glass ribbon. The ribbon then moves into the annealing lehr, which tempers and cools the glass to give it the proper mechanical properties. The finished glass ribbon is then cut into glass squares and packaged in two lines for shipment offsite. Scrap glass is ground and recycled back to the melter.

Since there is no radioactive material in this facility, there are no radiation shielding or special HVAC requirements, and there are no liquid or solid radioactive waste treatment facilities.

Three cost estimates were prepared for the commercial plant as shown in Table 5.1 based on different estimating assumptions,

FIGURE 5.1
BLOCK FLOW DIAGRAM
COMMERCIAL GLASS PLANT

Described below:

1. Lump sum, turnkey contract using open shop labor rates (\$30.32/hr), 10 percent engineering costs, 10 percent construction management costs, and no project management costs.
2. Lump sum, turnkey contract using union labor rates (\$47.60/hr), 10 percent engineering costs, and no project management costs.
3. Lump sum contract using Hanford labor rates (\$48.20/hr), 40 percent engineering costs, 10 percent construction management costs, and 15 percent project management costs. These assumptions are identical to those used for the contract maintained LLW vitrification facility.

Table 5.1. Estimated Costs for Commercial Glass Plant (\$Million)

DESCRIPTION	DIRECT COST	ENG/PME CM	SUB TOTAL	CONT @ 40%	TEC TOTAL
1. OPEN SHOP LABOR	104	21	125	50	\$175
2. UNION LABOR	116	23	140	56	\$196
3. HANFORD SITE	117	76	193	77	\$270

5.3 CONTACT MAINTAINED LLW VITRIFICATION FACILITY DESIGN

The contact maintained LLW vitrification facility design is shown in Appendix B. This plant will produce 200 MT/day of cullet. A block flow diagram of this process is shown in Figure 5.2.

The design assumption for the LLW vitrification facility was that contact maintenance would be performed on all equipment. A combustion melter was used since it represents the smallest and least expensive of the alternative melters evaluated for the Hanford LLW vitrification program. Technology issues such as cesium volatilization were assumed to be resolved. Cullet was selected as the waste form, which is then mixed with Sulfur Polymer Cement (SPC) and pumped to permanent, underground storage vaults. Again, this alternative was selected as representing the least expensive of the alternatives evaluated and technology issues such as performance assessment and pumping of SPC were assumed to be resolved.

Although the source term of the waste feed is sufficiently low to allow for full contact maintenance, it is not zero and shielding must be provided to allow for 40 hours per week occupancy (0.25 mrem/hr). Airborne contamination must also be controlled. The building is mostly concrete to meet these shielding and contamination confinement requirements.

Waste feed treatment (evaporation, chemical adjustment, etc.), liquid and solid radioactive waste treatment and handling, melter and vessel offgas decontamination, SPC handling, and an emergency diesel generator primarily for radioactive material confinement are all provided for in the facility layout.

The estimated capital cost of this facility, based on a lump sum contract using Hanford labor rates (\$48.20/hr), 40 percent engineering costs, 10 percent construction management costs, and 15 percent project management costs is \$904 million. This cost does not include common support facilities and necessary utilities.

5.4 DESIGN COMPARISONS

A comparison of the two block flow diagrams illustrates the additional systems that are required in a radioactive waste vitrification plant that are not needed in a commercial glass plant. Figure 5.3 presents a quick comparison of block flow diagrams for the LLW vitrification facility versus a commercial glass plant. Boxes with double lines around them describe systems that are unique to the radioactive plant. Boxes with only single lines describe systems that are common to both facilities. These additional systems account for a large portion of the difference in cost. The significant additional systems are:

- Melter and vessel offgas
- Waste feed receipt and preparation
- Analytical chemistry analyses
- Liquid radioactive waste treatment
- Solid radioactive waste decontamination and packaging
- Sulphur polymer cement handling
- Cullet transport systems and storage vaults

Beyond the additional systems required, several key characteristics differentiate a commercial glass plant from a LLW vitrification facility. These are:

- Direct and unrestricted access of personnel to all production areas
- Unimpeded contact maintenance (no respirators or special clothing)
- No restrictions on HVAC (filtration, zoning, monitoring, or emergency power)
- No liquid to evaporate in the melter

5.5 MATERIALS OF CONSTRUCTION

Alternative materials of construction are evaluated in this section for above ground structures. Below ground construction will be reinforced concrete due to strength requirements to resist soil pressures. Multiple criteria govern the selection process for above ground materials. The two basic materials considered herein are structural steel framing with metal siding and reinforced concrete.

The primary criteria for any industrial building is to provide support and weather protection for the installed equipment and facilities. If this facility were not processing radioactive materials, this would be the governing criteria and the choice of materials would boil down to cost. However, even though the concentration of radioactivity is low, it is not zero and radiological control criteria must be met. The two criteria of interest here are radiation shielding and radioactive material confinement.

5.5.1 Radiation Shielding

Interior rooms of the facility can be divided into two basic types: 1) controlled areas where radioactive materials, and thus radiation fields, are present, and 2) operating galleries where operators work full time (40 hours per week). In order to maintain personnel exposures to As Low As Reasonably Achievable (ALARA), Radiological Control Zones (Rad Zones) were developed. Appendix H provides a discussion of the development and implementation of Rad Zones for the TWRS Waste Processing Facilities. The current issue of the WHC Radiological Design Guide, WHC-SD-GN-DGS-30011 also addresses Rad Zones. According to project criteria, operating galleries with 40 hours/week occupancy must have radiation fields less than or equal to 2.5 $\mu\text{Sv/hr}$ (0.25 mrem/hr) and uncontrolled areas such as outside of buildings must have radiation fields less than or equal to 0.50 μSv (0.05 mrem/hr). Interior walls between controlled areas and operating galleries must provide sufficient shielding to reduce radiation fields to 2.5 μSv .

The shielding calculation for the Melter Feed Tank using the low source term feed resulted in a radiation field of 30 $\mu\text{Sv/hr}$. This requires a wall thickness around the tank of either 9" for concrete or 3" for steel to reduce the field to 2.5 $\mu\text{Sv/hr}$. Exterior walls must provide sufficient shielding to reduce radiation fields from 2.5 μSv to 0.5 μSv . This requires either a 4" concrete or a 1.2" steel wall thickness. Table 5.2 presents unit prices of concrete and steel:

Table 5.2. Unit Pricing for Concrete and Steel Structural Wall Construction

MATERIAL	UNIT COST PER VOLUME (\$/m ³)	UNIT COST OF WALL (\$/m ²) [*]
CONCRETE FOR WALLS (MATERIAL ONLY)	218	50
FABRICATED STRUCTURAL STEEL (\$1.58/lb)	27,340	2,080

* Based on equivalent shielding values (3" steel or 9" concrete)

5.5.2 Radioactive Material Confinement

The handling of radioactive culet creates the potential for airborne contamination. DOE Order 6430.1A mandates confinement in order to prevent or minimize the spread of contamination to occupied or uncontrolled areas (i.e. outside). The primary confinement system is the process loop and the secondary confinement system is the building enclosure and the ventilation system. As a secondary confinement, the building must be a pressure boundary. Achieving a minimum leakage pressure boundary from a concrete building is rather straight forward and easy to obtain. Achieving a minimum leakage pressure boundary from a steel building is more difficult. Several nuclear facilities have successfully utilized metal construction. The author is familiar with three of them. The Advanced Test Reactor, located at the Idaho National Engineering Laboratory (INEL) used steel for its above ground construction. It was plagued with leaks that had to be repaired during every periodic building leak test. The Gas Centrifuge Enrichment Facility in Portsmouth, Ohio and the New Waste Calcine Facility at INEL also used steel for their above ground construction. Both facilities encountered numerous leakage problems during startup testing. These can mostly be attributed to lack of proper construction techniques, such as double sealed seams, etc.

The NVAC system is also an integral part of the confinement system. This facility will use a negative pressure system containing two pressure zones, Zones II and III. Both systems incorporate HEPA filtration of the exhaust stream. Zone II areas maintain a minimum gage pressure of - 0.5 inches of water and Zone III areas maintain a minimum gage pressure of - 0.25 inches of water.

6.0 CONCLUSIONS

6.1 CONCLUSIONS FOR COMBUSTION MELTER BASED PLANT STUDIED

The following conclusions are made regarding the contact maintenance viability study for the low-level waste vitrification facility based on the Combustion Melter Plant studied:

- A. A general methodology for establishing the viability of specific equipment maintenance scenarios has been successfully developed and documented for five equipment examples, namely:
 1. Rotary Feeder Replacement
 2. Evaporator Heat Exchanger Replacement
 3. Mist Eliminator Candle Replacement
 4. Melter Feed Pump Replacement
 5. Offgas Pipe Replacement
- B. Radiation dose rate and time-integrated dose criteria have been used to test the viability of contact maintenance versus remote maintenance, namely a dose rate limit of 50 mrem/h and an integrated dose limit of 300 mrem per job.
- C. The major tank waste processing campaigns have been identified and seven different tank waste sources have been analyzed and compared/ranked for impact on low-level waste vitrification plant operation and maintenance, namely (from "hottest" to "coldest", as described in summary Table 2.1):

RANK SOURCE DESCRIPTION

 1. Double Shell Slurry Feed (DSSF) with no Pretreatment¹
 2. Max Theoretical (Conservative Maximum Limit Source)²
 3. High Blend (Original "Waste Envelope" Source)
 4. Neutralized Current Acid Waste (NCAW)
 5. Complexant Concentrate (CC) Waste
 6. Nominal Waste (Blended Tanks)
 7. Plutonium Finishing Plant (PFP) Waste
- D. A radiation analysis procedure has been used based on process flow stream constituents derived from ASPEN computer code runs that uses both the gamma radiation and beta-induced bremsstrahlung radiation to calculate the dose rates at three representative distances from the source (1 cm, 30 cm and 100 cm). The primary radiation source as well as the significant vicinity sources are used to calculate the dose rates to the maintenance crew.

¹ DSSF with no pretreatment assumes Cs DF = 1.

² Conservative maximum limit with base Cs DF = 100.

- E. A calculational procedure has been developed for handling a range of melter offgas recirculation fractions (0, 0.3, 0.5 and 0.8) which impact the concentration of Cs in process streams #400 through #406 (see Appendix I). Since the exact fraction of Cs in the melter offgas is not known for the LLW combustion melter, this parametric/range approach to the radiation analysis is a reasonable basis for the purposes of the contact maintenance study.
- F. The impact of preferred Cs plateout on combustion melter surfaces and offgas pipe exposed surfaces has been developed (see Section 4.7) and utilized as a basis for additional parametric analysis when residual glass thicknesses can be established (see Table 4.7 which gives both High Blend Source and NCAW Source total dose rates for four Cs recirculation fractions and four Cs plateout concentration factors (1, 10, 100 and 1000).
- G. A spreadsheet-based Maintenance Data Sheet has been developed that collects the required information, calculates the dose for the maintenance crew, and determines the potential viability for performing contact maintenance (see Section 4.8).
- H. A "generic" DF analysis has been performed for six of the seven waste sources for a fixed source size and cylindrical-shaped source container. This "generic" DF analysis is used as the basis for determining various DF combinations for waste constituents that will provide desired dose rate ratios compared to a base case DF of 100 for Cs (see Section 4.9 and Tables 4.8 to 4.13). Numerous radiation shielding analyses were performed to obtain the resulting dose rate for each selected combination of radionuclide concentrations (specifically Cs, Ba, Co and Sr were selected as being the important elements for DF increases from a radiation perspective). The resultant dose rate ratio is obtained merely by dividing the resulting dose rate for the selected DF increases to the base DF dose rate (i.e., for Cs DF = 100 and all others = 1).
- I. Various proposed combinations of pretreatment process Decontamination Factors (DF) for four important waste constituents (Cs, Eu, Co and Sr) of the NCAW source have been made based on the manipulation of the total dose rates applied to the Maintenance Data Sheets (see Section 4.10 and the results summarized in Table 4.15). The proposed DFs are based on a melter recirculation fraction of 55 percent (median between an estimated low of 30 percent and an estimated high of 80 percent) and a preferred Cs plateout concentration factor of 1.0 (future contact maintenance parametric analyses could have a Cs plateout concentration factor ranging from 10 to 1000, using the results from Table

4.7, which would result in higher DFs to allow contact maintenance for those maintenance operations within the melter cell/room). The impact on possible DF combinations for other sources (other than NCAW), other values of melter offgas recirculation fractions, and other Cs plateout concentration factors would be subject of future contact maintenance studies for a more complete set of maintenance operation scenarios than just the five examples presently studied.

- J. The methodology developed for this trade study to determine 1) the ability to perform contact versus remote maintenance and 2) the optimum DF for the pretreatment processing should be extended for other specific sources and other equipment maintenance scenarios for the LLW vitrification facility.
- K. Other possible approaches to achieving contact maintenance, other than increasing the DF of radioactive constituents, have been recognized, namely:
1. Use outside contract labor for the infrequent maintenance operations that involve higher than normal radiation exposures. This will reduce the exposure to the full time staff that accumulate dose through normal operations of the facility. Even though this option estimates the "site personnel" accumulated dose problem, since "people" (outside contract labor) are being exposed this approach violates the spirit of ALARA (only shifts the exposure from one group to another group).
 2. The use of temporary shadow shields during the short-term maintenance operations will reduce the exposure to the maintenance crew. Specialized wheeled/portable shields can effectively be used to "shadow" the close-in maintenance crew from the direct "line-of-sight" radiation from near-by equipment which can produce intense radiation fields.
 3. The use of greater than minimum required facility operating staff can lower the dose incurred by any individual within the staff. This option is the least desirable of the four since the overall "person-rem" will be the same, or even higher due to the inefficiencies associated with multiple people performing the same task. In addition, exposing multiple personnel to maintain individual doses is not considered to be within the spirit of ALARA. This option can be considered in extreme circumstances where the addition of outside contract labor (option #1) is not feasible.

- L The approach developed in this LLW contact maintenance viability study could be utilized as a "standard" methodology for determining the feasibility of contact maintenance for any specific activity. The results of this analysis would feedback as part of the basis for facility design since the areas requiring remote maintenance equipment can be identified based on the analysis methods developed in this study.
- M The Low Source Term "Lightly Shielded" LLW vitrification facility cost was validated by providing a comparison with commercial glass plants. It is concluded that the main cost increase from non-radioactive glass to radioactive glass facilities is due to providing the associated HVAC systems and building requirements for confinement and containment of potential airborne contamination, and the satisfaction of the numerous government regulations for design and operation of a federal facility.

6.2 APPLICABILITY OF CONCLUSIONS TO ALTERNATIVE LLW MELTER CONCEPTS

Besides the studied combustion melter, which was originally considered a likely candidate for the LLW production melter for vitrification at the start of this Lightly Shielded Low Level Waste Study, there are 5 other melters that are also considered potential candidates for the LLW vitrification process. These alternative melters are itemized in Table 6.1. Since all alternative melter systems have an off-gas system with associated glass plateout probability (those melter system configurations which minimize Cs vaporization and recirculation in the off-gas system have been indirectly considered in the subject study since 0% recirculation was considered).

The primary difference in the contact viability study based on a different LLW melter would be in the localized effects near the various potential melters due to differences in ceramic wall thicknesses and total glass source strength. Other plant/facility areas away from the melter (e.g., cullet storage, etc.) will not be impacted by the type of melter, assuming that the same type of glass product is produced. Thus, the type of melter will have a minor impact (localized only) on the general conclusions reached above.

The general methodology/approach is certainly valid for any melter used with only the local melter room dose rates being different for those specific maintenance scenarios taking place in the melter room (note that the source type and strength will probably have a greater impact on the viability of contact maintenance than the melter type). The general applicability of conclusion (L) above is re-emphasized.

Table 6.1: LLM Alternative Melters

Melter Make	Typical Melter Size	Quantity Needed For 200 MT/D	Comments/Type ¹
VORTEC	100 MT/D	2	Studied Here/Combustion
BAW	100 MT/D	2	Combustion Type
ENVITCO	50 MT/D	4	Joule Heated (LFCM) ²
WSTC	67 MT/D	3	Plasma Arc ³
B OF M	100 MT/D	2	Electric Arc (LFCM) ²
DURATEK	67 MT/D	3	LFCM ² with Cold Cap

Notes: ¹ Some of the LFCMs can be equipped to be operated as stirred melters

² LFCM = Liquid Pad Ceramic Melter

³ Plasma Arc is a quasi-combustion melter

6.3 SUMMARY CONCLUSIONS

The reason for desiring a contact maintained plant is lower capital and operating costs (life-cycle costs as compared to a remote maintained facility).

Radcon procedures require shielding to 0.2 mrem/h in normally occupied areas (up to full time or 40 hours per week) as well as complete confinement of potentially airborne radionuclide contamination. These two factors significantly impact the capital cost of the facility with the secondary question of contact versus remote maintenance viability having a lesser capital cost impact. This is summarized in Figure 5.1.

Figure 6.1 shows the capital cost portion of the facility costs (excluding operating costs which would tend to increase the costs for decreasing DRR (DRR = Dose Rate Ratio is the ratio of dose rate resulting from the higher DF (Decontamination Factor) - more radioisotopes removed -- to the resulting dose rate from the base case DF with the minimum radioisotopes removed). The points on the curve between the contact maintained facility capital costs (\$906M) and the remote maintained facility capital costs (\$1,350M) are based on the assumption that the five representative maintenance scenarios each represent groups of maintenance tasks with about 25% of the costs associated with each of the four step change intervals (two end-points and three mid-points for the five maintenance scenarios). It should be

noted from the curve that considerable reduction in radiation dose rate is required before any meaningful reduction in capital cost is realized. In addition, constructing a non-radioactive glass plant on a federal site with all its concomitant regulations causes a large step increase in cost from a comparable commercial glass plant of the same size and capacity, further compressing potential savings that could be realized from contact versus remote maintenance considerations.

Based on the results summarized in Figure 6.1, one of the key conclusions reached for the combined cost study and range of pre-treatment scenarios is that relatively nominal cost savings are realized in going from a mostly remote operations facility to a mostly contact maintenance facility (as mentioned above, this difference would become even less if full life-cycle operating costs were included). The specific maintenance activity DF analysis is performed indirectly since there are potentially several combinations of waste source constituent DF which could lead to the same overall dose rate reduction, i.e., there is not necessarily a unique solution to the DF requirement. The approach applied by working with the dose rate reduction factors (called DRR). Any combination of DFs that will produce a DRR less than that needed for contact maintenance will be acceptable for the purposes of achieving contact maintenance for the specific maintenance activity.

This approach is applied to the five example maintenance scenarios discussed in the report. Using these five NDSs, the DRRs were iteratively changed by manual trial and error until the maintenance activity just qualified to be contact maintainable based on the 50 mrem/h and the 300 mrem/job criteria. These results are summarized in Table 6.2 for the NCAW source:

Figure 6.1: Summary of Capital Costs Versus Dose Rate Ratio

DRR (DOSE RATE RATIO) = 1.0
 DP 10 = 100
 DP 20 = 1
 DP 30 = 1
 DP 40 = 1
 DP 50 = 1

ANY NUMBER OF COMBINATIONS OF 4 SELECTED ISOTOPES
 WILL GIVE SAME DOSE RATE RATIO

Table 6.2: Contact Maintenance Possible DF Combinations for NCAN Source

Maintenance Scenario	Combination #1				Combination #2				Combination #3			
	Ce	Eu	Co	Sr	Ce	Eu	Co	Sr	Ce	Eu	Co	Sr
Rotary Feeder	10k	100	10	100	10k	1k	1	100	10k	100	1	1k
Evaporator	10k	10	1	1	1k	10	1	10				
Mist Eliminator	100	1	1	1	Base Case							
Feed Pump	>10k	>1k	>100	>1k	Not Feasible							
Offgas Pipe	1000	1	1	1								

Note that these DF combinations are only approximately minimum since only whole factors of 10 are used for DFs for any individual constituent.

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APPENDICES

- A. PFDs for Option 4C
- B. Facility Layout Drawings for Option 2C
- C. ASPEN Runs for Seven Tank Wastes
- D. Shielding Source Spreadsheets for 7 Sources & Selected Process Streams
- E. Beta Spectra for Selected Sources/Streams
- F. Example Source Analysis for the High Blend Waste Source
- G. Selected Equipment Specifications from Equipment List Sorts
- H. Location of Expected Cs Accumulation Locations in a Combustion Melter
- I. Offgas Recirculation and Associated Bremsstrahlung Factor Analysis
- J. Specifics for the Various Maintenance Radiation Dose Rate Calculations for the High Blend Waste Streams
- K. Facility Layout Drawings for Non-Radioactive Glass Plant

APPENDIX A: PFDs for Option 4C

Appendix A
Process Flow Diagram
Sheet 13 of 13

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U.S. DEPARTMENT OF ENERGY	
Nuclear Energy Research and Development Administration	
San Jose, California	
PROCESS FLOW DIAGRAM	
PRETREATMENT - 200 T/D LLW COMBINATION	
SHEET 13 OF 13	
DATE	12/15/76
BY	W. J. B. / J. B. B.
CHECKED BY	W. J. B. / J. B. B.
APPROVED BY	W. J. B. / J. B. B.
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A. THERE ARE 4 PAGES OF SM RECEIPT/SAMPLE
BANKS. BANK NAME WILL BE INDICATED TO OTHER
SUSPICIOUSLY SERVICE OR CASH FEED SERVICE.
THE ALLOCATION OF BANKS TO SPENDING SERVICE
WILL BE DETERMINED LATER.

- ① WORK ITEMS TO BE USED IN THE OFFICIAL WORK RECORD OF INVESTIGATION ORIGINALLY. THESE ITEMS WILL REMAIN IN SERVICE FOLLOWING COMPLETION OF INVESTIGATION TO A HIGH DEGREE OF WORK OF CREATION, ALTHOUGH IN SOME CASES THE EQUIPMENT MAY BE TWO MONTHS NOT CHANGE.
- ② ITEMS TO BE USED WITH INVESTIGATION IS COMPLETED FROM LOW DEGREE OF 30 HIGH DEGREE OF

- (b) ITEMS TO BE ACCESSED MUST BE IDENTIFIED AS
COMING FROM THE PROGRAM OR TO HAVE ORIGIN IN

REF ID: A66086

[illegible]

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THE COURT:

[illegible]

Appendix A
Process Flow Diagram
Sheet 4 of 13

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6504-1073

21 4532

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Appendix A
Process Flow Diagram
Sheet 7 of 13

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NY 5-87

[illegible]

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DATE: 10/10/80 TIME: 10:00 AM BY: [signature] FOR: [signature]

U.S. DEPARTMENT OF ENERGY
Nuclear Energy Division
NED-100-1000

ES-DP-C-400

PROCESS FLOW DIAGRAM
PRETREATMENT -
200 T/D LCV
COMBINATION

8 13 C

Appendix A
Process Flow Diagram
Sheet 10 of 13

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FOCUS

① The U.S. military withdrew from the air campaign after the Saudi plane was hit.

② Some questioned why retired pilots staged such a risky mission without warning Congress.

[illegible]

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Appendix A
Process Flow Diagram
Sheet 12 of 13

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PROJECT NO.	DATE	BY	REVISION
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PROJECT LOCATION		PROJECT NO.	
10000		10000	
PROJECT DESCRIPTION		PROJECT NO.	
10000		10000	
PROJECT STATUS		PROJECT NO.	
10000		10000	
PROJECT COMMENTS		PROJECT NO.	
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PROJECT APPROVAL		PROJECT NO.	
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10000		10000	
PROJECT TIME		PROJECT NO.	
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PROJECT PLACE		PROJECT NO.	
10000		10000	
PROJECT METHOD		PROJECT NO.	
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PROJECT EQUIPMENT		PROJECT NO.	
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PROJECT MATERIALS		PROJECT NO.	
10000		10000	
PROJECT RESULTS		PROJECT NO.	
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PROJECT CONCLUSIONS		PROJECT NO.	
10000		10000	
PROJECT RECOMMENDATIONS		PROJECT NO.	
10000		10000	
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10000		10000	
PROJECT VIDEOS		PROJECT NO.	
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PROJECT AUDIO		PROJECT NO.	
10000		10000	
PROJECT OTHER		PROJECT NO.	
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PROJECT TOTAL		PROJECT NO.	
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PROJECT GRAND TOTAL		PROJECT NO.	
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PROJECT END		PROJECT NO.	
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APPENDIX B: Facility Layout Drawings for Option 2G

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Appendix B
(folded)
Sheet 2 of 6

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CASE 2C

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 100-443887-100

WFO	DATE	TIME	DATE
WFO	12/20/78	10:00	12/20/78
PROJECT		PROJECT	
U.S. DEPARTMENT OF ENERGY		U.S. DEPARTMENT OF ENERGY	
FACILITY		FACILITY	
340 FLOOR PLAN		340 FLOOR PLAN	
DETACHED LLW TREATMENT		DETACHED LLW TREATMENT	
LOW SOURCE TERM		LOW SOURCE TERM	
ES-ALT2C-01		ES-ALT2C-01

SECTION

A

SHTS 1, 2 & 3

CASE 2C

0 5 10 15 20 25 30
GRAPHIC SCALE IN METERS

0 10 20 30 40 50 60 70 80 90 100
GRAPHIC SCALE IN FEET

DATE: 10/1/93
BY: [Signature]
CHECKED: [Signature]
APPROVED: [Signature]
TITLE: [Signature]

U.S. DEPARTMENT OF ENERGY	
GENERAL INVESTIGATIVE DIVISION	
SECTION A	
DETACHED LWM TREATMENT	
LOW SOURCE TEAM	
DATE: 10/1/93	BY: [Signature]
CHECKED: [Signature]	APPROVED: [Signature]
TITLE: [Signature]	
PROJECT: [Signature]	
SHEET: 4 OF 6	
CASE: ES-ALT2C-01	

EQUIPMENT NUMBER	EQUIPMENT DESCRIPTION
B-427a-2	LLW GULLET DRY LAG STORAGE
B-2	LLW GULLET DRY LAG STORAGE
CE-615a-2	LLW WST DRAINAGE
B-2	LLW WST DRAINAGE
EC-428a-2	CONCRETE
B-2	CONCRETE
EC-610a-2	COOLER
B-2	COOLER
EC-617a-2	CHILLER
B-2	CHILLER
EL-418a-2	LLW MELTER
B-2	LLW MELTER
EV-402a-2	LLW FEED EVAPORATOR
FC-432a-2	CYCLONE WITH SMTERED METAL FILTERS
B-2	CYCLONE WITH SMTERED METAL FILTERS
FC-900a-2	CYCLONE WITH SMTERED METAL FILTERS
B-2	CYCLONE WITH SMTERED METAL FILTERS
FM-444a-2	METAL HEPA FILTERS
B1-2	METAL HEPA FILTERS
FM-505a1-2	METAL HEPA FILTERS
B1-2	METAL HEPA FILTERS
FM-613a1-2	METAL HEPA FILTERS
B1-2	METAL HEPA FILTERS
FM-700a1-2	METAL HEPA FILTERS
B1-2	METAL HEPA FILTERS
FM-701a1-2	METAL HEPA FILTERS
B1-2	METAL HEPA FILTERS
FS-422a-2	SCREEN
B-2	SCREEN
MB-444a-2	BLOWER
B-2	BLOWER
MM-444a-2	MIXER
B-2	MIXER
P-442a-2	SULFUR PUMP
B-2	SULFUR PUMP
S-412a-2	CLASS SEPARATOR
B-2	CLASS SEPARATOR
T-609a-2	LLW QUENCH TOWER
B-2	LLW QUENCH TOWER
TX-409a-2	LLW EVAPORATOR FEED TANK
B-2	LLW EVAPORATOR FEED TANK
TX-404a-2	LLW MELTER FEED ADJUSTMENT TANK
B-2	LLW MELTER FEED ADJUSTMENT TANK
TX-405a-2	LLW MELTER FEED ADJUSTMENT TANK
B-2	LLW MELTER FEED ADJUSTMENT TANK
TX-406a-2	LLW MELTER FEED TANK
B-2	LLW MELTER FEED TANK
TX-418a-2	LLW GULLET CATCH TANK
B-2	LLW GULLET CATCH TANK
TX-421a-2	LLW QUENCH WATER RECYCLE TANK
B-2	LLW QUENCH WATER RECYCLE TANK
TX-422a-2	LLW FILTER CATCH TANK
B-2	LLW FILTER CATCH TANK
TX-423a-2	LLW CONCRETE CATCH TANK
B-2	LLW CONCRETE CATCH TANK
TX-438a-2	SULFUR CEMENT MIXING TANK
B-2	SULFUR CEMENT MIXING TANK
TX-441a-2	SURGE TANK
B-2	SURGE TANK
TX-445a-2	FILTER WASH CATCH TANK
B-2	FILTER WASH CATCH TANK
TX-505a-2	RECYCLE GULLET CATCH TANK
B-2	RECYCLE GULLET CATCH TANK
TX-614a-2	LLW SCRUB FILTER TANK
B-2	LLW SCRUB FILTER TANK
TX-614a-2	LLW SCRUB SOLUTION TANK
B-2	LLW SCRUB SOLUTION TANK
TX-1000a-2	LLW GULLET STORAGE
B-2	LLW GULLET STORAGE
C-2	LLW GULLET STORAGE
D-2	LLW GULLET STORAGE
E-2	LLW GULLET STORAGE
F-2	LLW GULLET STORAGE

CASE 20

U.S. DEPARTMENT OF ENERGY	
FLUOR DYNAL, INC.	
ADVANCED TECHNOLOGY DIVISION	
EQUIPMENT LIST	
DETACHED LLW TREATMENT	
LOW SOURCE TERM	
DATE	20 JAN 1992
BY	AL20C-01
REV	0
REV	0
REV	0

DATE	20 JAN 1992
BY	AL20C-01
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REV	0

APPENDIX C: ASPEN Runs for Seven Tank Wastes

Revision 0

WASTE NAME	200	201	202	203	204	205	206	207	208	209
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WASTE NAME	320	321	322	323	324	325	326	327	328	329
WASTE NAME	330	331	332	333	334	335	336	337	338	339
WASTE NAME	340	341	342	343	344	345	346	347	348	349
WASTE NAME	350	351	352	353	354	355	356	357	358	359
WASTE NAME	360	361	362	363	364	365	366	367	368	369
WASTE NAME	370	371	372	373	374	375	376	377	378	379
WASTE NAME	380	381	382	383	384	385	386	387	388	389
WASTE NAME	390	391	392	393	394	395	396	397	398	399
WASTE NAME	400	401	402	403	404	405	406	407	408	409
WASTE NAME	410	411	412	413	414	415	416	417	418	419
WASTE NAME	420	421	422	423	424	425	426	427	428	429
WASTE NAME	430	431	432	433	434	435	436	437	438	439
WASTE NAME	440	441	442	443	444	445	446	447	448	449
WASTE NAME	450	451	452	453	454	455	456	457	458	459
WASTE NAME	460	461	462	463	464	465	466	467	468	469
WASTE NAME	470	471	472	473	474	475	476	477	478	479
WASTE NAME	480	481	482	483	484	485	486	487	488	489
WASTE NAME	490	491	492	493	494	495	496	497	498	499
WASTE NAME	500	501	502	503	504	505	506	507	508	509
WASTE NAME	510	511	512	513	514	515	516	517	518	519
WASTE NAME	520	521	522	523	524	525	526	527	528	529
WASTE NAME	530	531	532	533	534	535	536	537	538	539
WASTE NAME	540	541	542	543	544	545	546	547	548	549
WASTE NAME	550	551	552	553	554	555	556	557	558	559
WASTE NAME	560	561	562	563	564	565	566	567	568	569
WASTE NAME	570	571	572	573	574	575	576	577	578	579
WASTE NAME	580	581	582	583	584	585	586	587	588	589
WASTE NAME	590	591	592	593	594	595	596	597	598	599
WASTE NAME	600	601	602	603	604	605	606	607	608	609
WASTE NAME	610	611	612	613	614	615	616	617	618	619
WASTE NAME	620	621	622	623	624	625	626	627	628	629
WASTE NAME	630	631	632	633	634	635	636	637	638	639
WASTE NAME	640	641	642	643	644	645	646	647	648	649
WASTE NAME	650	651	652	653	654	655	656	657	658	659
WASTE NAME	660	661	662	663	664	665	666	667	668	669
WASTE NAME	670	671	672	673	674	675	676	677	678	679
WASTE NAME	680	681	682	683	684	685	686	687	688	689
WASTE NAME	690	691	692	693	694	695	696	697	698	699
WASTE NAME	700	701	702	703	704	705	706	707	708	709
WASTE NAME	710	711	712	713	714	715	716	717	718	719
WASTE NAME	720	721	722	723	724	725	726	727	728	729
WASTE NAME	730	731	732	733	734	735	736	737	738	739
WASTE NAME	740	741	742	743	744	745	746	747	748	749
WASTE NAME	750	751	752	753	754	755	756	757	758	759
WASTE NAME	760	761	762	763	764	765	766	767	768	769
WASTE NAME	770	771	772	773	774	775	776	777	778	779
WASTE NAME	780	781	782	783	784	785	786	787	788	789
WASTE NAME	790	791	792	793	794	795	796	797	798	799
WASTE NAME	800	801	802	803	804	805	806	807	808	809
WASTE NAME	810	811	812	813	814	815	816	817	818	819
WASTE NAME	820	821	822	823	824	825	826	827	828	829
WASTE NAME	830	831	832	833	834	835	836	837	838	839
WASTE NAME	840	841	842	843	844	845	846	847	848	849
WASTE NAME	850	851	852	853	854	855	856	857	858	859
WASTE NAME	860	861	862	863	864	865	866	867	868	869
WASTE NAME	870	871	872	873	874	875	876	877	878	879
WASTE NAME	880	881	882	883	884	885	886	887	888	889
WASTE NAME	890	891	892	893	894	895	896	897	898	899
WASTE NAME	900	901	902	903	904	905	906	907	908	909
WASTE NAME	910	911	912	913	914	915	916	917	918	919
WASTE NAME	920	921	922	923	924	925	926	927	928	929
WASTE NAME	930	931	932	933	934	935	936	937	938	939
WASTE NAME	940	941	942	943	944	945	946	947	948	949
WASTE NAME	950	951	952	953	954	955	956	957	958	959
WASTE NAME	960	961	962	963	964	965	966	967	968	969
WASTE NAME	970	971	972	973	974	975	976	977	978	979
WASTE NAME	980	981	982	983	984	985	986	987	988	989
WASTE NAME	990	991	992	993	994	995	996	997	998	999

CASE 1: NEUTRALIZED CURRENT ACID WASTE (NCAW)

Waste ID:	1.0E-01	1.0E-01	1.0E-01	1.0E-01	1.0E-01	1.0E-01	1.0E-01
Waste Sub ID:	1.0E-01	1.0E-01	1.0E-01	1.0E-01	1.0E-01	1.0E-01	1.0E-01
Waste Vol:	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Waste ID:	1.0E-01	1.0E-01	1.0E-01	1.0E-01	1.0E-01	1.0E-01	1.0E-01
Waste ID:	1.0E-01	1.0E-01	1.0E-01	1.0E-01	1.0E-01	1.0E-01	1.0E-01

Definition 0

[illegible]

Item #	Item Name	Unit	Quantity	Unit Price	Total Price	Remarks
1	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
2	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000
3	3.000000	3.000000	3.000000	3.000000	3.000000	3.000000
4	4.000000	4.000000	4.000000	4.000000	4.000000	4.000000
5	5.000000	5.000000	5.000000	5.000000	5.000000	5.000000
6	6.000000	6.000000	6.000000	6.000000	6.000000	6.000000
7	7.000000	7.000000	7.000000	7.000000	7.000000	7.000000
8	8.000000	8.000000	8.000000	8.000000	8.000000	8.000000
9	9.000000	9.000000	9.000000	9.000000	9.000000	9.000000
10	10.000000	10.000000	10.000000	10.000000	10.000000	10.000000

Revision 0									
ITEM NO.	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01
SPRINKLER (S)	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01
SPRINKLER (S)	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01
SPRINKLER (S)	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01
SPRINKLER (S)	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01	1.30E-01

CASE 3: NEUTRALIZED CURRENT ACID WASTE (WEAN) WHC-SD-WM-TI-763

DATE	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01
1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01
1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01
1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01
1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01	1.10.01

Revision 0

[illegible]

EXPANDED	40A	40B	40C	40D	40E	40F	40G	40H	40I	40J	40K	40L	40M	40N	40O	40P	40Q	40R	40S	40T	40U	40V	40W	40X	40Y	40Z	40AA	40AB	40AC	40AD	40AE	40AF	40AG	40AH	40AI	40AJ	40AK	40AL	40AM	40AN	40AO	40AP	40AQ	40AR	40AS	40AT	40AU	40AV	40AW	40AX	40AY	40AZ	40BA	40BB	40BC	40BD	40BE	40BF	40BG	40BH	40BI	40BJ	40BK	40BL	40BM	40BN	40BO	40BP	40BQ	40BR	40BS	40BT	40BU	40BV	40BW	40BX	40BY	40BZ	40CA	40CB	40CC	40CD	40CE	40CF	40CG	40CH	40CI	40CJ	40CK	40CL	40CM	40CN	40CO	40CP	40CQ	40CR	40CS	40CT	40CU	40CV	40CW	40CX	40CY	40CZ	40DA	40DB	40DC	40DD	40DE	40DF	40DG	40DH	40DI	40DJ	40DK	40DL	40DM	40DN	40DO	40DP	40DQ	40DR	40DS	40DT	40DU	40DV	40DW	40DX	40DY	40DZ	40EA	40EB	40EC	40ED	40EE	40EF	40EG	40EH	40EI	40EJ	40EK	40EL	40EM	40EN	40EO	40EP	40EQ	40ER	40ES	40ET	40EU	40EV	40EW	40EX	40EY	40EZ	40FA	40FB	40FC	40FD	40FE	40FF	40FG	40FH	40FI	40FJ	40FK	40FL	40FM	40FN	40FO	40FP	40FQ	40FR	40FS	40FT	40FU	40FV	40FW	40FX	40FY	40FZ	40GA	40GB	40GC	40GD	40GE	40GF	40GG	40GH	40GI	40GJ	40GK	40GL	40GM	40GN	40GO	40GP	40GQ	40GR	40GS	40GT	40GU	40GV	40GW	40GX	40GY	40GZ	40HA	40HB	40HC	40HD	40HE	40HF	40HG	40HH	40HI	40HJ	40HK	40HL	40HM	40HN	40HO	40HP	40HQ	40HR	40HS	40HT	40HU	40HV	40HW	40HX	40HY	40HZ	40IA	40IB	40IC	40ID	40IE	40IF	40IG	40IH	40II	40IJ	40IK	40IL	40IM	40IN	40IO	40IP	40IQ	40IR	40IS	40IT	40IU	40IV	40IW	40IX	40IY	40IZ	40JA	40JB	40JC	40JD	40JE	40JF	40JG	40JH	40JI	40JJ	40JK	40JL	40JM	40JN	40JO	40JP	40JQ	40JR	40JS	40JT	40JU	40JV	40JW	40JX	40JY	40JZ	40KA	40KB	40KC	40KD	40KE	40KF	40KG	40KH	40KI	40KJ	40KK	40KL	40KM	40KN	40KO	40KP	40KQ	40KR	40KS	40KT	40KU	40KV	40KW	40KX	40KY	40KZ	40LA	40LB	40LC	40LD	40LE	40LF	40LG	40LH	40LI	40LJ	40LK	40LM	40LN	40LO	40LP	40LQ	40LR	40LS	40LT	40LU	40LV	40LW	40LX	40LY	40LZ	40MA	40MB	40MC	40MD	40ME	40MF	40MG	40MH	40MI	40MJ	40MK	40ML	40MM	40MN	40MO	40MP	40MQ	40MR	40MS	40MT	40MU	40MV	40MW	40MX	40MY	40MZ	40NA	40NB	40NC	40ND	40NE	40NF	40NG	40NH	40NI	40NJ	40NK	40NL	40NM	40NN	40NO	40NP	40NQ	40NR	40NS	40NT	40NU	40NV	40NW	40NX	40NY	40NZ	40OA	40OB	40OC	40OD	40OE	40OF	40OG	40OH	40OI	40OJ	40OK	40OL	40OM	40ON	40OO	40OP	40OQ	40OR	40OS	40OT	40OU	40OV	40OW	40OX	40OY	40OZ	40PA	40PB	40PC	40PD	40PE	40PF	40PG	40PH	40PI	40PJ	40PK	40PL	40PM	40PN	40PO	40PP	40PQ	40PR	40PS	40PT	40PU	40PV	40PW	40PX	40PY	40PZ	40QA	40QB	40QC	40QD	40QE	40QF	40QG	40QH	40QI	40QJ	40QK	40QL	40QM	40QN	40QO	40QP	40QQ	40QR	40QS	40QT	40QU	40QV	40QW	40QX	40QY	40QZ	40RA	40RB	40RC	40RD	40RE	40RF	40RG	40RH	40RI	40RJ	40RK	40RL	40RM	40RN	40RO	40RP	40RQ	40RR	40RS	40RT	40RU	40RV	40RW	40RX	40RY	40RZ	40SA	40SB	40SC	40SD	40SE	40SF	40SG	40SH	40SI	40SJ	40SK	40SL	40SM	40SN	40SO	40SP	40SQ	40SR	40SS	40ST	40SU	40SV	40SW	40SX	40SY	40SZ	40TA	40TB	40TC	40TD	40TE	40TF	40TG	40TH	40TI	40TJ	40TK	40TL	40TM	40TN	40TO	40TP	40TQ	40TR	40TS	40TT	40TU	40TV	40TW	40TX	40TY	40TZ	40UA	40UB	40UC	40UD	40UE	40UF	40UG	40UH	40UI	40UJ	40UK	40UL	40UM	40UN	40UO	40UP	40UQ	40UR	40US	40UT	40UU	40UV	40UW	40UX	40UY	40UZ	40VA	40VB	40VC	40VD	40VE	40VF	40VG	40VH	40VI	40VJ	40VK	40VL	40VM	40VN	40VO	40VP	40VQ	40VR	40VS	40VT	40VU	40VV	40VW	40VX	40VY	40VZ	40WA	40WB	40WC	40WD	40WE	40WF	40WG	40WH	40WI	40WJ	40WK	40WL	40WM	40WN	40WO	40WP	40WQ	40WR	40WS	40WT	40WU	40WV	40WW	40WX	40WY	40WZ	40XA	40XB	40XC	40XD	40XE	40XF	40XG	40XH	40XI	40XJ	40XK	40XL	40XM	40XN	40XO	40XP	40XQ	40XR	40XS	40XT	40XU	40XV	40XW	40XX	40XY	40XZ	40YA	40YB	40YC	40YD	40YE	40YF	40YG	40YH	40YI	40YJ	40YK	40YL	40YM	40YN	40YO	40YP	40YQ	40YR	40YS	40YT	40YU	40YV	40YW	40YX	40YY	40YZ	40ZA	40ZB	40ZC	40ZD	40ZE	40ZF	40ZG	40ZH	40ZI	40ZJ	40ZK	40ZL	40ZM	40ZN	40ZO	40ZP	40ZQ	40ZR	40ZS	40ZT	40ZU	40ZV	40ZW	40ZX	40ZY	40ZZ
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[illegible]

[illegible]

CASE 2: FLUORION FINISHING PLANT WASTE (FFP)

1992-93								3.00E+01	
1993-94								1.00E+01	
1994-95								5.00E+00	
1995-96								1.00E+00	
1996-97								1.00E+00	
1997-98								5.00E+00	
1998-99								1.00E+01	
1999-00								1.00E+01	
2000-01								1.00E+01	
2001-02								1.00E+01	

CASE 9. COMPLAINT CONCENTRATE (CG)

WHC-SD-WM-TI-763

Revision 0

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Revision 0

[illegible]

CASE 6: NORMAL

Initials (SI)	2.88E-02					4.88E-02			1.88E-02
Initials (SI)	2.88E-02					4.88E-02			1.88E-02
Initials (SI)	2.88E-02					4.88E-02			1.88E-02
Initials (SI)	2.88E-02					4.88E-02			1.88E-02
Initials (SI)	2.88E-02					4.88E-02			1.88E-02

Factor	200	201	202	203	204	205	206	207	208	209
Factor 1	1.000000									
Factor 2	1.000000									
Factor 3	1.000000									
Factor 4	1.000000									
Factor 5	1.000000									
Factor 6	1.000000									
Factor 7	1.000000									
Factor 8	1.000000									
Factor 9	1.000000									
Factor 10	1.000000									
Factor 11	1.000000									
Factor 12	1.000000									
Factor 13	1.000000									
Factor 14	1.000000									
Factor 15	1.000000									
Factor 16	1.000000									
Factor 17	1.000000									
Factor 18	1.000000									
Factor 19	1.000000									
Factor 20	1.000000									
Factor 21	1.000000									
Factor 22	1.000000									
Factor 23	1.000000									
Factor 24	1.000000									
Factor 25	1.000000									
Factor 26	1.000000									
Factor 27	1.000000									
Factor 28	1.000000									
Factor 29	1.000000									
Factor 30	1.000000									
Factor 31	1.000000									
Factor 32	1.000000									
Factor 33	1.000000									
Factor 34	1.000000									
Factor 35	1.000000									
Factor 36	1.000000									
Factor 37	1.000000									
Factor 38	1.000000									
Factor 39	1.000000									
Factor 40	1.000000									
Factor 41	1.000000									
Factor 42	1.000000									
Factor 43	1.000000									
Factor 44	1.000000									
Factor 45	1.000000									
Factor 46	1.000000									
Factor 47	1.000000									
Factor 48	1.000000									
Factor 49	1.000000									
Factor 50	1.000000									
Factor 51	1.000000									
Factor 52	1.000000									
Factor 53	1.000000									

[illegible]

[illegible]

Description (m)	1.0000	1.0000	Division 6					
1.0000 (m)	1.0000	1.0000						
1.0000 (m)	1.0000	1.0000						
1.0000 (m)	1.0000	1.0000						
1.0000 (m)	1.0000	1.0000						
1.0000 (m)	1.0000	1.0000						
1.0000 (m)	1.0000	1.0000						

In. dia						Designation	
1400-001	4.000-01	4.000-01				4.000-01	4.000-01
1400-002	4.000-02	4.000-02				4.000-02	4.000-02
1400-003	4.000-03	4.000-03				4.000-03	4.000-03
1400-004	4.000-04	4.000-04				4.000-04	4.000-04
1400-005	4.000-05	4.000-05				4.000-05	4.000-05
1400-006	4.000-06	4.000-06				4.000-06	4.000-06
1400-007	4.000-07	4.000-07				4.000-07	4.000-07
1400-008	4.000-08	4.000-08				4.000-08	4.000-08
1400-009	4.000-09	4.000-09				4.000-09	4.000-09
1400-010	4.000-10	4.000-10				4.000-10	4.000-10
1400-011	4.000-11	4.000-11				4.000-11	4.000-11
1400-012	4.000-12	4.000-12				4.000-12	4.000-12
1400-013	4.000-13	4.000-13				4.000-13	4.000-13
1400-014	4.000-14	4.000-14				4.000-14	4.000-14
1400-015	4.000-15	4.000-15				4.000-15	4.000-15
1400-016	4.000-16	4.000-16				4.000-16	4.000-16
1400-017	4.000-17	4.000-17				4.000-17	4.000-17
1400-018	4.000-18	4.000-18				4.000-18	4.000-18
1400-019	4.000-19	4.000-19				4.000-19	4.000-19
1400-020	4.000-20	4.000-20				4.000-20	4.000-20
1400-021	4.000-21	4.000-21				4.000-21	4.000-21
1400-022	4.000-22	4.000-22				4.000-22	4.000-22
1400-023	4.000-23	4.000-23				4.000-23	4.000-23
1400-024	4.000-24	4.000-24				4.000-24	4.000-24
1400-025	4.000-25	4.000-25				4.000-25	4.000-25
1400-026	4.000-26	4.000-26				4.000-26	4.000-26
1400-027	4.000-27	4.000-27				4.000-27	4.000-27
1400-028	4.000-28	4.000-28				4.000-28	4.000-28
1400-029	4.000-29	4.000-29				4.000-29	4.000-29
1400-030	4.000-30	4.000-30				4.000-30	4.000-30
1400-031	4.000-31	4.000-31				4.000-31	4.000-31
1400-032	4.000-32	4.000-32				4.000-32	4.000-32
1400-033	4.000-33	4.000-33				4.000-33	4.000-33
1400-034	4.000-34	4.000-34				4.000-34	4.000-34
1400-035	4.000-35	4.000-35				4.000-35	4.000-35
1400-036	4.000-36	4.000-36				4.000-36	4.000-36
1400-037	4.000-37	4.000-37				4.000-37	4.000-37
1400-038	4.000-38	4.000-38				4.000-38	4.000-38
1400-039	4.000-39	4.000-39				4.000-39	4.000-39
1400-040	4.000-40	4.000-40				4.000-40	4.000-40
1400-041	4.000-41	4.000-41				4.000-41	4.000-41
1400-042	4.000-42	4.000-42				4.000-42	4.000-42
1400-043	4.000-43	4.000-43				4.000-43	4.000-43
1400-044	4.000-44	4.000-44				4.000-44	4.000-44
1400-045	4.000-45	4.000-45				4.000-45	4.000-45
1400-046	4.000-46	4.000-46				4.000-46	4.000-46
1400-047	4.000-47	4.000-47				4.000-47	4.000-47
1400-048	4.000-48	4.000-48				4.000-48	4.000-48
1400-049	4.000-49	4.000-49				4.000-49	4.000-49
1400-050	4.000-50	4.000-50				4.000-50	4.000-50

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Doc 001									
Doc 002									
Doc 003									
Doc 004									
Doc 005									

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Subtotal (a)									
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Revision 0

Revisions	20	25	30	35	40	45	50	55	60	65
Initial Review (Rev. 0)										
Rev. 0.1									4.33E+01	
Rev. 0.2									3.10E+00	
Rev. 0.3									3.10E+00	
Rev. 0.4									4.33E+01	
Rev. 0.5									4.33E+01	
Rev. 0.6									4.33E+01	
Rev. 0.7									4.33E+01	
Rev. 0.8									4.33E+01	
Rev. 0.9									4.33E+01	
Rev. 1.0									4.33E+01	
Rev. 1.1									4.33E+01	
Rev. 1.2									4.33E+01	
Rev. 1.3									4.33E+01	
Rev. 1.4									4.33E+01	
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Rev. 1.7									4.33E+01	
Rev. 1.8									4.33E+01	
Rev. 1.9									4.33E+01	
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Rev. 2.8									4.33E+01	
Rev. 2.9									4.33E+01	
Rev. 3.0									4.33E+01	
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Rev. 3.9									4.33E+01	
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Rev. 4.9									4.33E+01	
Rev. 5.0									4.33E+01	
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Rev. 6.9									4.33E+01	
Rev. 7.0									4.33E+01	
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Rev. 7.9									4.33E+01	
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Rev. 8.1									4.33E+01	
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Rev. 8.7									4.33E+01	
Rev. 8.8									4.33E+01	
Rev. 8.9									4.33E+01	
Rev. 9.0									4.33E+01	
Rev. 9.1									4.33E+01	
Rev. 9.2									4.33E+01	
Rev. 9.3									4.33E+01	
Rev. 9.4									4.33E+01	
Rev. 9.5									4.33E+01	
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Rev. 9.7									4.33E+01	
Rev. 9.8									4.33E+01	
Rev. 9.9									4.33E+01	
Rev. 10.0									4.33E+01	

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Case Name	5	6	7	8	9	10	11	12	13	14
Case Description	5	6	7	8	9	10	11	12	13	14
Case Type	5	6	7	8	9	10	11	12	13	14
Case ID	5	6	7	8	9	10	11	12	13	14
Case Status	5	6	7	8	9	10	11	12	13	14
Case Owner	5	6	7	8	9	10	11	12	13	14
Case Manager	5	6	7	8	9	10	11	12	13	14
Case Date	5	6	7	8	9	10	11	12	13	14
Case Location	5	6	7	8	9	10	11	12	13	14
Case Category	5	6	7	8	9	10	11	12	13	14
Case Subcategory	5	6	7	8	9	10	11	12	13	14
Case Priority	5	6	7	8	9	10	11	12	13	14
Case Urgency	5	6	7	8	9	10	11	12	13	14
Case Importance	5	6	7	8	9	10	11	12	13	14
Case Complexity	5	6	7	8	9	10	11	12	13	14
Case Risk	5	6	7	8	9	10	11	12	13	14
Case Impact	5	6	7	8	9	10	11	12	13	14
Case Effort	5	6	7	8	9	10	11	12	13	14
Case Cost	5	6	7	8	9	10	11	12	13	14
Case Budget	5	6	7	8	9	10	11	12	13	14
Case Resources	5	6	7	8	9	10	11	12	13	14
Case Tools	5	6	7	8	9	10	11	12	13	14
Case Methods	5	6	7	8	9	10	11	12	13	14
Case Standards	5	6	7	8	9	10	11	12	13	14
Case Guidelines	5	6	7	8	9	10	11	12	13	14
Case Policies	5	6	7	8	9	10	11	12	13	14
Case Procedures	5	6	7	8	9	10	11	12	13	14
Case Protocols	5	6	7	8	9	10	11	12	13	14
Case Frameworks	5	6	7	8	9	10	11	12	13	14
Case Models	5	6	7	8	9	10	11	12	13	14
Case Templates	5	6	7	8	9	10	11	12	13	14
Case Examples	5	6	7	8	9	10	11	12	13	14
Case Studies	5	6	7	8	9	10	11	12	13	14
Case Research	5	6	7	8	9	10	11	12	13	14
Case Analysis	5	6	7	8	9	10	11	12	13	14
Case Synthesis	5	6	7	8	9	10	11	12	13	14
Case Evaluation	5	6	7	8	9	10	11	12	13	14
Case Review	5	6	7	8	9	10	11	12	13	14
Case Feedback	5	6	7	8	9	10	11	12	13	14
Case Improvement	5	6	7	8	9	10	11	12	13	14
Case Innovation	5	6	7	8	9	10	11	12	13	14
Case Creativity	5	6	7	8	9	10	11	12	13	14
Case Collaboration	5	6	7	8	9	10	11	12	13	14
Case Communication	5	6	7	8	9	10	11	12	13	14
Case Documentation	5	6	7	8	9	10	11	12	13	14
Case Reporting	5	6	7	8	9	10	11	12	13	14
Case Presentation	5	6	7	8	9	10	11	12	13	14
Case Implementation	5	6	7	8	9	10	11	12	13	14
Case Deployment	5	6	7	8	9	10	11	12	13	14
Case Monitoring	5	6	7	8	9	10	11	12	13	14
Case Maintenance	5	6	7	8	9	10	11	12	13	14
Case Support	5	6	7	8	9	10	11	12	13	14
Case Training	5	6	7	8	9	10	11	12	13	14
Case Education	5	6	7	8	9	10	11	12	13	14
Case Research	5	6	7	8	9	10	11	12	13	14
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Case Synthesis	5	6	7	8	9	10	11	12	13	14
Case Evaluation	5	6	7	8	9	10	11	12	13	14
Case Review	5	6	7	8	9	10	11	12	13	14
Case Feedback	5	6	7	8	9	10	11	12	13	14
Case Improvement	5	6	7	8	9	10	11	12	13	14
Case Innovation	5	6	7	8	9	10	11	12	13	14
Case Creativity	5	6	7	8	9	10	11	12	13	14
Case Collaboration	5	6	7	8	9	10	11	12	13	14
Case Communication	5	6	7	8	9	10	11	12	13	14
Case Documentation	5	6	7	8	9	10	11	12	13	14
Case Reporting	5	6	7	8	9	10	11	12	13	14
Case Presentation	5	6	7	8	9	10	11	12	13	14
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Case Deployment	5	6	7	8	9	10	11	12	13	14
Case Monitoring	5	6	7	8	9	10	11	12	13	14
Case Maintenance	5	6	7	8	9	10	11	12	13	14
Case Support	5	6	7	8	9	10	11	12	13	14
Case Training	5	6	7	8	9	10	11	12	13	14
Case Education	5	6	7	8	9	10	11	12	13	14

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Region 411	1.20000	1.20000		1.20000	1.20000	1.20000	1.20000	1.20000	1.20000	1.20000
Region 412										
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935-940										
940-945										
945-950										
950-955										
955-960										
960-965										
965-970										
970-975										
975-980										
980-985										
985-990										
990-995										
995-1000										

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[illegible]

Model Name	001	002	003	004	005	006	007	008	009
Model_001	1.234567	2.345678	3.456789	4.567890	5.678901	6.789012	7.890123	8.901234	9.012345
Model_002	1.345678	2.456789	3.567890	4.678901	5.789012	6.890123	7.901234	8.012345	9.123456
Model_003	1.456789	2.567890	3.678901	4.789012	5.890123	6.901234	7.012345	8.123456	9.234567
Model_004	1.567890	2.678901	3.789012	4.890123	5.901234	6.012345	7.123456	8.234567	9.345678
Model_005	1.678901	2.789012	3.890123	4.901234	5.012345	6.123456	7.234567	8.345678	9.456789
Model_006	1.789012	2.890123	3.901234	4.012345	5.123456	6.234567	7.345678	8.456789	9.567890
Model_007	1.890123	2.901234	3.012345	4.123456	5.234567	6.345678	7.456789	8.567890	9.678901
Model_008	1.901234	2.012345	3.123456	4.234567	5.345678	6.456789	7.567890	8.678901	9.789012
Model_009	1.012345	2.123456	3.234567	4.345678	5.456789	6.567890	7.678901	8.789012	9.890123
Model_010	1.123456	2.234567	3.345678	4.456789	5.567890	6.678901	7.789012	8.890123	9.901234
Model_011	1.234567	2.345678	3.456789	4.567890	5.678901	6.789012	7.890123	8.901234	9.012345
Model_012	1.345678	2.456789	3.567890	4.678901	5.789012	6.890123	7.901234	8.012345	9.123456
Model_013	1.456789	2.567890	3.678901	4.789012	5.890123	6.901234	7.012345	8.123456	9.234567
Model_014	1.567890	2.678901	3.789012	4.890123	5.901234	6.012345	7.123456	8.234567	9.345678
Model_015	1.678901	2.789012	3.890123	4.901234	5.012345	6.123456	7.234567	8.345678	9.456789
Model_016	1.789012	2.890123	3.901234	4.012345	5.123456	6.234567	7.345678	8.456789	9.567890
Model_017	1.890123	2.901234	3.012345	4.123456	5.234567	6.345678	7.456789	8.567890	9.678901
Model_018	1.901234	2.012345	3.123456	4.234567	5.345678	6.456789	7.567890	8.678901	9.789012
Model_019	1.012345	2.123456	3.234567	4.345678	5.456789	6.567890	7.678901	8.789012	9.890123
Model_020	1.123456	2.234567	3.345678	4.456789	5.567890	6.678901	7.789012	8.890123	9.901234
Model_021	1.234567	2.345678	3.456789	4.567890	5.678901	6.789012	7.890123	8.901234	9.012345
Model_022	1.345678	2.456789	3.567890	4.678901	5.789012	6.890123	7.901234	8.012345	9.123456
Model_023	1.456789	2.567890	3.678901	4.789012	5.890123	6.901234	7.012345	8.123456	9.234567
Model_024	1.567890	2.678901	3.789012	4.890123	5.901234	6.012345	7.123456	8.234567	9.345678
Model_025	1.678901	2.789012	3.890123	4.901234	5.012345	6.123456	7.234567	8.345678	9.456789
Model_026	1.789012	2.890123	3.901234	4.012345	5.123456	6.234567	7.345678	8.456789	9.567890
Model_027	1.890123	2.901234	3.012345	4.123456	5.234567	6.345678	7.456789	8.567890	9.678901
Model_028	1.901234	2.012345	3.123456	4.234567	5.345678	6.456789	7.567890	8.678901	9.789012
Model_029	1.012345	2.123456	3.234567	4.345678	5.456789	6.567890	7.678901	8.789012	9.890123
Model_030	1.123456	2.234567	3.345678	4.456789	5.567890	6.678901	7.789012	8.890123	9.901234

100% (S)							1.45E-06	1.45E-05
100% (S)							1.45E-06	1.45E-05
100% (S)							4.13E-07	2.22E-06
100% (S)							1.58E-06	3.18E-05
100% (S)							7.02E-06	4.72E-05
100% (S)							4.70E-06	4.70E-05
100% (S)							1.17E-06	1.17E-05
100% (S)							1.17E-06	1.17E-05

[illegible]

137Cs (C1)			1.00E-01	1.00E-01	1.00E-01				1.00E-01	1.00E-01
137Cs (C2)			1.22E-01	7.28E-01	7.28E-01				1.43E-01	1.43E-01
137Cs (C3)			8.28E-01	6.00E-01	6.00E-01				1.00E-01	1.00E-01
137Cs (C4)			1.10E-01	2.70E-01	1.00E-01				1.00E-01	1.00E-01
137Cs (C5)			4.70E-01	6.00E-01	6.00E-01				1.00E-01	1.00E-01
137Cs (C6)			1.00E-01	1.00E-01	1.00E-01				1.00E-01	1.00E-01
137Cs (C7)			1.00E-01	1.00E-01	1.00E-01				1.00E-01	1.00E-01
137Cs (C8)			1.00E-01	1.00E-01	1.00E-01				1.00E-01	1.00E-01

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WASH (1)	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01
WASH (2)	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01
WASH (3)	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01
WASH (4)	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01
WASH (5)	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01
WASH (6)	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01
WASH (7)	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01
WASH (8)	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01
WASH (9)	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01
WASH (10)	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01

[illegible]

**APPENDIX D: Shielding Source Spreadsheets for
Seven Sources & Selected Process Streams**

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/Source Note 1	Total Ci Sol / Liq
C-14		0.85E+00	0.85E+00	2.80E-06	1.06E-05	
Co-60	2.34E+00	1.07E+02	1.09E+02	3.11E-05	1.18E-04	Sr + Y:
Sr-90*	2.92E+03	8.00E+04	8.29E+04	2.36E-02	8.82E-02	5.88E+03
Y-90*	2.92E+03	8.00E+04	8.29E+04	2.36E-02	8.82E-02	1.80E+05
Tc-99	3.98E+01	3.70E+03	3.74E+03	1.06E-03	4.02E-03	
I-129	1.14E-05	7.60E-02	7.60E-02	2.16E-08	8.17E-08	Cs + Ba:
Cs-137**	1.87E+03	7.70E+04	7.89E+04	2.24E-02	8.48E-02	3.86E+03
Ba-137**	1.79E+03	7.40E+04	7.58E+04	2.15E-02	8.15E-02	1.51E+05
Eu-154	1.99E+02	8.06E+03	8.26E+03	2.63E-03	9.96E-03	
Np-237	7.44E-02	3.54E+00	3.41E+00	9.70E-07	3.57E-06	239 + 240:
Pu-239***	1.35E+00	5.43E+01	5.57E+01	1.58E-06	5.99E-06	1.69E+00
Pu-240***	3.38E-01	1.36E+01	1.39E+01	3.98E-06	1.50E-05	6.79E+01
Pu-241						
Am-241	3.96E+01	1.40E+03	1.44E+03	4.09E-04	1.59E-03	
Cm-244	6.70E-01	2.55E+01	2.62E+01	7.43E-06	2.81E-05	
Total Ci	9.77E+03 Ci	3.25E+05 Ci	3.35E+05 Ci	9.52E-02 C/L	3.60E-01 C/Source	
Volume, L		3.52E+06	Liquid Only			
Mass Flow, Kg	9.40E+04	5.20E+06	Liquid Only	1.477 Check		
Sp. Gr., Kg/L		1.48				
Source Vol, L		3.7853	Libs Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/m3 Glass	C/m3 Cullet	C per Canister
C-14		9.85E+00	9.85E+00	2.22E-01	1.58E-01	1.62E+00
Co-60	2.34E+00	1.07E+02	1.09E+02	2.47E+00	1.73E+00	1.60E+01
Sr-90*	2.82E+03	8.00E+04	8.28E+04	1.87E+03	1.31E+03	1.37E+04
Y-90*	2.82E+03	8.00E+04	8.28E+04	1.87E+03	1.31E+03	1.37E+04
Zr-99	3.98E+01	3.70E+03	3.74E+03	8.44E+01	5.91E+01	6.17E+02
I-129	1.14E-05	7.60E-02	7.60E-02	1.72E-03	1.20E-03	1.25E-02
Cs-137**	1.87E+03	7.70E+04	7.89E+04	1.78E+03	1.25E+03	1.30E+04
Ba-137**	1.79E+03	7.40E+04	7.58E+04	1.71E+03	1.20E+03	1.25E+04
Eu-154	1.99E+02	9.08E+03	9.28E+03	2.09E+02	1.48E+02	1.53E+03
Np-237	7.44E-02	3.34E+00	3.41E+00	7.70E-02	5.39E-02	5.63E-01
Pu-239***	1.35E+00	5.43E+01	5.57E+01	1.26E+00	8.79E-01	9.18E+00
Pu-240***	3.38E-01	1.38E+01	1.39E+01	3.14E-01	2.20E-01	2.30E+00
Pu-241						
Am-241	3.98E+01	1.40E+03	1.44E+03	3.25E+01	2.27E+01	2.37E+02
Cm-244	6.70E-01	2.55E+01	2.62E+01	5.91E-01	4.13E-01	4.32E+00
Total Ci	9.77E+03	3.25E+05	3.35E+05	7.58E+03	5.29E+03	5.63E+04
Volume, L		3.62E+05	Liquid Only			
Mass Flow, Kg	8.40E+04	5.20E+08				
Sp. Grav, Kg/L		1.45	Liquid Only	1.477	Check	
Canister Vol.		10.44	cubic meters			
Na2O / Na2 = 1.35 Molecular Weight Ratio						
Na Solid(Kg)= 2.28E+00 From Table (Ref)						
Na Liquid(Kg)= 8.09E+05 From Table (Ref)						
Total Na(Kg)= 8.09E+05 Sum of Solid and Liquid						
Total Na2O = 2.34E+04 From Solid Table for NCAW, not from above ratio						
@20% = (x5) 1.17E+05 Kg of Glass (20% Sodium Oxide Loading)						
@1000Kg/ton= 117 Metric Tons of Glass						
Glass Density= 2.64 @ 155 lb/ft3						
Glass Volume= 44 cubic meters						
Cullet @70% = 0.70 Packing Fraction						
Cullet Vol = 63 cubic meters						

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/Sources Note 1	Total Ci Sol / Liq
C-14		9.85E+00	9.85E+00	2.63E-08	9.97E-08	
Co-60	3.41E+00	1.07E+02	1.10E+02	2.95E-05	1.12E-04	Sr + Y:
Sr-90*	3.73E+03	8.00E+04	8.37E+04	2.24E-02	8.47E-02	7.46E+03
Y-90*	3.73E+03	8.00E+04	8.37E+04	2.24E-02	8.47E-02	1.60E+05
Tc-99	5.85E+01	3.70E+03	3.76E+03	1.00E-03	3.80E-03	
I-129	1.14E-05	7.60E-02	7.60E-02	2.03E-08	7.60E-08	Ce + Ba:
Ce-137**	2.66E+03	7.70E+04	7.97E+04	2.13E-02	8.06E-02	5.19E+03
Ba-137**	2.64E+03	7.40E+04	7.65E+04	2.05E-02	7.75E-02	1.51E+05
Eu-154	2.90E+02	9.06E+03	9.35E+03	2.50E-03	9.46E-03	
Np-237	1.08E-01	3.34E+00	3.45E+00	9.22E-07	3.49E-06	239 + 240:
Pu-239***	1.90E+00	5.43E+01	5.62E+01	1.50E-05	5.69E-05	2.36E+00
Pu-240***	4.76E-01	1.36E+01	1.41E+01	3.78E-06	1.42E-05	8.79E+01
Pu-241			0.00E+00	0.00E+00	0.00E+00	
Am-241	5.38E+01	1.40E+03	1.46E+03	3.89E-04	1.47E-03	
Cm-244	9.27E-01	2.55E+01	2.64E+01	7.07E-06	2.67E-05	
Total Ci	1.31E+04 Ci	3.25E+05 Ci	3.38E+05 Ci	9.05E-02 C/L	3.43E-01 C/Sources	
Volume, L		3.74E+06	Liquid Only			
Mass Flow, Kg	1.38E+06	6.42E+06	Liquid Only	1.449 Check		
Sp. Gr., Kg/L		1.45	Liquid Only			
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Ce-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol, assumed attributable to liquid since typically liquid Kg >> solid Kg

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14		9.85E+00	9.85E+00	1.51E-01	1.08E-01	1.10E+00
Co-60	3.41E+00	1.07E+02	1.10E+02	1.69E+00	1.18E+00	1.23E+01
Sr-90*	3.73E+03	8.00E+04	8.37E+04	1.28E+03	8.97E+02	9.36E+03
Y-90*	3.73E+03	8.00E+04	8.37E+04	1.28E+03	8.97E+02	9.36E+03
Tc-99	5.85E+01	3.70E+03	3.76E+03	5.75E+01	4.03E+01	4.20E+02
I-129	1.14E-05	7.80E-02	7.80E-02	1.18E-03	8.14E-04	8.52E-03
Cs-137**	2.66E+03	7.70E+04	7.97E+04	1.22E+03	8.53E+02	8.91E+03
Ba-137**	2.54E+03	7.40E+04	7.65E+04	1.17E+03	8.20E+02	8.66E+03
Eu-154	2.80E+02	8.08E+03	8.36E+03	1.43E+02	1.00E+02	1.05E+03
Np-237	1.06E-01	3.34E+00	3.45E+00	5.28E-02	3.69E-02	3.86E-01
Pu-239***	1.80E+00	5.43E+01	5.62E+01	8.60E-01	6.02E-01	6.29E+00
Pu-240***	4.76E-01	1.38E+01	1.41E+01	2.15E-01	1.51E-01	1.57E+00
Pu-241						
Am-241	5.38E+01	1.40E+03	1.46E+03	2.22E+01	1.58E+01	1.63E+02
Cm-244	9.27E-01	2.55E+01	2.64E+01	4.04E-01	2.83E-01	2.96E+00
Total Ci	1.31E+04	3.25E+05	3.38E+05	5.18E+03	3.63E+03	3.79E+04
Volume, L		3.74E+08	Liquid Only			
Mass Flow, Kg	1.38E+05	5.42E+08	1.45		1.449 Check	
Sp. Grav, Kg/L			Liquid Only			
Canister Vol		10.44	cubic meters			
Na2O / Na2 = 1.35 Molecular Weight Ratio						
Na Solid(Kg)= 2.28E+00 From Table (Ref)						
Na Liquid(Kg)= 8.09E+05 From Table (Ref)						
Total Na(Kg)= 8.09E+05 Sum of Solid and Liquid						
Total Na2O = 3.45E+04 From Solid Table for NCAW, not from above ratio						
@20% = (x5) 1.73E+05 Kg of Glass (20% Sodium Oxide Loading)						
@1000Kg/ton = 173 Metric Tons of Glass						
Glass Density = 2.54 @ 165 lb/ft3						
Glass Volume = 85 cubic meters						
Cullet @70% = 0.70 Packing Fraction						
Cullet Vol = 83 cubic meters						

*Sr-90 : Y-90 Ratio = 50/50

**Cs-137 : Ba-137 Ratio = 51/49

***Pu-239 : Pu-240 Ratio = 80/20

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/Source Note 1	Total Ci Sol / Liq
C-14						
Co-60	1.07E+02		1.07E+02	ERR	ERR	Sr + Y: 1.62E+05 0.00E+00
Sr-90*	8.10E+04		8.10E+04	ERR	ERR	
Y-90*	8.10E+04		8.10E+04	ERR	ERR	
Tc-99	1.85E+03		1.85E+03	ERR	ERR	
I-129						Cs + Ba: 1.51E+05 0.00E+00
Cs-137**	7.70E+04		7.70E+04	ERR	ERR	
Ba-137**	7.40E+04		7.40E+04	ERR	ERR	
Eu-154	9.05E+03		9.05E+03	ERR	ERR	
Np-237	3.34E+00		3.34E+00	ERR	ERR	239 + 240: 6.84E+01 0.00E+00
Pu-239***	5.47E+01		5.47E+01	ERR	ERR	
Pu-240***	1.37E+01		1.37E+01	ERR	ERR	
Pu-241			0.00E+00	ERR	ERR	
Am-241	1.41E+03		1.41E+03	ERR	ERR	
Cm-244	2.56E+01		2.56E+01	ERR	ERR	
Total Ci	3.26E+05 Ci	0.00E+00 Ci	3.26E+05 Ci	ERR C/L	ERR C/Source	
Volume, L		0.00E+00	Liquid Only			
Mass Flow, Kg	4.35E+06	0.00E+00				
Sp. Gr., Kg/L		0.00	Liquid Only			ERR Check
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

Input Radionuclides	Solid Cl	Liquid Cl	Total Cl	C/m3 Glass	C/m3 Cullet	C/m3 Canister
C-14			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-50	1.07E+02		1.07E+02	5.18E-02	3.63E-02	3.79E-01
Sr-90*	8.10E+04		8.10E+04	3.92E+01	2.75E+01	2.87E+02
Y-90*	8.10E+04		8.10E+04	3.92E+01	2.75E+01	2.87E+02
Tc-99	1.85E+03		1.85E+03	8.96E-01	6.27E-01	6.55E+00
I-129						
Cs-137**	7.70E+04		7.70E+04	3.73E+01	2.61E+01	2.73E+02
Ba-137**	7.40E+04		7.40E+04	3.58E+01	2.51E+01	2.62E+02
Eu-154	9.06E+03		9.06E+03	4.39E+00	3.07E+00	3.21E+01
Np-237	3.34E+00		3.34E+00	1.62E-03	1.13E-03	1.18E-02
Pu-239***	5.47E+01		5.47E+01	2.65E-02	1.86E-02	1.94E-01
Pu-240***	1.37E+01		1.37E+01	6.83E-03	4.84E-03	4.84E-02
Pu-241			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Am-241	1.41E+03		1.41E+03	8.83E-01	4.78E-01	4.99E+00
Cm-244	2.56E+01		2.56E+01	1.24E-02	8.58E-03	8.06E-02
Total Cl	3.26E+05	0.00E+00	3.26E+05	1.58E+02	1.10E+02	1.15E+03
Volume, L		0.00E+00	Liquid Only			
Mass Flow, Kg	4.38E+08	0.00E+00				
Sp. Grav, Kg/L		0.00	Liquid Only	ERR Check		
Canister Vol.		10.44	cubic meters			
<p>Na2O / Na2 = 1.35 Molecular Weight Ratio Na Solid(Kg)= 0.00E+00 From Table (Ref) Na Liquid(Kg)= 0.00E+00 From Table (Ref) Total Na(Kg)= 0.00E+00 Sum of Solid and Liquid Total Na2O = 1.08E+06 From Solid Table for NCAW, not from above ratio @20% = (x5) 5.45E+06 Kg of Glass (20% Sodium Oxide Loading) @1000Kg/ton = 5450 Metric Tons of Glass Glass Density = 2.64 @ 165 lb/ft3 Glass Volume = 2064 cubic meters Cullet @70% = 0.70 Packing Fraction Cullet Vol = 2949 cubic meters</p>						

* Sr-90 : Y-90 Ratio = 60/60

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 20/20

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/Source Note 1	Total Ci Sol / Liq
C-14						Sr + Y: 6.36E+00 0.00E+00
Co-60						
Sr-90*	3.18E+00		3.18E+00	7.87E-05	2.96E-04	
Y-90*	3.18E+00		3.18E+00	7.87E-05	2.96E-04	Ca + Ba: 5.93E+00 0.00E+00
Tc-99	7.24E-02	4.86E+01	4.87E+01	1.20E-03	4.66E-03	
I-129						
Ca-137**	3.02E+00		3.02E+00	7.48E-05	2.83E-04	Zr + Ba: 5.93E+00 0.00E+00
Ba-137**	2.91E+00		2.91E+00	7.19E-05	2.72E-04	
Eu-154	2.46E+00		2.46E+00	6.08E-05	2.30E-04	
Np-237	1.31E-04		1.31E-04	3.24E-09	1.23E-08	239 + 240: 2.68E-03 0.00E+00
Pu-239***	2.14E-03		2.14E-03	5.31E-06	2.01E-07	
Pu-240***	5.36E-04		5.36E-04	1.33E-06	5.02E-08	
Pu-241						
Am-241	5.54E-02		5.54E-02	1.37E-06	5.19E-06	
Cm-244						
Total Ci	1.49E+01 Ci	4.86E+01 Ci	6.35E+01 Ci	1.57E-03 C/L	5.95E-03 C/Source	
Volume, L		4.04E+04	Liquid Only			
Mass Flow, Kg	1.77E+02	4.04E+04				
Sp. Gr., Kg/L		1.00	Liquid Only	1.000	Check	
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Ca-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

LIGHTLY SHIELDED LOW SHIELDING SOURCE - NCAW Only (from ASPEN Runs)
 FOR FLOW STREAM No: 628 (Mist Eliminator --- ME)

WHC-SD-VTM-TI-763

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14						
Co-60						
Sr-90*	3.18E+00		3.18E+00	3.82E+01	2.75E+01	2.87E+02
Y-90*	3.18E+00		3.18E+00	3.82E+01	2.75E+01	2.87E+02
Tc-99	7.24E-02	4.86E+01	4.87E+01	6.00E+02	4.20E+02	4.39E+03
I-129						
Cs-137**	3.02E+00		3.02E+00	3.73E+01	2.61E+01	2.73E+02
Ba-137**	2.91E+00		2.91E+00	3.68E+01	2.61E+01	2.62E+02
Eu-154	2.48E+00		2.48E+00	3.08E+01	2.12E+01	2.22E+02
Np-237	1.31E-04		1.31E-04	1.62E-03	1.13E-03	1.18E-02
Pu-239***	2.14E-03		2.14E-03	2.64E-02	1.85E-02	1.93E-01
Pu-240***	5.36E-04		5.36E-04	6.61E-03	4.63E-03	4.63E-02
Pu-241						
Am-241	5.54E-02		5.54E-02	6.83E-01	4.78E-01	4.99E+00
Cm-244						
Total Ci	5.49E+01	4.86E+01	6.35E+01	7.83E+02	5.48E+02	5.72E+03
Volume, L		4.04E+04	Liquid Only			
Mass Flow, Kg	1.77E+02	4.04E+04				
Sp. Grav, Kg/L		1.00	Liquid Only	1.000 Check		
Canister Vol		10.44	cubic meters			
Na2O / Na2 = 1.35 Molecular Weight Ratio						
Na Solid(Kg) = 0.00E+00 From Table (Ref)						
Na Liquid(Kg) = 0.00E+00 From Table (Ref)						
Total Na(Kg) = 0.00E+00 Sum of Solid and Liquid						
Total Na2O = 4.28E+01 From Solid Table for NCAW, not from above ratio						
@20% = (x5) 2.14E+02 Kg of Glass (20% Sodium Oxide Loading)						
@1000Kg/ton = 0 Metric Tons of Glass						
Glass Density = 2.64 @ 165 lb/ft3						
Glass Volume = 0 cubic meters						
Cullet @70% = 0.70 Packing Fraction						
Cullet Vol = 0 cubic meters						

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

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Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/S Source Note 1	Total Ci Sol / Liq
C-14	2.81E-05	9.69E-01	9.69E-01	8.58E-07	3.25E-08	Sr + Y: 1.19E+01 5.01E+00 Cs + Ba: 1.06E+01 9.42E+02 239 + 240: 5.90E-02 0.00E+00
Co-60	5.95E+00	2.51E+00	8.46E+00	7.48E-08	2.83E-09	
Sr-90*	5.95E+00	2.51E+00	8.46E+00	7.48E-08	2.83E-09	
Y-90*	3.70E-03		3.70E-03	3.27E-09	1.24E-08	
I-129						
Cs-137**	5.51E+00	4.80E+02	4.86E+02	4.30E-04	1.63E-03	
Ba-137**	5.20E+00	4.62E+02	4.67E+02	4.13E-04	1.56E-03	
Eu-154	9.59E-02		9.59E-02	8.48E-08	3.21E-07	
Np-237						
Pu-239***	4.72E-02		4.72E-02	4.18E-08	1.58E-07	
Pu-240***	1.18E-02		1.18E-02	1.04E-08	3.95E-08	
Pu-241	3.48E-02		3.48E-02	3.08E-08	1.17E-07	
Am-241	1.51E+00		1.51E+00	1.34E-08	5.06E-08	
Cm-244	3.81E-03		3.81E-03	3.37E-09	1.28E-08	
Total Ci	2.44E+01 Ci	9.48E+02 Ci	9.72E+02 Ci	8.81E-04 C/L	3.26E-03 C/Source	
Volume, L		1.13E+06	Liquid Only			
Mass Flow, Kg	1.58E+04	1.59E+06				
Sp. Gr., Kg/L		1.40	Liquid Only	1.407 Check		
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

LIGHTLY SHIELDED LLW SHIELDING SOURCE ~ PFP Waste Only (from ASPEN Run)
FOR FLOW STREAM No: 404 (LLW Feed Evaporator)

WHC-SD-V M-TI-763

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14	2.61E-05		2.61E-05	3.77E-06	2.64E-06	2.75E-05
Co-60	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90*	5.85E+00	2.81E+00	8.46E+00	1.13E+00	7.93E-01	8.28E+00
Y-90*	5.95E+00	2.51E+00	8.46E+00	1.13E+00	7.93E-01	8.28E+00
Tc-99	3.70E-03	0.00E+00	3.70E-03	4.95E-04	3.47E-04	3.62E-03
I-129						
Cs-137**	5.51E+00	4.80E+02	4.86E+02	6.51E+01	4.58E+01	4.76E+02
Ba-137**	5.29E+00	4.62E+02	4.67E+02	6.39E+01	4.38E+01	4.57E+02
Eu-154	9.55E-02	0.00E+00	9.55E-02	1.28E-02	8.99E-03	9.38E-02
Np-237	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-239***	4.72E-02	0.00E+00	4.72E-02	6.39E-03	4.43E-03	4.62E-02
Pu-240***	1.18E-02	0.00E+00	1.18E-02	1.58E-03	1.11E-03	1.16E-02
Pu-241	3.48E-02	0.00E+00	3.48E-02	4.85E-03	3.25E-03	3.41E-02
Am-241	1.51E+00		1.51E+00	2.02E-01	1.42E-01	1.48E+00
Cm-244						
Total Ci	2.44E+01	9.47E+02	9.71E+02	1.30E+02	9.11E+01	9.51E+02
Volume, L		1.13E+06	Liquid Only			
Mass Flow, Kg	1.58E+04	1.58E+06				
Sp. Grav, Kg/L		1.40	Liquid Only 1.407 Check			
Canister Vol.		10.44	cubic meters			
Na2O / Na2 = 1.35 Molecular Weight Ratio						
Na Solid(Kg) = 1.74E+00 From Table (Ref)						
Na Liquid(Kg) = 2.61E+05 From Table (Ref)						
Total Na(Kg) = 2.61E+05 Sum of Solid and Liquid						
Total Na2O = 3.94E+03 From Solid Table for PFP, not from Above Ratio						
@20% = (65) 1.07E+04 Kg of Glass (20% Sodium Oxide Loading)						
@1000Kg/ton = 20 Metric Tons of Glass						
Glass Density = 2.84 @ 165 lb/ft3						
Glass Volume = 7 cubic meters						
Cullet @70% = 0.70 Packing Fraction						
Cullet Vol = 11 cubic meters						

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

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Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/S Source Note 1	Total Ci Sol / Liq
C-14	2.81E-05	9.68E-01	9.68E-01	8.08E-07	2.87E-02	Sr + Y: 1.21E+01 5.01E+00 Cs + Ba: 2.04E+01 9.42E+02 238 + 240: 5.96E-01 0.00E+00
Co-60						
Sr-90*	6.05E+00	2.51E+00	8.56E+00	7.13E-06	2.54E-01	
Y-90*	6.05E+00	2.51E+00	8.56E+00	7.13E-06	2.54E-01	
Tc-99	3.73E-03		3.73E-03	3.11E-09	1.11E-04	
I-129						
Cs-137**	1.04E+01	4.80E+02	4.91E+02	4.08E-04	1.48E+01	
Ba-137**	1.00E+01	4.82E+02	4.72E+02	3.93E-04	1.40E+01	
Eu-154	9.68E-02		9.68E-02	8.07E-06	2.87E-03	
Np-237						
Pu-239***	4.77E-01		4.77E-01	3.97E-07	1.41E-02	
Pu-240***	1.19E-01		1.19E-01	9.93E-06	3.53E-03	
Pu-241	3.51E-02		3.51E-02	2.93E-06	1.04E-03	238 + 240: 5.96E-01 0.00E+00
Am-241	1.52E+00		1.52E+00	1.27E-06	4.51E-02	
Cm-244	3.84E-03		3.84E-03	3.20E-09	1.14E-04	
Total Ci	3.48E+01 Ci	9.48E+02 Ci	9.83E+02 Ci	8.19E-04 C/L	2.91E+01 C/S Source	
Volume, L		1.20E+06	Liquid Only			
Mass Flow, Kg	3.00E+04	1.66E+05	Liquid Only		1.383 Check	
Sp. Gr., Kg/L		1.38	Liquid Only			
Source Vol, L		35581.62	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 50/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

LIGHTLY SHIELDED LLW SHIELDING SOURCE - PFP Waste Only (from ASPEN Runs)
FOR FLOW STREAM No: 408 (LLW Meter Feed Tank Outlet)

WHC-SD-1/M-TI-763

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14	2.81E-05		2.81E-05	1.66E-06	1.39E-06	1.45E-06
Co-60						
Sr-90*	6.05E+00	2.51E+00	8.56E+00	6.03E-01	4.22E-01	4.41E+00
Y-90*	6.05E+00	2.51E+00	8.56E+00	6.03E-01	4.22E-01	4.41E+00
Tc-99	3.73E-03		3.73E-03	2.83E-04	1.84E-04	1.82E-03
I-129						
Cs-137**	1.04E+01	4.60E+02	4.61E+02	3.45E+01	2.42E+01	2.53E+02
Ba-137***	1.00E+01	4.62E+02	4.72E+02	3.32E+01	2.38E+01	2.43E+02
Eu-154	8.68E-02		8.68E-02	6.82E-03	4.78E-03	4.69E-02
Np-237						
Pu-239***	4.77E-01		4.77E-01	3.90E-02	2.95E-02	2.48E-01
Pu-240***	1.19E-01		1.19E-01	8.40E-03	5.88E-03	6.14E-02
Pu-241	3.51E-02		3.51E-02	2.47E-03	1.73E-03	1.61E-02
Am-241	1.52E+00		1.52E+00	1.07E-01	7.50E-02	7.83E-01
Cm-244	3.84E-03		3.84E-03	2.71E-04	1.89E-04	1.96E-03
Total Ci	3.48E+01	9.47E+02	9.82E+02	6.92E+01	4.84E+01	5.06E+02
Volume, L		1.20E+06	Liquid Only			
Mass Flow, Kg	3.00E+04	1.65E+06				
Sp. Grav, Kg/L		1.38	Liquid Only 1.353 Check			
Canister Vol.		10.44	cubic meters			
<p>Na2O / Na2 = 1.35 Molecular Weight Ratio Na Solid(Kg)= 1.74E+00 From Table (Ref) Na Liquid(Kg)= 2.61E+05 From Table (Ref) Total Na(Kg)= 2.61E+05 Sum of Solid and Liquid Total Na2O= 7.49E+03 From Solid Table for PFP, not from Above Ratio @20% = (p5) 3.75E+04 Kg of Glass (20% Sodium Oxide Loading) @1000Kg/ton= 37 Metric Tons of Glass Glass Density= 2.64 @ 165 lb/ft3 Glass Volume= 14 cubic meters Cullet @70% = 0.70 Packing Fraction Cullet Vol = 20 cubic meters</p>						

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

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Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/Sources Note 2	Total Ci Sol / Liq
C-14						
Co-60						Sr + Y:
Sr-90*	8.35E+00		8.35E+00	ERR	ERR	1.67E+01
Y-90*	8.35E+00		8.35E+00	ERR	ERR	0.00E+00
Tc-99	3.65E-03		3.65E-03	ERR	ERR	
I-129						Cs + Ba:
Cs-137**	4.81E+02		4.81E+02	ERR	ERR	9.41E+02
Ba-137**	4.83E+02		4.83E+02	ERR	ERR	0.00E+00
Eu-154	0.48E-02		0.48E-02	ERR	ERR	
Np-237						239 + 240:
Pu-239***	4.67E-01		4.67E-01	ERR	ERR	5.84E-01
Pu-240***	1.17E-01		1.17E-01	ERR	ERR	0.00E+00
Pu-241	3.44E-02		3.44E-02	ERR	ERR	
Am-241	1.49E+00		1.49E+00	ERR	ERR	
Cm-244	3.76E-03		3.76E-03	ERR	ERR	
Total Ci	9.63E+02 Ci	0.00E+00 Ci	9.63E+02 Ci	ERR C/L	ERR C/Sources	
Volume, L						
Mass Flow, Kg	1.41E+06	0.00E+00				
Sp. Gr., Kg/L		0.00				
Source Vol, L		35581.62				

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 61/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol, assumed attributable to liquid since typically liquid Kg >> solid Kg

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14						
Co-60						
Sr-90*	8.35E+00		8.35E+00	1.26E-02	8.79E-03	9.18E-02
Y-90*	8.35E+00		8.35E+00	1.26E-02	8.79E-03	9.18E-02
Tc-99	3.85E-03		3.85E-03	5.49E-06	3.84E-06	4.01E-05
I-129						
Ce-137**	4.61E+02		4.61E+02	7.24E-01	5.07E-01	5.28E+00
Ba-137**	4.63E+02		4.63E+02	6.96E-01	4.87E-01	5.08E+00
Eu-154	9.48E-02		9.48E-02	1.43E-04	9.98E-05	1.04E-03
Na-237						
Pu-239***	4.67E-01		4.67E-01	7.03E-04	4.92E-04	5.14E-03
Pu-240***	1.17E-01		1.17E-01	1.76E-04	1.23E-04	1.28E-03
Pu-241	3.44E-02		3.44E-02	5.17E-05	3.62E-05	3.78E-04
Am-241	1.48E+00		1.48E+00	2.24E-03	1.57E-03	1.64E-02
Cm-244	3.76E-03		3.76E-03	5.68E-06	3.98E-06	4.13E-05
Total Ci	9.63E+02	0.00E+00	9.63E+02	1.45E+00	1.01E+00	1.06E+01
Volume, L		0.00E+00	Liquid Only			
Mass Flow, Kg	1.41E+08	0.00E+00	Liquid Only			
Sp. Grav, Kg/L		0.00	Liquid Only	ERR Check		
Canister Vol.		10.44	cubic meters			
Na2O / Na2 = 1.35 Molecular Weight Ratio Na Solid(Kg) = 0.00E+00 From Table (Ref) Na Liquid(Kg) = 0.00E+00 From Table (Ref) Total Na(Kg) = 0.00E+00 Sum of Solid and Liquid Total Na2O = 3.51E+06 From Solid Table for PFP, not from Above Ratio @20% = (x5) 1.78E+08 Kg of Glass (20% Sodium Oxide Loading) @1000Kg/ton = 1755 Metric Tons of Glass Glass Density = 2.64 @ 165 lb/ft3 Glass Volume = 665 cubic meters Cullet @70% = 0.70 Packing Fraction Cullet Vol = 950 cubic meters						

* Sr-90 : Y-90 Ratio = 50/50

** Ce-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/SOURCE Note 1	Total Ci Sol / Liq
C-14						Sr + Y: 1.67E+01 0.00E+00
Co-60			0.00E+00	0.00E+00	0.00E+00	
Sr-90*			0.00E+00	0.00E+00	0.00E+00	
Y-90*			0.00E+00	0.00E+00	0.00E+00	
Tc-99			0.00E+00	0.00E+00	0.00E+00	Cs + Ba: 9.44E+02 0.00E+00
I-129						
Ce-137**			0.00E+00	0.00E+00	0.00E+00	
Ba-137**			0.00E+00	0.00E+00	0.00E+00	
Eu-154			0.00E+00	0.00E+00	0.00E+00	238 + 240: 5.84E-01 0.00E+00
Np-237						
Pu-238***			0.00E+00	0.00E+00	0.00E+00	
Pu-240***			0.00E+00	0.00E+00	0.00E+00	
Pu-241			0.00E+00	0.00E+00	0.00E+00	
Am-241			0.00E+00	0.00E+00	0.00E+00	
Cm-244			0.00E+00	0.00E+00	0.00E+00	
Total Ci	0.00E+00 Ci	0.00E+00 Ci	0.00E+00 Ci	0.00E+00 C/L	0.00E+00 C/SOURCE	
Volume, L		3.06E+06	Liquid Only			
Mass Flow, Kg	0.00E+00	3.06E+06	Liquid Only			
Sp. Gr., Kg/L		1.00	Liquid Only 1.000 Check			
Source Vol, L		35561.62	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Ce-137 : Ba-137 Ratio = 51/49

*** Pu-238 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14						
Co-60						
Sr-90*	0.00E+00		0.00E+00	ERR	ERR	ERR
Y-90*	0.00E+00		0.00E+00	ERR	ERR	ERR
Tc-99	0.00E+00		0.00E+00	ERR	ERR	ERR
I-129						
Cs-137**	0.00E+00		0.00E+00	ERR	ERR	ERR
Ba-137**	0.00E+00		0.00E+00	ERR	ERR	ERR
Eu-154	0.00E+00		0.00E+00	ERR	ERR	ERR
Np-237						
Pu-239***	0.00E+00		0.00E+00	ERR	ERR	ERR
Pu-240***	0.00E+00		0.00E+00	ERR	ERR	ERR
Pu-241	0.00E+00		0.00E+00	ERR	ERR	ERR
Am-241	0.00E+00		0.00E+00	ERR	ERR	ERR
Cm-244	0.00E+00		0.00E+00	ERR	ERR	ERR
Total Ci	0.00E+00	0.00E+00	0.00E+00	ERR	ERR	ERR
Volume, L		3.06E+08	Liquid Only			
Mass Flow, Kg	0.00E+00	3.06E+08				
Sp. Grav, Kg/L		1.00	Liquid Only		1.00 Check	
Canister Vol.		10.44	cubic meters			
<p>Na2O / Na2 = 1.35 Molecular Weight Ratio</p> <p>Na Solid(Kg) = 0.00E+00 From Table (Ref)</p> <p>Na Liquid(Kg) = 0.00E+00 From Table (Ref)</p> <p>Total Na(Kg) = 0.00E+00 Sum of Solid and Liquid</p> <p>Total Na2O = 0.00E+00 From Solid Table for PFP, not from Above Ratio</p> <p>@20% = (pS) 0.00E+00 Kg of Glass (20% Sodium Oxide Loading)</p> <p>@1000Kg/ton = 0 Metric Tons of Glass</p> <p>Glass Density = 2.64 @ 165 lb/ft3</p> <p>Glass Volume = 0 cubic meters</p> <p>Cullet @70% = 0.70 Packing Fraction</p> <p>Cullet Vol = 0 cubic meters</p>						

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

LIGHTLY SHIELDED LLW SHIELDING SOURCE - CC Waste Only (from ASPEN Hums)
FOR FLOW STREAM No: 404 (LLW Feed Evaporator)

WHC-SD-VM-TI-763

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	CU/Source Note 1	Total Ci Sol / Liq
C-14	9.44E-04		9.44E-04	4.31E-11	1.63E-10	
Co-60						Sr + Y:
Sr-90*	2.87E+04	1.32E+06	1.34E+06	6.14E-02	2.32E-01	5.74E+04
Y-90*	2.87E+04	1.32E+06	1.34E+06	6.14E-02	2.32E-01	2.63E+06
Tc-99	1.80E+02	1.69E+04	1.70E+04	7.78E-04	2.93E-03	
I-129						Cs + Ba:
Cs-137**	1.06E+03	4.43E+04	4.63E+04	2.07E-03	7.84E-03	2.11E+03
Ba-137**	1.03E+03	4.25E+04	4.36E+04	1.89E-03	7.53E-03	8.68E+04
Eu-154	3.77E+02	1.75E+04	1.79E+04	8.16E-04	3.09E-03	
Np-237						239 + 240:
Pu-239***	2.03E+01	9.28E+02	9.48E+02	4.33E-05	1.64E-04	2.54E+01
Pu-240***	5.08E+00	2.32E+02	2.37E+02	1.08E-05	4.10E-05	1.18E+03
Pu-241						
Am-241	1.31E+02	6.01E+03	6.14E+03	2.80E-04	1.06E-03	
Cm-244			0.00E+00	0.00E+00	0.00E+00	
Total Ci	6.02E+04 Ci	2.76E+06 Ci	2.82E+06 Ci	1.29E-01 C/L	4.87E-01 CU/Source	
Volume, L		2.19E+07	Liquid Only			
Mass Flow, Kg	5.65E+05	3.16E+07				
Sp. Gr., Kg/L		1.45	Liquid Only 1.443 Check			
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 90/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

LIGHTLY SHIELDED LLW SHIELDING SOURCE - CC Waste Only (from ASPEN Run)
FOR FLOW STREAM No: 404 (LLW Feed Evaporator)

WHC-SD-V M-TI-763

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14	8.44E-04		8.44E-04	3.41E-06	2.39E-06	2.48E-05
Co-60						
Sr-90*	2.87E+04	1.32E+06	1.34E+06	4.86E+03	3.40E+03	3.55E+04
Y-90*	2.87E+04	1.32E+06	1.34E+06	4.86E+03	3.40E+03	3.55E+04
Tc-99	1.80E+02	1.68E+04	1.70E+04	8.14E+01	4.30E+01	4.48E+02
I-129						
Cs-137**	1.08E+03	4.43E+04	4.53E+04	1.84E+02	1.15E+02	1.20E+03
Ba-137**	1.03E+03	4.25E+04	4.36E+04	1.58E+02	1.10E+02	1.15E+03
Sr-154	3.77E+02	1.75E+04	1.79E+04	6.47E+01	4.53E+01	4.72E+02
Np-237						
Pu-239***	2.03E+01	9.28E+02	9.48E+02	3.43E+00	2.40E+00	2.51E+01
Pu-240***	5.06E+00	2.32E+02	2.37E+02	8.57E-01	6.00E-01	6.27E+00
Pu-241						
Am-241	1.31E+02	5.01E+03	5.14E+03	2.22E+01	1.85E+01	1.82E+02
Cm-244						
Total Ci	6.02E+04	2.76E+06	2.82E+06	1.02E+04	7.14E+03	7.45E+04
Volume, L		2.19E+07	Liquid Only			
Mass Flow, Kg	5.85E+05	3.18E+07				
Sp. Grav, Kg/L		1.45	Liquid Only		1.443 Check	
Canister Vol.		10.44	cubic meters			
Na2O / Na2 = 1.35 Molecular Weight Ratio						
Na Solid(Kg)= 8.68E+00 From Table (Ref)						
Na Liquid(Kg)= 5.03E+05 From Table (Ref)						
Total Na(Kg)= 5.03E+05 Sum of Solid and Liquid						
Total Na2O= 1.46E+05 From Solid Table for CC (Not from Ratio)						
@20% = (x5) 7.30E+05 Kg of Glass (20% Sodium Oxide Loading)						
@1000Kg/ton= 730 Metric Tons of Glass						
Glass Density= 2.84 @ 16S lb/ft3						
Glass Volume= 277 cubic meters						
Cullet @70% = 0.70 Packing Fraction						
Cullet Vol = 395 cubic meters						

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

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Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/L Note 1	Ci/Source Note 1	Total Ci Sol / Liq
C-14	9.44E-04		9.44E-04	4.05E-11	1.44E-06	Sr + Y: 8.41E+04 2.63E+08
Co-60						
Sr-90*	4.21E+04	1.32E+06	1.36E+06	5.82E-02	2.07E+03	
Y-90*	4.21E+04	1.32E+06	1.36E+06	5.82E-02	2.07E+03	
Tc-99	2.65E+02	1.88E+00	2.67E+02	1.14E-05	4.07E-01	Cs + Ba: 2.99E+03 8.68E+04
I-129						
Cs-137**	1.32E+03	4.43E+04	4.56E+04	1.97E-03	6.89E+01	
Ba-137**	1.47E+03	4.25E+04	4.40E+04	1.89E-03	6.72E+01	
Eu-154	5.54E+02	1.75E+04	1.81E+04	7.75E-04	2.76E+01	239 + 240: 3.72E+01 1.16E+03
Np-237						
Pu-239***	2.98E+01	9.28E+02	9.58E+02	4.11E-05	1.45E+00	
Pu-240***	7.44E+00	2.32E+02	2.39E+02	1.03E-05	3.66E-01	
Pu-241						
Am-241	1.92E+02	6.01E+03	6.20E+03	2.68E-04	9.47E+00	
Cm-244						
Total Ci	8.81E+04 Ci	2.74E+06 Ci	2.83E+06 Ci	1.21E-01 Ci/L	4.32E+03 Ci/Source	
Volume, L		2.33E+07	Liquid Only			
Mass Flow, Kg	8.58E+05	3.30E+07				
Sp. Gr., Kg/L		1.42	Liquid Only			
Source Vol, L		35581.82	Liters Equivalent			
			1.416 Check			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

LIGHTLY SHIELDED LLW SHIELDING SOURCE - CC Waste Only (from ASPEN Plus)
FOR FLOW STREAM No: 406 (LLW Melt Feed Tank Outlet)

WHC-SD-VLM-TI-763

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14	9.44E-04		9.44E-04	2.32E-06	1.62E-06	1.69E-05
Co-60						
Sr-90*	4.21E+04	1.22E+06	1.30E+06	3.33E+03	2.33E+03	2.44E+04
Y-90*	4.21E+04	1.32E+06	1.36E+06	3.33E+03	2.33E+03	2.44E+04
Tc-99	2.65E+02	1.66E+00	2.67E+02	6.55E-01	4.58E-01	4.79E+00
I-129						
Cs-137**	1.52E+03	4.43E+04	4.58E+04	1.12E+02	7.87E+01	8.22E+02
Ba-137**	1.47E+03	4.25E+04	4.40E+04	1.08E+02	7.56E+01	7.80E+02
Eu-154	5.54E+02	1.75E+04	1.81E+04	4.43E+01	3.10E+01	3.24E+02
Np-237						
Pu-239***	2.96E+01	9.28E+02	9.58E+02	2.35E+00	1.65E+00	1.72E+01
Pu-240***	7.44E+00	2.32E+02	2.39E+02	5.88E-01	4.12E-01	4.30E+00
Pu-241						
Am-241	1.82E+02	6.01E+03	6.20E+03	1.52E+01	1.07E+01	1.11E+02
Cm-244						
Total Ci	8.81E+04	2.74E+06	2.83E+06	6.95E+03	4.86E+03	5.06E+04
Volume, L		2.33E+07	Liquid Only			
Mass Flow, Kg	6.59E+05	3.30E+07				
Sp. Grav, Kg/L		1.42	Liquid Only 1.416 Check			
Canister Vol.		10.44	cubic meters			
<p>Na2O / Na2 = 1.35 Molecular Weight Ratio</p> <p>Na Solid(Kg)= 8.68E+00 From Table (Ref)</p> <p>Na Liquid(Kg)= 5.03E+08 From Table (Ref)</p> <p>Total Na(Kg)= 5.03E+08 Sum of Solid and Liquid</p> <p>Total Na2O= 2.15E+06 From Solid Table for CC (Not from Ratio)</p> <p>@20% =(x5) 1.08E+09 Kg of Glass (20% Sodium Oxide Loading)</p> <p>@1000Kg/tom= 1075 Metric Tons of Glass</p> <p>Glass Density= 2.84 @ 185 lb/ft3</p> <p>Glass Volume= 407 cubic meters</p> <p>Cullet @70% = 0.70 Packing Fraction</p> <p>Cullet Vol = 582 cubic meters</p>						

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

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LIGHTLY SHIELDED LLW SHIELDING SOURCE - CC Waste Only (from ASPEN Plant)
FOR FLOW STREAM No: 437 (Dry Bin Rotary Feeder)

WHC-SD-WM-TI-763

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/Source Note 1	Total Ci Sol / Liq
C-14						Sr + Y: 2.63E+01 0.00E+00
Co-60						
Sr-90*	1.32E+01		1.32E+01	ERR	ERR	
Y-90*	1.32E+01		1.32E+01	ERR	ERR	
To-99	8.37E+00		8.37E+00	ERR	ERR	Cs + Ba: 8.57E-01 0.00E+00
I-129						
Cs-137**	4.42E-01		4.42E-01	ERR	ERR	
Ba-137**	4.26E-01		4.26E-01	ERR	ERR	
Eu-154	1.75E-01					239 + 240: 1.16E-02 0.00E+00
Np-237						
Pu-239***	9.28E-03		9.28E-03	ERR	ERR	
Pu-240***	2.32E-03		2.32E-03	ERR	ERR	
Pu-241						
Am-241	6.00E-02		6.00E-02	ERR	ERR	
Cm-244				ERR	ERR	
Total Ci	3.58E+01 Ci	0.00E+00 Ci	3.58E+01 Ci	ERR C/L	ERR C/Source	
Volume, L		0.00E+00	Liquid Only Liquid Only Liters Equivalent			
Mass Flow, Kg	2.71E+07	0.00E+00				
Sp. Gr., Kg/L		0.00				
Source Vol, L		3.7853				

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 90/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

LIGHTLY SHIELDED LLW SHIELDING SOURCE - CC Waste Only (from ASPEN Runs)
FOR FLOW STREAM No: 437 (Day Bin Rotary Feeder)

WHC-SD-WM-TI-763

Revision 0

REV 15

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14						
Co-60						
Sr-90*	1.32E+01		1.32E+01	1.02E-03	7.16E-04	7.47E-03
Y-90*	1.32E+01		1.32E+01	1.02E-03	7.16E-04	7.47E-03
Tc-99	8.37E+00		8.37E+00	6.51E-04	4.65E-04	4.76E-03
I-129						
Cs-137**	4.42E-01		4.42E-01	3.44E-05	2.41E-05	2.51E-04
Ba-137**	4.25E-01		4.25E-01	3.30E-05	2.31E-05	2.41E-04
Eu-154						
Np-237						
Pu-239***	9.28E-03		9.28E-03	7.22E-07	5.05E-07	5.27E-06
Pu-240***	2.32E-03		2.32E-03	1.80E-07	1.26E-07	1.32E-06
Pu-241						
Am-241	6.00E-02		6.00E-02	4.67E-06	3.27E-06	3.41E-05
Cm-244						
Total Ci	3.66E+01	0.00E+00	3.66E+01	2.77E-03	1.94E-03	2.02E-02
Volume, L		0.00E+00	Liquid Only			
Mass Flow, Kg	2.71E+07	0.00E+00	Liquid Only			
Sp. Grav, Kg/L		0.00	Liquid Only			
Canister Vol.		10.44	cubic meters			
<p>Na2O / Na2 = 1.35 Molecular Weight Ratio</p> <p>Na Solid(Kg) = 0.00E+00 From Table (Ref)</p> <p>Na Liquid(Kg) = 0.00E+00 From Table (Ref)</p> <p>Total Na(Kg) = 0.00E+00 Sum of Solid and Liquid</p> <p>Total Na2O = 5.79E+06 From Solid Table for CC (Not from Ratio)</p> <p>@20% = (x5) 3.40E+07 Kg of Glass (20% Sodium Oxide Loading)</p> <p>@1000Kg/ton = 33850 Metric Tons of Glass</p> <p>Glass Density = 2.64 @ 165 lb/ft3</p> <p>Glass Volume = 12860 cubic meters</p> <p>Cullet @70% = 0.70 Packing Fraction</p> <p>Cullet Vol = 18371 cubic meters</p>						

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 ; Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

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Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/S Source Note 1	Total Ci Sol / Liq
C-14						
Co-60						Sr + Y:
Sr-90*	5.15E+01		5.15E+01	4.68E-04	1.77E-03	1.03E+02
Y-90*	5.15E+01		5.15E+01	4.68E-04	1.77E-03	0.00E+00
Tc-99	3.29E-01	2.21E+02	2.21E+02	2.01E-03	7.62E-03	
I-129						Cs + Ba:
Cs-137**	1.73E+00		1.73E+00	1.58E-05	5.97E-05	3.40E+00
Ba-137**	1.67E+00		1.67E+00	1.51E-05	5.73E-05	0.00E+00
Eu-154	4.76E+00		4.76E+00	4.33E-05	1.64E-04	
Np-237						239 + 240:
Pu-239***	3.68E-02		3.68E-02	3.32E-07	1.26E-06	4.57E-02
Pu-240***	9.14E-03		9.14E-03	8.31E-08	3.15E-07	0.00E+00
Pu-241						
Am-241	2.36E-01		2.36E-01	2.15E-06	8.12E-06	
Cm-244						
Total Ci	1.12E+02 Ci	2.21E+02 Ci	3.33E+02 Ci	3.03E-03 C/L	1.15E-02 C/S Source	
Volume, L		1.10E+05	Liquid Only			
Mass Flow, Kg	1.08E+03	1.10E+06				
Sp. Gr., Kg/L		1.00	Liquid Only	1.000 Check		
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Cu/m3 Glass	Cu/m3 Cullet	Ci per Canister
C-14						
Co-60						
Sr-90*	5.15E+01		5.15E+01	1.02E+02	7.16E+01	7.47E+02
Y-90*	5.15E+01		5.15E+01	1.02E+02	7.16E+01	7.47E+02
Tc-99	3.29E-01	2.21E+02	2.21E+02	4.39E+02	3.06E+02	3.21E+03
I-129						
Cs-137**	1.73E+00		1.73E+00	3.44E+00	2.41E+00	2.62E+01
Ba-137**	1.67E+00		1.67E+00	3.31E+00	2.31E+00	2.42E+01
Eu-154						
Np-237						
Pu-239***	3.66E-02		3.66E-02	7.26E-02	5.06E-02	5.30E-01
Pu-240***	9.14E-03		9.14E-03	1.81E-02	1.27E-02	1.33E-01
Pu-241						
Am-241	2.39E-01		2.39E-01	4.68E-01	3.28E-01	3.42E+00
Cm-244						
Total Ci	1.07E+02	2.21E+02	3.28E+02	6.51E+02	4.56E+02	4.76E+03
Volums, L		1.10E+05	Liquid Only			
Mass Flow, Kg	1.06E+03	1.10E+05				
Sp. Grav, Kg/L		1.00	Liquid Only	1.000	Check	
Canister Vol.		10.44	cubic meters			
Na2O / Na2 = 1.35 Molecular Weight Ratio Na Solid(Kg)= 0.00E+00 From Table (Ref) Na Liquid(Kg)= 0.00E+00 From Table (Ref) Total Na(Kg)= 0.00E+00 Sum of Solid and Liquid Total Na2O = 2.66E+02 From Solid Table for GC (Not from Ratio) @20% =(x5) 1.33E+03 Kg of Glass (20% Sodium Oxide Loading) @1000Kg/ton = 1 Metric Tons of Glass Glass Density= 2.64 @ 185 lb/ft3 Glass Volume= 1 cubic meters Cullet @70% = 0.70 Packing Fraction Cullet Vol = 1 cubic meters						

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

LIGHTLY SHIELDED LLW SHIELDING SOURCE - NOMINAL Only (from ASPEN Runs)
FOR FLOW STREAM No: 404 (LLW Waste Feed Evaporator)

WHC-SD-V7M-TI-763

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	CvL Note 1	Ci/Source Note 1	Total Ci Sol / Lq
C-14	2.87E-01	3.31E+03	3.31E+03	9.60E-06	3.63E-05	Sr + Y: 5.10E+04 3.38E+06
Co-60						
Sr-90*	2.58E+04	1.66E+06	1.72E+06	4.97E-03	1.68E-02	
Y-90*	2.58E+04	1.66E+06	1.72E+06	4.97E-03	1.68E-02	
Tc-99	2.52E+02	2.26E+04	2.29E+04	6.82E-05	2.51E-04	Cs + Ba: 6.25E+03 4.68E+05
I-129	3.25E-05	1.80E+01	1.80E+01	4.84E-08	1.78E-07	
Cs-137**	3.19E+03	2.40E+05	2.52E+05	7.31E-04	2.77E-03	
Ba-137**	3.05E+03	2.36E+05	2.42E+05	7.02E-04	2.66E-03	
Eu-154						239 + 240: 2.19E+01 1.65E+03
Np-237	8.63E-02	6.05E+00	7.04E+00	2.04E-08	7.72E-08	
Pu-239***	1.75E+01	1.32E+03	1.34E+03	3.69E-06	1.47E-05	
Pu-240***	4.36E+00	3.30E+02	3.34E+02	9.69E-07	3.67E-06	
Pu-241						
Am-241	1.01E+02	7.89E+03	7.96E+03	2.32E-05	8.77E-05	
Cm-244	2.75E-01	7.68E+00	7.97E+00	2.31E-08	8.74E-08	
Total Ci	5.82E+04 Ci	3.90E+06 Ci	3.96E+06 Ci	1.15E-02 CvL	4.35E-02 Ci/Source	
Volume, L	4.81E+08	3.45E+08	Liquid Only			
Mass Flow, Kg		5.06E+08	Liquid Only		1.472 Check	
Sp. Gr., Kg/L		1.47	Liquid Only			
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 60/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Cm3 Glass	Cm3 Cullet	Ci per Canistar
C-14	2.87E-01	3.31E+03	3.31E+03	1.46E+00	1.02E+00	1.06E+01
Co-60						
Sr-90*	2.58E+04	1.68E+06	1.72E+06	7.55E+02	5.28E+02	5.52E+03
Y-90*	2.58E+04	1.68E+06	1.72E+06	7.55E+02	5.28E+02	5.52E+03
Ta-99	2.52E+02	2.28E+04	2.28E+04	1.01E+01	7.04E+00	7.35E+01
I-129	3.25E-05	1.60E+01	1.60E+01	7.04E-03	4.93E-03	5.14E-02
Cs-137**	3.19E+03	2.49E+05	2.52E+05	1.11E+02	7.79E+01	8.11E+02
Ba-137**	3.06E+03	2.39E+05	2.42E+05	1.07E+02	7.46E+01	7.79E+02
Eu-154						
Np-237	8.63E-02	8.85E+00	7.04E+00	3.10E-03	2.17E-03	2.26E-02
Pu-239***	1.75E+01	1.32E+03	1.34E+03	5.89E-01	4.12E-01	4.30E+00
Pu-240***	4.38E+00	3.30E+02	3.34E+02	1.47E-01	1.03E-01	1.08E+00
Pu-241						
Am-241	1.01E+02	7.89E+03	7.99E+03	3.52E+00	2.46E+00	2.57E+01
Cm-244	2.75E-01	7.88E+00	7.87E+00	3.50E-03	2.45E-03	2.60E-02
Total Ci	5.62E+04	3.90E+08	3.96E+08	1.74E+03	1.22E+03	1.27E+04
Volume, L		3.45E+08	Liquid Only			
Mass Flow, Kg	4.61E+06	5.08E+08				
Sp. Grav, Kg/L		1.47	Liquid Only	1.472	Check	
Canistar Vol.		10.44	cubic meters			
Na2O / Na2 = 1.35 Molecular Weight Ratio						
Na Solid(Kg)= 1.02E+02 From Table (Ref)						
Na Liquid(Kg)= 7.94E+07 From Table (Ref)						
Total Na(Kg)= 7.94E+07 Sum of Solid and Liquid						
Total Na2O= 1.20E+08 From Solid Table for NCAW, not from above ratio						
@20% =(x3) 5.00E+06 Kg of Glass (20% Sodium Oxide Loading)						
@1000Kg/ton= 5000 Metric Tons of Glass						
Glass Density= 2.64 @ 186 lb/ft3						
Glass Volume= 2273 cubic meters						
Cullet @70% = 0.70 Packing Fraction						
Cullet Vol = 3247 cubic meters						

* Sr-90 : Y-90 Ratio = 60/50

** Cs-137 : Ba-137 Ratio = 51/48

*** Pu-239 : Pu-240 Ratio = 50/20

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/L Note 1	Ci/Source Note 1	Total Ci Sol / Liq
C-14	2.87E-01	3.31E+03	3.31E+03	9.02E-06	3.41E-05	Sr + Y: 8.68E+04 3.38E+06 Cs + Ba: 1.12E+04 4.86E+05 238 + 240: 3.85E+01 1.65E+03
Co-60						
Sr-90*	4.29E+04	1.69E+06	1.73E+06	4.72E-03	1.79E-02	
Y-90*	4.29E+04	1.69E+06	1.73E+06	4.72E-03	1.79E-02	
Tc-99	4.62E+02	2.26E+05	2.26E+05	6.17E-04	2.34E-03	
I-129	3.25E-05	1.60E+02	1.60E+02	4.38E-07	1.69E-06	
Cs-137**	5.71E+03	2.49E+05	2.55E+05	6.94E-04	2.63E-03	
Ba-137**	5.49E+03	2.39E+05	2.45E+05	6.67E-04	2.62E-03	
Eu-154		6.35E+04	6.35E+04	1.46E-04	5.52E-04	
Np-237	1.57E-01	6.95E+00	7.11E+00	1.94E-05	7.33E-05	
Pu-239**	3.08E+01	1.32E+03	1.35E+03	3.69E-05	1.39E-05	
Pu-240**	7.70E+00	3.30E+02	3.38E+02	9.20E-07	3.46E-05	
Pu-241						
Am-241	1.91E+02	7.69E+00	8.07E+03	2.20E-05	8.32E-05	
Cm-244	3.55E-01	7.69E+00				
Total Ci	9.77E+04 Ci	4.16E+06 Ci	4.26E+06 Ci	1.16E-02 Ci/L	4.39E-02 Ci/Source	
Volume, L	9.13E+06	3.67E+06	Liquid Only		1.444 Check	
Mass Flow, Kg		5.30E+06	Liquid Only			
Sp. Gr., Kg/L		1.44	Liquid Only			
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

LIGHTLY SHIELDED LLW SHIELDING SOURCE - NOMINAL Only (from ASPEN Runs)
FOR FLOW STREAM No: 406 (LLW Meter Feed Tank Outlet)

WHC SD-WM-TL-763

Revision 0

Input Radionuclides	Solid Cl	Liquid Cl	Total Cl	Cu/m3 Glass	Cu/m3 Cullet	Cu/m3 Canister
C-14	2.87E-01	3.51E+03	3.51E+03	7.67E-01	5.37E-01	5.60E+00
Co-60						
Sr-90*	4.29E+04	1.69E+06	1.73E+06	4.01E+02	2.81E+02	2.93E+03
Y-90*	4.29E+04	1.69E+06	1.73E+06	4.01E+02	2.81E+02	2.93E+03
Tc-99	4.82E+02	2.26E+05	2.26E+05	5.24E+01	3.67E+01	3.83E+02
I-129	3.25E-05	1.60E+02	1.60E+02	3.71E-02	2.56E-02	2.71E-01
Cs-137**	5.71E+03	2.49E+05	2.55E+05	5.90E+01	4.13E+01	4.31E+02
Ba-137**	5.49E+03	2.39E+05	2.45E+05	5.66E+01	3.97E+01	4.14E+02
Eu-154		5.35E+04	5.35E+04	1.24E+01	8.67E+00	9.05E+01
Np-237	1.57E-01	6.95E+00	7.11E+00	1.95E-03	1.19E-03	1.20E-02
Pu-239***	3.09E+01	1.32E+03	1.35E+03	3.13E-01	2.19E-01	2.29E+00
Pu-240**	7.70E+00	3.30E+02	3.38E+02	7.82E-02	6.47E-02	6.72E-01
Pu-241						
Am-241	1.81E+02	7.89E+03	8.07E+03	1.87E+00	1.31E+00	1.37E+01
Cm-244	3.55E-01	7.69E+00	8.05E+00	1.86E-03	1.30E-03	1.36E-02
Total Cl	9.77E+04	4.16E+06	4.26E+06	9.86E+02	6.90E+02	7.21E+03
Volume, L		3.67E+06	Liquid Only			
Mass Flow, Kg	9.13E+06	6.30E+08				
Sp. Grav, Kg/L		1.44	Liquid Only	1.444	Check	
Canister Vol,		10.44	cubic meters			
<p>Na2O / Na2 = 1.35 Molecular Weight Ratio Na Solid(Kg)= 1.02E+02 From Table (Ref) Na Liquid(Kg)= 7.94E+07 From Table (Ref) Total Na(Kg)= 7.94E+07 Sum of Solid and Liquid Total Na2O= 2.28E+08 From Solid Table for Waste, not from above ratio @20% = (x3) 1.14E+07 Kg of Glass (20% Sodium Oxide Loading) @1000Kg/ton= 11400 Metric Tons of Glass Glass Density= 2.64 @ 165 lb/ft3 Glass Volume= 4318 cubic meters Cullet @70% = 0.70 Packing Fraction Cullet Vol = 6169 cubic meters</p>						

* Sr-90 : Y-90 Ratio = 60/60

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

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File: NOM-N406.WK3

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	Ci/Source Note 1	Total Ci Sol / Liq
C-14			3.30E+03	ERR	ERR	Sr + Y: 3.36E+06 0.00E+00 Cs + Ba: 4.68E+05 0.00E+00 Zr + Mo: 1.65E+03 0.00E+00
Co-60						
Sr-90*	1.70E+06		1.70E+06	ERR	ERR	
Y-90*	1.70E+06		1.70E+06	ERR	ERR	
Tc-99	2.26E+04		2.26E+04	ERR	ERR	
I-129						
Cs-137**	2.48E+05		2.48E+05	ERR	ERR	
Ba-137**	2.39E+05		2.39E+05	ERR	ERR	
Eu-154						
Np-237	6.96E+00		6.96E+00	ERR	ERR	
Pu-239***	1.32E+03		1.32E+03	ERR	ERR	
Pu-240***	3.30E+02		3.30E+02	ERR	ERR	
Pu-241						Sr + Y: 3.36E+06 0.00E+00 Cs + Ba: 4.68E+05 0.00E+00 Zr + Mo: 1.65E+03 0.00E+00
Am-241	7.91E+03		7.91E+03	ERR	ERR	
Cm-244	7.67E+00					
Total Ci	3.91E+06 Ci	0.00E+00 Ci	3.91E+06 Ci	ERR C/L	ERR Ci/Source	
Volume, L		0.00E+00	Liquid Only			
Mass Flow, Kg	4.28E+05	0.00E+00	Liquid Only			
Sp. Gr., Kg/L		0.00	Liquid Only	ERR Check		
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

LIGHTLY SHIELDED LLW SHIELDING SOURCE - NOMINAL Only (from ASPEN Run)
 FOR FLOW STREAM No: 437 (Day Bin Rotary Feeder)

WHC-SD-V M-TI-763

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14						
Co-60						
Sr-90*	1.70E+06		1.70E+06	8.36E+00	5.85E+00	6.11E+01
Y-90*	1.70E+06		1.70E+06	8.36E+00	5.85E+00	6.11E+01
Tc-99	2.26E+04		2.26E+04	1.12E-01	7.81E-02	8.15E-01
I-129						
Cs-137**	2.49E+05		2.49E+05	1.23E+00	8.60E-01	8.86E+00
Ba-137**	2.39E+05		2.39E+05	1.18E+00	8.26E-01	8.62E+00
Eu-154						
Np-237	6.96E+00		6.96E+00	3.43E-05	2.40E-05	2.51E-04
Pu-239***	1.32E+03		1.32E+03	6.51E-03	4.56E-03	4.76E-02
Pu-240***	3.30E+02		3.30E+02	1.63E-03	1.14E-03	1.19E-02
Pu-241						
Am-241	7.91E+03		7.91E+03	3.90E-02	2.73E-02	2.85E-01
Cm-244	7.87E+00		7.87E+00	3.88E-05	2.72E-05	2.84E-04
Total Ci	3.91E+06	0.00E+00	3.91E+06	1.83E+01	1.35E+01	1.41E+02
Volume, L		0.00E+00	Liquid Only			
Mass Flow, Kg	4.28E+08	0.00E+00				
Sp. Grav, Kg/L		0.00	Liquid Only	ERR. Check		
Canister Vol.		10.44	cubic meters			
Na2O / Na2 = 1.35 Molecular Weight Ratio Na Solid(Kg) = 0.00E+00 From Table (Ref) Na Liquid(Kg) = 0.00E+00 From Table (Ref) Total Na(Kg) = 0.00E+00 Sum of Solid and Liquid Total Na2O = 1.67E+08 From Solid Table for NCAW, not from above ratio @20% = (x5) 5.35E+08 Kg of Glass (20% Sodium Oxide Loading) @1000Kg/ton = 535000 Metric Tons of Glass Glass Density = 2.64 @ 165 lb/ft3 Glass Volume = 202852 cubic meters Cullet @70% = 0.70 Packing Fraction Cullet Vol = 289602 cubic meters						

* Sr-90 : Y-90 Ratio = 60/60

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 90/20

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Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/Source Note 1	Total Ci Sol / Liq
C-14			0.00E+00	0.00E+00	0.00E+00	Sr + Y: 0.00E+00 0.00E+00 Cs + Ba: 0.00E+00 0.00E+00 239 + 240: 0.00E+00 0.00E+00
Co-60			0.00E+00	0.00E+00	0.00E+00	
Sr-90*			0.00E+00	0.00E+00	0.00E+00	
Y-90*			0.00E+00	0.00E+00	0.00E+00	
Tc-99			0.00E+00	0.00E+00	0.00E+00	
I-128			0.00E+00	0.00E+00	0.00E+00	
Ce-137**			0.00E+00	0.00E+00	0.00E+00	
Ba-137**			0.00E+00	0.00E+00	0.00E+00	
Eu-154			0.00E+00	0.00E+00	0.00E+00	
Np-237			0.00E+00	0.00E+00	0.00E+00	
Pu-239***			0.00E+00	0.00E+00	0.00E+00	
Pu-240***			0.00E+00	0.00E+00	0.00E+00	
Pu-241			0.00E+00	0.00E+00	0.00E+00	
Am-241			0.00E+00	0.00E+00	0.00E+00	
Cm-244			0.00E+00	0.00E+00	0.00E+00	
Total Ci	0.00E+00 Ci	0.00E+00 Ci	0.00E+00 Ci	0.00E+00 C/L	0.00E+00 Ci/Source	
Volume, L	0.00E+00	1.17E+09	Liquid Only			
Mass Flow, Kg		1.17E+09	Liquid Only			
Sp. Gr., Kg/L		1.00	1.000 Check			
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Ce-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

LIGHTLY SHIELDED LLW SHIELDING SOURCE - NOMINAL Only (from ASPEN HUNT)
 FOR FLOW STREAM No: 828 (Mist Eliminator --- ME)

WHC-SD-VLM-TL-763

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14			0.00E+00	ERR	ERR	ERR
Co-60			0.00E+00	ERR	ERR	ERR
Sr-90*			0.00E+00	ERR	ERR	ERR
Y-90*			0.00E+00	ERR	ERR	ERR
Tc-99			0.00E+00	ERR	ERR	ERR
I-129			0.00E+00	ERR	ERR	ERR
Cs-137**			0.00E+00	ERR	ERR	ERR
Ba-137**			0.00E+00	ERR	ERR	ERR
Eu-154			0.00E+00	ERR	ERR	ERR
Np-237			0.00E+00	ERR	ERR	ERR
Pu-239***			0.00E+00	ERR	ERR	ERR
Pu-240***			0.00E+00	ERR	ERR	ERR
Pu-241			0.00E+00	ERR	ERR	ERR
Am-241			0.00E+00	ERR	ERR	ERR
Cm-244			0.00E+00	ERR	ERR	ERR
Total Ci	0.00E+00	0.00E+00	0.00E+00	ERR	ERR	ERR
Volume, L		1.17E+09	Liquid Only			
Mass Flow, Kg	0.00E+00	1.17E+09				
Sp. Grav, Kg/L		1.00	Liquid Only	1.000	Check	
Canister Vol.		10.44	cubic meters			
Na2O / Na2 = 1.35 Molecular Weight Ratio Na Solid(Kg) = 0.00E+00 From Table (Ref) Na Liquid(Kg) = 0.00E+00 From Table (Ref) Total Na(Kg) = 0.00E+00 Sum of Solid and Liquid Total Na2O = 0.00E+00 From Solid Table for NCAW, not from above ratio @20% = (x5) 0.00E+00 Kg of Glass (20% Sodium Oxide Loading) @1000Kg/ton = 0 Metric Tons of Glass Glass Density = 2.64 @ 165 lb/ft3 Glass Volume = 0 cubic meters Cullet @70% = 0.70 Packing Fraction Cullet Vol = 0 cubic meters						

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 60/20

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LIGHTLY SHIELDED LLW SHIELDING SOURCE - DSSF Only (from ASPEN Runs)

[DSSF No Pretreatment Source as of 3/21/85]

FOR FLOW STREAM No: 400 (LLW Evaporator Feed Tank)

W10-32-V M-TI-763

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/Source Note 1	Total Ci Sol / Liq
C-14		1.28E+01	1.28E+01	2.20E-07	8.32E-07	
Co-60		8.98E+02	8.98E+02	1.22E-05	4.61E-06	Sr + Y:
Sr-90*		8.55E+04	8.55E+04	1.67E-03	6.31E-03	0.00E+00
Y-90*		9.55E+04	9.55E+04	1.67E-03	6.31E-03	1.91E+06
Tc-99		4.59E+03	4.59E+03	5.01E-05	3.03E-04	
I-129		1.01E+01	1.01E+01	1.76E-07	6.67E-07	
Cs-134		6.56E+02	6.56E+02	1.50E-05	5.67E-05	Cs + Ba:
Cs-137**		1.07E+07	1.07E+07	1.87E-01	7.08E-01	0.00E+00
Ba-137**		1.03E+07	1.03E+07	1.80E-01	8.80E-01	2.10E+07
Eu-154		2.12E+02	2.12E+02	3.70E-06	1.40E-05	
Th-231			0.00E+00	0.00E+00	0.00E+00	
Th-234			0.00E+00	0.00E+00	0.00E+00	
Pa-233			0.00E+00	0.00E+00	0.00E+00	
Pa-234			0.00E+00	0.00E+00	0.00E+00	
U-235		1.04E-02	1.04E-02	1.82E-10	6.87E-10	
U-238		1.04E+00	1.04E+00	1.82E-08	6.87E-08	
Np-237		2.37E+01	2.37E+01	4.14E-07	1.57E-06	
Pu-238			0.00E+00	0.00E+00	0.00E+00	238 + 240:
Pu-239***		8.56E+01	8.56E+01	1.49E-06	3.65E-06	0.00E+00
Pu-240***		2.14E+01	2.14E+01	3.73E-07	1.41E-06	1.07E+02
Pu-241		3.67E+01	3.67E+01	6.75E-07	2.56E-06	
Am-241		3.57E+01	3.57E+01	6.23E-07	2.38E-06	
Cm-244		9.72E+00	9.72E+00	1.70E-07	6.42E-07	
Total Ci	0.00E+00 Ci	2.12E+07 Ci	2.12E+07 Ci	3.70E-01 C/L	1.40E+00 C/Source	
Volume, L		5.73E+07	Liquid Only			
Mass Flow, Kg	7.03E+05	7.18E+07	Liquid Only	1.253 Check		
Sp. Gr., Kg/L		1.25	Liquid Only			
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

File:DSSF0400.WK3

Page: 1

LIGHTLY SHIELDED LLW SHIELDING SOURCE -- DSSF Only (from ASPEN Run)

(DSSF No Pretreatment Source as 6/7/87/88)-WM-TL-763

FOR FLOW STREAM No: 400 (LLW Evaporator Feed Tank)

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14		1.28E+01	1.28E+01	4.73E-02	3.31E-02	3.45E-01
Co-60		6.96E+02	6.96E+02	2.62E+00	1.83E+00	1.91E+01
Sr-90*		9.55E+04	9.55E+04	3.56E+02	2.51E+02	2.62E+03
Y-90*		9.55E+04	9.55E+04	3.56E+02	2.51E+02	2.62E+03
Tc-99		4.59E+03	4.59E+03	1.72E+01	1.26E+01	1.26E+02
I-129		1.01E+01	1.01E+01	3.79E-02	2.65E-02	2.77E-01
Cs-134		8.58E+02	8.58E+02	3.22E+00	2.25E+00	2.35E+01
Cs-137**		1.07E+07	1.07E+07	4.02E+04	2.81E+04	2.94E+05
Ba-137**		1.03E+07	1.03E+07	3.86E+04	2.70E+04	2.82E+05
Eu-154		2.12E+02	2.12E+02	7.95E-01	5.57E-01	5.81E+00
Th-231			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-234			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pa-233			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pa-234			0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-235		1.04E-02	1.04E-02	3.90E-05	2.73E-05	2.85E-04
U-238		1.04E+00	1.04E+00	3.90E-03	2.73E-03	2.85E-02
Np-237		2.37E+01	2.37E+01	8.89E-02	6.22E-02	6.49E-01
Pu-238			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-239***		8.58E+01	8.58E+01	3.21E-01	2.25E-01	2.35E+00
Pu-240***		2.14E+01	2.14E+01	8.03E-02	5.62E-02	5.86E-01
Pu-241		3.87E+01	3.87E+01	1.45E-01	1.02E-01	1.05E+00
Am-241		3.57E+01	3.57E+01	1.34E-01	9.37E-02	9.78E-01
Cm-244		8.72E+00	8.72E+00	3.65E-02	2.55E-02	2.65E-01
Total Ci	0.00E+00 Ci	2.12E+07	2.12E+07	7.95E+04 Ci/m3	5.58E+04 Ci/m3	5.81E+05 Ci/Canister
Volume, L		5.73E+07	Liquid Only			
Mass Flow, Kg	7.03E+05	7.18E+07				
Sp. Grav, Kg/L		1.25	Liquid Only			
Canister Vol		10.44	cubic meters			
Na2O / Na2 = 1.35 Molecular Weight Ratio						
Na Solid(Kg)=	1.00E+05 From Table (Ref)					
Na Liquid(Kg)=	6.05E+06 From Table (Ref)					
Total Na(Kg)=	6.05E+06 Sum of Solid and Liquid					
Total Na2O =	1.78E+05 From Solid Table for Waste, not from above ratio					
@25% = (x4)	7.04E+05 Kg of Glass (25% Sodium Oxide Loading)					
@1000Kg/ton=	704 Metric Tons of Glass					
Glass Density=	2.64 @ 165 lb/ft3					
Glass Volume=	267 cubic meters					
Cullet @70% =	0.70 Packing Fraction					
Cullet Vol =	381 cubic meters					

LIGHTLY SHIELDED LLW SHIELDING SOURCE - DSSF Only (from ASPEN Runs)

(DSSF No Pretreatment Source as of 10/1/95)

FOR FLOW STREAM No: 404 (LLW Feed Evaporator)

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	Ci/Source Note 1	Total Ci Sol / Liq
C-14		1.28E+01	1.28E+01	4.79E-07	1.81E-06	
Co-60		8.98E+02	8.98E+02	2.65E-06	1.00E-04	
Sr-90*		9.55E+04	9.55E+04	3.63E-03	1.37E-02	Sr + Y: 0.00E+00
Y-90*		9.55E+04	9.55E+04	3.63E-03	1.37E-02	1.91E+05
Tc-99		4.58E+03	4.58E+03	1.75E-04	6.61E-04	
I-129		1.01E+01	1.01E+01	3.84E-07	1.45E-06	
Cs-134		8.58E+02	8.58E+02	3.29E-05	1.23E-04	Cs + Ba: 0.00E+00
Cs-137**		1.07E+07	1.07E+07	4.07E-01	1.54E+00	2.10E+07
Ba-137**		1.03E+07	1.03E+07	3.91E-01	1.48E+00	
Eu-154		2.12E+02	2.12E+02	8.05E-08	3.05E-05	
Th-231			0.00E+00	0.00E+00	0.00E+00	
Th-234			0.00E+00	0.00E+00	0.00E+00	
Pa-233			0.00E+00	0.00E+00	0.00E+00	
Pa-234			0.00E+00	0.00E+00	0.00E+00	
U-235		1.04E-02	1.04E-02	3.95E-10	1.50E-09	
U-238		1.04E+00	1.04E+00	3.95E-08	1.50E-07	
Np-237		2.37E+01	2.37E+01	8.01E-07	3.41E-06	
Pu-238			0.00E+00	0.00E+00	0.00E+00	238 + 240: 0.00E+00
Pu-239***		8.58E+01	8.58E+01	3.25E-06	1.23E-05	1.07E+02
Pu-240***		2.14E+01	2.14E+01	8.14E-07	3.08E-06	
Pu-241		3.87E+01	3.87E+01	1.47E-06	5.57E-06	
Am-241		3.57E+01	3.57E+01	1.38E-06	5.14E-06	
Cm-244		9.72E+00	9.72E+00	3.70E-07	1.40E-06	
Total Ci	0.00E+00 Ci	2.12E+07 Ci	2.12E+07 Ci	8.06E-01 C/L	3.06E+00 Ci/Source	
Volume, L		2.63E+07	Liquid Only			
Mass Flow, Kg	7.03E+05	4.08E+07	Liquid Only	1.551 Check		
Sp. Gr., Kg/L		1.55				
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

File:DSSF0404.WK3

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SLIGHTLY SHIELDED LLW SHIELDING SOURCE - DSSF Only (from ASPEN Plus)
 (DSSF No Pretreatment Source as of 8/27/95)
 FOR FLOW STREAM No: 404 (LLW Feed Evaporator)

WMSD-V M-TI-763
 Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14		1.28E+01	1.28E+01	4.73E-02	3.31E-02	3.45E-01
Co-60		8.98E+02	8.98E+02	2.62E+00	1.83E+00	1.91E+01
Sr-90*		9.55E+04	9.55E+04	3.58E+02	2.51E+02	2.62E+03
Y-90*		9.55E+04	9.55E+04	3.58E+02	2.51E+02	2.62E+03
Tc-99		4.59E+03	4.59E+03	1.72E+01	1.20E+01	1.26E+02
I-129		1.01E+01	1.01E+01	3.79E-02	2.65E-02	2.77E-01
Cs-134		8.58E+02	8.58E+02	3.22E+00	2.25E+00	2.35E+01
Cs-137*		1.07E+07	1.07E+07	4.02E+04	2.81E+04	2.94E+05
Ba-137**		1.03E+07	1.03E+07	3.88E+04	2.70E+04	2.82E+05
Eu-154		2.12E+02	2.12E+02	7.95E-01	5.57E-01	5.81E+00
Th-231			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-234			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pa-233			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pa-234			0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-235		1.04E-02	1.04E-02	3.90E-05	2.73E-05	2.85E-04
U-238		1.04E+00	1.04E+00	3.90E-03	2.73E-03	2.85E-02
Np-237		2.37E+01	2.37E+01	8.69E-02	6.22E-02	6.49E-01
Pu-238			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-239***		8.58E+01	8.58E+01	3.21E-01	2.25E-01	2.35E+00
Pu-240***		2.14E+01	2.14E+01	8.03E-02	6.62E-02	5.89E-01
Pu-241		3.87E+01	3.87E+01	1.45E-01	1.02E-01	1.06E+00
Am-241		3.57E+01	3.57E+01	1.34E-01	9.37E-02	9.78E-01
Cm-244		9.72E+00	9.72E+00	3.65E-02	2.55E-02	2.69E-01
Total Ci	0.00E+00 Ci	2.12E+07 Ci	2.12E+07 Ci	7.95E+04 Ci/m3	5.55E+04 Ci/m3	5.81E+05 Ci/Canister
Volume, L		2.63E+07	Liquid Only			
Mass Flow, Kg	7.03E+05	4.08E+07				
Sp. Grav, Kg/L		1.85	Liquid Only 1.551 Check			
Canister Vol.		10.44	cubic meters			
Na2O / Na2 =		1.35	Molecular Weight Ratio			
Na Solid(Kg)=		1.00E-05	From Table (Ref)			
Na Liquid(Kg)=		6.06E+06	From Table (Ref)			
Total Na(Kg)=		6.05E+06	Sum of Solid and Liquid			
Total Na2O =		1.78E+05	From Solid Table for Waste, not from above ratio			
@25% = (x4)		7.04E+05	Kg of Glass (25% Sodium Oxide Loading)			
@1000Kg/ton =		704	Metric Tons of Glass			
Glass Density =		2.64	@ 165 lb/ft3			
Glass Volume =		267	cubic meters			
Cullet @70% =		0.70	Packing Fraction			
Cullet Vol =		381	cubic meters			

LIGHTLY SHIELDED LLW SHIELDING SOURCE - DSSF Only (from ASPEN Huns)

(DSSF No Pretreatment Source as of 10/95) M-TI-763

FOR FLOW STREAM No: 406 (LLW Matter Feed Tank Outlet)

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/Source Note 1	Total Ci Sol / Liq
C-14		1.28E+01	1.28E+01	4.50E-07	1.70E-06	
Co-60		6.98E+02	6.98E+02	2.48E-05	9.44E-05	Sr + Y:
Sr-90*		9.55E+04	9.55E+04	3.41E-03	1.29E-02	0.00E+00
Y-90*		9.55E+04	9.55E+04	3.41E-03	1.29E-02	1.91E+06
Tc-99		4.59E+03	4.59E+03	1.64E-04	6.21E-04	
I-129		1.01E+01	1.01E+01	3.61E-07	1.37E-06	
Cs-134		6.58E+02	6.58E+02	3.08E-05	1.16E-04	Cs + Ba:
Cs-137**		1.07E+07	1.07E+07	3.83E-01	1.49E+00	0.00E+00
Ba-137**		1.03E+07	1.03E+07	3.66E-01	1.39E+00	2.10E+07
Eu-154		2.12E+02	2.12E+02	7.57E-06	2.87E-05	
Th-231			0.00E+00	0.00E+00	0.00E+00	
Th-234			0.00E+00	0.00E+00	0.00E+00	
Pa-233			0.00E+00	0.00E+00	0.00E+00	
Pa-234			0.00E+00	0.00E+00	0.00E+00	
U-235		1.04E-02	1.04E-02	3.71E-10	1.41E-09	
U-238		1.04E+00	1.04E+00	3.71E-08	1.41E-07	
Np-237		2.37E+01	2.37E+01	8.48E-07	3.20E-06	
Pu-238			0.00E+00	0.00E+00	0.00E+00	238 + 240:
Pu-239***		6.56E+01	6.56E+01	3.08E-06	1.16E-05	0.00E+00
Pu-240***		2.14E+01	2.14E+01	7.64E-07	2.89E-06	1.07E+02
Pu-241		3.87E+01	3.87E+01	1.38E-06	5.23E-06	
Am-241		3.57E+01	3.57E+01	1.28E-06	4.83E-06	
Cm-244		9.72E+00	9.72E+00	3.47E-07	1.31E-06	
Total Ci	0.00E+00 Ci	2.12E+07 Ci	2.12E+07 Ci	7.57E-01 Ci/L	2.87E+00 Ci/Source	
Volume, L		2.80E+07	Liquid Only			
Mass Flow, Kg	1.03E+06	4.29E+07	Liquid Only			
Sp. Gr., Kg/L		1.52	1.518 Check			
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 60/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

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LIGHTLY SHIELDED LLW SHIELDING SOURCE - DSSF Only (from ASPEN Runs)

[DSSF No Pretreatment Source as shown]

WM-TL-763

FOR FLOW STREAM No: 406 (LLW Meter Feed Tank Outlet)

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14		1.26E+01	1.26E+01	1.02E-03	7.13E-04	7.45E-03
Co-60		6.98E+02	6.98E+02	5.65E-02	3.95E-02	4.13E-01
Sr-90*		9.55E+04	9.55E+04	7.72E+00	5.41E+00	5.64E+01
Y-90*		9.55E+04	9.55E+04	7.72E+00	5.41E+00	5.64E+01
Tc-99		4.99E+03	4.99E+03	3.71E-01	2.60E-01	2.71E+00
I-129		1.01E+01	1.01E+01	8.17E-04	5.72E-04	5.97E-03
Cs-134		8.98E+02	8.98E+02	6.94E-02	4.66E-02	5.07E-01
Cs-137**		1.07E+07	1.07E+07	8.66E+02	6.06E+02	6.33E+03
Ba-137**		1.03E+07	1.03E+07	8.32E+02	5.83E+02	6.03E+03
Eu-154		2.12E+02	2.12E+02	1.71E-02	1.20E-02	1.25E-01
Th-231			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-234			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pa-233			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pa-234			0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-235		1.04E-02	1.04E-02	8.41E-07	5.89E-07	6.15E-06
U-238		1.04E+00	1.04E+00	8.41E-05	5.89E-05	6.15E-04
Np-237		2.37E+01	2.37E+01	1.92E-03	1.34E-03	1.40E-02
Pu-238			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-239***		8.68E+01	8.68E+01	6.92E-03	4.85E-03	5.06E-02
Pu-240***		2.14E+01	2.14E+01	1.73E-03	1.21E-03	1.26E-02
Pu-241		3.87E+01	3.87E+01	3.13E-03	2.18E-03	2.26E-02
Am-241		3.57E+01	3.57E+01	2.89E-03	2.02E-03	2.11E-02
Cm-244		9.72E+00	9.72E+00	7.66E-04	5.50E-04	5.75E-03
Total Ci	0.00E+00 Ci	2.12E+07 Ci	2.12E+07 Ci	1.71E+03 Ci/m3	1.20E+03 Ci/m3	1.25E+04 Ci/Canister
Volume, L		2.80E+07	Liquid Only			
Mass Flow, Kg	1.03E+08	4.25E+07				
Sp. Grav, Kg/L		1.52	Liquid Only			
Canister Vol.		10.44	cubic meters			
1.35 Molecular Weight Ratio						
Na2O / Na2 =	1.00E+06 From Table (Ref)					
Na Solid(Kg)=	6.05E+06 From Table (Ref)					
Na Liquid(Kg)=	6.05E+06 Sum of Solid and Liquid					
Total Na(Kg)=	8.16E+06 From Solid Table for Stream #437, not from above ratio					
Total Na2O=	3.26E+07 Kg of Glass (25% Sodium Oxide Loading)					
@25% = (x4)	32640 Metric Tons of Glass					
@1000Kg/ton=	2.64 @ 165 lb/ft3					
Glass Density=	12364 cubic meters					
Glass Volume=	0.70 Packing Fraction					
Cullet @70% =	17682 cubic meters					
Cullet Vol =						

LIGHTLY SHIELDED LLW SHIELDING SOURCE - High Blend Only (from ASPEN Runs)
FOR FLOW STREAM No: 400 (LLW Evaporator Feed Tank)

WHC-SD-WM-TI-763

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/Source Note 1	Total Sol / Liq
C-14		2.65E+01	2.65E+01	2.57E-06	9.74E-06	
Co-60	4.62E-02	2.40E+03	2.40E+03	2.33E-04	8.62E-04	Sr + Y:
Sr-90*	1.03E+00	8.75E+06	8.75E+06	8.55E-01	2.48E+00	2.03E+00
Y-90*	1.03E+00	6.75E+06	6.75E+06	6.55E-01	2.48E+00	1.35E+07
To-99	1.03E-02	3.11E+03	3.11E+03	3.02E-04	1.14E-03	
I-129	1.18E-03	7.86E-01	7.86E-01	7.67E-08	2.90E-07	
Cs-134	8.41E-04	1.28E+00	1.28E+00	1.25E-07	4.74E-07	Cs + Ba:
Cs-137**	2.17E+01	6.63E+04	6.63E+04	6.44E-03	2.44E-02	4.25E+01
Ba-137**	2.06E+01	6.37E+04	6.37E+04	6.19E-03	2.34E-02	1.30E+05
Eu-154	5.48E-01	1.67E+04	1.67E+04	1.62E-03	5.14E-03	
Th-231		1.88E+01	1.88E+01	1.83E-06	8.91E-06	
Th-234		2.60E+02	2.60E+02	2.52E-05	9.56E-05	
Pa-233		2.66E+01	2.66E+01	2.58E-06	9.78E-06	
Pa-234		2.69E+02	2.69E+02	2.61E-05	9.52E-05	
U-235	2.90E-06	1.86E+01	1.86E+01	1.83E-06	6.95E-06	
U-238		2.61E+02	2.61E+02	2.53E-05	9.59E-05	
Np-237	1.95E-03	2.66E+01	2.66E+01	2.58E-06	9.78E-06	
Pu-238		6.70E+03	6.70E+03	6.50E-04	2.46E-03	239 + 240:
Pu-239***	6.13E-02	1.50E+04	1.50E+04	1.46E-03	5.53E-03	6.41E-02
Pu-240***	1.28E-02	3.76E+03	3.76E+03	3.65E-04	1.38E-03	1.88E+04
Pu-241	5.56E-01	1.15E+05	1.15E+05	1.12E-02	4.23E-02	
Am-241	4.55E+00	3.35E+05	3.35E+05	3.25E-02	1.23E-01	
Cm-244		7.87E+00	7.87E+00	7.64E-07	2.88E-06	
Total Ci	5.03E+01 Ci	1.41E+07 Ci	1.41E+07 Ci	1.37E+00 C/L	5.18E+00 C/Source	
Volume, L		1.03E+07	Liquid Only			
Mass Flow, Kg	1.06E+05	1.35E+07	Liquid Only	1.214 Check		
Sp. Gr., Kg/L		1.21	Liquid Only			
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 61/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

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Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14		2.65E+01	2.65E+01	8.69E-01	6.08E-01	6.36E+00
Co-60	4.62E-02	2.40E+03	2.40E+03	7.87E+01	5.51E+01	5.75E+02
Sr-90*	1.03E+00	6.75E+06	6.75E+06	2.21E+05	1.55E+05	1.62E+08
Y-90*	1.03E+00	6.75E+06	6.75E+06	2.21E+05	1.55E+05	1.62E+08
Tc-99	1.03E-02	3.11E+03	3.11E+03	1.02E+02	7.14E+01	7.45E+02
I-129	1.18E-03	7.89E-01	7.90E-01	2.59E-02	1.81E-02	1.89E-01
Cs-134	8.41E-04	1.29E+00	1.29E+00	4.23E-02	2.86E-02	3.09E-01
Cs-137**	2.17E+01	6.63E+04	6.63E+04	2.19E+03	1.52E+03	1.59E+04
Ba-137**	2.08E+01	6.37E+04	6.37E+04	2.08E+03	1.46E+03	1.53E+04
Eu-154	5.48E-01	1.67E+04	1.67E+04	5.48E+02	3.83E+02	4.00E+03
Th-231		1.88E+01	1.88E+01	6.17E-01	4.32E-01	4.51E+00
Th-234		2.60E+02	2.60E+02	8.63E+00	5.97E+00	6.23E+01
Pa-233		2.68E+01	2.68E+01	8.72E-01	6.11E-01	6.38E+00
Pa-234		2.58E+02	2.58E+02	8.49E+00	5.95E+00	6.21E+01
U-235	2.90E-06	1.89E+01	1.89E+01	6.20E-01	4.34E-01	4.53E+00
U-238		2.61E+02	2.61E+02	8.58E+00	6.00E+00	6.26E+01
Np-237	1.95E-03	2.66E+01	2.66E+01	8.72E-01	6.11E-01	6.38E+00
Pu-238		6.70E+03	6.70E+03	2.20E+02	1.54E+02	1.61E+03
Pu-239***	5.13E-02	1.50E+04	1.50E+04	4.89E+02	3.45E+02	3.60E+03
Pu-240***	1.28E-02	3.78E+03	3.78E+03	1.23E+02	8.63E+01	9.01E+02
Pu-241	5.56E-01	1.15E+05	1.15E+05	3.77E+03	2.64E+03	2.78E+04
Am-241	4.65E+00	3.35E+05	3.35E+05	1.10E+04	7.69E+03	8.03E+04
Cm-244		7.87E+00	7.87E+00	2.58E-01	1.81E-01	1.89E+00
Total Ci	5.03E+01	1.41E+07	1.41E+07	4.63E+05	3.24E+05	3.38E+08
Volumes, L		1.03E+07	Liquid Only			
Mass Flow, Kg	1.08E+05	1.25E+07				
Sp. Grav, Kg/L		1.21	Liquid Only		1.214 Check	
Canister Vol.		10.44	cubic meters			
Na2O / Na2 = 1.35 Molecular Weight Ratio						
Na Solid(Kg)= 7.61E-01 From Table (Ref)						
Na Liquid(Kg)= 5.65E+05 From Table (Ref)						
Total Na(Kg)= 5.55E+05 Sum of Solid and Liquid						
Total Na2O= 1.61E+04 From Solid Table for Waste, not from above ratio						
@20% = (x5) 8.05E+04 Kg of Glass (20% Sodium Oxide Loading)						
@1000Kg/ton= 81 Metric Tons of Glass						
Glass Density= 2.64 @ 165 lb/ft3						
Glass Volume= 30 cubic meters						
Cullet @70% = 0.70 Packing Fraction						
Cullet Vol = 44 cubic meters						

SLIGHTLY SHIELDED LLW SHIELDING SOURCE - High Bland Only (from ASPEN Run)
FOR FLOW STREAM No: 404 (LLW Feed Evaporator)

WHC-SD-WM-TI-763

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/S Source Note 1	Total Est. Sol / Liq
C-14		2.65E+01	2.65E+01	1.10E-05	4.18E-05	
Co-60	4.62E-02	2.40E+03	2.40E+03	8.66E-04	3.77E-03	Sr + Y:
Sr-90*	1.03E+00	8.75E+06	8.75E+06	2.80E+00	1.05E+01	2.05E+00
Y-90*	1.03E+00	8.75E+06	8.75E+06	2.90E+00	1.06E+01	1.35E+07
Tc-99	1.03E-02	3.11E+03	3.11E+03	1.29E-03	4.88E-03	
I-129	1.18E-03	7.89E-01	7.90E-01	3.28E-07	1.24E-06	
Ce-134	8.41E-04	1.29E+00	1.29E+00	5.36E-07	2.03E-06	Ce + Ba:
Ce-137**	2.17E+01	6.63E+04	6.63E+04	2.75E-02	1.04E-01	4.25E+01
Ba-137**	2.08E+01	6.37E+04	6.37E+04	2.64E-02	1.00E-01	1.30E+05
Eu-154	5.48E-01	1.67E+04	1.67E+04	6.93E-03	2.62E-02	
Th-231		1.88E+01	1.88E+01	7.90E-06	2.95E-05	
Th-234		2.60E+02	2.60E+02	1.08E-04	4.08E-04	
Pa-233		2.66E+01	2.66E+01	1.10E-05	4.18E-05	
Pa-234		2.59E+02	2.59E+02	1.07E-04	4.07E-04	
U-235	2.90E-06	1.89E+01	1.89E+01	7.94E-06	2.97E-05	
U-238		2.61E+02	2.61E+02	1.09E-04	4.10E-04	
Np-237	1.95E-03	2.68E+01	2.68E+01	1.10E-05	4.18E-05	
Pu-239		6.70E+03	6.70E+03	2.78E-03	1.06E-02	239 + 240:
Pu-239***	5.13E-02	1.50E+04	1.50E+04	6.24E-03	2.36E-02	6.41E-02
Pu-240***	1.26E-02	3.76E+03	3.76E+03	1.56E-03	5.91E-03	1.66E+04
Pu-241	5.59E-01	1.15E+05	1.15E+05	4.77E-02	1.81E-01	
Am-241	4.55E+00	3.35E+05	3.35E+05	1.39E-01	5.28E-01	
Cm-244		7.87E+00	7.87E+00	3.27E-06	1.24E-05	
Total Ci	5.03E+01 Ci	1.41E+07 Ci	1.41E+07 Ci	5.86E+00 C/L	2.22E+01 C/S Source	
Volume, L		2.41E+08	Liquid Only			
Mass Flow, Kg	1.05E+05	4.51E+06	Liquid Only			
Sp. Gr., Kg/L		1.91	1.913 Check			
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Ce-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

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Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	CvM3 Glass	CvM3 Cullet	CvM3 Canister
C-14		2.65E+01	2.65E+01	6.59E-01	6.08E-01	6.35E+00
Co-60	4.82E-02	2.40E+03	2.40E+03	7.87E+01	5.51E+01	5.75E+02
Sr-90*	1.03E+00	6.75E+06	6.75E+06	2.21E+05	1.55E+05	1.62E+06
Y-90*	1.03E+00	6.75E+06	6.75E+06	2.21E+05	1.55E+05	1.62E+06
Tc-99	1.03E-02	3.11E+03	3.11E+03	1.02E+02	7.14E+01	7.45E+02
I-129	1.18E-03	7.89E-01	7.90E-01	2.58E-02	1.81E-02	1.89E-01
Cs-134	8.41E-04	1.29E+00	1.29E+00	4.23E-02	2.98E-02	3.09E-01
Cs-137**	2.17E+01	6.63E+04	6.63E+04	2.18E+03	1.52E+03	1.59E+04
Ba-137**	2.08E+01	6.37E+04	6.37E+04	2.09E+03	1.48E+03	1.53E+04
Eu-154	6.48E-01	1.67E+04	1.67E+04	5.48E+02	3.83E+02	4.00E+03
Th-231		1.88E+01	1.88E+01	6.17E-01	4.32E-01	4.51E+00
Th-234		2.80E+02	2.80E+02	8.53E+00	5.97E+00	6.23E+01
Pa-233		2.66E+01	2.66E+01	8.72E-01	8.11E-01	8.38E+00
Pa-234		2.59E+02	2.59E+02	8.49E+00	5.95E+00	6.21E+01
U-235	2.90E-06	1.89E+01	1.89E+01	6.20E-01	4.34E-01	4.53E+00
U-238		2.81E+02	2.81E+02	8.56E+00	5.99E+00	6.28E+01
Np-237	1.85E-03	2.88E+01	2.88E+01	8.72E-01	6.11E-01	6.38E+00
Pu-238		6.70E+03	6.70E+03	2.20E+02	1.54E+02	1.61E+03
Pu-239***	5.13E-02	1.50E+04	1.50E+04	4.93E+02	3.45E+02	3.60E+03
Pu-240***	1.28E-02	3.76E+03	3.76E+03	1.23E+02	8.63E+01	9.01E+02
Pu-241	5.56E-01	1.15E+05	1.15E+05	3.77E+03	2.64E+03	2.76E+04
Am-241	4.55E+00	3.35E+05	3.35E+05	1.10E+04	7.68E+03	7.93E+04
Cm-244		7.87E+00	7.87E+00	2.58E-01	1.81E-01	1.89E+00
Total Ci	5.03E+01	1.41E+07	1.41E+07	4.83E+05	3.24E+05	3.38E+06
Volume, L		2.41E+06	Liquid Only			
Mass Flow, Kg	1.06E+05	4.61E+06				
Sp. Grav, Kg/L		1.91	Liquid Only	1.913	Check	
Canister Vol.		10.44	cubic meters			
Na2O / Na2 =	1.35 Molecular Weight Ratio					
Na Solid(Kg)=	7.61E-01 From Table (Ref)					
Na Liquid(Kg)=	5.55E+05 From Table (Ref)					
Total Na(Kg)=	5.55E+05 Sum of Solid and Liquid					
Total Na2O=	1.81E+04 From Solid Table for Waste, not from above ratio					
@20% = (pS)	8.06E+04 Kg of Glass (20% Sodium Oxide Loading)					
@1000Kg/ton=	81 Metric Tons of Glass					
Glass Density=	2.84 @ 165 lb/m3					
Glass Volume=	30 cubic meters					
Cullet @70% =	0.70 Packing Fraction					
Cullet Vol =	44 cubic meters					

LIGHTLY SHIELDED LLW SHIELDING SOURCE - High Blend Only (from ASPEN Runs)
FOR FLOW STREAM No: 406 (LLW Melter Feed Tank Outlet)

WHC-SD-V M-TL-763

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/S Source Note 1	Total Ci Sol / Liq
C-14		2.65E+01	2.65E+01	9.99E-06	3.77E-05	
Co-60	4.02E-02	2.40E+03	2.40E+03	9.02E-04	3.42E-03	Sr + Y:
Sr-90*	1.03E+00	6.75E+06	6.75E+06	2.54E+00	9.61E+00	2.05E+00
Y-90*	1.03E+00	6.75E+06	6.75E+06	2.54E+00	9.61E+00	1.36E+07
Tc-99	1.03E-02	3.11E+03	3.11E+03	1.17E-03	4.43E-03	
I-129	1.18E-03	7.88E-01	7.90E-01	2.97E-07	1.12E-06	
Cs-134	8.41E-04	1.29E+00	1.29E+00	4.85E-07	1.84E-06	Cs + Ba:
Cs-137**	2.17E+01	6.63E+04	6.63E+04	2.49E-02	9.44E-02	4.25E+01
Ba-137**	2.08E+01	6.37E+04	6.37E+04	2.40E-02	9.07E-02	1.30E+05
Eu-154	5.48E-01	1.67E+04	1.67E+04	8.28E-03	2.38E-02	
Th-231		1.88E+01	1.88E+01	7.07E-06	2.68E-05	
Th-234		2.60E+02	2.60E+02	9.77E-05	3.70E-04	
Pb-233		2.65E+01	2.65E+01	1.00E-05	3.79E-05	
Pa-234		2.59E+02	2.59E+02	9.74E-05	3.69E-04	
U-236	2.90E-06	1.89E+01	1.89E+01	7.11E-06	2.69E-06	
U-238		2.61E+02	2.61E+02	9.81E-05	3.71E-04	
Np-237	1.95E-03	2.68E+01	2.68E+01	1.00E-05	3.79E-05	
Pu-238		6.70E+03	6.70E+03	2.52E-03	9.53E-03	238 + 240:
Pu-239***	6.13E-02	1.50E+04	1.50E+04	5.68E-03	2.14E-02	8.41E-02
Pu-240***	1.28E-02	3.76E+03	3.76E+03	1.41E-03	5.35E-03	1.88E+04
Pu-241	5.61E-01	1.15E+05	1.15E+05	4.32E-02	1.64E-01	
Am-241	4.55E+00	3.35E+05	3.35E+05	1.28E-01	4.77E-01	
Cm-244		7.87E+00	7.87E+00	2.96E-06	1.12E-05	
Total Ci	5.03E+01 Ci	1.41E+07 Ci	1.41E+07 Ci	5.31E+00 C/L	2.01E+01 C/S Source	
Volume, L		2.68E+06	Liquid Only			
Mass Flow, Kg	1.56E+05	4.86E+06				
Sp. Gr., Kg/L		1.83	Liquid Only	1.827 Check		
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 60/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

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Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14		2.65E+01	2.65E+01	5.90E-01	4.13E-01	4.31E+00
Co-60	4.62E-02	2.40E+03	2.40E+03	5.35E-01	3.74E-01	3.91E+02
Sr-90*	1.03E+00	6.75E+06	6.75E+06	1.50E+05	1.05E+05	1.10E+06
Y-90*	1.03E+00	6.75E+06	6.75E+06	1.50E+05	1.05E+05	1.10E+06
Tc-99	1.08E-02	3.11E+03	3.11E+03	6.80E-01	4.85E-01	5.06E+02
I-129	1.18E-03	7.89E-01	7.90E-01	1.78E-02	1.23E-02	1.29E-01
Cs-134	8.41E-04	1.28E+00	1.28E+00	2.88E-02	2.01E-02	2.10E-01
Cs-137**	2.17E+01	6.83E+04	6.83E+04	1.48E+03	1.03E+03	1.08E+04
Ba-137**	2.08E+01	6.37E+04	6.37E+04	1.42E+03	9.94E+02	1.04E+04
Eu-154	5.48E-01	1.67E+04	1.67E+04	3.72E+02	2.60E+02	2.72E+03
Th-231		1.88E+01	1.88E+01	4.19E-01	2.90E-01	3.08E+00
Th-234		2.80E+02	2.80E+02	5.79E+00	4.05E+00	4.23E+01
Pa-233		2.86E+01	2.86E+01	5.83E-01	4.15E-01	4.33E+00
Pa-234		2.59E+02	2.59E+02	5.77E+00	4.04E+00	4.22E+01
U-235	2.90E-06	1.89E+01	1.89E+01	4.21E-01	2.95E-01	3.08E+00
U-238		2.61E+02	2.61E+02	5.81E+00	4.07E+00	4.25E+01
Np-237	1.85E-03	2.66E+01	2.66E+01	5.93E-01	4.15E-01	4.33E+00
Pu-238		6.70E+03	6.70E+03	1.49E+02	1.04E+02	1.09E+03
Pu-239***	5.13E-02	1.50E+04	1.50E+04	3.35E+02	2.35E+02	2.45E+03
Pu-240***	1.28E-02	3.76E+03	3.76E+03	8.38E+01	5.86E+01	6.12E+02
Pu-241	5.81E-01	1.15E+05	1.15E+05	2.56E+03	1.79E+03	1.87E+04
Am-241	4.55E+00	3.35E+05	3.35E+05	7.46E+03	5.22E+03	5.45E+04
Cm-244		7.87E+00	7.87E+00	1.75E-01	1.23E-01	1.29E+00
Total Ci	5.03E+01	1.41E+07	1.41E+07	3.15E+05	2.20E+05	2.30E+06
Volume, L		2.68E+06	Liquid Only			
Mass Flow, Kg	1.56E+05	4.85E+06				
Sp. Grav, Kg/L		1.83	Liquid Only 1.827 Check			
Canister Vol.		10.44	cubic meters			
Na2O / Na2 = 1.35 Molecular Weight Ratio						
Na Solid(Kg)=	7.61E-01	From Table (Ref)				
Na Liquid(Kg)=	5.56E+06	From Table (Ref)				
Total Na(Kg)=	5.56E+06	Sum of Solid and Liquid				
Total Na2O=	2.87E+04	From Solid Table for Waste, not from above ratio				
@20% = (r6)	1.19E+06	Kg of Glass (20% Sodium Oxide Loading)				
@1000Kg/ton=	119	Metric Tons of Glass				
Glass Density=	2.64	@ 165 lb/lb3				
Glass Volume=	45	cubic meters				
Cullet @70% =	0.70	Packing Fraction				
Cullet Vol =	64	cubic meters				

LIGHTLY SHIELDED LLW SHIELDING SOURCE - High Blend Only (from ASPEN Runs)
FOR FLOW STREAM No: 410 (Off-Gas Line at Top of Separator)

WHC-SD-VT-TT-763

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/Sources Note 1	Total Ci Sol / Liq
C-14		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Ca-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Sr + Y: 0.00E+00 0.00E+00
Sr-90*	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Y-90*	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Tc-99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
I-129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Cs-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Cs + Ba: 0.00E+00 0.00E+00
Cs-137**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Ba-137**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Eu-154	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Th-231		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Th-234		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pa-233		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pa-234		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
U-235	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
U-238		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Np-237	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pu-238		0.00E+00	0.00E+00	0.00E+00	0.00E+00	238 + 240: 0.00E+00 0.00E+00
Pu-239***	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pu-240***	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pu-241	5.61E-03	0.00E+00	5.61E-03	1.04E-09	3.85E-09	
Am-241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Cm-244		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Total Ci	5.61E-03 Ci	0.00E+00 Ci	5.61E-03 Ci	1.04E-09 C/L	3.85E-09 C/Sources	
Volume, L		5.37E+06	Liquid Only			
Mass Flow, Kg	5.06E+04	5.37E+06				
Sp. Gr., Kg/L		1.00	Liquid Only 1.000 Check			
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol, assumed attributable to liquid since typically liquid Kg >> solid Kg

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LIGHTLY SHIELDED LLW SHIELDING SOURCE - High Blend Only (from ASPEN Runs)
FOR FLOW STREAM No: 410 (Off-Gas Line at Top of Separator)

WHC-SD-WM-TI-763

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Cm3 Glass	Cm3 Cullet	Cm3 Canister
C-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90*	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y-90*	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tc-99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-137**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ba-137**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Eu-154	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-231		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-234		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pa-233		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pa-234		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-235	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-238		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Np-237	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-238		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-238***	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-240***	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-241	5.61E-03	0.00E+00	5.61E-03	3.84E-04	2.69E-04	2.81E-03
Am-241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cm-244		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total Ci	5.61E-03	0.00E+00	5.61E-03	3.84E-04	2.69E-04	2.81E-03
Volume, L		5.37E+06	Liquid Only			
Mass Flow, Kg	5.09E+04	5.37E+06				
Sp. Grav, Kg/L		1.00	Liquid Only	1.000	Check	
Canister Vol,		10.44	cubic meters			
Na2O / Na2 =	1.35 Molecular Weight Ratio					
Na Solid(Kg)=	0.00E+00 From Table (Ref)					
Na Liquid(Kg)=	0.00E+00 From Table (Ref)					
Total Na(Kg)=	0.00E+00 Sum of Solid and Liquid					
Total Na2O =	7.71E+03 From Solid Table for Waste, not from above ratio					
@20% = (x5)	3.86E+04 Kg of Glass (20% Sodium Oxide Loading)					
@1000Kg/ton=	39 Metric Tons of Glass					
Glass Density=	2.64 @ 165 lb/ft3					
Glass Volume=	15 cubic meters					
Cullet @70% =	0.70 Packing Fraction					
Cullet Vol =	21 cubic meters					

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Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/S Source Note 1	Total Ci Sol / Liq
C-14		0.00E+00	0.00E+00	ERR	ERR	
Co-60	0.00E+00	0.00E+00	0.00E+00	ERR	ERR	
Sr-90*	0.00E+00	0.00E+00	0.00E+00	ERR	ERR	Sr + Y: 0.00E+00
Y-90*	0.00E+00	0.00E+00	0.00E+00	ERR	ERR	0.00E+00
Tc-99	0.00E+00	0.00E+00	0.00E+00	ERR	ERR	
I-129	0.00E+00	0.00E+00	0.00E+00	ERR	ERR	
Cs-134	0.00E+00	0.00E+00	0.00E+00	ERR	ERR	Cs + Ba: 0.00E+00
Cs-137**	0.00E+00	0.00E+00	0.00E+00	ERR	ERR	0.00E+00
Ba-137**	0.00E+00	0.00E+00	0.00E+00	ERR	ERR	0.00E+00
Eu-154	0.00E+00	0.00E+00	0.00E+00	ERR	ERR	
Th-231		0.00E+00	0.00E+00	ERR	ERR	
Th-234		0.00E+00	0.00E+00	ERR	ERR	
Pa-233		0.00E+00	0.00E+00	ERR	ERR	
Pa-234		0.00E+00	0.00E+00	ERR	ERR	
U-235	0.00E+00	0.00E+00	0.00E+00	ERR	ERR	
U-238		0.00E+00	0.00E+00	ERR	ERR	
Np-237	0.00E+00	0.00E+00	0.00E+00	ERR	ERR	
Pu-238		0.00E+00	0.00E+00	ERR	ERR	239 + 240: 0.00E+00
Pu-239***	0.00E+00	0.00E+00	0.00E+00	ERR	ERR	0.00E+00
Pu-240***	0.00E+00	0.00E+00	0.00E+00	ERR	ERR	0.00E+00
Pu-241	5.44E-01	0.00E+00	5.44E-01	ERR	ERR	
Am-241	0.00E+00	0.00E+00	0.00E+00	ERR	ERR	
Cm-244		0.00E+00	0.00E+00	ERR	ERR	
Total Ci	5.44E-01 Ci	0.00E+00 Ci	5.44E-01 Ci	ERR C/L	ERR C/Source	
Volume, L		0.00E+00	Liquid Only			
Mass Flow, Kg	4.63E+06	0.00E+00				
Sp. Gr., Kg/L		0.00	Liquid Only	ERR Check		
Source Vol, L		3.7853	Litre Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90*	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y-90*	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tc-99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-137**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ba-137**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Eu-154	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-231		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-234		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pa-233		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pr-234		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-235	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-238		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Np-237	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-238		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-239***	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-240***	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-241	5.44E-01	0.00E+00	5.44E-01	3.84E-04	2.89E-04	2.81E-03
Am-241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cm-244		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total Ci	5.44E-01	0.00E+00	5.44E-01	3.84E-04	2.89E-04	2.81E-03
Volume, L		0.00E+00	Liquid Only			
Mass Flow, Kg	4.93E+06	0.00E+00				
Sp. Grav, Kg/L		0.00	Liquid Only ERR Check			
Canister Vol.		10.44	cubic meters			
Na2O / Na2 =	1.35 Molecular Weight Ratio					
Na Solid(Kg) =	0.00E+00 From Table (Ref)					
Na Liquid(Kg) =	0.00E+00 From Table (Ref)					
Total Na(Kg) =	0.00E+00 Sum of Solid and Liquid					
Total Na2O =	7.48E+05 From Solid Table for Waste, not from above ratio					
@20% = (p5)	3.74E+05 Kg of Glass (20% Sodium Oxide Loading)					
@1000Kg/ton =	3740 Metric Tons of Glass					
Glass Density =	2.64 @ 165 lb/ft3					
Glass Volume =	1417 cubic meters					
Cullet @70% =	0.70 Packing Fraction					
Cullet Vol =	2024 cubic meters					

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	Ci/Source Note 1	Total Ci Sol/Liq
C-14		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Ca-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Sr + Y: 0.00E+00 0.00E+00
Sr-90*	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Y-90*	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Tc-99	0.00E+00	4.09E+01	4.09E+01	2.90E-03	1.10E-02	
I-129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Cs-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Cs + Ba: 0.00E+00 0.00E+00
Cs-137**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Ba-137**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Eu-154	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Th-231		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Th-234		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pa-233		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pa-234		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
U-235	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
U-238		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Np-237	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pu-238		0.00E+00	0.00E+00	0.00E+00	0.00E+00	239 + 240: 0.00E+00 0.00E+00
Pu-239***	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pu-240***	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pu-241	1.48E-04	0.00E+00	1.48E-04	1.05E-06	3.97E-08	
Am-241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Cm-244		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Total Ci	1.48E-04 Ci	4.09E+01 Ci	4.09E+01 Ci	2.90E-03 C/L	1.10E-02 Ci/Source	
Volume, L		1.41E+04	Liquid Only			
Mass Flow, Kg	1.65E+02	1.41E+04				
Sp. Gr., Kg/L		1.00	Liquid Only 1.000 Check			
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/m3 Glass	C/m3 Cullet	C per Canister
C-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90*	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y-90*	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tc-99	0.00E+00	4.08E+01	4.08E+01	7.37E+02	5.16E+02	5.39E+03
I-129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-137*	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ba-137**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Eu-154	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-231		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-234		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pa-233		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pa-234		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-235	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-238		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Np-237	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-238		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-239***	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-240***	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-241	1.48E-04	0.00E+00	1.48E-04	2.67E-03	1.87E-03	1.95E-02
Am-241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cm-244		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total Ci	1.48E-04	4.08E+01	4.08E+01	7.37E+02	5.16E+02	5.39E+03
Volume, L		1.41E+04	Liquid Only			
Mass Flow, Kg	1.85E+02	1.41E+04				
Sp. Grav, Kg/L		1.00	Liquid Only	1.000	Check	
Canister Vol.		10.44	cubic meters			
Na2O / Na2 =	1.35 Molecular Weight Ratio					
Na Solid(Kg)=	0.00E+00 From Table (Ref)					
Na Liquid(Kg)=	0.00E+00 From Table (Ref)					
Total Na(Kg)=	0.00E+00 Sum of Solid and Liquid					
Total Na2O=	2.93E+01 From Solid Table for Waste, not from above ratio					
@20% = (xS)	1.47E+02 Kg of Glass (20% Sodium Oxide Loading)					
@1000Kg/hon=	0 Metric Tons of Glass					
Glass Density=	2.64 @ 165 lb/ft3					
Glass Volume=	0 cubic meters					
Cullet @70% =	0.70 Packing Fraction					
Cullet Vol =	0 cubic meters					

LIGHTLY SHIELDED LLW SHIELDING SOURCE - High Blend (from ASPEN Plus) SD-YM-TI-763
 (Revised High Blend Source as of 2/24/85)
 FOR FLOW STREAM No: 404 (LLW Feed Evaporator) Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/Source Note 1	Total Ci Sol / Liq
C-14		2.65E+01	2.65E+01	1.10E-05	4.16E-05	
Co-60	4.62E-02	2.40E+03	2.40E+03	9.98E-04	3.77E-03	Sr + Y:
Sr-90*	1.03E+00	6.75E+06	6.75E+06	2.80E+00	1.06E+01	2.05E+00
Y-90*	1.03E+00	6.75E+06	6.75E+06	2.80E+00	1.06E+01	1.35E+07
Tc-99	2.01E+01	3.11E+03	3.13E+03	1.30E-03	4.92E-03	
I-129	1.18E-03	7.89E-01	7.90E-01	3.28E-07	1.24E-06	
Cs-134	8.22E-04	1.29E+00	1.29E+00	5.38E-07	2.03E-06	Cs + Ba:
Cs-137**	2.12E+01	8.48E+04	8.48E+04	2.69E-02	1.02E-01	4.15E+01
Ba-137**	2.03E+01	6.22E+04	6.23E+04	2.58E-02	9.79E-02	1.27E+05
Eu-154	5.48E-01	1.67E+04	1.67E+04	6.93E-03	2.62E-02	
Th-231		1.88E+01	1.88E+01	7.80E-06	2.95E-05	
Th-234		2.60E+02	2.60E+02	1.08E-04	4.08E-04	
Pa-233		2.66E+01	2.66E+01	1.10E-05	4.18E-05	
Pa-234		2.58E+02	2.58E+02	1.07E-04	4.07E-04	
U-235	2.90E-06	1.89E+01	1.89E+01	7.84E-06	2.87E-05	
U-238		1.10E+01	1.10E+01	4.58E-06	1.73E-05	
Np-237	1.95E-03	2.66E+01	2.66E+01	1.10E-05	4.18E-05	
Pu-238		6.70E+03	6.70E+03	2.78E-03	1.05E-02	238 + 240:
Pu-239***	5.13E-02	1.50E+04	1.50E+04	6.21E-03	2.35E-02	6.41E-02
Pu-240***	1.28E-02	3.74E+03	3.74E+03	1.56E-03	5.87E-03	1.87E+04
Pu-241	5.56E-01	1.15E+05	1.15E+05	4.77E-02	1.81E-01	
Am-241	4.55E+00	3.35E+05	3.35E+05	1.38E-01	5.28E-01	
Cm-244		7.86E+00	7.86E+00	3.28E-06	1.23E-05	
Total Ci	6.94E+01 Ci	1.41E+07 Ci	1.41E+07 Ci	5.86E+00 Ci/L	2.22E+01 Ci/Source	
Volume, L		2.41E+06	Liquid Only			
Mass Flow, Kg	6.44E+04	3.60E+06				
Sp. Gr., Kg/L		1.50	Liquid Only	1.494 Check		
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

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LIGHTLY SHIELDED LLW SHIELDING SOURCE - High Blend (from ASPEN Hubs)

[Revised High Blend Source as of 2/24/85]

FOR FLOW STREAM No: 404 (LLW Feed Evaporator)

WRC SD-WM-TI-763

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14		2.65E+01	2.65E+01	1.05E+00	7.60E-01	7.94E+00
Co-60	4.62E-02	2.40E+03	2.40E+03	9.84E+01	8.89E+01	7.19E+02
Sr-90*	1.03E+00	6.75E+06	6.75E+06	2.77E+05	1.94E+05	2.02E+06
Y-90*		6.75E+06	6.75E+06	2.77E+05	1.94E+05	2.02E+06
Tc-99	2.01E+01	3.11E+03	3.13E+03	1.26E+02	8.88E+01	8.38E+02
I-129	1.18E-03	7.89E-01	7.90E-01	3.24E-02	2.27E-02	2.37E-01
Cs-134	8.22E-04	1.29E+00	1.29E+00	5.29E-02	3.70E-02	3.87E-01
Cs-137**	2.12E+01	6.48E+04	6.48E+04	2.66E+03	1.88E+03	1.84E+04
Ba-137**	2.03E+01	6.22E+04	6.23E+04	2.55E+03	1.79E+03	1.86E+04
Eu-154	5.48E-01	1.67E+04	1.67E+04	8.85E+02	4.76E+02	5.00E+03
Th-231		1.88E+01	1.88E+01	7.71E-01	6.39E-01	6.83E+00
Th-234		2.80E+02	2.80E+02	1.07E+01	7.46E+00	7.79E+01
Pa-233		2.66E+01	2.66E+01	1.06E+00	7.43E-01	7.97E+00
Pa-234		2.66E+02	2.66E+02	1.06E+01	7.43E+00	7.78E+01
U-235	2.80E-06	1.86E+01	1.86E+01	7.75E-01	5.42E-01	5.69E+00
U-238		1.10E+01	1.10E+01	4.51E-01	3.16E-01	3.30E+00
Np-237	1.95E-03	2.66E+01	2.66E+01	1.09E+00	7.83E-01	7.97E+00
Pu-238		6.70E+03	6.70E+03	2.75E+02	1.82E+02	2.01E+03
Pu-239***	5.13E-02	1.50E+04	1.50E+04	6.13E+02	4.29E+02	4.48E+03
Pu-240***	1.28E-02	3.74E+03	3.74E+03	1.53E+02	1.07E+02	1.12E+03
Pu-241	5.56E-01	1.15E+05	1.15E+05	4.71E+03	3.30E+03	3.45E+04
Am-241	4.55E+00	3.35E+05	3.35E+05	1.37E+04	9.81E+03	1.00E+05
Cm-244		7.86E+00	7.86E+00	3.22E-01	2.26E-01	2.35E+00
Total Ci	8.94E+01	1.41E+07	1.41E+07	5.79E+05	4.05E+05	4.23E+06
Volume, L		2.41E+05	Liquid Only			
Mass Flow, Kg	8.44E+04	3.80E+06				
Sp. Grav, Kg/L		1.59	Liquid Only	1.494	Check	
Canister Vol.		10.44	cubic meters			
Na2O / Na2 ~	1.35 Molecular Weight Ratio					
Na Solid(Kg)=	7.81E-01 From Table (Ref)					
Na Liquid(Kg)=	5.54E+05 From Table (Ref)					
Total Na(Kg)=	5.54E+05 Sum of Solid and Liquid					
Total Na2O=	1.61E+04 From Solid Table for Waste, not from above ratio					
@25% = (x4)	6.44E+04 Kg of Glass (25% Sodium Oxide Loading)					
@1000Kg/ton=	64 Metric Tons of Glass					
Glass Density=	2.84 @ 165 lb/ft3					
Glass Volume=	24 cubic meters					
Cullet @70% =	3.70 Packing Fraction					
Cullet Vol =	35 cubic meters					

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	CvL Note 1	CvSource Note 1	Total Ci Sol / Liq
C-14		2.65E+01	2.65E+01	1.04E-05	3.82E-05	
Co-60	4.82E-02	2.40E+03	2.40E+03	9.36E-04	3.55E-03	Sr + Y:
Sr-90*	1.03E+00	6.75E+06	6.75E+06	2.64E+00	8.86E+00	2.05E+00
Y-90*	1.03E+00	6.75E+06	6.75E+06	2.64E+00	8.86E+00	1.35E+07
Tc-99	2.85E+01	3.11E+03	3.14E+03	1.22E-03	4.64E-03	
I-129	1.18E-03	7.89E-01	7.90E-01	3.06E-07	1.17E-06	
Ce-134	8.22E-04	1.28E+00	1.28E+00	5.04E-07	1.91E-06	Ce + Ba:
Ce-137**	2.12E+01	6.48E+04	6.48E+04	2.53E-02	9.58E-02	4.15E+01
Ba-137***	2.03E+01	6.22E+04	6.23E+04	2.43E-02	9.20E-02	1.27E+05
Eu-154	5.48E-01	1.67E+04	1.67E+04	6.52E-03	2.47E-02	
Th-231		1.88E+01	1.88E+01	7.34E-06	2.78E-05	
Th-234		2.60E+02	2.60E+02	1.02E-04	3.84E-04	
Pa-233		2.66E+01	2.66E+01	1.04E-05	3.93E-05	
Pa-234		2.58E+02	2.58E+02	1.01E-04	3.83E-04	
U-235	2.80E-06	1.89E+01	1.89E+01	7.38E-06	2.79E-05	
U-238		1.10E+01	1.10E+01	4.30E-06	1.63E-05	
Np-237	1.95E-03	2.66E+01	2.66E+01	1.04E-05	3.93E-05	
Pu-238		6.70E+03	6.70E+03	2.62E-03	8.91E-03	238 + 240:
Pu-239***	5.13E-02	1.50E+04	1.50E+04	5.84E-03	2.21E-02	6.41E-02
Pu-240***	1.28E-02	3.74E+03	3.74E+03	1.48E-03	5.53E-03	1.87E+04
Pu-241	5.61E-01	1.15E+05	1.15E+05	4.48E-02	1.70E-01	
Am-241	4.55E+00	3.35E+05	3.35E+05	1.31E-01	4.95E-01	
Cm-244		7.88E+00	7.88E+00	3.07E-06	1.16E-05	
Total Ci	7.88E+01 Ci	1.41E+07 Ci	1.41E+07 Ci	5.52E+00 CvL	2.09E+01 CvSource	
Volume, L		2.56E+06	Liquid Only			
Mass Flow, Kg	3.45E+04	3.79E+06				
Sp. Gr., Kg/L		1.47	Liquid Only	1.455 Check		
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Ce-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

LIGHTLY SHIELDED LLW SHIELDING SOLARCE - High Blend Only (from ASPEN Runs)

(Revised High Blend Source as of 2/5/95) SD-VTM-T1-763

FOR FLOW STREAM No: 405 (LLW Metal Feed Adjustment Tank)

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/m3 Glass	C/m3 Cullet	Ci per Canister
C-14		2.85E+01	2.85E+01	7.41E-01	5.19E-01	8.42E+00
Co-60	4.62E-02	2.40E+03	2.40E+03	6.71E+01	4.70E+01	4.91E+02
Sr-90*	1.03E+00	6.75E+06	6.75E+06	1.89E+05	1.32E+05	1.36E+06
Y-90*	1.03E+00	6.75E+06	6.75E+06	1.89E+05	1.32E+05	1.36E+06
Tc-99	2.95E+01	3.11E+03	3.14E+03	8.78E+01	6.15E+01	8.42E+02
I-129	1.18E-03	7.89E-01	7.90E-01	2.21E-02	1.55E-02	1.61E-01
Cs-134	8.22E-04	1.29E+00	1.29E+00	3.61E-02	2.53E-02	2.64E-01
Cs-137**	2.12E+01	6.48E+04	6.48E+04	1.81E+03	1.27E+03	1.32E+04
Ba-137**	2.03E+01	6.22E+04	6.23E+04	1.74E+03	1.22E+03	1.27E+04
Eu-154	5.48E-01	1.67E+04	1.67E+04	4.67E+02	3.27E+02	3.41E+03
Th-231		1.88E+01	1.88E+01	5.25E-01	3.68E-01	3.84E+00
Th-234		2.80E+02	2.80E+02	7.27E+00	5.06E+00	5.31E+01
Pa-233		2.66E+01	2.66E+01	7.44E-01	5.21E-01	5.44E+00
Pa-234		2.59E+02	2.59E+02	7.24E+00	5.07E+00	5.29E+01
U-235	2.90E-06	1.89E+01	1.89E+01	6.29E-01	3.70E-01	3.86E+00
U-238		1.10E+01	1.10E+01	3.08E-01	2.16E-01	2.25E+00
Np-237	1.89E-03	2.66E+01	2.66E+01	7.44E-01	5.21E-01	5.44E+00
Pu-238		6.70E+03	6.70E+03	1.87E+02	1.31E+02	1.37E+03
Pu-239***	5.13E-02	1.50E+04	1.50E+04	4.18E+02	2.93E+02	3.06E+03
Pu-240***	1.28E-02	3.74E+03	3.74E+03	1.05E+02	7.32E+01	7.64E+02
Pu-241	5.61E-01	1.15E+05	1.15E+05	3.22E+03	2.25E+03	2.35E+04
Am-241	4.55E+00	3.35E+05	3.35E+05	9.37E+03	6.58E+03	6.85E+04
Cm-244		7.86E+00	7.86E+00	2.20E-01	1.54E-01	1.61E+00
Total Ci	7.68E+01	1.41E+07	1.41E+07	3.95E+05	2.77E+05	2.63E+06
Volume, L		2.55E+06	Liquid Only			
Mass Flow, Kg	9.45E+04	3.75E+08				
Sp. Grav. Kg/L		1.47	Liquid Only	1.465 Check		
Canister Vol.		10.44	cubic meters			
Na2O / Na2 =	1.35 Molecular Weight Ratio					
Na Solid(Kg) =	7.61E-01	From Table (Ref)				
Na Liquid(Kg) =	5.54E+05	From Table (Ref)				
Total Na(Kg) =	5.54E+05	Sum of Solid and Liquid				
Total Na2O =	2.95E+04	From Solid Table for Waste, not from above ratio				
@25% = (x4)	9.44E+04	Kg of Glass (25% Sodium Oxide Loading)				
@1000Kg/ton =	94	Metric Tons of Glass				
Glass Density =	2.54	@ 155 lb/ft3				
Glass Volume =	38	cubic meters				
Cullet @70% =	0.70	Packing Fraction				
Cullet Vol =	51	cubic meters				

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Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/S Source Note 1	Total Ci Sol / Lq
C-14		2.65E+01	2.65E+01	1.04E-05	3.92E-05	
Co-60	4.62E-02	2.40E+03	2.40E+03	8.38E-04	3.55E-03	Sr + Y:
Sr-90*	1.03E+00	8.75E+08	8.75E+08	2.84E+00	9.86E+00	2.05E+00
Y-90*	1.03E+00	8.75E+08	8.75E+08	2.84E+00	9.86E+00	1.35E+07
Tc-99	2.95E+01	3.11E+03	3.14E+03	1.23E-03	4.84E-03	
I-129	1.18E-03	7.89E-01	7.90E-01	3.09E-07	1.17E-06	
Cs-134	8.22E-04	1.28E+00	1.29E+00	5.04E-07	1.91E-06	Cs + Ba:
Cs-137**	2.12E+01	6.48E+04	6.48E+04	2.53E-02	9.58E-02	4.15E+01
Ba-137**	2.03E+01	6.22E+04	6.23E+04	2.43E-02	9.20E-02	1.27E+06
Eu-154	5.48E-01	1.67E+04	1.67E+04	6.52E-03	2.47E-02	
Th-231		1.88E+01	1.88E+01	7.34E-06	2.78E-05	
Th-234		2.60E+02	2.60E+02	1.02E-04	3.84E-04	
Pa-233		2.66E+01	2.66E+01	1.04E-04	3.93E-05	
Pa-234		2.59E+02	2.59E+02	1.01E-04	3.83E-04	
U-236	2.90E-06	1.89E+01	1.89E+01	7.38E-06	2.79E-05	
U-238		1.10E+01	1.10E+01	4.30E-06	1.63E-05	
Np-237	1.86E-03	2.68E+01	2.68E+01	1.04E-06	3.93E-05	
Pu-238		8.70E+03	8.70E+03	2.62E-03	9.91E-03	239 + 240:
Pu-239***	5.13E-02	1.50E+04	1.50E+04	5.84E-03	2.21E-02	6.41E-02
Pu-240***	1.28E-02	3.74E+03	3.74E+03	1.48E-03	5.53E-03	1.87E+04
Pu-241	5.61E-01	1.15E+05	1.15E+05	4.48E-02	1.70E-01	
Am-241	4.55E+00	3.35E+05	3.35E+05	1.31E-01	4.95E-01	
Cm-244		7.86E+00	7.86E+00	3.07E-06	1.18E-05	
Total Ci	7.88E+01 Ci	1.41E+07 Ci	1.41E+07 Ci	5.52E+00 C/L	2.09E+01 C/S Source	
Volume, L		2.56E+06	Liquid Only			
Mass Flow, Kg	9.45E+04	3.75E+06				
Sp. Gr., Kg/L		1.47	Liquid Only	1.455 Check		
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically liquid Kg >> solid Kg

UNSHIELDED LLW SHIELDING SOURCE - High Blend Only (from ASPEN HONS)
 High Blend Source Scaled to 1.0E+6 gal (Revised High Blend Source as of 8/22/00)
 FOR FLOW STREAM No: 406 (LLW Meter Feed Tank Outlet) Revision 0

M-TI-763

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14		2.65E+01	2.65E+01	2.34E-02	1.64E-02	1.71E-01
Co-60	4.82E-02	2.40E+03	2.40E+03	2.12E+00	1.48E+00	1.55E+01
Sr-90*	1.00E+00	8.75E+08	8.75E+08	5.98E+03	4.17E+03	4.36E+04
Y-90*	1.00E+00	8.75E+08	8.75E+08	5.98E+03	4.17E+03	4.36E+04
Tc-99	2.85E+01	3.11E+03	3.14E+03	2.77E+00	1.94E+00	2.03E+01
I-129	1.18E-03	7.89E-01	7.90E-01	6.98E-04	4.89E-04	5.10E-03
Cs-134	8.22E-04	1.29E+00	1.29E+00	1.14E-03	7.98E-04	8.33E-03
Cs-137**	2.12E+01	6.48E+04	6.48E+04	5.72E+01	4.01E+01	4.18E+02
Ba-137**	2.03E+01	6.22E+04	6.23E+04	5.50E+01	3.85E+01	4.02E+02
Eu-154	5.48E-01	1.67E+04	1.67E+04	1.48E+01	1.03E+01	1.08E+02
Th-231		1.88E+01	1.88E+01	1.66E-02	1.16E-02	1.21E-01
Th-234		2.60E+02	2.60E+02	2.30E-01	1.61E-01	1.68E+00
Pa-233		2.68E+01	2.68E+01	2.38E-02	1.68E-02	1.72E-01
Pa-234		2.59E+02	2.59E+02	2.29E-01	1.60E-01	1.67E+00
U-235	2.80E-08	1.89E+01	1.89E+01	1.67E-02	1.17E-02	1.22E-01
U-238		1.10E+01	1.10E+01	8.72E-03	6.80E-03	7.10E-02
Np-237	1.95E-03	2.88E+01	2.88E+01	2.35E-02	1.66E-02	1.72E-01
Pu-238		6.70E+03	6.70E+03	5.92E+00	4.14E+00	4.33E+01
Pu-239***	5.13E-02	1.50E+04	1.50E+04	1.32E+01	9.25E+00	9.66E+01
Pu-240***	1.28E-02	3.74E+03	3.74E+03	3.30E+00	2.31E+00	2.41E+01
Pu-241	6.61E-01	1.15E+05	1.15E+05	1.02E+02	7.11E+01	7.40E+02
Am-241	4.55E+00	3.35E+05	3.35E+05	2.96E+02	2.07E+02	2.16E+03
Cm-244		7.88E+00	7.88E+00	6.94E-03	4.86E-03	5.06E-02
Total Ci	7.88E+01 Ci	1.41E+07 Ci	1.41E+07 Ci	1.25E+04 Ci/m3	8.74E+03 Ci/m3	9.12E+04 Ci/Canister
Volume, L		2.56E+08	Liquid Only			
Mass Flow, Kg	9.45E+04	3.75E+08				
Sp. Grav, Kg/L		1.47	Liquid Only	1.455	Check	
Canister Vol.		10.44	cubic meters			
Na2O / Na2 =	1.35	Molecular Weight Ratio				
Na Solid(Kg)=	7.61E-01	From Table (Ref)				
Na Liquid(Kg)=	5.54E+05	From Table (Ref)				
Total Na(Kg)=	5.54E+05	Sum of Solid and Liquid				
Total Na2O=	7.47E+05	From Solid Table for Stream #437, not from above ratio				
@25% = (x4)	2.99E+06	Kg of Glass (25% Sodium Oxide Loading)				
@100Kg/ton=	2988	Metric Tons of Glass				
Glass Density=	2.84	@ 165 lb/ft3				
Glass Volume=	1132	cubic meters				
Cullet @70% =	0.70	Packing Fraction				
Cullet Vol =	1617	cubic meters				

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	CV/Source Note 1	Total Ci Sol / Liq
C-14	5.38E-05	2.34E+01	2.34E+01	1.16E-05	4.38E-05	Sr + Y: 3.94E+04 1.75E+06
Ca-60	4.63E+01	2.14E+03	2.18E+03	1.08E-03	4.10E-03	
Sr-90*	1.87E+04	8.75E+05	8.85E+05	4.43E-01	1.88E+00	
Y-90*	1.97E+04	8.75E+05	8.85E+05	4.43E-01	1.88E+00	
Tc-99	5.64E+01	4.74E+03	4.80E+03	2.37E-03	8.89E-03	
I-129	2.08E-03	2.04E+00	2.04E+00	1.01E-06	3.83E-06	Cs + Ba: 4.27E+03 1.75E+05
Cs-134	2.65E-02	1.18E+00	1.21E+00	5.87E-07	2.26E-06	
Cs-137**	2.18E+03	8.93E+04	9.14E+04	4.53E-02	1.71E-01	
Ba-137**	2.08E+03	8.56E+04	8.78E+04	4.35E-02	1.65E-01	
Eu-154	3.67E+03	1.70E+05	1.74E+05	8.80E-02	3.25E-01	
Eu-155	6.86E+01	3.18E+03	3.25E+03	1.61E-03	6.06E-03	239 + 240: 1.15E-01 4.30E+00
Th-234		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pa-233		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Pa-234		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
U-236	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
U-238		0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Np-237	5.16E-01	2.35E+00	2.87E+00	1.42E-06	5.37E-06	
Pu-238	3.21E+00	1.46E+02	1.49E+02	7.39E-05	2.80E-04	
Pu-239***	9.20E-02	3.44E+00	3.53E+00	1.75E-06	6.62E-06	
Pu-240***	2.30E-02	8.60E-01	8.83E-01	4.37E-07	1.66E-06	
Pu-241	4.71E+01	2.14E+03	2.19E+03	1.08E-03	4.10E-03	
Am-241	8.43E+01	3.75E+03	3.83E+03	1.90E-03	7.19E-03	
Cm-244	1.90E+00	1.05E+01	1.25E+01	6.19E-06	2.34E-05	
Total Ci	4.76E+04 Ci	2.11E+06 Ci	2.16E+06 Ci	1.07E+00 C/L	4.05E+00 Ci/Source	
Volume, L		2.02E+08	Liquid Only			
Mass Flow, Kg	5.39E+04	3.00E+08	Liquid Only			
Sp. Gr., Kg/L		1.49	Liquid Only			
Source Vol, L		3.7853	Liters Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol assumed attributable to liquid since typically liquid Kg >> solid Kg

FOR FLOW STREAM No: 404 (LLW Feed Evaporator)

Revision 0

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Canister
C-14		2.34E+01	2.34E+01	8.65E-04	6.71E-04	7.61E+00
Co-60	4.63E+01	2.14E+03	2.19E+03	8.98E+01	8.27E+01	6.95E+02
Sr-90*	1.97E+04	8.75E+05	8.95E+05	3.67E+04	2.57E+04	2.68E+05
Y-90*	1.87E+04	8.75E+05	8.95E+05	3.67E+04	2.57E+04	2.68E+05
Tc-99	6.64E+01	4.74E+03	4.80E+03	1.67E+02	1.36E+02	1.44E+03
I-129	2.08E-03	2.04E+00	2.04E+00	8.37E-02	5.66E-02	6.12E-01
Cs-134	2.55E-02	1.16E+00	1.21E+00	4.04E-02	3.48E-02	3.61E-01
Ce-137**	2.16E+03	8.93E+04	9.14E+04	3.75E+03	2.62E+03	2.74E+04
Ba-137**	2.08E+03	8.58E+04	8.78E+04	3.60E+03	2.52E+03	2.63E+04
Eu-154	3.67E+03	1.70E+05	1.74E+05	7.12E+03	4.96E+03	5.20E+04
Th-231		3.18E+03	3.18E+03	1.30E+02	9.13E+01	9.63E+02
Th-234		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pa-233		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pa-234		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-233	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-238		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Np-237	5.16E-01	2.35E+00	2.87E+00	1.17E-01	8.22E-02	8.58E-01
Pu-238		1.46E+02	1.46E+02	5.89E+00	4.19E+00	4.37E+01
Pu-239***	8.20E-02	3.44E+00	3.53E+00	1.45E-01	1.01E-01	1.06E+00
Pu-240***	2.30E-02	8.60E-01	8.83E-01	3.82E-02	2.53E-02	2.65E-01
Pu-241	4.71E+01	2.14E+03	2.18E+03	8.87E+01	8.28E+01	6.55E+02
Am-241	8.43E+01	3.75E+03	3.83E+03	1.57E+02	1.10E+02	1.15E+03
Cm-244		1.06E+01	1.06E+01	4.35E-01	3.04E-01	3.18E+00
Total Ci	4.76E+04	2.11E+06	2.16E+06	8.65E+04	6.10E+04	6.47E+05
Volume, L		2.02E+08	Liquid Only			
Mass Flow, Kg	5.36E+04	3.00E+06				
Sp. Grav, Kg/L		1.49	Liquid Only 1.485 Check			
Canister Vol.		10.44	cubic meters			
Na2O / Na2 = 1.35 Molecular Weight Ratio						
Na Solid(Kg)=	7.61E+01 From Table (Ref)					
Na Liquid(Kg)=	5.54E+05 From Table (Ref)					
Total Na(Kg)=	5.64E+05 Sum of Solid and Liquid					
Total Na2O=	1.81E+04 From Solid Table for Waste, not from above ratio					
@25% =(x4)	8.44E+04 Kg of Glass (25% Sodium Oxide Loading)					
@100Kg/ton=	64 Metric Tons of Glass					
Glass Density=	2.84 @ 185 lb/ft3					
Glass Volume=	24 cubic meters					
Cullet @70% =	0.70 Packing Fraction					
Cullet Vol =	35 cubic meters					

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	C/L Note 1	C/Source Note 1	Total Ci Sol / Liq
C-14		2.85E+01	2.85E+01	1.04E-06	3.92E-05	
Co-60	4.62E-02	2.40E+03	2.40E+03	9.38E-04	3.55E-03	Sr + Y:
Sr-90*	1.03E+00	6.75E+06	6.75E+06	2.64E+00	9.98E+00	2.05E+00
Y-90*	1.03E+00	6.75E+06	6.75E+06	2.64E+00	9.98E+00	1.35E+07
Tc-99	2.85E+01	3.11E+03	3.14E+03	1.23E-03	4.64E-03	
I-129	1.18E-03	7.89E-01	7.90E-01	3.09E-07	1.17E-06	
Cs-134	8.22E-04	1.29E+00	1.29E+00	6.04E-07	1.91E-06	Cs + Ba:
Cs-137**	2.12E+01	6.48E+04	6.48E+04	2.53E-02	8.59E-02	4.15E+01
Ba-137**	2.03E+01	6.22E+04	6.23E+04	2.43E-02	8.20E-02	1.27E+05
Eu-154	5.48E-01	1.87E+04	1.87E+04	6.92E-03	2.47E-02	
Th-231		1.88E+01	1.88E+01	7.34E-06	2.78E-05	
Th-234		2.80E+02	2.80E+02	1.02E-04	3.84E-04	
Pa-233		2.68E+01	2.68E+01	1.04E-05	3.83E-05	
Pa-234		2.58E+02	2.58E+02	1.01E-04	3.83E-04	
U-235	2.90E-06	1.89E+01	1.89E+01	7.38E-06	2.79E-05	
U-238		1.10E+01	1.10E+01	4.30E-06	1.63E-05	
Np-237	1.95E-03	2.86E+01	2.86E+01	1.04E-05	3.83E-05	
Pu-238		6.70E+03	6.70E+03	2.82E-03	9.91E-03	239 + 240:
Pu-239***	5.13E-02	1.50E+04	1.50E+04	5.64E-03	2.21E-02	6.41E-02
Pu-240***	1.28E-02	3.74E+03	3.74E+03	1.48E-03	5.53E-03	1.87E+04
Pu-241	6.61E-01	1.15E+05	1.15E+05	4.48E-02	1.70E-01	
Am-241	4.55E+00	3.35E+05	3.35E+05	1.31E-01	4.95E-01	
Cm-244		7.86E+00	7.86E+00	3.07E-06	1.16E-05	
Total Ci	7.68E+01 Ci	1.41E+07 Ci	1.41E+07 Ci	5.52E+00 C/L	2.09E+01 C/Source	
Volume, L		2.58E+06	Liquid Only			
Mass Flow, Kg	9.45E+04	3.75E+05				
Sp. Gr., Kg/L		1.47	Liquid Only	1.485 Check		
Source Vol, L		3.7853	Uens Equivalent			

* Sr-90 : Y-90 Ratio = 50/50

** Cs-137 : Ba-137 Ratio = 51/49

*** Pu-239 : Pu-240 Ratio = 80/20

Note 1: Source vol. assumed attributable to liquid since typically Liquid Kg >> solid Kg

Input Radionuclides	Solid Ci	Liquid Ci	Total Ci	Ci/m3 Glass	Ci/m3 Cullet	Ci per Source
C-14		2.65E+01	2.65E+01	2.34E-02	1.64E-02	1.76E-03
Co-60	4.62E-02	2.40E+03	2.40E+03	2.12E+00	1.48E+00	1.69E-01
Sr-90*	1.03E+00	6.75E+06	6.75E+06	5.96E+03	4.17E+03	4.47E+02
Y-90*	1.03E+00	6.75E+06	6.75E+06	5.96E+03	4.17E+03	4.47E+02
Tc-99	2.66E+01	3.11E+03	3.14E+03	2.77E+00	1.94E+00	2.08E-01
I-129	1.18E-01	7.89E-01	7.89E-01	8.88E-04	4.89E-04	5.24E-05
Cs-134	8.22E-04	1.29E+00	1.29E+00	1.14E-03	7.88E-04	8.55E-05
Ce-137**	2.12E+01	6.48E+04	6.48E+04	5.72E+01	4.01E+01	4.28E+00
Ba-137**	2.03E+01	6.22E+04	6.22E+04	5.50E+01	3.85E+01	4.12E+00
Eu-154	5.48E-01	1.67E+04	1.67E+04	1.48E+01	1.03E+01	1.11E+00
Th-231		1.68E+01	1.68E+01	1.68E-02	1.16E-02	1.25E-03
Th-234		2.60E+02	2.60E+02	2.30E-01	1.61E-01	1.72E-02
Pa-233		2.68E+01	2.68E+01	2.35E-02	1.65E-02	1.76E-03
Pa-234		2.59E+02	2.59E+02	2.29E-01	1.60E-01	1.72E-02
U-235	2.80E-06	1.89E+01	1.89E+01	1.67E-02	1.17E-02	1.25E-03
U-238		1.10E+01	1.10E+01	9.72E-03	6.80E-03	7.26E-04
Np-237	1.95E-03	2.68E+01	2.68E+01	2.35E-02	1.65E-02	1.76E-03
Pu-238		6.70E+03	6.70E+03	5.82E+00	4.14E+00	4.44E-01
Pu-239***	5.13E-02	1.50E+04	1.50E+04	1.32E+01	9.25E+00	9.81E-01
Pu-240***	1.28E-02	3.74E+03	3.74E+03	3.30E+00	2.31E+00	2.48E-01
Pu-241	5.61E-01	1.15E+05	1.15E+05	1.02E+02	7.11E+01	7.62E+00
Am-241	4.55E+00	3.35E+05	3.35E+05	2.98E+02	2.07E+02	2.22E+01
Cm-244		7.88E+00	7.88E+00	6.94E-03	4.86E-03	5.21E-04
Total Ci	7.88E+01 Ci	1.41E+07 Ci	1.41E+07 Ci	1.25E+04 Ci/m3	8.74E+03 Ci/m3	9.35E+02 Ci/Canister
Volume, L		2.68E+06	Liquid Only			
Mass Flow, Kg	9.45E+04	3.75E+06				
Sp. Grav, Kg/L		1.47	Liquid Only 1.465 Check			
Source Vol.		0.1071	cubic meter Solid Glass: 0.075 OffGas Pipe			
Na2O / Na2 =	1.35 Molecular Weight Ratio					
Na Solid(Kg)=	7.81E-01 From Table (Ref)					
Na Liquid(Kg)=	5.54E+05 From Table (Ref)					
Total Na(Kg)=	5.54E+05 Sum of Solid and Liquid					
Total Na2O=	7.47E+05 From Solid Table for Stream #437, not from above ratio					
@25% = (x4)	2.99E+06 Kg of Glass (25% Sodium Oxide Loading)					
@1000Kg/ton=	2988 Metric Tons of Glass					
Glass Density=	2.64 @ 155 lb/m3					
Glass Volume=	1132 cubic meters					
Cullet @70% =	0.70 Packing Fraction					
Cullet Vol =	1617 cubic meters					

APPENDIX E: Beta Spectra for Selected Sources/Streams

Isotope	Max Energy	"LWY" (1) Comp/L3	Probability "LWY" Beta Per Decay/BetaDec/L3	(1) Note From Reduced Tables Based on ASPEN Code Name
Y-90	2.284E+00	2.340E+02	0.996890	731E+08
Str-90	5.440E+01	3.980E+02	1.000000	732E+08
Ta-90	2.808E+01	1.080E+03	0.999980	3.928E+07
Co-137	8.18E+01	3.240E+02	0.846000	7.040E+08

Y-90

Bin- Energy (MeV)	Dist Func	Avg Dist	Area	Fraction	Avg Energy (MeV)	BetaDec per L3
0.0000	0.0000	0.0000	0.000000	0.000000	0.0000	0.0000
0.1000	0.4000	0.3000	0.000000	0.000000	0.0000	0.0000
0.2000	0.8000	0.6000	0.000000	0.000000	0.0000	0.0000
0.3000	0.6150	0.5075	0.000000	0.000000	0.0000	0.0000
0.4000	0.4000	0.3000	0.000000	0.000000	0.0000	0.0000
0.5000	0.2000	0.1000	0.000000	0.000000	0.0000	0.0000
0.6000	0.1000	0.0500	0.000000	0.000000	0.0000	0.0000
0.7000	0.0500	0.0250	0.000000	0.000000	0.0000	0.0000
0.8000	0.0250	0.0125	0.000000	0.000000	0.0000	0.0000
0.9000	0.0125	0.00625	0.000000	0.000000	0.0000	0.0000
1.0000	0.00625	0.003125	0.000000	0.000000	0.0000	0.0000
1.1000	0.003125	0.0015625	0.000000	0.000000	0.0000	0.0000
1.2000	0.0015625	0.00078125	0.000000	0.000000	0.0000	0.0000
1.3000	0.00078125	0.000390625	0.000000	0.000000	0.0000	0.0000
1.4000	0.000390625	0.0001953125	0.000000	0.000000	0.0000	0.0000
1.5000	0.0001953125	0.00009765625	0.000000	0.000000	0.0000	0.0000
1.6000	0.00009765625	0.000048828125	0.000000	0.000000	0.0000	0.0000
1.7000	0.000048828125	0.0000244140625	0.000000	0.000000	0.0000	0.0000
1.8000	0.0000244140625	0.00001220703125	0.000000	0.000000	0.0000	0.0000
1.9000	0.00001220703125	0.000006103515625	0.000000	0.000000	0.0000	0.0000
2.0000	0.000006103515625	0.0000030517578125	0.000000	0.000000	0.0000	0.0000
2.1000	0.0000030517578125	0.00000152587890625	0.000000	0.000000	0.0000	0.0000
2.2000	0.00000152587890625	0.000000762939453125	0.000000	0.000000	0.0000	0.0000
2.3000	0.000000762939453125	0.0000003814697265625	0.000000	0.000000	0.0000	0.0000
Totals	0.000000	0.000000	0.000000	0.000000	0.0000	0.0000

Str-90

Bin- Energy (MeV)	Dist Func	Avg Dist	Area	Fraction	Avg Energy (MeV)	BetaDec per L3
0.0000	0.0000	0.0000	0.000000	0.000000	0.0000	0.0000
0.1000	2.0000	2.0000	0.000000	0.000000	0.0000	0.0000
0.2000	2.0000	2.0000	0.000000	0.000000	0.0000	0.0000
0.3000	0.0000	0.0000	0.000000	0.000000	0.0000	0.0000
0.4000	0.0000	0.0000	0.000000	0.000000	0.0000	0.0000
0.5000	0.0000	0.0000	0.000000	0.000000	0.0000	0.0000
Totals	0.000000	0.000000	0.000000	0.000000	0.0000	0.0000

Ta-90

Bin- Energy (MeV)	Dist Func	Avg Dist	Area	Fraction	Avg Energy (MeV)	BetaDec per L3
0.0000	7.0000	7.0000	0.000000	0.000000	0.0000	0.0000
0.1000	3.0000	0.4000	0.000000	0.000000	0.0000	0.0000
0.2000	0.0000	1.0000	0.000000	0.000000	0.0000	0.0000
Totals	10.000000	7.000000	1.000000	1.000000	0.0000	0.0000

Co-137

Bin- Energy (MeV)	Dist Func	Avg Dist	Area	Fraction	Avg Energy (MeV)	BetaDec per L3
0.0000	0.0000	0.0000	0.000000	0.000000	0.0000	0.0000
0.1000	2.0000	2.0000	0.000000	0.000000	0.0000	0.0000
0.2000	0.0000	0.0000	0.000000	0.000000	0.0000	0.0000
0.3000	0.0000	0.0000	0.000000	0.000000	0.0000	0.0000
0.4000	0.0000	0.0000	0.000000	0.000000	0.0000	0.0000
0.5000	0.0000	0.0000	0.000000	0.000000	0.0000	0.0000
Totals	7.000000	0.000000	0.000000	0.000000	0.0000	0.0000

File LWYBETAM.WND

RADIOISOTOPE BETA SPECTRA				Total L	3.753	Exp x 10 ⁻¹¹	Exp x 10 ⁻¹¹	Exp x 10 ⁻¹¹	Exp x 10 ⁻¹¹	Exp x 10 ⁻¹¹
Energy	Y-90	Br-80	Ta-90	Cs-137 Spectrum	Ls Equip	Weight(1)	Weight(2)	Weight(3)	Weight(4)	Weight(5)
0.076 3.112E+07	3.415E+06	3.064E+07	3.330E+06	7.562E+06	3.052E+06	2.147E+06	1.610E+07	1.208E+06	9.957E+04	9.957E+04
0.225 9.415E+07	3.080E+06	3.044E+06	2.816E+06	4.837E+06	2.512E+06	6.053E+06	1.272E+06	2.842E+07	8.430E+06	8.430E+06
0.375 7.391E+07	1.804E+06		1.405E+06	3.963E+06	1.611E+06	6.067E+06	1.194E+06	7.870E+07	3.669E+07	3.669E+07
0.525 7.349E+07	4.100E+07		2.422E+07	1.460E+06	6.505E+06	2.901E+06	1.523E+06	7.898E+07	4.187E+07	4.187E+07
0.675 6.287E+07				6.367E+07	3.137E+06	2.117E+06	1.428E+06	9.447E+07	4.512E+07	4.512E+07
0.825 6.362E+07				6.353E+07	3.182E+06	2.809E+06	1.180E+06	1.778E+06	1.465E+06	1.465E+06
0.975 6.387E+07				6.387E+07	3.157E+06	3.044E+06	0.862E+06	2.907E+06	3.358E+06	3.358E+06
1.125 7.849E+07				7.849E+07	3.023E+06	9.401E+06	3.828E+06	2.304E+06	4.842E+06	4.842E+06
1.275 7.384E+07				7.384E+07	3.706E+06	3.894E+06	4.544E+06	5.784E+06	7.387E+06	7.387E+06
1.425 8.549E+07				8.549E+07	3.479E+06	6.930E+06	5.034E+06	7.178E+06	1.922E+06	1.922E+06
1.575 5.460E+07				5.460E+07	3.874E+06	6.267E+06	5.146E+06	6.184E+06	1.270E+06	1.270E+06
1.725 4.110E+07				4.110E+07	1.854E+06	2.844E+06	4.028E+06	7.895E+06	1.377E+06	1.377E+06
1.875 2.839E+07				2.839E+07	9.613E+07	1.800E+06	3.373E+06	5.308E+06	1.189E+06	1.189E+06
2.025 1.100E+07				1.100E+07	4.427E+07	2.894E+07	1.918E+06	3.678E+06	7.444E+06	7.444E+06
2.175 3.007E+06				3.007E+06	1.186E+06	2.473E+07	6.379E+07	1.167E+06	5.346E+06	5.346E+06
				2.870E+06	8.787E+06					
Total				6.731E+06	6.732E+06	3.022E+07	7.840E+06	2.570E+06	3.7853	

NCAW Beta Spectra

Stream #404 [DF=Base, 3.7853 L (1.0 gal)]

Isotope	Mass Energy	"L3N" (%) Current	Previously "L3N" Status Per Decay Scheme (%)	(%) Note	From Reproduced Tables Based on the ASPEN Code Run
Y-90	2.284E+00	4.970E-09	0.936000	1.936E+08	
Y-90	5.480E+01	4.970E-09	1.000000	1.500E+08	
Ta-182	2.938E+01	6.825E-06	0.999990	2.448E+08	
Ca-107	5.116E+01	7.215E-04	0.940000	2.580E+07	

Y=80						
made on the dates on the						
Bin- Energy (MeV)	Det. func.	Arg. Det.	Area	Pradist.	Arg. Energy (MeV)	Residual per %
0.0000	0.3260					
0.1800	0.4420	0.3828	0.067375	0.058253	0.0975	0.0778E+07
0.3600	0.5200	0.4800	0.072900	0.073478	0.2225	1.851E+07
0.5400	0.6400	0.5300	0.062900	0.064194	0.376	1.546E+07
0.7200	0.8150	0.6735	0.066826	0.064468	0.5385	1.638E+07
0.9000	0.9250	0.7620	0.063505	0.064507	0.6776	1.494E+07
1.0800	0.9850	0.8250	0.067760	0.066875	0.8255	1.759E+07
1.2600	0.9180	0.9300	0.050300	0.064140	0.970	1.745E+07
1.4400	0.8806	0.8675	0.068828	0.064468	1.120	1.822E+07
1.6200	0.5250	0.5825	0.063757	0.064577	1.2778	1.886E+07
1.8000	0.4566	0.4900	0.073502	0.075010	1.426	1.570E+07
1.9800	0.3450	0.4100	0.061300	0.062783	1.675	1.614E+07
2.1600	0.2680	0.5076	0.044120	0.047022	1.738	1.854E+06
2.3400	0.1800	0.1800	0.039500	0.039500	1.876	0.449E+06
2.5200	0.0678	0.0678	0.013127	0.013127	2.056	2.480E+06
2.7000	0.0628	0.0628	0.003446	0.003446	2.1768	6.338E+05
Totals	8.449508	8.326500	0.879475	1.000000		1.320E+08

S1=90		S2=90		S3=90		S4=90	
Net Energy (MWh)	Dist. Loss	Avg. Dist.	Area	Perimeter	Avg. Energy (MWh)	Dist./Area per L	Perimeter
0.0000	2.8500						
0.1500	2.8500	2.8500	0.397500	0.381144	0.075	7.783E+07	
0.3000	2.1500	2.8500	0.540000	0.359284	0.025	2.141E+07	
0.4500	0.8500	1.8500	0.510000	0.305648	0.375	3.800E+07	
0.6000	0.0000	0.8500	0.645000	0.441970	0.025	4.021E+08	
Total	4.100000	4.750000	1.018280	0.800000		4.05E+08	

T-100						
Rate (Energy Dollars)	Cost Rate	Avg. Cost	Delta	Reaction	Avg. Energy (MWh)	Delta/Sec per t
0.0000	7.8000					
0.1000	3.1000	\$ 4800	0.817500	0.779857	3.075	1.305E+06
0.3000	0.1000	1.8800	0.332500	0.321429	0.325	5.494E+06
Total	10.000000	7.000000	1.000000	1.000000		

On-157						
Bin-Energy (MeV)	Dark Run	Avg. Dark	Area	Fraction	Avg. Energy (MeV)	Mass/Frac. per L
0.0000	2.3500					
0.1800	2.8500	0.7500	0.412500	0.424710	0.095	0.0075+0.07
0.3000	5.0000	2.3500	0.344750	0.358070	0.338	0.3475+0.08
0.4500	0.6000	1.8000	0.360000	0.365300	0.378	0.3475+0.08
0.6000	0.0000	0.0000	0.000000	0.000000	0.000	0.0000+0.00
Totals	7.800000	5.475000	0.912500	1.000000		2.8637+0.07

RADIOISOTOPE BETA SPECTRA				Total	3.7853 Engr x E ¹¹ Engr x E ¹² Engr x E ¹³ Engr x E ¹⁴				Real
Energy	Y-90	Sr-90	Ti-99	Os-137 Spectrum	L/Equip	Weight(1)	Weight(2)	Weight(3)	Weight(4)
0.075 1.077E+07 7.103E+07 1.907E+08 1.007E+07 0.547E+07 3.814E+08 3.740E+07 2.003E+06 1.825E+05 1.405E+04									
0.225 1.301E+07 0.514E+07 0.424E+05 1.187E+06 0.838E+07 3.346E+08 7.537E+07 1.894E+07 3.911E+06 0.874E+05									
0.375 1.546E+07 0.800E+07 4.742E+08 5.822E+07 2.204E+08 8.256E+07 3.004E+07 1.182E+07 4.358E+06									
0.525 1.682E+07 1.821E+08 7.802E+05 2.843E+07 1.000E+09 5.258E+07 2.757E+07 1.448E+07 7.802E+06									
0.675 1.748E+07 1.748E+07 1.748E+07 0.800E+07 0.480E+07 3.070E+07 2.032E+07 1.271E+07									
0.825 1.788E+07 1.788E+07 1.788E+07 0.800E+07 0.480E+07 3.070E+07 2.032E+07 1.271E+07									
0.975 1.748E+07 1.748E+07 1.748E+07 0.800E+07 0.480E+07 3.070E+07 2.032E+07 1.271E+07									
1.125 1.682E+07 1.682E+07 1.682E+07 0.800E+07 0.480E+07 3.070E+07 2.032E+07 1.271E+07									
1.275 1.556E+07 1.556E+07 1.556E+07 0.800E+07 0.480E+07 3.070E+07 2.032E+07 1.271E+07									
1.425 1.378E+07 1.378E+07 1.378E+07 0.800E+07 0.480E+07 3.070E+07 2.032E+07 1.271E+07									
1.575 1.164E+07 1.164E+07 1.164E+07 0.800E+07 0.480E+07 3.070E+07 2.032E+07 1.271E+07									
1.725 0.800E+06 0.800E+06 0.800E+06 0.800E+06 0.800E+06 0.800E+06 0.800E+06 0.800E+06									
1.875 0.240E+06 0.240E+06 0.240E+06 0.240E+06 0.240E+06 0.240E+06 0.240E+06 0.240E+06									
2.025 0.483E+06 0.483E+06 0.483E+06 0.483E+06 0.483E+06 0.483E+06 0.483E+06 0.483E+06									
2.175 0.283E+05 0.283E+05 0.283E+05 0.283E+05 0.283E+05 0.283E+05 0.283E+05 0.283E+05									
2.175 0.283E+05									
				3.958E+06 1.484E+06					
				1.658E+06 1.396E+06 2.440E+06 2.562E+07 3.864E+06 3.7853					

Nom Waste Beta Spectra

Stream #404 [DF=Base, 3.7853 L (1.0 gal)]

Isotope	Max Energy	LLW (%)	Probability	LLW Beta Per Decay Beta/sec/L3	(1) Note From Reduced Tables Based on ASPEN Code Runs
Y-90	2.284E+00	0.140E+02	0.934980	2.272E+08	
Str-90	2.466E+01	0.143E+02	1.000000	2.272E+08	
Ta-90	2.808E+01	7.786E+04	0.934980	2.807E+07	
Co-137	5.191E+01	2.570E+03	0.940000	7.245E+07	

Y-90					
Bin Energy (MeV)	Count/sec	Avg Dose	Area	Fraction	Avg Energy (MeV) Beta/sec per L3
0.0000	0.3250				
0.1800	0.4400	0.360E	0.06737E	0.0866E3	0.07E 1.330E+08
0.3600	0.5200	0.4800	0.072000	0.07347E	0.22E 1.420E+08
0.4600	0.5800	0.5200	0.042800	0.04410E	0.37E 1.510E+08
0.8000	0.6150	0.587E	0.03682E	0.03748E	0.52E 2.070E+08
0.7500	0.6280	0.6200	0.040000	0.04040E	0.47E 2.140E+08
0.8000	0.6250	0.6250	0.040750	0.04067E	0.42E 2.175E+08
1.0500	0.6180	0.6200	0.040000	0.04040E	0.37E 2.160E+08
1.2000	0.5800	0.597E	0.03682E	0.03748E	1.12E 2.070E+08
1.2800	0.5280	0.552E	0.03287E	0.03407E	1.27E 1.921E+08
1.8000	0.4500	0.4800	0.072500	0.07361E	1.42E 1.740E+08
1.8800	0.3880	0.4100	0.041600	0.04278E	1.57E 1.625E+08
1.8000	0.2300	0.237E	0.04112E	0.04170E	1.72E 1.640E+08
1.9800	0.1300	0.1800	0.036800	0.03680E	1.87E 1.597E+07
2.1000	0.0400	0.047E	0.01312E	0.01332E	2.02E 1.615E+07
2.2850	0.0000	0.000E	0.00000E	0.00000E	2.172E 1.605E+08
Totals					2.272E+08

Str-90					
Bin Energy (MeV)	Count/sec	Avg Dose	Area	Fraction	Avg Energy (MeV) Beta/sec per L3
0.0000	2.6500				
0.1800	2.6500	2.650E	0.387500	0.38154E	0.07E 0.840E+08
0.3600	2.1800	2.400E	0.380000	0.35424E	0.22E 0.948E+08
0.4600	0.6500	1.400E	0.240000	0.20684E	0.37E 1.040E+08
0.8000	0.0000	0.3250	0.040750	0.040750	0.32E 1.090E+08
Totals					2.272E+08

Ta-90					
Bin Energy (MeV)	Count/sec	Avg Dose	Area	Fraction	Avg Energy (MeV) Beta/sec per L3
0.0000	7.8000				
0.1500	5.1000	5.400E	0.817500	0.77987E	0.02E 2.333E+07
0.3000	0.0000	1.860E	0.230800	0.28142E	0.22E 0.349E+08
Totals					2.807E+07

Co-137					
Bin Energy (MeV)	Count/sec	Avg Dose	Area	Fraction	Avg Energy (MeV) Beta/sec per L3
0.0000	2.8500				
0.1800	2.0500	0.7500	0.432500	0.42671E	0.02E 0.872E+07
0.3600	2.6000	2.320E	0.346750	0.33873E	0.22E 2.802E+07
0.4500	0.4000	1.200E	0.180000	0.18832E	0.37E 1.340E+07
0.8000	0.0000	0.500E	0.030000	0.03088E	0.42E 2.286E+08
Totals					7.245E+07

File: LWR02744.WM2

Isotope	Max Energy	LLW (%) Curve/L3	Probability Per Decay	LLW Basis Beta/sec/L3	(?) Note From Reduced Table Based on ASPEN Code Name
Y-90	2.284E+00	7.460E-06	0.889890	2.797E+00	
Y-90	5.480E-01	7.460E-06	1.800000	2.788E+00	
Y-90	2.538E-01	2.270E-06	0.889890	1.240E+00	
Ca-137	5.118E-01	4.300E-04	0.889890	1.605E+00	

Y-90

Beta Energy (MeV)	Dist/L3	Avg Dist	Area	Fraction	Avg Energy (MeV)	Beta/sec per L3
0.0000	0.8285					
0.1800	0.4460	0.8828	0.067878	0.068523	0.076	1.880E+04
0.3000	0.8200	0.4800	0.072000	0.073479	0.200	2.863E+04
0.4500	0.8400	0.4800	0.069000	0.069184	0.300	2.300E+04
0.5000	0.8130	0.8878	0.088826	0.091488	0.425	2.831E+04
0.7500	0.8260	0.8260	0.085000	0.084930	0.478	2.836E+04
0.9000	0.8250	0.8250	0.085750	0.085876	0.608	3.888E+04
1.0500	0.8160	0.8500	0.086000	0.084410	0.870	2.826E+04
1.2000	0.8000	0.8078	0.086625	0.081408	1.185	2.831E+04
1.3500	0.8350	0.8320	0.088878	0.084577	1.278	2.840E+04
1.5000	0.8680	0.8680	0.079600	0.075090	1.425	2.079E+04
1.6500	0.8850	0.8100	0.061000	0.062783	1.675	1.707E+04
1.8000	0.8500	0.8078	0.048124	0.047072	1.725	1.808E+04
1.9500	0.1800	0.1800	0.028500	0.028045	1.878	0.040E+03
2.1000	0.0480	0.0478	0.018124	0.018888	2.025	3.707E+03
2.2400	0.0000	0.0225	0.008878	0.008444	2.1725	0.031E+03
Totals	0.895000	0.530800	0.978878	1.000000		2.780E+05

Sr-90

Beta Energy (MeV)	Dist/L3	Avg Dist	Area	Fraction	Avg Energy (MeV)	Beta/sec per L3
0.0000	2.4500					
0.1800	2.8500	2.8500	0.387000	0.391144	0.078	1.082E+00
0.3000	2.7600	2.4000	0.380000	0.384244	0.225	0.804E+04
0.4500	0.4500	1.4000	0.200000	0.204842	0.375	5.718E+04
0.6000	0.6000	0.3200	0.048750	0.047870	0.628	1.308E+04
Totals	0.100000	0.770000	0.940250	1.000000		2.780E+00

Ta-99

Beta Energy (MeV)	Dist/L3	Avg Dist	Area	Fraction	Avg Energy (MeV)	Beta/sec per L3
0.0000	7.8000					
0.1800	3.1000	5.4500	0.817500	0.778571	0.076	0.430E+01
0.3000	0.9000	1.0500	0.022000	0.021428	0.205	0.878E+01
Totals	10.800000	7.000000	1.060000	1.000000		1.210E+00

Ca-137

Beta Energy (MeV)	Dist/L3	Avg Dist	Area	Fraction	Avg Energy (MeV)	Beta/sec per L3
0.0000	2.8800					
0.1800	0.8300	2.7800	0.412800	0.424730	0.075	0.380E+00
0.3000	2.0000	2.3300	0.348000	0.358073	0.225	0.404E+00
0.4500	0.4000	1.2000	0.180000	0.185328	0.375	2.788E+00
0.6000	0.0000	0.2000	0.020000	0.020888	0.625	0.848E+00
Totals	7.900000	5.470000	0.971800	1.000000		1.590E+00

[illegible]

Isotope	Aux Energy	LJW (d) Outlets	Probability Per Decay	LJW Beta Beta/sec/L	(d) Note From Reduced Tables Based on ASPEN Code Pass
Y-90	2.284E+00	3.430E+09	0.000000	1.343E+06	
Str-90	5.489E+01	3.839E+09	1.000000	3.432E+06	
Yt-90	2.000E+01	1.760E+04	0.000000	6.476E+06	
Ce-137	6.116E+01	4.070E+01	0.000000	1.425E+10	

Y-90					
Beta Energy (MeV)	Outlets	Avg Dist	Area	Fraction	Avg Energy (MeV) Beta/sec per L
0.0000	0.3250				
0.1800	0.4400	0.3626	0.097375	0.000533	0.075 7.843E+06
0.3000	0.6000	0.4800	0.072000	0.073473	0.225 8.869E+06
0.4800	0.5800	0.5500	0.062500	0.061184	0.375 1.121E+07
0.8000	0.6150	0.5875	0.048625	0.047484	0.600 1.233E+07
0.7500	0.6250	0.6200	0.039000	0.038410	0.675 1.275E+07
0.8000	0.6200	0.6200	0.000780	0.000675	0.680 1.283E+07
1.0500	0.6100	0.6200	0.000000	0.000000	0.975 1.275E+07
1.2000	0.6000	0.5875	0.000025	0.000008	1.125 1.239E+07
1.3600	0.6200	0.6625	0.000075	0.000077	1.275 1.130E+07
1.5000	0.4350	0.4900	0.073800	0.070810	1.425 1.007E+07
1.6500	0.5650	0.4100	0.000000	0.000000	1.675 8.429E+06
1.8000	0.5500	0.3075	0.048125	0.047072	1.725 8.322E+06
1.9500	0.1350	0.1625	0.000000	0.000000	1.875 3.800E+06
2.1000	0.0450	0.0875	0.010100	0.010000	2.025 1.789E+06
2.2450	0.0000	0.0000	0.000000	0.000000	2.175 4.600E+05
Totals	0.000000	0.552500	0.073875	1.000000	1.343E+06

Str-90					
Beta Energy (MeV)	Outlets	Avg Dist	Area	Fraction	Avg Energy (MeV) Beta/sec per L
0.0000	2.5000				
0.1500	2.5500	2.5500	0.007500	0.001144	0.075 6.269E+07
0.3000	2.1600	2.4000	0.000000	0.000000	0.225 4.754E+07
0.4500	0.0000	1.4000	0.210000	0.238842	0.375 2.776E+07
0.6000	0.0000	0.3250	0.048750	0.047870	0.625 6.443E+06
Totals	0.100000	0.775000	0.016250	1.000000	1.343E+06

Yt-90					
Beta Energy (MeV)	Outlets	Avg Dist	Area	Fraction	Avg Energy (MeV) Beta/sec per L
0.0000	7.8000				
0.1500	0.1000	0.4500	0.017500	0.776971	0.075 8.041E+06
0.3000	0.8000	1.8500	0.238500	0.021428	0.225 1.434E+06
Totals	10.000000	7.000000	1.000000	1.000000	6.476E+06

Ce-137					
Beta Energy (MeV)	Outlets	Avg Dist	Area	Fraction	Avg Energy (MeV) Beta/sec per L
0.0000	2.8500				
0.1800	2.8500	2.7500	0.412500	0.424760	0.075 0.059E+09
0.3000	2.8500	2.3500	0.348750	0.348073	0.225 5.196E+08
0.4800	0.4500	1.2500	0.180000	0.163023	0.375 2.840E+08
0.8000	0.0000	0.3500	0.050000	0.050000	0.625 4.600E+08
Totals	7.000000	0.475000	0.971250	1.000000	1.425E+10

File: LJW2BETA.WKS

RADIOCESTOPIUM DATA SUMMARY				Technetium				RADIOCESTOPIUM DATA SUMMARY				Technetium						
Energy	Y-80	Se-80	Ta-80	Ce-137	Sum	Energy	Y-80	Se-80	Ta-80	Ce-137	Sum	Energy	Y-80	Se-80	Ta-80	Ce-137	Sum	
0.075	7.80E+06	6.25E+07	3.04E+08	4.05E+09	5.11E+09	2.31E+10	7.70E+09	3.00E+09	7.70E+09	7.70E+09	7.70E+09	0.075	7.80E+06	6.25E+07	3.04E+08	4.05E+09	5.11E+09	2.31E+10
0.238	0.00E+00	7.78E+07	1.34E+08	1.10E+09	6.17E+08	1.80E+09	4.40E+09	0.00E+00	2.20E+09	2.20E+09	2.20E+09	0.238	0.00E+00	7.78E+07	1.34E+08	1.10E+09	6.17E+08	1.80E+09
0.376	1.31E+07	2.77E+07	2.87E+08	1.04E+09	3.00E+09	4.40E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	0.376	1.31E+07	2.77E+07	2.87E+08	1.04E+09	3.00E+09	4.40E+09
0.528	1.20E+07	6.45E+08	4.40E+09	1.17E+09	4.78E+09	5.21E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	0.528	1.20E+07	6.45E+08	4.40E+09	1.17E+09	4.78E+09	5.21E+09
0.678	1.07E+07	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	0.678	1.07E+07	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09
0.805	1.20E+07	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	0.805	1.20E+07	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09
0.970	1.27E+07	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	0.970	1.27E+07	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09
1.128	1.20E+07	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	1.128	1.20E+07	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09
1.376	1.10E+07	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	1.376	1.10E+07	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09
1.452	1.07E+07	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	1.452	1.07E+07	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09
1.578	0.43E+09	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	1.578	0.43E+09	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09
1.708	0.30E+09	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	1.708	0.30E+09	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09
2.025	0.30E+09	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.025	0.30E+09	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09
2.178E+06	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.178E+06	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09	1.40E+09
2.172E+06	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.172E+06	4.30E+08	3.30E+09	2.30E+09	1.00E+09	1.40E+09	1.40E+09

DSSF Beta Spectra

Stream #404 [DF=Base, 3.7853 L (1.0 gal)]

Isotope	Max Energy	LLW (%) Cutoffs	Probability	LLW Beta Per Decay Beta Spec/L	(%) Note From Reactor Table Based on ASPEN Code Run
Y-90	0.224E+03	2.600E+00	0.999980	0.000E+11	
Str-90	0.480E+01	2.600E+00	0.000000	0.000E+11	
Te-98	0.000E+01	1.000E+03	0.999980	0.000E+07	
Cs-137	0.116E+01	2.600E+02	0.940000	0.418E+08	

Y-90

Beta Energy (MeV)	Dist/Sec	Avg Dist	Area	Fraction	Avg Energy (MeV)	Beta/sec per L
0.0000	0.3250					
0.1500	0.4000	0.0000	0.007076	0.000053	0.075	0.000E+00
0.3000	0.3200	0.4000	0.070000	0.073478	0.225	7.812E+00
0.4500	0.0400	0.0000	0.002500	0.004180	0.375	0.722E+00
0.6000	0.0150	0.0000	0.000000	0.001440	0.450	0.475E+00
0.7500	0.0050	0.0000	0.000000	0.000010	0.475	0.000E+00
0.9000	0.0000	0.0000	0.000000	0.000000	0.450	0.000E+00
1.0500	0.0000	0.0000	0.000000	0.000000	0.375	0.000E+00
1.2000	0.0000	0.0000	0.000000	0.000000	0.225	0.000E+00
1.3500	0.0000	0.0000	0.000000	0.000000	0.075	0.000E+00
1.5000	0.0000	0.0000	0.000000	0.000000	0.000	0.000E+00
1.6500	0.0000	0.0000	0.000000	0.000000	0.000	0.000E+00
1.8000	0.0000	0.0000	0.000000	0.000000	0.000	0.000E+00
1.9500	0.0000	0.0000	0.000000	0.000000	0.000	0.000E+00
2.1000	0.0000	0.0000	0.000000	0.000000	0.000	0.000E+00
2.2500	0.0000	0.0000	0.000000	0.000000	0.000	0.000E+00
Totals	0.000000	0.000000	0.000000	1.000000		1.000E+11

Str-90

Beta Energy (MeV)	Dist/Sec	Avg Dist	Area	Fraction	Avg Energy (MeV)	Beta/sec per L
0.0000	0.0000					
0.1500	0.0000	0.0000	0.000000	0.000000	0.075	0.000E+10
0.3000	0.0000	0.0000	0.000000	0.000000	0.225	0.000E+10
0.4500	0.0000	0.0000	0.000000	0.000000	0.375	0.000E+10
0.6000	0.0000	0.0000	0.000000	0.000000	0.450	0.000E+10
Totals	0.000000	0.000000	0.000000	1.000000		1.000E+11

Te-98

Beta Energy (MeV)	Dist/Sec	Avg Dist	Area	Fraction	Avg Energy (MeV)	Beta/sec per L
0.0000	7.0000					
0.1500	0.0000	0.0000	0.000000	0.000000	0.075	0.000E+07
0.3000	0.0000	0.0000	0.000000	0.000000	0.225	0.000E+07
Totals	0.000000	0.000000	0.000000	1.000000		0.000E+07

Cs-137

Beta Energy (MeV)	Dist/Sec	Avg Dist	Area	Fraction	Avg Energy (MeV)	Beta/sec per L
0.0000	2.0000					
0.1500	0.0000	0.0000	0.000000	0.000000	0.075	0.000E+08
0.3000	0.0000	0.0000	0.000000	0.000000	0.225	0.000E+08
0.4500	0.0000	0.0000	0.000000	0.000000	0.375	0.000E+08
0.6000	0.0000	0.0000	0.000000	0.000000	0.450	0.000E+07
Totals	0.000000	0.000000	0.000000	1.000000		0.000E+08

File: LSWBETA.m

RADIOISOTOPE BETA SPECTRA				Total	3.7853 L Equiv	3.7853 L Equiv	3.7853 L Equiv	3.7853 L Equiv	3.7853 L Equiv
Energy	Y-90	Sr-90	Ti-90	Ca-137 Spectrum	L Equiv	Weight(1)	Weight(2)	Weight(3)	Weight(4)
0.075 5.085E+00	0.060E+10	3.745E+07	3.995E+08	4.705E+10	1.790E+11	1.205E+10	1.025E+08	7.510E+07	5.530E+08
0.225 7.912E+08	3.870E+10	1.085E+07	3.395E+08	4.485E+10	1.885E+11	3.884E+10	1.884E+08	1.928E+08	4.330E+08
0.375 0.725E+08	2.141E+10			1.745E+08	3.130E+10	1.147E+11	4.300E+10	1.613E+10	5.040E+08
0.525 0.475E+08	4.570E+09			0.300E+07	1.447E+10	5.470E+10	2.870E+10	1.510E+10	7.400E+08
0.675 0.330E+08					0.532E+08	3.720E+10	2.512E+10	1.880E+10	1.145E+10
0.825 0.171E+08					0.111E+09	1.750E+10	3.880E+10	0.683E+10	0.107E+10
0.975 0.330E+08					0.332E+09	1.720E+10	3.420E+10	3.830E+10	3.440E+10
1.125 0.470E+08					0.470E+08	3.880E+10	4.020E+10	4.530E+10	3.107E+10
1.275 0.781E+08					0.781E+08	3.240E+10	4.220E+10	5.381E+10	4.070E+10
1.425 0.770E+08					0.770E+08	3.841E+10	4.181E+10	5.870E+10	3.811E+10
1.575 0.500E+08					0.500E+08	2.461E+10	3.070E+10	1.060E+10	0.616E+10
1.725 0.570E+08					0.570E+08	1.648E+10	0.184E+10	0.490E+10	0.474E+10
1.875 0.136E+08					0.136E+08	1.140E+10	0.104E+10	0.008E+10	7.510E+10
2.025 1.344E+08					1.344E+08	0.000E+08	1.084E+10	0.184E+10	0.480E+10
2.175 3.396E+08					3.396E+08	1.261E+08	0.000E+08	0.374E+08	1.080E+10
				2.042E+11	2.880E+11				
Total				1.096E+11	1.096E+11	4.610E+07	9.418E+06	2.080E+11	3.7853

High Blend Beta Spectra

Stream #404 [DF=Base, 3.7853 L (1.0 gal)]

MICROBETA II BETA SPECTRA				Total		3.7853 Solp = E**1 Solp = E**2 Solp = E**3 Solp = E**4 Solp = E**5		DIVISION 0	
Energy	Y-80	Sr-90	Tc-99	De-137 Spectrum	L, E, Solp	Weight(1)	Weight(2)	Weight(3)	Weight(4)
0.075 0.808E+06	6.411E+09	0.827E+07	0.734E+08	0.113E+09	3.071E+10	2.302E+09	1.727E+09	1.288E+07	0.718E+05
0.225 1.504E+08	5.308E+08	1.841E+07	5.052E+08	7.898E+09	2.077E+10	5.470E+09	1.468E+09	5.277E+08	7.372E+07
0.375 3.380E+08	3.367E+08		2.939E+08	9.081E+09	1.918E+10	7.784E+09	2.094E+09	1.010E+09	3.789E+08
0.525 1.498E+08	7.828E+08		4.896E+07	2.334E+08	5.038E+09	4.930E+09	2.433E+09	1.278E+09	6.713E+08
0.675 1.833E+08			1.093E+08	5.063E+08	3.974E+09	2.843E+09	1.811E+09	1.322E+08	
0.825 1.848E+08			1.549E+08	5.389E+08	4.887E+09	4.940E+09	3.203E+09	2.792E+08	
0.975 1.889E+08			1.953E+08	5.883E+08	5.741E+09	5.887E+09	5.483E+09	5.321E+08	
1.125 1.898E+08			1.498E+08	5.078E+08	5.364E+09	7.182E+09	8.078E+09	8.089E+08	
1.275 1.388E+08			1.288E+08	5.247E+08	5.880E+09	5.630E+09	1.088E+10	1.387E+10	
1.425 1.228E+08			1.228E+08	4.883E+08	5.809E+09	5.448E+09	1.247E+10	1.818E+10	
1.575 7.038E+08			7.038E+08	3.084E+09	8.128E+09	8.888E+09	1.338E+10	2.386E+10	
1.725 7.713E+08			7.713E+08	2.928E+09	8.007E+09	8.890E+09	1.488E+10	2.888E+10	
1.875 8.767E+08			8.767E+08	1.888E+09	5.286E+09	5.844E+09	1.188E+10	2.230E+10	
2.025 8.198E+08			2.025E+08	8.210E+08	1.880E+09	3.468E+09	8.800E+09	1.897E+10	
2.175 5.948E+07			5.948E+07	2.757E+08	4.843E+08	1.008E+09	2.181E+09	4.790E+08	
----- 3.475E+10 1.384E+11									
Total	8.838E+10	1.878E+10	7.843E+07	1.882E+08	9.447E+10	3.7853			

Max Theoret Beta Spect.

Stream #404 [Sr DF=1, 3.7853 L (1.0 gal)]

APPENDIX P: Example Source Analysis for the High Blend Waste Source

MicroShield 4.10 - Serial #4.10-00468

FLUOR DANIEL

Page : 2
 DOS File: LMPHOT44.N54
 Run Date: September 29, 1995
 Run Time: 9:19 a.m. Friday
 Duration: 0:22:48

File Ref: _____
 Date: ____/____/____
 By: _____
 Checked: _____

Case Title: LIN HIGH BLEND-#464 COMBINED PHOTON SOURCE (Beta +Gamma) 004

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches	
Dose point coordinate X:	37.938	1.0	2.7
Dose point coordinate Y:	13.405	0.0	5.3
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	26.81	0.0	10.6
Cylinder radius:	6.703	0.0	2.6
Air Gap:	30.0	0.0	11.6
Side Clad:	0.625	0.0	.3
End Clad:	0.635	0.0	.3

Source Volume: 3784.3 cm³ .133641 cu ft. 230.932 cu in.

Material	Source Shield	MATERIAL DENSITIES (g/cm ³)			
		Transition Shield	Air Gap	Side Clad Shield	End Clad Shield
Air		0.00122	0.00122		
Concrete	1.5			7.83	7.83
Iron					

BUILDUP

Method: Buildup Factor Tables
 The material reference is Side Clad

INTEGRATION PARAMETERS

	Quadrature Order
Radial	20
Circumferential	20
Y Direction (axial)	40

SOURCE WAS ENTERED AS ENERGIES ONLY

Page : 2
 DGS File: LHM0244.M64
 Run Date: September 29, 1995
 Run Time: 9:19 a.m. Friday
 Title : LLM HIGH BLEND-7404 COMBINED PHOTON SOURCE (Beta +Gamma) 004

WHC-SD-WM-TI-763
 Revision 0

RESULTS FOR SENSITIVITY REFERENCE CASE (X = 37.318) -----					
Energy	Activity	Energy Fluence Rate	Exposure Rate In Air		
(MeV)	(photons/sec)	(MeV/sq cm/sec)	(mR/hr)		
		No Buildup	With Buildup	No Buildup	With Buildup
0.0343	1.657e+010	8.385e-010	8.407e-010	5.624e-032	6.309e-032
0.06	1.687e+009	2.041e+000	2.790e+000	4.054e+003	5.543e+003
0.08	2.738e+009	1.434e+002	2.227e+002	2.254e+001	3.524e+001
0.1	4.138e+009	1.008e+003	1.755e+003	1.542e+000	2.665e+000
0.1224	4.081e+008	2.406e+003	4.591e+002	3.775e+001	7.204e+001
0.15	3.389e+009	3.674e+001	7.591e+003	6.051e+000	1.250e+002
0.2	1.421e+009	3.312e+001	7.421e+003	8.848e+000	1.310e+001
0.2486	6.553e+007	1.980e+002	4.518e+002	2.649e+001	8.327e+002
0.3	1.275e+009	0.237e+003	1.185e+004	9.934e+000	2.248e+001
0.3406	1.635e+006	8.192e+000	1.827e+001	1.576e+002	3.515e+002
0.4	4.435e+008	2.839e+003	6.154e+003	5.531e+000	1.199e+001
0.5	2.744e+008	2.444e+003	5.017e+003	4.798e+000	9.847e+000
0.6	2.368e+008	2.748e+003	5.350e+003	5.364e+000	1.044e+001
0.6818	2.279e+009	6.381e+004	8.279e+004	8.493e+001	1.605e+002
0.7281	2.535e+008	3.881e+003	7.124e+003	7.459e+000	1.349e+001
0.8	1.329e+008	2.325e+003	4.147e+003	4.423e+000	7.888e+000
0.8766	1.136e+008	2.659e+003	4.611e+003	5.000e+000	8.673e+000
1.0	3.332e+008	7.971e+003	1.330e+004	1.469e+001	2.452e+001
1.1732	1.458e+008	4.350e+003	6.928e+003	7.774e+000	1.278e+001
1.3737	4.941e+008	1.650e+004	2.568e+004	2.893e+001	4.503e+001
1.5	3.160e+007	1.398e+003	2.087e+003	2.352e+000	3.511e+000
1.5952	2.804e+007	1.266e+003	1.863e+003	2.094e+000	3.081e+000
1.7365	7.068e+005	3.567e+001	5.151e+001	5.757e+002	8.315e+002
1.8108	1.720e+005	9.828e+000	1.392e+001	1.542e+002	2.164e+002
2.0	6.068e+005	3.677e+001	5.182e+001	5.665e+002	7.983e+002
TOTAL:	3.768e+010	1.061e+005	1.949e+005	1.978e+002	3.644e+002

Page : 3
 DOS File: INPHOT44.M54
 Run Date: September 29, 1995
 Run Time: 9:19 a.m. Friday
 Title : LIA HIGH BLEND-#404 COMBINED PHOTON SOURCE (Beta +Gamma) 004

WHC-SD-WM-TI-763
 Revision 0

SENSITIVITY RESULTS For: X (cm)					
Case Number	Sensitivity Variable	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
	Value	No Buildup	With Buildup	No Buildup	With Buildup
1	8.338	1.323e+006	2.633e+006	2.468e+003	4.929e+003
2	107.938	1.302e+004	2.403e+004	2.428e+001	4.492e+001

Use the Display Menu for Energy Group Results for All Cases.

COMBINED LLW PHOTON SOURCE BASED ON BETA AND GAMMA SOURCE SPECTRA
 HIGH BLEND Waste Source for Stream #404, 1.0 gal in Cylindrical geometry @ 30 WMC-SD-WM-TI-763
 on 0

GROUP No. B or G	BETA SOURCE		GAMMA SOURCE		RESULTING COMBINED SPECTRA		
	ENERGY (MeV)	Beta Ph/sec	ENERGY (MeV)	Gamma Ph/sec	GROUP No. TOTAL	Selected ENERGY (MeV)	PHOTON SOURCE Ph/sec
1B	1G		0.0343	1.657E+10	1	0.0343	1.657E+10
		0.0600	1.587E+09		2	0.0600	1.687E+09
		0.0800	2.738E+09		3	0.0800	2.738E+09
		0.1000	4.138E+09		4	0.1000	4.138E+09
2B	2G		0.1226	4.081E+08	5	0.1226	4.081E+08
		0.1500	3.389E+08		6	0.1500	3.389E+08
			0.1699	5.779E+08	7		
		0.2000	1.815E+08		7	0.2000	1.821E+09
3B	3G		0.2486	6.555E+07	8	0.2486	6.555E+07
		0.3000	1.276E+09		9	0.3000	1.275E+09
			0.3406	1.535E+08	10	0.3406	1.635E+08
		0.4000	4.361E+08		11	0.4000	4.435E+08
4B	4G		0.4324	7.403E+06	11		
			0.4880	3.218E+06	12		
		0.5000	2.712E+08		12	0.5000	2.744E+08
			0.5882	6.058E+07	13		
5B	5G		0.6618	3.279E+09	13	0.6000	2.368E+08
		0.6000	1.762E+08		14	0.6618	3.279E+09
			0.7281	2.535E+08	15	0.7281	2.535E+08
		0.8000	1.181E+08		16	0.8000	1.329E+08
6B	6G		0.8260	1.382E+07	16		
			0.8786	1.336E+08	17	0.8786	1.338E+08
			0.9937	1.058E+08	18		
		1.0000	5.228E+07		18	1.0000	3.332E+08
7B	7G		1.0052	1.751E+08	18		
			1.1301	6.085E+06	19		
			1.1732	1.397E+08	19	1.1732	1.458E+08
			1.2737	3.543E+08	20	1.2737	4.941E+08
8B	8G		1.3325	1.398E+08	20		
			1.4150	7.880E+05	21		
			1.4946	6.368E+06	21		
		1.5000	2.842E+07		21	1.5000	3.360E+07
9B	9G		1.5952	2.804E+07	22	1.5952	2.804E+07
			1.6741	5.530E+05	23		
			1.7365	9.216E+04	23	1.7365	7.0660E+05
			1.7910	6.144E+04	23		
10B	10G		1.9108	1.720E+05	24	1.9108	1.720E+05
					25	2.0000	6.068E+05
		2.0000	6.068E+05				
			1.592E+10	2.176E+10			3.768E+10
							3.758E+10

Note: 25 Groups Maximum for MS4.10

File LWPHOTLS.WKS

Page : 1
DOS File: LWGAMA41.NSA
Run Date: September 29, 1995
Run Time: 8:53 a.m. Friday
Duration: 0:32:31

File Ref: _____
Date: ____/____/____
By: _____
Checked: _____

Case Title: LFN HIGH BLEND-#404 GAMMA SOURCE FOR PHOTON ENERGY SPEC 003

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches
Dose point coordinate X:	27.318	1.0 2.7
Dose point coordinate Y:	13.409	0.0 5.3
Dose point coordinate Z:	0.0	0.0 .0
Cylinder height:	26.81	0.0 10.6
Cylinder radius:	6.703	0.0 2.6
Air Gap:	30.0	0.0 11.8
Side Clad:	0.635	0.0 .3
End Clad:	0.635	0.0 .3

Source Volume: 3784.3 cm³ .133641 cu ft. 239.922 cu in.

MATERIAL DENSITIES (g/cm³)

Material	Source Shield	Transition Shield	Air Gap	Side Clad Shield	End Clad Shield
Air		0.00122	0.00122		
Concrete	1.5				
Iron				7.83	7.83

BUILDUP

Method: Buildup Factor Tables
The material reference is Side Clad

INTEGRATION PARAMETERS

	Quadrature Order
Radial	20
Circumferential	20
Y Direction (axial)	40

SOURCE NUCLIDES

Nuclide	curies	μCi/cm ³	Nuclide	curies	μCi/cm ³
Am-241	5.2600e-001	1.3900e+002	Ba-137m	9.7800e-002	2.5844e+001
C-14	4.1600e-005	3.0933e-002	Cm-244	3.2300e-005	3.2903e-003
Co-60	3.7700e-003	9.9622e-001	Cs-134	2.0300e-006	5.3643e-004
Cm-137	1.0200e-001	2.6933e+001	Eu-154	2.6200e-002	6.9233e+000
I-129	1.2400e-006	1.2767e-004	Np-237	4.1800e-005	1.1046e-002
Pa-233	4.1800e-005	2.1046e-002	Pu-234	4.0700e-004	1.0755e-001
Pu-238	1.0500e-002	2.7746e+000	Pu-239	2.1600e-002	6.2093e+000
Pu-240	5.8700e-003	1.5511e+000	Pu-241	1.8100e-001	4.7829e+001
Sr-90	1.0500e+001	2.8010e+003	Ta-99	4.9200e-003	1.3001e+000
Th-231	2.9500e-005	7.7934e-003	Th-234	4.0800e-004	1.0781e-001

Page : 2
 DOS File: LM2AHA43.M54
 Run Date: September 30, 1995
 Run Time: 8:53 a.m. Friday

WHC-SD-WM-TI-763
 Revision 0

Title : LBN HIGH BLEND-#404 GAMMA SOURCE FOR PHOTON ENERGY SPEC 003

Nuclide	curies	$\mu\text{Ci/cm}^2$	Nuclide	curies	$\mu\text{Ci/cm}^2$
U-235	2.9700e+005	7.8482e+003	U-238	1.7300e+005	4.5713e+003
Y-90	1.0600e+001	2.8010e+003			

RESULTS FOR SENSITIVITY REFERENCE CASE (X = 37,338)					
Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/eq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.0143	2.457e+010	8.966e+010	1.006e+009	6.060e+012	6.732e+012
0.1226	4.081e+008	2.404e+002	4.588e+002	3.773e+001	7.200e+001
0.1998	5.779e+006	1.179e+001	2.641e+001	2.081e+002	4.661e+002
0.2486	6.555e+007	1.978e+002	4.517e+002	3.648e+001	8.325e+001
0.3406	1.625e+006	8.192e+000	1.827e+001	1.576e+002	3.515e+002
0.4324	7.403e+006	5.323e+001	1.134e+002	1.041e+001	2.219e+001
0.488	1.218e+006	2.766e+001	5.715e+001	5.430e+002	1.122e+001
0.5882	6.088e+007	6.832e+002	1.138e+003	1.135e+000	2.614e+000
0.6618	3.279e+009	4.380e+004	8.277e+004	8.492e+001	1.605e+002
0.7281	2.505e+008	3.881e+003	7.123e+003	7.458e+000	1.369e+001
0.826	1.182e+007	2.530e+002	4.468e+002	4.793e+001	8.466e+001
0.8766	1.376e+008	2.658e+003	4.612e+003	4.998e+000	8.672e+000
0.8937	1.058e+008	2.508e+003	4.193e+003	4.629e+000	7.737e+000
1.0051	1.751e+008	4.120e+003	7.030e+003	7.771e+000	1.295e+001
1.1301	6.085e+006	1.724e+002	2.776e+002	3.106e+001	5.000e+001
1.1712	1.397e+008	4.168e+003	6.638e+003	7.448e+000	1.184e+001
1.2737	3.543e+008	1.182e+004	2.841e+004	2.075e+001	3.229e+001
1.3323	1.198e+008	4.961e+003	7.429e+003	8.607e+000	1.124e+001
1.415	7.880e+005	3.033e+001	4.591e+001	5.182e+001	7.845e+002
1.4946	6.389e+006	2.466e+002	3.953e+002	4.456e+001	6.656e+001
1.5952	2.804e+007	1.266e+003	1.863e+003	2.094e+000	3.081e+000
1.6741	9.530e+005	2.460e+001	3.873e+001	4.341e+002	6.318e+002
1.7365	9.216e+004	4.652e+000	6.718e+000	7.509e+003	1.085e+003
1.7911	6.144e+004	3.229e+000	4.453e+000	5.164e+003	7.411e+003
1.9108	1.720e+005	9.830e+000	1.393e+001	1.542e+002	2.164e+002
TOTAL:	2.176e+010	8.128e+004	1.440e+005	1.523e+002	2.708e+002

Page : 2
 DOS File: LMGAMA43.M94
 Run Date: September 29, 1995
 Run Time: 8:53 a.m. Friday

WHC-SD-WM-TL-763
 Revision 0

Title : LLW HIGH BLEND-#404 GAMMA SOURCE FOR PHOTON ENERGY SPEC 001

SENSITIVITY RESULTS For: X (cm)					
Case Number	Sensitivity Variable	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
	Value	No Buildup	With Buildup	No Buildup	With Buildup
1	8.338	1.034e+006	1.981e+006	1.936e+001	1.743e+001
2	107.138	9.978e+003	1.776e+004	1.870e+001	3.139e+001

Use the Display Menu For Energy Group Results For All Cases.

MicroShield 4.10 - Serial #4.10-00458

FLUOR DANIEL

Page : 1
 DOS File: INHETA42.N54
 Run Date: September 29, 1995
 Run Time: 8:25 a.m. Friday
 Duration: 0:12:22

File Ref: _____
 Date: ____/____/____
 By: _____
 Checked: _____

Case Title: LLN HIGH BLEND-#404 BETA SOURCE TEST 4 PROTON EQUIVALENC 002

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches
Dose point coordinate X:	37.938	1.0 2.7
Dose point coordinate Y:	12.405	0.0 5.3
Dose point coordinate Z:	0.0	0.0 .0
Cylinder height:	26.81	0.0 10.6
Cylinder radius:	6.703	0.0 2.4
Air Gap:	30.0	0.0 11.8
Side Clad:	0.635	0.0 .3
End Clad:	0.635	0.0 .3

Source Volume: 3784.3 cm³ .133641 cu ft. 230.932 cu in.MATERIAL DENSITIES (g/cm³)

Material	Source Shield	Transition Shield	Air Gap	Side Clad Shield	End Clad Shield
Air		0.00122	0.00122		
Concrete	1.5				
Iron				7.83	7.83

BUILDUP

Method: Buildup Factor Tables
 The material reference is Side Clad

INTEGRATION PARAMETERS

	Quadrature Order
Radial	20
Circumferential	20
Y Direction (axial)	40

SOURCE WAS ENTERED AS ENERGIES ONLY

Page : 2
 DOS File: INBETA42.H54
 Run Date: September 29, 1995
 Run Time: 8:25 a.m. Friday
 Title : LLW HIGH BLEND-#404 BETA SOURCE TEST 4 PHOTON EQUIVALENC 002

WHC-SD-WM-TI-763
 Revision 0

RESULTS FOR SENSITIVITY REFERENCE CASE (X = 37.338)					
Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.06	1.687e+009	2.042e+000	2.791e+000	4.055e-003	5.544e-003
0.08	2.738e+009	1.425e+002	2.227e+002	2.254e-001	1.525e-001
0.1	4.138e+009	1.008e+003	1.755e+003	1.543e+000	2.686e+000
0.15	3.389e+009	3.674e+003	7.591e+003	6.051e+000	1.250e+001
0.2	1.615e+009	1.100e+003	7.195e+003	5.835e+000	1.305e+001
0.3	1.275e+009	5.236e+003	1.185e+004	9.932e+000	2.248e+001
0.4	4.361e+008	2.791e+003	6.051e+003	5.438e+000	1.179e+001
0.5	2.712e+008	2.416e+003	4.957e+003	4.741e+000	9.731e+000
0.6	1.762e+008	2.085e+003	3.981e+003	3.992e+000	7.770e+000
0.8	1.191e+008	2.084e+003	3.716e+003	3.963e+000	7.068e+000
1.0	5.229e+007	1.251e+003	2.087e+003	2.306e+000	3.847e+000
1.5	2.442e+007	1.099e+003	1.640e+003	1.849e+000	2.760e+000
2.0	6.069e+005	3.677e+001	5.162e+001	5.685e-002	7.983e-002
TOTAL:	1.591e+010	3.509e+004	5.130e+004	4.593e+001	5.411e+001

Page : 3
 DOS File: LWBETA42.KS4
 Run Date: September 29, 1995
 Run Time: 8:25 a.m. Friday
 Title : LLW HIGH BLEND-F404 BETA SOURCE TEST 4 PHOTON EQUIVALENC 002

WHC-SD-WM-TI-763
 Revision 0

Case Number	Sensitivity Variable Value	SENSITIVITY RESULTS For: X (cm)			
		Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
1	5.338	2.922e+005	6.468e+006	5.371e+002	1.193e+003
2	107.338	1.075e+003	6.313e+003	5.629e+000	1.158e+001

Use the Display Menu For Energy Group Results For All Cases.

ENERGY (MeV)	Orig Input Ph/sec	INPUT Ph/sec	OUTPUT m/s/h	DESIRED m/s/h	NEW INPUT Ph/sec	
0.010	0.00000E+00	0.0000E+00	0.000E+00	0.000E+00		.015 MeV Used
0.015	0.00000E+00	0.0000E+00	0.000E+00	0.000E+00		
0.020	0.00000E+00	0.0000E+00	0.000E+00	0.000E+00		
0.030	0.00000E+00	0.0000E+00	0.000E+00	0.000E+00		
0.040	0.00000E+00	0.0000E+00	0.000E+00	0.000E+00		
0.050	0.00000E+00	0.0000E+00	0.000E+00	0.000E+00		
0.060	5.54467E-03	5.5447E-03	1.622E-14	5.545E-03	1.68734E+09	
0.080	3.52443E-01	3.5244E-01	4.536E-11	3.524E-01	2.73845E+09	
0.100	2.68499E+00	2.6850E+00	1.742E-09	2.686E+00	4.13849E+09	
0.150	1.25022E+01	1.2502E+01	4.612E-08	1.250E+01	3.36905E+09	
0.200	1.30542E+01	1.3054E+01	1.058E-07	1.305E+01	1.61528E+09	
0.300	2.24820E+01	2.2482E+01	3.965E-07	2.248E+01	1.27475E+09	
0.400	1.17906E+01	1.1791E+01	3.168E-07	1.179E+01	4.39067E+08	
0.500	8.73070E+00	8.7307E+00	3.492E-07	8.731E+00	2.71153E+08	
0.600	7.76946E+00	7.7695E+00	3.428E-07	7.769E+00	1.76196E+08	
0.800	7.06786E+00	7.0679E+00	4.185E-07	7.068E+00	1.19052E+08	
1.000	3.84669E+00	3.8467E+00	2.830E-07	3.847E+00	5.22663E+07	
1.500	2.75971E+00	2.7597E+00	2.883E-07	2.760E+00	2.64160E+07	
2.000	7.88209E-02	7.8821E-02	1.050E-08	7.882E-02	6.08798E+05	
3.000	0.00000E+00	0.0000E+00	0.000E+00	0.000E+00		

	9.41263E+01	9.4126E+01	2.562E-06	9.413E+01	1.59252E+10	

File:1WBSPEC9.WK3

Page : 1
 DOS File: LMBETA41.MS4
 Run Date: September 29, 1995
 Run Time: 8:10 a.m. Friday
 Duration: 0:12:22

File Ref: _____
 Date: _____
 By: _____
 Checked: _____

Case Title: LLN HIGH BLEND-#404 BETA SOURCE TEST 4 PHOTON EQUIVALENC 001

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches
Dose point coordinate X:	37.328	1.0 2.7
Dose point coordinate Y:	13.405	0.0 5.3
Dose point coordinate Z:	0.0	0.0 .0
Cylinder height:	26.81	0.0 10.6
Cylinder radius:	6.703	0.0 2.6
Air Gap:	10.0	0.0 11.8
Side Clad:	0.675	0.0 .3
End Clad:	0.635	0.0 .3

Source Volume: 3784.3 cm³ .133641 cu ft. 230.922 cu in.

Material	Source Shield	MATERIAL DENSITIES (g/cm ³)			
		Transition Shield	Air Gap	Side Clad Shield	End Clad Shield
Air		0.00122	0.00122		
Concrete	1.5				
Iron				7.83	7.83

BUILDUP

Method: Buildup Factor Tables
 The material reference is Side Clad

INTEGRATION PARAMETERS

	Quadrature Order
Radial	30
Circumferential	20
Y Direction (axial)	40

SOURCE WAS ENTERED AS ENERGIES ONLY

Page : 2
 DOS File: LMBETA41.N94
 Run Date: September 29, 1995
 Run Time: 8:10 a.m. Friday

WHC-SD-WM-TI-763
 Revision 0

Title : LHM HIGH BLEND-#404 BETA SOURCE TEST 4 PHOTON EQUIVALENC 001

----- RESULTS FOR SENSITIVITY REFERENCE CASE (X = 37.338) -----					
Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.06	5.543e+003	6.709e-012	9.171e-012	1.333e-014	1.822e-014
0.08	3.324e+001	1.833e-008	2.867e-008	2.901e-011	4.534e-011
0.1	2.685e+000	6.541e-007	1.139e-006	1.001e-009	1.742e-009
0.18	1.250e+001	1.355e-005	2.800e-005	2.232e-008	4.812e-008
0.2	1.305e+001	2.667e-005	5.976e-005	4.707e-008	1.055e-007
0.3	2.248e+001	9.234e-005	2.090e-004	1.752e-007	2.965e-007
0.4	1.179e+001	7.547e-005	1.636e-004	1.470e-007	3.188e-007
0.5	9.731e+000	8.569e-005	1.779e-004	1.702e-007	3.492e-007
0.6	7.770e+000	9.017e-005	1.755e-004	1.760e-007	3.426e-007
0.8	7.068e+000	1.237e-004	2.206e-004	2.352e-007	4.195e-007
1.0	3.867e+000	9.202e-005	1.339e-004	1.896e-007	2.820e-007
1.5	2.760e+000	1.149e-004	1.714e-004	1.932e-007	2.883e-007
2.0	7.982e+002	4.836e-006	6.791e-006	7.479e-009	1.050e-008
TOTAL:	9.413e+001	7.209e-004	1.367e-003	1.344e-006	2.562e-006

Page 13
 DOS File: LWBETA41.MS4
 Run Date: September 29, 1995
 Run Time: 6:10 a.m. Friday
 Title : LHM HIGH BLEND-#404 BETA SOURCE TEST 4 PHOTON EQUIVALENC 001

WHC-SD-WM-TI-763
 Revision 0

Case Number	Sensitivity Variable	SENSITIVITY RESULTS For: X (cm)			
		Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
1	Value 8.938	8.955e-003	1.839e-002	1.668e-005	3.445e-005
2	107.938	9.842e-005	1.884e-004	1.649e-007	3.156e-007

Use the Display Menu For Energy Group Results For All Cases.

ENERGY (MeV)	Orig Input Ph/sec	INPUT Ph/sec	OUTPUT m/h	DESIRED m/h	NEW INPUT Ph/sec	
0.010	0.00000E+00	0.0000E+00	0.000E+00	0.000E+00		.015 MeV Used
0.015	0.00000E+00	0.0000E+00	0.000E+00	0.000E+00		
0.020	0.00000E+00	0.0000E+00	0.000E+00	0.000E+00		
0.030	0.00000E+00	0.0000E+00	0.000E+00	0.000E+00		
0.040	0.00000E+00	0.0000E+00	0.000E+00	0.000E+00		
0.050	0.00000E+00	0.0000E+00	0.000E+00	0.000E+00		
0.080	5.64467E-03	5.6447E-03	1.822E-14	5.545E-03	1.68734E+09	
0.090	3.52443E-01	3.5244E-01	4.536E-11	3.524E-01	2.73845E+09	
0.100	2.68489E+00	2.6850E+00	1.742E-09	2.685E+00	4.13845E+09	
0.150	1.25022E+01	1.2502E+01	4.612E-08	1.250E+01	3.58009E+09	
0.200	1.30542E+01	1.3054E+01	1.058E-07	1.305E+01	1.61528E+09	
0.300	2.24820E+01	2.2482E+01	3.985E-07	2.248E+01	1.27475E+09	
0.400	1.17906E+01	1.1791E+01	3.198E-07	1.179E+01	4.30067E+08	
0.500	8.73070E+00	8.7307E+00	3.492E-07	8.731E+00	2.71153E+08	
0.600	7.78948E+00	7.7895E+00	3.426E-07	7.789E+00	1.78198E+08	
0.800	7.06788E+00	7.0679E+00	4.195E-07	7.068E+00	1.19062E+08	
1.000	3.84889E+00	3.8487E+00	2.830E-07	3.847E+00	5.22853E+07	
1.500	2.78971E+00	2.7897E+00	2.883E-07	2.780E+00	2.64169E+07	
2.000	7.88209E-02	7.8821E-02	1.060E-08	7.882E-02	6.08798E+05	
3.000	0.00000E+00	0.0000E+00	0.000E+00	0.000E+00		
	9.41263E+01	9.4126E+01	2.562E-06	9.413E+01	1.59252E+10	

File: LWBSPC9.WM3

37- 709 az 3.338 3 surface belly lower surface
 38- 709 sz 9.338 3 surface belly outer surface
 39- 709 sz 37.338 3 30 cm belly inner surface
 40- 706 az 30.338 3 30 cm belly outer surface
 41- 708 az 107.338 3 1 meter belly lower surface
 42- 706 az 106.338 3 1 meter belly upper surface
 43-
 44- 710 az 3.000 3 source radial segmentation for Superfences
 45- 711 az 4.229 3 source radial segmentation for Superfences
 46- 712 az 5.452 3 source radial segmentation for Superfences
 47- 713 az 6.680 3 source radial segmentation for Superfences
 48- 714 az 40.876 3 summarized out
 49- 715 az 43.810 3 summarized out
 50- 716 az 71.083 3 summarized out
 51- 717 az 73.841 3 summarized out
 52- 718 az 80.688 3 summarized out
 53-
 54- Mode 0 0
 55- offset segm01 segm02 segm03 segm04 D 1
 56- pose 0.00 0.00 15.000 3 normal height (old-source height)
 57- par=3 seg=7.800-11 3 superseed screen (M40 source 115 group)
 58-
 59- shield source operation (1.0 get stream (M40))
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117-	#	alt	rad	els
118-		h	g	w
119-		-12.4250	0.0	0.0
120-		-12.4641	0.05	0.25
121-		-9.3135	0.10	0.10
122-		-6.7528	0.10	0.10
123-		0.	0.25	0.25
124-		6.7625	0.25	0.25
125-		9.3803	0.10	0.10
126-		12.4641	0.10	0.10
127-		12.4690	0.01	0.05
128-	c			
129-	c	sigma section materials		
130-	c			
131-	d	WHC Reference glass (1.56 g/cc)		
132-	d			
133-	wt	3406.07g - 1.78242-02 g/L		
134-	material	1 is not used in the problem.		
135-		5000.01g - 0.06344-02 g		
136-		8000.01g - 4.02182-01 g		
137-		11000.01g - 7.67152-02 g		
138-		12000.01g - 6.43309-03 g		
139-		13000.01g - 2.28449-01 g		
140-		14000.01g - 1.29975-01 g		
141-		20000.01g - 2.64541-02 g		
142-		25000.01g - 9.09991-01 g		
143-		34000.01g - 2.60979-02 g		
144-	c			
145-	c	air (0.0012 g/cc)		
146-	c			
147-	wt	6004.07g - 0.00077 g		
148-		7604.07g - 0.79410 g		
149-		9609.07g - 0.21075 g		
150-		14009.07g - 0.56376 g		
151-	c			
152-	c	ordinary concrete (simulated search slurry at lower density)		
153-	wt	1000.01g - 0.0023 g		
154-		4000.01g - 0.0025 g		
155-		8000.01g - 1.2431 g		
156-		11000.01g - 0.0076 g		
157-		12000.01g - 0.0047 g		
158-		13000.01g - 0.0797 g		
159-		14000.01g - 0.7977 g		
160-		17000.01g - 0.0305 g		
161-		20000.01g - 0.1053 g		
162-		24000.01g - 0.0319 g		
163-	c			
164-	c	scintillator steel 3041 (7.83 g/cc)		
165-	c			
166-	wt	4000.01g - 0.0005 g		
167-		14000.01g - 0.0075 g		
168-		25000.01g - 0.0045 g		
169-		36000.01g - 0.0073 g		
170-		21000.01g - 0.0001 g		
171-		25000.01g - 0.0200 g		
172-	d	25000.01g - 0.0045 g		
173-		28000.01g - 0.1000 g		
174-	c			
175-	c	water (1.00 g/cc)		


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179+ c
177+ w5 1000.01p 0.11111 km
opening, preprint 5 is used in the problem.
180+ 3000.01p 0.00000 km
181+ c
182+ c
183+ c
184+ physics 20.0 0 0
185+ physics 20.0 0 0 0 1 1 1 1
186+ c
187+ w energy-dependent physics (100-keV to 10-MeV) rate generation features (mev/c)
188+ # den qm qd
189+ 0.010 0.00000252 0.010
190+ 0.010 0.00000002 0.010
191+ 0.020 0.00000002 0.020
192+ 0.030 0.00000002 0.030
193+ 0.040 0.00000002 0.040
194+ 0.050 0.00000002 0.050
195+ 0.060 0.00000002 0.060
196+ 0.070 0.00000002 0.070
197+ 0.080 0.00000002 0.080
198+ 0.090 0.00000002 0.090
199+ 0.100 0.00000002 0.100
200+ 0.120 0.00000002 0.120
201+ 0.140 0.00000002 0.140
202+ 0.160 0.00000002 0.160
203+ 0.180 0.00000002 0.180
204+ 0.200 0.00000002 0.200
205+ 0.250 0.00000002 0.250
206+ 0.300 0.00000002 0.300
207+ 0.400 0.00000002 0.400
208+ 0.500 0.00000002 0.500
209+ 0.600 0.00000002 0.600
210+ 0.800 0.00000002 0.800
211+ 1.000 0.00000002 1.000
212+ 1.500 0.00000002 1.500
213+ 2.000 0.00000002 2.000
214+ 3.000 0.00000002 3.000
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253+ c
254+ c

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235- cellk data rate in gram/h
 236- f114up 2502
 237- d
 238- f114d data rate in gram/h
 239- f124up 2502
 240- d
 241- E
 242- E age 2000
 243- exp 000
 244- print -20 -85 -130 -140
 245- test
 246- print 0 -120 5 E

128000	1.7033E+05	0.9090	0.4221	2.7	3.6E-05	9.1062E+01	0.1195	9.4635	2.9	2.8E+01	1.0424E+01	0.0796	0.2107	10.0	5.3E-01
148000	1.1791E+05	0.9736	0.1736	2.9	4.2E-05	9.7340E+01	0.1005	0.5820	2.6	1.2E+01	1.0207E+01	0.0644	0.0207	10.0	5.4E-01
168000	1.1296E+05	0.9646	0.3196	2.7	4.3E-05	9.3647E+01	0.0881	0.5535	3.0	1.4E+01	1.0244E+01	0.0608	0.0195	10.0	5.3E-01
208000	1.1221E+05	0.9571	0.1219	3.0	5.0E-05	9.2160E+01	0.0773	0.5087	2.9	1.7E+01	1.0184E+01	0.0553	0.0161	10.0	5.3E-01
254000	1.1172E+05	0.0515	0.5404	3.3	5.4E-05	9.1040E+05	0.0709	0.4826	3.0	2.9E+01	1.0408E+05	0.0538	0.0178	10.0	4.9E-01
288000	1.1174E+05	0.0517	0.2323	3.4	4.3E-05	9.2237E+05	0.0649	0.3334	3.0	2.0E+01	1.0599E+05	0.0597	0.1846	4.1	0.5E-01
320000	1.1149E+05	0.0484	0.2080	2.8	4.0E-05	9.2817E+01	0.0677	0.3049	3.0	2.9E+01	1.0571E+01	0.0540	0.0890	4.1	0.8E-01
325000	1.1181E+05	0.0478	0.1990	2.8	4.7E-05	9.4326E+01	0.0619	0.3017	3.0	2.9E+01	1.0717E+01	0.0594	0.0830	4.2	3.0E-01

=====

dump no. 9 on file Reptmgr app = 5251000 cell = 362777014 eta = 900.01 app = 2440827625

01 morning snapshots in file.

End 167164(03) jobs 15 total used 900 minutes of computer time.

computer time = 900.22 minutes

dump version 4a 08/01/95

02/25/95 06:39:11

probid = 02/27/95 15:16:18

**APPENDIX G: Selected Equipment Specifications from
Equipment List Series**

B = STUPEUR BITE
 BG = BECKEN
 CH = CHASSE
 E = EMBLEME, ENGAGE
 EN = ENSEMBLE, ENCLINATOR
 EC = COMMERCE, CRIMES, COULE
 EN = ENCLINATOR
 EV = EVANGELISME DE LA CROIX
 F = FALGUNE, FALGUNE, FALGUNE
 EC = FALGUNE, FALGUNE

[illegible]

DATE 22, REVEREND DR MARTIN LUTHER KING, JR.
ALL THE PEOPLE OF THE WORLD

COMPONENT DESCRIPTION	QUANTITY	CAPACITY/OPEN DATE	PHYSICAL SIZE	MATERIAL
MAINTENANCE OF BATTERY FEEDER AT COLLECT STORAGE TANKS				
1. 1 BATTERY STAIN FEEDER	N-435A-2	0", 0.5 HP	24 x 27-1/2" x 27-1/2"	304L SS
1. 2 BATTERY STAIN FEEDER	N-435B-2	0", 0.5 HP	24 x 27-1/2" x 27-1/2"	304L SS
1. 3 BATTERY STAIN FEEDER	N-435A-2	0", 0.5 HP	24 x 27-1/2" x 27-1/2"	304L SS
1. 4 BATTERY STAIN FEEDER	N-435B-2	0", 0.5 HP	24 x 27-1/2" x 27-1/2"	304L SS
1. 5 BATTERY STAIN FEEDER	N-5011-2	0", 0.50 HP	24 x 27-1/2" x 27-1/2"	304L SS
1. 6 BATTERY STAIN FEEDER	N-5012-2	0", 0.50 HP	24 x 27-1/2" x 27-1/2"	304L SS
1. 7 LSI COLLECT STORAGE	TC-2002N-2	600 ML	30" x 18 25" 1/2	304L SS
1. 8 LSI COLLECT STORAGE	TC-2002N-2	600 ML	30" x 18 25" 1/2	304L SS
1. 9 COLLECT PANEL, REJECTOR SYSTEM	N-20030-3	21,000 LBS/HR	6" PIPS	304L SS

● 11月17日 星期三 ● 晴

WHC-SD-WM-TT-763
Revision 0

Page No. 2
09/21/95

EQUIPMENT LIST
CASE NO. REVISION 02 ISSUED ON 05/17/94
(LHM 200 I/O STAND ALONE)

EQUIPMENT DESCRIPTION	EQUIPMENT ID	CAPACITY/FLOW RATE	PERIODIC, SIZE	WARRANTY
WARRANTY OF REPLACEMENT PROVIDED				
2. 1 60W Food Compressor	EC-602-Z	50 HOURS/YR	18" W x 32" L x 36" H	WARRANTY 2-YR
2. 2 1.5LW COMPRESSOR FOOD FREE	EC-602-Z	7,000 GALLON	32" D x 36" H	3-YR, 3Y

DISSEMINATION STATE: UNCLASSIFIED

Page No. 3
07/2/95

EQUIPMENTS LIST
CANE 2C, ADVISORY OF TENDR ON 06/12/94
ILLM 200 1/2 STAMP ALONG

EQUIPMENT DESCRIPTION	EQUIPMENT ID	CAPACITY/PLUM TYPE	PHYSICAL SIZE	REMARKS
MAINTENANCE OF WEST ELIMINATOR IN HELPER ROOM				
3. 1 LHM WTS ELIMINATOR	00-618A-2	872 GPM	7' 00" X 14'-2" H	RESELLER C-22
3. 2 LHM WTS ELIMINATOR	00-618B-2	872 GPM	7' 00" X 14'-2" H	RESELLER C-22
3. 3 Chiller	EC-617A-2	80,000 BTU/H	RESELLER ON TR-614A/B-2	RESELLER C-22 TUNE, 304L SS SMALL
3. 4 Chiller	EC-617B-2	80,000 BTU/H	RESELLER ON TR-614A/B-2	RESELLER C-22 TUNE, 304L SS SMALL
3. 5 COOLER	EC-616A-2	30.3 MWH/HR	9' 00" X 20' H	RESELLER C-22 TUNE, 304L SS SMALL
3. 6 COOLER	EC-616B-2	30.3 MWH/HR	9' 00" X 20' H	RESELLER C-22 TUNE, 304L SS SMALL
3. 7 LHM Scrub Retention Tank	TR-614A-2	9,400 GALLONS	12' 00" X 12' 1/2" (10' 00")	RESELLER C-22
3. 8 LHM Scrub Retention Tank	TR-614B-2	9,400 GALLONS	12' 00" X 12' 1/2" (10' 00")	RESELLER C-22
3. 9 LHM WASTE TANK	T-609A-2	4,200 GPM	11' 2" X 15' 1/2" (20'-0" H)	RETRACTORY LINES INSIDE 600
3. 10 LHM WASTE TANK	T-609B-2	4,200 GPM	11' 2" X 15' 1/2" (20'-0" H)	RETRACTORY LINES INSIDE 600
3. 11 LHM GULLEY CATCH TANK	TR-614A-2	7,100 GALLONS	11' 10" X 17'-0" (10' 00")	304L SS
3. 12 LHM GULLEY CATCH TANK	TR-614B-2	7,100 GALLONS	11' 10" X 17'-0" (10' 00")	304L SS
3. 13 LHM Meltier	EM-612A-2	800 MTPH	17'-00" W X 20' L X 24'-00" H	REFRACTORY LINES
3. 14 LHM Meltier	EM-612B-2	800 MTPH	17'-00" W X 20' L X 24'-00" H	REFRACTORY LINES
3. 15 Glass Suppressor	S-473A-2	1 MTPH	2' 00" X 30' L X 8' H	REFRACTORY LINES
3. 16 Glass Suppressor	S-473B-2	1 MTPH	2' 00" X 30' L X 8' H	REFRACTORY LINES

DIRECTOR: CAMEL TOWN: SPENCER: SPENCER: 7/1

Attachment-318

WHC-SD-WM-TI-763
Revision 0

REQUISITION LIST
CNSC 25, revision 83 issued on 05/02/94
CLASS 206 T/O 30000 M/CMB

MAINTENANCE OF CSDS EQUIP AT THE 00-100 0000 LANE	DESCRIPTION	EQUIPMENT #	CAPACITY/FLUX RATE	PHYSICAL SIZE	REVISION
4. 1 Pump		P-407A-2	700 CPM, 100 PSI	HEIGHTEN 10' 10" x 10"	3104 85
4. 2 Pump		P-407B-2	100 CPM, 100 PSI	HEIGHTEN 10' 10" x 10"	3104 85
4. 3 Pump		P-407C-2	100 CPM, 100 PSI	HEIGHTEN 10' 10" x 10"	3104 85
4. 4 Pump		P-407D-2	100 CPM, 100 PSI	HEIGHTEN 10' 10" x 10"	3104 85
4. 5 1000 Miller Feed Tank		TC-400A-2	9,400 GALLON	12' 10" x 10"	MAINTENANCE C-22
4. 6 1000 Miller Feed Tank		TC-400B-2	9,400 GALLON	12' 10" x 10"	MAINTENANCE C-22
4. 7 1000 Miller Feed Tank		TC-400C-2	9,400 GALLON	12' 10" x 10"	MAINTENANCE C-22
4. 8 1000 Miller Feed Tank		TC-400D-2	9,400 GALLON	12' 10" x 10"	MAINTENANCE C-22
4. 9 1000 Miller Feed Adjustment Tank		TC-400E-2	9,400 GALLON	12' 10" x 10"	MAINTENANCE C-22
4. 10 1000 Miller Feed Adjustment Tank		TC-400F-2	9,400 GALLON	12' 10" x 10"	MAINTENANCE C-22
4. 11 1000 Miller Feed Adjustment Tank		TC-400G-2	9,400 GALLON	12' 10" x 10"	MAINTENANCE C-22
4. 12 1000 Miller Feed Adjustment Tank		TC-400H-2	9,400 GALLON	12' 10" x 10"	MAINTENANCE C-22

EQUIPMENT DESCRIPTION	EQUIPMENT NO	CAPACITY/FLUX RATE	PHYSICAL SIZE	INTERNAL
MAINTENANCE OF OFFICE LINE AT TOP OF WATER DEPARTMENT				
S. 1 Glass Separator	1-413A-2	1 m3/dp 1u	8' W X 30' L X 8' H	RETRACTABLE LINES
S. 2 Glass Separator	1-413B-2	1 m3/dp 1u	8' W X 30' L X 8' H	RETRACTABLE LINES
S. 3 Glass Separator	1B-413A-2	100 m3/d	12' W X 24' L X 36' H	RETRACTABLE LINES
S. 4 Glass Separator	1B-413B-2	100 m3/d	12' W X 24' L X 36' H	RETRACTABLE LINES
S. 5 LIME CHALKER WATER TANK	1B-414A-2	2,000 GALLONS	12' W X 12' L X 4' H	310L 22
S. 6 LIME CHALKER WATER TANK	1B-414B-2	2,000 GALLONS	12' W X 12' L X 4' H	310L 22
S. 7 LIME CHALKER TANK	1-414A-2	4,000 GPM	12' X 12' L X 4' H	4" RETRACTABLE LINES INSIDE 400
S. 8 LIME CHALKER TANK	1-414B-2	4,000 GPM	12' X 12' L X 4' H	4" RETRACTABLE LINES INSIDE 400
S. 9 FILLER WATER TANK TANK	1B-415A-2	3,000 GALLONS	8' W X 14' L X 4' H	310L 22
S.10 FILLER WATER TANK TANK	1B-415B-2	3,000 GALLONS	8' W X 14' L X 4' H	310L 22
S.11 Glass Separator Solution Tank	1B-416A-2	4,000 GALLONS	12' W X 12' L X 4' H	RETRACTABLE LINES
S.12 Glass Separator Solution Tank	1B-416B-2	4,000 GALLONS	12' W X 12' L X 4' H	RETRACTABLE LINES

**APPENDIX H: Location of Expected Cs Accumulation Locations
in a Combustion Heater**

APPENDIX E
LOCATION OF EXPECTED Cs SPOTS IN A COMBUSTION MELTER

1. Melter

1.1 In the CRV

Cs (and other volatiles) can condense in the thermal insulation, between the refractory and the water cooled jacket. The refractory liner in the CRV consists of several pieces of refractory. During operating time, additional cracks in this refractory will occur. Cs vapor will penetrate through the joints and cracks in this refractory, which is not covered by molten glass, i.e. in the upper part of the CRV. Before start-up with radioactive material, the melter will be fed with non radioactive glass. This glass penetrates through the joints of the refractory and freezes behind the refractory in the insulation layer, when it's viscosity becomes too high.

During operation, molten radioactive glass will penetrate through additional cracks and freeze in the insulation layer.

At the end of operation, the melter is rinsed with non radioactive glass, to dilute (remove) the radioactive glass.

The condensed Cs and the frozen glass (which contains also Cs) can not be removed by decontamination of the melter.

1.2 In the Cyclone

Molten glass will penetrate through the joints and the additional cracks and will freeze behind the refractory in the insulation layer, when it's viscosity becomes too high. Less penetration of Cs vapor into the insulation is expected, because the inner surface of the cyclone is covered with glass.

1.3 In the Separator

The separator consists of a small glass pool and a plenum, which is not touched by the molten glass.

The produced off-gas passes this plenum before it enters the refractory lined off-gas pipe. The off-gas temperature at this point is >1300°C. Cs vapor can penetrate through the joints and cracks in the refractory and will condense in the thermal insulation.

2. Off-gas Pipe

To prevent plugging of the off-gas pipe, a cleaning device for periodical removing of the solids is necessary. The mechanism for Cs accumulation between the refractory/insulation and the enveloped steel liner is similar as described before.

3. Quench Tower

Critical location for solid precipitation is the mouth of the off-gas pipe where it enters the quench tower. Here the off-gas is cooled down drastically from 1300°C to <100°C.

To what extent these solids can be removed by decontaminating the quench tower, is doubtful.

4. Estimation of the inner, Geometrical¹ surface of a combustion melter (100 Mg/24h)

CRV	≈ 35 m ²
Cyclone	≈ 40 m ²
Separator (total)	≈ 70 m ²
Separator, surface covered with molten glass	≈ 20 m ²
Separator (plenum)	≈ 50 m ²

5. Estimation of the inner, Geometrical¹ surface of the off-gas pipe

Inner diameter (assumption)	≈ 0.8 m
Length (assumption)	≈ 1 m
Inner Surface	≈ 7.5 m ²

6. Cs accumulation in the combustion melter and off-gas pipe between melter and quench tower during their lifetime.

¹ The inner, visible surface can be seen when you are in the center of the cylinder.

² The inner, visible surface can be seen when you are in the center of the off-gas pipe.

During the lifetime of the melter, Cs accumulation can occur:

- in the CRV, behind the refractory in the insulation
- in the glass, inside the CRV on the refractory
- in the glass, inside the cyclone on the refractory
- in the glass, inside the separator on the refractory
- in the insulation behind the refractory of the separator plenum
- in the glass, inside the off-gas pipe on the refractory
- in the off-gas pipe, behind the refractory in the insulation

6. Pamela Experience

The process conditions in the Pamela process are completely different compared with the combustion melter. The main differences are:

	Combustion Melter	Pamela Process
Off-gas temperature	* > 1300°C	* 250 - 400°C
Volatilization of components	<ul style="list-style-type: none"> • no cold cap • high volatilization of components with low vapor pressure are expected 	* cold cap covered > 85% of the total melting surface
Off-gas pipe	<ul style="list-style-type: none"> • covered with refractory enveloped by insulation • joints between the refractory 	* stainless steel pipe with dust removing device

In one year operating time, about 27 Mg high level waste glass¹ was produced.

During this time, ~ 10 kg solids were precipitated in the off-gas pipe. About 1% of these solids were identified as Cesium.

But, be careful in using these data for an estimation of expected Cs accumulation in the combustion melter because of the not comparable process conditions!

¹ Specific radioactivity of the liquid waste was 160 Ci/l. Waste oxide loading in the glass was about 10%.

**APPENDIX I: Office Recirculation and Associated Bremsstrahlung
Factor Analysis**

APPENDIX IOFFGAS RECIRCULATION
AND
ASSOCIATED BREMSSTRAHLUNG FACTOR ANALYSIS

The basis for the halter offgas recirculation analysis is presented in Figure 4.3 in the body of the report. The conclusion of the analysis is that the ratio of the quantity of C_{w_i} in C_i of the recirculated stream (n_i) to the input stream (n_1) is given as follows:

$$\frac{n_i}{n_1} = \frac{1}{(1 - R)}$$

Where: R = Recirculation Fraction (e.g., 30% = 0.3)

In addition to the offgas recirculation concentration of C_w , a beta radiation induced bremsstrahlung photon dose rate has been calculated for the High Blend source based on a 1.0 gal volume. It was determined that bremsstrahlung contributed about 26 percent (25.93 percent) of the total dose rate for the 1.0 gal source of stream #404 (it is assumed that the other streams (#400, #405 and #406) between the Evaporator Feed Tank and the Halter have a similar 26 percent bremsstrahlung contribution to the total dose rate.

The issue of Cs recirculation requires an adjustment to the bremsstrahlung factor, since now the gamma based dose rate will be higher independent of the bremsstrahlung and so an over-estimation of the total dose rate will result if the same 26 percent is used with the higher gamma dose rate. The factor applied to the gamma dose rate is calculated to be:

$$T = \text{Total Dose Rate} = T + B$$

$$T = B \left(\frac{1}{1 - 0.2593} \right)$$

$$\text{Where: } \frac{B}{T} = 0.2593$$

$$T = 1$$

$$\text{Bremsstrahlung Factor} = \left(\frac{1}{1 - 0.2583} \right) = 1.348$$

Thus, total dose rate = gamma dose rate x 1.348.

The new bremsstrahlung factor based on the old bremsstrahlung factor and the Cs recirculation dose rate factor is:

$$F_n = 1 + \left(\frac{F_o - 1}{F_r} \right)$$

Where: F_n = New Bremsstrahlung Factor

F_o = Old Bremsstrahlung Factor

F_r = Recirculation Factor, Based on Table 3.1 Averages

With Cs recirculation factors of 1.21, 1.58 and 2.81 for the 30 percent, 55 percent and 80 percent recirculation fractions, respectively, the new bremsstrahlung factors become:

Recirculation Fraction	Bremsstrahlung Old Factor	Recirculation Factor	Bremsstrahlung New Factor
0%	1.348	1.00	1.348
30%	1.348	1.21	1.282
55%	1.348	1.58	1.220
80%	1.348	2.81	1.124

The new total dose rate with various fractions of salted offgas (Cs) recirculation is given by the following:

$$T_n = G_n F_n = G_n \left(\frac{G_n}{G_o} \right) F_n = G_n F_n F_n = G_n H_1$$

Where: T_n = New Total Dose Rate for Recirculated Off-Gas

G_n = Γ -Ray Dose Rate with Recirculation

G_o = Γ -Ray Dose Rate with No Recirculation

H_1 = Combined Factor for Total Dose Rate = $F_n F_n$

Based on the above values of New Bremsstrahlung Factors and Recirculation Factors, the following dose rate Combined Factors are obtained:

Recirculation Fraction	Bremsstrahlung New Factor	Recirculation Factor	Combined Dose Rate New Factor
0%	1.348	1.00	1.348
30%	1.293	1.23	1.578
55%	1.220	1.58	1.928
60%	1.124	2.81	3.158

**APPENDIX J: Specification for the Various Maintenance Radiation Dose
Rate Calculations for the High Level Waste Streams**

**THE FOLLOWING PAGES ARE TYPED-UP VERSIONS
OF THE ORIGINAL CALC SHEETS**

APPENDIX J-1:**MAINTENANCE OF ROTARY FEEDER AT CULLET STORAGE TANKS**

The radiation analysis for the Rotary Feeder at the Cullet Storage Tanks is based on the configuration shown in Figure J-1.

VICINITY SOURCES:

The following specifics apply to Cullet Storage Tank:

Cullet Storage Tank = 30 ft diameter x 20 ft T/T
 Assume 0.5 in. thick tank walls of 304L stainless steel
 Capacity = 600 MT ----> (Cullet density = 1.848 MT/m³)
 Volume of Cullet = 324.675 m³, (600/1.848)

For an assumed cylindrical shaped tank, the following is used to get the equivalent cullet height:

$$V_{\text{eq}} = \pi \frac{d^2}{4} \times h$$

$$h = \frac{4V_{\text{eq}}}{\pi d^2} = \frac{4(324.675 \text{ m}^3)}{\pi (30\text{ft} \times 0.3048 \text{ m/ft})^2} = 4.944 \text{ m}$$

Corresponding cylinder height = 4.944 m (100% cullet source height in tank)

CULLET TANK SOURCE:

5% of 4.944 m height = 0.2472 m

5% Volume = 16.234 m³ and using this volume for an assumed equivalent volume conical section (assuming all cullet in the bottom conical section):

$$V_{\text{cone}} = \frac{\pi r^2 h}{3} = \frac{\pi d^2}{12} \times h$$

FIGURE J-1: ROTARY FEEDER AT COLLET STORAGE TANKS

ROTARY FEEDER AT
COLLET STORAGE TANKS

FIGURE J-1

$$h = \frac{12V_{\text{cone}}}{\pi d^2} = \frac{12(16.234 \text{ m}^3)}{\pi(43.6127 \text{ m}^2)} = 0.7416 \text{ m}$$

This bottom cone height of 0.7416 m is used for the 5t full analysis. For the 10 ft diameter tank, this represents a bottom cone angle of 9.223°.

As a check, calculate the height if the bottom cone were at a 45° angle,
or, $h = r$

$$V_{\text{cone}} = \frac{\pi h^3}{3} = \frac{\pi h^3}{3}$$

$$h = \sqrt[3]{\frac{3V_{\text{cone}}}{\pi}} = \sqrt[3]{\frac{3(16.234 \text{ m}^3)}{\pi}} = \sqrt[3]{15.5023 \text{ m}^3} = 2.4934 \text{ m}$$

The 45° angle cone height is too large at 2.4934 m, so the full diameter cone height of 0.7416 m is used for the analysis.

Culter bremsstrahlung factor (from 1.0 m² sample at 10 cm):

$$\text{Area Factor} = \frac{\text{Dose Rate } (\beta)}{\text{Dose Rate (Total)}} = \frac{1.806 \times 10^3}{1.368 \times 10^4} = 0.1174$$

Where, Total = $\gamma + \beta$

$$\text{Total Dose Rate} = \frac{\text{Dose Rate } (\gamma)}{1 - 0.1174} = \frac{\text{Dose Rate } (\gamma)}{0.8826}$$

or, Total Dose Rate = 1.1330 Dose Rate (γ)

**APPENDIX J-2:
MAINTENANCE OF EVAPORATOR REBOILER**

The Evaporator Reboiler is process stream #404. Since the reboiler is not well defined, Figure J-2 of the evaporator (equipment number EV-402-2) will be used as the source configuration. This has the dimensions of

10 ft W x 32 ft L x 38 ft H, which is assumed to be 5% full (residual heel).

VICINITY SOURCES:

TX-400-2 = 12 ft ID x 19 ft H (316 SS) (9400 gal capacity)
(100% full) Stream #400

The solid component is the same as stream #404, the liquid component radionuclide total Ci is the same as stream #404, but the concentration is less due to the higher liquid volume of the Evaporator Feed Tank.

Assume that the mid-height of the Evaporator Feed Tank (EFT) 9400 gal capacity is at the mid-height of the Evaporator Reboiler. The liquid height in the 32 ft diameter tank is 9400 gal or 35,581.82 t:

$$V_{cyl} = \pi \frac{d^2}{4} \times h$$

$$h = \frac{4V_{cyl}}{\pi d^2} = \frac{4(9400 \text{ gal}) \times (0.13368 \text{ ft}^3/\text{gal})}{\pi (32 \text{ ft})^2} = 11.11 \text{ ft}$$

h = 11.1 ft = 338.65 cm
d = 32.0 ft = 965.76 cm, r = 162.88 cm

Assume 0.5 in. thick iron tank wall material

EVAPORATOR:

Assume the entire Evaporator volume is at 1% full since no data is available on the size of the Evaporator Reboiler.

Volume = 10 ft W x 32 ft L x 38 ft H = 1.216 x 10⁴ ft³
Volume = 1.216 x 10⁴ ft³ x (28.316 t/ft³) = (3.442 x 10⁵ t)
1% of the total volume = 3.4432 x 10³ t

FIGURE J-2: MAINTENANCE OF EVAPORATOR REBOILER

J-5

Bremsstrahlung Factor:

Factors for the Evaporator Feed Tank and Evaporator (See Stream #404 for the Evaporator) -

The analysis of the Melter Feed Tank (using Stream #404), gives the following values for the bremsstrahlung factors as a function of offgas recirculation:

$$F_n = 1 + \left(\frac{F_o - 1}{R_1} \right)$$

where: F_n = New Bremsstrahlung Factor
 F_o = Old Bremsstrahlung Factor
 R_1 = Recirculation Fraction Factor

Using the above relationship, the following New Bremsstrahlung Factors are obtained for four values of Cs recirculation percentages:

Cs Recirc %	No Recirculation Old Brem Factor, F_o	Recirc Fraction R_1	New Brem Factor F_n
0%	1.348	1.00	1.348
10%	1.348	1.23	1.283
55%	1.348	1.58	1.220
80%	1.348	2.81	1.124

The new total dose rate for various recirculated off-gas percentages is given by:

$$T_n = G_o F_n = G_o \left(\frac{G_n}{G_o} \right) F_n = G_n R_1 F_n$$

where: T_n = New total dose rate for recirculated offgas
 G_o = Gamma dose rate with no recirculated offgas
 G_n = New Gamma dose rate with offgas recirculation
 R_1 = Values from above Table (third column)
 F_n = Values from above Table (last column)

The following product of $R \times F$ values for the four corresponding recirculation fractions are:

<u>Or Recirc. %</u>	<u>R x F</u>
0%	1.348
30%	1.5781
55%	1.9276
80%	3.1584

The following are the results for the High Blend Source:

Evap Locath from Surface (cm)	Evaporator (mR/h)	Evaporator Feed Tank (mR/h)	Total (mR/h)	Total w/Brem & Recirc Recirculation Fractions			
				0%	30%	55%	80%
1 cm	66.34	222.1	288.44	388.82	499.19	556.00	911.01
30 cm	63.99	243.6	307.59	414.63	489.41	592.91	976.49
100 cm	63.18	208.7	271.88	501.29	586.86	716.84	1174.55

As a check on the values in the above table, the individual components of the dose rate are calculated and then added for the 0% recirculation parameter. The results of this check calculation are shown in the following table:

Evap Locath from Surface (cm)	Total with Just Bremstr. (mR/h)	Total with Brem. & Recirc. % (mR/h)	Evaporator Component (mR/h)	Evaporator Feed Tank Component (mR/h)	Check Total (mR/h)
1 cm	288.44	288.82	89.426	299.391	388.82
30 cm	307.59	414.63	86.259	328.373	414.63
100 cm	271.88	501.29	851.67	416.126	501.29

The third column values (obtained from the fifth column in the previous table) agree with the values in the last column and therefore the totals check.

APPENDIX J-3:
MAINTENANCE OF MIST ELIMINATOR IN WELDER ROOM

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The Mist Eliminator (ME) is identified as equipment number DE-618A-2 and whose waste stream is characterized by process stream #628. The material of the ME is Hastalloy C-22 and cylindrical ME has dimensions of:

7 ft OD x 14 ft = 2 in. height

VICINITY SOURCES:

The ME has six significant vicinity sources with the associated item number and dimensions:

Cooler	(EC-615A-2)	9 ft OD x 20 ft Height
Chiller	(EC-617A-1)	Mounted on TK 614A-2
Scrub Solution Tank (TK-614A-2)		12 ft OD x 12 ft T/T*, 19 ft Height
Quench Tower	(T-609A-2)	11 ft OD x 15 ft T/T, 20 ft = 2 in. H
Walter	(EM-412A-2)	17 ft - 9 in. W x 26 ft L x 36 ft - 4 in. H
Separator	(S-412A-2)	8 ft W x 30 ft L x 8 ft H
Cullet Catch Tank (TK-416A-4)		11 ft ID x 17 ft - 6 in. H (7100 gal)

* Note: T/T = Tangent-to-Tangent, H = Top-to-Bottom Overall Height

(See Figure J-3)

The approximate volumes of the above vicinity equipment/tanks are as follows:

<u>Mist Eliminator:</u>	15.438 m ³	15,438 l
<u>Cooler:</u>	16.029 m ³	16,029 l
<u>Chiller:</u>	5.890 m ³	5,890 l
<u>Scrub Solution Tank:</u>	53.392 m ³	53,392 l
<u>Cullet Catch Tank:</u>	26.876 m ³	26,876 l (7100 gal vol.)

(note: effective density = cullet density + water density =
0.7 @ 2.64 + 0.3 @ 1.00 = 2.148 g/cm³)

- CRV	8 1 cm thick glass plateout = 0.330 m ³	350t
- Cyclone	8 1 cm thick glass plateout = 0.400 m ³	400t
- Separator Plenum	8 1 cm thick glass plateout = 0.500 m ³	500t
- Off-Gas Pipe	8 1 cm thick glass plateout = 0.075 m ³	75t
- Separator Pool	8 12 in. glass pool height = 5.748 m ³	5,748t

The following calculations support the above estimated source volumes:

Mist Eliminator:

$$V_{\text{MEL}} = \pi \frac{d^2}{4} \times h = \frac{\pi (2.2336 \text{ m})^2 (4.318 \text{ m})}{4} = 15.438 \text{ m}^3$$

Cooler:

$$V_{\text{CO}} = \pi \frac{d^2}{4} \times h = \frac{\pi (2.7432 \text{ m})^2 (6.096 \text{ m})}{4} = 36.029 \text{ m}^3$$

Chiller: (Assume, scaled from drawing that OD = 1.0 m and h = 7.5 m)

$$V_{\text{CH}} = \pi \frac{d^2}{4} \times h = \frac{\pi (1.0 \text{ m})^2 (7.5 \text{ m})}{4} = 5.890 \text{ m}^3$$

Scrub Solution Tank:

Total Volume $V_t = V_{\text{MEL}} + V_{\text{CO}} + V_{\text{CH}} = V_1 + V_2$

$$V_1 = \pi \frac{d^2}{4} \times h = \frac{\pi (3.658 \text{ m})^2 (3.638 \text{ m})}{4} = 39.4433 \text{ m}^3$$

Assume that the Top + Bottom = Ellipsoid with 12 ft circular diameter (6 ft radius) and half-height of (19 ft - 12 ft)/2 = 3.5 ft = h in the following equation.

$$V_2 = \frac{4}{3} \pi r^2 h = \frac{\pi d^2}{3} h = \frac{\pi (3.658 \text{ m})^2 (1.0668 \text{ m})}{3} = 14.949 \text{ m}^3$$

$$V_1 = V_i + V_r = 38.4493 \text{ m}^3 + 14.949 \text{ m}^3 = 53.392 \text{ m}^3$$

Gullet Catch Tank: (Note: Effective gullet height used to get 7100 gal)

$$V_{gt} = \pi \frac{d^2}{4} \times h = \frac{\pi (3.3528 \text{ m})^2 (3.0461 \text{ m})}{4} = 26.8756 \text{ m}^3$$

Welter: Various Components - Note that the component internal areas are based on the information provided in Appendix E related to the Cs plateout areas in the welter (See Figure J-4).

- CRV Plateout area estimated to be 35 m² (Appendix E)
- Cyclona Plateout area estimated to be 40 m² (Appendix E)
- Separator Plenum

The area of the plenum = top + 2 ends + 2 sides (See Figure J-5).

Separator has dimensions of 8 ft W x 30 ft L x 8 ft H, with 6 in. of refractory insulation liner all around the inside leaving net dimensions of 7 ft W x 29 ft L x 7 ft H (plenum height above the glass pool of less an additional 12 in. of glass pool depth); for a net plenum height of 6 ft. Since the pool area is included in the glass pool below, the plenum area for glass plateout analysis is thus:

$$\begin{aligned} \text{top} &= 203 \text{ ft}^2 \\ 2 \times \text{sides} &= 84 \text{ ft}^2 \\ 2 \times \text{sides} &= 112 \text{ ft}^2 \\ \text{Total} &= 399 \text{ ft}^2 \end{aligned}$$

Note that 399 ft² = 36.99 m² (which is close to the Appendix E estimated value of 50 m² for the Cs plateout of the Separator Plenum).

- Off-Gas Pipe See the last section of this Appendix J for the analysis of the Offgas Pipe plateout area.

FIGURE J-4: GLASS MELTER COMPONENTS

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FIGURE J-5: SEPARATOR PLENUM / POOL GLASS ALLOCATION

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- Separator Pool

The glass pool is assumed to be 1 ft deep inside the 8 ft high total separator height. The separator has horizontal dimensions of 8 ft wide by 30 ft long (outside). Accounting for the 6 in. thick refractory liner gives the following:

Pool Area = 7 ft x 29 ft = 203 ft², 12 in. deep glass = 203 ft³ glass pool volume. This converts to 5.7483 m³.

As a summary to the above, the following areas and glass plateout volumes are used:

MELTER COMPONENT	PLATEOUT AREA	GLASS VOLUME @ 1 cm THICKNESS
CRV	35 m ²	0.350 m ³
CYCLONE	40 m ²	0.400 m ³
SEPARATOR POOL	20 m ²	0.200 m ³
SEPARATOR PLENUM	50 m ²	0.500 m ³
OFFGAS PIPE	7.5 m ²	0.075 m ³

As a first order approximation, all vicinity sources are measured from the center of the Mist Eliminator, with additional locations being taken as the "top" and "bottom" of the Mist Eliminator to give a lower limit and an upper limit to be added to the dose rates directly from the Mist Eliminator (See Figures J-6A/B/C, J-7, J-8, J-9 and J-10). However, the radiation field from the nearby Mist Eliminator is calculated at 1 cm, 30 cm and 100 cm distances to obtain realistic dose rates for the various maintenance personnel.

For the purposes of the analysis, it is assumed that the solid glass has the same bremsstrahlung factor as the glass collat, namely 1.133. This bremsstrahlung factor is used to multiply each of the resulting dose rates to account for the bremsstrahlung contribution for the glass for the base case of 0% Cs recirculation and the base case of 1x Cs concentration factor for the various Cs plateout considerations.

FIGURE J-6A: DISTANCES FROM VICINITY EQUIPMENT TO M.E. (ELEVATION A)

DISTANCES FROM VICINITY
EQUIPMENT TO M.E.
ELEVATION A

FIGURE J-6A

by [illegible]

by [illegible]

by [illegible]

FIGURE J-6B: DISTANCES FROM VICINITY EQUIPMENT TO M.E.
(ELEVATION B)

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DISTANCES FROM VICINITY
EQUIPMENT TO M.E.
(ELEVATION B)

FIGURE J-6B

11-10-88

11-10-88

FIGURE J-10 MIST ELIMINATOR MAINTENANCE ANALYSIS (ELEVATION VIEW #2)

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MIST ELIMINATOR
MAINTENANCE ANALYSIS
ELEVATION VIEW #2

FIGURE J-10

1-10-10

1-10-10

A new material is needed for the MicroShield analysis for the Cullet Catch Tank (Cullet + Water). The following table provides the individual elemental data needed to specify the new mixture for the MicroShield analysis (with an effective density of 2.148 g/cm³ from above):

1	CULLET ELEMENT	Z	ρ_i (g/cm ³)	70% ρ_i (g/cm ³)	Total O ₂
1	Li	3	0.045	0.0322	1.1702
2	B	5	0.102	0.0714	
3	O	8	1.302	0.9115	
4	Na	11	0.702	0.4914	
5	Al(Mg)*	13(12)	0.714.059	0.0532	
6	Si	14	0.631	0.4417	
7	Cn	20	0.054	0.0378	
8	Cr	24	0.034	0.0169	
9	Fe	26	0.203	0.1414	
-----			-----	-----	
Total			2.64	1.848	
1	WATER	2	ρ_i (g/cm ³)	90% ρ_i (g/cm ³)	
10	H	1	0.111	0.0999	
1**	O	8	0.889	0.7997	
			-----	-----	
			1.00	0.900	

* Note: MicroShield can only accept 10 total elements for material specifications, so Al and Mg were added with the somewhat larger Al used for the effective Z (gammas are primarily attenuated as a slowly varying function of Z, so this is a good approximation).

** Note: The Oxygen from the water is added to the Oxygen from the Glass Cullet to obtain the total Oxygen in the new material mixture (see last column).

The following results are obtained for the various vicinity glass-based sources (note that from the flow streams for the Cooler, Chiller and Scrub Solution Tank, there are no radioisotopes in these pieces of equipment during the proposed operations):

SOURCE	NE - BOTTOM (mR/h)		NE - MID-HEIGHT (mR/h)		NE - TOP (mR/h)	
	Gamma	W/Brem*	Gamma	W/Brem*	Gamma	W/Brem*
Catch Tank	10.14	11.49	9.212	10.44	8.392	9.508
Separator Pool	20.20	22.89	17.99	20.28	16.10	18.24
Separator Plenum	3.151	3.570	2.867	3.248	2.931	3.368
Welter CRV	1.315	1.480	1.013	1.140	.7214	.8173
Welter Cyclone	.1693	.1918	.2290	.2595	.2784	.3164
Off-Gas Pipe	.3743	.4241	.3310	.3750	.2812	.3186

* Note: The bremsstrahlung factor of 1.133 is used to account for the glass total radiation source contribution.

These results are used in the body of the report to calculate the radiation fields around the Mist Eliminator.

APPENDIX J-4c

MAINTENANCE OF FEED PUMP AT THE MELTER FEED TANK

The Melter Feed Pump is at the bottom of the Melter Feed Tank. The analysis use two adjacent tanks: another Melter Feed Tank (Stream #406) and a Melter Feed Adjustment Tank (Stream #405). The attached/closed Melter Feed Tank is assumed to be "drained" during maintenance with a 5% heel left in the tank. The tanks are assumed to be made of 0.5 in. thick Hastelloy steel (Hastelloy-C with a density of 8.3 g/cm³). The two adjacent tanks are assumed to be 100% full for the purposes of the analysis. The analysis configuration is shown in the Figure J-11.

Note (a) to Figure J-11: The entire Melter Feed Tank = 12 ft Diameter x 19 ft high, which is equivalent to 16,074 gal for an assumed cylindrical shape. Since the residual solution can be anywhere in the tank, the equivalent tank volume of 16,074 gal is used as a basis for the 5% residual volume (heel) to give a resulting source volume of 803.7 gal or 3642.3 l.

The beta radiation produced bremsstrahlung radiation is shown to be about 26% of the total dose (25.8% for Stream #404) to give bremsstrahlung factor of 1.348:

$$\begin{aligned}\frac{B}{T} &= 0.2538 \\ B &= 0.2538T \\ T &= 0.2538T + G \\ T &= \frac{G}{1 - 0.2538} = 1.348G\end{aligned}$$

Therefore, Total Dose Rate = (Gamma Dose Rate) x 1.348

Three separate calculations are performed:

1. Melter Feed Tank source @ 8.5 m & distance (Stream #404)
2. Melter Feed Adjustment Tank source @ 8.5 m & distance (Stream #405)
3. Melter Feed Tank source (along centerline, 5%, Stream #406)

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 FIGURE J-11: MAINTENANCE OF MELTER FEED PUMP AT MELTER FEED TANK
 Revision 0

Total source in liters for each:

1. $9400 \text{ gal} = (3.7853 \text{ l/gal}) \times (9400 \text{ gal}) = 3.5519 \times 10^4 \text{ l}$
(#406)
2. $9400 \text{ gal} = (3.7853 \text{ l/gal}) \times (9400 \text{ gal}) = 3.5519 \times 10^4 \text{ l}$
(#405)
3. $(0.05) \times (3.7853 \text{ l/gal}) \times (16,074 \text{ gal}) = 3.0422 \times 10^1 \text{ l}$
(#406)

Note that 1, 2 & 3 (#406, #405 & #406, respectively) need a bremsstrahlung factor, even 2 (Stream #405) which is close to Stream #406 that has a combined $\gamma + \beta$ source calculated from the tank waste comparison study (recall that Stream #404 is used for all of the tank waste sources). The bremsstrahlung factor is needed because the relatively small 1.0 gal source used for the tank waste comparisons is unrealistic for the large 9400 gal tank (the source self absorption would be different).

Considering Cs recirculation, the bremsstrahlung factor changes since it is based on calculating the total dose rate from the gamma dose rate. The following relationship is used to determine the change in the bremsstrahlung factor with variations in recirculation percentages (recirculation factor/fraction) of main flow rate:

$$\begin{aligned}
 T_o &= G_o F_o = G_o + B \\
 B + G_o F_o - G_o &= G_o (F_o - 1) \\
 T_o &= G_o F_o = G_o + B \\
 B + G_o F_o - G_o &= G_o (F_o - 1)
 \end{aligned}$$

But, $B = B$. Therefore,

$$\begin{aligned}
 G_o (F_o - 1) &= G_o (F_o - 1) \\
 \frac{G_o}{G_o} &= R_1 = \frac{F_o - 1}{F_o - 1}
 \end{aligned}$$

Where R_1 = Recirculation Factor

Thus, F_o can be obtained in terms of F_o and R_1 , the original bremsstrahlung factor (1.348) without recirculation ($R_1 = 1.0$, or 0%) and the Cs recirculation factors (1.23, 1.58 and 2.81 for 30%, 55% and 80% recirculation, respectively).

Solving for F_n , the new bremsstrahlung factor is given by:

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$$F_n = 1 + \left(\frac{F_o - 1}{R_2} \right)$$

This gives the following values for the new bremsstrahlung factor, F_n , for each respective Cs recirculation fraction/factor:

Cs Recirc %	No Recirculation Old Brem Factor (F_o)	R_2	New Bremsstrahlung Factor (F_n)
0%	1.348	1.00	1.348
30%	1.348	1.23	1.283
55%	1.348	1.58	1.220
80%	1.348	2.81	1.124

MAINTENANCE OF OFFGAS LINE AT TOP OF MELTER SEPARATOR

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OFFGAS PIPE:

The Offgas Line runs from the top of the Melter Separator to Tank T-609A-2 and has the approximate dimensions of 42 in. I.D. with a 6 in. thick refractory liner (leaving a net flow ID of 30 in., or 0.762 m - 0.8 m) and a length of about 3 m, as scaled from the preliminary drawings.

VICINITY SOURCES:

The following vicinity potential sources are around the Offgas Line (See Figures J-12 and J-13A/B):

Filter Wash Catch Tank: (TK-445-2) 8 ft ID x 14 ft -16 in. H (3400 gal), 316 SS

Gullat Catch Tank: (TK-414B-2) 11 ft ID x 17 ft -6 in. H (7100 gal), 316 SS

Scrub Solution Tank: (TK-614B-2) 12 ft OD x 12 ft T/T (19 ft overall) (9400 gal)

Quench Tower: (T-609-2) 11 ft ID x 15 ft T/T (20 ft -4 in. overall) with a 6 in. thick refractory lining, tank material - Inconel 690.

Melter: (EM-412-2) 17 ft -8 in. W x 26 ft L x 16 ft -4 in. H, 6 in. thick refractory lined. The refractory lined Separator (S-413H-2) has the dimensions of 8 ft W x 30 ft L x 8 ft H.

OFFGAS PIPE:

The following model is used for the Offgas Pipe with residual glass plated out on the inside of the refractory liner walls:

For the purposes of the contact maintenance study, the offgas pipe is assumed to be a straight pipe of about 3 m in length (approximate as scaled from preliminary drawings) and a 42 in. ID with an internal liner of 6 in. of ceramic (assumed to be monofrac) thermal protective insulation, giving a net ID of 42 in. - 2x6 in. = 30 in. = 0.762 m = 0.8 m ID.

For the previous Mist Eliminator radiation analysis, residual/plated out glass is assumed to be the primary source with a range of Cs concentration factors (1, 10, 100, and 1000 times the base case Cs concentration) in an assumed 1 cm thick glass layer inside the offgas pipe (See Figure J-14).

FIGURE J-11: OFFGAS PIPE MAINTENANCE (PLAN VIEW)

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 FIGURE J-13A: DISTANCES FROM VICINITY EQUIPMENT TO OFFGAS PIPE
 (ELEVATION A) Revision 0

DISTANCES FROM VICINITY
 EQUIPMENT TO OFFGAS PIPELINE
 (ELEVATION A)

FIGURE J-13A

1/10/00 1/10/00

WUC-SD-WM-TI-763
 FIGURE J-13B: DISTANCES FROM VICINITY EQUIPMENT TO OFFGAS PIPE
 (PLAN VIEW) REVISION 0

J-31

OFFGAS PIPE
MODEL OF PLATED-OUT
GLASS

FIGURE J-14

4-10-76

4-10-76

4-10-76

The volume of glass was primarily calculated for the Offgas Pipe Revision 0, for the Mist eliminator (ME) maintenance scenario based on the 0.8 m ID and 3 m length giving about a 7.5 m³ internal area which translates into about 0.075 m³ volume of glass for the 1 cm thick glass plateout. Using the above more accurate dimensions, gives a glass volume of 0.072 m³, so the original ME value of 0.075 m³ can be used as a good approximation to be consistent (less than a 5% difference between the two values). This annular cylinder model is used in the MicroShield 4.10 code radiation analysis.

Based on the above sources, the following radiation intensity results are obtained using the original "High Blend" source:

DOSE RATES	± 1 cm Distance		± 30 cm Distance		± 100cm Distance	
	mR/h	u/Brm	mR/h	u/Brm	mR/h	u/Brm
Offgas Pipe	67.57	76.037	45.33	48.980	23.08	25.017
Welter VCR	1.864	2.1373	1.960	2.231	2.189	2.480
Welter Cyclone	2.069	2.344	2.108	2.388	2.184	2.475
Separator Plenum	17.60	20.187	16.92	18.170	15.03	17.029
Separator Pool	68.56	88.010	65.31	73.996	38.28	66.031
Cullet Catch Tank	18.66	21.142	18.22	20.643	17.19	19.465

These results can be scaled to the NCAN source based on the results of Table 2.1 in the main body of the report. The following scaled results are obtained for the NCAN source (based on $\times 0.447$ @ 30 cm and 100 cm):

DOSE RATE	@ 1 cm Distance		@ 30 cm Distance		@ 100cm Distance	
	mR/h	w/Straw	mR/h	w/Straw	mR/h	w/Straw
Offgas Pipe	30.20	34.221	19.32	21.894	9.870	11.026
Melter VCR	0.833	0.9354	0.876	0.993	0.978	1.109
Melter Cyclone	0.925	1.049	0.943	1.067	0.976	1.106
Separator Plenum	7.954	9.0144	7.563	8.5690	6.718	7.6119
Separator Pool	30.65	39.240	29.19	33.076	26.04	29.516
Gullet Catch Tank	8.341	9.4505	8.144	9.2374	7.679	8.7009

**APPENDIX K: Facility Layout Drawings for Non-Radioactive
Class Plant**

K-1

CASE 9
COMMERCIAL GLASS
MANUFACTURING PLANT

[illegible]

367/368

CASE 9
COMMERCIAL GLASS
MANUFACTURING PLANT

[illegible]

LEGEND

LOW LEVEL WASTE TREATMENT PLANT 371/372

AF	ANALYTICAL FACILITY
BCH	BULK GOLD CHEMICAL BUILDING
BHA	BULK HANDLING AREA
BGB	BIOGENIC GENERATOR
ENC	EMERGENCY RESPONSE CENTER
FAS	FABRICATION & ASSEMBLY SHOP
LCWAP	LLW INTERMEDIARY BUILDING
LCBA	CONTACT FILTER/WHEEL ROOM (LL)
NCA	CONDENSATE COLLECTION AREA (LL)
LCBA	CONDENSATE STAGING AREA (LL)
LFA	PULVERIZER AREA (LL)
LFT2	REGULATED FACILITY ENTRY AREA (LL)
MUB	MEDICAL UTILITY BUILDING
OSB	OPERATIONS SUPPORT BUILDING
ACE	REGULATED PMS CONTROL ENTRY
SCB/STOR	STORAGE/STORAGE TANK
SCB	STORAGE BUILDING
SHR/RECNG	SHIPPING AND RECEIVING BUILDING
WAB	WATER TOWER
WH	WATER PUMP HOUSE

COMMERCIAL FLAT GLASS PLANT

CAB	ADMINISTRATION BUILDING
CWAP	BULK MATERIAL HANDLING FACILITY
CCT	COOLING TOWER
CUF	MANUFACTURING FACILITY
CUS	MAINTENANCE SHOP
CUB	UTILITY BUILDING
CWSE	DELIVERY WAREHOUSE

NOTE:

1. RAIN WATER AND SANITARY WATER ARE ASSUMED TO BE INTO EXISTING UNDERGROUND LINES
2. NO ON-SITE SEWAGE TREATMENT. THE SEWAGE SYSTEM IS ASSUMED TO BE INTO THE PROPOSED (L-118) 200 AREA SANITARY SEWER SYSTEM

U.S. DEPARTMENT OF ENERGY	
Nuclear Power Plant	
Project Name: 200mg/D LLW PLANT AND CONTIGUOUSLY BUILT COMMERCIAL 200mg/D FLAT GLASS PLANT ON DOE LAND	
Project No.	ES-AL19A-011
Rev.	4
Date	4/4/00

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