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Design Features of the Cold Vacuum Drying Facility to Keep Worker Doses as Low as Reasonably Achievable

J. V. Nelson

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Abstract: This report describes the design features and steps taken to ensure that the Cold Vacuum Drying Facility satisfies regulatory requirements that personnel doses be kept as low as reasonably achievable (ALARA). This report also documents an analysis of worker doses and demonstrates that the ALARA goal of limiting individual doses to 500 mrem per year can be met.

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**DESIGN FEATURES OF THE COLD VACUUM DRYING
FACILITY TO KEEP WORKER DOSES AS LOW
AS REASONABLY ACHIEVABLE**

March 1999

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LIST OF TERMS

ALARA	as low as reasonably achievable
CSB	Canister Storage Building
CVDF	Cold Vacuum Drying Facility
DOE	U.S. Department of Energy
IXM	ion exchange module
MCO	multi-canister overpack
MCS	monitoring and control system
NRC	U.S. Nuclear Regulatory Commission
PWC	process water conditioning
SCIC	safety class instrumentation and control
SNF	spent nuclear fuel

1.0 INTRODUCTION

The goal of the Spent Nuclear Fuel (SNF) Project is to remove all SNF from the K Basins in the Hanford 100K Area and put it in interim dry storage at the Canister Storage Building (CSB) in the 200 East Area. Removal of SNF from the K Basins entails loading the intact fuel canisters and fuel scrap into specially designed baskets, which are stacked in water-filled multi-canister overpacks (MCOs). The mission of the Cold Vacuum Drying Facility (CVDF), also located in the 100K Area, is to remove and process the free water in the loaded MCOs before they are transported to the CSB. Removal of the water from the MCOs is necessary to prevent water-induced corrosion of exposed fuel surfaces and to allow the loaded MCOs to be safely transported to and stored in the CSB.

1.1 PURPOSE

The purpose of this report is to outline the steps taken to ensure that the CVDF meets the regulatory requirements that dose rates be maintained as low as reasonably achievable (ALARA). This report documents the regulatory requirements, design and analysis inputs, applicable assumptions, radiological source terms, expected worker doses, and the design review process used. The report also documents the optimization that has resulted in ALARA design features implemented for normal processing, maintenance, and the eventual decommissioning of the facility.

1.2 SCOPE

This report considers only the engineering design features and controls used to keep personnel dose rates ALARA. Standard administrative controls for ALARA, such as training, radiation monitoring, posting, labeling, access control, job planning, and records keeping and reporting are also implemented at the CVDF, but engineering controls are the primary means of providing radiation protection.

This report considers radiation protection to CVDF personnel only. Doses from normal CVDF operations to Hanford Site workers outside the CVDF and to the general public are insignificant, and potential dose rates under accident scenarios are covered in the CVDF Safety Analysis Report.

2.0 OVERVIEW OF THE COLD VACUUM DRYING FACILITY AND OPERATIONS

This section provides a brief overview of the CVDF and the routine operations conducted there to receive, drain, and prepare an MCO for transport to the CSB and to process water extracted from the MCO before it is shipped back to the K Basins. Details of these operations

can be found in the SNF-2356, *Spent Nuclear Fuel Cold Vacuum Drying Facility Operations Manual*.

The cask-MCO handling operation starts with the receipt of the cask-MCO transporter at the CVDF process bay. Operators raise the door to allow the transporter to back into the process bay. The transporter is backed into a predetermined position, the landing legs are raised on the transporter, and the truck is disconnected. The truck is driven out of the bay, and the bay door is closed, establishing bay confinement. Radiation surveys are conducted on the cask and transporter, and the quality assurance package is delivered to the CVDF shift operations manager.

The process bay instrument air service is connected to the transporter air supply control station. The transporter is leveled and set onto the transporter suspension hard points. A bridge is installed from the process bay mezzanine to the transporter work platform. Contamination control supplies are installed on the work platform. The top of the cask is prepared for venting, purging, and cask lid removal.

The MCO then is vented to the cask headspace. The cask annulus was partially filled with water by operations at the K Basins (see Figure 2-1). The cask headspace was purged and filled with helium at approximately 3 psig before it left the basin. During transport to the CVDF, hydrogen generated by fuel corrosion is vented to the cask. Temperature increases associated with radioactive decay heat, solar heating, and water-uranium corrosion reactions also increase pressure. Gas is vented to the cold vacuum drying process vent system through special venting hardware and flex lines connected to the cask lid port and the CVDF process vent system. After venting, the cask headspace is purged with helium. Following purging, the cask lid is removed by the CVDF process bay overhead crane using a dedicated lifting fixture. The cold vacuum drying process hood/seal ring is installed onto the cask, and the MCO is prepped for the process operations described below. A depiction of the MCO-cask with the processing system connected is shown in Figure 2-2.

The process is performed according to prescribed operating procedures. The process operations include the following steps: bulk water removal, helium purging, evacuation with and without helium purge, an initial pressure rebound test, an extended operation under vacuum at the base pressure of the system, a final pressure rebound test, an integrated leak test of the MCO mechanical seals, and backfilling with helium. The majority of all process actions are automatically actuated from the remote control room by the monitoring and control system (MCS) with input (start/stop commands) from the operators. There are two normal operator interfaces, the MCS computers and the safety class instrument and control (SCIC) mode switch; both are located in the CVDF control room.

Minimal manual operator actions are involved in the process sequences. Some specific field operator actions are required (e.g., connecting the MCO process connectors, deionized water/helium rinse/blowdown after draining, and tempered water connections). The control room operator actions include acknowledging alarms or instructing the MCS to proceed with the next step. Valve state changes, water temperature control, and other process parameter changes are performed by the MCS.

Figure 2-1. Cask-Multi-Canister Overpack Configuration upon Receipt at the Cold Vacuum Drying Facility.

Figure 2-2. Cask-Multi-Canister Overpack Configuration with Process Systems at the Cold Vacuum Drying Facility.

Protection from off-site consequences is provided by maintaining water in the cask-MCO annulus space, pressure venting using a 30-psig rupture disc, and automatically actuating the SCIC system. The 30-psig vent path is passive, and the system maintaining annulus water is, for the most part, passive. The SCIC will prevent the tempered water temperatures from exceeding 50 °C by stopping the tempered water heater and circulation pump upon detection of high temperatures.

The contaminated MCO water that was pumped to the receiver tanks into the process water conditioning (PWC) room is processed through an ion-exchange module (IXM) until the water is purified sufficiently to be returned to the K Basins. The water is then processed through a mechanical finishing filter (referred to as the PWC filter) and into a large (5,000-gal) storage tank. The water then is loaded into tanker trucks and shipped back to the K Basins.

Following the cold vacuum drying process, the cask-MCO transporter is prepped for shipment to the CSB. This operation is the reverse of the receipt operation. The cask-MCO is brought to a temperature of 25 °C. The MCO is pressurized with helium to 11 ± 0.5 psig and is then closed. Next, the cask annulus is drained and dried with an instrument air purge, a helium leak test of the MCO is performed, and the cask lid is reinstalled. Only 1 atm of air is left in the cask annulus. Finally, the transporter is connected to the truck and released for shipment to the CSB.

In addition to the operations described above to process an MCO, there are other ongoing activities at the CVDF. These activities, which are discussed in Sections 9.2 and 9.3, include periodic equipment maintenance and calibration and daily patrols, surveillances, housekeeping, and contamination control.

3.0 REGULATORY AND PROCEDURAL REQUIREMENTS

DOE N5480.6, *DOE Radiological Control Manual*, and HSRCM-1, *Hanford Site Radiological Control Manual*, require that equipment and procedures be designed to ensure that worker whole body exposure remains below the ALARA design goal of 500 mrem/year. The federal law governing radiation exposure for this type of work is provided in Title 10, *Code of Federal Regulations*, Part 835, "Occupational Radiation Protection" (10 CFR 835). This code establishes radiation protection standards for the conduct of U.S. Department of Energy (DOE) activities. The annual limit for total effective dose equivalent is 5 rem. An administrative limit of 1.0 rem for whole body dose is set by 10 CFR 835 for occupational workers. Compliance with this limit is assured when the 500-mrem ALARA design goal is achieved. Section 10.0 demonstrates how these ALARA design goals have been met.

Radiological protection standards at the CVDF are required to achieve U.S. Nuclear Regulatory Commission (NRC) equivalency (HNF-SD-SNF-DB-003 and HNF-SD-SNF-SP-012). Other NRC requirements pertaining to radiation protection are delineated in 10 CFR 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste." The NRC requirements in 10 CFR 72 are similar to

the requirements delineated in DOE orders (e.g., DOE Order 5480.23, *Nuclear Safety Analysis Reports*).

Both HNF-SD-SNF-DB-003, *Spent Nuclear Fuel Project Path Forward, Additional NRC Requirements*, and HNF-SD-SNF-SP-012, *Additional Guidance for Including Nuclear Safety Equivalency in the Canister Storage Building and the Cold Vacuum Drying Facility Final Safety Analysis Reports*, require that the CVDF have devices that restrict access to all high-radiation areas, and that the installation of those devices conform to Section 20.1601 of 10 CFR 20, "Standards for Protection against Radiation." High-radiation areas are defined in Section 20.1003 of 10 CFR 20 to be 0.1 rem in 1 h at 30 cm. This is more restrictive than 10 CFR 835, where entry control devices are not required until doses in accessible areas reach 1 rem in 1 h at 30 cm. HNF-SD-SNF-DB-003 also requires that the CVDF incorporate applicable requirements of NRC Regulatory Guide 8.8, *Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be as Low as Reasonably Achievable*. The applications of the requirements for engineered controls in NRC Regulatory Guide 8.8 to the CVDF design are described in Section 8.1.

4.0 DESIGN AND ANALYSIS INPUTS

A block flow diagram for the cold vacuum drying process was developed during the conceptual design phase and revised during the definitive design phase. Throughout the CVDF design phase, process durations were extracted from the block flow diagrams and dose constraints were established based on the expected dose at each facility location. The current flow diagram, which is documented in SNF-2356, identifies each step in the cold vacuum drying process and provides an estimate of the time required for each step. The time estimates, along with dose rate maps for a typical process bay and the PWC room, were used as a basis for calculating personnel radiation exposure. The dose rate maps, which are documented in HNF-2850, *Shielding Analysis for the Cold Vacuum Drying Project*, were produced for various elevations in a processing bay and in the PWC room.

The dose rates used in constructing the maps were computed using the computer programs ISO-PC 1.98 (WHC-SD-WM-UM-030) and MCNPH (WHC-SD-MP-SWD-30001). ISO-PC 1.98 is a point-kernel program based on ISOSHL (BNWL-236 SUP1). MCNPH is the Hanford version of the Monte Carlo program MCNP 4A (Breismeister 1993), which was developed and is maintained at Los Alamos National Laboratory. Both the MCNP 4A and ISOSHL programs are widely used, well tested, and proven to give reliable results.

By combining the dose rate contour maps with information from the process diagram and estimates of manpower required to maintain and calibrate equipment and complete routine patrol, surveillance, housekeeping, and contamination control activities, a model of the CVDF was developed to determine the personnel exposure to radiation that could be expected during operation of the facility. That analysis, "Cold Vacuum Drying Facility Worker Radiation Dose Assessment," is included as Attachment A to this report. Each activity at the CVDF was evaluated to determine the integrated radiation exposure of the personnel performing the activity.

By using this model, the activities that produced the highest personnel exposure were identified and investigated for possible exposure reduction as part of the ALARA review process. After accounting for the final ALARA design features described in Section 8.0, a final assessment of integrated personnel was made. The results of that assessment are presented in Section 9.0.

5.0 ASSUMPTIONS

The radiation sources used in the shielding calculations are defined in Section 6.0. Personnel activities and their assumed duration were based on information given in SNF-2356. The duration of each operational activity was assumed to be as given in Attachment A. It was also assumed that the basin water drained from the MCO was processed through an IXM and a PWC filter in the PWC room. To reduce the exposure of personnel in the room, the six ion-exchange columns in each IXM are housed in steel canisters and shielded by concrete, while the filter is encased in steel 1.5 in. thick.

Assumptions about the frequency of maintenance activities, calibration activities, and the IXM and filter changeouts are given in Section 9.2.

6.0 SOURCE TERM

Potential radiation sources associated with the cold vacuum drying process are:

- The SNF and contaminated water inside the MCO
- Dissolved fission products and fuel particulate contained in the water extracted from each MCO
- Radioactive particulate associated with gases that are purged or evacuated from the MCO.

The radioactive particulate that could be carried by gases is confined inside the shielded MCO by the metal high-efficiency particulate air filter in the MCO and, thus, is assumed to constitute an insignificant radiation source compared to the SNF and contaminated MCO water.

Conversion of fuel mass (grams) to radionuclide activity (curies) was done using the average fuel curies per metric tonne uranium (Ci/MTU) data tabulated in HNF-SD-SNF-TI-009, *105-K Basin Material Design Basis Feed Description for Spent Nuclear Fuel Project Facilities*. Table 6-1 lists the significant radionuclides and their activity levels. The activity units in Table 6-1 are microcuries per gram ($\mu\text{Ci/g}$) of fuel plus fission products, which are equivalent to the units of Ci/MTU reported in HNF-SD-SNF-TI-009.

SNF source material compositions can be divided into two classes for the ALARA analysis, as specified in HNF-2850, Appendix A. The first class includes the SNF in an MCO and unfiltered water extracted from an MCO. The composition of this material is listed in the "Unfiltered" column of Table 6-1. In the second class (filtered process water), there is only water and ^{137}Cs / $^{137\text{m}}\text{Ba}$, under the assumption that all insoluble constituents included in the first class have been removed by the IXM and mechanical filter in the PWC room. The composition of the filtered process water is listed under the "Filtered" column in Table 6-1.

Table 6-1. Radionuclide Concentrations in Source Material.*

Radionuclide	Concentration ($\mu\text{Ci/g}$ Fuel)	
	Unfiltered	Filtered
Co-60	1.89 E+00	
Kr-85	2.81 E+02	
Sr-90	4.81 E+03	
Y-90	4.81 E+03	
Sb-125	1.60 E+01	
Cs-134	7.57 E+00	
Cs-137	6.29 E+03	6.29 E+03
Ba-137m	5.95 E+03	5.95 E+03
Pm-147	2.20 E+02	
Sm-151	8.38 E+01	
Eu-154	5.09 E+01	
Eu-155	1.05 E+01	
Pu-238	5.28 E+01	
Pu-239	1.04 E+02	
Pu-240	5.67 E+01	
Pu-241	3.18 E+03	
Am-241	1.79 E+02	

*Source: HNF-SD-SNF-TI-009, 105-K Basin Material Design Feed Description for Spent Nuclear Fuel Projects Facilities.

The fuel inventory in an MCO was assumed to be 5.25 MTU. The concentration of fuel and associated fission products in water varied by PWC component, as described in HNF-2850. The concentrations used in HNF-2850 to determine radiation source strengths are listed in Table 6-2.

Table 6-2. Source Material Concentration in each Process Water Conditioning Component.

Component	Source specification	Fuel concentration in process water (g/cm ³)
Piping	62.6 g fuel removed with 490 L of process water (unfiltered)	1.27 E-04
Check valve	3 g fuel per valve (1 cm ³ volume) (unfiltered)	3.00 E+00
Receiver tanks	62.6 g fuel suspended in 490 L process water (unfiltered)	1.27 E-04
Ion exchange modules	2.5 kg fuel in each IXM (unfiltered)	4.06 E-03
PWC filter	Contains ¹³⁷ Cs / ^{137m} Ba from 62.6 g fuel (filtered)	5.52 E-03
5,000 gallon tank	Contains ¹³⁷ Cs / ^{137m} Ba from 62.6 g fuel (filtered)	3.31 E-06

Source: HNF-2850, Shielding Analysis for the Cold Vacuum Drying Project.

IXM = ion exchange module.

PWC = process water conditioning.

Only photon radiation exposures were computed in HNF-2850. Existing shielding, pipes, and vessel walls effectively attenuate alpha and beta radiation. However, bremsstrahlung was accounted for in the ISO-PC calculations. Neutron dose rates from SNF sources are orders of magnitude less than photon dose rates outside unshielded, water-shielded, or concrete-shielded containers. This was verified by estimating the neutron dose rate for one case using the method given in *Estimation of Neutron Dose Rates from Nuclear Waste Packages* (Nelson 1996). In that case, the neutron dose rate 30 cm from a check valve with a 3-g deposit of fuel particulate (an assumed worst case) was computed and compared to the photon dose rate reported in HNF-2850. The result of this comparison was that the neutron dose rate was only 0.04% of the photon dose rate (0.022 versus 52.1 mrem/h). Steel, on the other hand, is much more effective at attenuating photons than neutrons. Thus, the fractional contribution of neutrons to the total dose rate outside the MCO transportation cask will be higher. However, previous analyses (WHC-SD-SNF-CAVR-001 and HNF-SD-SNF-CN-026) determined that neutrons still account for only about 10% of the dose rate outside an MCO cask.

7.0 RADIOLOGICAL DESIGN REVIEW PROCESS

The ALARA requirements and objectives followed during the CVDF design are given below.

1. Optimization principles, as discussed in ICRP Publication 37, *Cost-Benefit Analysis in the Optimization of Radiation Protection*, shall be used in developing and justifying design and physical controls.

2. External exposure shall not exceed 500 mrem per year (DOE N5480.6 and HSRM-1).
3. Airborne radioactive particles are to be contained and filtered so that no internal exposure is expected under normal operating conditions.
4. Ease of maintenance, decontamination, and decommissioning are to be considered in the design and selection of materials.

ICRP Publication 37 discusses the principles and methods for achieving the optimization required as part of a system dose limitation. The guidance given is that all exposures shall be kept ALARA, with economic and social factors taken into account.

Engineering controls selected for maintaining the internal and external radiation exposure ALARA included the use of confinement, ventilation, remote handling, and shielding. The process was an iterative one that addressed ALARA issues as the design evolved. Thus, ALARA features were integrated during the design process, rather than being identified and incorporated after the completion of the definitive design.

Operations personnel and radiological control personnel were involved in the ongoing design and review process to identify opportunities of dose radiation.

The NRC Regulatory Guide 8.8 provides information for ensuring that occupational radiation exposures at nuclear power stations will be ALARA. Although the CVDF is not a nuclear power plant, much of the information in the guide can be applied; these items were included in CVDF design as required by HNF-SD-SNF-DB-003 and HNF-SD-SNF-SP-012. Every design feature listed in Sections 8.1 and 8.2 complies with one or more recommendations from the NRC Regulatory Guide 8.8. Although this guide does not address decommissioning, the design features listed in Section 8.3 for keeping personnel dose rates ALARA during decommissioning of the CVDF have a basis in the guide.

8.0 FINAL ALARA DESIGN FEATURES INCORPORATED

8.1 PROCESS DESIGN

The areas of high radiation exposure were identified from the block flow diagram and the model of the cold vacuum drying process. Many of the design features were then revised to reduce the amount of expected exposure to the personnel performing the activities. Examples of revised design features are included in this section.

An early CVDF design change to keep personnel doses ALARA involved incorporating shield walls between the bays to reduce exposure from an MCO in an adjacent bay. The concrete walls between the bays reduced the background to 0.1 mrem/h, thereby mitigating the dose rate from an MCO in an adjacent bay.

A shield collar was incorporated over the annular space between the MCO and cask. This eliminated the need to use long-handled tools to perform the operations over the MCO, thereby reducing the duration, dose rate, and total exposure from these tasks.

During the course of the definitive design process, the estimate of the source term for SNF in the water removed from an MCO was significantly increased. To mitigate the resulting increase expected in personnel exposure, a shielded PWC room was provided for collection of the water and removal of the dissolved and entrained SNF in shielded IXMs. The PWC room now allows for the most radioactive source material outside the MCO cask shielding to be segregated from the remainder of the facility.

To reduce the effect of potential airborne releases from an MCO, a local exhaust hood was incorporated into the cold vacuum drying configuration to capture any contamination that could be released when making and breaking process connections to the MCO. The process hood is attached to the seal ring and is designed to provide local ventilation for operator protection while allowing manual access to process ports on the MCO.

A check valve was added to the PWC transfer line to keep low or uncontaminated condensate lines free from accumulating contamination from the MCO water transfer and flush activities that are expected to have significantly higher contamination. Although not expected, SNF particulate could become trapped in PWC transfer line check valves. To prepare for this possibility, the PWC piping system is designed to allow field installation of at least one inch of lead shielding if dose monitoring indicates this operational mitigation feature is required.

While not implemented within the cold vacuum drying part of the project, the need for a filter to remove SNF entrained in gases from the MCO was identified. The best possible location for the filter was determined to be inside the MCO. A process filter would protect the downstream portion of the line, but not the portion of the line from the MCO to the filter. The suggestion of including a filter in each MCO was forwarded to the MCO project, and subsequently a filter was included as a feature of the MCO design.

Potentially, the highest dose rates in the CVDF occur in the PWC room. To avoid unnecessary and inadvertent doses to personnel, the doors to the PWC room are provided with locks that can be used to control access in compliance with HNF-SD-SNF-DB-003 and HNF-SD-SNF-SP-012. Also, radiation levels are routinely monitored. The number, type, and location of radiation monitors in the CVDF are listed in Table 8-1.

A video camera with remote control tilt, pan, and zoom features also was added to the PWC room. This camera reduces the need for personnel to enter the room.

Table 8-1. Radiation Monitors in the Cold Vacuum Drying Facility.

Quantity	Type/description	Location
4	Eberline PCM-1B Personnel Contamination Monitors	1 in each change room
1	Eberline PCM-6A Automated Personnel Monitor	On the administrative side of door 32, which is between the transfer corridor and the Administration Building.
10	Eberline EC4-8 Area Radiation Monitors with model DAI-6 detectors, 4-20mA logarithmic output, and external dry alarm contacts	2 in each of the four operating bays, 1 in the mechanical room, 1 in the PWC room
13	Eberline AMS-4 Beta CAMs	2 in each of the four operating bays, 2 in the transfer corridor,
13	Eberline Alpha 5/5A Alpha CAMs	2 in the mechanical room, 1 in the PWC room

CAM = continuous air monitor.

PWC = process water conditioning.

Research and experience has shown that one of the major contributors to personnel exposure is from replacing filters. To minimize this contributor, a backwashable filter is used in the PWC room. This filter is expected to last the lifetime of the project and only require flushing after processing ten MCOs. Also, an inherent feature of the IXM design selected for PWC water cleanup is that the IXMs are removed and replaced with their thick concrete shielding intact. Personnel exposure to radiation during changeout operations then is largely a function of the background dose rate in the PWC room, rather than from the material trapped in the IXMs.

An effort also was made to select equipment with long service life and a low frequency of maintenance and calibration. An example of such equipment is the tempered water and PWC pumps. These are self-contained pumps with a canned rotor and stator that will not need lubrication.

Several features were included in the design of the receiver tanks to minimize the deposition of material in the tanks. First, the conical shape of the tanks helps to reduce buildup by directing the material towards the outlet. Second, the smooth electro-polished finish minimizes plate-out of material on the sides of the tank.

Surfaces of other CVDF components were also designed to reduce contamination buildup. Whenever practical, equipment and components were specified to be stainless steel. When this was not possible, items were painted to facilitate decontamination. Where accumulation of contamination is possible, the floors and bottom 4 ft of facility walls were seal-coated.

The PWC transfer lines will be among the most radioactive items in the PWC system. Not only were they specified to be stainless steel, but also to be constructed of thick-walled Schedule 160 pipe to provide additional shielding.

As a result of the high dose rates computed around the filter in the PWC room, 1.5 in. of steel shielding was added around the filter. This shielding reduces the dose rates by a factor of ten.

Another design improvement involved the hoses that connect into the top of the MCO. Originally the hoses were loose and, once connected, hung in place around the MCO. These loose hoses would have been hard for the operators to handle. In addition, a potential for contamination spread resulted from the hanging or swinging hoses. As a result of the design review process, the design was modified to bundle the hoses together and create a "home" position used when the hoses are not connected to the MCO. These design improvements reduce the time operators need to connect the hoses and also reduce the potential for spreading contamination.

8.2 EQUIPMENT RELIABILITY ASSESSMENT AND MAINTENANCE

One of the most wide-ranging and variable parts of any collective dose estimation results from maintenance operations in radiation areas. Two key factors that affect related personnel exposures are (1) the reliability and serviceability of the installed equipment and (2) the layout of the equipment. For example, providing adequate space for ease of maintenance and other operations can allow the work to be completed more quickly, reducing worker exposure to radiation. Both of these factors were considered in designing the CVDF.

Equipment selected for the CVDF typically has a specified design life of at least five years. For instance, the receiver tanks on the process equipment skid have a design life of ten years. Thus, equipment maintenance activities should be minimal, resulting in very low personnel exposure. To further minimize personnel exposure associated with maintenance activities, the process equipment has been configured to facilitate access for maintenance, removal, and replacement. For example, the design of the equipment skids specified that, when practical, conduit should be run along the frame members and routes should be selected so that the conduit does not restrict access to components such as pumps or valves or interfere with their maintenance or replacement.

If replacement of a component is required, steps have been taken to minimize the time needed to complete the task. One of these steps is the use of jumper connections between the skid and the process lines. Because they are not welded, it is easy to disconnect the lines in the unlikely event that replacement or repair is necessary.

8.3 DECOMMISSIONING

The decommissioning phase of the CVDF life cycle must also be considered in estimating the collective dose for the facility. An effort was made in the CVDF design to limit personnel exposure during decommissioning. CVDF features designed to keep this exposure ALARA are described in this section.

Two methods have been used to reduce the amount of deposited radioactive material within the process equipment. The first method is by providing features that permit recirculation or flushing of fluids with the capability of removing radioactive materials through chemical or physical action. An example of this is that the MCO water transfer lines will be flushed after each MCO is processed to prevent a buildup of contamination within these lines. Also, as described earlier, the receiver tanks and the PWC filter have flushing provisions. The second method used is making surfaces smooth, nonporous, and free of cracks, crevices, and sharp corners.

A number of features to reduce contamination buildup and facilitate decontamination are described in Section 8.1. The PWC receiver tanks have conical bottoms to improve draining in addition to being specified with an electro-polished interior to minimize the buildup of contamination. Such features will also help to keep personnel dose rates ALARA during decommissioning.

The CVDF components expected to contain the most residual SNF inventory are provided with shielding; these components will be removed with the shielding intact. Removing such a component and its shielding as one unit will reduce the amount of time workers will need to be in a radiation field, while the shielding will continue to protect them during the activity.

Another feature that will help keep personnel doses ALARA during decommissioning is the design of the PWC transfer line. As described in Section 8.1, these lines were designed to reduce deposition of contaminated material and provide shielding. In addition, the lines are located so as to provide personnel easy access to them, thereby reducing exposure to the personnel who will remove the lines.

The design of the equipment skids will help keep personnel doses ALARA during decommissioning. These skids contain most of the equipment used in the cold vacuum drying process and can be easily and quickly removed from the building. The skids also are connected to other components by flanged couplings instead of being welded in place; this further facilitates decommissioning.

Finally, an effort was made in the CVDF design to segregate items with the highest potential for radioactivity into the PWC room. In this room, the liquid from the MCOs will be processed and the IXM and filter will remove the entrained SNF. Because these potentially radioactive components are centrally located and confined to one area, it will be easier to limit personnel doses associated with the decommissioning of the facility.

8.4 INSTALLATION

The only installation process that will result in personnel dose rates is the field radiography of the process piping. It was determined that the only piping that will require radiography is the MCO water transfer line between the process bays and the PWC room. Furthermore, project personnel in conjunction with the manager of Radiological Control Support have determined that controls in place during this activity will ensure that the associated dose rate is negligible. Thus, no further ALARA considerations are required.

9.0 ASSESSMENT OF PERSONNEL DOSES

Estimates of personnel doses accumulated during normal processing of MCOs at the CVDF and during equipment maintenance and instrument calibration activities are given in this section. There is no significant personnel exposure to radiation during the installation phase of the CVDF life cycle. Personnel doses accumulated during facility decommissioning are not quantified in this report.

Computed dose rates around a loaded MCO in a transportation cask were reported in WHC-SD-SNF-CAVR-001. The radionuclide inventory used in those calculations is consistent with that listed in Table 6-1. The shielding analysis documented in HNF-2850 determined that the dose rates in the process bay are dominated by the photon source in the MCO, except possibly at locations near a check valve in the abnormal event that it contains a significant trapped fuel deposit.

Dose rates in the PWC room, which are reported in HNF-2850, potentially are dominated by fuel particulate trapped in the PWC filter, or fuel and fission products in the receiver tanks. However, personnel would not normally be in the PWC room when there is contaminated water in the receiver tanks. As discussed in Section 8.1, 1.5 in. of steel shielding was added around the filter to reduce the dose rates from this source by a factor of ten.

9.1 NORMAL OPERATIONS

Dose rates, obtained from HNF-2850 and WHC-SD-SNF-CAVR-001 for use in computing personnel exposures during normal operations, are listed in Table 9-1. Data shown account for shielding added to the PWC filter. Dose rates in Table 9-1 were combined with the position of each worker and the time required to complete each activity given in the flow diagrams in Attachment A. Details of the personnel dose assessments for normal operations at the CVDF are also given in Attachment A. The results shown in Table 9-2 as dose per MCO will be used for planning purposes to ensure that personnel annual doses are kept under the 500 mrem limit. Under the assumption that 440 MCOs are processed in 3 years, annual doses can be estimated by multiplying the given doses per MCO by 147.

9.2 EQUIPMENT MAINTENANCE AND CALIBRATION

Maintenance activities can potentially result in personnel exposures higher than during normal operations. To meet ALARA goals, CVDF equipment is designed to require little maintenance and minimize the time needed to complete necessary maintenance activities, as described in Section 8.2. Table 9-3 lists anticipated maintenance activities, with estimates of frequency and manpower (time and number of personnel) requirements. Some of the activities listed are routine tasks, so the estimates are expected to be reasonably accurate. However, other listed activities are intended to cover accidents, equipment failures, and other contingencies. The estimates listed for these cases are highly uncertain.

Table 9-1. General Locations and Dose Rates in the Cold Vacuum Drying Facility.

General location and operation condition	Dose rate* (mrem/h)
Flooded cask in CVDF process bay:	
Mezzanine at <1 m from cask	1.00
Mezzanine at 1 to 3 m from cask	0.50
Mezzanine at 3 to 5 m from cask	0.25
Mezzanine at >5 m from cask	0.10
Mezzanine with cask lid off,	
MCO port plate on	0.34
MCO port plate off	1.50
Main floor at <1 m from cask	2.50
Main floor at 1 to 3 m from cask	1.00
Main floor at 3 to 5 m from cask	0.50
Main floor >5 m from cask	0.25
Main floor at drain port	2.30
Dry cask in CVDF process bay:	
Mezzanine at <1 m from cask	2.00
Mezzanine at 1 to 3 m from cask	1.00
Mezzanine at 3 to 5 m from cask	0.50
Mezzanine at >5 m from cask	0.25
Mezzanine with cask lid off,	
MCO port plate on	0.34
MCO port plate off	1.50
Main floor at <1 m from cask	5.00
Main floor at 1 to 3 m from cask	2.00
Main floor at 3 to 5 m from cask	1.00
Main floor >5 m from cask	0.50
Main floor at drain port	2.30
PWC room:	
Main floor at <1 m from filter	10.00
Main floor at 1 to 1.5 m from filter	5.00
Main floor at 1.5 to 3.5 m from filter	2.00
Main floor at >3.5 m from filter	1.50

*Dose rates were obtained from contour maps in HNF-2850, *Shielding Analysis for the Cold Vacuum Drying Project*. See SNF-2850 and Attachment A of this report for details.

CVDF = Cold Vacuum Drying Facility.

MCO = multi-canister overpack.

PWC = process water conditioning.

Table 9-2. Cold Vacuum Drying Facility Personnel Exposure per Multi-Canister Overpack Processed.

CVDF personnel	Cold vacuum drying process exposure (mrem)*	PWC process exposure (mrem)*
Operator 1	25.4	6.01
Operator 2	14.7	0.01
Facility manager	0.81	0.01
RCT	10.0	5.01
Truck driver	0.86	0.01
Process engineer	0.01	0.01
QA/QC	0.01	0.01
Total per process	51.8	11.1
Total	62.9	

*Under the assumption that 440 MCOs are processed in 3 years, annual doses can be estimated by multiplying the given doses per MCO by 147.

CVDF = Cold Vacuum Drying Facility

PWC = process water conditioning.

QA = quality assurance.

QC = quality control.

RCT = radiological control technician.

Table 9-3. Cold Vacuum Drying Facility Personnel Exposure During Maintenance and Repair Operations.

Activity	Number of personnel ^a	Duration (h)	Frequency (per yr)	Dose rate ^b (mrem/h)	Annual dose (mrem) ^c	
					Per person	Total
HEPA filter qualification						
- in PWC room	3	16	1	1	16	48
- in process bays	3	16	4	0.3 ^d	19	57
HEPA Filter change-out	4	8	1	1	8	32
IXM change out	7	8	2	1	16	112
Corrective action on MCOs in process bay	2	2	22	2	88	176
Corrective action in PWC						
- processed water in receiver tanks	2	2	22	2	88	176
- unprocessed water in receiver tanks	2	2	2	20	80	160
Instrument maintenance and calibration ^e						
- in PWC room	2	1	4	2	8	16
- in process bays	2	1	126	0.3 ^d	38	76
Facility total						853

^aPersonnel in radiation zone only.

^bDose rates were estimated from data in HNF-2850, *Shielding Analysis for the Cold Vacuum Drying Project*.

^cUnder the assumption that 147 MCOs are processed per year, the dose per MCO can be estimated by dividing a given annual dose by 147.

^d0.3 mrem/h is an average dose rate assuming that an MCO is in the bay 50% of the time that work is in progress.

^eFrom the list of instruments and controls in HNF-SD-SNF-SEL-002, *Spent Nuclear Fuel Project Cold Vacuum Drying Facility Safety Equipment List*, and the list of radiation monitors given in Table 8-1. Annual maintenance or calibration of each is assumed.

HEPA = high-efficiency particulate air.

IXM = ion exchange module.

MCO = multi-canister overpack.

PWC = process water conditioning.

RCT = radiation control technician.

The exposures listed in Table 9-3 are annual doses. Under the assumption that 147 MCOs are processed per year, doses per MCO can be estimated by dividing the given annual doses by 147. Thus, the total personnel exposure per MCO from equipment maintenance and calibration activities is 851 mrem per year divided by 147 MCOs per year, which is 5.8 mrem per MCO.

9.3 ROUTINE PATROL, SURVEILLANCE, HOUSEKEEPING, AND CONTAMINATION CONTROL

Operations at the CVDF will be on a 24-hours-per-day, 7-days-per-week basis, with 3 shifts per day. During each of the daily shifts, operations personnel will patrol the facility and radiological control technicians will complete a surveillance of the facility. Also, housekeeping and contamination control activities will be conducted daily. As listed in Table 9-4, the total personnel dose incurred during these routine tasks is estimated to be 1,387 mrem per year. Because of the frequency of these activities, the associated dose is higher than the equipment maintenance and calibration dose given in Section 9.2, but is considerably less, on an annual basis, than the total dose resulting from activities directly related to the MCO drying process.

Table 9-4. Cold Vacuum Drying Facility Personnel Exposure during Routine Patrol, Surveillance, Housekeeping, and Contamination Control.

Activity	Number of personnel ^a	Duration (h)	Frequency (per day)	Dose rate ^b (mrem/h)	Annual dose (mrem) ^c	
					Per person	Total
Operations patrol						
- in PWC room	1	0.25	3	1	274	274
- in process bay	1	0.75	3	0.3 ^d	246	246
RCT surveillance						
- in PWC room	1	0.25	3	1	274	274
- in process bay	1	0.75	3	0.3 ^d	246	246
Housekeeping & contamination control						
- in PWC room	1	0.5	1	1	183	183
- in process bay	1	1.5	1	0.3 ^d	164	164
Facility total						1,387

^aPersonnel in radiation zone only.

^bDose rates were estimated from data given in HNF-2850, *Shielding Analysis for the Cold Vacuum Drying Project*.

^cUnder the assumption that 147 MCOs are processed per year, the dose per MCO can be estimated by dividing a given annual dose by 147.

^d0.3 mrem/h is an average dose rate assuming that an MCO is in the bay 50% of the time that work is in progress.

MCO = multi-canister overpack.

PWC = process water conditioning.

RCT = radiation control technician.

10.0 CONCLUSION

The total exposure of CVDF personnel during MCO processing is 62.9 mrem per MCO, as given in Table 9-2. Assuming that 147 MCOs are processed per year, the annual personnel exposure incurred during MCO processing is then 9,246 mrem. Adding the annual maintenance and calibration dose of 853 mrem given in Table 9-3 and the annual dose of 1,387 mrem from routine patrol, surveillance, housekeeping, and contamination control activities (Table 9-4) gives a total CVDF annual dose of 11,500 mrem. HNF-SD-SNF-PD-011, *Spent Nuclear Fuel Project Operations Staffing Plan*, calls for a work force of 25 operators and 15 radiological control technicians to be stationed at the CVDF. Thus, the average worker dose per year is 287 mrem, which is below the 500 mrem ALARA design goal. In addition, travelling crews associated with MCO transport (15 operators, 5 radiological control technicians, and 5 drivers are listed in HNF-SD-SNF-PD-011) help CVDF personnel in handling the MCO transporter and cask, and there are 35 persons associated with the shared maintenance response crew. When consideration is given to this shared staff that assists CVDF personnel, it can be concluded that the average worker dose associated with CVDF operations is well below the ALARA goal.

In conclusion, this report demonstrates that the CVDF meets the regulatory requirements applying to the use of engineering controls for maintaining personnel doses ALARA. Many engineered features were included in the CVDF design to reduce dose rates ALARA. As potentially high dose rates were identified during the design phase, changes or additions to the design were made to mitigate the excessive dose rates. Also to keep doses ALARA, the engineered features will be augmented by administrative controls and training programs that are beyond the scope of this report.

11.0 REFERENCES

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- 10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*, as amended.
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WHC-SD-WM-UM-030, 1995, *ISO-PC Version 1.98 - User's Guide*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

ATTACHMENT A
COLD VACUUM DRYING FACILITY WORKER
RADIATION DOSE ASSESSMENT

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From: Process Engineering
 Phone: 372-3743 R3-86
 Date: September 3, 1998
 Subject: COLD VACUUM DRYING FACILITY WORKER RADIATION DOSE
 ASSESSMENT

JJI-98-003

To: A. H. McNeil R3-86

cc: W. C. Alaconis R3-86
 D. E. Bullock R3-86
 T. Choho R3-86
 J. E. Kurtz X3-67
 C. M. Miska R3-86
 C. C. Pitkoff R3-86
 C. Pili-Vincens R3-26
 Project Files R3-11
 JJI File/LB

- References: (1) HNF-SD-SNF-DRD-002, 1998, Cold Vacuum Drying Facility Design Requirements, Rev. 3, Fluor Daniel Hanford, Incorporated, Richland, Washington.
- (2) SNF-2356, 1998, Spent Nuclear Fuel Project - Cold Vacuum Facility Operations Manual, Rev. 0a, Fluor Daniel Hanford, Incorporated, Richland, Washington.
- (3) HNF-2850, Shielding Analysis for the Cold Vacuum Drying Project, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.
- (4) H-1-82166, Cold Vacuum Drying Facility Process Equipment Skid Flow Diagram, Fluor Daniel Hanford, Incorporated, Richland, Washington.
- (5) H-1-83766, Cold Vacuum Drying Facility Process System P&ID, Fluor Daniel Hanford, Incorporated, Richland, Washington.

Introduction

This letter documents the CVDF worker dose assessment that was done to support the CVDF ALARA analysis. Current CVDF designs, operation sequences, staffing plans and radiation shielding analyses were used to perform the dose assessment. Using the CVDF project current process flow concepts and knowledge from CVDF Design Authorities and operational personnel, an assessment of the CVDF project radiological exposure and resource requirements was completed.

Assumptions

The current CVDF design requirements are specified in the CVDF DRD (Reference 1), a description of the CVDF and its various systems is defined in the CVDF Operations Manual

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(Reference 2). These documents formed the basis for the physical configurations utilized in the CVDF worker dose assessment.

The current operation sequences for the CVD process are defined in the CVDF Operations Manual (Reference 2). The Operations Manual defines a step by step operation sequence for the CVD process, each operation step also has an estimated time to complete. Using operational and engineering knowledge and experience, a best estimate for the completion time for the process step, personnel location during the step, personnel resources to complete the step and the validity of the step was provided.

The current CVDF Staffing plan for the dose assessment was developed by the CVDF operations staff. Table 1 defines the CVDF operations staffing level assumed for this assessment.

Table 1. CVDF Personnel Occupancy

Personnel	CVDF Occupancy
Operator 1	Continuous/shift
Operator 2	Continuous/shift
Facility Manager	Continuous/shift
HPT	Continuous/shift
Truck Driver	Variable
Process Engineer	Continuous/shift
QA/QC	Continuous/shift

The normal CVD and PWC process system operations are shown in the block flow diagrams, Figures 1 through 4 (Attachment 3), process flow diagram (H-1-82166), and defined on the system P&ID (H-1-83766). The basic process concept utilized for the assessment is as follows.

Cold Vacuum Drying Systems Operations Overview:

- Cold Vacuum Drying Facility Prerequisites for the Cask-Multi-Canister Overpack Transporter Receipt Operation and Normal Cold Vacuum Drying Process Operation (SNF-2356, section 3.4.1, step 1)
- Cask-Multi-Canister Overpack Transporter Receipt Operation (SNF-2356, section 3.4.2, steps 2 through 13)
- Cask Preparations for Cold Vacuum Drying - Cask Venting (SNF-2356, section 3.4.3, steps 14 and 15)
- Cask Preparations for Cold Vacuum Drying - Cask Lid Removal (SNF-2356, section 3.4.4, steps 16 and 17)
- Cask-Multi-Canister Overpack Preparations for Cold Vacuum Drying - Multi-Canister Overpack/Process Hood/Seal Ring Installation (SNF-2356, section 3.4.5, steps 18 and 19)

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- Multi-Canister Overpack Preparations for Cold Vacuum Drying - Vacuum and Purge System Hookup (SNF-2356, section 3.4.6, steps 20 through 22)
- Cask-Multi-Canister Overpack Preparations for Cold Vacuum Drying - Tempered Water System Hookup and Heatup (SNF-2356, section 3.4.7, steps 23 and 24)
- Vacuum and Purge System Operation - Drain Operation (SNF-2356, section 3.4.8, step 25, section 3.4.9, step 26)
- Vacuum and Purge System Operation - Vacuum/Purge Drying Operation (SNF-2356, section 3.4.10 through 3.4.16, steps 27 through 40)
- Vacuum and Purge System Operation - Proof of Dryness Demonstration (SNF-2356, section 3.4.17, steps 41, section 3.4.18, step 42)
- Vacuum and Purge System Operation - Cooldown to 25 °C (77 °F) Operation (SNF-2356, section 3.4.19, steps 43 and 44)
- Multi-Canister Overpack Helium Leak Test (SNF-2356, section 3.4.20, steps 45 through 54)
- Preparation of Cask for Departure (SNF-2356, section 3.4.21, steps 55 through 57)
- Preparation of Trailer for Transport (SNF-2356, section 3.4.22, steps 58 through 65)
- Transport Cask-Multi-Canister Overpack Out of the Cold Vacuum Drying Facility (SNF-2356, section 3.4.23, steps 66 and 67)

Process Water Conditioning System Operation:

- Process Water Conditioning Vacuum Pumping and Receiving - Prerequisite (SNF-2356, section 3.5.1, steps 1 through 5)
- Process Water Conditioning Vacuum Pumping and Receiving - MCO Bulk Water Draining (SNF-2356, section 3.5.2, steps 6 through 8)
- Process Water Conditioning Vacuum Pumping and Receiving - VPS Condenser Tank Draining (SNF-2356, section 3.5.3, steps 9 through 12)
- Process Water Conditioning Vacuum Pumping and Receiving - Tempered Water System Draining (SNF-2356, section 3.5.4, steps 13 through 16)
- Process Water Conditioning Vacuum Pumping and Receiving - Cask-MCO Annulus Draining (SNF-2356, section 3.5.5, steps 17 through 20)
- Process Water Conditioning Impurity Removal (SNF-2356, section 3.5.6, steps 21 through 22)
- Process Water Conditioning IXM Water Sampling (SNF-2356, section 3.5.7, steps 23 through 26)

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- Process Water Conditioning Transfer to PWC Holding Tank, PWC-TK-4001 (SNF-2356, section 3.5.8, steps 27 through 28)
- Process Water Conditioning Transfer from PWC-TK-4001 to KW Basin Tractor Trailer (SNF-2356, section 3.5.9, steps 29 through 33)
- Process Water Conditioning Transfer Line Flushing (SNF-2356, section 3.5.10).

The radiation levels assumed for this dose assessment were derived from the CVDF DRD and HNF-2850. (References 1 and 3). Exposure levels for personnel working near the MCO and Cask package and the PWC tank room were obtained from engineering projections for exposures at contact (< 5 cm), 1 to 3 meter, 3 to 5 meters, and 5 meters to standby area. This information was used to provide exposure estimates for each individual involved in the process step based on expected location and to provide a basis for the operational staffing needed to complete the step.

Project specific assumptions are as follows:

- The MCO and Cask package source terms utilized are tabulated in Table 2.
- The PWC tank room source terms utilized are tabulated in Table 2. The dose fields reflect that shielding is present on the PWC filter reducing that source by an order of magnitude.
- Facility surveillance, cold vacuum drying operations will be completed on a 3 shifts per day, 24 hours a day, 7 days a week, Monday through Sunday shift to the completion of the defined process activity.

Table 2. General Locations and Dose Rates

CVDF General Location and Operation Condition	Dose Rate,mRem/hr
Flooded Cask in CVDF Process Bay	
Mezzanine at <1 meter from Cask	1.00
Mezzanine at 1 to 3 meter from Cask	0.05
Mezzanine at 3 to 5 meter from Cask	0.25
Mezzanine at 5 meter to Standby area	0.10
Mezzanine with Cask Lid Off, MCO port plate on	0.34
Mezzanine at Cask Lid Off, MCO port plate off	1.50
Main Floor at <1 meter from Cask	2.50
Main Floor at 1 to 3 meter from Cask	1.00
Main Floor at 3 to 5 meter from Cask	0.50

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Main Floor at 5 meter to Standby area	0.25
Main Floor at Drain Port	2.30
Dry Cask in CVDF Process Bay	
Mezzanine at < 1 meter from Cask	2.00
Mezzanine at 1 to 3 meter from Cask	1.00
Mezzanine at 3 to 5 meter from Cask	0.50
Mezzanine at 5 meter to Standby area	0.25
Mezzanine with Cask Lid Off, MCO port plate on	0.34
Mezzanine at Cask Lid Off, MCO port plate off	1.50
Main Floor at < 1 meter from Cask	5.00
Main Floor at 1 to 3 meter from Cask	2.00
Main Floor at 3 to 5 meter from Cask	1.00
Main Floor at 5 meter to Standby area	0.50
Main Floor at Drain Port	2.30
PWC Tank Room	
Main Floor at < 1 meter from Filter	10.0
Main Floor at 1 to 1.5 meter from Filter	5.00
Main Floor at 1.5 to 3.5 meter from Filter	2.00
Main Floor at 3.5 meter to Standby area	1.50

- Time durations shown in the work sheets (Tables 4 and 5 [Attachments 1 and 2]) are actual work times. For example, a 48 hour evolution will require 8 shifts to complete assuming 6 hours of in field work completed per shift. 12 shifts to complete if only 4 hours of field work is completed per shift.
- Operations and HPT personnel are available based on the following training requirements.
- Full time employee (FTE) paid at 1820 hours per year, 227 days per year.
- Operator or HPT training estimated to be 7.5% for an average year. 17 days
- Available time for in basin activity - 210 days.

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- Facility work time based on the following for special work permit clothing dress and undress times and shift relief.
- Estimated basin work shift (actual work time) 4 to 6 hours per shift.
- 30 minutes per dress and undress cycle, time includes survey time out of basin.
- Two to four dress and undress cycles per shift, per day. Number of cycles greater than two primarily dependent on operator break times.
- Shift relief times 0730 to 0800, 1530 to 1600 and 2300 to 0000. Operational processing will be minimal during relief.
- Pre-job briefing and crew time nominally 15 to 30 minutes a day.

Results

The total calculated personnel exposure for the defined process operations is summarized in Table 3. The contributors to this exposure on a facility basis are as defined in Tables 4 and 5.

Table 3. CVDF Personnel Exposure per MCO

CVDF Personnel	CVD Process Exposure, mR	PWC Process Exposure, mR
Operator 1	25.38	6.01
Operator 2	14.70	0.01
Facility Manager	0.81	0.01
HPT	10.04	5.01
Truck Driver	0.86	0.01
Process Engineer	0.01	0.01
QA/QC	0.01	0.01
Total per operation per MCO	51.8	11.07
Total per MCO	62.88	

For an assumed population of 440 MCO's this results in a facility dose of 27,667 mR.

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Internal
Memo

Acknowledgments

The team members listed below provided the exchange of knowledge and information which made the dose and resource integration effort a workable task. Without their work and experience this effort would have failed.

Team Members:	Walt Alaconis	CVDF Operations
	Dave Bullock	CVDF Operations
	John J Irwin	CVDF Design Authority

If you have any questions, please call Mr. J. J. Irwin on 372-3743.

J.J. Irwin, SNF Project CVDF Design Authority
Process Engineering

bmb

Attachments 3

JJI-98-003

ATTACHMENT 1

Table 4

consisting of 11 pages,
including cover page

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CVD Bay Operations- Dose per MCO

Table 4

Updated 9/2/98

C-14										C-13										C-12										C-11										C-10										C-9										C-8										C-7										C-6										C-5										C-4										C-3										C-2										C-1										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0										C-0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CVD Bay Operations: Dose per MCO

Table 4

Update: 9/2/98

	A	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
1	Cold Vacuum Dry	13c Prepare platform work area	14a Remove cask lid vent port cover	14b Install vent equip.	14c Evacuate vent line	14d Open vent port & record pressure	14e Take gas sample	14f Vent cask	14g Complete 6 vent & repressurize cycles	15 Install cask lid lifting fixture	16a Retract cask lid bolts	16b Remove vent equip.
2												
3	background min/hr											
4	Steady Background min/hr	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
5	Part planes off	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
6	Down port	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30
7												
8	Dose Field											
9	<1m	1	1	1	1	1	1	1	1	1	1	1
10	1m to 3m	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
11	3m to 5m	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
12	5m to standby area	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
13	Duration: hours in red field	0.08	0.17	0.17	0.17	0.05	0.08	0.03	0.25	0.25	0.50	0.17
14	: minutes for task	10	5	10	10	3	5	2	15	15	30	10
15	Frequency of activity per MCO	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
16	Personnel:											
17	Control room Operator											
18	Dose Rate-min/hr											
19	Dose-person-min/MCO											
20												
21	Operator 1	1	1.00	1	1	1	1	1	1	1	1	1
22	Dose Rate-min/hr	0.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
23	Dose-person-min/MCO	0.08	0.08	0.17	0.17	0.05	0.08	0.03	0.25	0.25	0.50	0.17
24	Operator 2	1	1	1	1	1	1	1	1	1	1	1
25	Dose Rate-min/hr	0.50		1.00	1.00							
26	Dose-person-min/MCO	0.08		0.17	0.17							
27	Mgr											
28	Dose Rate-min/hr											
29	Dose-person-min/MCO											
30	HPT											
31	Dose Rate-min/hr	1	1.00									
32	Dose-person-min/MCO	0.08										
33	Truck Driver											
34	Dose Rate-min/hr											
35	Dose-person-min/MCO											
36												
37	SWP/shift											
38												
39	Control room Operator											
40	Operator 1	0.08	0.08	0.17	0.17	0.05	0.08	0.03	0.25	0.25	0.50	0.17
41	Operator 2	0.08		0.17	0.17				0.25	0.25	0.50	0.17
42	Mgr											
43	HPT		0.08								0.50	0.17
44	Truck Driver											
45	Totals:	0.17	0.17	0.33	0.33	0.05	0.08	0.03	0.50	0.50	1.50	0.50
46												

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CVD Bay Operations- Dose per MCO												Update 9/2/98	
	A	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	
1	Cold Vacuum Dry	17a Remove cask lid	17b Perform dose rate and cont. survey	18b Dicon cask (10% of time)	17c Record MCO serial #	18a Remove port cover	18b Close Port plug	18c Remove long tube port cover	18d Attach hood lift fixture	18e Install hood/seat ring	19a Install bolts & torque to spec.	19b Verify hood flow	
2													
3	background mnmfr	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	
4	Standby Background mnmfr	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	
5	Port plates off	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	
6	Drain port												
7													
8	Dose Field	1	1	1	1	1	1	1	1	1	1	1	
9	<1m	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	
10	1m to 3m	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	
11	3m to Standby area	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	
12	Duration: Hours in rad field	0.08	0.08	0.50	0.08	0.08	0.08	0.08	0.17	0.08	0.17	0.08	
13	: minutes in rad field	5	5	30	5	5	5	5	5	5	5	5	
14	: minutes for task	5	5	30	5	5	5	5	5	5	5	5	
15	Frequency of activity per MCO	100%	100%	10%	100%	100%	100%	100%	100%	100%	100%	105%	
16	Personnel:												
17	Control room Operator												
18	Dose Rate-mnmfr												
19	Dose-person-mnmfr/MCO												
20	Operator 1	1	1	1	1	1	1	1	1	1	1	1	
21	Dose Rate-mnmfr	1.00	1.00	1.00	0.05	2.50	2.50	2.50	2.50	2.50	2.50	2.50	
22	Dose-person-mnmfr/MCO	0.08				0.21	0.21	0.21	0.42	0.21	0.42	0.22	
23	Operator 2	1	1	1	1	1	1	1	1	1	1	1	
24	Dose Rate-mnmfr	1.00	1.00	1.00	0.05	2.50	2.50	2.50	2.50	2.50	2.50	2.50	
25	Dose-person-mnmfr/MCO	0.08				0.21	0.21	0.21	0.42	0.21	0.42	0.25	
26	Mjr												
27	Dose Rate-mnmfr				1.00								
28	Dose-person-mnmfr/MCO				0.08								
29	HPT	1	1	1									
30	Dose Rate-mnmfr	1.00	1.00	1.00		2.50		2.50	2.50	2.50	2.50	2.50	
31	Dose-person-mnmfr/MCO	0.08	0.08	0.05		0.21	0.21	0.21	0.42	0.21	0.42	0.25	
32	Truck Driver												
33	Dose Rate-mnmfr												
34	Dose-person-mnmfr/MCO												
35													
36													
37	SWP/Shift												
38													
39	Control room Operator	0.08		0.05		0.21	0.21	0.21	0.42	0.21	0.42	0.22	
40	Operator 1	0.08		0.05		0.21	0.21	0.21	0.42	0.21	0.42	0.25	
41	Operator 2				0.08								
42	Mjr												
43	HPT	0.08	0.08	0.05		0.21	0.21	0.21	0.42	0.21	0.42	0.25	
44	Truck Driver												
45	Totals:	0.25	0.08	0.15	0.08	0.63	0.21	0.63	0.83	0.42	0.83	0.24	
46													
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CVD Bay Operations- Dose per MCO										Table 4				Updated 9/2/98			
1	Cold Vacuum Dry	AT	AU	20a	Connect to MCO process ports	21a & b	AV	22a	AW	22b	AX	AY	AZ	BA	BB	BC	BD
1	Remove lifting fixture	18c															
2	background m/min																
3	Standby Background m/min	0.10	0.10														
4	Port plates off	1.50	1.50														
5	Drain port	2.30	2.30														
6	Dose Field																
7																	
8																	
9																	
10	1m to 3m	0.50	0.50														
11	3m to 5m	0.25	0.25														
12	5m to standby area	0.10	0.10														
13	Duration: Hours in red field	0.17	0.25														
14	minutes in red field	10	15														
15	minutes for task	10	15														
16	Frequency of activity per MCO	105%	105%														
17	Personnel:																
18	Control room Operator																
19	Dose Rate-m/min																
20	Dose-person-m/min/MCO																
21	Operator 1	1	1														
22	Dose Rate-m/min	2.50	2.50														
23	Dose-person-m/min/MCO	0.44	0.66														
24	Operator 2	1	1														
25	Dose Rate-m/min	2.50	2.50														
26	Dose-person-m/min/MCO	0.44	0.66														
27	Mgr																
28	Dose Rate-m/min																
29	Dose-person-m/min/MCO																
30	HPT																
31	Dose Rate-m/min																
32	Dose-person-m/min/MCO																
33	Truck Driver																
34	Dose Rate-m/min																
35	Dose-person-m/min/MCO																
36																	
37	SWP/shift																
38																	
39	Control room Operator																
40	Operator 1	0.44	0.66														
41	Operator 2	0.44	0.66														
42	Mgr																
43	Truck Driver																
44																	
45	Totals:	0.88	1.31														
46																	

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CVD Bay Operations- Dose per MCO												Table 4				Update 9/2/98			
A	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN	BO								
1	Cold Vacuum Dry	23h	23i	24a & b	25a - d	25e, 1 & 2	25f	25g	26	27	28								
		Connect vac. Initiate Pump to seal pumpdown ring	Verify tempered water time & temp.	Initiate MCO drain	Maintain valve line up during drain & He break thru.	Flush PWC line with deionized water	Disconnect deionized water	Initiate He purge in MCO	PWC & He purge	1st Vacuum drying cycle	Initial no vacuum check								
2																			
3	background m/hr	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10								
4	Standby Background m/hr	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50								
5	Port plates off	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30								
6	Dose Field	1	1	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00								
7	1m to 3m	0.50	0.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00								
8	3m to 5m	0.25	0.25	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50								
9	5m to standby area	0.10	0.10	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25								
10	Duration: Hours in rad field	0.17	0.17	0.05	0.05			0.17			0.25								
11	minutes in rad field	10	10	3	3			10			15								
12	minutes for task	10	10	3	3	22	35	20	10	2	60								
13	Frequency of activity per MCO	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%								
14	Personnel:																		
15	Control room Operator	1	1	1	1	1	1	1	1	1	1								
16	Dose Rate-mrem/hr																		
17	Dose-person-mrem/MCO	1	1																
18	Operator 1	1	1																
19	Dose Rate-mrem/hr	1.00	1.00																
20	Dose-person-mrem/MCO	0.17	0.17																
21	Operator 2																		
22	Dose Rate-mrem/hr																		
23	Dose-person-mrem/MCO																		
24	Mgr																		
25	Dose Rate-mrem/hr																		
26	Dose-person-mrem/MCO																		
27	Dose Rate-mrem/hr																		
28	Dose-person-mrem/MCO																		
29	HPT																		
30	Dose Rate-mrem/hr																		
31	Dose-person-mrem/MCO																		
32	Truck Driver																		
33	Dose Rate-mrem/hr																		
34	Dose-person-mrem/MCO																		
35	SWP Shift																		
36	Control room Operator																		
37	Operator 1	0.17	0.17																
38	Operator 2																		
39	Mgr																		
40	HPT																		
41	Truck Driver																		
42	Totals:	0.17	0.17	0.10	0.10	0.10	0.33	0.33	0.33	0.33	0.25								
43																			
44																			
45																			
46																			

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CVD Bay Operations - Dose per MCO										Table 4				Updates/298			
	A	BP	BQ	BR	BS	BT	BU	BV	BW	BX	BY	BZ					
1	Cold Vacuum Dry	29 230	31	32	33 - 36	37 - 39	40	41	42	43	44	45					
	Pressure rebound pre test	1st thermal purge cycle	1st thermal purge cycle	Isolate & bypass VPS condenser	2nd Vacuum drying cycle	2nd thermal reset purge cycle	1st formal pressure rebound test	Proof of dynamometer demonstration	2nd Formal pressure rebound test	Cool down	Close MCO port plugs	Remove valve operator bolts					
2																	
3	background mfm/hr																
4	Standby Background mfm/hr																
5	Port plates off	1.50	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
6	Drain port	2.30	2.30	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
7																	
8	Dose Field	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
9	<1m	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1m to 3m	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
11	3m to 5m	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
12	5m to standby area																
13	Duration: Hours in and field																
14	minutes for task	210	270	10	240	240	60	1140	60	180	5	5	5	5	5	5	5
15	Frequency of activity per MCO	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
16	Personnel:																
17	Control room Operator	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	Dose Rate-mem/hr																
19	Dose-person-mem/MCO																
20	Operator 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	Dose Rate-mem/hr																
22	Dose-person-mem/MCO																
23	Operator 2	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
24	Dose Rate-mem/hr																
25	Dose-person-mem/MCO																
26	Mgr																
27	Dose Rate-mem/hr																
28	Dose-person-mem/MCO																
29	HPT																
30	Dose Rate-mem/hr																
31	Dose-person-mem/MCO																
32	Truck Driver																
33	Dose Rate-mem/hr																
34	Dose-person-mem/MCO																
35	SWP/flight																
36	Control room Operator																
37	Operator 1																
38	Operator 2																
39	Truck Driver																
40	Dose Rate-mem/hr																
41	Dose-person-mem/MCO																
42	Totals:																
43																	
44																	
45																	
46																	

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CVD Bay Operations- Dose per MCO

CVD Bay Operations- Dose per MCO													Table 4				Update#8298		
	A	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK							
1	Cold Vacuum Dry	46a Remove valve operations	46b Survey MCO process ports	47 Leak check MCO process ports	48 Replace port blind flanges	49 Drain & purge annulus space	50 Disconnect drain & install blank flange	51 Install He leak test equip.	52 Helium leak check	53 Disconnect He leak test equip. & put store away	54 Deflate, unbolt, and store hood/seal ring	55 Initial cask lid with crane							
2																			
3	Background mtr/hr	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10							
4	Standby Background mtr/hr	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50							
5	Port plates off	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30							
6	Drain port																		
7																			
8	Dose Field	2.00	2.00	2.00	2.00	5.00	5.00	2.00	2.00	2.00	2.00	2.00							
9	5' x 5'	1.00	1.00	1.00	1.00	2.00	2.00	1.00	1.00	1.00	1.00	1.00							
10	1m to 3m	0.50	0.50	0.50	0.50	1.00	1.00	0.50	0.50	0.50	0.50	0.50							
11	3m to 6m	0.25	0.25	0.25	0.25	0.50	0.50	0.25	0.25	0.25	0.25	0.25							
12	5m to standby area																		
13	Duration: Hours in rad field	0.17	0.50	0.58	0.50	1.00	0.17	0.50	0.50	0.25	0.25	0.75							
14	minutes in rad field	10	30	35	30	60	60	10	30	30	15	45							
15	minutes for task	10	30	35	30	60	60	10	30	60	15	45							
16	Frequency of activity per MCO	100%	120%	100%	100%	100%	100%	100%	100%	100%	100%	100%							
17	Personnel:																		
18	Control room Operator																		
19	Dose Rate-mtr/hr																		
20	Dose-person-mtr/m/MCO																		
21	Operator 1	1	1	1	1	1	1	1	1	1	1	1							
22	Dose Rate-mtr/hr	3.50	3.50	3.50	3.50	0.50	7.30	2.00	2.00	2.00	2.00	2.00							
23	Dose-person-mtr/m/MCO	0.58	2.10	2.04	1.75	0.50	1.22	1.00	1.00	0.50	0.50	1.50							
24	Operator 2	1	1	1	1	1	1	1	1	1	1	1							
25	Dose Rate-mtr/hr	3.50	0.10	0.35	3.50	0.50	7.30	2.00	0.50	2.00	2.00	2.00							
26	Dose-person-mtr/m/MCO	0.58	0.06	0.20	1.75	0.50	1.22	1.00	0.25	0.50	0.50	1.50							
27	Mgr																		
28	Dose Rate-mtr/hr																		
29	Dose-person-mtr/m/MCO																		
30	HPT	1	1	1	1	1	1	1	1	1	1	1							
31	Dose Rate-mtr/hr	3.50	3.50			0.50	7.30				2.00								
32	Dose-person-mtr/m/MCO	0.58	2.10			0.50	1.22				0.50								
33	Truck Driver																		
34	Dose Rate-mtr/hr																		
35	Dose-person-mtr/m/MCO																		
36																			
37	SWP/shift																		
38																			
39	Control room Operator																		
40	Operator 1	0.58	2.10	2.04	1.75	0.50	1.22	1.00	1.00	0.50	0.50	1.50							
41	Operator 2	0.58	0.06	0.20	1.75	0.50	1.22	1.00	0.25	0.50	0.50	1.50							
42	Mgr																		
43	HPT	0.58	2.10			0.50	1.22				0.50								
44	Truck Driver																		
45	Totals:	1.75	4.26	2.25	3.50	1.50	3.65	2.00	1.25	1.00	1.50	3.00							
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CVD Bay Operations- Dose per MCO										Table 4				Updated 8/2/98									
A										CL	GM	CN	CO	CP	CQ	CR	CS	CT	CU	CV			
1	Cold Vacuum Dry	56	Dry & survey cask surfaces	57	Survey and decon cask & trailer	58	Connect air to trailer landing leg	59	Attach trunk, open door, attach tractor	60	Check trailer latched	61	Set tractor brakes, shut off tractor	62	Raise landing legs, change bldg air to trailer supply	63	Change override valve to auto	64	Connect tractor air and elec.	65	Perform pre trip inspection	66	Release cask to CSB
2																							
3	background m/hr																						
4	Standby Background m/hr	0.10		0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	
5	Port plates off	1.50		1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	
6	Drain port	2.30		2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	
7																							
8	Dose Field																						
9	41m to 3m	2.00		5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	
10	1m to 3m	1.00		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	
11	3m to 5m	0.50		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
12	5m to standby area	0.25		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	
13	Duration: Hours in rad field	0.50		0.50	0.08	0.08	0.25	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.17	0.08		
14	minutes in rad field	30		30	5	5	15	5	5	5	5	5	5	5	5	5	5	5	5	10	5		
15	minutes for task	30		30	30	5	15	5	15	5	15	5	5	5	5	5	5	5	5	10	5		
16	Frequency of activity per MCO	100%		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
17	Personnel:																						
18	Control room Operator																						
19	Dose Rate-m/hr																						
20	Dose-person-m/hr/MCO																						
21	Operator 1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
22	Dose Rate-m/hr	2.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
23	Dose-person-m/hr/MCO	1.00		0.50	0.50	0.50	0.25	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.33	0.04		
24	Operator 2	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
25	Dose Rate-m/hr	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
26	Dose-person-m/hr/MCO	0.50		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	
27	Mgr																						
28	Dose Rate-m/hr																						
29	Dose-person-m/hr/MCO																						
30	HPT	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
31	Dose Rate-m/hr	2.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
32	Dose-person-m/hr/MCO	1.00		0.50	0.50	0.50	0.13	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.17	0.04		
33	Truck Driver	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
34	Dose Rate-m/hr	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
35	Dose-person-m/hr/MCO	0.50		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	
36																							
37	SWP/Shift																						
38																							
39	Control room Operator																						
40	Operator 1	1.00		0.50	0.50	0.50	0.08	0.25	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.33	0.33	0.04	0.04	
41	Operator 2	0.50		0.50	0.50	0.50	0.50	0.38	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.08	0.08	0.08	0.08	
42	Mgr																						
43	HPT	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
44	Truck Driver																						
45	Totals:	2.50		1.00	1.00	1.00	0.09	0.38	0.13	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.08	0.08	0.17	0.08	0.04	
46																							

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Table 4

CVD Bay Operations- Dose per MCO			
	A	CW	CX
1	Cold Vacuum Dry	67	
		Drive truck out, close door	
2			
3	background m/hr		
4	Standby Background m/hr	0.10	
5	Port plates off	1.50	
6	Drain port	2.30	
7			
8	Dose Field		
9	<1m	5.00	
10	1m to 3m	2.00	
11	3m to 5m	1.00	
12	5m to standby area	0.30	
13	Duration: Hours in rad field	0.25	17.78
14	: minutes for task	15	
15	Frequency of activity per MCO	15	77.108333
16	Personnel	100%	
17	Control room Operator		Totals:
18	Dose Rate-m/hr		
19	Dose-person-m/hr		
20	Dose-person-m/m/MCO		
21	Operator 1		
22	Dose Rate-m/hr		
23	Dose-person-m/m/MCO		25.38
24	Operator 2		
25	Dose Rate-m/hr		
26	Dose-person-m/m/MCO		14.70
27	Mgr		
28	Dose Rate-m/hr		
29	Dose-person-m/m/MCO		0.81
30	HPT		
31	Dose Rate-m/hr		
32	Dose-person-m/m/MCO		10.04
33	Truck Driver	1	
34	Dose Rate-m/hr	0.50	
35	Dose-person-m/m/MCO	0.13	0.86
36			
37	SWP/Shift		
38			Totals:
39	Control room Operator		
40	Operator 1		25.38
41	Operator 2		14.70
42	Mgr		0.81
43	HPT		10.04
44	Truck Driver	0.13	0.86
45	Totals:	0.13	51.79
46			

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ATTACHMENT 2

Table 5

consisting of 5 pages,
including cover page

CVD PWC room Operations- Dose per MCO													Updated 9/2/98	
Table 5														
A	B	C	D	E	F	G	H	I	J	K	L			
1 Cold Vacuum Dry step #	1 to 5	6 to 8	9.0	10.0	11.0	12.0	12a	13	13a	14	15.0			
	Verify PWC system ready to operate	Covered by steps 25a-25g of ops. Manual	Verify PWC system ready	Verify step 43 of MCO process is complete	Establish valve lineup with MCS	Drain and purge condensate tank	Return valve lineup to pre-start condition	Verify PWC system ready	Verify step 48 of MCO process is complete	Verify TW system shutdown	Open PWC-V-051 on the PES			
2														
3 background m/hr		0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10			
4 Empty Bay Bldg m/hr		1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50			
5 PWC room standby area		2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30			
6 Drain port														
7														
8 Dose Field														
9 1-m from filter														
10 1m to 1.5m														
11 1.5m to 3.5m														
12 3.5m to standby area														
13 Duration House in rad field														
14 Duration House in rad field														
15 minutes for task	15	100%	100%	5	15	10	15	5	5	5	5			
16 Frequency of activity per MCO														
17 Personnel														
18 Control room Operator	1	1	1	1	1	1	1	1	1	1	1			
19 Dose Rate-m/hr														
20 Dose-person-intem/MCO														
21 Operator 1														
22 Dose Rate-m/hr														
23 Dose-person-intem/MCO														
24 Operator 2														
25 Dose Rate-m/hr														
26 Dose-person-intem/MCO														
27 Mgr														
28 Dose Rate-m/hr														
29 Dose-person-intem/MCO														
30 HPT														
31 Dose Rate-m/hr														
32 Dose-person-intem/MCO														
33 Truck Driver														
34 Dose Rate-m/hr														
35 Dose-person-intem/MCO														
36														
37 SWP/Plant														
38														
39 Control room Operator														
40 Operator 1														
41 Operator 2														
42 Mgr														
43 HPT														
44 Truck Driver														
45 Totals:														
46														
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Page 1

CVD PWC room Operations- Dose per MCO													Updated 9/29/8		
Table 5															
A	M	N	O	P	Q	R	S	T	U	V	W				
1 Cold Vacuum Dry step #	15a	16	17	17a	18 + 19	20	21 + 22	23 - 26	27	28a	28b				
Drain TW system and dose PWC-V water as required	Refill TW sys. With DI	Verify PWC system ready	Verify step 48 of MCO process is complete	Covered by Step 49 of ops manual	Covered by Step 50 of ops manual	PWC recirc through IXMs	Change out sample bottles in PWC room	Verify PWC system ready for transfer	Verify PWC-V-013, PWC-V-002, PWC-V-015 closed	Verify PWC-V-019 open					
2															
3 background m/hr															
4 Empty Bay Blgd m/hr	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10				
5 PWC room standby area	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50				
6 Drain port	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30				
7															
8 Dose Field								10							
9 <1m from filter	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00				
10 1m to 1.5m	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00				
11 1.5m to 3.5m	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00				
12 3.5m to standby area	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50				
13 Duration: Hours in rad field	0.25							0.50		0.03					
14 minutes in rad field	15							30		2					
15 minutes for task	15							30		2					
16 Frequency of activity per MCO	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%				
17 Personnel:															
18 Control room Operator		1					1		1						
19 Dose Rate-m/hr															
20 Dose-person-m/hr/MCO															
21 Operator 1	1	21	Operator 1	1			1		1		1				
22 Dose Rate-m/hr	0.10	0.10						10.00	10.00	10.00	10.00				
23 Dose-person-m/hr/MCO	0.03	0.03						5.00	0.33	0.33	0.33				
24 Operator 2															
25 Dose Rate-m/hr															
26 Dose-person-m/hr/MCO															
27 Mgr															
28 Dose Rate-m/hr															
29 Dose-person-m/hr/MCO															
30 HPT								1							
31 Dose Rate-m/hr								10.00							
32 Dose-person-m/hr/MCO								5.00							
33 Truck Driver															
34 Dose Rate-m/hr															
35 Dose-person-m/hr/MCO															
36															
37 SWP/Shift															
38															
39 Control room Operator															
40 Operator 1	0.03	0.03						5.00		0.33	0.33				
41 Operator 2															
42 Mgr															
43 HPT								5.00							
44 Truck Driver															
Total:	0.03	0.03						10.00		0.33	0.33				
45															

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CVP PWC room Operations- Dose per MCO

Table 5

Updated 9/2/98

	A	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
1	Cold Vacuum Dry step #	28c Position to GOV-4057 to PWC-1TC to 4001	28d Open PWC- GOV-4057 to GOV-4057 to PWC-1TC to 4001	29 Close PWC- GOV-4057 to GOV-4057 to PWC-1TC to 4001	30 Receive transfer truck in Bay 1	31 Verify PWC room valve lineup	32a Connect transfer line to truck, open valve	32b Open 3 PWC valves in PWC rm.	33 Start PWC p-001 from the MCS & drain tank	34a Close 4 Valves in the transfer line PWC rm.	34b Disconnect the transfer line	34c Close HEPA & fill ports on truck
2												
3	background m/hr	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
4	Empty Bay Bldg m/hr	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
5	PWC room standby area	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30
6	Drain port											
7												
8	Dose Field	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
9	<1m from filter	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
10	1m to 1.5m	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
11	1.5m to 3.5m	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
12	3.5m to standby area											
13	Duration: Hours in rad field		0.50	0.50	0.50	0.50	0.17	0.08	0.08	0.08	0.50	0.25
14	: minutes in rad field	30	30	30	30	30	10	10	5	5	30	15
15	: minutes for task	100%	100%	100%	100%	100%	10	10	5	15	30	15
16	frequency of activity per MCO						10%	10%	10%	10%	10%	10%
17	Personnel											
18	Control room Operator	1										
19	Dose Rate											
20	Dose-person-m/hr											
21	Operator 1				1	1	1	1	1	1	1	1
22	Dose Rate-m/hr				0.10	10.00	0.10	2.00	0.02	10.00	0.10	0.10
23	Dose-person-m/hr				0.01	0.17	0.00	0.02		0.08	0.01	0.00
24	Operator 2				1							
25	Dose Rate-m/hr				0.10							
26	Dose-person-m/hr				0.01							
27	Mgr											
28	Dose Rate-m/hr											
29	Dose-person-m/hr											
30	HPT											
31	Dose Rate-m/hr										1	1
32	Dose-person-m/hr										0.10	0.10
33	Truck Driver										0.01	0.00
34	Dose Rate-m/hr											
35	Dose-person-m/hr											
36	SWP/Shift											
37	Control room Operator											
38	Operator 1											
39	Operator 2				0.01	0.17	0.00	0.02		0.08	0.01	0.00
40	Mgr				0.01							
41	HPT											
42	Truck Driver											
43	Dose Rate-m/hr											
44	Dose-person-m/hr											
45	Totals:				0.01	0.17	0.00	0.02		0.08	0.01	0.01

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Table 5

CVD PWC room Operations-Dose per MCO

	A	AI	AJ	AK
1	Cold Vacuum Dry step #	34d		
		Survey and release truck		
2				
3	background mfr/hr			
4	Empty Bay Bkgd mrem/hr	0.10		
5	PWC room standby area	1.50		
6	Drain port	2.30		
7				
8	Dose Field			
9	<1m from filter	10.00		
10	1m to 1.5m	5.00		
11	1.5m to 3.3m	2.50		
12	3.5m to standby area	1.50		
13	Duration: Hours in red field	0.50	1.33	
14	Duration: Hours in yellow field	30		
15	minutes for task	30	7.85	
16	Frequency of safety per MCO	10%		
17	Personnel:		Totals:	
18	Control room Operator			
19	Dose Rate-mrem/hr			
20	Dose-person-mrem/MCO			
21	Operator 1	1		
22	Dose Rate-mrem/hr	0.10		
23	Dose-person-mrem/MCO	0.01	6.01	
24	Operator 2			
25	Dose Rate-mrem/hr			
26	Dose-person-mrem/MCO		0.01	
27	Mjr			
28	Dose Rate-mrem/hr			
29	Dose-person-mrem/MCO			
30	HPT	1		
31	Dose Rate-mrem/hr	0.10		
32	Dose-person-mrem/MCO	0.01	5.01	
33	Truck Driver			
34	Dose Rate-mrem/hr			
35	Dose-person-mrem/MCO			
36				
37	SWP/shift		Totals:	
38				
39	Control room Operator			
40	Operator 1	0.01	6.01	
41	Operator 2		0.01	
42	Mjr			
43	HPT	0.01	5.01	
44	Truck Driver			
45	Totals:	0.01	11.02	
46				

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ATTACHMENT 3

Figures 1 through 4
consisting of 5 pages

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From Fig 3-1

5 min

Step 18a Remove Process Vent Port Cover

5 min

Step 18b Close Process Vent Port Plug

5 min

Step 18c Remove Long Process Tube Port Cover

10 min

Step 18d Attach Lift Fixture to Hood/Seal Ring

10 min

Step 18e Place Hood/Seal Ring onto Cask

10 min

Step 19a Install Hooding Bolt and Torque to Spec.

2 min

Step 19b Perform Lifting Activity (See Sheet 1)

2 min

Step 20a Install Connections onto MCO Process Ports (2)

10 min

Step 20b Remove Lifting Fixture & Crane

10 min

Step 20c Initiate Rampdown & Verify < 10 Torr

10 min

Step 20d Connect Vac. Pmp. to Seal Ring Vac. Port

30 min

Step 25a.1 Maintain Valve Line-Up During Drain Operation

1 min

Step 25a.2 Open MCO-to-PMC Isolation Valves

2 min

Step 25a.3 Pressure MCO to 4 psig

2 min

Step 25c Open VPS-V-019

15 min

Step 25b Purge PWC Tank w/ H₂O

2 min

Step 25a Verify PMC System Status

2 min

Step 24b Verify TIC-3005 Remains at 46 °C

2 min

Step 24a Verify Tempered Water Circulated for 3 Hours

1 min

Step 23g Circulate Tempered Water Through Cask Annulus for 3 Hr.

180 min

Step 23f Verify TIC-3005 Indicates 46 °C & Start 3 Hour Heat-Up Clock

2 min

Step 23e Check for Leaks/Adjust Tank Level

5 min

Step 23d Establish Tempered Water Supply Line

2 min

Step 23c Pressurize Inflatable Seals

2 min

Step 23b Circulate Tempered Water Through Supply Line

5 min

Step 23a Remove Cover Plate From Cask's Lower Port

5 min

Step 25d.1 Flush PWC Line With Deionized Water

20 min

Step 25d.2 Maintain Valve Line-Up After He Break-Thru

5 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

2 min

Step 25g Initiate He Purge Through MCO

2 min

Step 25f Purge MCO

2 min

Step 25e Purge MCO

2 min

Step 25d Purge MCO

2 min

Step 25c Purge MCO

2 min

Step 25b Purge MCO

2 min

Step 25a Purge MCO

<

Figure 3. Cold Vacuum Drying Facility Block Flow Diagram
Estimated Average MCO and Cask/MCO Preparation for Shipping Times.

Figure 4. Cold Vacuum Drying Facility Block Flow Diagram Estimated Average PWC System Operation Times.

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Design Features of the Cold Vacuum Drying Facility to Keep Worker Doses as Low as Reasonably Achievable		

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