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ANTICIPATED DOSE TO WORKERS FOR PLUTONIUM STABILIZATION AND HANDLING AT PFP - PROJECT W-460

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Report provides estimates of expected whole body and extremity radiological dose to workers conducting planned Pu stabilization and packaging operations at PFP.

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**ANTICIPATED DOSE TO WORKERS
FOR PLUTONIUM STABILIZATION AND HANDLING
At PFP**

PROJECT W-460

Issued by:

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Executive Summary

This report provides estimates of the expected whole body and extremity radiological dose, expressed as Dose Equivalent (DE), to workers conducting planned plutonium (Pu) stabilization and packaging operations at the Hanford Plutonium Finishing Plant (PFP). The report is based on a time and motion dose study commissioned for Project W-460 Plutonium Stabilization and Handling to provide personnel exposure estimates for operation of stabilization and packaging equipment to be installed at PFP. It provides rough estimates of anticipated dose during construction work in the PFP storage vault area. No detailed work was done to provide a basis for estimates of dose for maintenance tasks associated with this equipment, however the dose to maintenance worker can be conservatively stated as equivalent to the dose received during operations.

An earlier time and motion dose study conducted in 1996 (Faust 1996) provided some of the measured exposure data along with current measurements. A similar task was conducted in 1998 (Kraje 1998) for the purpose of modeling stabilization operations within 234-5Z Building. That task utilized process task analyses, calculated dose rates, throughput and time in evaluating personnel doses. Data from both tasks were considered in the current work.

For this study, field walkthroughs with PFP staff provided the anticipated process work flow and timing. Field radiological exposure measurements were taken where needed. Processing duration was taken from PFP programmatic planning documents. Dose calculations were based on formulas given in the *Health Physics Manual of Good Practices for Plutonium Facilities* (PNL 1988) plus data from PFP including Pu masses, isotopic composition and crew size. These data were then scaled to the proposed processes. Where data from previous studies was used, the values were normalized for differences in isotopic composition, throughput and crew size while individual workloads, hood gloves, and shields were kept the same.

The resulting estimates may be used for the purposes of updating crew size estimates based on anticipated annual average DE, and for providing bounding estimates to environmental decision analysis.

Dose calculations for the current study were based on the number of items listed in the plutonium inventory categories provided in Table 3-1 of the *Plutonium Finishing Plant Final Environmental Impact Statement* (DOE 1996).

There are two predominate reasons for the differences in results. First, although the total amount of Special Nuclear Material (SNM) to be stabilized is the same for all studies, the time estimated for various operations varies. For instance, in one area of the EIS (*Appendix D*), one stabilization operation is assumed to continue at full crew levels for 16 years versus 2.5 years (operational cycle) for the current study. The other difference is the change in background radiation levels, i.e., the radiation level in an area without SNM within the processing equipment. Background radiation levels are currently much lower in 2736-ZB than in 234-5Z, and would be anticipated to continue lower (averaging 1.3 mrem/h versus 4.5 to 5 mrem/h in 234-5Z). This difference is caused by the presence of SNM holdup from the fifty-year extended processing operations in the main facility versus less than twenty years of packaging operations in the vault support area.

Table A.

Whole Body and Extremity DE Summary for PFP Stabilization and Packaging Program
(Packaging included in each material category)

Activity	Whole Body DE per Activity (rem)			Extremity DE per Activity (rem)		
	234-5Z	2736-ZB	Vaults**	234-5Z	2736-ZB	Vaults**
Solutions	27	4.5		120	20.85	
Metals & Alloys	18.9	11.7		212.1	235	
Oxide/MOX	63.6	80		1326.4	1986.9	
Sludges	23.7	3		52.4	32	
Polycubes	27	0.9		81.6	7.8	
Residue/Cementation	145.5			930		
Vault Construction			64			64
Total DE in each Facility	305.7	100.1	64	2722.5	2282.55	64
Total DE (Whole Body / Extremity)	469.8			5069.05		
Number of Workers in Crew	54	30	6*	54	30	6*
Average DE per worker for entire program	5.7	3.3	10.6*	50.4	76.1	10.6*
Length of Program (calendar months)	54	42	39	54	42	39
Average Annual DE/worker/year	1.3	1.0	3.3	11.2	21.7	3.3

* Crews will be rotated

** Vault DE included in building process total

Table B.

Whole Body and Extremity DE Summary For PFP "3013" Packaging Only
(from canning through placement activity for each material category)

Activity	Whole Body DE per Activity (rem)	Extremity DE per Activity (rem)
Solutions	4.5	20.8
Metals & Alloys	11.7	235
Oxide/MOX	41.4	1026
Polycubes	0.9	7.8
Sludges	3	32
Total DE	61.5	1321.6

Acknowledgments

This report is based on extensive field and analytical work conducted during the first six months of 1999 by Mr. Leo Faust of Global Technologies, Incorporated (GTI) with the administrative assistance of Mr. Nathan Dirkmaat. Mr. Jose Mejia and Mr. Rob Gregory provided lead technical assistance from the Plutonium Finishing Plant. Vault operations and stabilization operations staff also provided field assistance for determining planned process work flow, determining dose rates and determining staff needed for the work process flows. Mr. Jim Lilly of the Project W-460 team provided logistical assistance plus calculation of the vault construction dose rates. Ms. Evelyn Weiss compiled this report from the detailed analytical tables plus a study report draft provided by Mr. Faust in May 1999.

ABBREVIATIONS AND ACRONYMS

ALARA	As Low As Reasonably Achievable
BTC	Bagless Transfer Can
BTS	Bagless Transfer System
BWHC	B&W Hanford Company
CAM	Continuous Air Monitor
CCTV	Closed Circuit Television
C/S	Containment and Surveillance
CSER	Criticality Safety Evaluation Report
DA	Destructive Assay
DE	Dose Equivalent
DBA	Design Basis Accident
DBE	Design Basis Earthquake
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U. S. Department of Energy
ECO	Environmental Compliance Officer
EIS	Environmental Impact Statement
EM-60	DOE HQ Environmental Management
FSAR	Final Safety Analysis Report
FDH	Fluor Daniel Hanford
FDNW	Fluor Daniel Hanford Northwest, Inc.
GTI	Global Technologies, Inc.
HLAN	Hanford Local Area Network
HEPA	High Efficiency Particulate Air
HNF	Document designator for Hanford Site after October 1, 1996
HQ	DOE Headquarters
IAEA	International Atomic Energy Agency
LANL	Los Alamos National Laboratory
LCU	Local Control Unit
LOI	Loss on ignition
LLNL	Lawrence Livermore National Laboratory
LLWTF	Low Level Waste Treatment Facility
MAA	Material Access Area
Mo	Molybdenum
MOX	Mixed oxides (mixed fissile materials, e.g., plutonium and uranium)
N	Moderating Factor (used in dose calculations)
NDA	Nondestructive Assay
NMSTG	Nuclear Materials Stabilization Task Group (EM-66)
NPO	Nuclear Process Operator
OAK	DOE Oakland Office
PFP	Plutonium Finishing Plant
PIV	Physical Inventory Verification
PHMC	Project Hanford Management Contract

PNL (PNNL)	Battelle Pacific Northwest National Laboratory
PSAP	Personnel Security Assurance Program
PSE	Preliminary Safety Evaluation
Pu	Plutonium
PuSAP	Plutonium Stabilization and Packaging
PuSH	Plutonium Stabilization and Handling Project W-460
PVMP	Plutonium Vulnerability Management Plan
Q	Neutron Quality Factor (used in dose calculations)
QAPD	Hanford Quality Assurance Program Description
rem	Roentgen-Equivalent Man
RCT	Radiological Control Technician
RFETS	Rocky Flats Environmental Test Site
RL	U.S. Department of Energy-Richland Office
RMC	Remote Mechanical "C" Line (processing area within PFP)
SGSAS	Segmented Gamma Scan Assay System
SISMP	Site Integrated Stabilization Management Plan
SNM	Special Nuclear Material
SPE	Stabilization and Packaging Equipment
SPS	Stabilization and Packaging System
SRS	Savannah River Site
TV	television
U	Uranium
WIPP	Waste Isolation Pilot Plant (Carlsbad, New Mexico)
Wt-%	percent of total content by weight

DEFINITIONS

Absorbed Dose. Energy Absorbed by matter from ionizing radiation, per unit mass of irradiated material, at the place of interest in that material. The absorbed dose is expressed in units of rad or Sieverts.

Collective Dose. The sum of the total effective dose equivalent values for all individuals in a specified population. Collective dose is expressed in units of person-rem.

Dose (D). The amount of energy deposited in body tissue due to radiation exposure. Various technical terms, such as 'dose equivalent,' 'effective dose equivalent,' and 'collective dose' are used to evaluate the amount of radiation an exposed individual receives. These terms are used to describe the differing interactions of radiation with tissue as well as to assist in the management of personnel exposure to radiation.

Dose equivalent (DE). Some types of radiation such as neutron and alpha deposit their energy more densely in affected tissue than gamma radiation, thereby causing more damage to that tissue. The term 'dose equivalent,' measured in units of rem, is used to take into account this difference in tissue damage. Therefore, one (1) rem from gamma radiation cause damage equivalent to one (1) rem from alpha radiation. The value for dose equivalent is calculated as the product of absorbed dose (D) in tissues, a "quality" factor (Q), and other modifying factors (N). In this report, dose is used interchangeably with dose equivalent.

Loss on Ignition (LOI). A test to determine stability in nuclear material as measured by the absence of residual moisture and volatiles. A sample mass is measured before and after the sample is heated to drive off moisture and volatiles. A decrease in weight of less than a specified requirement (e.g., less than 0.5 weight percent total mass) is desirable. A gain in weight is undesirable, as that may indicate the material is still reactive.

Plutonium Finishing Plant (PFP). Former nonreactor defense nuclear materials production facility located in the 200 West area of the Hanford site. Plutonium nitrate solution was converted to plutonium oxide and metal forms. The defense mission ended in 1989; the current mission is to stabilize remaining special nuclear materials for long-term storage, and to stabilize the facility in readiness for decommissioning.

Special Nuclear Material. Chemical elements, mixtures and compounds which contain certain transuranic fissile chemicals.

Source material. For the purposes of this document, any special nuclear material within PFP destined for eventual stabilization and long-term storage.

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1.0 INTRODUCTION

This report provides estimates of the expected whole body and extremity radiological dose, expressed as Dose Equivalent (DE), to workers conducting planned plutonium (Pu) stabilization processes at the Hanford Plutonium Finishing Plant (PFP). The report is based on a time and motion dose study commissioned for Project W-460 Plutonium Stabilization and Handling, to provide personnel exposure estimates for construction work in the PFP storage vault area plus operation of stabilization and packaging equipment at PFP.

An earlier time and motion dose study conducted in 1996 (Faust 1996) provided some of the measured exposure data along with current measurements. A similar task was begun in late 1998 for the purpose of modeling stabilization operations within 234-5Z Building, but is not yet completed. That task utilized process task analyses, calculated dose rates, throughput and time in evaluating personnel doses. Data from both tasks were considered in the current work.

Five process operations were considered in this study. The first four deal with SNM defined as requiring long-term storage, that is material containing more than 30 weight-percent (wt-%) plutonium plus uranium. The four are thermal stabilization of Pu-bearing solutions via fluid-bed calcining, thermal stabilization of oxides and related solids via muffle furnace, stabilization and metals and alloys via brushing of corrosion products (e.g., oxides and nitrates) from the surface, and thermal stabilization of polycubes via pyrolysis or furnace. The use of a cementation process to solidify some residues (SNM of less than 30 wt-percent plutonium) for discarding and storage, perhaps in WIPP, has been proposed. That process then makes up the fifth method for consideration. Each of these processes is addressed in this report.

This study was initiated to support a decision regarding location for a totally remote process, which was assumed (DOE) to be the preferred means to stabilize and package the plutonium materials into a compliant package for long-term storage while minimizing worker DE. Work at Hanford and other sites informally determined that the processing steps, which result in most of the dose, were not the automated steps. Several factors including dose considerations led to a programmatic decision after the analytical/field aspects of this study were completed, to switch from the automated unit to a combination of manually operated muffle furnaces plus two packaging units, a simple packaging process called "Bagless Transfer System" (BTS) for inner welded cans plus a commercial welder for the outer welded cans. This equipment is to be located in 2736-ZB. The 234-5Z background dose work was accomplished prior to the decision for placement of furnaces in 234-5Z building was included in this report, as it may be useful for other future decisions.

1.1 Background

Plutonium-bearing solids (non-fuel) containing greater than 30 weight-percent of certain fissile materials (total of plutonium plus uranium) will be processed in a system designed to stabilize the material to an oxide form (with the exception of alloyed and unalloyed metals) and to remove volatiles and moisture in preparation for safe, stable 50-year storage.

The radionuclide content of materials to be processed is predominantly ^{239}Pu , with varying proportions of other isotopes of plutonium plus uranium. Some alloys contain

other metals in small quantities. The distribution of ^{240}Pu in the inventory to be handled is approximately as shown in Table 1 below.

Table 1
PFP Inventory by ^{240}Pu Isotopic Range

Percent ^{240}Pu	<3.99	4.00 - 6.99	7.00 - 9.99	10.00 - 12.99	13.00 - 15.99	16.00 - 18.99	>19.00
# Items	0.003%	40%	5%	27%	3%	18%	7%

The types of SNM to be handled for stabilization and packaging include the following:

• Plutonium Oxides	Thermally stabilize and package
• Mixed Plutonium-Uranium Oxides (MOX)	Thermally stabilize and package
• Metals and Alloys	Brush and package
• Plutonium Solutions	Solidify, thermally stabilize, package
• Other solid forms (polycubes, etc)	Thermally stabilize and package

Although PFP has an active program for stabilizing remaining inventories of SNM, the Site presently does not have the capability to package stabilized SNM into the welded containers specified by DOE-STD-3013-96⁶. In addition, the container configuration designed and accepted to date is larger than that which is currently in use at the PFP and will not physically fit into the existing storage fixtures in secure vault storage at the PFP. Project W-460 is comprised of several equipment modules that will assist in complying with the commitments of DNFSB Recommendation 94-1 to stabilize and package SNM at PFP. Project W-460 provides stabilization equipment and controls, packaging equipment and controls, vault storage rack modifications and infrastructure modifications in the PFP storage support facility. The Project will add more stabilization capability plus packaging, and storage functions into a single location within the PFP facility, the 2736-Z Complex. This will allow eventual deactivation of other PFP facility areas while maintaining the functions required for safe storage. For the stabilization program, PFP will use a combination of equipment located in both facilities.

1.2 Stabilization Program Process Description

Incoming materials will be received in a variety of container configurations and sizes. The stabilization and packaging equipment will receive the majority of existing storage packages via sphincter seal, with provision for an alternate receipt mechanism for packages other than the most prevalent ("7-inch can" and Hanford Convenience Can).

The material flow for materials to be handled in the stabilization and packaging program is shown in Figure 1 below.

Figure 1.

Summary Work Process Flow for PFP Stabilization Program

2.0 Study Methodology

This study consists of analysis of the timing and location of process task steps, correlated with location and assumed quantities of SNM in the process locations of the operators during each step plus the duration of each step. These data are combined with calculated DE rates for the SNM isotopic compositions and masses expected and the measured process area background DE rates to estimate a DE for each task. At each step, the number of estimated task repetitions was based on the mass to be processed. This was then used to determine the total DE expected from the task. Summarizing the DEs for all steps provides a total DE for each major task, and hence for the entire program. Of primary interest is the annual estimated dose for each worker. To estimate an average, the total DE was divided by the number of workers and by the total duration. This average provides a “big picture” planning figure, however detailed operational planning will require use of the detailed data to calculate an average dose per worker for a given year for a particular operation, which may be higher or lower, to plan for crew rotation as needed.

A preliminary DE calculation in the 1996 study³ provided an estimate of the upper bound for the operators. The determination was based on 1996 personnel dosimetry data obtained during a sludge run conducted in the main facility, 234-5Z Building (234-5Z). These data were then scaled to what is to be accomplished during the planned stabilization program, resulting in a rough-upper-bound estimate of about 3.3 rem/year per worker.

For this study, a more detailed analysis was undertaken in order to assure that actual dose will be significantly less than the upper bound mentioned above. Task descriptions were compiled based on steps defined in the operating procedures provided by PFP staff. Times for each task, worker location, and distances to the radiation sources were estimated based on observation of the processes either currently being performed, from past studies, or on previous glovebox operating experience for those processes not yet underway. Measured background dose rates were included to assess the background DE sources for each of the processes and storage rooms to determine background contribution to each process task. Estimates of both whole body and extremity locations, relative to the SNM, are included in the model to provide both direct and background DE estimates. Verification of these estimated parameters has been performed by observing the actual operation or by operator interviews where operations could not be observed. The task analyses were then used in conjunction with calculated DE rates for the SNM masses and forms to determine DE contributions from each task.

2.1 Source Data for Study

In order to simplify determination of the effects of the different isotopic mixes present in the PFP inventory, three average isotopic compositions were compiled. The average isotopic compositions for the three groups are shown below in Table 2.

Table 2.
Isotopic Composition Distribution for PFP Inventory

Isotope	Low ²⁴⁰Pu 4-6 wt%	Mid ²⁴⁰Pu 7-12%	High ²⁴⁰Pu 13-40%
²³⁸ Pu	0.01 wt-%	.15 wt-%	.18 wt-%
²³⁹ Pu	92.4 wt-%	85.63 wt-%	80.06 wt-%
²⁴⁰ Pu	6.1 wt-%	12.45 wt-%	17.84 wt-%
²⁴¹ Pu	.2 wt-%	1.03 wt-%	1.05 wt-%
²⁴² Pu	0.04 wt-%	.37 wt-%	.73 wt-%
²⁴¹ Am	0.2 wt-%	1.19 wt-%	2.01 wt-%
Total Mass (Mt)	1.5 Mt	0.6 Mt	1.5 Mt

Using the average isotopic compositions and assuming an average of 28 years since chemical separation, DE rates for various shielding configurations and chemical forms were calculated using formulas given in "*Health Physics Manual of Good Practices for Plutonium Facilities*"². Appendix A contains the formulas used to determine the DE rates.

Table 3 "PFP SNM to be Stabilized and Packaged" below, summarizes the number of inventory items in each material category.

The selection of a finite number of isotopic compositions and masses for which estimated DE values would be calculated was obtained by consolidation of the inventory data and similar processing tasks to be performed on each type of material.

Based on the consolidation described above, the mass and isotopic values were selected and DE rates calculated. The results are presented in Table 4, "DE Rates at 1-cm for Various Isotopic Compositions and Batch Sizes." The DE rate is determined by summing the gamma and the neutron contributions (see Appendix A for formulas.)

Using the data in Table 3 and 4 in conjunction with the task analyses provides the basis for estimating the DE for each of the four major treatment methods. Detailed task analyses and DEs are contained in Appendix D, issued separately. Once DE values were calculated, the total were divided by the number of operators and the duration of the campaign to determine the average annual DE for whole body and extremities.

Table 3.
PFP SNM to be Stabilized and Packaged

MATERIAL GROUPS	# ITEMS	DESCRIPTION
SOLUTIONS	431	Includes nitrates, filtrates, caustic, chloride, organic and other actinide solutions (≈4300 liters in 8 and 10 liter bottles)
METAL AND ALLOYS	477	Includes Metal, Pu-U-Mo Alloys, Pu-U alloys, Pu-Al alloys
OXIDE / MOX/ SOURCES		
Oxide (>30 wt-% Pu)	2779	Includes high assay, all isotopic compositions, and impure oxides
Sand Slag & Crucible ^a	266	RMC line and similar reduction residues
MOX Scrap	2297	Includes enriched, normal and depleted U-Pu pellets, powder, compounds and scrap
Sources	202	Includes encapsulated and sealed sources
POLYCUBES	260	Polystyrene cubes containing Pu, some also contain U
RESIDUES and COMPOUNDS		
Ash ^a	527	Incinerator ash
Residue oxides <30 wt-% Pu	400	Includes scrap oxides
Other / Miscellaneous	40	Includes glovebox floor scrapings, sludge, Pu metal, Pu graphite, scrap, combustibles
Compounds ^b	26	Includes various compounds of Plutonium
TOTAL ITEMS TO BE STABILIZED	6512	

^a Material to be sent to WIPP once packaged.

^b Stabilization of compounds is assumed to require the same steps as oxide stabilization

Table 4.
DE Rates at 1 cm for Various Isotopic Compositions and Batch Sizes

Range of ²⁴⁰ Pu Content	Nominal Batch (g)		Bare Gamma DE (mrem/h)	Pb Glove Gamma DE (mrem/h)	Whole Body Neutron DE (mrem/h)	Extremity Neutron DE (mrem/h)
Low ²⁴⁰ Pu	L-1	200	2394	349	223	22
	L2	700	2394	349	779	78
	L-3	800	2394	349	890	89
	L-4	1500	2394	349	1670	167
	L-5	2000	2394	349	2227	223
Mid ²⁴⁰ Pu	M-1	200	8947	1231	454	45
	M-2	700	8947	1231	1588	159
	M-3	1500	8947	1231	3404	340
	M-4	2000	8947	1231	4539	454
High ²⁴⁰ Pu	H-1	200	9254	1250	624	62
	H-2	700	9254	1250	2183	218
	H-3	1500	9254	1250	4678	468
	H-4	2000	9254	1250	6237	624

2.2 Vault Construction Calculations

Racks will be installed in conjunction with existing pedestals within existing cubicles in the PFP storage vaults in order to accommodate the larger dual welded containers required for long term storage. No procedure yet exists for installation of these racks, anticipated to take place on a cubicle-by-cubicle basis. It is presumed that material will be emptied from any cubicle for installation via normal stabilization operations, but that SNM will remain in surrounding cubicles. See Appendix C for assumptions and calculation of an average dose per cubicle rack installation.

3.0 RESULTS

The method described in Section 2 was performed for all material types mentioned. Facility operating procedures developed for each process were used to define the steps for calculation of the estimates of both whole body and extremity DE. The results of these calculations are described below. It must be noted that some of the individual processes are still under consideration for change at some future date yet to be determined. However, the resultant DEs should be in the same order of magnitude, as the SNM inventory to be processed will remain relatively constant. It is also important to note that for each step in the five tables, the step is shown for a single worker to perform. At the end of each table, the aggregate crew dose is calculated by doubling the whole body dose to account for the continuous attendance of two workers. The extremity dose remains the same; e.g. one worker will likely handle the material for any given step.

For vault construction, the average aggregate crew dose for each rack install was estimated at 321 mrem. It is assumed that 200 cubicles will be converted, therefore the total dose for vault construction is estimated at 64 person-rem.

3.1 Solution Stabilization Activities

Solution Treatment is estimated in the *Plutonium Finishing Plant Stabilization Final Environmental Impact Statement*⁴ (PFP EIS) to require 43 weeks of processing time. A total of 431 items is to be handled. Primary treatment procedures involved with this activity are (Vertical Calcining is being replaced by Magnesium Hydroxide Precipitation, dose rates are equivalent):

1. Nitrate Load In/Load Out - Procedure ZO-188-015 and ZO-188-020 - Bottled solution and/or Product Receiver Can (PRC can) entry into facility piping system via an open-faced hood.
2. Ion Exchange - Procedure not written - Remove impurities from the Pu nitrate solution, conversion of chlorides and fluorides to nitrates (Consists of column loading, washing solution reconditioning) requires 6.5 weeks with 3 shifts/d, 5 d/wk at a 70% efficiency. There is no manual handling required to complete this process.
3. Vertical Calcining - Procedure not written - Converts Pu nitrate to oxide (operating at 800 to 850°C with 1 to 4 liter/h throughput). Manual off-loading of product must be conducted hourly from the Calciner collector. The collector is emptied into a container for transfer to the Thermal Stabilization process.
4. Supplemental Thermal Stabilization - ZO-160-032 - Ensures complete oxidation by removal of volatiles and moisture to meet storage requirements. Requires 19.5 weeks with 3/shifts/d, 5d/wk using 10 muffle furnaces or equivalent.

The calciner product tray would be loaded with between 300 to 600 g of plutonium oxide prior to removal of each batch. A nominal value of 350 g was selected to establish a conservative estimate of operator attendance requirements.

Table 5, "Solution Stabilization and Packaging Estimated DE" below, lists process tasks and shows the calculated value for the estimated whole body and extremity DE associated with each step. The total DE is summarized.

Table 5.
Solution Stabilization and Packaging Estimated DE

Task Step	Worker	Whole Body DE (mrem per task)	Extremity DE (mrem per task)	Estimated Number of Task Cycles	Total Whole Body DE (mrem)		Total Extremity DE (Mrem)	
Activities Completed in 234-SZ								
Vault Access – Rm 236	Vault Ops	1.82	33	459	835		15147	
Movement to Rm 227	NPO	4.00	18	459	1836		8262	
Nitrate Load In	NPO	2.80	25	459	1285		11475	
Ion Exchange	NPO	Remote Operations	Remote Operations	Remote Operations	Remote Operations		Remote Operations	
Vertical Calciner Offload	NPO	1.63	16	459	748		7344	
Remove Package (seal out)	NPO	0.93	12	459	427		5508	
Transfer to Furnace Glovebox	NPO	4.00	18	459	1836		8262	
Package Seal In	NPO	1.60	15	245	392		3675	
Furnace Operations	NPO	3.57	39	245	875		9555	
Batch Breakout	NPO	0.27	15	245	66		3675	
Batch Screening	NPO	0.67	15	184	123		2760	
Batch Sampling	NPO	2.22	9	184	408		1656	
Package Seal Out ^a	NPO	0.94	15	184	173		2760	
Activities Completed in 2736-ZB								
Canning	NPO	0.20	16	184		37		2944
NDA- Isotopic	NPO	1.53	11	184		282		2024
NDA- Calorimetry	NPO	2.80	38	184		773		6992
Movement to Vault & Access	Vault Ops	11.00	43	46		506		1978
Total per worker					9004	1598	80079	13938
Aggregate Crew Total (rem)					27	4.5	120	20.85
[Whole Body- 2 workers plus contingency; Extremity- worker plus contingency]								

^a Item already packaged in HCC

3.2 Metal Stabilization Activities

The stabilization method used for Pu metals and alloys consist of brushing corrosion products from the surface. Brushing and repackaging of Pu metals and alloys is estimated in the PFP EIS⁴ to require 50 weeks of processing time. The repackaging procedure to be used is ZO-200-504, "Re-Can Plutonium Metal." Table 6 "Metal & Alloys Stabilization and Repackaging Estimated DEs" lists process tasks and shows the calculated value for the estimated whole body and extremity DE associated with each step. The dose associated with the metal brushing operation was estimated from within the main facility (234-5Z). Packaging would take place in 2736-ZB. The total DE is summarized for both of these options.

Table 6.^a

Metal & Alloys Stabilization and Repackaging Estimated DE

Task Step	Worker	Whole Body DE (mrem per task)		Extremity DE (mrem per task)		Estimated Number of Task Cycles	Total Whole Body DE (mrem)		Total Extremity DE (Mrem)	
		-5Z	ZB	-5Z	ZB		-5Z	ZB	-5Z	ZB
Vault Access - SNM Removal	Vault Operators	11.30		157.0		350	3955		54950	
Movement Vault to Glovebox	Nuclear Operators	0.7		0.7		70	49		49	
Seal In	Nuclear Operators	2.10		45.0		350	735		15750	
Recan Pu Metal	Nuclear Operators	2.20		159.0		350	770		55650	
Seal Out^b	Nuclear Operators	2.20		43.0		350	770		15050	
<i>Activities Completed in 2736-ZB</i>										
Canning	Nuclear Operators		1.1		156.0	350		385		54600
Movement-Glovebox to NDA	Nuclear Operators		1.10		1.1	70		77		77
NDA - Isotopic	Nuclear Operators		1.60		47.0	350		560		16450
NDA - Coincidence	Nuclear Operators		0.16		91.0	350		56		31850
NDA - Calorimetry	Nuclear Operators		2.70		71.0	350		945		24850
Movement NDA for Vault	Nuclear Operators		0.20		0.0	70		70		0
Vault Access - SNM Deposit	Vault Operators		5.10		82.0	350		1785		28700
Total per worker							6279	3878	141449	156527
Aggregate Crew Total (rem)							18.9	11.7	212.1	235
[Whole Body- 2 workers plus contingency; Extremity- worker plus contingency]										

^aAll brushing of Metal & Alloys will be performed in 234-5Z and packaged in 2736-ZB

^bItem already packaged in HCC

3.3 Thermal Stabilization

Thermal stabilization of Pu oxides and mixed oxides is estimated in the PFP EIS⁴ to require 82 weeks of processing time assuming 75% efficiency and a 10% recycle rate. Table 7 "Oxide/MOX Thermal Stabilization and Packaging Estimated DE" lists the process steps and the whole body and extremity DE associated with each step, and estimates DEs required for treatment of the oxide and process area holdup inventory, respectively. Again, since the distribution of processing operations was not finally determined while this study was in progress, the estimated DE is calculated for stabilization of 50 % of the entire amount in the main facility (234-5Z) and 50 % in the vault support facility (2736-ZB). Packaging would take place in 2736-ZB.

Table 7.

Oxide/MOX Treatment Estimated DE

Task Step	Workers	Whole Body DE (mrem per task)		Extremity DE (mrem per task)		Est Number Task Cycles ^b	Total Whole Body DE (mrem)		Total Extremity DE (mrem)	
		-5Z	ZB	-5Z	ZB		-5Z	ZB	-5Z	ZB
Vault Access – SNM Removal	Vault Ops	3.0	3.0	27.6	27.6	5488	8230	8230	75740	75740
Move to Glovebox	NPO	2.0	2.0	21.7	21.7	1100	1100	11000	11932	11932
Seal In	NPO	1.7	0.3	17.7	16.7	5488	4551	821	48627	45888
Furnace Operation	NPO	0.6	0.5	35.4	31.3	5488	1599	1283	97226	85894
Screen & Crush	NPO	1.2	0.3	144.5	143.6	5488	3172	701	396533	394092
Sample	NPO	2.3	0.4	18.2	16.0	1740	2001	317	15820	13916
Seal Out ^a	NPO	0.6	0.5	19.9	15.1	1740	552	475	17322	13130
<i>Activities Completed in 2736-ZB</i>										
Canning	NPO		0.2		61.2	1740		268		106552
Move to NDA	NPO		1.0		10.9	348		348		3793
NDA – Isotopic	NPO		1.3		34.0	1740		2290		59158
NDA – Calorimetry	NPO		2.2		182.4	1740		3820		317434
Movement NDA for Vault	NPO		1.0		10.9	348		348		3793
Vault Access – SNM Deposit	Vault Ops		3.9		111.1	1740		6722		193302
TOTAL per worker							21205	26723	663200	1324619
Aggregate Crew Total (rem)							63.6	80	1326.4	1986.9
[Whole Body- 2 workers plus contingency; Extremity- worker plus contingency]										

^aItem already packaged in HCC

^bAssumes 50 % of items processed in 234-5Z, and 50 % processed in 2736-ZB

3.4 Polycube Stabilization Activities

Stabilization of polycubes and a small amount of other combustible materials are estimated in the PFP EIS to require 21 weeks of processing time assuming 75% efficiency and a 10% re-cycle rate. The primary procedure to be used for thermal stabilization is ZO-160-032 "Operate HC-21C Muffle Furnace." At the time of this study, the method of extracting styrene from the polycubes prior to full stabilization of the remaining Pu was anticipated to be pyrolysis. Process steps were roughly developed for the purposes of this study. That scenario is represented in Table 8, "Polycube/Combustibles Treatment Estimated DE". At the time of this report, it is anticipated that a longer thermal stabilization time within the 234-5Z muffle furnaces will suffice to convert the styrene to carbon dioxide gas and water vapor, which would leave the furnace in the offgas. That scenario would likely result in a lower worker dose to that shown in the table below since the pyrolysis step is a candidate for elimination.

Table 8.

Polycube Stabilization and Packaging Estimated DE

Task Step	Worker	Whole Body DE (mrem per task)	Extremity DE (mrem per task)	Estimated Number of Task Cycles	Total Whole Body DE (mrem)	Total Extremity DE (Mrem)
<i>Activity Completed in 234-5Z</i>						
Vault Access	Vault Ops	4	55	273	1127	15015
Move to Room	NPO	4	59	56	224	3304
Seal In	NPO	3.1	38	273	838	10374
Charge Preparation	NPO	1.0	27	273	284	7371
Pyrolysis Furnace Operation	NPO	16.5	39	273	4496	10647
Move to Furnace	NPO	6.00	6	273	1638	1638
Furnace Operations	NPO	12.7	96	28	356	2688
Breakout	NPO	0.23	37	28	6.4	1036
Screen	NPO	1.04	28	28	29	784
Sample	NPO	2.43	8	28	68	224
Seal Out*	NPO	0.22	47	28	6.2	1316
<i>Activity Completed in 2736-ZB</i>						
Can SNM	NPO	2.30	28	28	64	284
NDA- Isotopic	NPO	1.62	28	28	45	784
NDA - Coincidence	NPO	0.63	27	28	18	756
NDA- Calorimetry	NPO	2.73	70	28	76	1960
Move to Vault	NPO	1.00	0.06	7	7	0.40
Vault Access	Vault Ops	3.40	50	28	95	1400
Total per worker					9074	54397
Aggregate Crew Total (rem)						
[Whole Body- 2 workers plus contingency; Extremity- worker plus contingency]					27	7.8

*Product already packaged in HCC

3.5 Thermal Stabilization of Process Area Holdup

Thermal stabilization of retrieved process area holdup (Sludges) is part of the oxide duration estimated in the PFP EIS⁴ to require 82 weeks of processing time assuming a 75% efficiency and a 10% recycle rate. Table 9 "Sludge Thermal Stabilization Estimated DE" lists the process steps and the whole body and extremity DE associated with each step, and estimates DEs required for treatment of the oxide and process area holdup inventory, respectively. Again, since the distribution of processing operations was not finally determined while this study was in progress, the estimated DE is calculated for furnaces in the main facility (234-5Z) and the vault support facility (2736-ZB). For the final summary, this activity is presumed to take place in 234-5Z.

Table 9.
Sludge Stabilization and Packaging Estimated DE

Task Step	Worker	Whole Body DE (mrem per task)		Extremity DE (mrem per task)		Estimated Number of Task Cycles	Total Whole Body DE (mrem)		Total Extremity DE (Mrem)	
		-5Z	ZB	-5Z	ZB		-5Z	ZB	-5Z	ZB
Vault Access - SNM Removal	Vault Ops	3.00		9		1477	4431		13290	
Move to Room (5 items per wagon)	NPO	2.00		7		296	592		2072	
Seal In (1 item at a time)	NPO	1.60		7		1477	2363		10339	
Furnace Operations	NPO	0.25		14		148	37		2072	
Screening	NPO	1.90		24		148	281		3552	
Sampling	NPO	2.30		4		148	163		2812	
Seal Out ^a	NPO	0.40		5		148	59		740	
Canning	NPO		0.10		20	148		15		2960
Move to NDA - Isotopic	NPO		0.68		7	185		101		1036
NDA - Calorimetry & Coincidence	NPO		1.20		65	148		178		9620
Vault Access - SNM Deposit	Vault Ops		6.00		54	185		777		7659
TOTAL per worker							7926	1071	34877	21275
Aggregate Crew Total (rem)							23.7	3	52.4	32
[Whole Body- 2 workers plus contingency; Extremity- worker plus contingency]										

^aItem already packaged in HCC

3.6 Cementation of Pu Residues

The cementing process primary procedure ZO-160-060, "Stabilization via Cementation," describes the processes used in cementation of residues, material defined as containing less than 30 wt- % Pu. A six-month campaign time is estimated which is spread over several years. Each batch of cemented residue is placed into a can and then in turn placed into a 6-inch Schedule 80 right circular cylinder pipe, welded shut at one end with a bolted flanged closure on the other. There are three containers in each cylinder. These cylinders are eventually placed into 55-gallon drums for storage and shipment. Table 10 "Estimated DE for Residue Stabilization via Cementation" lists the process steps and the whole body and extremity DE associated with each step, and estimates DEs required for each step and the whole campaign. The individual task DEs are derived from the oxide data work sheets corrected for background and obvious differences. The cementing and canning operation tasks are estimated from the oxide stabilization and canning of high ²⁴⁰Pu materials.

Table 10.
Estimated DE for Residue Stabilization and Packaging via Cementation

Task Step	Worker	Whole Body DE (mrem per task)	Extremity DE (mrem per task)	Estimated Number of Task Cycles	Total Whole Body DE (mrem)	Total Extremity DE (Mrem)
Vault Access (5 items per wagon)	Vault Ops	3.0	38	1500	4500	57000
Move to Room (5 items per wagon)	NPO	1.0	29	300	300	8700
Seal In (1 item at a time)	NPO	3.6	37	1500	5400	55500
Cementing & Canning Operations	NPO	2.90	88	4036	11701	355080
Seal Out (1 item at a time)	NPO	3.60	19	4036	14526	36324
Load Cylinder	NPO	2.5	12	4036	10090	48432
Movement to Drum & Loading Drums	NPO	1.0	9	1345	1345	12105
Drum Storage ^b	NPO	0.5	5	1345	672	6725
Total per worker					48534	620207
Aggregate Crew Total (rem)					145.5	930
[Whole Body- 2 workers plus contingency; Extremity- worker plus contingency]						

^b Assumed to be equivalent to oxide movement back to the vault.

3.7 Summation of Results

In Table 11 "Summary of Worker Dose for PFP Stabilization and Packaging Activities," calculated whole body and extremity DEs are summarized for stabilization and packaging of the material types discussed in the report. Note that packaging steps are contained within this summary. Operations for various material types are split between the main and vault support facilities according to the current (FY2000 IPMP) program planning.

Table 11.
Whole Body and Whole Body and Extremity DE Summary for PFP Stabilization and Packaging Program
(Packaging included in each material category)

Activity	Whole Body DE per Activity (rem)			Extremity DE per Activity (rem)		
	234-5Z	2736-ZB	Vaults**	234-5Z	2736-ZB	Vaults**
Solutions	27	4.5		120	20.85	
Metals & Alloys	18.9	11.7		212.1	235	
Oxide/MOX	63.6	80		1326.4	1986.9	
Sludges	23.7	3		52.4	32	
Polycubes	27	0.9		81.6	7.8	
Residue/Cementation	145.5			930		
Vault Construction			64			64
Total DE in each Facility	305.7	100.1	64	2722.5	2282.55	64
Total DE (Whole Body / Extremity)	469.8			5069.05		
Number of Workers in Crew	54	30	6*	54	30	6*
Average DE per worker for entire program	5.7	3.3	10.6*	50.4	76.1	10.6*
Length of Program (calendar months)	54	42	39	54	42	39
Average Annual DE/worker/year	1.3	1.0	3.3	11.2	21.7	3.3

* Crews will be rotated

** Vault DE is included in process activities

A breakout of the worker DE from the packaging steps [to place stabilized materials in dual welded containers to meet the criteria in DOE-STD-3013-96] is of interest from a perspective of comparison to previous dose calculations in the PFP EIS which do not include these steps. These data are collected in Table 12 below. The whole body and extremity DE totals from each material category were derived from the tables seen previously in this section, and may be found as the "canning" through "vault access-SNM deposit" steps. As in the totals for the material

category tables, the whole body dose is doubled to account for the continuous presence of two workers while the extremity dose is kept at one worker per step.

Table 12.

Whole Body and Extremity DE Summary For PFP "3013" Packaging Only
(from canning through placement activity for each material category)

Activity	Whole Body DE per Activity (rem)	Extremity DE per Activity (rem)
Solutions	4.5	20.8
Metals & Alloys	11.7	2.5
Oxide/MOX	41.7	1026
Polycubes	0.9	7.8
Sludges	3	32
Total DE	61.5	1321.6

References

1. DOE 1994, *Radiological Control Manual*, DOE/EH-0256T, Rev. 1, U.S. Department of Energy, Washington, D.C.
2. PNNL 1988, *Health Physics Manual of Good Practices for Plutonium Facilities*, PNL-6534, Pacific Northwest National Laboratory Richland, WA.
3. Chew 1996, MH Chew & Associates (Mr. LG Faust), *Dose Equivalent Estimates for the Plutonium Finishing Plant Stabilization Project*, Letter Report, Richland, WA.
4. DOE 1995, DOE/EIS-0244-F, *Plutonium Finishing Plant Stabilization Final Environmental Impact Statement*, May 1995. U.S. Department of Energy, Richland, WA.
5. Mejia 1999, Letter Report, *Project W-460 Staffing Profile*, B&W Hanford Company, Richland, WA.
6. DOE 1996b, DOE-STD-3013-96, *Criteria for the Stabilization and Packaging of Plutonium-Bearing Materials*, U.S. Department of Energy, Washington, D.C.
7. HNF-5444, Rev. 0., *PFP Dose Estimate - Historical Documentation*, Excel Files.

Appendix A

Dose Rate Calculation Formulas

Calculated DE rate estimates are based on formulas given in "*A Guide to Good Practices at Plutonium Facilities*," BNWL-2086, L. G. Faust et al., September 1977.

For direct photon dose:

$$D_s (\text{rad/h}) = 171f_{238} + 0.51f_{239} + 2.4f_{240} + 8.7f_{241} + 0.15f_{242} + (0.074f_{241}) t,$$

Where D_s = the surface DE rate of plutonium dioxide or metal in rad/h, f_i is the weight fraction of the i^{th} isotope of plutonium, and t = number of days since chemical separation.

For photon dose through a lead-loaded glove (0.1 cm lead equivalent):

$$D_{\text{PbGI}} (\text{rad/h}) = 2.83f_{238}e^{-0.00789t} + 0.104f_{239} + 0.0315f_{240} + 6.35E_{242} + \\ F_{241} (158.5e^{-0.0016t} - 152.5e^{-0.0457t}) t,$$

Where D_{PbGI} = the surface DE rate of plutonium dioxide or metal in rad/h, f_i is the weight fraction of the i^{th} isotope of plutonium, and t = number of days since chemical separation.

For photon whole body dose through a lead-loaded glove at 24" from the source (whole body location)

$$D_{\text{WB}} = D_{\text{PbGI}}/(r^2), \text{ where } r = 24 \text{ inches.}$$

For neutron dose from Pu metals,

$$D_{\text{nmetal}} (\text{mrem/h}) = (3.7E4f_{239} + 2.62E3f_{238} + 3E-2f_{239} + 1.02E3f_{240} + 1.7E3f_{242} + \\ 1.6f_{\text{AM-241}}(0.0097)(1/r^2)) g,$$

Where D_n = the neutron DE rate of plutonium metal caused by spontaneous fission in mrem/h, f_i is the weight fraction of the i^{th} isotope of plutonium, g is the mass in grams, and r is the distance to the point of interest.

For neutron dose from Pu oxides,

$$D_{\text{noxide}} (\text{mrem/h}) = 4.63E5f_{236} + 1.63E4f_{238} + 4.5E1f_{239} + 1.07E3f_{240} + 1.8f_{241} + 1.5E3f_{242} \\ + 2.7E3f_{\text{AM-241}}(0.0097)(1/r^2) g,$$

Where D_{noxide} = the neutron DE rate of plutonium oxide caused by spontaneous fission and α -n reactions in mrem/h, f_i is the weight fraction of the i^{th} isotope of plutonium, g is the mass in grams, and r is the distance to the point of interest.

For neutron dose from Pu fluorides,

$$D_{\text{nfluoride}} (\text{mrem/h}) = (6.5\text{E}7f_{236} + 2.1\text{E}6f_{238} + 4.3\text{E}3f_{239} + 1.7\text{E}4f_{240} + 1.7\text{E}2f_{241} + \\ 1.67\text{E}3f_{242} + 1.40\text{E}5f_{\text{AM-241}}(0.0097)(1/r^2) \text{ g},$$

Where $D_{\text{nfluoride}}$ = the neutron DE rate of plutonium fluoride caused by spontaneous fission and α -n reactions in mrem/h, f_i is the weight fraction of the i^{th} isotope of plutonium, g is the mass in grams, and r is the distance to the point of interest.

The total contact DE rate was estimated by multiplying the leaded glove shielded DE rate, then adding one tenth of the oxide neutron DE rate to extremity dose.

The total whole body DE rate was estimated by multiplying the leaded glove shielded DE rate then adding the oxide neutron DE rate for a given batch then multiplying this product times $1/r^2$ to adjust for the whole body location.

Appendix B

Summary Data for Cementation of Pu-Bearing Material

1. Residues will be repackaged in cans hereafter referred to as "coffee cans" each assumed to contain about 55 g Pu each.
2. The coffee cans in turn are to be loaded into a schedule 80 right circular cylinder, welded closed at one end and closed with a bolted flange at the other. The height of the cylinder is such that it contains 3 coffee cans. The assumed nominal mass of Pu is therefore 165 g/cylinder.
3. Number of cylinders required is $4036 \text{ coffee cans} / 3 = 1345 \text{ cylinders}$. Since there is only one cylinder per shipping drum, there is also 1345 drums.
4. Schedule 80 pipe has a nominal wall thickness of 0.432 in.
5. The Pu is considered to be all oxide and of high- ^{240}Pu content since this would be the conservative case. High- ^{240}Pu is >12 weight percent and more importantly, the ^{239}Pu content is $<87\%$. This is important because shielding is less effective (e.g., dose rate higher for unit mass) at higher weight percents of ^{239}Pu for a given thickness.
6. The dose rate for cemented residues is reduced once the coffee cans are placed in the cylinder by an approximate factor of 13; therefore the shielded dose rate is about 0.075 times the unshielded dose rate.
7. Step 6 above does not take any credit in dose reduction from the cemented solids in the coffee can, only for the cylinder. The plutonium materials once cemented and at least somewhat distributed throughout the can volume would be further reduced by at least a factor of 2 (page 4.73 PNL 6534)².
8. The neutron dose rate can be calculated by determining the surface area and neutron source strength of the coffee can. That can then be converted by use of appropriate conversion factors into the neutron dose equivalent rate. The calculation yields a neutron DE :

$$\text{DE} = 0.122 \text{ mrem/hr/n/cm}^2 \times 25 \text{ n/sec/1267 cm}^2 \times 3 \text{ cans per cylinder} = 0.007 \text{ mrem/hr.}$$

This dose equivalent rate does not take any credit for reduction due to the shielding by the concrete or the cylinder. This low value compared to background leads to the conclusion that the neutron dose rate is negligible compared to the photon dose rate once cemented.

9. The actual dose rate and resultant dose are assumed to be similar to that calculated for the oxides. This calculation was based on that premise, using the above modifications to account for known differences.

Appendix C

Estimate of Rack Installation Dose Rates for Proposed Vault Alterations

Assumptions:

- a) All material in vault cubicle removed to support 3013 packaging efforts prior to construction entry. [material not handled twice]
- b) 2 person PSAP rule in effect when construction accesses the vault.
- c) Special Nuclear Material Custodians open the appropriate vault
- d) Custodian will enter the vault and open appropriate cubicle.
- e) Construction craft bring in vault cubicle hardware in one piece. Simple installation of new 3013 container racks that fit onto existing cubicle racks.
- f) RCT will dose rate cubicle per RWP.
- g) Front of cubicle dose is estimated at 60 mrem/hr as a conservative number -- cubicle will be empty and actual dose rate will be measurably less than this figure.
- h) Cubicle hallway dose is estimated at 20 mrem/hr.
- i) Vault corridor dose is estimated at 03 mrem/hr.
- j) Extremity dose will be higher but the whole body limit will be reached first in all cases because of the higher limits.
- k) Actual times may vary; times below are estimated as averages.

Task Steps:

- 1. RCT dose rates cubicle (1 minute from cubicle hallway)
- 2. Special Nuclear Material Custodians open the appropriate vault. (2 custodians present during entire entry – observe activities from cubicle hallway)
- 3. Nuclear Process Operator (NPO) will enter vault and proceed to selected cubicle. Assure cubicle is open or open cubicle if closed, assuring cubicle is empty of product. Two-man rule on entry. Minimum time in front of cubicle (1 minute and 1 minute leaving vault).
- 4. Construction craft enter vault and move pre-fabricated (new) rack to candidate cubicle. (3 minutes for two craft).
- 5. Construction craft install pre-fabricated 3013 rack onto existing cubicle rack assemblies. (117 minutes for two craft)
- 6. Two custodians and two craft exit the vault after cubicle rack task completion (1 minute for 2 custodians and 2 construction craft)
- 7. Survey out of vault area, (say, 2 1/2 minutes each individual in vault corridor)

Staff involved:

- 1 RCT
- 2 Special Nuclear Material Custodians / PSAP staff
- 2 Construction Craft persons
- 1 [part of time] Nuclear Process Operator (NPO)

Table C
Estimated Construction Dose Rates
Per Rack Installation

Activity	Number of Workers	Estimated Duration (min)	Location	Estimated Dose Rate (mrem/hr)	Dose (mrem)
1 Open and Observe Area	2 Custodians or Cust & PSAP worker	123	vault aisle	20	82
2 check dose rate	RCT	1	vault aisle	20	<1
3 check cubicle	NPO & RCT	1	vault aisle	20	<1
		1	cubicle	60	1
4 bring in rack	2 Crafts	3	vault aisle	20	2
5 install rack	2 Crafts	117	cubicle	60	234
6 exit and secure room	2 Crafts & 2 Cust/PSAP	1	vault aisle	20	<1
7 survey people and tools	NPO & RCT	2.5	corridor	3	<1
	Craft	2.5	corridor	3	<1
	Craft	2.5	corridor	3	<1
	custodian	5	corridor	3	<1
	cust/PSAP	5	corridor	3	<1
	RCT (tools)	15	corridor	3	<1
TOTAL DOSE PER CUBICLE RACK					321
TOTAL DOSE FOR VAULT RACK INSTALLATION					
TOTAL OF 200 CUBICLES					64200

DISTRIBUTION SHEET

To Distribution	From PFP Project Management	Page 1 of 1
		Date 11/30/99
Project Title/Work Order Anticipated Dose to workers for Plutonium Stabilization and Handling at PFP - Project W-460		EDT No. 620671
		ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
R. R. Allen	T5-11	X			
J. E. Bramson	T5-54	X			
R. E. Gregory	T5-08	X			
D. R. Groth	X3-88	X			
W. A. Holstein	H6-03	X			
M. T. Jansky	G1-27	X			
G. A. Johnston	B4-09	X			
J. T. Lilly	H6-03	X			
J. L. Mejia	H6-03	X			
T. D. Merklng	T5-57	X			
D. W. Nelson	H6-03	X			
J. J. O'Connor	T5-03	X			
C. T. O'Neill	B4-39	X			
P. E. Roeger	T5-57	X			
E. V. Weiss	T5-45	X			
Central Files	B1-07	X			
DOE Reading Room	H2-53	X			