MOV.19950217.0043

DOC ID: A00000000-01717-0200-00006 REV 2
WBS: 9.2.1
QA: N/A

Civilian Radioactive Waste Management System
Management and Operating Contractor

HEALTH AND SAFETY IMPACTS ANALYSIS FOR THE MULTI-PURPOSE CANISTER SYSTEM AND ALTERNATIVES

Revision 2

June 15, 1994

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DE-AC01-91RW00134

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EXECUTIVE SUMMARY

PURPOSE

This report compares the health and safety impacts of a Civilian Radioactive Waste Management System (CRWMS) that uses the Multi-purpose Canister (MPC) with three alternative systems. The other alternative systems being evaluated are the reference scenario, a dual purpose cask system: the Transportable Storage Cask (TSC) system, and a multi-purpose cask system: the Multi-purpose Unit (MPU) system.

This report is intended to provide information to support the relative comparison of the MPC system and alternative systems. Health and safety estimates are as accurate as current information permits, and, where uncertainties limit the accuracy of estimates, conservative assumptions were made. The same level of conservatism is used for facilities and transportation.

METHODOLOGY

Impacts to public and to occupational health and safety are evaluated. Radiological and non-radiological impacts caused by routine (day-to-day) activities and incidents (accidents) are included. Radiological impacts are measured by the radiological exposure received by persons and non-radiological impacts are measured by fatalities, injuries, and the emission of non-radioactive toxic materials. Health and safety impacts at facilities and during transportation are evaluated separately. Facilities include utility and other spent nuclear fuel (SNF) storage sites (called utilities herein), the Monitored Retrievable Storage (MRS) facility, the cask maintenance facility (CMF), and the Mined Geologic Disposal System (MGDS). Systems were evaluated both with and without an MRS. Health and safety impacts at the utilities, the MRS, and the MGDS are computed from impacts caused by handling spent nuclear fuel (SNF) and SNF casks. The MGDS also includes impacts caused by the handling of vitrified high level waste (HLW) canisters and waste packages. Impacts associated with the CMF result from routine maintenance of contaminated casks. Transportation impacts result from shipping of both loaded and unloaded SNF casks between facilities.

Health and safety impacts are addressed in four areas:

• Radiological Routine Exposures -	Includes radiation exposure during routine facility operations and during transportation.
• Radiological Incident Exposures -	Includes radiation exposure from incidents involving SNF fuel, HLW, and cask/canister handling, and from transportation incidents.
• Non-Radiological Routine Impacts -	Includes routine non-radioactive toxic effluents from facilities and during transportation.
• Non-Radiological Incident Impacts -	Includes non-radiation-related incidents at facilities and during transportation.

Table ES-1 illustrates the total system health and safety impacts for both radiological exposure and non-radiological impacts caused by routine activities and incidents. Note that all health and safety impacts are about the same for any of the four alternative systems with the exception of at-facility routine radiological exposures. Routine radiological exposures result in 99.6% of all exposures, with incidents contributing to about 0.4% for any of the alternative systems.

Table ES-1. Total System Health and Safety Impacts
(total program)

System Impact Area	Single Purpose Cask System (Reference)	Dual Purpose Cask System (TSC)	Multi-purpose Cask System (MPU)	Multi-purpose Canister System (MPC)
Radiological Routine (person-rem)				
• Facilities	42,080	43,820	53,920	56,980
• Transportation[a]	1,450	1,450	1,450	1,450
Radiological Incident (person-rem)				
• Facilities[b]	0.10	0.08	0.04	0.04
• Transportation[a]	430	430	430	430
Non-Radiological Routine (emissions)				
• Facilities[b,c]	.1 tons	.1 tons	.1 tons	.1 tons
• Transportation[a,c]	12,290 tons	12,290 tons	12,290 tons	12,290 tons
Non-Radiological Incidents (injuries and fatalities)				
• Facilities				
injuries	470	470	470	470
fatalities	4	4	4	4
• Transportation[a]				
injuries	132	132	132	132
fatalities	30	30	30	30

Notes:
a) Values shown include all truck, rail, barge, and heavy-haul.
b) Systems approximately the same; within regulatory limits.
c) Includes particulates, sulphur and nitrogen oxides, and hydrocarbon vapors that are toxic or potential carcinogens.

Effectively all of the facility radiological exposures are incurred by workers in the nuclear/waste management industries. As can be seen in Table ES-1, the at-facility routine radiological exposures are approximately 35% higher for the MPC system than for the reference scenario. These higher exposures are caused primarily by the MPC welding operations at the utilities and at the MRS. Welding associated operations at these facilities alone contribute to about 85% (12,600 person-rem) of the difference between the MPC system and reference scenario exposures.

Table ES-2 illustrates how routine radiological exposures are distributed among the facilities and transportation. The radiological exposures at the utilities are significantly higher for the MPC system than for the reference scenario (26,000 versus 13,000 person-rem). This is dominated by the welding operations that contribute 11,500 of the person-rem difference. Though not as significant, welding operations at the MRS (1,100 person-rem) have a large impact on the higher MPC system exposures. The dominant impact of a single operation, welding, suggests that the use of automated canister sealing operations or other techniques could significantly lower the MPC and MPU system exposures to be effectively equivalent to those of the reference system.

Table ES-2. Total System Radiological Routine Impacts
(person-rem)

	Single Purpose Cask System (Reference)	**Dual Purpose Cask System (TSC)**	**Multi-purpose Cask System (MPU)**	**Multi-purpose Canister System (MPC)**
Facilities: • Utilities	13,110	14,550	25,880	25,660
• MRS	8,200	6,140	7,420	10,700
• CMF	160	140	60	60
• MGDS	20,610	22,990	20,550	20,550
Total	42,080	43,820	53,920	56,980
Transport: • Occupational	770	770	770	770
• Public	680	680	680	680
Total	1,450	1,450	1,450	1,450
Program Total	43,530	45,270	55,370	58,430

The MGDS exposures caused by the MPU and MPC systems are lower than those caused by the reference scenario and the TSC system. This reduction is a result of additional shielding provided by the canisters during waste package sealing. Because of an additional bolted lid that must be removed while unloading a TSC, the TSC system produces higher exposures at the MGDS than does the reference scenario. The CMF exposures are small for all systems. Transportation exposures are equal for all systems. Public exposure is the same for all systems and makes up less than 2% of the total system exposure.

Health and safety changes with no MRS in any of the alternative systems were also evaluated. Table ES-3 contains the estimated health and safety values with an MRS, and with no MRS.

Table ES-3. With-MRS/No-MRS Total System Health and Safety Impacts
(total program)

System Impact Area	Single Purpose Cask System (Reference)	Dual Purpose Cask System (TSC)	Multi-purpose Cask System (MPU)	Multi-purpose Canister System (MPC)
Radiological Routine (person-rem)				
• Facilities	42,080/40,150	43,820/37,510	53,920/50,700	56,980/50,860
• Transportation[a]	1,450/1,430	1,450/1,430	1,450/1,430	1,450/1,430
Radiological Incident (person-rem)				
• Facilities[b]	0.1	0.08	0.04	0.04
• Transportation[a]	430/410	430/410	430/410	430/410
Non-Radiological Routine (emissions)				
• Facilities[b,c]	.1 tons	.1 tons	.1 tons	.1 tons
• Transportation[a,c]	12,290/9,440 tons	12,290/9,440 tons	12,290/9,440 tons	12,290/9,440 tons
Non-Radiological Incidents (injuries and fatalities)				
• Facilities				
injuries	470	470	470	470
fatalities	4	4	4	4
• Transportation[a]				
injuries	132/90	132/90	132/90	132/90
fatalities	30/22	30/22	30/22	30/22

Notes: a) Values shown include all truck, rail, barge, and heavy-haul.
b) Systems approximately the same; within regulatory limits.
c) Includes particulates, sulphur and nitrogen oxides, and hydrocarbon vapors that are toxic or potential carcinogens.

With no MRS there is more storage at some utilities, followed by shipment to a MGDS. With no MRS there were 5% less routine radiological exposures at facilities for the reference scenario as compared to the systems with an MRS. Without an MRS in the TSC system, its facility routine exposures were less than the exposures of the Reference scenario with no MRS, and the lowest of all of the alternatives. With no MRS the MPC system routine exposures were 15% less than the exposures of an MPC system with an MRS. The facility radiological incident exposures, nonradiological emissions, injuries and fatalities did not change significantly whether with an MRS or with no MRS. Transportation routine exposures were 5% lower for all alternatives with no MRS, compared to systems with an MRS. Transportation had 23% less nonradiological emission, 25% fewer fatalities, and 32% fewer injuries with no MRS, compared to the systems with an MRS.

CONCLUSIONS

Table ES-1 shows that all health and safety impacts are effectively equivalent for any of the four alternative systems with the exception of routine radiological exposures at facilities. Effectively all of the facility radiological exposures are incurred by workers in the nuclear waste management industries.

As can be seen in Table ES-1, the total routine radiological exposures at facilities are 35% higher for the MPC system than for the reference scenario (57,000 versus 42,000 person-rem). These higher exposures are dominated by the MPC welding operations at the utilities and at the MRS. Welding operations at these facilities alone contribute about 85% (12,600 person-rem) of the difference between the MPC and reference scenario exposures. Total exposures are small relative to expected background radiation exposures (e.g., natural sources, medical uses, radon, etc.) to the U.S. population of 3.5 billion person-rem over the same period of time as the CRWMS program.

Table ES-2 shows that the radiological exposures at the utilities are almost 2 times higher for the MPC system than for the reference technology (25,700 versus 13,100 person-rem). The MPC at-utility exposures again are dominated by welding operations that contribute to 70% (11,500 out of 13,000) of the person-rem difference.

The majority of the increased exposure caused by the MPC system is related to one operation: canister welding. The reference system, on the other hand, is not dominated by a single source or activity so there is no specific opportunity for significant exposure reduction. This strongly suggests that the application of automated canister sealing operations or other techniques could significantly lower the MPC system exposures to be effectively equivalent to those of the reference scenario.

Table ES-3 indicates that with no MRS the evaluated system health and safety impacts will decrease or remain the same for all of the alternative systems. The magnitude of the results for the systems without an MRS are similar to those with an MRS (e.g., for MPC system; 56,970 person-rem with an MRS and 50,860 person-rem with no MRS.) The MPC facility health and safety impacts for systems with no MRS are higher than for the reference scenario with no MRS. In addition, the MPC facility health and safety impacts for systems with an MRS are higher than for the reference scenario with an MRS.

This report estimates the impacts to health and safety associated with operations and procedures as they are currently defined on the basis of nuclear power industry technology demonstrations, current practice, and estimation procedures as described in Appendix A. The development and use of as low as is reasonably achievable (ALARA) techniques can reduce the estimated health and safety impacts in all areas for all alternative systems. Financial costs, schedule impact, and public acceptance should be considered in final decisions determining where and when ALARA techniques are implemented.

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1. INTRODUCTION

1.1 BACKGROUND

The Office of the Civilian Radioactive Waste Management (OCRWM) of the U.S. Department of Energy is developing a Multi-purpose Canister (MPC) system. The MPC system relies on the use of a clean, sealed metal canister for all Civilian Radioactive Waste Management System (CRWMS) operations including storage, transportation, and disposal. The MPC system is being developed as an alternative to systems relying on a single purpose cask design. Other alternatives being evaluated are a dual purpose cask system: the Transportable Storage Cask (TSC) system, and a multi-purpose cask system: the Multi-purpose Unit (MPU) system.

As a result of the initial findings in the study "A Preliminary Evaluation of Using Multi-purpose Canisters within the Civilian Radioactive Waste Management System," (Reference 58) the CRWMS Management and Operating (M&O) contractor was directed to evaluate the MPC system design against the reference scenario for other alternatives. This information is provided to OCRWM for use regarding the development of an MPC system.

1.2 OBJECTIVE

The objective of this report is to determine and compare the health and safety impacts caused by the reference scenario, the MPC, the TSC, and the MPU alternative systems. The results provide information for use in the continuing development of the MPC system.

1.3 SCOPE

This report provides information to support the relative comparison of the MPC system and alternative systems. Health and safety estimates are as accurate as current information permits, and, where uncertainties limit the accuracy, conservative assumptions have been made.

Health and safety impacts evaluated include both radiological and non-radiological impacts on the public and occupational workers within the CRWMS. Radiological impacts are measured by the radiological exposure received by persons and non-radiological impacts are measured by injuries, fatalities, and the emission of toxic materials. Impacts caused by both routine (day-to-day) activities and incidents (accidents) are considered. Total health and safety impacts are computed by combining logistics data with impacts associated with processing spent nuclear fuel (SNF) and high level waste (HLW). Four CRWMS systems are evaluated for their health and safety impacts: the reference scenario, the MPC system, the TSC system, and the MPU system. The reference scenario and MPC systems are defined in the report "Concept of Operations for the Multi-purpose Canister System," (Reference 55). The TSC and MPU systems are defined in the report "Evaluation of Alternative Cask/canister Systems," (Reference 65). Logistics data are in the report "Operational Throughput for the Multi-purpose Canister System," (Reference 57). Health and safety impacts are evaluated for systems with and without a monitored retrieval storage facility (MRS).

1.4 QUALITY ASSURANCE

A QAP-2 analysis has determined that this activity is not quality affecting. The analysis is documented in the Reference 61.

2. APPROACH

Health and safety impacts are evaluated for four alternative systems: the reference scenario, the MPC system, the TSC system, and the MPU system. Each system is responsible for managing SNF from the utility storage pool to final emplacement and the processing of HLW from the time it is delivered to the repository through emplacement. Both public and occupational health and safety impacts are considered. Radiological and non-radiological impacts caused by routine (day-to-day) activities and incidents (accidents) are included. Radiological impacts are measured by the radiological exposure received by persons and non-radiological impacts are measured by injuries, fatalities, and the emission of toxic materials.

Health and safety impacts at the utility storage sites, the Monitored Retrievable Storage (MRS) facility, and the Mined Geologic Disposal System (MGDS) are computed from impacts caused by handling SNF and SNF casks. The MGDS also includes impacts caused by HLW and waste package handling. Transportation impacts result from the shipping of both loaded and unloaded SNF casks between facilities. Impacts associated with the cask maintenance facility (CMF) result from routine maintenance of contaminated casks. Systems with and without an MRS are evaluated.

Health and safety impacts are addressed in four areas:

- Radiological Routine Exposures - Includes radiation exposure during routine facility operations and during transportation.
- Radiological Incident Exposures - Includes radiation exposure from incidents involving SNF fuel, HLW, and cask/canister handling, and from transportation incidents.
- Non-Radiological Routine Impacts - Includes routine non-radioactive toxic effluents from facilities and during transportation.
- Non-Radiological Incident Impacts - Includes non-radiation related accidents at facilities and during transportation.

Results are compared within each impact area and in the aggregate.

This report evaluates the impacts to health and safety associated with operations and procedures as they are currently defined on the basis of technology demonstrations, current practice, and nuclear power industry procedures for Nuclear Regulatory Commission (NRC) license application as described in Appendix A. The routine exposure estimates are conservative by about 10 times both for the facilities and for transportation. The development and use of as low as is reasonably achievable (ALARA) techniques can reduce the estimated health and safety impacts in all areas for all alternative systems. Measurements at a utility for operational use of multi-element storage containers (MESCs) has shown that as low as 10% of the estimates could be achieved. Financial costs, schedule impact, and public acceptance should be considered in final decisions determining where and when ALARA techniques are implemented.

2.1 METHODOLOGY

Radiological and non-radiological health and safety impacts caused by both routine activities and incidents are evaluated. All radiological impacts are measured by the radiological exposure received by persons and all non-radiological impacts are measured by injuries, fatalities, and emission of toxic materials. Health and safety impacts caused by activities at the CRWMS facilities and those caused by transportation are addressed separately.

2.1.1 Facility Health and Safety Impacts

Health and safety impacts are determined for the utility storage sites, the MRS, the CMF, and the MGDS. Facility health and safety impacts to occupational workers are computed only for the time the workers spend within a facility. Occupational workers are defined as all badged employees including subcontractors, temporary employees, and suppliers. The public will incur health and safety impacts from facility operations only when outside the facility, taking VIP tours within a facility, or at facility visitor centers.

Radiological exposures caused by routine activities within a facility are computed based on inputs from the CRWMS design organizations. This information includes the type of operations performed at each facility, the radiological exposures per operation, the number of workers required, and the total number of operations. Radiological exposures caused by incidents at a facility are based on the number of fuel and cask handlings coupled with the probability of events and potential radiological releases. High level waste (HLW) was considered, from its arrival at the facility entrance control point.

Non-radiological impacts at each facility include injuries, fatalities, and the emission of toxic materials. Injuries and fatalities are computed by combining the man-years worked at all facilities with data for industrial accidents.

2.1.2 Transportation Health and Safety Impacts

Transportation health and safety impacts are computed for the shipment of both loaded and unloaded SNF casks. Truck, rail, barge, and heavy-haul modes of transportation are included.

Radiological exposures caused by routine activities or by incidents during transportation are evaluated using the RADTRAN 4 computer code (Reference 48). The INTERLINE (Reference 29) and HIGHWAY (Reference 30) transportation routing codes are used to compute the demographic characteristics of each route. These include the distances, the population densities, and the portions that are rural, suburban, or urban. These values are computed using the 1990 block-census data. Transportation of HLW was outside the scope of this analysis.

Non-radiological impacts caused by routine transportation are evaluated based on the projected emissions from the vehicles used. See "An Assessment of the Safety of Spent Nuclear Fuel Transportation in Urban Environments," (Reference 43). Emission estimates assume that pollution control technologies and engine efficiencies remain fixed at 1982 levels. Non-radiological impacts caused by incidents are computed from shipment miles combined with transportation accident data.

2.2 ASSUMPTIONS

The system parameters and assumptions used for the reference scenario and the MPC system are defined in the report "Concept of Operations for the Multi-Purpose Canister System report," (Reference 55). Assumptions for the TSC and MPU systems are contained in the study "Evaluation of Alternative Cask/Canister Systems," (Reference 65). Throughput assumptions for SNF and SNF casks/canisters are taken from the report "Operational Throughput for the Multi-purpose Canister System," (Reference 57).

The radiation exposure inputs developed by the design organizations can be found in Appendix A, Facility Routine Radiation Exposures. The transportation mode characteristics used with RADTRAN 4 are those of the expected CRWMS operating practices, listed in Appendix B. Fuel characteristics assumptions and lists of related isotopes are included in Appendix C. Information about the MGDS are in Appendix D. Remaining assumptions are stated in the individual sections of the report.

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3.1.2 Routine Exposures at the MRS

Table 3-3 shows the exposures incurred at the MRS for each of the alternative systems. The exposures from the TSC and MPU systems are lower than those from either the reference scenario or the MPC. This is because the reference scenario requires more cask loadings and unloadings and the MPC requires overpack exchanges. The MPC system exposures are higher than the reference scenario because of MPC welding and an increased number of storage operations, caused by the smaller MPC storage capacities relative to reference scenario storage casks, as well as overpack exchanges.

Table 3-3. MRS Radiological Routine Exposures
(person-rem)

	Single Purpose Cask System (Reference)	Dual Purpose Cask System (TSC)	Multi-purpose Cask System (MPU)	Multi-purpose Canister System (MPC)
Truck casks	2,590	2,590	2,590	2,590
Storage and rail casks	4,860	2,930	4,210	7,490
Radioactive waste	750	620	620	620
Total	8,200	6,140	7,420	10,700

3.1.3 Routine Exposures at the CMF

Routine radiological exposure to occupational workers at the cask maintenance facility (CMF) occurs during routine maintenance of contaminated casks. It is assumed that every cask in the transportation cask fleet will return to the CMF for routine maintenance three times in a given year. This is typically once per campaign. The cask fleet size is defined in the "Operational Throughput for the Multi-Purpose Canister System," report (Reference 57). Exposures at the CMF are estimated as 20 person-millirem for cleaning the inside and the outside of the TSCs and the transportation casks associated with the reference scenario. A 5 person-millirem exposure is expected for cleaning the transportation overpacks associated with the MPC system since they transport clean sealed canisters. Total exposure at the CMF is 155 person-rem for the reference scenario, 141 person-rem for the TSC system, 58 person-rem for the MPC system and 58 person-rem for the MPU system. These exposures are relatively small.

3.1.4 Routine Exposures at the MGDS

Table 3-4 shows the routine exposures incurred at the MGDS. MGDS exposures include SNF and HLW receipt, preparation in waste packages, emplacement, followed by the potential retrieval, inspection, and re-emplacement of 10 waste packages per year, and the monitoring of the waste packages. The activities are still largely to be defined.

The reference scenario, MPU and MPC system exposures are lower than those caused by the TSC systems. Because of an additional bolted lid that must be removed while unloading a TSC, the TSC system produces higher exposures at the MGDS than does the reference scenario.

Table 3-4. MGDS Radiological Routine Exposures
(person-rem)

	Single Purpose Cask System (Reference)	**Dual Purpose Cask System (TSC)**	**Multi-purpose Cask System (MPU)**	**Multi-purpose Canister System (MPC)**
Truck casks	390	390	390	390
Rail casks	18,250	20,810	18,380	18,380
HLW casks	730	730	730	730
Radioactive facility waste	1,040	860	860	860
Retrieve, inspect and replace WPs	200	200	200	200
Monitor WPs	<1	<1	<1	<1
Total	20,610	22,990	20,560	20,560

Exposures related to HLW are the same for all of the alternative systems. The Characteristics Data Base shows that averaged over the fleet, a HLW canister has an average gamma flux rate that is about one third of the flux from an average SNF assembly. Most exposure, to a first order magnitude, is attributed to the closest assembly or canister. Until more detailed data is available, it is assumed that the exposures to unload and handle a HLW shipment are one third of the exposures for a truck SNF cask.

Exposures from HLW are about 4% of the total exposure incurred at the MGDS. This evaluation assumes 4 HLW canisters per waste package. Handling of the HLW, including the loading of waste packages, provides about 1% of the total CRWMS exposures.

Assuming a .01 person-millirem exposure per package per year, monitoring produces a negligible fraction of the MGDS totals. Retrieval, inspection, and re-emplacement of waste packages are essentially undefined activities at this time but are expected to result in exposures of about 1% of the total MGDS exposures.

Exposures for all MGDS operations have a higher degree of uncertainty than those at the utilities, the MRS, or the CMF because many of the MGDS specific design and operation decisions are not as well developed.

3.1.5 Routine Exposures to the Public

The routine radiological exposures of the public near facilities handling spent fuel are extremely low. Public exposures result from the release of radioactive gases during facility operation, and visits by the public to the facilities. The routine exposures due to radioactive gas discharges depend on the handling and storage technology selected, such as single-purpose cask, TSC, MPU and MPC for the Single-Purpose, Dual-Purpose, and Multi-purpose Systems, respectively. In contrast, the exposures to visitors depend on discretionary choices by individual members of the public, for each visit.

3.1.5.1 Exposures Resulting From Releases of Radioactive Gases

Normal operations at spent fuel storage sites result in the occasional release of radioactive gases into the atmosphere. Reference 54 assumes that radioactive gases are emitted during handling of fuel assemblies in spent fuel storage pools, and in dry transfer cells. Conservatively, the gases are assumed to be released in the proportions described in References 54 and 68. It is assumed that no releases take place from sealed casks and canisters, except in severe incidents.

The action of handling a fuel assembly is assumed to cause a release of radioactive gases for a susceptible fraction of the assemblies handled. This assumes that all fuel assemblies are handled with care, in compliance with authorized procedures. An NRC estimate of the conservative, design-basis gas fractions release from a ruptured fuel assembly is provided in Reference 68. Less severe releases would follow less severe damage, i.e., the if only one fuel pin were vented per incident, the estimate based on the NRC guide could be conservative by 100 to 200 times. Information about the build-up and decay of radioactive gases in spent fuel pins are in Reference 69. The exposure, at the facility perimeter, per fuel assembly release for each facility type were from Reference 54.

Public exposures were estimated for the people within a ten miles radius of the facilities, based on 10 CFR Part 50 Appendix E which describes the emergency planning zones for radioactive gas releases for nuclear power plants. The potential routine exposure to the public near each facility are the product of the number of bare fuel assemblies handled at each type of facility, multiplied by the probability of a release per handling, times the potential exposure per gas release, times an average dilution rate as the gases reach the surrounding area, and finally multiplied times the average population density within the 10 miles radius.

A conservative dispersion dilution trend for surface releases was obtained from Reference 68. Reference 54 assumes a probability that 2.5×10^{-4} multiplied times the number of fuel assemblies handled may vent radioactive gases. The numbers of bare spent fuel assemblies handled and probably vented at the facilities are shown in Table 3-5.

Table 3-5. Bare Fuel Assemblies Handled/Vented at Each Facility Type

Facility Type	Single-Purpose System (Reference)	Dual-Purpose System (TSC)	Multi-purpose Systems (MPC and MPU)
Spent Fuel Pool	364,770/91	308,210/77	308,210/77
MRS Facility	121,970/30	31,500/8	31,500/8
MGDS	298,310/75	298,310/75	5,000/2

The radioactive gases released from vented spent fuel assemblies have long half-lives and are dispersed in the air. The offsite dose consequences associated with the venting of all of the fuel rods of one spent fuel assembly (PWR) are shown in Tables 3-6 and 3-7, assuming a site boundary distance of 800 meters, and an atmospheric dispersion factor per Reference 68, NRC Regulatory Guide 1.25. Table 3-7 applies to the program life cycle. The assumed release fractions, type of spent fuel (PWR) and dispersion factors are conservative.

Table 3-6. Maximum Individual Site Boundary Doses per Single (PWR) Fuel Assembly (based on 800 meters to site boundary, References 54 and 68)

Gases (Krypton, Tritium, Iodine)	micro-rems
Vented in Dry Environment	1.00
Vented in Pool	1.03

Table 3-7. Maximum Individual Estimated Doses from All Bare Fuel Assemblies Events (micro-rems)

Facility Type	Single-Purpose System (Reference)	Dual-Purpose System (TSC)	Multi-purpose Systems (MPC and MPU)
Spent Fuel Pool (all transfers)	9.1	7.7	7.7
MRS Facility (transfer-cell)	30	8	8
MGDS(transfer-cell)	75	75	2

10 CFR Part 72 will be complied with. Exposure at each utilities, MRS and MGDS boundaries will be less than 25 millirem per year (25,000 micro-rem/year). 40 CFR Part 61 will also be complied with, which requires that exposure from normal operation airborne emissions from each

facility to any member of the public must be less than 10 millirem per year (10,000 micro-rem/year).

Public exposures were estimated for each facility type by integrating the dose as a function of distance (assuming the wind dispersion factors of Reference 68) over the population within radial distances from 2500 feet of the spent fuel location, out to a distance of 10 miles to obtain the population doses shown in Table 3-7. The average population density within 10 miles radius of the utility controlled area is estimated as 170 people per square mile, and conservatively assumed to be uniformly distributed. The population density was estimated from data in Reference 70. For a Western MRS facility in a rural area, in the vicinity of a route that can be used for transporting spent fuel, typical population densities were estimated by using the HIGHWAY and INTERLINE computer codes. The population data are 1990 block level census data. West of the Mississippi River and East of the states of California, Oregon, and Washington, an average population density about 5 people per square mile is representative. About 3 person per square mile near an MGDS in a Western remote rural area is plausible, assuming that the conditions near Yucca Mountain, NV are representative.

Table 3-8. Estimated Population Dose During the Life of the Program (Bare Fuel Assemblies Vented When Handled at Each Facility Type)
(units are person-millirem)

Facility Type	Single Purpose System (Reference)	Dual-Purpose System (TSC)	Multi-purpose Systems (MPC and MPU)
Spent Fuel Pool	3.4	2.87	2.87
MRS Facility	0.33	0.09	0.09
MGDS	0.49	0.49	0.013
Program total, person-rems*	4.22	3.45	2.97

*totals are rounded.

3.1.5.2 Exposures Resulting From Public Visits

The program architecture includes visitor centers at the MRS facility and the MGDS. An estimate was prepared to illustrate the magnitudes of possible exposures to visitors at the facilities. The visitors are assumed to receive less than 1 mrem per person (equivalent to an exposure during a jet aircraft trip of 2500 miles), assuming one 6-hour visit per person. The tourist visitor rate is assumed to be 3 people per day. Therefore, the total for all tourists is less than 1 person-rem/year. Very Important People (VIP, e.g., stakeholders) visitors may be offered more extensive tours with exposures equivalent roughly to a "medical chest x-ray" (50 mrem). Doses to 10 VIPs per year can total about 0.5 person-rem/year. The total for visitors is roughly (1+0.5) x 40 = 60 person-rems during 40 years of MGDS operation, and about 45 person-rems at the MRS facility during approximately 30 years of operation. There is no comparable plan for waste disposal related visitor centers at the utility spent fuel storage areas.

3.1.5.3 Summary of Routine Public Exposures

The primary exposure of the public at the facilities may be primarily from routine visits by the public, including stakeholders and VIPs, (about 105 person-rems) rather than from facility radioactive gas emissions (3.0 to 4.3 person-rems).

3.2 RADIOLOGICAL INCIDENT EXPOSURES

Unplanned contact or "bumping" during the lift-handling (lift and movement) of casks, canisters, or fuel assemblies is the key factor associated with incident exposure. Lift-handling combines a significant possibility of an incident, with gravitational potential or speed sufficient to cause personnel injuries and/or radiological release.

A comprehensive review of NRC reports was undertaken to determine the observed rate of lift-handling events, see References 12, 13, 15, and 17 through 28. Other pertinent technical reports (References 5, 29, 33, 34, 36, 37 and 54) were also reviewed. Lift-handling incidents within a transfer facility were reported to have a probability of 10^{-4}. For incidents that occur within design conditions, the probability of radiological release is less than 10^{-4} for each incident. All crane operations and all on-site movements of casks, canisters, and SNF are assumed to be well within design limitations. Therefore, the cumulative probability of lift-handling incidents causing radiological release is less than 10^{-8} per operation, see Reference 55.

3.2.1 Radiological Exposures from SNF Handling Incidents

It is assumed that only lift-handlings can create an environment that can result in the damage to fuel assemblies and the possible release of radioactive material. Other types of handlings are not included in this evaluation.

A total of about 298,000 SNF assemblies, containing 86,000 MTU, are projected to be discharged from reactors over the lifetime of the program.

3.2.1.1 Incidents from SNF Handlings in the Reference Scenario

For the reference scenario all fuel assemblies at the utilities are lift-handled at least once when loading transportation or storage casks. Assemblies loaded into dry storage (about 10%) must be lift-handled two more times: once for unloading the assembly from the dry storage cask and again for reloading it into the transportation cask. Because not all assemblies will pass through the MRS, thirty percent of the SNF assemblies are lift-handled at the MRS for storage and repackaging. All fuel assemblies are lift-handled at least once at the MGDS to load the waste packages. There are about 2.5 lift-handlings for every fuel assembly. Approximately 74 fuel assemblies may fall or be bumped, combined for the activity at the utilities, MRS and MGDS. See Reference 6.

3.2.1.2 Incidents from SNF Handlings in the TSC System

For the TSC system all fuel assemblies are lift-handled at least once to load TSCs at the utilities. Fuel assemblies loaded into truck casks (about 10%) require one more lift-handling at the MRS. All fuel assemblies are lift-handled at least once at the MGDS to load waste packages. There are approximately 2.1 lift-handlings for each fuel assembly. Approximately 62 fuel assemblies, combined for the activity at the utilities, MRS and MGDS, may fall or be bumped.

3.2.1.3 Incidents from SNF Handlings in the MPC and MPU Systems

For the MPC and MPU systems all fuel assemblies are lift-handled at least once to load the MPC or MPU at the utilities. Fuel assemblies loaded into truck casks (about 10%) require one more lift-handling at the MRS. A few fuel assemblies (0.5%) are lift-handled one more time at the MGDS to load waste packages. There are approximately 1.1 lift-handlings for each fuel assembly. Approximately 33 fuel assemblies, combined for the activity at the utilities, MRS and MGDS, may fall or be bumped.

3.2.1.4 Expected Exposures from SNF Handling Incidents

If a gas release from a single spent fuel assembly occurs following a lift-handling incident, the site boundary exposure, i.e., diluted over the facility, is expected to be no more than 10^{-6} rem at an MRS or MGDS. See Reference 55, "Monitored Retrieval Storage (MRS) Conceptual Design Report," May 1, 1992, Volume II, Book II. Particles would be trapped by the High Efficiency Particle (HEPA) filters. Personnel are assumed to be uniformly distributed, in the absence of specific information about site layouts relative to the average wind direction and so forth.

Based on the expected number of lift-handling incidents, the cumulative rem are about 3.3×10^{-5} for the MPU and MPC systems, about 6.2×10^{-5} for the TSC system, and about 7.4×10^{-5} for the reference scenario. These exposures are within the 5 rem exposure limit for accidents stated in 10CFR72. The total person-rems on-site are estimated from the release and the population data. Assuming that the MRS with the CMF have 750 full time equivalent (FTE) staff, the MGDS has about 500 in the surface facility (see Section 3.4 of this report), and about 50 FTE at utilities, the occupational incident person-rem exposures of the program are about 0.043 for the MPU and MPC systems, 0.081 for the TSC system, and 0.10 for the reference scenario.

As a result of the decreased number of fuel assembly handlings in the MPU and MPC systems, radiological incident impacts as a result of fuel assembly handlings are lower for the MPU and MPC systems relative to the TSC system and reference scenario. The expected incident exposures for all of the systems are below regulatory limits and practically equivalent.

3.2.2 Radiological Impacts from Cask Handling Incidents

It is assumed that only lift-handlings of casks can create an environment that can result in the damage to a cask and the possible release of radioactive material. Other types of cask handlings are not included in this evaluation. Because the facility handling equipment and procedures are the same, the handling incident severities are expected to be equivalent for the alternatives. Cask handling incidents and resulting health and safety impacts are evaluated for the MPC system as an illustrative example.

3.2.2.1 Expected Cask Handling Incidents

As a result of the canister overpack transfer operations, the MPC system requires the maximum number of cask/canister handlings. MPC lift-handling operations include placing the MPC into an overpack as well as lifting the MPC alone.

All MPCs, approximately 10,000, that originate at the utilities are lift-handled at least twice for loading. MPCs loaded at facilities limited by a 100-ton crane capacity (16%) require a transfer cask and are lift-handled one additional time. About 40% of the MPCs are loaded into dry storage and must be lift-handled once from the transfer cask into dry storage and once from dry storage into a transportation cask. MPCs that flow into MRS storage from the utilities (15%) are lift-handled four additional times: MPC cask from rail car into transfer facility, MPC from transport cask to storage mode, and the reverse steps. Approximately 1000 MPCs originating at the MRS, due to loading SNF from truck casks, require 1.5 lift-handlings each. All MPCs are lift handled four times at the MGDS: MPC cask from rail car to surface facility, MPC from transfer cask to disposal container, MPC disposal container from facility to transporter, and MPC transporter to emplacement position in a drift.

Thus, there are about 7.5 lift-handlings per MPC loaded at the utility sites, 5.5 lift-handlings per MPC loaded at the MRS, and 4 lift-handlings per MPC at the MGDS. This is about 150,000 total cask/canister lift-handlings. With crane reliability of about 10^{-4} incidents per hour, and about 0.2 hours per handling, then 3 casks or canisters may fall or be bumped, for the combined locations.

3.2.2.2 Expected Exposures from Cask Handlings Incidents

Since the probability of radioactive release from an incident that occurs within design specification is less than 10^{-3} and exposures from a cask handling incident are estimated to be 10^{-6} person-rems, (Reference 55) exposure caused by the lift-handling of SNF casks and canisters is expected to be in the range 10^{-6} to 10^{-9}, (i.e., near zero).

Canisters of vitrified HLW will also be handled at the MGDS. The total number of HLW canister packages is estimated to be on the same order as the number of MPC waste packages. HLW canisters have an improved incident response over SNF canisters. We therefore expect radiological releases involving HLW incidents to be less than those involving SNF.

It is estimated that all cask/canister handling incidents result in negligible exposure for all of the systems.

3.3 NON-RADIOLOGICAL ROUTINE IMPACTS

Non-radiological impacts are measured by injuries, fatalities, and the emission of toxic materials. Both routine activities and incidents may cause non-radiological impacts to both the public and occupational workers.

3.3.1 Routine Non-Radiological Impacts to CRWMS Occupational Workers

Non-radiological routine impacts such as noise, dust, and on-site engine exhaust pollution are assumed to affect only occupational workers and to be within regulatory limits for all of the systems.

3.3.2 Routine Non-Radiological Impacts to the Public

Non-radiological routine impacts to public health and safety are caused by non-radioactive effluents routinely released from a facility. All effluents produced at facilities are assumed to be within regulatory limits at the boundaries of each facility. Based on an estimated order of magnitude 5 pounds per year release of airborne particulates and other potentially toxic or carcinogenic emissions (SO_x, NO_x and hydrocarbons), facilities prime-movers used for movement of on-site loaded and unloaded cask and canisters will produce about 0.1 tons of such emissions for a 40-year program based on the data of Reference 43. These emissions will be essentially equal for all alternative systems because the facilities to be operated will be very similar.

3.4 NON-RADIOLOGICAL INCIDENT IMPACTS

Industrial accidents pose a non-radiological impact to the health and safety of occupational workers. The accident rate for the nuclear power industry in 1992 was about 0.38 per 100,000 manhours. See Reference 38, "Power Engineering Journal," June 1993. Since there were no fatalities reported in that year, the statistics indicate the injuries, and a lower-bound statistical limit on the probability of a fatality at less than 1 per 100,000 hours. Since the number of manhours are comparable for all systems, non-radiological incident impacts for facilities are essentially the same for all of the systems.

For a combined MRS and CMF facility consisting of 750 full time equivalent (FTE) employees, Reference 57, we expect about 5.7 accidents per year, for a total of 165 for an MRS 29-year period of operation. For an MGDS facility consisting of about 500 FTEs for the surface facilities, and about 500 for all underground operations, we expect about 7.6 industrial accidents per year at the same accident rate, Reference 38, for a total of 304 for a 40 year program. The total facility accidents for the MRS, CMF, and MGDS are therefore estimated to be about 469. Fatalities are computed using an on-the-job fatality rate of 0.03 fatalities per 1,000,000 hours worked, based on an average across all U.S. industries (Reference 67). The fatalities total roughly 4 for the lifetime of the program, for any of the systems.

3.5 FACILITY HEALTH AND SAFETY IMPACTS FOR NO MRS (DIRECT SHIPMENT)

With no MRS, the direct shipment of SNF to the MGDS, without an MRS in the system, has little impact on the overall facility health and safety impacts as shown by the pairs of values with-MRS/no-MRS in Tables 3-9. Most of the activities formerly carried on at the MRS, and the exposures, are shifted to the utilities as shown in Table 3-10. Changes in the transportation exposures and nonradiological risks, are described in section 4.6.

Table 3-9. With-MRS/No-MRS Facility Health and Safety Impacts
(total program)

System Impact Area	Single Purpose Cask System (Reference)	Dual Purpose Cask System (TSC)	Multi-purpose Cask System (MPU)	Multi-purpose Canister System (MPC)
Radiological Routine (person-rem) • Facilities	42,080/40,150	43,820/37,510	53,920/50,700	56,980/50,860
Radiological Incident (person-rem) • Facilities[a]	0.1/0.1	0.08/0.08	0.04/0.04	0.04/0.04
Non-Radiological Routine (emissions) • Facilities[a,b]	.1/.1 tons	.1/.1 tons	.1/.1 tons	.1/.1 tons
Non-Radiological Incidents (injuries and fatalities) • Facilities injuries fatalities	470/470 4/4	470/470 4/4	470/470 4/4	470/470 4/4

Notes: a) Systems approximately the same; within regulatory limits.
b) Particulates, sulphur, nitrogen oxides, and hydrocarbon vapors that are toxic or potential carcinogens.

Table 3-10. No MRS (Direct Shipment) Facility Health and Safety Routine Impacts
(person-rem)

	Single Purpose Cask System (Reference)	Dual Purpose Cask System (TSC)	Multi-purpose Cask System (MPU)	Multi-purpose Canister System (MPC)
Facilities: • Utilities	17,380	12,720	28,940	28,270
• CMF	160	140	60	60
• MGDS	22,610	24,650	21,700	22,530
Program Total	40,150	37,510	50,700	50,860

4. TRANSPORTATION HEALTH AND SAFETY IMPACTS

The most visible public health and safety effect will result from transportation. The four alternative systems, the reference scenario, and TSC, MPU, and MPC systems, assume the same transportation modal splits and effectively the same transportation cask capacities. As a result the transportation health and safety impacts are the same for all of the alternative systems. This chapter presents a single set of health and safety impacts that are applicable to any of the alternative systems.

It is assumed that 63,000 MTU of SNF are shipped through a generic western MRS to a first MGDS. For the purpose of this evaluation, the first MGDS is assumed to be located at Yucca Mountain, NV. An additional 23,000 MTU will be shipped directly to a generic western MGDS. Health and safety impacts during vitrified HLW transportation to the MGDSs are the same for all systems and are not evaluated here.

For each SNF storage site, the mode of transportation selected (truck, rail, barge, and heavy-haul) and travel distances are based on References 56 and 60. The capacities of PWR and BWR fuel casks are obtained from References 56 and 59.

Using these data the cask-miles traveled from each site are estimated. Radiological exposure impacts are estimated using U.S. Department of Transportation (DOT) data, the RADTRAN transportation radiation exposure code, and population densities along the routes. Any benefits caused by safety measures, such as the use of police or security escorts for trucks traveling in high population density areas, are excluded from the estimates.

Radiological routine and incident exposures for transportation shipments are estimated by using the RADTRAN 4 computer code, Reference 49. The transportation characteristics are based on the expected CRWMS operating practices, which are listed in Appendix B. INTERLINE (Reference 31) and HIGHWAY (Reference 32) transportation routing codes, using 1990 Census data, compute population densities along each route and the fraction of each route that is rural, suburban, or urban. These values are used in the RADTRAN estimates. The rail, barge, and heavy-haul routes follow commercial practices.

All truck trips are assumed to be carrying loaded casks from the SNF sites to the MRS or MGDS and empty casks on return trips. Trucks are assumed to be combination type tractor-trailers with a cab and a single attached cask-carrier. A two-person crew is assumed for each truck. Routes used comply with HM-164 and use non-interstate highways only for local access to or from the interstates. Statistics for this class of vehicle and highways used in the evaluations were based on DOT data.

Rail shipments are by dedicated train with 3 casks carried between the utilities and the MRS and 5 casks between the MRS and MGDS. Estimates of damage to SNF casks carried by rail are based on DOT data indicating that typically only 1.03 hazardous material cars are damaged per accident involving trains hauling hazardous materials. The damage rate was independent of the number of hazardous material cars in each train and the total number cars in each train.

Heavy-haul truck transporters are used at utility storage sites to carry large rail casks to a nearby rail siding for transfer onto rail cars. At a few locations heavy-haul vehicles are transported on a barge from a dock near an SNF site to a dock near a rail siding. Each barge is assumed to carry 4 heavy-haul transporters, with 1 large rail cask each. Barge and heavy-haul vehicles are assumed to transport only loaded large (100 tons or greater) rail casks. DOT accident statistics for barge shipments on inland waterways, (such as rivers, barge canals, and the Great Lakes) are used in the evaluations. Heavy-haul accident statistics are derived from those used for trucks, with a reduction for the lower speeds and protected movement of the heavy-haul vehicles. Data are provided in Appendix B.

All transportation health and safety estimates are for the operational life cycle of the program. There are no known transportation health and safety impacts that depend on the annual shipment rates. Sections 4.1 through 4.5 address systems with an MRS; Section 4.6 addresses the same systems without an MRS.

4.1 RADIOLOGICAL ROUTINE EXPOSURES

Radiological routine exposures were calculated using the RADTRAN 4 computer code as described above. Each SNF cask is designed to exactly comply with the maximum permissible regulatory criteria routine radiation exposures. This includes radiation at the cask surface and at 2 meters from the cask when loaded with the design basis SNF. Actual exposures based on average cask contents (number of assemblies, radiological inventory) are estimated to be about one-half of the regulatory exposures (see Appendix B). Routine public and occupational radiation exposures are displayed in Table 4-1.

All systems use rail at 85% of the facilities and trucks at the remaining 15%. Because the transportation modes and cask capacities are effectively the same for all systems (see Reference 55), the total number of cask shipment-miles are essentially the same.

Table 4-1. Transportation Radiological Routine Exposures
(total program)

Mode	**Routine Exposure (person-rem)**	
	Occupational	Public
• Rail, barge, and heavy haul	50	340
• Trucks	720	340
• Total program	1,450	

4.2 RADIOLOGICAL INCIDENT EXPOSURES

If an incident occurs, the cask damage severity can range from no damage to the release of radioactive particulates and gases. The severity probability distributions are derived from a study of nationwide accidents of vehicles, similar to those planned for this program. See Reference 9. This analysis uses the severity data listed for each transportation mode in Appendix B.

Radiological incident exposures are calculated using the RADTRAN 4 computer code with information from Reference 10, and assumptions described above. The DOT highway offices and the Federal Rail Administration (FRA) report (Reference 64) identify the statistical probability of accidents. References 51 and 64 screened the data for statistics of similar vehicles under comparable conditions. Radiological impacts and exposures during empty cask shipments to the utility sites are negligible. The accident probabilities used in the RADTRAN estimates were derived from References 51 and 64.

The RADTRAN computer code estimates, for incidents, use appropriate isotopic distribution of the material released. Lists of the isotopes are provided in Appendix C. The isotope inventories contribute over 99% of the health hazard of the spent fuel, Reference 48 (RADTRAN 4 User Guide, pp. 5-23).

Total expected-person-rem exposure from incidents is summarized in Table 4-2. Estimates assume the isotope distribution for a nominal design basis PWR SNF described in Appendix C and Reference 72. Isotope inventories are listed in Appendix B.

RADTRAN calculations indicate no expected early fatalities from radiological releases. Expected-person-rem for the program are essentially the same for all systems. Use of truck transport always leads to higher incident exposures because of the larger number of casks required to ship equal amounts of SNF. Rail shipment exposures include any associated off-site heavy-haul or barge use. The total of rail plus barge and heavy-haul exposures on any route is always less than the corresponding expected person-rem for the use of trucks alone.

Table 4-2. Expected Population Exposure for Transportation Incidents
(total program)

Mode	Expected Exposure (person-rem)
• Dedicated Unit Trains, Barge and Heavy-haul	420
• Trucks	10
• Total program	430

The systems uses rail at 85% of the sites and truck at the remaining 15%. If all sites use rail there will be a reduction in the total exposure from incidents. As with routine exposure, shipping truck casks on rail-cars will also reduce the exposures, since the expected frequency of accidents and the severity are reduced.

4.3 NON-RADIOLOGICAL ROUTINE IMPACTS

Transportation health and safety routine effects will occur from vehicular emissions. Non-radiological health and safety effects to the public and occupational workers are computed together. The non-radiological effects are essentially the same for all systems since they have identical transportation modes and effectively the same cask capacities.

Engine exhaust is the major source of toxic, and potentially carcinogenic, pollution during transportation. The total emission weights, based on the data of Reference 43, are summarized in Table 4-3.

Table 4-3. Non-Radiological Routine Emissions During Transportation
(two-way travel, program total)

Products (tons)	Trucks	Dedicated unit trains
• Particulates	40	510
• Sulfur oxides	250	1,130
• Nitrogen oxides	630	7,380
• Hydrocarbon vapors	160	2,160
• Traction rubber (tires)	30	na
• Total	1,110	11,180
Program	12,290	

The health-related emissions include airborne hydrocarbon combustion particulates, sulfur oxides, nitrogen oxides, and hydrocarbon vapors that are either toxic or potentially carcinogenic. Pollution emissions accumulate during 40 years of operations, with over 16,000 cask shipments, and at least 80 million miles of travel. The estimates are conservative by at least 2 times and conservatively assume that the transportation pollution control technologies remain at 1982 efficiency levels. It is assumed that the emission rates of the prime mover engines, per mile traveled, are independent of the road conditions and whether the SNF containers are loaded.

4.4 NON-RADIOLOGICAL INCIDENT IMPACTS

Estimates of the injuries and fatalities from CRWMS transportation operations are provided in Table 4-4. The data are based on information from References 51 and 64, and extremely conservative assumptions. Barge and heavy-haul values are extremely small and are included with the dedicated train totals, since they are used together exclusively.

Table 4-4. Non-Radiological Public and Occupational Injuries and Fatalities
(program total)

	Trucks (HM-164 Highways)	Dedicated Unit Trains
• Injuries	10	120
• Fatalities	1	29

All estimates are based on two-way travel, with empty casks to the utilities and loaded casks to the MRS and MGDS. Dedicated rail is always used between the MRS and the MGDS. These injuries and fatalities are accumulated during the total system operations, with over 16,000 cask shipments and at least 80 million miles. The estimates assume that the transportation safety accident rates remain fixed at the early 1990s levels. Non-radiological routine impacts are effectively the same for all systems.

For comparison, total transportation fatalities for large trucks in the U.S. over the same 40-year period as the CRWMS program (about 29 years for an MRS) are estimated to be 190,000 fatalities (190,000 times the number of truck fatalities estimated for the CRWMS). Similarly, for comparison, total rail transportation fatalities over the same 40-year period are estimated to be 44,000 fatalities, which even with the extremely conservative assumptions used to develop the rail results for this report, is 1,600 times the number of rail fatalities estimated for the CRWMS.

4.5 GENERAL FREIGHT RAIL SHIPMENTS

Dedicated unit trains are evaluated as the basis for this report, since special ALARA and operating procedures could be used to reduce routine radiological exposures. However, a potentially lower cost alternative to the use of dedicated unit trains for all loaded cask shipments is the use of general manifest freight shipments from the utilities to the MRS or from utilities to the MGDS. For general freight use from utilities, a set of 3 empty or unloaded cask cars are shipped to a utility, and the other cars of the general freight train continue onward to other shippers. At a later time a rail carrier locomotive will connect to the loaded 3-car block from the utility and ship the casks to the destination in accordance with general commercial rail routing and handling practices. This means that a cask car block can be removed from the general train for classification and routing at switchyards enroute, and delayed by the rail carrier when necessary to make connections. (In contrast, dedicated unit trains from the MRS, with 3 cask cars per train, are preceded by general freight shipment of the empty casks to the utilities.)

General freight trains may carry any number of cask cars. For general freight trains, all conventional commercial railroad practices are assumed to apply. General freight shipment evaluations herein use DOT statistics that include all accidents, injuries, and fatalities, with all railroad equipment (including passenger trains) under all conditions on all classes of rail lines (including switchyards). The DOT national average data (for 1992) indicate that typically only 1.03 hazardous material cars on average were damaged in each accident to a train containing hazardous materials. These evaluations assume that these DOT statistics apply to shipment of SNF casks.

General freight, in contrast to dedicated trains, moves at greater speeds in rural areas, receive more delays through switchyards, and inspections can be performed frequently and slowly. Delays in switchyards and sidings while awaiting pickup and delivery are expected to be longer for general freight than for dedicated unit trains. Railroad workers are in close proximity to the casks in switchyards and on sidings while performing duties on adjacent unrelated cars and the cask cars. Roughly half of the reported injuries, although few of the fatalities occur in switchyards. However, the statistical allocation of injuries, and fatalities on a pro-rata basis per car of each general freight train means a considerable reduction in the estimated fatalities and injuries. Comparisons of health and safety impacts for general freight versus the analysis baseline dedicated freight shipments are presented in Table 4-5, at the program level.

Table 4-5. Comparison of Health and Safety Impacts for General vs. Dedicated Freight

	General freight for loaded casks shipped to MRS and dedicated freight from MRS to MGDs	Dedicated freight baseline of all loaded casks to MRS and from MRS to MGDS
Radiological		
Routine, person-rem		
occupational	1,360	770
public	990	680
Total	2,350	1,450
Incidents, expected-person-rem	40	430
Total Exposure, person-rem	2,390	1,880
Non-Radiological		
Routine, emission - tons	12,290	12,290
Incidents		
injuries	128	132
fatalities	15	30

4.6 TRANSPORTATION HEALTH AND SAFETY IMPACTS FOR NO MRS SYSTEM (DIRECT SHIPMENT)

An alternative is the use of direct shipments from the utilities to the MGDS. A set of 3 empty or unloaded cask cars would be shipped to a utility. At a later time a rail carrier locomotive will connect to the loaded 3-car block from the utility and ship the casks to the destination in accordance with commercial rail routing and handling practices. Direct shipment to a MGDS reduces all of the impacts on the environment, health and safety. Marshalling the rail-cars to increase the numbers of cask cars per train from 3 to 6 would reduce the incident exposures, injuries, and fatalities about 50% if the total cask-car mileage remained the same, as could be done most simply by using 6 cask-car shipping campaigns.

Health and safety impacts at the program level for direct shipments of all loaded casks are presented in Table 4-6.

Table 4-6. Transportation Health and Safety Impacts for No MRS System (Direct shipment)

	Direct Shipment of all loaded casks to MGDS (no MRS)
Radiological	
Routine, person-rem	
occupational	770
public	660
Total	1,430
Incidents, expected-person-rem	410
Total Exposure, person-rem	1,840
Non-Radiological	
Routine, emission - tons	9,440
Incidents	
injuries	90
fatalities	22

4.7 PUBLIC EXPOSURE TO RADIATION FROM SNF TRANSPORT

Public exposure will take place enroute (sometimes within a few feet during gridlock in urban areas), at enroute stops, or from roadside and railside positions. The roadside and railside (between truck stops and rail yards) public exposure per mile, are essentially the same for rail and HM-164 highway routes. However, the number of people exposed at close range while on the highways is markedly larger for truck transportation than for rail. The relative enroute traveler exposures, based on the standard default values of RADTRAN 4, Reference 48, are displayed in Table 4-7. The numbers presented in this table are the number of people on the highways and railroads within 800 meters of a shipping cask. Heavy-haul comparable data are not available from Reference 49 nor from other sources.

In urban areas, the margin of truck over rail, for number of people receiving at least some exposure, is about 600:1. In suburban areas, the margin drops to about 150:1, and in rural areas the margin is about 500:1. Barges, used to reach rail-transfer points with large rail casks, will create essentially zero exposure to enroute travelers. However, actual routes are mostly in rural areas, and rarely in the cities, so a more realistic estimate should reflect that situation. Actual trip routes on a national average contain about 1% urban travel, about 19% suburban, and 80% rural. Weighing exposures by these percentages will define a "unit trip." During each "unit trip" the normalized exposure will be about 560 people per truck, compared to two people per train. Further, since large rail casks contain about 4.5 times more MTUs than truck casks, there will be fewer rail trips per MTU disposed. Thus the cumulative enroute exposure ratio of truck shipments compared to rail is about 1000:1.

Table 4-7. Relative Numbers of Public Receiving Radiation Exposure During Travel on Highways and Railroads

	Truck	Rail
Travelers per hour, one way, on the route: • Urban	2800	5
• Suburban	780	5
• Rural	470	1
• Normalized to a Unit Trip	560	1.8
• Trips per MTU Ratio (truck casks are smaller)	4.5	1
• Normalized Unit Trip Multiplied by MTU per Trip Ratio	2,520	1.8

5. SUMMARY AND CONCLUSIONS

5.1 SUMMARY

This report evaluates the health and safety impacts of a CRWMS that uses the MPC in comparison with three other alternative systems.

The MPC system relies on the use of a clean, sealed, metal canister for all CRWMS operations including storage, transportation, and disposal. Other alternative systems being evaluated are the reference scenario, a dual purpose cask system: the TSC system, and a multi-purpose cask system: the MPU system.

Impacts to public and to occupational health and safety are evaluated. Radiological and non-radiological impacts caused by routine (day-to-day) activities and incidents (accidents) are included. Radiological impacts are measured by the radiological exposure received by persons and non-radiological impacts are measured by fatalities, injuries, and the emission of non-radioactive toxic materials. Health and safety impacts at facilities and during transportation are evaluated separately. Facilities include utilities and other SNF storage sites (called utilities herein), the MRS facility, the CMF, and the MGDS. Systems are evaluated both with and without an MRS. Health and safety impacts at the utilities, the MRS, and the MGDS are computed from impacts caused by handling spent nuclear fuel (SNF) and SNF casks. The MGDS also includes impacts caused by the handling of vitrified HLW canisters and waste packages. Impacts associated with the CMF result from routine maintenance of contaminated casks. Transportation impacts result from the shipping of both loaded and unloaded SNF casks between facilities. Health and safety impacts are addressed in four areas:

• Radiological Routine Exposures -	Includes radiation exposure during routine facility operations and during transportation.
• Radiological Incident Exposures -	Includes radiation exposure from incidents involving SNF fuel, HLW, and cask/canister handling, and transportation.
• Non-Radiological Routine Impacts -	Includes routine non-radioactive toxic effluents from facilities and during transportation.
• Non-Radiological Incident Impacts -	Includes non-radiation-related incidents at facilities and during transportation.

Table 5-1 illustrates the total system health and safety impacts for both radiological exposure and non-radiological impacts caused by routine activities and incidents. Note that all health and safety impacts are equivalent for any of the four alternative systems with the exception of at-facility routine radiological exposures. Routine radiological exposures result in 99.6% of all exposures, with incidents contributing to about 0.4% for any of the alternative systems.

Table 5-1. Total System Health and Safety Impacts
(total program, with MRS)

System Impact Area	Single Purpose Cask System (Reference)	Dual Purpose Cask System (TSC)	Multi-purpose Cask System (MPU)	Multi-purpose Canister System (MPC)
Radiological Routine (person-rem)				
• Facilities	42,080	43,820	53,920	56,980
• Transportation[a]	1,450	1,450	1,450	1,450
Radiological Incident (person-rem)				
• Facilities[b]	0.10	0.08	0.04	0.04
• Transportation[a]	430	430	430	430
Non-Radiological Routine (emissions)				
• Facilities[b,c]	.1 tons	.1 tons	.1 tons	.1 tons
• Transportation[a,c]	12,290 tons	12,290 tons	12,290 tons	12,290 tons
Non-Radiological Incidents (injuries and fatalities)				
• Facilities				
injuries	470	470	470	470
fatalities	4	4	4	4
• Transportation[a]				
injuries	132	132	132	132
fatalities	30	30	30	30

Notes: a) Values shown are for all truck, rail, barge, and heavy-haul.
b) Systems approximately the same; within regulatory limits.
c) Includes particulates, sulphur and nitrogen oxides, and hydrocarbon vapors that are toxic or potential carcinogens.

Effectively all of the facility radiological exposures are incurred by occupational workers in the nuclear/waste management industries. As can be seen in Table 5-1, the at-facility routine radiological exposures are approximately 35% higher for the MPC system than for the reference scenario (56,980 versus 42,080 person-rem). These higher exposures are caused primarily by the MPC welding operations at the utilities and at the MRS. Welding associated operations at these facilities alone contribute to about 80% (12,600 person-rem) of the difference between the MPC system and reference scenario exposures. The dominant impact of a single operation, welding, suggests that the use of automated canister sealing operations or other techniques could significantly lower the MPC and MPU system exposures to be effectively equivalent to those of the reference system.

Table 5-2. Total System Radiological Routine Impacts (person-rem)

	Single Purpose Cask System (Reference)	Dual Purpose Cask System (TSC)	Multi-purpose Cask System (MPU)	Multi-purpose Canister System (MPC)
Facilities: • Utilities	13,110	14,550	25,880	25,660
• MRS	8,200	6,140	7,420	10,700
• CMF	160	140	60	60
• MGDS	20,610	22,990	20,560	20,560
Total	42,080	43,820	53,920	56,980
Transport: • Occupational	770	770	770	770
• Public	680	680	680	680
Total	1,450	1,450	1,450	1,450
Program Total	43,530	45,270	55,370	58,430

Table 5-2 illustrates how routine radiological exposures are distributed among the facilities and transportation. The radiological exposures at the utilities are significantly higher for the MPC system than for the reference scenario (26,000 versus 13,000 person-rem). This is dominated by the welding operations that contribute 11,500 of the 13,000 person-rem difference. Though not as significant, welding operations at the MRS (1,100 person-rem) have a large impact on the higher MPC system exposures.

The MGDS exposures caused by the reference system, MPU and MPC systems are about the same and lower than those caused by the TSC system. Because of an additional bolted lid that must be removed while unloading a TSC, the TSC system produces higher exposures at the MGDS than the other alternative systems. The CMF exposures are small for all systems.

Transportation exposures are equal for all systems. Public exposure is the same for all of the alternative systems and makes up less than 2% of the total system exposure.

Changes with no MRS in all of the alternative systems were also evaluated. With no MRS there will be more interim storage at some utilities, followed by direct shipment to a MGDS. Table 5-3 contains the values with an MRS, and with no MRS. The facility radiological incident exposures, nonradiological emissions, injuries and fatalities did not change significantly. There were from 5% less for the reference scenario, to 15% less for the MPC of routine radiological exposures at facilities. Without an MRS, the TSC system facility exposure is below that of the reference scenario. Transportation had 23% less nonradiological emission, 25% fewer fatalities, and 32% fewer injuries with no MRS.

Table 5-3. With-MRS/No-MRS Total System Health and Safety Impacts (total program)

System Impact Area	**Single Purpose Cask System (Reference)**	**Dual Purpose Cask System (TSC)**	**Multi-purpose Cask System (MPU)**	**Multi-purpose Canister System (MPC)**
Radiological Routine (person-rem)				
• Facilities	42,080/40,150	43,820/37,510	53,920/50,700	56,980/50,860
• Transportation[a]	1,450/1,430	1,450/1,430	1,450/1,430	1,450/1,430
Radiological Incident (person-rem)				
• Facilities[b]	0.10	0.08	0.04	0.04
• Transportation[a]	430/410	430/410	430/410	430/410
Non-Radiological Routine (emissions)				
• Facilities[b,c]	.1 tons	.1 tons	.1 tons	.1 tons
• Transportation[a,c]	12,290/9,440 tons	12,290/9,440 tons	12,290/9,440 tons	12,290/9,440 tons
Non-Radiological Incidents (injuries and fatalities)				
• Facilities injuries fatalities	 470 4	 470 4	 470 4	 470 4
• Transportation[a] injuries fatalities	 132/90 30/22	 132/90 30/22	 132/90 30/22	 132/90 30/22

Notes: a) Values shown are for all truck, rail, barge, and heavy-haul.
b) Systems approximately the same; within regulatory limits.
c) Particulates, sulphur and nitrogen oxides, and hydrocarbon vapors that are toxic or potential carcinogens.

5.2 CONCLUSIONS

Table 5-1 shows that all health and safety impacts are effectively equivalent for any of the four alternative systems with the exception of routine radiological exposures at facilities. Effectively all of the facility radiological exposures are incurred by workers in the nuclear waste management industries.

As can be seen in Table 5-1, the total routine radiological exposures at facilities are 35% higher for the MPC system than for the reference scenario (57,000 versus 42,000 person-rem). These higher exposures are dominated by the MPC welding operations at the utilities and at the MRS. Welding operations at these facilities alone contribute about 85% (12,600 person-rem) of the difference between the MPC and reference scenario exposures. Total exposures are small relative to expected background radiation exposures (e.g., natural sources, medical uses, radon, etc.) to the U.S. population of 3.5 billion person-rem over the same period of time as the CRWMS program.

Table 5-2 shows that the radiological exposures at the utilities are almost 2 times higher for the MPC system than for the reference technology (25,700 versus 13,100 person-rem). The MPC at-utility exposures again are dominated by welding operations that contribute to 70% (11,500 out of 13,000) of the person-rem difference.

The majority of the increased exposure caused by the MPC system is related to one operation: canister welding. The reference system, on the other hand, is not dominated by a single source or activity so there is no specific opportunity for significant exposure reduction. This strongly suggests that the application of automated canister sealing operations or other techniques could significantly lower the MPC system exposures to be effectively equivalent to those of the reference scenario.

Table 5-3 indicates that with no MRS the evaluated system health and safety impacts will decrease or remain the same for all of the alternative systems. The magnitude of the results for the systems without an MRS are similar to those with an MRS (e.g., for MPC system; 50,860 person-rem with MRS and 56,970 person-rem without an MRS). The facility health and safety impacts for systems without an MRS are higher for the MPC system than for the reference scenario, and the same trend exists for the systems with an MRS.

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APPENDIX A

FACILITY ROUTINE RADIATION EXPOSURES

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A1. FACILITY ROUTINE RADIATION EXPOSURES EVALUATION

This portion of Appendix A provides flow charts and copies of the key spreadsheets used to evaluate the routine radiation exposures at each of the CRWMS facilities (utilities, MRS, and MGDS) for four designs (reference scenario, the TSC, the MPU, and the MPC system designs). These are based on MPC facility routine exposure calculations that are described in Section A2. In this section, the radiation exposures for the each system are made consistent within each CRWMS facility. The facility radiation exposure estimates in Section A2 and the spreadsheets were based on nuclear utility operations experience and data from Electric Power Research Institute (EPRI) reports. This exposure data, along with the definitions of operations, are then used to create the detailed exposures spreadsheets for the alternative CRWMS designs, including the reference scenario, TSC, MPU, and MPC system. This process includes organizing and harmonizing of the input data to create a consistent basis among all four alternatives. Consistent conservatism was maintained among the alternatives by using the same dose rates versus distance for each, comparable staffs, and comparable exposure times for each step. The level of conservatism is potentially more than two times.

The calculations for this report, as shown in the first section of this Appendix, are based on the nominal exposure values and times. The estimates do not assume the use of As Low As is Reasonably Achievable (ALARA) techniques. In Section A2 are examples of what can be achieved to reduce exposures by the use of ALARA techniques.

The empirical data on which these calculations are based on dose rates measured during comparable operations with comparable casks under conditions similar to those expected in the reference scenario and the MPC systems. Conservative values are obtained since these data describe the handling times for the first casks and canisters in the program. Learning curve experience can provide significant reductions in the exposures per operation, in view of the many thousands of repetitive operations, especially at the MRS and MGDS, in the forty-year program life cycle.

Figures A1-1, A1-2, A1-3, and A1-4 describe the exposures, numbers of cask/canisters handled, and the resulting exposures for each major step at CRWMS facilities. Each arrow represents a cask/canister handling. The quantities adjacent to these arrows are the exposure rates, the number of casks/canisters, and total exposures. The dashed arrows without quantities designate transportation, which is dealt with in Appendixes B and C.

Detailed spreadsheets used in estimating the routine radiological exposures for each of the CRWMS system designs at each facility are provided in Table A1-1 and those following. These tables are based on the detailed technical information and logistics data of References 55, and 57, of the body of this report. Those reports should be consulted for the definitive descriptions of each of the cask, canister, and handling requirements of the alternative systems.

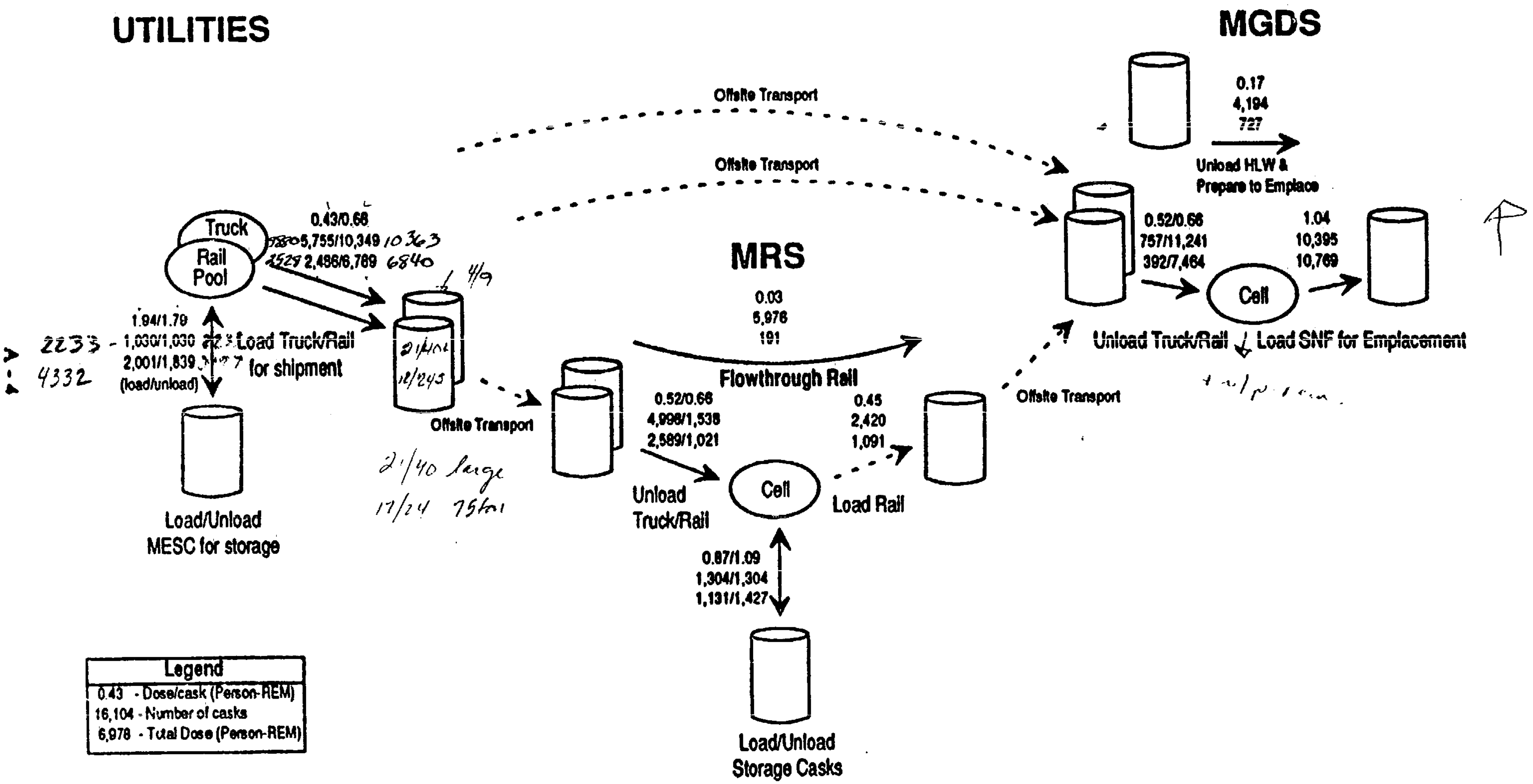


Figure A1.1. Single-Purpose System Occupational Routine Radiological Exposure-Primary Operations for SNF

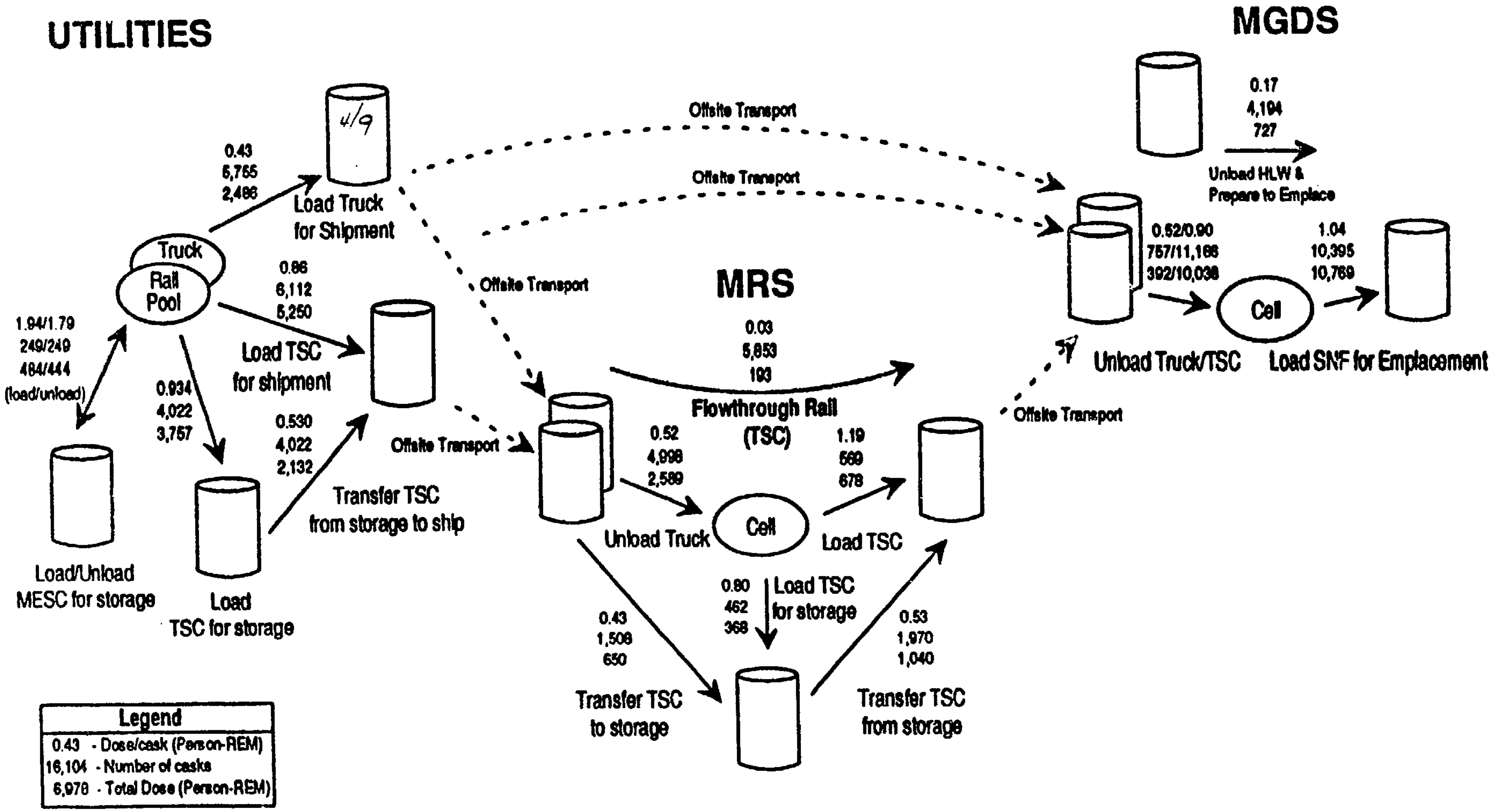


Figure A1.2. TSC System-Routine Occupational Radiation Exposure

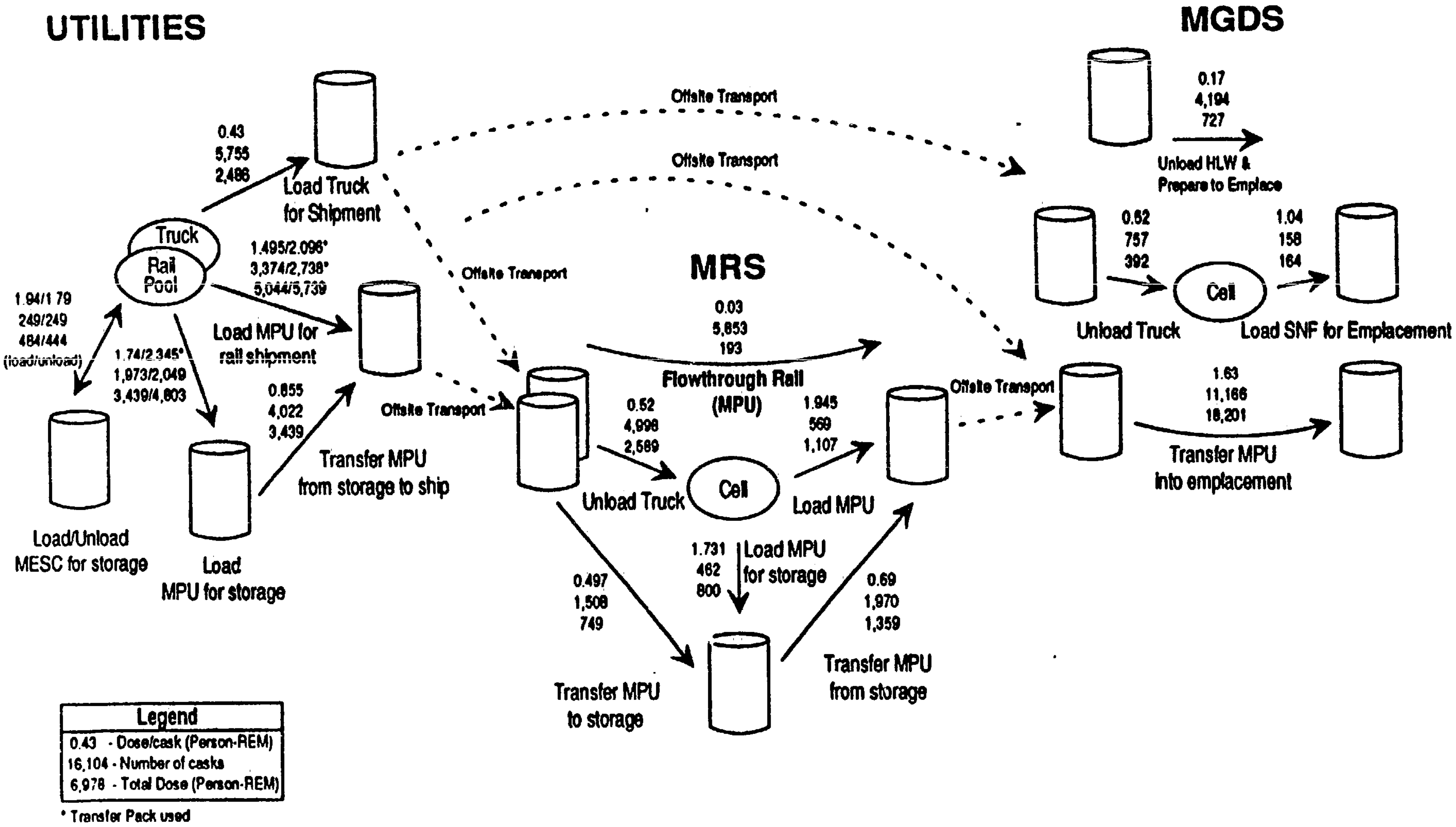
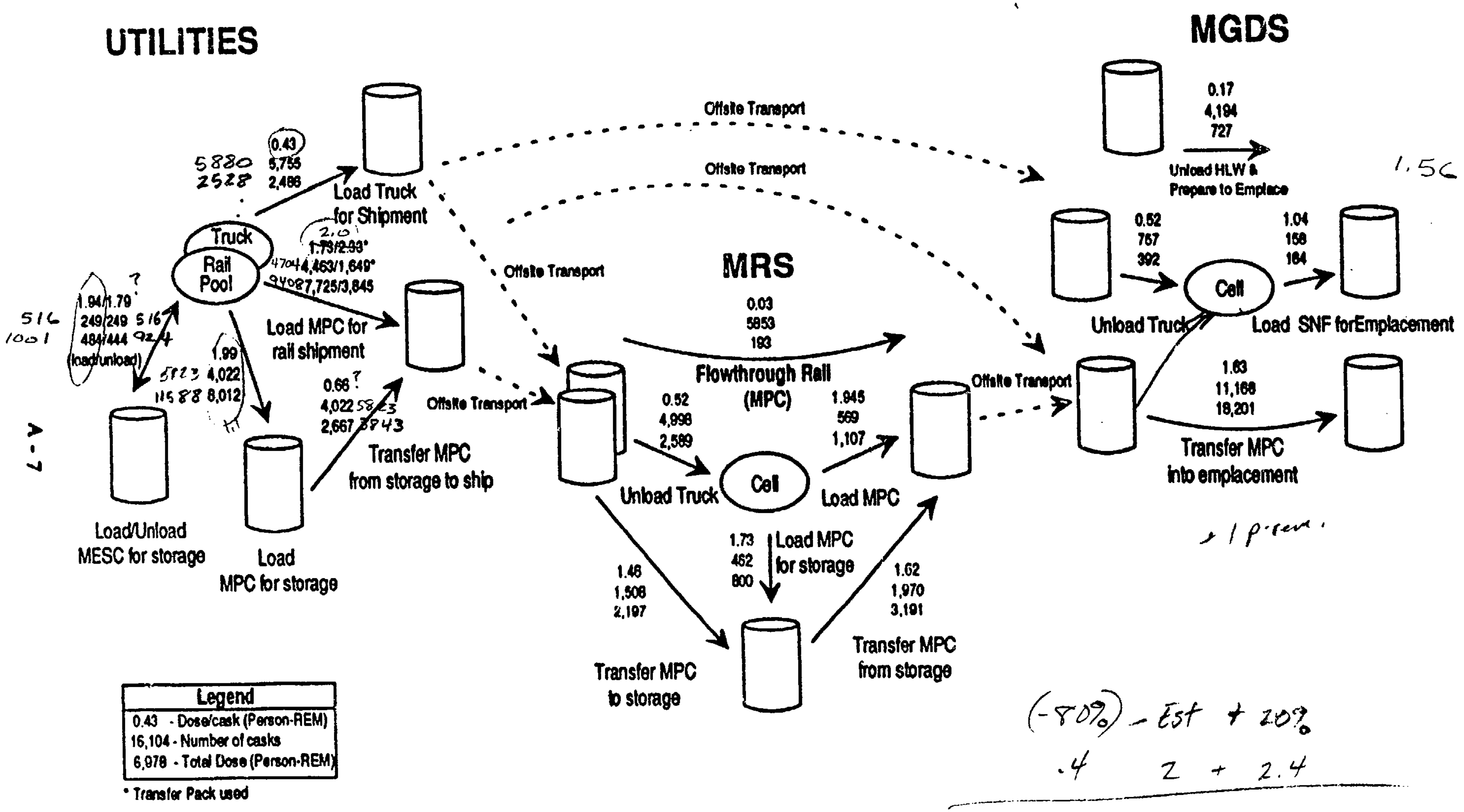


Figure A1.3. MPU System-Routine Occupational Radiation Exposure



(-80%) - Est + 20%
.4 2 + 2.4

-80% Est + 40%
.4 - 2 - 2.8

Figure A1.4. MPC System-Routine Occupational Radiation Exposure

Table A1-1 through A1-4. SNF Storage Sites

Table A1-1. Utilities-Reference

Total Doses per Cask Handling for SPS at the Utilities				Truck & Rail mrem/hr		Background		
				Lid doses		mrem/hr		
	Direct	Bkgd	Sum	inner	220	area	dose	
Load for Shipping	(person-mrem)			outer	60	crane	0.25	
Steps-(1,2,3a,4a,5) Truck for all : SPS, TSC, MPU, MPC	349	82	432	Tp/fx cask lid	60	decor	1	
Steps-(1,2,3b,4b,5b) Rail for SPs only.	533	122	656	Lateral Skin	59	pool	3	
				Storage cask mrem/hr		ISFSI	2	
				Lid doses				
				inner	220	null	0	
Load MESC: Steps-(6,7,8,9,10,11,12,13)	1,820	123	1,943	outer	97			
Unload MESC: Steps-(14,15,16,17,18)	1,650	135	1,785	Tp/fx cask lid	70			
				Lateral Skin	70			
Cask Handling Operations	Total Task Time(Min.)	Dose time(Min.)	Personnel Required (Persons/Task)	Occupation	Working Distance (Feet)	Cask Dose Rate(mrem/hr)	Dose Received(Person-mrem)	Facility dose background (person-mrems)
1. Receive Unloaded Transportation Cask				assume crane area background. 0.25 mrem/hr				
a. Inspect Bills of Lading, Other Shipping Papers	10	10	1	Operator	0	0	0.0	0.0
b. Release Off-Site Prime Mover (PM)	10	10	1	Prime Mover Operator	15	0	0.0	0.0
c. Hitch On-Site Prime Mover	10	10	1	Prime Mover Operator	15	0	0.0	0.0
d. Perform Receipt HP Survey	40	40	2	Radiation Protection	2	0	0.0	0.0
e. Move Cask to Protected Area Gate	20	20	1	Prime Mover Operator	15	0	0.0	0.0
f. Security Inspection	30	30	2	Security Officers	2	0	0.0	0.0
g. Open Prep Area Door	5	5	1	Operator	0	0	0.0	0.0
h. Move Cask to Prep Area	30	30	1	Prime Mover Operator	15	0	0.0	0.0
i. Remove Personnel Barrier/Impact Limiters	90	90	2	Operators	2	0	0.0	0.8
		90	1	Crane Operator	20	0	0.0	0.4
j. Close Prep Area Door	5	5	1	Operator	0	0	0.0	0.0
k. Remove Cask Restraints	60	60	2	Operators	2	0	0.0	0.5
l. Perform Preliminary HP Survey	40	40	2	Radiation Protection	2	0	0.0	0.3
m. Engage Yoke to Cask	5	5	1	Operators	2	0	0.0	0.0
		5	1	Flagman	10	0	0.0	0.0
		6	1	Crane Operator	20	0	0.0	0.0
n. Lift Cask Into Prep Area	30	30	2	Operators	10	0	0.0	0.3
		30	1	Crane Operator	20	0	0.0	0.1
Total	385	515					0.0	2.4
2. Prep Transportation Cask for loading in Pool				assume pool area	bkgd 3 mrem/hr			
a. Install Shield Platform	30	30	1	Operator	6	0	0.0	1.5
b. Attach Gas Sampling/Vent Equipment	5	5	1	Operator	2	0	0.0	0.3
c. Sample Gas Cavity	30	30	1	Operator	2	0	0.0	1.5
d. Vent Cask Cavity	30	30	1	Operator	2	0	0.0	1.5
e. Fill Cask with Water	60	60	2	Operators	2	0	0.0	6.0
f. Remove Sampling/Venting Equipment	5	5	1	Operator	2	0	0.0	0.3
g. Loosen Cask Lid Bolts	20	20	2	Operators	2	0	0.0	2.0
h. Attach Lid Sling to Cask Yoke	10	10	1	Operator	2	0	0.0	0.5
		10	1	Flagman	10	0	0.0	0.5
		10	1	Crane Operator	20	0	0.0	0.5
i. Install Contamination Protection on Cask	30	30	2	Operators	2	0	0.0	3.0
j. Remove Shield Platform	30	30	1	Operator	6	0	0.0	1.5
k. Lift Cask onto Pool Platform	20	20	2	Operators	10	0	0.0	2.0
		20	1	Crane Operator	20	0	0.0	1.0
l. Remove Remaining Lid Bolts	30	30	2	Operators	2	0	0.0	3.0
m. Lift Cask to Pool Bottom	30	30	2	Operators	30	0	0.0	3.0
		30	1	Crane Operator	40	0	0.0	1.5
n. Disengage Yoke	10	10	1	Operator	30	0	0.0	0.5
		10	1	Flagman	30	0	0.0	0.5
		10	1	Crane Operator	40	0	0.0	0.5
o. Remove Yoke and Cask Lid from Pool	20	20	1	Operator	2	0	0.0	1.0
		20	1	Flagman	10	0	0.0	1.0
		20	1	Crane Operator	20	0	0.0	1.0
Total	360	490					0.0	34.0
3a. Load SNF into Truck Transportation Cask				assume pool area				
a. Attach SNF Grapple to Crane	10	10	2	Operator	20	0.5	0.2	1.0
b. Engage One SNF Assembly, (12 min. per assembly)								

Table A1-1. Utilities-Reference (continued)

b1. Time for cask	50	50	2	Operator	20	0.5	0.8	5.0
c. Load SNF into Transfer Cask	70	70	2	Operator	20	0.5	1.2	7.0
Total	130	130					2.2	13.0
3b. Load SNF into Rail Transportation Cask				assume pool area				
a. SNF Grapple Attached to Crane	10	10	2	Operators	20	0.5	0.2	1.0
b. Engage One SNF Assembly. (12 min. per assembly)								
b1. Time for cask	250	250	2	Operators	20	0.5	4.2	25.0
c. Load SNF into cask	70	70	2	Operators	20	0.5	1.2	7.0
Total	330	330					5.5	33.0
4a. Prep Truck Transportation Cask from Pool				assume pool area background dose				
a. Inspect Cask Seal	10	10	1	Operator	2	0	0.0	0.5
b. Place Cask Lid and Engage Yoke	25	25	2	Operators	30	0	0.0	2.5
		25	1	Flagman	30	0	0.0	1.3
		25	1	Crane Operator	40	0	0.0	1.3
c. Lift Cask to Pool Surface	10	10	2	Operators	10	0	0.0	1.0
		10	1	Crane Operator	20	0	0.0	0.5
d. Install Two Cask Lid Bolts	5	5	1	Operator	2	60	5.0	0.3
e. Lift Cask into Prep/Decon Area	20	20	2	Operators	10	1.8	1.2	2.0
		20	1	Crane Operator	20	0.5	0.2	1.0
f. Decontaminate Yoke and Cask	45	45	1	Operator	10	8.7	6.5	2.3
		45	1	Crane Operator	20	0.5	0.4	2.3
g. Disengage Yoke and Lid Sling from Cask	10	10	1	Operator	2	17	2.8	0.5
		10	1	Flagman	10	8.7	1.5	0.5
		10	1	Crane Operator	20	0.5	0.1	0.5
h. Attach Vent and Drain Lines	5	5	1	Operator	2	60	5.0	0.3
i. Drain Cask	60	20	1	Operator	2	17	5.7	1.0
j. HP Survey	45	20	2	Radiation Protection	2	43	28.7	2.0
k. Secure Cask Bolted Lid	30	30	2	Operators	2	60	60.0	3.0
l. Connect Drying and Inerting Equipment	10	10	1	Operator	2	60	10.0	0.5
m. Drain, Dry, and Inert Cask	90	90	1	Operator	2	17	25.5	4.5
		90	1	Operator	10	8.7	13.1	4.5
n. Remove Drain, Drying, and Inerting Equipment	10	10	1	Operator	2	60	10.0	0.5
o. Perform Leak Test on Seal	10	10	1	Operator	2	17	2.8	0.5
Total	385	555					178.4	33.0
4b. Prep Rail Transportation Cask from Pool (times are scaled by diameter ratio to rail from 4a => 1.8.)							pool area	
a. Inspect Cask Seal (s)	20	20	1	Operator	2	0	0.0	1.0
b. Place Cask Lid and Engage Yoke	25	25	2	Operators	30	0	0.0	2.5
		25	1	Flagman	30	0	0.0	1.3
		25	1	Crane Operator	40	0	0.0	1.3
c. Lift Cask to Pool Surface	10	10	2	Operators	10	0	0.0	1.0
		10	1	Crane Operator	20	0	0.0	0.5
d. Install Two Cask Lid Bolts	5	5	1	Operator	2	60	5.0	0.3
e. Lift Cask into Prep/Decon Area	20	20	2	Operators	10	1.8	1.2	2.0
		20	1	Crane Operator	20	0.5	0.2	1.0
f. Decontaminate	80	80	1	Operator	10	8.7	11.6	4.0
Yoke and Cask (s)		80	1	Crane Operator	20	0.5	0.7	4.0
g. Disengage Yoke and Lid Sling from Cask	10	10	1	Operator	2	17	2.8	0.5
		10	1	Flagman	10	8.7	1.5	0.5
		10	1	Crane Operator	20	0.5	0.1	0.5
h. Attach Vent and Drain Lines	5	5	1	Operator	2	60	5.0	0.3
i. Drain Cask(s)	110	35	1	Operator	2	17	9.9	1.8
j. HP Survey(s)	80	35	2	Radiation Protection	2	43	50.2	3.5
k. Secure Cask Bolted Lid(s)	55	55	2	Operators	2	60	110.0	5.5
l. Connect Drying and Inerting Equipment	10	10	1	Operator	2	60	10.0	0.5
m. Drain, Dry, and Inert Cask(s)	160	160	1	Operator	2	17	45.3	8.0
		160	1	Operator	10	8.7	23.2	8.0
n. Remove Drain, Drying, and Inerting Equipment	10	10	1	Operator	2	60	10.0	0.5
o. Perform Leak Test on Seal(s)	20	20	1	Operator	2	17	5.7	1.0
Total	620	840					292.3	49.3
5a. Prep Truck Transportation Cask from Pool Prep Area to Ship				assume null background dose				
a. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0
b. Move On-Site PM and Transporter to Prep Area	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
c. Unhitch On-Site PM	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
d. Engage Yoke to Cask	10	10	1	Operator	2	17	2.8	0.0
	10	10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
d1 Close Pool Prep Area Door, simultaneously		0	1	Operator	0	0	0.0	0.0
e. Place Cask on Transporter	45	45	2	Operators	10	1.8	2.7	0.0
		45	1	Crane Operator	20	0.5	0.4	0.0
f. Perform Release HP Survey	45	20	2	Radiation Protection	2	43	28.7	0.0
g. Install Cask Restraints	30	30	2	Operators	2	32	32.0	0.0
		30	1	Crane Operator	20	0.5	0.3	0.0
h. Install Impact Limiters	30	30	2	Operators	2	32	32.0	0.0
		30	1	Crane Operator	20	0.5	0.3	0.0

Table A1-1. Utilities-Reference (continued)

i. Install Personnel Barrier	60	60	2	Operators	2	32	64.0	0.0
		30	1	Crane Operator	20	0.5	0.3	0.0
j. Prepare Shipping Papers	10	0	1	Operator	0	0	0.0	0.0
k. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0
l. Hitch On-Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
m. Move Cask to Protected Area Gate	20	20	1	Prime Mover Operator	15	0.5	0.2	0.0
n. Perform security check	5	5	2	Security Officers	2	17	3.4	0.0
o. Un-hitch On-Site Prime Mover	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
p. Hitch Off-Site Prime Mover	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
Total	**310**	**410**					**168.7**	**0.0**
5b. Prep Rail Transportation Cask from Pool Prep Area to				assume null background dose				
Ship (times are scaled by diameter ratio to rail from 5a.=>			1.8	scale perimeter from tru	1.2)			
a. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0
b. Move On-Site PM and Transporter to Prep Area	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
c. Unhitch On-Site PM	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
d. Engage Yoke to Cask	10	10	1	Operator	2	17	2.8	0.0
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
d1. Close Pool Prep Area Door, simultaneously with St		0	1	Operator	0	0	0.0	0.0
e. Place Cask on Transporter	45	45	2	Operators	10	1.8	2.7	0.4
		45	1	Crane Operator	20	0.5	0.4	0.2
f. Perform Release HP Survey(s -diameter)	80	35	2	Radiation Protection	2	43	50.2	0.3
g. Install Cask Restraints(s -perimeter)	35	35	2	Operators	2	32	37.3	0.3
		35	1	Crane Operator	20	0.5	0.3	0.1
h. Install Impact Limiters(s- diameter)	55	55	2	Operators	2	32	58.7	0.5
		55	1	Crane Operator	20	0.5	0.5	0.2
i. Install Personnel Barrier(s- perimeter)	70	70	2	Operators	2	32	74.7	0.6
		35	1	Crane Operator	20	0.5	0.3	0.1
j. Prepare Shipping Papers	10	0	1	Operator	0	0	0.0	0.0
k. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0
l. Hitch On-Site Prime Mover	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
m. Move Cask to Protected Area Gate (null backgroun	30	30	1	Prime Mover Operator	15	0.5	0.3	0.1
n. Perform security check	5	5	2	Security Officers	2	17	3.4	0.0
o. Un-hitch On-Site Prime Mover	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
p. Make-up with other cask cars per train (assume 3 ca	60	60	2	Operator-rail	15	1.2	2.4	0.5
q. Hitch Off-Site Prime Mover (assume rail siding dose sc	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
Total	**440**	**565**					**235.6**	**3.6**
6. Receive Empty MESC				no background dose				
a. Inspect Bills of Lading, Other Shipping Papers	10	10	1	Operator	0	0	0.0	0.0
b. Take MESC to Warehouse	60	60	1	Prime Mover Operator	15	0	0.0	0.0
c. Up-end MESC at Warehouse and Store	30	30	2	Operators	10	0	0.0	0.0
		30	1	Crane Operator	20	0	0.0	0.0
d. Release Off-Site Prime Mover (PM)	10	10	1	Prime Mover Operator	15	0	0.0	0.0
e. Hitch On-Site PM	10	10	1	Prime Mover Operator	15	0	0.0	0.0
f. Move MESC to Protected Area	20	20	1	Prime Mover Operator	15	0	0.0	0.0
g. Security Inspection(assume crane enclosure)	30	30	2	Security Officers	2	0	0.0	0.3
h. Open Staging Area Door	5	5	1	Operator	0	0	0.0	0.0
i. Move MESC to Staging Area	30	30	1	Prime Mover Operator	15	0	0.0	0.1
j. Perform Preliminary HP Survey of MESC	40	40	2	Radiation Protection	2	0	0.0	0.3
k. Attach Lifting Device to MESC	10	10	2	Operators	2	0	0.0	0.1
		10	1	Flagman	10	0	0.0	0.0
		10	1	Crane Operator	20	0	0.0	0.0
k1. Close Staging Area Door, simultaneously with Step k.		10	1	Operator	0	0	0.0	0.0
l. Lift MESC into Prep Area	30	30	2	Operators	10	0	0.0	0.3
		30	1	Crane Operator	20	0	0.0	0.1
Total	**285**	**375**					**0.0**	**1.3**
7. Receive Unloaded On-Site MESC Transfer Cask: ISFSI To Prep				assume unloaded cask in crane enclosure				
a. Move Cask to Storage	60	60	2	Operators	10	0	0.0	0.5
		60	1	Prime Mover Operator	15	0	0.0	0.3
		60	1	Crane Operator	20	0	0.0	0.3
		60	1	Radiation Protection	10	0	0.0	0.3
b. Release On-site PM	5	5	2	Operators	10	0	0.0	0.0
		5	1	Prime Mover Operator	15	0	0.0	0.0
		5	1	Crane Operator	20	0	0.0	0.0
		5	1	Radiation Protection	10	0	0.0	0.0
c. Hitch On-Site PM	10	10	2	Operators	10	0	0.0	0.1
		10	1	Prime Mover Operator	15	0	0.0	0.0
		10	1	Crane Operator	20	0	0.0	0.0
		10	1	Radiation Protection	10	0	0.0	0.0
d. Move Cask to Protected Area	20	20	2	Operators	10	0	0.0	0.2
		20	1	Prime Mover Operator	15	0	0.0	0.1
		20	1	Crane Operator	20	0	0.0	0.1
		20	1	Radiation Protection	10	0	0.0	0.1
e. Security Inspection	30	30	2	Security Officers	2	0	0.0	0.3
f. Open Prep Door	5	5	1	Operator	0	0	0.0	0.0
g. Move Cask into Prep Area	30	30	1	Prime Mover Operator	15	0	0.0	0.0

Table A1-1. Utilities-Reference (continued)

h. Release PM	5	5	1	Prime Mover Operator	15	0	0.0	0.0
i. Close Prep Area Door(use decon area backgro	5	5	1	Operator	0	0	0.0	0.1
j. Perform Preliminary HP Survey	40	40	2	Radiation Protection	2	0	0.0	1.3
k. Decontaminate Cask	60	60	2	Operators	2	0	0.0	2.0
l. Remove Cask Restraints	60	60	2	Operators	2	0	0.0	2.0
m. Perform HP Survey	40	40	2	Radiation Protection	2	0	0.0	1.3
n. Decontaminate Cask	60	60	2	Operators	2	0	0.0	2.0
o. Engage Yoke to Cask	5	5	1	Operator	2	0	0.0	0.1
		5	1	Operator	10	0	0.0	0.1
		5	1	Crane Operator	20	0	0.0	0.1
p. Lift Cask into Prep Area	25	25	2	Operators	10	0	0.0	0.8
		25	1	Crane Operator	20	0	0.0	0.4
Total	460	780					0.0	12.6
8. Load Empty MESC into Transfer-overpack				assume crane enclosure background				
a. Align MESC with Cask	10	10	1	Operator	2	0	0.0	0.0
		10	1	Operator	10	0	0.0	0.0
		10	1	Crane Operator	20	0	0.0	0.0
b. Lower MESC into Cask	20	20	2	Operators	2	0	0.0	0.2
		20	1	Operator	10	0	0.0	0.1
		20	1	Crane Operator	20	0	0.0	0.1
c. Disengage and Remove Lifting Device From MESC	10	10	1	Operator	2	0	0.0	0.0
		10	1	Operator	10	0	0.0	0.0
d. Verify MESC Configuration for SNF	10	10	2	Operators	2	0	0.0	0.1
e. Fill Annulus with Demineralized Water	30	30	2	Operators	2	0	0.0	0.3
f. Install MESC Contamination Protection	30	30	2	Operators	2	0	0.0	0.3
g. Connect Annulus Float Hoses	5	5	2	Operators	2	0	0.0	0.0
h. Fill MESC With Water	60	60	2	Operators	2	0	0.0	0.5
Total	175	245					0.0	1.7
9. Prep Unloaded MESC/Transfer for Pool				assume crane area background initially				
a. Attach Cask Yoke to Crane	10	10	1	Operator	2	0	0.0	0.0
		10	1	Flagman	10	0	0.0	0.0
		10	1	Crane Operator	20	0	0.0	0.0
b. Engage Yoke to Cask	25	25	1	Operator	2	0	0.0	0.1
		25	1	Flagman	10	0	0.0	0.1
		25	1	Crane Operator	20	0	0.0	0.1
c. Move Cask to Fuel Loading Pool Floor	30	30	2	Operators	10	0	0.0	0.3
(assume pool area background)		30	1	Crane Operator	20	0	0.0	0.1
d. Disengage Yoke From Cask	20	20	1	Operator	30	0	0.0	1.0
		20	1	Flagman	30	0	0.0	1.0
		20	1	Crane Operator	40	0	0.0	1.0
e. Remove Yoke From Pool	10	10	2	Operators	10	0	0.0	1.0
		10	1	Flagman	10	0	0.0	0.5
		10	1	Crane Operator	20	0	0.0	0.5
Total	95	255					0.0	5.8
10. Load SNF into MESC/Transfer								
a. SNF Grapple Attached to Crane	10	10	2	Operators	20	0.5	0.2	1.0
b. Engage One SNF Assembly, (12 min. per assembly)							0.0	0.0
b1. Time for cask	250	250	2	Operators	20	0.5	4.2	25.0
c. Load SNF into cask	70	70	2	Operators	20	0.5	1.2	7.0
Total	330	330					6.6	33.0
11. Prep MESC/Transfer from pool				assume pool bacground dose, 3 mrem/hr				bkgd
a. Attach MESC Shield Plug Lift Fixture to Crane	5	5	2	Operators	2	0	0.0	0.5
		5	1	Flagman	10	0	0.0	0.3
		5	1	Crane Operator	20	0	0.0	0.3
b. Install MESC Shield Plug	20	20	0	Remote	0	0	0.0	0.0
c. Engage Yoke to Cask	5	5	1	Operator	30	0	0.0	0.3
		5	1	Flagman	30	0	0.0	0.3
		5	1	Crane Operator	40	0	0.0	0.3
d. Lift MESC/Cask to Pool Surface	5	5	2	Operators	10	0	0.0	0.5
		5	1	Crane Operator	20	0	0.0	0.3
e. Install Shield Plug Retainers	10	10	1	Operator	2	220	36.7	0.5
f. Lift MESC/Cask into Prep/Decon Area	30	25	2	Operators	10	8.7	7.3	2.5
(use decon background dose rate)		30	1	Crane Operator	20	0.5	0.3	1.5
g. Disengage Yoke from Cask	5	5	1	Operator	2	59	4.9	0.1
		5	1	Flagman	10	8.7	0.7	0.1
		5	1	Crane Operator	20	0.5	0.0	0.1
h. Remove Shield Plug Retainers	10	10	1	Operator	2	220	36.7	0.2
i. Decon MESC/Cask and Yoke	120	90	1	Operator	10	8.7	13.1	1.5
		40	1	Crane Operator	20	0.5	0.3	0.7
j. Hook Up Drain Equipment	10	10	1	Operator	2	220	36.7	0.2
k. Partially Drain MESC and Annulus	20	20	1	Operator	10	8.7	2.9	0.3
l. Remove Annulus Seal	10	10	2	Operators	2	220	73.3	0.3
m. Check MESC/Cask for Contamination	30	10	2	Radiation Protection	2	59	19.7	0.3
n. Install Annulus Welding Protection	10	10	2	Operators	2	220	73.3	0.3
o. Install Remote Welding Equipment	45	30	1	Welder	2	220	110.0	0.5

Table A1-1. Utilities-Reference (continued)

		10	1	Crane Operator	20	0.5	0.1	0.2
p. Inner Lid Weld	1000	0	0	Remote	0	0	0.0	0.0
p1. Perform NDE on Weld	30	20	1	QA Welder	2	220	73.3	0.3
q. Remove Welding Equipment	20	20	1	Welder	2	220	73.3	0.3
		10	1	Crane Operator	20	0.5	0.1	0.2
r. Drain, Dry, and Inert MPC	350	10	1	Operator	2	220	36.7	0.2
		350	1	Operator	10	8.7	50.8	5.8
s. Remove Drain, Dry, and Inerting Equipment	10	10	1	Operator	2	220	36.7	0.2
t. Perform Leak Tests on Seal Weld	20	20	1	Operator	2	37	12.3	0.3
u. Weld Valve Cover Plates	90	90	1	Welder	2	220	330.0	1.5
v. Place MESC Outer Lid	20	10	1	Operator	2	97	16.2	0.2
		10	1	Flagman	10	8.7	1.5	0.2
		10	1	Crane Operator	20	0.5	0.1	0.2
w. Set Up Remote Welding Equipment	45	30	1	Welder	2	97	48.5	0.5
		10	1	Crane Operator	20	0.5	0.1	0.2
x. Weld MESC Outer Lid	1000	0	0	Remote	0	0	0.0	0.0
x1. Perform NDT on Weld	30	20	1	QA Welder	2	97	32.3	0.3
y. Remove Annulus Weld Protection	10	10	1	Operator	2	97	16.2	0.2
z. Place Transfer Cask Lid	10	10	1	Operator	2	97	16.2	0.2
		10	1	Flagman	10	8.7	1.5	0.2
		10	1	Crane Operator	20	0.5	0.1	0.2
aa. Decon Cask	30	30	2	Operators	2	59	59.0	1.0
		30	1	Crane Operator	20	0.5	0.3	0.5
bb. Perform HP Survey	45	20	2	Radiation Protection	2	59	39.3	0.7
cc. Secure Transfer Cask Bolted Lid	30	30	2	Operators	2	97	97.0	1.0
Total	3075	1,150					1357.1	26.9
12. Prep MESC/Transfer-overpack								
for ISFSI				assume crane area background dose				
a. Open Staging Area Door	5	0	1	Operator	0	0	0.0	0.0
b. Move On-Site PM and Transporter to Staging A	10	10	1	Prime Mover Operator	15	0	0.0	0.0
		10	1	Transporter Operator	15	0	0.0	0.0
c. Unhitch On-Site PM	5	5	1	Prime Mover Operator	15	0	0.0	0.0
d. Engage Yoke to MESC/Cask	10	10	1	Operator	2	37	6.2	0.0
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
d1. Close Staging Area Door, simultaneously w		0	1	Operator	0	0	0.0	0.0
e. Place MESC/Cask on Transporter	45	45	2	Operators	10	8.7	13.1	0.4
		45	1	Crane Operator	20	0.5	0.4	0.2
f. Perform Release HP Survey	60	30	2	Radiation Protection	2	59	59.0	0.3
g. Install Cask Restraints	60	60	2	Operators	2	32	64.0	0.5
h. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0
i. Prepare Transfer Papers	10	0	1	Operator	0	0	0.0	0.0
j. Move MESC/Cask Outside Protected Area	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
k. Move MESC/Cask to ISFSI	60	30	2	Operators	10	8.7	8.7	0.0
		30	1	Prime Mover Operator	15	0.5	0.3	0.0
		30	1	Crane Operator	20	0.5	0.3	0.0
		30	1	Radiation Protection	10	8.7	4.4	0.0
Total	280	365					157.8	1.6
13. Transfer MESC from Transfer-								
Overpack to ISFSI				assume ISFI background dose				
a. Prepare Cask for MESC Transfer	60	30	2	Operators	2	70	70.0	2.0
		60	1	Prime Mover Operator	15	0.5	0.5	2.0
		60	1	Crane Operator	20	0.5	0.5	2.0
		60	1	Radiation Protection	10	8.7	8.7	2.0
a1. Open ISFSI Storage Door, simultaneously w		20	1	Operator	2	70	23.3	0.7
Step a.		0	0	Prime Mover Operator	15	0.5	0.0	0.0
		0	0	Crane Operator	20	0.5	0.0	0.0
		0	1	Radiation Protection	10	8.7	0.0	0.0
b. Align Cask With ISFSI	60	30	2	Operators	10	8.7	8.7	2.0
		60	1	Prime Mover Operator	15	0.5	0.5	2.0
		60	1	Crane Operator	20	0.5	0.5	2.0
		60	1	Radiation Protection	10	8.7	8.7	2.0
c. Prepare Transfer Equipment	60	30	2	Operators	2	70	70.0	2.0
		60	1	Prime Mover Operator	15	0.5	0.5	2.0
		60	1	Crane Operator	20	0.5	0.5	2.0
		60	1	Radiation Protection	10	8.7	8.7	2.0
d. Transfer MESC From Cask to ISFSI	30	30	2	Operators	10	8.7	8.7	2.0
		30	1	Prime Mover Operator	15	0.5	0.3	1.0
		30	1	Crane Operator	20	0.5	0.3	1.0
		30	1	Radiation Protection	10	8.7	4.4	1.0
e. Close ISFSI Storage Door	30	30	1	Operator	2	70	35.0	1.0
		30	1	Prime Mover Operator	15	0.5	0.3	1.0
		30	1	Crane Operator	20	0.5	0.3	1.0
		30	1	Radiation Protection	10	8.7	4.4	1.0
f. Prepare for Transportation of MESC On-Site Transfer Cask from							0.0	0.0
ISFSI	60	30	2	Operators	2	35	35.0	2.0
		60	1	Prime Mover Operator	15	0.5	0.5	2.0

Table A1-1. Utilities-Reference (continued)

		60	1	Crane Operator	20	0.5	0.5	2.0
		60	1	Radiation Protection	10	8.7	8.7	2.0
Total	380	1,100					299.2	41.7
14. Transfer MESC from ISFSI to Transfer-overpack				assume ISFI background dose				
a. Prepare Cask for MESC Transfer	60	30	2	Operators	2	0	0.0	2.0
		60	1	Prime Mover Operator	15	0	0.0	2.0
		60	1	Crane Operator	20	0	0.0	2.0
		60	1	Radiation Protection	10	0	0.0	2.0
b. Align Cask with ISFSI	60	30	2	Operators	2	0	0.0	2.0
		60	1	Prime Mover Operator	15	0	0.0	2.0
		60	1	Crane Operator	20	0	0.0	2.0
		60	1	Radiation Protection	10	0	0.0	2.0
c. Open ISFSI Storage Door	0	20	1	Operators	2	70	23.3	0.7
		0	1	Prime Mover Operator	15	0.5	0.0	0.0
		0	1	Crane Operator	20	0.5	0.0	0.0
		0	1	Radiation Protection	10	8.7	0.0	0.0
d. Prepare Transfer Equipment	60	30	2	Operators	2	70	70.0	2.0
		60	1	Prime Mover Operator	15	0.5	0.5	2.0
		60	1	Crane Operator	20	0.5	0.5	2.0
		60	1	Radiation Protection	10	8.7	8.7	2.0
e. Transfer MESC to Transfer Cask	30	30	2	Operators	10	8.7	8.7	2.0
		30	1	Prime Mover Operator	15	0.5	0.3	1.0
		30	1	Crane Operator	20	0.5	0.3	1.0
		30	1	Radiation Protection	10	8.7	4.4	1.0
f. Close ISFSI Storage Door	30	30	2	Operators	2	70	70.0	2.0
		30	1	Prime Mover Operator	15	0.5	0.3	1.0
		30	1	Crane Operator	20	0.5	0.3	1.0
		30	1	Radiation Protection	10	8.7	4.4	1.0
g. Install Cask Closure	55	55	2	Operators	2	70	128.3	3.7
		55	1	Prime Mover Operator	15	0.5	0.5	1.8
		55	1	Crane Operator	20	0.5	0.5	1.8
		55	1	Radiation Protection	10	8.7	8.0	1.8
h. Prepare to Move Off-Site Transportation Cask From ISFSI Storage							0.0	0.0
Yard	60	30	2	Operators	2	70	70.0	2.0
		60	1	Prime Mover Operator	15	0.5	0.5	2.0
		60	1	Crane Operator	20	0.5	0.5	2.0
		60	1	Radiation Protection	10	8.7	8.7	2.0
Total	355	1,320					408.4	51.8
15. Prep MESC/Transfer from ISFSI for Pool				assume pool background 3 mrem/hr				
a. Move MESC/Cask to Stagging Area	60	30	2	Operators	10	8.7	8.7	3.0
		30	1	Prime Mover Operator	15	0.5	0.3	1.5
		30	1	Crane Operator	20	0.5	0.3	1.5
		30	1	Radiation Protection	10	8.7	4.4	1.5
b. Open Prep Area Door	5	5	1	Operator	0	0	0.0	0.3
c. Remove Cask Restraints	60	60	2	Operators	2	32	64.0	6.0
d. Remove MESC/Cask from Transporter	45	45	2	Operators	10	8.7	13.1	4.5
		45	1	Crane Operator	20	0.5	0.4	2.3
d1. Close Staging Area Door; simultaneously w		45	1	Operator	0	0	0.0	2.3
e. Install Cask Lid Lifting Device	20	20	2	Operators	2	97	64.7	2.0
		10	1	Flagman	10	8.7	1.5	0.5
		10	1	Crane Operator	20	0.5	0.1	0.5
f. Loosen/Remove Cask Lid	90	45	2	Operators	2	97	145.5	4.5
		20	1	Flagman	10	8.7	2.9	1.0
		20	1	Crane Operator	20	0.5	0.2	1.0
g. Set Up Remote Cutting Equipment	45	30	1	Welder	2	97	48.5	1.5
		10	1	Crane Operator	20	0.5	0.1	0.5
h. Cut MESC Lid	1000	0	0	Remote	0	0	0.0	0.0
i. Remove Annulus Cutting Protection	10	10	1	Operator	2	97	16.2	0.5
j. Remove MESC Outer Lid	20	20	1	Operator	2	97	32.3	1.0
		10	1	Flagman	10	8.7	1.5	0.5
		10	1	Crane Operator	20	0.5	0.1	0.5
k. Install Annulus Cutting Protection	10	10	2	Operators	2	220	73.3	1.0
l. Install Remote Cut Equipment	45	30	1	Welder	2	220	110.0	1.5
		10	1	Crane Operator	20	0.5	0.1	0.5
m. Inner Lid Cut	1000	0	0	Remote	0	0	0.0	0.0
n. Remove Cutting Equipment	20	20	1	Welder	2	220	73.3	1.0
		10	1	Crane Operator	20	0.5	0.1	0.5
o. Fill Annulus with Demineralized Water	30	30	2	Operators	2	59	59.0	3.0
p. Install MESC Contamination Protection	30	30	2	Operators	2	220	220.0	3.0
q. Connect Annulus Float Hoses	5	5	2	Operators	2	220	36.7	0.5
r. Fill MESC With Water	60	60	2	Operators	2	59	118.0	6.0
s. Attach Cask Yoke to Crane	10	10	1	Operator	2	0	0.0	0.5
		10	1	Flagman	10	0	0.0	0.5
		10	1	Crane Operator	20	0	0.0	0.5
t. Engage Yoke to Cask	25	25	1	Operator	2	59	24.6	1.3
		25	1	Flagman	10	8.7	3.6	1.3

Table A1-1. Utilities-Reference (continued)

		25	1	Crane Operator	20	0.5	0.2	1.3
u. Move Cask to Fuel Loading Pool Floor	30	30	2	Operators	10	0	0.0	3.0
		30	1	Crane Operator	20	0	0.0	1.5
v. Disengage Yoke From Cask	20	20	1	Operator	30	0	0.0	1.0
		20	1	Flagman	30	0	0.0	1.0
		20	1	Crane Operator	40	0	0.0	1.0
w. Remove Yoke From Pool	10	10	2	Operators	10	0	0.0	1.0
		10	1	Flagman	10	0	0.0	0.5
		10	1	Crane Operator	20	0	0.0	0.5
Total	2650	995					1123.3	68.5
16. Unload SNF from MESC/Transfer				assume shielded to 0.5 mrem/hr				
a. SNF Grapple Attached to Crane	10	10	2	Operators	20	0.5	0.2	0.0
b. Engage One SNF Assembly, (12 min. per assembly)							0.0	0.0
b1. Time for cask	250	250	2	Operators	20	0.5	4.2	0.0
c. Load SNF into cask	70	70	2	Operators	20	0.5	1.2	0.0
Total	330	330					6.6	0.0
17. Prep Unloaded MESC/Transfer from pool				assume pool background dose 3 mrem/hr				
a. Attach MESC Shield Plug Lift Fixture to Crane	5	5	2	Operators	2	0	0.0	0.5
		5	1	Flagman	10	0	0.0	0.3
		5	1	Crane Operator	20	0	0.0	0.3
b. Install MESC Shield Plug	20	20	0	Remote	0	0	0.0	0.0
c. Engage Yoke to Cask	5	5	1	Operator	30	0	0.0	0.3
		5	1	Flagman	30	0	0.0	0.3
		5	1	Crane Operator	40	0	0.0	0.3
d. Lift MESC/Cask to Pool Surface	5	5	2	Operators	10	0	0.0	0.5
		5	1	Crane Operator	20	0	0.0	0.3
e. Install Shield Plug Retainers	10	10	1	Operator	2	11	1.8	0.5
f. Lift MESC/Cask into Prep/Decon Area	30	25	2	Operators	10	0.5	0.4	2.5
(use decon building backgd dose)		30	1	Crane Operator	20	0.5	0.3	1.5
g. Disengage Yoke from Cask	5	5	1	Operator	2	11	0.9	0.1
		5	1	Flagman	10	0.5	0.0	0.1
		5	1	Crane Operator	20	0.5	0.0	0.1
h. Remove Shield Plug Retainers	10	10	1	Operator	2	11	1.8	0.2
i. Decon MESC/Cask and Yoke	120	90	1	Operator	10	0.5	0.8	1.5
		40	1	Crane Operator	20	0.5	0.3	0.7
j. Hook Up Drain Equipment	10	10	1	Operator	2	11	1.8	0.2
k. Partially Drain MESC and Annulus	20	20	1	Operator	10	0.5	0.2	0.3
l. Remove Annulus Seal	10	10	2	Operators	2	11	3.7	0.3
m. Check MESC/Cask for Contamination	30	10	2	Radiation Protection	2	11	3.7	0.3
s. Drain, Dry	350	10	1	Operator	2	11	1.8	0.2
bb. Place Cask Lid	20	10	1	Operator	2	11	1.8	0.2
		10	1	Flagman	10	0.5	0.1	0.2
		10	1	Crane Operator	20	0.5	0.1	0.2
cc. Decon Cask	30	30	2	Operators	2	11	11.0	1.0
		30	1	Crane Operator	20	0.5	0.3	0.5
dd. Perform HP Survey	45	20	2	Radiation Protection	2	11	7.3	0.7
ee. Secure Cask Bolted Lid	30	30	2	Operators	2	11	11.0	1.0
Total	755	480					49.2	14.6
18. Prep Unloaded MESC/Transfer-				assume no background dose				
Overpack for ISFSI								
a. Open Staging Area Door	5	0	1	Operator	0	0	0.0	0.0
b. Move On-Site PM and Transporter to Staging Area	10	10	1	Prime Mover Operator	15	0	0.0	0.0
		10	1	Transporter Operator	15	0	0.0	0.0
c. Unhitch On-Site PM	5	5	1	Prime Mover Operator	15	0	0.0	0.0
d. Engage Yoke to MESC/Cask	10	10	1	Operator	2	11	1.8	0.0
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
d1. Close Staging Area Door, simultaneously		0	1	Operator	0	0	0.0	0.0
e. Place MESC/Cask on Transporter	45	45	2	Operators	10	8.7	13.1	0.0
		45	1	Crane Operator	20	0.5	0.4	0.0
f. Perform Release HP Survey	60	30	2	Radiation Protection	2	11	11.0	0.0
g. Install Cask Restraints	60	60	2	Operators	2	11	22.0	0.0
h. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0
i. Prepare Transfer Papers	10	0	1	Operator	0	0	0.0	0.0
j. Move MESC/Cask Outside Protected Area	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
k. Move MESC/Cask to ISFSI	60	30	2	Operators	10	8.7	8.7	0.0
		30	1	Prime Mover Operator	15	0.5	0.3	0.0
		30	1	Crane Operator	20	0.5	0.3	0.0
		30	1	Radiation Protection	10	8.7	4.4	0.0
Total	280	365					63.4	0.0

Table A1-2. Utilities-TSC

Total Doses per Cask for TSC at the Utilities				Rail mrem/hr		Background	
Revised 20 May 94/HWG				Lid doses		mrem/hr	
	Direct	Bkgd	Sum	inner	97	area	dose
Load TSC for Rail Shipment	(person-mrem)			outer	60	crane	0.25
Steps-(1,2,3,4,5)	717	142	859	Tp/Tx cask lid	60	decon	1
				Lateral Skin	59	pool	3
Load TSC for Storage				Storage cask mrem/hr		ISFSI	2
Steps-(1,2,3,4,6)	782	152	934	Lid doses			
				inner	220	null	0
Get TSC from Storage for Rail Shipment				outer	97		
Steps-(7)	492	37	530	Tp/Tx cask lid	70		
				Lateral Skin	70		

Cask Handling Operations	Total Task Time(Min.)	Dose time(Min.)	Personnel Required (Persons/Task)	Occupation	Working Distance (Feet)	Cask Dose Rate(mrem/hr)	Dose Received (Person-mrem)	Facility dose background (person-mrem)
1. Receive Unloaded TSC				assume crane area background				
a. Inspect Bills of Lading, Other Shipping Papers	10	10	1	Operator	0	0	0.0	0.0
b. Release Off-Site Prime Mover (PM)	10	10	1	Prime Mover Operator	15	0	0.0	0.0
c. Hitch On-Site Prime Mover	10	10	1	Prime Mover Operator	15	0	0.0	0.0
d. Perform Receipt HP Survey	40	40	2	Radiation Protection	2	0	0.0	0.0
e. Move Cask to Protected Area Gate	20	20	1	Prime Mover Operator	15	0	0.0	0.0
f. Security Inspection	30	30	2	Security Offices	2	0	0.0	0.0
g. Open Prep Area Door	5	5	1	Operator	0	0	0.0	0.0
h. Move Cask to Prep Area	30	30	1	Prime Mover Operator	15	0	0.0	0.0
i. Remove Personnel Barrier/Impact Limiters	90	90	2	Operators	2	0	0.0	0.8
		90	1	Crane Operator	20	0	0.0	0.4
j. Close Prep Area Door	5	5	1	Operator	0	0	0.0	0.0
k. Remove Cask Restraints	60	60	2	Operators	2	0	0.0	0.5
l. Perform Preliminary HP Survey	40	40	2	Radiation Protection	2	0	0.0	0.3
m. Engage Yoke to Cask	5	5	1	Operators	2	0	0.0	0.0
		5	1	Flagman	10	0	0.0	0.0
		5	1	Crane Operator	20	0	0.0	0.0
n. Lift Cask into Prep Area	30	30	2	Operators	10	0	0.0	0.3
		30	1	Crane Operator	20	0	0.0	0.1
Total - Receive Unloaded TSC	385	396					0.0	2.4
2. Prep TSC for loading in Pool				assume pool area				
a. Install Shield Platform	30	30	1	Operator	6	0	0.0	1.5
b. Attach Gas Sampling/Vent Equipment	5	5	1	Operator	2	0	0.0	0.3
c. Sample Gas Cavity	30	30	1	Operator	2	0	0.0	1.5
d. Vent Cask Cavity	30	30	1	Operator	2	0	0.0	1.5
e. Install Cask Lid Lifting Device	20	20	2	Operators	2	0	0.0	2.0
		20	1	Flagman	10	0	0.0	1.0
		20	1	Crane Operator	20	0	0.0	1.0
f. Loosen/Remove Cask Outer Lid	60	60	2	Operators	2	0	0.0	6.0
		60	1	Flagman	10	0	0.0	3.0
		60	1	Crane Operator	20	0	0.0	3.0
g. Fill Cask with Water	60	60	2	Operators	2	0	0.0	6.0
h. Remove Sampling/Venting Equipment	5	5	1	Operator	2	0	0.0	0.3
i. Loosen Cask Inner Lid Bolts	20	20	2	Operators	2	0	0.0	2.0
j. Attach Lid Sling to Cask Yoke	10	10	1	Operator	2	0	0.0	0.5
		10	1	Flagman	10	0	0.0	0.5
		10	1	Crane Operator	20	0	0.0	0.5
k. Install Contamination Protection on Cask	30	30	2	Operators	2	0	0.0	3.0
l. Remove Shield Platform	30	30	1	Operator	6	0	0.0	1.5
m. Lift Cask onto Pool Platform	20	20	2	Operators	10	0	0.0	2.0
		20	1	Crane Operator	20	0	0.0	1.0
n. Remove Remaining Lid Bolts	30	30	2	Operators	2	0	0.0	3.0
o. Lift Cask to Pool Bottom	30	30	2	Operators	30	0	0.0	3.0
		30	1	Crane Operator	40	0	0.0	1.5
p. Disengage Yoke	10	10	1	Operator	30	0	0.0	0.5
		10	1	Flagman	30	0	0.0	0.5
		10	1	Crane Operator	40	0	0.0	0.5
q. Remove Yoke and Cask Lid from Pool	20	20	1	Operator	2	0	0.0	1.0
		20	1	Flagman	10	0	0.0	1.0
		20	1	Crane Operator	20	0	0.0	1.0

Table A1-2. Utilities-TSC (continued)

Total - Prep TSC for loading in Pool	440	595					0.0	50.0
3 Load SNF into Rail Transportation Cask				assume pool area				
a. SNF Grapple Attached to Crane	10	10	2	Operators	20	0.5	0.2	1.0
b. Engage One SNF Assembly, (12 min. per assembly)							0.0	
b1. Time for cask	250	250	2	Operators	20	0.5	4.2	25.0
c. Load SNF into Cask	70	70	2	Operators	20	0.5	1.2	7.0
Total - Load SNF into Rail Transportation Cask	330	330					5.5	33.0
4. Prep TSC from Pool								
(scale up from truck for area or diameter=		2	)	assume pool area				
a. Inspect Cask Seal (s:diameter)	20	20	1	Operator	2	0	0.0	1.0
b. Place Cask Inner Lid and Engage Yoke	25	25	2	Operators	30	0	0.0	2.5
		25	1	Flagman	30	0	0.0	1.3
		25	1	Crane Operator	40	0	0.0	1.3
c. Lift Cask to Pool Surface	10	10	2	Operators	10	0	0.0	1.0
		10	1	Crane Operator	20	0	0.0	0.5
d. Install Two Cask Lid Bolts	5	5	1	Operator	2	97	8.1	0.3
e. Lift Cask into Prep/Decon Area	20	20	2	Operators	10	1.8	1.2	2.0
		20	1	Crane Operator	20	0.5	0.2	1.0
f. Decontaminate Yoke and Cask(s:diameter)	80	80	1	Operator	10	8.7	11.6	4.0
		80	1	Crane Operator	20	0.5	0.7	4.0
g. Disengage Yoke and Lid Sling from Cask	10	10	1	Operator	2	17	2.8	0.5
		10	1	Flagman	10	8.7	1.5	0.5
		10	1	Crane Operator	20	0.5	0.1	0.5
h. Attach Vent and Drain Lines	5	5	1	Operator	2	97	8.1	0.3
i. Drain Cask(s:diameter)	110	35	1	Operator	2	17	9.9	1.8
j. HP Survey(s:diameter)	80	35	2	Radiation Protection	2	43	50.2	3.6
k. Secure Inner Cask Bolted Lid(s:diameter)	55	55	2	Operators	2	97	177.8	5.5
l. Place Cask Outer Lid and Engage Yoke	10	10	2	Operators	30	0	0.0	1.0
		10	1	Flagman	30	0	0.0	0.5
		10	1	Crane Operator	40	0	0.0	0.5
m. Secure outer Cask Bolted Lid	55	55	2	Operators	2	60	110.0	5.5
n. Connect Drying and Inerting Equipment	10	10	1	Operator	2	60	10.0	0.5
o. Drain, Dry, and Inert Cask(s:diameter)	160	160	1	Operator	2	17	45.3	8.0
		160	1	Operator	10	8.7	23.2	8.0
p. Remove Drain, Drying, and Inerting Equipment	10	10	1	Operator	2	60	10.0	0.5
q. Perform Leak Test on Seal(s:diameter)	20	20	1	Operator	2	17	5.7	1.0
Total - Prep TSC from Pool	685	925					476.3	56.8
5. Prep TSC from Pool Prep area for Shipping								
(scale up from truck for area or diam=		1.80	scale periphery=>		1.2	assume null backgroun		
a. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0
b. Move On-Site PM and Transporter to Prep Area	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
c. Unhitch On-Site PM	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
d. Engage Yoke to Cask	10	10	1	Operator	2	17	2.8	0.0
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
d1. Close Pool Prep Area Door, simultaneously with Step d.		0	1	Operator	0	0	0.0	0.0
e. Place Cask on Transporter	45	45	2	Operators	10	1.8	2.7	0.0
		45	1	Crane Operator	20	0.5	0.4	0.0
f. Perform Release HP Survey (s:area -diameter)	80	35	2	Radiation Protection	2	43	50.2	0.0
g. Install Cask Restraints(s:periphery)	35	35	2	Operators	2	32	37.3	0.0
		35	1	Crane Operator	20	0.5	0.3	0.0
h. Install Impact Limiters(s:area -diameter)	55	55	2	Operators	2	32	58.7	0.0
		55	1	Crane Operator	20	0.5	0.5	0.0
i. Install Personnel Barrier(s:periphery)	70	70	2	Operators	2	32	74.7	0.0
		35	1	Crane Operator	20	0.5	0.3	0.0
j. Prepare Shipping Papers	10	0	1	Operator	0	0	0.0	0.0
k. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0
l. Hitch On-Site Prime Mover	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
m. Move Cask to Protected Area Gate	30	30	1	Prime Mover Operator	15	0.5	0.3	0.0
n. Perform Security check	5	5	2	Security Officers	2	17	2.8	0.0
o. Un-hitch On-Site Prime Mover	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
p. Make-up with other cask cars per train	60	60	2	operator-rail	15	1.2	2.4	0.0
q. Hitch Off-Site Prime Mover	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
Total - Prep TSC from Pool Prep area for Shipping	440	665					236.1	0.0
6. Prep TSC for Storage(scale up from truck for area or diam=		2	scale periphry=>		1.2	assume null dose until i		
a. Open Staging Area Door	5	0	1	Operator	0	0	0.0	0.0
b. Move On-Site PM and Transporter to Staging Area	10	10	1	Prime Mover Operator	15	0	0.0	0.0
		10	1	Transporter Operator	15	0	0.0	0.0
c. Unhitch On-Site PM	5	5	1	Prime Mover Operator	15	0	0.0	0.0
d. Engage Yoke to TSC	10	10	1	Operator	2	17	2.8	0.0
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
d1. Close Staging Area Door, simultaneously		0	1	Operator	0	0	0.0	0.0
e. Place TSC on Transporter	45	45	2	Operators	10	8.7	13.1	0.0
		45	1	Crane Operator	20	0.5	0.4	0.0

Table A1-2. Utilities-TSC (continued)

f. Perform Release HP Survey (s: diameter)	110	55	2	Radiation Protection	2	59	108.2	0.0
g. Install Cask Restraints (s: periphery)	70	70	2	Operators	2	32	74.7	0.0
h. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0
i. Prepare Transfer Papers	10	0	1	Operator	0	0	0.0	0.0
j. Move TSC Outside Protected Area	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
k. Move TSC to Storage	60	30	2	Operators	10	8.7	8.7	0.0
		30	1	Prime Mover Operator	15	0.5	0.3	0.0
		30	1	Crane Operator	20	0.5	0.3	0.0
		30	1	Radiation Protection	10	8.7	4.4	0.0
l. Unsecure Cask from Transporter	20	10	2	Operators	2	59	19.7	0.7
(use ISR background dose)		20	1	Transporter Operator	15	0.5	0.2	0.7
		10	1	Radiation Protection	10	8.7	1.5	0.3
m. Place Storage Cask on Pad	60	30	2	Operators	2	59	59.0	2.0
		60	1	Transporter Operator	15	0.5	0.5	2.0
		30	1	Radiation Protection	10	8.7	4.4	1.0
n. Return Transport to Transfer Facility	50	25	2	Operators	10	0.5	0.4	1.7
		25	1	Transporter Operator	15	0.5	0.2	0.8
		25	1	Radiation Protection	10	0.5	0.2	0.8
Total - Prep TSC for Storage	470	635					300.2	10.0
7. Prep TSC from ISFSI for shipping(scale up from truck for area or diam=			1.8	scale periphry=>	1.2)			
a. Prepare to Move Off-Site Transportation Cask From ISFSI Storage Yard	60	60	2	Operators	2	19.7	39.4	4.0
		60	1	Prime Mover Operator	15	0.5	0.5	2.0
		60	1	Crane Operator	20	0.5	0.5	2.0
		60	1	Radiation Protection	10	8.7	8.7	2.0
b. Perform Shipping HP Survey Cask(s: periphery)	70	70	2	Operators	10	8.7	20.3	4.7
		70	1	Prime Mover Operator	15	0.5	0.6	2.3
		70	1	Crane Operator	20	0.5	0.6	2.3
		70	1	Radiation Protection	2	43	50.2	2.3
c. Decontaminate Cask (s:area)	110	10	2	Operators	2	43	14.3	0.7
(if needed)		10	1	Prime Mover Operator	15	0.5	0.1	0.3
		10	1	Crane Operator	20	0.5	0.1	0.3
		10	1	Radiation Protection	10	8.7	1.5	0.3
d. Install Cask Restraints (s:periphery)	70	70	2	Operators	2	43	100.3	4.7
		70	1	Prime Mover Operator	15	0.5	0.6	2.3
		70	1	Crane Operator	20	0.5	0.6	2.3
		70	1	Radiation Protection	10	8.7	10.2	2.3
e. Install Impact Limiters (s:diameter -area)	110	110	2	Operators	2	43	157.7	7.3
		110	1	Prime Mover Operator	15	0.5	0.9	3.7
		110	1	Crane Operator	20	0.5	0.9	3.7
		110	1	Radiation Protection	10	8.7	16.0	3.7
f. Install Personnel Barrier (s: periphery)	35	35	2	Operators	2	43	50.2	2.3
		35	1	Prime Mover Operator	15	0.5	0.3	1.2
		35	1	Crane Operator	20	0.5	0.3	1.2
		35	1	Radiation Protection	10	8.7	5.1	1.2
f1. Open Receiving and Shipping Bay Door, simultaneously with s.		0	1	Operator	0	0	0.0	0.0
f2. Hitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
g. Prepare Shipping Papers	20	0	1	Operator	0	0	0.0	0.0
h. Move Cask to ISFSI Protected Area Gate	10	10	2	Operators	10	8.7	2.9	0.0
(assume rail siding background dose same as crane enclosure)		10	1	Prime Mover Operator	15	0.5	0.1	0.0
(assume null background while moving)		10	1	Crane Operator	20	0.5	0.1	0.0
		10	1	Radiation Protection	10	8.7	1.5	0.0
h1 Perform Security check	5	5	2	Security Officers	2	17	2.8	0.0
i. Unhitch On-Site Prime Mover	5	5	2	Operators	10	8.7	1.5	0.0
		5	1	Prime Mover Operator	15	0.5	0.0	0.0
j. Make-up with other cask cars per train (assume 3 cars)	60	60	2	operator-rail	15	1.2	2.4	0.5
k. Hitch Off-Site Prime Mover	5	5	2	Operators	10	8.7	1.5	0.0
		5	1	Prime Mover Operator	15	0.5	0.0	0.0
Total - Prep TSC from ISFSI for shipping	570	1,555					492.4	37.2

Table A1-3. Utilities-MPU

Total Doses per Cask Handling for MPU at the UTS				Roll mrem/hr		Background		
1 June 1994/hwg	Direct	Bkgd	Sum	Lid doses		mrem/hr		
Load MPU for Shipping	(person-mrem)			Inner	220	area	dose	
Steps - (1,2,4,5,6,7,9)	1,424	71	1,495	outer	97	crane	0.25	
				Tp/tx cask lid	60	decon	1	
Load MPU for Shipping with Transfer				Lateral Skin	59	pool	3	
Steps - (1,3,4,5,6,7,8,9)	2,002	94	2,096	Storage cask mrem/hr		ISFSI	2	
				Lid doses				
Load MPU for Storage				Inner	220	null	0	
Steps - (1,2,4,5,6,7,10)	1,665	79	1,743	outer	97			
				Tp/tx cask lid	70			
Load MPU for Storage with Transfer				Lateral Skin	70			
Steps - (1,3,4,5,6,7,8,10)	2,243	102	2,344					
Transfer MPU from storage for shipping								
Steps - (11,12)	798	57	855					
Cask Handling Operations	Total Task Time(Min.)	Dose time(Min.)	Personnel Requirements(Persons /Task)	Occupation	WorkingDistance(Feet)	Cask Dose Rate(mrem hr)	Base Dose Received(Person-mrem)	Facility dose background (person-mrem)
1. Receive Empty MPU				assume prep has crane area background				
a. Inspect Bills of Lading, Other Shipping Papers	10	10	1	Operator	0	0	0.0	0.0
b. Take MPU to Warehouse	60	60	1	Prime Mover Operator	15	0	0.0	0.0
c. Up-end MPU at Warehouse and Store	30	30	2	Operators	10	0	0.0	0.0
		30	1	Crane Operator	20	0	0.0	0.0
d. Release Off-Site Prime Mover (PM)	10	10	1	Prime Mover Operator	15	0	0.0	0.0
e. Hitch On-Site PM	10	10	1	Prime Mover Operator	15	0	0.0	0.0
f. Move MPC to Protected Area	20	20	1	Prime Mover Operator	15	0	0.0	0.0
g. Security Inspection	30	30	2	Security Officers	2	0	0.0	0.0
h. Open Staging Area Door	5	5	1	Operator	0	0	0.0	0.0
i. Move MPU to Prep Area	30	30	1	Prime Mover Operator	15	0	0.0	0.0
j. Perform Preliminary HP Survey of MPC	40	40	2	Radiation Protection	2	0	0.0	0.33
k. Attach Lifting Device to MPU	5	5	2	Operators	2	0	0.0	0.04
		5	1	Rigman	10	0	0.0	0.02
		5	1	Crane Operator	20	0	0.0	0.02
k1.Close Staging Area Door, simultaneous		5	1	Operator	0	0	0.0	0.02
l. Lift MPC Into Prep Area	30	30	2	Operators	10	0	0.0	0.25
		30	1	Crane Operator	20	0	0.0	0.13
Total	280	366					0.0	0.8
2. Receive Unloaded Universal-overpack (MPU)				assume prep has crane area background				
a. Inspect bills of Lading, Other Shipping Papers	10	10	1	Operator	0	0	0.0	0.00
b. Release Off-Site PM	10	10	1	Prime Mover Operator	15	0	0.0	0.00
c. Hitch On-Site PM	10	10	1	Prime Mover Operator	15	0	0.0	0.00
d. Perform Receipt HP Survey	40	40	2	Radiation Protection	2	0	0.0	0.00
e. Move Cask to Protected Area	20	20	1	Prime Mover Operator	15	0	0.0	0.00
f. Security Inspection	30	30	2	Security Officers	2	0	0.0	0.00
g. Open Staging/Area Door	5	5	1	Operator	0	0	0.0	0.00
h. Move Cask to Prep Area	30	30	1	Prime Mover Operator	15	0	0.0	0.00
i. Remove Personnel Barrier/Impact Limiters	90	90	2	Operators	2	0	0.0	0.75
		90	1	Crane Operator	10	0	0.0	0.38
j. Close Staging Area Door	5	5	1	Operator	0	0	0.0	0.02
k. Remove Cask Restraints	60	60	2	Operators	2	0	0.0	0.50
l. Perform Preliminary HP Survey	40	40	2	Radiation Protection	2	0	0.0	0.33
m. Engage Yoke to Cask	5	5	1	Operator	2	0	0.0	0.02
		5	1	Operator	10	0	0.0	0.02
		5	1	Crane Operator	20	0	0.0	0.02
n. Lift Cask Into Prep Area	30	30	2	Operators	10	0	0.0	0.25
		30	1	Crane Operator	20	0	0.0	0.13
Total	385	515					0.0	2.4
3. Receive Unloaded Transfer-Overpack: ISFSI To Prep								
a. Move Cask to Storage	60	60	2	Operators	10	0	0.0	0.5
		60	1	Prime Mover Operator	15	0	0.0	0.3

Table A1-3. Utilities-MPU (continued)

		60	1	Crane Operator	20	0	0.0	0.3
		60	1	Radiation Protection	10	0	0.0	0.3
b. Release PM	5	5	2	Operators	10	0	0.0	0.0
		5	1	Prime Mover Operator	15	0	0.0	0.0
		5	1	Crane Operator	20	0	0.0	0.0
		5	1	Radiation Protection	10	0	0.0	0.0
c. Hitch On-Site PM	10	10	2	Operators	10	0	0.0	0.1
		10	1	Prime Mover Operator	15	0	0.0	0.0
		10	1	Crane Operator	20	0	0.0	0.0
		10	1	Radiation Protection	10	0	0.0	0.0
d. Move Cask to Protected Area	20	20	2	Operators	10	0	0.0	0.2
		20	1	Prime Mover Operator	15	0	0.0	0.1
		20	1	Crane Operator	20	0	0.0	0.1
		20	1	Radiation Protection	10	0	0.0	0.1
e. Security Inspection	30	30	2	Security Officers	2	0	0.0	0.3
f. Open Prep Door	5	5	1	Operator	—	0	0.0	0.0
g. Move Cask Into Prep Area	30	30	1	Prime Mover Operator	15	0	0.0	0.0
h. Release PM	5	5	1	Prime Mover Operator	15	0	0.0	0.0
i. Close Prep Area Door (use decon background)	5	5	1	Operator	—	0	0.0	0.1
j. Perform Preliminary HP Survey	40	40	2	Radiation Protection	2	0	0.0	1.3
k. Decontaminate Cask	60	60	2	Operators	2	0	0.0	2.0
l. Remove Cask Restraints	60	60	2	Operators	2	0	0.0	2.0
m. Perform HP Survey	40	40	2	Radiation Protection	2	0	0.0	1.3
n. Decontaminate Cask	60	60	2	Operators	2	0	0.0	2.0
o. Engage Yoke to Cask	5	5	1	Operator	2	0	0.0	0.1
		5	1	Operator	10	0	0.0	0.1
		5	1	Crane Operator	20	0	0.0	0.1
p. Lift Cask into Prep Area	25	25	2	Operators	10	0	0.0	0.8
		25	1	Crane Operator	20	0	0.0	0.4
							0.0	12.5
Total:	460	780						
4. Load MPC into Universal - or								
Transfer-overpack								
a. Align MPC with Cask	10	10	1	Operator	2	0	0.0	0.0
		10	1	Operator	10	0	0.0	0.0
		10	1	Crane Operator	20	0	0.0	0.0
b. Lower MPC into Cask	20	20	2	Operators	2	0	0.0	0.2
		20	1	Operator	10	0	0.0	0.1
		20	1	Crane Operator	20	0	0.0	0.1
c. Disengage and Remove Lifting Device From MPC	10	10	1	Operator	2	0	0.0	0.0
		10	1	Operator	10	0	0.0	0.0
							0.0	0.0
d. Verify MPC Configuration for SNF	10	10	2	Operators	2	0	0.0	0.1
e. Fill Annulus with Demineralized Water	30	30	2	Operators	2	0	0.0	0.3
f. Install MPC Contamination Protection	30	30	2	Operators	2	0	0.0	0.3
g. Connect Annulus Float Hoses	5	5	2	Operators	2	0	0.0	0.0
h. Fill MPC With Water	60	60	2	Operators	2	0	0.0	0.5
							0.0	1.7
Total	175	245						
5. Prep MPC/Universal or								
MPC/Transfer for Pool								
a. Attach Cask Yoke to Crane	10	10	1	Operator	2	0	0.0	0.0
		10	1	Flagman	10	0	0.0	0.0
		10	1	Crane Operator	20	0	0.0	0.0
b. Engage Yoke to Cask	25	25	1	Operator	2	0	0.0	0.1
		25	1	Flagman	10	0	0.0	0.1
		25	1	Crane Operator	20	0	0.0	0.1
c. Move Cask to Fuel Loading Pool Floor	30	30	2	Operators	10	0	0.0	0.3
		30	1	Crane Operator	20	0	0.0	0.1
d. Disengage Yoke From Cask	20	20	1	Operator	30	0	0.0	1.0
		20	1	Flagman	30	0	0.0	1.0
		20	1	Crane Operator	40	0	0.0	1.0
e. Remove Yoke From Pool	10	10	2	Operators	10	0	0.0	1.0
		10	1	Flagman	10	0	0.0	0.5
		10	1	Crane Operator	20	0	0.0	0.5
							0.0	5.8
Total	95	255						
6. Load SNF into MPU/Universal								
or MPU/Transfer								
a. SNF Grapple Attached to Crane	10	10	2	Operators	20	0.5	0.2	1.0
b. Engage One SNF Assembly. (12 min. per assembly)							0.0	0.0
b1. Time for 4 element cask	250	250	2	Operators	20	0.5	4.2	25.0
c. Load SNF Into MPU	70	70	2	Operators	20	0.5	1.2	7.0
							5.5	33.0
Total	330	330						
7. Prep MPU/Universal or								
MPU/Transfer from pool								
a. Attach MPU Shield Plug Lift Fixture to Crane	5	5	2	Operators	2	0	0.0	0.5

Table A1-3. Utilities-MPU (continued)

		5	1	Flagman	10	0	0.0	0.3
		5	1	Crane Operator	20	0	0.0	0.3
b. Install MPU Shield Plug	20	20	0	Remote	0	0	0.0	0.0
c. Engage Yoke to Cask	5	5	1	Operator	30	0	0.0	0.3
		5	1	Flagman	30	0	0.0	0.3
		5	1	Crane Operator	40	0	0.0	0.3
d. Lift MPU/Cask to Pool Surface	5	5	2	Operators	10	0	0.0	0.5
		5	1	Crane Operator	20	0	0.0	0.3
e. Install Shield Plug Retainers	10	10	1	Operator	2	220	36.7	0.5
f. Lift MPU/Cask into Prep/Decon Area	30	25	2	Operators	10	11	9.2	2.5
		30	1	Crane Operator	20	0.5	0.3	1.5
g. Disengage Yoke from Cask	5	5	1	Operator	2	59	4.9	0.1
		5	1	Flagman	10	11	0.9	0.1
		5	1	Crane Operator	20	0.5	0.0	0.1
h. Remove Shield Plug Retainers	10	10	1	Operator	2	220	36.7	0.2
i. Decon MPU/Cask and Yoke	120	90	1	Operator	10	11	16.5	1.5
		40	1	Crane Operator	20	0.5	0.3	0.7
j. Hook Up Drain Equipment	10	10	1	Operator	2	220	36.7	0.2
k. Partially Drain MPU and Annulus	20	20	1	Operator	10	11	3.7	0.3
l. Remove Annulus Seal	10	10	2	Operators	2	220	73.3	0.3
m. Check MPU/Cask for Contamination	30	10	2	Radiation Protection	2	59	19.7	0.3
n. Install Annulus Welding Protection	10	10	2	Operators	2	220	73.3	0.3
o. Install Remote Welding Equipment	45	30	1	Welder	2	220	110.0	0.5
		10	1	Crane Operator	20	0.5	0.1	0.2
p. Inner Lid Weld	1000	0	0	Remote	0	0	0.0	0.0
q. Perform NDE on Weld	30	20	1	QA Welder	2	220	73.3	0.3
r. Remove Welding Equipment	20	20	1	Welder	2	220	73.3	0.3
		10	1	Crane Operator	20	0.5	0.1	0.2
s. Drain, Dry, and Inert MPU	350	10	1	Operator	2	220	36.7	0.2
		350	1	Operator	10	11	64.2	5.8
t. Remove Drain, Dry, and Inerting Equipment	10	10	1	Operator	2	220	36.7	0.2
u. Perform Leak Tests on Seal Weld	20	20	1	Operator	2	37	12.3	0.3
v. Weld Valve Cover Plates	90	90	1	Welder	2	220	330.0	1.5
w. Place MPU Lid	20	10	1	Operator	2	97	16.2	0.2
		10	1	Flagman	10	11	1.8	0.2
		10	1	Crane Operator	20	0.5	0.1	0.2
x. Set Up Remote Welding Equipment	45	30	1	Welder	2	97	48.5	0.5
		10	1	Crane Operator	20	0.5	0.1	0.2
y. Weld MPU Lid	1000	0	0	Remote	0	0	0.0	0.0
z. Perform NDT on Weld	30	20	1	QA Welder	2	97	32.3	0.3
aa. Remove Annulus Weld Protection	10	10	1	Operator	2	97	16.2	0.2
bb. Place Cask Lid	10	10	1	Operator	2	70	11.7	0.2
		10	1	Flagman	10	11	1.8	0.2
		10	1	Crane Operator	20	0.5	0.1	0.2
cc. Decon Cask	30	30	2	Operators	2	59	59.0	1.0
		30	1	Crane Operator	20	0.5	0.3	0.5
dd. Perform HP Survey	45	20	2	Radiation Protection	2	59	39.3	0.7
ee. Secure Cask Bolted Lid	60	60	2	Operators	2	70	140.0	2.0
Total	3105	1180					1,416	26.9
8. Transfer MPU from Transfer-overpack to Universal-overpack								
a. Open Staging Area Door	5	0	1	Operator	0	0	0.0	0.0
b. Move On-Site PM and Transporter to Staging Area	10	10	1	Prime Mover Operator	15	0	0.0	0.0
		10	1	Transporter Operator	15	0	0.0	0.0
c. Unhitch On-Site PM	5	5	1	Prime Mover Operator	15	0	0.0	0.0
d. Engage Yoke to MPC/Cask	10	10	1	Operator	2	17	2.8	0.3
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
d1. Close Staging Area Door, simultaneously with Step d.		0	1	Operator	0	0	0.0	0.0
e. Place MPC/Cask on Transporter	45	45	2	Operators	10	8.7	13.1	0.4
		45	1	Crane Operator	20	0.5	0.4	0.2
f. Perform Release HP Survey	60	30	2	Radiation Protection	2	59	59.0	0.3
g. Install Cask Restraints	60	60	2	Operators	2	32	64.0	0.5
h. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0
i. Prepare Transfer Papers	10	0	1	Operator	0	0	0.0	0.0
j. Move MPC/Cask Outside Protected Area	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
k. Move MPC/Cask to Transfer Area	60	30	2	Operators	10	8.7	8.7	0.0
		30	1	Prime Mover Operator	15	0.5	0.3	0.0
		30	1	Crane Operator	20	0.5	0.3	0.0
		30	1	Radiation Protection	10	8.7	4.4	0.0
l. Prepare Cask for MPC Transfer	60	30	2	Operators	2	70	70.0	1.0
		60	1	Prime Mover Operator	15	0.5	0.5	1.0
		60	1	Crane Operator	20	0.5	0.5	1.0
		60	1	Radiation Protection	10	11	11.0	1.0
m. Engage Crane to MPC Lift Attachment	10	5	1	Operator	2	39.4	3.3	0.1
		10	1	Flagman	10	11	1.8	0.2
		10	1	Crane Operator	20	0.5	0.1	0.2

Table A1-3. Utilities-MPU (continued)

n. Verify Vertical Alignment of MPC to Storage Cask	10	10	1	Operator	2	97	16.2	0.2
o. Clear Operators to a Shielded Area	5	0	0	Operators	0	0	0.0	0.0
o1. Close Transfer Room Doors		0	1	Operator	0	0	0.0	0.0
p. Raise MPC from Storage Cask	30	0	0	Remote	0	0	0.0	0.0
q. Move MPC Over Transport Cask	5	0	0	Remote	0	0	0.0	0.0
r. Verify Vertical Alignment of MPC to Transport Cask	10	0	0	Remote	0	0	0.0	0.0
s. Correct Vertical Alignment	20	0	0	Remote	0	0	0.0	0.0
t. Lower MPC into Transport Cask	30	0	0	Remote	0	0	0.0	0.0
t1. Open Transfer Room Doors		0	0	Remote	0	0	0.0	0.0
u. Radiation and Contamination Survey	10	10	2	Radiation Protection	2	43	14.3	0.3
v. Remove MPC Lift Attachment from MPC	30	20	2	Operators	2	97	64.7	0.7
		15	1	Ragman	10	8.7	2.2	0.3
		15	1	Crane Operator	20	0.5	0.1	0.3
w. Disengage Crane from MPC Lift Attachment	10	5	1	Operator	2	39.4	3.3	0.1
		10	1	Ragman	10	8.7	1.5	0.2
		10	1	Crane Operator	20	0.5	0.1	0.2
x. Place Cask Lid	10	10	1	Operator	2	97	16.2	0.2
		10	1	Ragman	10	8.7	1.5	0.2
		10	1	Crane Operator	20	0.5	0.1	0.2
y. Decon Cask	30	30	2	Operators	2	59	59.0	1.0
		30	1	Crane Operator	20	0.5	0.3	0.5
z. Perform HP Survey	45	20	2	Radiation Protection	2	59	39.3	0.7
aa. Secure Cask Bolted Lid	60	60	2	Operators	2	59	118.0	2.0
Total	510	695					578.2	12.8
9. Prep MPU/Universal-								
overpack from Pool Prep for shipping								
a. Open Staging Area Door	5	0	1	Operator	0	0	0.0	0.0
b. Move On-Site PM and Off-Site Transporter to Prep Are	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
c. Unhitch On-Site PM	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
d. Engage Yoke to MPU/Cask	10	10	1	Operator	2	17	2.8	0.0
		10	1	Ragman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
d1. Close _Prep Area Door, simultaneous		0	1	Operator	0	0	0.0	0.0
e. Place MPU/Cask on Transporter	45	45	2	Operators	10	1.8	2.7	0.4
		45	1	Crane Operator	20	0.5	0.4	0.2
f. Perform Shipping HP Survey	80	35	2	Radiation Protection	2	43	50.2	0.3
g. Neutron Shields and Install Cask Restraints	35	35	2	Operators	2	32	37.3	0.3
		35	1	Crane Operator	20	0.5	0.3	0.1
h. Install Impact Limiters	55	55	2	Operators	2	32	58.7	0.5
		55	1	Crane Operator	20	0.5	0.5	0.2
i. Install Personnel Barrier	70	70	2	Operators	2	32	74.7	0.6
		35	1	Crane Operator	20	0.5	0.3	0.1
j. Prepare Shipping Papers	10	0	1	Operator	0	0	0.0	0.0
k. Open Staging Area Door	5	0	1	Operator	0	0	0.0	0.0
l. Hitch On-Site PM	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
m. Move Cask/MPU Outside Protected Area	30	30	1	Prime Mover Operator	15	0.5	0.3	0.1
n. Perform security check	5	5	2	Security Officers	2	17	3.4	0.0
n1. Unhitch On-Site PM	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
n2. Make-up with other cask cars per train (assume 3 car	60	60	2	Operator-rail	15	1.2	2.4	0.5
o. Hitch Off-Site PM	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
Total	440	565					235.6	3.6
10. Prep MPU/Universal-overpack								
from Pool prep for ISFSI								
a. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0
b. Move On-Site PM and Transporter to Staging Area	10	10	1	Prime Mover Operator	15	0	0.0	0.0
		10	1	Transporter Operator	15	0	0.0	0.0
c. Unhitch On-Site PM	5	5	1	Prime Mover Operator	15	0	0.0	0.0
d. Engage Yoke to MPU/Cask	10	10	1	Operator	2	37	6.2	0.0
		10	1	Ragman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
d1. Close Prep Area Door, simultaneous		0	1	Operator	0	0	0.0	0.0
e Place MPU/Cask on Transporter	45	45	2	Operators	10	8.7	13.1	0.4
		45	1	Crane Operator	20	0.5	0.4	0.2
f. Perform Release HP Survey	60	30	2	Radiation Protection	2	59	59.0	0.3
g. Install Cask Restraints	60	60	2	Operators	2	32	64.0	0.5
h. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0
i. Prepare Transfer Papers	10	0	1	Operator	0	0	0.0	0.0
j. Move MPU/Cask Outside Protected Area	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
k. Move MPU/Cask to ISFSI	60	30	2	Operators	10	8.7	8.7	0.0
(null background dose while moving)		30	1	Prime Mover Operator	15	0.5	0.3	0.0
		30	1	Crane Operator	20	0.5	0.3	0.0
		30	1	Radiation Protection	10	8.7	4.4	0.0
l. Unsecure Cask from Transporter	20	10	2	Operators	2	59	19.67	0.7
(ISFSI background dose)		20	1	Transporter Operator	15	0.5	0.17	0.7
		10	1	Radiation Protection	10	8.7	1.45	0.3
m. Place Cask on Pad	60	30	2	Operators	2	59	59	2.0
		60	1	Transporter Operator	15	0.5	0.5	2.0

Table A1-3. Utilities-MPU (continued)

		30	1	Radiation Protection	10	8.7	4.35	1.0
n. Return Transport to Transfer Facility	50	25	2	Operators	10	0	0	0.0
(null background while moving and no cask)		25	1	Transporter Operator	15	0	0	0.0
		25	1	Radiation Protection	10	0	0	0.0
Total	410	400					242.9	8.3
11. Move MPU from ISFSI storage								
a. Get Transport from Transfer Facility	50	25	2	Operators	10	0	0	0.0
		25	1	Transporter Operator	15	0	0	0.0
		25	1	Radiation Protection	10	0	0	0.0
b. Raise Cask from Pad	60	30	2	Operators	2	59	59	2.0
(ISFSI background dose)		60	1	Transporter Operator	15	0.5	0.5	2.0
		30	1	Radiation Protection	10	22	11	1.0
c. Move MPU/Cask, from ISFSI	60	30	2	Operators	10	8.7	8.7	2.0
		30	1	Prime Mover Operator	15	0.5	0.3	1.0
		30	1	Crane Operator	20	0.5	0.3	1.0
		30	1	Radiation Protection	10	8.7	4.4	1.0
d. Unsecure Cask from Transporter	20	10	2	Operators	2	59	19.67	0.0
(null background dose)		20	1	Transporter Operator	15	0.5	0.17	0.7
		10	1	Radiation Protection	10	22	3.67	0.3
e. Return transporte: to transfer facility	50	50	1	Transport Op.	15	0	0.00	0.0
Total	190	355					440.4	25.9
12. Prep MPU/Universal from storage to shipping								
(derived from Steps of 5b, rail, of UTS-RDS spreadsheet)				assume ISFSI background dose, except at rail siding				
a. Perform Release HP Survey(s -diameter)	80	40	2	Radiation Protection	2	43	57.3	2.7
b. Install Nuetron Shield and Cask Restraints	90	90	2	Operators	2	43	129.0	6.0
		90	1	Prime Mover Operator	15	0.5	0.8	3.0
		90	1	Crane Operator	20	0.5	0.8	3.0
		90	1	Radiation Protection	10	19.7	29.6	3.0
c. Install Impact Limiters(s- diameter)	55	55	2	Operators	2	32	58.7	3.7
		55	1	Crane Operator	20	0.5	0.5	1.8
d. Install Personnel Barrier(s- perimeter)	70	70	2	Operators	2	32	74.7	4.7
		35	1	Crane Operator	20	0.5	0.3	1.2
e. Prepare Shipping Papers	10	0	1	Operator	0	0	0.0	0.0
f. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0
g. Hitch On-Site Prime Mover	5	5	1	Prime Mover Operator	15	0.5	0.0	0.2
h. Move Cask to Protected Area Gate (null background d	30	30	1	Prime Mover Operator	15	0.5	0.3	1.0
i. Perform security check	5	5	2	Security Officers	2	17	3.4	0.0
j. Un-hitch On-Site Prime Mover	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
k. Make-up with other cask cars per train (assume 3 cars)	60	60	2	Operator-rail	15	1.2	2.4	0.5
l. Hitch Off-Site Prime Mover (assume rail siding dose same	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
Total	420	725					357.6	30.7

Table A1-4. Utilities-MPC

Total Doses per Cask Handling for MPC at the Utilities				Rail cask mrem/hr		Background			
Revised 20 May 94/HWG				Lid doses		mrem/hr		Probabilityset	
	Direct	Bkgd	Sum	inner	220	area	dose	all	1
	(person-mrems)			outer	97	crane	0.25	few	0.001
Load MPC for Shipping, direct into Transport pack									
Steps - (1,2,4,5,6,7,9)	1,657	74	1,731	Tp/Tx cask lid	60	deco	1	rare	1E-04
				Lateral Skin	59	pool	3	none	0
Load MPC for Shipping, from ISFSI with on-siteTransfer Overpack									
Steps - (1,3,4,5,6,7,8,9)	2,235	97	2,332	Storage cask mrem/hr		ISFSI	2		
				Lid doses					
				inner	220	null	0		
				outer	97			all=> 1.0	
Load MPC for ISFSI Storage									
Steps - (1,2,4,5,6,7,10,11)	1,879	114	1,992	Tp/Tx cask lid	70			few=> 0.001	
				Lateral Skin	70			rare=>0.0001	
Transfer MPC from ISFSI storage for shipping								none=>0.0	
Steps - (12,13)	592	71	663						

Cask Handling Operations	Total Task Time(Min.)	Dose time(Min.)	Personnel Required(Persons /Task)	Occupation	Working Distance(Feet)	Cask Dose Rate(mrem/hr)	Base Dose Received(Person-mrem)	Facility dose background (person-mrem)	Probability of event, fraction	Dose Received(Person-mrem)	Facility dose background (person-mrem)
1. Receive Empty MPC				assume prep has crane area background, 0.25 mrem/hr							
a. Inspect Bills of Lading, Other Shipping Papers	10	10	1	Operator	0	0	0.0	0.00	1	0.0	0
b. Take MPC to Warehouse	60	60	1	Prime Mover Operator	15	0	0.0	0.00	1	0.0	0
c. Up-end MPC at Warehouse and Store	30	30	2	Operators	10	0	0.0	0.00	1	0.0	0
		30	1	Crane Operator	20	0	0.0	0.00	1	0.0	0
d. Release Off-Site Prime Mover (PM)	10	10	1	Prime Mover Operator	15	0	0.0	0.00	1	0.0	0
e. Hitch On-Site PM	10	10	1	Prime Mover Operator	15	0	0.0	0.00	1	0.0	0
f. Move MPC to Protected Area Gate	20	20	1	Prime Mover Operator	15	0	0.0	0.00	1	0.0	0
g. Security Inspection	30	30	2	Security Officers	2	0	0.0	0.00	1	0.0	0
h. Open Prep Area Door	5	5	1	Operator	0	0	0.0	0.00	1	0.0	0
i. Move MPC to Prep Area	30	30	1	Prime Mover Operator	15	0	0.0	0.00	1	0.0	0
j. Perform Preliminary HP Survey	40	40	2	Radiation Protection	2	0	0.0	0.33	1	0.0	0.333
k. Engage Yoke to MPC	5	5	1	Operators	2	0	0.0	0.02	1	0.0	0.021
		5	1	Flagman	10	0	0.0	0.02	1	0.0	0.021
		5	1	Crane Operator	20	0	0.0	0.02	1	0.0	0.021
k1.Close Staging Area Door, simultaneously		5	1	Operator	0	0	0.0	0.02	1	0.0	0.021
l. Lift MPC into Prep Area	30	30	2	Operators	10	0	0.0	0.25	1	0.0	0.25
		30	1	Crane Operator	20	0	0.0	0.13	1	0.0	0.125
							0.0	0.8	17.0	0.0	0.8
Total	280	365									
2. Receive Unloaded Transport-overpack at Front Gate				assume prep has crane area background, 0.25 mrem/hr							
a. Inspect bills of Lading, Other Shipping Papers	10	10	1	Operator	0	0	0.0	0.0	1	0.0	0
b. Release Off-Site PM	10	10	1	Prime Mover Operator	15	0	0.0	0.0	1	0.0	0
c. Hitch On-Site PM	10	10	1	Prime Mover Operator	15	0	0.0	0.0	1	0.0	0
d. Perform Receipt HP Survey	40	40	2	Radiation Protection	2	0	0.0	0.0	1	0.0	0
e. Move Cask to Protected Area	20	20	1	Prime Mover Operator	15	0	0.0	0.0	1	0.0	0
f. Security Inspection	30	30	2	Security Officers	2	0	0.0	0.0	1	0.0	0
g. Open Prep/Area Door	5	5	1	Operator	0	0	0.0	0.0	1	0.0	0
h. Move Cask to Prep Area	30	30	1	Prime Mover Operator	15	0	0.0	0.0	1	0.0	0
i. Remove Personnel Barrier/Impact Limiters	90	90	2	Operators	2	0	0.0	0.8	1	0.0	0.75
		90	1	Crane Operator	20	0	0.0	0.4	1	0.0	0.375
j. Close Staging Area Door	5	5	1	Operator	0	0	0.0	0.0	1	0.0	0.021
k. Remove Cask Restraints	60	60	2	Operators	2	0	0.0	0.5	1	0.0	0.5
l. Perform Preliminary HP Survey	40	40	2	Radiation Protection	2	0	0.0	0.3	1	0.0	0.333
m. Engage Yoke to Cask	5	5	1	Operator	2	0	0.0	0.0	1	0.0	0.021
		5	1	Operator	10	0	0.0	0.0	1	0.0	0.021
		5	1	Crane Operator	20	0	0.0	0.0	1	0.0	0.021
n. Lift Cask into Prep Area	30	30	2	Operators	10	0	0.0	0.3	1	0.0	0.25
		30	1	Crane Operator	20	0	0.0	0.1	1	0.0	0.125
							0.0	2.4	18.0	0.0	2.4
Total	385	516									
3. Return Unloaded Transfer-Overpack: ISFSI To Prep				assume non-isfsi area so null background dose // transfer cask is unload							
a. Move Cask to Storage	60	60	2	Operators	10	0	0.0	0.5	1	0.0	0.5
		60	1	Prime Mover Operator	15	0	0.0	0.3	1	0.0	0.25
		60	1	Crane Operator	20	0	0.0	0.3	1	0.0	0.25
		60	1	Radiation Protection	10	0	0.0	0.3	1	0.0	0.25
b. Release On-site PM	5	5	2	Operators	10	0	0.0	0.0	1	0.0	0.042
		5	1	Prime Mover Operator	15	0	0.0	0.0	1	0.0	0.021

Table A1-4. Utilities-MPC (continued)

		5	1	Crane Operator	20	0	0.0	0.0	1	0.0	0.021
		5	1	Radiation Protection	10	0	0.0	0.0	1	0.0	0.021
c. Hitch On-Site PM	10	10	2	Operators	10	0	0.0	0.1	1	0.0	0.083
		10	1	Prime Mover Operator	15	0	0.0	0.0	1	0.0	0.042
		10	1	Crane Operator	20	0	0.0	0.0	1	0.0	0.042
		10	1	Radiation Protection	10	0	0.0	0.0	1	0.0	0.042
d. Move Cask to Protected Area	20	20	2	Operators	10	0	0.0	0.2	1	0.0	0.167
		20	1	Prime Mover Operator	15	0	0.0	0.1	1	0.0	0.083
		20	1	Crane Operator	20	0	0.0	0.1	1	0.0	0.083
		20	1	Radiation Protection	10	0	0.0	0.1	1	0.0	0.083
e. Security Inspection	30	30	2	Security Officers	2	0	0.0	0.3	1	0.0	0.25
f. Open Prep Door	5	5	1	Operator	—	0	0.0	0.0	1	0.0	0
g. Move Cask into Prep Area	30	30	1	Prime Mover Operator	15	0	0.0	0.0	1	0.0	0
h. Release PM	5	5	1	Prime Mover Operator	15	0	0.0	0.0	1	0.0	0
i. Close Prep Area Door (use decon area background dos	5	5	1	Operator	—	0	0.0	0.1	1	0.0	0.083
j. Perform Preliminary HP Survey	40	40	2	Radiation Protection	2	0	0.0	1.3	1	0.0	1.333
k. Decontaminate Cask(few events)	60	60	2	Operators	2	0	0.0	2.0	0	0.0	0.002
l. Remove Cask Restraints	60	60	2	Operators	2	0	0.0	2.0	1	0.0	2
m. Perform HP Survey	40	40	2	Radiation Protection	2	0	0.0	1.3	1	0.0	1.333
n. Decontaminate Cask(rare event)	60	60	2	Operators	2	0	0.0	2.0	0	0.0	2E-04
o. Engage Yoke to Cask	5	5	1	Operator	2	0	0.0	0.1	1	0.0	0.083
		5	1	Flagman	10	0	0.0	0.0	1	0.0	0.021
		5	1	Crane Operator	20	0	0.0	0.1	1	0.0	0.083
p. Lift Cask into Prep Area	25	25	2	Operators	10	0	0.0	0.8	1	0.0	0.833
		25	1	Crane Operator	20	0	0.0	0.4	1	0.0	0.417
Total:	460	780					0.0	12.4	29.0	0.0	8.4
4. Load Empty MPC into Transportation- or				assume crane enclosure background							
Transfer-overpack (no SNF present)											
a. Align MPC with Cask	10	10	1	Operator	2	0	0.0	0.0	1	0.0	0.042
		10	1	Operator	10	0	0.0	0.0	1	0.0	0.042
		10	1	Crane Operator	20	0	0.0	0.0	1	0.0	0.042
b. Lower MPC into Cask	20	20	2	Operators	2	0	0.0	0.2	1	0.0	0.167
		20	1	Operator	10	0	0.0	0.1	1	0.0	0.083
		20	1	Crane Operator	20	0	0.0	0.1	1	0.0	0.083
c. Disengage and Remove Lifting Device From MPC	10	10	1	Operator	2	0	0.0	0.0	1	0.0	0.042
		10	1	Operator	10	0	0.0	0.0	1	0.0	0.042
d. Verify MPC Configuration for SNF	10	10	2	Operators	2	0	0.0	0.1	1	0.0	0.083
e. Fill Annulus with Demineralized Water	30	30	2	Operators	2	0	0.0	0.3	1	0.0	0.25
f. Install MPC Contamination Protection	30	30	2	Operators	2	0	0.0	0.3	1	0.0	0.25
g. Connect Annulus Float Hoses	5	5	2	Operators	2	0	0.0	0.0	1	0.0	0.042
h. Fill MPC With Water	60	60	2	Operators	2	0	0.0	0.5	1	0.0	0.5
Total	175	245					0.0	1.7	13.0	0.0	1.7
5. Prep Empty MPC/Transport or MPC/Transfer for Pool				assume crane area initially							
a. Attach Cask Yoke to Crane	10	10	1	Operator	2	0	0.0	0.0	1	0.0	0.042
		10	1	Flagman	10	0	0.0	0.0	1	0.0	0.042
		10	1	Crane Operator	20	0	0.0	0.0	1	0.0	0.042
b. Engage Yoke to Cask	25	25	1	Operator	2	0	0.0	0.1	1	0.0	0.104
		25	1	Flagman	10	0	0.0	0.1	1	0.0	0.104
		25	1	Crane Operator	20	0	0.0	0.1	1	0.0	0.104
c. Move Cask to Fuel Loading Pool Floor	30	30	2	Operators	10	0	0.0	0.3	1	0.0	0.25
(assume pool area background)		30	1	Crane Operator	20	0	0.0	0.1	1	0.0	0.125
d. Disengage Yoke From Cask	20	20	1	Operator	30	0	0.0	1.0	1	0.0	1
		20	1	Flagman	30	0	0.0	1.0	1	0.0	1
		20	1	Crane Operator	40	0	0.0	1.0	1	0.0	1
e. Remove Yoke From Pool	10	10	2	Operators	10	0	0.0	1.0	1	0.0	1
		10	1	Flagman	10	0	0.0	0.5	1	0.0	0.5
		10	1	Crane Operator	20	0	0.0	0.5	1	0.0	0.5
Total	95	255					0.0	5.8	14.0	0.0	5.8
6. Load SNF into MPC/Transportation											
or MPC/Transfer											
a. SNF Grapple Attached to Crane	10	10	2	Operators	20	0.5	0.2	1.0	1	0.2	1
b. Engage One SNF Assembly. (12 min. per assembly)							0.0	0.0	1	0.0	0
b1. Time for 4 element cask	250	250	2	Operators	20	0.5	4.2	25.0	1	4.2	25
c. Load SNF into MPC	70	70	2	Operators	20	0.5	1.2	7.0	1	1.2	7
Total	330	330					5.5	33.0	4.0	5.5	33.0
7. Prep MPC/Transportation or											
MPC/Transfer from pool											
a. Attach MPC Shield Plug Lift Fixture to Crane	5	5	2	Operators	2	0	0.0	0.5	1	0.0	0.5
		5	1	Flagman	10	0	0.0	0.3	1	0.0	0.25
		5	1	Crane Operator	20	0	0.0	0.3	1	0.0	0.25
b. Install MPC Shield Plug	20	20	0	Remote	0	0	0.0	0.0	1	0.0	0
c. Engage Yoke to Cask	5	5	1	Operator	30	0	0.0	0.3	1	0.0	0.25
		5	1	Flagman	30	0	0.0	0.3	1	0.0	0.25
		5	1	Crane Operator	40	0	0.0	0.3	1	0.0	0.25

Table A1-4. Utilities-MPC (continued)

d. Lift MPC/Cask to Pool Surface	5	5	2	Operators	10	0	0.0	0.5	1	0.0	0.5
		5	1	Crane Operator	20	0	0.0	0.3	1	0.0	0.25
e. Install Shield Plug Retainers	10	10	1	Operator	2	220	36.7	0.5	1	36.7	0.5
f. Lift MPC/Cask into Prep/Decon Area	30	25	2	Operators	10	11	9.2	2.5	1	9.2	2.5
(background dose for decon area)		30	1	Crane Operator	20	0.5	0.3	1.5	1	0.3	1.5
g. Disengage Yoke from Cask	5	5	1	Operator	2	59	4.9	0.1	1	4.9	0.083
		5	1	Flagman	10	11	0.9	0.1	1	0.9	0.083
		5	1	Crane Operator	20	0.5	0.0	0.1	1	0.0	0.083
h. Remove Shield Plug Retainers	10	10	1	Operator	2	220	36.7	0.2	1	36.7	0.167
i. Decon MPC/Cask and Yoke	120	90	1	Operator	10	11	16.5	1.5	1	16.5	1.5
		40	1	Crane Operator	20	0.5	0.3	0.7	1	0.3	0.667
j. Hook Up Drain Equipment	10	10	1	Operator	2	220	36.7	0.2	1	36.7	0.167
k. Partially Drain MPC and Annulus	20	20	1	Operator	10	11	3.7	0.3	1	3.7	0.333
l. Remove Annulus Seal	10	10	2	Operators	2	220	73.3	0.3	1	73.3	0.333
m. Check MPC/Cask for Contamination	30	10	2	Radiation Protection	2	59	19.7	0.3	1	19.7	0.333
n. Install Annulus Welding Protection	10	10	2	Operators	2	220	73.3	0.3	1	73.3	0.333
o. Install Remote Welding Equipment	45	30	1	Welder	2	220	110.0	0.5	1	110.0	0.5
		10	1	Crane Operator	20	0.5	0.1	0.2	1	0.1	0.167
p. Inner Lid Weld	1000	0	0	Remote	0	0	0.0	0.0	1	0.0	0
q. Perform NDE on Weld	30	20	1	QA Welder	2	220	73.3	0.3	1	73.3	0.333
r. Remove Welding Equipment	20	20	1	Welder	2	220	73.3	0.3	1	73.3	0.333
		10	1	Crane Operator	20	0.5	0.1	0.2	1	0.1	0.167
s. Drain, Dry, and Inert MPC	350	10	1	Operator	2	220	36.7	0.2	1	36.7	0.167
		350	1	Operator	10	11	64.2	5.8	1	64.2	5.833
t. Remove Drain, Dry, and Inerting Equipment	10	10	1	Operator	2	220	36.7	0.2	1	36.7	0.167
u. Perform Leak Tests on Seal Weld	20	20	1	Operator	2	37	12.3	0.3	1	12.3	0.333
v. Weld Valve Cover Plates	90	90	1	Welder	2	220	330.0	1.5	1	330.0	1.5
w. Place MPC Outer Lid	20	10	1	Operator	2	97	16.2	0.2	1	16.2	0.167
		10	1	Flagman	10	11	1.8	0.2	1	1.8	0.167
		10	1	Crane Operator	20	0.5	0.1	0.2	1	0.1	0.167
x. Set Up Remote Welding Equipment	45	30	1	Welder	2	97	48.5	0.5	1	48.5	0.5
		10	1	Crane Operator	20	0.5	0.1	0.2	1	0.1	0.167
y. Weld MPC Outer Lid	1000	0	0	Remote	0	0	0.0	0.0	1	0.0	0
z. Perform NDT on Weld	30	20	1	QA Welder	2	97	32.3	0.3	1	32.3	0.333
aa. Remove Annulus Weld Protection	10	10	1	Operator	2	97	16.2	0.2	1	16.2	0.167
bb. Place transport/transfer Cask Lid	10	10	1	Operator	2	70	11.7	0.2	1	11.7	0.167
		10	1	Flagman	10	11	1.8	0.2	1	1.8	0.167
		10	1	Crane Operator	20	0.5	0.1	0.2	1	0.1	0.167
cc. Decon Cask(always event)	30	30	2	Operators	2	59	59.0	1.0	1	59.0	1
		30	1	Crane Operator	20	0.5	0.3	0.5	1	0.3	0.5
dd. Perform HP Survey	45	20	2	Radiation Protection	2	59	39.3	0.7	1	39.3	0.667
ee. Secure Cask Bolted Lid	60	60	2	Operators	2	70	140.0	2.0	1	140.0	2
Total	3106	1180					1,416	26.9	49.0	1416.1	26.9
8. Transfer MPC from Transfer-overpack											
to Transport-overpack				assume crane background dose in the prep area							
a. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0			
b. Move On-Site PM and Transporter to Staging Area	10	10	1	Prime Mover Operator	15	0	0.0	0.0			
		10	1	Transporter Operator	15	0	0.0	0.0			
c. Unhitch On-Site PM	6	5	1	Prime Mover Operator	15	0	0.0	0.0			
d. Engage Yoke to MPC/Cask	10	10	1	Operator	2	17	2.8	0.0			
		10	1	Flagman	10	8.7	1.5	0.0			
		10	1	Crane Operator	20	0.5	0.1	0.0			
d1. Close Prep Area Door, simultaneously with Step d.		0	1	Operator	0	0	0.0	0.0			
e. Place MPC/Cask on Transporter	45	45	2	Operators	10	8.7	13.1	0.4			
		45	1	Crane Operator	20	0.5	0.4	0.2			
f. Perform Release HP Survey	60	30	2	Radiation Protection	2	59	59.0	0.3			
g. Install Cask Restraints	60	60	2	Operators	2	32	64.0	0.5			
h. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0			
i. Prepare Transfer Papers	10	0	1	Operator	0	0	0.0	0.0			
j. Move MPC/Cask Outside Protected Area	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0			
k. Move MPC/Cask to Transfer Area	60	30	2	Operators	10	8.7	8.7	0.0			
(null backgound dose while moving)		30	1	Prime Mover Operator	15	0.5	0.3	0.0			
		30	1	Crane Operator	20	0.5	0.3	0.0			
		30	1	Radiation Protection	10	8.7	4.4	0.0			
l. Prepare Cask for MPC Transfer	60	30	2	Operators	2	70	70.0	1.0			
(assume decon area background dose)		60	1	Prime Mover Operator	15	0.5	0.5	1.0			
		60	1	Crane Operator	20	0.5	0.5	1.0			
		60	1	Radiation Protection	10	11	11.0	1.0			
m. Engage Crane to MPC Lift Attachment	10	5	1	Operator	2	39.4	3.3	0.1			
		10	1	Flagman	10	11	1.8	0.2			
		10	1	Crane Operator	20	0.5	0.1	0.2			
n. Verify Vertical Alignment of MPC to Storage Cask	10	10	1	Operator	2	97	16.2	0.2			
o. Clear Operators to a Shielded Area	5	0	0	Operators	0	0	0.0	0.0			
o1. Close Transfer Room Doors		0	1	Operator	0	0	0.0	0.0			
p. Raise MPC from Storage Cask	30	0	0	Remote	0	0	0.0	0.0			
q. Move MPC Over Transport Cask	5	0	0	Remote	0	0	0.0	0.0			
r. Verify Vertical Alignment of MPC to Transport Cask	10	0	0	Remote	0	0	0.0	0.0			
s. Correct Vertical Alignment	20	0	0	Remote	0	0	0.0	0.0			

Table A1-4. Utilities-MPC (continued)

t. Lower MPC into Transport Cask	30	0	0	Remote	0	0	0.0	0.0			
t1. Open Transfer Room Doors		0	0	Remote	0	0	0.0	0.0			
u. Radiation and Contamination Survey	10	10	2	Radiation Protection	2	43	14.3	0.3			
v. Remove MPC Lift Attachment from MPC	30	20	2	Operators	2	97	64.7	0.7			
		15	1	Flagman	10	8.7	2.2	0.3			
		15	1	Crane Operator	20	0.5	0.1	0.3			
w. Disengage Crane from MPC Lift Attachment	10	5	1	Operator	2	39.4	3.3	0.1			
		10	1	Flagman	10	8.7	1.5	0.2			
		10	1	Crane Operator	20	0.5	0.1	0.2			
x. Place Transport Cask Lid	10	10	1	Operator	2	97	16.2	0.2			
		10	1	Flagman	10	8.7	1.5	0.2			
		10	1	Crane Operator	20	0.5	0.1	0.2			
y. Decon Cask	30	30	2	Operators	2	59	59.0	1.0			
		30	1	Crane Operator	20	0.5	0.3	0.5			
z. Perform HP Survey	45	20	2	Radiation Protection	2	59	39.3	0.7			
aa. Secure Overpack Cask Bolted Lid	60	60	2	Operators	2	59	118.0	2.0			
Total	510	695					578.2	12.8			
9. Prep MPC/Transportation-overpack from Pool Prep for shipping				assume crane area background dose							
a. Open Staging Area Door	5	0	1	Operator	0	0	0.0	0.0			
b. Move On-Site PM and Off-Site Transporter to Staging Ar	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0			
c. Unhitch On-Site PM	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0			
d. Engage Yoke to MPC/Cask	10	10	1	Operator	2	17	2.8	0.0			
		10	1	Flagman	10	8.7	1.6	0.0			
		10	1	Crane Operator	20	0.5	0.1	0.0			
d1. Close Staging Area Door, simultaneously with Step d.		0	1	Operator	0	0	0.0	0.0			
e. Place MPC/Cask on Transporter	45	45	2	Operators	10	1.8	2.7	0.4			
		45	1	Crane Operator	20	0.5	0.4	0.2			
f. Perform Shipping HP Survey	80	35	2	Radiation Protection	2	43	50.2	0.3			
g. Install Cask Restraints	35	35	2	Operators	2	32	37.3	0.3			
		35	1	Crane Operator	20	0.5	0.3	0.1			
h. Install Impact Limiters	55	55	2	Operators	2	32	58.7	0.5			
		55	1	Crane Operator	20	0.5	0.5	0.2			
i. Install Personnel Barrier	70	70	2	Operators	2	32	74.7	0.6			
		35	1	Crane Operator	20	0.5	0.3	0.1			
j. Prepare Shipping Papers	10	0	1	Operator	0	0	0.0	0.0			
k. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0			
l. Hitch On-Site PM	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0			
m. Move Cask/MPC to Protected Area	30	30	1	Prime Mover Operator	15	0.5	0.3	0.1			
n. Perform security check	5	5	2	Security Officers	2	17	2.4	0.0			
n. Unhitch On-Site PM	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0			
n1. Make-up with other cask cars per train (assume 3 cars)	60	60	2	Operator-rail	15	1.2	2.4	0.5			
o. Hitch Off-Site PM	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0			
Total	440	565					235.6	3.6			
10. Prep MPC/Transfer-overpack from Pool Prep for ISFSI				assume crane enclosure background dose							
a. Open Staging Area Door	5	0	1	Operator	0	0	0.0	0.0			
b. Move On-Site PM and Transporter to Staging Area	10	10	1	Prime Mover Operator	15	0	0.0	0.0			
		10	1	Transporter Operator	15	0	0.0	0.0			
c. Unhitch On-Site PM	5	5	1	Prime Mover Operator	15	0	0.0	0.0			
d. Engage Yoke to MPC/Cask	10	10	1	Operator	2	37	6.2	0.0			
		10	1	Flagman	10	8.7	1.5	0.0			
		10	1	Crane Operator	20	0.5	0.1	0.0			
d1. Close Staging Area Door, simultaneously with Step d.		0	1	Operator	0	0	0.0	0.0			
e. Place MPC/Cask on Transporter	45	45	2	Operators	10	8.7	13.1	0.4			
		45	1	Crane Operator	20	0.5	0.4	0.2			
f. Perform Release HP Survey	60	30	2	Radiation Protection	2	59	59.0	0.3			
g. Install Cask Restraints	60	60	2	Operators	2	32	64.0	0.5			
h. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0			
i. Prepare Transfer Papers	10	0	1	Operator	0	0	0.0	0.0			
j. Move MPC/Cask Outside Protected Area	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0			
k. Move MPC/Cask to ISFSI	60	30	2	Operators	10	8.7	8.7	0.0			
(assume null background dose while moving)		30	1	Prime Mover Operator	15	0.5	0.3	0.0			
		30	1	Crane Operator	20	0.5	0.3	0.0			
		30	1	Radiation Protection	10	8.7	4.4	0.0			
Total	280	365					157.8	1.6			
11. Transfer Loaded MPC from Transfer-overpack to ISFSI (like step 12, following)				assume ISFSI background dose			x times aligned with UTS-RDS step				
a. Prepare Cask for MPC Transfer	60	30	2	Operators	2	70	70.0	2.0			
		60	1	Prime Mover Operator	15	0.5	0.5	2.0			
		60	1	Crane Operator	20	0.5	0.5	2.0			
		60	1	Radiation Protection	10	8.7	8.7	2.0			
a1. Open ISFSI Storage Door, simultaneously		20	1	Operator	2	70	23.3	0.7			
(only one crane, PM operator and HP in crew)		0	0	Prime Mover Operator	15	0.5	0.0	0.0			
		0	0	Crane Operator	20	0.5	0.0	0.0			
		0	0	Radiation Protection	10	8.7	0.0	0.0			
b. Align Cask With ISFSI	60	30	2	Operators	10	8.7	8.7	2.0			

Table A1-4. Utilities-MPC (continued)

		60	1	Prime Mover Operator	15	0.5	0.5	2.0		
		60	1	Crane Operator	20	0.5	0.5	2.0		
		60	1	Radiation Protection	10	8.7	8.7	2.0		
c. Prepare Transfer Equipment	60	30	2	Operators	2	70	70.0	2.0		
		60	1	Prime Mover Operator	15	0.5	0.5	2.0		
		60	1	Crane Operator	20	0.5	0.5	2.0		
		60	1	Radiation Protection	10	8.7	8.7	2.0		
d. Transfer MPC From Cask to ISFSI	30	30	2	Operators	10	8.7	8.7	2.0		
		30	1	Prime Mover Operator	15	0.5	0.3	1.0		
		30	1	Crane Operator	20	0.5	0.3	1.0		
		30	1	Radiation Protection	10	8.7	4.4	1.0		
e. Close ISFSI Storage Door	30	30	1	Operator	2	70	35.0	1.0		
		30	1	Prime Mover Operator	15	0.5	0.3	1.0		
		30	1	Crane Operator	20	0.5	0.3	1.0		
		30	1	Radiation Protection	10	8.7	4.4	1.0		
f. Prepare for Transportation of MPC On-Site Transfer Cask							0.0	0.0		
from ISFSI	60	30	2	Operators	2	35	35.0	2.0		
		60	1	Prime Mover Operator	15	0.5	0.5	2.0		
		60	1	Crane Operator	20	0.5	0.5	2.0		
		60	1	Radiation Protection	10	8.7	8.7	2.0		
Total	300	1100					299.2	41.7		
12. Transfer MPC from/to Transportation-overpack										
in ISFSI (like Step 13. of UTS-RDS spreadsheet)				assume ISFSI background dose; times aligned with UTS-RDS step 13 val						
a. Prepare Cask for MPC Transfer	60	30	2	Operators	2	0	0.0	2.0		
		60	1	Prime Mover Operator	15	0	0.0	2.0		
		60	1	Crane Operator	20	0	0.0	2.0		
		60	1	Radiation Protection	10	0	0.0	2.0		
b. Align Cask with ISFSI	60	30	2	Operators	2	0	0.0	2.0		
		60	1	Prime Mover Operator	15	0	0.0	2.0		
		60	1	Crane Operator	20	0	0.0	2.0		
		60	1	Radiation Protection	10	0	0.0	2.0		
c. Open ISFSI Storage Door	0	20	1	Operators	2	60	20.0	0.7		
simultaneous with step a		0	0	Prime Mover Operator	15	0.5	0.0	0.0		
(only one crane, PM operator and HP in crew)		0	0	Crane Operator	20	0.5	0.0	0.0		
		0	0	Radiation Protection	10	8.7	0.0	0.0		
d. Prepare Transfer Equipment	60	30	2	Operators	2	60	60.0	2.0		
		60	1	Prime Mover Operator	15	0.5	0.5	2.0		
		60	1	Crane Operator	20	0.5	0.5	2.0		
		60	1	Radiation Protection	10	8.7	8.7	2.0		
e. Transfer MPC to Off-Site Transportation Cask	30	30	2	Operators	10	8.7	8.7	2.0		
		30	1	Prime Mover Operator	15	0.5	0.3	1.0		
		30	1	Crane Operator	20	0.5	0.3	1.0		
		30	1	Radiation Protection	10	8.7	4.4	1.0		
f. Close ISFSI Storage Door	30	30	2	Operators	2	60	60.0	2.0		
		30	1	Prime Mover Operator	15	0.5	0.3	1.0		
		30	1	Crane Operator	20	0.5	0.3	1.0		
		30	1	Radiation Protection	10	8.7	4.4	1.0		
g. Install Cask Closure	55	55	2	Operators	2	60	110.0	3.7		
		55	1	Prime Mover Operator	15	0.5	0.5	1.8		
		55	1	Crane Operator	20	0.5	0.5	1.8		
		55	1	Radiation Protection	10	8.7	8.0	1.8		
h. Prepare to Move Off-Site Transportation Cask From ISFSI							0.0	0.0		
Storage Yard	60	30	2	Operators	2	60	60.0	2.0		
		60	1	Prime Mover Operator	15	0.5	0.5	2.0		
		60	1	Crane Operator	20	0.5	0.5	2.0		
		60	1	Radiation Protection	10	8.7	8.7	2.0		
Total	355	1320					366.7	51.8		
13. Prep MPC/Transportation-overpack from ISFSI for Shipping										
(derived from Steps of 5b. rail, of UTS-RDS spreadsheet)				assume ISFSI background dose, except at rail siding						
a. Perform Release HP Survey(s -diameter)	80	40	2	Radiation Protection	2	43	57.3	2.7		
b. Install Cask Restraints(s -perimeter)	35	35	2	Operators	2	32	37.3	2.3		
		35	1	Crane Operator	20	0.5	0.3	1.2		
c. Install Impact Limiter(s- diameter)	55	55	2	Operators	2	32	58.7	3.7		
		55	1	Crane Operator	20	0.5	0.5	1.8		
d. Install Personnel Barrier(s- perimeter)	70	70	2	Operators	2	32	74.7	4.7		
		35	1	Crane Operator	20	0.5	0.3	1.2		
e. Prepare Shipping Papers	10	0	1	Operator	0	0	0.0	0.0		
f. Open Prep Area Door	5	0	1	Operator	0	0	0.0	0.0		
g. Hitch On-Site Prime Mover	5	5	1	Prime Mover Operator	15	0.5	0.0	0.2		
h. Move Cask to Protected Area Gate (null background do	30	30	1	Prime Mover Operator	15	0.5	0.3	1.0		
i. Perform security check	5	5	2	Security Officers	2	17	3.4	0.0		
j. Un-hitch On-Site Prime Mover	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0		
k. Make-up with other cask cars per train (assume 3 cars)	60	60	2	Operator-rail	15	1.2	2.4	0.5		
l. Hitch Off-Site Prime Mover (assume rail siding dose same a	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0		
Total	365	435					235.2	19.2		

Table A1-5 through A1-8. Monitored Retrievable Storage (MRS) Facility

Table A1-5. MRS-Reference

Total Doses per Cask Handling for SPS at the MRS				Truck & Rail mrem/hr		Background	
Revised 20 May 94/HWG	Direct	Bkgd	Sum	Lid doses		mrem/hr	
	(person-mrems)			inner	220	area	dose
Unload Truck Cask-Steps-(1a,3,5) for SPS, TSC, MPU, MPC	507	11	518	outer	60	crane	0.25
Unload Rail Cask-Steps-(1b,3,5): only SPS technology	651	12	664	Tp/Tx cask lid	60	decon	1
Unload rail is also used at the MGDS.				Lateral Skin	59	pool	3
				Storage cask mrem/hr		ISFSI	2
Load Storage Cask	853	13	867	Lid doses			
Steps - (2,3,4)				inner	220	null	0
				outer	97		
Unload Storage Cask	1,083	11	1,094	Tp/Tx cask lid	70		
Steps - (3,7)				Lateral Skin	70		
Load Rail Cask & Ship	443	8	451				
Steps - (2,3,6)							
Rail Flow-Through (Step 8)	32.0	0	32				
Rail flow through is the same for all technologies.							

Cask Handling Operations	Total Task Time(Min.)	Dose time(Min.)	Personnel Required(Persons /Task)	Occupation	Working Distance(Feet)	Cask Dose Rate(mrem/hr)	Dose Received(Person-mrem)	Facility dose background (person-mrem)
1a. Receive and Prep Loaded Truck Cask (all				assume null dose initially				
Transportation Cask for Unloading								
a. Inspect Bills of Lading, Other Shipping Papers	10	0	1	Operator	0	0	0.00	0.00
b. Pull Cask into Security Area	5	5	1	Prime Mover Operator	15	0.5	0.04	0.00
c. Security Inspection	30	20	2	Security Officers	2	17	11.33	0.00
d. Perform HP Survey of Cask Externals and Trailer	30	10	2	Radiation Protection	2	43	14.33	0.00
e. Take Cask to Protected Area	10	10	1	Prime Mover Operator	15	0.5	0.08	0.00
f. Unhitch Off-Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.08	0.00
g. Hitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.08	0.00
h. Take Cask to Receiving and Shipping Bay Door	10	10	1	Prime Mover Operator	15	0.5	0.08	0.00
h1. Open Receiving and Shipping Bay Door, simultaneous		0	1	Operator	0	0	0.00	0.00
i. Take Cask into Receiving and Shipping Bay	5	5	1	Prime Mover Operator	15	0.5	0.04	0.00
		5	1	Flagman	10	8.7	0.73	0.00
j. Unhitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.08	0.00
j1. Close Receiving and Shipping Bay Door, simultaneously		0	1	Operator	0	0	0.00	0.00
k. Remove Personnel Barrier	25	25	2	Operators	3	32	26.67	0.21
(crane area background dose)		25	1	Crane Operator	20	0.5	0.21	0.10
l. HP Survey	25	10	2	Radiation Protection	2	43	14.33	0.08
m. Remove Impact Limiters	60	60	2	Operators	3	32	64.00	0.50
		60	1	Crane Operator	20	0.5	0.50	0.25
n. Remove Tiedowns	35	35	2	Operators	3	32	37.33	0.29
		35	1	Crane Operator	20	0.5	0.29	0.15
o. Remove Trunnion Blocks	10	10	2	Operators	3	32	10.67	0.08
		10	1	Crane Operator	20	0.5	0.08	0.04
o1. Open SNF Transport Cask Prep Room Door, simultaneous		0	1	Operator	0	0	0.00	0.00
p. Attach Crane to Yoke	5	5	1	Operator	2	0	0.00	0.02
		5	1	Flagman	10	0	0.00	0.02
		5	1	Crane Operator	20	0	0.00	0.02
q. Engage Yoke to Cask	5	5	1	Operator	2	17	1.42	0.02
		5	1	Flagman	10	8.7	0.73	0.02
		5	1	Crane Operator	20	0.5	0.04	0.02
							0.00	0.00
r. Move Cask into SNF Transport Cask Prep Room Washdown Area	10	10	2	Operators	10	1.8	0.60	0.08
		10	1	Crane Operator	20	0.5	0.08	0.04
s. Install Platform	10	10	1	Operator	6	8.7	1.45	0.04
t. Washdown Cask	30	35	2	Operator	2	17	19.83	0.29
u. HP Survey	35	15	2	Radiation Protection	2	43	21.50	0.13
v. Remove Platform	10	10	1	Operator	6	8.7	1.45	0.04
w. Move Transport Cask to Carrier	10	10	2	Operators	10	1.8	0.60	0.08
		10	1	Crane Operator	20	0.5	0.08	0.04
x. Place Transport Cask on Carrier	20	20	2	Operators	10	8.7	5.80	0.17
		20	1	Crane Operator	20	0.5	0.17	0.08
y. Secure Cask to Carrier	20	20	2	Operator	2	43	28.67	0.17
y1. Disengage Crane with Yoke from Cask, simultaneous		10	1	Operator	2	17	2.83	0.04

Table A1-5. MRS-Reference (continued)

		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
z. Install Shield Platform	30	30	1	Operator	6	8.7	4.35	0.13
aa. Attach Lid cavity Gas Sampling/Venting Rig	10	10	1	Operator	2	60	10.00	0.04
bb. Sample Gas Cavity	10	5	1	Operator	3	53	4.42	0.02
cc. Vent Cask Cavity	10	5	1	Operator	3	53	4.42	0.02
dd. Remove Sampling/Venting Rig	10	10	1	Operator	2	60	10.00	0.04
ee. Install Lid Handling Device	25	25	2	Operators	2	60	50.00	0.21
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
ff. Loosen Cask Lid Bolts	90	45	2	Operators	2	60	90.00	0.38
		20	1	Flagman	10	8.7	2.90	0.08
		20	1	Crane Operator	20	0.5	0.17	0.08
gg. Attach Interface Fixture	30	30	2	Operators	2	60	60.00	0.25
hh. Remove Platform	10	10	1	Operator	6	8.7	1.45	0.04
ii. Operators Clear Prep Room	5	0	0	Operators	0	0	0.00	0.00
jj. Move Cask Under Cell Port	5	0	0	Remote	0	0	0.00	0.00
kk. Mate Cask to Port	30	0	0	Remote	0	0	0.00	0.00
ll. Open Port and Remove Cask Lid	30	0	0	Remote	0	0	0.00	0.00
Total	735	825					507	6
1b. Receive & Prep Loaded Rail Cask (only SPS technology) to Unload					assume null background			
(scale lid and area operations from truck diameter=>	1.8	; scale others from walk-around peri ###)						
a. Inspect Bills of Lading, Other Shipping Papers	10	10	1	Operator	0	0	0.00	0.00
b. Pull Cask into Security Area	5	5	1	Prime Mover Operator	15	0.5	0.04	0.00
c. Security Inspection (s-perim)	45	25	2	Security Officers	2	17	14.17	0.00
d. Perform HP Survey of Cask Externals and Trailer (s-perim)	35	10	2	Radiation Protection	2	43	14.33	0.00
e. Take Cask to Protected Area	10	10	1	Prime Mover Operator	15	0.5	0.08	0.00
f. Unhitch Off-Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.08	0.00
g. Hitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.08	0.00
h. Take Cask to Receiving and Shipping Bay Door	10	10	1	Prime Mover Operator	15	0.5	0.08	0.00
h1. Open Receiving and Shipping Bay Door, simultaneous		0	1	Operator	0	0	0.00	0.00
i. Take Cask into Receiving and Shipping Bay	5	5	1	Prime Mover Operator	15	0.5	0.04	0.00
		5	1	Flagman	10	8.7	0.73	0.00
j. Unhitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.08	0.00
j1. Close Receiving and Shipping Bay Door,							0.00	0.00
simultaneously with j.		0	1	Operator	0	0	0.00	0.00
k. Remove Personnel Barrier (s-perim)	30	30	2	Operators	3	32	32.00	0.25
(assume crane enclosure background dose)		25	1	Crane Operator	20	0.5	0.21	0.10
l. HP Survey (s-diameter)	45	45	2	Radiation Protection	2	43	64.50	0.38
m. Remove Impact Limiters (s-diameter)	110	110	2	Operators	3	32	117.33	0.92
		110	1	Crane Operator	20	0.5	0.92	0.46
n. Remove Tiedowns (s-perim)	45	45	2	Operators	3	32	48.00	0.38
		45	1	Crane Operator	20	0.5	0.38	0.19
o. Remove Trunnion Blocks	10	10	2	Operators	3	32	10.67	0.08
		10	1	Crane Operator	20	0.5	0.08	0.04
o1. Open SNF Transport Cask Prep Room Door, simultaneous		0	1	Operator	0	0	0.00	0.00
p. Attach Crane to Yoke	5	5	1	Operator	2	0	0.00	0.02
		5	1	Flagman	10	0	0.00	0.02
		5	1	Crane Operator	20	0	0.00	0.02
q. Engage Yoke to Cask	5	5	1	Operator	2	17	1.42	0.02
		5	1	Flagman	10	8.7	0.73	0.02
		5	1	Crane Operator	20	0.5	0.04	0.02
r. Move Cask into SNF Transport Cask Prep Room							0.00	0.00
Washdown Area	10	10	2	Operators	10	1.8	0.60	0.08
		10	1	Crane Operator	20	0.5	0.08	0.04
s. Install Platform	10	10	1	Operator	6	8.7	1.45	0.04
t. Washdown Cask (s-diameter)	55	45	2	Operator	2	17	25.50	0.38
u. HP Survey (s-diameter)	65	30	2	Radiation Protection	2	43	43.00	0.25
v. Remove Platform	10	10	1	Operator	6	8.7	1.45	0.04
w. Move Transport Cask to Carrier	10	10	2	Operators	10	1.8	0.60	0.08
		10	1	Crane Operator	20	0.5	0.08	0.04
x. Place Transport Cask on Carrier	20	20	2	Operators	10	8.7	5.80	0.17
		20	1	Crane Operator	20	0.5	0.17	0.08
y. Secure Cask to Carrier (s-perim)	20	20	2	Operator	2	43	28.67	0.17
y1. Disengage Crane with Yoke from Cask, simultaneous		10	1	Operator	2	17	2.83	0.04
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
y2. Close SNF Transport Cask Prep Room Door, simultaneous		0	1	Operator	0	0	0.00	0.00
z. Install Shield Platform	30	30	1	Operator	6	8.7	4.35	0.13
aa. Attach Gas Sampling/Venting Rig	10	10	1	Operator	2	60	10.00	0.04
bb. Sample Gas Cavity	10	5	1	Operator	3	53	4.42	0.02
cc. Vent Cask Cavity (s-diameter)	20	10	1	Operator	3	53	8.83	0.04
dd. Remove Sampling/Venting Rig	10	10	1	Operator	2	60	10.00	0.04
ee. Install Lid Handling Device	25	25	2	Operators	2	60	50.00	0.21
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
ff. Loosen Cask Lid Bolts (s-diameter)	160	40	2	Operators	2	60	80.00	0.33
		20	1	Flagman	10	8.7	2.90	0.08

Table A1-5. MRS-Reference (continued)

		20	1	Crane Operator	20	0.5	0.17	0.08
gg. Attach Interface Fixture	30	30	2	Operators	2	60	60.00	0.25
hh. Remove Platform	10	10	1	Operator	6	8.7	1.45	0.04
ii. Operators Clear Prep Room	5	0	0	Operators	0	0	0.00	0.00
jj. Move Cask Under Cell Port	5	0	0	Remote	0	0	0.00	0.00
kk. Mate Cask to Port	30	0	0	Remote	0	0	0.00	0.00
ll. Open Port and Remove Cask Lid	30	0	0	Remote	0	0	0.00	0.00
Total	975	1,025					661	5.77
2. Receive and Prep Unloaded Storage, Emplacement or Transportation Cask for Loading				assume null background initially				
a. Inspect Bills of Lading, Other Shipping Papers	10	10	1	Operator	0	0	0.00	0.00
b. Pull Cask Into Security Area	5	5	1	Prime Mover Operator	15	0	0.00	0.00
c. Security Inspection	30	30	2	Security Officers	2	0	0.00	0.00
d. Perform HP Survey of Cask Externals and Trailer	30	30	2	Radiation Protection	2	0	0.00	0.00
e. Take Cask to Protected Area	10	10	1	Prime Mover Operator	15	0	0.00	0.00
f. Unhitch Off-Site Prime Mover	10	10	1	Prime Mover Operator	15	0	0.00	0.00
g. Hitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0	0.00	0.00
h. Take Cask to Receiving and Shipping Bay Door	10	10	1	Prime Mover Operator	15	0	0.00	0.00
h1. Open Receiving and Shipping Bay Door, simultaneous		0	1	Operator	0	0	0.00	0.00
i. Take Cask into Receiving and Shipping Bay	5	5	1	Prime Mover Operator	15	0	0.00	0.00
		0	1	Flagman	10	0	0.00	0.00
j. Unhitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0	0.00	0.00
j1. Close Receiving and Shipping Bay Door, simultaneous		0	1	Operator	0	0	0.00	0.00
n. Remove Tiedowns	50	50	2	Operators	3	0	0.00	0.42
o. Remove Trunnion Blocks	10	10	2	Operators	3	0	0.00	0.08
		0	1	Crane Operator	20	0	0.00	0.00
o1. Open SNF Transport Cask Prep Room Door, simultaneous		0	1	Operator	0	0	0.00	0.00
p. Attach Crane to Yoke	5	5	1	Operator	2	0	0.00	0.02
		5	1	Flagman	10	0	0.00	0.02
		5	1	Crane Operator	20	0	0.00	0.02
q. Engage Yoke to Cask	5	5	1	Operator	2	0	0.00	0.02
		5	1	Flagman	10	0	0.00	0.02
		5	1	Crane Operator	20	0	0.00	0.02
r. Move Cask Into SNF Transport Cask Prep Room							0.00	0.00
Washdown Area	30	30	2	Operators	10	0	0.00	0.25
	30	30	1	Crane Operator	20	0	0.00	0.13
s. Install Platform	10	10	1	Operator	6	0	0.00	0.04
t. Washdown Cask	30	30	2	Operator	2	0	0.00	0.25
u. HP Survey	35	35	2	Radiation Protection	2	0	0.00	0.29
v. Remove Platform	10	10	1	Operator	6	0	0.00	0.04
w. Move Transport Cask to Carrier	10	10	2	Operators	10	0	0.00	0.08
		10	1	Crane Operator	20	0	0.00	0.04
x. Place Transport Cask on Carrier	20	20	2	Operators	10	0	0.00	0.17
		20	1	Crane Operator	20	0	0.00	0.08
y. Secure Cask to Carrier	20	20	2	Operator	2	0	0.00	0.17
	20	20	1	Crane Operator	20	0	0.00	0.08
y1. Close SNF Transport Cask Prep Room Door							0.00	0.00
simultaneously with y		0	1	Operator	0	0	0.00	0.00
z. Install Shield Platform	30	30	1	Operator	6	0	0.00	0.13
aa. Loosen Cask Lid Bolts	60	60	2	Operators	2	0	0.00	0.50
bb. Install Lid Handling Device	25	25	2	Operators	2	0	0.00	0.21
cc. Attach Interface Fixture	30	30	2	Operators	2	0	0.00	0.25
dd. Remove Platform	10	10	1	Operator	6	0	0.00	0.04
ee. Operators Clear Prep Room	5	5	0	Operators	0	0	0.00	0.00
ff. Move Cask Under Cell Port	5	5	0	Remote	0	0	0.00	0.00
gg. Mate Cask to Port	30	30	0	Remote	0	0	0.00	0.00
hh. Open Port and Remove Cask Lid	30	30	0	Remote	0	0	0.00	0.00
Total	610	690					0.00	3.38
3. Load/Unload SNF (Transfer)								
a. Install a Spacer	20	0	0	Remote	0	0	0.00	0.00
b. Get Bare SNF Grapple	10	0	0	Remote	0	0	0.00	0.00
c. Get and Inspect One Bare SNF assembly	10	0	0	Remote	0	0	0.00	0.00
d. Emplace Bare SNF assembly if necessary	10	0	0	Remote	0	0	0.00	0.00
e. Put Bare SNF In Can	20	0	0	Remote	0	0	0.00	0.00
f. Install Can Lid	30	0	0	Remote	0	0	0.00	0.00
Total	100	0					0.00	0.00
4. Prep DVCC Storage Cask from SNF Transfer Cell for Storage				assume crane enclosure background				
a. From Cell, Install MPC Shield Plug	25	0	0	Remote	0	0	0.00	0.00
b. Replace Port Plug	10	0	0	Remote	0	0	0.00	0.00
c. Unmate Storage Cask from Port	10	0	0	Remote	0	0	0.00	0.00
d. Open Transfer Station Door	5	0	1	Operator	0	0	0.00	0.00
e. Move Cask Into Storage Cask Prep Room	30	30	1	Operator	10	8.7	4.35	0.13
f. HP Survey	60	30	2	Radiation Protection	2	59	59.00	0.25
g. Remove Lid Handling Device	25	20	2	Operators	2	97	64.67	0.17
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04

Table A1-5. MRS-Reference (continued)

g1. Close Transfer Station Door, simultaneous		0	1	Operator	0	0	0.00	0.00
h. Secure Cask Bolted Lid	30	30	2	Operators	2	97	97.00	0.25
i. Connect Evacuation/Inerting Equipment	10	10	1	Operator	2	97	16.17	0.04
j. Evacuate and Inert Cask	45	10	1	Operator	2	37	6.17	0.04
		45	1	Operator	10	8.7	6.53	0.19
k. Disconnect Evacuation/Inerting Equipment	5	5	1	Operator	2	97	8.08	0.02
l. Place and Seal Weld Valve Cover	90	90	1	Welder	2	97	145.50	0.38
m. Place Storage Outer Lid	30	30	1	Operator	2	97	48.50	0.13
		30	1	Flagman	10	8.7	4.35	0.13
		30	1	Crane Operator	20	0.5	0.25	0.13
n. Setup Remote Welding Equipment	45	45	1	Welder	2	70	52.50	0.19
o. Weld Storage Casks Outer Lid	600	0	0	0	0	0	0.00	0.00
p. Verify Storage Casks Outer Lid Weld	60	30	1	QA Welder	2	70	35.00	0.13
q. Remove Remote Welding Equipment	20	20	1	Welder	2	70	23.33	0.08
r. HP Survey Cask	60	30	2	Radiation Protection	2	59	59.00	0.25
s. Open Storage Cask Prep Room Door	5	0	1	Operator	0	0	0.00	0.00
t. Move Cask to Storage Cask Staging Area	30	30	1	Operator	10	8.7	4.35	0.13
		30	1	Transporter Operator	15	0.5	0.25	0.13
u. Close Storage Cask Prep Room Door	5	0	1	Operator	0	0	0.00	0.00
v. Unsecure Cask from Carrier	10	10	2	Operators	2	59	19.67	0.08
w. Engage Storage Cask with Transporter	60	30	2	Operators	2	59	59.00	0.25
		30	1	Transporter Operator	15	0.5	0.25	0.13
x. Secure Cask to Transporter	20	20	2	Operators	2	59	39.33	0.17
y. Move Cask to Storage Yard	60	30	2	Operators	10	8.7	8.70	0.00
(null background dose while moving)		60	1	Transporter Operator	15	0.5	0.50	0.00
		30	1	Radiation Protection	10	8.7	4.35	0.00
z. Unsecure Cask from Transporter	20	10	2	Operators	2	59	19.67	0.67
		20	1	Transporter Operator	15	0.5	0.17	0.67
		10	1	Radiation Protection	10	8.7	1.45	0.33
aa. Place Storage Cask on Pad	60	30	2	Operators	2	59	59.00	2.00
		60	1	Transporter Operator	15	0.5	0.50	2.00
		30	1	Radiation Protection	10	8.7	4.35	1.00
bb. Return Transport to Transfer Facility	50	25	2	Operators	10	0	0.00	0.00
(without a cask and null background dose)		25	1	Transporter Operator	15	0	0.00	0.00
		25	1	Radiation Protection	10	0	0.00	0.00
Total	1480	1,010					853	10
5 Prep Unloaded Cask from SNF Transfer to Shipping				assume crane enclosure background dose				
a. Replace Cask Lid	20	20	2	Operators	2	0	0.00	0.17
		20	1	Operator	10	0	0.00	0.08
		20	1	Crane Operator	20	0	0.00	0.06
b. Replace Port Plug	10	10	2	Operators	2	0	0.00	0.08
		10	1	Operator	10	0	0.00	0.04
		10	1	Crane Operator	20	0	0.00	0.04
c. Unmate Cask from Port	10	10		Remote	0	0	0.00	0.00
d. Open Transfer Station Door	5	5	1	Operator	0	0	0.00	0.02
e. Move Cask into SNF Transport Cask Prep Room	10	10	2	Operators	10	0	0.00	0.08
f. Close Transfer Station Door	5	5	1	Operator	0	0	0.00	0.02
g. Install Shield Platform	30	30	1	Operator	6	0	0.00	0.13
h. Remove Interface Fixture	30	30	2	Operators	2	0	0.00	0.25
i. Remove Cask Lid Handling Device	25	25	2	Operators	2	0	0.00	0.21
		25	1	Flagman	10	0	0.00	0.10
		25	1	Crane Operator	20	0	0.00	0.10
j. Install Cask Lid	60	60	2	Operators	20	0	0.00	0.50
		60	1	Flagman	10	0	0.00	0.25
		60	1	Crane Operator	20	0	0.00	0.25
k. Test Cask Closure	45	45	2	Operators	2	0	0.00	0.38
l. HP Survey Cask	30	30	2	Radiation Protection	2	0	0.00	0.25
m. Remove Shield Platform	10	10	1	Operator	6	0	0.00	0.04
m1. Unsecure Cask from Carrier, simultaneous							0.00	0.00
n. Attach Crane to Yoke	5	5	1	Operator	2	0	0.00	0.02
		5	1	Flagman	10	0	0.00	0.02
		5	1	Crane Operator	20	0	0.00	0.02
n1. Open Prep Room Door, simultaneous	5	5	1	Operator	0	0	0.00	0.02
o. Engage Yoke to Cask	5	5	1	Operator	2	0	0.00	0.02
		5	1	Flagman	10	0	0.00	0.02
		5	1	Crane Operator	20	0	0.00	0.02
p. Lift Cask out of Prep Room onto Trailer	30	30	2	Operators	10	0	0.00	0.25
		30	1	Crane Operator	20	0	0.00	0.13
q. Disengage Crane and Yoke	10	10	1	Operators	2	0	0.00	0.04
		10	1	Flagman	10	0	0.00	0.04
		10	1	Crane Operator	20	0	0.00	0.04
q1. Close Prep Room Door, simultaneous	5	5	1	Operator	0	0	0.00	0.02
r. Install Trunnion Blocks	20	20	2	Operators	2	0	0.00	0.17
		20	1	Crane Operator	20	0	0.00	0.08
s. HP Survey	20	20	2	Radiation Protection	2	0	0.00	0.17
t. Install Tiedowns	60	60	2	Operators	2	0	0.00	0.50
		60	1	Crane Operator	20	0	0.00	0.25
u. Install Impact Limiters	60	60	2	Operators	2	0	0.00	0.50

Table A1-5. MRS-Reference (continued)

		60	1	Crane Operator	20	0	0.00	0.25
v. Install Personnel Barrier	60	60	2	Operators	2	0	0.00	0.50
		60	1	Crane Operator	20	0	0.00	0.25
w. Hitch Site Prime Mover	5	5	1	Prime Mover Operator	15	0	0.00	0.02
x. Open Receiving and Shipping Bay Door	5	5	1	Operator	0	0	0.00	0.02
y. Prepare Shipping Paperwork	10	10	1	Operator	0	0	0.00	0.04
z. Move Cask to Protected Area Gate	10	10	1	Prime Mover Operator	15	0	0.00	0.04
aa. Unhitch Site Prime Mover	10	5	1	Prime Mover Operator	15	0	0.00	0.02
Total	610	1,106					0.00	6.56
6. Prep Rail Transportation Cask								
from SNF Transfer Cell to Ship				assume crane enclosure background dose				
a. From Cell, Install Cask Shield Plug	25	0	0	Remote	0	0	0.00	0.00
b. Replace Port Plug	10	0	0	Remote	0	0	0.00	0.00
c. Unmate Cask from Port	10	0	0	Remote	0	0	0.00	0.00
d. Open Transfer Station Door	5	0	1	Operator	0	0	0.00	0.00
e. Move Cask into Cask Prep Room	30	30	1	Operator	10	8.7	4.35	0.13
f. HP Survey	60	30	2	Radiation Protection	2	59	59.00	0.25
g. Remove Lid Handling Device	25	20	2	Operators	2	60	40.00	0.17
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
g1. Close Transfer Station Door, simultaneous		0	1	Operator	0	0	0.00	0.00
h. Secure Cask Bolted Lid	30	30	2	Operators	2	60	60.00	0.25
i. Connect Evacuation/Inerting Equipment	10	10	1	Operator	2	60	10.00	0.04
j. Evacuate and Inert Cask	45	10	1	Operator	2	37	6.17	0.04
		45	1	Operator	10	8.7	6.53	0.19
k. Disconnect Evacuation/Inerting Equipment	5	5	1	Operator	2	60	5.00	0.02
l. Open Prep Area Door	5	0	1	Operator	0	0	0.00	0.00
m. Move On-Site PM and Transporter to Prep Area	10	10	1	Prime Mover Operator	15	0.5	0.08	0.04
n. Unhitch On-Site PM	5	5	1	Prime Mover Operator	15	0.5	0.04	0.02
o. Engage Yoke to Cask	10	10	1	Operator	2	17	2.83	0.04
	10	10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
o1. Close Pool Prep Area Door, simultaneous		0	1	Operator	0	0	0.00	0.00
p. Place Cask on Transporter	45	45	2	Operators	10	1.8	2.70	0.38
		45	1	Crane Operator	20	0.5	0.38	0.19
q. Perform Release HP Survey	45	20	2	Radiation Protection	2	43	28.67	0.17
r. Install Cask Restraints	90	90	2	Operators	2	32	96.00	0.75
		90	1	Crane Operator	20	0.5	0.75	0.38
s. Install Impact Limiters	90	90	2	Operators	2	32	96.00	0.75
		90	1	Crane Operator	20	0.5	0.75	0.38
t. Install Personnel Barrier	30	30	2	Operators	2	17	17.00	0.25
		30	1	Crane Operator	20	0.5	0.25	0.13
u. Prepare Shipping Papers	10	0	1	Operator	0	0	0.00	0.00
v. Open Prep Area Door	5	0	1	Operator	0	0	0.00	0.00
w. Hitch On-Site Prime Mover	5	5	1	Prime Mover Operator	15	0.5	0.04	0.02
x. Move Cask to Protected Area Gate(null background dose	30	30	1	Prime Mover Operator	15	0.5	0.25	0.00
y. Perform Security Check	5	5	2	Security Officers	2	17	2.83	0.00
z. Un-hitch On-Site Prime Mover	5	5	1	Prime Mover Operator	15	0.5	0.04	0.00
aa. Hitch Off-Site Prime Mover	5	5	1	Prime Mover Operator	15	0.5	0.04	0.00
Total	640	825					443	6
7. Prep Storage Cask from								
Storage to SNF Transfer Cell for Unloading				assume null background initially				
a. Get Transport from Transfer Facility	50	25	2	Operators	10	8.7	7.25	0.00
		25	1	Transporter Operator	15	0.5	0.21	0.00
		25	1	Radiation Protection	10	8.7	3.63	0.00
		5	1	Flagman	10	8.7	0.73	0.00
b. Remove Storage Cask from Pad	60	30	2	Operators	2	59	59.00	2.00
(assume ISFSI background dose)		60	1	Transporter Operator	15	0.5	0.50	2.00
		30	1	Radiation Protection	10	8.7	4.35	1.00
c. Secure Cask to Transporter	20	10	2	Operators	2	59	19.67	0.67
		20	1	Transporter Operator	15	0.5	0.17	0.67
		10	1	Radiation Protection	10	8.7	1.45	0.33
d. Move Cask to Staging Area(null backgd while move)	60	30	2	Operators	10	8.7	8.70	0.00
e. Open Storage Cask Prep Room Door	5	0	1	Operator	0	0	0.00	0.00
f. Move Cask to Storage Cask Prep Area	30	30	1	Operator	10	8.7	4.35	0.13
(assume crane enclosure background)		30	1	Transporter Operator	15	0.5	0.25	0.13
g. Close Storage Cask Prep Room Door	5	0	1	Operator	0	0	0.00	0.00
h. Unsecure Cask from Transporter	20	20	2	Operators	2	59	39.33	0.17
i. HP Survey Cask	60	30	2	Radiation Protection	2	59	59.00	0.25
j. Remove Storage Cask Lid	180	120	1	Operator	2	97	194.00	0.50
		20	1	Flagman	10	8.7	2.90	0.08
		20	1	Crane Operator	20	0.5	0.17	0.08
k. Move Storage Cask to Carrier	10	10	2	Operators	10	1.8	0.60	0.08
		10	1	Crane Operator	20	0.5	0.08	0.04
l. Place Storage Cask on Carrier	20	20	2	Operators	10	8.7	5.80	0.17
		20	1	Crane Operator	20	0.5	0.17	0.08
m. Secure Cask to Carrier	20	20	2	Operator	2	43	28.67	0.17

Table A1-5. MRS-Reference (continued)

	20	20	1	Crane Operator	20	0.5	0.17	0.08
m1. Close SNF Transport Cask Prep Room Door							0.00	0.00
simultaneously with y		0	1	Operator	0	0	0.00	0.00
n. Setup Remote Cutting Equipment	45	45	1	Welder	2	97	72.75	0.19
o. Cut Storage Cask Outer Lid	600	0	0	Remote	0	0	0.00	0.00
p. Remove Remote Cutting Equipment	20	20	1	Welder	2	97	32.33	0.08
q. Remove Storage Cask Outer Lid	30	30	1	Operator	2	97	48.50	0.13
		30	1	Flagman	10	8.7	4.35	0.13
		30	1	Crane Operator	20	0.5	0.25	0.13
r. Attach Gas Sampling/Venting Rig	10	10	1	Operator	2	97	16.17	0.04
s. Sample Gas Cavity	10	5	1	Operator	3	53	4.42	0.02
t. Vent Cask Cavity	10	5	1	Operator	3	53	4.42	0.02
u. Remove Sampling/Venting Rig	10	10	1	Operator	2	97	16.17	0.04
v. Loosen Cask Lid Bolts	90	80	2	Operators	2	97	258.67	0.67
w. Install Lid Handling Device	25	25	2	Operators	2	97	80.83	0.21
x. Attach Interface Fixture	30	30	2	Operators	2	97	97.00	0.25
y. Remove Platform	10	10	1	Operator	6	8.7	1.45	0.04
z. Operators Clear Prep Room	5	0	0	Operators	0	0	0.00	0.00
aa. Move Cask Under Cell Port	5	0	0	Remote	0	0	0.00	0.00
bb. Mate Cask to Port	30	0	0	Remote	0	0	0.00	0.00
cc. Open Port and Remove Cask Lid	30	0	0	Remote	0	0	0.00	0.00
		60	1	Transporter Operator	15	0.5	0.50	0.25
		30	1	Radiation Protection	10	8.7	4.35	0.13
Total	1520	1,060					1,083	11
8. Receive and Prep Loaded Rail Cask/canister								
for Marshalling and Reshipping (Flow-Through)				assume null background				
a. Inspect Bills of Lading, Other Shipping Papers	10	0	1	Operator	0	0	0.0	0.0
b. Pull Cask Into Security Area	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
c. Security Inspection	40	30	2	Security Officers	2	17	17.0	0.0
d. Perform HP Survey of Cask Externals and Trailer	30	10	2	Radiation Protection	2	43	14.3	0.0
e. Take Cask to Protected Area	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
f. Unhitch Off-Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
g. Hitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
h. Move Cask to Protected Area Gate	30	30	1	Prime Mover Operator	15	0.5	0.3	0.0
i. Prepare Shipping Paperwork	20	0	2	Security Officers	0	0	0.0	0.0
j. Un-hitch On-Site Prime Mover	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
k. Hitch Off-Site Prime Mover	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
Total	175	115					32.0	0.0

Table A1-6. MRS-TSC

Total Doses per Cask Handling for TSC at the MRS								
Revised 20 May 94/HWG	Direct	Bkgd	Sum	Rail mrem/hr		Background		
	(person-rems)			Lid doses		mrem/hr		
Transfer Rail TSC into MRS Storage	420	10	431	inner	97	area	dose	
Step - (1)				outer	60	crane	0.25	
Load Rail TSC for Storage, from truck SPS cask				Tp/fx cask lid	60	deco	1	
Steps - (2,3,4)	784	14	798	Lateral Sdn	59	pool	3	
				Storage cask mrem/hr		ISFSI	2	
Load Rail TSC for Rail shipping, from truck SPS casks				Lid doses				
Steps - (2,3,5)	1,149	44	1,193	inner	220	null	0	
				outer	97			
Get Rail TSC from MRS Storage & ship				Tp/fx cask lid	70			
Step - (6)	466	65	530	Lateral Sdn	70			
Rail Flow Through (computed on MRS-RDS flow sheet)								
Rail flow through is the same for all technologies.								

Cask Handling Operations	Total Task Time(Min.)	Dose time(Min.)	Personnel Required(Persons /Task)	Occupation	Working Distance(feet)	Cask Dose Rate(mrem/hr)	Dose Received(Person-mrem)	Facility Background Dose (Person-mrem)
1. Receive and Prep TSC for Storage				assume null background dose initially				
a. Inspect Bills of Lading, Other Shipping Papers	10	0	1	Operator	0	0	0.00	0.00
b. Pull Cask into Security Area	5	5	1	Prime Mover Operator	15	0.5	0.04	0.00
c. Security Inspection	40	30	2	Security Officers	2	17	17.00	0.00
d. Perform HP Survey of Cask Externals and Trailer	30	10	2	Radiation Protection	2	43	14.33	0.00
e. Take Cask to Protected Area	10	10	1	Prime Mover Operator	15	0.5	0.08	0.00
f. Unhitch Off-Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.08	0.00
g. Hitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.08	0.00
h. Take Cask to Receiving and Shipping Bay Door	10	10	1	Prime Mover Operator	15	0.5	0.08	0.00
hi. Open Receiving and Shipping Bay Door, simultaneous		0	1	Operator	0	0	0.00	0.00
i. Take Cask into Receiving and Shipping Bay	5	5	1	Prime Mover Operator	15	0.5	0.04	0.00
		5	1	Ragman	10	8.7	0.73	0.00
j. Unhitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.08	0.00
j1. Close Receiving and Shipping Bay Door, simultaneous		0	1	Operator	0	0	0.00	0.00
k. Remove Personnel Barrier	25	25	2	Operators	2	32	26.67	0.21
(assume crane area background dose)		25	1	Crane Operator	20	0.5	0.21	0.10
l. HP Survey	25	10	2	Radiation Protection	2	43	14.33	0.08
m. Remove Impact Limiters	90	90	2	Operators	3	32	96.00	0.75
		90	1	Crane Operator	20	0.5	0.75	0.38
n. Remove Tiedowns	50	50	2	Operators	2	32	53.33	0.42
		50	1	Crane Operator	20	0.5	0.42	0.21
o. Remove Trunnion Blocks	10	10	2	Operators	2	32	10.67	0.08
		10	1	Crane Operators	20	0.5	0.08	0.04
p. Attach Crane to Yoke	5	5	1	Operators	2	0	0.00	0.02
		5	1	Ragman	10	0	0.00	0.02
		5	1	Crane Operator	20	0	0.00	0.02
q. Engage Yoke to Cask	5	5	1	Operators	2	17	1.42	0.02
(same as MRS-MPC to this point)		5	1	Ragman	10	8.7	0.73	0.02
		5	1	Crane Operator	20	0.5	0.04	0.02
r. Open Prep Room Door	5	0	1	Operator	0	0	0.0	0.00
s. Move Cask into Cask Prep Room Washdown Area	10	10	2	Operators	10	1.8	0.6	0.08
		10	1	Crane Operator	20	0.5	0.1	0.04
s1. Install Platform	10	10	1	Operator	6	8.7	1.5	0.04
s11.Close SNF Transport Cask Prep Room Door, simultaneous		0	1	Operator	0	0	0.0	0.00
s2. Washdown Cask	30	30	2	Operators	2	17	17.0	0.25
s3.HP Survey	36	15	1	Radiation Protection	2	43	10.8	0.06
s4. Remove Platform	10	10	1	Operator	6	8.7	1.5	0.04
s5. Move Transport Cask to Carrier	10	10	2	Operators	10	1.8	0.6	0.08
		10	1	Crane Operator	20	0.5	0.1	0.04
s6. Place Transport Cask on Carrier	30	30	2	Operators	10	8.7	8.7	0.25
		30	1	Crane Operator	20	0.5	0.3	0.13
s7. Secure Cask to Carrier	20	20	2	Operators	2	59	39.33	0.17
s8. Disengage Crane with Yoke from Cask, simultaneously		10	1	Operator	2	17	2.8	0.04
		10	1	Ragman	10	8.7	1.5	0.04
		10	1	Crane Operator	20	0.5	0.1	0.04
t. Move Cask to Storage Yard	60	30	2	Operators	10	8.7	8.70	0.00
(null background dose while moving)		60	1	Transporter Operator	15	0.5	0.50	0.00

Table A1-6. MRS-TSC (continued)

		30	1	Radiation Protection	10	8.7	4.35	0.00
u. Unsecure Cask from Transporter	10	10	2	Operators	2	59	19.67	0.67
(assume ISFSI background dose)		10	1	Transporter Operator	15	0.5	0.08	0.33
		10	1	Radiation Protection	10	8.7	1.45	0.33
v. Place Storage Cask on Pad	60	30	2	Operators	2	59	59.00	2.00
		60	1	Transporter Operator	15	0.5	0.50	2.00
		30	1	Radiation Protection	10	8.7	4.35	1.00
w. Return UnloadedTransport to Transfer Facility	50	25	2	Operators	10	0	0.00	0.00
(null background dose while moving)		25	1	Transporter Operator	15	0	0.00	0.00
		25	1	Radiation Protection	10	0	0.00	0.00
Total	690	1065					420	10
2. Receive and Prep Empty TSC for Loading				assume null background dose				
a. Inspect Bills of Lading, Other Shipping Papers	10	10	1	Operator	0	0	0.00	0.00
b. Pull Cask Into Security Area	5	5	1	Prime Mover Operator	15	0	0.00	0.00
c. Security Inspection	30	30	2	Security Officers	2	0	0.00	0.00
d. Perform HP Survey of Cask Externals and Trailer	30	30	2	Radiation Protection	2	0	0.00	0.00
e. Take Cask to Protected Area	10	10	1	Prime Mover Operator	15	0	0.00	0.00
f. Unhitch Off-Site Prime Mover	10	10	1	Prime Mover Operator	15	0	0.00	0.00
g. Hitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0	0.00	0.00
h. Take Cask to Receiving and Shipping Bay Door	10	10	1	Prime Mover Operator	15	0	0.00	0.00
h1. Open Receiving and Shipping Bay							0.00	0.00
Door, simultaneously		0	1	Operator	0	0	0.00	0.00
i. Take Cask into Receiving and Shipping Bay	5	5	1	Prime Mover Operator	15	0	0.00	0.00
		5	1	Flagman	10	0	0.00	0.00
j. Unhitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0	0.00	0.00
j1. Close Receiving and Shipping Bay							0.00	0.00
Door, simultaneously		0	1	Operator	0	0	0.00	0.00
k. Remove Tiedowns	50	50	2	Operators	3	0	0.00	0.42
l. Remove Trunnion Blocks	10	10	2	Operators	3	0	0.00	0.08
(assume crane enclosure background dose)		10	1	Crane Operator	20	0	0.00	0.04
l1. Open SNF Transport Cask Prep Room							0.00	0.00
Door, simultaneously		0	1	Operator	0	0	0.00	0.00
m. Attach Crane to Yoke	5	5	1	Operator	2	0	0.00	0.02
(assume crane enclosure background dose)		5	1	Flagman	10	0	0.00	0.02
		5	1	Crane Operator	20	0	0.00	0.02
n. Engage Yoke to Cask	5	5	1	Operator	2	0	0.00	0.02
		5	1	Flagman	10	0	0.00	0.02
		5	1	Crane Operator	20	0	0.00	0.02
o. Move Cask into SNF Transport Cask Prep Room							0.00	0.00
Washdown Area	30	30	2	Operators	10	0	0.00	0.25
	30	30	1	Crane Operator	20	0	0.00	0.13
p. Install Platform	10	10	1	Operator	6	0	0.00	0.04
q. Washdown Cask	30	30	2	Operator	2	0	0.00	0.25
r. HP Survey	35	35	2	Radiation Protection	2	0	0.00	0.29
s. Remove Platform	10	10	1	Operator	6	0	0.00	0.04
t. Move Transport Cask to Carrier	10	10	2	Operators	10	0	0.00	0.08
		10	1	Crane Operator	20	0	0.00	0.04
u. Place Transport Cask on Carrier	20	20	2	Operators	10	0	0.00	0.17
		20	1	Crane Operator	20	0	0.00	0.08
v. Secure Cask to Carrier	20	20	2	Operator	2	0	0.00	0.17
	20	20	1	Crane Operator	20	0	0.00	0.08
v1. Close SNF Transport Cask Prep							0.00	0.00
Room Door simultaneously		5	1	Operator	0	0	0.00	0.02
w. Install Shield Platform	30	30	1	Operator	6	0	0.00	0.13
x. Loosen Cask Lid Bolts	90	90	2	Operators	2	0	0.00	0.75
y. Install Lid Handling Device	25	25	2	Operators	2	0	0.00	0.21
z. Attach Interface Fixture	30	30	2	Operators	2	0	0.00	0.25
aa. Remove Platform	10	10	1	Operator	6	0	0.00	0.04
bb. Operators Clear Prep Room	5	5	0	Operators	0	0	0.00	0.00
cc. Move Cask Under Cell Port	5	5	0	Remote	0	0	0.00	0.00
dd. Mate Cask to Port	30	30	0	Remote	0	0	0.00	0.00
ee. Open Port and Remove Cask Lid	30	30	0	Remote	0	0	0.00	0.00
Total	670	740					0.00	3.69
3. Load/Unload SNF (Transfer)				assume null background dose				
a. Install a Spacer	20	0	0	Remote	0	0	0.00	0.00
b. Get Bare SNF Grapple	10	0	0	Remote	0	0	0.00	0.00
c. Get and Inspect One Bare SNF assembly	10	0	0	Remote	0	0	0.00	0.00
d. Emplace Bare SNF assembly if necessary	10	0	0	Remote	0	0	0.00	0.00
e. Put Bare SNF in Can	20	0	0	Remote	0	0	0.00	0.00
f. Install Can Lid	30	0	0	Remote	0	0	0.00	0.00
Total	100	0					0.00	0.00
4. Prep TSC from SNF Transfer								
Cell for Storage				assume crane enclosure background dose				
a. From Cell, Install TSC Shield Plug	25	0	0	Remote	0	0	0.00	0.00
b. Replace Port Plug	10	0	0	Remote	0	0	0.00	0.00
c. Unmate Storage Cask from Port	10	0	0	Remote	0	0	0.00	0.00

Table A1-6. MRS-TSC (continued)

d. Open Transfer Station Door	5	0	1	Operator	0	0	0.00	0.00
e. Move Cask into Storage Cask Prep Room	30	30	1	Operator	10	8.7	4.35	0.13
f. HP Survey	60	30	2	Radiation Protection	2	59	59.00	0.25
g. Remove Inner Lid Handling Device	25	20	2	Operators	2	97	64.67	0.17
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
g1. Close Transfer Station Door, simultaneously		0	1	Operator	0	0	0.00	0.00
h. Secure Cask Bolted Inner Lid	30	30	2	Operators	2	97	97.00	0.25
i. Connect Evacuation/Inerting Equipment	10	10	1	Operator	2	97	16.17	0.04
j. Evacuate and Inert Cask	45	10	1	Operator	2	37	6.17	0.04
		45	1	Operator	10	8.7	6.53	0.19
k. Disconnect Evacuation/Inerting Equipment	5	5	1	Operator	2	97	8.08	0.02
l. Place and Seal Weld Valve Cover	90	90	1	Welder	2	97	145.50	0.38
m. Place Outer Lid	30	30	1	Operator	2	60	30.00	0.13
		30	1	Flagman	10	8.7	4.35	0.13
		30	1	Crane Operator	20	0.5	0.25	0.13
n. Secure Cask Bolted Outer Lid	30	30	2	Operators	2	60	60.00	0.25
o. HP Survey Cask	60	30	2	Radiation Protection	2	59	59.00	0.25
p. Open Storage Cask Prep Room Door	5	0	1	Operator	0	0	0.00	0.00
q. Move Cask to Storage Cask Staging Area	30	30	1	Operator	10	8.7	4.35	0.13
		30	1	Transporter Operator	15	0.5	0.25	0.13
r. Close Storage Cask Prep Room Door	5	0	1	Operator	0	0	0.00	0.00
s. Unsecure Cask from Carrier	10	10	2	Operators	2	59	19.67	0.08
t. Engage Storage Cask with Transporter	60	30	2	Operators	2	59	59.00	0.25
	60	30	1	Transporter Operator	15	0.5	0.25	0.13
u. Secure Cask to Transporter	20	20	2	Operators	2	59	39.33	0.17
v. Move Cask to Storage Yard	60	30	2	Operators	10	8.7	8.70	0.00
(null dose background while moving)		60	1	Transporter Operator	15	0.5	0.50	0.00
		30	1	Radiation Protection	10	8.7	4.35	0.00
w. Unsecure Cask from Transporter	20	10	2	Operators	2	59	19.67	0.67
(assume ISFSI background dose)		20	1	Transporter Operator	15	0.5	0.17	0.67
		10	1	Radiation Protection	10	8.7	1.45	0.33
x. Place Storage Cask on Pad	60	30	2	Operators	2	59	59.00	2.00
		60	1	Transporter Operator	15	0.5	0.50	2.00
		30	1	Radiation Protection	10	8.7	4.35	1.00
y. Return Unloaded Transport to Transfer Facility	48	25	2	Operators	10	0	0.00	0.00
(assume null dose while moving)		25	1	Transporter Operator	15	0	0.00	0.00
		25	1	Radiation Protection	10	0	0.00	0.00
Total	843	945					784	10
6. Prep TSC from SNF Transfer Cell to Ship				assume crane enclosure background dose				
a. From Cell, Install Cask Shield Plug	25	0	0	Remote	0	0	0.00	0.00
b. Replace Port Plug	10	0	0	Remote	0	0	0.00	0.00
c. Unmate Cask from Port	10	0	0	Remote	0	0	0.00	0.00
d. Open Transfer Station Door	5	0	1	Operator	0	0	0.00	0.00
e. Move Cask into Cask Prep Room	30	30	1	Operator	10	8.7	4.35	0.13
f. HP Survey	60	30	2	Radiation Protection	2	59	59.00	0.25
g. Remove Lid Handling Device	25	20	2	Operators	2	97	64.67	0.17
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
g1. Close Transfer Station Door, simultaneous		0	1	Operator	0	0	0.00	0.00
h. Secure Cask Inner Bolted Lid	30	30	2	Operators	2	97	97.00	0.25
k. Connect Evacuation/Inerting Equipment	10	10	1	Operator	2	97	16.17	0.04
l. Evacuate and Inert Cask	45	10	1	Operator	2	37	6.17	0.04
		45	1	Operator	10	8.7	6.53	0.19
m. Disconnect Evacuation/Inerting Equipment	5	5	1	Operator	2	220	18.33	0.02
l. Place and Seal Weld Valve Cover	90	90	1	Welder	2	220	330.00	0.38
i. Place Outer Lid	30	30	1	Operator	2	60	30.00	0.13
		30	1	Flagman	10	8.7	4.35	0.13
		30	1	Crane Operator	20	0.5	0.25	0.13
j. Secure Cask Bolted outer Lid	30	30	2	Operators	2	60	60.00	0.25
o. HP Survey Cask	60	30	2	Radiation Protection	2	59	59.00	0.25
n. Open Prep Area Door	5	0	1	Operator	0	0	0.00	0.00
o. Move On-Site PM and Transporter to Prep Area	10	10	1	Prime Mover Operator	15	0.5	0.08	0.04
p. Unhitch On-Site PM	5	5	1	Prime Mover Operator	15	0.5	0.04	0.02
q. Engage Yoke to Cask	10	10	1	Operator	2	17	2.83	0.04
	10	10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
q1. Close Pool Prep Area Door, simultaneous		0	1	Operator	0	0	0.00	0.00
r. Place Cask on Transporter	45	45	2	Operators	10	1.8	2.70	0.38
		45	1	Crane Operator	20	0.5	0.38	0.19
s. Perform Release HP Survey	45	20	2	Radiation Protection	2	43	28.67	0.17
t. Install Cask Restrants	70	70	2	Operators	2	43	100.3	4.7
		70	1	Prime Mover Operator	15	0.5	0.6	2.3
		70	1	Crane Operator	20	0.5	0.6	2.3
		70	1	Radiation Protection	10	8.7	10.2	2.3
u. Install Impact Limites	110	110	2	Operators	2	43	157.7	7.3
		110	1	Prime Mover Operator	15	0.5	0.9	3.7
		110	1	Crane Operator	20	0.5	0.9	3.7

Table A1-6. MRS-TSC (continued)

		110	1	Radiation Protection	10	8.7	16.0	3.7
v. Install Personnel Barrier	35	35	2	Operators	2	43	50.2	2.3
		35	1	Prime Mover Operator	15	0.5	0.3	1.2
		35	1	Crane Operator	20	0.5	0.3	1.2
		35	1	Radiation Protection	10	8.7	5.1	1.2
x. Open Receiving and Shipping Bay Door, simultaneous		0	1	Operator	0	0	0.0	0.0
x1. Hitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
x2. Prepare Shipping Papers	20	0	1	Operator	0	0	0.0	0.0
x3. Move Cask to Protected Area Gate	10	10	2	Operators	10	8.7	2.9	0.0
(assume rail siding background dose same as crane enclosure)		10	1	Prime Mover Operator	15	0.5	0.1	0.0
(assume null background while moving)		10	1	Crane Operator	20	0.5	0.1	0.0
		10	1	Radiation Protection	10	8.7	1.5	0.0
x4. Perform Security check	5	5	2	Security Officers	2	17	2.8	0.0
	5	5	2	Operators	10	8.7	1.5	0.0
		5	1	Prime Mover Operator	15	0.5	0.0	0.0
y. Make-up with other cask cars per train (assume 3 cars)	60	60	2	operator-rail	15	1.2	2.4	0.5
z. Hitch Off-Site Prime Mover	5	5	2	Operators	10	8.7	1.5	0.0
		5	1	Prime Mover Operator	15	0.5	0.0	0.0
Total	925	1590					1,149	40
6. Prep TSC from ISFSI Storage for Shipping				assume ISFSI background dose				
a. Install Cask Closure	60	60	2	Operators	2	60	120.00	4.00
		60	1	Prime Mover Operator	15	0.5	0.50	2.00
		60	1	Crane Operator	20	0.5	0.50	2.00
		60	1	Radiation Protection	10	8.7	8.70	2.00
							0.00	0.00
b. Prepare to Move Off-Site Transportation Cask From ISFSI Storage Yard	60	60	2	Operators	2	8.7	17.40	4.00
		60	1	Prime Mover Operator	15	0.5	0.50	2.00
		60	1	Crane Operator	20	0.5	0.50	2.00
		60	1	Radiation Protection	10	8.7	8.70	2.00
c. Perform Shipping HP Survey Cask	60	60	2	Operators	10	8.7	17.40	4.00
		60	1	Prime Mover Operator	15	0.5	0.50	2.00
		60	1	Crane Operator	20	0.5	0.50	2.00
		60	1	Radiation Protection	2	43	43.00	2.00
d. Decontaminate Cask	60	30	2	Operators	2	43	43.00	2.00
		60	1	Prime Mover Operator	15	0.5	0.50	2.00
		60	1	Crane Operator	20	0.5	0.50	2.00
		60	1	Radiation Protection	10	8.7	8.70	2.00
e. Install Cask Restraints	90	60	2	Operators	2	32	64.00	4.00
		60	1	Prime Mover Operator	15	0.5	0.50	2.00
		60	1	Crane Operator	20	0.5	0.50	2.00
		60	1	Radiation Protection	10	8.7	8.70	2.00
f. Install Impact Limiters	90	60	2	Operators	2	32	64.00	4.00
		60	1	Prime Mover Operator	15	0.5	0.50	2.00
		60	1	Crane Operator	20	0.5	0.50	2.00
		60	1	Radiation Protection	10	8.7	8.70	2.00
g. Install Personnel Barrier	30	30	2	Operators	2	32	32.00	2.00
		30	1	Prime Mover Operator	15	0.5	0.25	1.00
		30	1	Crane Operator	20	0.5	0.25	1.00
		30	1	Radiation Protection	10	8.7	4.35	1.00
h. Prepare Shipping Papers	18	0	1	Operator	10	8.7	0.00	0.00
		0	1	Prime Mover Operator	15	0.5	0.00	0.00
		0	1	Crane Operator	20	0.5	0.00	0.00
		0	1	Radiation Protection	10	8.7	0.00	0.00
i. Move Cask to ISFSI Protected Area Gate	10	10	2	Operators	10	8.7	2.90	0.67
(assume null background dose at gate)		10	1	Prime Mover Operator	15	0.5	0.08	0.33
		10	1	Crane Operator	20	0.5	0.08	0.33
		10	1	Radiation Protection	10	8.7	1.45	0.33
j. Unhitch On-Site PM	10	10	2	Operators	10	8.7	2.90	0.00
		10	1	Prime Mover Operator	15	0.5	0.08	0.00
k. Hitch Off-Site PM	10	10	2	Operators	10	8.7	2.90	0.00
		10	1	Prime Mover Operator	15	0.5	0.08	0.00
Total	498	1610					466	65

Table A1-7. MRS-MPU

Total Doses per Cask Handling for MPUs at the MRS				Rcs mrem/hr		Background		
Revised 2 June 94/HWG				Ud doses		mrem/hr		
	Direct	Bkgd	Sum	Inner	220	area	dose	
Load MPU for Shipping	(person-rems)			outer	97	crane	0.25	
Steps - (2,3,4,5,6,8)	1,873	71	1,945	Tp/Tx cask lid	70	decon	1	
				Lateral Skin	59	pool	3	
Load MPU for Storage				Storage cask mrem/hr		ISFSI	2	
Steps - (2,3,4,5,6,7)	1,703	28	1,731	Ud doses				
				Inner	220	null	0	
Transfer MPU into Storage				outer	97			
Steps - (1)	461	5	466	Tp/Tx cask lid	70			
				Lateral Skin	70			
Transfer MPU from storage for shipping								
Steps - (9)	551	71	622					
Rail Flow Through all technologies								
Shown on MRS- RDS spreadsheet								
Cask Handling Operations	Total Task Time(Min.)	Dose time(Min.)	Personnel Required(Persons/Task)	Occupation	Working Distances(Feet)	Cask Dose Rate(mrem/hr)	Dose Received(Person-mrem)	Facility dose background (person-mrem)
1. Receive and Prep MPU for								
Storage				assume null background dose initially				
a. Inspect Bills of Lading, Other Shipping Papers	10	10	1	Operator	0	0	0.0	0.00
b. Pull Cask into Security Area	5	5	1	Prime Mover Operator	15	0.5	0.0	0.00
c. Security Inspection	40	30	2	Security Officers	2	17	17.0	0.00
d. Perform HP Survey of Cask Externals and Trail	30	10	2	Radiation Protection	2	43	14.3	0.00
e. Take Cask to Protected Area	10	10	1	Prime Mover Operator	15	0.5	0.1	0.00
f. Unhitch Off-Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.1	0.00
g. Hitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.1	0.00
h. Take Cask to Receiving and Shipping Bay Do	10	10	1	Prime Mover Operator	15	0.5	0.1	0.00
h1. Open Receiving and Shipping Bay Door, simultaneou		0	1	Operator	0	0	0.0	0.00
i. Take Cask into Receiving and Shipping Bay	5	5	1	Prime Mover Operator	15	0.5	0.0	0.00
		5	1	Flagman	10	8.7	0.7	0.00
j. Unhitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.1	0.00
j1.Close Receiving and Shipping Bay Door, simultaneous		0	1	Operator	0	0	0.0	0.00
k. Remove Personnel Barrier	25	25	2	Operators	2	32	26.7	0.00
		25	1	Crane Operator	20	0.5	0.2	0.00
l. HP Survey	25	10	2	Radiation Protection	2	43	14.3	0.08
m. Remove Impact Limiters and Neutron Shield	90	90	2	Operators	3	32	96.0	0.75
		90	1	Crane Operator	20	0.5	0.8	0.38
n. Remove Tiedowns	50	50	2	Operators	2	32	53.3	0.42
		50	1	Crane Operator	20	0.5	0.4	0.21
o. Remove Trunnion Blocks	10	10	2	Operators	2	32	10.7	0.08
		10	1	Crane Operators	20	0.5	0.1	0.04
p. Attach Crane to Yoke	5	5	1	Operators	2	0	0.0	0.02
		5	1	Flagman	10	0	0.0	0.02
		5	1	Crane Operator	20	0	0.0	0.02
q. Engage Yoke to Cask	5	5	1	Operators	2	17	1.4	0.02
		5	1	Flagman	10	8.7	0.7	0.02
		5	1	Crane Operator	20	0.5	0.0	0.02
r. Engage Storage Cask with Transporter	60	30	2	Operators	2	59	59.0	0.25
		60	1	Radiation Protection	2	11	11.0	0.25
		60	1	Transporter Operator	15	0.5	0.5	0.25
s. Secure Cask to Transporter	20	20	2	Operators	2	59	39.3	0.17
		20	1	Radiation Protection	2	11	3.7	0.08
		20	1	Transporter Operator	15	0.5	0.2	0.08
t. Move Cask to Storage Yard	60	30	2	Operators	10	8.7	8.7	0.25
		60	1	Transporter Operator	15	0.5	0.5	0.25
		30	1	Radiation Protection	10	8.7	4.4	0.13
u. Unsecure Cask from Transporter	20	10	2	Operators	2	59	19.7	0.08
		20	1	Transporter Operator	15	0.5	0.2	0.08
		10	1	Radiation Protection	10	8.7	1.5	0.04
v. Place Storage Cask on Pad	60	30	2	Operators	2	59	59.0	0.25
		60	1	Transporter Operator	15	0.5	0.5	0.25
		30	1	Radiation Protection	10	8.7	4.4	0.13
w. Return Transport to Transfer Facility	50	25	2	Operators	10	8.7	7.3	0.21

Table A1-7. MRS-MPU (continued)

		25	1	Transporter Operator	15	0.5	0.2	0.10
		25	1	Radiation Protection	10	8.7	3.6	0.10
Total	620	1070					461	5
2. Receive Empty MPU (see MPC table Step 2)	280	8					0.00	4.65
3. Receive Unloaded Universal								
overpack (see MPC table, Step 6)	400	8					0.00	8.35
4. Load MPU into Overpack (see MPC table St	180	8					0.00	1.90
5. Prep MPU/Universal overpack for SNF transfer Cell								
a. Install Platform	10	10	1	Operator	6	0	0.00	0.0
b. Engage Crane to MPU Lift Attachment	10	10	1	Operator	2	0	0.00	0.0
		10	1	Flagman	10	0	0.00	0.0
		10	1	Crane Operator	20	0	0.00	0.0
c. Move MPU Over Storage Cask	10	10	2	Operators	10	0	0.00	0.1
		10	1	Crane Operator	20	0	0.00	0.0
d. Verify Vertical Alignment of MPU to Storage	10	10	1	Operator	2	0	0.00	0.0
		10	1	Flagman	10	0	0.00	0.0
		10	1	Crane Operator	20	0	0.00	0.0
f. Lower MPU into Storage Cask	30	30	1	Operator	2	0	0.00	0.1
		30	1	Flagman	10	0	0.00	0.1
		30	1	Crane Operator	20	0	0.00	0.1
g. Disengage MPU Lifting Attachment	10	10	1	Operator	2	0	0.00	0.0
		10	1	Flagman	10	0	0.00	0.0
		10	1	Crane Operator	20	0	0.00	0.0
h. Install a Spacer	10	10	2	Operators	2	0	0.00	0.1
		10	1	Crane Operator	20	0	0.00	0.0
i. Place MPU Shield Plug	30	30	2	Operators	2	0	0.00	0.3
		30	1	Flagman	10	0	0.00	0.1
		30	1	Crane Operator	20	0	0.00	0.1
j. Attach Interface Fixture	10	10	2	Operators	2	0	0.00	0.1
k. Remove Platform	10	10	1	Operator	6	0	0.00	0.0
l. Move Storage Cask Under Cell Port	30	30	0	Remote	0	0	0.00	0.0
m. Mate Storage Cask to Cell Port	30	30	0	Remote	0	0	0.00	0.0
n. Remove Port Plug and MPU Shield Plug	15	15	2	Operators	2	0	0.00	0.1
		15	1	Flagman	10	0	0.00	0.1
		15	1	Crane Operator	20	0	0.00	0.1
Total	215	445					0.00	1.9
6. Load SNF into MPU/Transportation- or MPU/Storage-overpack or Emplacement								
Total	100	8					0.00	0.0
7. Prep MPU/Universal-overpack from SNF transfer cell to storage				assume crane enclosure background dose				
Total	3,255	1,235					1,703	11
8. Prep MPU/Universal-overpack from SNF transfer Cell for Shipping					assume crane enclosure ba			
		110	1	Crane Operator	20	0.5	0.9	3.7
		110	1	Radiation Protection	10	8.7	16.0	3.7
nn. Install Personnel Barrier	35	35	2	Operators	2	43	50.2	2.3
		35	1	Prime Mover Operator	15	0.5	0.3	1.2
		35	1	Crane Operator	20	0.5	0.3	1.2
		35	1	Radiation Protection	10	8.7	5.1	1.2
nn1. Open Receiving and Shipping Bay Door, simultaneo		0	1	Operator	0	0	0.0	0.0
nn2. Hitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
nn3. Prepare Shipping Papers	20	0	1	Operator	0	0	0.0	0.0
oo. Move Cask to Protected Area Gate	10	10	2	Operators	10	8.7	2.9	0.0
(assume rail siding background dose same as crane en		10	1	Prime Mover Operator	15	0.5	0.1	0.0
(assume null background while moving)		10	1	Crane Operator	20	0.5	0.1	0.0
		10	1	Radiation Protection	10	8.7	1.5	0.0
pp. Perform Security check	5	5	2	Security Officers	2	17	2.8	0.0
pp1. Unhitch On-Site Prime Mover	5	5	2	Operators	10	8.7	1.5	0.0
		5	1	Prime Mover Operator	15	0.5	0.0	0.0
qq. Make-up with other cask cars per train (ass	60	60	2	operator-rail	15	1.2	2.4	0.5
rr. Hitch Off-Site Prime Mover	5	5	2	Operators	10	8.7	1.5	0.0
		5	1	Prime Mover Operator	15	0.5	0.0	0.0
Total	3,580	2,275					1,873	55
9. Prep MPU from Storage for Shipping				assume initially in ISFSI for background dose				
a. Install Cask Closure	60	60	2	Operators	2	70	140.0	4.0
		60	1	Prime Mover Operator	15	0.5	0.5	2.0
		60	1	Crane Operator	20	0.5	0.5	2.0
		60	1	Radiation Protection	10	8.7	8.7	2.0
							0.0	0.0
b. Prepare to Move Off-Site Transportation Cask From								
ISFSI Storage Yard	60	60	2	Operators	2	19.7	39.4	4.0
		60	1	Prime Mover Operator	15	0.5	0.5	2.0
		60	1	Crane Operator	20	0.5	0.5	2.0
		60	1	Radiation Protection	10	8.7	8.7	2.0

Table A1-7. MRS-MPU (continued)

c. Perform Shipping HP Survey Cask	70	70	2	Operators	10	8.7	20.3	4.7
		70	1	Prime Mover Operator	15	0.5	0.6	2.3
		70	1	Crane Operator	20	0.5	0.6	2.3
		70	1	Radiation Protection	2	43	50.2	2.3
d. Decontaminate Cask	60	5	2	Operators	2	43	7.2	0.3
(if needed)		5	1	Prime Mover Operator	15	0.5	0.0	0.2
		5	1	Crane Operator	20	0.5	0.0	0.2
		5	1	Radiation Protection	10	8.7	0.7	0.2
e. Install Cask Restraints	70	70	2	Operators	2	32	74.7	4.7
		70	1	Prime Mover Operator	15	0.5	0.6	2.3
		70	1	Crane Operator	20	0.5	0.6	2.3
		70	1	Radiation Protection	10	8.7	10.2	2.3
f. Install Impact Limiters and Neutron Shields	110	110	2	Operators	2	32	117.3	7.3
		110	1	Prime Mover Operator	15	0.5	0.9	3.7
		110	1	Crane Operator	20	0.5	0.9	3.7
		110	1	Radiation Protection	10	8.7	16.0	3.7
g. Install Personnel Barrier	35	35	2	Operators	2	32	37.3	2.3
		35	1	Prime Mover Operator	15	0.5	0.3	1.2
		35	1	Crane Operator	20	0.5	0.3	1.2
		35	1	Radiation Protection	10	8.7	5.1	1.2
h. Prepare Shipping Papers	20	0	1	Operator	10	8.7	0.0	0.0
		0	1	Prime Mover Operator	15	0.5	0.0	0.0
		0	1	Crane Operator	20	0.5	0.0	0.0
		0	1	Radiation Protection	10	8.7	0.0	0.0
h1. hitch On-Site PM	5	5	2	Operators	10	8.7	1.5	0.3
		5	1	Prime Mover Operator	15	0.5	0.0	0.2
i. Move Cask to ISFSI Protected Area Gate	10	10	2	Operators	10	8.7	2.9	0.7
		10	1	Prime Mover Operator	15	0.5	0.1	0.3
		10	1	Crane Operator	20	0.5	0.1	0.3
		10	1	Radiation Protection	10	8.7	1.5	0.3
j. Unhitch On-Site PM	5	5	2	Operators	10	8.7	1.5	0.0
(null background dose)		5	1	Prime Mover Operator	15	0.5	0.0	0.0
k. Hitch Off-Site PM	5	5	2	Operators	10	8.7	1.5	0.0
		5	1	Prime Mover Operator	15	0.5	0.0	0.0
Total	610	1,710					661.5	70.5

Table A1-8. MRS-MPC

Total Doses per Cask Handling for MPC at the MRS				Rail mrem/hr		Background	
Revised 2 June 94/HWG				Lid doses		mrem/hr	
	Direct	Bkgd	Sum	inner	220	area	dose
Load MPC for Shipping	(person-rems)			outer	97	crane	0.25
Steps - (10,11,12,13,14,16)	1,873	71	1945	Tp/Tx cask lid	70	decor	1
				Lateral Skin	59	pool	3
Load MPC for Storage				Storage cask mrem/hr		ISFSI	2
Steps - (10,11,12,13,14,15)	1,703	28	1,731	Lid doses			
				inner	220	null	0
Transfer MPC into Storage				outer	97		
Steps - (1,2,3,4)	1,438	19	1,457	Tp/Tx cask lid	70		
				Lateral Skin	70		
Transfer MPC from storage for shipping							
Steps - (5,6,7,8,9)	1,534	86	1,620				
Rail Flow Through all technologies							
Shown on MRS- RDS spreadsheet							

Cask Handling Operations	Total Task Time(Min.)	Dose time(Min.)	Personnel Required (Persons/Task)	Occupation	Working Distance(Feet)	Cask Dose Rate(mrem/hr)	Dose Received(Person-mrem)	Facility dose background (person-mrem
1. Receive and Prep MPC/Transportation-								
overpack for MPC transfer				assume null background dose initially				
a. Inspect Bills of Lading, Other Shipping Papers	10	10	1	Operator	0	0	0.0	0.00
b. Pull Cask into Security Area	5	5	1	Prime Mover Operator	15	0.5	0.0	0.00
c. Security Inspection	40	30	2	Security Officers	2	17	17.0	0.00
d. Perform HP Survey of Cask Externals and RR car	30	10	2	Radiation Protection	2	43	14.3	0.00
e. Take Cask to Protected Area	10	10	1	Prime Mover Operator	15	0.5	0.1	0.00
f. Unhitch Off-Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.1	0.00
g. Hitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.1	0.00
h. Take Cask to Receiving and Shipping Bay Door	10	10	1	Prime Mover Operator	15	0.5	0.1	0.00
hl. Open Receiving and Shipping Bay Door, simultaneous		0	1	Operator	0	0	0.0	0.00
i. Take Cask into Receiving and Shipping Bay	5	5	1	Prime Mover Operator	15	0.5	0.0	0.00
		5	1	Flagman	10	8.7	0.7	0.00
j. Unhitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.1	0.00
jl. Close Receiving and Shipping Bay Door, simultaneous		0	1	Operator	0	0	0.0	0.00
k. Remove Personnel Barrier	25	25	2	Operators	2	32	26.7	0.00
		25	1	Crane Operator	20	0.5	0.2	0.00
l. HP Survey	25	10	2	Radiation Protection	2	43	14.3	0.08
m. Remove Impact Limiters	90	90	2	Operators	3	32	96.0	0.75
		90	1	Crane Operator	20	0.5	0.8	0.38
n. Remove Tiedowns	50	50	2	Operators	2	32	53.3	0.42
		50	1	Crane Operator	20	0.5	0.4	0.21
o. Remove Trunnion Blocks	10	10	2	Operators	2	32	10.7	0.08
		10	1	Crane Operators	20	0.5	0.1	0.04
p. Attach Crane to Yoke	5	5	1	Operators	2	0	0.0	0.02
		5	1	Flagman	10	0	0.0	0.02
		5	1	Crane Operator	20	0	0.0	0.02
q. Engage Yoke to Cask	5	5	1	Operators	2	17	1.4	0.02
		5	1	Flagman	10	8.7	0.7	0.02
		5	1	Crane Operator	20	0.5	0.0	0.02
r. Open Prep Room Door	5	0	1	Operator	0	0	0.0	0.00
s. Move Cask into Transport Cask Prep Room Washdown Area	10	10	2	Operators	10	1.8	0.6	0.08
		10	1	Crane Operator	20	0.5	0.1	0.04
t. Install Platform	10	10	1	Operator	6	8.7	1.5	0.04
tl. Close SNF Transport Cask Prep Room Door, simultaneous		0	1	Operator	0	0	0.0	0.00
u. Washdown Cask	30	30	2	Operators	2	17	17.0	0.25
v. HP Survey	35	15	1	Radiation Protection	2	43	10.8	0.06
w. Remove Platform	10	10	1	Operator	6	8.7	1.5	0.04
x. Move Transport Cask to Carrier	10	10	2	Operators	10	1.8	0.6	0.08
		10	1	Crane Operator	20	0.5	0.1	0.04
y. Place Transport Cask on Carrier	30	30	2	Operators	10	8.7	8.7	0.25
		30	1	Crane Operator	20	0.5	0.3	0.13

Table A1-8. MRS-MPC (continued)

z. Secure Cask to Carrier	20	20	2	Operators	2	17	11.3	0.17
z1. Disengage Crane with Yoke from Cask, simultaneous		10	1	Operator	2	17	2.8	0.04
		10	1	Flagman	10	8.7	1.5	0.04
		10	1	Crane Operator	20	0.5	0.1	0.04
aa. Open MPC Transfer Room Door	5	0	1	Operator	0	0	0.0	0.00
bb. Move Cask Carrier into MPC Transfer Room	45	45	1	Operator	10	8.7	6.5	0.19
bb1. Close MPC Transfer Room Door		0	1	Operator	0	0	0.0	0.00
cc. Attach Vent Rig	10	10	1	Operator	2	97	16.2	0.04
dd. Vent Cask Cavity	10	5	1	Operator	2	39.4	3.3	0.02
dd1. Install Platform Extension		10	1	Operator	6	8.7	1.5	0.04
ee. Remove Vent Rig	10	10	1	Operator	2	97	16.2	0.04
ff. Install Cask Lid Lifting Device	20	20	2	Operators	2	97	64.7	0.17
		10	1	Flagman	10	8.7	1.5	0.04
		10	1	Crane Operator	20	0.5	0.1	0.04
gg. Loosen/Remove Cask Lid	60	45	2	Operators	2	97	145.5	0.38
		30	1	Flagman	10	8.7	4.4	0.13
		30	1	Crane Operator	20	0.5	0.3	0.13
hh. Install Contamination Control	10	10	2	Operators	2	43	14.3	0.08
ii. Engage MPC Crane Lifting Attachment to MPC	35	25	2	Operators	2	220	183.3	0.21
		20	1	Flagman	10	8.7	2.9	0.08
		20	1	Crane Operator	20	0.5	0.2	0.08
Total	715	1,020					754	5
2. Receive and Prep Storage-overpack								
(emplacement-overpack) for MPC Transfer				assume crane enclosure background dose				
a. Open Storage Cask Prep Room Door	5	5	1	Operator	0	0	0.0	0.02
b. Engage Crane and Yoke to Storage Cask	10	10	1	Operator	2	0	0.0	0.04
		10	1	Flagman	10	0	0.0	0.04
		10	1	Crane Operator	20	0	0.0	0.04
c. Move Cask to Empty Storage Cask Staging Area	20	20	2	Operators	10	0	0.0	0.17
		20	1	Crane Operator	20	0	0.0	0.08
c1. Close Storage Cask Prep Door, simultaneously with c.		20	1	Operator	0	0	0.0	0.08
d. HP Survey	35	35	2	Radiation Protection	2	0	0.0	0.29
e. Decontaminate Cask	60	60	2	Operators	2	0	0.0	0.50
f. Move Storage Cask to Carrier	10	10	2	Operators	2	0	0.0	0.08
		10	1	Crane Operator	20	0	0.0	0.04
g. Place Empty Storage Cask on Carrier	35	35	2	Operators	10	0	0.0	0.29
		35	1	Crane Operator	20	0	0.0	0.15
h. Secure Empty Storage Cask on Carrier	20	20	2	Operators	2	0	0.0	0.17
h1. Disengage Crane and Yoke from Storage Cask, simultaneous		20	1	Operator	2	0	0.0	0.08
		20	1	Flagman	10	0	0.0	0.08
		20	1	Crane Operator	20	0	0.0	0.08
i. Open MPC Transfer Room Door	5	5	1	Operator	0	0	0.0	0.02
j. Move Empty Storage Cask to MPC Transfer Room	45	45	2	Operators	20	0	0.0	0.38
k. Install Platform Extension	10	10	1	Operator	6	0	0.0	0.04
k1. Close MPC Transfer Room Door, simultaneous		10	1	Operator	0	0	0.0	0.04
l. Prep Empty Storage Cask for Opening	20	20	2	Operators	2	0	0.0	0.17
m. Attach Lid Lifting Device	20	20	2	Operator	2	0	0.0	0.17
		20	1	Flagman	10	0	0.0	0.08
		20	1	Crane Operator	20	0	0.0	0.08
n. Remove Cask Lid	55	55	2	Operators	2	0	0.0	0.46
		55	1	Flagman	10	0	0.0	0.23
		55	1	Crane Operator	20	0	0.0	0.23
o. Remove Lid Lifting Device	20	20	2	Operators	2	0	0.0	0.17
		20	1	Flagman	10	0	0.0	0.08
		20	1	Crane Operator	20	0	0.0	0.08
p. Install Contamination Control	20	20	2	Operators	2	0	0.0	0.17
Total	390	755					0.0	4.65
3. Transfer MPC from Transportation-								
overpack to Storage-overpack				assume crane enclosure background dose				
a. Engage Crane to MPC Lift Attachment	10	5	2	Operators	2	39.4	6.6	0.0
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
b. Verify Vertical Alignment of MPC to Transport Cask	10	10	1	Operator	2	97	16.2	0.0
c. Clear Operators to a Shielded Area	10	0	0	0	0	0	0.0	0.0
c1. Close Transfer Room Doors		0	0	Remote	0	0	0.0	0.0
d. Raise MPC from Transportation Cask	30	0	0	Remote	0	0	0.0	0.0
e. Move MPC Over Storage Cask	5	0	0	Remote	0	0	0.0	0.0
f. Verify Vertical Alignment of MPC to Storage Cask	10	0	0	Remote	0	0	0.0	0.0
g. Correct Vertical Alignment	20	0	0	Remote	0	0	0.0	0.0
h. Lower MPC into Storage Cask	30	0	0	Remote	0	0	0.0	0.0
h1. Open Transfer Room Doors		0	0	Remote	0	0	0.0	0.0
i. Radiation and Contamination Survey	45	45	2	Radiation Protection	2	59	88.5	0.4

Table A1-8. MRS-MPC (continued)

j. Remove MPC Lift Attachment from MPC	30	20	2	Operators	10	8.7	5.8	0.2
		15	1	Flagman	10	8.7	2.2	0.1
		15	1	Crane Operator	20	0.5	0.1	0.1
k. Disengage Crane from MPC Lift Attachment	10	5	2	Operators	2	39.4	6.6	0.0
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
Total	210	155					129.0	1.0
4. Prep Loaded MPC/Storage-overpack from MPC								
transfer cell to storage				assume crane enclosure background dose				
a. Remove Contamination Control From Loaded Storage C	20	20	2	Operators	2	59	39.3	0.2
b. Install Storage Cask Lid	60	30	2	Operators	2	97	97.0	0.3
		30	1	Flagman	10	8.7	4.4	0.1
		30	1	Crane Operator	20	0.5	0.3	0.1
		60	1	Welder	2	97	97.0	0.3
c. Remove Platform Extension	5	5	2	Operators	6	11	1.8	0.0
cl. Open MPC Transfer Room Door, simultaneously with c.		0	1	Operator	0	0	0.0	0.0
d. Move Loaded Storage Cask to Storage Cask Prep Room	10	10	1	Operator	10	8.7	1.5	0.0
e. Close MPC Transfer Room Door	5	0	1	Operator	0	0	0.0	0.0
f. HP Survey Cask	60	30	2	Radiation	2	59	59.0	0.3
g. Unsecure Loaded Storage Cask from Carrier	20	10	2	Operators	2	59	19.7	0.1
gl. Engage Crane with Yoke		5	2	Operators	2	39.4	6.6	0.0
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
h. Open Storage Cask Prep Room Door	5	0	1	Operator	0	0	0.0	0.0
i. Move Loaded Storage Cask to Transporter Bay	10	10	2	Operators	10	8.7	2.9	0.1
		10	1	Crane Operator	20	0.5	0.1	0.0
j. Disengage Crane from Loaded Storage Cask	10	10	2	Operators	2	39.4	13.1	0.1
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
jl. Close Storage Cask Prep Room, simultaneous		0	1	Operator	0	0	0.0	0.0
k. Engage Loaded Storage Cask with Transporter	60	30	2	Operators	2	59	59.0	0.3
		30	1	Transporter Operator	15	0.5	0.3	0.1
kl. Secure Loaded Storage Cask to Transporter for Moveme	20	20	2	Operators	2	59	39.3	0.2
l. Move Loaded Storage Cask to Storage yard	60	30	2	Operators	10	8.7	8.7	0.0
(null background dose while moving)		60	1	Transporter Operator	15	0.5	0.5	0.0
		30	1	Radiation Protection	10	8.7	4.4	0.0
m. Unsecure Loaded Storage Cask from Transporter	20	10	2	Operators	2	70	23.3	0.7
		20	1	Transporter Operator	15	0.5	0.2	0.7
		10	1	Radiation Protection	10	8.7	1.5	0.3
n. Place Loaded Storage Cask on Storage Pad	60	30	2	Operators	2	70	70.0	2.0
		60	1	Transporter Operator	15	0.5	0.5	2.0
		10	1	Radiation Protection	10	8.7	1.5	0.3
o. Return Transporter to Transfer Facility	50	25	2	Operators	10	0	0.0	0.0
(unloaded & null background dose while moving)		50	1	Transporter Operator	15	0	0.0	0.0
		25	1	Radiation Protection	10	0	0.0	0.0
Total	475	740					554.7	8.3
5. Prep Loaded MPC/Storage-overpack for MPC Transfer for shipping				assume ISFSI background dose				
a. Engage Storage Cask with Transporter	60	30	2	Operator	2	59	59.0	2.0
		30	1	Radiation Protection	2	59	29.5	1.0
		60	1	Transporter Operator	15	0.5	0.5	2.0
b. Secure Storage Cask to Transporter	20	20	2	Operators	2	59	39.3	1.3
		20	1	Radiation Protection	2	59	19.7	0.7
		20	1	Transporter Operator	15	0.5	0.2	0.7
c. Move Cask to Storage Cask Staging Area outside ISDSI	60	60	2	Operator	10	8.7	17.4	0.0
(null dose background while moving)		60	1	Flagman	10	8.7	8.7	0.0
		60	1	Crane Operator	15	0.5	0.5	0.0
d. Unsecure Storage Cask from Transporter	20	20	2	Operators	2	59	39.3	0.2
(assume crane enclosure background dose)		20	1	Radiation Protection	2	59	19.7	0.1
		20	1	Transporter Operator	15	0.5	0.2	0.1
e. Engage Crane with Yoke to Storage Cask	10	5	1	Operator	2	39.4	3.3	0.0
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
f. Move Storage Cask into Storage Cask Prep Room	10	10	2	Operators	10	8.7	2.9	0.1
		10	1	Crane Operator	20	0.5	0.1	0.0
fl. Open Storage Cask Prep Room Door, simultaneous		0	1	Operator	0	0	0.0	0.0
g. Close Storage Cask Prep Room Door	5	0	1	Operator	0	0	0.0	0.0
h. HP Survey	45	20	2	Radiation Protection	2	59	39.3	0.2
i. Move Storage Cask to Carrier	10	10	2	Operators	10	8.7	2.9	0.1
		10	1	Crane Operator	20	0.5	0.1	0.0
j. Place Cask on Carrier	35	35	2	Operators	10	8.7	10.2	0.3
		35	1	Crane Operator	20	0.5	0.3	0.1
k. Secure Cask on Carrier	20	20	2	Operators	2	59	39.3	0.2

Table A1-8. MRS-MPC (continued)

k1. Disengage Crane with Yoke from Cask, simultaneous		10	1	Operator	2	39.4	6.6	0.0
		10	1	Crane Operator	10	8.7	1.5	0.0
		10	1	Flagman	20	0.5	0.1	0.0
l. Open MPC Transfer Room Door	5	5	1	Operator	10	8.7	0.7	0.0
m. Move Cask to MPC Transfer Room	45	45	1	Operator	10	8.7	6.5	0.2
		45	1	Transporter Operator	20	0.5	0.4	0.2
m1. Close MPC Transfer Room Door, simultaneous		5	1	Operator	0	0	0.0	0.0
n. Install Platform Extension	10	10	1	Operator	3	8.7	1.5	0.0
o Prep Cask for Opening	150	30	2	Operators	2	59	59.0	0.3
		30	1	Radiation Protection	10	8.7	4.4	0.1
		90	1	Welder	2	59	88.5	0.4
p. Install Cask Lid Lifting Device	20	20	2	Operators	2	59	39.3	0.2
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
q. Remove Cask Lid	30	15	2	Operators	2	97	48.5	0.1
		30	1	Operators	10	8.7	4.4	0.1
		30	1	Operators	20	0.5	0.3	0.1
r. HP Survey	45	20	2	Radiation Protection	2	59	39.3	0.2
s. Install Contamination Control	20	20	2	Operators	2	59	39.3	0.2
t. Engage Crane MPC Lifting Attachment to MPC	35	25	2	Operators	2	39.4	32.8	0.2
		20	1	Flagman	20	0.5	0.2	0.1
		20	1	Crane Operator	20	0.5	0.2	0.1
Total	655	1,105					708.7	11.8
6. Receive and Prep Unloaded Transportation-overpack								
for MPC transfer				assume crane enclosure background dose				
a. Inspect Bills of Lading, Other Shipping Papers	10	10	1	Operator	0	0	0.0	0.0
b. Pull Cask into Security Area	5	5	1	Prime Mover Operator	15	0	0.0	0.0
c. Security Inspection	40	40	2	Security Officers	2	0	0.0	0.3
d. Perform HP Survey of Cask Externals	30	30	2	Radiation Protection	2	0	0.0	0.3
e. Perform Local Decontamination(If needed)	60	10	2	Operators	2	0	0.0	0.1
f. Contain Contamination	60	60	2	Operators	2	0	0.0	0.5
g. Take Cask to Protected Area Gate	10	10	1	Prime Mover Operator	15	0	0.0	0.0
h. Unhitch Off-Site Prime Mover	10	10	1	Prime Mover Operator	15	0	0.0	0.0
i. Hitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0	0.0	0.0
j. Take Cask to Receiving and Shipping Bay Door	10	10	1	Prime Mover Operator	15	0	0.0	0.0
j1. Open Receiving and Shipping Bay Door, simultaneous		0	1	Operator	0	0	0.0	0.0
k. Take Cask into Receiving Bay	5	5	1	Operator	10	0	0.0	0.0
		5	1	Prime Mover Operator	15	0	0.0	0.0
l. Unhitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0	0.0	0.0
l1. Close Receiving and Shipping Bay Door, simultaneous		0	1	Operator	0	0	0.0	0.0
m. Remover Personnel Barrier	35	35	2	Operators	2	0	0.0	0.3
		35	1	Crane Operator	20	0	0.0	0.1
n. HP Survey	25	25	2	Radiation Protection	2	0	0.0	0.2
o. Rope Off and Decontaminate Rail Car(If needed)	60	10	2	Operators	2	0	0.0	0.1
p. Remove Impact Limiters	90	90	2	Operators	2	0	0.0	0.8
		90	1	Crane Operators	20	0	0.0	0.4
q. HP Survey of Impact Limiter/Cask Interface	10	10	2	Radiation Protection	2	0	0.0	0.1
r. Decontaminate Impact Limiter/Cask Interface(If needed)	60	10	2	Operators	2	0	0.0	0.1
s. Remove Tiedowns	50	50	2	Operators	2	0	0.0	0.4
		50	1	Crane Operator	20	0	0.0	0.2
t. Remove Trunnion Blocks	10	10	2	Operators	2	0	0.0	0.1
u. Attach Yoke to Crane	5	5	2	Operators	2	0	0.0	0.0
		5	1	Flagman	10	0	0.0	0.0
		5	1	Crane Operator	20	0	0.0	0.0
v. Engage Yoke to Cask	5	5	2	Operators	2	0	0.0	0.0
		5	1	Flagman	10	0	0.0	0.0
		5	1	Crane Operator	20	0	0.0	0.0
w. Open Prep Room Door	5	5	1	Operator	0	0	0.0	0.0
x. Move Cask into Transport Cask Prep Room Washdown Are	10	10	2	Operators	10	0	0.0	0.1
		10	1	Crane Operator	20	0	0.0	0.0
y. Install Platform	10	10	1	Operator	6	0	0.0	0.0
y1. Close Transport Cask Prep Room Door, simultaneous		0	1	Operator	0	0	0.0	0.0
z. Washdown Cask	30	30	2	Operators	2	0	0.0	0.3
aa. HP Survey	35	30	2	Radiation Protection	2	0	0.0	0.3
bb. Remove Platform	5	5	1	Operator	6	0	0.0	0.0
cc. Move Transport Cask to Carrier	10	10	2	Operators	10	0	0.0	0.1
		10	1	Crane Operator	20	0	0.0	0.0
dd. Place Transport Cask on Carrier	30	30	2	Operators	10	0	0.0	0.3
		30	1	Crane Operator	20	0	0.0	0.1
ee. Secure Cask to Carrier	20	20	2	Operators	2	0	0.0	0.2
ee1. Disengage Crane with Yoke from Cask, simultaneous		10	1	Operator	2	0	0.0	0.0
		10	1	Flagman	10	0	0.0	0.0
		10	1	Crane Operator	20	0	0.0	0.0

Table A1-8.. MRS-MPC (continued)

ff. Open MPC Transfer Room Door	5	5	1	Operators	0	0	0.0	0.0
gg. Move Cask Carrier into MPC Transfer Room	45	45	2	Operators	10	0	0.0	0.4
gg1. Close MPC Transfer Room Door, simultaneous		0	1	Operator	0	0	0.0	0.0
ii1. Install Platform Extension, simultaneously with ii.		10	2	Operators	6	0	0.0	0.1
kk. Install Cask Lid Lifting Device	20	20	2	Operators	2	0	0.0	0.2
		20	1	Flagman	10	0	0.0	0.1
		20	1	Crane Operator	20	0	0.0	0.1
ll. Loosen/Remove Cask Lid	60	60	2	Operators	2	0	0.0	0.5
		60	1	Flagman	10	0	0.0	0.3
		60	1	Crane Operator	20	0	0.0	0.3
mm. Install Contamination Control	10	10	2	Operators	2	0	0.0	0.1
nn. Engage MPC Crane Lifting Attachment to the MPC	35	35	2	Operators	2	0	0.0	0.3
		35	1	Flagman	10	0	0.0	0.1
		35	1	Crane Operator	20	0	0.0	0.1
Total	940	1,305					0	8.35
6a. Cut open MPC (not included in any routine operation estimates)								
Total	3,375	435					1,121	
7. Transfer MPC from Storage-overpack to								
Transportation-overpack (assume in ISFSI area)				assume ISFSI initially				
a. Engage Crane to MPC Lift Attachment	10	5	1	Operators	2	39.4	3.3	0.2
		10	1	Flagman	10	11	1.8	0.3
		10	1	Crane Operator	20	0.5	0.1	0.3
b. Verify Vertical Alignment of MPC to Storage Cask	10	10	1	Operator	2	97	16.2	0.3
c. Clear Operators to a Shielded Area	5	0	0	Operators	0	0	0.0	0.0
c1. Close Transfer Room Doors		0	1	Operator	0	0	0.0	0.0
d. Raise MPC from Storage Cask	30	0	0	Remote	0	0	0.0	0.0
e. Move MPC Over Transport Cask	5	0	0	Remote	0	0	0.0	0.0
f. Verify Vertical Alignment of MPC to Transport Cask	10	0	0	Remote	0	0	0.0	0.0
g. Correct Vertical Alignment	20	0	0	Remote	0	0	0.0	0.0
h. Lower MPC into Transport Cask	30	0	0	Remote	0	0	0.0	0.0
h1. Open Transfer Room Doors		0	0	Remote	0	0	0.0	0.0
i. Radiation and Contamination Survey	10	10	2	Radiation Protection	2	43	14.3	0.7
j. Remove MPC Lift Attachment from MPC	30	20	2	Operators	2	70.0	46.7	1.3
		15	1	Flagman	10	8.7	2.2	0.5
		15	1	Crane Operator	20	0.5	0.1	0.5
k. Disengage Crane from MPC Lift Attachment	10	5	1	Operators	2	39.4	3.3	0.2
		10	1	Flagman	10	8.7	1.5	0.3
		10	1	Crane Operator	20	0.5	0.1	0.3
Total	170	120					89.5	5.0
8. Prep Unloaded Storage-overpack from MPC								
Transfer Cell to Storage Yard				assume crane enclosure background initially				
a. Remove Contamination Control from Unloaded Storage	20	20	2	Operators	2	0	0.0	0.2
b. Install Storage Cask Lid	60	60	2	Operators	2	0	0.0	0.5
		60	1	Flagman	10	0	0.0	0.3
		60	1	Crane Operator	20	0	0.0	0.3
c. Remove Platform Extension	5	5	2	Operators	6	0	0.0	0.0
c1. Open MPC Transfer Room Door, simultaneously with c.	5	5	1	Operator	0	0	0.0	0.0
d. Move Unloaded Storage Cask to Storage Cask Prep Room	10	10	2	Operators	10	0	0.0	0.1
e. Close MPC Transfer Room Door	5	5	1	Operator	0	0	0.0	0.0
f. HP Survey Cask	45	45	2	Radiation Protection	2	0	0.0	0.4
g. Engage Crane with Yoke to Storage Cask	10	10	1	Operator	2	0	0.0	0.0
		10	1	Flagman	10	0	0.0	0.0
		10	1	Crane Operator	20	0	0.0	0.0
g1. Unsecure Unloaded Storage Cask from Carrier, simultaneous		30	2	Operators	2	0	0.0	0.3
		30	1	Crane Operator	20	0	0.0	0.1
h. Open Storage Cask Prep Room Door	5	5	1	Operator	0	0	0.0	0.0
i. Move Unloaded Storage Cask to Transporter Bay	10	10	1	Operators	10	0	0.0	0.0
		10	1	Crane Operator	20	0	0.0	0.0
j. Engage Unloaded Storage Cask with Transporter	60	60	2	Operators	2	0	0.0	0.5
		60	1	Crane Operator	20	0	0.0	0.3
j1. Close Storage Cask Prep Room Door, simultaneous		0	1	Operator	20	0	0.0	0.0
k. Secure Unloaded Storage Cask to Transporter for Movem	20	20	2	Operators	2	0	0.0	0.2
k1. Disengage Crane from Unloaded Storage Cask, simultan	10	10	1	Operator	2	0	0.0	0.0
		10	1	Flagman	10	0	0.0	0.0
		10	1	Crane Operator	20	0	0.0	0.0
l. Move Unloaded Storage Cask to Storage Yard	60	60	2	Operators	10	0	0.0	0.0
(null background while moving)		60	1	Transporter Operator	15	0	0.0	0.0
		60	1	Radiation Protection	10	0	0.0	0.0
m. Unsecure Unloaded Storage Cask from Transporter	20	20	2	Operators	2	0	0.0	1.3
(assume ISFSI background dose		20	1	Transporter Operator	15	0	0.0	0.7
		20	1	Radiation Protection	10	0	0.0	0.7

Table A1-8. MRS-MPC (continued)

n. Place Unloaded Storage Cask on Storage Pad	60	60	2	Operators	2	0	0.0	4.0
		60	1	Transporter Operator	15	0	0.0	2.0
		60	1	Radiation Protection	10	0	0.0	2.0
o. Return Transporter to Transfer Facility	50	50	2	Operators	10	0	0.0	0.0
(null background while moving)		50	1	Transporter Operator	15	0	0.0	0.0
		50	1	Radiation Protection	10	0	0.0	0.0
Total	455	1,125					0.0	14.0
9. Prep MPC/Transportation-overpack from								
MPC Transfer Cell for Shipping				assume crane enclosure background dose				
a. Remove Contamination Control	20	20	2	Operators	2	43	28.7	0.2
b. Inspect MPC Transportation Cask Seal Surfaces	40	20	2	Operators	2	43	28.7	0.2
c. Install Cask Lid	30	30	2	Operators	2	70	70.0	0.3
		20	1	Flagman	10	8.7	2.9	0.1
		20	1	Crane Operator	20	0.5	0.2	0.1
d. Remove Platform Extension	5	5	1	Operator	6	8.7	0.7	0.0
d1. Open MPC Transfer Room Door, simultaneous		0	1	Operator	0	0	0.0	0.0
e. Move Transport Cask into MPC Transportation Cask Prep R	10	10	1	Operator	10	8.7	1.5	0.0
e1. Close MPC Transportation Room Door, simultaneous		0	1	Operator	0	0	0.0	0.0
f. Unsecure Cask from Carrier	10	10	2	Operators	2	43	14.3	0.1
f1. Engage Crane with Yoke to Transport Cask, simultaneous		10	1	Operator	2	17	2.8	0.0
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
g. Move Transport Cask to Washdown	10	10	2	Operators	10	8.7	2.9	0.1
		10	1	Crane Operator	20	0.5	0.1	0.0
h. Install Platform	10	10	1	Operator	6	8.7	1.5	0.0
i. Decontaminate Cask	180	180	1	Operator	6	8.7	26.1	0.8
j. HP Survey	40	20	2	Radiation Protection	2	43	28.7	0.2
k. Remove Platform	5	5	1	Operator	6	8.7	0.7	0.0
k1. Open MPC Transportation Cask Prep Room Door, simultaneous		0	1	Operator	0	0	0.0	0.0
l. Move Transport to Receiving and Shipping	10	10	2	Operator	2	8.7	2.9	0.1
		10	1	Crane Operator	20	0.5	0.1	0.0
l1. Close MPC Transportation Cask Prep Room Door, simultaneous		0	1	Operator	0	0	0.0	0.0
m. Lift Cask onto Rail Car	40	40	2	Operator	10	1.8	2.4	0.3
		40	1	Crane Operator	20	0.5	0.3	0.2
n. Disengage Yoke	10	5	1	Operator	2	17	1.4	0.0
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
o. Install Trunnion Blocks	20	20	2	Operators	2	32	21.3	0.2
		20	1	Crane Operator	20	0.5	0.2	0.1
p. HP Survey	70	70	2	Radiation Protection	2	43	100.3	0.6
		70	1	Prime Mover Operator	15	0.5	0.6	2.3
		70	1	Crane Operator	20	0.5	0.6	2.3
		70	1	Radiation Protection	2	43	50.2	2.3
q. Install Cask Restraints	70	70	2	Operators	2	43	100.3	4.7
		70	1	Prime Mover Operator	15	0.5	0.6	2.3
		70	1	Crane Operator	20	0.5	0.6	2.3
		70	1	Radiation Protection	10	8.7	10.2	2.3
r. Install Impact Limiters	110	110	2	Operators	2	43	157.7	7.3
		110	1	Prime Mover Operator	15	0.5	0.9	3.7
		110	1	Crane Operator	20	0.5	0.9	3.7
		110	1	Radiation Protection	10	8.7	16.0	3.7
s. Install Personnel Barrier	35	35	2	Operators	2	43	50.2	2.3
		35	1	Prime Mover Operator	15	0.5	0.3	1.2
		35	1	Crane Operator	20	0.5	0.3	1.2
		35	1	Radiation Protection	10	8.7	5.1	1.2
s1. Open Receiving and Shipping Bay Door, simultaneous		0	1	Operator	0	0	0.0	0.0
t. Hitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
t1. Prepare Shipping Paperwork, simultaneous	20	0	1	Operator	0	0	0.0	0.0
u. Move Cask to Protected Area Gate	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
v. Unhitch Site Prime Mover	5	5	1	Prime Mover Operator	15	0.5	0.0	0.0
k. Hitch Off-Site PM	5	5	2	Operators	10	8.7	1.45	
		5	1	Prime Mover Operator	15	0.5	0.04	
Total	770	1,730					736.2	46.6
10. Receive Empty MPC (see step 2)	280	0		assume null background dose			0.0	4.7
11. Receive Unloaded Transportation- or				assume null background dose				
Storage-overpack (see step 6)	400	0					0.0	8.4
12. Load MPC into Overpack (see step 13)	180	0		assume null background dose			0.0	1.9
13. Prep Empty MPC/Unloaded-Transportation- or								
MPC/Storage-overpack for SNF transfer Cell				assume crane enclosure background				

Table A1-8. MRS-MPC (continued)

a. Install Platform	10	10	1	Operator	6	0	0.0	0.0
b. Engage Crane to MPC Lift Attachment	10	10	1	Operator	2	0	0.0	0.0
		10	1	Flagman	10	0	0.0	0.0
		10	1	Crane Operator	20	0	0.0	0.0
c. Move MPC Over Storage Cask	10	10	2	Operators	10	0	0.0	0.1
		10	1	Crane Operator	20	0	0.0	0.0
d. Verify Vertical Alignment of MPC to Storage Cask	10	10	1	Operator	2	0	0.0	0.0
		10	1	Flagman	10	0	0.0	0.0
		10	1	Crane Operator	20	0	0.0	0.0
f. Lower MPC into Storage Cask	30	30	1	Operator	2	0	0.0	0.1
		30	1	Flagman	10	0	0.0	0.1
		30	1	Crane Operator	20	0	0.0	0.1
g. Disengage MPC Lifting Attachment	10	10	1	Operator	2	0	0.0	0.0
		10	1	Flagman	10	0	0.0	0.0
		10	1	Crane Operator	20	0	0.0	0.0
h. Install a Spacer	10	10	2	Operators	2	0	0.0	0.1
		10	1	Crane Operator	20	0	0.0	0.0
i. Place MPC Shield Plug	30	30	2	Operators	2	0	0.0	0.3
		30	1	Flagman	10	0	0.0	0.1
		30	1	Crane Operator	20	0	0.0	0.1
j. Attach Interface Fixture	10	10	2	Operators	2	0	0.0	0.1
k. Remove Platform	10	10	1	Operator	6	0	0.0	0.0
l. Move Storage Cask Under Cell Port	30	30	0	Remote	0	0	0.0	0.0
m. Mate Storage Cask to Cell Port	30	30	0	Remote	0	0	0.0	0.0
n. Remove Port Plug and MPC Shield Plug	15	15	2	Operators	2	0	0.0	0.1
		15	1	Flagman	10	0	0.0	0.1
		15	1	Crane Operator	20	0	0.0	0.1
Total	215	445					0.0	1.9
14. Load SNF into MPC/Transportation- or MPC/Storage-overpack or Emplacement				assume null background dose				
a. Install a Spacer	20	0	0	Remote	0	0	0.0	0.0
b. Get Bare SNF Grapple	10	0	0	Remote	0	0	0.0	0.0
c. Get and Inspect One Bare SNF assembly	10	0	0	Remote	0	0	0.0	0.0
d. Emplace Bare SNF assembly if necessary	10	0	0	Remote	0	0	0.0	0.0
e. Put Bare SNF in Can	20	0	0	Remote	0	0	0.0	0.0
f. Install Can Lid	30	0	0	Remote	0	0	0.0	0.0
Total	100	0					0.0	0.0
15. Prep MPC/Storage-overpack from SNF transfer cell to storage				assume crane enclosure background dose				
a. From Cell, Install MPC Inner Shield Plug&lid	25	0	0	Remote	0	0	0.0	0.0
b. Replace Port Plug	10	0	0	Remote	0	0	0.0	0.0
c. Unmate Storage Cask from Port	10	0	0	Remote	0	0	0.0	0.0
d. Open Transfer Station Door	5	0	1	Operator	0	0	0.0	0.0
e. Move Cask into Storage Cask Prep Room	30	30	1	Operator	10	8.7	4.4	0.1
f. HP Survey	60	30	2	Radiation Protection	2	59	59.0	0.3
g. Remove Lid Handling Device	25	20	2	Operators	2	220	146.7	0.2
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
g1. Close Transfer Station Door, simultaneously with g.		0	1	Operator	0	0	0.0	0.0
h. Setup Remote Welding Equipment	45	45	1	Welder	2	220	165.0	0.2
i. Weld MPC Inner Lid	1,500	0	0	Remote	0	0	0.0	0.0
j. Verify Weld	60	30	1	QA Welder	2	220	110.0	0.1
k. Remove Remote Welding Equipment	20	20	1	Welder	2	220	73.3	0.1
l. Connect Evacuation/Inerting Equipment	10	10	1	Operator	2	220	36.7	0.0
m. Evacuate and Inert MPC	45	10	1	Operator	2	37	6.2	0.0
		45	1	Operator	10	8.7	6.5	0.2
n. Disconnect Evacuation/Inerting Equipment	5	5	1	Operator	2	220	18.3	0.0
o. Place and Seal Weld Valve Cover	90	90	1	Welder	2	220	330.0	0.4
p. Place MPC Outer Lid	30	30	1	Operator	2	220	110.0	0.1
		30	1	Flagman	10	8.7	4.4	0.1
		30	1	Crane Operator	20	0.5	0.3	0.1
q. Setup Remote Welding Equipment	45	45	1	Welder	2	97	72.8	0.2
r. Weld MPC Outer Lid	600	0	0	Remote	0	0	0.0	0.0
s. Verify MPC Outer Lid Weld	60	30	1	QA Welder	2	97	48.5	0.1
t. Remove Remote Welding Equipment	20	20	1	Welder	2	97	32.3	0.1
u. Install Storage Cask Lid	180	120	1	Operator	2	97	194.0	0.5
		20	1	Flagman	10	8.7	2.9	0.1
		20	1	Crane Operator	20	0.5	0.2	0.1
v. HP Survey Cask	60	30	2	Radiation Protection	2	59	59.0	0.3
w. Open Storage Cask Prep Room Door	5	0	1	Operator	0	0	0.0	0.0
x. Move Cask to Storage Cask Staging Area	30	30	1	Operator	10	8.7	4.4	0.1
		30	1	Transporter Operator	15	0.5	0.3	0.1

Table A1-8. MRS-MPC (continued)

y. Close Storage Cask Prep Room Door	5	0	1	Operator	0	0	0.0	0.0
z. Unsecure Cask from Carrier	10	10	2	Operators	2	59	19.7	0.1
aa. Engage Storage Cask with Transporter	60	30	2	Operators	2	59	59.0	0.3
		30	1	Transporter Operator	15	0.5	0.3	0.1
bb. Secure Cask to Transporter	20	20	2	Operators	2	59	39.3	0.2
cc. Move Cask to Storage Yard	60	30	2	Operators	10	8.7	8.7	0.0
(assume null background dose while moving)		60	1	Transporter Operator	15	0.5	0.5	0.0
		30	1	Radiation Protection	10	8.7	4.4	0.0
dd. Unsecure Cask from Transporter	20	10	2	Operators	2	59	19.7	0.7
(assume ISFSI background dose)		20	1	Transporter Operator	15	0.5	0.2	0.7
		10	1	Radiation Protection	10	8.7	1.5	0.3
ee. Place Storage Cask on Pad	60	30	2	Operators	2	59	59.0	2.0
		60	1	Transporter Operator	15	0.5	0.5	2.0
		30	1	Radiation Protection	10	8.7	4.4	1.0
ff. Return Unloaded Transport to Transfer Facility	50	25	2	Operators	10	0	0.0	0.0
(assume null background dose)		25	1	Transporter Operator	15	0	0.0	0.0
		25	1	Radiation Protection	10	0	0.0	0.0
Total	3,255	1,235					1,703	11
16. Prep MPC/Transportation-overpack from								
SNF transfer Cell for Shipping				assume crane enclosure background dose				
a. From Cell, Install MPC Shield Plug	25	0	0	Remote	0	0	0.0	0.0
b. Replace Port Plug	10	0	0	Remote	0	0	0.0	0.0
c. Unmate Transportation-overpack from Port	10	0	0	Remote	0	0	0.0	0.0
d. Open Transfer Station Door	5	0	1	Operator	0	0	0.0	0.0
e. Move Cask into Storage Cask Prep Room	30	30	1	Operator	10	8.7	4.4	0.1
f. HP Survey	60	30	2	Radiation Protection	2	59	59.0	0.3
g. Remove Lid Handling Device	25	20	2	Operators	2	220	146.7	0.2
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
g1. Close Transfer Station Door, simultaneously		0	1	Operator	0	0	0.0	0.0
h. Setup Remote Welding Equipment	45	45	1	Welder	2	220	165.0	0.2
i. Weld MPC Inner Lid	1,500	0	0	Remote	0	0	0.0	0.0
j. Verify Weld	60	30	1	QA Welder	2	220	110.0	0.1
k. Remove Remote Welding Equipment	20	20	1	Welder	2	220	73.3	0.1
l. Connect Evacuation/Inerting Equipment	10	10	1	Operator	2	220	36.7	0.0
m. Evacuate and Inert MPC	45	10	1	Operator	2	37	6.2	0.0
		45	1	Operator	10	8.7	6.5	0.2
n. Disconnect Evacuation/Inerting Equipment	5	5	1	Operator	2	220	18.3	0.0
o. Place and Seal Weld Valve Cover	90	90	1	Welder	2	220	330.0	0.4
p. Place MPC Outer Lid	30	30	1	Operator	2	220	110.0	0.1
		30	1	Flagman	10	8.7	4.4	0.1
		30	1	Crane Operator	20	0.5	0.3	0.1
q. Setup Remote Welding Equipment	45	45	1	Welder	2	97	72.8	0.2
r. Weld MPC Outer Lid	600	0	0	Remote	0	0	0.0	0.0
s. Verify MPC Outer Lid Weld	60	30	1	QA Welder	2	97	48.5	0.1
t. Remove Remote Welding Equipment	20	20	1	Welder	2	97	32.3	0.1
u. Install Transportation Cask Lid	30	30	1	Operator	2	97	48.5	0.1
		20	1	Flagman	10	8.7	2.9	0.1
		20	1	Crane Operator	20	0.5	0.2	0.1
v. HP Survey Cask	60	30	2	Radiation Protection	2	59	59.0	0.3
w. Open Transportation Cask Prep Room Door	5	0	1	Operator	0	0	0.0	0.0
x. Move Cask to Transportation Cask Staging Area	30	30	1	Operator	10	8.7	4.4	0.1
		30	1	Transporter Operator	15	0.5	0.3	0.1
y. Close Transportation Cask Prep Room Door	5	0	1	Operator	0	0	0.0	0.0
z. Unsecure Cask from Carrier	10	10	2	Operators	2	59	19.7	0.1
z1. Engage Crane with Yoke to Transport Cask, simultaneous		10	1	Operator	2	17	2.8	0.0
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0
aa. Move Transport Cask to Washdown	10	10	2	Operators	10	8.7	2.9	0.1
		10	1	Crane Operator	20	0.5	0.1	0.0
bb. Install Platform	10	10	1	Operator	6	8.7	1.5	0.0
cc. Decontaminate Cask (if needed)	180	10	1	Operator	6	8.7	1.5	0.0
dd. HP Survey	40	20	2	Radiation Protection	2	43	28.7	0.2
ee. Remove Platform	5	5	1	Operator	6	8.7	0.7	0.0
ee1. Open MPC Transportation Cask Prep Room Door, simultaneous		0	1	Operator	0	0	0.0	0.0
ff. Move Transport to Receiving and Shipping	10	10	2	Operator	2	8.7	2.9	0.1
		10	1	Crane Operator	20	0.5	0.1	0.0
ff1. Close MPC Transportation Cask Prep Room Door, simultaneous		0	1	Operator	0	0	0.0	0.0
gg. Lift Cask onto Rail Car	35	35	2	Operators	10	1.8	2.1	0.3
		35	1	Crane Operator	20	0.5	0.3	0.1
hh. Disengage Yoke	10	5	1	Operator	2	17	1.4	0.0
		10	1	Flagman	10	8.7	1.5	0.0
		10	1	Crane Operator	20	0.5	0.1	0.0

Table A1-8. MRS-MPC (continued)

ii. Install Trunnion Blocks	20	20	2	Operators	2	32	21.3	0.2
		20	1	Crane Operator	20	0.5	0.2	0.1
jj. Perform Shipping HP Survey Cask(s: periphery)	70	70	2	Operators	10	8.7	20.3	4.7
		70	1	Prime Mover Operator	15	0.5	0.6	2.3
		70	1	Crane Operator	20	0.5	0.6	2.3
		70	1	Radiation Protection	2	43	50.2	2.3
kk. Decontaminate Cask	60	10	2	Operators	2	43	14.3	0.7
(if needed)		10	1	Prime Mover Operator	15	0.5	0.1	0.3
		10	1	Crane Operator	20	0.5	0.1	0.3
		10	1	Radiation Protection	10	8.7	1.5	0.3
ll. Install Cask Restraints	70	70	2	Operators	2	43	100.3	4.7
		70	1	Prime Mover Operator	15	0.5	0.6	2.3
		70	1	Crane Operator	20	0.5	0.6	2.3
		70	1	Radiation Protection	10	8.7	10.2	2.3
mm. Install Impact Limiters	110	110	2	Operators	2	43	157.7	7.3
		110	1	Prime Mover Operator	15	0.5	0.9	3.7
		110	1	Crane Operator	20	0.5	0.9	3.7
		110	1	Radiation Protection	10	8.7	16.0	3.7
nn. Install Personnel Barrier	35	35	2	Operators	2	43	50.2	2.3
		35	1	Prime Mover Operator	15	0.5	0.3	1.2
		35	1	Crane Operator	20	0.5	0.3	1.2
		35	1	Radiation Protection	10	8.7	5.1	1.2
nn1. Open Receiving and Shipping Bay Door, simultaneous		0	1	Operator	0	0	0.0	0.0
nn2. Hitch Site Prime Mover	10	10	1	Prime Mover Operator	15	0.5	0.1	0.0
nn3. Prepare Shipping Papers	20	0	1	Operator	0	0	0.0	0.0
oo. Move Cask to Protected Area Gate	10	10	2	Operators	10	8.7	2.9	0.0
(assume rail siding background dose same as crane enclosure)		10	1	Prime Mover Operator	15	0.5	0.1	0.0
(assume null background while moving)		10	1	Crane Operator	20	0.5	0.1	0.0
		10	1	Radiation Protection	10	8.7	1.5	0.0
pp. Perform Security check	5	5	2	Security Officers	2	17	2.8	0.0
pp1. Unhitch On-Site Prime Mover	5	5	2	Operators	10	8.7	1.5	0.0
		5	1	Prime Mover Operator	15	0.5	0.0	0.0
qq. Make-up with other cask cars per train (assume 3 cars)	60	60	2	operator-rail	15	1.2	2.4	0.5
rr. Hitch Off-Site Prime Mover	5	5	2	Operators	10	8.7	1.5	0.0
		5	1	Prime Mover Operator	15	0.5	0.0	0.0
Total	3,580	2,275					1,873	55

Table A1-9 through A1-12. Mined Geologic Disposal System (MGDS)

Due to lack of design detail at the MGDS, projected personnel exposures are interpolated from the MRS data. The majority of the difference in exposures is related to the different modal mix of rail and trucks expected at the MRS versus the MGDS. In addition, at the MGDS specialized activities such as the handling of HLW will take place, and the impacts are roughly estimated.

Table A1-9. MGDS-Reference

Total Doses per Cask Handling for SPSs at the MGDS						Background		
Revised 20 May 94/HWG						mrem/hr		
						area	dose	
Unload Rail Cask (obtain from MRS-RD/SPS)						crane	0.25	
						decon	1	
	Direct	Bkgd	Sum			pool	3	
Load Emplacement Cask	(person-mrems)					ISFSI	2	
Steps - (1,2)	1,030	6.60	1,036					
						null	0	
Cask Handling Operations	Total Task Time(Min.)	Dose time(Min.)	Personnel Required(Persons /Task)	Occupation	Working Distance(Feet)	Cask Dose Rate(mrem/hr)	Dose Received(Person-mrem)	Facility dose background (person-mrem)
1. Receive and Prep Empty								
Storage, Emplacement or								
Transportation Cask for Loading				assume null background dose, initially				
a. Inspect Bills of Lading, Other Shipping Papers	10	10	1	Operator	0	0	0.00	0.0
b. Pull Cask into Security Area	5	5	1	Prime Mover Operator	15	0	0.00	0.0
c. Security Inspection	30	30	2	Security Officers	2	0	0.00	0.0
d. Perform HP Survey of Cask Externals and Trailer	30	30	2	Radiation Protection	2	0	0.00	0.0
e. Take Cask to Protected Area	10	10	1	Prime Mover Operator	15	0	0.00	0.0
f. Unhitch Off-Site Prime Mover	5	5	1	Prime Mover Operator	15	0	0.00	0.0
g. Hitch Site Prime Mover	5	5	1	Prime Mover Operator	15	0	0.00	0.0
h. Take Cask to Receiving and Shipping Bay Door	10	10	1	Prime Mover Operator	15	0	0.00	0.0
h1. Open Receiving and Shipping Bay Door,							0.00	0.0
simultaneously with step h.			1	Operator	0	0	0.00	0.0
i. Take Cask into Receiving and Shipping Bay	5	5	1	Prime Mover Operator	15	0	0.00	0.0
			1	Flagman	10	0	0.00	0.0
j. Unhitch Site Prime Mover	5	5	1	Prime Mover Operator	15	0	0.00	0.0
j1. Close Receiving and Shipping Bay Door,							0.00	0.0
simultaneously with j.			1	Operator	0	0	0.00	0.0
n. Remove Tiedowns	50	50	2	Operators	3	0	0.00	0.0
o. Remove Trunnion Blocks	10	10	2	Operators	3	0	0.00	0.0
			1	Crane Operator	20	0	0.00	0.0
o1. Open SNF Cask Prep Room Door,							0.00	0.0
simultaneously with o.		10	1	Operator	0	0	0.00	0.0
p. Attach Crane to Yoke	5	5	1	Operator	2	0	0.00	0.0
			1	Flagman	10	0	0.00	0.0
			1	Crane Operator	20	0	0.00	0.0
q. Engage Yoke to Cask	5	5	1	Operator	2	0	0.00	0.0
			1	Flagman	10	0	0.00	0.0
			1	Crane Operator	20	0	0.00	0.0
r. Move Cask into SNF Cask Prep Room							0.00	0.0
Washdown Area (assume crane enclosure background dos	30	30	2	Operators	10	0	0.00	0.25
	30	30	1	Crane Operator	20	0	0.00	0.13
s. Install Platform	10	10	1	Operator	6	0	0.00	0.04
t. Washdown Cask	30	30	2	Operator	2	0	0.00	0.25
u. HP Survey	35	35	2	Radiation Protection	2	0	0.00	0.29
v. Remove Platform	10	10	1	Operator	6	0	0.00	0.04
w. Move Cask to Carrier	10	10	2	Operators	10	0	0.00	0.08
		10	1	Crane Operator	20	0	0.00	0.04
x. Place Cask on Carrier	20	20	2	Operators	10	0	0.00	0.17
		20	1	Crane Operator	20	0	0.00	0.08
y. Secure Cask to Carrier	20	20	2	Operator	2	0	0.00	0.17
	20	20	1	Crane Operator	20	0	0.00	0.08
y1 Close SNF Cask Prep Room Door							0.00	0.00
simultaneously with y			1	Operator	0	0	0.00	0.00
z Install Shield Platform	30	30	1	Operator	6	0	0.00	0.13
aa Loosen Cask Lid Bolts	90	90	2	Operators	2	0	0.00	0.75
bb Install Lid Handling Device	25	25	2	Operators	2	0	0.00	0.21
cc Attach Interface Fixture	30	30	2	Operators	2	0	0.00	0.25
dd Remove Platform	10	10	1	Operator	6	0	0.00	0.04

Table A1-9. MGDS-Reference (continued)

ee. Operators Clear Prep Room	5	5	0	Operators	0	0	0.00	0.00
ff. Move Cask Under Cell Port	5	5	0	Remote	0	0	0.00	0.00
gg. Mate Cask to Port	30	30	0	Remote	0	0	0.00	0.00
hh. Open Port and Remove Cask Lid	30	30	0	Remote	0	0	0.00	0.00
Total	665	695					0.00	3
2. Prep Emplacement Cask from SNF Transfer Cell for Emplacement				assume crane enclosure background dose				
a. From Cell, Install Shield Plug	25	0	0	Remote	0	0	0.00	0.00
b. Replace Port Plug	10	0	0	Remote	0	0	0.00	0.00
c. Unmate Emplacement Cask from Port	10	0	0	Remote	0	0	0.00	0.00
d. Open Transfer Station Door	5	5	1	Operator	0	0	0.00	0.02
e. Move Cask into Storage Cask Prep Room	30	30	1	Operator	10	11	5.50	0.13
f. HP Survey	60	30	2	Radiation Protection	2	59	59.00	0.25
g. Remove Inner Lid Handling Device	25	20	2	Operators	2	220	146.67	0.17
		10	1	Flagman	10	11	1.83	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
g1. Close Transfer Station Door, simultaneous		0	1	Operator	0	0	0.00	0.00
h. Setup Remote Welding Equipment	45	45	1	Welder	2	220	165.00	0.19
i. Weld Storage Casks Outer Lid	600	0	0	Remote	0	0	0.00	0.00
j. Verify Storage Casks Outer Lid Weld	60	30	1	QA Welder	2	97	48.50	0.13
k. Remove Remote Welding Equipment	20	20	1	Welder	2	97	32.33	0.08
l. Connect Evacuation/Inerting Equipment	10	10	1	Operator	2	97	16.17	0.04
m. Evacuate and Inert Cask	45	10	1	Operator	2	37	6.17	0.04
		45	1	Operator	10	8.5	6.38	0.19
n. Disconnect Evacuation/Inerting Equipment	5	5	1	Operator	2	97	8.08	0.02
o. Place and Seal Weld Valve Cover	90	90	1	Welder	2	97	145.50	0.38
p. Place Emplacement Outer Lid	30	30	1	Operator	2	97	48.50	0.13
		30	1	Flagman	10	8.5	4.25	0.13
		30	1	Crane Operator	20	0.5	0.25	0.13
q. Setup Remote Welding Equipment	45	45	1	Welder	2	97	72.75	0.19
r. Weld Emplacement Casks Outer Lid	600	0	0	Remote	0	0	0.00	0.00
s. Verify Emplacement Casks Outer Lid Weld	60	30	1	QA Welder	2	97	48.50	0.13
t. Remove Remote Welding Equipment	20	20	1	Welder	2	97	32.33	0.08
u. HP Survey Cask	60	30	2	Radiation Protection	2	59	59.00	0.25
v. Open Storage Cask Prep Room Door	5	0	1	Operator	0	0	0.00	0.00
w. Move Emplacement Cask Underground	30	30	1	Operator	10	8.5	4.25	0.13
		30	1	Transporter Operator	15	0.5	0.25	0.13
x. Close Storage Cask Prep Room Door	5	0	1	Operator	0	0	0.00	0.00
y. Unsecure Cask from Carrier	10	10	2	Operators	2	59	19.67	0.08
z. Engage Storage Cask with Transporter	60	30	2	Operators	2	59	59.00	0.25
	60	30	1	Transporter Operator	15	0.5	0.25	0.13
aa. Secure Cask to Transporter	20	20	2	Operators	2	59	39.33	0.17
Total	2045	725					1,030	4

Table A1-10. MGDS-TSC

Total Doses per Cask Handling for TSC at the MGDS				Rail mrem/hr		Background		
Revised 3 June 1994,HWG	Direct	Bkgd	Sum	Lid doses		mrem/hr		
Unload TSC	(person-mrem)			inner	97	area	dose	
Steps - (1)	894	5.10	899	outer	60	crane	0.25	
				Tp/Tx cask lid	60	deco	1	
Load Emplacement is described in the MGDS-RD/SPS spreadsheet				Lateral Skin	59	pool	3	
						ISFSI	2	
						null	0	
Cask Handling Operations	Total Task Time(Min.)	Dose time(Min.)	Personnel Required (Persons /Task)	Occupation	Working Distance(Feet)	Cask Dose Rate(mrem/hr)	Dose Received(Person-mrem)	Facility dose background (person-mrem)
1. Receive and Prep Loaded TSC								
for Unloading				assume null background dose, initially				
a. Inspect Bills of Lading, Other Shipping Papers	10	0	1	Operator	0	0	0.00	0.00
b. Pull Cask into Security Area	5	5	1	Prime Mover Operato	15	0.5	0.04	0.00
c. Security Inspection	30	20	2	Security Officers	2	17	11.33	0.00
d. Perform HP Survey of Cask Externals and Traile	30	10	2	Radiation Protection	2	43	14.33	0.00
e. Take Cask to Protected Area	10	10	1	Prime Mover Operato	15	0.5	0.08	0.00
f. Unhitch Off-Site Prime Mover	10	10	1	Prime Mover Operato	15	0.5	0.08	0.00
g. Hitch Site Prime Mover	10	10	1	Prime Mover Operato	15	0.5	0.08	0.00
h. Take Cask to Receiving and Shipping Bay Do	10	10	1	Prime Mover Operato	15	0.5	0.08	0.00
h1. Open Receiving and Shipping Bay Door,							0.00	0.00
simultaneously with step h.		0	1	Operator	0	0	0.00	0.00
i. Take Cask into Receiving and Shipping Bay	5	5	1	Prime Mover Operato	15	0.5	0.04	0.00
		5	1	Flagman	10	8.7	0.73	0.00
j. Unhitch Site Prime Mover	10	10	1	Prime Mover Operato	15	0.5	0.08	0.00
j1. Close Receiving and Shipping Bay Door,							0.00	0.00
simultaneously with j.		0	1	Operator	0	0	0.00	0.00
k. Remove Personnel Barrier	25	25	2	Operators	3	32	26.67	0.21
(assume crane enclosure background dose)		25	1	Crane Operator	20	0.5	0.21	0.10
l. HP Survey	25	10	2	Radiation Protection	2	43	14.33	0.08
m. Remove Impact Limiters	60	60	2	Operators	3	32	64.00	0.50
		60	1	Crane Operator	20	0.5	0.50	0.25
n. Remove Tiedowns	10	10	2	Operators	3	32	10.67	0.08
o. Remove Trunnion Blocks	10	10	2	Operators	3	32	10.67	0.08
		10	1	Crane Operator	20	0.5	0.08	0.04
o1. Open SNF Transport Cask Prep Room Door,							0.00	0.00
simultaneously with o.		0	1	Operator	0	0	0.00	0.00
p. Attach Crane to Yoke	5	5	1	Operator	2	0	0.00	0.02
		5	1	Flagman	10	0	0.00	0.02
		5	1	Crane Operator	20	0	0.00	0.02
q. Engage Yoke to Cask	5	5	1	Operator	2	17	1.42	0.02
		5	1	Flagman	10	8.7	0.73	0.02
		5	1	Crane Operator	20	0.5	0.04	0.02
r. Move Cask into SNF Transport Cask Prep Room							0.00	0.00
Washdown Area	30	30	2	Operators	10	1.8	1.80	0.25
	30	30	1	Crane Operator	20	0.5	0.25	0.13
s. Install Platform	10	10	1	Operator	6	8.7	1.45	0.04
t. Washdown Cask	30	25	2	Operator	2	17	14.17	0.21
u. HP Survey	35	15	2	Radiation Protection	2	43	21.50	0.13
v. Remove Platform	10	10	1	Operator	6	8.7	1.45	0.04
w. Move Transport Cask to Carrier	10	10	2	Operators	10	1.8	0.60	0.08
		10	1	Crane Operator	20	0.5	0.08	0.04
x. Place Transport Cask on Carrier	20	20	2	Operators	10	8.7	5.80	0.17
		20	1	Crane Operator	20	0.5	0.17	0.08
y. Secure Cask to Carrier	20	20	2	Operator	2	43	28.67	0.17
	20	20	1	Crane Operator	20	0.5	0.17	0.08
y1. Close SNF Transport Cask Prep Room Door							0.00	0.00
simultaneously with y		0	1	Operator	0	0	0.00	0.00

Table A1-10. MGDS-TSC (continued)

z. Install Shield Platform	30	30	1	Operator	6	8.7	4.35	0.13
aa. Attach Gas Sampling/Venting Rig	10	10	1	Operator	2	60	10.00	0.04
bb. Sample Gas Cavity	10	5	1	Operator	3	53	4.42	0.02
cc. Vent Cask Cavity	10	5	1	Operator	3	53	4.42	0.02
dd. Remove Sampling/Venting Rig	10	10	1	Operator	2	60	10.00	0.04
ee. Install Cask Lid Lifting Device	20	20	2	Operators	2	60	40.00	0.17
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
ff. Loosen/Remove Outer Cask Lid	90	45	2	Operators	2	97	145.50	0.38
		20	1	Flagman	10	8.7	2.90	0.08
		20	1	Crane Operator	20	0.5	0.17	0.08
gg. Loosen Inner TSC Lid Bolts	90	80	2	Operators	2	97	258.67	0.67
hh. Install Lid Handling Device	25	25	2	Operators	2	97	80.83	0.21
ii. Attach Interface Fixture	30	30	2	Operators	2	97	97.00	0.25
jj. Remove Platform	10	10	1	Operator	6	8.7	1.45	0.04
kk. Operators Clear Prep Room	5	0	0	Operators	0	0	0.00	0.00
ll. Move Cask Under Cell Port	5	0	0	Remote	0	0	0.00	0.00
mm. Mate Cask to Port	30	0	0	Remote	0	0	0.00	0.00
nn. Open Port and Remove Inner Cask Lid	30	0	0	Remote	0	0	0.00	0.00
Total	890	885					894	5.10

Table A1-11 MGDS-MPU

Total Doses per Cask Handling for MPU at the MGDS						Background		
Revised 3 June 94/HWG						mrem/hr		
	Direct	Bkgd	Sum			area	dose	
Transfer MPU into Emplacement	(person-mems)					crane	0.25	
Steps - (1,2,3,4)	1,616	15.00	1,631			deco	1	
						pool	3	
						ISFSI	2	
						null	0	
Cask Handling Operations	Total Task Time(Min.)	Dose time(Min.)	Personnel Required (Persons/Task)	Occupation	Working Distance(Feet)	Cask Dose Rate (mrem/hr)	Dose(Person-mrem)	Facility dose background person-mrem
1. Receive and Prep MPU/Transportation-								
overpack for MPU transfer				assume null background dose, initially				
a .Inspect Bills of Lading, Other Shipping Paper:	10	10	1	Operator	0	0	0.00	0.00
b. Pull Cask into Security Area	5	5	1	Prime Mover Operato	15	0.5	0.04	0.00
c. Security Inspection	40	25	2	Security Officers	2	17	14.17	0.00
d. Perform HP Survey of Cask Externals and Trailer	40	10	2	Radiation Protection	2	43	14.33	0.00
e. Unhitch Off-Site Prime Mover	10	10	1	Prime Mover Operato	15	0.5	0.08	0.00
f. Hitch Site Prime Mover	10	10	1	Prime Mover Operato	15	0.5	0.08	0.00
g. Take Cask to Receiving and Shipping Bay Door	10	10	1	Prime Mover Operato	15	0.5	0.08	0.00
gl. Open Receiving and Shipping Bay Door, simultaneous.		0	1	Operator	0	0	0.00	0.00
h. Take Cask into Receiving and Shipping Bay	5	5	1	Prime Mover Operato	15	0.5	0.04	0.00
		5	1	Flagman	10	8.7	0.73	0.00
i. Unhitch Site Prime Mover	10	10	1	Prime Mover Operato	15	0.5	0.08	0.00
il. Close Receiving and Shipping Bay Door, simultaneous		0	1	Operator	0	0	0.00	0.00
j. Remove Personnel Barrier	30	30	2	Operators	2	32	32.00	0.25
(assume crane enclosure background dose)		25	1	Crane Operator	20	0.5	0.21	0.10
k. HP Survey	45	20	2	Radiation Protection	2	43	28.67	0.17
l. Remove Impact Limiters	110	110	2	Operators	3	32	117.33	0.92
		110	1	Crane Operator	20	0.5	0.92	0.46
m. Remove Tiedowns	45	45	2	Operators	2	32	48.00	0.38
		45	1	Crane Operator	20	0.5	0.38	0.19
n. Remove Trunnion Blocks	10	10	2	Operators	2	32	10.67	0.08
		10	1	Crane Operators	20	0.5	0.08	0.04
o. Attach Crane to Yoke	5	5	1	Operators	2	0	0.00	0.02
		5	1	Flagman	10	0	0.00	0.02
		5	1	Crane Operator	20	0	0.00	0.02
p. Engage Yoke to Cask	6	5	1	Operators	2	17	1.42	0.02
		5	1	Flagman	10	8.7	0.73	0.02
		5	1	Crane Operator	20	0.5	0.04	0.02
q. Open Prep Room Door	5	0	1	Operator	0	0	0.00	0.00
r. Move Cask into Cask Prep Room Washdown Area	10	10	2	Operators	10	1.8	0.60	0.08
		10	1	Crane Operator	20	0.5	0.08	0.04
s. Install Platform	10	10	1	Operator	6	8.7	1.45	0.04
t. Close SNF Cask Prep Room Door, simultaneously		0	1	Operator	0	0	0.00	0.00
u. Washdown Cask	55	45	2	Operators	2	17	25.50	0.38
v. HP Survey	65	25	1	Radiation Protection	2	43	17.92	0.10
w. Remove Platform	10	10	1	Operator	6	8.7	1.45	0.04
x. Move Transport Cask to Carrier	10	10	2	Operators	10	1.8	0.60	0.08
		10	1	Crane Operator	20	0.5	0.08	0.04
y. Place Transport Cask on Carrier	20	20	2	Operators	10	8.7	5.80	0.17
		20	1	Crane Operator	20	0.5	0.17	0.08
z. Secure Cask to Carrier	20	20	2	Operators	2	17	11.33	0.17
zl . Disengage Crane with Yoke from Cask, simultaneous		10	1	Operator	2	17	2.83	0.04
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
aa. Open MPU Transfer Room Door	5	0	1	Operator	0	0	0.00	0.00
bb. Move Cask Carrier into Transfer Room	45	45	1	Operator	10	8.7	6.53	0.19
bbl. CloseTransfer Room Door		0	1	Operator	0	0	0.00	0.00
cc. Attach Vent Rig	10	10	1	Operator	2	70	11.67	0.04
dd. Sample Gas Cavity	10	5	1	Operator	3	53	4.42	0.02
ee.. Vent Cask Cavity	20	10	1	Operator	2	39.4	6.57	0.04

Table A1-11 MGDS-MPU (continued)

ee1. Install Platform Extension		10	1	Operator	6	8.7	1.45	0.04
ff. Remove Vent Rig	10	10	1	Operator	2	70	11.67	0.04
gg. Install Cask Lid Lifting Device	25	25	2	Operators	2	70	58.33	0.21
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
hh. Loosen/Remove Cask Lid	160	40	2	Operators	2	70	93.33	0.33
		20	1	Flagman	10	8.7	2.90	0.08
		20	1	Crane Operator	20	0.5	0.17	0.08
ii. Install Contamination Control	10	10	2	Operators	2	43	14.33	0.08
jj. Engage MPC Crane Lifting Attachment to MPU	40	25	2	Operators	2	97	80.83	0.21
		20	1	Flagman	10	8.7	2.90	0.08
		20	1	Crane Operator	20	0.5	0.17	0.08
Total	931	1045					636	5.69
2. Receive and Prep Storage-overpack (Emplacement-overpack) for MPU Transfer				assume crane area background				
a. Open Cask Prep Room Door	5	5	1	Operator	0	0	0.00	0.02
b. Engage Crane and Yoke to Storage Cask	10	10	1	Operator	2	0	0.00	0.04
		10	1	Flagman	10	0	0.00	0.04
		10	1	Crane Operator	20	0	0.00	0.04
c. Move Cask to Empty Cask Staging Area	20	20	2	Operators	10	0	0.00	0.17
		20	1	Crane Operator	20	0	0.00	0.08
c1. Close Cask Prep Door, simultaneously with c.		20	1	Operator	0	0	0.00	0.08
d. HP Survey	35	35	2	Radiation Protection	2	0	0.00	0.29
e. Decontaminate Cask	60	60	2	Operators	2	0	0.00	0.50
f. Move Storage Cask to Carrier	10	10	2	Operators	2	0	0.00	0.08
		10	1	Crane Operator	20	0	0.00	0.04
g. Place Empty Storage Cask on Carrier	35	35	2	Operators	10	0	0.00	0.29
		35	1	Crane Operator	20	0	0.00	0.15
h. Secure Empty Storage Cask on Carrier	20	20	2	Operators	2	0	0.00	0.17
h1. Disengage Crane and Yoke from Storage Cask, simultaneou		20	1	Operator	2	0	0.00	0.08
		20	1	Flagman	10	0	0.00	0.08
		20	1	Crane Operator	20	0	0.00	0.08
i. Open Transfer Room Door	5	5	1	Operator	0	0	0.00	0.02
j. Move Empty Storage Cask to Transfer Room	45	45	2	Operators	20	0	0.00	0.38
k. Install Platform Extension	10	10	1	Operator	6	0	0.00	0.04
k1. Close Transfer Room Door, simultaneously		10	1	Operator	0	0	0.00	0.04
l. Prep Empty Storage Cask for Opening	20	20	2	Operators	2	0	0.00	0.17
m. Attach Lid Lifting Device	20	20	2	Operator	2	0	0.00	0.17
		20	1	Flagman	10	0	0.00	0.08
		20	1	Crane Operator	20	0	0.00	0.08
n. Remove Cask Lid	55	55	2	Operators	2	0	0.00	0.46
		55	1	Flagman	10	0	0.00	0.23
		55	1	Crane Operator	20	0	0.00	0.23
o. Remove Lid Lifting Device	20	20	2	Operators	2	0	0.00	0.17
		20	1	Flagman	10	0	0.00	0.08
		20	1	Crane Operator	20	0	0.00	0.08
p. Install Contamination Control	20	20	2	Operators	2	0	0.00	0.17
Total	390	755					0.00	4.65
3. Transfer MPU from Transportation- overpack to Storage-overpack (Emplacement-overpack)				asssume crane enclosure background dose				
a. Engage Crane to MPU Lift Attachment	10	5	2	Operators	2	39.4	6.57	0.04
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
b. Verify Vertical Alignment of MPC to Transport Cask	10	10	1	Operator	2	97	16.17	0.04
c. Clear Operators to a Shielded Area	10	0	0	0	0	0	0.00	0.00
c1. Close Transfer Room Doors		0	0	Remote	0	0	0.00	0.00
d. Raise MPU from Transportation Cask	30	0	0	Remote	0	0	0.00	0.00
e. Move MPU Over Storage Cask	5	0	0	Remote	0	0	0.00	0.00
f. Verify Vertical Alignment of MPU to Storage Cask	10	0	0	Remote	0	0	0.00	0.00
g. Correct Vertical Alignment	20	0	0	Remote	0	0	0.00	0.00
h. Lower MPC into Storage Cask	30	0	0	Remote	0	0	0.00	0.00
h1. Open Transfer Room Doors		0	0	Remote	0	0	0.00	0.00
i. Radiation and Contamination Survey	45	45	2	Radiation Protection	2	59	88.50	0.38
j. Remove MPC Lift Attachment from MPU	30	20	2	Operators	10	8.7	5.80	0.17
		15	1	Flagman	10	8.7	2.18	0.06
		15	1	Crane Operator	20	0.5	0.13	0.06
k. Disengage Crane from MUC Lift Attachment	10	5	2	Operators	2	39.4	6.57	0.04
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
Total	210	155					129	0.96
4. Prep MPU/Emplacement-overpack from								

Table A1-11 MGDS-MPU (continued)

Transfer Cell for Emplacement				assume crane enclosure background dose				
a. Remove Contamination Control From Loaded Storage C	20	20	2	Operators	2	59	39.33	0.17
b. Install Inner Emplacement Lid	60	30	2	Operators	2	97	97.00	0.25
		30	1	Flagman	10	8.7	4.35	0.13
		30	1	Crane Operator	20	0.5	0.25	0.13
c. Setup Remote Welding Equipment	45	45	1	Welder	2	97	72.75	0.19
d. Weld MPU Inner Lid	1500	0	0	Remote	0	0	0.00	0.00
e. Verify Weld	60	30	1	QA Welder	2	97	48.50	0.13
f. Remove Remote Welding Equipment	20	20	1	Welder	2	97	32.33	0.08
g. Connect Evacuation/Inerting Equipment	10	10	1	Operator	2	97	16.17	0.04
h. Evacuate and Inert Emplacement	45	10	1	Operator	2	37	6.17	0.04
		45	1	Operator	10	8.7	6.53	0.19
i. Disconnect Evacuation/Inerting Equipment	5	5	1	Operator	2	97	8.08	0.02
j. Place and Seal Weld Valve Cover	90	90	1	Welder	2	97	145.50	0.38
k. Place Emplacement Outer Lid	30	30	1	Operator	2	97	48.50	0.13
		30	1	Flagman	10	8.7	4.35	0.13
		30	1	Crane Operator	20	0.5	0.25	0.13
l. Setup Remote Welding Equipment	45	45	1	Welder	2	97	72.75	0.19
m. Weld Emplacement Outer Lid	600	0	0	Remote	0	0	0.00	0.00
n. Verify Emplacement Outer Lid Weld	60	30	1	QA Welder	2	97	48.50	0.13
o. Remove Remote Welding Equipment	20	20	1	Welder	2	97	32.33	0.08
p. Remove Platform Extension	5	5	2	Operators	6	11	1.83	0.04
pl.Open Emplacement Transfer Room Door, simultaneously		0	1	Operator	0	0	0.00	0.00
q. Move Loaded Storage Cask to Storage Cask Prep Room	10	10	1	Operator	10	8.7	1.45	0.04
r. Close Emplacement Transfer Room Door	5	0	1	Operator	0	0	0.00	0.00
s. HP Survey Cask	60	30	2	Radiation	2	59	59.00	0.25
t. Unsecure Loaded Emplacement Cask from Carrier	20	10	2	Operators	2	59	19.67	0.08
tl. Engage Crane with Yoke		5	2	Operators	2	39.4	6.57	0.04
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
u. Open Emplacement Cask Prep Room Door	5	0	1	Operator	0	0	0.00	0.00
v. Move Loaded Emplacement Cask to Transporter Bay	10	10	2	Operators	10	8.7	2.90	0.08
		10	1	Crane Operator	20	0.5	0.08	0.04
w. Disengage Crane from Loaded Emplacement Cask	10	10	2	Operators	2	39.4	13.13	0.08
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
wl. Close Emplacement Cask Prep Room, simultaneously		0	1	Operator	0	0	0.00	0.00
x. Engage Loaded Emplacement Cask with Transporter	60	30	2	Operators	2	59	59.00	0.25
xl. Secure Loaded Emplacement Cask to Transporter for Move		30	1	Transporter Operator	15	0.5	0.25	0.13
Total	2795	740					851	3.71

Table A1-12 MGDS-MPC

Total Doses per Cask Handling for MPC at the MGDS						Background		
Revised 3 June 94/HWG						mrem/hr		
	Direct	Bkgd	Sum			area	dose	
Transfer MPC into Emplacement	(person-mrems)					crane	0.25	
Steps - (1,2,3,4)	1,616	15.00	1,631			deco	1	
						pool	3	
						ISFSI	2	
						null	0	
Cask Handling Operations	Total Task Time(Min.)	Dose time(Min.)	Personnel Required (Persons/Task)	Occupation	Working Distance(Feet)	Cask Dose Rate (mrem/hr)	Dose(Person-mrem)	Facility dose background person-mrem
1. Receive and Prep MPC/Transportation-								
overpack for MPC transfer				assume null background dose, initally				
a .Inspect Bills of Lading, Other Shipping Papers	10	10	1	Operator	0	0	0.00	0.00
b. Pull Cask into Security Area	5	5	1	Prime Mover Operato	15	0.5	0.04	0.00
c. Security Inspection	40	25	2	Security Officers	2	17	14.17	0.00
d. Perform HP Survey of Cask Externals and Trailer	40	10	2	Radiation Protection	2	43	14.33	0.00
e. Unhitch Off-Site Prime Mover	10	10	1	Prime Mover Operato	15	0.5	0.08	0.00
f. Hitch Site Prime Mover	10	10	1	Prime Mover Operato	15	0.5	0.08	0.00
g. Take Cask to Receiving and Shipping Bay Door	10	10	1	Prime Mover Operato	15	0.5	0.08	0.00
gl. Open Receiving and Shipping Bay Door, simultaneous.		0	1	Operator	0	0	0.00	0.00
h. Take Cask into Receiving and Shipping Bay	5	5	1	Prime Mover Operato	15	0.5	0.04	0.00
		5	1	Flagman	10	8.7	0.73	0.00
i. Unhitch Site Prime Mover	10	10	1	Prime Mover Operato	15	0.5	0.08	0.00
Il. Close Receiving and Shipping Bay Door, simultaneous		0	1	Operator	0	0	0.00	0.00
j. Remove Personnel Barrier	30	30	2	Operators	2	32	32.00	0.25
(assume crane enclosure background dose)		25	1	Crane Operator	20	0.5	0.21	0.10
k. HP Survey	45	20	2	Radiation Protection	2	43	28.67	0.17
l. Remove Impact Limiters	110	110	2	Operators	3	32	117.33	0.92
		110	1	Crane Operator	20	0.5	0.92	0.46
m. Remove Tiedowns	45	45	2	Operators	2	32	48.00	0.38
		45	1	Crane Operator	20	0.5	0.38	0.19
n. Remove Trunnion Blocks	10	10	2	Operators	2	32	10.67	0.08
		10	1	Crane Operators	20	0.5	0.08	0.04
o. Attach Crane to Yoke	5	5	1	Operators	2	0	0.00	0.02
		5	1	Flagman	10	0	0.00	0.02
		5	1	Crane Operator	20	0	0.00	0.02
p. Engage Yoke to Cask	6	5	1	Operators	2	17	1.42	0.02
		5	1	Flagman	10	8.7	0.73	0.02
		5	1	Crane Operator	20	0.5	0.04	0.02
q. Open Prep Room Door	5	0	1	Operator	0	0	0.00	0.00
r. Move Cask into Cask Prep Room Washdown Area	10	10	2	Operators	10	1.8	0.60	0.08
		10	1	Crane Operator	20	0.5	0.08	0.04
s. Install Platform	10	10	1	Operator	6	8.7	1.45	0.04
t. Close SNF Cask Prep Room Door, simultaneously		0	1	Operator	0	0	0.00	0.00
u. Washdown Cask	55	45	2	Operators	2	17	25.50	0.38
v. HP Survey	65	25	1	Radiation Protection	2	43	17.92	0.10
w. Remove Platform	10	10	1	Operator	6	8.7	1.45	0.04
x. Move Transport Cask to Carrier	10	10	2	Operators	10	1.8	0.60	0.08
		10	1	Crane Operator	20	0.5	0.08	0.04
y. Place Transport Cask on Carrier	20	20	2	Operators	10	8.7	5.80	0.17
		20	1	Crane Operator	20	0.5	0.17	0.08
z. Secure Cask to Carrier	20	20	2	Operators	2	17	11.33	0.17
zl . Disengage Crane with Yoke from Cask, simultaneous		10	1	Operator	2	17	2.83	0.04
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
aa. Open MPC Transfer Room Door	5	0	1	Operator	0	0	0.00	0.00
bb. Move Cask Carrier into MPC Transfer Room	45	45	1	Operator	10	8.7	6.53	0.19
bbl. Close MPC Transfer Room Door		0	1	Operator	0	0	0.00	0.00
cc. Attach Vent Rig	10	10	1	Operator	2	70	11.67	0.04
dd Sample Gas Cavity	10	5	1	Operator	3	53	4.42	0.02
ee.. Vent Cask Cavity	20	10	1	Operator	2	39.4	6.57	0.04

Table A1-12 MGDS-MPC (continued)

eel. Install Platform Extension		10	1	Operator	6	8.7	1.45	0.04
ff. Remove Vent Rig	10	10	1	Operator	2	70	11.67	0.04
gg. Install Cask Lid Lifting Device	25	25	2	Operators	2	70	58.33	0.21
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
hh. Loosen/Remove Cask Lid	160	40	2	Operators	2	70	93.33	0.33
		20	1	Flagman	10	8.7	2.90	0.08
		20	1	Crane Operator	20	0.5	0.17	0.08
ii. Install Contamination Control	10	10	2	Operators	2	43	14.33	0.08
jj. Engage MPC Crane Lifting Attachment to MPC	40	25	2	Operators	2	97	80.83	0.21
		20	1	Flagman	10	8.7	2.90	0.08
		20	1	Crane Operator	20	0.5	0.17	0.08
Total	931	1045					636	5.69
2. Receive and Prep Storage-overpack								
(Emplacement-overpack) for MPC Transfer				assume crane area background				
a. Open Cask Prep Room Door	5	5	1	Operator	0	0	0.00	0.02
b. Engage Crane and Yoke to Storage Cask	10	10	1	Operator	2	0	0.00	0.04
		10	1	Flagman	10	0	0.00	0.04
		10	1	Crane Operator	20	0	0.00	0.04
c. Move Cask to Empty Cask Staging Area	20	20	2	Operators	10	0	0.00	0.17
		20	1	Crane Operator	20	0	0.00	0.08
c1. Close Cask Prep Door, simultaneously with c.		20	1	Operator	0	0	0.00	0.08
d. HP Survey	35	35	2	Radiation Protection	2	0	0.00	0.29
e. Decontaminate Cask	60	60	2	Operators	2	0	0.00	0.50
f. Move Storage Cask to Carrier	10	10	2	Operators	2	0	0.00	0.08
		10	1	Crane Operator	20	0	0.00	0.04
g. Place Empty Storage Cask on Carrier	35	35	2	Operators	10	0	0.00	0.29
		35	1	Crane Operator	20	0	0.00	0.15
h. Secure Empty Storage Cask on Carrier	20	20	2	Operators	2	0	0.00	0.17
h1. Disengage Crane and Yoke from Storage Cask, simultaneou		20	1	Operator	2	0	0.00	0.08
		20	1	Flagman	10	0	0.00	0.08
		20	1	Crane Operator	20	0	0.00	0.08
i. Open MPC Transfer Room Door	5	5	1	Operator	0	0	0.00	0.02
j. Move Empty Storage Cask to MPC Transfer Room	45	45	2	Operators	20	0	0.00	0.38
k. Install Platform Extension	10	10	1	Operator	6	0	0.00	0.04
k1. Close MPC Transfer Room Door, simultaneously with k.		10	1	Operator	0	0	0.00	0.04
l. Prep Empty Storage Cask for Opening	20	20	2	Operators	2	0	0.00	0.17
m. Attach Lid Lifting Device	20	20	2	Operator	2	0	0.00	0.17
		20	1	Flagman	10	0	0.00	0.08
		20	1	Crane Operator	20	0	0.00	0.08
n. Remove Cask Lid	55	55	2	Operators	2	0	0.00	0.46
		55	1	Flagman	10	0	0.00	0.23
		55	1	Crane Operator	20	0	0.00	0.23
o. Remove Lid Lifting Device	20	20	2	Operators	2	0	0.00	0.17
		20	1	Flagman	10	0	0.00	0.08
		20	1	Crane Operator	20	0	0.00	0.08
p. Install Contamination Control	20	20	2	Operators	2	0	0.00	0.17
Total	390	755					0.00	4.65
3. Transfer MPC from Transportation- overpack to Storage-overpack								
(Emplacement-overpack)				asssume crane enclosure background dose				
a. Engage Crane to MPC Lift Attachment	10	5	2	Operators	2	39.4	6.57	0.04
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
b. Verify Vertical Alignment of MPC to Transport Cask	10	10	1	Operator	2	97	16.17	0.04
c. Clear Operators to a Shielded Area	10	0	0	0	0	0	0.00	0.00
c1. Close Transfer Room Doors		0	0	Remote	0	0	0.00	0.00
d. Raise MPC from Transportation Cask	30	0	0	Remote	0	0	0.00	0.00
e. Move MPC Over Storage Cask	5	0	0	Remote	0	0	0.00	0.00
f. Verify Vertical Alignment of MPC to Storage Cask	10	0	0	Remote	0	0	0.00	0.00
g. Correct Vertical Alignment	20	0	0	Remote	0	0	0.00	0.00
h. Lower MPC into Storage Cask	30	0	0	Remote	0	0	0.00	0.00
h1. Open Transfer Room Doors		0	0	Remote	0	0	0.00	0.00
i. Radiation and Contamination Survey	45	45	2	Radiation Protection	2	59	88.50	0.38
j. Remove MPC Lift Attachment from MPC	30	20	2	Operators	10	8.7	5.80	0.17
		15	1	Flagman	10	8.7	2.18	0.06
		15	1	Crane Operator	20	0.5	0.13	0.06
k. Disengage Crane from MPC Lift Attachment	10	5	2	Operators	2	39.4	6.57	0.04
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
Total	210	155					129	0.96
4. Prep MPC/Emplacement-overpack from								

Table A1-12 MGDS-MPC (continued)

MPC transfer Cell for Emplacement				assume crane enclosure background dose				
a. Remove Contamination Control From Loaded Storage C	20	20	2	Operators	2	59	39.33	0.17
b. Install Inner Emplacement Lid	60	30	2	Operators	2	97	97.00	0.25
		30	1	Flagman	10	8.7	4.35	0.13
		30	1	Crane Operator	20	0.5	0.25	0.13
c. Setup Remote Welding Equipment	45	45	1	Welder	2	97	72.75	0.19
d. Weld MPC Inner Lid	1500	0	0	Remote	0	0	0.00	0.00
e. Verify Weld	60	30	1	QA Welder	2	97	48.50	0.13
f. Remove Remote Welding Equipment	20	20	1	Welder	2	97	32.33	0.08
g. Connect Evacuation/Inerting Equipment	10	10	1	Operator	2	97	16.17	0.04
h. Evacuate and Inert Emplacement	45	10	1	Operator	2	37	6.17	0.04
		45	1	Operator	10	8.7	6.53	0.19
i. Disconnect Evacuation/Inerting Equipment	5	5	1	Operator	2	97	8.08	0.02
j. Place and Seal Weld Valve Cover	90	90	1	Welder	2	97	145.50	0.38
k. Place Emplacement Outer Lid	30	30	1	Operator	2	97	48.50	0.13
		30	1	Flagman	10	8.7	4.35	0.13
		30	1	Crane Operator	20	0.5	0.25	0.13
l. Setup Remote Welding Equipment	45	45	1	Welder	2	97	72.75	0.19
m. Weld Emplacement Outer Lid	600	0	0	Remote	0	0	0.00	0.00
n. Verify Emplacement Outer Lid Weld	60	30	1	QA Welder	2	97	48.50	0.13
o. Remove Remote Welding Equipment	20	20	1	Welder	2	97	32.33	0.08
p. Remove Platform Extension	5	5	2	Operators	6	11	1.83	0.04
pl.Open Emplacement Transfer Room Door, simultaneously		0	1	Operator	0	0	0.00	0.00
q. Move Loaded Storage Cask to Storage Cask Prep Room	10	10	1	Operator	10	8.7	1.45	0.04
r. Close Emplacement Transfer Room Door	5	0	1	Operator	0	0	0.00	0.00
s. HP Survey Cask	60	30	2	Radiation	2	59	59.00	0.25
t. Unsecure Loaded Emplacement Cask from Carrier	20	10	2	Operators	2	59	19.67	0.08
tl. Engage Crane with Yoke		5	2	Operators	2	39.4	6.57	0.04
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
u. Open Emplacement Cask Prep Room Door	5	0	1	Operator	0	0	0.00	0.00
v. Move Loaded Emplacement Cask to Transporter Bay	10	10	2	Operators	10	8.7	2.90	0.08
		10	1	Crane Operator	20	0.5	0.08	0.04
w. Disengage Crane from Loaded Emplacement Cask	10	10	2	Operators	2	39.4	13.13	0.08
		10	1	Flagman	10	8.7	1.45	0.04
		10	1	Crane Operator	20	0.5	0.08	0.04
wl. Close Emplacement Cask Prep Room, simultaneously		0	1	Operator	0	0	0.00	0.00
x. Engage Loaded Emplacement Cask with Transporter	60	30	2	Operators	2	59	59.00	0.25
xl. Secure Loaded Emplacement Cask to Transporter for Move		30	1	Transporter Operator	15	0.5	0.25	0.13
Total	2795	740					851	3.71

A2. FACILITY ROUTINE RADIATION EXPOSURES INPUTS

This portion of the Appendix A forms a foundation for the facility routine exposure calculations that were shown in Appendix Section A1. The facility operation procedures and initial estimates of exposures are based on utility operations experience and data from EPRI reports. The operation exposures for the MPC system and the alternative systems are made consistent within each CRWMS facility, and are used to create the detailed exposures steps and tables for other CRWMS designs, including the reference scenario, TSC system, and MPU system. This process includes organizing and harmonizing of the input data to provide a consistent basis for all alternatives.

These data are used to estimate the routine radiological exposures in the CRWMS facilities. The data are based on dose rates measured during operations with comparable casks under conditions similar to those of the reference scenario and the MPC system. In this appendix the exposures with the more readily justified ALARA techniques, and the basic conventional operating practices exposures are shown. Results of the final tradeoffs of cost and occupational exposures will determine the actual occupational exposures during facilities operations. These estimates correspond to the exposures during the first 2 to 5 cask handlings at each facility. Learning experience will improve handling times and positioning to reduce exposures subsequently. The conservatism introduced by neglecting learning is about 10 to 30% of exposure reduction during 6,000 handlings at plausible learning rates, Reference 6 of this Appendix.

The estimated exposures are conservative since specific use of ALARA techniques was not yet included in the estimated times or the exposures. The calculations for this report, as shown in the first section of this appendix, are based on the nominal exposure values and do not use the ALARA data.

A2.1 APPLYING ALARA TECHNIQUES

The dose estimates were reviewed to identify high dose activities. The high dose activities are associated with radiation streaming from the cask during lid installation, whether the lid was welded or bolted. The dose for these operations can be reduced by using temporary lead shielding, such as lead blankets, tubular lead shields, and curved lead inserts for the annulus, to reduce the dose received by workers setting up or removing welding equipment and welding valve cover plates. The thicknesses of these shields vary depending on the worker dose rate permissible.

The ALARA techniques are based on an assumption that the welding equipment can be modified to do some of the activities now performed manually at most utilities. For example, cameras could be attached to welding equipment to inspect the weld so that manual close-range Quality Assurance (QA) inspection would not be needed near the lid of the cask. Also, welding equipment could be lowered with the cask lid so that operators would not have to guide the lid down onto the cask. The welding equipment could also be designed to provide automatic centering and alignment. Of course, this automatic processing may take longer than manual setup and removal of equipment. Detailed studies for time versus exposure need to be performed to determine the best way to set up and remove the welding equipment.

The welding equipment could also be used for other ALARA dose reduction procedures. A 1-part water fluorescing dye could be applied to the lid weld, with an attachment to the welding system. After the required dwell time a water rinse could be applied, with a close coupled vacuum system to remove water. Once the excess water is removed a close-up video camera could be used to examine the weld area for defects disclosed by the dye. Although such modifications can be made to existing welding systems to reduce workers' exposures, cost tradeoffs of worker exposure versus automation are needed to determine if the changes are reasonable.

Other ALARA procedures, such as the installation and use of remote controlled automated equipment, can reduce the radiation exposure to workers to near zero, since no workers are required nearby during high dose operations. Remote automated equipment is usually more expensive than temporary shielding or modifications of existing equipment. Examples of equipment are robotic arms with welding equipment that are programmed to weld cask lids of specific diameters. Robots could take "swipes" of incoming casks to quantify the amount of contamination on the cask, and robots could be designed and programmed to place and torque bolts on the transportation casks. Sandia National Laboratory is reviewing the use of remote automated equipment at the MRS facility to reduce occupational exposure. Sandia National Laboratory has visually and physically demonstrated several types of automated equipment that would reduce worker exposures. However, ALARA techniques have to be cost-justified to determine if the procedures are worth the expense.

In this dose assessment, an assumption was made based on utility experience and topical reports from cask vendors that the welding related dose can be reduced by a factor of 10 if suitable temporary shielding is used in the welding equipment setup and removal. Temporary shielding around the lid can obstruct the quality assurance activities for lid weld verification. For this report, no dose reduction was assumed for these activities. The results of the ALARA evaluation, which take credit for use of common, easily justified dose reduction techniques, are included in the tables of this appendix.

A2.2 BASIS OF ROUTINE EXPOSURE EVALUATION

A2.2.1 Fuel Characteristics and Heat Generation

In these dose assessments, actual dose rates from existing Independent Spent Fuel Storage Installations (ISFSIs) were used to determine the occupational exposures incurred from handling the MPCs and the reference scenario. Utilities with SNF storage facilities on-site provided fuel characteristic information as well as dose rate profiles for their particular fuel and casks. All of the fuel assemblies currently in storage at the existing ISFSIs, that we contacted, were 15 x 15 PWR fuel assemblies. The burnup of the fuel assemblies stored ranged from 21 gigawatt-days (GWD)/MTU to 36 GWD/MTU. The enrichments for the fuel in the casks reviewed ranged from 1.86 % to 3.2 % U-235. The fuel enrichment and burnup are representative of the fuel that will be handled in the CRWMS.

A2.2.2 Dose Rate Profiles

Representative dose rate profiles based on several types of casks are used, depending on the cask handling operations taking place. Figures A2-1 through A2-7 are based on actual dose rate profiles for representative 24 element PWR storage cask and transportation casks. Figures A2-1 through A2-5 show conservative estimates based on the TN-24P and MC-10 casks used at Virginia Power's ISFSI; and, the Nuclear Horizontal Module Storage (NUHOMS)-24P ISFSI at Duke Power's Oconee Nuclear Station. Dose rate profiles are similar for these casks. The dose rate profile estimates were based on actual dose rate profiles documented in two Electric Power Research Institute (EPRI) reports, EPRI NP-5128 and EPRI NP-5268, (References 2 and 3, respectively). Figures A2-6 and A2-7 illustrate the GA-4 transportation cask dose rates on the truck. The data are from the GA-4 and GA-9 Final Design Reports, References 4 and 5.

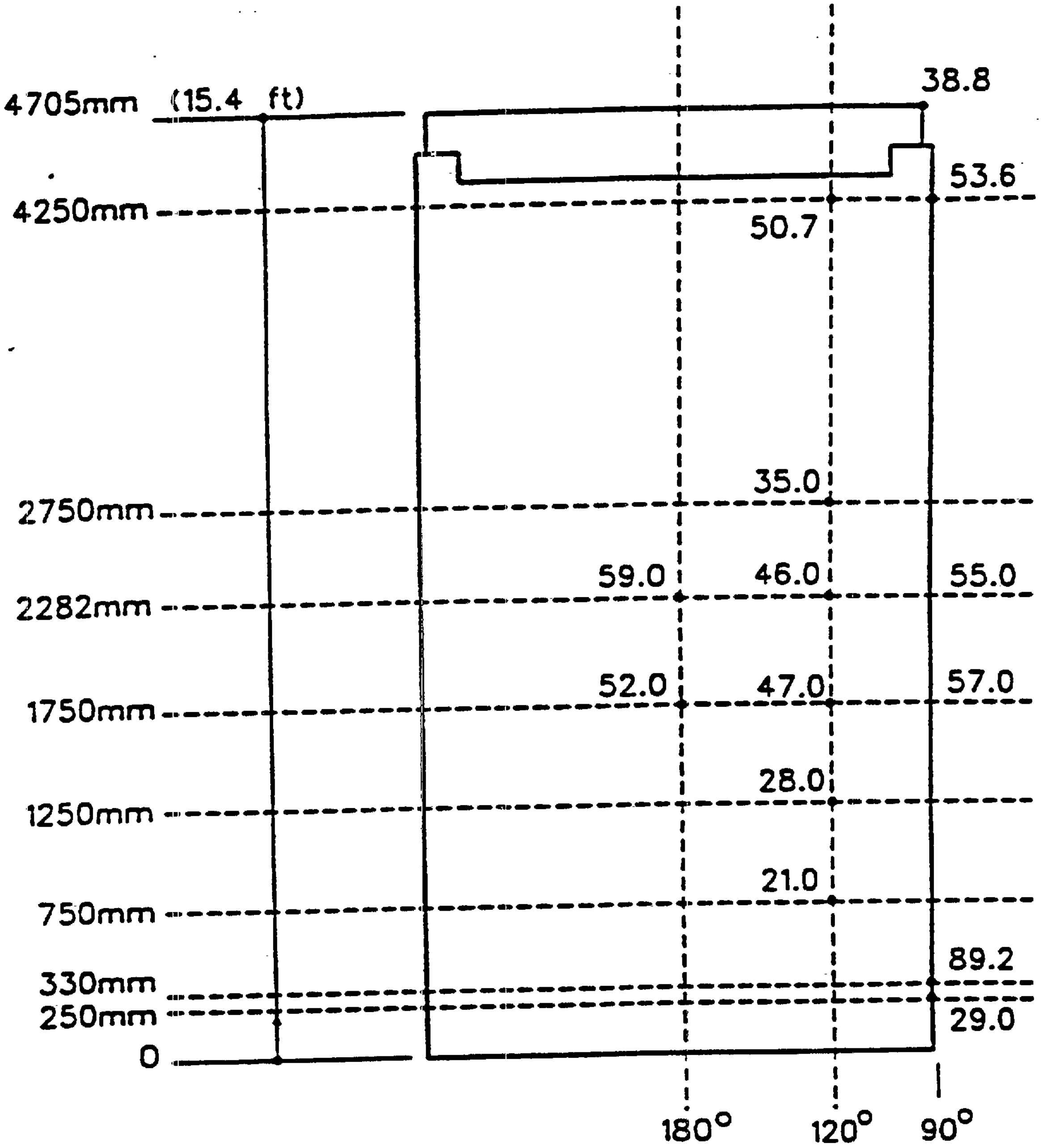
The GA-4 transportation cask dose rate profile was used to represent dose rates due to relatively distant handling of loaded truck or rail casks, while the casks are on the truck or rail vehicles. Doses at over 6 feet depend on the reflection from the truck or rail vehicle beds. Doses in facilities or ISFSI areas, especially at working distances of over 6 feet, will include a background flux. With unloaded or empty casks, canisters, and overpacks the background is the only dose. For ALARA some protection of workers against the background dose probably will be provided. The GA-4 transportation casks can transport 4 PWR assemblies. The same transportation cask dose rate profile was used for both truck and rail. Although there was a GA-9 BWR transportation cask for transporting 9 BWR assemblies, the PWR transportation cask had a more conservative total dose rate profile than the BWR cask.

The radiation protection survey area dose rate, 43 mrem/hr, was an average taken at the surface on the transportation cask. Any vehicle operator, including a crane operator, is assumed to be in a shielded cab or at a distance so that the dose rate in the cab is 0.5 mrem/hr. This is based on the GA-4 transportation cask cab dose rate, Reference 4. Welding operations performed on primary lids, installed after installing the shield plug, are assumed to have a streaming dose rate equivalent to that of a cask with water in the annulus, as shown in Figure A2-5.

The transporter at the MRS facility is assumed to be a transporter/crane combination. The transporter operator could operate the crane used in moving MPCs to and from the storage pad. However, at the utilities, the transporter and crane are separate vehicles that are used in taking the MPC or transfer cask to and retrieving it from the at-reactor storage yard. Also, the general working area dose rate in the storage area is assumed to be roughly 2 for average loading, with a maximum of 11 mrem/hr. The average storage area dose rate depends on the average spacing between casks, orientation of the casks vertical or horizontal, number of casks in storage, and the storage area pad or cell loading/unloading sequence, and the traffic flow pattern used to minimize traffic movement near loaded storage casks.

A Prime Mover referred to any type of heavy haul equipment that was used to move transfer casks and transportation casks at utilities, the MRS or the MGDS facility. A Prime Mover may be a train engine for rail transportation casks or a tractor/trailer used to move the casks on-site or off-site.

Metal Cask Side Surface Dose Rate Profile With Neutron Shielding



DOSE RATE IN UNITS OF mr/hr
DISTANCE IN mm

Figure A2-1. Distance Versus Dose Rate Profile For the Metal Cask With Neutron Shielding

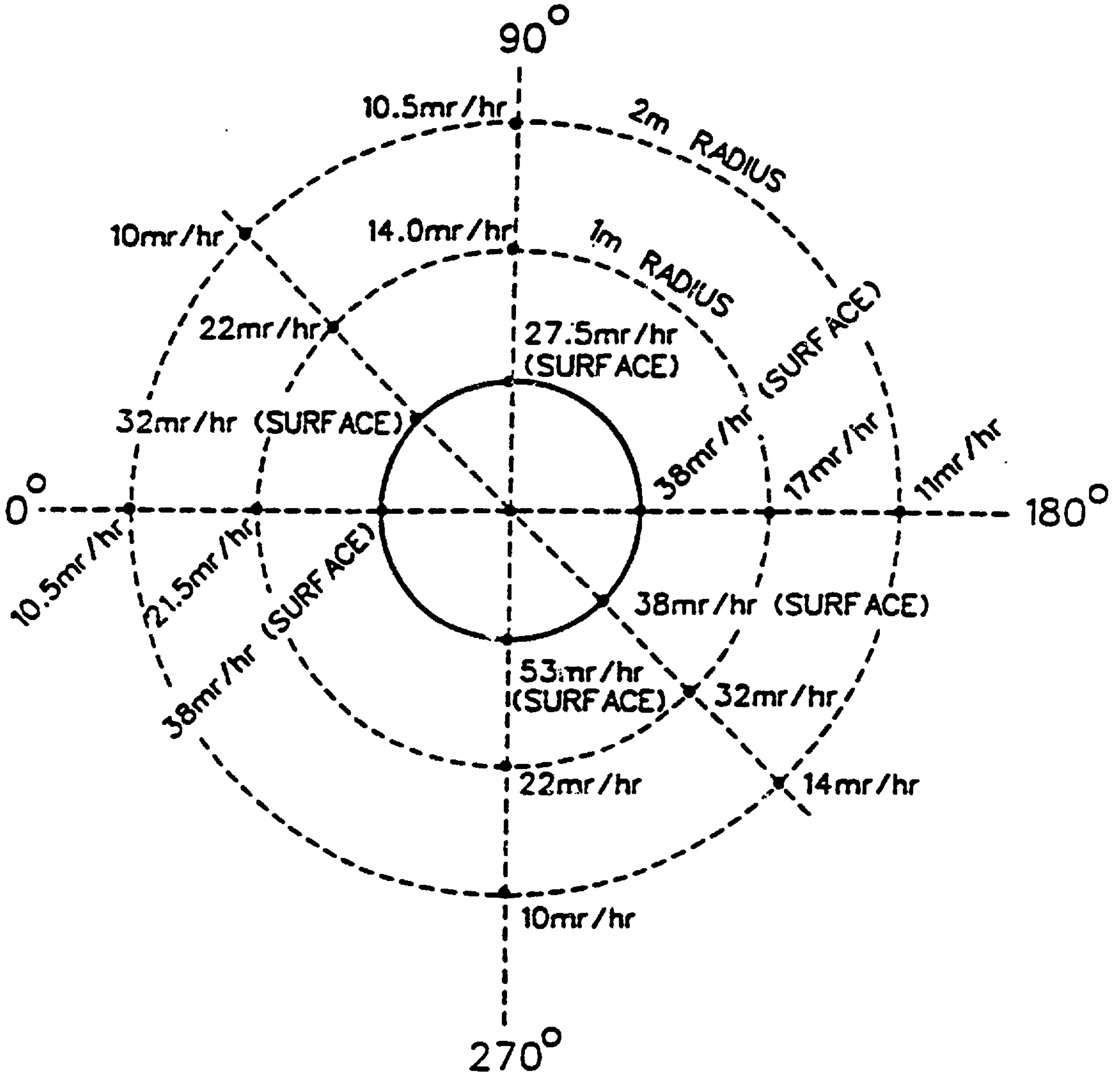


Figure A2-2. Distance Versus Dose Rate Profile For the Metal Cask With Neutron Shielding

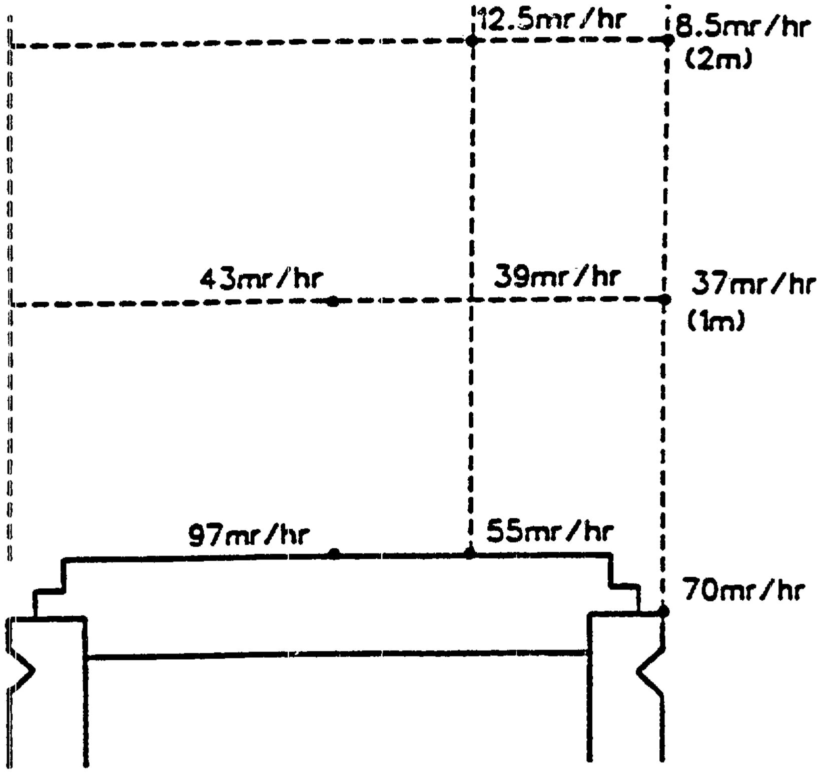


Figure A2-3. Metal Cask Top Dose Rate Profile With No Neutron Shielding

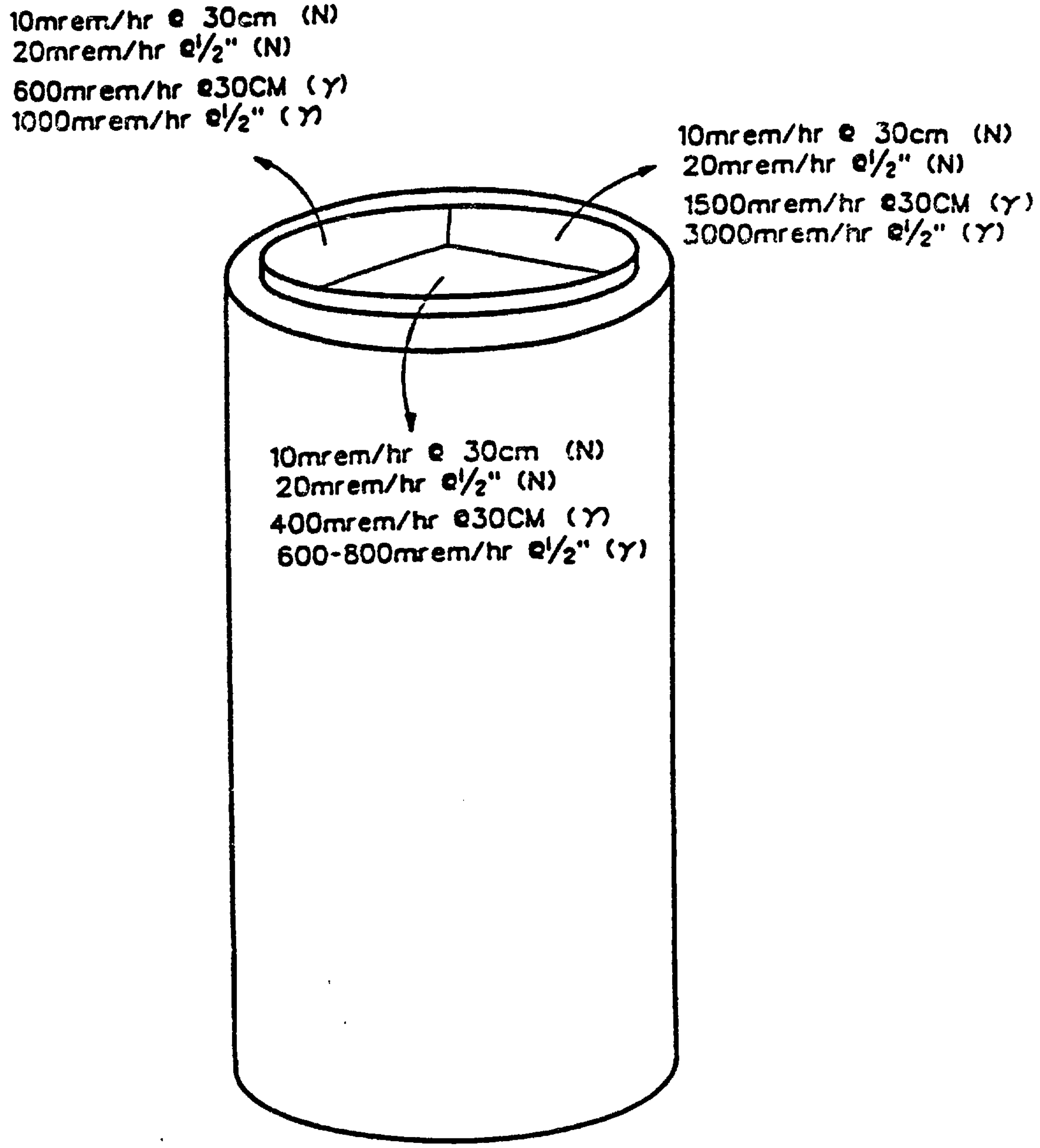


Figure A2-4. Working Condition Dose Rates for Welding of the Top Cover Plate Weld

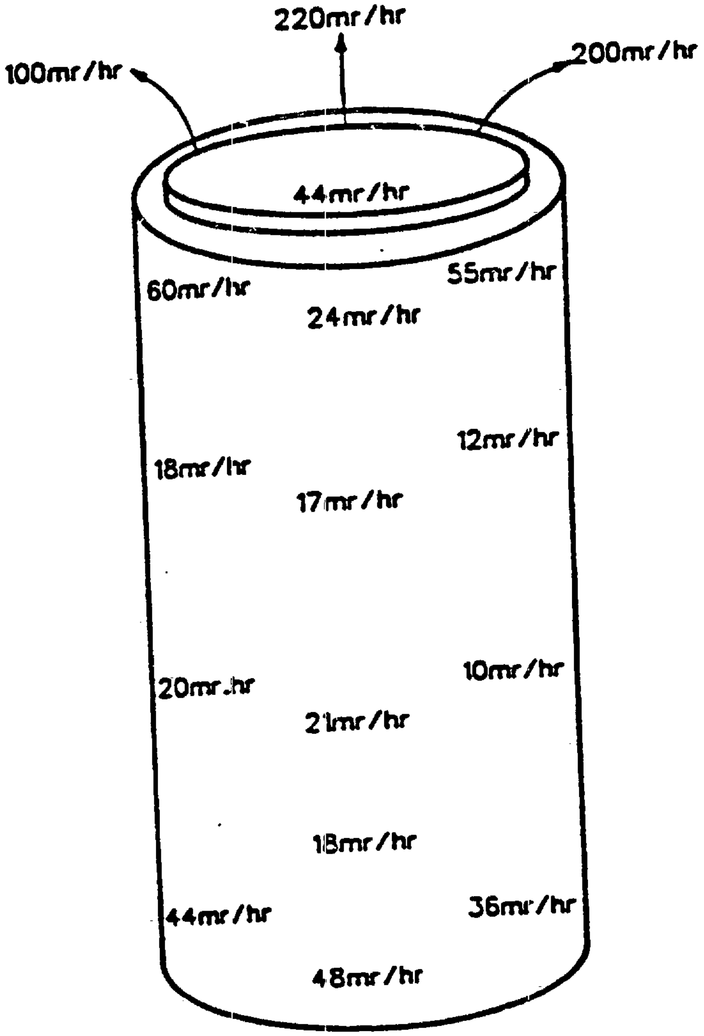


Figure A2-5. Working Area Dose Rates for the Shield Plug Welding (Gamma and Neutron Exposure with Water in the Cask and Annulus)

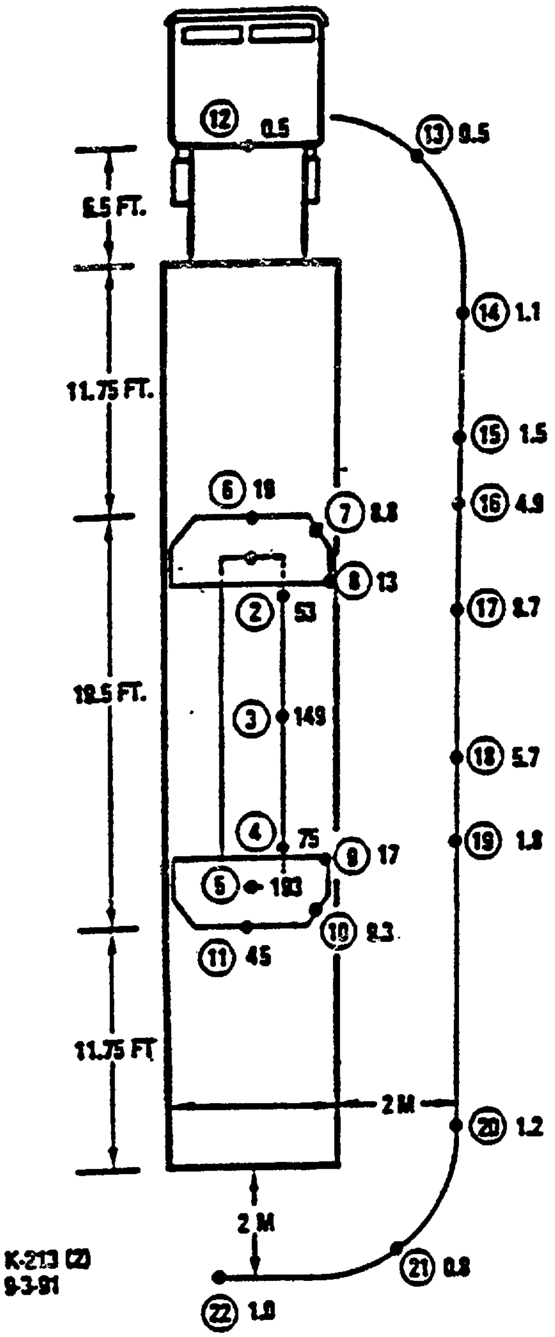
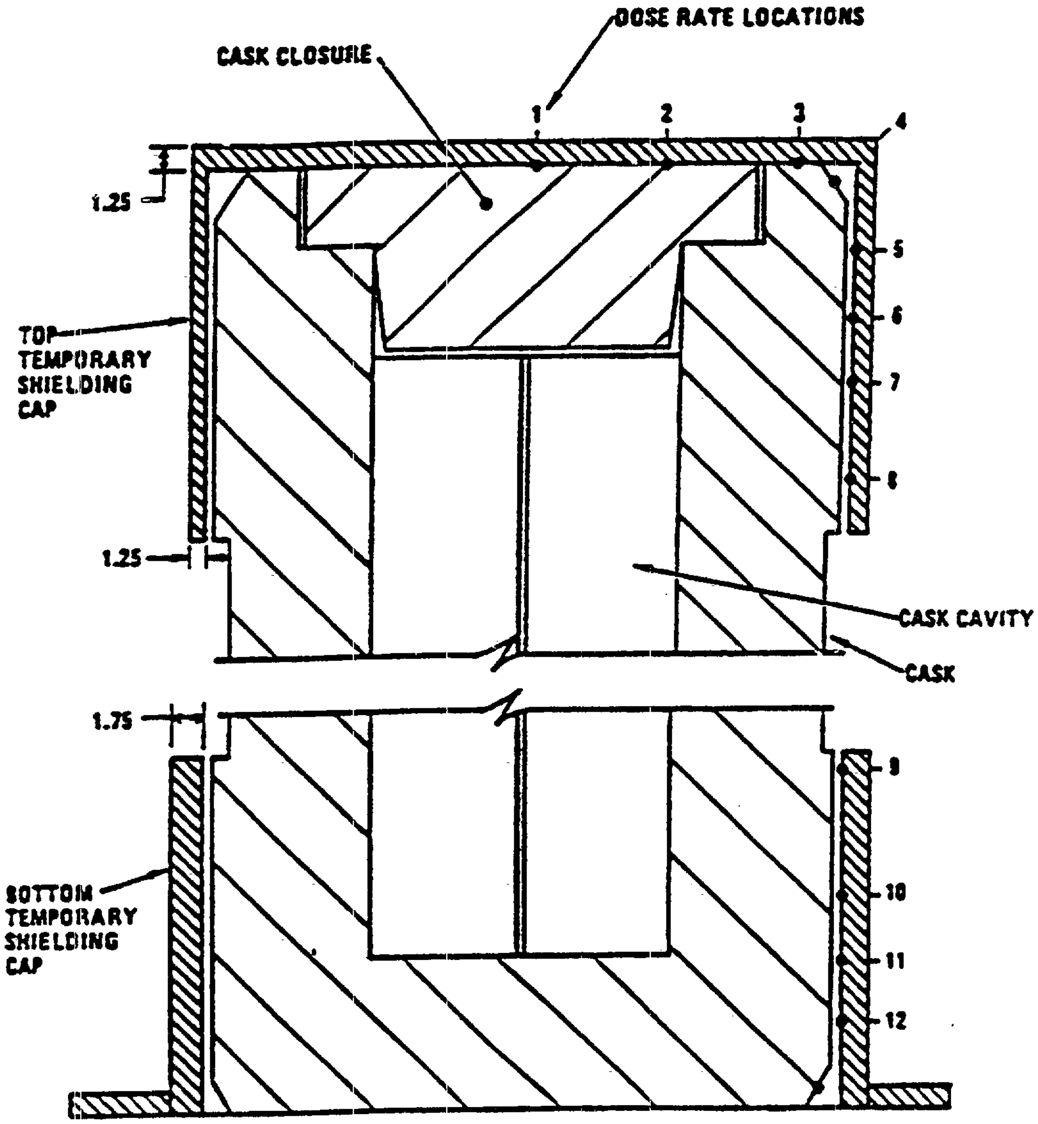


Figure A2-6. Total Dose Rate (mrem/hr) Near GA-4 Cask in Normal Condition. Ref. 5



Dose rate at numbered points: See Table A-11

Figure A2-7. GA-4 Cask Corner Surface Dose Rates Ref. 5 (Dimension in Inches) with Dose Point Rates. (see Table A2-1)

Table A2-1. GA-4 Cask Corner Surface Dose Rates (Reference 5)

Dose Point	Dose Rate Without Temporary Shielding (mrem/hr)	Dose Rate With Temporary Shielding (mrem/hr)
1	197.3	110.2
2	114.8	63.7
3	34.0	18.5
4	120.5	19.4
5	469.5	96.7
6	267.8	68.7
7	148.4	47.7
8	160.4	61.0
9	81.4	28.3
10	220.9	48.6
11	663.5	99.1
12	620.2	77.5

A2.3 RADWASTE FACILITY EXPOSURE

A2.3.1 Utilities

No dose assessment was performed on radwaste handling operations at utilities, with respect to loading casks for shipment to the MRS facility. The radwaste generated at the utility during the loading operations in the utility spent fuel pool is assumed to be negligible compared to the amount of radwaste that is normally generated at the utility for normal pool cleaning and dry active waste processing. The difference in radwaste produced during the loading of a transportation cask via the spent fuel pool and the loading of a MPC via the spent fuel pool is not significant because the same operations are used.

A2.3.2 MRS Facility

MRS facility radwaste in the reference scenario included high efficiency particulate air (HEPA) filters from the ventilation system, fluid filters from cask decontamination, and dry active low level waste. The volume of radwaste expected to be produced in the reference scenario was summarized in Table A2-2. The occupational exposure due to the handling of the reference scenario radwaste was larger than the MPC system radwaste occupational exposure value, because the volume of HEPA filters disposed of in the reference scenario was greater than in the MPC system. The reduction in bare SNF handling reduced the expected wastes from bare fuel handling operations.

Table A2-2. Reference Scenario Radwaste

Radwaste Type	Volume (ft^3)	Activity (Curies Cobalt-60 equivalent)
Dry HEPA filters	720	90
Transfer cell vacuum filter	1	477
Wet cartridge filters	6	9
Wet demineralization resins	90	5
Dry active waste	200	10

Radwaste at the MPC system MRS facility also included high efficiency particulate air (HEPA) filters from the ventilation system, fluid filters resulting from cask decontamination, and dry active low level waste. The amount of Radwaste produced at the MPC system MRS facility as a result of handling MPCs was included in Table A2-3 below.

Table A2-3. MPC System Radwaste

Radwaste Type	Volume (ft^3)	Activity (Curies Co^{60} equivalent)
Dry HEPA filters	144	18
Transfer cell vacuum filter	1	52
Wet cartridge filters	6	9
Wet demineralization resins	90	5
Dry active waste	150	10

Workers in the Radwaste Facility portion of the MRS facility will incur some exposure due to changing out filters in various systems, handling dry active low level waste, mechanical maintenance, security, or any other type of occupational requirements in the Radwaste areas. Dose assessments of the Radwaste Facility were performed in five areas expected to contribute to occupational exposure, as described here.

1. Radioactive Contaminants accumulate in the HEPA filters due to the ventilation flow through these filters. Based on the current design of the MRS facility, we assume that 4 banks (2 banks of HEPA filter and 2 banks of refilters), totaling 12 filters, are changed per year. The dose rate is assumed to be about 5 rem/hr per filter bank, on contact. The labor requirements for the changeout of these filter banks are two persons for 1 hour in a 50 mrem/hr field, using extension tools and a shielding transfer container. Based on these assumptions, the exposure to personnel for filter changeout is,

   (4 filter banks/year)(50 mrem/hr)(2 persons)(1 hr)(1 rem/1000 mrem)
   = 0.4 person-rem/year, for transfer cell HEPA filter operations

   All other HEPA filters operations in areas such as the cask preparation area, storage cask load-out, maintenance bay, and operation gallery are assumed to yield a personnel exposure equivalent to 0.4 person-rem/year.

2. Filters and demineralizers process the decontamination fluid; approximately 200 gallons per cask, produced during cask decontamination. Two filters per year are assumed to be changed out. The filter dose rate on contact was assumed to be 5 rem per hour. Handling operations are based on ALARA practices to reduce the working area dose rate to 50 mrem/hr. The dose to two persons changing out the fluid filter is as follows:

   (2 filters/year)(2 persons)(1 hr)(50 mrem/hr-filter)(1 rem/1000 mrem)
   = 0.2 person-rem/year, for fluid filter changeout

   Personnel exposure from changing-out demineralizer resins and associated activities is estimated as 0.2 person-rem/year.

3. The collecting, sorting, compacting, drumming, storing, handling, and loading of dry active low level waste requires two persons working 5 days a week, 24 hours a day, year around.

The working area dose rate is 0.5 mrem/hr. Based on the assumptions, the total personnel exposure from handling dry active low level waste is as follows:

(2 persons)(6,240 hr/year)(0.5 mrem/hr)(1 rem/1000 mrem)
= 6.2 person-rem/yr, for low level waste handling

4. Exposure of personnel as a result of laundry processing activities is estimated to be approximately 5 person-rem/year.

5. Access to the Radwaste area is required for mechanical maintenance activities, inspections, security, and radiation protection requirements. The occupational exposure is from the access requirements and exposure rates in the area. Access exposure estimates are based on 10 persons per day for one hour in a 2.5 mrem/hr exposure rate area. The requirement results in personnel exposure as follows:

(10 persons/day)(1 hr)(365 days/year)(2.5 mrem/hr)(1 rem/1000 mrem)
= 9.1 person-rem/year, for radwaste area access

The assumptions for occupational exposure due to MPC system radwaste handling were conservative based on current operational information. The exposure is summarized as follows:

0.4 person-rem/year	Transfer Cell prefilter and HEPA filter changeout
0.4 person-rem/year	other HEPA filter operations
0.2 person-rem/year	fluid filter changeouts
0.2 person-rem/year	demineralizer operations
6.2 person-rem/year	low level waste
5.0 person-rem/year	handling laundry and contaminated clothing
9.1 person-rem/year	radwaste area access
21.5 person-rem/year	all radwaste facility activities, for MPC system

The reference system occupational exposure is estimated to be 26. person-rem/year. This value was included in the total estimated occupational exposure for the reference MRS system facility in the MRS Conceptual Design Report (MRS CDR), Reference 1. The assumptions for occupational exposure from reference scenario radwaste handling were conservative based on current operational information.

A2.4 UTILITIES SYSTEM DOSE ASSESSMENT

A2.4.1 Reference Scenario

The exposure associated with cask handling at the utilities in the reference scenario are normalized to the MPC system utility SNF transfer and storage operations. The major differences between the reference scenario and the MPC system are that more transportation casks are handled in the reference scenario, and the casks have bolted rather than welded lids. The following scenarios are used for the utilities in the reference scenario. A description of the typical estimated dose from operations is included.

Truck ("25 ton") transportation cask loaded in-pool at reactor and placed on a truck for shipment to an MRS

The operations with this scenario are identical to Table A2-5, Steps 1 through 5 of the MPC utilities dose estimate. These operations expose personnel to 0.4 person-rem/cask handled. Application of ALARA techniques could reduce the exposure to 0.2 person-rem/cask.

Large ("100 ton") and moderate ("75 ton") sized rail transportation cask loaded in-pool at reactor and placed on a train for shipment to an MRS

These operations are similar to Table A2-5, Steps 1 through 5 with the exception of the times associated with the lid installation and decontamination tasks for the rail transportation cask. ALARA procedures can be applied in Step 4 of Table A2-5. The rail-times should be used in Table A2-5, as appropriate.

Large and moderate sized rail transportation casks loaded at utilities and placed on a train for shipment to a MRS (includes cask-to-cask transfer for an optimistic capability scenario)

This exposure steps per cask are identical to the steps in Table A2-4, Steps 1 through 6 and 10 through 11 for rail transportation casks used in the cask-to-cask transfer method, excepting the lid installation and decontamination with the rail transportation cask. An ALARA based exposure is 1.9, reduced from 2.4. ALARA techniques may be used in Step 4 of the Table A2-4.

Large and small non-transportable MESCs loaded in-pool at reactor and placed in concrete modules for on-site dry storage

These tasks for large and small non-transportable multiple element storage containers (MESCs) loaded in-pool at reactors and placed in concrete modules for on-site dry storage are similar to those of Table A2-3, Steps 1 through 5 and Steps 11-13 of the MPC utilities. The total exposure during loading of large and small MESCs at-reactor, plus storing the MESCs on-site, is 2.6 person-rem/cask. Use of ALARA techniques reduces the exposure to 1.5 person-rem/cask.

Large and small non-transportable MESCs retrieved from storage, returned to pool, cut open, and SNF transferred to rail and truck transportation casks for shipment to an MRS

Retrieving MESCs from on-site storage for shipment to the MRS facility requires the reverse of the operations in Table A2-3, Steps 1 through 5 and Steps 11 through 13, which result in a worker exposure of 2.1 person-rem/cask, without an adjustment downward for decay. Application of ALARA techniques could reduce the exposure to 1.5 person-rem/cask. The cask-to-cask, in-storage delay, while decay acted, is conservatively assumed to be zero. Cutting open the MESC lid is expected to result in the same or slightly lower worker exposure, as compared to the welding operations.

A2.4.2 MPC System

Transportation casks in the MPC system are treated in the same way for the purposes of this dose assessment, whether truck, rail, or barge casks, and in this section are shown as though independent of weight. Actual dose rates from the GA-4 transportation cask are used to estimate the transportation cask handling exposures, and these dose rates are assumed to be representative of any type of existing transportation casks. Transportation cask dose rates are limited by 10 CFR 71. The GA-4 transportation cask dose rates compare favorably to 10 CFR 71 dose rate limits. Representative 24 element storage casks are used to estimate typical dose rates for the MPC transfer operations and dose rates for the MPC storage operations. The TN-24P, MC-10, and NUHOMS-24 storage casks are assumed to be representative. The dose rate profiles representing transportation casks and storage casks are used throughout to estimate the SNF handling related occupational exposures at utilities.

Several components make up the utility SNF transfer and storage operations for MPCs. Some utilities receive MPCs, transfer SNF to these MPCs directly in their pools, and ship the loaded MPCs to the MRS facility. Some MPCs may be transferred to and from on-site storage facilities. Other utilities can transfer fuel from a local type cask to the MPC/Transportation cask for shipment to the MRS/MPC facility. Finally, various utilities will not be able to handle MPCs at all, for whatever reason, so bare fuel will be transferred to transportation casks for shipment to the MRS facility, similar to the methods used in the reference scenario. The MPC cask handling operations are summarized in Tables A2-3 through A2-5. Scenarios 1/2 represent cask handling steps required for the receipt of MPCs at utilities and for the transfer of fuel from the spent fuel pool or ISFSI to the MPCs. Scenario 3 represents a cask to cask transfer.

Scenario 3 differs from Scenario 1/2 because a transfer cask is loaded in the spent fuel pool and moved to a cask-to-cask transfer area. In the transfer area, the fuel is transferred from the transfer cask to the MPC. This operation is repeated until the MPC is full. In Scenarios 1 through 3, MPCs can be moved to on-site storage or retrieved from on-site storage for transfer to the MRS/MPC facility or the MGDS facility.

Scenario 4 was established for cask operations at utilities that cannot handle MPCs, or be modified to do so. In Scenario 4, spent nuclear fuel is transferred from the spent fuel pool to a transportation cask for transfer to an MRS facility or to the MGDS facility.

Truck, Rail, or Barge Transportation Cask Loaded in Pool at Reactors and Shipped to the MRS/MPC Facility or MGDS Facility

Truck, rail, and barge transportation casks are represented by the GA-4 transportation cask dose rate profiles since all transportation casks must meet the dose rate limits of 10 CFR 71. The dose profiles are assumed to be the same for all transportation casks. The dose rate profiles for the GA-4 cask include data at the surface, 1 and 2 meters. The dose rates are applied at the working distances for each step. Dose rates for distances at 10 feet in this section are taken from the 2-meter distance on the dose rate profile. Dose rates at 2 feet are assumed to be the surface dose rate.

Dose rates for the 24 element cask include side dose rates at 1 and 2 meters, in addition to surface dose rates. Where dose rates at 2 feet are needed, surface dose rates are used. At 10 feet, 2 meter dose rates are used. Thus, the storage yard was assumed to have a working area dose rate of 11 mrem/hr, based on the 2 meter dose rate for the 24 element cask. The 11 mrem/hr was used for ISFSIs and the MRS facility storage yard. In the spreadsheets, the working area doses were separated into a direct dose, and a backgound dose, with the result that the total dose rate remained at 11 mrem/hr in the ISFSI and MRS facility storage yards.

Welding operations are assumed to be performed using a remote controlled welder. The largest exposure to workers is during setting up the remote welding equipment. Also, a flagman is assumed to be used for directing crane operations, during actions where the crane operator's visibility of the object being moved is reduced.

Some operations involve only unloaded or empty casks. "Unloaded" implies that the cask was loaded previously, but does not hold fuel at the present time. "Empty" implies that the cask was never loaded with SNF. In either case, no dose is incurred by workers during the transportation cask or MPC operations. Other operations are performed by machines at the canisters or casks and controlled remotely, so no people are near the casks and no dose is received by workers.

Table A2-4 identifies the steps of Scenario 1/2, for dose assessment. Steps 1 through 6 of the handling operations relate to transportation cask loading and preparation for shipping to the MRS or MGDS facility. Scenario 1/2 begins with the receipt of an empty MPC at the utility. The MPC is loaded into a transportation cask and put in the spent fuel pool for fuel loading. The SNF loading is controlled remotely. Once the fuel is loaded, the cask lids are installed and preparations are made to load the transportation cask onto the off-site vehicle that takes the cask to the MRS or the MGDS facility. A summary of the dose received by workers for each step of the operations is listed below. The application of ALARA dose reduction procedures, discussed previously, could result in a dose of 0.7 person-rem/cask for this scenario.

Table A2-4. MPC Load by Cask-to-Cask and Prepare to Ship

Handling Operations	Exposure (person-rem)	
	ALARA	Nominal
1. Empty MPC received in Prep area	0	0
2. MPC loaded into transportation cask	0	0
3. MPC/cask loaded into utility's spent fuel pool	0	0
4. SNF loaded into MPC/cask	0.01	0.01
5. Loaded MPC/cask moved from pool to Prep area	0.5	1.5
6. Loaded MPC/cask moved from Prep area to gate	0.2	0.2
Total exposure per cask	0.7	1.7

A2.4.3 MPC Loaded by Cask-to-Cask Transfer and Shipped

The same assumptions concerning dose rates for the transportation and 24 element casks established in the previous section apply for cask-to-cask transfer operation steps.

Scenario 3 deals with transfer of SNF to a MPC outside of the spent fuel pool, by using a shielded transfer canister and a cask-to-cask transfer exclusively. The detailed operational steps for this scenario are shown in Table A2-4. In this scenario, the on-site transfer cask is moved into the pool Prep area. The on-site transfer cask is prepared and placed in the spent fuel pool. The SNF is loaded into the on-site transfer cask by remote controlled operations. The loaded transfer cask is moved back into the pool prep area. The on-site transfer cask is moved from the pool Prep area to the cask-to-cask transfer area, for the SNF transfer to the MPC. In addition, an unloaded MPC has been received at the utility for this step.

The MPC is moved to the cask-to-cask transfer area. Steps 1 through 6 of Table A2-5 and Steps 7 through 9 are the operations to prepare the on-site transfer cask and the MPC for fuel transfer. Step 10 describes the actual cask-to-cask transfer. Step 10 involves moving the SNF from the on-site transfer cask to the MPC by a cask-to-cask transfer method. For this dose assessment, these operations are assumed to yield a dose of 1.0 person-rem/cask to workers.

Once the MPC is loaded, the loaded off-site transportation cask is moved to the gate area for the final check out, before moving from the utility site. Steps 12 and 13 include the operational steps to move the loaded on-site MPC transfer cask from the cask-to-cask transfer area to the ISFSI, at the utility. The off-site transportation cask is moved into the ISFSI area to retrieve the MPC for transport to the MRS or MGDS facility, as described in Steps 14 through 16.

The exposure received by workers during the cask-to-cask transfer operations occurs during three activities: 1) SNF transfer from the on-site transfer cask to the MPC/transport cask; 2) MPC storage in the ISFSI, from the cask-to-cask transfer area; and, 3) MPC retrieval from the ISFSI for shipment off-site. The cask-to-cask transfer dose estimate is summarized below. The application of ALARA dose reduction procedures, discussed previously, could result in a dose of 1.5 person-rem/cask for Steps 1 through 11.

Table A2-5. MPC Load by Cask-to Cask and Prepare to Ship

Handling Operations	Exposure (person-rem)	
	ALARA	Nominal
1. Transfer cask moved from cask-to-cask transfer area to pool Prep area	0	0
2. Transfer cask moved from pool Prep into spent fuel pool	0	0
3. SNF loaded into the transfer cask	0.01	0.01
4. Loaded on-site transfer cask moved to pool Prep area	0.2	0.4
5. Loaded on-site transfer cask from pool Prep to cask-to-cask transfer area	0.1	0.1

6. Unloaded off-site MPC transportation cask moved into cask-to-cask Prep area	0	0
10. SNF transferred from transfer cask to MPC/cask	1.0	1.0
11. Loaded off-site transportation cask moved to gate	0.2	0.2
Total exposure/cask	1.5	1.7

Handling Operations (2) (ALARA and Nominal)	Exposure
12. Prepare loaded on-site MPC transfer cask for move to ISFSI	0.2
13. Loaded on-site MPC transfer cask moved to ISFSI	0.4
Total exposure/cask	0.6

Handling Operations (3) (ALARA and Nominal)	Exposure
14. Unloaded off-site MPC transportation cask receipt to ISFSI	0.1
15. MPC transfer to off-site transportation cask	0.5
16. Loaded transportation cask moved from ISFSI to gate	0.3
Total exposure/cask	0.9

A2.4.4 MPC Loaded at the Utility and Placed in On-Site Storage

Scenario 1/2 provided in Table A2-3 also encompasses MPC storage at the utility site after the MPC has been loaded in the spent fuel pool at the utility. Steps 7 and 8 of this scenario, included in Table A2-4 (extended), describe the operational steps involved in placing the MPC into storage. The dose incurred by workers loading the MPC is 1.7 person-rem/cask as discussed earlier in Steps 1 through 6. If the MPC is stored on site, then Steps 7 and 8 contribute to the dose. Once the MPC is loaded, it is prepared and moved to the ISFSI area for on-site storage. The MPC is transferred to the on-site storage facility. The transporter is prepared for movement back to the protected area. The added dose was 0.6 person-rem, for on-site storage of an MPC.

A2.4.5 MPC Retrieved from On-Site Storage and Shipped Off-Site

Steps 9 and 10 of Table A2-4 involve the receipt of an unloaded on-site transfer cask and an unloaded transportation cask to the prep area, and result in a 0.054 person-rem dose to workers. Steps 11 through 13 of Table A2-4 list the operational steps required to retrieve the MPC from an on-site ISFSI to be shipped off-site. The off-site transportation cask is moved to the ISFSI as described in Step 12. The MPC is transferred to the off-site transportation cask. The off-site transportation cask is moved to the gate for a final check-out before leaving the utility site. The dose estimated for retrieving a MPC from on-site storage is one person-rem. No ALARA reductions were shown for these steps.

TABLE A2-4. (extended)

Handling Operations	Exposure (person-rem)
1-6. Loading a MPC	1.7
7. Loaded on-site MPC transfer cask prep for ISFSI	0.2
8. Loaded MPC transferred to ISFSI	0.4
Total exposure/cask	2.3

Handling Operations	Exposure
9-10. Receive unloaded transfer cask and transport cask	0.054
11. MPC transfer to off-site transportation cask	0.6
12. Unloaded off-site transportation cask moved to ISFSI	0.1
13. Loaded off-transportation cask moved from ISFSI to gate	0.3
Total exposure/cask	1.0

A2.4.6 SNF Loaded into Transportation Cask at Utility for Shipment Off-Site

Scenario 4 of the utility SNF transfer and storage operations, Table A2-6, was developed to estimate the dose for the utilities that cannot accommodate MPCs and cannot be modified to handle MPCs. In the scenario, a transportation cask is received at the utility and sent to the Prep area. The transportation cask is prepared and lowered into the spent fuel pool. The SNF is remotely loaded into the transportation cask. The transportation cask is removed from the pool. The cask lids are installed in the Prep area. Then the transportation cask is secured to the off-site prime mover and moved to the gate. The application of ALARA dose reduction procedures could result in a dose of 0.2 person-rem/cask.

Table A2-6. MRS, SNF Load and Prepare to Ship Exposures

Handling Operations	Exposure (person-rem)	
	ALARA	Nominal
1. Unloaded off-site SNF transportation cask moved to Prep area	0	0
2. Off-site transportation cask moved to the spent fuel pool	0	0
3. SNF loaded into the off-site transportation cask	0.002	0.002
4. Loaded off-site transportation cask moved from pool, to Prep area	0.1	0.3
5. Move loaded off-site transportation cask from Prep area to gate	0.1	0.1
Total exposure/cask	0.2	0.4

A2.5 MRS FACILITY

A2.5.1 Reference Scenario

Refer to the MRS CDR, Reference 1, for the details about the basis of the reference scenario dose assessment. The reference scenario dose estimates were updated to reflect more details of handling operations for transportation and storage casks so that the comparison of the original reference scenario and the MPC system will be more accurate.

A2.5.2 MPC System

The MPC system involves more varied operational steps than the reference scenario. A discussion of the scenarios for the handling of MPCs follows. The reduced exposures in steps where ALARA techniques could be applied during lid installation operations are shown in the tables.

A2.5.2.1 SNF Transferred to Large MPC and Placed in Storage at the MRS

The GA-4 transportation cask and the 24 element cask dose rate profiles are used in the MRS/MPC facility dose assessment for the generic transportation cask and the MPC/Storage cask, respectively. The assumptions stated previously concerning the remote operations, crane operations, and storage yard working dose rates are the same for the MRS facility. The operational steps for the bare SNF transfer concept are identified in Table A2-6. The bare SNF transfer at the MRS begins with the receipt of a loaded transportation cask. The loaded transportation cask is inspected, surveyed, and prepared for movement into the transfer cell area. An empty storage cask is brought into the transfer cell area and mated with the cell port.

The SNF is remotely offloaded into the lag storage area until the lag storage contains a full MPC load of SNF. The SNF is taken out of the lag storage area and placed into an MPC/storage cask. The storage cask is unmated from the transfer cell port and moved into the welding area of the bare SNF transfer facility for lid installation and welding. The unloaded transportation cask is moved into the dispatch area. The transportation cask is then prepared to be shipped to another utility to pick up bare SNF. The steps are listed in Table A2-7. The application of ALARA dose reduction procedures could result in a dose of 1.4 person-rem/cask for this scenario.

Table A2-7. MRS, SNF Transfer and Storage Exposures

Handling Operations	Exposure(person-rem)	
	ALARA	Nominal
1. Loaded transportation cask received to bare SNF transfer facility	0.3	0.8
2. Empty MPC/storage cask moved into the bare SNF transfer facility	0	0
3. SNF loaded into the MPC/storage cask	0	0
4. Transportation cask lid is inspected	0	0
5. Loaded MPC/storage cask moved to the facility storage yard	0.6	1.8
6. Unloaded truck moved from transfer cell to dispatch area	0	0
Total exposure/cask	0.9	2.6
Table 7. Step 9; Loaded rail cask moved from Prep to Dispatch -MGDS	0.5	0.5
Total exposure/cask	1.4	3.1

A2.5.2.2 MPC Arrives at MRS and Stored in the Storage Yard

Most utilities will be capable of handling a large or small type of MPC. In these cases, MPCs will arrive at the MRS to be transferred to the facility storage yard for storage until shipment to the MGDS, later. Table A2-8.1 gives a description of the operations and exposures.

Transportation casks are received at the MRS MPC transfer area. Preparations are made in order to move the MPC/transportation cask into the MPC transfer room, as described in Step 1. An empty storage cask is moved into the transfer room and prepared for the receipt of a MPC. The loaded MPC is transferred from the transportation cask to the storage cask by remote operations once the area is cleared. The loaded storage cask is then moved from the MPC transfer room to the storage yard. The unloaded transportation cask is then moved to the dispatch area and prepared for shipment to another utility to pick up SNF. A summary, Table A2-8, follows. The application of ALARA dose reduction procedures, discussed previously, could result in a dose of 1.1 person-rem/cask for this scenario.

Table A2-8.1. MRS, Cask Arrival and Storage

Handling Operations	Exposure(person-rem) ALARA	Nominal
1. Loaded rail transportation cask received at the MRS facility MPC transfer room	0.4	0.7
2. Empty storage cask moved to the MPC transfer room	0	0
3. MPC is loaded and checked for contamination	0.1	0.1
4. Loaded MPC/storage cask is moved from the MPC transfer room to the storage yard	0.6	0.8
5. Rail transportation cask moved to the dispatch area and preparations are made for shipment to another utility	0	0
Total exposure/cask	1.1	1.6

Table A2-8.2. Cask Preparation for Shipment

	ALARA	Nominal
6. Loaded MPC/storage cask moved from MRS facility storage yard to the MPC transfer room	0.7	0.7
7. Unloaded rail transportation cask received and moved to the MPC transfer room	0	0
8. Loaded MPC prepared and transferred to the rail transportation cask	0.1	0.1
9. Loaded rail transportation moved from cask prep area to dispatch	0.5	0.7
10. Unloaded storage cask moved back to MRS storage yard	0.1	0.1
Total exposure/cask	1.4	1.6

A2.5.2.3 Bare SNF Transferred to MPC and Shipped to MGDS

Table A2-7, Steps 1 through 6 were discussed previously and refer to bare SNF transfer to a MPC in the MRS facility transfer cell. The dose estimate for this operation is about 0.8 person-rem/cask to the point of loading a MPC, excluding the exposure during the movement of a loaded MPC to the storage yard, which takes place in Steps 4 through 6 of Table A2-7. Welding the MPC closed results in a dose of 1.3 person-rem/cask. Assuming SNF was loaded into a MPC, then Table A2-8.2, Step 9 describes an additional operational step for preparing a loaded MPC for shipment off-site. The exposure for preparing a loaded MPC for shipment to the MGDS is approximately 0.9 person-rem/cask. The total dose received by workers for moving bare fuel from a transportation cask to a MPC and preparing the MPC for shipment off-site is 3.0 person-rem/cask.

A2.5.2.4 MPC Arrives at MRS Facility for Shipment to MGDS

Table A2-8.2, Step 9 contains the steps necessary to prepare a loaded MPC/transportation cask for shipment to the MGDS. If the MRS facility is only being used as a check point for the MPC/transportation cask between the utility and the MGDS, then the steps involved in checking the MPC/transportation cask are identical to those in Step 9 of Table A2-8.2. Therefore, the exposure received by workers surveying the cask for transportation is about 0.06 person-rem/cask. No dose reductions were foreseeable from use of ALARA procedures.

A2.5.2.5 MPC Retrieved from MRS Facility Storage Yard for Shipment to MGDS

The next scenario in the MRS/MPC system considers the retrieval of a MPC/storage cask from the MRS facility storage yard for shipment to the MGDS. In the scenario, a loaded MPC is moved from the storage yard to the MPC transfer room. An unloaded rail transforation cask is also moved into the MPC transfer room. The storage cask and the rail transportation cask are prepared for MPC transfer. The loaded MPC is transferred from the storage cask to the transportation cask. The loaded rail transportation cask is surveyed and prepared for shipment to the MGDS. The unloaded storage cask is moved back to the MRS facility storage yard. Table A2-8 Steps 6 through 10 describe these operational steps. The dose estimate follows. The application of ALARA dose reduction procedures, discussed previously, could result in a dose of 1.4 person-rem/cask for this scenario.

A2.6 CASK MAINTENANCE FACILITY

A2.6.1 Reference Scenario

The Cask Maintenance Facility (CMF) personnel clean the transportation cask, install spacer grids, and clean the fuel storage baskets, if necessary. The cleaning operations are performed underwater, in a pool. Some of the transportation cask internals as well as the cask interior will require cleaning to remove radioactive crud. The amount of crud will vary because each fuel assembly has unique characteristics that influence the amount of crud produced.

Since some of the cleaning operations are performed in a pool, the dose rate from the crud on the baskets or spacers is reduced. Each cask will be handled without SNF in the cask. Each truck cask and rail cask in the active fleet each year is handled at the CMF at least 3 times. Handling the truck casks and rail casks is assumed to result in the same exposure to personnel. The dose for each transportation and rail cask handled at the CMF was assumed to be 20 person-mrem/cask on the average, for all cask handling operations. The estimate is based on cleaning and maintenance operations on the casks. Table A2-9 summarizes the exposures.

Table A2-9. Reference Scenario Exposures at CMF

Cask type	Dose per cask (person-mrem/cask)
Truck	20
Rail	20

A2.6.2 MPC System

Truck casks used for handling bare SNF, and rail casks used for handling MPCs, will be handled at the MPC system CMF at least three times per year. The dose for each truck cask is higher than the rail dose due to the probable need to clean and maintain internal structures of truck casks. Rail casks and canisters receive only an external cleaning. Each transportation cask and each rail cask handled at the CMF is assumed to be 20 person-mrem/cask on the average for all cask handling operations at the CMF. The value was based on the use of pool operations for cleaning the cask, and other maintenance operations on the cask. Exposures are summarized in Table A2-10.

Table A2-10. MPC System Exposures at CMF

Cask type	Dose per cask (person-mrem/cask)
Truck	20
Rail	5

A2.7 REFERENCES

1. *Monitored Retrievable Storage (MRS) Facility Conceptual Report, Volumes 1 - 3*, November 30, 1992, U. S. D.O.E. Office of Civilian Radioactive Waste Management, Washington, D.C., Contract Number DE-AC01-91RW00134, CRWMS M&O Document Number TSO.92.0323.0257.

2. *The TN-24P PWR Spent Fuel Storage Cask: Testing and Analyses*, EPRI N-5128, April 1987, Pacific Northwest Laboratory, Virginia Power Company, and EG&G, Idaho National Engineering Laboratory.

3. *The MC-10 PWR Spent Fuel Storage Cask: Testing and Analyses*, EPRI N-5268, July 1987, Pacific Northwest Laboratory, Virginia Power Company, and EG&G, Idaho National Engineering Laboratory.

4. *GA-4 Legal Weight Truck From Reactor Spent Fuel Shipping Cask, Final Design Report*, November 1991, General Atomics Project 3462, U. S. D.O.E. Contract Number DE-AC07-881D12698.

5. *GA-9 Legal Weight Truck From Reactor Spent Fuel Shipping Cask, Final Design Report*, December 1991, General Atomics Project 3462, U. S. D.O.E. Contract Number DE-AC07-881D12698.

6 *"Use of Transportable Storage Casks in the Waste Management System,"* Appendix (P.A-2), December 1987, ORNL/SUB/86-SA094/2 (or JAI-289).

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APPENDIX B

TRANSPORTATION MODE CHARACTERISTICS

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TRANSPORTATION MODE CHARACTERISTICS

These tables support health and safety evaluations of truck, rail, barge, and heavy-haul transport. Parameters shown with the value "route" receive the a value obtained from HIGHWAY or INTERLINE.

Table B-1. Truck Transportation

Input Parameter	Value	
Population density	route	people/sq.km
Fraction Rural Travel	route	decimal
Fraction Suburban Travel	route	decimal
Fraction Urban Travel	route	decimal
Velocity, rural	97	km/hr
Velocity, suburban	80	km/hr
Velocity, urban	64	km/hr
Crew number	2	-
Avg. distance from crew to cask	10	meters
Number of handlings	0	-
Stop time (inspections, meals, etc.)	.0031	hr/km
Minimum stop time	0	hr
Distance independent rail stop time	0	hr
Minimum number of rail inspections	0	-
People near cask during stops	50	-
Average radius to people during stops	50	m
Storage time, en route	0	hr
Number of people nearby during storage	0	-
Average distance, storage, cask to people	0	m
Number of people per vehicle on road	1.2	-
Urban rush hour travel, fraction	0	-
Urban surface street travel, fraction	0	-
Rural and suburban routes on freeway	1	-
One way rural traffic count	470	vehicles/hr

Table B-1. Truck Transportation (continued)

One way suburban traffic count	780	vehicles/hr
One way urban traffic count	2800	vehicles/hr

Accident rates

(reported incidents per million kilometers)

rural	.20
suburban	.28
urban	.36

	Probabilities		
Accident Severity category	Rural	Suburban	Urban
1	.603	.603	.603
2	.39146	.39145	.3936
3	.00386	.00386	.003399
4	.001675	.001679	.00000048
5	.000003	.000006	.00000038
6	.000002	.000005	.00000014

Table B-2. Dedicated Rail Transportation

Cask Type: Rail Cask

Input Parameter	Value	
Population density	route	people/sq.km
Fraction Rural Travel	route	decimal
Fraction Suburban Travel	route	decimal
Fraction Urban Travel	route	decimal
Velocity, rural	43.4	km/hr
Velocity, suburban	32	km/hr
Velocity, urban	24	km/hr
Crew number, while moving	4.5	-
Average distance from crew to cask	152	meters
Handlers	0	-
Stop time (inspections, meals, etc.)	.004	hr/km
Minimum stop time	0	hr
Distance independent rail stop time	2.75	hr
Minimum number of rail inspections	0	-
People near cask during stops	fixed - suburban population density	
Average radius to people during stops	fixed - 800 m	
Storage time, en route	0	hr
Number of people nearby during storage	0	-
Average distance, storage, cask to people	0	m
Number of people per vehicle on road	3	-
Urban rush hour travel, fraction	0	-
Urban surface street travel, fraction	0	-
Rural and suburban routes on freeway	0	-
One way rural traffic count	1	vehicles/hr
One way suburban traffic count	5	vehicles/hr
One way urban traffic count	5	vehicles/hr

Table B-2. Dedicated Rail Transportation (continued)

Cask Type: Rail Cask

Accident rates (reported incidents per million kilometers)	
rural	1.6
suburban	1.7
urban	3.4

	Probabilities		
Accident Severity category	Rural	Suburban	Urban
1	.602	.602	.605
2	.39142	.39162	.3948
3	.00453	.00522	.000199
4	.00125	.001139	.00000048
5	.00059	.000016	.00000038
6	.00021	.000005	.00000014

Table B-3. Barge Transportation

Cask type: Large Rail cask

Input Parameter	Value	
Population density	route	people/sq.km
Fraction Rural Travel	route	decimal
Fraction Suburban Travel	route	decimal
Fraction Urban Travel	route	decimal
Velocity, rural	11	km/hr
Velocity, suburban	8.1	km/hr
Velocity, urban	3.2	km/hr
Crew number	5	(3 persons/tugboat + 2 barge handlers)
Avg. distance from crew to casks	46	meters
Handlers	0	-
Stop time (inspections, meals, etc.)	0	hr/km
Minimum stop time	0	hr
Load time for 3 casks	0	hr
Minimum number rail inspections	0	-
People near during loading	0	-
Average radius to people, load & unload	1	m
Time to unload 3 casks from barge	0	hr
Number of people during unloading	0	-
Avg. distance to people during unloading	0	m
Number of people per nearby barge/boat	3	-
Rush hour travel, fraction	0	-
Urban surface street travel, fraction	0	-
One way rural traffic count	0	vehicles/hr
One way suburban traffic count	1	vehicles/hr
One way urban traffic count	0	vehicles/hr

Table B-3. Barge Transportation (continued)

Cask type: Large Rail cask

Accident rates (reported incidents per million kilometers)	
rural	3.82
suburban	4.24
urban	4.56

	Probabilities		
Accident Severity category	Rural	Suburban	Urban
1	.604	.604	.604
2	.39596	.39595	.3956
3	.000037	.000047	.0003997
4	.000001	.000001	.0000001
5	.000001	.000001	.0000001
6	.000001	.000001	.0000001

Table B-4. Heavy-Haul Truck Transportation

Cask type: Large Rail

Input Parameter	Value	
Population density	route	people/sq.km
Fraction Rural Travel	route	decimal
Fraction Suburban Travel	route	decimal
Fraction Urban Travel	route	decimal
Velocity, rural	16	km/hr
Velocity, suburban	8	km/hr
Velocity, urban	3	km/hr
Crew number, while moving	3	-
Average distance from crew to cask	25	meters
Handlers	0	-
Stop time (inspections, meals, etc.)	0	hr/km
Minimum stop time	0	hr
Start and afloat time	0	hr
Minimum number rail inspections	0	-
People near stopped unit, en route	0	-
Avg radius to people during stops en route	1	m
Time for cask afloat	0	hr
Number of people during afloat	0	-
Avg. distance to people, during afloat	0	m
Number of people per on-link vehicle	1.2	-
Rush hour travel, fraction	0	-
Urban surface street travel, fraction	0	-
Freeway fraction	1	-
One way rural traffic count	2	vehicles/hr
One way suburban traffic count	4	vehicles/hr
One way urban traffic count	6	vehicles/hr

Table B-4. Heavy-Haul Truck Transportation (continued)

Cask type: Large Rail

Accident rates (reported incidents per million kilometers)	
rural	.35
suburban	.003
urban	.003

	Probabilities		
Accident Severity category	Rural	Suburban	Urban
1	.604	.604	.604
2	.39599	.39599	.395999
3	.0000097	.0000097	.00000097
4	.0000001	.0000001	.00000001
5	.0000001	.0000001	.00000001
6	.0000001	.0000001	.00000001

APPENDIX C

ISOTOPES LIST

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ISOTOPES LIST

This isotopes list was prepared from the "Characteristics Data Base" computer files dated June 23, 1993. The spent fuel characteristics assumed are a PWR assembly with an initial enrichment of 3.75 weight percent, a burnup of 40,000 MWD/MTIHM, and an age (decay) of 10 years after discharge from a reactor.

Isotope	curies/MTIHM
H-3	517
Co-60	2,550
Kr-85	5,670
Sr-90	68,500
Ru-106	1,140
Sb-125	1,460
Cs-134	7,400
Cs-137	191,000
Pm-147	9,160
Eu-154	5,670
Eu-155	2,110
Pu-238	4,180
Pu-240	580
Pu-241	95,300
Am-241	2,140
Cm-244	281

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APPENDIX D

MGDS HEALTH AND SAFETY IMPACTS

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MGDS HEALTH AND SAFETY IMPACTS

D.1 METHOD

Expert knowledge and experience data were tailored and applied for the estimation of health and safety impacts at Yucca Mountain, NV. The criteria used in selecting the specific routine and incident impacts for evaluation were the impact types (plausibility), probability, potential severity, radiological release, consequences, and mitigation.

Screening of potential incidents used the data, procedures, and results from Reference 66. The largest off-site dose was calculated to be 220 mrem, which was less than the 500 mrem value used to define items important to safety in 10 CFR 60. Uncertainties however, warrant further clarification as design details are established.

External events that can initiate accidents were identified and screened into several groups: 1) external events, 2) foreseeable conditions or stresses with impact considered within the "design-basis," 3) events not applicable or not credible, 4) events without significant radiological or injuries/fatalities consequences, and 5) events beyond the scope of this document. A brief list of major items follows in Table D-1.

Table D-1. Incidents List

External Events:
Earthquakes, sandstorm, high wind, surface flooding, loss of off-site power, undetected geologic features (joints)

Design Basis Conditions
Thermal loading
Waste and rock interaction
Rock deformation
Geochemical alteration

Events Beyond Scope
Orogenic diastrophism (mountain building)
Military accidents (such as aircraft impacts near Nellis AFL, NV)
Sabotage (employee or terrorist)

Events Not Applicable to Yucca Mountain, NV or Not Credible
(probability of event less than 10^{-6} in the operational phase of the program)
volcanic activity
commercial aircraft crash
hurricanes
forest fires
inadvertent intrusion by people
meteorite impact

In a similar manner, the "internal" accident events triggered by on-site people, equipment, or procedures were screened. External initiating events such as earthquakes can combine with internal imitating events or conditions in a way that increases the probability of an event. The results of the evaluation are in Table D-2.

Table D-2. Results of Screening Evaluation

Events Selected for Consideration
Drift collapse (earthquake)
Transporter slide
Transporter runaway (uncontrolled)
Transporter collision
Container failure (design-basis)
Container grapple or hoist failure

Events Combined with Other Initiating Events
Transporter collision with structures, stationary objects, or moving objects were combined as "transporter collision"
All modes of container damage during emplacement or removal of containers were combined as "container failure"

Events that were Not Credible (less than 10^{-6} probability of occurrence)
Explosion caused by volatile gases in the underground or surface facility
Collision of waste transporter and explosive truck

Events with Insignificant Radiological Consequences
Failure of lifting system on transporter or in facilities during lift
Explosion or fire at diesel refueling stations
Fire resulting from used oil collection process
Explosion resulting from pressurized gases in welding shops
Mechanical failure of containment system for contaminated water
Accidents due to use of explosives
Rupture of fuel pipes
Rupture of water pipes
Rockfall resulting from structural stress relaxation in drifts and tunnels.

Evaluation of specific impacts and consequences are described in the following sections of the appendix.

D.2 MGDS SURFACE FACILITIES

D.2.1 On-Site

D.2.1.1 Construction

Health and safety impacts during surface facility construction were not evaluated for this document.

D.2.1.2 Operation

During surface site operation, casks will be received, stored temporarily, prepared for emplacement, moved by on-site heavy-haul, and emplaced. Both SNF and HLW may be handled. Operations on individual casks for repackaging, inspection, and other purposes may take place. After cask emplacements cease, a period of monitoring of casks in the underground site will continue, followed by closing of the site. Administrative surface facilities, including security operations, will be on-site. Authorized visitors will be present from time to time. Rough order of magnitude estimates of the exposures for handling, HLW, underground transportation and positioning of waste packages, retrieval inspection, monitoring, and visitors were included in the estimates of overall program routine exposures for completeness. Omission of estimated values of incompletely defined operations was considered to result in a 100 % unconservative error and an appearance that the risks were not recognized, whereas a rough order of magnitude estimate would indicate recognition of risks which can be accurately estimated when better data permit.

D.2.1.2.1 Radiological Impacts During Operational Phase, Only

D.2.1.2.1.1 Routine

D.2.1.2.1.1.1 Occupational

Exposure doses per operation were based on MRS data. The total exposures were the product of the exposure per operation multiplied by the logistics data. The logistics data describe the numbers of casks and fuel assemblies handled at the MGDS. The main influence of the presence of an MRS in the system was that large rail casks were received in place of truck casks. HLW casks were assumed to be handled like truck casks, since truck casks may have 4 fuel assemblies and the received HLW casks were expected to contain 5 vitrified waste logs. However, since the Characteristics Data Base showed an inventory radiation flux average for HLW of about one third of the flux from design basis SNF, the HLW waste routine occupational doses were scaled down to one third of the doses for handling a similar number of truck casks of SNF.

Emplacement transportation surface movement and underground exposure doses were estimated as roughly 0.0001 person-rem per waste package, assuming a highly automated system and without an approved baseline waste package design, nor an approved on-site transportation method. Use of thin wall metal containers can result in strong local radiation fields, Reference 65, which would potentially warrant considerable automation of the surface and underground transportation. The RADTRAN 4 transportation exposures code was inappropriate for estimation of exposures during underground movement since the absorption and reflection of radiation in tunnels with rock walls are not contained in that code.

D.2.1.2.1.1.2 Visitors

Authorized on-site visitors were assumed to arrive via the facility security and outreach programs. VIP visitors were assumed to be provided focused tour routes and procedures for topics of interest. Outreach programs may offer conducted tours for selected groups. General tourist access was assumed to be limited to a "visitor center" and security post at a public gate. The vehicle entry gates, (truck or railroad gates), were assumed to be at least 1 km from occupational personnel and public access gates.

Doses were estimated as less than 10 mrem/hr at 2 meters from each cask per NRC requirements. Estimating with a 1/r law for radiation dose attenuation with distance, and a linear source for conservatism, leads to less than 0.1 mrem/hr at 200 meters and less than 0.01 mrem/hr at 2 km from exposed casks.

The following examples were offered. The general visitors were assumed to receive less than 1 mrem per person (equivalent to an exposure during a jet aircraft trip of 2500 miles), assuming one 6-hour visit per person. General visitor totals were assumed as 1000 people per year, and thus these people receive in total less than 1 person-rem/year. Very Important People (VIP) visitors can be offered tours with exposures equivalent roughly to a "medical chest x-ray" (50 mrem) or somewhat less. Doses to 250 VIPs per year could total to 12.5 person-rem. The total dose for visitors was (1 + 12.5) x 40 = 540 person-rem during the forty-year program.

D.2.1.2.1.2 Nonroutine (Incidents)

Screening of initiating incidents was described previously. The largest plausible release was associated with an earthquake induced common mode failure of facility lifting equipment, structures, and radiation alarm and ventilation systems. The combined events probability was estimated as less than 5×10^{-7} for a potential dose of 100 mrem; (based on Table 8-1 of the reference report). HLW handling incidents were considered to be essentially incapable of radioactive gases releases or comparable releases that are the main potential components of exposures following SNF incidents. Thus the HLW incident release doses were estimated to be negligible, and not shown in the report.

These values were compared to the 10 CFR 100.11 sitting criteria (NRC) maximum permissible exposure of 25 rem for accidents ". . . of exceedingly low probability of occurrence and low risk . . ."; or total dose to the public under special circumstances (DOE order 5400.5) of 500 mrem/yr if the average dose is less than 100 mrem/year.

D.2.1.2.2 Non-Radiological Impacts

The occupational impacts were influenced by the location of the MGDS in desert terrain. Occupational activities during operation are repetitive, and at a steady level of effort. There were no identified significant routine or nonroutine impacts to the public, including on-site authorized visitors.

D.2.1.2.2.1 Occupational Routine and Nonroutine (Incidents)

The occupational impact factors included: noise, dust (mineral and organic), repetitive motion/impact, "traffic" accidents, and frequent large-object handling. Reported accidents were assumed to be typical of nuclear power industry experience, involving human errors in use of tools, etc., and thus estimated on the basis of nuclear power industry injuries and hours lost per million hours worked. Using the industry data, the impacts were estimated as follows.

Ri = accident frequency rate 3.85 per million person-hours worked, in 1992. This rate was reduced by nuclear industry safety programs from 10.5 per million in 1980.

P = personnel work hours for program (assume 500 people, 40 hr/week, 52 weeks/yr, 40 years) = 41.6 million manhours.

Losses = Ri*P implies 160 reportable accidents, conceivably including a fatality, during the operational program.

D.2.2 Public Off-Site Impacts

D.2.2.1 Non-Radiological Impacts

There were no identifiable non-radiological off-site impacts to the public caused by the facility. Impacts connected with transportation were dealt with in that section of the document. Dust, debris, noise and other regulated phenomena that may be generated on the site will be controlled to levels less than permitted by the specifications at the facility perimeters.

D.2.2.2 Radiological Impacts During Operational Phase Only

At the perimeter the maximum emissions and airborne releases to any member of the public was estimated at less than the 10 mrem/year of airborne release permitted by DOE Order 5400.5 and 40 CFR 61.92 (EPA).

For an illustrative estimate: at the primary surface road vehicle gates the estimated rate was less than 0.01 mrem, and for an estimated four vehicles gate-visitors/day, 30 minutes each vehicle: the estimated annual dose would be less than 0.730 person rem/year [less than 10 mrem/hr at 2 meters (per NRC requirements) and use a $1/r^2$ law for radiation dose dilution with distance, ≥ 1 x 10^{-3} mrem/hr at 200 meters and 1 x 10^{-5} mrem/hr at 2 km]. The annual dose would be less than 0.1 per year.

Off-site radiological exposures can only occur following radiological release within the above-ground or underground components of the facility. The probability and severity of such events are described in the on-site radiological incident section. As at nuclear power sites, human error and equipment failure-induced punctures of casks could conceivably permit radioactive gas dispersal off-site extremely diluted. Earthquakes can conceivably induce emissions that reach off-site locations as extremely dilute radioactive gases.

The most plausible release was associated with an earthquake that induced common mode failure of on-site facility lifting equipment, structures, and radiation alarms and ventilation systems. The combined events probability was estimated at 5 x 10^{-7} for a potential dose of 100 mrem (based on Table 8-1 of the Reference 66). Table 8-1 of the Reference provided the estimated probabilities and doses for several scenarios, on the access ramps and in the underground sections of the MGDS. Notably the highest probability was 10^{-5}, for about 100 mrem.

These values were compared to the 10 CFR 100.11 sitting criteria (NRC) maximum permissible exposure of 25 rem for accidents ". . . of exceedingly low probability of occurrence and low risk . . ."; or total dose to the public under special circumstances (DOE order 5400.5) of 500 mrem/yr if the average dose is less than 100 mrem/year.

D.3 MGDS UNDERGROUND

Impacts underground were estimated for operations after the initial waste emplacement capability was established. Impacts during site preparation, before the first operational emplacements of waste packages, were not considered. Activities conducted underground consisted of continued excavation, emplacement of waste packages, monitoring, backfilling, closure, and the extraction /return of waste packages.

D.3.1 Construction Influence on Operational Safety

Construction (excavation, mapping, and reinforcement) may continue through the life of the facility. Risks were involved in the excavation, installation of structural reinforcement such as rock-bolts and mesh, and during backfilling. Rockfall risks decline rapidly to a steady low rate after the initial excavation at the rock-face, and following structural reinforcement installation at each newly opened section of the works. Continuous monitoring of the ceiling structures by commercially available local rock movement mechanical indicators was assumed to detect and remedy any previously undetected weak positions.

Deformable structural linings in fully lined tunnels will prevent rockfall, except in earthquakes that cause severe collapse of the short sections of the tunnels. Structural reinforcement (lining) with rock-bolts and mesh reinforcement exhibited a largest size of rockfall that was defined by the greatest size ceiling rock pyramid possible between the rock-bolts. Probability of a rockfall happening will depend on the local rock quality index (spacing between fracture lines), method of construction, span of the tunnel, time since excavation of the section, and factors such as earthquakes. The cumulative probability of a rockfall increased with tunnel length, if all other factors remained fixed.

Well designed and installed reinforcement mesh attached to the tunnel walls can reduce the severity of rockfalls if the loose rock fragments exceed the mesh size, and if the total weight of the rockfall is below the rip-out capacity of the mesh attachments to the tunnel rock roof and walls. Weak rock areas will be mapped and reinforced. Undetected weaknesses are a plausible risk, and can be minimized by advance inspection technologies, up to levels triggered only by major seismic disturbances.

Thermally induced stresses during heat-up can increase the probability of exfoliation-shooting and slabbing. Further, interior cooling of the tunnel drifts can induce rockfall, by reducing clamping forces, especially after stress rheological relaxation flow movement of the tuff.

Statistics from comparable underground facilities were the best basis of meaningful estimates of the frequency and severity of rockfalls. The only known comparable facility is at the National Test Site (NTS). Tunnel sections constructed by tunnel boring machines are most pertinent.

pertinent. Drill-and-blast excavation experience would be very conservative, overestimating the impacts, since the blasting degrades the rock integrity for several meters into the remaining rock wall and roof structure. In contrast, tunnel boring machines damage the rock walls and ceiling only to a thickness (depth) of a few centimeters. There is a high probability of small fragments, up to the size promoted by the depth of damage created by the excavation process, and almost zero probability of fragments larger than the tunnel width.

The factor Ri, the fatal accident frequency rate in conventional metal and nonmetal mines, was reportedly 3 per 10,000 person-hours worked, to the year 1993. Scaling for the smaller working face per worker at the MGDS, compared to mineral extraction mines, provides an exposure factor of about 0.001. Thus P = personnel work hours for the program (assume 50 people underground in potentially hazardous operations, 40 hr/week, 52 weeks/yr, 40 years) = 4.2 million manhours. Losses = Ri*P implies less than one fatal accident, during the operational phases of the program. Reference 71 described the comparative safety records of two tunnels, one driven by tunnel boring machine and the other by conventional drill and blast methods, in the same geology at a single site, about 1965. The lost time accidents per 10,000 feet tunneled was 28 man-days for the machine, and 525 man-days for the conventional method. This is a safety advantage of 525/28, or about 20 times.

D.3.2 Radiological Exposures

Significant exposures are expected during transportation of waste packages to and from the positions in the drifts, orientation placement of each package at its assigned location, and for periodic inspections during the operational period of the MGDS. Each emplacement trip, including a simple in-drift placement, was estimated to provide roughly the same person-mrem. Monitoring of in-situ casks was estimated at one person-mrem per cask per year. These were combined with throughput data to obtain the program life-cycle doses listed in the report. There were no (zero) identified plausible radiological incident releases projected, short of a catastrophic earthquake.

The estimates are based on comparable activities at the utilities and MRS for on-site transportation and dry storage. Estimates are still uncertain because the final designs of the transporter, its shielding, and robotic support (if any) have not yet been selected. Thus the estimates shown in the primary section of the report are rough order of magnitude in accuracy. Clarification will be needed as the designs and procedures are refined.

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MPC Robotic Welding:

Simulation and

Benefit-Cost Analysis Report

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Submitted to:
TRW Environmental Safety Systems
Duke Engineering & Services, Inc.

August 17, 1994

Approval:
Date: 8/15/94

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Executive Summary

This report compares the economic and radiation dose impacts of robotic handling methods to those of manual handling methods for closing and welding Multi-Purpose Canisters (MPC). It describes the graphical simulation techniques used to develop and support assumptions for the economic analysis, including the creation and operation of the animated workcell depicting MPC closure operations at a commercial reactor site. This work further describes and utilizes the economic analysis methods recommended by the U.S. Government Office of Management and Budget. The economic analysis uses assumptions based on manual operations defined by TRW Environmental Safety Systems, and robotic operations based on MPC closure simulation. which is in turn validated for robotic equipment in use at Sandia National Laboratories. This report presents the cost and benefit results of the analysis, comparing use of robotic machinery to traditional manual methods in the MPC closure operations.

The results of this analysis present a compelling case for choosing the robotic method over the baseline manual methods for specific MPC closure and welding operations. The use of robots to execute these operations offers a unique win-win opportunity, simultaneously saving 1538 person-rem and $52 Million over a 13-year operational period, including developmental costs, as compared to the manual method. Payback is achieved within 26 months of start of operations.

This savings can be accomplished with the potential to more than double the manual through-put rates, matching the manual rates at a minimum. Further, additional MPC operations may be possible using the robotic machinery and controls, and the operational lifetime may be significantly extended, reducing additional radiation dose, through-put time and costs.

Pursuit of the robotic method holds low risk from the economic and technical standpoint. Most of the operations have been demonstrated individually, simulations indicate high-success probability, and the potential savings of $52 Million is significant. Even should the entire $52 Million be used to cover cost increases, cost of additional units and demonstration work, essentially free person-rem savings would remain "reasonable" from the ALARA standpoint.

Therefore, if no preferable alternative is found, robotic closure and welding operations should be pursued and demonstrated for application at commercial reactor sites, as well as any other sites where MPCs are loaded.

MPC Robotic Welding: Simulation and Benefit-Cost Analysis Report

1.0 Introduction

This work is sponsored by the U. S. Department of Energy (DOE) and TRW Environmental Safety Systems (TESS), the DOE Management and Operating contractor for the Civilian Radioactive Waste Management System (CRWMS). The purpose of this report is to provide decision information to determine whether robotic methods are a viable option to reduce radiation exposure during Multi-Purpose Canister (MPC) closure and welding operations. The MPC is a sealed metallic canister intended for storage, transportation and disposal of spent nuclear fuel (SNF) assemblies throughout the CRWMS. MPCs are sealed to provide a dry, inert environment for SNF and are over-packed separately and uniquely for the various system elements of storage, transportation, and geologic disposal. Closure of the MPCs results in a significant dose to personnel using traditional manual means, and alternate methods are desirable. Robotic manipulators offer a means of completing the closure operations without the presence of radiation workers, and an opportunity to reduce radiation doses for each robotic operation by up to 88%. Therefore, information regarding technical feasibility, operational speed, dose savings and cost are needed to compare potential robotic MPC operations to manual counterparts, and determine whether to pursue robotic application.

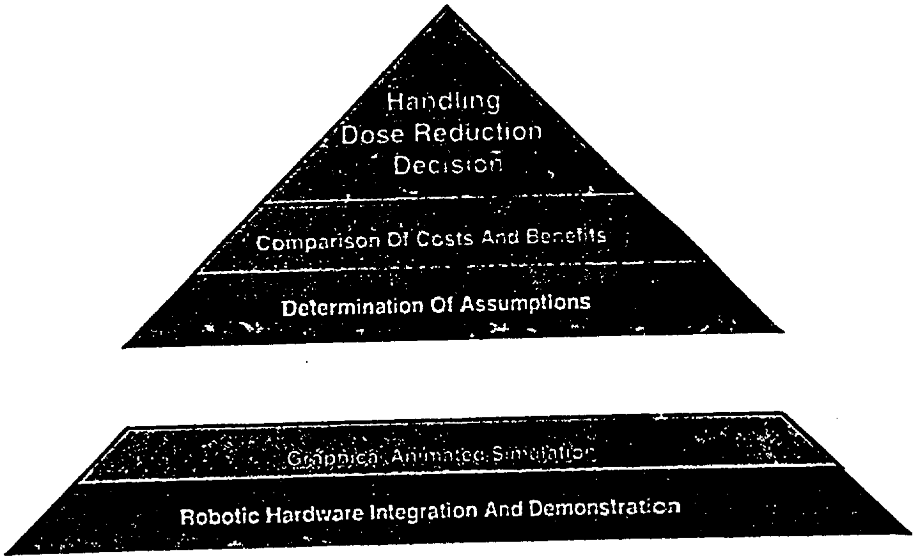

Figure 1.1 MPC closure and welding method decision process.

Figure 1.1 illustrates the steps needed to support the decision process. The first step is a comparison of costs and benefits for each radiation reduction method proposed. Underlying the cost/benefit analysis of each method are the assumptions, including dose rates, labor costs, capital costs, through-put rates, etc.

This effort seeks to support the assumptions used for robotic operations by adding the two elements in the lower part of the pyramid in Figure 1.1. Graphical animated simulation is extensively used at Sandia National Laboratories (SNL) as a part of general robot control systems. That is, graphical models of the robot and its environment are generated and used for both preview and real-time control of robot motions. For this reason, all graphical models of the robots in use at SNL have been validated. Further, many of the closure operations required for the MPC have been demonstrated at SNL using robots with the graphical programming capability. Thus, confidence in robotic assumptions for the cost/benefit analysis is high.

This report compares the economic and radiation dose impacts of robotic handling methods to those of manual handling methods for closing and welding Multi-Purpose Canisters (MPC). It describes the graphical simulation techniques used to develop and support assumptions for the economic analysis, including the creation and operation of the animated workcell depicting MPC closure operations at a commercial reactor site. This report further describes the economic analysis methods used, inputs to the economic analysis, and presents the costs and benefits of using robotic machinery in lieu of traditional manual methods in the MPC closure operations.

Robotic handling cost estimates are based upon graphical simulations of a workcell in generic fuel handing building at a commercial nuclear reactor site. The simulation uses software which accurately models the dimensional and kinematic characteristics of the robots, facility, casks, and ancillary equipment. The simulation identifies operations that can be automated with robotic machinery, examine how those operations can be executed automatically, identify equipment requirements and operational characteristics for the automation, and determine potential process times for each automated operation. Equipment cost is estimated based on identified requirements.

Manual handling cost estimates are based on process timing, dose rates, labor rates and crew size information provided by TESS[1,10]. Minimum crew size per shift for each workcell is estimated at 3, plus one QA welder for all shifts. Additional crews may be rotated in to avoid exceeding radiation dose limits. Labor costs are then calculated, representing the majority of the manual handling cost.

Economic analysis methods recommended by the U.S. Government Office of Management and Budget are applied to the resulting investment and operating cost estimates to determine lifetime costs. The economic analysis uses assumptions based on manual operations from TESS described above, and robotic operations based on the MPC closure simulation, which is in turn validated for robotic equipment in use at SNL. Cost and benefit results of the analysis, comparing use of robotic machinery to traditional manual methods in the MPC closure operations are presented and discussed.

2.0 Simulation Description

Modeling and simulation are executed using IGRIP software from Deneb Robotics, Inc., on SiliconGraphics workstations. IGRIP is used to accurately model the dimensional and kinematic characteristics of the robots, facility, casks, and ancillary equipment. Embedded into this modeling is a high degree of component detail with programmable machine parameters to match most commercially available robotic systems. This accuracy, together with previous validation of the IGRIP modeling environment and its integration into real-time control of SNL industrial robot systems[2], leads to high-confidence estimates of the through-put of the workcell.

The MPC welding venue chosen for simulation is a generic fuel handling building with a decontamination pit near the fuel storage pool (Figure 2.1). A decontamination pit places the top of the MPC near the floor. This allows robotic equipment and tooling to be mounted near the floor, reducing potential safety hazards and facilitating service and maintenance. Other mounting schemes may be required for those utilities without decontamination pits or with conditions otherwise preventing floor mounting.

A robot is mounted on a mounting plate at the side of the pit, and rotated on the plate into position above the MPC after the MPC has been placed in the pit by the facility crane. The mounting plate footprint is approximately 6 x 6 feet. The robot chosen for this simulation is a Staubli Unimation NEATER 762 robot (Figure 2.2). Based upon the Unimation PUMA 762 industrial robot, the NEATER robot has been engineered for radiation tolerance up to 10^8 Rads. This is sufficient to survive a continuous field of 200 Rads per hour for 57 years, which eliminates most reliability concerns related to radiation exposure. Though it is not yet clear whether specific radiation hardening is required, this level was assumed to be sufficient for the lifetime dose imparted by the MPC operations, and offers the option of trading the industrial machine for the commercially available and kinematically similar radiation tolerant machine.

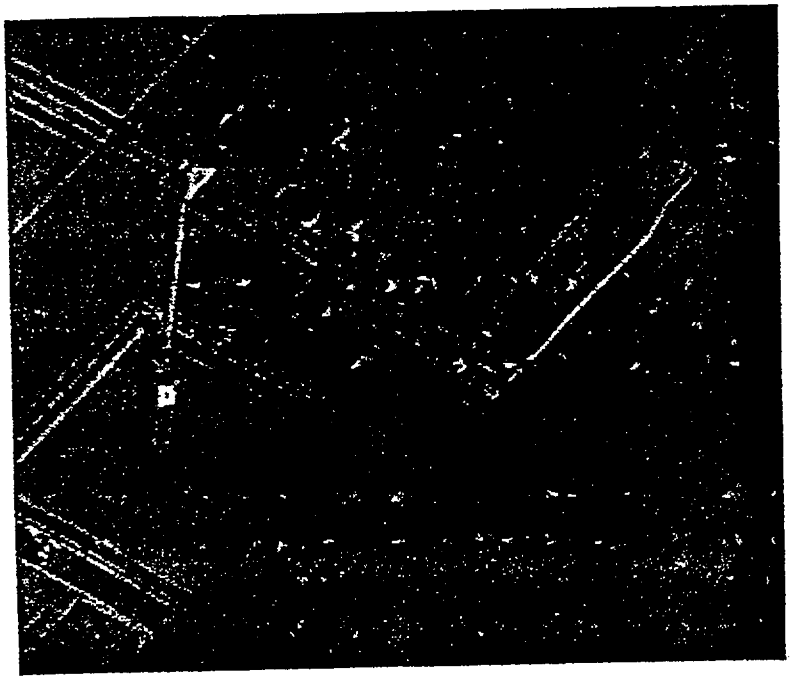

Figure 2.1 Simulated generic fuel handling building with decontamination pit

Figure 2.2 NEATER 762 robot in action. *Source: AEA Technology*

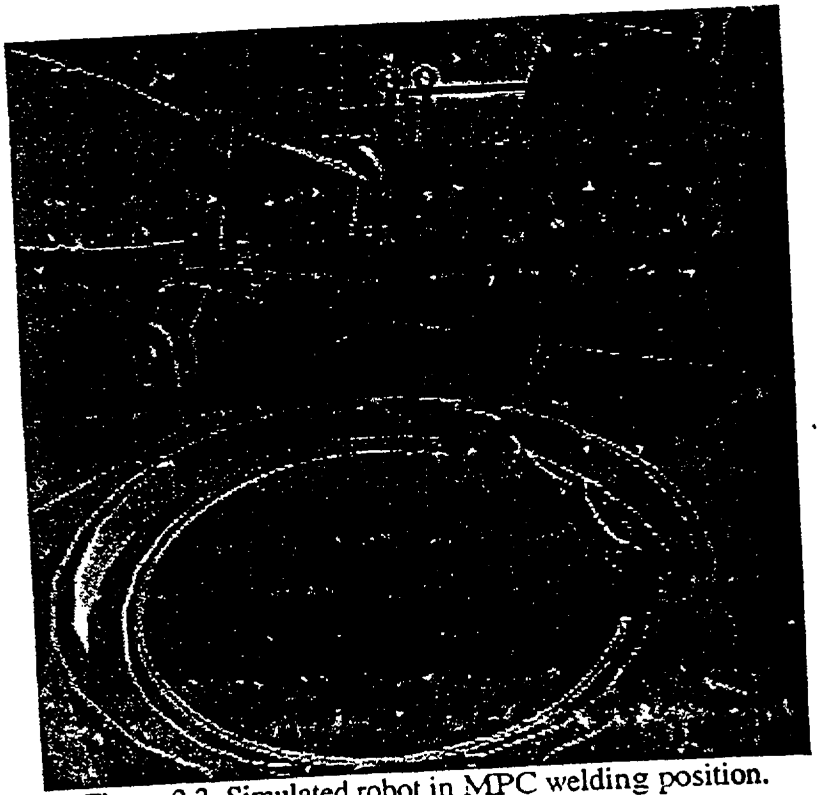

Figure 2.3 Simulated robot in MPC welding position.

The NEATER 762 has a 20 kg load capacity at full extension, with sufficient work volume (verified by simulation) to cover the MPC head area for both inner and outer lid welding when positioned over the MPC. A similar robot has been used by AEA Technologies Winfrith to weld intermediate level waste drums closed using a synergic pulsed Metal Inert Gas (MIG) process[3]. Figure 2.3 shows the simulated NEATER robot in position for MPC closure and welding operations.

To further assure technical feasibility, available technologies, hardware and software are assumed. In particular the SMART control approach, and sensors including capacitive seam tracking and distance measurement, force/torque sensors and machine vision are assumed.

Sequential Modular Control Architecture for Robotics and Teleoperation, or SMART, is a real-time distributed, modular control architecture based on passive network theory that guarantees stability as control modules are added or removed[4]. SMART allows for control strategies to be changed through software or even during operation of a robot through supervisory control. In the MPC case, SMART would allow the welding operator to "take over" from autonomous operations as needed. It also permits use of sensor input for path adjustment such as arc voltage, distance and obstacle detection, and contact forces. SMART modules for robots, sensors, path planners, feed-back mechanisms and graphical control schemes can and have been built and assembled into working control systems. SMART has been implemented and demonstrated to TESS representatives on a PUMA 760 series robot at SNL. This demonstration included program execution of part of the simulation described in this report.

Capacitive sensing is assumed for both seam tracking and path compensation due to warpage. The sensors produce an electric field between appropriately spaced electrodes. These fields are perturbed by the workpiece, resulting in capacitance changes which can be interpreted and utilized for motion control purposes. Several versions of sensors exist. One is used to determine lateral and forward distances to an object. Another is used as a robot "skin," detecting obstacles and preventing collisions. The third, a Multi-Axis Seam Tracking (MAST) sensor, has been designed and successfully applied to manufacture Delta rocket booster engines at Rocketdyne[5]. The engines consist of hundreds of specially-shaped tubes brazed together to form a solid assembly. A robot arm scans the surface of the nozzle with a MAST sensor, determines the position and orientation of tubes and seams, and automatically generates paths for braze paste dispensing.

Force/torque sensing and control is assumed for all contact operations. Standard position control relies on the robot moving to a calculated position in space. If that position is intended to be on an object surface, any error in calculation or in robot performance may result in either undesirable force build-up or no contact at all. Therefore, force sensors are used to detect forces and adjust forces applied when robots are operating in contact with objects. Force control is used industrially for grinding and deburring operations[6]. Force control is used extensively at SNL in all robots requiring contact operations on workpieces. Examples of SNL-demonstrated operations where force control is used are nuclear fuel transportation cask swipe surveys and bolting operations[7], grinding, deburring, pipe cutting, and part assembly and disassembly.

Machine vision is assumed for fast orientation of the robotic equipment to the MPC and lids. Since the robot will be removed from its operating position when lids are installed and then repositioned over the MPC, a means of calibrating the robot movements to the position of the MPC and its components is needed. Machine vision finds three points on the MPC, defining its position and orientation relative to the robot. Each point can be determined in approximately 30 seconds.

Two examples of machine vision use at SNL include spent nuclear fuel transport cask handling and part deburring demonstrations. In an RW-sponsored demonstration, an SNL gantry robot using machine vision located a 1/2 scale transport cask in its workcell with an accuracy of approximately .04 inches[8]. This enabled the subsequent operations of cask inspection, radiation surveys, contamination swiping in contact with the cask, impact limiter removal, tie-down removal and uprighting. In a separate manufacturing demonstration, a crown-shaped part was located and oriented to an ADEPT robot, which then generated a path based on a part CAD model, and used a grinder with force feed-back to remove burrs from the teeth of the crown[9].

Table 2.1 lists the operations carried out in the simulation by the robot, together with the time required for execution of each operation and a manual comparison from Reference 1. Since 100% velocity may be unacceptable for safety reasons, Table 2.1 includes execution time for the robot moving at 25% of full speed. This combination brackets the range of likely allowable speeds at a reactor site. In each case, it is assumed that no human presence is required in the proximity of the MPC.

Note that Table 2.1 only includes operations expected to be performed by a robot. Other time consuming operations, such as cask loading, unloading, MPC fuel loading, MPC decontamination and MPC lid fit-up are not included. See reference (1) for a complete listing.

The right-column entries in Table 2.1 indicate expected manual operation times provided in (1). Some manual operations, such as repetitions of the NDE processes, were not included in (1). Positioning the robot and locating the MPC are roughly the equivalent of installing the current remote welding device. A significant difference in expected time is in the inner and outer lid welding. While manual operations are expected to take approximately 1000 minutes per weld, robot execution, programmed to move identically to the current welding machine at 8 inches per minute during welding, appears to require only about 385 minutes. Several factors influence this difference.

First, the 1000 minute estimate is based on current operations of an Independent Spent Fuel Storage Installation (ISFSI) at Duke Power's Oconee Station. The ISFSI canister design includes a key way at the side of the canister to accommodate draining and venting ports, resulting in a deviation of the weld from a circular path. Because of the corners thus generated, and the inability of the current remote welding machine to adequately weld these corners, time-consuming manual welding is required in the corners. By contrast, the MPC design has a circular weld path, and the robot manipulator, though capable of key way deviations, is not required to deviate from the circular path.

Table 2.1
Simulated MPC Closure and Welding Operations: Execution Times and Manual Comparison

		100% speed	25% speed	Manual Speed
		Task Time (m)	Task Time (m)	Task Time (m)
1	Install welder			45
2	Robot positioning	0.23	0.23	
3	Locate MPC	0.5	0.5	
4	Inner lid weld	382.1	387.0	1000
5	Tack weld innner lid	5.5	6.1	
6	Drain/dry connection operation	1.5	2.3	22
	Inner lid weld NDE inspection			30
7	Inner lid dye application	4.4	4.6	
8	Inner lid dye removal	2.3	2.6	
9	Inner lid powder application	1.9	2.0	
10	Inner lid camera inspection	1.9	2.0	
11	Inner lid helium leak check	5.7	6.0	20
12	Port cover welding	31.5	31.5	90
13	Port cover installation	0.91	1.6	
	Port weld NDE inspection			
14	Port cover dye application	3.8	4.4	
15	Port cover dye removal	6.9	7.2	
16	Port cover powder application	3.8	4.1	
17	Port cover visual inspection	0.3	0.5	
18	Port cover helium leak detection	9.5	10.0	
19	Locate MPC (install welder)	0.5	0.5	45
20	Outer lid weld	382.1	387.0	1000
21	Tack weld outer lid	5.4	6.1	
	Outer lid weld NDE inspection			
22	Outer lid dye application	2.33	2.8	30
23	Outer lid dye removal	4.46	4.7	
24	Outer lid powder application	2.28	2.5	
25	Outer lid camera inspection	1.87	2.0	
26	Outer lid helium leak detection	5.61	5.9	
27	Operations complete (remove weld equipment)	0.19	0.3	20
	Elapsed Time	867	885	2282

Secondly, finish grinding is apparently required prior to NDE testing, and may have been included in the welding time estimate. Finish grinding was not given in Reference (1) specifically, and was not identified as a normal operation for simulation. However, grinding was included as an off-normal event in the simulation. Adding a single grinding pass at the weld speed of 8 inches per minute would add approximately 24 minutes for each weld.

Third, weld tip cleaning is not included in the weld timing analysis, and will increase the simulated timing. It is not clear at this writing how much the frequency or duration of the cleaning process will impact the operational timing, but discussions with welding equipment vendors are continuing. Additional verification should be made that all necessary welding parameters and subtasks have been addressed. Fourth, the automatic sensors and controls assumed for the robotic system will minimize welding delays.

Finally, even if 1000 minutes is substituted for the 385 minute robotic simulation welding time, the total robotic process time becomes approximately equal to the manual estimate. Figure 2.4 illustrates the inner lid welding in the simulation.

Figure 2.4 Simulation of inner MPC lid welding operation

Drain/dry connection operations include both making and breaking port connections, but does not include the draining, vacuum drying and backfilling operational times for either handling method.

Significant discrepancies between manual and robotic operation time here may be due to equipment design concept differences. For the draining, drying and backfilling process, a quick-release connection mechanism was simulated based on a SNL design and demonstrated in the Cask Head Project[8]. Shown in Figure 2.5, a sleeve containing the female portion of a quick-release valve with ball detents is inserted into the port hole and connected with a simple pushing motion. Release is accomplished by a linear pulling motion. The sleeve has a diamond-shaped pintle attached to the top that is gripped by a specialized diamond gripper commonly used at SNL. A similar pintle was assumed to be attached to the port covers for gripping and placement over the drain and drying ports using the same diamond gripper.

These quick-release mechanisms are cheaper and simpler to use than valves requiring first a physical connection then a valve opening procedure. If the latter valves are used the execution time for this step will rise and tooling complexity increase, possibly quadrupling the cost of this tool.

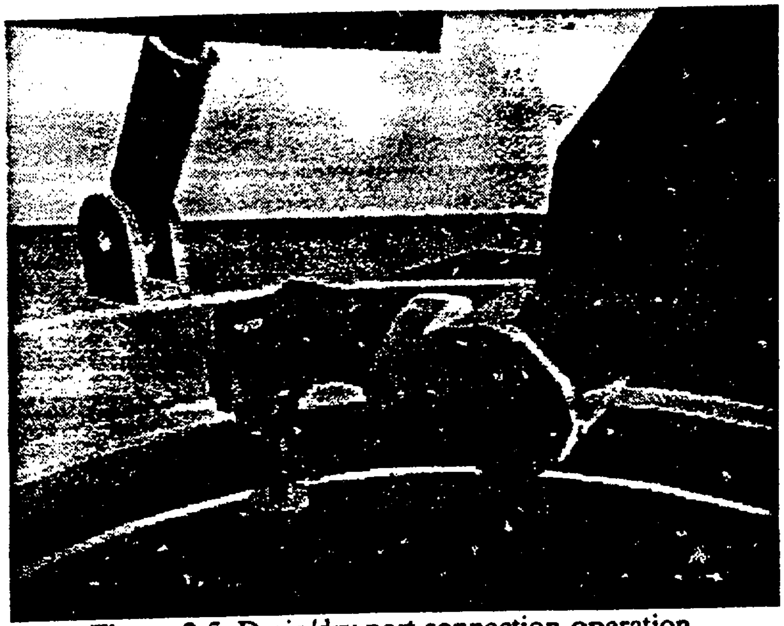

Figure 2.5 Drain/dry port connection operation.

Draining and drying is accomplished in concept by pressurizing the gas port, forcing water through the drain pipe at the MPC bottom up through the drain port and out of the MPC. After the water is removed, any residual water is boiled away using a vacuum process through the same drain and drying ports. Helium is then backfilled into the MPC, providing an inert atmosphere inhibiting corrosion and assisting in heat transfer and leak detection functions.

Upon completion of the draining/drying/backfilling process, the ports are welded closed. First, port covers are emplaced over each of the two ports using the gripper described above. Then the welding rig is brought in to weld the covers in place and provide the primary seal over the valves. All welds are then inspected as described below.

As discussed above, a finish grinding operation may take place after the welds are complete. Though not included in the timing analysis, the approximate time for each weld may be found by dividing the weld circumference by the grinding speed, and adding one minute for tool changes. Grinding speed has been assumed to be equal to the welding speed of 8 inches/minute.

Current weld non-destructive evaluation (NDE) inspection practice at Duke Power Company's Independent Spent Fuel Storage Installation (ISFSI) at the Oconee plant is a three-step dye penetrant test. The test requires the application of dye, removal of excess dye, and the application of a developer. Three separate tools were simulated to execute these tests. The first is a dye applicator that either sprays or brushes dye onto the weld surface. The second is a dryer that blows air across the surface toward a vacuum attachment on the other side. The third tool is a powder applicator blowing a low-velocity developer powder aerosol onto the weld surface. It is recognized that use of pressurized sprays may not be ideal for the dye penetrant process, as pressure may inadvertently force penetrant from the very cracks and crevasses being sought. However, tooling may be designed to overcome this difficulty such as sponge daubers and low-velocity vacuuming with little anticipated cost difference.

After the welds are inspected and the MPC has been drained, dried and backfilled with helium, a helium leak check is performed to assure hermetic sealing. The helium leak check uses a sniffer wand attached to a mass spectrometer tuned for helium. A sniffer tool, based on a hand-held device, was simulated for this operation. The robot passed the sniffer once over each of the main and port welds at a speed of 0.5 inches/sec.

When inner lid operations are complete, the robot retracts for emplacement and fit-up of the outer lid using the facility crane. The welding and inspection operations described above are then essentially repeated for the outer lid.

One additional set of operations for off-normal weld conditions is simulated. If a bad weld area is detected, the simulation stops, indicates to the operator where the detected flaws were, and asks the operator whether the flaws should be repaired. If the answer is yes, the robot retrieves a grinder and executes the material removal process in the indicated area. Once sufficient material is removed, the weld head applies repair metal, and the NDE process is repeated for the affected areas. Due to rare occurrence and variation in operator choices for this off-normal sequence, timing analysis does not include these operations.

Table 2.2 lists the equipment and associated estimated costs necessary to execute the closure and welding operations robotically as described above, based on SNL experience.

Supervisory control systems represent those systems that coordinate the activities of the robot, welding equipment, sensors and operator interface. The NEATER robot is the articulated manipulator fielding all the welding and sensory equipment. The stereo vision locating system allows the robot to find the MPC within its work volume and thus orient all movement on the MPC. Location must be done each time the robot is moved, such as during inner and outer lid installations when the robot is rotated away from the head of the MPC. Each of the tools necessary for the above operations are listed together with a cost estimate. The welding system was originally quoted by PAR for use with a gantry robot to weld MPCs in an MRS environment. However, Dimetrics has verbally quoted $70K for a track welding system large enough to weld barrels. If such a system is adequate, the cost would be reduced potentially by half for this item.

The total capital cost for a robotic closure and welding system is approximately $647 K. The estimated cost for a remote automated welder such as those currently in use at Duke Power Company's Oconee plant and at Baltimore Gas and Electric Company's Calvert Cliffs plant is $350 K. However, this welder is only capable of making the inner and outer lid welds, where robots are capable of additional dose-saving tasks.

Table 2.2
MPC Closure And Welding Equipment And Cost Estimation

Item	Est. Unit Cost	Quantity	Cost	Source	Totals
Supervisory control					
Support computing system	$17,400	1	$17,400		
VxWorks real-time operating system	$22,400	1	$22,400		
SiliconGraphics workstation	$45,000	1	$45,000	SiliconGraphics	
IGRIP graphical programming software	$60,000	1	$60,000	Deneb Robotics	
Auxiliary workstation	$15,000	1	$15,000	Sun	
Supervisory Subtotal					$159,800
NEATER 760 Radiation Tolerant Robot	$220,437	1	$220,437	AEA Technologies	
NEATER 761/2 N robot arm					
Interconects and radiation tolerant adapter box					
Brake release box					
CS3 VAL controller, VAL II control, I/O module					
Teach pendant					
Disk and manual set					
Industrial VDT with integral disk drive					
NEATER Robot Subtotal					$220,437
Stereo vision locating system					
Cohu 6412 cameras	$1,545	2	$3,090	Scientific Systems	
25 mm lenses	$200	2	$400	Scientific Systems	
VME rack, Force back plane, power 20	$4,990	1	$4,990	I M Systems	
CPU-30	$4,990	1	$4,990	I M Systems	
Framestore board	$3,750	1	$3,750	DATACUBE	
Digimax board	$2,250	1	$2,250	DATACUBE	
VFIR MKII board	$7,800	1	$7,800	DATACUBE	
Max SP board	$1,450	1	$1,450	DATACUBE	
SNAP board	$3,000	1	$3,000	DATACUBE	
Featuremax board	$3,000	1	$3,000	DATACUBE	
Stereo vision locating system Subtotal					$34,720
Tools					
Gripper	$2,000	1	$2,000		
Port couplings	$4,000	2	$8,000		
Dye applicator (NDE)	$10,000	1	$10,000		
Dye remover (NDE)	$10,000	1	$10,000		
Dye developer (NDE)	$10,000	1	$10,000		
Grinder	$5,000	1	$5,000		
Port cover holder	$500	1	$500		
Tool rack	$500	4	$2,000		
Tools Subtotal					$47,500

Table 2.2 cont.'
MPC Closure And Welding Equipment And Cost Estimation

Mounting Frame					$30,000
Cask mounting ring					
Robot mounting plate					
Robot mounting plate support frame					
Trunnion clamps					
Welding system	$155,000	1	$155,000	PAR Systems	
Automatic Process Control					
APC computer, board and software					
Current sensors					
Welding equipment					
Power supply					
Welding controller					
Wire feed and dispenser					
Cabling and hose package					
Torch (MIG)					
Cable and hose termination block					
Flow switches and controls					
Welding equipment brackets					
Miscellaneous welding supplies					
Services					
Design					
Test					
Documentation					
Installation supervision (160 hrs)					
Software engineering					
Welding system subtotal					$155,000
MPC Site Welding Total					$647,457

Simulated operations do not include a tip cleaning operation, nor does the list of equipment include a tip cleaning station. Discussions with Dimetrics indicate an absolute need for this procedure and support equipment. Cost figures are not available at this writing, but are expected to fit into the estimated welding system subtotal presented in Table 2.2.

3.0 Economic Analysis Method

The economic analysis method used to compare the robotic and manual handling methods is a Benefit-Cost Analysis using net present value and related outcome measures as defined by the Office of Management and Budget (OMB)[10]. All of the known cost drivers required over the life of the project are included in the analysis. Cost drivers consist of the labor, dose, investment, maintenance, and energy costs for the required operations on the MPC. Driver estimates are listed in Table 3.1 as the basic assumptions to determine whether automation is economically advantageous.

Table 3.1
Cost Driver Estimates for MPC Closure and Welding Operations

Assumption	Manual Method	Robotic Method
Project Life (Years)	13	13
Annual Labor Cost (Operator)		$150,000
NL Operator	$75,000	$75,000
Welder	$75,000	$75,000
QA Welder	$75,000	$75,000
Annual Dose Limit	1	1
Dose Cost per Rem	$10,000	$10,000
Discount Rate	3.00%	3.00%
Investment Cost/Unit	$350,000	$647,457
Development Costs		$5,000,000
Robot Maintenance Cost	$5,000	$35,000
Computer Maintenance Cost	$0	$3,600
Software Maintenance Cost	$0	$9,000
Down Time (%)	0.00%	5.00%
Automated Welding Units	5	5
Energy Cost per KWH	$0.08	$0.08
Energy Requirement (kW)	0	10
Weld MPC-125:		
Operator dose (mrem/MPC)	193.9	73.4
Welder dose (mrem/MPC)	696.6	0
QA welder dose (mrem/MPC	146.6	0
Weld MPC-75:		
Operator dose (mrem/MPC)	193.9	73.4
Welder dose (mrem/MPC)	696.6	0
QA welder dose (mrem/MPC	146.6	0

Project life is assumed to be 13 years based on partial MPC loading schedules provided by TESS[11].

Labor cost is the value required for each operator per year. Manual operator rates were provided by TESS[12], and are based on the lower ranges of $35,000 to $50,000 per year times an overhead factor of 2.15 for operators and $35,000 to $40,000 per year times an overhead factor of 2.15 for welders. Robotic operators are assumed to have a higher cost than radiation workers and are assumed for this analysis to be at the high end, approximately $70,000 times the same overhead factor .

The minimum number of individuals required to carry out operations manually for three shifts is six non-licensed (NL) operators, three qualified welders and one QA welder for inspection purposes. In the event robotic machinery is down this minimum crew must be on hand to continue process flow. Once an operator reaches the dose limit for the year, a replacement operator will be required to resume operation. Therefore, more than the minimum number of operators may be required for that particular year.

Radiation dose is a major driver in the cost analysis. As described above, the number of operators required depends upon how many operators reach the annual dose limit. The current regulatory limit is 5 rem/year. However, DOE has set a design goal of 1 rem/year, and lower if possible following the As Low As Reasonably Achievable (ALARA) philosophy. A dose limit of 1 person-rem/year is assumed for consistency with DOE policy. Dose rates are estimated on an MPC basis. Manual dose rates for the 125 ton MPC were determined by TESS[1], and were assumed the same for the 75 ton MPC. Manual operator dose rates in Table 3.1 represent combined rates for all operators. Dose rates for the robotic case are assumed for robotic equipment deployment and based on MPC lid installation rates. Doses imparted during robot down-time are not normal operations and therefore not listed in Table 3.1, however they are considered in the personnel requirement in Table 4.4. Annual and total doses are then found by multiplying the rate and throughput for each MPC. A cost of $10,000 is applied to each rem imparted to each operator based on the range of industrial values and current TESS practice.

The discount rate of 3% is the nominal discount rate used by TESS to bring all dollars to the present value for comparative purposes.

The investment cost is the capital investment required to implement each handling method, such as buying robotic and computing equipment. The investment values above represent one MPC robotic welding unit. The cost of a remote welding rig for manual handling similar to those used by Duke Power Company and by Baltimore Gas and Electric, quoted by PCI Services, is compared in Table 3.1 to automated handling capital costs of robotic equipment, sensors, supervisory computers and tools. Five units were assumed sufficient to service all MPC-loading utilities in a given year.

Development costs are estimated at $5 Million, including prototype equipment procurement, system integration and refinement, and demonstrations for all operations.

Maintenance cost is the amount required for a maintenance per year for each method. Here, $20,000 reflects an estimated annual maintenance contract with AEA Technologies for each robotic machine. Though maintenance contracts have been issued[13] to British Nuclear Fuels Limited for approximately $6,000, demand for immediate response will likely raise the contract price. An additional $15,000 is added for maintenance contracts on computer hardware and software.

The down time is the expected maintenance and repair time associated with robotic machinery. Since industrial evidence indicates availability of 95% [14], a down time of 5% was chosen.

An energy cost is also assigned for machine operation based on "Monthly Energy Review."[15] This value is used to determine the energy cost per year by multiplying the power cost times the total power required for each year. Energy requirements represent a difference between manual and robotic methods, ignoring the power required to drive the manual welding machine servo motors.

4.0 MRS/MPC Cost-Benefit Results: Robotic *versus* Manual Operations

Using the process and cost drivers described above, total cost, differential cost and cost per rem are calculated for comparative purposes. Tables 4.1 through 4.3 examine the manual MPC closure and welding case for operations described above. Table 4.1 describes the expected annual occupational dose to each of the three classes of workers. Table 4.2 determines the number and cost of labor for each of the worker classifications, and Table 4.3 lists expected costs for the manual method. Tables 4.4 through 4.6 repeat the process for the robotic MPC closure and welding method. Table 4.7 examines various economic parameters, concluding with the "pay-back" period expected for the 5-unit robotic scenario.

Table 4.1
Annual Dose Using Manual MPC Closure and Welding Methods

Year	Loadings of: MPC 125	Loadings of: MPC 75	Total MPCs	Dose to Personnel			
				Operators (rem)	Welders (rem)	QA Welders (rem)	Total (rem)
1998	48	22	70	13.6	48.8	10.3	72.6
1999	50	63	113	21.9	78.7	16.6	117.2
2000	84	53	137	26.6	95.4	20.1	142.1
2001	75	69	144	27.9	100.3	21.1	149.3
2002	85	43	128	24.8	89.2	18.8	132.7
2003	86	56	142	27.5	98.9	20.8	147.3
2004	94	22	116	22.5	80.8	17.0	120.3
2005	85	48	133	25.8	92.6	19.5	137.9
2006	107	20	127	24.6	88.5	18.6	131.7
2007	87	37	124	24.0	86.4	18.2	128.6
2008	101	39	140	27.1	97.5	20.5	145.2
2009	90	36	126	24.4	87.8	18.5	130.7
2010	147	40	187	36.3	130.3	27.4	193.9
Totals	1139	548	1687	327.1	1175.2	247.3	1749.6

The MPC loading values in Table 4.1 were provided by TESS[6] and represent the currently anticipated fuel loading schedule. Radiation doses per MPC from Table 3.1 are multiplied by the number of MPC loadings to determine the dose imparted to each worker classification, then summed for an annual total dose.

In Table 4.2, the required personnel and labor costs are determined by the maximum of the following.

1. For each of three shifts and each welding unit, a minimum of two non-licensed operators and one qualified welder is required, totaling six and three, respectively. A minimum of one QA welder per welding unit is required. It is assumed that the QA welder can be scheduled to inspect each weld when it is complete. Thus, with the number of units at five, a minimum of 30 operators, 15 welders and 5 QA welders would be expected.

2. If the radiation dose imparted reaches the DOE dose limit, a rotation of workers is required. The relatively high dose rates for welders and QA welders result in higher numbers of these individuals.

Table 4.2
Annual Labor Cost Using Manual MPC Closure and Welding Methods

Year	Required Personnel			Labor Cost			
	Operators	Welders	QA Welders	Operators	Welders	QA Welders	Total
1998	30	49	11	$2,250,000	$3,675,000	$825,000	$6,750,000
1999	30	79	17	$2,250,000	$5,925,000	$1,275,000	$9,450,000
2000	30	96	21	$2,250,000	$7,200,000	$1,575,000	$11,025,000
2001	30	101	22	$2,250,000	$7,575,000	$1,650,000	$11,475,000
2002	30	90	19	$2.250,000	$6,750,000	$1,425,000	$10,425,000
2003	30	99	21	$2,250,000	$7,425,000	$1,575,000	$11,250,000
2004	30	81	18	$2,250,000	$6,075,000	$1,350,000	$9,675,000
2005	30	93	20	$2,250,000	$6,975,000	$1,500,000	$10,725,000
2006	30	89	19	$2,250,000	$6,675,000	$1,425,000	$10,350,000
2007	30	87	19	$2,250,000	$6,525,000	$1,425,000	$10,200,000
2008	30	98	21	$2,250,000	$7,350,000	$1,575,000	$11,175,000
2009	30	88	19	$2,250,000	$6,600,000	$1,425,000	$10,275,000
2010	37	131	28	$2,775,000	$9,825,000	$2,100,000	$14,700,000

Annual labor costs are determined by multiplying the labor rates listed in Table 3.1 by the number of workers determined in Table 4.2, and summing the three products. It is assumed that each worker is paid full annual salary, whether or not the individual's radiation dose limit has been reached.

Table 4.3
Annual List of Costs Using Manual MPC Closure and Welding Methods

Year	Labor Cost	Dose Cost	Energy Cost	Maintenance Cost	Investment Cost	Total Cost	Discount Factor	Discounted Cost
0					$1,750,000	$1,750,000	1	$1,750,000
1	$6,750,000	$725,970	$0	$25,000	0	$7,500,970	0.9853	$7,390,925
2	$9,450,000	$1,171,923	$0	$25,000	0	$10,646,923	0.9566	$10,185,170
3	$11,025,000	$1,420,827	$0	$25,000	0	$12,470,827	0.9288	$11,582,497
4	$11,475,000	$1,493,424	$0	$25,000	0	$12,993,424	0.9017	$11,716,377
5	$10,425,000	$1,327,488	$0	$25,000	0	$11,777,488	0.8755	$10,310,629
6	$11,250,000	$1,472,682	$0	$25,000	0	$12,747,682	0.8500	$10,834,939
7	$9,675,000	$1,203,036	$0	$25,000	0	$10,903,036	0.8252	$8,997,161
8	$10,725,000	$1,379,343	$0	$25,000	0	$12,129,343	0.8012	$9,717,579
9	$10,350,000	$1,317,117	$0	$25,000	0	$11,692,117	0.7778	$9,094,456
10	$10,200,000	$1,286,004	$0	$25,000	0	$11,511,004	0.7552	$8,692,798
11	$11,175,000	$1,451,940	$0	$25,000	0	$12,651,940	0.7332	$9,276,118
12	$10,275,000	$1,306,746	$0	$25,000	0	$11,606,746	0.7118	$8,261,947
13	$14,700,000	$1,939,377	$0	$25,000	0	$16,664,377	0.6911	$11,516,586
Totals	$137,475,000	$17,495,877	$0	$325,000	$1,750,000	$157,045,877		$129,327,183

Table 4.3 lists the costs associated with manual MPC closure and welding operations. Labor costs are drawn directly from Table 4.2. Dose costs are determined by the product of the total annual dose imparted (Table 4.1) and the cost per person-rem in Table 3.1. Energy costs are assumed to be negligible since the same welding power supply is expected for both the remote manual and robotic welding units. Annual maintenance contracts for each of the welding units results in the maintenance figures. Investment costs are unit cost times the number of units drawn from Table 3.1. These costs are summed for total cost, and discounted according to the OMB procedure referenced in Section 3 to determine an annual present value cost.

Annual doses imparted using robotic MPC closure and welding methods are listed in Table 4.4. Doses are determined in a similar manner to those in Table 4.1, with the exception that only 12% of the dose found in Table 4.1 is imparted. This is due to the absence of workers in the MPC vicinity except during installation and during the 5% down time of the robotic machines. It is assumed that the workers manually execute operations during such down time. However, it is unlikely that the welders would personally weld the MPCs due to the high radiation dose rates involved. Either the robotic machinery would be repaired and robotic welding continued, or a remote manual unit could be installed. Costs for the latter case have not been considered in this analysis.

Table 4.4
Annual Dose Using Robotic MPC Closure and Welding Methods

Year	Loadings of: MPC 125	Loadings of: MPC 75	Total	Dose to Personnel				
				Robot Operators (rem)	Operators (rem)	Welders (rem)	QA Welders (rem)	Total (rem)
1998	48	22	70	0	5.8	2.4	0.5	8.8
1999	50	63	113	0	9.4	3.9	0.8	14.2
2000	84	53	137	0	11.4	4.8	1.0	17.2
2001	75	69	144	0	12.0	5.0	1.1	18.0
2002	85	43	128	0	10.6	4.5	0.9	16.0
2003	86	56	142	0	11.8	4.9	1.0	17.8
2004	94	22	116	0	9.6	4.0	0.9	14.5
2005	85	48	133	0	11.1	4.6	1.0	16.7
2006	107	20	127	0	10.6	4.4	0.9	15.9
2007	87	37	124	0	10.3	4.3	0.9	15.5
2008	101	39	140	0	11.6	4.9	1.0	17.5
2009	90	36	126	0	10.5	4.4	0.9	15.8
2010	147	40	187	0	15.5	6.5	1.4	23.4
Totals	1139	548	1687	0	140.2	58.8	12.4	211.3

Table 4.5
Annual Labor Cost Using Robotic MPC Closure and Welding Methods

Year	Required Personnel				Labor Costs				
	Operators	Welders	QA Welders	Robot Operators	Operators	Welders	QA Welders	Robot Operators	Total
1998	30	15	5	15	$2,250,000	$1,125,000	$375,000	$2,250,000	$6,000,000
1999	30	15	5	15	$2,250,000	$1,125,000	$375,000	$2,250,000	$6,000,000
2000	30	15	5	15	$2,250,000	$1,125,000	$375,000	$2,250,000	$6,000,000
2001	30	15	5	15	$2,250,000	$1,125,000	$375,000	$2,250,000	$6,000,000
2002	30	15	5	15	$2,250,000	$1,125,000	$375,000	$2,250,000	$6,000,000
2003	30	15	5	15	$2,250,000	$1,125,000	$375,000	$2,250,000	$6,000,000
2004	30	15	5	15	$2,250,000	$1,125,000	$375,000	$2,250,000	$6,000,000
2005	30	15	5	15	$2,250,000	$1,125,000	$375,000	$2,250,000	$6,000,000
2006	30	15	5	15	$2,250,000	$1,125,000	$375,000	$2,250,000	$6,000,000
2007	30	15	5	15	$2,250,000	$1,125,000	$375,000	$2,250,000	$6,000,000
2008	30	15	5	15	$2,250,000	$1,125,000	$375,000	$2,250,000	$6,000,000
2009	30	15	5	15	$2,250,000	$1,125,000	$375,000	$2,250,000	$6,000,000
2010	30	15	5	15	$2,250,000	$1,125,000	$375,000	$2,250,000	$6,000,000

Table 4.5 lists the expected annual labor costs for robotic MPC closure and welding operations. The required workers are the minimum described under Table 4.2, due to the low doses imparted during robotic operations. Labor costs are therefore driven by minimum crew needs and not by radiation doses and limits.

Table 4.6
Annual List of Costs Using Robotic MPC Closure and Welding Methods

Year	Labor Cost	Dose Cost	Energy Cost	Maintenance Cost	Investment Cost	Total Cost	Discount Factor	Discounted Cost
0					$8,237,287	$8,237,287	1	$8,237,287
1	$6,000,000	$87,679	$60,800	$187,600	0	$6,336,079	0.9853	$6,243,124
2	$6,000,000	$141,538	$60,800	$187,600	0	$6,389,938	0.9566	$6,112,803
3	$6,000,000	$171,599	$60,800	$187,600	0	$6,419,999	0.9288	$5,962,686
4	$6,000,000	$180,367	$60,800	$187,600	0	$6,428,767	0.9017	$5,796,921
5	$6,000,000	$160,326	$60,800	$187,600	0	$6,408,726	0.8753	$5,610,534
6	$6,000,000	$177,862	$60,800	$187,600	0	$6,426,262	0.8500	$5,462,025
7	$6,000,000	$145,296	$60,800	$187,600	0	$6,393,696	0.8252	$5,276,063
8	$6,000,000	$156,589	$60,800	$187,600	0	$6,414,989	0.8012	$5,139,451
9	$6,000,000	$159,074	$60,800	$187,600	0	$6,407,474	0.7778	$4,983,913
10	$6,000,000	$155,316	$60,800	$187,600	0	$6,403,716	0.7552	$4,835,913
11	$6,000,000	$175,357	$60,800	$187,600	0	$6,423,757	0.7332	$4,709,754
12	$6,000,000	$157,821	$60,800	$187,600	0	$6,406,221	0.7118	$4,560,095
13	$6,000,000	$234,227	$60,800	$187,600	0	$6,482,627	0.6911	$4,480,079
Totals	$78,000,000	$2,113,052	$790,400	$2,438,800	$8,237,287	$83,342,252		$69,173,367

Annual costs for the robotic method are listed in Table 4.6. Labor costs are drawn directly from Table 4.5. Dose costs are determined by the product of the total annual dose imparted (Table 4.4) and the cost per person-rem in Table 3.1. Energy costs are calculated by multiplying the robot power requirement and kilowatt charge listed in Table 3.1, and 16,000 hours of annual operation. This represents three shifts of 2000 hours at 10 kW (60,000 kW-h) for the robot itself, and an additional 100,000 kW-h for computer and sensor operations. Also drawn from Table 3.1 are investment costs and annual maintenance contracts for each of the welding units resulting in the maintenance figures. These costs are summed for total cost, and discounted according to the OMB procedure referenced in Section 3 to determine an annual present value cost.

Table 4.7 provides cost comparative numbers as outlined by the OMB. For each successive year of information provided, the total costs are drawn from Tables 4.3 and 4.6, and subtracted to find differential costs between manual and robotic MPC closure and welding methods. In this case, the differential costs represent a significant annual savings by using robotic methods. Results are shown in graphical form in Figure 4.1.

Table 4.7
Differential Cost For Manual And Robotic Methods

Year	Annual Costs Manual Method	Annual Costs Robotic Method	Differential Costs	Discount Factor	Discounted Differential	Cumulative Differential	Investment/ Differential	Cumulative Amortization
1	$7,500,970	$6,336,079	$1,164,892	0.9853	$1,147,802	$1,147,802	5.65192271	1.00
2	$10,646,923	$6,389,938	$4,256,985	0.9566	$4,072,361	$5,220,163	1.24273646	2.00
3	$12,470,827	$6,419,999	$6,050,828	0.9288	$5,619,811	$10,839,974	0.59845961	2.12
4	$12,993,424	$6,428,767	$6,564,657	0.9017	$5,919,455	$16,759,429	0.38708279	0.00
5	$11,777,488	$6,408,726	$5,368,762	0.8755	$4,700,095	$21,459,524	0.30230338	0.00
6	$12,747,682	$6,426,262	$6,321,420	0.8500	$5,372,914	$26,832,438	0.24177030	0.00
7	$10,903,036	$6,393,696	$4,509,340	0.8252	$3,721,097	$30,553,535	0.21232523	0.00
8	$12,129,343	$6,414,989	$5,714,354	0.8012	$4,578,128	$35,131,663	0.18465640	0.00
9	$11,692,117	$6,407,474	$5,284,643	0.7778	$4,110,544	$39,242,207	0.16531401	0.00
10	$11,511,004	$6,403,716	$5,107,288	0.7552	$3,856,885	$43,099,092	0.15052026	0.00
11	$12,651,940	$6,423,757	$6,228,183	0.7332	$4,566,364	$47,665,456	0.13610038	0.00
12	$11,606,746	$6,406,221	$5,200,525	0.7118	$3,701,852	$51,367,308	0.12629213	0.00
13	$16,664,377	$6,482,627	$10,181,750	0.6911	$7,036,507	$58,403,815	0.11107642	0.00

To bring the differential costs into present value (1994) dollars, a discount factor is calculated and multiplied by the differential cost to determine the discounted differential. The discount factor (DF) is calculated using the following equation:

$$DF = (1+\text{Discount rate})^{-(0.5+\text{Previous year})}$$

For example,

$$DF_1 = 1.03^{-0.5} = 0.9853$$
$$DF_2 = 1.03^{-1.5} = 0.9566$$

The cumulative differential is then tracked through each year of operation, resulting in an operational cost savings of $52 Million in 1994 Dollars at the end of year 13, or the year 2010. Note that the differential cost and the discounted differential cost does not include the investment costs required for each method.

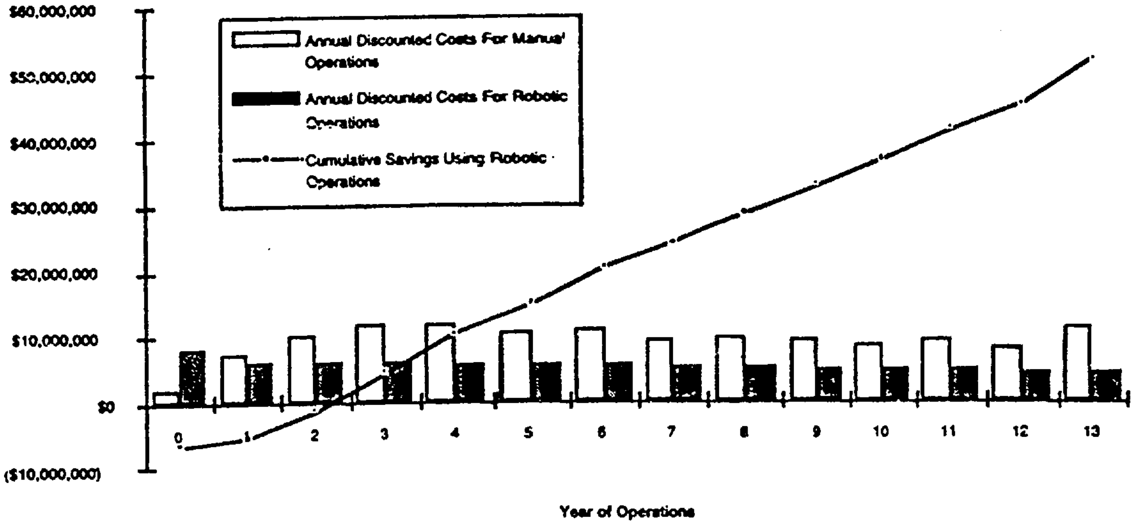

Figure 4.1 Economic Analysis Results: Robotic versus Manual MPC Welding and Closure Operations

Table 4.8 summarizes the comparison results. Total savings using the robotic method is determined by subtracting the investment differential from the cumulative differential, resulting in over $52 Million in savings over the manual method.

Table 4.8
Summary of Automated MPC Closure/Welding Operations
Cost/Benefit Analysis

Total Cost for Manual Method	$157,045,877
Total Cost for Robotic Method	$91,579,538
Discounted Cost for Manual Method	$129,327,183
Discounted Cost for Robotic Method	$77,410,654
Differential Cost Manual to Robotic	$71,953,625
Discounted Differential Cost Manual to Robotic	$58,403,815
Differential Investment Cost	$6,487,287
Total Cost (Savings) for the Project Life	($51,916,529)
Amortization (Years)	2.12
Dose Savings for the Project Life (rem)	1538.28
Cost (Savings) per Rem for the Project Life	($33,750)

The amortization is the time in years required to "pay back" the investment based on the annual discounted savings. To determine the amortization, the difference in total capital investment between manual and robotic equipment is divided by the cumulative differential operating costs (Investment/Differential column). The total difference in investment cost is the difference between the robotic and manual welding equipment times the number of units, all shown in Table 3.1. The result in this analysis is a payback in 2.12 years, or within approximately 25.5 months of operation.

Total lifetime dose savings for the robotic operations considered is approximately 1538 person-rem.

An additional figure of merit by which to judge the workcell potential for automation is the cost or savings per rem eliminated. This number is recommended by the International Commission on Radiation Protection to determine whether a radiation protection measure is economically feasible. Dividing the lifetime operational dose savings by the lifetime total cost yields a savings of $33,750 per person-rem.

5.0 Discussion

This effort presents a workable robotic solution to MPC closure and welding operations. However, the simulation basis is not optimized and several additional points should be addressed about the analysis and its assumptions.

First, using a dexterous robotic manipulator to execute the examined operations yields an opportunity to automate still more operations, saving the associated doses. Some of the possibilities are enumerated in Table 5.1. Table 5.1 indicates elimination of nearly 293 additional person-rem per MPC may be possible using the robotic manipulator for the operations listed.

Secondly, several questions arise about the use of the NEATER robot. First, it is not clear at this writing that the radiation tolerant NEATER robot is required to perform the necessary operations. A survey of parts of its industrial PUMA counterpart should be conducted to determine if the PUMA could perform the required MPC tasks satisfactorily. If so, the cost of the robot could be cut by 50%, or about $100,000 each.

The second question, regarding mounting the NEATER, is potentially more serious regarding the simulation executed for this effort. Although initial inquiries into the horizontal mounting of a NEATER such that the work volume suited the MPC head operations yielded no concerns, later simulation demonstrations and discussions with AEA Technology representatives resulted in a concern about performance of the bearings in joint number 1, which is the waist bearing. This bearing is designed for mounting of the robot in a vertical or inverted position. Mounting of the NEATER in a horizontal position as required for sufficient reach, shown in Figure 2.3, may result in reduced performance and payload capacity, both undesirable results that may hinder execution of many robotic closure and welding operations.

Table 5.1
Possible Additional Robotic Operations

Potential Added Operations	Manual Time Estimate (minutes)	Manual Dose Estimate (person-mrem)
Remove annulus seal	12	
Operator		26.9
Operator		26.9
Check for contamination	30	
Rad Protection		9.9
Rad Protection		9.9
Install annulus welding protection	12	
Operator		26.9
Operator		26.9
Remove annulus welding protection	12	
Operator		14.7
Operator		14.7
Perform HP survey	45	
Rad Protection		19.7
Rad Protection		19.7
Secure cask bolted lid	30	
Operator		48.5
Operator		48.5
TOTAL Additional Potential	141	292.7

Discussions with TESS have also included concerns about mounting a robot on the floor of a fuel handling building by anchoring into the floor. Possible solutions include a gantry-type mounting, where the robot is suspended in an inverted position over the MPC, whether the MPC is in a decontamination pit or in sitting on the fuel handling building floor. This would solve the joint 1 bearing difficulties in the NEATER, but it is not clear that in this orientation the NEATER would have sufficient reach to execute full-circle welding operations. A second possibility is to mount the robot directly over the MPC on a frame that attaches to the cask itself. The cost estimate includes this possibility.

Other radiation tolerant robot manipulators are commercially available that may satisfy the welding requirements. Two alternative robots are supplied by AEA Technology: The NEATER 660 ($210,000) and the NEATER 860 ($270,000). Both have sufficient work volume to perform MPC operations, both have improved payload capacity over the NEATER 760 series examined here, and both can be mounted in any orientation. Neither has an industrial-grade (non-radiation-hardened) counterpart, and neither has been tested in a welding environment nor using the SNL control systems. Schilling Development, Inc., offers HELIOS ($295,000), a radiation tolerant, electric robot alternative. It also has superior reach and payload capacity, and can be mounted in any orientation. HELIOS has not been tested in a welding application, but Schilling is familiar with the SNL approach to control systems and offers the ability to link to current systems.

A third general question regarding the simulation is the performance of NDE on the MPC welds. As mentioned in Section 2, the expected means of NDE is a three-step dye penetrant examination. First, if dye penetrant methods are used, other possibilities such as a two-step procedure may be desirable, reducing the number of steps and tools required to execute the operation. Such a procedure may also reduce the time required to execute the examination manually and reduce the number of QA welders required annually, and thus the associated labor costs.

Second, an NDE concern was raised by TESS that the simulated spray tooling may adversely impact the dye penetrant by inadvertently blowing the dye from the very cracks and crevasses the test is intended to detect. While non-contact operations may be preferable to contact operations for compliance and positional error reasons, contact is routinely made under sensory control and daub/roil-on tools for applying and removing excess dye and developers can be assumed. Such tools are likely as simple as the spray tools and approximately the same size. Thus, the simulation, though showing non-contact weld NDE, is valid for contact tools.

The third NDE question is that of possible alternatives to dye penetrant tests. Autoradiography, with sufficient columnation, filtering and shielding, may be a viable, non-contact alternative. Using autoradiography, it may be possible for sensors to image the welds in real-time, and more quickly than dye penetrant testing. Depending on ultimate inspection requirements, this or other alternatives may be used to detect sub-surface cracks and voids in MPC welds.

A fourth general question for discussion is the choice of assumptions and their impacts. Changing dose limits to 5 person-rem/year in Table 3.1 results in a 13-year cost of approximately $43.5 Million to implement robotic welding. This equates to a cost of approximately $28,000 per person-rem. However, as suggested above, it is assumed that DOE design goals are maintained and a 1 person-rem/year limit is imposed on a DOE-designed system, and that the5 person-rem/year limit is not applicable.

It is possible that the welders could be used in the robotic handling case as the robotic operators. This is the case for operation of the current remote welding machines, and would eliminate the need for the robot operator position. Changing the welder's labor rate to the equivalent of the robot operators results in a 13-year savings of approximately $64.1 Million, or a savings of $41,643 per person-rem.

In this analysis it is assumed that the crew members were paid annual salary charged to MPC loading whether individuals have reached the dose limits or not. Another approach would be to assign labor costs to MPC loading only for those hours specific to the skills required. Assuming a 1-week turn-around per MPC and that all crew members are needed during that week, a 13-year cost savings of $1.7 Million could be realized, or a savings of $1,117 per person-rem. This savings is independent of dose rate. However, these assumptions constitute rotation of crews, which is counter to DOE design guidelines. Further, it is reasonable to assume full-time crews traveling with each welding unit, particularly welders and robotic operators, who require special training. Such an arrangement could not be accomplished by paying partial salaries.

A final general point of discussion is the choice of five welding units to serve the utilities loading MPCs each year. Current loading schedules will result in 19 sites loading MPCs in 1998, 24 sites in 1999, 11 sites in 2000, 9 sites in 2001, 5 sites in 2002, and 7 sites in 2003. This schedule is subject to change based on utility and DOE action, and is therefore a relatively unreliable basis for choice of welding unit copies. It is assumed that the welding units are portable and can serve three to five sites each year. It is further assumed that satisfactory utility site scheduling can be achieved to make this possible. A basis of 5 units was therefore chosen for cost analysis purposes, but since this choice impacts the final economic numbers, further clarification of unit needs should be undertaken.

6.0 Conclusions and Recommendations

The results of this analysis present a compelling case for choosing the robotic method over the baseline manual methods for MPC closure and welding operations. The use of robots to execute these operations offers a unique win-win opportunity, simultaneously saving 1538 person-rem and $52 Million over a 13-year operational period, as compared to the manual method.

This savings can be accomplished with the potential to more than double the manual through-put rates, matching the manual rates at a minimum. Further, additional MPC operations may be possible using the robotic machinery and controls, and the operational lifetime may be significantly extended, reducing additional radiation dose, through-put time and costs.

Such results are highly consistent with the ALARA philosophy of reducing radiation doses "as low as reasonably achievable," since savings in both dose and costs, while maintaining or improving through-put must be considered reasonable.

These results should be compared to other operational alternatives, such as manual operations using movable shielding and long-handled tools. However, such alternatives generally do not improve through-put, nor do they reduce radiation doses as significantly as removal of the operator from the radiation field. However, personnel requirements may be reduced, resulting in lower labor costs than the baseline manual method, and equipment requirements may be reduced with respect to the robotic method, resulting in lower capital costs.

Pursuit of the robotic method holds low risk from the economic and technical standpoint. Most of the operations have been demonstrated individually, simulations indicate high-success probability, and the potential savings of $52 Million is significant. Even should the entire $52 Million be used to cover cost increases, cost of additional units and demonstration work, essentially free person-rem savings would remain "reasonable" from the ALARA standpoint.

Therefore, if no preferable alternative is found, robotic closure and welding operations should be pursued and demonstrated for application at commercial reactor sites, as well as any other sites where MPCs are loaded.

7.0 References

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ALARA Benefits of an MPC Robotic Welding System

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Summary

The potential occupational exposure savings for a robotic welding system for the MPC system as described in the Sandia Report (ref. 1) could be as much as 900 mili-person-Rem (mpR) for a single MPC loaded to a storage system or to a transportation cask. For the entire DOE MPC system this could reduce the at-reactor exposure by as much as 9,600 person-Rem for the full 86,000 metric tons of projected commercial spent fuel inventory over a 33 year time period. The system may also be applied to other canister welding operations and to the waste package closure operations at the MGDS. It is also projected to decrease the time to perform welding operations and to utilize far fewer qualified welders and operating personnel. This reduction in occupational exposure would reduce the at-reactor portion of the MPC system exposure to a value less than that for the reference system. (See Table 3-1 in the Health and Safety report, reference 2)

Current Reference System

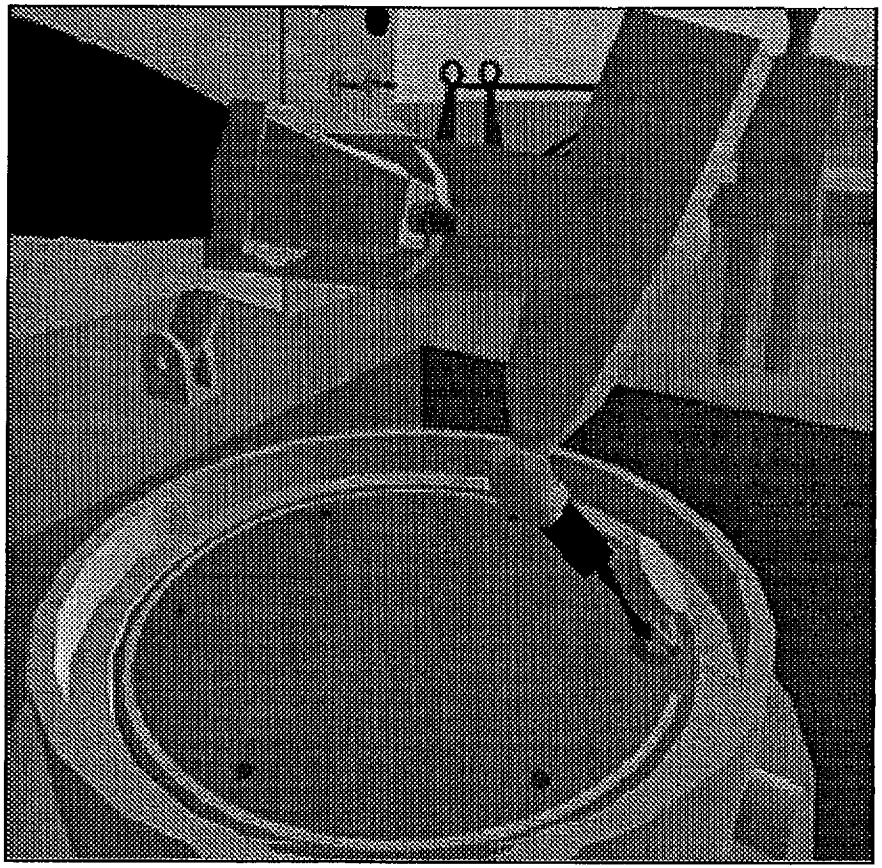
The current occupational exposure estimates for the reference MPC system assume the use of the semi-automated welding system utilized in current at-reactor dry storage systems with welded closures. Welding operations include the following operations:

- Temporary radiation protection shielding installation,
- Welding equipment set-up,
- Inner and outer lid welding,
- Non-destructive examination (NDE) preparation (weld slag grinding),
- NDE including dye penetrant and helium leak tests,
- Weld repairs,
- Equipment and shielding removal.

These activities associated with canister closure operations account for approximately 50% of at-reactor dry storage occupational exposures.

Robotic System

The use of a fully automated robotic arm with the appropriate computer controlled supervision as shown in figure 1 from the Sandia National Lab report could substantially reduce at-reactor occupational exposures. The robotic system uses a commercially available robotic arm with the appropriate degrees of freedom and work area for the MPC lid welding operations. The system is furnished with the appropriate end-effectors necessary to perform the functions for all welding operations as described above. The computer control system developed at Sandia National Labs is designed to support fully automated or fully manual operations. That is, a qualified welder and weld inspector may need only to view via a CCTV the operations performed by the robot and interrupt action if necessary or the welder may take total control of the system at any time to fully control the robot and end-effector. The integration of the robotic arm and the computer controlled system for these welding operations is unique for this type of application.



MPC Robotic Welding System Simulation

Figure 1

An additional advantage of this robotic welding system is its ability to provide support for other operations. The flexibility of the system allows for the capability to perform NDE, remove a poor quality weld and re-weld over a small area needing repair. The inherent dexterity of the system also allows for welding in corners and tight curved spaces as in the area around the canister drain and vent ports or for the valve covers. These are areas where welding is currently performed manually and are responsible for a large percentage of the normal operating exposures.

ALARA Justification

The estimated cost of the system is $5 million for development and demonstration of the system and $650K for each system. This is compared to about $350K for the existing semi-automated system. Engineering development includes design of the welding equipment and other end-effectors to be integral to the robotic arm and the design of the control system to assure the capabilty to perform all welding operations. The demonstration includes all welding equipment, the robotic arm , NDE equipment and a setup of the top portion of the MPC lid and shell. A mockup of the transport cask may be necessary to demonstrate the support system design.

The combination of the robotic arm and the computer software controls that are specialized for the function of ASME certified welding at each purchaser site presents a unique challenge for the system and its developers. Engineering development and system demonstration are necessary to assure safe and reliable operation for MPC program acceptance. At $10,000 per person-Rem saved, this system could be worth more than $3,000,000 per year in exposure savings alone. For individual annual exposure limits of 1 person Rem, the required number of welders and operating personnel can be reduced based on the reduced exposure. This will result in savings of approximately $4,000,000 per year.

An additional issue is associated with the availability of sufficient qualified welders for the current reference system. To keep individual exposures below 1 person-Rem per year for each individual, more than 300 additional qualified welders would be necessary to support the OCRWM MPC program at the steady state SNF acceptance rate. This impact would significantly impact the demand and potential cost of this work group.

Other Advantages

Another potential advantage of the development of the robotic welding system is in its application to other dry storage welded canister storage systems. The demonstration of the principle of robotic welding could be applied to non-MPC systems as well as to the repository operations.

DOE Unique Opportunity

This ALARA cost justification for a robotic welding system would be difficult for any individual utility facing dry storage needs. For instance, for a typical utility requiring two reactor units of annual discharged SNF per year, approximately 5 storage units may be necessary. The exposure may be as much as 10 person-Rem per year for the current reference system. Estimated savings for a robotic welding system could save about 5 person-Rem. At $10,000 per person-Rem savings, this is insufficient to justify the 4 to 5 million dollars of development and capital cost of a fully automated system as proposed. However, once the development and demonstration has been completed, the capital cost difference to procure a robotic system ($300,000) may be justified by individual purchaser sites.

Summary Dose Assessment

The current dose assessment (ref 3) is used to define all activities that may be impacted by the use of the robotic welding system. A list of these operating steps for a single MPC loading are summarized here.

I. Estimated exposure associated with current semi-automated welding system

	Activities	Exposure (mpR)	
1.	Install and remove welding equipment and temporary shielding for inner lid and perform welding operation .	220	
2.	Perform inner lid NDE preparation and NDE.	100	
3.	Perform cover plate weld.	330	
4.	Install and remove weld equipment and temporary shielding for the final lid.	220	
5.	Perform final lid NDT and NDT preparation.	100	
	Total occupational exposure from current semi-automated welding operations:		**970**

II. Estimated exposure associated with the robotic welding system

1.	Set up and remove welding system for the inner lid.	50	
2.	Set up and remove welding system for the final lid.	50	
	Total occupational exposure for the robotic welding system operations:		**100**

Potential occupational Exposure Savings Due to Robotic Welding Operations:	**870**

Total MPC System Potential At-Reactor Exposure Savings

Assuming 900 mpR savings per canister weld operation; the total system savings for the entire 86,000 MTU of commercial spent nuclear fuel for at-reactor operations is calculated as follows: (see reference 2, figure A1.4)

I. The Reference MPC System Exposure Assumptions

Activities	Occ. Exposure (p-Rem)
1. Load/unload non-MPC caniaters to at-reactor storage	
load:1.9 p-rem/cask * 249 casks =	484
unload: 1.8 p-Rem/cask * 249 Casks =	444
2. Load MPC's for at-reactor storage	
load: 2.0 p-Rem/cask * 4022 casks =	8012
unload to transport: 0.7 p-Rem/cask * 4022 casks =	2667
3. Load MPC's for transportation:	
load direct: 1.7 p-Rem/cask * 4463 =	7725
load enhanced method: 2.3 p-Rem/cask * 1649 =	3845
4. Load Load truck casks for shipment:	
load: 0.4 p-Rem/cask * 5755=	2486

The total reference system at-reactor occupational exposure estimate: 25,663

II. The Robotic Welding System Exposure Total System Estimate

Activities	Occ. Exposure (p-Rem)
1. Load/unload non-MPC caniaters to at-reactor storage	
load:1.0 p-rem/cask * 249 casks =	249
unload: 0.9 p-Rem/cask * 249 Casks =	224
2. Load MPC's for at-reactor storage	
load: 1.1 p-Rem/cask * 4022 casks =	4424
unload to transport: 0.7 p-Rem/cask * 4022 casks =	2815
3. Load MPC's for transportation:	
load direct: 0.8 p-Rem/cask * 4463 =	3570
load enhanced method: 1.4 p-Rem/cask * 1649 =	2309
4. Load Load truck casks for shipment:	
load: 0.4 p-Rem/cask * 5755=	2486
The Robotic Welding System At-Reactor Occupational Exposure Total MPC System:	**16,077**
The Potential Total System Exposure Savings:	**9600**

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