

Process Design Concepts for Stabilization of High Level Waste Calcine

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Alan K. Herbst

June 2005

**Idaho
Cleanup
Project**

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Idaho Falls, Idaho 83415

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ABSTRACT

The current baseline assumption is that packaging “as is” and direct disposal of high level waste (HLW) calcine in a Monitored Geologic Repository will be allowed. The fall back position is to develop a stabilized waste form for the HLW calcine, that will meet repository waste acceptance criteria currently in place, in case regulatory initiatives are unsuccessful. A decision between direct disposal or a stabilization alternative is anticipated by June 2006.

The purposes of this Engineering Design File (EDF) are to provide a pre-conceptual design on three low temperature processes under development for stabilization of high level waste calcine (i.e., the grout, hydroceramic grout, and iron phosphate ceramic processes) and to support a down selection among the three candidates. The key assumptions for the pre-conceptual design assessment are that a) a waste treatment plant would operate over eight years for 200 days a year, b) a design processing rate of 3.67 m³/day or 4670 kg/day of HLW calcine would be needed, and c) the performance of waste form would remove the HLW calcine from the hazardous waste category, and d) the waste form loadings would range from about 21-25 wt% calcine.

The conclusions of this EDF study are that:

- To date, the grout formulation appears to be the best candidate stabilizer among the three being tested for HLW calcine and appears to be the easiest to mix, pour, and cure.
- Only minor differences would exist between the process steps of the grout and hydroceramic grout stabilization processes. If temperature control of the mixer at about 80°C is required, it would add a major level of complexity to the iron phosphate stabilization process.
- It is too early in the development program to determine which stabilizer will produce the minimum amount of stabilized waste form for the entire HLW inventory, but the volume is assumed to be within the range of 12,250 to 14,470 m³.
- The stacked vessel height of the hot process vessels in the hydroceramic grout process (i.e., 21 m) appears to be about the same as that estimated by the Direct Cementitious Waste Process in 1998, for which a conceptual design was developed. Some of the conceptual design efforts in the 1998 study may be applicable to the stabilizer processes addressed in this EDF.
- The gamma radiation fields near the process vessels handling HLW calcine would vary from a range of about 300-350 R/hr at a distance of 2.5 cm from the side of the vessels to a range of about 50-170 R/hr at a distance of 100 cm from the side of the vessels. The calculations were made for combined calcine, which was defined as the total HLW calcine inventory uniformly mixed.
- The gamma radiation fields near the stabilized waste in canisters would range from about 25-170 R/hr at 2.5 cm from the side of the canister and 5-35 R/hr at 100 cm from the side of the canister, depending on the which bin set was the source of calcine.

The recommendations from this EDF study are:

- A value engineering session and cost benefit study should be done to determine if redundant process vessel trains would be needed. Due to the nature of remote operations and maintenance, a second process train may be needed to provide a greater certainty that production goals would be met in case process upsets were to occur.
- Pre-blended dry stabilizer ingredients should be used where possible to reduce the number of process vessels that would be required to deliver the cold ingredients (i.e., the number of bulk, day, and batch vessels required) to the mixer. In the case of the grout process, which uses three ingredients, a pre-blended mix would reduce the number of cold process vessels for the dry solids from nine to three.
- If sampling is required, a minimum of two day vessels for the HLW calcine would be required to allow one to undergo sampling and analysis while the other is feeding the grout mixer. An assessment of analytical turn around time for sample analysis should be done to determine the number of day vessels that will be required. The waste treatment plant should have a dedicated hot laboratory for required analytical services.
- Single batch vessels for solids and liquids should be used in the process vessel train to prevent overfilling the mixer and to better control the formulation for the HLW calcine and stabilizer ingredients.
- Pilot-scale studies with automated remote process steps are needed to test mixer designs, and to demonstrate process control during the addition of ingredients to the mixer, the mixing process, and transfer of the mix to the canister.
- As a starting point for gravity feed hopper design, a critical friction angle of 20° should be used for the calcine hoppers. However, this friction angle does not take into consideration the effects of fines on the calcine flow and additional testing should be done to determine this effect.

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ACRONYMS

BBWI	Bechtel BWXT Idaho, LLC
BFS	Blast Furnace Slag
CSSFs	Calcined Solids Storage Facilities
DIAL-MSU	Diagnostics Instrumentation and Analytical Laboratory-Mississippi State University
DOE/ID	Department of Energy Idaho Operations Office
DOE/HQ	Department of Energy Headquarters
DOE/EM	Department of Energy Environmental Management
DOE/NE-ID	Department of Energy Idaho Operations Office-Nuclear Energy
DWPF	Defense Waste Processing Facility
DWCO	Direct Cementitious Waste Option
EA	Environmental Assessment
EDF	Engineering Design File
FA	Fly Ash from Coal Fired Power Plant
FY	Fiscal Year
HC	Hydroceramic Process
HLW	High Level Waste
ICP	Idaho Cleanup Project
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
OPC	Ordinary Portland Cement
PCT	Product Consistency Test
RCRA	Resource Conservation and Recovery Act
S&A	Sample and Analysis
SBW	Sodium Bearing Waste
SNF	Spent Nuclear Fuel

TCLP	Toxicity Characteristic Leaching Procedure
UTS	Universal Treatment Standards
WAPS	Waste Acceptance Performance Specifications
WASRD	Waste Acceptance Systems Requirements Document

Process Design Concepts for Stabilization of High Level Waste Calcine

1. INTRODUCTION

Spent nuclear fuel (SNF) was reprocessed until 1992 at the Idaho Chemical Processing Plant (now called the Idaho Nuclear Technology and Engineering Center [INTEC]) located at the Idaho National Laboratory (INL). Reprocessing produced liquid high level waste (HLW) that was subsequently converted to a dry granular solid waste by a process called calcination. The solid waste, called HLW calcine, is primarily composed of various metal oxides, calcium fluoride, and sodium and potassium nitrates depending on the type of SNF that was reprocessed. Calcine is highly radioactive and also meets the Resource Conservation and Recovery Act (RCRA) definition of a hazardous waste because it exhibits the RCRA hazardous characteristic of toxicity for one or more toxic metal constituents and contains listed constituents associated with the RCRA hazardous waste numbers F001, F002, F005, and U134 (PLN-1144 2002). A Calcine Disposition Project baseline assumption is that implementation of a strategy to effectively work within the current RCRA regulatory framework to remove the calcined HLW from RCRA regulation as a hazardous waste is necessary to allow disposal at the Monitored Geologic Repository at Yucca Mountain, Nevada. The current DOE prohibition of disposing RCRA hazardous waste in the repository drives the need to either pursue specific exclusion of calcined HLW from regulation as hazardous waste or develop effective treatment to remove the waste from regulation as hazardous waste.

An estimated 4400 m³ of granular HLW calcine is stored at INTEC in six Calcined Solids Storage Facilities (CSSFs) of varying designs, which contain from 3-12 stainless steel bins housed in concrete vaults (Staiger and Swenson 2005). The bins range from 20 to 68 ft in height and up to 13.5 ft in diameter. As of 2005, the storage periods of the calcine range from about 41 years for the oldest calcine in CSSF I to about 5 years for some of the calcine in the CSSF VI. The major types of calcine in the CSSFs are: alumina in CSSF I; alumina and zirconia in CSSF II; mostly zirconia and some zirconia blended with sodium bearing waste (SBW) in CSSF III; and zirconia blended with increasing amounts of SBW waste in CSSFs IV-VI. Some of the key milestones in the Department of Energy Idaho Operations Office (DOE/ID) Performance Management Plan for Accelerating Cleanup of the INEEL regarding the HLW calcine are to (DOE/ID 2002):

- Complete a sample retrieval and characterization demonstration by September 2007
- Issue a record of decision on calcine treatment path forward by December 2009
- Submit an application for a RCRA Part B Permit for calcine treatment, retrieval, and packaging process by a date to be determined (note, per the DOE Request for Proposals for the Idaho Cleanup Project (ICP) contract, this date is September 30, 2009)
- Complete retrieval, packaging, alternative treatment, and shipping to a repository by December 2035.

The Calcine Disposition Project was initiated in fiscal year (FY) 2003. In support of the DOE/ID Performance Management Plan, the Calcine Disposition Project is developing design concepts for retrieval, treatment, and packaging of the calcine and conducting scientific and engineering studies to support the design concepts. The current baseline assumption being used for planning and scheduling is that packaging “as is” and direct disposal of HLW calcine in a Monitored Geologic Repository will be allowed (DOE/NE-ID 2005). The fall back position is to develop a stabilized waste form for the HLW calcine, that will meet repository waste acceptance criteria currently in place, in case regulatory initiatives are unsuccessful.

2. PURPOSE

With DOE/ID guidance that vitrification was no longer the preferred option as a waste form (Frei 2002), the Calcine Disposition Project evaluated 56 candidate stabilizers for potential application to the HLW calcine in FY 2004. As a result of this evaluation, three low-temperature stabilizers were selected as potential candidates for development (Thomas and Childs 2004). These three candidates (iron phosphate ceramic, hydroceramic grout and grout cement) are currently under development (Plodinec et. al. 2004) by the Diagnostic Instrumentation and Analysis Laboratory at Mississippi State University (DIAL-MSU). The purpose of this Engineering Design File (EDF) is to:

- Provide pre-conceptual process designs for the stabilizers under development
- Compare the process complexities among the three candidate stabilizers
- Estimate the volumes of stabilized waste that would be generated
- Provide engineering guidance in down selecting a stabilizer if more than one of the processes appear promising based on the DIAL-MSU studies
- Support the project schedule to down select a reference stabilization process for development by June 2006, if approval of “as is” packaging of HLW calcine is not obtained.

3. KEY ASSUMPTIONS

The key assumptions for calcine processing rate, sizing of process vessels, canister size and percent fill are given in Sections 3.1, 3.2, and 3.3, respectively.

3.1 HLW Calcine Processing Rate

The draft Mission Need Statement for the Calcine Disposition Project assumes that all of the HLW calcine will be retrieved and packaged for shipment to a Monitored Geologic Repository over a period of eight years between 2015 and 2022 (DOE/NE-ID 2005). In this document, it is assumed that a plant designed to stabilize the HLW calcine would operate 24 hours per day, 200 days per year, which would correspond to a plant uptime of 55%. The remaining 45% downtime would be used for maintenance and recovery from potential process upsets. The total number of operating days of a calcine treatment plant would equate to 1600 days based on the above assumptions of an eight year operating period and 200 days per year.

The total volume and mass of HLW calcine stored in the calcine bin sets at INTEC are estimated to be 4400 m³ and 5.6 × 10⁶ kg, respectively (Staiger and Swenson 2005). Dividing these inventory numbers by 1600 days of operation equates to an average required processing rate that can be expressed either as 2.75 m³/day or 3500 kg/day. A further assumption is that the design capacity of the calcine treatment plant should be 33% greater than the required average processing rate capacity. This design philosophy provides a contingency for processing at greater rates, if process upsets cause operations to fall below the average required rate. Adding 33% to the average required processing rate equates to a design processing rate that can be expressed either as 3.67 m³/day or 4670 kg/day. The design volume processing rate was used in this document for sizing vessels. The design mass processing rate was used for developing the process mass balance.

3.2 Sizing of Process Vessels

An evaluation of type, size, and the basic shape of process vessels was undertaken for each of the stabilization options and the results are given in Sections 4 through 7. The evaluation in this document is preconceptual in nature and not intended to be viewed as an optimized approach for process vessel arrays and configurations. For example, two bulk calcine receipt vessels may be needed instead of one, if one is being filled while the other is feeding the calcine treatment plant (i.e., these operations may not be compatible for the same vessel at the same time). As indicated in Section 3.1, the sizes of the vessels were based on a design calcine processing rate of 3.67 m³/day. Some of the higher level assumptions used to select and size the vessels were:

- The bulk calcine receipt and stabilizer ingredient vessels would be sized to contain enough calcine feed (i.e., 25.7 m³ of calcine) and stabilizer feed for a seven-day operating period
- The bulk vessels would feed day vessels, which would be sized to hold enough feed for a 24-hour operating period (i.e., 3.67 m³ of calcine)
- The day vessels would feed single batch vessels, which would be sized to hold enough feed to prepare one canister of stabilized waste
- The batch vessels would feed the grout mixer vessel, which would be sized to mix and transfer one canister batch of stabilized calcine.

The basic shape chosen for the process vessels to handle solids was a funnel flow hopper design, which consists of a cylindrical top section and a conical bottom section. Liquid vessels would be traditional cylindrical shaped vessels. The grout mixer would be based on commercially available mixers which are described in Section 4.2 of this document. For the cylindrical section of the funnel flow hopper, a height to diameter ratio of about 2:1 was selected. The dimensions of the conical section were constrained by three parameters:

- The diameter of the cylindrical section above it
- A critical hopper friction angle of 20° from the vertical axis of the cylindrical section
- A bottom hopper opening with a radius of 0.152 m (6 in.).

The critical hopper friction angle is based on tests done in 1991 by Johanson and Johanson on calcine flow properties in hoppers (Wanke 1993). The results were based on tests done with bed particles of cold calcine simulants with the caveat that the addition of fines would significantly alter the observed performance and that tests should be repeated with fines. An evaluation in 2004 also identified the need to determine the minimum conical hopper slope to ensure solids flow as a major development need for calcine retrieval technology (Thomas 2004). In this document, the critical friction angle was used for all the vessels that handled dry solids with the understanding that more testing is required to better define the critical angles for both the radioactive and cold ingredients. The Johanson and Johanson study assumed a hopper outlet radius of 0.152 m, which is also assumed in this document. An illustration of the method and the equations for sizing the solids process vessels is given in Appendix A, using the above set of assumptions.

3.3 Canister Size and Percent Fill

The current version of the DOE Waste Acceptance System Requirements Document (WASRD) allows for the repository use of HLW canisters with an outside diameter of 64 cm and two optional lengths of 301 or 451 cm (DOE/RW 2002), which are commonly referred to as the 2 ft by 10 ft and 2 ft by 15 ft canisters. The WASRD has deleted the requirement for percent fill of the canister, but a requirement of $\geq 80\%$ fill still resides in the current version of the Waste Acceptance Product Specifications for Vitrified High-Level Waste Forms (DOE/EM 1996). A recent study on the trade off of canister sizes versus number of canisters produced via packaging calcine “as is” assumed a 98% fill for the 2 ft by 10 ft and 2 ft by 15 ft canisters (Kerr 2005). For this document, the 2 ft by 15 ft canister with a 90% fill was assumed to estimate the number of canisters that would be produced by the stabilization options under consideration. The 90% fill requires less process control in the quantity of stabilized waste delivered to the canister and reduces the process potential for an overflow situation. Based on an empty volume of 1.1 m³ for the 2 ft by 15 ft canister with a 1.27 cm wall thickness (Rahl 2003), a 90% fill equates to about 1.0 m³. The empty canister volume cited by Rahl is based on a length less than 451 cm due to the impact plates and skirts at both ends in the canister design. A waste volume of 1.0 m³ per canister at 90% fill is used in this document to estimate the number of canisters that would be produced by each of the candidate processes if the entire inventory of HLW calcine were stabilized.

4. GROUT STABILIZATION PROCESS

The grout formulation and process described in Sections 4.1 and 4.2 are based on studies to develop cement waste forms for sodium bearing waste and the low level waste fraction of HLW calcine for application at INTEC (Herbst 1997, Herbst et. al. 1998). A grout formulation consisting of equal portions of ordinary Portland Cement (OPC), ground blast furnace slag (BFS), Class F fly ash (FA), and a water-to-total solids ratio of 0.40 was developed for calcined SBW and zirconia and alumina simulants to make waste form loadings of 7-24 weight percent (wt%). The total solids was defined as the sum of the weight for the waste, OPC, BFS, and FA. The wt % waste loadings were based on the ratio of the weight of the calcine to the weight of the total solids and water used in the formulation. The general observation was that for waste loadings up to 17 wt%, the grout was fluid and could be poured into molds. For waste loadings between 21-24 wt%, the grout piled up in the molds rather than leveling off. Formulation development is currently underway at DIAL-MSU to optimize calcine waste loadings while maintaining a low enough viscosity for mixing and meeting waste form performance standards. It is anticipated that the formulation of equal parts OPC:BFS:FA and the water required will need to be modified for application to HLW calcine. However, for flow sheet development in this document, a 21.5 wt% waste loading is assumed with a stabilizer consisting of equal parts OPC:BFS:FA and the prior target water-to-total solids ratio of 0.40.

4.1 Mass Balance Flow Sheet

Stabilization of calcine via grouting would be accomplished by mixing the calcine with a blend of OPC, BFS, and FA and water to make a slurry mixture. Further, a reductant, such as sodium sulfide, could be added to promote stabilization of the RCRA toxic metals. Table 4-1 presents the mass balance flow sheet by wt% for a batch large enough to fill one canister to 1.0 m³ (see Section 3.3 for canister description). These components are combined batch wise in a grout mixer, mixed, and then poured into a waste disposal canister. This formulation was used to size the vessels discussed below in Section 4.2 and as the starting point in the flow sheet calculations given in Appendix B-1 for the grouting process steps.

4.2 Major Process Steps and Equipment Design

As noted in Section 3.1 “HLW Calcine Processing Rate”, the grouting process is designed to process 4,670 kg of calcine per day. This would meet the production rate required to complete calcine treatment in eight years. It is recommended a value engineering or other cost-benefit studies be done to determine if a redundant train is needed to meet production goals if the first train were down for a few

Table 4-1. Calcine waste form composition and recipe for 1.0 m³ of grouted waste.

Component	Weight Percent (wt%)	One Batch Mass (kg)
Calcine	21.5%	383.1
Portland Cement	16.6%	295.8
Blast Furnace Slag	16.6%	295.8
Coal Fly Ash	16.6%	295.8
Water	28.7%	508.2
Sodium Sulfide	<1%	<18

weeks for any reason. Due to the nature of remote operations and maintenance, the need for a second grout train is highly recommended. Due to the hygroscopic nature of the calcine and solids used in the grouting process, the solid ingredients should not be exposed to humid gases prior to their addition to the grout mixing vessel. The solids process vessels will most likely require a small purge of dry air or nitrogen. The major process steps and vessel sizes are described below and illustrated in Figure 4-1. The process steps follow the five major feed steps described in Section 3.2 where the calcine and feed material move through: (a) bulk vessels to (b) day vessels to (c) single batch vessels to (d) the grout mixer, and to (e) the canister. The vessel dimensions are based on the methods described in Section 3.2 and Appendix A. Also per Appendix A, the critical friction angle of the hopper for the bulk, day, and single batch vessels was based on the most conservative value of 20° recommended in the Johanson and Johanson study (Wanke 1993). The dimensions of the process vessels, which are discussed below, are summarized in Appendix B-2.

4.2.1 Bulk Receiving Vessels

For the grouting process, bulk vessels will have capacities for a seven day supply of calcine and stabilizer powders; thus, sufficient feed will be needed to fill a total of about 85 canisters. To provide this capacity, the calcine bulk vessel will be 30 m³ and the bulk stabilizer vessel will be 60 m³.

The bulk calcine vessel will receive calcine from the calcine retrieval system. This vessel will need to be a hopper design described in Section 3.2 to handle the calcine. As noted in Appendix B-2, the vessel would be about 2.7 m in diameter and 7.4 m high. As indicated in Section 4.2, the outlet angle of this hopper should be no greater than 20° from the vertical. This steep angle is needed to prevent bridging or blockage of the calcine. It is further anticipated that the vessel will need an auger at the base to control delivery to the day vessels.

The 60 m³ bulk stabilizer vessel will also need to be a hopper design to handle the cement powders. Per calculations in Appendix B-2, the approximate dimensions are 3.4 m in diameter by 9.4 m high. The vessel would also use an auger system to deliver powders to the day vessel. Since the OPC, BFS, and FA are all commercially available products, it is recommended that they be purchased from a cement vendor premixed to the required blend. Current experiments show a blend of equal measures of each stabilizer as noted in Table 4-1. The pre-blending eliminates the need for an individual bulk tank for each stabilizer.

To supply the needed 60 m³ of stabilizer per week, a railroad hopper car of blended OPC, BFS, and FA powders would be needed each week. A common hopper car can handle about 100,000 kg or 115 m³ of materials. Assuming a bulk density of 1500 kg/m³ for the blended stabilizers, 60 m³ would weigh 90,000 kg. Thus, the hopper car would be about one half full, but would be near maximum weight capacity. A method of transferring the stabilizers from the railroad hopper to the bulk vessel would be needed in the facility. To prepare the stabilizers, a vendor would need the capacity to blend 60 m³ (20 m³ each) and transport the material to the INL weekly. If such a vendor is not available, it would be necessary to have individual bulk tanks. Then a train of three hopper cars with 60 m³ of each stabilizer ingredient would provide the facility with a three week supply. If this latter method is selected, the facility would need a system to blend the stabilizer ingredients. Preblending the stabilizer ingredients eliminates the need to control four separate powder feed lines to the grout mixer and reduces the probability of a formulation being out of specification.

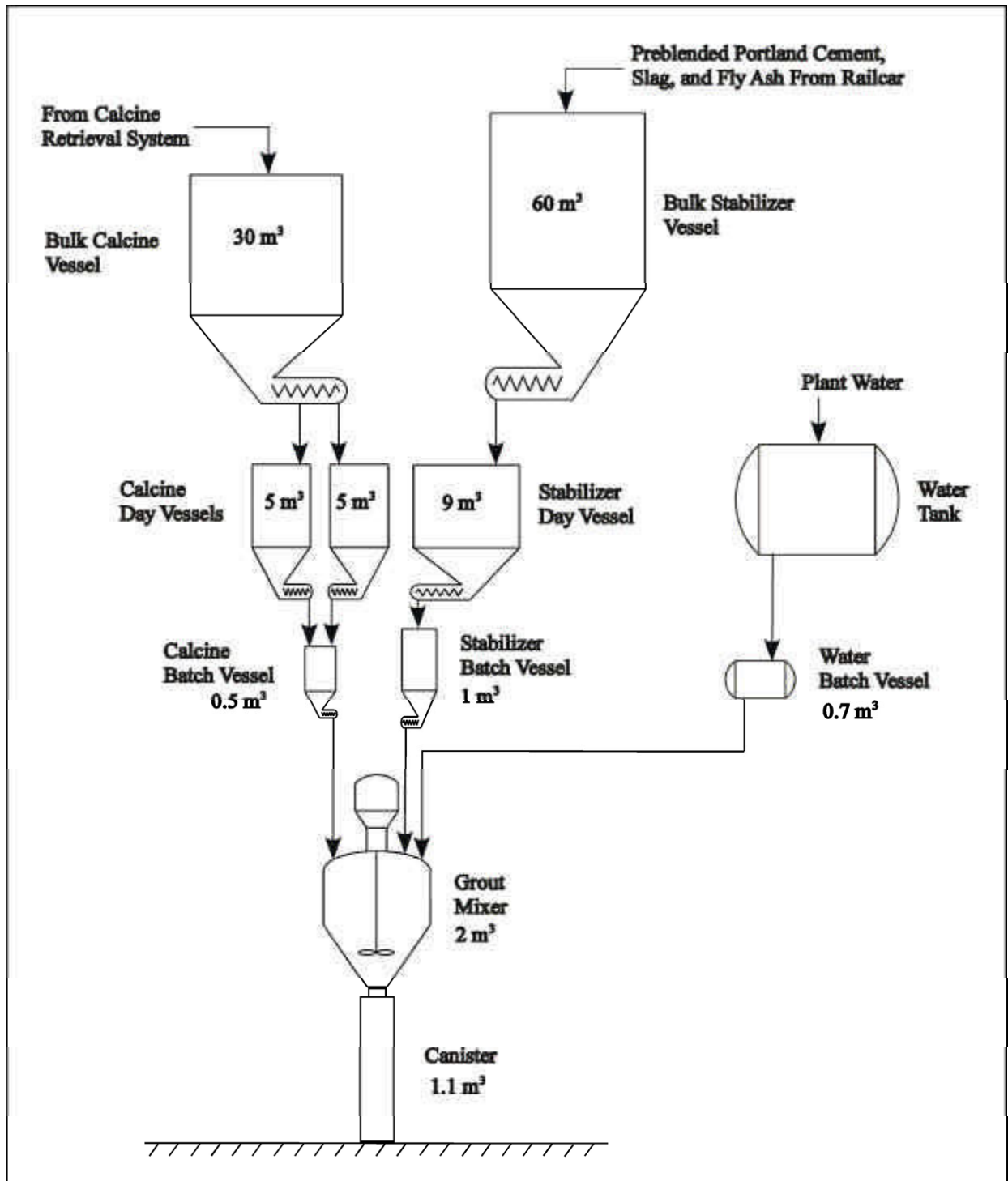


Figure 4-1. Calcine grout stabilization process diagram.

4.2.2 Day Vessels

Day vessels would be sized to hold sufficient materials for 12 batches. For calcine, it is recommended to have a minimum of two day vessels. This would provide the opportunity to sample and analyze one vessel, if required, while the other is being used as feed for processing. If this does not provide enough analytical time, then more day tanks may be needed. It is anticipated that the treatment facility would have its own dedicated hot laboratory for analytical services to expedite turn around time in the analyses. Per calculations in Appendix B-2, the calcine day vessels would be 5 m³ hoppers about 1.5 m in diameter by 3.9 m high each. Both day vessels would supply calcine via augers to a single batch vessel. These vessels also require the steep hopper angle.

The stabilizer day vessel would be a 9 m³ hopper about 1.8 m in diameter and 4.8 m high. This vessel will also supply a single batch vessel as noted in Figure 4-1. If there are no requirements to sample the day stabilizer vessel and if the feed controls are accurate, the stabilizer day vessel may not be needed as the bulk vessel could feed the single batch vessel directly.

A water supply tank capable of holding one or more days of process water will be needed. This is recommended in the event of an unexpected water or power outage and water is needed in the mixer vessel to prevent in-mixer solidification. The water supply vessel will also feed a single batch tank.

4.2.3 Single Batch Vessels

Single batch vessels for solids and water are recommended in order to prevent overfilling the mixer and to control the grout/calcine mix formulation. Each batch vessel is thus sized to provide enough feed for one canister batch as noted in Table 4-1 and additional head space to accommodate variation in solids densities. For example, the estimated average densities of HLW calcine categorized by bin range from 740 to 1,410 kg/m³ (Staiger and Swenson 2005). The calcine batch vessel would be about 0.5 m³, the stabilizer batch vessel would be about 1 m³, and the water batch tank would be about 0.7 m³. These solids vessels would need to meter the desired material to the mixer at a rate to provide good mixing. For example, the solids feed rate should be slow enough to allow the mixer to blend the solids with the water and not have solids build up on the grout surface or the mixer walls. If a chemical reductant, such as sodium sulfide, is needed for RCRA toxic metal stabilization, this chemical would be dissolved in water and added to the water batch tank as part of the required water.

4.2.4 Calcine and Grout Mixing

The calcine, stabilizer, and water batch vessels would each feed the grout mixer. As currently envisioned, the mixer could be a 1.5 to 2 m³ (400+ gal) planetary batch mixer with a bottom discharge to the disposal canister such as a Ross DPM 400 mixer (Charles and Ross and Son Co 2005). The mixer will need to be covered to prevent fugitive dust during the filling and mixing operations. The cover will need entry points for the calcine, stabilizer, and water and a vessel off-gas exit for displaced air and dust. The mixer should be instrumented with paddle torque as noted in Section 4.3.

The full amount of water required would be added first to the mixer. With the mixer running, calcine and stabilizer powders could then be metered in over a period of time (approximately 15 to 30 minutes) to permit adequate mixing and blending. When fully mixed, the grouted waste would be discharged into the canister mounted directly below the mixer. As soon as the mixer is empty, the next batch of water should immediately be added to prevent drying or caking of any remaining grout in the mixer. This water would then be used for the next batch of calcine grout.

To facilitate a batch mixer, the “wet” grouted waste viscosity must be fluid enough to allow bottom discharge and easy filling of the canister. The DIAL-MSU studies will provide this information and later pilot-scale studies are recommended. Depending on the final waste form mixing viscosity, the selection of a continuous mixer may be more applicable. If the grout is more viscous, a continuous processor mixer may be considered, such as those made by Autocon or Readco (Autocon 2005, Readco 2005). This would necessitate changes in the batch vessel design and controls. Pilot scale testing is recommended to determine if the mixer can be adapted to remote control operation.

4.2.5 Canister

Per the discussion in Section 3.3, the waste disposal canister is assumed to be 64 cm (2 ft) in diameter by 451 cm (15 ft) high. It is planned to make the canister out of 1.27 cm (0.5 in) thick 316 stainless steel; thus, the canister mass would be about 930 kg (2050 lb) (Rahl 2003). A method of handling and positioning the empty canisters under the mixer will need to be developed. Once the canister is filled with 1.0 m³ of calcine grout at 1800 kg (3960 lb), the total mass of the canister and grout will be about 2,730 kg (6010 lb). The filled canister would then be moved to a curing area.

It is anticipated that initial set (i.e., hardening) of the grout should take place within 24 hours; thus, the curing area would need to stage up to 12 canisters for one day of processing. After the first day, the canister should be inspected for bleed water. The grout formulation should be designed to avoid bleed water, but the process must allow for such an event. A desiccant such as silica gel could be added to fill the canister void space. This would absorb bleed water and control any later condensation from the grout. At this point the canister could be capped.

Following capping, the canister would be moved to a decontamination area where it would be cleaned and surveyed. Once decontaminated, the canister would be ready for shipment. It would be moved to the packaging area where the canisters are placed in shipping casks. An interim storage area may be needed to allow for shipping delays or receiving delays at the repository. Such an area would need to hold up to 85 canisters for a week or up to 340 for a month. If the interim area were full, processing would need to be halted until shipping could continue.

4.3 Process Monitors and Sampling Steps

The process monitors and sampling steps illustrated in Figure 4-2 are discussed below and are preconceptual in nature. No decisions have been made on the level of inventory tracking, the need for solids mixing in process vessels, the need for sampling the calcine feed or waste form product, or the need to monitor the filling of the canister. It is assumed that these decisions will be addressed once a stabilizer process has been developed, selected as the preferred treatment alternative, and taken through the conceptual design process. The discussion below starts with the potential monitoring needs of the bulk vessels and steps through the grout stabilization process by describing the potential process monitoring needs of the day vessels, the single batch vessels, the grout mixer, and the waste canister, respectively.

4.3.1 Bulk Vessel Process Monitors

The process monitoring needs for the large seven-day supply bulk vessels will be to avoid overfilling them during solids transfers and tracking the amount left as they are used to feed the day vessels. As indicated in Figure 4-2, examples of process monitors that could fulfill these functions are paddle detectors and load cells. Dry material level switches using a stainless steel shaft with paddle blades, which are turned by an externally mounted motor, are commercially available for this application (OMEGA 1992a). The detectors can be mounted vertically on the side or horizontally on top of vessels.

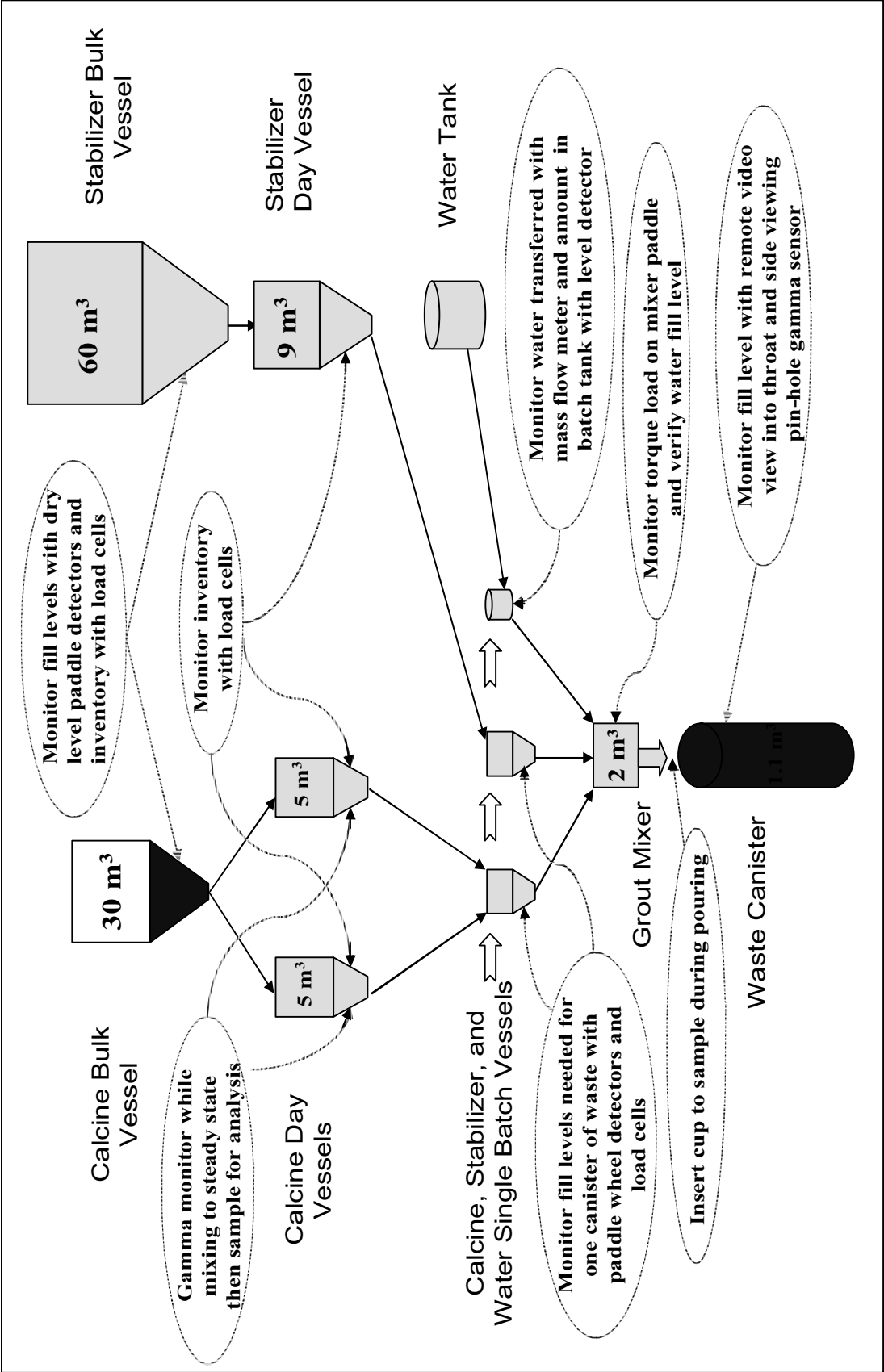


Figure 4-2. Process monitoring steps for the grout stabilization process.

Side mounted paddle detectors could serve to indicate when the fill level is at a point that the vessel should be refilled. They work on the principal of turning the paddle with a low-torque, slow-speed motor, which actuates a cut off switch if resistance from solids is encountered and they resume turning when the resistance ceases. Their specific application is to prevent vessels from overflowing and they are commonly found in the chemical, food, mining, plastics, and ceramics industries. Because the motors reside outside the vessel, they could be shielded to avoid radiation damage and they are designed for replacement, if they fail.

For tracking inventory or solids fill level, internal detectors mounted inside the top of the bulk vessel such as a non-contact ultrasonic sensor or a laser level detector may have potential application but their suitability to a highly radioactive and/or dusty environment was not evaluated. External sensors are preferable to avoid the hostile environment inside the vessel. Double ended shear beam load cells are specifically designed for industrial application to process vessels, hoppers, tanks and trucks. They come with a flat mounting plate upon which the legs of the process vessels and tanks can be bolted. The process vessel should be totally supported by the load cells with the weight as uniformly distributed as possible. Vendor information indicates that load cells constructed with nickel-plated steel for corrosive environments and full scale ranges between 5000 and 150,000 lb are available with full scale accuracies of 0.03% (OMEGA 1992b). Because of the wide variety of full-scale ranges available, they could be applied to most of the process vessels and tanks where inventory tracking is required.

4.3.2 Day Vessel Process Monitors

The process needs for the calcine and stabilizer day vessels will be to accurately monitor inventory. An additional need for the calcine day vessels may be to monitor the approach to steady state mixing of the calcine prior to sampling and analysis (S&A), if feed characterization for process control is required. An option for monitoring the approach to steady state mixing may be a pin-hole gamma monitor (i.e., a field of view with a small volume component relative to the vessel volume) positioned at the side of the day vessel. An alternative to gamma monitoring would be to experimentally determine the minimum time required for steady state mixing based on the mixing mechanism, vessel configuration, and calcine type. Although requirements for the frequency of sampling and which constituents will need to be analyzed are undefined at this point in time, it is anticipated some level of S&A would be required for quality and process control in a future grouting plant.

A similar assumption was made in developing a conceptual design for a hydroceramic grouting plant (Dafoe and Losinski 1998) for HLW calcine, which was done to support the Idaho High-Level & Facilities Disposition Environmental Impact Statement. The prior conceptual design assumed that the production control samples would be taken from a large 50 m³ batch vessel, which would hold enough calcine for a one week production schedule. As with the bulk vessels, the load cells described in Section 4.3.1 could be used to determine inventory in the day vessels prior to S&A, track the inventory, and track the amount of feed delivered to the single batch vessels.

4.3.3 Single Batch Vessels

The process monitoring needs for the single batch vessels (i.e., sized to contain the ingredients for mixing one waste canister of grouted waste) would be to avoid overfilling and to verify the quantity of feed that was delivered from the day vessels. This is a crucial process monitoring step to avoid the potential for making a batch of grouted waste that could overflow the waste canister, which has 0.1 m³ of headspace available at 90% fill to handle some minor variations in the volume of ingredients delivered through the process. As indicated in Section 4.2.3, the batch volumes will vary due to the variability in calcine density and a determination of a proper batch size needs to be based on weight rather than volume. The weight of calcine and stabilizer removed from the day vessels would be compared to the

weight gain in the single batch vessels. If an excessive amount of ingredients were determined to be in the single batch vessels, the load cells could be used as a final control step to track the required amount of solids being added to the grout mixer. Paddle wheel detectors could also be mounted in the top of the single batch vessels to detect a process upset state of completely filling the vessels.

The water required for the grout formulations would be metered in via a mass flow meter between the day water tank and the single batch tank. The water transferred to the single batch tank would be the amount required to mix one canister of grouted waste. The water inventory in the batch tank would be monitored via some sort of level detector. Since this tank will be in a non-radioactive zone, there are a number of different types of level detectors that could be used such as mechanical floats, radiofrequency probes, ultrasonic probes, capacitance probes, pressure differential bubblers, and non-contact level indicators using ultrasonic and laser sensors. An example of the type of accuracy available is the ability to measure the level of a liquid within 1/32" for ultrasonic level probes and 1.25" for non-contact ultrasonic level detectors (OMEGA 1992a). The accuracy for measuring the liquid volume with level detectors would depend, in part, on the geometry of the vessel and the depth of the liquid. For example, using a level detector with a 1.25" accuracy in a cylindrical vessel with 508 L of water (i.e., 508 kg per Table 4-1) and a height two times the diameter (i.e., 137.2 cm by 68.6 cm) would equate to a volume accuracy of about 2.3%.

4.3.4 Grout Mixer

The main process monitoring need for the grout mixer would be to monitor the viscosity of mix to ensure that it was not becoming too viscous for the pouring step. The process mixing time for acceptable mixing and pouring viscosities would be based on cold and hot full-scale qualification runs. The process correction to an unexpected high viscosity would be to immediately add more water. This is a crucial process control step to avoid an irreversible process upset in which the grout becomes unmixable and hardens in the mixer. As indicated in Figure 4-2, the torque on the mixer paddle would be monitored to avoid the upset situation.

A secondary process monitoring need would be to verify the water fill level in the mixer if it were in a standby mode for several days. As indicated in Section 4.2.3, it is anticipated that the water input to the mixer would be monitored via mass balance measurements on the single batch water tank during normal operation. However, if the mixer were placed in standby mode, water loss could occur via evaporation to the off-gas system or leakage through the pour valve to the canister. Because the mixer vessel will be subjected to the forces of vibration and torque from the mixing action, load cells are not considered the best choice for determining water inventory. In addition the load cells would not be able to discriminate between the weight of the residual grout left in mixer and the water content. The use of internal contact or non-contact level sensors that were discussed in Section 4.3.4 are also not recommended due to the vessel vibration and the anticipation that the inside of the vessel will eventually be coated to some degree by residual grout.

To verify the amount of water in the mixer prior to restart after an extended shutdown, a gamma densitometer using cobalt-60 as the radiation source and gamma detector(s) on the opposite side of the vessel could be used as an external, non-intrusive, non-contact detector to measure the difference in the gamma attenuation depending on whether it is passing through water or air in the vessel. Cobalt-60 has three predominant photo peaks at 1.17, 1.33, and 1.63 million electron volts (Mev) which could be measured in the presence of the 0.66 Mev Cs-137 photo peak. The cobalt-60 radiation source and a gamma detector could be designed to track up and down the vertical axis of the mixer vessel to determine the location of the liquid level-headspace interface in the vessel. An alternative approach would be to fix the cobalt-60 radiation source on one side of the vessel and fix several gamma detectors on the opposite side and calibrate the gamma detector readings based on the fill level of the mixer.

4.3.5 Waste Canister

The crucial process monitoring need for the waste canister is to avoid overfilling and having to recover, crush, and recycle the grouted waste. As indicated in Figure 4-2, two methods are proposed to monitor the filling process. A pin-hole gamma sensor could be positioned on a vertical rack, which allows it to track up and down the length of the canister. It could be initially positioned near the bottom and rise vertically with the grout level as the canister is being filled. An alternative approach would be to position several gamma sensors along the length of the canister. The coupling mechanism of the pour spout to the canister and the availability of viewing space down the neck are still undefined. Neck diameters of 3, 4, and 6 in. are under consideration for the canister design (Rahl 2003). If the neck designs allow sufficient viewing space, a small fiber optic cable connected to a video camera could be used to view the progress of filling also.

It is anticipated that some sort of insertable cup would be designed to allow small pour samples to be taken as a final check on quality control of the product. This sampling need was also envisioned in the conceptual design of the hydroceramic grouting plant although the sample would be taken from the grout mixer rather than during the pouring operation (Dafoe and Losinski 1998). A precedent for sampling the final HLW product has been set by the Defense Waste Processing Facility at the Savannah River Site, which designed and used a stainless steel cup to take molten glass samples during the filling operation of Canisters 50 and 61 with HLW in borosilicate glass (Bibler et. al. 1998).

5. HYDROCERAMIC GROUT STABILIZATION PROCESS

Hydroceramic (HC) cements are a class of geopolymeric concretes made from a mixture of waste material, calcined clay, sodium hydroxide, water, and minor additives. The HC stabilizer additives are designed to chemically combine with the calcine such that the major components of aluminum, silicon, and sodium produce a sodalite with the generic formula $(\text{NaAlSiO}_4)_3 \cdot \text{NaX}$ where X can be a sulfate, nitrate or chloride. There must be sufficient caustic (sodium hydroxide) in the mix to dissolve the alumina and silica in the stabilizer additives. The grout formulation and process described in Sections 5.1 and 5.2 are based on studies to develop the HC cement waste forms for application to sodium bearing waste and HLW calcine located at INTEC (Siemer 2002, Siemer et. al. 2002). The conceptual design proposed for application of the HC grouting process to HLW calcine (Dafoe and Losinski 1998) would produce an extremely viscous paste that would require kneading for mixing and extrusion for transfer from the mixer to the canister. Curing would require an autoclaving step at about 275°C, which would be followed by a dewatering step at 250°C (Dafoe and Losinski 1998). To expedite mixing and pouring, studies are underway at DIAL-MSU to developed HC grouts that are more fluid and can be cured below 80°C (Plodinec et. al. 2004). For flow sheet development in this document, a formulation similar to prior work (i.e., a silica additive has been substituted for vermiculite additive) and a 24.4 wt% waste loading is assumed.

5.1 Mass Balance Flow Sheet

Stabilization of calcine via hydroceramic grouting would be accomplished by mixing the calcine with a blend of metakaolin clay, silica fume, and sodium hydroxide (30 wt% solution). A reductant, sodium sulfide, will be added to promote stabilization of the RCRA toxic metals. Table 5-1 presents the mass balance flow sheet by weight percent and kilograms for a batch large enough to fill one canister to 1.0 m³. As indicated in the table, the final waste loading would be 24.4 wt%. These components would be combined batchwise in a grout mixer, mixed, and then poured into a waste disposal canister. This formulation was also used to size the vessels discussed below in Section 5.2 and as the starting point in the flow sheet calculations given in Appendix C-1 for the hydroceramic grouting process steps.

5.2 Major Process Steps and Equipment Design

As noted in Section 3.1 “HLW Calcine Processing Rate,” the hydroceramic process would be designed to grout 4760 kg of calcine per day to produce about 11 canisters of waste per day. This would meet the production rate required to complete calcine treatment in eight years. It is recommended a value engineering or other cost-benefit studies be done to determine if a redundant train is needed to meet

Table 5-1. Calcine Waste Form Composition and Recipe for 1.0 m³ of Hydroceramic Waste.

Component	Weight Percent (wt%)	One Batch Mass (kg)
Calcine	24.4%	410.7
Metakaolin Clay	40.7%	685.0
Silica Fume	7.3%	122.9
Sodium Hydroxide (30 wt% solution)	26.8%	451.0
Sodium Sulfide	0.8%	13.5

production goals if the first train were down for a few weeks for any reason. Due to the nature of remote operations and maintenance, the need for a second grout train is highly recommended. Due to the hygroscopic nature of the calcine and solids used in the hydroceramic process, the solid ingredients should not be exposed to humid gases prior to their addition to the grout mixing vessel. The solids process vessels will most likely require a small purge of dry air or nitrogen. The major process steps and vessel sizes are described below and illustrated in Figure 5-1. The process steps follow the five major feed steps described in Section 3.2 where the calcine and feed material move through: (a) bulk vessels to (b) day vessels to (c) batch vessels to (d) the grout mixer, and to e) the canister. The vessel dimensions are based on the methods described in Section 3.2 and Appendix A. Also per Appendix A, the critical friction angle of the hopper for the bulk, day, and single batch vessels was based on the most conservative value of 20° recommended in the Johanson and Johanson study (Wanke 1993). The dimensions of the process vessels, which are discussed below, are summarized in Appendix C-2.

5.2.1 Bulk Receiving Vessels

The hydroceramic process bulk vessels will have capacity for a seven day supply of calcine and stabilizer powders. To provide this capacity, the calcine bulk vessel will be 30 m³ and the clay and silica bulk stabilizer vessel will need to be 140 m³ due to the material's low density. For the hydroceramic process, the bulk calcine vessel will be the same as in the grout process (see Section 4.2.1). The 140 m³ bulk stabilizer vessel will also need to be a hopper design to handle the clay and silica fume. The approximate dimensions would be 4.5 m in diameter by 12.6 m high. The vessel would also use an auger system to deliver powders to the day vessel. Metakaolin clay and silica fume are commercially available products. It is recommended that they be purchased from a vendor that will pre-blend the needed mixture. Preblending the powders eliminates the need for an individual bulk tank for each stabilizer.

To supply the needed 130 m³ of stabilizer per week, two railroad hopper cars of blended clay and silica would be needed each week. A method of transferring the stabilizers from the railroad hopper to the bulk vessel would be needed in the facility. To prepare the stabilizers, a vendor would need the capacity to blend 110 m³ clay with 20 m³ silica and transport the material to the INL weekly. If such a vendor is not available, it would be necessary to have individual bulk vessels. The individual bulk vessels could replace the 140 m³ bulk vessel. Both bulk vessels would then feed the day vessel. In this case, the day vessel would need mixing capability to blend and homogenize the clay and silica.

The bulk sodium hydroxide would be stored in a 35 m³ vessel along with the needed sodium sulfide. A supply of 30 wt% liquid sodium hydroxide will be needed, approximately 28 m³ (37,100 kg) each week. As an alternative, 11,450 kg of solid sodium hydroxide could be supplied and mixed with 25,100 kg water on site to prepare the needed 30 wt% solution. Additionally, 1,070 kg of sodium sulfide will need to be added to the sodium hydroxide solution. It would be best if the sodium sulfide could be pre-blended with the 30 wt% sodium hydroxide as a liquid; otherwise, such liquid/solid blending equipment will be needed in the bulk vessel.

5.2.2 Day Vessels

Day vessels are sized to hold sufficient materials to process 4760 kg of calcine per day and produce about 11 canisters of waste per day. For calcine, it is recommended to have a minimum of two day vessels as noted in Section 4.2.2. This provides the opportunity to sample and analyze one vessel while the other is being used for processing. If this does not provide enough analytical time, then more day tanks may be needed. The calcine day vessels would be 5 m³ hoppers about 1.5 m in diameter by 3.9 m high each. Both day vessels would supply calcine via augers to a single batch vessel. These vessels also require the steep hopper angle.

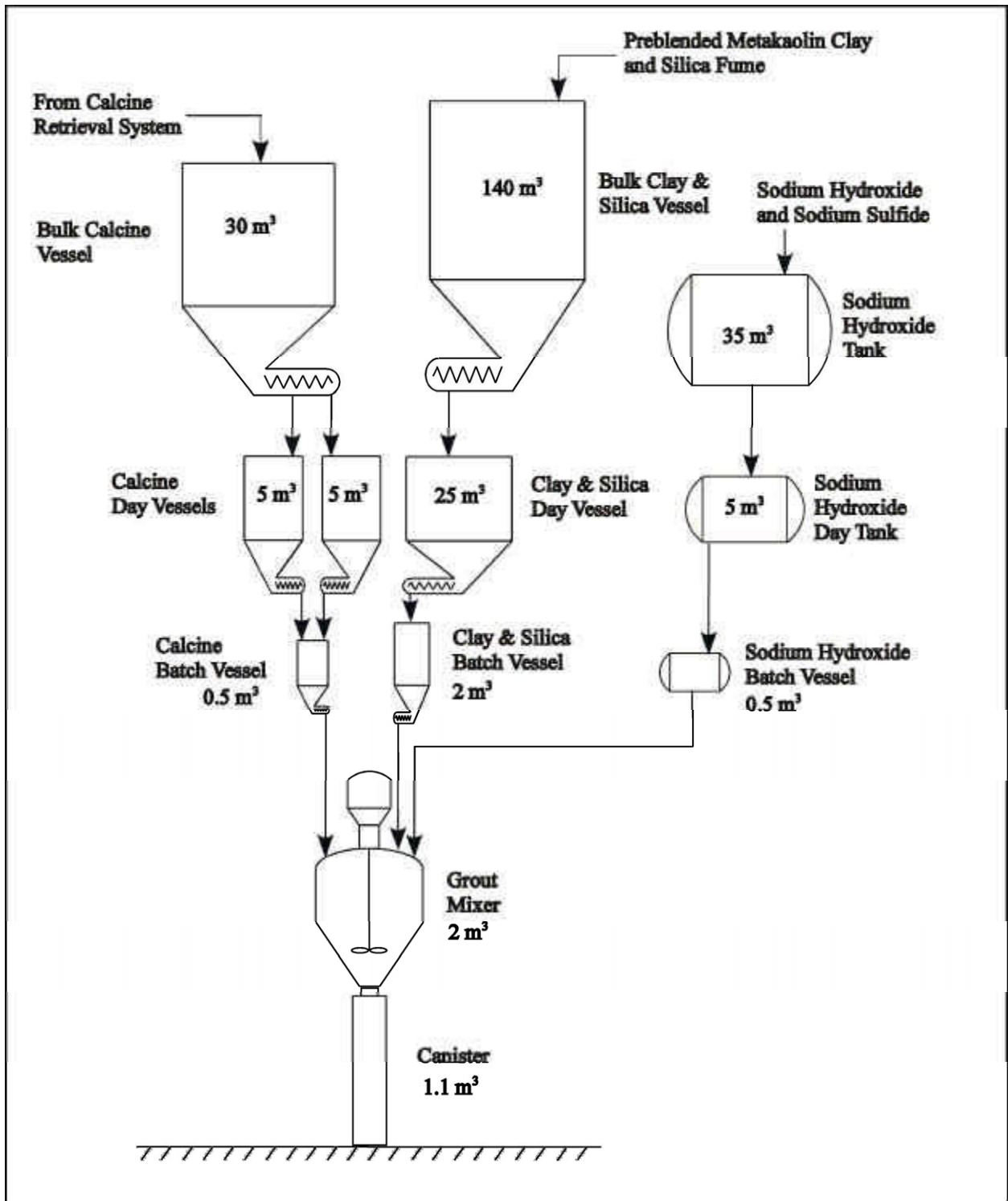


Figure 5-1. Calcine hydroceramic cement stabilization process diagram.

The clay and silica day vessel would be a 25 m³ hopper about 2.5 m in diameter and 6.9 m high. This vessel will also supply a single batch vessel as shown in Figure 5-1. As noted in Section 5.2.1, this day vessel may need mixing capability if pre-blended clay and silica are not available. A 5 m³ day vessel is needed for about 11 batches of the 30 wt% sodium hydroxide and sodium sulfide solution. This vessel will also supply a single batch sodium hydroxide tank.

5.2.3 Single Batch Vessels

Single batch vessels for solids and liquids are recommended in order to prevent overfilling the mixer and to control the grout/calcine mix formulation. Each batch vessel needs to be capable of providing the needed amount for one canister batch as noted in Table 5-1. The calcine batch vessel would be about 0.5 m³, the clay and silica stabilizer batch vessel would be about 2 m³, and the sodium hydroxide batch tank would be about 0.5 m³. The solids vessels would need to meter the desired material to the mixer at a rate to provide good mixing. The calcine single batch vessel needs the same design angle to prevent bridging as in the other calcine vessels.

5.2.4 Calcine and Hydroceramic Grout Mixing

The calcine, clay and silica stabilizers, and sodium hydroxide batch vessels would each feed the grout mixer. As currently envisioned, the mixer could be a 1.5 to 2 m³ (400+ gallon) planetary batch mixer with a bottom discharge to the disposal canister such as Ross DPM 400 mixer (Charles and Ross and Son Co 2005). The mixer will need to be covered to prevent fugitive dust during the filling and mixing operations. The cover will need entry points for the calcine, stabilizers, and water and a vessel off-gas exit for displaced air and dust. The mixer should be instrumented with paddle torque as noted in Section 5.3.

The full amount of sodium hydroxide would be added first to the mixer. With the mixer running, calcine and stabilizers could then be metered in over a period of time (approximately 15 to 30 minutes) to permit adequate mixing and blending. When fully mixed, the grouted waste would be discharged into the canister mounted directly below the mixer. As soon as the mixer is empty, the next batch of sodium hydroxide should immediately be added to prevent drying or caking of any remaining grout in the mixer. This sodium hydroxide would then be used for the next batch of calcine grout. If a shutdown or maintenance were anticipated, water could be added to the mixer rather than sodium hydroxide. Thus, a water inlet to the mixer is needed for rinse and flush. This would further present a need to deal with any rinse water.

To facilitate a batch mixer, the waste mixture's viscosity must be fluid enough to allow bottom discharge and easy filling of the canister. Section 5 noted that the original hydroceramic formulation was very viscous and required a mixer extruder. DIAL-MSU is working to develop a fluid "wet" grout. If the hydroceramic grout is more viscous, a continuous processor mixer may be considered, such as those made by Autocon or Readco (Autocon 2005, Readco 2005). This would necessitate changes in the batch vessel design and controls.

5.2.5 Canister

The waste disposal canisters used in this process would be the same as described in Section 4.2.5 as well as the curing, capping, decontamination, and shipping areas.

5.3 Process Monitors and Sampling Steps

Most of the process monitors and sampling steps illustrated in Figure 4-2 and described in Sections 4.3.1 through 4.3.5 for the grout stabilization process would also be applicable to the hydroceramic grout stabilization process. The different or additional requirements for the hydroceramic grout stabilization process are described below.

5.3.1 Bulk Vessel Process Monitors

The additional requirement beyond monitoring the fill levels and inventories of the bulk calcine and stabilizer vessels described in Section 4.3.1 would be the need to monitor the liquid level of the bulk sodium hydroxide tank shown in Figure 5-1. A mass flow meter would also be required to monitor the amount of caustic transferred to the sodium hydroxide day tank. Since the bulk sodium hydroxide tank will be in a non-radioactive zone, there are a number of different types of level detectors that could be used such as mechanical floats, radiofrequency probes, ultrasonic probes, capacitance probes, pressure differential bubblers, and non-contact level indicators using ultrasonic and laser sensors. An example of the type of accuracy available is the ability to measure the level of a liquid within 1/32" for ultrasonic level probes and 1.25" for non-contact ultrasonic level detectors (OMEGA 1992a). Materials of construction such as stainless steel would be required for components of instrumentation in direct contact with the caustic solution.

5.3.2 Day Vessel Process Monitors

The additional requirement beyond monitoring the fill levels and inventories of the day calcine and stabilizer vessels described in Section 4.3.2 would be the need to monitor the liquid level of the day sodium hydroxide tank shown in Figure 5-1. A mass flow meter would also be required to monitor the amount of caustic transferred to the sodium hydroxide batch tank. As indicated in Section 5.3.1, there are a number of different types of level detectors that could be used.

5.3.3 Single Batch Vessels

The additional requirement beyond monitoring the fill levels and inventories of the single batch calcine and stabilizer vessels described in Section 4.3.3 would be the need to monitor the liquid level of the single batch sodium hydroxide tank shown in Figure 5-1. As indicated in Section 5.3.1, there are a number of different types of level detectors that could be used.

5.3.4 Grout Mixer

There are no different or additional monitoring requirements anticipated for this step between the grout and hydroceramic stabilization processes.

5.3.5 Waste Canister

There are no different or additional monitoring requirements anticipated for this step between the grout and hydroceramic stabilization processes.

6. IRON PHOSPHATE CERAMIC STABILIZATION PROCESS

The iron phosphate ceramic process described in Sections 6.1 and 6.2 is based on studies to develop it as a stabilization agent for mixed low level waste and transuranic waste (Medvedev et. al. 1998, Aloy et. al. 2000). The process results not only in micro- and macro-encapsulation of contaminants, but also in chemical binding of the waste in the form of phosphates. Phosphate binders are a heterogeneous system consisting of a powder with metal oxides and a solution of phosphoric acid. A chemical reaction between these constituents leads to hydrated salts of orthophosphoric acid that can be characterized as an inorganic polymer. The use of the iron phosphate ceramic process for application to HLW calcine simulants has not been reported. Studies are currently underway at DIAL-MSU to develop a formulation and method that will stabilize HLW calcine simulants (Plodinec 2004) and, to date, the studies indicate that the reported formulation for other types of simulants will have to be modified for application to HLW calcine. However, for the flow sheet development in this document the literature values (Medvedev et. al. 1998, Aloy et. al. 2000) of about 13 wt% magnetite mixed with 25 wt% simulant and added to 62 wt% of 50% phosphoric acid are used.

6.1 Mass Balance Flow Sheet

Stabilization of calcine via the iron phosphate ceramic process would be accomplished by mixing the calcine with magnetite (black iron oxide, Fe_3O_4) and then adding the solid ingredients to phosphoric acid (50 wt% solution). Based on current DIAL-MSU studies, the phosphoric acid must be heated to about 60°C before adding the solid ingredients. Once the exothermic chemical reaction begins, the temperature must be maintained between 60 to 80°C during mixing. Curing in the canister may also require maintenance of 80°C for up to a week. Table 6-1 presents the mass balance flow sheet by weight percent and kilograms for a batch large enough to fill one canister to 1.0 m³. As indicated in the table, the final waste loading would be 25.4 wt%. The calcine and powdered magnetite would first be blended together as solids. Next, the calcine and magnetite mixture would be combined batchwise with phosphoric acid in a grout mixer, mixed, and then poured into a waste disposal canister. This formulation was also used to size the vessels discussed below in Section 6.2 and as the starting point in the flow sheet calculations given in Appendix D-1 for the iron phosphate ceramic process steps.

6.2 Major Process Steps and Equipment Design

As noted in Section 3.1 “HLW Calcine Processing Rate”, the iron phosphate ceramic process would be designed to process 4760 kg calcine per day and produce about 10 canisters of waste per day. This would meet the production rate required to complete calcine treatment in 8 years. It is recommended a value engineering or other cost-benefit studies be done to determine if a redundant train is needed to meet production goals if the first train were down for a few weeks for any reason. Due to the nature of remote operations and maintenance, the need for a second process train is highly recommended. Due to the hygroscopic nature of the calcine and solids used in the iron phosphate ceramic process, the solid

Table 6-1. Calcine waste form composition and recipe for 1.0 m³ of iron phosphate waste.

Component	Weight Percent (wt%)	One Batch Mass (kg)
Calcine	25.4%	452.6
Iron Oxide (Magnetite)	12.7%	226.3
Phosphoric Acid	61.9%	1103.1

ingredients should not be exposed to humid gases prior to their addition to the grout mixing vessel. The solids process vessels will most likely require a small purge of dry air or nitrogen. The major process steps and vessel sizes are described below and illustrated in Figure 6-1. The process steps follow the five major feed steps described in Section 3.2 where the calcine and feed material move through (a) bulk vessels to (b) day vessels to (c) batch vessels to (d) the grout mixer, and to (e) the canister. The vessel dimensions found in Appendix D-1 are based on the methods described in Section 3.2 and Appendix A.

6.2.1 Bulk Receiving Vessels

The iron phosphate process bulk vessels will also have capacity for a seven day supply of calcine and stabilizers. To provide this capacity, the calcine bulk vessel will be 30 m³, the bulk magnetite vessel will be 8 m³, and the phosphoric acid bulk tank will be 70 m³. The bulk calcine vessel will be the same as described in the grout process (Section 4.2.1). The 8 m³ bulk magnetite vessel will also need to be a hopper design to handle the powdered magnetite. The approximate dimensions would be 1.7 m in diameter by 4.6 m high. The vessel would also use an auger system to deliver magnetite to both calcine day vessels. The bulk phosphoric acid tank would be 70 m³ with an approximate diameter of 3.5 m and 7.1 m in length. A supply of approximately 60 m³ (80,300 kg) each week of 50 wt% phosphoric acid will be needed.

6.2.2 Day Vessels

Day vessels are sized to hold sufficient materials to meet the daily process rate of 4760 kg calcine per day. For calcine, it is recommended to have a minimum of two day vessels as noted in Section 4.2.2. This provides the opportunity to sample and analyze one vessel while the other is being used for processing. If this does not provide enough analytical time, then more day vessels would be needed. The calcine day vessels would be 6 m³ hoppers about 1.6 m in diameter by 4.1 m high each. Both day vessels would supply calcine via augers to a single batch vessel. These vessels also require the steep hopper angle. For the iron phosphate process, the calcine day vessel must be able to blend calcine with magnetite.

Calcine blending was noted in the other processes to provide an average mixture of calcine for analyses, but here, it is essential to obtain a homogenous mixture of calcine and magnetite to provide the proper amount of stabilizer to the calcine. A 10 m³ day vessel is needed for about 10 batches of the 50 wt% phosphoric acid. This vessel will also supply a single batch tank.

6.2.3 Single Batch Vessels

Single batch vessels for solids and liquids are recommended in order to prevent overfilling the mixer and to control the mix formulation. Each batch vessel needs to be capable of providing the needed amount for one canister batch as noted in Table 6-1. The calcine/magnetite batch vessel would be about 0.7 m³ and the phosphoric acid batch tank would be about 1.0 m³. The solids vessel would need to meter the desired material to the mixer at a rate to provide good mixing. The calcine/magnetite single batch vessel should have the same design angle to prevent bridging as in the other calcine vessels.

6.2.4 Calcine and Iron Phosphate Ceramic Mixing

The calcine/magnetite and phosphoric acid batch vessels will each feed the grout mixer. As currently envisioned, the mixer could be a 1.5 to 2 m³ (400+ gallon) planetary batch mixer with a bottom discharge to the disposal canister (such as Ross DPM 400 mixer). For this process, the mixer must have heating/cooling capability and it needs to be covered to prevent fugitive dust during the filling and mixing

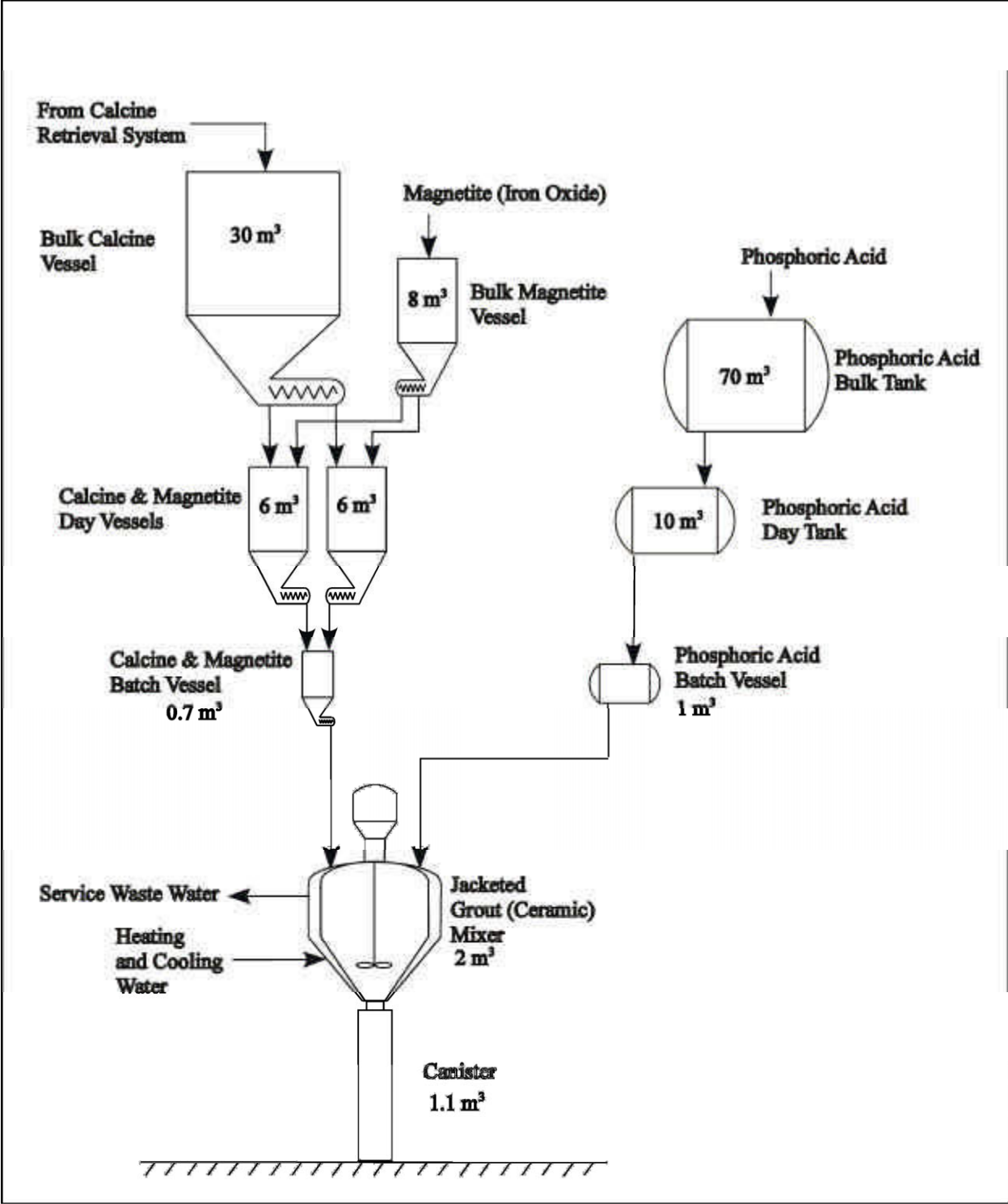


Figure 6-1. Calcine iron phosphate ceramic stabilization process diagram.

operations. The cover will need entry points for the calcine/magnetite and the acid and a vessel off-gas exit for displaced air and dust. The mixer should be instrumented with temperature control and paddle torque.

The full amount of phosphoric acid would be added first to the mixer and while stirring the acid would be heated to 60°C. Then the calcine/magnetite mixture could be metered in over a period of time (approximately 15 to 30 minutes) to permit adequate mixing and blending. During the mixing phase, the mixture temperature must be kept under 80°C. When fully mixed, the grouted waste would be discharged into the canister mounted directly below the mixer. As soon as the mixer is empty, the next batch of phosphoric acid should immediately be added to prevent drying or caking of any remaining grout in the mixer. This phosphoric acid would then be used for the next batch of calcine grout. If a shutdown were anticipated, water should be added to the mixer rather than phosphoric acid. Thus, a water inlet to the mixer is needed for rinse and flush. This would further present a need to deal with any rinse water.

To facilitate a batch mixer, the waste mixture's viscosity must be fluid enough to allow bottom discharge and easy filling of the canister. If the iron phosphate ceramic is more viscous, a continuous processor mixer may be considered, such as those made by Autocon or Readco. This would necessitate changes in the batch vessel design and controls.

6.2.5 Canister

The waste disposal canisters used in this process will be the same as described in Section 4.2.5. For the iron phosphate ceramic, the capped canister would need to be placed in a curing room for a week where the temperature is maintained at 80°C to allow the waste ceramic cure properly. (Laboratory studies show the waste ceramic remains a sludge without the heated curing.)

6.3 Process Monitors and Sampling Steps

The process monitoring requirements for the iron phosphate ceramic stabilization process shown in Figure 6-1 would be virtually identical to the hydroceramic stabilization process shown in Figure 5-1 and described in Sections 5.3.1 through 5.3.5. The major exception would be the need to monitor and maintain the temperature of reaction between 60-80°C in the ceramic mixer. Although, a process variation occurs in which the magnetite would be mixed with the HLW calcine prior to addition to the ceramic mixer, the requirement to sample and analyze the day vessels is common to all three stabilizer processes and would not introduce an additional process monitoring requirement for the iron phosphate ceramic process.

7. COMPARISON OF STABILIZATION PROCESSES

7.1 Waste Form Performance Data to Date

As indicated in Section 2, the three candidate stabilizer processes described in Sections 4 through 6 are currently under development. Per a collaborative DIAL/BBWI test plan for the period of June 2004 through February 2006 (Plodinec et. al. 2004), the main objectives are to develop stabilized waste forms that:

- Have compressive strengths > 500 psi
- Meet the Universal Treatment Standard (UTS) limits for RCRA metals in the toxicity characteristic leaching procedure (TCLP)
- Perform as well as the Environmental Assessment (EA) borosilicate glass in the product consistency test (PCT)
- Have a minimum waste loading of 25 wt% on a dry weight basis
- Optimize the waste form loadings while maintaining mixing and pouring properties that would be compatible with large scale remote operations.

An assessment of these objectives based on test data generated through April 2005 indicated the following (Thomas 2005):

- Grout and hydroceramic grout waste forms have been developed which have average compressive strengths of 2800 and 760 psi, respectively. Formulations for the iron phosphate waste forms have not been found which can meet the > 500 psi criterion.
- Grout formulations have been developed which can meet the UTS limits for Cd, Cr, Hg, and Ni in the TCLP for waste loadings tested (i.e., between 25 and 35 dry wt%). At the 35 dry wt% loadings, the concentrations of Cd and Cr in the TCLP were close to the UTS limits. The hydroceramic grout and iron phosphate ceramic waste forms exceeded the UTS limits for one or more of the four RCRA metals tested in the TCLP.
- All three waste forms exceeded the EA borosilicate glass leach limits in the PCT for Na (i.e., failed PCT leach limit). Test data to date indicate that none of the stabilizers under development may be able to pass the PCT.
- Waste loadings of > 25 wt% on a dry weight basis was obtained for all three waste forms.
- Preliminary results indicate that about 35 dry wt% waste loadings in grout will be the upper limit for the waste loading at which the mixture becomes too viscous to mix and pour. Based on a water-to-total solids ratio of 0.4 used as the reference formulation (i.e., see Section 4), 35 dry wt% corresponds to waste loading of 25 wt% when the water is factored in.

Tests to optimize waste form loadings and improve the leaching characteristics of the waste forms in the TCLP and PCT are planned for May through September, 2005. To date, the grout formulation appears to be the best candidate stabilizer among the three being tested for HLW calcine. This assessment

is based on its ability to pass the compression test, TCLP and waste loading performance criteria. In addition, the formulation appears to be the easiest to mix, pour, and cure. However, additional testing with the grout and other two stabilizers must be completed before a candidate is selected for cold mock-up studies and hot bench scale tests.

7.2 Relative Process Complexity

Based on the illustrations of the grout, hydroceramic grout and iron phosphate ceramic stabilization processes given in Figures 4-1, 5-1, and 6-1, only minor differences would exist among the process steps between the bulk feed vessels and the waste canister. With the exception that sodium hydroxide is used in place of water, there is no difference between the grout and the hydroceramic grout processes in the process flow diagrams. The iron phosphate ceramic process requires that one of the stabilizer reagents (i.e., the magnetite) be added and mixed with the calcine feed in the day vessels rather than each constituent being fed directly to the grout or ceramic mixer. This process variation should not add process complexity given that mixing and sampling is envisioned for the day vessels in all three cases. Formulation development to date indicates that the mixing step of the iron phosphate step may require maintaining the ceramic mixer between 60°C to 80°C (Thomas 2005). If so, this will be a major process complexity relative to running the grout mixer at ambient cell temperature. Development to date, indicates that the curing step for the waste in the canister may have to be elevated from room temperature to about 80°C for both the hydroceramic grout and iron phosphate ceramic waste forms, with the elevation being done in two steps involving room and the higher temperature for the hydroceramic grout (Thomas 2005). If so, this will also add significant process complexity for these two processes relative to the grout process which would use room temperature for curing.

7.3 Number of Waste Canisters Produced

As indicated in the Appendices B-1, C-1, and D-1, the waste loadings for the mass balance flow sheets were assumed to be 21.5, 24.4, and 25.4 wt% (based on all constituents added) for the grout, hydroceramic grout, and iron phosphate ceramic stabilization processes, respectively. These waste loadings are values that have been reported in the literature and were used as a starting point for the DIAL-MSU stabilizer development work (Plodinec 2004). As indicated in Section 7.1, the studies to optimize the waste loadings with regard to performance parameters remain to be done. There will be little or no variation in the numbers of canisters produced by the three stabilizer processes due to waste form density because the densities are assumed to be about the same (i.e., 1700 or 1800 kg/m³). To estimate the number of waste canisters that would be produced, it is assumed that the waste loadings will be between 21.5 and 25.4 wt% and that the waste form density will be 1800 kg/m³, regardless of which process is chosen. As indicated in Section 3.1, the assumed total HLW calcine inventory is 5.6 × 10⁶ kg. Per Section 3.3, the assumed volume of stabilized waste per canister is 1.0 m³. The volume of waste that would be produced at waste loadings of 21.5 and 25.4 wt% are, respectively:

$$[(5.6 \times 10^6 \text{ kg calcine}) / (0.215)] / (1800 \text{ kg waste/m}^3) = 14,470 \text{ m}^3$$

$$[(5.6 \times 10^6 \text{ kg calcine}) / (0.254)] / (1800 \text{ kg waste/m}^3) = 12,250 \text{ m}^3$$

These volumes also equate to the number of canisters that would be produced assuming each canister contains 1.0 m³ of waste product.

7.4 Comparison to the Direct Cementitious Waste Option

In 1997, a conceptual design for application of the Direct Cementitious Waste Option (DCWO) to HLW calcine was developed (Dafoe and Losinski 1998) to provide input to the Idaho HLW & Facilities Disposition Environmental Impact Statement (DOE/EIS 2002). The hydroceramic grout development work at DIAL-MSU is based, in part, on the formulation and process flow sheet that was developed for the DCWO conceptual design. The DCWO process is different in that the stabilizer and calcine would be mixed as a thick paste rather than a pourable slurry, it would involve the use of kneading and extrusion operations in and from the mixer, and the curing process would require high temperature autoclaving and dewatering steps between 250-300°C.

The processing rate used for sizing the process vessels in the DCWO conceptual design assumed all of the HLW calcine would be stabilized in five years, which is similar to the eight year processing rate period assumed in this document. Some of the features of the DCWO waste treatment facility illustrated in drawing DCWO-A-13 of the conceptual design report are (Dafoe and Losinski 1998):

- One 80 m³ calcine receipt vessel (4 m diameter by 15 m tall) designed to hold a two week supply of calcine feed and supply the calcine dry process lot tank
- One 50 m³ calcine dry process lot tank (3 m diameter by 4 m tall) that would:
 - Provide a one week supply of calcine feed to the calcine batch vessels
 - Be mechanically mixed
 - Be sampled, analyzed, and assigned a process lot number
 - Provide feed to the calcine batch vessels
- Four 1.5 m³ calcine batch vessels (1 m diameter by 2 m tall) sized to hold the single batch feed to the mixer
- Four 3.6 m³ kneader mixers (2 m wide by 2 m long by 3 m high) for mixing and extruding the stabilized waste mixture
- Four canister fill stations with canisters (0.61 m diameter by 3 m high), which are fed by the kneader mixers
- Process vessels and tanks to add the dry stabilizer and sodium hydroxide to the kneader mixers.

The vessel sequence, sizing, and functions of the DCWO are similar to the hydroceramic grout stabilization process shown in Figure 5-1 of this document in which the calcine would be:

- Received by a receipt bulk vessel (30 m³), which holds a one week supply of feed
- Transferred to calcine day vessels (5 m³), which would hold a one day supply of feed, be mechanically mixed, be sampled and analyzed, and hold a one day supply of feed
- Transferred to a calcine batch vessel (0.5 m³), which would hold a one canister batch supply of feed

- Transferred to the grout mixer (2 m³), which would also receive the dry and liquid stabilizer reagents for required for one canister of waste
- Transferred to the canister for curing.

The conceptual design of the DCWO waste treatment facility illustrated in drawing DCWO-A-13 indicates that the calcine process vessels and canisters would be stacked in five levels of shielded cells, which would require a building height of about 48 m (156 ft). The stacked height of the vessels and the canister without consideration of the separation by the shielded cells and piping (i.e., the sum of the vessels and canister heights cited above) would be about 27 m (88 ft). The DWCO stacked vessel height estimate is similar to that for hydroceramic grout stabilization process given in Appendix B-2 of this document, which is 21 m (69 ft). The major contributor to the greater vessel stack height in the DWCO process is the use of a calcine receipt vessel to hold a two weeks supply of calcine rather than a one week supply assumed here. If the 15 m high vessel in the DWCO process were reduced to a one week supply vessel (i.e., reduced to a 7.5 m height), there would be no apparent difference between the estimates for the stacked vessel height of the DWCO conceptual design and the hydroceramic grout stabilization process described here.

8. GAMMA RADIATION FIELD ESTIMATES

Several MicroShield calculations were completed to provide gamma radiation field estimates for the calcine in the grout stabilization process. MicroShield 6.10 is a radiation shielding software program that is validated for ICP/INL use. To calculate the radiation estimates, calcine and stabilizer compositions, calcine source data, vessel sizes, waste loadings, and waste densities were needed. Stabilizer compositions are given in Appendices B-1, C-1, and D-1. Calcine chemical compositions were taken from Table 6-1 in EDF-4504 (Dahl et. al. 2004). Calcine source data were taken from INEEL/EXT-98-00455 Rev. 2 (Staiger 2005). Specifically, Table A14 provided each CSSF curie activity by radionuclide decayed to January 2016 and Table A17 provided bulk density, mass, and volume for each CSSF. A spreadsheet was developed to calculate the curie concentration for the calcine in each CSSF and the average curie concentration for the total calcine inventory. In the calculations, the total radionuclide curie activity in each CSSF and the total calcine inventory was divided by the applicable calcine volume to obtain an average $\mu\text{Ci}/\text{m}^3$ or divided by the mass to obtain an average Ci/kg . Based on the calcine wt% waste loading in the grout, the radioactivity for the grout was calculated in terms of $\mu\text{Ci}/\text{m}^3$. Sample calculations are provided in Appendix E as well as the source term spreadsheets. The calcine and grout source concentrations were then entered into MicroShield to estimate the radiation field from the calcine in the process vessels and in the waste canister. MicroShield uses the calcine and grout densities as the source material density. The case results are included in Appendix E. Since the vessel sizes are only preliminary estimates, the gamma radiation field results are not to be used for final design calculations. These preliminary results are provided as initial input for conceptual design.

8.1 Process Vessel Radiation Field Estimates

As noted in Figure 4-1 for the grout process, calcine is collected in the bulk vessel (30 m^3) from the retrieval system. The calcine is then transferred to a day vessel (5 m^3). Next the calcine goes to an individual batch vessel (0.5 m^3) and then to the grout mixer (2 m^3) where the stabilizer cements are added. Finally, the grouted calcine is dispensed to the waste canister (1.1 m^3). The estimated dimensions for each of these process vessels are noted in Appendix B-2. For the process vessels, it was assumed the vessel will be constructed of 3/8-in. 316 stainless steel; thus, this steel provides the shielding in these calculations. Each vessel has a hopper section that is conical; however, since MicroShield can not handle multiple geometries, the vessel was treated as a complete cylinder for the height and diameter. Additionally, the vessel was considered “full” in that the entire volume was filled with source material. The waste canister was modeled as 90% full. Table 8-1 and Figure 8-1 below show the MicroShield

Table 8-1. Gamma radiation fields (R/hr) from grouting process vessels for combined calcine.^a

Vessel	Material	R/hr at Distance from Vessel Source		
		2.5 cm	30.5 cm	100 cm
Bulk	Calcine	349.7	257.4	167.2
Day	Calcine	331.5	215.8	114.4
Batch	Calcine	299.9	145.1	46.3
Mixer	Grouted Calcine	75.9	44.8	20.3
Canister	Grouted Calcine	57.8	28.6	12.0

^aCombined calcine is defined as the total HLW calcine inventory uniformly mixed.

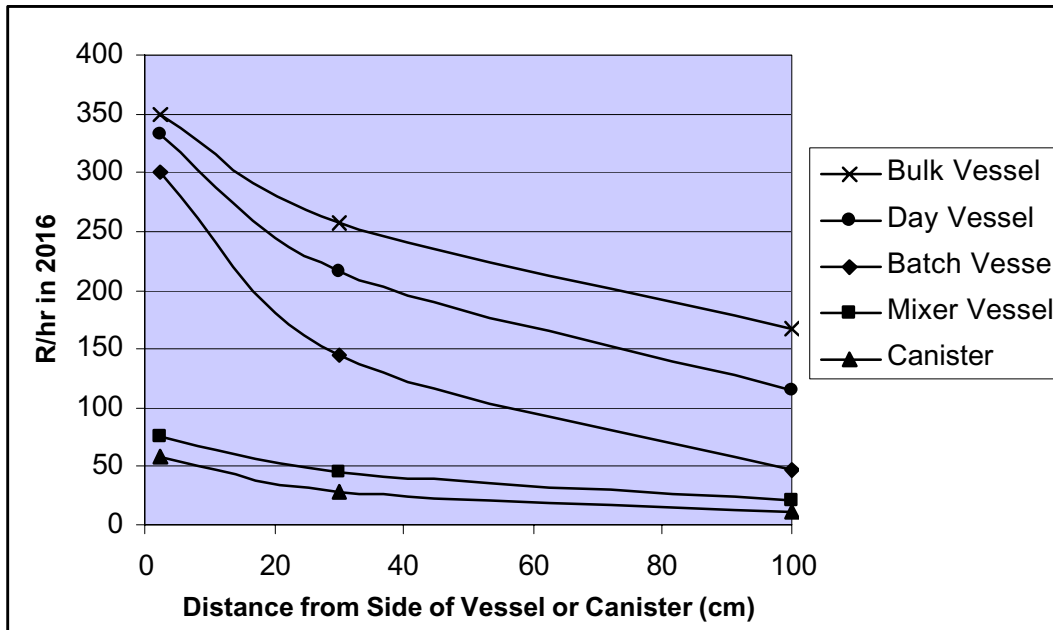


Figure 8-1. Gamma radiation field from the side of the grouting process vessels and canister for combined calcine (i.e., total HLW calcine inventory uniformly mixed).

results in terms of Roentgen per hour (R/hr) at three points from the vertical center of the vessel, specifically, 2.5 cm, 30.5 cm, and 100 cm (corresponding to 1 in., 1 ft, and 1 m from the side of the vessel). For these calculations, the average radionuclide activities for the total HLW calcine inventory (i.e., combined calcine) were used. From Table 8-1, it is readily noted that these vessels will have high radiation fields and will need to be in shielded cells. Since various instrumentation and controls and solids handling equipment will be on or near these vessels, remote maintenance will be needed to reduce/prevent personnel exposure. Process control instrumentation may need to be radiation hardened or shielded to operate next to or near the process vessels and canister.

For comparison purposes a gamma radiation field estimate was made on the bulk calcine using 2 ft of concrete as the vessel wall. With the concrete shielding, the radiation field dropped to milli-Roentgen (mR) levels with 7.1 mR/hr at 2.54 cm and 4.6 mR/hr at 1 m. As a design consideration, perhaps the bulk vessel could be constructed as a concrete vault. The radiation field due to the bulk vessel would be greatly reduced by the concrete; however, the calcine transfer auger at the base of the vessel would still contain calcine that would add to the radiation fields.

8.2 Waste Canister Radiation Field Estimates

Gamma radiation field estimates were calculated for each CSSF bin set calcine. As indicated in Section 3.3, the canister is assumed to be 90% full and contain 1.0 m³ of grouted waste. Using the 24-in. diameter and the 90% grout fill, the height for the MicroShield calculations was 337.86 cm (11.1 ft). (Note: The fill portion of the 15 ft canister height is reduced by the crush sections on the top and bottom to 12.3 ft; then, multiplied by 90% yields 11.1 ft.) For the canister, 1/2-in. 316 stainless steel was used as the material of construction and the radiation shield. The MicroShield cases are based on the grout stabilization flowsheet at 21.5 wt% waste loading and a waste density of 1800 kg/m³. The radiation field results are given in Table 8-2 and graphed in Figure 8-2. It is readily noted, that CSSF I has the “hottest” calcine and CSSF VI the “coolest”. At 2.5 cm the radiation field varies from a maximum of about

169 R/hr to a minimum of 27 R/hr with the combined calcine at 58 R/hr. Remote handling will be required for the filled canisters. The case reports are included in Appendix E.

Table 8-2. Gamma radiation fields (R/hr) from calcine in waste canister grouted at 21.5 wt%.

Calcine Source	R/hr at Distance from Canister		
	2.5 cm	30.5 cm	100 cm
CSSF I	169.0	83.5	35.1
CSSF II	63.4	31.3	13.2
CSSF III	51.1	25.3	10.6
CSSF IV	64.5	31.9	13.4
CSSF V	62.9	31.0	13.1
CSSF VI	26.8	13.3	5.7
Combined ^a	57.8	28.6	12.0

^aCombined calcine is defined as the total HLW calcine inventory uniformly mixed.

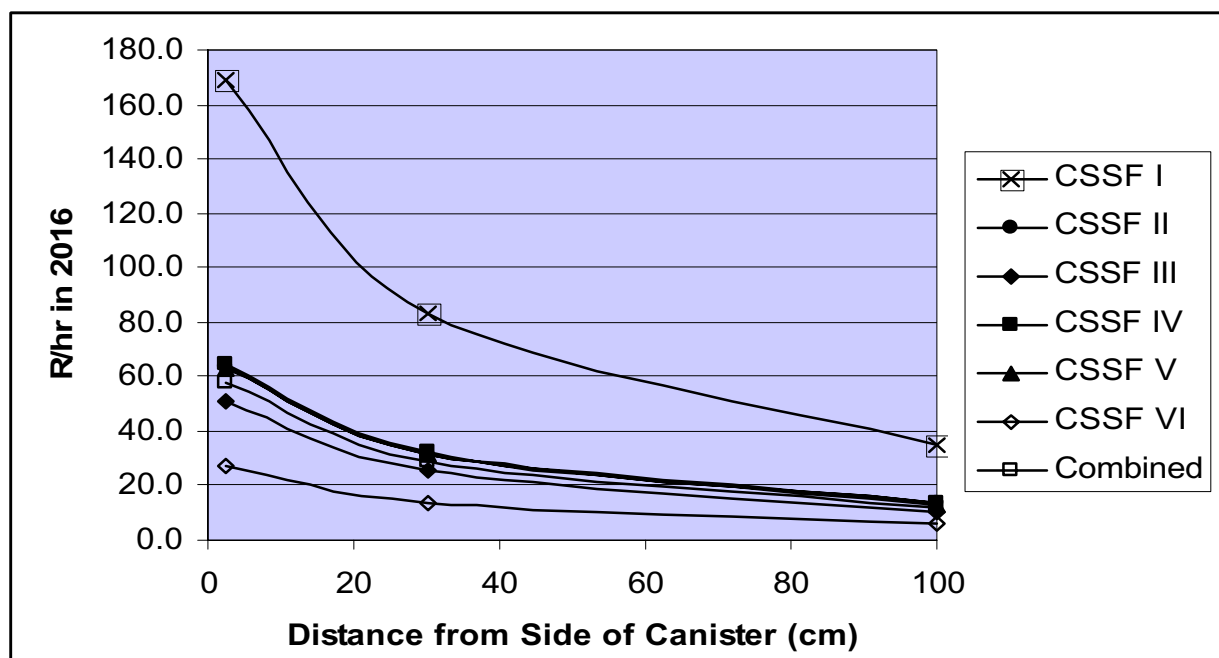


Figure 8-2. Gamma radiation fields from waste canister filled with various grouted calcines (combined calcine is defined as the total HLW calcine inventory uniformly mixed).

An attempt was made to estimate the radiation field above the filled waste canister that would be experienced by a video camera if such a device were used to view the filling process. MicroShield is not able to model a shield with a hole in it as a canister cap with an open inlet nozzle; thus, radiation estimates were made with and without a cap. The actual results would be somewhere in between. However, if the cap has a 6-in. open hole, the results may not be much lower than the open top results. The estimates are given in Table 8-3 and Figure 8-3. The contact radiation fields between the open and closed canister are quite different (double); however, the 30.5 cm and 1 m levels are very similar. These estimates do not include the radiation from the grout mixer which would be positioned above the canister.

Table 8-3. Gamma radiation fields (R/hr) from above top of waste canister.

Material	R/hr with Open Top			R/hr with Closed Top		
	2.5 cm	30.5 cm	100 cm	2.5 cm	30.5 cm	100 cm
Grouted Calcine	122.8	32.9	6.1	62.5	22.3	4.3

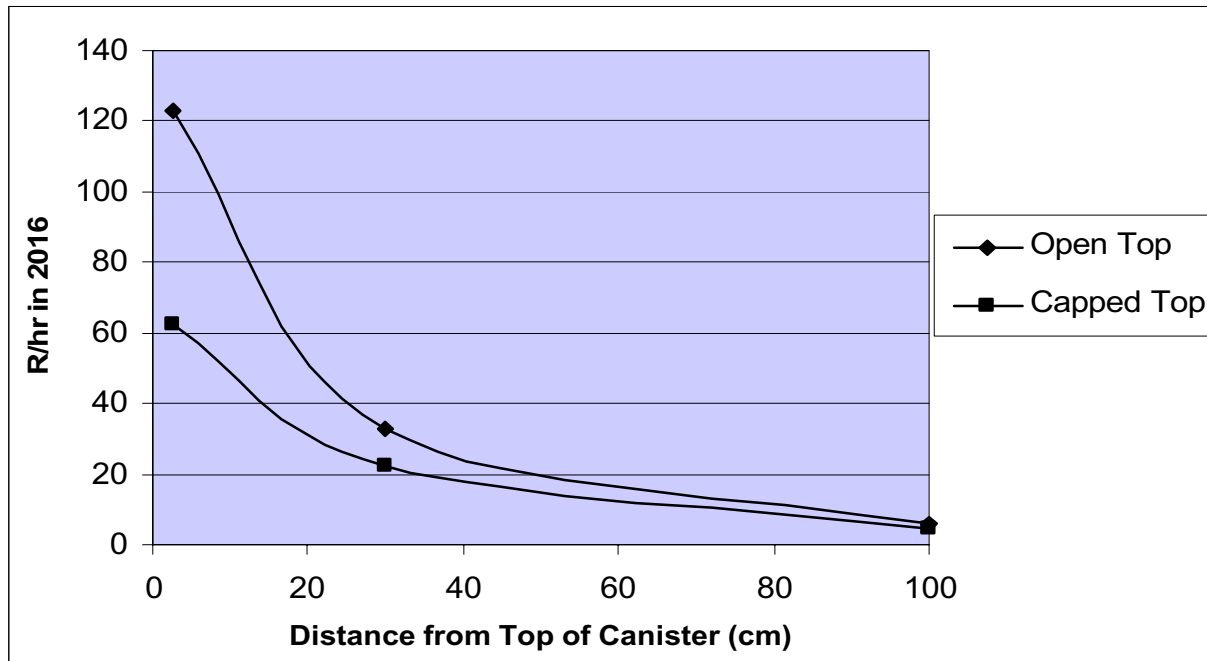


Figure 8-3. Gamma radiation fields from above a filled canister for combined calcine (i.e., the total HLW calcine inventory uniformly mixed).

9. CONCLUSIONS

Based on the information presented in this EDF, the following conclusions can be made regarding the grout, hydroceramic grout, and iron phosphate ceramic stabilization processes under development:

- To date, the grout formulation appears to be the best candidate stabilizer among the three being tested for HLW calcine. This assessment is based on its ability to pass the compression test, TCLP and waste loading performance criteria. In addition, the formulation appears to be the easiest to mix, pour, and cure.
- Test data to date indicate that none of the stabilizers under development may be able to pass the PCT.
- Only minor differences would exist between the process steps of the grout and hydroceramic grout stabilization processes. If temperature control of the mixer at about 80°C is required, it would add a major level of complexity to the iron phosphate stabilization process. If not, only minor differences would exist among the three candidate processes up to the point of pouring the waste into a canister. If temperature control at about 80°C is required during the curing step of the hydroceramic grout and iron phosphate ceramic stabilization processes, it would add an additional level of process complexity also.
- It is too early in the development program to determine which stabilizer will produce the minimum amount of waste but, in this EDF, the volume is assumed to be within the range of 12,250 to 14,470 m³.
- The stacked vessel height of the hot process vessels in the hydroceramic grout process (i.e., 21 m) appears to be about the same as that estimated the DCWO process in 1998, for which a conceptual design was developed. Therefore, some of the conceptual design efforts in the 1998 study may be applicable to the stabilizer processes addressed in this EDF.
- The gamma radiation fields near the process vessels handling HLW calcine would vary from a range of about 300 to 350 R/hr at a distance of 2.5 cm from the side of the vessels to a range of about 50 to 170 at a distance of 100 cm from the side of the vessels. The calculations were made for combined calcine, which was defined as the HLW calcine inventory uniformly mixed.
- The gamma radiation fields near the stabilized waste in canisters would range from about 25 to 170 R/hr at 2.5 cm from the side of the canister and 5 to 35 R/hr at 100 cm from the side of the canister, depending on the CSSF source of calcine.

10. DESIGN ISSUES BEYOND SCOPE OF DOCUMENT

During the review cycle of this document, several engineering questions were raised which were considered beyond the scope of this pre-conceptual design document. These questions and reasons why they were not addressed are given below. Once a stabilizer has been selected as the preferred alternative and follow-on mock-up, hot bench scale, pilot plant studies and conceptual design efforts conducted, these questions will be addressed.

- What methods would be used to avoid buildup of stabilizer residue in the grout/ceramic mixer shown in Figures 4-1 through 6-1, especially in the headspace, and what methods would be used to clean the residue? How would secondary waste streams be handled?

Response: To determine this, the stabilizer needs to be selected and the mixing properties of viscosity and set up time need to be established. If the process has a low viscosity, the liquid for the next batch could be introduced as a high pressure spray to wash down deposits. Or it may be determined that any deposit build up would become self limiting in thickness and not a problem. The amount of secondary liquid waste streams is unknown but it is anticipated they would be sent to a hold tank and recycled into the mixer as a liquid stream.

- What would be the process for filling bulk stabilizer vessels from rail cars or trucks?

Response: It is anticipated that pneumatic air lift or conveyer belt lift would be used.

- What should be done with mixer if an abrupt shutdown is required and it still contains grout?

Response: Backup or standby power must be available to avoid abrupt shutdowns and allow an orderly discharge of grout to the canister and addition of make water to the mixer for the next batch.

- What should be done to design calcine receipt lag storage capacity beyond one week into the treatment plant to avoid shut down after a given bin has been emptied? It may take much longer to move the pneumatic retrieval apparatus from bin to bin or bin set to bin set which would require that the treatment plant be shut down.

Response: Options include larger or more bulk receipt vessels or scheduling treatment plant maintenance in conjunction with relocation of pneumatic retrieval equipment. Once the treatment and pneumatic retrieval processes enter the conceptual design phase, they should be designed together with this issue in mind.

- Is the 6-in. radius opening on the bottom of the hoppers the correct size for adequate flow or should a different size be selected? There should be a huge amount of expertise in handling similar dry solids with lots of fines that one could draw on for sizing vessels, openings, and cone angles.

Response: Commercial vendor information should be used to design the hoppers and openings for the cold stabilizer ingredients, for which ample information should be available. However, only one study regarding the flow properties of calcine simulants in hoppers was found (Wanke 1993) and that study indicated that additional studies were needed to design the hopper. This need is noted in Section 11 on Recommendations.

- Frequent sampling and analysis seems to be the wrong way to deal with calcine. The process should have a recipe that envelops the major types of calcine that will be encountered in the process so one does not have to sample. Sampling means mixing to get uniformity which is another major complication to be avoided if possible.

Response: The treatment process should be designed to be as generic as possible for all types of major calcines. The need for sampling and analysis should be determined during the conceptual design phase. No attempt was made to resolve the need for sampling and analysis in this document other than to show where sampling capabilities might be built into the process design.

- The use of desiccants to absorb bleed water from the waste form in a canister will not be acceptable unless they are stable at repository temperatures and if radiolysis of the water in the desiccant and stabilizer will be a problem. This needs to be determined before any stabilizer using water is selected. Drying may be required to get the residual water content low enough to avoid excessive radiolysis and pressurization of the waste canister.

Response: The objective is to develop a stabilizer formulation that does not bleed water. The comment with regard to the use of a desiccant was stated as a potential solution to an off-normal process event. The effect of high temperature storage will be tested using waste forms with calcine simulants and a literature review of studies on radiolysis is planned. Radiolysis and container pressurization at repository temperatures are issues that require the stabilization of actual radioactive waste calcine, which are planned for the hot bench scale studies.

- Why didn't this document address detailed operating scenarios for the process steps, determine the credible failures that could occur at each step, then determine the desired prevention or mitigation method for each failure mode?

Response: It is too early in the stabilizer development process to address design information at this level of detail. A stabilizer should be developed to the point that it is down selected as the preferred treatment alternative and the issues addressed during the conceptual design stage.

- How would it be determined if out-of-spec grout has been produced and, if it is, how would the grouted waste be recycled and reprocessed?

Response: Periodic grout sampling as it is being poured was proposed as a method to check for out-of-spec grout. Definitions for what is considered out-of-spec and provisions for recycling the waste as feed to the grout mixer would be addressed during the conceptual design phase.

- Is a coupling device needed between the grout mixer and the canister for the pouring operation? The risk of contamination spread should be small if the fill nozzle is a short distance above the canister opening. This would avoid the remote operations complexity to mate a coupling or insert a tapered nozzle into the canister.

Response: As indicated in Section 4.3.5, the coupling mechanism of the pour spout to the canister is still undefined. This issue would be addressed during the conceptual design phase, especially with regard to how contamination free the canister throat and top needs to be for the curing period and the capping operation.

- Taking samples of the grouted waste product should be avoided if at all possible. Qualification of the waste form should be done by qualifying the stabilizer recipe.

Response: Sampling requirements for verification that the stabilized waste form meets product specifications is an issue that will have to be negotiated and resolved with the regulatory acceptance agency. Given this may occur long after a conceptual design is issued and the plant is built, it would be a good contingency plan to build the product sampling capability into the treatment plant as was done for the Defense Waste Treatment Plant at the Savannah River Site.

- If the hopper opening or auger becomes blocked, how will the solids vessel be emptied? What about seismic safety issues associated with stacking process vessels, especially those containing HLW calcine?

Response: These issues will be addressed during the conceptual design phase.

- Vessel off-gas dust control systems and secondary wastes generated seem to be significant process issues that were not addressed in this document. What kind of off-gas control systems would be required?

Response: It is anticipated that a small dry gas purge will be required in all the solids vessels to keep the materials dry and free flowing. This comment was made in Sections 4.2, 5.2, and 6.2. It is also anticipated that vessel off-gas would be vented through HEPA filters for dust control. Detailed consideration of the off-gas issue and secondary waste generated will be addressed during the conceptual design phase.

11. RECOMMENDATIONS

Based on the information presented in this EDF, the following recommendations can be made regarding the grout, hydroceramic grout, and iron phosphate ceramic stabilization processes under development:

- A value engineering session and cost benefit study should be done to determine if redundant process vessel trains would be needed. Due to the nature of remote operations and maintenance, a second process train may be needed to provide a greater certainty that production goals would be met in case process upsets were to occur.
- Pre-blended dry stabilizer ingredients should be used where possible to reduce the number of process vessels that would be required to deliver the cold ingredients (i.e., the number of bulk, day, and batch vessels required) to the mixer. In the case of the grout process, which uses three ingredients, a pre-blended mix would reduce the number of cold process vessels for the dry solids from nine to three.
- A minimum of two day vessels for the HLW calcine would be required to allow one to undergo sampling and analysis while the other is feeding the grout mixer. An assessment of analytical turn around time for sample analysis should be done to determine the number of day vessels that will be required. The waste treatment plant should have a dedicated hot laboratory for required analytical services.
- Single batch vessels for solids and liquids should be used in the process vessel train to prevent overfilling the mixer and to better control the formulation for the HLW calcine and stabilizer ingredients.
- Pilot-scale studies with automated process steps are needed to test mixer designs and to demonstrate process control during the addition of ingredients to the mixer, the mixing process, and transfer of the mix to the canister.
- As a starting point for gravity feed hopper design, a critical friction angle of 20° should be used for the calcine hoppers. However, this friction angle does not take into consideration the effects of fines on the calcine flow properties and additional testing should be done to determine this effect.

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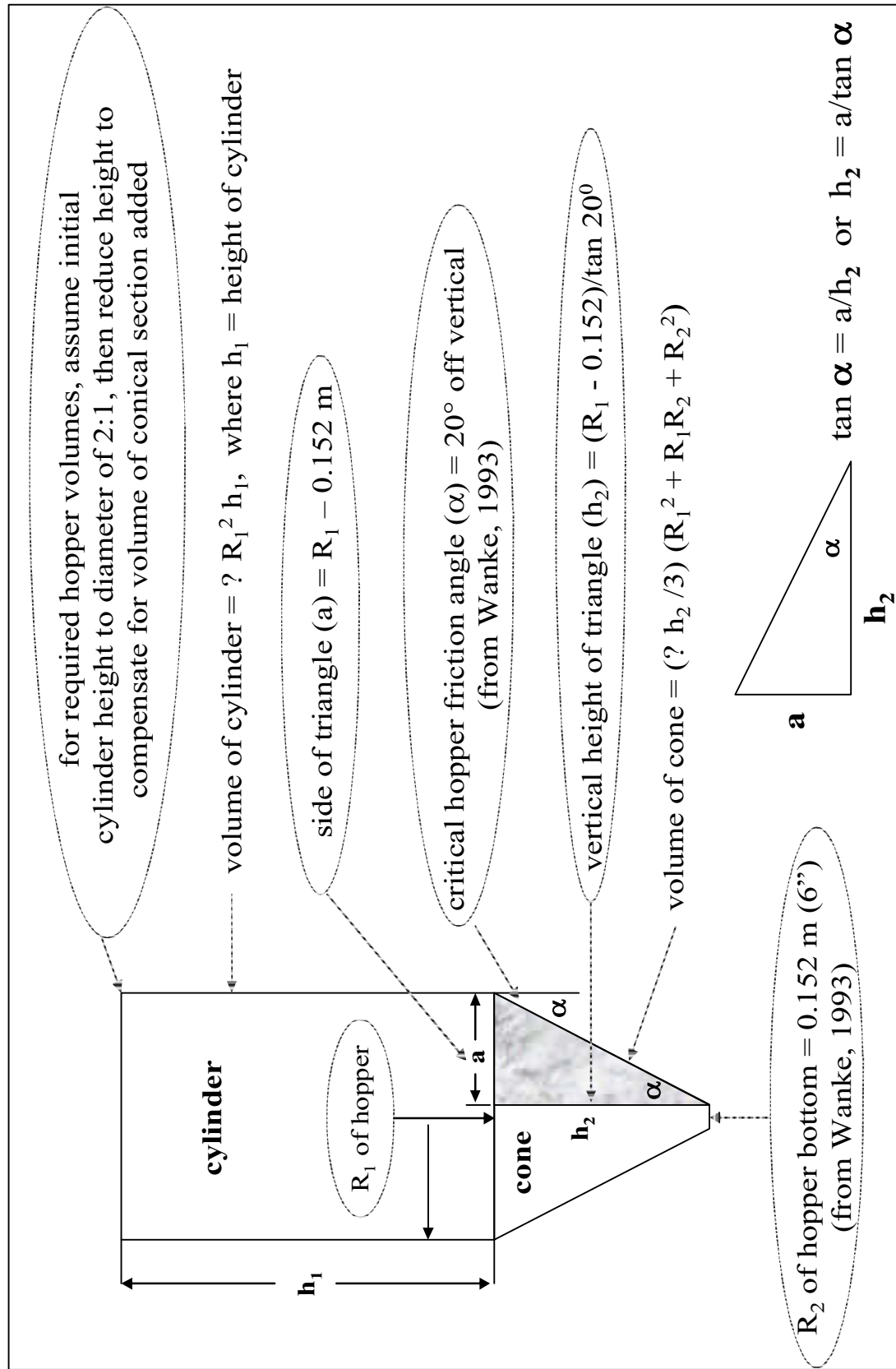
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Appendix A

Method for Sizing Funnel Flow Hoppers

Appendix A

Method for Sizing Funnel Flow Hoppers



Appendix B-1

Mass Flow Sheet Calculations for the Grout Stabilization Process

Appendix B-1

Mass Flow Sheet Calculations for the Grout Stabilization Process

	Calcine Retrieval Vessel		Calcine Day Vessel 1		Calcine Day Vessel 2		Stabilizer Day Vessel		Calcine Batch Vessel		Stabilizer Batch Vessel		Grout Mixer		Waste Canister	
	Vessel	30	Vessel	5	Vessel	5	Vessel	9	Vessel	0.5	Vessel	1	Mixer	2	Canister	1.1
Mass (kg)																
Calcine	32719		4674		4674		3609		383		296		383.1		383.1	
Portland Cement						25262						295.8		295.8		295.8
Blast Furnace Slag						25262						296		295.8		295.8
Coal Fly Ash						25262						296		295.8		295.8
Water														508.2		508.2
Total Mass =	32719		4674		4674		10827		383		887		1779		1779	
Material Volume (m³) =	25.8		3.7		3.7		7.2		0.3		0.6		1.0		1.0	

Assumptions

1. Average production rate required = 3500 kg calcine /day 9.1 canisters/day to meet average production rate
2. Day vessels sized for design rate = 4670 kg calcine /day 12.2 canisters/day to meet design rate
3. Bulk vessels sized for a week's supply
4. Canister fill = 90.0% (Initial estimate)
5. Calcine Density = 1270 kg/m³ (Based on calcine average)
6. Bulk Cement = 1500 kg/m³ (Based on Perry's ChE Handbook)
7. Grouted Calcine = 1800 kg/m³ (Based on DIAL Initial results)
8. Waste Loading = 21.5% (Based on DIAL Initial results)
9. Water to Solids = 0.40 (Based on DIAL Initial results)

Appendix B-2

Estimated Process Vessel Sizes for Grout Stabilization Process

Appendix B-2 Estimated Process Vessel Sizes for Grout Stabilization Process

	Calcine Retrieval Vessel	Stabilizer Bulk Vessel	Calcine Day Vessel 1	Calcine Day Vessel 2	Stabilizer Day Vessel	Calcine Batch Vessel	Stabilizer Batch Vessel	Grout Mixer	Waste Canister
	30	60	5	5	9	0.5	1	2	1.1
Vessel Capacity (m ³) =									

Approximate Vessel Size

Vessel Diameter (m) =	2.7	3.4	1.5	1.5	1.8	0.7	0.9	1.1	0.6
Vessel Height (m) =	4.1	5.2	2.3	2.3	2.8	1.1	1.3	1.7	4.6
Vessel Volume (m ³) =	23.1	46.3	3.9	3.9	7.0	0.4	0.8	1.6	
Hopper Height (m) =	3.3	4.2	1.6	1.6	2.0	0.5	0.8	1.1	0.0
Hopper Volume (m ³) =	6.9	13.7	1.1	1.1	2.0	0.1	0.2	0.4	0.0
Combined Height (m) =	7.4	9.4	3.9	3.9	4.8	1.6	2.1	2.8	4.6
Combined Volume (m ³) =	30.0	60.0	5.0	5.0	9.0	0.5	1.0	2.0	1.1

Stacked Height

	m	ft
Calcine Retrieval Vessel	7.4	24.2
Auger	0.3	1.0
Calcine Day Calcine	3.9	12.7
Auger	0.3	1.0
Calcine Batch Vessel	1.6	5.3
Auger	0.3	1.0
Grout Mixer	2.8	9.0
Canister	4.6	15.0
Total Height =	21.1	69.2

	m	ft
Stabilizer Bulk Vessel	9.4	30.8
Auger	0.3	1.0
Stabilizer Day Vessel	4.8	15.8
Auger	0.3	1.0
Stabilizer Batch Vessel	2.1	6.9
Auger	0.3	1.0
Grout Mixer	2.8	9.0
Canister	4.6	15.0
Total Height =	24.6	80.5

Appendix C-1

Mass Flow Sheet Calculations for the Hydroceramic Grout Stabilization Process

Appendix C-1: Mass Flow Sheet Calculations for the Hydroceramic Grout Stabilization Process

	Calcine Stabilizer Retrieval		NaOH Bulk Tank		Calcine Day Vessel 1		Calcine Day Vessel 2		Calcine Stabilizer Day Vessel		NaOH Day Tank		Calcine Stabilizer Batch Vessel		NaOH Batch Tank		Grout Mixer		Waste Canister	
	Vessel	Vessel	Tank	Tank	Vessel 1	Vessel 2	Day	Day	Day	Day	Day	Tank	Vessel	Vessel	Tank	Tank	Mixer	Mixer	Canister	Canister
Vessel Capacity (m³) =	30	140	35		5	5	5	25	5	5	5	0.5	2	0.5	0.5	2	2	2	1.1	1.1
Mass (kg)																				
Calcine	32770			4681	4681	4681	7809	411					685			410.7				410.7
Metakaolin		54661					1401						123			685.0				685.0
Silica		9804														122.9				122.9
Sodium Hydroxide			10879						1554						136	136.3				136.3
Water			25115						3588						315	314.7				314.7
Sodium Sulfide			1074						153						13	13.5				13.5
Total Mass =	32770	64466	37068	4681	4681	4681	9209	411	5295	808	1683	465	808	1.6	0.3	1683	1.0	1.0	1.0	1.0
Material Volume (m³) =	25.8	128.9	27.9	3.7	3.7	3.7	18.4	0.3	4.0	1.6	0.3	0.3	1.6	0.3	0.3	1.0	1.0	1.0	1.0	1.0

Assumptions

1. Average production rate required = 3500 kg/day
2. Day vessels sized for design rate = 4670 kg/day
3. Bulk vessels sized for a week's supply
4. Canister fill = 90.0% (Initial estimate)
5. Calcine Density = 1270 kg/m³ (Based on calcine average)
6. Bulk Solids = 500 kg/m³ (Based on metakaolin MSDS by Advanced Cement Tech)
7. Bulk Liquids = 1330 kg/m³ (Based on Perry's ChE Handbook for 30% NaOH)
8. Grouted Calcine = 1700 kg/m³ (Based on DIAL initial results)
9. Waste Loading = 24.4% (Based on DIAL initial results)

Appendix C-2

Estimated Process Vessel Sized for the Hydroceramic Grout Stabilization Process

Appendix C-2 Estimated Process Vessel Sized for the Hydroceramic Grout Stabilization Process

	Calcine Retrieval Vessel	Stabilizer Bulk Vessel	NaOH Bulk Tank	Calcine Day Vessel 1	Calcine Day Vessel 2	Stabilizer Day Vessel	NaOH Day Tank	Calcine Batch Vessel	Stabilizer Batch Vessel	NaOH Batch Tank	Grout Mixer	Waste Canister
Vessel Capacity (m ³) =	30	140	35	5	5	25	5	0.5	2	0.5	2	1.1

Approximate Vessel Size

Vessel Diameter (m) =	2.7	4.5	2.8	1.5	1.5	2.5	1.5	0.7	1.1	0.7	1.1	0.6
Vessel Height (m) =	4.1	6.9	5.6	2.3	2.3	3.9	2.9	1.1	1.7	1.4	1.7	4.6
Vessel Volume (m ³) =	23.1	108.0	35.0	3.9	3.9	19.3	5.0	0.4	1.6	0.5	1.6	1.6

Hopper Height (m) =	3.3	5.7	0.0	1.6	1.6	3.0	0.0	0.5	1.1	0.0	1.1	0.0
Hopper Volume (m ³) =	6.9	32.0	0.0	1.1	1.1	5.7	0.0	0.1	0.4	0.0	0.4	0.0

Combined Height (m)	7.4	12.6	5.6	3.9	3.9	6.9	2.9	1.6	2.8	1.4	2.8	4.6
Combined Volume (m ³) =	30.0	140.0	35.0	5.0	5.0	25.0	5.0	0.5	2.0	0.5	2.0	1.1

	m	ft	m	ft	m	ft	m	ft	m	ft
Stacked Height										
Calcine Retrieval Vessel	7.4	24.2	Stabilizer Bulk Vessel	12.6	41.4	NaOH Bulk Tank	5.6	18.5		
Auger	0.3	1.0	Auger	0.3	1.0	Piping	0.3	1.0		
Calcine Day Vessel	3.9	12.7	Stabilizer Day Vessel	6.9	22.7	NaOH Day Tank	2.9	9.6		
Auger	0.3	1.0	Auger	0.3	1.0	Piping	0.3	1.0		
Calcine Batch Vessel	1.6	5.3	Stabilizer Batch Vessel	2.8	9.0	NaOH Batch Tank	1.4	4.5		
Auger	0.3	1.0	Auger	0.3	1.0					
Grout Mixer	2.8	9.0	Grout Mixer	2.8	9.0	Grout Mixer	2.8	9.0		
Canister	4.6	15.0	Canister	4.6	15.0	Canister	4.6	15.0		
Total Height =	21.1	69.2	Total Height =	30.5	100.1	Total Height =	17.9	58.6		

Appendix D-1

Mass Flow Sheet Calculations for the Iron Phosphate Ceramic Grout Stabilization Process

Appendix D-1 Mass Flow Sheet Calculations for the Iron Phosphate Ceramic Grout Stabilization Process

	Calcine Retrieval Vessel		Fe ₃ O ₄ Bulk Vessel		H ₃ PO ₄ Bulk Tank		Calcine Day Vessel 1		Calcine Day Vessel 2		H ₃ PO ₄ Day Tank		Calcine Batch Vessel		H ₃ PO ₄ Batch Tank		Grout Mixer		Waste Canister		
	Vessel	30	Vessel	8	Tank	70	Vessel 1	6	Vessel 2	6	Tank	10	Vessel	0.7	Tank	1	Mixer	2	Canister	1.1	
Vessel Capacity (m³) =																					
Mass (kg)																					
Calcine	32951						4707	4707	4707	4707			453	453			452.6	452.6			452.6
Iron Oxide (Magnetite)			16476				2354	2354	2354				226	226			226.3	226.3			226.3
Phosphoric Acid					80303						11472				1103		1103.1	1103.1			1103.1
Total Mass =	32951		16476		80303		7061	7061	7061	7061	11472		679	679	1103		1782	1782			1782
Material Volume (m³) =	25.9		6.3		60.2		4.6	4.6	4.6	4.6	8.6		0.4	0.4	0.8		1.0	1.0			1.0

Assumptions

1. Average production rate required = 3500 kg/day 7.7 canisters/day to meet average production rate
2. Day vessels sized for design rate = 4670 kg/day 10.4 canisters/day to meet design rate
3. Bulk vessels sized for a week's supply
4. Canister fill = 90.0% (Initial estimate)
5. Calcine Density = 1270 kg/m³ (Based on calcine average)
6. H₃PO₄ Density = 1335 kg/m³ (Based on Perry's ChE Handbook for 50% H₃PO₄)
7. Fe₃O₄ Density = 2600 kg/m³ (Based on Engineering Resources - Bulk Density Chart)
8. Grouted Calcine = 1800 kg/m³ (Based on DIAL Initial results)
9. Waste Loading = 25.4% (Based on DIAL initial results)

Appendix D-2

Estimated Process Vessel Sizes for the Iron Phosphate Ceramic Grout Stabilization Process

Appendix D-2 Estimated Process Vessel Sizes for the Iron Phosphate Ceramic Grout Stabilization Process

	Calcine Retrieval Vessel	Fe ₃ O ₄ Bulk Vessel	H ₃ PO ₄ Bulk Tank	Calcine Day Vessel 1	Calcine Day Vessel 2	H ₃ PO ₃ Day Tank	Calcine Batch Vessel	H ₃ PO ₃ Batch Tank	Grout Mixer	Waste Canister
Vessel Capacity (m ³) =	30	8	70	6	6	10	0.7	1	2	1.1

Approximate Vessel Size

Vessel Diameter (m) =	2.7	1.7	3.5	1.6	1.6	1.9	0.8	0.9	1.1	0.6
Vessel Height (m) =	4.1	2.7	7.1	2.4	2.4	3.7	1.2	1.7	1.7	4.6
Vessel Volume (m ³) =	23.1	6.2	70.0	4.6	4.6	10.0	0.5	1.0	1.6	
Hopper Length (m) =	3.3	1.9	0.0	1.7	1.7	0.0	0.6	0.0	1.1	0.0
Hopper Volume (m ³) =	6.9	1.8	0.0	1.4	1.4	0.0	0.2	0.0	0.4	0.0
Combined Length (m) =	7.4	4.6	7.1	4.1	4.1	3.7	1.8	1.7	2.8	4.6
Combined Volume (m ³) =	30.0	8.0	70.0	6.0	6.0	10.0	0.7	1.0	2.0	1.1

Stacked Height

	m	ft		m	ft
Calcine Retrieval Vessel	7.4	24.2	Bulk Fe ₃ O ₄ Vessel	4.6	15.1
Auger	0.3	1.0	Auger	0.3	1.0
Calcine Day Vessel	4.1	13.6	Calcine Day Vessel	4.1	13.6
Auger	0.3	1.0	Auger	0.3	1.0
Calcine Batch Vessel	1.8	6.0	Calcine Batch Vessel	1.8	6.0
Auger	0.3	1.0	Auger	0.3	1.0
Grout Mixer	2.8	9.0	Grout Mixer	2.8	9.0
Canister	4.6	15.0	Canister	4.6	15.0
Total Height =	21.6	70.8		18.8	61.7
				20.8	68.1

Appendix E

MicroShield Calculations for Gamma Field Radiation Estimate

SAMPLE CALCULATIONS

Curie Concentration in Calcine and Calcine Grout
Used in MicroShield Dose Calculations

Example: CSSF 1, Am-241

Table A14 lists Am-241 at 7.15E+01 curies for Bin Set 1 in January 2016

Table A17 lists CSSF 1 volume as 2.22E+05 liters = 222 m³

Table A17 lists CSSF 1 mass as 1.83E+05 kg

From DIAL work grout waste loading is 21.5 wt%

From DIAL work grout density is 1.80 g/cm³ = 1800 kg/m³

Usable canister volume = 66860 in³ with 12 in radius

Canister filled to 90%

Curie Concentration in Calcine:

$$\frac{(7.15E+01 \text{ Ci}) (10^6 \text{ } \mu\text{Ci/Ci})}{(222 \text{ m}^3) (10^6 \text{ cm}^3/\text{m}^3)} = 3.22E-01 \text{ } \mu\text{Ci/cm}^3$$

Curie Concentration in Grout:

$$\frac{(7.15E+01 \text{ Ci}) (21.5 \text{ kg calcine}/100 \text{ kg grout}) (1800 \text{ kg grout}/\text{m}^3) (10^6 \text{ } \mu\text{Ci/Ci})}{(1.83E+05 \text{ kg calcine}) (10^6 \text{ cm}^3/\text{m}^3)} = 1.51E-1 \text{ } \mu\text{Ci/cm}^3$$

90% Canister Fill Level:

$$L_f = \frac{(66860 \text{ in}^3) (0.90)}{(3.14)(12 \text{ in})^2} = 133.01 \text{ in} = 337.86 \text{ cm}$$

CSSF 1 Calcine Source Term
 Based on INEEL/EXT-98-00455 Rev. 2
 Table A14 and Table A17

CSSF 1 Calcine Volume = 222 m³
 Calcine Mass = 1.83E+05 kg
 Grout Waste Loading = 21.50%
 Grout Waste Density = 1800 kg/m³

Nuclide	Year 2016 Curies	Calcine Ci/m ³	Calcine uCi/cm ³	Calcine Ci/kg	Grout Ci/kg	Grout Ci/m ³	Grout uCi/cm ³
Am-241	7.15E+01	3.22E-01	3.22E-01	3.91E-04	8.40E-05	1.51E-01	1.51E-01
Am-243	8.68E-03	3.91E-05	3.91E-05	4.74E-08	1.02E-08	1.84E-05	1.84E-05
Ba-137m	7.68E+05	3.46E+03	3.46E+03	4.20E+00	9.02E-01	1.62E+03	1.62E+03
Ce-144	3.74E-14	1.68E-16	1.68E-16	2.04E-19	4.39E-20	7.91E-17	7.91E-17
Cm-242	7.24E-03	3.26E-05	3.26E-05	3.96E-08	8.51E-09	1.53E-05	1.53E-05
Cm-244	1.36E-02	6.13E-05	6.13E-05	7.43E-08	1.60E-08	2.88E-05	2.88E-05
Co-60	3.83E-01	1.73E-03	1.73E-03	2.09E-06	4.50E-07	8.10E-04	8.10E-04
Cs-134	5.12E-03	2.31E-05	2.31E-05	2.80E-08	6.02E-09	1.08E-05	1.08E-05
Cs-135	1.08E+01	4.86E-02	4.86E-02	5.90E-05	1.27E-05	2.28E-02	2.28E-02
Cs-137	8.12E+05	3.66E+03	3.66E+03	4.44E+00	9.54E-01	1.72E+03	1.72E+03
Eu-152	7.00E+00	3.15E-02	3.15E-02	3.83E-05	8.22E-06	1.48E-02	1.48E-02
Eu-154	4.33E+02	1.95E+00	1.95E+00	2.37E-03	5.09E-04	9.16E-01	9.16E-01
Eu-155	2.26E+01	1.02E-01	1.02E-01	1.23E-04	2.66E-05	4.78E-02	4.78E-02
I-129	8.97E-02	4.04E-04	4.04E-04	4.90E-07	1.05E-07	1.90E-04	1.90E-04
Ni-63	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Np-237	1.09E+00	4.91E-03	4.91E-03	5.96E-06	1.28E-06	2.31E-03	2.31E-03
Pa-233	1.09E+00	4.91E-03	4.91E-03	5.96E-06	1.28E-06	2.31E-03	2.31E-03
Pm-147	2.98E+00	1.34E-02	1.34E-02	1.63E-05	3.50E-06	6.30E-03	6.30E-03
Pr-144	3.74E-14	1.68E-16	1.68E-16	2.04E-19	4.39E-20	7.91E-17	7.91E-17
Pu-238	3.17E+02	1.43E+00	1.43E+00	1.73E-03	3.72E-04	6.70E-01	6.70E-01
Pu-239	4.28E+01	1.93E-01	1.93E-01	2.34E-04	5.03E-05	9.05E-02	9.05E-02
Pu-240	1.71E+01	7.70E-02	7.70E-02	9.34E-05	2.01E-05	3.62E-02	3.62E-02
Pu-241	1.19E+02	5.36E-01	5.36E-01	6.50E-04	1.40E-04	2.52E-01	2.52E-01
Pu-242	9.89E-03	4.45E-05	4.45E-05	5.40E-08	1.16E-08	2.09E-05	2.09E-05
Ru-106	1.90E-10	8.56E-13	8.56E-13	1.04E-15	2.23E-16	4.02E-13	4.02E-13
Sb-125	1.22E-01	5.50E-04	5.50E-04	6.67E-07	1.43E-07	2.58E-04	2.58E-04
Sb-126	1.54E+00	6.94E-03	6.94E-03	8.42E-06	1.81E-06	3.26E-03	3.26E-03
Sb-126m	1.10E+01	4.95E-02	4.95E-02	6.01E-05	1.29E-05	2.33E-02	2.33E-02
Sm-151	1.65E+04	7.43E+01	7.43E+01	9.02E-02	1.94E-02	3.49E+01	3.49E+01
Sr-90	6.93E+05	3.12E+03	3.12E+03	3.79E+00	8.14E-01	1.47E+03	1.47E+03
Tc-99	4.26E+02	1.92E+00	1.92E+00	2.33E-03	5.00E-04	9.01E-01	9.01E-01
Th-230	1.15E-01	5.18E-04	5.18E-04	6.28E-07	1.35E-07	2.43E-04	2.43E-04
Th-231	2.39E-02	1.08E-04	1.08E-04	1.31E-07	2.81E-08	5.05E-05	5.05E-05
U-232	8.13E-05	3.66E-07	3.66E-07	4.44E-10	9.55E-11	1.72E-07	1.72E-07
U-233	1.57E-04	7.07E-07	7.07E-07	8.58E-10	1.84E-10	3.32E-07	3.32E-07
U-234	3.44E+00	1.55E-02	1.55E-02	1.88E-05	4.04E-06	7.27E-03	7.27E-03
U-235	2.39E-02	1.08E-04	1.08E-04	1.31E-07	2.81E-08	5.05E-05	5.05E-05
U-236	5.55E-02	2.50E-04	2.50E-04	3.03E-07	6.52E-08	1.17E-04	1.17E-04
U-237	3.90E-03	1.76E-05	1.76E-05	2.13E-08	4.58E-09	8.25E-06	8.25E-06
U-238	1.35E-03	6.08E-06	6.08E-06	7.38E-09	1.59E-09	2.85E-06	2.85E-06
Y-90	6.93E+05	3.12E+03	3.12E+03	3.79E+00	8.14E-01	1.47E+03	1.47E+03
Total	2.98E+06						

CSSF 2 Calcine Source Term
 Based on INEEL/EXT-98-00455 Rev. 2
 Table A14 and Table A17

CSSF 2 Calcine Volume = 851 m³
 Calcine Mass = 1.03E+06 kg
 Grout Waste Loading = 21.50%
 Grout Waste Density = 1800 kg/m³

Nuclide	Year 2016 Curies	Calcine Ci/m ³	Calcine uCi/cm ³	Calcine Ci/kg	Grout Ci/kg	Grout Ci/m ³	Grout uCi/cm ³
Am-241	1.05E+03	1.23E+00	1.23E+00	1.02E-03	2.19E-04	3.95E-01	3.95E-01
Am-243	8.96E-01	1.05E-03	1.05E-03	8.70E-07	1.87E-07	3.37E-04	3.37E-04
Ba-137m	1.62E+06	1.90E+03	1.90E+03	1.57E+00	3.38E-01	6.09E+02	6.09E+02
Ce-144	7.47E-12	8.78E-15	8.78E-15	7.25E-18	1.56E-18	2.81E-15	2.81E-15
Cm-242	2.59E+00	3.04E-03	3.04E-03	2.51E-06	5.41E-07	9.73E-04	9.73E-04
Cm-244	9.00E-01	1.06E-03	1.06E-03	8.74E-07	1.88E-07	3.38E-04	3.38E-04
Co-60	2.27E+01	2.67E-02	2.67E-02	2.20E-05	4.74E-06	8.53E-03	8.53E-03
Cs-134	4.02E-01	4.72E-04	4.72E-04	3.90E-07	8.39E-08	1.51E-04	1.51E-04
Cs-135	2.66E+01	3.13E-02	3.13E-02	2.58E-05	5.55E-06	9.99E-03	9.99E-03
Cs-137	1.71E+06	2.01E+03	2.01E+03	1.66E+00	3.57E-01	6.42E+02	6.42E+02
Eu-152	4.06E+01	4.77E-02	4.77E-02	3.94E-05	8.47E-06	1.53E-02	1.53E-02
Eu-154	2.87E+03	3.37E+00	3.37E+00	2.79E-03	5.99E-04	1.08E+00	1.08E+00
Eu-155	1.64E+02	1.93E-01	1.93E-01	1.59E-04	3.42E-05	6.16E-02	6.16E-02
I-129	1.65E-01	1.94E-04	1.94E-04	1.60E-07	3.44E-08	6.20E-05	6.20E-05
Ni-63	5.77E+04	6.78E+01	6.78E+01	5.60E-02	1.20E-02	2.17E+01	2.17E+01
Np-237	1.29E+00	1.52E-03	1.52E-03	1.25E-06	2.69E-07	4.85E-04	4.85E-04
Pa-233	1.29E+00	1.52E-03	1.52E-03	1.25E-06	2.69E-07	4.85E-04	4.85E-04
Pm-147	5.14E+01	6.04E-02	6.04E-02	4.99E-05	1.07E-05	1.93E-02	1.93E-02
Pr-144	7.47E-12	8.78E-15	8.78E-15	7.25E-18	1.56E-18	2.81E-15	2.81E-15
Pu-238	9.01E+03	1.06E+01	1.06E+01	8.75E-03	1.88E-03	3.39E+00	3.39E+00
Pu-239	1.81E+02	2.13E-01	2.13E-01	1.76E-04	3.78E-05	6.80E-02	6.80E-02
Pu-240	1.52E+02	1.79E-01	1.79E-01	1.48E-04	3.17E-05	5.71E-02	5.71E-02
Pu-241	4.58E+03	5.38E+00	5.38E+00	4.45E-03	9.56E-04	1.72E+00	1.72E+00
Pu-242	3.55E-01	4.17E-04	4.17E-04	3.45E-07	7.41E-08	1.33E-04	1.33E-04
Ru-106	2.82E-07	3.31E-10	3.31E-10	2.74E-13	5.89E-14	1.06E-10	1.06E-10
Sb-125	7.48E+01	8.79E-02	8.79E-02	7.26E-05	1.56E-05	2.81E-02	2.81E-02
Sb-126	2.87E+00	3.37E-03	3.37E-03	2.79E-06	5.99E-07	1.08E-03	1.08E-03
Sb-126m	2.05E+01	2.41E-02	2.41E-02	1.99E-05	4.28E-06	7.70E-03	7.70E-03
Sm-151	2.46E+04	2.89E+01	2.89E+01	2.39E-02	5.13E-03	9.24E+00	9.24E+00
Sr-90	1.49E+06	1.75E+03	1.75E+03	1.45E+00	3.11E-01	5.60E+02	5.60E+02
Tc-99	7.77E+02	9.13E-01	9.13E-01	7.54E-04	1.62E-04	2.92E-01	2.92E-01
Th-230	1.48E-01	1.74E-04	1.74E-04	1.44E-07	3.09E-08	5.56E-05	5.56E-05
Th-231	5.97E-02	7.02E-05	7.02E-05	5.80E-08	1.25E-08	2.24E-05	2.24E-05
U-232	9.18E-03	1.08E-05	1.08E-05	8.91E-09	1.92E-09	3.45E-06	3.45E-06
U-233	2.12E-03	2.49E-06	2.49E-06	2.06E-09	4.43E-10	7.97E-07	7.97E-07
U-234	2.19E+01	2.57E-02	2.57E-02	2.13E-05	4.57E-06	8.23E-03	8.23E-03
U-235	5.59E-02	6.57E-05	6.57E-05	5.43E-08	1.17E-08	2.10E-05	2.10E-05
U-236	1.55E-01	1.82E-04	1.82E-04	1.50E-07	3.24E-08	5.82E-05	5.82E-05
U-237	1.25E-01	1.47E-04	1.47E-04	1.21E-07	2.61E-08	4.70E-05	4.70E-05
U-238	3.39E-03	3.98E-06	3.98E-06	3.29E-09	7.08E-10	1.27E-06	1.27E-06
Y-90	1.49E+06	1.75E+03	1.75E+03	1.45E+00	3.11E-01	5.60E+02	5.60E+02
Total	6.41E+06						

CSSF 3 Calcine Source Term
 Based on INEEL/EXT-98-00455 Rev. 2
 Table A14 and Table A17

CSSF 3 Calcine Volume = 1120 m³
 Calcine Mass = 1.44E+06 kg
 Grout Waste Loading = 21.50%
 Grout Waste Density = 1800 kg/m³

Nuclide	Year 2016 Curies	Calcine Ci/m ³	Calcine uCi/cm ³	Calcine Ci/kg	Grout Ci/kg	Grout Ci/m ³	Grout uCi/cm ³
Am-241	2.33E+03	2.08E+00	2.08E+00	1.62E-03	3.48E-04	6.26E-01	6.26E-01
Am-243	1.54E+00	1.38E-03	1.38E-03	1.07E-06	2.30E-07	4.14E-04	4.14E-04
Ba-137m	1.83E+06	1.63E+03	1.63E+03	1.27E+00	2.73E-01	4.92E+02	4.92E+02
Ce-144	1.50E-09	1.34E-12	1.34E-12	1.04E-15	2.24E-16	4.03E-13	4.03E-13
Cm-242	3.72E+00	3.32E-03	3.32E-03	2.58E-06	5.55E-07	1.00E-03	1.00E-03
Cm-244	1.27E+00	1.13E-03	1.13E-03	8.82E-07	1.90E-07	3.41E-04	3.41E-04
Co-60	4.14E+01	3.70E-02	3.70E-02	2.88E-05	6.18E-06	1.11E-02	1.11E-02
Cs-134	8.93E-01	7.97E-04	7.97E-04	6.20E-07	1.33E-07	2.40E-04	2.40E-04
Cs-135	3.69E+01	3.29E-02	3.29E-02	2.56E-05	5.51E-06	9.92E-03	9.92E-03
Cs-137	1.93E+06	1.72E+03	1.72E+03	1.34E+00	2.88E-01	5.19E+02	5.19E+02
Eu-152	7.07E+01	6.31E-02	6.31E-02	4.91E-05	1.06E-05	1.90E-02	1.90E-02
Eu-154	2.24E+03	2.00E+00	2.00E+00	1.56E-03	3.34E-04	6.02E-01	6.02E-01
Eu-155	1.79E+02	1.60E-01	1.60E-01	1.24E-04	2.67E-05	4.81E-02	4.81E-02
I-129	1.67E-01	1.49E-04	1.49E-04	1.16E-07	2.49E-08	4.49E-05	4.49E-05
Ni-63	1.20E+05	1.07E+02	1.07E+02	8.33E-02	1.79E-02	3.23E+01	3.23E+01
Np-237	7.68E+00	6.86E-03	6.86E-03	5.33E-06	1.15E-06	2.06E-03	2.06E-03
Pa-233	7.68E+00	6.86E-03	6.86E-03	5.33E-06	1.15E-06	2.06E-03	2.06E-03
Pm-147	7.42E+01	6.63E-02	6.63E-02	5.15E-05	1.11E-05	1.99E-02	1.99E-02
Pr-144	1.50E-09	1.34E-12	1.34E-12	1.04E-15	2.24E-16	4.03E-13	4.03E-13
Pu-238	4.07E+04	3.63E+01	3.63E+01	2.83E-02	6.08E-03	1.09E+01	1.09E+01
Pu-239	3.28E+02	2.93E-01	2.93E-01	2.28E-04	4.90E-05	8.82E-02	8.82E-02
Pu-240	4.05E+02	3.62E-01	3.62E-01	2.81E-04	6.05E-05	1.09E-01	1.09E-01
Pu-241	1.09E+04	9.73E+00	9.73E+00	7.57E-03	1.63E-03	2.93E+00	2.93E+00
Pu-242	1.02E+00	9.11E-04	9.11E-04	7.08E-07	1.52E-07	2.74E-04	2.74E-04
Ru-106	4.63E-07	4.13E-10	4.13E-10	3.22E-13	6.91E-14	1.24E-10	1.24E-10
Sb-125	4.50E+00	4.02E-03	4.02E-03	3.13E-06	6.72E-07	1.21E-03	1.21E-03
Sb-126	2.96E+00	2.64E-03	2.64E-03	2.06E-06	4.42E-07	7.96E-04	7.96E-04
Sb-126m	2.11E+01	1.88E-02	1.88E-02	1.47E-05	3.15E-06	5.67E-03	5.67E-03
Sm-151	1.43E+04	1.28E+01	1.28E+01	9.93E-03	2.14E-03	3.84E+00	3.84E+00
Sr-90	1.72E+06	1.54E+03	1.54E+03	1.19E+00	2.57E-01	4.62E+02	4.62E+02
Tc-99	7.76E+02	6.93E-01	6.93E-01	5.39E-04	1.16E-04	2.09E-01	2.09E-01
Th-230	2.89E-02	2.58E-05	2.58E-05	2.01E-08	4.31E-09	7.77E-06	7.77E-06
Th-231	7.49E-02	6.69E-05	6.69E-05	5.20E-08	1.12E-08	2.01E-05	2.01E-05
U-232	9.17E-02	8.19E-05	8.19E-05	6.37E-08	1.37E-08	2.46E-05	2.46E-05
U-233	5.04E-03	4.50E-06	4.50E-06	3.50E-09	7.53E-10	1.35E-06	1.35E-06
U-234	1.59E+01	1.42E-02	1.42E-02	1.10E-05	2.37E-06	4.27E-03	4.27E-03
U-235	4.07E-02	3.63E-05	3.63E-05	2.83E-08	6.08E-09	1.09E-05	1.09E-05
U-236	1.09E-01	9.73E-05	9.73E-05	7.57E-08	1.63E-08	2.93E-05	2.93E-05
U-237	2.66E-01	2.38E-04	2.38E-04	1.85E-07	3.97E-08	7.15E-05	7.15E-05
U-238	3.61E-03	3.22E-06	3.22E-06	2.51E-09	5.39E-10	9.70E-07	9.70E-07
Y-90	1.72E+06	1.54E+03	1.54E+03	1.19E+00	2.57E-01	4.62E+02	4.62E+02
Total	7.39E+06						

CSSF 4 Calcine Source Term
 Based on INEEL/EXT-98-00455 Rev. 2
 Table A14 and Table A17

CSSF 4 Calcine Volume = 486 m³
 Calcine Mass = 6.46E+05 kg
 Grout Waste Loading = 21.50%
 Grout Waste Density = 1800 kg/m³

Nuclide	Year 2016 Curies	Calcine Ci/m ³	Calcine uCi/cm ³	Calcine Ci/kg	Grout Ci/kg	Grout Ci/m ³	Grout uCi/cm ³
Am-241	1.56E+03	3.21E+00	3.21E+00	2.41E-03	5.19E-04	9.35E-01	9.35E-01
Am-243	8.59E-01	1.77E-03	1.77E-03	1.33E-06	2.86E-07	5.15E-04	5.15E-04
Ba-137m	1.03E+06	2.12E+03	2.12E+03	1.59E+00	3.43E-01	6.17E+02	6.17E+02
Ce-144	2.37E-08	4.88E-11	4.88E-11	3.67E-14	7.89E-15	1.42E-11	1.42E-11
Cm-242	1.98E+00	4.07E-03	4.07E-03	3.07E-06	6.59E-07	1.19E-03	1.19E-03
Cm-244	5.80E-01	1.19E-03	1.19E-03	8.98E-07	1.93E-07	3.47E-04	3.47E-04
Co-60	3.62E+01	7.45E-02	7.45E-02	5.60E-05	1.20E-05	2.17E-02	2.17E-02
Cs-134	2.72E+00	5.60E-03	5.60E-03	4.21E-06	9.05E-07	1.63E-03	1.63E-03
Cs-135	2.15E+01	4.42E-02	4.42E-02	3.33E-05	7.16E-06	1.29E-02	1.29E-02
Cs-137	1.09E+06	2.24E+03	2.24E+03	1.69E+00	3.63E-01	6.53E+02	6.53E+02
Eu-152	4.09E+01	8.42E-02	8.42E-02	6.33E-05	1.36E-05	2.45E-02	2.45E-02
Eu-154	3.40E+03	7.00E+00	7.00E+00	5.26E-03	1.13E-03	2.04E+00	2.04E+00
Eu-155	1.47E+02	3.02E-01	3.02E-01	2.28E-04	4.89E-05	8.81E-02	8.81E-02
I-129	9.34E-02	1.92E-04	1.92E-04	1.45E-07	3.11E-08	5.60E-05	5.60E-05
Ni-63	7.09E+04	1.46E+02	1.46E+02	1.10E-01	2.36E-02	4.25E+01	4.25E+01
Np-237	1.86E+01	3.83E-02	3.83E-02	2.88E-05	6.19E-06	1.11E-02	1.11E-02
Pa-233	1.86E+01	3.83E-02	3.83E-02	2.88E-05	6.19E-06	1.11E-02	1.11E-02
Pm-147	3.81E+01	7.84E-02	7.84E-02	5.90E-05	1.27E-05	2.28E-02	2.28E-02
Pr-144	2.37E-08	4.88E-11	4.88E-11	3.67E-14	7.89E-15	1.42E-11	1.42E-11
Pu-238	1.70E+04	3.50E+01	3.50E+01	2.63E-02	5.66E-03	1.02E+01	1.02E+01
Pu-239	4.08E+02	8.40E-01	8.40E-01	6.32E-04	1.36E-04	2.44E-01	2.44E-01
Pu-240	2.28E+02	4.69E-01	4.69E-01	3.53E-04	7.59E-05	1.37E-01	1.37E-01
Pu-241	6.36E+03	1.31E+01	1.31E+01	9.85E-03	2.12E-03	3.81E+00	3.81E+00
Pu-242	5.87E-01	1.21E-03	1.21E-03	9.09E-07	1.95E-07	3.52E-04	3.52E-04
Ru-106	4.28E-06	8.81E-09	8.81E-09	6.63E-12	1.42E-12	2.56E-09	2.56E-09
Sb-125	6.37E+00	1.31E-02	1.31E-02	9.86E-06	2.12E-06	3.82E-03	3.82E-03
Sb-126	1.66E+00	3.42E-03	3.42E-03	2.57E-06	5.52E-07	9.94E-04	9.94E-04
Sb-126m	1.19E+01	2.45E-02	2.45E-02	1.84E-05	3.96E-06	7.13E-03	7.13E-03
Sm-151	7.00E+03	1.44E+01	1.44E+01	1.08E-02	2.33E-03	4.19E+00	4.19E+00
Sr-90	9.39E+05	1.93E+03	1.93E+03	1.45E+00	3.13E-01	5.63E+02	5.63E+02
Tc-99	4.34E+02	8.93E-01	8.93E-01	6.72E-04	1.44E-04	2.60E-01	2.60E-01
Th-230	4.62E-03	9.51E-06	9.51E-06	7.15E-09	1.54E-09	2.77E-06	2.77E-06
Th-231	2.98E-02	6.13E-05	6.13E-05	4.61E-08	9.92E-09	1.79E-05	1.79E-05
U-232	6.26E-02	1.29E-04	1.29E-04	9.69E-08	2.08E-08	3.75E-05	3.75E-05
U-233	3.06E-03	6.30E-06	6.30E-06	4.74E-09	1.02E-09	1.83E-06	1.83E-06
U-234	1.53E+01	3.15E-02	3.15E-02	2.37E-05	5.09E-06	9.17E-03	9.17E-03
U-235	2.98E-02	6.13E-05	6.13E-05	4.61E-08	9.92E-09	1.79E-05	1.79E-05
U-236	8.82E-02	1.81E-04	1.81E-04	1.37E-07	2.94E-08	5.28E-05	5.28E-05
U-237	1.56E-01	3.21E-04	3.21E-04	2.41E-07	5.19E-08	9.35E-05	9.35E-05
U-238	2.14E-03	4.40E-06	4.40E-06	3.31E-09	7.12E-10	1.28E-06	1.28E-06
Y-90	9.39E+05	1.93E+03	1.93E+03	1.45E+00	3.13E-01	5.63E+02	5.63E+02
Total	4.11E+06						

CSSF 5 Calcine Source Term
 Based on INEEL/EXT-98-00455 Rev. 2
 Table A14 and Table A17

CSSF 5 Calcine Volume = 1010 m³
 Calcine Mass = 1.41E+06 kg
 Grout Waste Loading = 21.50%
 Grout Waste Density = 1800 kg/m³

Nuclide	Year 2016 Curies	Calcine Ci/m ³	Calcine uCi/cm ³	Calcine Ci/kg	Grout Ci/kg	Grout Ci/m ³	Grout uCi/cm ³
Am-241	3.24E+03	3.21E+00	3.21E+00	2.30E-03	4.94E-04	8.89E-01	8.89E-01
Am-243	1.93E+00	1.91E-03	1.91E-03	1.37E-06	2.94E-07	5.30E-04	5.30E-04
Ba-137m	2.19E+06	2.17E+03	2.17E+03	1.55E+00	3.34E-01	6.01E+02	6.01E+02
Ce-144	9.57E-06	9.48E-09	9.48E-09	6.79E-12	1.46E-12	2.63E-09	2.63E-09
Cm-242	4.91E+00	4.86E-03	4.86E-03	3.48E-06	7.49E-07	1.35E-03	1.35E-03
Cm-244	1.75E+00	1.73E-03	1.73E-03	1.24E-06	2.67E-07	4.80E-04	4.80E-04
Co-60	7.58E+02	7.50E-01	7.50E-01	5.38E-04	1.16E-04	2.08E-01	2.08E-01
Cs-134	3.95E+01	3.91E-02	3.91E-02	2.80E-05	6.02E-06	1.08E-02	1.08E-02
Cs-135	4.30E+01	4.26E-02	4.26E-02	3.05E-05	6.56E-06	1.18E-02	1.18E-02
Cs-137	2.32E+06	2.30E+03	2.30E+03	1.65E+00	3.54E-01	6.37E+02	6.37E+02
Eu-152	8.40E+01	8.32E-02	8.32E-02	5.96E-05	1.28E-05	2.31E-02	2.31E-02
Eu-154	7.08E+03	7.01E+00	7.01E+00	5.02E-03	1.08E-03	1.94E+00	1.94E+00
Eu-155	6.14E+02	6.08E-01	6.08E-01	4.35E-04	9.36E-05	1.69E-01	1.69E-01
I-129	2.00E-01	1.98E-04	1.98E-04	1.42E-07	3.05E-08	5.49E-05	5.49E-05
Ni-63	1.41E+05	1.40E+02	1.40E+02	1.00E-01	2.15E-02	3.87E+01	3.87E+01
Np-237	3.84E+01	3.80E-02	3.80E-02	2.72E-05	5.86E-06	1.05E-02	1.05E-02
Pa-233	3.84E+01	3.80E-02	3.80E-02	2.72E-05	5.86E-06	1.05E-02	1.05E-02
Pm-147	9.76E+01	9.66E-02	9.66E-02	6.92E-05	1.49E-05	2.68E-02	2.68E-02
Pr-144	9.57E-06	9.48E-09	9.48E-09	6.79E-12	1.46E-12	2.63E-09	2.63E-09
Pu-238	2.86E+04	2.83E+01	2.83E+01	2.03E-02	4.36E-03	7.85E+00	7.85E+00
Pu-239	9.42E+02	9.33E-01	9.33E-01	6.68E-04	1.44E-04	2.59E-01	2.59E-01
Pu-240	4.43E+02	4.39E-01	4.39E-01	3.14E-04	6.75E-05	1.22E-01	1.22E-01
Pu-241	1.27E+04	1.26E+01	1.26E+01	9.01E-03	1.94E-03	3.49E+00	3.49E+00
Pu-242	1.09E+00	1.08E-03	1.08E-03	7.73E-07	1.66E-07	2.99E-04	2.99E-04
Ru-106	3.22E-04	3.19E-07	3.19E-07	2.28E-10	4.91E-11	8.84E-08	8.84E-08
Sb-125	3.84E+01	3.80E-02	3.80E-02	2.72E-05	5.86E-06	1.05E-02	1.05E-02
Sb-126	3.55E+00	3.51E-03	3.51E-03	2.52E-06	5.41E-07	9.74E-04	9.74E-04
Sb-126m	2.53E+01	2.50E-02	2.50E-02	1.79E-05	3.86E-06	6.94E-03	6.94E-03
Sm-151	1.88E+04	1.86E+01	1.86E+01	1.33E-02	2.87E-03	5.16E+00	5.16E+00
Sr-90	2.12E+06	2.10E+03	2.10E+03	1.50E+00	3.23E-01	5.82E+02	5.82E+02
Tc-99	9.33E+02	9.24E-01	9.24E-01	6.62E-04	1.42E-04	2.56E-01	2.56E-01
Th-230	5.51E-02	5.46E-05	5.46E-05	3.91E-08	8.40E-09	1.51E-05	1.51E-05
Th-231	9.88E-02	9.78E-05	9.78E-05	7.01E-08	1.51E-08	2.71E-05	2.71E-05
U-232	8.55E-02	8.47E-05	8.47E-05	6.06E-08	1.30E-08	2.35E-05	2.35E-05
U-233	5.66E-03	5.60E-06	5.60E-06	4.01E-09	8.63E-10	1.55E-06	1.55E-06
U-234	9.52E+00	9.43E-03	9.43E-03	6.75E-06	1.45E-06	2.61E-03	2.61E-03
U-235	1.25E-01	1.24E-04	1.24E-04	8.87E-08	1.91E-08	3.43E-05	3.43E-05
U-236	4.91E-01	4.86E-04	4.86E-04	3.48E-07	7.49E-08	1.35E-04	1.35E-04
U-237	3.10E-01	3.07E-04	3.07E-04	2.20E-07	4.73E-08	8.51E-05	8.51E-05
U-238	4.19E-02	4.15E-05	4.15E-05	2.97E-08	6.39E-09	1.15E-05	1.15E-05
Y-90	2.12E+06	2.10E+03	2.10E+03	1.50E+00	3.23E-01	5.82E+02	5.82E+02
Total	8.97E+06						

CSSF 6 Calcine Source Term
 Based on INEEL/EXT-98-00455 Rev. 2
 Table A14 and Table A17

CSSF 6 Calcine Volume = 724 m³
 Calcine Mass = 8.83E+05 kg
 Grout Waste Loading = 21.50%
 Grout Waste Density = 1800 kg/m³

Nuclide	Year 2016 Curies	Calcine Ci/m ³	Calcine uCi/cm ³	Calcine Ci/kg	Grout Ci/kg	Grout Ci/m ³	Grout uCi/cm ³
Am-241	6.00E+02	8.29E-01	8.29E-01	6.80E-04	1.46E-04	2.63E-01	2.63E-01
Am-243	5.76E-01	7.96E-04	7.96E-04	6.52E-07	1.40E-07	2.52E-04	2.52E-04
Ba-137m	5.87E+05	8.11E+02	8.11E+02	6.65E-01	1.43E-01	2.57E+02	2.57E+02
Ce-144	4.17E-06	5.76E-09	5.76E-09	4.72E-12	1.02E-12	1.83E-09	1.83E-09
Cm-242	1.49E+00	2.06E-03	2.06E-03	1.69E-06	3.63E-07	6.53E-04	6.53E-04
Cm-244	9.04E-01	1.25E-03	1.25E-03	1.02E-06	2.20E-07	3.96E-04	3.96E-04
Co-60	1.10E+02	1.52E-01	1.52E-01	1.25E-04	2.68E-05	4.82E-02	4.82E-02
Cs-134	9.13E+00	1.26E-02	1.26E-02	1.03E-05	2.22E-06	4.00E-03	4.00E-03
Cs-135	1.08E+01	1.49E-02	1.49E-02	1.22E-05	2.63E-06	4.73E-03	4.73E-03
Cs-137	6.20E+05	8.56E+02	8.56E+02	7.02E-01	1.51E-01	2.72E+02	2.72E+02
Eu-152	2.23E+01	3.08E-02	3.08E-02	2.53E-05	5.43E-06	9.77E-03	9.77E-03
Eu-154	1.41E+03	1.95E+00	1.95E+00	1.60E-03	3.43E-04	6.18E-01	6.18E-01
Eu-155	1.63E+02	2.25E-01	2.25E-01	1.85E-04	3.97E-05	7.14E-02	7.14E-02
I-129	9.13E+00	1.26E-02	1.26E-02	1.03E-05	2.22E-06	4.00E-03	4.00E-03
Ni-63	3.40E+04	4.70E+01	4.70E+01	3.85E-02	8.28E-03	1.49E+01	1.49E+01
Np-237	6.22E+00	8.59E-03	8.59E-03	7.04E-06	1.51E-06	2.73E-03	2.73E-03
Pa-233	6.22E+00	8.59E-03	8.59E-03	7.04E-06	1.51E-06	2.73E-03	2.73E-03
Pm-147	3.66E+01	5.06E-02	5.06E-02	4.14E-05	8.91E-06	1.60E-02	1.60E-02
Pr-144	4.17E-06	5.76E-09	5.76E-09	4.72E-12	1.02E-12	1.83E-09	1.83E-09
Pu-238	4.59E+03	6.34E+00	6.34E+00	5.20E-03	1.12E-03	2.01E+00	2.01E+00
Pu-239	3.91E+02	5.40E-01	5.40E-01	4.43E-04	9.52E-05	1.71E-01	1.71E-01
Pu-240	1.15E+02	1.59E-01	1.59E-01	1.30E-04	2.80E-05	5.04E-02	5.04E-02
Pu-241	3.25E+03	4.49E+00	4.49E+00	3.68E-03	7.91E-04	1.42E+00	1.42E+00
Pu-242	1.81E+02	2.50E-01	2.50E-01	2.05E-04	4.41E-05	7.93E-02	7.93E-02
Ru-106	1.64E-04	2.27E-07	2.27E-07	1.86E-10	3.99E-11	7.19E-08	7.19E-08
Sb-125	1.31E+01	1.81E-02	1.81E-02	1.48E-05	3.19E-06	5.74E-03	5.74E-03
Sb-126	9.39E-01	1.30E-03	1.30E-03	1.06E-06	2.29E-07	4.12E-04	4.12E-04
Sb-126m	6.71E+00	9.27E-03	9.27E-03	7.60E-06	1.63E-06	2.94E-03	2.94E-03
Sm-151	5.74E+03	7.93E+00	7.93E+00	6.50E-03	1.40E-03	2.52E+00	2.52E+00
Sr-90	5.84E+05	8.07E+02	8.07E+02	6.61E-01	1.42E-01	2.56E+02	2.56E+02
Tc-99	2.47E+02	3.41E-01	3.41E-01	2.80E-04	6.01E-05	1.08E-01	1.08E-01
Th-230	2.37E-02	3.27E-05	3.27E-05	2.68E-08	5.77E-09	1.04E-05	1.04E-05
Th-231	7.51E-02	1.04E-04	1.04E-04	8.51E-08	1.83E-08	3.29E-05	3.29E-05
U-232	1.26E-02	1.74E-05	1.74E-05	1.43E-08	3.07E-09	5.52E-06	5.52E-06
U-233	1.34E-03	1.85E-06	1.85E-06	1.52E-09	3.26E-10	5.87E-07	5.87E-07
U-234	3.17E+00	4.38E-03	4.38E-03	3.59E-06	7.72E-07	1.39E-03	1.39E-03
U-235	8.12E-02	1.12E-04	1.12E-04	9.20E-08	1.98E-08	3.56E-05	3.56E-05
U-236	1.92E-01	2.65E-04	2.65E-04	2.17E-07	4.67E-08	8.41E-05	8.41E-05
U-237	8.36E-02	1.15E-04	1.15E-04	9.47E-08	2.04E-08	3.66E-05	3.66E-05
U-238	8.05E-02	1.11E-04	1.11E-04	9.12E-08	1.96E-08	3.53E-05	3.53E-05
Y-90	5.84E+05	8.07E+02	8.07E+02	6.61E-01	1.42E-01	2.56E+02	2.56E+02
Total	2.43E+06						

Combined Calcine Source Term
 Based on INEEL/EXT-98-00455 Rev. 2
 Table A14 and Table A17

Total Calcine Volume = 4411 m³
 Total Calcine Mass = 5.59E+06 kg
 Grout Waste Loading = 21.50%
 Grout Waste Density = 1800 kg/m³

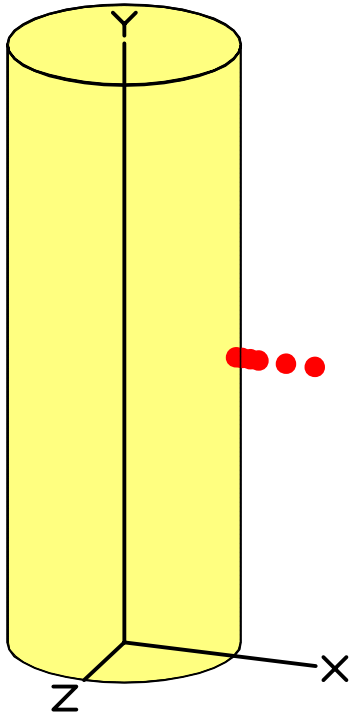
Nuclide	Year 2016 Curies	Calcine Ci/m ³	Calcine uCi/cm ³	Calcine Ci/kg	Grout Ci/kg	Grout Ci/m ³	Grout uCi/cm ³
Am-241	8.85E+03	2.01E+00	2.01E+00	1.58E-03	3.40E-04	6.12E-01	6.12E-01
Am-243	5.81E+00	1.32E-03	1.32E-03	1.04E-06	2.23E-07	4.02E-04	4.02E-04
Ba-137m	8.02E+06	1.82E+03	1.82E+03	1.43E+00	3.08E-01	5.55E+02	5.55E+02
Ce-144	1.38E-05	3.13E-09	3.13E-09	2.47E-12	5.31E-13	9.55E-10	9.55E-10
Cm-242	1.47E+01	3.33E-03	3.33E-03	2.63E-06	5.65E-07	1.02E-03	1.02E-03
Cm-244	5.42E+00	1.23E-03	1.23E-03	9.69E-07	2.08E-07	3.75E-04	3.75E-04
Co-60	9.69E+02	2.20E-01	2.20E-01	1.73E-04	3.73E-05	6.71E-02	6.71E-02
Cs-134	5.27E+01	1.19E-02	1.19E-02	9.42E-06	2.03E-06	3.65E-03	3.65E-03
Cs-135	1.49E+02	3.38E-02	3.38E-02	2.66E-05	5.73E-06	1.03E-02	1.03E-02
Cs-137	8.48E+06	1.92E+03	1.92E+03	1.52E+00	3.26E-01	5.87E+02	5.87E+02
Eu-152	2.66E+02	6.03E-02	6.03E-02	4.76E-05	1.02E-05	1.84E-02	1.84E-02
Eu-154	1.74E+04	3.94E+00	3.94E+00	3.11E-03	6.69E-04	1.20E+00	1.20E+00
Eu-155	1.29E+03	2.92E-01	2.92E-01	2.31E-04	4.96E-05	8.93E-02	8.93E-02
I-129	7.68E-01	1.74E-04	1.74E-04	1.37E-07	2.95E-08	5.32E-05	5.32E-05
Ni-63	4.23E+05	9.59E+01	9.59E+01	7.56E-02	1.63E-02	2.93E+01	2.93E+01
Np-237	7.33E+01	1.66E-02	1.66E-02	1.31E-05	2.82E-06	5.07E-03	5.07E-03
Pa-233	7.33E+01	1.66E-02	1.66E-02	1.31E-05	2.82E-06	5.07E-03	5.07E-03
Pm-147	3.01E+02	6.82E-02	6.82E-02	5.38E-05	1.16E-05	2.08E-02	2.08E-02
Pr-144	1.38E-05	3.13E-09	3.13E-09	2.47E-12	5.31E-13	9.55E-10	9.55E-10
Pu-238	1.00E+05	2.27E+01	2.27E+01	1.79E-02	3.84E-03	6.92E+00	6.92E+00
Pu-239	2.29E+03	5.19E-01	5.19E-01	4.10E-04	8.80E-05	1.58E-01	1.58E-01
Pu-240	1.36E+03	3.08E-01	3.08E-01	2.43E-04	5.23E-05	9.41E-02	9.41E-02
Pu-241	3.79E+04	8.59E+00	8.59E+00	6.78E-03	1.46E-03	2.62E+00	2.62E+00
Pu-242	1.84E+02	4.17E-02	4.17E-02	3.29E-05	7.07E-06	1.27E-02	1.27E-02
Ru-106	4.91E-04	1.11E-07	1.11E-07	8.78E-11	1.89E-11	3.40E-08	3.40E-08
Sb-125	1.37E+02	3.11E-02	3.11E-02	2.45E-05	5.27E-06	9.48E-03	9.48E-03
Sb-126	1.35E+01	3.06E-03	3.06E-03	2.41E-06	5.19E-07	9.34E-04	9.34E-04
Sb-126m	9.66E+01	2.19E-02	2.19E-02	1.73E-05	3.71E-06	6.69E-03	6.69E-03
Sm-151	8.69E+04	1.97E+01	1.97E+01	1.55E-02	3.34E-03	6.01E+00	6.01E+00
Sr-90	7.55E+06	1.71E+03	1.71E+03	1.35E+00	2.90E-01	5.23E+02	5.23E+02
Tc-99	3.59E+03	8.14E-01	8.14E-01	6.42E-04	1.38E-04	2.48E-01	2.48E-01
Th-230	3.75E-01	8.50E-05	8.50E-05	6.71E-08	1.44E-08	2.60E-05	2.60E-05
Th-231	3.62E-01	8.21E-05	8.21E-05	6.47E-08	1.39E-08	2.51E-05	2.51E-05
U-232	2.62E-01	5.94E-05	5.94E-05	4.69E-08	1.01E-08	1.81E-05	1.81E-05
U-233	1.74E-02	3.94E-06	3.94E-06	3.11E-09	6.69E-10	1.20E-06	1.20E-06
U-234	6.92E+01	1.57E-02	1.57E-02	1.24E-05	2.66E-06	4.79E-03	4.79E-03
U-235	3.56E-01	8.07E-05	8.07E-05	6.37E-08	1.37E-08	2.46E-05	2.46E-05
U-236	1.09E+00	2.47E-04	2.47E-04	1.95E-07	4.19E-08	7.54E-05	7.54E-05
U-237	9.45E-01	2.14E-04	2.14E-04	1.69E-07	3.63E-08	6.54E-05	6.54E-05
U-238	1.33E-01	3.02E-05	3.02E-05	2.38E-08	5.11E-09	9.20E-06	9.20E-06
Y-90	7.55E+06	1.71E+03	1.71E+03	1.35E+00	2.90E-01	5.23E+02	5.23E+02
Total	3.23E+07						

MicroShield v6.10 (0028)
INEEL

Page : 1
 DOS File : Combined Calcine in Bulk Tank.ms6
 Run Date : May 3, 2005
 Run Time : 2:38:06 PM
 Duration : 00:01:05

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

Case Title: Combined Calcine
Description: Combined Calcine in Bulk Retrieval Vessel (3/8" 316 SS)
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	740.0 cm	24 ft 3.3 in
Radius	135.0 cm	4 ft 5.1 in

Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	138.493 cm 4 ft 6.5 in	370 cm 12 ft 1.7 in	0 cm 0.0 in
# 2	166.433 cm 5 ft 5.5 in	370 cm 12 ft 1.7 in	0 cm 0.0 in
# 3	235.953 cm 7 ft 8.9 in	370 cm 12 ft 1.7 in	0 cm 0.0 in
# 4	145.953 cm 4 ft 9.5 in	370 cm 12 ft 1.7 in	0 cm 0.0 in
# 5	155.953 cm 5 ft 1.4 in	370 cm 12 ft 1.7 in	0 cm 0.0 in
# 6	200.953 cm 6 ft 7.1 in	370 cm 12 ft 1.7 in	0 cm 0.0 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	4.24e+07 cm ³	Combined Calcine	1.27
Transition		Air	0.00122
Air Gap		Air	0.00122
Wall Clad	.953 cm	Iron	7.95
Top Clad	.953 cm	Iron	7.95

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included
Library : ICRP-38

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm³</u>	<u>Bq/cm³</u>
Am-241	8.5162e+001	3.1510e+012	2.0100e+000	7.4370e+004
Am-243	5.5927e-002	2.0693e+009	1.3200e-003	4.8840e+001
Ba-137m	7.7112e+004	2.8531e+015	1.8200e+003	6.7340e+007
Ce-144	1.3262e-007	4.9068e+003	3.1300e-009	1.1581e-004
Cm-242	1.4109e-001	5.2203e+009	3.3300e-003	1.2321e+002
Cm-244	5.2114e-002	1.9282e+009	1.2300e-003	4.5510e+001
Co-60	9.3212e+000	3.4488e+011	2.2000e-001	8.1400e+003
Cs-134	5.0419e-001	1.8655e+010	1.1900e-002	4.4030e+002
Cs-135	1.4321e+000	5.2987e+010	3.3800e-002	1.2506e+003
Cs-137	8.1349e+004	3.0099e+015	1.9200e+003	7.1040e+007
Eu-152	2.5549e+000	9.4530e+010	6.0300e-002	2.2311e+003
Eu-154	1.6693e+002	6.1766e+012	3.9400e+000	1.4578e+005
Eu-155	1.2372e+001	4.5776e+011	2.9200e-001	1.0804e+004
I-129	7.3722e-003	2.7277e+008	1.7400e-004	6.4380e+000
Ni-63	4.0632e+003	1.5034e+014	9.5900e+001	3.5483e+006
Np-237	7.0333e-001	2.6023e+010	1.6600e-002	6.1420e+002
Pa-233	7.0333e-001	2.6023e+010	1.6600e-002	6.1420e+002
Pm-147	2.8896e+000	1.0691e+011	6.8200e-002	2.5234e+003

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>µCi/cm³</u>	<u>Bq/cm³</u>
Pr-144	1.3262e-007	4.9068e+003	3.1300e-009	1.1581e-004
Pu-238	9.6178e+002	3.5586e+013	2.2700e+001	8.3990e+005
Pu-239	2.1990e+001	8.1361e+011	5.1900e-001	1.9203e+004
Pu-240	1.3050e+001	4.8284e+011	3.0800e-001	1.1396e+004
Pu-241	3.6395e+002	1.3466e+013	8.5900e+000	3.1783e+005
Pu-242	1.7668e+000	6.5371e+010	4.1700e-002	1.5429e+003
Ru-106	4.7030e-006	1.7401e+005	1.1100e-007	4.1070e-003
Sb-125	1.3177e+000	4.8754e+010	3.1100e-002	1.1507e+003
Sb-126	1.2965e-001	4.7970e+009	3.0600e-003	1.1322e+002
Sb-126m	9.2788e-001	3.4332e+010	2.1900e-002	8.1030e+002
Sm-151	8.3467e+002	3.0883e+013	1.9700e+001	7.2890e+005
Sr-90	7.2451e+004	2.6807e+015	1.7100e+003	6.3270e+007
Tc-99	3.4488e+001	1.2761e+012	8.1400e-001	3.0118e+004
Th-230	3.6014e-003	1.3325e+008	8.5000e-005	3.1450e+000
Th-231	3.4785e-003	1.2870e+008	8.2100e-005	3.0377e+000
U-232	2.5167e-003	9.3119e+007	5.9400e-005	2.1978e+000
U-233	1.6693e-004	6.1766e+006	3.9400e-006	1.4578e-001
U-234	6.6519e-001	2.4612e+010	1.5700e-002	5.8090e+002
U-235	3.4192e-003	1.2651e+008	8.0700e-005	2.9859e+000
U-236	1.0465e-002	3.8721e+008	2.4700e-004	9.1390e+000
U-237	9.0670e-003	3.3548e+008	2.1400e-004	7.9180e+000
U-238	1.2795e-003	4.7343e+007	3.0200e-005	1.1174e+000
Y-90	7.2451e+004	2.6807e+015	1.7100e+003	6.3270e+007

Buildup
The material reference is : Source

Integration Parameters

Radial	24
Circumferential	24
Y Direction (axial)	24

Results - Dose Point # 1 - (138.493,370,0) cm

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u>		<u>Exposure Rate</u>	
		<u>MeV/cm²/sec</u>	<u>MeV/cm²/sec</u>	<u>mR/hr</u>	<u>mR/hr</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.603e+12	2.274e-236	8.613e-22	1.951e-237	7.387e-23
0.02	1.450e+12	1.370e-124	6.085e-22	4.745e-126	2.108e-23
0.03	1.729e+14	6.676e-36	1.394e-19	6.616e-38	1.382e-21
0.04	4.257e+13	5.235e-14	7.858e-14	2.315e-16	3.475e-16
0.05	3.767e+11	1.032e-07	1.931e-07	2.748e-10	5.143e-10
0.06	1.132e+12	1.985e-03	4.496e-03	3.944e-06	8.930e-06
0.08	1.488e+11	3.980e-01	1.163e+00	6.298e-04	1.840e-03
0.1	2.636e+12	1.244e+02	4.185e+02	1.903e-01	6.403e-01
0.15	8.425e+09	5.600e+00	2.150e+01	9.222e-03	3.541e-02
0.2	4.358e+11	8.152e+02	3.313e+03	1.439e+00	5.847e+00
0.3	5.185e+10	2.693e+02	1.085e+03	5.108e-01	2.057e+00
0.4	1.057e+11	9.978e+02	3.812e+03	1.944e+00	7.428e+00
0.5	3.368e+10	4.908e+02	1.760e+03	9.634e-01	3.456e+00
0.6	2.562e+15	5.277e+07	1.779e+08	1.030e+05	3.472e+05
0.8	2.363e+12	8.346e+04	2.537e+05	1.587e+02	4.826e+02
1.0	2.308e+12	1.236e+05	3.465e+05	2.278e+02	6.387e+02
1.5	2.786e+12	3.154e+05	7.649e+05	5.306e+02	1.287e+03
2.0	1.173e+08	2.206e+01	4.923e+01	3.411e-02	7.613e-02
3.0	1.242e+04	4.570e-03	9.088e-03	6.201e-06	1.233e-05

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec No Buildup	<u>Fluence Rate</u> MeV/cm ² /sec With Buildup	<u>Exposure Rate</u> mR/hr No Buildup	<u>Exposure Rate</u> mR/hr With Buildup
TOTALS:	2.794e+15	5.329e+07	1.793e+08	1.039e+05	3.497e+05

Results - Dose Point # 2 - (166.433,370,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec No Buildup	<u>Fluence Rate</u> MeV/cm ² /sec With Buildup	<u>Exposure Rate</u> mR/hr No Buildup	<u>Exposure Rate</u> mR/hr With Buildup
0.015	2.603e+12	5.145e-189	6.070e-22	4.413e-190	5.207e-23
0.02	1.450e+12	9.883e-88	4.289e-22	3.423e-89	1.486e-23
0.03	1.729e+14	2.597e-25	9.828e-20	2.574e-27	9.740e-22
0.04	4.257e+13	3.755e-10	5.504e-10	1.661e-12	2.434e-12
0.05	3.767e+11	3.345e-06	5.933e-06	8.912e-09	1.580e-08
0.06	1.132e+12	7.339e-03	1.553e-02	1.458e-05	3.085e-05
0.08	1.488e+11	3.685e-01	1.010e+00	5.832e-04	1.598e-03
0.1	2.636e+12	8.749e+01	2.849e+02	1.339e-01	4.359e-01
0.15	8.425e+09	3.833e+00	1.503e+01	6.312e-03	2.476e-02
0.2	4.358e+11	5.726e+02	2.397e+03	1.011e+00	4.230e+00
0.3	5.185e+10	1.932e+02	7.965e+02	3.666e-01	1.511e+00
0.4	1.057e+11	7.221e+02	2.806e+03	1.407e+00	5.468e+00
0.5	3.368e+10	3.568e+02	1.296e+03	7.004e-01	2.544e+00
0.6	2.562e+15	3.847e+07	1.309e+08	7.509e+04	2.556e+05
0.8	2.363e+12	6.103e+04	1.865e+05	1.161e+02	3.547e+02
1.0	2.308e+12	9.050e+04	2.544e+05	1.668e+02	4.689e+02
1.5	2.786e+12	2.312e+05	5.602e+05	3.889e+02	9.425e+02
2.0	1.173e+08	1.617e+01	3.599e+01	2.500e-02	5.566e-02
3.0	1.242e+04	3.348e-03	6.639e-03	4.542e-06	9.007e-06
TOTALS:	2.794e+15	3.885e+07	1.319e+08	7.576e+04	2.574e+05

Results - Dose Point # 3 - (235.953,370,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec No Buildup	<u>Fluence Rate</u> MeV/cm ² /sec With Buildup	<u>Exposure Rate</u> mR/hr No Buildup	<u>Exposure Rate</u> mR/hr With Buildup
0.015	2.603e+12	1.243e-188	3.475e-22	1.066e-189	2.980e-23
0.02	1.450e+12	5.226e-88	2.455e-22	1.810e-89	8.504e-24
0.03	1.729e+14	1.380e-25	5.625e-20	1.368e-27	5.575e-22
0.04	4.257e+13	2.603e-10	3.818e-10	1.151e-12	1.689e-12
0.05	3.767e+11	2.378e-06	4.217e-06	6.336e-09	1.123e-08
0.06	1.132e+12	5.073e-03	1.073e-02	1.008e-05	2.130e-05
0.08	1.488e+11	2.498e-01	6.843e-01	3.954e-04	1.083e-03
0.1	2.636e+12	5.881e+01	1.914e+02	8.998e-02	2.929e-01
0.15	8.425e+09	2.550e+00	9.983e+00	4.200e-03	1.644e-02
0.2	4.358e+11	3.790e+02	1.580e+03	6.690e-01	2.789e+00
0.3	5.185e+10	1.273e+02	5.214e+02	2.415e-01	9.891e-01
0.4	1.057e+11	4.745e+02	1.831e+03	9.246e-01	3.567e+00
0.5	3.368e+10	2.341e+02	8.436e+02	4.594e-01	1.656e+00
0.6	2.562e+15	2.520e+07	8.505e+07	4.918e+04	1.660e+05
0.8	2.363e+12	3.988e+04	1.208e+05	7.585e+01	2.297e+02
1.0	2.308e+12	5.901e+04	1.643e+05	1.088e+02	3.029e+02
1.5	2.786e+12	1.501e+05	3.603e+05	2.525e+02	6.061e+02
2.0	1.173e+08	1.046e+01	2.308e+01	1.618e-02	3.568e-02
3.0	1.242e+04	2.158e-03	4.241e-03	2.928e-06	5.754e-06
TOTALS:	2.794e+15	2.545e+07	8.570e+07	4.962e+04	1.672e+05

Results - Dose Point # 4 - (145.953,370,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.603e+12	2.804e-198	7.681e-22	2.405e-199	6.588e-23
0.02	1.450e+12	1.415e-91	5.427e-22	4.902e-93	1.880e-23
0.03	1.729e+14	6.049e-26	1.244e-19	5.995e-28	1.232e-21
0.04	4.257e+13	4.773e-10	7.013e-10	2.111e-12	3.102e-12
0.05	3.767e+11	5.449e-06	9.661e-06	1.452e-08	2.574e-08
0.06	1.132e+12	1.092e-02	2.295e-02	2.169e-05	4.558e-05
0.08	1.488e+11	4.612e-01	1.248e+00	7.298e-04	1.975e-03
0.1	2.636e+12	1.039e+02	3.358e+02	1.590e-01	5.137e-01
0.15	8.425e+09	4.515e+00	1.776e+01	7.435e-03	2.924e-02
0.2	4.358e+11	6.780e+02	2.858e+03	1.197e+00	5.044e+00
0.3	5.185e+10	2.302e+02	9.576e+02	4.367e-01	1.817e+00
0.4	1.057e+11	8.631e+02	3.387e+03	1.682e+00	6.600e+00
0.5	3.368e+10	4.275e+02	1.568e+03	8.391e-01	3.078e+00
0.6	2.562e+15	4.617e+07	1.587e+08	9.013e+04	3.097e+05
0.8	2.363e+12	7.346e+04	2.265e+05	1.397e+02	4.308e+02
1.0	2.308e+12	1.092e+05	3.094e+05	2.012e+02	5.703e+02
1.5	2.786e+12	2.799e+05	6.830e+05	4.709e+02	1.149e+03
2.0	1.173e+08	1.962e+01	4.394e+01	3.034e-02	6.795e-02
3.0	1.242e+04	4.072e-03	8.115e-03	5.525e-06	1.101e-05
TOTALS:	2.794e+15	4.664e+07	1.599e+08	9.094e+04	3.118e+05

Results - Dose Point # 5 - (155.953,370,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.603e+12	1.571e-190	6.789e-22	1.347e-191	5.824e-23
0.02	1.450e+12	2.973e-88	4.797e-22	1.030e-89	1.662e-23
0.03	1.729e+14	3.002e-25	1.099e-19	2.975e-27	1.089e-21
0.04	4.257e+13	5.088e-10	7.454e-10	2.250e-12	3.297e-12
0.05	3.767e+11	3.859e-06	6.825e-06	1.028e-08	1.818e-08
0.06	1.132e+12	7.799e-03	1.647e-02	1.549e-05	3.270e-05
0.08	1.488e+11	3.912e-01	1.073e+00	6.191e-04	1.699e-03
0.1	2.636e+12	9.388e+01	3.064e+02	1.436e-01	4.688e-01
0.15	8.425e+09	4.155e+00	1.634e+01	6.843e-03	2.690e-02
0.2	4.358e+11	6.224e+02	2.611e+03	1.098e+00	4.608e+00
0.3	5.185e+10	2.104e+02	8.699e+02	3.992e-01	1.650e+00
0.4	1.057e+11	7.872e+02	3.069e+03	1.534e+00	5.981e+00
0.5	3.368e+10	3.893e+02	1.419e+03	7.641e-01	2.786e+00
0.6	2.562e+15	4.200e+07	1.434e+08	8.197e+04	2.800e+05
0.8	2.363e+12	6.669e+04	2.045e+05	1.269e+02	3.889e+02
1.0	2.308e+12	9.898e+04	2.790e+05	1.825e+02	5.144e+02
1.5	2.786e+12	2.532e+05	6.150e+05	4.259e+02	1.035e+03
2.0	1.173e+08	1.772e+01	3.953e+01	2.740e-02	6.114e-02
3.0	1.242e+04	3.672e-03	7.295e-03	4.982e-06	9.897e-06
TOTALS:	2.794e+15	4.242e+07	1.445e+08	8.271e+04	2.819e+05

Results - Dose Point # 6 - (200.953,370,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.603e+12	1.845e-188	4.476e-22	1.583e-189	3.839e-23
0.02	1.450e+12	8.272e-88	3.162e-22	2.865e-89	1.095e-23

Page : 5
 DOS File : Combined Calcine in Bulk Tank.ms6
 Run Date: May 3, 2005
 Run Time: 2:38:06 PM
 Duration : 00:01:05

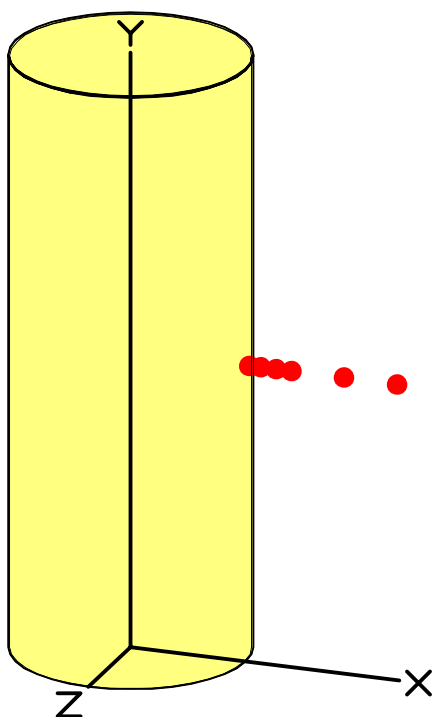
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.03	1.729e+14	1.537e-25	7.246e-20	1.523e-27	7.182e-22
0.04	4.257e+13	3.120e-10	4.575e-10	1.380e-12	2.023e-12
0.05	3.767e+11	2.830e-06	5.016e-06	7.538e-09	1.336e-08
0.06	1.132e+12	6.037e-03	1.276e-02	1.199e-05	2.535e-05
0.08	1.488e+11	2.981e-01	8.164e-01	4.718e-04	1.292e-03
0.1	2.636e+12	7.038e+01	2.291e+02	1.077e-01	3.504e-01
0.15	8.425e+09	3.061e+00	1.199e+01	5.041e-03	1.974e-02
0.2	4.358e+11	4.559e+02	1.903e+03	8.046e-01	3.360e+00
0.3	5.185e+10	1.534e+02	6.305e+02	2.911e-01	1.196e+00
0.4	1.057e+11	5.727e+02	2.217e+03	1.116e+00	4.321e+00
0.5	3.368e+10	2.827e+02	1.023e+03	5.549e-01	2.008e+00
0.6	2.562e+15	3.046e+07	1.032e+08	5.945e+04	2.015e+05
0.8	2.363e+12	4.826e+04	1.468e+05	9.179e+01	2.792e+02
1.0	2.308e+12	7.148e+04	1.999e+05	1.318e+02	3.686e+02
1.5	2.786e+12	1.822e+05	4.393e+05	3.065e+02	7.391e+02
2.0	1.173e+08	1.272e+01	2.818e+01	1.967e-02	4.358e-02
3.0	1.242e+04	2.629e-03	5.189e-03	3.566e-06	7.040e-06
TOTALS:	2.794e+15	3.076e+07	1.040e+08	5.998e+04	2.029e+05

MicroShield v6.10 (0028)
INEEL

Page : 1
 DOS File : Combined Calcine in Day Tank.ms6
 Run Date : April 5, 2005
 Run Time : 1:17:38 PM
 Duration : 00:01:04

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

Case Title: Combined Calcine
Description: Combined Calcine in Day Tank (3/8" 316 SS)
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	390.0 cm	12 ft 9.5 in
Radius	75.0 cm	2 ft 5.5 in

Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	78.493 cm 2 ft 6.9 in	195 cm 6 ft 4.8 in	0 cm 0.0 in
# 2	106.433 cm 3 ft 5.9 in	195 cm 6 ft 4.8 in	0 cm 0.0 in
# 3	175.953 cm 5 ft 9.3 in	195 cm 6 ft 4.8 in	0 cm 0.0 in
# 4	85.953 cm 2 ft 9.8 in	195 cm 6 ft 4.8 in	0 cm 0.0 in
# 5	95.953 cm 3 ft 1.8 in	195 cm 6 ft 4.8 in	0 cm 0.0 in
# 6	140.953 cm 4 ft 7.5 in	195 cm 6 ft 4.8 in	0 cm 0.0 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	6.89e+06 cm ³	Combined Calcine	1.27
Transition		Air	0.00122
Air Gap		Air	0.00122
Wall Clad	.953 cm	Iron	7.95
Top Clad	.953 cm	Iron	7.95

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included

Library : ICRP-38

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>µCi/cm³</u>	<u>Bq/cm³</u>
Am-241	1.3853e+001	5.1255e+011	2.0100e+000	7.4370e+004
Am-243	9.0973e-003	3.3660e+008	1.3200e-003	4.8840e+001
Ba-137m	1.2543e+004	4.6410e+014	1.8200e+003	6.7340e+007
Ce-144	2.1572e-008	7.9815e+002	3.1300e-009	1.1581e-004
Cm-242	2.2950e-002	8.4915e+008	3.3300e-003	1.2321e+002
Cm-244	8.4770e-003	3.1365e+008	1.2300e-003	4.5510e+001
Co-60	1.5162e+000	5.6100e+010	2.2000e-001	8.1400e+003
Cs-134	8.2013e-002	3.0345e+009	1.1900e-002	4.4030e+002
Cs-135	2.3295e-001	8.6190e+009	3.3800e-002	1.2506e+003
Cs-137	1.3232e+004	4.8960e+014	1.9200e+003	7.1040e+007
Eu-152	4.1558e-001	1.5376e+010	6.0300e-002	2.2311e+003
Eu-154	2.7154e+001	1.0047e+012	3.9400e+000	1.4578e+005
Eu-155	2.0124e+000	7.4460e+010	2.9200e-001	1.0804e+004
I-129	1.1992e-003	4.4370e+007	1.7400e-004	6.4380e+000
Ni-63	6.6093e+002	2.4454e+013	9.5900e+001	3.5483e+006
Np-237	1.1441e-001	4.2330e+009	1.6600e-002	6.1420e+002
Pa-233	1.1441e-001	4.2330e+009	1.6600e-002	6.1420e+002
Pm-147	4.7003e-001	1.7391e+010	6.8200e-002	2.5234e+003
Pr-144	2.1572e-008	7.9815e+002	3.1300e-009	1.1581e-004

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>µCi/cm³</u>	<u>Bq/cm³</u>
Pu-238	1.5645e+002	5.7885e+012	2.2700e+001	8.3990e+005
Pu-239	3.5769e+000	1.3234e+011	5.1900e-001	1.9203e+004
Pu-240	2.1227e+000	7.8540e+010	3.0800e-001	1.1396e+004
Pu-241	5.9201e+001	2.1904e+012	8.5900e+000	3.1783e+005
Pu-242	2.8739e-001	1.0633e+010	4.1700e-002	1.5429e+003
Ru-106	7.6500e-007	2.8305e+004	1.1100e-007	4.1070e-003
Sb-125	2.1434e-001	7.9305e+009	3.1100e-002	1.1507e+003
Sb-126	2.1089e-002	7.8030e+008	3.0600e-003	1.1322e+002
Sb-126m	1.5093e-001	5.5845e+009	2.1900e-002	8.1030e+002
Sm-151	1.3577e+002	5.0235e+012	1.9700e+001	7.2890e+005
Sr-90	1.1785e+004	4.3605e+014	1.7100e+003	6.3270e+007
Tc-99	5.6100e+000	2.0757e+011	8.1400e-001	3.0118e+004
Th-230	5.8581e-004	2.1675e+007	8.5000e-005	3.1450e+000
Th-231	5.6582e-004	2.0935e+007	8.2100e-005	3.0377e+000
U-232	4.0938e-004	1.5147e+007	5.9400e-005	2.1978e+000
U-233	2.7154e-005	1.0047e+006	3.9400e-006	1.4578e-001
U-234	1.0820e-001	4.0035e+009	1.5700e-002	5.8090e+002
U-235	5.5617e-004	2.0578e+007	8.0700e-005	2.9859e+000
U-236	1.7023e-003	6.2985e+007	2.4700e-004	9.1390e+000
U-237	1.4749e-003	5.4570e+007	2.1400e-004	7.9180e+000
U-238	2.0813e-004	7.7010e+006	3.0200e-005	1.1174e+000
Y-90	1.1785e+004	4.3605e+014	1.7100e+003	6.3270e+007

Buildup
The material reference is : Source

Integration Parameters

Radial	24
Circumferential	24
Y Direction (axial)	24

Results - Dose Point # 1 - (78.493,195,0) cm

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u>		<u>Exposure Rate</u> <u>mR/hr</u>	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	4.234e+11	4.730e-211	4.514e-22	4.057e-212	3.872e-23
0.02	2.358e+11	1.063e-97	3.190e-22	3.683e-99	1.105e-23
0.03	2.812e+13	9.535e-28	7.309e-20	9.450e-30	7.244e-22
0.04	6.925e+12	1.030e-10	1.522e-10	4.553e-13	6.731e-13
0.05	6.128e+10	3.450e-06	6.196e-06	9.190e-09	1.650e-08
0.06	1.842e+11	1.101e-02	2.352e-02	2.186e-05	4.672e-05
0.08	2.420e+10	5.590e-01	1.512e+00	8.845e-04	2.393e-03
0.1	4.288e+11	1.200e+02	3.816e+02	1.837e-01	5.838e-01
0.15	1.370e+09	4.905e+00	1.903e+01	8.077e-03	3.134e-02
0.2	7.089e+10	7.281e+02	3.043e+03	1.285e+00	5.370e+00
0.3	8.435e+09	2.459e+02	1.018e+03	4.664e-01	1.931e+00
0.4	1.720e+10	9.204e+02	3.601e+03	1.793e+00	7.017e+00
0.5	5.478e+09	4.555e+02	1.667e+03	8.941e-01	3.272e+00
0.6	4.167e+14	4.918e+07	1.687e+08	9.599e+04	3.292e+05
0.8	3.844e+11	7.819e+04	2.406e+05	1.487e+02	4.576e+02
1.0	3.754e+11	1.161e+05	3.282e+05	2.141e+02	6.050e+02
1.5	4.532e+11	2.973e+05	7.215e+05	5.001e+02	1.214e+03
2.0	1.908e+07	2.079e+01	4.621e+01	3.215e-02	7.145e-02
3.0	2.020e+03	4.297e-03	8.466e-03	5.830e-06	1.149e-05
TOTALS:	4.545e+14	4.967e+07	1.700e+08	9.685e+04	3.315e+05

Results - Dose Point # 2 - (106.433,195,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	4.234e+11	9.000e-188	2.636e-22	7.720e-189	2.261e-23
0.02	2.358e+11	3.835e-86	1.862e-22	1.328e-87	6.451e-24
0.03	2.812e+13	3.910e-25	4.267e-20	3.875e-27	4.229e-22
0.04	6.925e+12	3.844e-10	5.631e-10	1.700e-12	2.491e-12
0.05	6.128e+10	3.052e-06	5.405e-06	8.130e-09	1.440e-08
0.06	1.842e+11	6.418e-03	1.356e-02	1.275e-05	2.694e-05
0.08	2.420e+10	3.171e-01	8.681e-01	5.019e-04	1.374e-03
0.1	4.288e+11	7.493e+01	2.437e+02	1.146e-01	3.729e-01
0.15	1.370e+09	3.263e+00	1.277e+01	5.374e-03	2.102e-02
0.2	7.089e+10	4.861e+02	2.027e+03	8.579e-01	3.578e+00
0.3	8.435e+09	1.636e+02	6.713e+02	3.103e-01	1.273e+00
0.4	1.720e+10	6.104e+02	2.360e+03	1.189e+00	4.599e+00
0.5	5.478e+09	3.012e+02	1.088e+03	5.913e-01	2.136e+00
0.6	4.167e+14	3.245e+07	1.098e+08	6.333e+04	2.143e+05
0.8	3.844e+11	5.139e+04	1.559e+05	9.774e+01	2.966e+02
1.0	3.754e+11	7.607e+04	2.121e+05	1.402e+02	3.910e+02
1.5	4.532e+11	1.935e+05	4.641e+05	3.256e+02	7.809e+02
2.0	1.908e+07	1.349e+01	2.965e+01	2.085e-02	4.585e-02
3.0	2.020e+03	2.775e-03	5.418e-03	3.765e-06	7.350e-06
TOTALS:	4.545e+14	3.277e+07	1.106e+08	6.390e+04	2.158e+05

Results - Dose Point # 3 - (175.953,195,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	4.234e+11	3.143e-188	1.168e-22	2.696e-189	1.002e-23
0.02	2.358e+11	1.589e-86	8.256e-23	5.504e-88	2.860e-24
0.03	2.812e+13	2.465e-25	1.892e-20	2.443e-27	1.875e-22
0.04	6.925e+12	2.265e-10	3.317e-10	1.002e-12	1.467e-12
0.05	6.128e+10	1.792e-06	3.174e-06	4.773e-09	8.455e-09
0.06	1.842e+11	3.770e-03	7.969e-03	7.489e-06	1.583e-05
0.08	2.420e+10	1.849e-01	5.061e-01	2.925e-04	8.008e-04
0.1	4.288e+11	4.332e+01	1.408e+02	6.628e-02	2.154e-01
0.15	1.370e+09	1.853e+00	7.197e+00	3.051e-03	1.185e-02
0.2	7.089e+10	2.729e+02	1.123e+03	4.816e-01	1.982e+00
0.3	8.435e+09	9.070e+01	3.646e+02	1.721e-01	6.916e-01
0.4	1.720e+10	3.359e+02	1.268e+03	6.545e-01	2.471e+00
0.5	5.478e+09	1.649e+02	5.805e+02	3.236e-01	1.139e+00
0.6	4.167e+14	1.768e+07	5.823e+07	3.450e+04	1.137e+05
0.8	3.844e+11	2.778e+04	8.201e+04	5.283e+01	1.560e+02
1.0	3.754e+11	4.086e+04	1.109e+05	7.531e+01	2.043e+02
1.5	4.532e+11	1.027e+05	2.398e+05	1.727e+02	4.035e+02
2.0	1.908e+07	7.092e+00	1.520e+01	1.097e-02	2.351e-02
3.0	2.020e+03	1.444e-03	2.753e-03	1.959e-06	3.736e-06
TOTALS:	4.545e+14	1.785e+07	5.866e+07	3.480e+04	1.144e+05

Results - Dose Point # 4 - (85.953,195,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	4.234e+11	5.595e-190	3.776e-22	4.799e-191	3.239e-23
0.02	2.358e+11	1.147e-86	2.668e-22	3.972e-88	9.242e-24
0.03	2.812e+13	7.400e-25	6.114e-20	7.334e-27	6.059e-22

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.04	6.925e+12	6.106e-10	8.935e-10	2.701e-12	3.952e-12
0.05	6.128e+10	3.956e-06	6.991e-06	1.054e-08	1.862e-08
0.06	1.842e+11	7.868e-03	1.661e-02	1.563e-05	3.299e-05
0.08	2.420e+10	3.974e-01	1.091e+00	6.289e-04	1.726e-03
0.1	4.288e+11	9.549e+01	3.116e+02	1.461e-01	4.767e-01
0.15	1.370e+09	4.224e+00	1.660e+01	6.956e-03	2.733e-02
0.2	7.089e+10	6.326e+02	2.653e+03	1.117e+00	4.682e+00
0.3	8.435e+09	2.139e+02	8.837e+02	4.057e-01	1.676e+00
0.4	1.720e+10	8.001e+02	3.117e+03	1.559e+00	6.073e+00
0.5	5.478e+09	3.956e+02	1.440e+03	7.765e-01	2.827e+00
0.6	4.167e+14	4.267e+07	1.455e+08	8.328e+04	2.840e+05
0.8	3.844e+11	6.773e+04	2.071e+05	1.288e+02	3.939e+02
1.0	3.754e+11	1.005e+05	2.822e+05	1.852e+02	5.201e+02
1.5	4.532e+11	2.564e+05	6.193e+05	4.314e+02	1.042e+03
2.0	1.908e+07	1.791e+01	3.963e+01	2.769e-02	6.129e-02
3.0	2.020e+03	3.695e-03	7.258e-03	5.013e-06	9.847e-06
TOTALS:	4.545e+14	4.309e+07	1.466e+08	8.403e+04	2.859e+05

Results - Dose Point # 5 - (95.953,195,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	4.234e+11	5.539e-188	3.123e-22	4.751e-189	2.678e-23
0.02	2.358e+11	4.729e-86	2.206e-22	1.638e-87	7.643e-24
0.03	2.812e+13	5.163e-25	5.056e-20	5.117e-27	5.011e-22
0.04	6.925e+12	4.053e-10	5.937e-10	1.793e-12	2.626e-12
0.05	6.128e+10	3.362e-06	5.959e-06	8.956e-09	1.587e-08
0.06	1.842e+11	7.194e-03	1.520e-02	1.429e-05	3.020e-05
0.08	2.420e+10	3.560e-01	9.747e-01	5.634e-04	1.542e-03
0.1	4.288e+11	8.430e+01	2.743e+02	1.290e-01	4.197e-01
0.15	1.370e+09	3.687e+00	1.444e+01	6.072e-03	2.379e-02
0.2	7.089e+10	5.503e+02	2.299e+03	9.712e-01	4.057e+00
0.3	8.435e+09	1.855e+02	7.627e+02	3.518e-01	1.447e+00
0.4	1.720e+10	6.925e+02	2.685e+03	1.349e+00	5.231e+00
0.5	5.478e+09	3.420e+02	1.239e+03	6.713e-01	2.432e+00
0.6	4.167e+14	3.686e+07	1.251e+08	7.194e+04	2.441e+05
0.8	3.844e+11	5.842e+04	1.779e+05	1.111e+02	3.383e+02
1.0	3.754e+11	8.656e+04	2.422e+05	1.596e+02	4.464e+02
1.5	4.532e+11	2.205e+05	5.307e+05	3.711e+02	8.930e+02
2.0	1.908e+07	1.538e+01	3.394e+01	2.379e-02	5.249e-02
3.0	2.020e+03	3.171e-03	6.211e-03	4.302e-06	8.426e-06
TOTALS:	4.545e+14	3.722e+07	1.260e+08	7.259e+04	2.458e+05

Results - Dose Point # 6 - (140.953,195,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	4.234e+11	4.789e-188	1.680e-22	4.108e-189	1.441e-23
0.02	2.358e+11	1.955e-86	1.187e-22	6.772e-88	4.112e-24
0.03	2.812e+13	3.145e-25	2.720e-20	3.117e-27	2.696e-22
0.04	6.925e+12	2.856e-10	4.183e-10	1.263e-12	1.850e-12
0.05	6.128e+10	2.263e-06	4.009e-06	6.029e-09	1.068e-08
0.06	1.842e+11	4.764e-03	1.007e-02	9.463e-06	2.000e-05

Page : 5
 DOS File : Combined Calcine in Day Tank.ms6
 Run Date: April 5, 2005
 Run Time: 1:17:38 PM
 Duration : 00:01:04

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.08	2.420e+10	2.341e-01	6.408e-01	3.705e-04	1.014e-03
0.1	4.288e+11	5.506e+01	1.790e+02	8.424e-02	2.739e-01
0.15	1.370e+09	2.381e+00	9.291e+00	3.921e-03	1.530e-02
0.2	7.089e+10	3.531e+02	1.465e+03	6.231e-01	2.586e+00
0.3	8.435e+09	1.182e+02	4.813e+02	2.243e-01	9.130e-01
0.4	1.720e+10	4.399e+02	1.684e+03	8.571e-01	3.282e+00
0.5	5.478e+09	2.166e+02	7.741e+02	4.252e-01	1.520e+00
0.6	4.167e+14	2.329e+07	7.787e+07	4.545e+04	1.520e+05
0.8	3.844e+11	3.675e+04	1.101e+05	6.991e+01	2.095e+02
1.0	3.754e+11	5.425e+04	1.494e+05	1.000e+02	2.753e+02
1.5	4.532e+11	1.372e+05	3.248e+05	2.309e+02	5.465e+02
2.0	1.908e+07	9.520e+00	2.066e+01	1.472e-02	3.195e-02
3.0	2.020e+03	1.948e-03	3.757e-03	2.643e-06	5.097e-06
TOTALS:	4.545e+14	2.352e+07	7.846e+07	4.585e+04	1.530e+05

MicroShield v6.10 (0028)
INEEL

Page : 1
 DOS File : Combined Calcine in Batch Tank.ms6
 Run Date : April 5, 2005
 Run Time : 1:20:38 PM
 Duration : 00:01:03

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

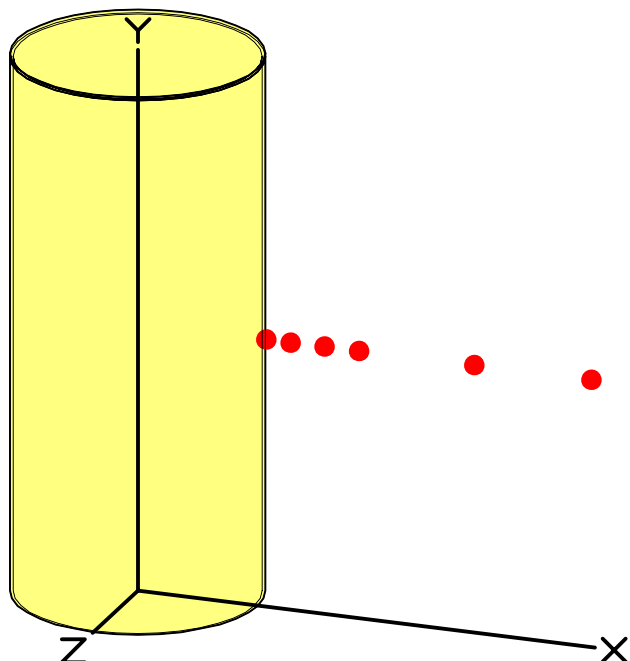
Case Title: Combined Calcine
Description: Combined Calcine in Batch Tank (3/8" 316 SS)
Geometry: 7 - Cylinder Volume - Side Shields

Source Dimensions

Height	160.0 cm	5 ft 3.0 in
Radius	35.0 cm	1 ft 1.8 in

Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	38.493 cm 1 ft 3.2 in	80 cm 2 ft 7.5 in	0 cm 0.0 in
# 2	66.433 cm 2 ft 2.2 in	80 cm 2 ft 7.5 in	0 cm 0.0 in
# 3	135.953 cm 4 ft 5.5 in	80 cm 2 ft 7.5 in	0 cm 0.0 in
# 4	45.953 cm 1 ft 6.1 in	80 cm 2 ft 7.5 in	0 cm 0.0 in
# 5	55.953 cm 1 ft 10.0 in	80 cm 2 ft 7.5 in	0 cm 0.0 in
# 6	100.953 cm 3 ft 3.7 in	80 cm 2 ft 7.5 in	0 cm 0.0 in



Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	6.16e+05 cm ³	Combined Calcine	1.27
Transition		Air	0.00122
Air Gap		Air	0.00122
Wall Clad	.953 cm	Iron	7.95
Top Clad	.953 cm	Iron	7.95

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included
Library : ICRP-38

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>µCi/cm³</u>	<u>Bq/cm³</u>
Am-241	1.2377e+000	4.5793e+010	2.0100e+000	7.4370e+004
Am-243	8.1279e-004	3.0073e+007	1.3200e-003	4.8840e+001
Ba-137m	1.1207e+003	4.1465e+013	1.8200e+003	6.7340e+007
Ce-144	1.9273e-009	7.1310e+001	3.1300e-009	1.1581e-004
Cm-242	2.0505e-003	7.5867e+007	3.3300e-003	1.2321e+002
Cm-244	7.5738e-004	2.8023e+007	1.2300e-003	4.5510e+001
Co-60	1.3547e-001	5.0122e+009	2.2000e-001	8.1400e+003
Cs-134	7.3275e-003	2.7112e+008	1.1900e-002	4.4030e+002
Cs-135	2.0812e-002	7.7006e+008	3.3800e-002	1.2506e+003
Cs-137	1.1822e+003	4.3743e+013	1.9200e+003	7.1040e+007
Eu-152	3.7130e-002	1.3738e+009	6.0300e-002	2.2311e+003
Eu-154	2.4261e+000	8.9764e+010	3.9400e+000	1.4578e+005
Eu-155	1.7980e-001	6.6526e+009	2.9200e-001	1.0804e+004
I-129	1.0714e-004	3.9642e+006	1.7400e-004	6.4380e+000
Ni-63	5.9051e+001	2.1849e+012	9.5900e+001	3.5483e+006
Np-237	1.0221e-002	3.7819e+008	1.6600e-002	6.1420e+002
Pa-233	1.0221e-002	3.7819e+008	1.6600e-002	6.1420e+002
Pm-147	4.1994e-002	1.5538e+009	6.8200e-002	2.5234e+003
Pr-144	1.9273e-009	7.1310e+001	3.1300e-009	1.1581e-004

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>µCi/cm³</u>	<u>Bq/cm³</u>
Pu-238	1.3978e+001	5.1717e+011	2.2700e+001	8.3990e+005
Pu-239	3.1958e-001	1.1824e+010	5.1900e-001	1.9203e+004
Pu-240	1.8965e-001	7.0171e+009	3.0800e-001	1.1396e+004
Pu-241	5.2893e+000	1.9570e+011	8.5900e+000	3.1783e+005
Pu-242	2.5677e-002	9.5004e+008	4.1700e-002	1.5429e+003
Ru-106	6.8348e-008	2.5289e+003	1.1100e-007	4.1070e-003
Sb-125	1.9150e-002	7.0855e+008	3.1100e-002	1.1507e+003
Sb-126	1.8842e-003	6.9715e+007	3.0600e-003	1.1322e+002
Sb-126m	1.3485e-002	4.9894e+008	2.1900e-002	8.1030e+002
Sm-151	1.2130e+001	4.4882e+011	1.9700e+001	7.2890e+005
Sr-90	1.0529e+003	3.8959e+013	1.7100e+003	6.3270e+007
Tc-99	5.0122e-001	1.8545e+010	8.1400e-001	3.0118e+004
Th-230	5.2339e-005	1.9365e+006	8.5000e-005	3.1450e+000
Th-231	5.0553e-005	1.8705e+006	8.2100e-005	3.0377e+000
U-232	3.6576e-005	1.3533e+006	5.9400e-005	2.1978e+000
U-233	2.4261e-006	8.9764e+004	3.9400e-006	1.4578e-001
U-234	9.6673e-003	3.5769e+008	1.5700e-002	5.8090e+002
U-235	4.9691e-005	1.8386e+006	8.0700e-005	2.9859e+000
U-236	1.5209e-004	5.6274e+006	2.4700e-004	9.1390e+000
U-237	1.3177e-004	4.8755e+006	2.1400e-004	7.9180e+000
U-238	1.8596e-005	6.8804e+005	3.0200e-005	1.1174e+000
Y-90	1.0529e+003	3.8959e+013	1.7100e+003	6.3270e+007

Buildup
The material reference is : Source

Integration Parameters

Radial	24
Circumferential	24
Y Direction (axial)	24

Results - Dose Point # 1 - (38.493,80,0) cm

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u>		<u>Exposure Rate</u> <u>mR/hr</u>	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	3.783e+10	5.468e-192	1.842e-22	4.690e-193	1.580e-23
0.02	2.107e+10	1.157e-86	1.301e-22	4.009e-88	4.508e-24
0.03	2.512e+12	7.586e-25	2.982e-20	7.518e-27	2.955e-22
0.04	6.187e+11	7.442e-10	1.089e-09	3.291e-12	4.818e-12
0.05	5.475e+09	4.833e-06	8.527e-06	1.288e-08	2.271e-08
0.06	1.646e+10	8.714e-03	1.831e-02	1.731e-05	3.636e-05
0.08	2.162e+09	4.179e-01	1.147e+00	6.614e-04	1.815e-03
0.1	3.831e+10	1.010e+02	3.301e+02	1.546e-01	5.051e-01
0.15	1.224e+08	4.498e+00	1.771e+01	7.408e-03	2.916e-02
0.2	6.333e+09	6.752e+02	2.836e+03	1.192e+00	5.006e+00
0.3	7.536e+08	2.285e+02	9.421e+02	4.334e-01	1.787e+00
0.4	1.536e+09	8.539e+02	3.305e+03	1.664e+00	6.440e+00
0.5	4.894e+08	4.216e+02	1.518e+03	8.276e-01	2.980e+00
0.6	3.723e+13	4.540e+07	1.525e+08	8.861e+04	2.976e+05
0.8	3.435e+10	7.175e+04	2.146e+05	1.365e+02	4.081e+02
1.0	3.354e+10	1.059e+05	2.891e+05	1.952e+02	5.328e+02
1.5	4.049e+10	2.664e+05	6.174e+05	4.482e+02	1.039e+03
2.0	1.705e+06	1.834e+01	3.862e+01	2.836e-02	5.972e-02
3.0	1.804e+02	3.691e-03	6.839e-03	5.008e-06	9.279e-06
TOTALS:	4.060e+13	4.584e+07	1.536e+08	8.940e+04	2.996e+05

Results - Dose Point # 2 - (66.433,80,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	3.783e+10	9.148e-188	7.246e-23	7.847e-189	6.215e-24
0.02	2.107e+10	1.640e-85	5.120e-23	5.680e-87	1.773e-24
0.03	2.512e+12	4.168e-25	1.173e-20	4.131e-27	1.163e-22
0.04	6.187e+11	2.909e-10	4.260e-10	1.287e-12	1.884e-12
0.05	5.475e+09	2.277e-06	4.032e-06	6.064e-09	1.074e-08
0.06	1.646e+10	4.789e-03	1.012e-02	9.512e-06	2.010e-05
0.08	2.162e+09	2.352e-01	6.435e-01	3.722e-04	1.018e-03
0.1	3.831e+10	5.529e+01	1.796e+02	8.459e-02	2.747e-01
0.15	1.224e+08	2.384e+00	9.269e+00	3.925e-03	1.526e-02
0.2	6.333e+09	3.523e+02	1.452e+03	6.218e-01	2.562e+00
0.3	7.536e+08	1.173e+02	4.707e+02	2.226e-01	8.929e-01
0.4	1.536e+09	4.343e+02	1.629e+03	8.463e-01	3.173e+00
0.5	4.894e+08	2.129e+02	7.410e+02	4.179e-01	1.454e+00
0.6	3.723e+13	2.278e+07	7.385e+07	4.447e+04	1.441e+05
0.8	3.435e+10	3.564e+04	1.027e+05	6.780e+01	1.953e+02
1.0	3.354e+10	5.215e+04	1.370e+05	9.612e+01	2.526e+02
1.5	4.049e+10	1.290e+05	2.877e+05	2.170e+02	4.841e+02
2.0	1.705e+06	8.771e+00	1.779e+01	1.356e-02	2.751e-02
3.0	1.804e+02	1.738e-03	3.109e-03	2.358e-06	4.219e-06
TOTALS:	4.060e+13	2.300e+07	7.438e+07	4.485e+04	1.451e+05

Results - Dose Point # 3 - (135.953,80,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	3.783e+10	3.567e-188	2.042e-23	3.059e-189	1.752e-24
0.02	2.107e+10	7.950e-86	1.443e-23	2.754e-87	4.999e-25
0.03	2.512e+12	1.964e-25	3.307e-21	1.946e-27	3.277e-23
0.04	6.187e+11	1.390e-10	2.035e-10	6.146e-13	9.001e-13
0.05	5.475e+09	1.084e-06	1.919e-06	2.886e-09	5.113e-09
0.06	1.646e+10	2.247e-03	4.745e-03	4.464e-06	9.424e-06
0.08	2.162e+09	1.041e-01	2.830e-01	1.648e-04	4.478e-04
0.1	3.831e+10	2.301e+01	7.354e+01	3.521e-02	1.125e-01
0.15	1.224e+08	9.034e-01	3.388e+00	1.488e-03	5.579e-03
0.2	6.333e+09	1.281e+02	5.037e+02	2.262e-01	8.891e-01
0.3	7.536e+08	4.116e+01	1.564e+02	7.809e-02	2.968e-01
0.4	1.536e+09	1.496e+02	5.307e+02	2.915e-01	1.034e+00
0.5	4.894e+08	7.239e+01	2.385e+02	1.421e-01	4.682e-01
0.6	3.723e+13	7.671e+06	2.357e+07	1.497e+04	4.601e+04
0.8	3.435e+10	1.182e+04	3.238e+04	2.248e+01	6.159e+01
1.0	3.354e+10	1.709e+04	4.286e+04	3.151e+01	7.901e+01
1.5	4.049e+10	4.143e+04	8.875e+04	6.971e+01	1.493e+02
2.0	1.705e+06	2.783e+00	5.443e+00	4.304e-03	8.416e-03
3.0	1.804e+02	5.439e-04	9.431e-04	7.379e-07	1.279e-06
TOTALS:	4.060e+13	7.742e+06	2.374e+07	1.510e+04	4.630e+04

Results - Dose Point # 4 - (45.953,80,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	3.783e+10	1.621e-187	1.339e-22	1.391e-188	1.148e-23
0.02	2.107e+10	3.805e-85	9.459e-23	1.318e-86	3.276e-24
0.03	2.512e+12	5.862e-25	2.167e-20	5.810e-27	2.148e-22

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.04	6.187e+11	4.135e-10	6.057e-10	1.829e-12	2.679e-12
0.05	5.475e+09	3.361e-06	5.954e-06	8.954e-09	1.586e-08
0.06	1.646e+10	7.062e-03	1.492e-02	1.403e-05	2.963e-05
0.08	2.162e+09	3.492e-01	9.560e-01	5.527e-04	1.513e-03
0.1	3.831e+10	8.268e+01	2.690e+02	1.265e-01	4.115e-01
0.15	1.224e+08	3.613e+00	1.414e+01	5.950e-03	2.328e-02
0.2	6.333e+09	5.387e+02	2.246e+03	9.507e-01	3.964e+00
0.3	7.536e+08	1.812e+02	7.410e+02	3.438e-01	1.406e+00
0.4	1.536e+09	6.753e+02	2.592e+03	1.316e+00	5.050e+00
0.5	4.894e+08	3.328e+02	1.188e+03	6.532e-01	2.332e+00
0.6	3.723e+13	3.577e+07	1.191e+08	6.983e+04	2.326e+05
0.8	3.435e+10	5.640e+04	1.672e+05	1.073e+02	3.181e+02
1.0	3.354e+10	8.306e+04	2.248e+05	1.531e+02	4.144e+02
1.5	4.049e+10	2.082e+05	4.782e+05	3.502e+02	8.046e+02
2.0	1.705e+06	1.429e+01	2.982e+01	2.210e-02	4.612e-02
3.0	1.804e+02	2.866e-03	5.261e-03	3.888e-06	7.137e-06
TOTALS:	4.060e+13	3.612e+07	1.200e+08	7.044e+04	2.341e+05

Results - Dose Point # 5 - (55.953,80,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	3.783e+10	1.434e-187	9.638e-23	1.230e-188	8.267e-24
0.02	2.107e+10	2.036e-85	6.810e-23	7.051e-87	2.359e-24
0.03	2.512e+12	4.928e-25	1.560e-20	4.884e-27	1.547e-22
0.04	6.187e+11	3.482e-10	5.099e-10	1.540e-12	2.255e-12
0.05	5.475e+09	2.717e-06	4.812e-06	7.237e-09	1.282e-08
0.06	1.646e+10	5.729e-03	1.211e-02	1.138e-05	2.404e-05
0.08	2.162e+09	2.822e-01	7.721e-01	4.465e-04	1.222e-03
0.1	3.831e+10	6.649e+01	2.161e+02	1.017e-01	3.306e-01
0.15	1.224e+08	2.885e+00	1.126e+01	4.752e-03	1.854e-02
0.2	6.333e+09	4.286e+02	1.779e+03	7.565e-01	3.139e+00
0.3	7.536e+08	1.436e+02	5.827e+02	2.724e-01	1.105e+00
0.4	1.536e+09	5.337e+02	2.028e+03	1.040e+00	3.952e+00
0.5	4.894e+08	2.624e+02	9.266e+02	5.151e-01	1.819e+00
0.6	3.723e+13	2.815e+07	9.265e+07	5.496e+04	1.808e+05
0.8	3.435e+10	4.424e+04	1.294e+05	8.414e+01	2.462e+02
1.0	3.354e+10	6.495e+04	1.734e+05	1.197e+02	3.196e+02
1.5	4.049e+10	1.617e+05	3.662e+05	2.721e+02	6.161e+02
2.0	1.705e+06	1.105e+01	2.273e+01	1.709e-02	3.515e-02
3.0	1.804e+02	2.203e-03	3.989e-03	2.989e-06	5.412e-06
TOTALS:	4.060e+13	2.843e+07	9.332e+07	5.543e+04	1.820e+05

Results - Dose Point # 6 - (100.953,80,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	3.783e+10	5.179e-188	3.517e-23	4.442e-189	3.017e-24
0.02	2.107e+10	1.091e-85	2.485e-23	3.780e-87	8.608e-25
0.03	2.512e+12	2.682e-25	5.694e-21	2.658e-27	5.643e-23
0.04	6.187e+11	1.893e-10	2.772e-10	8.371e-13	1.226e-12
0.05	5.475e+09	1.478e-06	2.619e-06	3.938e-09	6.975e-09
0.06	1.646e+10	3.104e-03	6.560e-03	6.166e-06	1.303e-05

Page : 5
 DOS File : Combined Calcine in Batch Tank.ms6
 Run Date: April 5, 2005
 Run Time: 1:20:38 PM
 Duration : 00:01:03

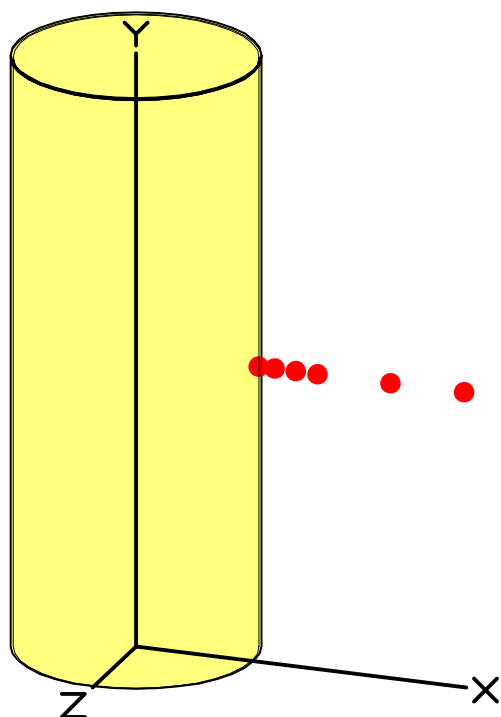
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.08	2.162e+09	1.506e-01	4.112e-01	2.383e-04	6.507e-04
0.1	3.831e+10	3.461e+01	1.117e+02	5.295e-02	1.708e-01
0.15	1.224e+08	1.424e+00	5.424e+00	2.345e-03	8.932e-03
0.2	6.333e+09	2.054e+02	8.215e+02	3.625e-01	1.450e+00
0.3	7.536e+08	6.683e+01	2.586e+02	1.268e-01	4.905e-01
0.4	1.536e+09	2.443e+02	8.820e+02	4.761e-01	1.719e+00
0.5	4.894e+08	1.187e+02	3.977e+02	2.330e-01	7.807e-01
0.6	3.723e+13	1.262e+07	3.939e+07	2.463e+04	7.689e+04
0.8	3.435e+10	1.953e+04	5.427e+04	3.715e+01	1.032e+02
1.0	3.354e+10	2.834e+04	7.199e+04	5.223e+01	1.327e+02
1.5	4.049e+10	6.906e+04	1.495e+05	1.162e+02	2.516e+02
2.0	1.705e+06	4.654e+00	9.189e+00	7.197e-03	1.421e-02
3.0	1.804e+02	9.128e-04	1.595e-03	1.238e-06	2.165e-06
TOTALS:	4.060e+13	1.274e+07	3.967e+07	2.484e+04	7.738e+04

MicroShield v6.10 (0028)
INEEL

Page : 1
 DOS File : Combined Calcine in Mixer.ms6
 Run Date : April 5, 2005
 Run Time : 1:24:23 PM
 Duration : 00:01:03

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

Case Title: Combined Calcine
Description: Combined Calcine in Grout Mixer (3/8" 316 SS)
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	280.0 cm	9 ft 2.2 in
Radius	55.0 cm	1 ft 9.7 in

Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	58.493 cm 1 ft 11.0 in	140 cm 4 ft 7.1 in	0 cm 0.0 in
# 2	86.433 cm 2 ft 10.0 in	140 cm 4 ft 7.1 in	0 cm 0.0 in
# 3	155.953 cm 5 ft 1.4 in	140 cm 4 ft 7.1 in	0 cm 0.0 in
# 4	65.953 cm 2 ft 2.0 in	140 cm 4 ft 7.1 in	0 cm 0.0 in
# 5	75.953 cm 2 ft 5.9 in	140 cm 4 ft 7.1 in	0 cm 0.0 in
# 6	120.953 cm 3 ft 11.6 in	140 cm 4 ft 7.1 in	0 cm 0.0 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	2.66e+06 cm ³	Concrete	1.8
Transition		Air	0.00122
Air Gap		Air	0.00122
Wall Clad	.953 cm	Iron	7.95
Top Clad	.953 cm	Iron	7.95

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included

Library : ICRP-38

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>µCi/cm³</u>	<u>Bq/cm³</u>
Am-241	1.6285e+000	6.0254e+010	6.1200e-001	2.2644e+004
Am-243	1.0697e-003	3.9579e+007	4.0200e-004	1.4874e+001
Ba-137m	1.4768e+003	5.4642e+013	5.5500e+002	2.0535e+007
Ce-144	2.5412e-009	9.4024e+001	9.5500e-010	3.5335e-005
Cm-242	2.7141e-003	1.0042e+008	1.0200e-003	3.7740e+001
Cm-244	9.9785e-004	3.6920e+007	3.7500e-004	1.3875e+001
Co-60	1.7855e-001	6.6063e+009	6.7100e-002	2.4827e+003
Cs-134	9.7124e-003	3.5936e+008	3.6500e-003	1.3505e+002
Cs-135	2.7408e-002	1.0141e+009	1.0300e-002	3.8110e+002
Cs-137	1.5620e+003	5.7793e+013	5.8700e+002	2.1719e+007
Eu-152	4.8961e-002	1.8116e+009	1.8400e-002	6.8080e+002
Eu-154	3.1931e+000	1.1815e+011	1.2000e+000	4.4400e+004
Eu-155	2.3762e-001	8.7920e+009	8.9300e-002	3.3041e+003
I-129	1.4156e-004	5.2378e+006	5.3200e-005	1.9684e+000
Ni-63	7.7965e+001	2.8847e+012	2.9300e+001	1.0841e+006
Np-237	1.3491e-002	4.9916e+008	5.0700e-003	1.8759e+002
Pa-233	1.3491e-002	4.9916e+008	5.0700e-003	1.8759e+002
Pm-147	5.5347e-002	2.0479e+009	2.0800e-002	7.6960e+002
Pr-144	2.5412e-009	9.4024e+001	9.5500e-010	3.5335e-005

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm^3
Pu-238	1.8414e+001	6.8130e+011	6.9200e+000	2.5604e+005
Pu-239	4.2043e-001	1.5556e+010	1.5800e-001	5.8460e+003
Pu-240	2.5039e-001	9.2646e+009	9.4100e-002	3.4817e+003
Pu-241	6.9716e+000	2.5795e+011	2.6200e+000	9.6940e+004
Pu-242	3.3794e-002	1.2504e+009	1.2700e-002	4.6990e+002
Ru-106	9.0472e-008	3.3474e+003	3.4000e-008	1.2580e-003
Sb-125	2.5226e-002	9.3335e+008	9.4800e-003	3.5076e+002
Sb-126	2.4853e-003	9.1956e+007	9.3400e-004	3.4558e+001
Sb-126m	1.7802e-002	6.5866e+008	6.6900e-003	2.4753e+002
Sm-151	1.5992e+001	5.9171e+011	6.0100e+000	2.2237e+005
Sr-90	1.3917e+003	5.1492e+013	5.2300e+002	1.9351e+007
Tc-99	6.5991e-001	2.4417e+010	2.4800e-001	9.1760e+003
Th-230	6.9184e-005	2.5598e+006	2.6000e-005	9.6200e-001
Th-231	6.6789e-005	2.4712e+006	2.5100e-005	9.2870e-001
U-232	4.8163e-005	1.7820e+006	1.8100e-005	6.6970e-001
U-233	3.1931e-006	1.1815e+005	1.2000e-006	4.4400e-002
U-234	1.2746e-002	4.7160e+008	4.7900e-003	1.7723e+002
U-235	6.5459e-005	2.4220e+006	2.4600e-005	9.1020e-001
U-236	2.0063e-004	7.4235e+006	7.5400e-005	2.7898e+000
U-237	1.7402e-004	6.4389e+006	6.5400e-005	2.4198e+000
U-238	2.4481e-005	9.0578e+005	9.2000e-006	3.4040e-001
Y-90	1.3917e+003	5.1492e+013	5.2300e+002	1.9351e+007

Buildup
 The material reference is : Source

Integration Parameters

Radial	24
Circumferential	24
Y Direction (axial)	24

Results - Dose Point # 1 - (58.493,140,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	6.055e+11	7.935e-201	1.271e-21	6.806e-202	1.090e-22
0.02	2.773e+10	7.538e-90	9.160e-23	2.611e-91	3.173e-24
0.03	3.311e+12	2.154e-25	2.418e-20	2.135e-27	2.396e-22
0.04	8.153e+11	7.686e-10	2.839e-09	3.399e-12	1.256e-11
0.05	7.209e+09	6.320e-06	3.627e-05	1.684e-08	9.661e-08
0.06	2.165e+10	1.019e-02	7.731e-02	2.025e-05	1.536e-04
0.08	2.857e+09	3.048e-01	2.803e+00	4.823e-04	4.435e-03
0.1	5.043e+10	5.122e+01	4.787e+02	7.836e-02	7.323e-01
0.15	1.612e+08	1.427e+00	1.137e+01	2.351e-03	1.872e-02
0.2	8.336e+09	1.770e+02	1.223e+03	3.124e-01	2.159e+00
0.3	9.935e+08	5.269e+01	2.962e+02	9.995e-02	5.619e-01
0.4	2.024e+09	1.896e+02	9.178e+02	3.694e-01	1.788e+00
0.5	6.443e+08	9.227e+01	3.973e+02	1.811e-01	7.798e-01
0.6	4.907e+13	9.891e+06	3.865e+07	1.931e+04	7.543e+04
0.8	4.521e+10	1.560e+04	5.267e+04	2.966e+01	1.002e+02
1.0	4.416e+10	2.310e+04	7.009e+04	4.258e+01	1.292e+02
1.5	5.330e+10	5.910e+04	1.500e+05	9.944e+01	2.524e+02
2.0	2.244e+06	4.167e+00	9.530e+00	6.444e-03	1.474e-02
3.0	2.378e+02	8.823e-04	1.771e-03	1.197e-06	2.403e-06
TOTALS:	5.406e+13	9.990e+06	3.892e+07	1.948e+04	7.592e+04

Results - Dose Point # 2 - (86.433,140,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	6.055e+11	4.289e-187	6.501e-22	3.679e-188	5.576e-23
0.02	2.773e+10	5.720e-85	4.685e-23	1.981e-86	1.623e-24
0.03	3.311e+12	7.345e-25	1.237e-20	7.280e-27	1.226e-22
0.04	8.153e+11	4.818e-10	1.761e-09	2.131e-12	7.788e-12
0.05	7.209e+09	3.210e-06	1.846e-05	8.550e-09	4.916e-08
0.06	2.165e+10	5.587e-03	4.318e-02	1.110e-05	8.577e-05
0.08	2.857e+09	1.884e-01	1.766e+00	2.981e-04	2.795e-03
0.1	5.043e+10	3.235e+01	3.035e+02	4.950e-02	4.644e-01
0.15	1.612e+08	8.912e-01	7.003e+00	1.468e-03	1.153e-02
0.2	8.336e+09	1.094e+02	7.423e+02	1.931e-01	1.310e+00
0.3	9.935e+08	3.223e+01	1.774e+02	6.113e-02	3.364e-01
0.4	2.024e+09	1.153e+02	5.459e+02	2.246e-01	1.064e+00
0.5	6.443e+08	5.585e+01	2.353e+02	1.096e-01	4.619e-01
0.6	4.907e+13	5.967e+06	2.282e+07	1.165e+04	4.454e+04
0.8	4.521e+10	9.355e+03	3.095e+04	1.779e+01	5.887e+01
1.0	4.416e+10	1.379e+04	4.105e+04	2.543e+01	7.567e+01
1.5	5.330e+10	3.500e+04	8.735e+04	5.889e+01	1.470e+02
2.0	2.244e+06	2.455e+00	5.528e+00	3.796e-03	8.548e-03
3.0	2.378e+02	5.166e-04	1.023e-03	7.009e-07	1.388e-06
TOTALS:	5.406e+13	6.025e+06	2.298e+07	1.175e+04	4.482e+04

Results - Dose Point # 3 - (155.953,140,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	6.055e+11	1.388e-187	2.447e-22	1.191e-188	2.099e-23
0.02	2.773e+10	2.833e-85	1.764e-23	9.815e-87	6.109e-25
0.03	3.311e+12	4.008e-25	4.656e-21	3.973e-27	4.614e-23
0.04	8.153e+11	2.595e-10	9.489e-10	1.148e-12	4.197e-12
0.05	7.209e+09	1.736e-06	9.983e-06	4.624e-09	2.659e-08
0.06	2.165e+10	3.011e-03	2.328e-02	5.980e-06	4.624e-05
0.08	2.857e+09	1.005e-01	9.404e-01	1.590e-04	1.488e-03
0.1	5.043e+10	1.698e+01	1.578e+02	2.597e-02	2.414e-01
0.15	1.612e+08	4.506e-01	3.442e+00	7.421e-04	5.669e-03
0.2	8.336e+09	5.418e+01	3.543e+02	9.563e-02	6.252e-01
0.3	9.935e+08	1.564e+01	8.253e+01	2.967e-02	1.565e-01
0.4	2.024e+09	5.531e+01	2.509e+02	1.078e-01	4.889e-01
0.5	6.443e+08	2.658e+01	1.073e+02	5.217e-02	2.107e-01
0.6	4.907e+13	2.821e+06	1.035e+07	5.505e+03	2.019e+04
0.8	4.521e+10	4.375e+03	1.391e+04	8.321e+00	2.646e+01
1.0	4.416e+10	6.395e+03	1.832e+04	1.179e+01	3.378e+01
1.5	5.330e+10	1.597e+04	3.851e+04	2.687e+01	6.479e+01
2.0	2.244e+06	1.108e+00	2.417e+00	1.714e-03	3.737e-03
3.0	2.378e+02	2.301e-04	4.427e-04	3.121e-07	6.007e-07
TOTALS:	5.406e+13	2.847e+06	1.042e+07	5.553e+03	2.032e+04

Results - Dose Point # 4 - (65.953,140,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	6.055e+11	7.391e-188	1.015e-21	6.340e-189	8.704e-23
0.02	2.773e+10	7.752e-85	7.314e-23	2.685e-86	2.533e-24
0.03	3.311e+12	1.331e-24	1.931e-20	1.319e-26	1.913e-22

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.04	8.153e+11	6.346e-10	2.314e-09	2.807e-12	1.023e-11
0.05	7.209e+09	4.124e-06	2.376e-05	1.099e-08	6.329e-08
0.06	2.165e+10	7.390e-03	5.731e-02	1.468e-05	1.138e-04
0.08	2.857e+09	2.537e-01	2.384e+00	4.015e-04	3.772e-03
0.1	5.043e+10	4.391e+01	4.134e+02	6.718e-02	6.324e-01
0.15	1.612e+08	1.223e+00	9.668e+00	2.014e-03	1.592e-02
0.2	8.336e+09	1.508e+02	1.032e+03	2.662e-01	1.821e+00
0.3	9.935e+08	4.465e+01	2.482e+02	8.470e-02	4.708e-01
0.4	2.024e+09	1.601e+02	7.664e+02	3.120e-01	1.493e+00
0.5	6.443e+08	7.776e+01	3.310e+02	1.526e-01	6.498e-01
0.6	4.907e+13	8.321e+06	3.216e+07	1.624e+04	6.277e+04
0.8	4.521e+10	1.308e+04	4.374e+04	2.488e+01	8.320e+01
1.0	4.416e+10	1.933e+04	5.814e+04	3.564e+01	1.072e+02
1.5	5.330e+10	4.928e+04	1.242e+05	8.292e+01	2.090e+02
2.0	2.244e+06	3.467e+00	7.884e+00	5.362e-03	1.219e-02
3.0	2.378e+02	7.326e-04	1.464e-03	9.939e-07	1.987e-06
TOTALS:	5.406e+13	8.403e+06	3.239e+07	1.639e+04	6.318e+04

Results - Dose Point # 5 - (75.953,140,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	6.055e+11	4.815e-187	8.011e-22	4.130e-188	6.871e-23
0.02	2.773e+10	8.822e-85	5.774e-23	3.056e-86	2.000e-24
0.03	3.311e+12	7.990e-25	1.524e-20	7.918e-27	1.511e-22
0.04	8.153e+11	5.472e-10	2.002e-09	2.420e-12	8.855e-12
0.05	7.209e+09	3.691e-06	2.121e-05	9.833e-09	5.651e-08
0.06	2.165e+10	6.407e-03	4.952e-02	1.273e-05	9.836e-05
0.08	2.857e+09	2.167e-01	2.033e+00	3.430e-04	3.218e-03
0.1	5.043e+10	3.733e+01	3.507e+02	5.711e-02	5.365e-01
0.15	1.612e+08	1.032e+00	8.129e+00	1.700e-03	1.339e-02
0.2	8.336e+09	1.270e+02	8.641e+02	2.241e-01	1.525e+00
0.3	9.935e+08	3.747e+01	2.071e+02	7.108e-02	3.929e-01
0.4	2.024e+09	1.342e+02	6.387e+02	2.614e-01	1.245e+00
0.5	6.443e+08	6.509e+01	2.756e+02	1.278e-01	5.411e-01
0.6	4.907e+13	6.959e+06	2.676e+07	1.358e+04	5.223e+04
0.8	4.521e+10	1.093e+04	3.635e+04	2.078e+01	6.914e+01
1.0	4.416e+10	1.613e+04	4.827e+04	2.973e+01	8.897e+01
1.5	5.330e+10	4.103e+04	1.029e+05	6.902e+01	1.732e+02
2.0	2.244e+06	2.882e+00	6.525e+00	4.457e-03	1.009e-02
3.0	2.378e+02	6.079e-04	1.210e-03	8.247e-07	1.641e-06
TOTALS:	5.406e+13	7.027e+06	2.695e+07	1.370e+04	5.256e+04

Results - Dose Point # 6 - (120.953,140,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	6.055e+11	1.934e-187	3.766e-22	1.659e-188	3.230e-23
0.02	2.773e+10	3.697e-85	2.714e-23	1.281e-86	9.402e-25
0.03	3.311e+12	5.262e-25	7.165e-21	5.215e-27	7.101e-23
0.04	8.153e+11	3.384e-10	1.237e-09	1.496e-12	5.472e-12
0.05	7.209e+09	2.263e-06	1.301e-05	6.027e-09	3.466e-08
0.06	2.165e+10	3.927e-03	3.036e-02	7.801e-06	6.030e-05

Page : 5
 DOS File : Combined Calcine in Mixer.ms6
 Run Date: April 5, 2005
 Run Time: 1:24:23 PM
 Duration : 00:01:03

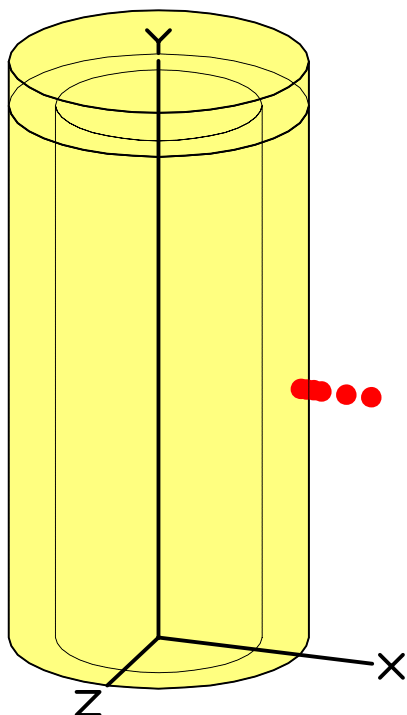
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.08	2.857e+09	1.318e-01	1.235e+00	2.086e-04	1.955e-03
0.1	5.043e+10	2.253e+01	2.109e+02	3.446e-02	3.227e-01
0.15	1.612e+08	6.130e-01	4.768e+00	1.009e-03	7.852e-03
0.2	8.336e+09	7.464e+01	4.987e+02	1.317e-01	8.802e-01
0.3	9.935e+08	2.180e+01	1.176e+02	4.135e-02	2.231e-01
0.4	2.024e+09	7.755e+01	3.596e+02	1.511e-01	7.006e-01
0.5	6.443e+08	3.743e+01	1.543e+02	7.347e-02	3.028e-01
0.6	4.907e+13	3.985e+06	1.491e+07	7.778e+03	2.910e+04
0.8	4.521e+10	6.213e+03	2.011e+04	1.182e+01	3.826e+01
1.0	4.416e+10	9.118e+03	2.657e+04	1.681e+01	4.897e+01
1.5	5.330e+10	2.293e+04	5.610e+04	3.858e+01	9.438e+01
2.0	2.244e+06	1.598e+00	3.532e+00	2.471e-03	5.461e-03
3.0	2.378e+02	3.336e-04	6.494e-04	4.526e-07	8.811e-07
TOTALS:	5.406e+13	4.023e+06	1.501e+07	7.846e+03	2.928e+04

MicroShield v6.10 (0028)
INEEL

Page : 1
 DOS File : Combined Calcine in Bulk Vault.ms6
 Run Date : May 3, 2005
 Run Time : 2:56:35 PM
 Duration : 00:01:09

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

Case Title: Combined Calcine
Description: Combined Calcine in Bulk Retrieval Vault (2 ft Concrete)
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	740.0 cm	24 ft 3.3 in
Radius	135.0 cm	4 ft 5.1 in

Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	198.5 cm 6 ft 6.1 in	370 cm 12 ft 1.7 in	0 cm 0.0 in
# 2	226.44 cm 7 ft 5.1 in	370 cm 12 ft 1.7 in	0 cm 0.0 in
# 3	295.96 cm 9 ft 8.5 in	370 cm 12 ft 1.7 in	0 cm 0.0 in
# 4	205.96 cm 6 ft 9.1 in	370 cm 12 ft 1.7 in	0 cm 0.0 in
# 5	215.96 cm 7 ft 1.0 in	370 cm 12 ft 1.7 in	0 cm 0.0 in
# 6	260.96 cm 8 ft 6.7 in	370 cm 12 ft 1.7 in	0 cm 0.0 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	4.24e+07 cm ³	Combined Calcine	1.27
Transition		Air	0.00122
Air Gap		Air	0.00122
Wall Clad	60.96 cm	Concrete	2.4
Top Clad	60.96 cm	Concrete	2.4

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included

Library : ICRP-38

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm³</u>	<u>Bq/cm³</u>
Am-241	8.5162e+001	3.1510e+012	2.0100e+000	7.4370e+004
Am-243	5.5927e-002	2.0693e+009	1.3200e-003	4.8840e+001
Ba-137m	7.7112e+004	2.8531e+015	1.8200e+003	6.7340e+007
Ce-144	1.3262e-007	4.9068e+003	3.1300e-009	1.1581e-004
Cm-242	1.4109e-001	5.2203e+009	3.3300e-003	1.2321e+002
Co-60	9.3212e+000	3.4488e+011	2.2000e-001	8.1400e+003
Cs-134	5.0419e-001	1.8655e+010	1.1900e-002	4.4030e+002
Cs-135	1.4321e+000	5.2987e+010	3.3800e-002	1.2506e+003
Cs-137	8.1349e+004	3.0099e+015	1.9200e+003	7.1040e+007
Eu-152	2.5549e+000	9.4530e+010	6.0300e-002	2.2311e+003
Eu-154	1.6693e+002	6.1766e+012	3.9400e+000	1.4578e+005
Eu-155	1.2372e+001	4.5776e+011	2.9200e-001	1.0804e+004
I-129	7.3722e-003	2.7277e+008	1.7400e-004	6.4380e+000
Ni-63	4.0632e+003	1.5034e+014	9.5900e+001	3.5483e+006
Np-237	7.0333e-001	2.6023e+010	1.6600e-002	6.1420e+002
Pa-233	7.0333e-001	2.6023e+010	1.6600e-002	6.1420e+002
Pm-147	2.8896e+000	1.0691e+011	6.8200e-002	2.5234e+003
Pr-144	1.3262e-007	4.9068e+003	3.1300e-009	1.1581e-004

Nuclide	curies	becquerels	μCi/cm ³	Bq/cm ³
Pu-238	9.6178e+002	3.5586e+013	2.2700e+001	8.3990e+005
Pu-239	2.1990e+001	8.1361e+011	5.1900e-001	1.9203e+004
Pu-240	1.3050e+001	4.8284e+011	3.0800e-001	1.1396e+004
Pu-241	3.6395e+002	1.3466e+013	8.5900e+000	3.1783e+005
Pu-242	1.7668e+000	6.5371e+010	4.1700e-002	1.5429e+003
Ru-106	4.7030e-006	1.7401e+005	1.1100e-007	4.1070e-003
Sb-125	1.3177e+000	4.8754e+010	3.1100e-002	1.1507e+003
Sb-126	1.2965e-001	4.7970e+009	3.0600e-003	1.1322e+002
Sb-126m	9.2788e-001	3.4332e+010	2.1900e-002	8.1030e+002
Sm-151	8.3467e+002	3.0883e+013	1.9700e+001	7.2890e+005
Sr-90	7.2451e+004	2.6807e+015	1.7100e+003	6.3270e+007
Tc-99	3.4488e+001	1.2761e+012	8.1400e-001	3.0118e+004
Th-230	3.6014e-003	1.3325e+008	8.5000e-005	3.1450e+000
Th-231	3.4785e-003	1.2870e+008	8.2100e-005	3.0377e+000
U-232	2.5167e-003	9.3119e+007	5.9400e-005	2.1978e+000
U-233	1.6693e-004	6.1766e+006	3.9400e-006	1.4578e-001
U-234	6.6519e-001	2.4612e+010	1.5700e-002	5.8090e+002
U-235	3.4192e-003	1.2651e+008	8.0700e-005	2.9859e+000
U-236	1.0465e-002	3.8721e+008	2.4700e-004	9.1390e+000
U-237	9.0670e-003	3.3548e+008	2.1400e-004	7.9180e+000
U-238	1.2795e-003	4.7343e+007	3.0200e-005	1.1174e+000
Y-90	7.2451e+004	2.6807e+015	1.7100e+003	6.3270e+007

Buildup
 The material reference is : Source

Integration Parameters

Radial	24
Circumferential	24
Y Direction (axial)	24

Results - Dose Point # 1 - (198.5,370,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	3.162e+13	0.000e+00	5.544e-21	0.000e+00	4.755e-22
0.02	1.449e+12	4.352e-228	3.224e-22	1.507e-229	1.117e-23
0.03	1.729e+14	2.868e-72	7.389e-20	2.842e-74	7.323e-22
0.04	4.257e+13	2.677e-35	2.790e-20	1.184e-37	1.234e-22
0.05	3.767e+11	8.139e-24	4.355e-22	2.168e-26	1.160e-24
0.06	1.132e+12	3.486e-17	1.034e-16	6.925e-20	2.054e-19
0.08	1.488e+11	9.092e-13	5.313e-12	1.439e-15	8.408e-15
0.1	2.636e+12	2.993e-09	3.141e-08	4.578e-12	4.805e-11
0.15	8.425e+09	2.861e-09	7.849e-08	4.712e-12	1.293e-10
0.2	4.358e+11	2.577e-06	1.282e-04	4.548e-09	2.262e-07
0.3	5.185e+10	9.337e-06	5.889e-04	1.771e-08	1.117e-06
0.4	1.057e+11	1.753e-04	1.016e-02	3.416e-07	1.980e-05
0.5	3.368e+10	2.898e-04	1.405e-02	5.689e-07	2.758e-05
0.6	2.562e+15	8.082e+01	3.206e+03	1.578e-01	6.258e+00
0.8	2.363e+12	5.382e-01	1.506e+01	1.024e-03	2.865e-02
1.0	2.308e+12	2.288e+00	4.789e+01	4.217e-03	8.828e-02
1.5	2.786e+12	3.382e+01	4.228e+02	5.691e-02	7.114e-01
2.0	1.173e+08	6.987e-03	6.433e-02	1.080e-05	9.948e-05
3.0	1.242e+04	5.195e-06	3.246e-05	7.048e-09	4.403e-08
TOTALS:	2.823e+15	1.175e+02	3.692e+03	2.199e-01	7.086e+00

Results - Dose Point # 2 - (226.44,370,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	3.162e+13	0.000e+00	4.504e-21	0.000e+00	3.863e-22
0.02	1.449e+12	3.517e-228	2.620e-22	1.218e-229	9.074e-24
0.03	1.729e+14	2.113e-72	6.003e-20	2.094e-74	5.949e-22
0.04	4.257e+13	2.399e-35	2.267e-20	1.061e-37	1.002e-22
0.05	3.767e+11	7.350e-24	3.553e-22	1.958e-26	9.464e-25
0.06	1.132e+12	3.082e-17	9.139e-17	6.122e-20	1.815e-19
0.08	1.488e+11	7.903e-13	4.616e-12	1.251e-15	7.305e-15
0.1	2.636e+12	2.593e-09	2.721e-08	3.968e-12	4.164e-11
0.15	8.425e+09	2.480e-09	6.806e-08	4.084e-12	1.121e-10
0.2	4.358e+11	2.236e-06	1.112e-04	3.946e-09	1.963e-07
0.3	5.185e+10	8.109e-06	5.118e-04	1.538e-08	9.708e-07
0.4	1.057e+11	1.523e-04	8.832e-03	2.968e-07	1.721e-05
0.5	3.368e+10	2.519e-04	1.222e-02	4.945e-07	2.398e-05
0.6	2.562e+15	7.026e+01	2.787e+03	1.371e-01	5.440e+00
0.8	2.363e+12	4.678e-01	1.309e+01	8.898e-04	2.490e-02
1.0	2.308e+12	1.988e+00	4.160e+01	3.665e-03	7.669e-02
1.5	2.786e+12	2.938e+01	3.670e+02	4.942e-02	6.175e-01
2.0	1.173e+08	6.064e-03	5.580e-02	9.378e-06	8.629e-05
3.0	1.242e+04	4.505e-06	2.812e-05	6.111e-09	3.816e-08
TOTALS:	2.823e+15	1.021e+02	3.209e+03	1.911e-01	6.159e+00

Results - Dose Point # 3 - (295.96,370,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	3.162e+13	0.000e+00	2.938e-21	0.000e+00	2.520e-22
0.02	1.449e+12	1.789e-228	1.709e-22	6.196e-230	5.920e-24
0.03	1.729e+14	1.675e-72	3.916e-20	1.660e-74	3.881e-22
0.04	4.257e+13	1.830e-35	1.479e-20	8.095e-38	6.540e-23
0.05	3.767e+11	5.475e-24	2.331e-22	1.458e-26	6.209e-25
0.06	1.132e+12	2.304e-17	6.832e-17	4.576e-20	1.357e-19
0.08	1.488e+11	5.940e-13	3.471e-12	9.399e-16	5.492e-15
0.1	2.636e+12	1.952e-09	2.049e-08	2.986e-12	3.134e-11
0.15	8.425e+09	1.868e-09	5.127e-08	3.076e-12	8.443e-11
0.2	4.358e+11	1.684e-06	8.385e-05	2.973e-09	1.480e-07
0.3	5.185e+10	6.113e-06	3.860e-04	1.160e-08	7.321e-07
0.4	1.057e+11	1.149e-04	6.662e-03	2.239e-07	1.298e-05
0.5	3.368e+10	1.900e-04	9.217e-03	3.730e-07	1.809e-05
0.6	2.562e+15	5.300e+01	2.103e+03	1.034e-01	4.104e+00
0.8	2.363e+12	3.529e-01	9.875e+00	6.713e-04	1.878e-02
1.0	2.308e+12	1.500e+00	3.138e+01	2.765e-03	5.785e-02
1.5	2.786e+12	2.215e+01	2.767e+02	3.727e-02	4.655e-01
2.0	1.173e+08	4.572e-03	4.205e-02	7.069e-06	6.502e-05
3.0	1.242e+04	3.393e-06	2.117e-05	4.604e-09	2.872e-08
TOTALS:	2.823e+15	7.701e+01	2.421e+03	1.442e-01	4.646e+00

Results - Dose Point # 4 - (205.96,370,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	3.162e+13	0.000e+00	5.230e-21	0.000e+00	4.486e-22
0.02	1.449e+12	4.250e-228	3.042e-22	1.472e-229	1.054e-23

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.03	1.729e+14	2.576e-72	6.970e-20	2.553e-74	6.908e-22
0.04	4.257e+13	2.565e-35	2.632e-20	1.134e-37	1.164e-22
0.05	3.767e+11	7.945e-24	4.114e-22	2.117e-26	1.096e-24
0.06	1.132e+12	3.390e-17	1.005e-16	6.734e-20	1.997e-19
0.08	1.488e+11	8.770e-13	5.123e-12	1.388e-15	8.107e-15
0.1	2.636e+12	2.878e-09	3.020e-08	4.403e-12	4.620e-11
0.15	8.425e+09	2.748e-09	7.538e-08	4.525e-12	1.241e-10
0.2	4.358e+11	2.475e-06	1.231e-04	4.368e-09	2.172e-07
0.3	5.185e+10	8.969e-06	5.659e-04	1.701e-08	1.073e-06
0.4	1.057e+11	1.685e-04	9.765e-03	3.282e-07	1.903e-05
0.5	3.368e+10	2.785e-04	1.351e-02	5.467e-07	2.652e-05
0.6	2.562e+15	7.768e+01	3.082e+03	1.516e-01	6.016e+00
0.8	2.363e+12	5.174e-01	1.448e+01	9.840e-04	2.754e-02
1.0	2.308e+12	2.199e+00	4.603e+01	4.054e-03	8.485e-02
1.5	2.786e+12	3.251e+01	4.063e+02	5.469e-02	6.835e-01
2.0	1.173e+08	6.714e-03	6.180e-02	1.038e-05	9.557e-05
3.0	1.242e+04	4.990e-06	3.117e-05	6.770e-09	4.229e-08
TOTALS:	2.823e+15	1.129e+02	3.549e+03	2.114e-01	6.812e+00

Results - Dose Point # 5 - (215.96,370,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	3.162e+13	0.000e+00	4.853e-21	0.000e+00	4.163e-22
0.02	1.449e+12	3.927e-228	2.823e-22	1.360e-229	9.777e-24
0.03	1.729e+14	2.297e-72	6.468e-20	2.277e-74	6.410e-22
0.04	4.257e+13	2.474e-35	2.442e-20	1.094e-37	1.080e-22
0.05	3.767e+11	7.675e-24	3.823e-22	2.045e-26	1.018e-24
0.06	1.132e+12	3.243e-17	9.617e-17	6.442e-20	1.910e-19
0.08	1.488e+11	8.330e-13	4.866e-12	1.318e-15	7.700e-15
0.1	2.636e+12	2.731e-09	2.866e-08	4.179e-12	4.384e-11
0.15	8.425e+09	2.609e-09	7.158e-08	4.297e-12	1.179e-10
0.2	4.358e+11	2.351e-06	1.170e-04	4.150e-09	2.064e-07
0.3	5.185e+10	8.526e-06	5.381e-04	1.617e-08	1.021e-06
0.4	1.057e+11	1.602e-04	9.286e-03	3.121e-07	1.809e-05
0.5	3.368e+10	2.649e-04	1.284e-02	5.199e-07	2.521e-05
0.6	2.562e+15	7.387e+01	2.931e+03	1.442e-01	5.720e+00
0.8	2.363e+12	4.919e-01	1.376e+01	9.357e-04	2.618e-02
1.0	2.308e+12	2.091e+00	4.376e+01	3.854e-03	8.066e-02
1.5	2.786e+12	3.090e+01	3.861e+02	5.198e-02	6.496e-01
2.0	1.173e+08	6.380e-03	5.871e-02	9.866e-06	9.079e-05
3.0	1.242e+04	4.740e-06	2.960e-05	6.431e-09	4.016e-08
TOTALS:	2.823e+15	1.074e+02	3.374e+03	2.010e-01	6.477e+00

Results - Dose Point # 6 - (260.96,370,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	3.162e+13	0.000e+00	3.598e-21	0.000e+00	3.086e-22
0.02	1.449e+12	2.385e-228	2.092e-22	8.263e-230	7.248e-24
0.03	1.729e+14	1.856e-72	4.795e-20	1.839e-74	4.752e-22
0.04	4.257e+13	2.112e-35	1.810e-20	9.341e-38	8.007e-23

Page : 5
 DOS File : Combined Calcine in Bulk Vault.ms6
 Run Date: May 3, 2005
 Run Time: 2:56:35 PM
 Duration : 00:01:09

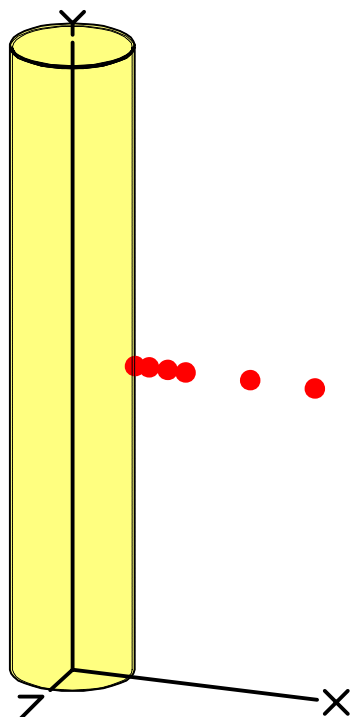
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.05	3.767e+11	6.282e-24	2.846e-22	1.673e-26	7.582e-25
0.06	1.132e+12	2.634e-17	7.811e-17	5.232e-20	1.551e-19
0.08	1.488e+11	6.789e-13	3.967e-12	1.074e-15	6.277e-15
0.1	2.636e+12	2.231e-09	2.342e-08	3.413e-12	3.583e-11
0.15	8.425e+09	2.135e-09	5.859e-08	3.515e-12	9.648e-11
0.2	4.358e+11	1.924e-06	9.577e-05	3.397e-09	1.690e-07
0.3	5.185e+10	6.982e-06	4.406e-04	1.324e-08	8.359e-07
0.4	1.057e+11	1.312e-04	7.605e-03	2.556e-07	1.482e-05
0.5	3.368e+10	2.169e-04	1.052e-02	4.258e-07	2.065e-05
0.6	2.562e+15	6.049e+01	2.400e+03	1.181e-01	4.684e+00
0.8	2.363e+12	4.028e-01	1.127e+01	7.661e-04	2.143e-02
1.0	2.308e+12	1.712e+00	3.581e+01	3.155e-03	6.601e-02
1.5	2.786e+12	2.528e+01	3.158e+02	4.253e-02	5.313e-01
2.0	1.173e+08	5.217e-03	4.799e-02	8.068e-06	7.421e-05
3.0	1.242e+04	3.873e-06	2.417e-05	5.255e-09	3.280e-08
TOTALS:	2.823e+15	8.789e+01	2.763e+03	1.645e-01	5.303e+00

MicroShield v6.10 (0028)
INEEL

Page : 1
 DOS File : CSSF 1 Calcine in Grout.ms6
 Run Date : April 5, 2005
 Run Time : 3:08:15 PM
 Duration : 00:01:02

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

Case Title: CSSF 1 Calcine Grout
Description: CSSF 1 Calcine Grouted at 21.5 wt% in Storage Canister
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions			
Height	337.86 cm	11 ft 1.0 in	
Radius	30.48 cm	1 ft	

Dose Points			
	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	34.29 cm 1 ft 1.5 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 2	61.75 cm 2 ft 0.3 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 3	131.75 cm 4 ft 3.9 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 4	41.75 cm 1 ft 4.4 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 5	51.75 cm 1 ft 8.4 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 6	96.75 cm 3 ft 2.1 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in

Shields			
<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	9.86e+05 cm ³	Concrete	1.8
Transition		Air	0.00122
Air Gap		Air	0.00122
Wall Clad	1.27 cm	Iron	7.95
Top Clad	1.27 cm	Iron	7.95

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included

Library : ICRP-38

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm³</u>	<u>Bq/cm³</u>
Am-241	1.4890e-001	5.5093e+009	1.5100e-001	5.5870e+003
Am-243	1.8144e-005	6.7133e+005	1.8400e-005	6.8080e-001
Ba-137m	1.6073e+003	5.9471e+013	1.6300e+003	6.0310e+007
Ce-144	7.8000e-017	2.8860e-006	7.9100e-017	2.9267e-012
Cm-242	1.5087e-005	5.5823e+005	1.5300e-005	5.6610e-001
Cm-244	2.8399e-005	1.0508e+006	2.8800e-005	1.0656e+000
Co-60	7.9873e-004	2.9553e+007	8.1000e-004	2.9970e+001
Cs-134	1.0650e-005	3.9404e+005	1.0800e-005	3.9960e-001
Cs-135	2.2483e-002	8.3187e+008	2.2800e-002	8.4360e+002
Cs-137	1.6961e+003	6.2755e+013	1.7200e+003	6.3640e+007
Eu-152	1.4594e-002	5.3998e+008	1.4800e-002	5.4760e+002
Eu-154	9.0326e-001	3.3421e+010	9.1600e-001	3.3892e+004
Eu-155	4.7135e-002	1.7440e+009	4.7800e-002	1.7686e+003
I-129	1.8736e-004	6.9322e+006	1.9000e-004	7.0300e+000
Ni-63				
Np-237	2.2779e-003	8.4281e+007	2.3100e-003	8.5470e+001
Pa-233	2.2779e-003	8.4281e+007	2.3100e-003	8.5470e+001
Pm-147	6.2124e-003	2.2986e+008	6.3000e-003	2.3310e+002
Pr-144	7.8000e-017	2.8860e-006	7.9100e-017	2.9267e-012

Nuclide	curies	becquerels	μCi/cm ³	Bq/cm ³
Pu-238	6.6068e-001	2.4445e+010	6.7000e-001	2.4790e+004
Pu-239	8.9241e-002	3.3019e+009	9.0500e-002	3.3485e+003
Pu-240	3.5696e-002	1.3208e+009	3.6200e-002	1.3394e+003
Pu-241	2.4849e-001	9.1943e+009	2.5200e-001	9.3240e+003
Pu-242	2.0609e-005	7.6254e+005	2.0900e-005	7.7330e-001
Ru-106	3.9641e-013	1.4667e-002	4.0200e-013	1.4874e-008
Sb-125	2.5441e-004	9.4132e+006	2.5800e-004	9.5460e+000
Sb-126	3.2147e-003	1.1894e+008	3.2600e-003	1.2062e+002
Sb-126m	2.2976e-002	8.5011e+008	2.3300e-002	8.6210e+002
Sm-151	3.4415e+001	1.2733e+012	3.4900e+001	1.2913e+006
Sr-90	1.4496e+003	5.3633e+013	1.4700e+003	5.4390e+007
Tc-99	8.8847e-001	3.2873e+010	9.0100e-001	3.3337e+004
Th-230	2.3962e-004	8.8659e+006	2.4300e-004	8.9910e+000
Th-231	4.9798e-005	1.8425e+006	5.0500e-005	1.8685e+000
U-232	1.6961e-007	6.2755e+003	1.7200e-007	6.3640e-003
U-233	3.2738e-007	1.2113e+004	3.3200e-007	1.2284e-002
U-234	7.1689e-003	2.6525e+008	7.2700e-003	2.6899e+002
U-235	4.9798e-005	1.8425e+006	5.0500e-005	1.8685e+000
U-236	1.1537e-004	4.2688e+006	1.1700e-004	4.3290e+000
U-237	8.1352e-006	3.0100e+005	8.2500e-006	3.0525e-001
U-238	2.8104e-006	1.0398e+005	2.8500e-006	1.0545e-001
Y-90	1.4496e+003	5.3633e+013	1.4700e+003	5.4390e+007

Buildup
 The material reference is : Source

Integration Parameters

Radial	24
Circumferential	24
Y Direction (axial)	24

Results - Dose Point # 1 - (34.29,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	6.813e+09	8.522e-268	2.201e-23	7.310e-269	1.888e-24
0.02	3.243e+09	1.054e-119	1.648e-23	3.652e-121	5.710e-25
0.03	3.601e+12	2.677e-34	4.048e-20	2.653e-36	4.012e-22
0.04	8.637e+11	1.341e-13	5.362e-13	5.931e-16	2.371e-15
0.05	1.999e+09	2.495e-08	1.677e-07	6.646e-11	4.466e-10
0.06	1.992e+09	1.035e-04	9.669e-04	2.056e-07	1.921e-06
0.08	5.589e+08	3.265e-02	3.690e-01	5.167e-05	5.839e-04
0.1	1.408e+10	1.333e+01	1.506e+02	2.039e-02	2.304e-01
0.15	4.191e+07	5.177e-01	4.883e+00	8.525e-04	8.042e-03
0.2	2.343e+09	7.812e+01	6.309e+02	1.379e-01	1.114e+00
0.3	2.670e+08	2.428e+01	1.562e+02	4.606e-02	2.963e-01
0.4	1.143e+09	1.910e+02	1.042e+03	3.723e-01	2.030e+00
0.5	1.547e+08	4.061e+01	1.944e+02	7.971e-02	3.816e-01
0.6	5.339e+13	2.011e+07	8.645e+07	3.925e+04	1.687e+05
0.8	1.277e+10	8.455e+03	3.089e+04	1.608e+01	5.875e+01
1.0	1.070e+10	1.095e+04	3.547e+04	2.018e+01	6.538e+01
1.5	1.325e+10	2.953e+04	7.823e+04	4.969e+01	1.316e+02
2.0	6.170e+05	2.333e+00	5.484e+00	3.607e-03	8.481e-03
3.0	1.064e+00	8.088e-06	1.641e-05	1.097e-08	2.226e-08
TOTALS:	5.793e+13	2.016e+07	8.659e+07	3.934e+04	1.690e+05

Results - Dose Point # 2 - (61.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	6.813e+09	1.719e-250	9.658e-24	1.475e-251	8.284e-25
0.02	3.243e+09	2.941e-113	7.234e-24	1.019e-114	2.506e-25
0.03	3.601e+12	2.647e-33	1.777e-20	2.623e-35	1.761e-22
0.04	8.637e+11	1.280e-13	5.073e-13	5.660e-16	2.244e-15
0.05	1.999e+09	1.367e-08	9.059e-08	3.642e-11	2.413e-10
0.06	1.992e+09	4.934e-05	4.579e-04	9.801e-08	9.096e-07
0.08	5.589e+08	1.568e-02	1.803e-01	2.481e-05	2.853e-04
0.1	1.408e+10	6.644e+00	7.664e+01	1.017e-02	1.173e-01
0.15	4.191e+07	2.630e-01	2.487e+00	4.331e-04	4.095e-03
0.2	2.343e+09	3.960e+01	3.177e+02	6.990e-02	5.607e-01
0.3	2.670e+08	1.225e+01	7.788e+01	2.323e-02	1.477e-01
0.4	1.143e+09	9.603e+01	5.173e+02	1.871e-01	1.008e+00
0.5	1.547e+08	2.036e+01	9.625e+01	3.996e-02	1.889e-01
0.6	5.339e+13	1.006e+07	4.272e+07	1.963e+04	8.339e+04
0.8	1.277e+10	4.215e+03	1.523e+04	8.017e+00	2.896e+01
1.0	1.070e+10	5.443e+03	1.745e+04	1.003e+01	3.217e+01
1.5	1.325e+10	1.462e+04	3.839e+04	2.459e+01	6.458e+01
2.0	6.170e+05	1.151e+00	2.687e+00	1.781e-03	4.156e-03
3.0	1.064e+00	3.983e-06	8.032e-06	5.403e-09	1.090e-08
TOTALS:	5.793e+13	1.008e+07	4.279e+07	1.968e+04	8.351e+04

Results - Dose Point # 3 - (131.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	6.813e+09	4.951e-251	3.269e-24	4.247e-252	2.804e-25
0.02	3.243e+09	1.136e-113	2.448e-24	3.937e-115	8.480e-26
0.03	3.601e+12	1.238e-33	6.013e-21	1.227e-35	5.959e-23
0.04	8.637e+11	5.881e-14	2.331e-13	2.601e-16	1.031e-15
0.05	1.999e+09	6.256e-09	4.148e-08	1.666e-11	1.105e-10
0.06	1.992e+09	2.262e-05	2.100e-04	4.492e-08	4.172e-07
0.08	5.589e+08	7.165e-03	8.242e-02	1.134e-05	1.304e-04
0.1	1.408e+10	3.022e+00	3.483e+01	4.623e-03	5.328e-02
0.15	4.191e+07	1.179e-01	1.104e+00	1.942e-04	1.818e-03
0.2	2.343e+09	1.758e+01	1.387e+02	3.103e-02	2.447e-01
0.3	2.670e+08	5.376e+00	3.340e+01	1.020e-02	6.336e-02
0.4	1.143e+09	4.187e+01	2.198e+02	8.158e-02	4.283e-01
0.5	1.547e+08	8.829e+00	4.064e+01	1.733e-02	7.977e-02
0.6	5.339e+13	4.344e+06	1.795e+07	8.478e+03	3.503e+04
0.8	1.277e+10	1.807e+03	6.346e+03	3.436e+00	1.207e+01
1.0	1.070e+10	2.318e+03	7.228e+03	4.273e+00	1.332e+01
1.5	1.325e+10	6.148e+03	1.571e+04	1.034e+01	2.643e+01
2.0	6.170e+05	4.801e-01	1.091e+00	7.424e-04	1.687e-03
3.0	1.064e+00	1.641e-06	3.225e-06	2.226e-09	4.376e-09
TOTALS:	5.793e+13	4.354e+06	1.798e+07	8.496e+03	3.508e+04

Results - Dose Point # 4 - (41.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	6.813e+09	7.060e-252	1.641e-23	6.056e-253	1.407e-24
0.02	3.243e+09	1.948e-113	1.229e-23	6.747e-115	4.257e-25
0.03	3.601e+12	4.671e-33	3.018e-20	4.630e-35	2.991e-22

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.04	8.637e+11	2.229e-13	8.826e-13	9.858e-16	3.903e-15
0.05	1.999e+09	2.094e-08	1.381e-07	5.578e-11	3.678e-10
0.06	1.992e+09	7.246e-05	6.718e-04	1.439e-07	1.334e-06
0.08	5.589e+08	2.351e-02	2.715e-01	3.720e-05	4.296e-04
0.1	1.408e+10	1.009e+01	1.168e+02	1.543e-02	1.787e-01
0.15	4.191e+07	4.036e-01	3.833e+00	6.646e-04	6.312e-03
0.2	2.343e+09	6.102e+01	4.920e+02	1.077e-01	8.683e-01
0.3	2.670e+08	1.893e+01	1.211e+02	3.591e-02	2.297e-01
0.4	1.143e+09	1.487e+02	8.055e+02	2.898e-01	1.570e+00
0.5	1.547e+08	3.156e+01	1.500e+02	6.196e-02	2.945e-01
0.6	5.339e+13	1.561e+07	6.666e+07	3.047e+04	1.301e+05
0.8	1.277e+10	6.552e+03	2.378e+04	1.246e+01	4.524e+01
1.0	1.070e+10	8.471e+03	2.728e+04	1.561e+01	5.029e+01
1.5	1.325e+10	2.279e+04	6.011e+04	3.835e+01	1.011e+02
2.0	6.170e+05	1.798e+00	4.213e+00	2.780e-03	6.515e-03
3.0	1.064e+00	6.228e-06	1.261e-05	8.450e-09	1.711e-08
TOTALS:	5.793e+13	1.565e+07	6.677e+07	3.054e+04	1.303e+05

Results - Dose Point # 5 - (51.75,168.93,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	6.813e+09	1.470e-250	1.224e-23	1.261e-251	1.050e-24
0.02	3.243e+09	3.823e-113	9.168e-24	1.324e-114	3.176e-25
0.03	3.601e+12	3.510e-33	2.252e-20	3.479e-35	2.231e-22
0.04	8.637e+11	1.491e-13	5.907e-13	6.594e-16	2.613e-15
0.05	1.999e+09	1.623e-08	1.077e-07	4.323e-11	2.869e-10
0.06	1.992e+09	5.937e-05	5.511e-04	1.179e-07	1.095e-06
0.08	5.589e+08	1.888e-02	2.170e-01	2.987e-05	3.434e-04
0.1	1.408e+10	8.009e+00	9.243e+01	1.225e-02	1.414e-01
0.15	4.191e+07	3.179e-01	3.009e+00	5.236e-04	4.956e-03
0.2	2.343e+09	4.793e+01	3.850e+02	8.459e-02	6.795e-01
0.3	2.670e+08	1.484e+01	9.450e+01	2.814e-02	1.793e-01
0.4	1.143e+09	1.164e+02	6.280e+02	2.268e-01	1.224e+00
0.5	1.547e+08	2.468e+01	1.169e+02	4.845e-02	2.295e-01
0.6	5.339e+13	1.220e+07	5.191e+07	2.381e+04	1.013e+05
0.8	1.277e+10	5.115e+03	1.851e+04	9.729e+00	3.521e+01
1.0	1.070e+10	6.608e+03	2.123e+04	1.218e+01	3.913e+01
1.5	1.325e+10	1.776e+04	4.674e+04	2.988e+01	7.864e+01
2.0	6.170e+05	1.400e+00	3.275e+00	2.165e-03	5.064e-03
3.0	1.064e+00	4.847e-06	9.798e-06	6.576e-09	1.329e-08
TOTALS:	5.793e+13	1.223e+07	5.200e+07	2.386e+04	1.015e+05

Results - Dose Point # 6 - (96.75,168.93,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	6.813e+09	7.666e-251	5.187e-24	6.575e-252	4.449e-25
0.02	3.243e+09	1.523e-113	3.884e-24	5.275e-115	1.346e-25
0.03	3.601e+12	1.714e-33	9.540e-21	1.699e-35	9.455e-23
0.04	8.637e+11	8.094e-14	3.208e-13	3.580e-16	1.419e-15
0.05	1.999e+09	8.601e-09	5.702e-08	2.291e-11	1.519e-10
0.06	1.992e+09	3.109e-05	2.886e-04	6.176e-08	5.733e-07

Page : 5
 DOS File : CSSF 1 Calcine in Grout.ms6
 Run Date: April 5, 2005
 Run Time: 3:08:15 PM
 Duration : 00:01:02

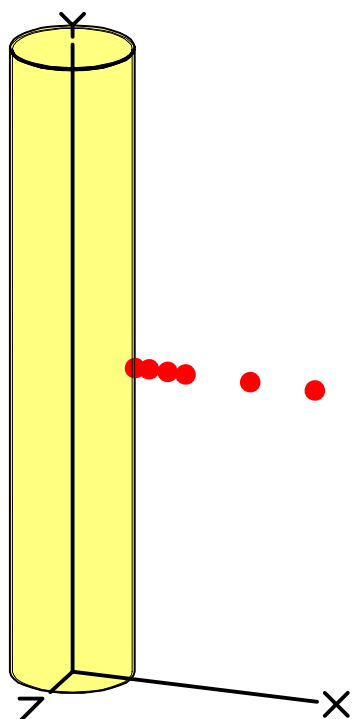
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.08	5.589e+08	9.856e-03	1.133e-01	1.560e-05	1.793e-04
0.1	1.408e+10	4.166e+00	4.806e+01	6.373e-03	7.352e-02
0.15	4.191e+07	1.642e-01	1.550e+00	2.704e-04	2.552e-03
0.2	2.343e+09	2.466e+01	1.969e+02	4.352e-02	3.475e-01
0.3	2.670e+08	7.599e+00	4.794e+01	1.441e-02	9.095e-02
0.4	1.143e+09	5.944e+01	3.172e+02	1.158e-01	6.180e-01
0.5	1.547e+08	1.258e+01	5.885e+01	2.469e-02	1.155e-01
0.6	5.339e+13	6.204e+06	2.606e+07	1.211e+04	5.087e+04
0.8	1.277e+10	2.592e+03	9.254e+03	4.930e+00	1.760e+01
1.0	1.070e+10	3.339e+03	1.057e+04	6.154e+00	1.949e+01
1.5	1.325e+10	8.916e+03	2.312e+04	1.500e+01	3.891e+01
2.0	6.170e+05	6.995e-01	1.612e+00	1.082e-03	2.493e-03
3.0	1.064e+00	2.406e-06	4.791e-06	3.264e-09	6.500e-09
TOTALS:	5.793e+13	6.219e+06	2.611e+07	1.214e+04	5.095e+04

MicroShield v6.10 (0028)
INEEL

Page : 1
 DOS File : CSSF 2 Calcine in Grout.ms6
 Run Date : April 5, 2005
 Run Time : 3:10:00 PM
 Duration : 00:01:02

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

Case Title: CSSF 2 Calcine Grout
Description: CSSF 2 Calcine Grouted at 21.5 wt% in Storage Canister
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	337.86 cm	11 ft 1.0 in
Radius	30.48 cm	1 ft

Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	34.29 cm 1 ft 1.5 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 2	61.75 cm 2 ft 0.3 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 3	131.75 cm 4 ft 3.9 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 4	41.75 cm 1 ft 4.4 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 5	51.75 cm 1 ft 8.4 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 6	96.75 cm 3 ft 2.1 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	9.86e+05 cm ³	Concrete	1.8
Transition		Air	0.00122
Air Gap		Air	0.00122
Wall Clad	1.27 cm	Iron	7.95
Top Clad	1.27 cm	Iron	7.95

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included
Library : ICRP-38

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>µCi/cm³</u>	<u>Bq/cm³</u>
Am-241	3.8951e-001	1.4412e+010	3.9500e-001	1.4615e+004
Am-243	3.3231e-004	1.2296e+007	3.3700e-004	1.2469e+001
Ba-137m	6.0053e+002	2.2220e+013	6.0900e+002	2.2533e+007
Ce-144	2.7709e-015	1.0252e-004	2.8100e-015	1.0397e-010
Cm-242	9.5947e-004	3.5500e+007	9.7300e-004	3.6001e+001
Cm-244	3.3330e-004	1.2332e+007	3.3800e-004	1.2506e+001
Co-60	8.4113e-003	3.1122e+008	8.5300e-003	3.1561e+002
Cs-134	1.4890e-004	5.5093e+006	1.5100e-004	5.5870e+000
Cs-135	9.8510e-003	3.6449e+008	9.9900e-003	3.6963e+002
Cs-137	6.3307e+002	2.3424e+013	6.4200e+002	2.3754e+007
Eu-152	1.5087e-002	5.5823e+008	1.5300e-002	5.6610e+002
Eu-154	1.0650e+000	3.9404e+010	1.0800e+000	3.9960e+004
Eu-155	6.0743e-002	2.2475e+009	6.1600e-002	2.2792e+003
I-129	6.1138e-005	2.2621e+006	6.2000e-005	2.2940e+000
Ni-63	2.1398e+001	7.9173e+011	2.1700e+001	8.0290e+005
Np-237	4.7825e-004	1.7695e+007	4.8500e-004	1.7945e+001
Pa-233	4.7825e-004	1.7695e+007	4.8500e-004	1.7945e+001
Pm-147	1.9032e-002	7.0417e+008	1.9300e-002	7.1410e+002
Pr-144	2.7709e-015	1.0252e-004	2.8100e-015	1.0397e-010

Nuclide	curies	becquerels	μCi/cm ³	Bq/cm ³
Pu-238	3.3428e+000	1.2369e+011	3.3900e+000	1.2543e+005
Pu-239	6.7054e-002	2.4810e+009	6.8000e-002	2.5160e+003
Pu-240	5.6306e-002	2.0833e+009	5.7100e-002	2.1127e+003
Pu-241	1.6961e+000	6.2755e+010	1.7200e+000	6.3640e+004
Pu-242	1.3115e-004	4.8525e+006	1.3300e-004	4.9210e+000
Ru-106	1.0453e-010	3.8674e+000	1.0600e-010	3.9220e-006
Sb-125	2.7709e-002	1.0252e+009	2.8100e-002	1.0397e+003
Sb-126	1.0650e-003	3.9404e+007	1.0800e-003	3.9960e+001
Sb-126m	7.5929e-003	2.8094e+008	7.7000e-003	2.8490e+002
Sm-151	9.1115e+000	3.3712e+011	9.2400e+000	3.4188e+005
Sr-90	5.5221e+002	2.0432e+013	5.6000e+002	2.0720e+007
Tc-99	2.8794e-001	1.0654e+010	2.9200e-001	1.0804e+004
Th-230	5.4827e-005	2.0286e+006	5.5600e-005	2.0572e+000
Th-231	2.2088e-005	8.1727e+005	2.2400e-005	8.2880e-001
U-232	3.4020e-006	1.2587e+005	3.4500e-006	1.2765e-001
U-233	7.8591e-007	2.9079e+004	7.9700e-007	2.9489e-002
U-234	8.1155e-003	3.0027e+008	8.2300e-003	3.0451e+002
U-235	2.0708e-005	7.6619e+005	2.1000e-005	7.7700e-001
U-236	5.7390e-005	2.1234e+006	5.8200e-005	2.1534e+000
U-237	4.6346e-005	1.7148e+006	4.7000e-005	1.7390e+000
U-238	1.2523e-006	4.6336e+004	1.2700e-006	4.6990e-002
Y-90	5.5221e+002	2.0432e+013	5.6000e+002	2.0720e+007

Buildup
 The material reference is : Source

Integration Parameters

Radial	24
Circumferential	24
Y Direction (axial)	24

Results - Dose Point # 1 - (34.29,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	1.032e+10	1.291e-267	3.334e-23	1.107e-268	2.859e-24
0.02	6.304e+09	2.049e-119	3.204e-23	7.099e-121	1.110e-24
0.03	1.346e+12	1.001e-34	1.513e-20	9.919e-37	1.500e-22
0.04	3.292e+11	5.112e-14	2.044e-13	2.261e-16	9.040e-16
0.05	2.356e+09	2.940e-08	1.976e-07	7.832e-11	5.264e-10
0.06	5.180e+09	2.692e-04	2.515e-03	5.346e-07	4.994e-06
0.08	7.149e+08	4.177e-02	4.719e-01	6.609e-05	7.468e-04
0.1	1.659e+10	1.572e+01	1.776e+02	2.404e-02	2.716e-01
0.15	5.210e+07	6.436e-01	6.071e+00	1.060e-03	9.997e-03
0.2	2.828e+09	9.428e+01	7.614e+02	1.664e-01	1.344e+00
0.3	2.527e+08	2.298e+01	1.478e+02	4.359e-02	2.805e-01
0.4	9.518e+08	1.591e+02	8.680e+02	3.101e-01	1.691e+00
0.5	2.866e+08	7.521e+01	3.600e+02	1.476e-01	7.067e-01
0.6	1.995e+13	7.513e+06	3.230e+07	1.467e+04	6.305e+04
0.8	1.497e+10	9.912e+03	3.621e+04	1.885e+01	6.888e+01
1.0	1.282e+10	1.312e+04	4.249e+04	2.418e+01	7.832e+01
1.5	1.587e+10	3.539e+04	9.375e+04	5.954e+01	1.577e+02
2.0	7.236e+05	2.736e+00	6.432e+00	4.230e-03	9.947e-03
3.0	1.120e+01	8.517e-05	1.728e-04	1.156e-07	2.345e-07
TOTALS:	2.172e+13	7.572e+06	3.248e+07	1.477e+04	6.336e+04

Results - Dose Point # 2 - (61.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	1.032e+10	2.605e-250	1.463e-23	2.234e-251	1.255e-24
0.02	6.304e+09	5.718e-113	1.406e-23	1.981e-114	4.871e-25
0.03	1.346e+12	9.894e-34	6.642e-21	9.806e-36	6.582e-23
0.04	3.292e+11	4.879e-14	1.934e-13	2.158e-16	8.552e-16
0.05	2.356e+09	1.611e-08	1.068e-07	4.292e-11	2.844e-10
0.06	5.180e+09	1.283e-04	1.191e-03	2.549e-07	2.365e-06
0.08	7.149e+08	2.006e-02	2.306e-01	3.174e-05	3.649e-04
0.1	1.659e+10	7.833e+00	9.036e+01	1.198e-02	1.382e-01
0.15	5.210e+07	3.270e-01	3.091e+00	5.384e-04	5.091e-03
0.2	2.828e+09	4.779e+01	3.834e+02	8.435e-02	6.767e-01
0.3	2.527e+08	1.159e+01	7.371e+01	2.199e-02	1.398e-01
0.4	9.518e+08	7.999e+01	4.309e+02	1.559e-01	8.396e-01
0.5	2.866e+08	3.770e+01	1.783e+02	7.401e-02	3.499e-01
0.6	1.995e+13	3.759e+06	1.596e+07	7.336e+03	3.116e+04
0.8	1.497e+10	4.942e+03	1.785e+04	9.399e+00	3.395e+01
1.0	1.282e+10	6.521e+03	2.091e+04	1.202e+01	3.853e+01
1.5	1.587e+10	1.752e+04	4.600e+04	2.947e+01	7.739e+01
2.0	7.236e+05	1.350e+00	3.152e+00	2.088e-03	4.874e-03
3.0	1.120e+01	4.194e-05	8.458e-05	5.690e-08	1.148e-07
TOTALS:	2.172e+13	3.788e+06	1.605e+07	7.387e+03	3.131e+04

Results - Dose Point # 3 - (131.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	1.032e+10	7.500e-251	4.951e-24	6.433e-252	4.247e-25
0.02	6.304e+09	2.209e-113	4.759e-24	7.653e-115	1.649e-25
0.03	1.346e+12	4.627e-34	2.248e-21	4.585e-36	2.228e-23
0.04	3.292e+11	2.242e-14	8.885e-14	9.915e-17	3.929e-16
0.05	2.356e+09	7.373e-09	4.889e-08	1.964e-11	1.302e-10
0.06	5.180e+09	5.882e-05	5.462e-04	1.168e-07	1.085e-06
0.08	7.149e+08	9.164e-03	1.054e-01	1.450e-05	1.668e-04
0.1	1.659e+10	3.562e+00	4.106e+01	5.450e-03	6.281e-02
0.15	5.210e+07	1.466e-01	1.372e+00	2.414e-04	2.260e-03
0.2	2.828e+09	2.122e+01	1.673e+02	3.745e-02	2.953e-01
0.3	2.527e+08	5.088e+00	3.161e+01	9.652e-03	5.997e-02
0.4	9.518e+08	3.488e+01	1.831e+02	6.796e-02	3.567e-01
0.5	2.866e+08	1.635e+01	7.527e+01	3.210e-02	1.477e-01
0.6	1.995e+13	1.623e+06	6.706e+06	3.168e+03	1.309e+04
0.8	1.497e+10	2.118e+03	7.440e+03	4.029e+00	1.415e+01
1.0	1.282e+10	2.777e+03	8.660e+03	5.120e+00	1.596e+01
1.5	1.587e+10	7.368e+03	1.883e+04	1.240e+01	3.168e+01
2.0	7.236e+05	5.630e-01	1.279e+00	8.707e-04	1.978e-03
3.0	1.120e+01	1.728e-05	3.396e-05	2.344e-08	4.608e-08
TOTALS:	2.172e+13	1.635e+06	6.742e+06	3.190e+03	1.315e+04

Results - Dose Point # 4 - (41.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	1.032e+10	1.069e-251	2.485e-23	9.173e-253	2.132e-24
0.02	6.304e+09	3.787e-113	2.389e-23	1.312e-114	8.275e-25
0.03	1.346e+12	1.746e-33	1.128e-20	1.731e-35	1.118e-22

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.04	3.292e+11	8.497e-14	3.364e-13	3.758e-16	1.488e-15
0.05	2.356e+09	2.468e-08	1.627e-07	6.574e-11	4.335e-10
0.06	5.180e+09	1.884e-04	1.747e-03	3.743e-07	3.470e-06
0.08	7.149e+08	3.007e-02	3.472e-01	4.758e-05	5.495e-04
0.1	1.659e+10	1.189e+01	1.377e+02	1.820e-02	2.107e-01
0.15	5.210e+07	5.018e-01	4.765e+00	8.263e-04	7.846e-03
0.2	2.828e+09	7.364e+01	5.937e+02	1.300e-01	1.048e+00
0.3	2.527e+08	1.792e+01	1.146e+02	3.399e-02	2.174e-01
0.4	9.518e+08	1.239e+02	6.710e+02	2.414e-01	1.307e+00
0.5	2.866e+08	5.846e+01	2.779e+02	1.148e-01	5.455e-01
0.6	1.995e+13	5.834e+06	2.491e+07	1.139e+04	4.862e+04
0.8	1.497e+10	7.681e+03	2.788e+04	1.461e+01	5.304e+01
1.0	1.282e+10	1.015e+04	3.268e+04	1.871e+01	6.025e+01
1.5	1.587e+10	2.732e+04	7.203e+04	4.596e+01	1.212e+02
2.0	7.236e+05	2.109e+00	4.941e+00	3.261e-03	7.641e-03
3.0	1.120e+01	6.559e-05	1.328e-04	8.898e-08	1.801e-07
TOTALS:	2.172e+13	5.879e+06	2.504e+07	1.147e+04	4.885e+04

Results - Dose Point # 5 - (51.75,168.93,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	1.032e+10	2.227e-250	1.854e-23	1.910e-251	1.590e-24
0.02	6.304e+09	7.433e-113	1.782e-23	2.575e-114	6.174e-25
0.03	1.346e+12	1.312e-33	8.417e-21	1.301e-35	8.342e-23
0.04	3.292e+11	5.683e-14	2.252e-13	2.513e-16	9.959e-16
0.05	2.356e+09	1.913e-08	1.269e-07	5.096e-11	3.381e-10
0.06	5.180e+09	1.544e-04	1.433e-03	3.066e-07	2.846e-06
0.08	7.149e+08	2.414e-02	2.775e-01	3.821e-05	4.392e-04
0.1	1.659e+10	9.442e+00	1.090e+02	1.445e-02	1.667e-01
0.15	5.210e+07	3.952e-01	3.741e+00	6.509e-04	6.161e-03
0.2	2.828e+09	5.784e+01	4.646e+02	1.021e-01	8.201e-01
0.3	2.527e+08	1.404e+01	8.943e+01	2.663e-02	1.696e-01
0.4	9.518e+08	9.695e+01	5.231e+02	1.889e-01	1.019e+00
0.5	2.866e+08	4.571e+01	2.165e+02	8.973e-02	4.250e-01
0.6	1.995e+13	4.559e+06	1.940e+07	8.898e+03	3.786e+04
0.8	1.497e+10	5.997e+03	2.170e+04	1.141e+01	4.128e+01
1.0	1.282e+10	7.917e+03	2.543e+04	1.459e+01	4.688e+01
1.5	1.587e+10	2.128e+04	5.601e+04	3.581e+01	9.424e+01
2.0	7.236e+05	1.642e+00	3.841e+00	2.539e-03	5.940e-03
3.0	1.120e+01	5.104e-05	1.032e-04	6.925e-08	1.400e-07
TOTALS:	2.172e+13	4.594e+06	1.950e+07	8.960e+03	3.805e+04

Results - Dose Point # 6 - (96.75,168.93,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	1.032e+10	1.161e-250	7.856e-24	9.960e-252	6.739e-25
0.02	6.304e+09	2.960e-113	7.552e-24	1.025e-114	2.616e-25
0.03	1.346e+12	6.409e-34	3.566e-21	6.352e-36	3.535e-23
0.04	3.292e+11	3.085e-14	1.223e-13	1.365e-16	5.408e-16
0.05	2.356e+09	1.014e-08	6.720e-08	2.700e-11	1.790e-10
0.06	5.180e+09	8.085e-05	7.506e-04	1.606e-07	1.491e-06

Page : 5
 DOS File : CSSF 2 Calcine in Grout.ms6
 Run Date: April 5, 2005
 Run Time: 3:10:00 PM
 Duration : 00:01:02

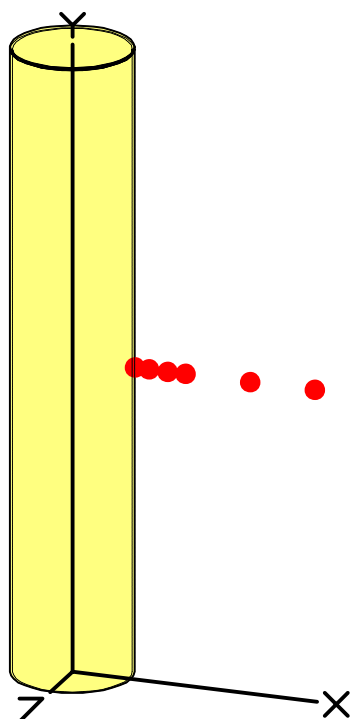
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.08	7.149e+08	1.261e-02	1.449e-01	1.995e-05	2.294e-04
0.1	1.659e+10	4.911e+00	5.665e+01	7.514e-03	8.668e-02
0.15	5.210e+07	2.042e-01	1.926e+00	3.362e-04	3.172e-03
0.2	2.828e+09	2.976e+01	2.376e+02	5.252e-02	4.194e-01
0.3	2.527e+08	7.191e+00	4.537e+01	1.364e-02	8.607e-02
0.4	9.518e+08	4.952e+01	2.642e+02	9.648e-02	5.148e-01
0.5	2.866e+08	2.329e+01	1.090e+02	4.572e-02	2.140e-01
0.6	1.995e+13	2.318e+06	9.739e+06	4.525e+03	1.901e+04
0.8	1.497e+10	3.039e+03	1.085e+04	5.780e+00	2.064e+01
1.0	1.282e+10	4.000e+03	1.267e+04	7.373e+00	2.335e+01
1.5	1.587e+10	1.068e+04	2.771e+04	1.798e+01	4.662e+01
2.0	7.236e+05	8.204e-01	1.891e+00	1.269e-03	2.924e-03
3.0	1.120e+01	2.534e-05	5.045e-05	3.437e-08	6.845e-08
TOTALS:	2.172e+13	2.336e+06	9.791e+06	4.556e+03	1.910e+04

MicroShield v6.10 (0028)
INEEL

Page : 1
 DOS File : CSSF 3 Calcine in Grout.ms6
 Run Date : April 5, 2005
 Run Time : 3:11:44 PM
 Duration : 00:01:02

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

Case Title: CSSF 3 Calcine Grout
Description: CSSF 3 Calcine Grouted at 21.5 wt% in Storage Canister
Geometry: 7 - Cylinder Volume - Side Shields



	Source Dimensions		
Height	337.68 cm	11 ft 0.9 in	
Radius	30.48 cm	1 ft	

	Dose Points		
	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	34.29 cm 1 ft 1.5 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 2	61.75 cm 2 ft 0.3 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 3	131.75 cm 4 ft 3.9 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 4	41.75 cm 1 ft 4.4 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 5	51.75 cm 1 ft 8.4 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 6	96.75 cm 3 ft 2.1 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in

	Shields		
<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	9.86e+05 cm ³	Concrete	1.8
Transition		Air	0.00122
Air Gap		Air	0.00122
Wall Clad	1.27 cm	Iron	7.95
Top Clad	1.27 cm	Iron	7.95

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included

	Library : ICRP-38			
<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm³</u>	<u>Bq/cm³</u>
Am-241	6.1696e-001	2.2828e+010	6.2600e-001	2.3162e+004
Am-243	4.0802e-004	1.5097e+007	4.1400e-004	1.5318e+001
Ba-137m	4.8490e+002	1.7941e+013	4.9200e+002	1.8204e+007
Ce-144	3.9718e-013	1.4696e-002	4.0300e-013	1.4911e-008
Cm-242	9.8556e-004	3.6466e+007	1.0000e-003	3.7000e+001
Cm-244	3.3608e-004	1.2435e+007	3.4100e-004	1.2617e+001
Co-60	1.0940e-002	4.0477e+008	1.1100e-002	4.1070e+002
Cs-134	2.3654e-004	8.7518e+006	2.4000e-004	8.8800e+000
Cs-135	9.7768e-003	3.6174e+008	9.9200e-003	3.6704e+002
Cs-137	5.1151e+002	1.8926e+013	5.1900e+002	1.9203e+007
Eu-152	1.8726e-002	6.9285e+008	1.9000e-002	7.0300e+002
Eu-154	5.9331e-001	2.1952e+010	6.0200e-001	2.2274e+004
Eu-155	4.7406e-002	1.7540e+009	4.8100e-002	1.7797e+003
I-129	4.4252e-005	1.6373e+006	4.4900e-005	1.6613e+000
Ni-63	3.1834e+001	1.1778e+012	3.2300e+001	1.1951e+006
Np-237	2.0303e-003	7.5120e+007	2.0600e-003	7.6220e+001
Pa-233	2.0303e-003	7.5120e+007	2.0600e-003	7.6220e+001
Pm-147	1.9613e-002	7.2567e+008	1.9900e-002	7.3630e+002
Pr-144	3.9718e-013	1.4696e-002	4.0300e-013	1.4911e-008

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm^3
Pu-238	1.0743e+001	3.9748e+011	1.0900e+001	4.0330e+005
Pu-239	8.6927e-002	3.2163e+009	8.8200e-002	3.2634e+003
Pu-240	1.0743e-001	3.9748e+009	1.0900e-001	4.0330e+003
Pu-241	2.8877e+000	1.0685e+011	2.9300e+000	1.0841e+005
Pu-242	2.7004e-004	9.9917e+006	2.7400e-004	1.0138e+001
Ru-106	1.2221e-010	4.5218e+000	1.2400e-010	4.5880e-006
Sb-125	1.1925e-003	4.4124e+007	1.2100e-003	4.4770e+001
Sb-126	7.8451e-004	2.9027e+007	7.9600e-004	2.9452e+001
Sb-126m	5.5882e-003	2.0676e+008	5.6700e-003	2.0979e+002
Sm-151	3.7846e+000	1.4003e+011	3.8400e+000	1.4208e+005
Sr-90	4.5533e+002	1.6847e+013	4.6200e+002	1.7094e+007
Tc-99	2.0598e-001	7.6214e+009	2.0900e-001	7.7330e+003
Th-230	7.6578e-006	2.8334e+005	7.7700e-006	2.8749e-001
Th-231	1.9810e-005	7.3296e+005	2.0100e-005	7.4370e-001
U-232	2.4245e-005	8.9706e+005	2.4600e-005	9.1020e-001
U-233	1.3305e-006	4.9229e+004	1.3500e-006	4.9950e-002
U-234	4.2084e-003	1.5571e+008	4.2700e-003	1.5799e+002
U-235	1.0743e-005	3.9748e+005	1.0900e-005	4.0330e-001
U-236	2.8877e-005	1.0685e+006	2.9300e-005	1.0841e+000
U-237	7.0468e-005	2.6073e+006	7.1500e-005	2.6455e+000
U-238	9.5600e-007	3.5372e+004	9.7000e-007	3.5890e-002
Y-90	4.5533e+002	1.6847e+013	4.6200e+002	1.7094e+007

Buildup
 The material reference is : Source

Integration Parameters

Radial	24
Circumferential	24
Y Direction (axial)	24

Results - Dose Point # 1 - (34.29,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	2.646e+10	3.427e-267	8.553e-23	2.939e-268	7.336e-24
0.02	1.220e+10	4.026e-119	6.203e-23	1.395e-120	2.149e-24
0.03	1.087e+12	8.118e-35	1.222e-20	8.045e-37	1.212e-22
0.04	2.639e+11	4.105e-14	1.642e-13	1.816e-16	7.260e-16
0.05	1.401e+09	1.750e-08	1.176e-07	4.663e-11	3.133e-10
0.06	8.182e+09	4.254e-04	3.974e-03	8.450e-07	7.893e-06
0.08	5.735e+08	3.352e-02	3.787e-01	5.304e-05	5.993e-04
0.1	9.516e+09	9.016e+00	1.019e+02	1.379e-02	1.559e-01
0.15	3.316e+07	4.097e-01	3.865e+00	6.747e-04	6.365e-03
0.2	1.567e+09	5.227e+01	4.222e+02	9.226e-02	7.451e-01
0.3	2.746e+08	2.498e+01	1.607e+02	4.739e-02	3.049e-01
0.4	4.405e+08	7.369e+01	4.019e+02	1.436e-01	7.830e-01
0.5	1.085e+08	2.849e+01	1.364e+02	5.593e-02	2.677e-01
0.6	1.611e+13	6.070e+06	2.609e+07	1.185e+04	5.093e+04
0.8	8.420e+09	5.579e+03	2.038e+04	1.061e+01	3.877e+01
1.0	7.542e+09	7.721e+03	2.501e+04	1.423e+01	4.611e+01
1.5	9.164e+09	2.044e+04	5.415e+04	3.440e+01	9.111e+01
2.0	4.391e+05	1.661e+00	3.905e+00	2.569e-03	6.039e-03
3.0	1.457e+01	1.108e-04	2.249e-04	1.504e-07	3.051e-07
TOTALS:	1.755e+13	6.104e+06	2.619e+07	1.191e+04	5.111e+04

Results - Dose Point # 2 - (61.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	2.646e+10	6.684e-250	3.753e-23	5.733e-251	3.219e-24
0.02	1.220e+10	1.107e-112	2.722e-23	3.834e-114	9.429e-25
0.03	1.087e+12	7.993e-34	5.364e-21	7.921e-36	5.317e-23
0.04	2.639e+11	3.913e-14	1.551e-13	1.730e-16	6.859e-16
0.05	1.401e+09	9.586e-09	6.353e-08	2.554e-11	1.692e-10
0.06	8.182e+09	2.028e-04	1.882e-03	4.028e-07	3.738e-06
0.08	5.735e+08	1.610e-02	1.851e-01	2.548e-05	2.929e-04
0.1	9.516e+09	4.495e+00	5.184e+01	6.876e-03	7.932e-02
0.15	3.316e+07	2.082e-01	1.968e+00	3.428e-04	3.241e-03
0.2	1.567e+09	2.650e+01	2.126e+02	4.677e-02	3.752e-01
0.3	2.746e+08	1.260e+01	8.014e+01	2.390e-02	1.520e-01
0.4	4.405e+08	3.704e+01	1.995e+02	7.217e-02	3.887e-01
0.5	1.085e+08	1.428e+01	6.753e+01	2.804e-02	1.326e-01
0.6	1.611e+13	3.036e+06	1.290e+07	5.926e+03	2.517e+04
0.8	8.420e+09	2.781e+03	1.005e+04	5.290e+00	1.911e+01
1.0	7.542e+09	3.839e+03	1.231e+04	7.076e+00	2.268e+01
1.5	9.164e+09	1.012e+04	2.657e+04	1.702e+01	4.471e+01
2.0	4.391e+05	8.200e-01	1.914e+00	1.268e-03	2.959e-03
3.0	1.457e+01	5.458e-05	1.101e-04	7.404e-08	1.493e-07
TOTALS:	1.755e+13	3.053e+06	1.295e+07	5.956e+03	2.526e+04

Results - Dose Point # 3 - (131.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	2.646e+10	1.924e-250	1.270e-23	1.651e-251	1.089e-24
0.02	1.220e+10	4.277e-113	9.211e-24	1.481e-114	3.191e-25
0.03	1.087e+12	3.738e-34	1.815e-21	3.704e-36	1.799e-23
0.04	2.639e+11	1.798e-14	7.125e-14	7.951e-17	3.151e-16
0.05	1.401e+09	4.387e-09	2.909e-08	1.169e-11	7.748e-11
0.06	8.182e+09	9.295e-05	8.632e-04	1.846e-07	1.715e-06
0.08	5.735e+08	7.356e-03	8.462e-02	1.164e-05	1.339e-04
0.1	9.516e+09	2.044e+00	2.356e+01	3.127e-03	3.604e-02
0.15	3.316e+07	9.335e-02	8.737e-01	1.537e-04	1.439e-03
0.2	1.567e+09	1.176e+01	9.277e+01	2.076e-02	1.637e-01
0.3	2.746e+08	5.531e+00	3.437e+01	1.049e-02	6.519e-02
0.4	4.405e+08	1.615e+01	8.477e+01	3.146e-02	1.652e-01
0.5	1.085e+08	6.195e+00	2.851e+01	1.216e-02	5.596e-02
0.6	1.611e+13	1.311e+06	5.417e+06	2.559e+03	1.057e+04
0.8	8.420e+09	1.192e+03	4.187e+03	2.267e+00	7.964e+00
1.0	7.542e+09	1.635e+03	5.097e+03	3.014e+00	9.396e+00
1.5	9.164e+09	4.255e+03	1.087e+04	7.160e+00	1.830e+01
2.0	4.391e+05	3.418e-01	7.766e-01	5.286e-04	1.201e-03
3.0	1.457e+01	2.248e-05	4.419e-05	3.050e-08	5.995e-08
TOTALS:	1.755e+13	1.318e+06	5.437e+06	2.571e+03	1.061e+04

Results - Dose Point # 4 - (41.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	2.646e+10	2.758e-251	6.376e-23	2.366e-252	5.469e-24
0.02	1.220e+10	7.345e-113	4.624e-23	2.544e-114	1.602e-24
0.03	1.087e+12	1.411e-33	9.114e-21	1.398e-35	9.032e-23

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.04	2.639e+11	6.813e-14	2.698e-13	3.013e-16	1.193e-15
0.05	1.401e+09	1.468e-08	9.681e-08	3.911e-11	2.579e-10
0.06	8.182e+09	2.978e-04	2.761e-03	5.914e-07	5.484e-06
0.08	5.735e+08	2.413e-02	2.787e-01	3.819e-05	4.410e-04
0.1	9.516e+09	6.824e+00	7.902e+01	1.044e-02	1.209e-01
0.15	3.316e+07	3.195e-01	3.034e+00	5.261e-04	4.996e-03
0.2	1.567e+09	4.083e+01	3.292e+02	7.206e-02	5.810e-01
0.3	2.746e+08	1.948e+01	1.246e+02	3.695e-02	2.363e-01
0.4	4.405e+08	5.736e+01	3.107e+02	1.118e-01	6.054e-01
0.5	1.085e+08	2.215e+01	1.053e+02	4.347e-02	2.067e-01
0.6	1.611e+13	4.713e+06	2.012e+07	9.198e+03	3.927e+04
0.8	8.420e+09	4.323e+03	1.569e+04	8.223e+00	2.985e+01
1.0	7.542e+09	5.974e+03	1.924e+04	1.101e+01	3.547e+01
1.5	9.164e+09	1.578e+04	4.161e+04	2.655e+01	7.001e+01
2.0	4.391e+05	1.280e+00	3.000e+00	1.980e-03	4.639e-03
3.0	1.457e+01	8.535e-05	1.728e-04	1.158e-07	2.344e-07
TOTALS:	1.755e+13	4.739e+06	2.020e+07	9.244e+03	3.941e+04

Results - Dose Point # 5 - (51.75,168.93,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.646e+10	5.720e-250	4.757e-23	4.906e-251	4.080e-24
0.02	1.220e+10	1.439e-112	3.450e-23	4.985e-114	1.195e-24
0.03	1.087e+12	1.060e-33	6.799e-21	1.050e-35	6.738e-23
0.04	2.639e+11	4.558e-14	1.806e-13	2.016e-16	7.987e-16
0.05	1.401e+09	1.138e-08	7.553e-08	3.032e-11	2.012e-10
0.06	8.182e+09	2.440e-04	2.265e-03	4.846e-07	4.498e-06
0.08	5.735e+08	1.938e-02	2.227e-01	3.066e-05	3.525e-04
0.1	9.516e+09	5.418e+00	6.252e+01	8.289e-03	9.565e-02
0.15	3.316e+07	2.517e-01	2.382e+00	4.144e-04	3.923e-03
0.2	1.567e+09	3.207e+01	2.576e+02	5.660e-02	4.547e-01
0.3	2.746e+08	1.527e+01	9.723e+01	2.896e-02	1.844e-01
0.4	4.405e+08	4.489e+01	2.422e+02	8.747e-02	4.720e-01
0.5	1.085e+08	1.732e+01	8.203e+01	3.399e-02	1.610e-01
0.6	1.611e+13	3.683e+06	1.567e+07	7.188e+03	3.059e+04
0.8	8.420e+09	3.375e+03	1.222e+04	6.420e+00	2.323e+01
1.0	7.542e+09	4.661e+03	1.497e+04	8.591e+00	2.760e+01
1.5	9.164e+09	1.229e+04	3.236e+04	2.069e+01	5.444e+01
2.0	4.391e+05	9.970e-01	2.332e+00	1.542e-03	3.606e-03
3.0	1.457e+01	6.642e-05	1.343e-04	9.012e-08	1.822e-07
TOTALS:	1.755e+13	3.703e+06	1.573e+07	7.224e+03	3.069e+04

Results - Dose Point # 6 - (96.75,168.93,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.646e+10	2.979e-250	2.015e-23	2.555e-251	1.729e-24
0.02	1.220e+10	5.731e-113	1.462e-23	1.985e-114	5.063e-25
0.03	1.087e+12	5.178e-34	2.880e-21	5.131e-36	2.855e-23
0.04	2.639e+11	2.474e-14	9.806e-14	1.094e-16	4.337e-16
0.05	1.401e+09	6.031e-09	3.998e-08	1.607e-11	1.065e-10
0.06	8.182e+09	1.278e-04	1.186e-03	2.538e-07	2.356e-06

Page : 5
 DOS File : CSSF 3 Calcine in Grout.ms6
 Run Date: April 5, 2005
 Run Time: 3:11:44 PM
 Duration : 00:01:02

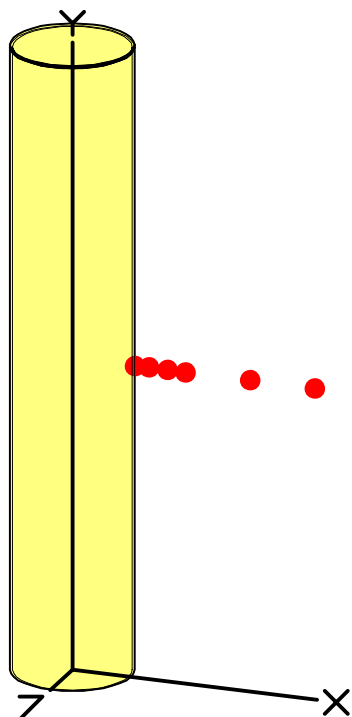
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.08	5.735e+08	1.012e-02	1.163e-01	1.601e-05	1.841e-04
0.1	9.516e+09	2.818e+00	3.251e+01	4.311e-03	4.973e-02
0.15	3.316e+07	1.300e-01	1.227e+00	2.141e-04	2.020e-03
0.2	1.567e+09	1.650e+01	1.317e+02	2.912e-02	2.325e-01
0.3	2.746e+08	7.818e+00	4.933e+01	1.483e-02	9.357e-02
0.4	4.405e+08	2.293e+01	1.223e+02	4.467e-02	2.384e-01
0.5	1.085e+08	8.825e+00	4.129e+01	1.732e-02	8.105e-02
0.6	1.611e+13	1.873e+06	7.867e+06	3.655e+03	1.536e+04
0.8	8.420e+09	1.710e+03	6.106e+03	3.253e+00	1.161e+01
1.0	7.542e+09	2.355e+03	7.458e+03	4.340e+00	1.375e+01
1.5	9.164e+09	6.172e+03	1.601e+04	1.038e+01	2.693e+01
2.0	4.391e+05	4.981e-01	1.148e+00	7.703e-04	1.775e-03
3.0	1.457e+01	3.297e-05	6.565e-05	4.473e-08	8.906e-08
TOTALS:	1.755e+13	1.883e+06	7.897e+06	3.673e+03	1.541e+04

MicroShield v6.10 (0028)
INEEL

Page : 1
 DOS File : CSSF 4 Calcine in Grout.ms6
 Run Date : April 5, 2005
 Run Time : 3:13:55 PM
 Duration : 00:01:02

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

Case Title: CSSF 4 Calcine Grout
Description: CSSF 4 Calcine Grouted at 21.5 wt% in Storage Canister
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	337.86 cm	11 ft 1.0 in
Radius	30.48 cm	1 ft

Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	34.29 cm 1 ft 1.5 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 2	61.75 cm 2 ft 0.3 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 3	131.75 cm 4 ft 3.9 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 4	41.75 cm 1 ft 4.4 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 5	51.75 cm 1 ft 8.4 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 6	96.75 cm 3 ft 2.1 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	9.86e+05 cm ³	Concrete	1.8
Transition		Air	0.00122
Air Gap		Air	0.00122
Wall Clad	1.27 cm	Iron	7.95
Top Clad	1.27 cm	Iron	7.95

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included
Library : ICRP-38

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>µCi/cm³</u>	<u>Bq/cm³</u>
Am-241	9.2199e-001	3.4114e+010	9.3500e-001	3.4595e+004
Am-243	5.0784e-004	1.8790e+007	5.1500e-004	1.9055e+001
Ba-137m	6.0842e+002	2.2511e+013	6.1700e+002	2.2829e+007
Ce-144	1.4002e-011	5.1809e-001	1.4200e-011	5.2540e-007
Cm-242	1.1734e-003	4.3418e+007	1.1900e-003	4.4030e+001
Cm-244	3.4217e-004	1.2660e+007	3.4700e-004	1.2839e+001
Co-60	2.1398e-002	7.9173e+008	2.1700e-002	8.0290e+002
Cs-134	1.6073e-003	5.9471e+007	1.6300e-003	6.0310e+001
Cs-135	1.2721e-002	4.7066e+008	1.2900e-002	4.7730e+002
Cs-137	6.4392e+002	2.3825e+013	6.5300e+002	2.4161e+007
Eu-152	2.4159e-002	8.9389e+008	2.4500e-002	9.0650e+002
Eu-154	2.0116e+000	7.4430e+010	2.0400e+000	7.5480e+004
Eu-155	8.6875e-002	3.2144e+009	8.8100e-002	3.2597e+003
I-129	5.5221e-005	2.0432e+006	5.6000e-005	2.0720e+000
Ni-63	4.1909e+001	1.5506e+012	4.2500e+001	1.5725e+006
Np-237	1.0946e-002	4.0499e+008	1.1100e-002	4.1070e+002
Pa-233	1.0946e-002	4.0499e+008	1.1100e-002	4.1070e+002
Pm-147	2.2483e-002	8.3187e+008	2.2800e-002	8.4360e+002
Pr-144	1.4002e-011	5.1809e-001	1.4200e-011	5.2540e-007

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>µCi/cm³</u>	<u>Bq/cm³</u>
Pu-238	1.0058e+001	3.7215e+011	1.0200e+001	3.7740e+005
Pu-239	2.4061e-001	8.9024e+009	2.4400e-001	9.0280e+003
Pu-240	1.3509e-001	4.9985e+009	1.3700e-001	5.0690e+003
Pu-241	3.7570e+000	1.3901e+011	3.8100e+000	1.4097e+005
Pu-242	3.4710e-004	1.2843e+007	3.5200e-004	1.3024e+001
Ru-106	2.5244e-009	9.3402e+001	2.5600e-009	9.4720e-005
Sb-125	3.7669e-003	1.3937e+008	3.8200e-003	1.4134e+002
Sb-126	9.8017e-004	3.6266e+007	9.9400e-004	3.6778e+001
Sb-126m	7.0308e-003	2.6014e+008	7.1300e-003	2.6381e+002
Sm-151	4.1317e+000	1.5287e+011	4.1900e+000	1.5503e+005
Sr-90	5.5517e+002	2.0541e+013	5.6300e+002	2.0831e+007
Tc-99	2.5638e-001	9.4862e+009	2.6000e-001	9.6200e+003
Th-230	2.7315e-006	1.0106e+005	2.7700e-006	1.0249e-001
Th-231	1.7651e-005	6.5309e+005	1.7900e-005	6.6230e-001
U-232	3.6978e-005	1.3682e+006	3.7500e-005	1.3875e+000
U-233	1.8045e-006	6.6768e+004	1.8300e-006	6.7710e-002
U-234	9.0424e-003	3.3457e+008	9.1700e-003	3.3929e+002
U-235	1.7651e-005	6.5309e+005	1.7900e-005	6.6230e-001
U-236	5.2066e-005	1.9264e+006	5.2800e-005	1.9536e+000
U-237	9.2199e-005	3.4114e+006	9.3500e-005	3.4595e+000
U-238	1.2622e-006	4.6701e+004	1.2800e-006	4.7360e-002
Y-90	5.5517e+002	2.0541e+013	5.6300e+002	2.0831e+007

Buildup
 The material reference is : Source

Integration Parameters

Radial	24
Circumferential	24
Y Direction (axial)	24

Results - Dose Point # 1 - (34.29,168.93,0) cm

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u>		<u>Exposure Rate</u> <u>mR/hr</u>	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.671e+10	3.341e-267	8.629e-23	2.866e-268	7.401e-24
0.02	1.533e+10	4.985e-119	7.795e-23	1.727e-120	2.700e-24
0.03	1.364e+12	1.014e-34	1.533e-20	1.005e-36	1.520e-22
0.04	3.416e+11	5.304e-14	2.121e-13	2.346e-16	9.380e-16
0.05	4.368e+09	5.451e-08	3.663e-07	1.452e-10	9.759e-10
0.06	1.224e+10	6.359e-04	5.940e-03	1.263e-06	1.180e-05
0.08	1.087e+09	6.352e-02	7.177e-01	1.005e-04	1.136e-03
0.1	3.125e+10	2.960e+01	3.344e+02	4.528e-02	5.116e-01
0.15	9.891e+07	1.222e+00	1.152e+01	2.012e-03	1.898e-02
0.2	5.200e+09	1.734e+02	1.400e+03	3.060e-01	2.471e+00
0.3	5.963e+08	5.423e+01	3.489e+02	1.029e-01	6.618e-01
0.4	9.699e+08	1.622e+02	8.845e+02	3.160e-01	1.723e+00
0.5	3.551e+08	9.320e+01	4.462e+02	1.829e-01	8.757e-01
0.6	2.022e+13	7.613e+06	3.273e+07	1.486e+04	6.388e+04
0.8	2.826e+10	1.872e+04	6.838e+04	3.560e+01	1.301e+02
1.0	2.433e+10	2.490e+04	8.066e+04	4.589e+01	1.487e+02
1.5	3.015e+10	6.722e+04	1.781e+05	1.131e+02	2.996e+02
2.0	1.355e+06	5.123e+00	1.204e+01	7.922e-03	1.863e-02
3.0	2.850e+01	2.167e-04	4.396e-04	2.940e-07	5.965e-07
TOTALS:	2.210e+13	7.724e+06	3.306e+07	1.506e+04	6.447e+04

Results - Dose Point # 2 - (61.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	2.671e+10	6.741e-250	3.787e-23	5.782e-251	3.248e-24
0.02	1.533e+10	1.391e-112	3.421e-23	4.818e-114	1.185e-24
0.03	1.364e+12	1.003e-33	6.729e-21	9.936e-36	6.669e-23
0.04	3.416e+11	5.062e-14	2.006e-13	2.239e-16	8.874e-16
0.05	4.368e+09	2.987e-08	1.979e-07	7.957e-11	5.273e-10
0.06	1.224e+10	3.031e-04	2.813e-03	6.021e-07	5.588e-06
0.08	1.087e+09	3.051e-02	3.507e-01	4.827e-05	5.549e-04
0.1	3.125e+10	1.475e+01	1.702e+02	2.257e-02	2.603e-01
0.15	9.891e+07	6.207e-01	5.868e+00	1.022e-03	9.664e-03
0.2	5.200e+09	8.789e+01	7.051e+02	1.551e-01	1.244e+00
0.3	5.963e+08	2.735e+01	1.739e+02	5.188e-02	3.299e-01
0.4	9.699e+08	8.151e+01	4.391e+02	1.588e-01	8.555e-01
0.5	3.551e+08	4.672e+01	2.209e+02	9.171e-02	4.336e-01
0.6	2.022e+13	3.808e+06	1.617e+07	7.433e+03	3.157e+04
0.8	2.826e+10	9.330e+03	3.370e+04	1.775e+01	6.410e+01
1.0	2.433e+10	1.238e+04	3.968e+04	2.282e+01	7.315e+01
1.5	3.015e+10	3.327e+04	8.737e+04	5.598e+01	1.470e+02
2.0	1.355e+06	2.529e+00	5.902e+00	3.911e-03	9.127e-03
3.0	2.850e+01	1.067e-04	2.152e-04	1.448e-07	2.919e-07
TOTALS:	2.210e+13	3.863e+06	1.634e+07	7.530e+03	3.186e+04

Results - Dose Point # 3 - (131.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	2.671e+10	1.941e-250	1.282e-23	1.665e-251	1.099e-24
0.02	1.533e+10	5.374e-113	1.158e-23	1.862e-114	4.010e-25
0.03	1.364e+12	4.688e-34	2.277e-21	4.646e-36	2.257e-23
0.04	3.416e+11	2.326e-14	9.219e-14	1.029e-16	4.077e-16
0.05	4.368e+09	1.367e-08	9.063e-08	3.641e-11	2.414e-10
0.06	1.224e+10	1.389e-04	1.290e-03	2.760e-07	2.563e-06
0.08	1.087e+09	1.394e-02	1.603e-01	2.206e-05	2.537e-04
0.1	3.125e+10	6.709e+00	7.732e+01	1.026e-02	1.183e-01
0.15	9.891e+07	2.783e-01	2.605e+00	4.583e-04	4.290e-03
0.2	5.200e+09	3.902e+01	3.077e+02	6.886e-02	5.431e-01
0.3	5.963e+08	1.201e+01	7.460e+01	2.278e-02	1.415e-01
0.4	9.699e+08	3.554e+01	1.866e+02	6.925e-02	3.635e-01
0.5	3.551e+08	2.027e+01	9.327e+01	3.978e-02	1.831e-01
0.6	2.022e+13	1.644e+06	6.795e+06	3.210e+03	1.326e+04
0.8	2.826e+10	3.999e+03	1.405e+04	7.606e+00	2.672e+01
1.0	2.433e+10	5.272e+03	1.644e+04	9.718e+00	3.030e+01
1.5	3.015e+10	1.399e+04	3.576e+04	2.355e+01	6.017e+01
2.0	1.355e+06	1.054e+00	2.396e+00	1.630e-03	3.704e-03
3.0	2.850e+01	4.396e-05	8.641e-05	5.964e-08	1.172e-07
TOTALS:	2.210e+13	1.668e+06	6.862e+06	3.251e+03	1.338e+04

Results - Dose Point # 4 - (41.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	2.671e+10	2.768e-251	6.433e-23	2.374e-252	5.518e-24
0.02	1.533e+10	9.212e-113	5.811e-23	3.191e-114	2.013e-24
0.03	1.364e+12	1.769e-33	1.143e-20	1.754e-35	1.133e-22

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.04	3.416e+11	8.816e-14	3.491e-13	3.899e-16	1.544e-15
0.05	4.368e+09	4.575e-08	3.017e-07	1.219e-10	8.037e-10
0.06	1.224e+10	4.451e-04	4.127e-03	8.841e-07	8.198e-06
0.08	1.087e+09	4.573e-02	5.281e-01	7.237e-05	8.357e-04
0.1	3.125e+10	2.240e+01	2.593e+02	3.427e-02	3.968e-01
0.15	9.891e+07	9.525e-01	9.045e+00	1.569e-03	1.490e-02
0.2	5.200e+09	1.354e+02	1.092e+03	2.390e-01	1.927e+00
0.3	5.963e+08	4.228e+01	2.704e+02	8.021e-02	5.129e-01
0.4	9.699e+08	1.262e+02	6.838e+02	2.460e-01	1.332e+00
0.5	3.551e+08	7.245e+01	3.444e+02	1.422e-01	6.760e-01
0.6	2.022e+13	5.911e+06	2.524e+07	1.154e+04	4.926e+04
0.8	2.826e+10	1.450e+04	5.265e+04	2.759e+01	1.001e+02
1.0	2.433e+10	1.926e+04	6.204e+04	3.551e+01	1.144e+02
1.5	3.015e+10	5.188e+04	1.368e+05	8.729e+01	2.302e+02
2.0	1.355e+06	3.949e+00	9.253e+00	6.106e-03	1.431e-02
3.0	2.850e+01	1.669e-04	3.378e-04	2.264e-07	4.583e-07
TOTALS:	2.210e+13	5.997e+06	2.549e+07	1.169e+04	4.971e+04

Results - Dose Point # 5 - (51.75,168.93,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.671e+10	5.765e-250	4.799e-23	4.944e-251	4.117e-24
0.02	1.533e+10	1.808e-112	4.336e-23	6.263e-114	1.502e-24
0.03	1.364e+12	1.330e-33	8.529e-21	1.318e-35	8.453e-23
0.04	3.416e+11	5.897e-14	2.336e-13	2.608e-16	1.033e-15
0.05	4.368e+09	3.546e-08	2.353e-07	9.446e-11	6.269e-10
0.06	1.224e+10	3.647e-04	3.385e-03	7.244e-07	6.724e-06
0.08	1.087e+09	3.672e-02	4.221e-01	5.811e-05	6.679e-04
0.1	3.125e+10	1.778e+01	2.052e+02	2.720e-02	3.140e-01
0.15	9.891e+07	7.503e-01	7.102e+00	1.236e-03	1.170e-02
0.2	5.200e+09	1.064e+02	8.545e+02	1.877e-01	1.508e+00
0.3	5.963e+08	3.313e+01	2.110e+02	6.285e-02	4.003e-01
0.4	9.699e+08	9.880e+01	5.331e+02	1.925e-01	1.039e+00
0.5	3.551e+08	5.665e+01	2.683e+02	1.112e-01	5.267e-01
0.6	2.022e+13	4.619e+06	1.965e+07	9.016e+03	3.836e+04
0.8	2.826e+10	1.132e+04	4.098e+04	2.154e+01	7.794e+01
1.0	2.433e+10	1.503e+04	4.827e+04	2.770e+01	8.898e+01
1.5	3.015e+10	4.043e+04	1.064e+05	6.802e+01	1.790e+02
2.0	1.355e+06	3.075e+00	7.193e+00	4.755e-03	1.112e-02
3.0	2.850e+01	1.299e-04	2.625e-04	1.762e-07	3.561e-07
TOTALS:	2.210e+13	4.686e+06	1.985e+07	9.133e+03	3.871e+04

Results - Dose Point # 6 - (96.75,168.93,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.671e+10	3.005e-250	2.033e-23	2.578e-251	1.744e-24
0.02	1.533e+10	7.201e-113	1.837e-23	2.494e-114	6.363e-25
0.03	1.364e+12	6.494e-34	3.614e-21	6.436e-36	3.581e-23
0.04	3.416e+11	3.201e-14	1.269e-13	1.416e-16	5.611e-16
0.05	4.368e+09	1.879e-08	1.246e-07	5.006e-11	3.319e-10
0.06	1.224e+10	1.910e-04	1.773e-03	3.794e-07	3.522e-06

Page : 5
 DOS File : CSSF 4 Calcine in Grout.ms6
 Run Date: April 5, 2005
 Run Time: 3:13:55 PM
 Duration : 00:01:02

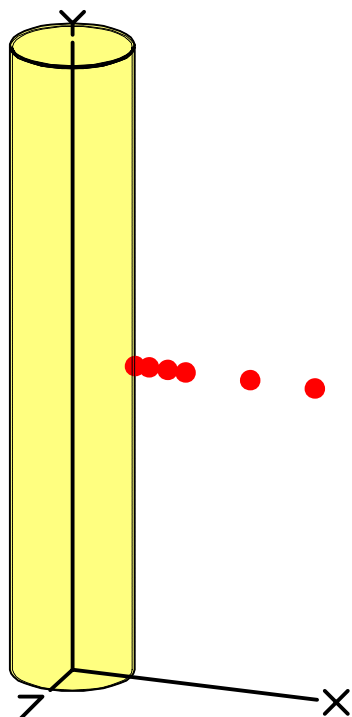
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.08	1.087e+09	1.917e-02	2.204e-01	3.034e-05	3.489e-04
0.1	3.125e+10	9.249e+00	1.067e+02	1.415e-02	1.632e-01
0.15	9.891e+07	3.876e-01	3.657e+00	6.382e-04	6.022e-03
0.2	5.200e+09	5.472e+01	4.369e+02	9.658e-02	7.712e-01
0.3	5.963e+08	1.697e+01	1.071e+02	3.219e-02	2.031e-01
0.4	9.699e+08	5.046e+01	2.692e+02	9.831e-02	5.246e-01
0.5	3.551e+08	2.887e+01	1.351e+02	5.666e-02	2.651e-01
0.6	2.022e+13	2.349e+06	9.868e+06	4.585e+03	1.926e+04
0.8	2.826e+10	5.738e+03	2.049e+04	1.091e+01	3.896e+01
1.0	2.433e+10	7.593e+03	2.405e+04	1.400e+01	4.433e+01
1.5	3.015e+10	2.029e+04	5.263e+04	3.414e+01	8.855e+01
2.0	1.355e+06	1.536e+00	3.540e+00	2.376e-03	5.475e-03
3.0	2.850e+01	6.445e-05	1.283e-04	8.744e-08	1.741e-07
TOTALS:	2.210e+13	2.383e+06	9.966e+06	4.644e+03	1.943e+04

MicroShield v6.10 (0028)
INEEL

Page : 1
 DOS File : CSSF 5 Calcine in Grout.ms6
 Run Date : April 5, 2005
 Run Time : 3:15:31 PM
 Duration : 00:01:02

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

Case Title: CSSF 5 Calcine Grout
Description: CSSF 5 Calcine Grouted at 21.5 wt% in Storage Canister
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	337.86 cm	11 ft 1.0 in
Radius	30.48 cm	1 ft

Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	34.29 cm 1 ft 1.5 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 2	61.75 cm 2 ft 0.3 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 3	131.75 cm 4 ft 3.9 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 4	41.75 cm 1 ft 4.4 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 5	51.75 cm 1 ft 8.4 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 6	96.75 cm 3 ft 2.1 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	9.86e+05 cm ³	Concrete	1.8
Transition		Air	0.00122
Air Gap		Air	0.00122
Wall Clad	1.27 cm	Iron	7.95
Top Clad	1.27 cm	Iron	7.95

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included

Library : ICRP-38

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>µCi/cm³</u>	<u>Bq/cm³</u>
Am-241	8.7663e-001	3.2435e+010	8.8900e-001	3.2893e+004
Am-243	5.2263e-004	1.9337e+007	5.3000e-004	1.9610e+001
Ba-137m	5.9264e+002	2.1928e+013	6.0100e+002	2.2237e+007
Ce-144	2.5934e-009	9.5956e+001	2.6300e-009	9.7310e-005
Cm-242	1.3312e-003	4.9255e+007	1.3500e-003	4.9950e+001
Cm-244	4.7332e-004	1.7513e+007	4.8000e-004	1.7760e+001
Co-60	2.0511e-001	7.5889e+009	2.0800e-001	7.6960e+003
Cs-134	1.0650e-002	3.9404e+008	1.0800e-002	3.9960e+002
Cs-135	1.1636e-002	4.3053e+008	1.1800e-002	4.3660e+002
Cs-137	6.2814e+002	2.3241e+013	6.3700e+002	2.3569e+007
Eu-152	2.2779e-002	8.4281e+008	2.3100e-002	8.5470e+002
Eu-154	1.9130e+000	7.0782e+010	1.9400e+000	7.1780e+004
Eu-155	1.6665e-001	6.1660e+009	1.6900e-001	6.2530e+003
I-129	5.4136e-005	2.0030e+006	5.4900e-005	2.0313e+000
Ni-63	3.8162e+001	1.4120e+012	3.8700e+001	1.4319e+006
Np-237	1.0354e-002	3.8310e+008	1.0500e-002	3.8850e+002
Pa-233	1.0354e-002	3.8310e+008	1.0500e-002	3.8850e+002
Pm-147	2.6427e-002	9.7781e+008	2.6800e-002	9.9160e+002
Pr-144	2.5934e-009	9.5956e+001	2.6300e-009	9.7310e-005

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm³</u>	<u>Bq/cm³</u>
Pu-238	7.7408e+000	2.8641e+011	7.8500e+000	2.9045e+005
Pu-239	2.5540e-001	9.4497e+009	2.5900e-001	9.5830e+003
Pu-240	1.2030e-001	4.4512e+009	1.2200e-001	4.5140e+003
Pu-241	3.4415e+000	1.2733e+011	3.4900e+000	1.2913e+005
Pu-242	2.9484e-004	1.0909e+007	2.9900e-004	1.1063e+001
Ru-106	8.7170e-008	3.2253e+003	8.8400e-008	3.2708e-003
Sb-125	1.0354e-002	3.8310e+008	1.0500e-002	3.8850e+002
Sb-126	9.6045e-004	3.5537e+007	9.7400e-004	3.6038e+001
Sb-126m	6.8435e-003	2.5321e+008	6.9400e-003	2.5678e+002
Sm-151	5.0882e+000	1.8826e+011	5.1600e+000	1.9092e+005
Sr-90	5.7390e+002	2.1234e+013	5.8200e+002	2.1534e+007
Tc-99	2.5244e-001	9.3402e+009	2.5600e-001	9.4720e+003
Th-230	1.4890e-005	5.5093e+005	1.5100e-005	5.5870e-001
Th-231	2.6723e-005	9.8875e+005	2.7100e-005	1.0027e+000
U-232	2.3173e-005	8.5741e+005	2.3500e-005	8.6950e-001
U-233	1.5284e-006	5.6552e+004	1.5500e-006	5.7350e-002
U-234	2.5737e-003	9.5227e+007	2.6100e-003	9.6570e+001
U-235	3.3823e-005	1.2514e+006	3.4300e-005	1.2691e+000
U-236	1.3312e-004	4.9255e+006	1.3500e-004	4.9950e+000
U-237	8.3916e-005	3.1049e+006	8.5100e-005	3.1487e+000
U-238	1.1340e-005	4.1958e+005	1.1500e-005	4.2550e-001
Y-90	5.7390e+002	2.1234e+013	5.8200e+002	2.1534e+007

Buildup
 The material reference is : Source

Integration Parameters

Radial	24
Circumferential	24
Y Direction (axial)	24

Results - Dose Point # 1 - (34.29,168.93,0) cm

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u>		<u>Exposure Rate</u> <u>mR/hr</u>	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.171e+10	2.715e-267	7.012e-23	2.329e-268	6.014e-24
0.02	1.376e+10	4.473e-119	6.994e-23	1.549e-120	2.423e-24
0.03	1.329e+12	9.878e-35	1.494e-20	9.790e-37	1.480e-22
0.04	3.329e+11	5.169e-14	2.067e-13	2.286e-16	9.140e-16
0.05	4.334e+09	5.408e-08	3.634e-07	1.441e-10	9.682e-10
0.06	1.167e+10	6.065e-04	5.666e-03	1.205e-06	1.125e-05
0.08	2.000e+09	1.169e-01	1.320e+00	1.849e-04	2.089e-03
0.1	3.035e+10	2.875e+01	3.248e+02	4.398e-02	4.969e-01
0.15	9.582e+07	1.184e+00	1.116e+01	1.949e-03	1.838e-02
0.2	4.963e+09	1.655e+02	1.336e+03	2.921e-01	2.359e+00
0.3	5.659e+08	5.146e+01	3.311e+02	9.762e-02	6.281e-01
0.4	1.007e+09	1.683e+02	9.179e+02	3.279e-01	1.788e+00
0.5	3.684e+08	9.670e+01	4.629e+02	1.898e-01	9.086e-01
0.6	1.969e+13	7.416e+06	3.188e+07	1.447e+04	6.223e+04
0.8	2.719e+10	1.801e+04	6.579e+04	3.425e+01	1.251e+02
1.0	2.998e+10	3.067e+04	9.936e+04	5.654e+01	1.832e+02
1.5	3.551e+10	7.919e+04	2.097e+05	1.332e+02	3.529e+02
2.0	1.363e+06	5.153e+00	1.212e+01	7.969e-03	1.874e-02
3.0	2.732e+02	2.077e-03	4.214e-03	2.818e-06	5.717e-06
TOTALS:	2.154e+13	7.544e+06	3.226e+07	1.470e+04	6.289e+04

Results - Dose Point # 2 - (61.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	2.171e+10	5.478e-250	3.077e-23	4.699e-251	2.639e-24
0.02	1.376e+10	1.248e-112	3.069e-23	4.323e-114	1.063e-24
0.03	1.329e+12	9.766e-34	6.555e-21	9.679e-36	6.497e-23
0.04	3.329e+11	4.933e-14	1.955e-13	2.182e-16	8.648e-16
0.05	4.334e+09	2.963e-08	1.964e-07	7.894e-11	5.231e-10
0.06	1.167e+10	2.891e-04	2.683e-03	5.743e-07	5.330e-06
0.08	2.000e+09	5.612e-02	6.451e-01	8.881e-05	1.021e-03
0.1	3.035e+10	1.433e+01	1.653e+02	2.192e-02	2.528e-01
0.15	9.582e+07	6.013e-01	5.685e+00	9.902e-04	9.362e-03
0.2	4.963e+09	8.389e+01	6.730e+02	1.481e-01	1.188e+00
0.3	5.659e+08	2.596e+01	1.651e+02	4.924e-02	3.131e-01
0.4	1.007e+09	8.459e+01	4.557e+02	1.648e-01	8.878e-01
0.5	3.684e+08	4.848e+01	2.292e+02	9.515e-02	4.499e-01
0.6	1.969e+13	3.710e+06	1.576e+07	7.241e+03	3.075e+04
0.8	2.719e+10	8.978e+03	3.243e+04	1.708e+01	6.168e+01
1.0	2.998e+10	1.525e+04	4.889e+04	2.811e+01	9.011e+01
1.5	3.551e+10	3.919e+04	1.029e+05	6.594e+01	1.732e+02
2.0	1.363e+06	2.544e+00	5.938e+00	3.934e-03	9.182e-03
3.0	2.732e+02	1.023e-03	2.063e-03	1.388e-06	2.798e-06
TOTALS:	2.154e+13	3.773e+06	1.594e+07	7.352e+03	3.108e+04

Results - Dose Point # 3 - (131.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	2.171e+10	1.577e-250	1.041e-23	1.353e-251	8.933e-25
0.02	1.376e+10	4.822e-113	1.039e-23	1.670e-114	3.598e-25
0.03	1.329e+12	4.567e-34	2.219e-21	4.526e-36	2.199e-23
0.04	3.329e+11	2.267e-14	8.984e-14	1.002e-16	3.973e-16
0.05	4.334e+09	1.356e-08	8.991e-08	3.612e-11	2.395e-10
0.06	1.167e+10	1.325e-04	1.231e-03	2.632e-07	2.445e-06
0.08	2.000e+09	2.564e-02	2.950e-01	4.058e-05	4.668e-04
0.1	3.035e+10	6.516e+00	7.510e+01	9.968e-03	1.149e-01
0.15	9.582e+07	2.696e-01	2.524e+00	4.440e-04	4.156e-03
0.2	4.963e+09	3.724e+01	2.937e+02	6.573e-02	5.184e-01
0.3	5.659e+08	1.139e+01	7.080e+01	2.161e-02	1.343e-01
0.4	1.007e+09	3.688e+01	1.936e+02	7.187e-02	3.773e-01
0.5	3.684e+08	2.103e+01	9.677e+01	4.127e-02	1.900e-01
0.6	1.969e+13	1.602e+06	6.619e+06	3.127e+03	1.292e+04
0.8	2.719e+10	3.848e+03	1.352e+04	7.319e+00	2.571e+01
1.0	2.998e+10	6.495e+03	2.025e+04	1.197e+01	3.733e+01
1.5	3.551e+10	1.648e+04	4.213e+04	2.774e+01	7.088e+01
2.0	1.363e+06	1.061e+00	2.410e+00	1.640e-03	3.727e-03
3.0	2.732e+02	4.214e-04	8.282e-04	5.717e-07	1.124e-06
TOTALS:	2.154e+13	1.629e+06	6.696e+06	3.174e+03	1.305e+04

Results - Dose Point # 4 - (41.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	2.171e+10	2.249e-251	5.228e-23	1.929e-252	4.484e-24
0.02	1.376e+10	8.264e-113	5.214e-23	2.863e-114	1.806e-24
0.03	1.329e+12	1.724e-33	1.114e-20	1.708e-35	1.104e-22

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.04	3.329e+11	8.591e-14	3.402e-13	3.800e-16	1.505e-15
0.05	4.334e+09	4.539e-08	2.993e-07	1.209e-10	7.974e-10
0.06	1.167e+10	4.246e-04	3.937e-03	8.433e-07	7.820e-06
0.08	2.000e+09	8.413e-02	9.715e-01	1.331e-04	1.537e-03
0.1	3.035e+10	2.175e+01	2.519e+02	3.328e-02	3.854e-01
0.15	9.582e+07	9.228e-01	8.763e+00	1.520e-03	1.443e-02
0.2	4.963e+09	1.292e+02	1.042e+03	2.281e-01	1.839e+00
0.3	5.659e+08	4.013e+01	2.566e+02	7.612e-02	4.868e-01
0.4	1.007e+09	1.310e+02	7.096e+02	2.553e-01	1.383e+00
0.5	3.684e+08	7.517e+01	3.573e+02	1.475e-01	7.014e-01
0.6	1.969e+13	5.758e+06	2.458e+07	1.124e+04	4.798e+04
0.8	2.719e+10	1.395e+04	5.066e+04	2.654e+01	9.636e+01
1.0	2.998e+10	2.373e+04	7.643e+04	4.374e+01	1.409e+02
1.5	3.551e+10	6.112e+04	1.612e+05	1.028e+02	2.712e+02
2.0	1.363e+06	3.972e+00	9.308e+00	6.143e-03	1.439e-02
3.0	2.732e+02	1.599e-03	3.238e-03	2.170e-06	4.393e-06
TOTALS:	2.154e+13	5.857e+06	2.487e+07	1.141e+04	4.850e+04

Results - Dose Point # 5 - (51.75,168.93,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.171e+10	4.684e-250	3.900e-23	4.018e-251	3.345e-24
0.02	1.376e+10	1.622e-112	3.890e-23	5.619e-114	1.347e-24
0.03	1.329e+12	1.295e-33	8.308e-21	1.284e-35	8.234e-23
0.04	3.329e+11	5.746e-14	2.277e-13	2.541e-16	1.007e-15
0.05	4.334e+09	3.518e-08	2.335e-07	9.372e-11	6.219e-10
0.06	1.167e+10	3.479e-04	3.229e-03	6.910e-07	6.414e-06
0.08	2.000e+09	6.755e-02	7.765e-01	1.069e-04	1.229e-03
0.1	3.035e+10	1.727e+01	1.993e+02	2.642e-02	3.049e-01
0.15	9.582e+07	7.269e-01	6.880e+00	1.197e-03	1.133e-02
0.2	4.963e+09	1.015e+02	8.156e+02	1.792e-01	1.439e+00
0.3	5.659e+08	3.144e+01	2.003e+02	5.965e-02	3.799e-01
0.4	1.007e+09	1.025e+02	5.532e+02	1.998e-01	1.078e+00
0.5	3.684e+08	5.878e+01	2.784e+02	1.154e-01	5.465e-01
0.6	1.969e+13	4.499e+06	1.914e+07	8.782e+03	3.737e+04
0.8	2.719e+10	1.089e+04	3.943e+04	2.072e+01	7.500e+01
1.0	2.998e+10	1.851e+04	5.947e+04	3.413e+01	1.096e+02
1.5	3.551e+10	4.762e+04	1.253e+05	8.012e+01	2.109e+02
2.0	1.363e+06	3.093e+00	7.236e+00	4.784e-03	1.119e-02
3.0	2.732e+02	1.245e-03	2.516e-03	1.689e-06	3.413e-06
TOTALS:	2.154e+13	4.577e+06	1.937e+07	8.918e+03	3.777e+04

Results - Dose Point # 6 - (96.75,168.93,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.171e+10	2.442e-250	1.652e-23	2.095e-251	1.417e-24
0.02	1.376e+10	6.461e-113	1.648e-23	2.238e-114	5.709e-25
0.03	1.329e+12	6.326e-34	3.520e-21	6.270e-36	3.489e-23
0.04	3.329e+11	3.120e-14	1.236e-13	1.380e-16	5.468e-16
0.05	4.334e+09	1.864e-08	1.236e-07	4.967e-11	3.292e-10
0.06	1.167e+10	1.822e-04	1.691e-03	3.619e-07	3.359e-06

Page : 5
 DOS File : CSSF 5 Calcine in Grout.ms6
 Run Date: April 5, 2005
 Run Time: 3:15:31 PM
 Duration : 00:01:02

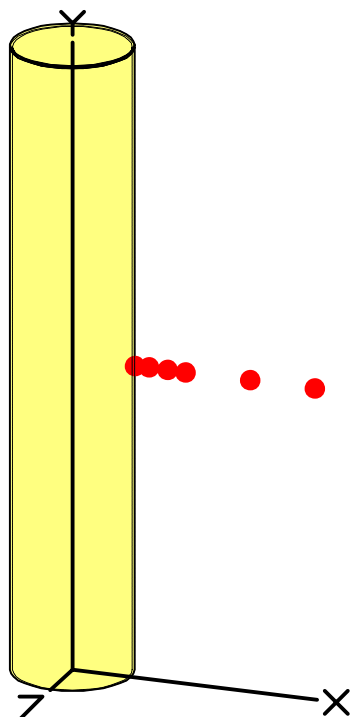
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.08	2.000e+09	3.527e-02	4.055e-01	5.581e-05	6.418e-04
0.1	3.035e+10	8.983e+00	1.036e+02	1.374e-02	1.585e-01
0.15	9.582e+07	3.755e-01	3.543e+00	6.183e-04	5.834e-03
0.2	4.963e+09	5.223e+01	4.171e+02	9.219e-02	7.361e-01
0.3	5.659e+08	1.610e+01	1.016e+02	3.055e-02	1.928e-01
0.4	1.007e+09	5.236e+01	2.794e+02	1.020e-01	5.444e-01
0.5	3.684e+08	2.995e+01	1.401e+02	5.879e-02	2.751e-01
0.6	1.969e+13	2.288e+06	9.612e+06	4.466e+03	1.876e+04
0.8	2.719e+10	5.521e+03	1.971e+04	1.050e+01	3.749e+01
1.0	2.998e+10	9.354e+03	2.963e+04	1.724e+01	5.461e+01
1.5	3.551e+10	2.391e+04	6.200e+04	4.022e+01	1.043e+02
2.0	1.363e+06	1.546e+00	3.561e+00	2.390e-03	5.507e-03
3.0	2.732e+02	6.178e-04	1.230e-03	8.381e-07	1.669e-06
TOTALS:	2.154e+13	2.327e+06	9.724e+06	4.534e+03	1.896e+04

MicroShield v6.10 (0028)
INEEL

Page : 1
 DOS File : CSSF 6 Calcine in Grout.ms6
 Run Date : April 5, 2005
 Run Time : 2:02:52 PM
 Duration : 00:01:03

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

Case Title: CSSF 6 Calcine Grout
Description: CSSF 6 Calcine Grouted at 21.5 wt% in Storage Canister
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	337.86 cm	11 ft 1.0 in
Radius	30.48 cm	1 ft

Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	34.29 cm 1 ft 1.5 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 2	61.75 cm 2 ft 0.3 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 3	131.75 cm 4 ft 3.9 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 4	41.75 cm 1 ft 4.4 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 5	51.75 cm 1 ft 8.4 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 6	96.75 cm 3 ft 2.1 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	9.86e+05 cm ³	Concrete	1.8
Transition		Air	0.00122
Air Gap		Air	0.00122
Wall Clad	1.27 cm	Iron	7.95
Top Clad	1.27 cm	Iron	7.95

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included

Library : ICRP-38

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm³</u>	<u>Bq/cm³</u>
Am-241	2.5934e-001	9.5956e+009	2.6300e-001	9.7310e+003
Am-243	2.4849e-004	9.1943e+006	2.5200e-004	9.3240e+000
Ba-137m	2.5343e+002	9.3767e+012	2.5700e+002	9.5090e+006
Ce-144	1.8045e-009	6.6768e+001	1.8300e-009	6.7710e-005
Cm-242	6.4392e-004	2.3825e+007	6.5300e-004	2.4161e+001
Cm-244	3.9049e-004	1.4448e+007	3.9600e-004	1.4652e+001
Co-60	4.7530e-002	1.7586e+009	4.8200e-002	1.7834e+003
Cs-134	3.9444e-003	1.4594e+008	4.0000e-003	1.4800e+002
Cs-135	4.6642e-003	1.7258e+008	4.7300e-003	1.7501e+002
Cs-137	2.6822e+002	9.9240e+012	2.7200e+002	1.0064e+007
Eu-152	9.6341e-003	3.5646e+008	9.7700e-003	3.6149e+002
Eu-154	6.0940e-001	2.2548e+010	6.1800e-001	2.2866e+004
Eu-155	7.0407e-002	2.6051e+009	7.1400e-002	2.6418e+003
I-129	3.9444e-003	1.4594e+008	4.0000e-003	1.4800e+002
Ni-63	1.4693e+001	5.4363e+011	1.4900e+001	5.5130e+005
Np-237	2.6920e-003	9.9605e+007	2.7300e-003	1.0101e+002
Pa-233	2.6920e-003	9.9605e+007	2.7300e-003	1.0101e+002
Pm-147	1.5777e-002	5.8377e+008	1.6000e-002	5.9200e+002
Pr-144	1.8045e-009	6.6768e+001	1.8300e-009	6.7710e-005

Nuclide	curies	becquerels	μCi/cm ³	Bq/cm ³
Pu-238	1.9820e+000	7.3336e+010	2.0100e+000	7.4370e+004
Pu-239	1.6862e-001	6.2390e+009	1.7100e-001	6.3270e+003
Pu-240	4.9699e-002	1.8389e+009	5.0400e-002	1.8648e+003
Pu-241	1.4002e+000	5.1809e+010	1.4200e+000	5.2540e+004
Pu-242	7.8197e-002	2.8933e+009	7.9300e-002	2.9341e+003
Ru-106	7.0900e-008	2.6233e+003	7.1900e-008	2.6603e-003
Sb-125	5.6602e-003	2.0943e+008	5.7400e-003	2.1238e+002
Sb-126	4.0627e-004	1.5032e+007	4.1200e-004	1.5244e+001
Sb-126m	2.8991e-003	1.0727e+008	2.9400e-003	1.0878e+002
Sm-151	2.4849e+000	9.1943e+010	2.5200e+000	9.3240e+004
Sr-90	2.5244e+002	9.3402e+012	2.5600e+002	9.4720e+006
Tc-99	1.0650e-001	3.9404e+009	1.0800e-001	3.9960e+003
Th-230	1.0255e-005	3.7945e+005	1.0400e-005	3.8480e-001
Th-231	3.2442e-005	1.2004e+006	3.2900e-005	1.2173e+000
U-232	5.4432e-006	2.0140e+005	5.5200e-006	2.0424e-001
U-233	5.7883e-007	2.1417e+004	5.8700e-007	2.1719e-002
U-234	1.3707e-003	5.0715e+007	1.3900e-003	5.1430e+001
U-235	3.5105e-005	1.2989e+006	3.5600e-005	1.3172e+000
U-236	8.2930e-005	3.0684e+006	8.4100e-005	3.1117e+000
U-237	3.6091e-005	1.3354e+006	3.6600e-005	1.3542e+000
U-238	3.4809e-005	1.2879e+006	3.5300e-005	1.3061e+000
Y-90	2.5244e+002	9.3402e+012	2.5600e+002	9.4720e+006

Buildup
 The material reference is : Source

Integration Parameters

Radial	24
Circumferential	24
Y Direction (axial)	24

Results - Dose Point # 1 - (34.29,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	6.271e+09	7.844e-268	2.026e-23	6.728e-269	1.738e-24
0.02	4.039e+09	1.313e-119	2.053e-23	4.548e-121	7.112e-25
0.03	5.683e+11	4.224e-35	6.388e-21	4.186e-37	6.331e-23
0.04	1.406e+11	2.184e-14	8.731e-14	9.657e-17	3.861e-16
0.05	1.432e+09	1.787e-08	1.201e-07	4.760e-11	3.199e-10
0.06	3.463e+09	1.799e-04	1.681e-03	3.574e-07	3.339e-06
0.08	8.346e+08	4.876e-02	5.510e-01	7.716e-05	8.719e-04
0.1	9.816e+09	9.296e+00	1.050e+02	1.422e-02	1.607e-01
0.15	3.110e+07	3.842e-01	3.624e+00	6.327e-04	5.968e-03
0.2	1.595e+09	5.317e+01	4.294e+02	9.384e-02	7.579e-01
0.3	1.946e+08	1.770e+01	1.139e+02	3.357e-02	2.160e-01
0.4	3.792e+08	6.340e+01	3.458e+02	1.235e-01	6.737e-01
0.5	1.274e+08	3.344e+01	1.601e+02	6.565e-02	3.143e-01
0.6	8.420e+12	3.171e+06	1.363e+07	6.189e+03	2.661e+04
0.8	8.701e+09	5.762e+03	2.105e+04	1.096e+01	4.004e+01
1.0	8.931e+09	9.139e+03	2.960e+04	1.685e+01	5.457e+01
1.5	1.068e+10	2.380e+04	6.305e+04	4.005e+01	1.061e+02
2.0	4.347e+05	1.643e+00	3.864e+00	2.541e-03	5.975e-03
3.0	6.331e+01	4.813e-04	9.765e-04	6.529e-07	1.325e-06
TOTALS:	9.185e+12	3.210e+06	1.375e+07	6.257e+03	2.681e+04

Results - Dose Point # 2 - (61.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	6.271e+09	1.583e-250	8.890e-24	1.358e-251	7.625e-25
0.02	4.039e+09	3.664e-113	9.010e-24	1.269e-114	3.121e-25
0.03	5.683e+11	4.176e-34	2.803e-21	4.139e-36	2.778e-23
0.04	1.406e+11	2.084e-14	8.260e-14	9.216e-17	3.653e-16
0.05	1.432e+09	9.792e-09	6.489e-08	2.608e-11	1.729e-10
0.06	3.463e+09	8.578e-05	7.961e-04	1.704e-07	1.581e-06
0.08	8.346e+08	2.342e-02	2.692e-01	3.706e-05	4.260e-04
0.1	9.816e+09	4.634e+00	5.345e+01	7.089e-03	8.177e-02
0.15	3.110e+07	1.952e-01	1.845e+00	3.214e-04	3.039e-03
0.2	1.595e+09	2.695e+01	2.162e+02	4.757e-02	3.816e-01
0.3	1.946e+08	8.927e+00	5.677e+01	1.693e-02	1.077e-01
0.4	3.792e+08	3.187e+01	1.717e+02	6.209e-02	3.345e-01
0.5	1.274e+08	1.677e+01	7.927e+01	3.291e-02	1.556e-01
0.6	8.420e+12	1.586e+06	6.737e+06	3.096e+03	1.315e+04
0.8	8.701e+09	2.872e+03	1.038e+04	5.464e+00	1.974e+01
1.0	8.931e+09	4.544e+03	1.457e+04	8.375e+00	2.685e+01
1.5	1.068e+10	1.178e+04	3.094e+04	1.982e+01	5.205e+01
2.0	4.347e+05	8.113e-01	1.893e+00	1.255e-03	2.928e-03
3.0	6.331e+01	2.370e-04	4.780e-04	3.215e-07	6.484e-07
TOTALS:	9.185e+12	1.605e+06	6.793e+06	3.130e+03	1.325e+04

Results - Dose Point # 3 - (131.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	6.271e+09	4.557e-251	3.009e-24	3.909e-252	2.581e-25
0.02	4.039e+09	1.415e-113	3.049e-24	4.903e-115	1.056e-25
0.03	5.683e+11	1.953e-34	9.487e-22	1.935e-36	9.403e-24
0.04	1.406e+11	9.576e-15	3.795e-14	4.235e-17	1.679e-16
0.05	1.432e+09	4.481e-09	2.971e-08	1.194e-11	7.915e-11
0.06	3.463e+09	3.932e-05	3.651e-04	7.809e-08	7.253e-07
0.08	8.346e+08	1.070e-02	1.231e-01	1.693e-05	1.948e-04
0.1	9.816e+09	2.107e+00	2.429e+01	3.224e-03	3.716e-02
0.15	3.110e+07	8.753e-02	8.193e-01	1.441e-04	1.349e-03
0.2	1.595e+09	1.196e+01	9.437e+01	2.112e-02	1.666e-01
0.3	1.946e+08	3.919e+00	2.435e+01	7.434e-03	4.619e-02
0.4	3.792e+08	1.389e+01	7.294e+01	2.707e-02	1.421e-01
0.5	1.274e+08	7.272e+00	3.347e+01	1.427e-02	6.570e-02
0.6	8.420e+12	6.850e+05	2.830e+06	1.337e+03	5.524e+03
0.8	8.701e+09	1.231e+03	4.325e+03	2.342e+00	8.226e+00
1.0	8.931e+09	1.935e+03	6.034e+03	3.567e+00	1.112e+01
1.5	1.068e+10	4.955e+03	1.266e+04	8.337e+00	2.131e+01
2.0	4.347e+05	3.382e-01	7.685e-01	5.230e-04	1.188e-03
3.0	6.331e+01	9.764e-05	1.919e-04	1.325e-07	2.604e-07
TOTALS:	9.185e+12	6.931e+05	2.854e+06	1.351e+03	5.565e+03

Results - Dose Point # 4 - (41.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	6.271e+09	6.499e-252	1.510e-23	5.574e-253	1.295e-24
0.02	4.039e+09	2.426e-113	1.531e-23	8.404e-115	5.302e-25
0.03	5.683e+11	7.371e-34	4.762e-21	7.305e-36	4.720e-23

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.04	1.406e+11	3.629e-14	1.437e-13	1.605e-16	6.356e-16
0.05	1.432e+09	1.500e-08	9.891e-08	3.995e-11	2.635e-10
0.06	3.463e+09	1.260e-04	1.168e-03	2.502e-07	2.320e-06
0.08	8.346e+08	3.510e-02	4.054e-01	5.555e-05	6.415e-04
0.1	9.816e+09	7.035e+00	8.146e+01	1.076e-02	1.246e-01
0.15	3.110e+07	2.995e-01	2.844e+00	4.933e-04	4.684e-03
0.2	1.595e+09	4.153e+01	3.348e+02	7.329e-02	5.910e-01
0.3	1.946e+08	1.380e+01	8.825e+01	2.618e-02	1.674e-01
0.4	3.792e+08	4.935e+01	2.673e+02	9.616e-02	5.209e-01
0.5	1.274e+08	2.600e+01	1.236e+02	5.103e-02	2.426e-01
0.6	8.420e+12	2.462e+06	1.051e+07	4.805e+03	2.052e+04
0.8	8.701e+09	4.465e+03	1.621e+04	8.493e+00	3.083e+01
1.0	8.931e+09	7.071e+03	2.277e+04	1.303e+01	4.198e+01
1.5	1.068e+10	1.837e+04	4.845e+04	3.091e+01	8.151e+01
2.0	4.347e+05	1.267e+00	2.968e+00	1.959e-03	4.590e-03
3.0	6.331e+01	3.706e-04	7.503e-04	5.028e-07	1.018e-06
TOTALS:	9.185e+12	2.492e+06	1.060e+07	4.858e+03	2.067e+04

Results - Dose Point # 5 - (51.75,168.93,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	6.271e+09	1.353e-250	1.127e-23	1.161e-251	9.664e-25
0.02	4.039e+09	4.762e-113	1.142e-23	1.650e-114	3.955e-25
0.03	5.683e+11	5.539e-34	3.553e-21	5.490e-36	3.521e-23
0.04	1.406e+11	2.428e-14	9.619e-14	1.074e-16	4.254e-16
0.05	1.432e+09	1.163e-08	7.714e-08	3.097e-11	2.055e-10
0.06	3.463e+09	1.032e-04	9.580e-04	2.050e-07	1.903e-06
0.08	8.346e+08	2.819e-02	3.240e-01	4.460e-05	5.127e-04
0.1	9.816e+09	5.585e+00	6.446e+01	8.545e-03	9.861e-02
0.15	3.110e+07	2.360e-01	2.233e+00	3.885e-04	3.678e-03
0.2	1.595e+09	3.262e+01	2.620e+02	5.757e-02	4.625e-01
0.3	1.946e+08	1.081e+01	6.888e+01	2.051e-02	1.307e-01
0.4	3.792e+08	3.862e+01	2.084e+02	7.526e-02	4.061e-01
0.5	1.274e+08	2.033e+01	9.629e+01	3.990e-02	1.890e-01
0.6	8.420e+12	1.924e+06	8.186e+06	3.755e+03	1.598e+04
0.8	8.701e+09	3.486e+03	1.262e+04	6.630e+00	2.400e+01
1.0	8.931e+09	5.516e+03	1.772e+04	1.017e+01	3.266e+01
1.5	1.068e+10	1.432e+04	3.767e+04	2.409e+01	6.338e+01
2.0	4.347e+05	9.865e-01	2.307e+00	1.525e-03	3.568e-03
3.0	6.331e+01	2.884e-04	5.830e-04	3.913e-07	7.910e-07
TOTALS:	9.185e+12	1.947e+06	8.255e+06	3.796e+03	1.610e+04

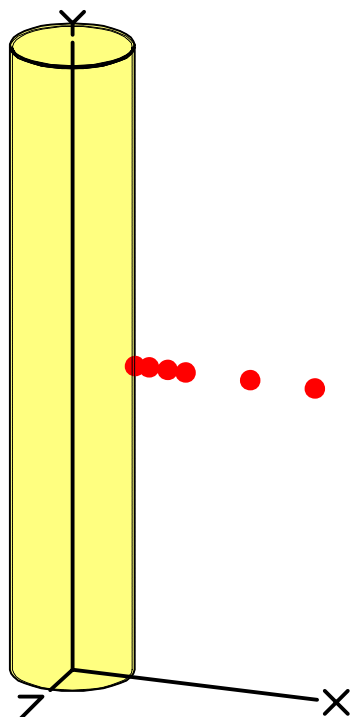
Results - Dose Point # 6 - (96.75,168.93,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	6.271e+09	7.056e-251	4.774e-24	6.052e-252	4.095e-25
0.02	4.039e+09	1.897e-113	4.838e-24	6.570e-115	1.676e-25
0.03	5.683e+11	2.705e-34	1.505e-21	2.681e-36	1.492e-23
0.04	1.406e+11	1.318e-14	5.223e-14	5.829e-17	2.310e-16
0.05	1.432e+09	6.161e-09	4.084e-08	1.641e-11	1.088e-10
0.06	3.463e+09	5.405e-05	5.018e-04	1.074e-07	9.966e-07

Page : 5
 DOS File : CSSF 6 Calcine in Grout.ms6
 Run Date: April 5, 2005
 Run Time: 2:02:52 PM
 Duration : 00:01:03

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.08	8.346e+08	1.472e-02	1.692e-01	2.329e-05	2.678e-04
0.1	9.816e+09	2.905e+00	3.351e+01	4.445e-03	5.127e-02
0.15	3.110e+07	1.219e-01	1.150e+00	2.007e-04	1.894e-03
0.2	1.595e+09	1.678e+01	1.340e+02	2.962e-02	2.365e-01
0.3	1.946e+08	5.539e+00	3.495e+01	1.051e-02	6.629e-02
0.4	3.792e+08	1.973e+01	1.053e+02	3.844e-02	2.051e-01
0.5	1.274e+08	1.036e+01	4.847e+01	2.033e-02	9.514e-02
0.6	8.420e+12	9.784e+05	4.110e+06	1.910e+03	8.022e+03
0.8	8.701e+09	1.766e+03	6.307e+03	3.360e+00	1.200e+01
1.0	8.931e+09	2.787e+03	8.827e+03	5.137e+00	1.627e+01
1.5	1.068e+10	7.186e+03	1.864e+04	1.209e+01	3.136e+01
2.0	4.347e+05	4.929e-01	1.136e+00	7.621e-04	1.756e-03
3.0	6.331e+01	1.432e-04	2.851e-04	1.942e-07	3.868e-07
TOTALS:	9.185e+12	9.902e+05	4.144e+06	1.930e+03	8.083e+03

Case Title: Grouted Calcine
Description: Combined Calcine Grouted at 21.5 wt% in Storage Canister
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	337.86 cm	11 ft 1.0 in
Radius	30.48 cm	1 ft

Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	34.29 cm 1 ft 1.5 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 2	61.75 cm 2 ft 0.3 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 3	131.75 cm 4 ft 3.9 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 4	41.75 cm 1 ft 4.4 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 5	51.75 cm 1 ft 8.4 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in
# 6	96.75 cm 3 ft 2.1 in	168.93 cm 5 ft 6.5 in	0 cm 0.0 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	9.86e+05 cm ³	Concrete	1.8
Transition		Air	0.00122
Air Gap		Air	0.00122
Wall Clad	1.27 cm	Iron	7.95
Top Clad	1.27 cm	Iron	7.95

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included

Library : ICRP-38

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm³</u>	<u>Bq/cm³</u>
Am-241	6.0349e-001	2.2329e+010	6.1200e-001	2.2644e+004
Am-243	3.9641e-004	1.4667e+007	4.0200e-004	1.4874e+001
Ba-137m	5.4728e+002	2.0249e+013	5.5500e+002	2.0535e+007
Ce-144	9.4172e-010	3.4843e+001	9.5500e-010	3.5335e-005
Cm-242	1.0058e-003	3.7215e+007	1.0200e-003	3.7740e+001
Cm-244	3.6978e-004	1.3682e+007	3.7500e-004	1.3875e+001
Co-60	6.6167e-002	2.4482e+009	6.7100e-002	2.4827e+003
Cs-134	3.5992e-003	1.3317e+008	3.6500e-003	1.3505e+002
Cs-135	1.0157e-002	3.7580e+008	1.0300e-002	3.8110e+002
Cs-137	5.7883e+002	2.1417e+013	5.8700e+002	2.1719e+007
Eu-152	1.8144e-002	6.7133e+008	1.8400e-002	6.8080e+002
Eu-154	1.1833e+000	4.3782e+010	1.2000e+000	4.4400e+004
Eu-155	8.8058e-002	3.2581e+009	8.9300e-002	3.3041e+003
I-129	5.2460e-005	1.9410e+006	5.3200e-005	1.9684e+000
Ni-63	2.8892e+001	1.0690e+012	2.9300e+001	1.0841e+006
Np-237	4.9995e-003	1.8498e+008	5.0700e-003	1.8759e+002
Pa-233	4.9995e-003	1.8498e+008	5.0700e-003	1.8759e+002
Pm-147	2.0511e-002	7.5889e+008	2.0800e-002	7.6960e+002
Pr-144	9.4172e-010	3.4843e+001	9.5500e-010	3.5335e-005

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>µCi/cm³</u>	<u>Bq/cm³</u>
Pu-238	6.8237e+000	2.5248e+011	6.9200e+000	2.5604e+005
Pu-239	1.5580e-001	5.7647e+009	1.5800e-001	5.8460e+003
Pu-240	9.2791e-002	3.4333e+009	9.4100e-002	3.4817e+003
Pu-241	2.5836e+000	9.5592e+010	2.6200e+000	9.6940e+004
Pu-242	1.2523e-002	4.6336e+008	1.2700e-002	4.6990e+002
Ru-106	3.3527e-008	1.2405e+003	3.4000e-008	1.2580e-003
Sb-125	9.3481e-003	3.4588e+008	9.4800e-003	3.5076e+002
Sb-126	9.2101e-004	3.4077e+007	9.3400e-004	3.4558e+001
Sb-126m	6.5969e-003	2.4409e+008	6.6900e-003	2.4753e+002
Sm-151	5.9264e+000	2.1928e+011	6.0100e+000	2.2237e+005
Sr-90	5.1573e+002	1.9082e+013	5.2300e+002	1.9351e+007
Tc-99	2.4455e-001	9.0484e+009	2.4800e-001	9.1760e+003
Th-230	2.5638e-005	9.4862e+005	2.6000e-005	9.6200e-001
Th-231	2.4751e-005	9.1578e+005	2.5100e-005	9.2870e-001
U-232	1.7848e-005	6.6038e+005	1.8100e-005	6.6970e-001
U-233	1.1833e-006	4.3782e+004	1.2000e-006	4.4400e-002
U-234	4.7234e-003	1.7476e+008	4.7900e-003	1.7723e+002
U-235	2.4258e-005	8.9754e+005	2.4600e-005	9.1020e-001
U-236	7.4351e-005	2.7510e+006	7.5400e-005	2.7898e+000
U-237	6.4490e-005	2.3861e+006	6.5400e-005	2.4198e+000
U-238	9.0720e-006	3.3567e+005	9.2000e-006	3.4040e-001
Y-90	5.1573e+002	1.9082e+013	5.2300e+002	1.9351e+007

Buildup
The material reference is : Source

Integration Parameters

Radial	24
Circumferential	24
Y Direction (axial)	24

Results - Dose Point # 1 - (34.29,168.93,0) cm

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u>		<u>Exposure Rate</u> <u>mR/hr</u>	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	1.847e+10	2.311e-267	5.968e-23	1.982e-268	5.119e-24
0.02	1.028e+10	3.341e-119	5.225e-23	1.157e-120	1.810e-24
0.03	1.227e+12	9.120e-35	1.379e-20	9.039e-37	1.367e-22
0.04	3.021e+11	4.691e-14	1.876e-13	2.075e-16	8.296e-16
0.05	2.671e+09	3.333e-08	2.240e-07	8.880e-11	5.968e-10
0.06	8.024e+09	4.169e-04	3.895e-03	8.281e-07	7.736e-06
0.08	1.059e+09	6.186e-02	6.990e-01	9.789e-05	1.106e-03
0.1	1.869e+10	1.770e+01	2.000e+02	2.708e-02	3.059e-01
0.15	5.974e+07	7.379e-01	6.961e+00	1.215e-03	1.146e-02
0.2	3.089e+09	1.030e+02	8.319e+02	1.818e-01	1.468e+00
0.3	3.682e+08	3.348e+01	2.154e+02	6.351e-02	4.086e-01
0.4	7.502e+08	1.254e+02	6.841e+02	2.444e-01	1.333e+00
0.5	2.388e+08	6.267e+01	3.000e+02	1.230e-01	5.889e-01
0.6	1.818e+13	6.847e+06	2.944e+07	1.337e+04	5.746e+04
0.8	1.675e+10	1.109e+04	4.053e+04	2.110e+01	7.710e+01
1.0	1.636e+10	1.675e+04	5.425e+04	3.087e+01	9.999e+01
1.5	1.975e+10	4.405e+04	1.167e+05	7.410e+01	1.963e+02
2.0	8.316e+05	3.144e+00	7.392e+00	4.862e-03	1.143e-02
3.0	8.813e+01	6.700e-04	1.359e-03	9.090e-07	1.844e-06
TOTALS:	1.983e+13	6.920e+06	2.965e+07	1.349e+04	5.784e+04

Results - Dose Point # 2 - (61.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.015	1.847e+10	4.662e-250	2.619e-23	3.999e-251	2.246e-24
0.02	1.028e+10	9.323e-113	2.293e-23	3.230e-114	7.942e-25
0.03	1.227e+12	9.017e-34	6.053e-21	8.936e-36	5.998e-23
0.04	3.021e+11	4.477e-14	1.775e-13	1.980e-16	7.848e-16
0.05	2.671e+09	1.827e-08	1.210e-07	4.866e-11	3.224e-10
0.06	8.024e+09	1.987e-04	1.844e-03	3.948e-07	3.664e-06
0.08	1.059e+09	2.971e-02	3.415e-01	4.701e-05	5.404e-04
0.1	1.869e+10	8.822e+00	1.018e+02	1.350e-02	1.557e-01
0.15	5.974e+07	3.749e-01	3.544e+00	6.174e-04	5.837e-03
0.2	3.089e+09	5.222e+01	4.189e+02	9.216e-02	7.393e-01
0.3	3.682e+08	1.689e+01	1.074e+02	3.203e-02	2.037e-01
0.4	7.502e+08	6.305e+01	3.396e+02	1.229e-01	6.618e-01
0.5	2.388e+08	3.142e+01	1.485e+02	6.167e-02	2.916e-01
0.6	1.818e+13	3.425e+06	1.455e+07	6.686e+03	2.840e+04
0.8	1.675e+10	5.531e+03	1.998e+04	1.052e+01	3.800e+01
1.0	1.636e+10	8.325e+03	2.669e+04	1.535e+01	4.920e+01
1.5	1.975e+10	2.180e+04	5.725e+04	3.668e+01	9.632e+01
2.0	8.316e+05	1.552e+00	3.622e+00	2.400e-03	5.602e-03
3.0	8.813e+01	3.299e-04	6.654e-04	4.476e-07	9.027e-07
TOTALS:	1.983e+13	3.461e+06	1.465e+07	6.749e+03	2.858e+04

Results - Dose Point # 3 - (131.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.015	1.847e+10	1.343e-250	8.863e-24	1.152e-251	7.602e-25
0.02	1.028e+10	3.602e-113	7.760e-24	1.248e-114	2.688e-25
0.03	1.227e+12	4.216e-34	2.048e-21	4.179e-36	2.030e-23
0.04	3.021e+11	2.057e-14	8.154e-14	9.098e-17	3.606e-16
0.05	2.671e+09	8.359e-09	5.542e-08	2.227e-11	1.476e-10
0.06	8.024e+09	9.110e-05	8.460e-04	1.809e-07	1.680e-06
0.08	1.059e+09	1.357e-02	1.561e-01	2.148e-05	2.471e-04
0.1	1.869e+10	4.012e+00	4.624e+01	6.138e-03	7.074e-02
0.15	5.974e+07	1.681e-01	1.574e+00	2.768e-04	2.591e-03
0.2	3.089e+09	2.318e+01	1.828e+02	4.091e-02	3.227e-01
0.3	3.682e+08	7.413e+00	4.606e+01	1.406e-02	8.736e-02
0.4	7.502e+08	2.749e+01	1.443e+02	5.357e-02	2.812e-01
0.5	2.388e+08	1.363e+01	6.272e+01	2.675e-02	1.231e-01
0.6	1.818e+13	1.479e+06	6.112e+06	2.887e+03	1.193e+04
0.8	1.675e+10	2.371e+03	8.327e+03	4.509e+00	1.584e+01
1.0	1.636e+10	3.546e+03	1.106e+04	6.536e+00	2.038e+01
1.5	1.975e+10	9.169e+03	2.343e+04	1.543e+01	3.942e+01
2.0	8.316e+05	6.471e-01	1.470e+00	1.001e-03	2.274e-03
3.0	8.813e+01	1.359e-04	2.672e-04	1.844e-07	3.625e-07
TOTALS:	1.983e+13	1.494e+06	6.155e+06	2.914e+03	1.201e+04

Results - Dose Point # 4 - (41.75,168.93,0) cm

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.015	1.847e+10	1.914e-251	4.449e-23	1.642e-252	3.816e-24
0.02	1.028e+10	6.174e-113	3.895e-23	2.139e-114	1.349e-24
0.03	1.227e+12	1.591e-33	1.028e-20	1.577e-35	1.019e-22

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.04	3.021e+11	7.797e-14	3.087e-13	3.448e-16	1.365e-15
0.05	2.671e+09	2.798e-08	1.845e-07	7.453e-11	4.915e-10
0.06	8.024e+09	2.918e-04	2.706e-03	5.797e-07	5.375e-06
0.08	1.059e+09	4.453e-02	5.143e-01	7.047e-05	8.138e-04
0.1	1.869e+10	1.339e+01	1.551e+02	2.049e-02	2.373e-01
0.15	5.974e+07	5.753e-01	5.463e+00	9.474e-04	8.996e-03
0.2	3.089e+09	8.045e+01	6.487e+02	1.420e-01	1.145e+00
0.3	3.682e+08	2.610e+01	1.669e+02	4.952e-02	3.167e-01
0.4	7.502e+08	9.765e+01	5.289e+02	1.903e-01	1.031e+00
0.5	2.388e+08	4.872e+01	2.316e+02	9.562e-02	4.546e-01
0.6	1.818e+13	5.316e+06	2.270e+07	1.038e+04	4.431e+04
0.8	1.675e+10	8.597e+03	3.121e+04	1.635e+01	5.936e+01
1.0	1.636e+10	1.296e+04	4.173e+04	2.388e+01	7.692e+01
1.5	1.975e+10	3.399e+04	8.965e+04	5.719e+01	1.508e+02
2.0	8.316e+05	2.423e+00	5.679e+00	3.748e-03	8.781e-03
3.0	8.813e+01	5.159e-04	1.044e-03	7.000e-07	1.417e-06
TOTALS:	1.983e+13	5.372e+06	2.286e+07	1.047e+04	4.460e+04

Results - Dose Point # 5 - (51.75,168.93,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	1.847e+10	3.987e-250	3.319e-23	3.419e-251	2.847e-24
0.02	1.028e+10	1.212e-112	2.906e-23	4.198e-114	1.007e-24
0.03	1.227e+12	1.196e-33	7.671e-21	1.185e-35	7.602e-23
0.04	3.021e+11	5.215e-14	2.066e-13	2.307e-16	9.139e-16
0.05	2.671e+09	2.169e-08	1.439e-07	5.777e-11	3.833e-10
0.06	8.024e+09	2.391e-04	2.220e-03	4.749e-07	4.409e-06
0.08	1.059e+09	3.576e-02	4.110e-01	5.659e-05	6.505e-04
0.1	1.869e+10	1.063e+01	1.227e+02	1.627e-02	1.877e-01
0.15	5.974e+07	4.532e-01	4.290e+00	7.463e-04	7.064e-03
0.2	3.089e+09	6.319e+01	5.076e+02	1.115e-01	8.959e-01
0.3	3.682e+08	2.046e+01	1.303e+02	3.880e-02	2.472e-01
0.4	7.502e+08	7.642e+01	4.124e+02	1.489e-01	8.035e-01
0.5	2.388e+08	3.809e+01	1.804e+02	7.477e-02	3.542e-01
0.6	1.818e+13	4.154e+06	1.768e+07	8.109e+03	3.450e+04
0.8	1.675e+10	6.712e+03	2.429e+04	1.277e+01	4.620e+01
1.0	1.636e+10	1.011e+04	3.247e+04	1.863e+01	5.985e+01
1.5	1.975e+10	2.649e+04	6.971e+04	4.457e+01	1.173e+02
2.0	8.316e+05	1.887e+00	4.414e+00	2.918e-03	6.826e-03
3.0	8.813e+01	4.015e-04	8.116e-04	5.448e-07	1.101e-06
TOTALS:	1.983e+13	4.198e+06	1.781e+07	8.185e+03	3.473e+04

Results - Dose Point # 6 - (96.75,168.93,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	1.847e+10	2.079e-250	1.406e-23	1.783e-251	1.206e-24
0.02	1.028e+10	4.826e-113	1.231e-23	1.672e-114	4.265e-25
0.03	1.227e+12	5.841e-34	3.250e-21	5.789e-36	3.221e-23
0.04	3.021e+11	2.831e-14	1.122e-13	1.252e-16	4.963e-16
0.05	2.671e+09	1.149e-08	7.618e-08	3.061e-11	2.029e-10
0.06	8.024e+09	1.252e-04	1.163e-03	2.487e-07	2.309e-06

Page : 5
 DOS File : Combined Calcine in Grout.ms6
 Run Date: April 5, 2005
 Run Time: 3:17:39 PM
 Duration : 00:01:02

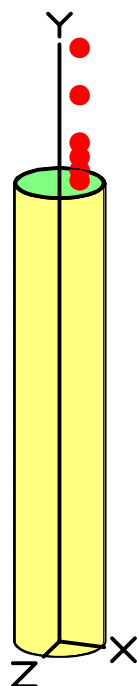
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.08	1.059e+09	1.867e-02	2.147e-01	2.955e-05	3.397e-04
0.1	1.869e+10	5.531e+00	6.381e+01	8.462e-03	9.762e-02
0.15	5.974e+07	2.341e-01	2.209e+00	3.855e-04	3.637e-03
0.2	3.089e+09	3.251e+01	2.596e+02	5.738e-02	4.582e-01
0.3	3.682e+08	1.048e+01	6.610e+01	1.987e-02	1.254e-01
0.4	7.502e+08	3.903e+01	2.083e+02	7.605e-02	4.058e-01
0.5	2.388e+08	1.941e+01	9.083e+01	3.810e-02	1.783e-01
0.6	1.818e+13	2.113e+06	8.875e+06	4.124e+03	1.732e+04
0.8	1.675e+10	3.401e+03	1.214e+04	6.470e+00	2.310e+01
1.0	1.636e+10	5.106e+03	1.617e+04	9.413e+00	2.981e+01
1.5	1.975e+10	1.330e+04	3.449e+04	2.237e+01	5.802e+01
2.0	8.316e+05	9.429e-01	2.173e+00	1.458e-03	3.360e-03
3.0	8.813e+01	1.993e-04	3.969e-04	2.704e-07	5.384e-07
TOTALS:	1.983e+13	2.135e+06	8.939e+06	4.162e+03	1.744e+04

MicroShield v6.10 (0028)
INEEL

Page : 1
 DOS File : Combined Calcine Grout in Canister - Top - No Lid.ms6
 Run Date : April 5, 2005
 Run Time : 2:39:39 PM
 Duration : 00:01:05

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

Case Title: Combined Calcine Grt
Description: Radiation measured from above open canister.
Geometry: 8 - Cylinder Volume - End Shields



	Source Dimensions	
Height	337.86 cm	11 ft 1.0 in
Radius	30.48 cm	1 ft

	Dose Points		
	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	15.24 cm 6.0 in	341.67 cm 11 ft 2.5 in	0 cm 0.0 in
# 2	15.24 cm 6.0 in	369.61 cm 12 ft 1.5 in	0 cm 0.0 in
# 3	15.24 cm 6.0 in	439.13 cm 14 ft 4.9 in	0 cm 0.0 in
# 4	15.24 cm 6.0 in	349.13 cm 11 ft 5.5 in	0 cm 0.0 in
# 5	15.24 cm 6.0 in	359.13 cm 11 ft 9.4 in	0 cm 0.0 in
# 6	15.24 cm 6.0 in	404.13 cm 13 ft 3.1 in	0 cm 0.0 in

	Shields		
<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	9.86e+05 cm ³	Concrete	1.8
Air Gap		Air	0.00122
Wall Clad	1.27 cm	Iron	7.95

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included
Library : ICRP-38

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm³</u>	<u>Bq/cm³</u>
Am-241	6.0349e-001	2.2329e+010	6.1200e-001	2.2644e+004
Am-243	3.9641e-004	1.4667e+007	4.0200e-004	1.4874e+001
Ba-137m	5.4728e+002	2.0249e+013	5.5500e+002	2.0535e+007
Ce-144	9.4172e-010	3.4843e+001	9.5500e-010	3.5335e-005
Cm-242	1.0058e-003	3.7215e+007	1.0200e-003	3.7740e+001
Co-60	6.6167e-002	2.4482e+009	6.7100e-002	2.4827e+003
Cs-134	3.5992e-003	1.3317e+008	3.6500e-003	1.3505e+002
Cs-135	1.0157e-002	3.7580e+008	1.0300e-002	3.8110e+002
Cs-137	5.7883e+002	2.1417e+013	5.8700e+002	2.1719e+007
Eu-152	1.8144e-002	6.7133e+008	1.8400e-002	6.8080e+002
Eu-154	1.1833e+000	4.3782e+010	1.2000e+000	4.4400e+004
Eu-155	8.8058e-002	3.2581e+009	8.9300e-002	3.3041e+003
I-129	5.2460e-005	1.9410e+006	5.3200e-005	1.9684e+000
Ni-63	2.8892e+001	1.0690e+012	2.9300e+001	1.0841e+006
Np-237	4.9995e-003	1.8498e+008	5.0700e-003	1.8759e+002
Pa-233	4.9995e-003	1.8498e+008	5.0700e-003	1.8759e+002
Pm-147	2.0511e-002	7.5889e+008	2.0800e-002	7.6960e+002
Pr-144	9.4172e-010	3.4843e+001	9.5500e-010	3.5335e-005
Pu-238	6.8237e+000	2.5248e+011	6.9200e+000	2.5604e+005
Pu-239	1.5580e-001	5.7647e+009	1.5800e-001	5.8460e+003
Pu-240	9.2791e-002	3.4333e+009	9.4100e-002	3.4817e+003

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>µCi/cm³</u>	<u>Bq/cm³</u>
Pu-241	2.5836e+000	9.5592e+010	2.6200e+000	9.6940e+004
Pu-242	1.2523e-002	4.6336e+008	1.2700e-002	4.6990e+002
Ru-106	3.3527e-008	1.2405e+003	3.4000e-008	1.2580e-003
Sb-125	9.3481e-003	3.4588e+008	9.4800e-003	3.5076e+002
Sb-126	9.2101e-004	3.4077e+007	9.3400e-004	3.4558e+001
Sb-126m	6.5969e-003	2.4409e+008	6.6900e-003	2.4753e+002
Sm-151	5.9264e+000	2.1928e+011	6.0100e+000	2.2237e+005
Sr-90	5.1573e+002	1.9082e+013	5.2300e+002	1.9351e+007
Tc-99	2.4455e-001	9.0484e+009	2.4800e-001	9.1760e+003
Th-230	2.5638e-005	9.4862e+005	2.6000e-005	9.6200e-001
Th-231	2.4751e-005	9.1578e+005	2.5100e-005	9.2870e-001
U-232	1.7848e-005	6.6038e+005	1.8100e-005	6.6970e-001
U-233	1.1833e-006	4.3782e+004	1.2000e-006	4.4400e-002
U-234	4.7234e-003	1.7476e+008	4.7900e-003	1.7723e+002
U-235	2.4258e-005	8.9754e+005	2.4600e-005	9.1020e-001
U-236	7.4351e-005	2.7510e+006	7.5400e-005	2.7898e+000
U-237	6.4490e-005	2.3861e+006	6.5400e-005	2.4198e+000
U-238	9.0720e-006	3.3567e+005	9.2000e-006	3.4040e-001
Y-90	5.1573e+002	1.9082e+013	5.2300e+002	1.9351e+007

Buildup
 The material reference is : Source

Integration Parameters

Radial	24
Circumferential	24
Y Direction (axial)	24

Results - Dose Point # 1 - (15.24,341.67,0) cm

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u>		<u>Exposure Rate</u>	
		<u>MeV/cm²/sec</u>	<u>MeV/cm²/sec</u>	<u>mR/hr</u>	<u>mR/hr</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.244e+11	2.043e-03	2.224e-03	1.753e-04	1.907e-04
0.02	1.028e+10	2.117e-01	2.435e-01	7.335e-03	8.434e-03
0.03	1.227e+12	3.019e+03	4.005e+03	2.992e+01	3.970e+01
0.04	3.021e+11	3.755e+03	5.902e+03	1.661e+01	2.610e+01
0.05	2.671e+09	7.584e+01	1.383e+02	2.020e-01	3.685e-01
0.06	8.024e+09	3.819e+02	8.325e+02	7.586e-01	1.654e+00
0.08	1.059e+09	9.461e+01	2.445e+02	1.497e-01	3.869e-01
0.1	1.869e+10	2.464e+03	6.950e+03	3.770e+00	1.063e+01
0.15	5.974e+07	1.436e+01	4.222e+01	2.365e-02	6.953e-02
0.2	3.089e+09	1.103e+03	3.148e+03	1.947e+00	5.556e+00
0.3	3.682e+08	2.276e+02	5.951e+02	4.318e-01	1.129e+00
0.4	7.502e+08	6.862e+02	1.659e+03	1.337e+00	3.233e+00
0.5	2.388e+08	2.966e+02	6.741e+02	5.822e-01	1.323e+00
0.6	1.818e+13	2.905e+07	6.251e+07	5.670e+04	1.220e+05
0.8	1.675e+10	3.994e+04	7.924e+04	7.596e+01	1.507e+02
1.0	1.636e+10	5.334e+04	9.977e+04	9.832e+01	1.839e+02
1.5	1.975e+10	1.140e+05	1.924e+05	1.918e+02	3.237e+02
2.0	8.316e+05	7.171e+00	1.140e+01	1.109e-02	1.762e-02
3.0	8.813e+01	1.322e-03	1.940e-03	1.793e-06	2.632e-06
TOTALS:	2.003e+13	2.927e+07	6.291e+07	5.712e+04	1.228e+05

Results - Dose Point # 2 - (15.24,369.61,0) cm

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u>		<u>Exposure Rate</u>	
		<u>MeV/cm²/sec</u>	<u>MeV/cm²/sec</u>	<u>mR/hr</u>	<u>mR/hr</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.244e+11	1.772e-03	1.929e-03	1.520e-04	1.654e-04

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.02	1.028e+10	1.580e-01	1.813e-01	5.473e-03	6.279e-03
0.03	1.227e+12	1.499e+03	1.946e+03	1.486e+01	1.929e+01
0.04	3.021e+11	1.384e+03	2.052e+03	6.120e+00	9.076e+00
0.05	2.671e+09	2.428e+01	4.058e+01	6.469e-02	1.081e-01
0.06	8.024e+09	1.153e+02	2.316e+02	2.289e-01	4.600e-01
0.08	1.059e+09	2.733e+01	6.576e+01	4.325e-02	1.041e-01
0.1	1.869e+10	7.007e+02	1.863e+03	1.072e+00	2.850e+00
0.15	5.974e+07	4.024e+00	1.131e+01	6.627e-03	1.863e-02
0.2	3.089e+09	3.069e+02	8.424e+02	5.418e-01	1.487e+00
0.3	3.682e+08	6.285e+01	1.592e+02	1.192e-01	3.020e-01
0.4	7.502e+08	1.885e+02	4.443e+02	3.673e-01	8.657e-01
0.5	2.388e+08	8.121e+01	1.807e+02	1.594e-01	3.546e-01
0.6	1.818e+13	7.933e+06	1.677e+07	1.548e+04	3.273e+04
0.8	1.675e+10	1.087e+04	2.130e+04	2.067e+01	4.051e+01
1.0	1.636e+10	1.448e+04	2.687e+04	2.669e+01	4.952e+01
1.5	1.975e+10	3.086e+04	5.201e+04	5.191e+01	8.751e+01
2.0	8.316e+05	1.940e+00	3.092e+00	3.000e-03	4.781e-03
3.0	8.813e+01	3.582e-04	5.298e-04	4.860e-07	7.188e-07
TOTALS:	2.003e+13	7.993e+06	1.688e+07	1.561e+04	3.294e+04

Results - Dose Point # 3 - (15.24,439.13,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.244e+11	6.495e-04	7.067e-04	5.571e-05	6.061e-05
0.02	1.028e+10	4.184e-02	4.784e-02	1.449e-03	1.657e-03
0.03	1.227e+12	2.795e+02	3.584e+02	2.770e+00	3.552e+00
0.04	3.021e+11	2.330e+02	3.404e+02	1.031e+00	1.505e+00
0.05	2.671e+09	4.040e+00	6.754e+00	1.076e-02	1.799e-02
0.06	8.024e+09	1.924e+01	3.882e+01	3.822e-02	7.711e-02
0.08	1.059e+09	4.602e+00	1.133e+01	7.282e-03	1.793e-02
0.1	1.869e+10	1.186e+02	3.257e+02	1.815e-01	4.983e-01
0.15	5.974e+07	6.869e-01	2.011e+00	1.131e-03	3.311e-03
0.2	3.089e+09	5.267e+01	1.512e+02	9.296e-02	2.669e-01
0.3	3.682e+08	1.087e+01	2.893e+01	2.062e-02	5.488e-02
0.4	7.502e+08	3.283e+01	8.146e+01	6.397e-02	1.587e-01
0.5	2.388e+08	1.422e+01	3.334e+01	2.792e-02	6.545e-02
0.6	1.818e+13	1.396e+06	3.112e+06	2.726e+03	6.075e+03
0.8	1.675e+10	1.930e+03	3.990e+03	3.672e+00	7.589e+00
1.0	1.636e+10	2.593e+03	5.073e+03	4.780e+00	9.351e+00
1.5	1.975e+10	5.621e+03	9.978e+03	9.457e+00	1.679e+01
2.0	8.316e+05	3.583e-01	6.009e-01	5.541e-04	9.292e-04
3.0	8.813e+01	6.756e-05	1.050e-04	9.166e-08	1.425e-07
TOTALS:	2.003e+13	1.407e+06	3.133e+06	2.748e+03	6.115e+03

Results - Dose Point # 4 - (15.24,349.13,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.244e+11	2.012e-03	2.190e-03	1.726e-04	1.879e-04
0.02	1.028e+10	2.088e-01	2.401e-01	7.232e-03	8.315e-03
0.03	1.227e+12	2.744e+03	3.618e+03	2.719e+01	3.586e+01
0.04	3.021e+11	3.046e+03	4.674e+03	1.347e+01	2.067e+01

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.05	2.671e+09	5.706e+01	9.921e+01	1.520e-01	2.643e-01
0.06	8.024e+09	2.763e+02	5.719e+02	5.487e-01	1.136e+00
0.08	1.059e+09	6.618e+01	1.619e+02	1.047e-01	2.561e-01
0.1	1.869e+10	1.701e+03	4.559e+03	2.602e+00	6.975e+00
0.15	5.974e+07	9.785e+00	2.755e+01	1.611e-02	4.537e-02
0.2	3.089e+09	7.467e+02	2.050e+03	1.318e+00	3.618e+00
0.3	3.682e+08	1.529e+02	3.868e+02	2.901e-01	7.338e-01
0.4	7.502e+08	4.587e+02	1.077e+03	8.937e-01	2.099e+00
0.5	2.388e+08	1.975e+02	4.374e+02	3.878e-01	8.585e-01
0.6	1.818e+13	1.929e+07	4.054e+07	3.765e+04	7.912e+04
0.8	1.675e+10	2.640e+04	5.135e+04	5.022e+01	9.766e+01
1.0	1.636e+10	3.514e+04	6.461e+04	6.478e+01	1.191e+02
1.5	1.975e+10	7.469e+04	1.245e+05	1.257e+02	2.095e+02
2.0	8.316e+05	4.683e+00	7.370e+00	7.241e-03	1.140e-02
3.0	8.813e+01	8.602e-04	1.255e-03	1.167e-06	1.703e-06
TOTALS:	2.003e+13	1.943e+07	4.080e+07	3.794e+04	7.962e+04

Results - Dose Point # 5 - (15.24,359.13,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.244e+11	1.942e-03	2.114e-03	1.666e-04	1.813e-04
0.02	1.028e+10	1.889e-01	2.170e-01	6.544e-03	7.516e-03
0.03	1.227e+12	2.079e+03	2.717e+03	2.061e+01	2.693e+01
0.04	3.021e+11	2.058e+03	3.091e+03	9.102e+00	1.367e+01
0.05	2.671e+09	3.682e+01	6.219e+01	9.807e-02	1.657e-01
0.06	8.024e+09	1.754e+02	3.550e+02	3.485e-01	7.050e-01
0.08	1.059e+09	4.165e+01	1.004e+02	6.591e-02	1.589e-01
0.1	1.869e+10	1.068e+03	2.835e+03	1.633e+00	4.337e+00
0.15	5.974e+07	6.129e+00	1.716e+01	1.009e-02	2.826e-02
0.2	3.089e+09	4.672e+02	1.277e+03	8.246e-01	2.253e+00
0.3	3.682e+08	9.560e+01	2.410e+02	1.813e-01	4.571e-01
0.4	7.502e+08	2.866e+02	6.714e+02	5.584e-01	1.308e+00
0.5	2.388e+08	1.234e+02	2.727e+02	2.422e-01	5.352e-01
0.6	1.818e+13	1.204e+07	2.529e+07	2.351e+04	4.936e+04
0.8	1.675e+10	1.648e+04	3.206e+04	3.134e+01	6.098e+01
1.0	1.636e+10	2.193e+04	4.038e+04	4.043e+01	7.444e+01
1.5	1.975e+10	4.663e+04	7.795e+04	7.846e+01	1.312e+02
2.0	8.316e+05	2.926e+00	4.623e+00	4.525e-03	7.149e-03
3.0	8.813e+01	5.384e-04	7.894e-04	7.304e-07	1.071e-06
TOTALS:	2.003e+13	1.214e+07	2.545e+07	2.369e+04	4.967e+04

Results - Dose Point # 6 - (15.24,404.13,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.244e+11	1.103e-03	1.201e-03	9.464e-05	1.030e-04
0.02	1.028e+10	7.920e-02	9.066e-02	2.743e-03	3.140e-03
0.03	1.227e+12	5.764e+02	7.408e+02	5.712e+00	7.342e+00
0.04	3.021e+11	4.894e+02	7.160e+02	2.164e+00	3.167e+00
0.05	2.671e+09	8.478e+00	1.412e+01	2.259e-02	3.761e-02
0.06	8.024e+09	4.027e+01	8.083e+01	7.999e-02	1.605e-01
0.08	1.059e+09	9.590e+00	2.333e+01	1.518e-02	3.692e-02

Page : 5
 DOS File : Combined Calcine Grout in Canister - Top - No Lid.ms6
 Run Date: April 5, 2005
 Run Time: 2:39:39 PM
 Duration : 00:01:05

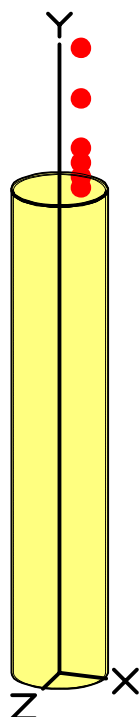
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1	1.869e+10	2.466e+02	6.669e+02	3.772e-01	1.020e+00
0.15	5.974e+07	1.422e+00	4.086e+00	2.342e-03	6.729e-03
0.2	3.089e+09	1.088e+02	3.059e+02	1.920e-01	5.399e-01
0.3	3.682e+08	2.237e+01	5.822e+01	4.244e-02	1.104e-01
0.4	7.502e+08	6.735e+01	1.633e+02	1.312e-01	3.182e-01
0.5	2.388e+08	2.910e+01	6.666e+01	5.712e-02	1.308e-01
0.6	1.818e+13	2.851e+06	6.208e+06	5.564e+03	1.212e+04
0.8	1.675e+10	3.924e+03	7.927e+03	7.464e+00	1.508e+01
1.0	1.636e+10	5.253e+03	1.005e+04	9.682e+00	1.852e+01
1.5	1.975e+10	1.130e+04	1.962e+04	1.902e+01	3.302e+01
2.0	8.316e+05	7.162e-01	1.175e+00	1.108e-03	1.817e-03
3.0	8.813e+01	1.338e-04	2.037e-04	1.816e-07	2.764e-07
TOTALS:	2.003e+13	2.873e+06	6.248e+06	5.609e+03	1.220e+04

MicroShield v6.10 (0028)
INEEL

Page : 1
 DOS File : Combined Calcine Grout in Canister - Top - with Lid.ms6
 Run Date : April 5, 2005
 Run Time : 2:42:18 PM
 Duration : 00:01:06

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

Case Title: Combined Calcine Grt
Description: Radiation measured from above closed canister.
Geometry: 8 - Cylinder Volume - End Shields



Source Dimensions

Height	337.86 cm	11 ft 1.0 in
Radius	30.48 cm	1 ft

Dose Points

	<u>X</u>	<u>Y</u>	<u>Z</u>
# 1	15.24 cm 6.0 in	341.67 cm 11 ft 2.5 in	0 cm 0.0 in
# 2	15.24 cm 6.0 in	369.61 cm 12 ft 1.5 in	0 cm 0.0 in
# 3	15.24 cm 6.0 in	439.13 cm 14 ft 4.9 in	0 cm 0.0 in
# 4	15.24 cm 6.0 in	349.13 cm 11 ft 5.5 in	0 cm 0.0 in
# 5	15.24 cm 6.0 in	359.13 cm 11 ft 9.4 in	0 cm 0.0 in
# 6	15.24 cm 6.0 in	404.13 cm 13 ft 3.1 in	0 cm 0.0 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	9.86e+05 cm ³	Concrete	1.8
Air Gap		Air	0.00122
Wall Clad	1.27 cm	Iron	7.95
Top Clad	1.27 cm	Iron	7.95

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included
Library : ICRP-38

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>μCi/cm³</u>	<u>Bq/cm³</u>
Am-241	6.0349e-001	2.2329e+010	6.1200e-001	2.2644e+004
Am-243	3.9641e-004	1.4667e+007	4.0200e-004	1.4874e+001
Ba-137m	5.4728e+002	2.0249e+013	5.5500e+002	2.0535e+007
Ce-144	9.4172e-010	3.4843e+001	9.5500e-010	3.5335e-005
Cm-242	1.0058e-003	3.7215e+007	1.0200e-003	3.7740e+001
Co-60	6.6167e-002	2.4482e+009	6.7100e-002	2.4827e+003
Cs-134	3.5992e-003	1.3317e+008	3.6500e-003	1.3505e+002
Cs-135	1.0157e-002	3.7580e+008	1.0300e-002	3.8110e+002
Cs-137	5.7883e+002	2.1417e+013	5.8700e+002	2.1719e+007
Eu-152	1.8144e-002	6.7133e+008	1.8400e-002	6.8080e+002
Eu-154	1.1833e+000	4.3782e+010	1.2000e+000	4.4400e+004
Eu-155	8.8058e-002	3.2581e+009	8.9300e-002	3.3041e+003
I-129	5.2460e-005	1.9410e+006	5.3200e-005	1.9684e+000
Ni-63	2.8892e+001	1.0690e+012	2.9300e+001	1.0841e+006
Np-237	4.9995e-003	1.8498e+008	5.0700e-003	1.8759e+002
Pa-233	4.9995e-003	1.8498e+008	5.0700e-003	1.8759e+002
Pm-147	2.0511e-002	7.5889e+008	2.0800e-002	7.6960e+002
Pr-144	9.4172e-010	3.4843e+001	9.5500e-010	3.5335e-005
Pu-238	6.8237e+000	2.5248e+011	6.9200e+000	2.5604e+005
Pu-239	1.5580e-001	5.7647e+009	1.5800e-001	5.8460e+003

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>µCi/cm³</u>	<u>Bq/cm³</u>
Pu-240	9.2791e-002	3.4333e+009	9.4100e-002	3.4817e+003
Pu-241	2.5836e+000	9.5592e+010	2.6200e+000	9.6940e+004
Pu-242	1.2523e-002	4.6336e+008	1.2700e-002	4.6990e+002
Ru-106	3.3527e-008	1.2405e+003	3.4000e-008	1.2580e-003
Sb-125	9.3481e-003	3.4588e+008	9.4800e-003	3.5076e+002
Sb-126	9.2101e-004	3.4077e+007	9.3400e-004	3.4558e+001
Sb-126m	6.5969e-003	2.4409e+008	6.6900e-003	2.4753e+002
Sm-151	5.9264e+000	2.1928e+011	6.0100e+000	2.2237e+005
Sr-90	5.1573e+002	1.9082e+013	5.2300e+002	1.9351e+007
Tc-99	2.4455e-001	9.0484e+009	2.4800e-001	9.1760e+003
Th-230	2.5638e-005	9.4862e+005	2.6000e-005	9.6200e-001
Th-231	2.4751e-005	9.1578e+005	2.5100e-005	9.2870e-001
U-232	1.7848e-005	6.6038e+005	1.8100e-005	6.6970e-001
U-233	1.1833e-006	4.3782e+004	1.2000e-006	4.4400e-002
U-234	4.7234e-003	1.7476e+008	4.7900e-003	1.7723e+002
U-235	2.4258e-005	8.9754e+005	2.4600e-005	9.1020e-001
U-236	7.4351e-005	2.7510e+006	7.5400e-005	2.7898e+000
U-237	6.4490e-005	2.3861e+006	6.5400e-005	2.4198e+000
U-238	9.0720e-006	3.3567e+005	9.2000e-006	3.4040e-001
Y-90	5.1573e+002	1.9082e+013	5.2300e+002	1.9351e+007

Buildup
 The material reference is : Source

Integration Parameters

Radial	24
Circumferential	24
Y Direction (axial)	24

Results - Dose Point # 1 - (15.24,341.67,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u>		<u>Exposure Rate</u>	
		<u>MeV/cm²/sec</u> No Buildup	<u>MeV/cm²/sec</u> With Buildup	<u>mR/hr</u> No Buildup	<u>mR/hr</u> With Buildup
0.015	2.244e+11	2.742e-252	5.337e-22	2.352e-253	4.577e-23
0.02	1.028e+10	1.473e-113	3.846e-23	5.103e-115	1.332e-24
0.03	1.227e+12	1.449e-33	1.015e-20	1.436e-35	1.006e-22
0.04	3.021e+11	8.945e-14	3.547e-13	3.956e-16	1.569e-15
0.05	2.671e+09	3.715e-08	2.462e-07	9.895e-11	6.560e-10
0.06	8.024e+09	4.080e-04	3.791e-03	8.105e-07	7.529e-06
0.08	1.059e+09	6.227e-02	7.188e-01	9.854e-05	1.137e-03
0.1	1.869e+10	1.885e+01	2.192e+02	2.884e-02	3.353e-01
0.15	5.974e+07	8.249e-01	7.884e+00	1.358e-03	1.298e-02
0.2	3.089e+09	1.163e+02	9.392e+02	2.053e-01	1.658e+00
0.3	3.682e+08	3.791e+01	2.401e+02	7.192e-02	4.554e-01
0.4	7.502e+08	1.418e+02	7.539e+02	2.762e-01	1.469e+00
0.5	2.388e+08	7.056e+01	3.271e+02	1.385e-01	6.421e-01
0.6	1.818e+13	7.677e+06	3.179e+07	1.499e+04	6.206e+04
0.8	1.675e+10	1.232e+04	4.305e+04	2.344e+01	8.188e+01
1.0	1.636e+10	1.842e+04	5.679e+04	3.396e+01	1.047e+02
1.5	1.975e+10	4.736e+04	1.186e+05	7.968e+01	1.995e+02
2.0	8.316e+05	3.314e+00	7.347e+00	5.125e-03	1.136e-02
3.0	8.813e+01	6.849e-04	1.312e-03	9.292e-07	1.779e-06
TOTALS:	2.003e+13	7.756e+06	3.201e+07	1.512e+04	6.245e+04

Results - Dose Point # 2 - (15.24,369.61,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u>		<u>Exposure Rate</u>	
		<u>MeV/cm²/sec</u> No Buildup	<u>MeV/cm²/sec</u> With Buildup	<u>mR/hr</u> No Buildup	<u>mR/hr</u> With Buildup
0.015	2.244e+11	1.902e-252	1.859e-22	1.631e-253	1.594e-23

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.02	1.028e+10	1.237e-113	1.340e-23	4.284e-115	4.640e-25
0.03	1.227e+12	1.480e-33	3.537e-21	1.466e-35	3.505e-23
0.04	3.021e+11	8.864e-14	3.514e-13	3.920e-16	1.554e-15
0.05	2.671e+09	3.559e-08	2.355e-07	9.482e-11	6.274e-10
0.06	8.024e+09	3.705e-04	3.413e-03	7.359e-07	6.779e-06
0.08	1.059e+09	4.910e-02	5.470e-01	7.770e-05	8.657e-04
0.1	1.869e+10	1.307e+01	1.412e+02	1.999e-02	2.160e-01
0.15	5.974e+07	4.684e-01	3.876e+00	7.714e-04	6.383e-03
0.2	3.089e+09	6.008e+01	4.083e+02	1.060e-01	7.207e-01
0.3	3.682e+08	1.790e+01	9.428e+01	3.395e-02	1.788e-01
0.4	7.502e+08	6.365e+01	2.823e+02	1.240e-01	5.501e-01
0.5	2.388e+08	3.057e+01	1.191e+02	6.000e-02	2.337e-01
0.6	1.818e+13	3.233e+06	1.133e+07	6.311e+03	2.212e+04
0.8	1.675e+10	4.969e+03	1.490e+04	9.451e+00	2.834e+01
1.0	1.636e+10	7.185e+03	1.926e+04	1.324e+01	3.551e+01
1.5	1.975e+10	1.745e+04	3.896e+04	2.935e+01	6.555e+01
2.0	8.316e+05	1.180e+00	2.374e+00	1.825e-03	3.671e-03
3.0	8.813e+01	2.352e-04	4.176e-04	3.191e-07	5.666e-07
TOTALS:	2.003e+13	3.263e+06	1.141e+07	6.364e+03	2.225e+04

Results - Dose Point # 3 - (15.24,439.13,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	2.244e+11	1.672e-252	5.694e-23	1.434e-253	4.884e-24
0.02	1.028e+10	1.149e-113	4.104e-24	3.980e-115	1.421e-25
0.03	1.227e+12	1.238e-33	1.083e-21	1.227e-35	1.074e-23
0.04	3.021e+11	5.916e-14	2.341e-13	2.616e-16	1.035e-15
0.05	2.671e+09	1.851e-08	1.211e-07	4.932e-11	3.226e-10
0.06	8.024e+09	1.548e-04	1.390e-03	3.074e-07	2.760e-06
0.08	1.059e+09	1.507e-02	1.592e-01	2.385e-05	2.519e-04
0.1	1.869e+10	3.381e+00	3.407e+01	5.173e-03	5.213e-02
0.15	5.974e+07	1.027e-01	7.926e-01	1.692e-04	1.305e-03
0.2	3.089e+09	1.252e+01	8.022e+01	2.210e-02	1.416e-01
0.3	3.682e+08	3.601e+00	1.818e+01	6.831e-03	3.449e-02
0.4	7.502e+08	1.263e+01	5.428e+01	2.461e-02	1.058e-01
0.5	2.388e+08	6.020e+00	2.290e+01	1.182e-02	4.495e-02
0.6	1.818e+13	6.337e+05	2.183e+06	1.237e+03	4.262e+03
0.8	1.675e+10	9.687e+02	2.883e+03	1.843e+00	5.484e+00
1.0	1.636e+10	1.398e+03	3.745e+03	2.576e+00	6.904e+00
1.5	1.975e+10	3.395e+03	7.662e+03	5.712e+00	1.289e+01
2.0	8.316e+05	2.307e-01	4.718e-01	3.567e-04	7.296e-04
3.0	8.813e+01	4.648e-05	8.435e-05	6.305e-08	1.144e-07
TOTALS:	2.003e+13	6.395e+05	2.198e+06	1.247e+03	4.287e+03

Results - Dose Point # 4 - (15.24,349.13,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	2.244e+11	1.913e-252	3.670e-22	1.641e-253	3.148e-23
0.02	1.028e+10	1.253e-113	2.645e-23	4.342e-115	9.162e-25
0.03	1.227e+12	1.491e-33	6.982e-21	1.478e-35	6.920e-23
0.04	3.021e+11	8.956e-14	3.551e-13	3.961e-16	1.571e-15

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.05	2.671e+09	3.698e-08	2.452e-07	9.852e-11	6.533e-10
0.06	8.024e+09	4.072e-04	3.783e-03	8.087e-07	7.514e-06
0.08	1.059e+09	6.174e-02	7.100e-01	9.770e-05	1.123e-03
0.1	1.869e+10	1.836e+01	2.102e+02	2.809e-02	3.216e-01
0.15	5.974e+07	7.664e-01	6.987e+00	1.262e-03	1.151e-02
0.2	3.089e+09	1.049e+02	7.936e+02	1.851e-01	1.401e+00
0.3	3.682e+08	3.306e+01	1.938e+02	6.271e-02	3.676e-01
0.4	7.502e+08	1.211e+02	5.942e+02	2.359e-01	1.158e+00
0.5	2.388e+08	5.934e+01	2.539e+02	1.165e-01	4.984e-01
0.6	1.818e+13	6.373e+06	2.439e+07	1.244e+04	4.761e+04
0.8	1.675e+10	1.002e+04	3.246e+04	1.906e+01	6.174e+01
1.0	1.636e+10	1.473e+04	4.229e+04	2.716e+01	7.795e+01
1.5	1.975e+10	3.675e+04	8.645e+04	6.183e+01	1.455e+02
2.0	8.316e+05	2.523e+00	5.290e+00	3.901e-03	8.180e-03
3.0	8.813e+01	5.099e-04	9.327e-04	6.918e-07	1.265e-06
TOTALS:	2.003e+13	6.435e+06	2.455e+07	1.255e+04	4.790e+04

Results - Dose Point # 5 - (15.24,359.13,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.244e+11	1.952e-252	2.527e-22	1.674e-253	2.168e-23
0.02	1.028e+10	1.247e-113	1.821e-23	4.320e-115	6.308e-25
0.03	1.227e+12	1.486e-33	4.808e-21	1.473e-35	4.765e-23
0.04	3.021e+11	8.929e-14	3.540e-13	3.949e-16	1.566e-15
0.05	2.671e+09	3.678e-08	2.438e-07	9.798e-11	6.495e-10
0.06	8.024e+09	3.991e-04	3.697e-03	7.927e-07	7.343e-06
0.08	1.059e+09	5.704e-02	6.453e-01	9.026e-05	1.021e-03
0.1	1.869e+10	1.601e+01	1.776e+02	2.450e-02	2.717e-01
0.15	5.974e+07	6.149e-01	5.300e+00	1.013e-03	8.727e-03
0.2	3.089e+09	8.105e+01	5.748e+02	1.430e-01	1.014e+00
0.3	3.682e+08	2.469e+01	1.353e+02	4.684e-02	2.567e-01
0.4	7.502e+08	8.879e+01	4.084e+02	1.730e-01	7.957e-01
0.5	2.388e+08	4.295e+01	1.729e+02	8.431e-02	3.393e-01
0.6	1.818e+13	4.568e+06	1.649e+07	8.917e+03	3.220e+04
0.8	1.675e+10	7.075e+03	2.175e+04	1.346e+01	4.138e+01
1.0	1.636e+10	1.029e+04	2.817e+04	1.896e+01	5.193e+01
1.5	1.975e+10	2.518e+04	5.709e+04	4.237e+01	9.605e+01
2.0	8.316e+05	1.710e+00	3.478e+00	2.645e-03	5.379e-03
3.0	8.813e+01	3.419e-04	6.112e-04	4.639e-07	8.293e-07
TOTALS:	2.003e+13	4.611e+06	1.660e+07	8.992e+03	3.239e+04

Results - Dose Point # 6 - (15.24,404.13,0) cm

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec		<u>Exposure Rate</u> mR/hr	
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.244e+11	1.785e-252	9.186e-23	1.531e-253	7.879e-24
0.02	1.028e+10	1.199e-113	6.620e-24	4.154e-115	2.293e-25
0.03	1.227e+12	1.415e-33	1.748e-21	1.403e-35	1.732e-23
0.04	3.021e+11	7.616e-14	3.017e-13	3.369e-16	1.334e-15
0.05	2.671e+09	2.676e-08	1.759e-07	7.127e-11	4.687e-10
0.06	8.024e+09	2.462e-04	2.234e-03	4.890e-07	4.437e-06
0.08	1.059e+09	2.687e-02	2.886e-01	4.252e-05	4.567e-04

Page : 5
 DOS File : Combined Calcine Grout in Canister - Top - with Lid.ms6
 Run Date: April 5, 2005
 Run Time: 2:42:18 PM
 Duration : 00:01:06

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.1	1.869e+10	6.345e+00	6.507e+01	9.707e-03	9.955e-02
0.15	5.974e+07	2.010e-01	1.570e+00	3.310e-04	2.586e-03
0.2	3.089e+09	2.477e+01	1.599e+02	4.372e-02	2.822e-01
0.3	3.682e+08	7.170e+00	3.627e+01	1.360e-02	6.880e-02
0.4	7.502e+08	2.519e+01	1.081e+02	4.907e-02	2.106e-01
0.5	2.388e+08	1.201e+01	4.553e+01	2.357e-02	8.937e-02
0.6	1.818e+13	1.264e+06	4.333e+06	2.467e+03	8.457e+03
0.8	1.675e+10	1.931e+03	5.703e+03	3.672e+00	1.085e+01
1.0	1.636e+10	2.782e+03	7.386e+03	5.128e+00	1.362e+01
1.5	1.975e+10	6.731e+03	1.502e+04	1.133e+01	2.526e+01
2.0	8.316e+05	4.555e-01	9.199e-01	7.044e-04	1.422e-03
3.0	8.813e+01	9.116e-05	1.632e-04	1.237e-07	2.214e-07
TOTALS:	2.003e+13	1.276e+06	4.361e+06	2.488e+03	8.507e+03