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WTSD-TME-009

PRELIMINARY RADIATION DOSE ASSESSMENT TO WIPP WASTE HANDLING PERSONNEL

waste isolation pilot plant

TECHNICAL SUPPORT CONTRACT

DE-AC04-78ALO5346

WESTINGHOUSE ELECTRIC CORP.

IT CORPORATION

DRAVO ENGINEERS, INC.

GIBBS & HILL, INC.

DISCLAIMER

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February 1985

DISCLAIMER

U. S. Department of Energy
Waste Isolation
Pilot Plant

Carlsbad, New Mexico

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I. Introduction

This document presents a preliminary assessment of the radiation doses to be received by the major occupational groups involved in waste handling operations at the Waste Isolation Pilot Plant (WIPP) Project. The WIPP Project is being developed by the Department of Energy for the purpose of providing a research and development facility to demonstrate the safe disposal of radioactive wastes (primarily transuranics) resulting from the defense activities and programs of the United States. Transuranic waste is defined as material having no significant economic value which is contaminated with alpha-emitting radionuclides with atomic numbers greater than 92 and half-lives greater than 20 years, in concentrations greater than 100 nCi/g (Reference 1).

The major operations considered in this document include the receipt and emplacement of contact handled transuranic (CH TRU) wastes, the receipt and emplacement of remotely handled transuranic (RH TRU) wastes, and the receipt and emplacement of experimental or defense high level wastes (DHLW). The manpower necessary to perform each of these operations is now allocated to two major occupational groups - waste handlers and radiation control personnel. In addition, estimates of the doses received by these personnel during the various support activities were also made.

To obtain the dose assessments, the estimated time and manpower to perform each required operational step comprising the major operations was correlated with the expected radiation levels. These estimates were then combined with the expected number of repetitions of each step per year to determine the annual dose (man-rem) for each occupational group.

II. Description of Waste and Handling Activities

II.A Contact Handled Transuranic (CH TRU) Waste Handling

Contact handled transuranic (CH TRU) waste refers to materials that have been packaged in such a manner that the surface dose rate of the package is not greater than 200 mrem/hr. The waste exists in a variety of forms ranging from unprocessed general trash and concrete-stabilized sludge to decommisioned machine tools and glove boxes. The material has been packaged to minimize the potential for fires or other events which could lead to dispersion into the air. In addition, no free liquids will be accepted at the WIPP Project. The bounding criteria for determining what waste will be acceptable at the WIPP Project may be found in the WIPP Waste Acceptance Criteria (Reference 2).

The WIPP Project has a design throughput of 500,000 ft^3 of CH TRU waste per year. The actual amounts of waste received will be much less and is expected to be about 300,000 ft^3 per year. Most of this waste will arrive packaged in fifty-five gallon steel drums. For handling purposes, these drums will be bound together in groups of six and secured as six-packs. These six-packs will in turn be transported to the WIPP site in groups of six in containers known as TRUPACTs (Transuranic Waste Package Transporter). A total of 1094 TRUPACT shipments or about 6564 six-packs are expected to be received each year.

Once received at the WIPP site, a TRUPACT will be moved into the waste handling facility and the six-packs individually removed. The TRUPACT will then be checked for contamination or damage, decontaminated or repaired if necessary, and transported from the site for reuse. The removed six-packs will also be checked for contamination or damage and be decontaminated or overpacked as required. For the purpose of this dose assessment, it is assumed that one percent of the six-packs (66) received will need to be either decontaminated or overpacked. All six-packs will then be palletized, four to a pallet, for ease of handling. These pallets will be moved through the waste handling building to the hoist cage and transferred two at a time to the underground area. An underground transporter will move these pallets to the storage area. There the six-packs will be removed from the pallets, placed into the storage area, and a salt backfill placed over them. An outline of the operational steps involved in CH TRU waste handling is contained in Appendix A. Specific details concerning the operational steps involved in receiving and unloading the TRUPACT container were obtained from Reference 3.

II.B Remotely Handled Transuranic (RH TRU) Waste

Remotely handled transuranic (RH TRU) wastes are characterized as packaged materials exhibiting an external surface dose rate of greater than 200 mrem/hr but less than 100 rem/hr. The physical or chemical form

of RH TRU waste has not been well characterized. Because of its generally inert nature and the small total quantity produced, RH TRU waste has not been processed unless it contained chemically active waste material such as elemental sodium.

The RH TRU waste will be shipped to the WIPP site by both rail and truck in heavily shielded transportation containers. The RH TRU canister itself is a carbon steel cylinder approximately 10 feet long with an outside diameter of approximately 26 inches. The annual design throughput for RH TRU wastes is a maximum of 250 of these waste canisters or approximately 7,500 ft^3 of waste. The number of canisters actually expected per year is much less and is currently estimated at only 50. During the first five years of operation, only 10 RH TRU waste canisters will be received on a trial basis.

Transporters carrying RH TRU waste shipping casks are moved into the RH waste handling area of the waste handling building. The shipping cask is removed from the transporter, vented, transferred to the cask unloading room for unloading, and its external surfaces decontaminated as required. Waste canisters are removed from the shipping cask and moved into the hot cell where they are inspected and prepared for storage. The waste canisters are then loaded into a shielded facility cask, lowered through the waste shaft to the underground storage area, and moved to a storage room. As a last step, the waste canisters are inserted horizontally into predrilled holes with steel sleeves in the pillar. After the waste canisters are inserted, a sleeve shield plug is installed in the end of the sleeve. Sleeves will not be used after the decision has been made not to retrieve the RH TRU waste canisters. A detailed outline of RH TRU waste handling operations is provided in Appendix C.

II.C Experimental or Defense High Level Waste (DHLW)

The experimental waste consists predominantly, but not exclusively, of high level waste. The waste will be in a borosilicate glass matrix and encased in either a type 304L stainless steel or Ti Code 12 cylinder. The overall length is just under 10 feet and has an outside diameter of 24 inches. If the stainless steel canister is used, then a relatively thick walled overpack will be added to satisfy structural and corrosion resistance requirements. The Ti Code 12 cylinder will be used directly and requires no overpack. In either case the surface dose rate of the cylinder is calculated to be approximately 7,000 rem/hr and may not exceed 10,000 rem/hr. The estimated thermal output for the reference case is approximately 470 watts, but the thermal output for certain cases may be as high as 800 watts. The thermal density and radiation level may be enhanced by the addition of certain radionuclides (Cs-137 or Sr-90) during the vitrification process.

The operational aspects and equipment for handling experimental wastes are still in the preliminary design phase. Based on these preliminary

designs, it is expected that the receipt and handling aspects associated with the experimental wastes will be similar to that for RH TRU waste handling operations. The emplacement operation itself will be vertical instead of horizontal and, based on preliminary time estimates, will take approximately 3.5 times longer to perform than the RH TRU emplacement operation. It should be emphasized that these times are based on preliminary designs and represent only crude estimates. These estimates will become more firm as the designs become more detailed and defined.

The equipment and operational steps for retrieval of DHLW canisters are in very early states of development. For this reason, the retrieval of DHLW canisters will not be considered in this preliminary dose assessment, but will be considered in future dose assessments after the design has become more developed.

III. Dose Assessment Methodology

This section describes the general methodology used to assess the expected radiation doses to WIPP waste handling personnel during normal operations. The major operations considered are the receipt and emplacement of CH TRU wastes, the receipt and emplacement of RH TRU wastes, and the receipt and emplacement of experimental or defense high level wastes. Both external whole body doses and internal organ doses are evaluated in this section.

III.A General Description of Method

The initial step in assessing expected radiation doses was the determination of the individual tasks comprising each major operation. For each of these tasks, the basic manpower requirements and estimated performance times were prepared. Two major occupational work groups were considered in evaluating manpower requirements. These were waste handlers (WH) and radiation control personnel (RC). For each group the total time (man-minutes) to perform each task was distributed through six dose rate ranges or Radiation Zones which had been developed from the dose rates calculated in Section III.B. These time distributions were based on best estimates of the workers' locations in relation to the radiation sources represented by the various waste configurations to be handled.

The yearly dose (man-rem) per task was then calculated by multiplying the number of repetitions of each task in one year by the time spent in the Radiation Zone (man-min) and the average dose rate calculated for that Radiation Zone (mrem/hr). For Radiation Zone I the upper bound of the dose rate range was used. This value of 0.1 mrem/hr was estimated from the dose rates calculated in Section III.B as being the average ambient radiation level near work locations within the waste handling facilities. For Radiation Zone IV the dose rate was variable and was based on an assessment of each individual task and worker location. The expected doses for each occupational group per individual task were then accumulated to provide total doses per group per major operation. The doses calculated for each operation will be presented in the following sections.

III.B Calculated Dose Rates

The dose rates external to the various waste configurations were determined by the methods presented in The Photon Shielding Manual by Anthony Foderaro (Reference 4). This manual allows the calculation of dose rates around most regular geometric shapes through the combined

application of analytical solutions and empirically derived data. Of the twenty geometrical configurations or models described in the manual, only two models, the slab source (S10) and the cylindrical source (S20), were used in this evaluation. These two models were interactively programmed to facilitate the large number of calculations required. Details of the calculational procedure are contained in Appendix E.

Dose rates were calculated around the various drum configurations, the TRUPACT container, and the facility cask. The drum or six-pack configurations evaluated included a single six-pack, stacked six-packs (2 high), and the hoist cage, surge storage, and underground storage arrays. For each configuration, the total dose rate at a specific location was determined by summing the individual dose rate contributions from all drums in the configuration. Table 1 provides a summary of the dose rates calculated about the various waste configurations.

The dose rates at the surface of the TRUPACT shipping container were based on the sources derived for the CH TRU waste drum. A fully loaded TRUPACT containing six six-packs or a total of thirty-six waste drums was assumed. Details of TRUPACT construction, such as wall thicknesses for shielding evaluation, were obtained from Reference 5. The dose rate calculated at the external surface of the TRUPACT along the centerline of the long side of the container was 0.4 mrem/hr.

Similarly the dose rates expected at the surface of the RH TRU facility cask were calculated with a photon source strength derived for a RH TRU canister with an average surface dose rate of 30 rem/hr. Information concerning the shielding capabilities of the facility cask were obtained from Reference 6. These dose rates were calculated at a series of points perpendicular to the centerline of the facility cask. These values are summarized in Table 2. As may be noted from the table, the facility cask has been designed to maintain dose rates quite low.

III.C Calculated Doses for CH TRU Waste Handling Activities

The doses estimated for CH TRU waste handling operations were based on the expected annual receipt of 1094 TRUPACT shipments or 6564 six-packs. The operational steps are outlined in Appendix A and the doses calculated per occupational group per task are provided in Appendix B. In summary, the annual doses for each occupational group involved in CH TRU waste handling operations are estimated at 7.89 man-rem for the waste handlers and 1.48 man-rem for the radiation control personnel.

III.D Calculated Doses for RH TRU Waste Handling Activities

The doses estimated for RH TRU waste handling operations were based on the expected receipt of 50 RH waste canisters per year. For the first five

TABLE 1

SUMMARY TABLE FOR CH-TRU WASTE CONFIGURATIONS

DOSE RATES (mrem/hr) VS DISTANCE FROM CONFIGURATION

CONFIGURATION*	DISTANCE FROM CONFIGURATION SURFACE (ft)													
	0.5	1.0	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0
Side of sixpack (2 X 1)	7.8	5.3	2.7	0.96	0.48	0.28	0.18	0.14	0.10					
Side of sixpack (3 x 1)	9.5	6.6	3.5	1.4	0.70	0.42	0.27	0.21	0.15					
Stacked sixpacks (2 x 2)	8.3	6.4	3.9	1.7	0.90	0.54	0.36	0.26	0.20	0.16	0.12	0.10		
Stacked sixpacks (3 x 2)	10.7	8.3	5.3	2.4	1.3	0.80	0.54	0.39	0.30	0.22	0.18	0.15		
Hoist cage array (4 x 2)	11.9	9.5	6.3	3.0	1.7	1.0	0.70	0.50	0.38	0.30	0.24	0.20	0.16	0.12
Hoist cage array (6 x 2)	13.6	11.1	7.6	3.9	2.3	1.5	1.0	0.72	0.56	0.44	0.36	0.30	0.24	0.18
Surge storage (6 x 3)	14.6	12.2	8.9	5.1	3.2	2.1	1.5	1.1	0.82	0.64	0.52	0.42	0.36	0.30
Surge storage (12 x 3)	17.1	14.7	11.3	7.1	4.7	3.3	2.4	1.9	1.5	1.2	0.96	0.80	0.68	0.58
Storage array (15 x 3)	17.9	15.4	11.8	7.5	5.1	3.7	2.8	2.2	1.7	1.4	1.2	0.95	0.80	0.70

*The configurations are specified as (2 x 1) or 2 drums wide and 1 drum high.

NOTES: 1. The calculated dose rates are based on the assumption that each CH-TRU waste drum (55 gallon) exhibits an average surface dose rate of 6 mrem/hr as measured at 4 inches.

TABLE 2

SUMMARY TABLE FOR RH-TRU WASTE CANISTER IN FACILITY CASK

DOSE RATES (mrem/hr) VS DISTANCE FROM FACILTY CASK

CONFIGURATION	DISTANCE FROM FACILITY CASK SURFACE (ft)												
	0.5	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	15.0	20.0
Perpendicular to side of facility cask on the centerline	1.70	1.53	1.23	1.01	0.86	0.72	0.63	0.54	0.48	0.42	0.38	0.21	0.14

NOTES: 1. As described in Appendix E, the RH-TRU waste canister is assumed to have an average external dose rate of approximately 30 rem/hr at 4 inches.

years of operation, only ten RH TRU waste canisters are to be received for trial operation and emplacement at the WIPP Project. Operational steps are outlined in Appendix C and the doses calculated per occupational group per task are provided in Appendix D. Summarizing the doses calculated in Appendix D, the annual dose breakdown per occupational group involved in RH TRU waste handling operations is estimated at 0.72 man-rem for the waste handlers and 0.08 man-rem for radiation control personnel.

III.E Calculated Doses for DHLW Handling Activities

The preliminary nature of DHLW equipment and operations precluded the formation of detailed operational steps. Expected doses were therefore derived from the doses calculated due to RH TRU waste handling operations. The operations associated with handling these two waste forms are expected to be similar in many respects, but final operational steps and dose rates about the emplacement equipment for the DHLW could be quite different. The doses calculated here for DHLW are very preliminary and should therefore be used with care.

A total of 40 equivalent canisters are planned for emplacement at WIPP. The equivalent canister concept is based on a total curie limit for DHLW at the WIPP site. It allows the receipt and emplacement of any number of canisters as long as the total curie limit is not exceeded. For the purpose of these dose estimates, 30 DHLW canisters are assumed to be received and emplaced during the year. The number of canisters received is expected to be much higher in the early years and taper off after several years. The contribution of this component to the total yearly doses to the various occupational groups is therefore expected to decrease after the first few years.

From Reference 7, rough estimates as to the actual times expected to perform the emplacement operations were obtained. These times were compared with those estimated for only the emplacement tasks for RH TRU waste canisters and found to be approximately 3.5 times higher. Receipt and handling tasks designed around these emplacement tasks were assumed to be the same as for the RH TRU waste canister. In addition, dose rates external to the waste handling equipment and facility casks were assumed to be similar for both waste operations.

The estimated DHLW doses were now calculated in two segments. First the RH TRU operations were separated into receipt and handling, and emplacement phases. The doses for each of these phases were then calculated for each occupational group. The emplacement doses were increased for both the waste handlers and the radiation control personnel by the increased time factor of 3.5. These doses were then added to the doses calculated for the other operational steps involved in the receipt and handling. Since this total was based on 50 canisters, the total was now scaled down to represent only 30 canisters of DHLW. The final doses calculated for DHLW operations were 1.16 man-rem for waste handlers and 0.12 man-rem for radiation control personnel.

III.F Dose Assessment for Support Activities

Doses resulting from the various support activities were also estimated. The two main activities considered were Real Time Radiography and Assay (RTR/A) and CH TRU waste salt coverage or backfilling. The RTR/A activities were estimated to take waste handling personnel 360 man-min per shift. The estimated dose rate for this activity was 0.5 mrem/hr. The total annual dose for waste handling personnel for RTR/A activities was therefore calculated to be 0.75 man-rem.

For CH TRU salt backfilling, doses are expected to be received by both waste handlers and radiation control personnel. The waste handlers are estimated to spend 240 man-min per shift performing this activity while the radiation control personnel are expected to spend 60 man-min per shift. The average dose rate is estimated at 0.5 mrem/hr and the calculated annual doses to waste handlers and radiation control personnel due to backfilling operations are 0.50 and 0.13 man-rem, respectively.

In addition to the above activities, an estimate of the doses accumulated by workers while on site but not directly involved in waste handling activities was made. These doses were estimated by first determining the total unaccounted times for waste handling (WH) and radiation control (RC) personnel on site. This determination was made by calculating the total time spent on site for a workforce of 16 WH and 8 RC personnel. Standard work times of 250 days per year with one eight-hour shift per day were used. The total accounted time on site was derived from the work descriptions and assumptions for CH TRU, RH TRU, and DHLW waste handling operations. The total unaccounted time was then determined by subtracting the accounted time from the total time.

For the waste handling group, essentially all of the time was accounted for in the waste handling operations and no additional dose estimate was required. The unaccounted time for radiation control personnel represented a significant fraction of the total time and assuming that 75% of this time was spent in the lowest radiation zone (0.1 mrem/hr) rather than a background area, then a cumulative dose of 0.60 man-rem can be calculated.

III.G Internal Dose Assessment

Internal dose calculations were based on Reference 8, WIPP-DOE-176 (Revision 1), Estimates of Internal Dose Equivalent From Inhalation and Ingestion of Selected Radionuclides. This document contains calculated estimates of the one year and fifty year dose committment per unit of both ingested or inhaled activity. Internal dose conversions are calculated for the various retention classes (D,W, or Y) and for particle sizes corresponding to activity mean aerodynamic diameters (AMAD) of 0.3, 1.0, and 5.0 microns.

The residence times of workers in the various above and below ground areas were calculated from the task descriptions contained in Appendices A and B. In addition to these times, the workers were further estimated to spend approximately 75 percent of their additional time on site in either an above or below ground airborne area. Time on site was based on an eight hour day and 250 days per year. Particles were assumed to have an AMAD of 1.0 micron and the breathing rate was taken as that for light work activity. Airborne concentrations in above ground waste handling areas and below ground waste storage areas were taken from Table 6.2-4 of the WIPP SAR. The 50 year dose committments for both whole body and selected internal organs are summarized in Table 3.

TABLE 3
INTERNAL DOSE SUMMARY
FIFTY-YEAR COMMITTED DOSE (man-rem)

Occupational Group	Critical Organ			
	Whole Body	Liver	Bone	Lungs
Waste Handlers				
Above Ground	1.4E-01	4.3E-01	2.0E+00	2.2E-01
Below Ground	1.4E-06	4.4E-06	2.0E-05	1.4E-06
Total	1.4E-01	4.3E-01	2.0E+00	2.2E-01
Radiation Control				
Above Ground	8.3E-02	2.6E-01	1.2E+00	1.3E-01
Below Ground	5.2E-07	1.7E-06	7.5E-06	5.3E-07
Total	8.3E-02	2.6E-01	1.2E+00	1.3E-01
Total Dose	2.2E-01	6.9E-01	3.2E+00	3.5E-01

IV. Summary and Conclusions

The segments of the waste handling operations representing the highest percentages of the total doses are summarized below. For CH TRU waste handling operations, the receipt and unloading of the TRUPACT is estimated to result in doses to the waste handlers and radiation control personnel of 4.46 man-rem and 0.45 man-rem, respectively. On a percentage basis, this represents approximately 57 percent of the total CH TRU waste handling dose for waste handlers and 30 percent of the total CH TRU waste handling dose for radiation control personnel. These relatively high doses result from the extensive manual manipulations required to handle the TRUPACT and its contents. Many of these manipulations must be performed in close proximity to the waste containers.

Another portion of the CH TRU waste handling operation which is estimated to result in a relatively high percentage of the total dose is the transfer of CH TRU waste containers from the hoist cage area and subsequent storage in the underground areas. The doses calculated for waste handling and radiation control personnel are 1.87 and 0.45 man-rem, respectively. These doses represent 24 percent and 30 percent of the total CH TRU waste handling doses for these two occupational groups. In combination with the above, these two operational segments represent roughly 80 percent of the total estimated dose incurred during CH TRU waste handling to waste handlers and almost 60 percent of the total estimated dose to radiation control personnel.

For RH TRU waste handling the doses are more evenly distributed over the operational steps. The only operational segment which may be clearly considered as resulting in a large percentage of the total RH TRU waste handling dose is the emplacement operation. The series of steps comprising the emplacement operation result in 0.35 man-rem and 0.034 man-rem to the waste handlers and radiation control personnel, respectively. These doses represent 49 percent and 42 percent of the total RH TRU waste handling doses to these respective occupational groups.

Annual, external wholebody doses for all waste handling operations and support activities are estimated as 11.02 man-rem for waste handlers and 2.41 man-rem for radiation control personnel. With current manpower levels of 16 waste handlers and 8 radiation control personnel, the calculated dose per worker is 0.69 rem for waste handlers and 0.30 rem for radiation control personnel. Combining the highest calculated organ dose with the external wholebody dose, the total dose to the bone per worker is 0.81 rem for waste handlers and 0.45 rem for radiation control personnel. These estimated doses fall below the Department of Energy design requirement that the combined external and internal doses be less than one rem per person per year (Reference 12).

V. References

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3. TTC-0460, Draft, Operations and Maintenance Manual - TRUPACT I, October 1983, GA Tecnologies Inc.

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6. Waste Isolation Pilot Plant RH TRU Facility Cask Assembly, Drawing Number 41-F-245-014, Rev. 4, Bechtel Corporation.

7. WTSD-TMI-008, Vertical Emplacement and Retrieval Equipment for DHLW Experiments in the WIPP, Preliminary Design Report, November 1984, Waste Technology Services Division, Westinghouse Electric Corporation.

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10. DOE/RW-0006, Spent Fuel and Radioactive Waste Inventories, Projections,and Characteristics, September 1984,

11. Draft Report, Review of Remote-handled Special Case TRU Waste Characterization Summary, February 1984, J. A. Detamore, Rocky Flats Plant, Rockwell International.

12. U. S. Department of Energy, DOE Order 6430.1, Chapter XXI, subject: General Design Criteria Manual, dated December 12, 1983.

APPENDIX A

CH TRU Waste Handling Activities

CONTACT HANDLED WASTES
WORK TASK DESCRIPTIONS AND DOSE ASSESSMENTS

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Time per Radiation Zone (man-min) I	II	III	IV	V	VI
1.	1.		Receive railcar or truck transporter at site	6.0	RC WH	 1	 6.0					
	2.		Check radiation and contamination levels on TRUPACT and transporter	10.0	RC WH	1 1	5.0 10.0	5.0				
	3.		Transfer TRUPACT into facility									
		1.	Position TRUPACT transporter for unloading	5.0	RC WH	 2	 10.0					
		2.	Move straddle carrier over TRUPACT	5.0	RC WH	 2	 10.0					
		3.	Release ISO tie downs	3.0	RC WH	 2	 6.0					
		4.	Hoist TRUPACT & move onto air pallet	5.0	RC WH	 2	 10.0					
		5.	Open outer airlock door	1.5	RC WH	 2	 3.0					
		6.	Move TRUPACT into airlock	1.5	RC WH	 2	 3.0					
		7.	Close outer airlock door	1.5	RC WH	 2	 3.0					
		8.	Open inner airlock door	1.5	RC WH	 2	 3.0					
		9.	Move TRUPACT into facility	3.0	RC WH	 2	 6.0					
		10.	Close inner airlock door	1.5	RC WH	 2	 3.0					
	4.		Prepare TRUPACT for unloading									
		1.	Using ratchet-strap assembly remove load from shear pins	2.0	RC WH	1 2	2.0 4.0					
		2.	Retract the shear pins and slowly open the outer door by use of the ratchet-strap assembly	5.0	RC WH	1 2	5.0 10.0					

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Time per Radiation Zone (man-min) I	II	III	IV	V	VI
1.	4.	3.	Perform contamination survey around the inner door	2.0	RC WH	1 2	1.0 4.0	1.0				
		4.	Via the quick-connect gas valves on the inner door, draw a sample of the inner cavity atmosphere and verify airborne radioactivity levels are within allowable limits	5.0	RC WH	1 2	2.5 4.0	2.5				
		5.	Unbolt the thirty-six closure bolts and open the inner door	60.0	RC WH	1 2	60.0 20.0	100.0				
		6.	Perform contamination survey around the inner door seals	2.0	RC WH	1 2	 4.0			1.0	1.0	
		7.	Latch the inner and outer doors together in their full open position	2.0	RC WH	1 2	2.0 2.0	2.0				
		8.	Install protective covers over seals and seal surfaces	5.0	RC WH	1 2	5.0	1.0	1.0	3.0	5.0	
		9.	Release any tie downs and remove accessible dunnage	10.0	RC WH	1 2	10.0				20.0	
		10.	Using the hydraulic pump, raise the cavity rollers to the up position	2.0	RC WH	1 2	2.0 2.0		2.0			
		11.	Align and engage loading platform with roller floor	2.0	RC WH	1 2	2.0	4.0				
	5.		Unload six-pack from container (six per TRUPACT)									
		1.	Remove two six-packs over the roller floor to the platform	1.0	RC WH	1 2	1.0 1.0				1.0	
		2.	Remove six-pack by forklift	3.0	RC WH	1 2	3.0	6.0				
		3.	Visually inspect six-pack for damage and survey for surface contamination	2.0	RC WH	1 2	 4.0		1.0	1.0		
		4.	Decon and/or overpack containers (one percent of containers assumed - 66)	60.0	RC WH	 2	 30.0	60.0	30.0			
		5.	Check overpacked containers for contamination	2.0	RC WH	1		2.0				
		6.	Palletize waste containers (six-pack)	1.0	RC WH	1 2	1.0	1.0	1.0			
2.	1.		Transfer loaded pallet to surge storage area (one percent assumed routed through surge storage)	3.0	RC WH	1 1	3.0	3.0				

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Time per Radiation Zone (man-min) I	II	III	IV	V	VI
2.	2.		Transfer loaded pallets from surge storage to loading area	3.0	RC WH	1 1	3.0	3.0				
	3.		Load palletized waste onto cage loading car (2 pallets/cage)	4.5	RC WH	1 1	4.5			4.5		
	4.		Return unused/empty pallets to storage area (two percent of required - 16)	3.0	RC WH	1	3.0					
	5.		Transfer pallets onto hoist cage									
		1.	Open inner airlock door and hoist cage door	1.0	RC WH	1			1.0			
		2.	Lower movable rails	0.5	RC WH	1	0.5					
		3.	Run car into hoist cage	1.0	RC WH	1				1.0		
		4.	Lower pallets onto stands	0.5	RC WH	1				0.5		
		5.	Remove car from cage	1.0	RC WH	1				1.0		
		6.	Raise movable rails	0.5	RC WH	1	0.5					
		7.	Close hoist cage door and inner airlock door	1.0	RC WH	1			1.0			
	6.		Remove empty pallets from hoist cage									
		1.	Open inner airlock door and hoist cage door	1.0	RC WH	1	1.0					
		2.	Lower movable rails	0.5	RC WH	1	0.5					
		3.	Run car into hoist cage	1.0	RC WH	1	1.0					
		4.	Raise pallets off stands	0.5	RC WH	1	0.5					
		5.	Remove car from cage	1.0	RC WH	1	1.0					

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Time per Radiation Zone (man-min) I	II	III	IV	V	VI
2.	6.	6.	Close inner airlock door	0.5	RC							
					WH	1	0.5					
	7.		Lower waste to repository level	5.0	(No Exposure)							
	8.		Remove waste from hoist cage									
		1.	Open hoist cage door	1.0	RC							
					WH	1			1.0			
		2.	Lower movable rails	0.5	RC							
					WH	1	0.5					
		3.	Run car into hoist cage	1.0	RC							
					WH	1				1.0		
		4.	Raise pallets from stands	0.5	RC							
					WH	1				0.5		
		5.	Move car and pallets from cage	1.0	RC							
					WH	1				1.0		
		6.	Raise movable rails	0.5	RC							
					WH	1	0.5					
		7.	Close hoist cage door	1.0	RC							
					WH	1			1.0			
	9.		Return hoist cage to surface	5.0	(No Exposure)							
3.	1.		Load pallet on underground transporter									
		1.	Run car into loading area	1.5	RC	1		1.5				
					WH	1				1.5		
		2.	Unload pallet from car and load on underground transporter	5.0	RC	1		5.0				
					WH	1				5.0		
	2.		Load empty pallets onto hoist cage									
		1.	Spot forklift by empty pallets	1.0	RC	1	1.0					
					WH	1	1.0					
		2.	Transfer pallets to cage loading car	2.0	RC	1	2.0					
					WH	1	2.0					
		3.	Run car into hoist cage	1.0	RC	1	1.0					
					WH	1	1.0					

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Time per Radiation Zone (man-min) I	II	III	IV	V	VI
3.	2.	4.	Lower pallets onto stands	0.5	RC	1	0.5					
					WH	1	0.5					
		5.	Move car out of hoist cage	1.0	RC	1	1.0					
					WH	1	1.0					
		6.	Close hoist cage door	1.0	RC	1	1.0					
					WH	1	1.0					
	3.		Transfer underground transporter to storage room	14.0	RC							
					WH	1			14.0			
	4.		Unload and stack six-packs with forklift	7.5	RC	1		7.5				
					WH	2		10.0	5.0			
	5.		Return underground transporter to cage loading area	14.0	RC							
					WH	1	14.0					
1.	6.		Prepare empty container for dispatch	5.0	RC							
					WH	1	5.0					
	7.		Load cargo container onto transporter									
		1.	Inspect inner area and door seals for damage	10.0	RC	1	10.0					
					WH	2	20.0					
		2.	Close and bolt inner door	60.0	RC							
					WH	2	120.0					
		3.	Close and secure outer door	3.0	RC							
					WH	2	6.0					
		4.	Open inner airlock door	1.5	RC							
					WH	2	3.0					
		5.	Move TRUPACT into airlock	3.0	RC							
					WH	2	6.0					
		6.	Close inner airlock door	1.5	RC							
					WH	2	3.0					
		7.	Open outer airlock	1.5	RC							
					WH	2	3.0					

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Time per Radiation Zone (man-min) I	II	III	IV	V	VI
1.	7.	8.	Move TRUPACT onto outdoor pad	1.5	RC WH	2	3.0					
		9.	Close outer airlock door	1.5	RC WH	2	3.0					
		10.	Move straddle carrier over TRUPACT	5.0	RC WH	2	10.0					
		11.	Hoist TRUPACT and move onto transporter	10.0	RC WH	2	20.0					
		12.	Secure TRUPACT on transporter with ISO tie-downs	5.0	RC WH	2	10.0					
	8.		Dispatch transporter from site	6.0	RC WH	1	6.0					

Radiation Zone Definitions

Zone ID	Dose Rate Range (mrem/hr)
I	DR < 0.1
II	0.1 < DR < 1.0
III	1.0 < DR < 2.0
IV	2.0 < DR < 4.0
V	4.0 < DR < 6.0
VI	DR > 6.0

APPENDIX B

CH TRU Waste Handling Dose Assessment

CONTACT HANDLED WASTES
WORK TASK DESCRIPTIONS AND DOSE ASSESSMENTS

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Whole Body Gamma Dose per Radiation Zone per Year (man-rem) I	II	III	IV	V	VI
1.	1.		Receive railcar or truck transporter at site	6.0	RC WH	 1	 0.0109					
	2.		Check radiation and contamination levels on TRUPACT and transporter	10.0	RC WH	1 1	0.0091 0.0182	0.0501				
	3.		Transfer TRUPACT into facility									
		1.	Position TRUPACT transporter for unloading	5.0	RC WH	 2	 0.0182					
		2.	Move straddle carrier over TRUPACT	5.0	RC WH	 2	 0.0182					
		3.	Release ISO tie downs	3.0	RC WH	 2	 0.0109					
		4.	Hoist TRUPACT & move onto air pallet	5.0	RC WH	 2	 0.0182					
		5.	Open outer airlock door	1.5	RC WH	 2	 0.0055					
		6.	Move TRUPACT into airlock	1.5	RC WH	 2	 0.0055					
		7.	Close outer airlock door	1.5	RC WH	 2	 0.0055					
		8.	Open inner airlock door	1.5	RC WH	 2	 0.0055					
		9.	Move TRUPACT into facility	3.0	RC WH	 2	 0.0109					
		10.	Close inner airlock door	1.5	RC WH	 2	 0.0055					
	4.		Prepare TRUPACT for unloading									
		1.	Using ratchet-strap assembly remove load from shear pins	2.0	RC WH	1 2	0.0036 0.0073					
		2.	Retract the shear pins and slowly open the outer door by use of the ratchet-strap assembly	5.0	RC WH	1 2	0.0091 0.0182					

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Whole Body Gamma Dose per Radiation Zone per Year (man-rem) I	II	III	IV	V	VI
1.	4.	3.	Perform contamination survey around the inner door	2.0	RC	1	0.0018	0.0100				
					WH	2	0.0073					
		4.	Via the quick-connect gas valves on the inner door, draw a sample of the inner cavity atmosphere and verify airborne radioactivity levels are within allowable limits	5.0	RC	1	0.0046	0.0251				
					WH	2	0.0073					
		5.	Unbolt the thirty-six closure bolts and open the inner door	60.0	RC	1	0.1094					
					WH	2	0.0365	1.0028				
		6.	Perform contamination survey around the inner door seals	2.0	RC	1				0.0547	0.0912	
					WH	2	0.0073					
		7.	Latch the inner and outer doors together in their full open position	2.0	RC	1	0.0036					
					WH	2	0.0036	0.0201				
		8.	Install protective covers over seals and seal surfaces	5.0	RC	1	0.0091					
					WH	2		0.0100	0.0274	0.1641	0.4558	
		9.	Release any tie downs and remove accessible dunnage	10.0	RC	1	0.0182					
					WH	2					1.8233	
		10.	Using the hydraulic pump, raise the cavity rollers to the up position	2.0	RC	1	0.0036					
					WH	2	0.0036		0.0547			
		11.	Align and engage loading platform with roller floor	2.0	RC	1	0.0036					
					WH	2		0.0401				
	5.		Unload six-pack from container (six per TRUPACT)									
		1.	Remove two six-packs over the roller floor to the platform	1.0	RC	1	0.0055					
					WH	2	0.0055				0.2735	
		2.	Remove six-pack by forklift	3.0	RC	1	0.0328					
					WH	2		0.3610				
		3.	Visually inspect six-pack for damage and survey for surface contamination	2.0	RC	1			0.1641	0.3282		
					WH	2	0.0438					
		4.	Decon and/or overpack containers (one percent of containers assumed - 66)	60.0	RC							
					WH	2	0.0033	0.0363	0.0495			
		5.	Check overpacked containers for contamination	2.0	RC	1		0.0012				
					WH							
		6.	Palletize waste containers (six-pack)	1.0	RC	1	0.0109					
					WH	2		0.0602	0.1641			
2.	1.		Transfer loaded pallet to surge storage area (one percent assumed routed through surge storage)	3.0	RC	1	0.0001					
					WH	1		0.0004				

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Whole Body Gamma Dose per Radiation Zone per Year (man-rem) I	II	III	IV	V	VI
2.	2.		Transfer loaded pallets from surge storage to loading area	3.0	RC	1	0.0001					
					WH	1		0.0004				
	3.		Load palletized waste onto cage loading car (2 pallets/cage)	4.5	RC	1		0.0000				
					WH	1				0.3692		
	4.		Return unused/empty pallets to storage area (two percent of required - 16)	3.0	RC							
					WH	1	0.0001					
	5.		Transfer pallets onto hoist cage									
		1.	Open inner airlock door and hoist cage door	1.0	RC							
					WH	1			0.0206			
		2.	Lower movable rails	0.5	RC							
					WH	1	.0000					
		3.	Run car into hoist cage	1.0	RC							
					WH	1				0.0411		
		4.	Lower pallets onto stands	0.5	RC							
					WH	1				0.0206		
		5.	Remove car from cage	1.0	RC							
					WH	1				0.0411		
		6.	Raise movable rails	0.5	RC							
					WH	1	.0000					
		7.	Close hoist cage door and inner airlock door	1.0	RC							
					WH	1			0.0206			
	6.		Remove empty pallets from hoist cage									
		1.	Open inner airlock door and hoist cage door	1.0	RC							
					WH	1	0.0014					
		2.	Lower movable rails	0.5	RC							
					WH	1	0.0007					
		3.	Run car into hoist cage	1.0	RC							
					WH	1	0.0014					
		4.	Raise pallets off stands	0.5	RC							
					WH	1	0.0007					
		5.	Remove car from cage	1.0	RC							
					WH	1	0.0014					

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Whole Body Gamma Dose per Radiation Zone per Year (man-rem) I	II	III	IV	V	VI
2.	6.	6.	Close inner airlock door	0.5	RC							
					WH	1	0.0007					
	7.		Lower waste to repository level	5.0	(No Exposure)							
	8.		Remove waste from hoist cage									
		1.	Open hoist cage door	1.0	RC							
					WH	1			0.0206			
		2.	Lower movable rails	0.5	RC							
					WH	1	0.0007					
		3.	Run car into hoist cage	1.0	RC							
					WH	1				0.0411		
		4.	Raise pallets from stands	0.5	RC							
					WH	1				0.0206		
		5.	Move car and pallets from cage	1.0	RC							
					WH	1				0.0411		
		6.	Raise movable rails	0.5	RC							
					WH	1	0.0007					
		7.	Close hoist cage door	1.0	RC							
					WH	1			0.0206			
	9.		Return hoist cage to surface	5.0	(No Exposure)							
3.	1.		Load pallet on underground transporter									
		1.	Run car into loading area	1.5	RC	1		0.0113				
					WH	1				0.0617		
		2.	Unload pallet from car and load on underground transporter	5.0	RC	1		0.0377				
					WH	1				0.2055		
	2.		Load empty pallets onto hoist cage									
		1.	Spot forklift by empty pallets	1.0	RC	1	0.0014					
					WH	1	0.0014					
		2.	Transfer pallets to cage loading car	2.0	RC	1	0.0027					
					WH	1	0.0027					
		3.	Run car into hoist cage	1.0	RC	1	0.0014					
					WH	1	0.0014					

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Whole Body Gamma Dose per Radiation Zone per Year (man-rem) I	II	III	IV	V	VI
3.	2.	4.	Lower pallets onto stands	0.5	RC	1	0.0007					
					WH	1	0.0007					
		5.	Move car out of hoist cage	1.0	RC	1	0.0014					
					WH	1	0.0014					
		6.	Close hoist cage door	1.0	RC	1	0.0014					
					WH	1	0.0014					
	3.		Transfer underground transporter to storage room	14.0	RC							
					WH	1			0.2877			
	4.		Unload and stack six-packs with forklift	7.5	RC	1		0.4513				
					WH	2		0.6017	0.8205			
	5.		Return underground transporter to cage loading area	14.0	RC							
					WH	1	0.0192					
1.	6.		Prepare empty container for dispatch	5.0	RC							
					WH	1	0.0091					
	7.		Load cargo container onto transporter									
		1.	Inspect inner area and door seals for damage	10.0	RC	1	0.0182					
					WH	2	0.0365					
		2.	Close and bolt inner door	60.0	RC							
					WH	2	0.2188					
		3.	Close and secure outer door	3.0	RC							
					WH	2	0.0109					
		4.	Open inner airlock door	1.5	RC							
					WH	2	0.0055					
		5.	Move TRUPACT into airlock	3.0	RC							
					WH	2	0.0109					
		6.	Close inner airlock door	1.5	RC							
					WH	2	0.0055					
		7.	Open outer airlock	1.5	RC							
					WH	2	0.0055					

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Whole Body Gamma Dose per Radiation Zone per Year (man-rem) I	II	III	IV	V	VI
1.	7.	8.	Move TRUPACT onto outdoor pad	1.5	RC WH	2	0.0055					
		9.	Close outer airlock door	1.5	RC WH	2	0.0055					
		10.	Move straddle carrier over TRUPACT	5.0	RC WH	2	0.0182					
		11.	Hoist TRUPACT and move onto transporter	10.0	RC WH	2	0.0365					
		12.	Secure TRUPACT on transporter with ISO tie-downs	5.0	RC WH	2	0.0182					
	8.		Dispatch transporter from site	6.0	RC WH	1	0.0109					

Radiation Zone Definitions

Zone ID	Dose Rate Range (mrem/hr)
I	DR < 0.1
II	0.1 < DR < 1.0
III	1.0 < DR < 2.0
IV	2.0 < DR < 4.0
V	4.0 < DR < 6.0
VI	DR > 6.0

CH TRU Waste Handling Dose Summaries

Radiation Control	1.48
Waste Handlers	7.89
Total Dose	9.37

APPENDIX C

RH TRU Waste Handling Activities

REMOTELY HANDLED WASTES
WORK TASK DESCRIPTIONS AND DOSE ASSESSMENT

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Time per Radiation Zone (man-min) I	II	III	IV	V	VI
1.	1.		Receive transporter at RH dock									
		1.	Open door	2.0	RC WH	 2		 2.0	 2.0			
		2.	Transfer cask transporter into building	2.0	RC WH	 2		 2.0	 2.0			
		3.	Disconnect car mover	2.0	RC WH	 2		 2.0	 2.0			
		4.	Remove prime mover to outside of building	2.0	RC WH	 2		 2.0	 2.0			
		5.	Close door	2.0	RC WH	 2		 2.0	 2.0			
	2.		Unload cask from transporter									
		1.	Inspect cask for contamination	10.0	RC WH	1 3	 10.0	 10.0	 10.0	5.0	5.0	
		2.	Attach cask lifting yoke	11.0	RC WH	 3	 11.0	 11.0	 6.0	5.0		
		3.	Lift and rotate cask to vertical and place on air mover	15.0	RC WH	 3	 25.0	 10.0	 10.0			
	3.		Transfer cask to decontamination and preparation area	10.0	RC WH	1 2		10.0 20.0				
	4.		Prepare cask for unloading									
		1.	Vent cask	14.0	RC WH	1 2		4.0 12.0	5.0 8.0	5.0 8.0		
		2.	Remove cask head bolts	60.0	RC WH	 2			15.0	15.0	90.0	
		3.	Install cask head removal adapter and cask seal collar	20.0	RC WH	 2			5.0	5.0	30.0	

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Time per Radiation Zone (man-min) I	II	III	IV	V	VI
1.	5.		Transfer cask to unloading room									
		1.	Move cask to shield door and open door	7.0	RC WH	1 2		7.0 4.0	10.0			
		2.	Move cask to unloading room	5.0	RC WH	1 2		5.0 3.0	7.0			
		3.	Set down air mover	2.0	RC WH	1 2		2.0 1.0	3.0			
		4.	Inflate seal collar and close shield door	5.0	RC WH	1 2		5.0 3.0	7.0			
2.	1.		Process waste canister through hot cell									
		1.	Remove hot cell shield plugs and cask head	15.0	RC WH	1 2	15.0 30.0					
		2.	Remove spacer and lay down	5.0	RC WH	1 2	5.0 10.0					
		3.	Remove canister and transfer to inspection station	12.0	RC WH	1 2	12.0 24.0					
		4.	Transfer drawer travel (2x3.0 min)	6.0	RC WH	1 2	6.0 12.0					
		5.	Swipe canister and verify clean	84.0	RC WH	1 2	84.0 168.0					
		6.	Count swipes	20.0	RC WH	1 2	20.0 40.0					
		7.	Wait for crane	3.0	RC WH	1 2	3.0 6.0					
		8.	Open hot cell shield valve	15.0	RC WH	1 2	15.0 30.0					
		9.	Place canister in transfer cell shuttle car	7.0	RC WH	1 2	7.0 14.0					
		10.	Raise grapple and close hot cell shield valve	5.0	RC WH	1 2	5.0 10.0					

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Time per Radiation Zone (man-min) I	II	III	IV	V	VI
3.	1.		Load canister into facility cask									
		1.	Position canister under valve and engage telescoping port shield	8.0	RC	1	8.0					
					WH	2	16.0					
		2.	Open loading room shield valve	1.5	RC	1	1.5					
					WH	2	3.0					
		3.	Open cask valves	3.0	RC	1	3.0					
					WH	2	6.0					
		4.	Lower grapple and pull canister into cask	5.0	RC	1	5.0					
					WH	2	10.0					
		5.	Close bottom cask valve	1.5	RC	1	1.5					
					WH	2	3.0					
		6.	Close loading room shield valve and retract telescoping shield	3.5	RC	1	3.5					
					WH	2	7.0					
		7.	Release grapple from cylinder and retract to shield bell	1.0	RC	1	1.0					
					WH	2	2.0					
		8.	Close top cask valve	1.5	RC	1	1.5					
					WH	2	3.0					
		9.	Lift shield bell and grapple	1.5	RC	1	1.5					
					WH	2	3.0					
		10.	Downend cask to horizontal position	7.5	RC	1	7.5					
					WH	2	15.0					
		11.	Connect power cable	2.0	RC	1	2.0					
					WH	2		2.0			2.0	
	2.		Load facility cask car onto conveyance									
		1.	Open shaft room shield door	0.5	RC	1	0.5					
					WH	1	0.5					
		2.	Open gate and lower pivoting rails	1.0	RC	1	1.0					
					WH	1	1.0					
		3.	Run RH car into conveyance	2.0	RC	1	2.0					
					WH	1				1.0	1.0	
		4.	Disconnect power cable and retract	1.0	RC	1	1.0					
					WH	1					1.0	
		5.	Raise pivoting rails up	0.5	RC	1	0.5					
					WH	1				0.5		

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Time per Radiation Zone (man-min) I	II	III	IV	V	VI
3.	2.	6.	Close gate and close shaft room shield door	1.0	RC	1	1.0					
					WH	1		1.0				
	3.		Lower waste to repository level	5.5	(No Exposure)							
	4.		Unload cask from conveyance									
		1.	Open gate and lower pivoting rails	1.0	RC	1	1.0					
					WH	2	2.0					
		2.	Connect underground tractor and power cable to RH car	3.0	RC	1	3.0					
					WH	2	2.0	2.0	2.0			
		3.	Pull RH car out of conveyance	1.5	RC	1	1.5					
					WH	2	1.0	1.0	1.0			
		4.	Raise pivoting rails and close gate	1.0	RC	1	1.0					
					WH	2	2.0					
		5.	RH car tugged to unloading area	3.5	RC	1	3.5					
					WH	2	7.0					
	5.		Load cask onto transporter									
		1.	Pick up cask with forklift	3.0	RC	1	3.0					
					WH	2		2.0	2.0	2.0		
		2.	Set on transporter	5.0	RC	1	5.0					
					WH	2		3.0	4.0	3.0		
		3.	Transporter to emplacement area and RH car to shunt station	15.0	RC	1	15.0					
					WH	2	20.0	10.0				
	6.		Waste emplacement									
		1.	Transport alignment fixture assembly to borehole location	10.0	RC							
					WH	4	40.0					
		2.	Install alignment fixture assembly on sleeve	10.0	RC							
					WH	4	40.0					
		3.	Hook up control console and power supply cabinets	5.0	RC							
					WH	4	20.0					
		4.	Lower screw jacks on alignment fixture assembly	5.0	RC							
					WH	4	20.0					
		5.	Transport waste transfer machine assembly to borehole location	5.0	RC							
					WH	4	20.0					
		6.	Install waste transfer machine assembly on alignment fixture	10.0	RC							
					WH	4	40.0					

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Time per Radiation Zone (man-min) I	II	III	IV	V	VI
3.	6.	7.	Install cables between the two assemblies	5.0	RC WH	 4	 20.0					
		8.	Align waste transfer machine assembly by operating rear screw jack	5.0	RC WH	 4	 20.0					
		9.	Retract staging platform	10.0	RC WH	 4	 40.0					
		10.	Install facility cask on waste transfer machine assembly	5.0	RC WH	1 4		 5.0	5.0 10.0	 5.0		
		11.	Hook up air supply and cable connections to facility cask	5.0	RC WH	1 4	5.0	 5.0	 10.0	 5.0		
		12.	Check for alignment and make any adjustments as required	10.0	RC WH	1 4	 10.0	10.0 20.0	 10.0			
		13.	Extend staging platform to engage facility cask with sleeve	10.0	RC WH	1 4	 30.0	10.0 5.0	 5.0			
		14.	Extend transfer carriage	15.0	RC WH	1 4	 40.0	15.0 20.0				
		15.	Install waste package in borehole	15.0	RC WH	1 4		10.0 20.0	5.0 20.0	 20.0		
		16.	Retract transfer mechanism	10.0	RC WH	1 4		10.0 10.0	 20.0	 10.0		
		17.	Retract transfer carriage	15.0	RC WH	1 4		15.0 15.0	 30.0	 15.0		
		18.	Move plug to emplacement area	15.0	RC WH	 2	 15.0	 15.0				
		19.	Install shield plug carriage with shield plug	5.0	RC WH	1 4	5.0 5.0	 10.0	 5.0			
		20.	Install shield plug in borehole	10.0	RC WH	1 4		10.0 10.0	 20.0	 10.0		
		21.	Retract transfer mechanism	10.0	RC WH	1 4		10.0 10.0	 20.0	 10.0		
		22.	Extend transfer carriage	5.0	RC WH	1 4		5.0 5.0	 10.0	 5.0		
		23.	Retract staging platform	10.0	RC WH	1 4		10.0 10.0	 20.0	 10.0		

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Time per Radiation Zone (man-min) I	II	III	IV	V	VI
3.	6.	24.	Disconnect air supply and cable connections from facility cask	5.0	RC WH	4		5.0	10.0	5.0		
		25.	Unload facility cask from waste transfer machine assembly	5.0	RC WH	4		5.0	10.0	5.0		
		26.	Disconnect cables between alignment fixture and waste transfer machine	5.0	RC WH	4		5.0	10.0	5.0		
		27.	Remove waste transfer machine assembly from alignment fixture assembly	5.0	RC WH	1 4	5.0	5.0	10.0	5.0		
		28.	Disconnect alignment fixture assembly from sleeve	5.0	RC WH	1 4	5.0	5.0	10.0	5.0		
		29.	Transport alignment fixture to the next borehole location	5.0	RC WH	4	5.0	10.0	5.0			
	7.		Return cask to conveyance (reverse of 3.5)	23.0	RC WH	2	23.0	11.5	11.5			
	8.		Return cask to loading room (reverse of 3.4, 3.3,& 3.2)	19.5	RC WH	2	19.5	19.5				

Radiation Zone Definitions

Zone ID	Dose Rate Range (mrem/hr)
I	DR < 0.1
II	0.1 < DR < 0.5
III	0.5 < DR < 1.0
IV	1.0 < DR < 1.5
V	1.5 < DR < 2.0
VI	DR > 2.0

APPENDIX D

RH TRU Waste Handling Dose Assessment

REMOTELY HANDLED WASTES
WORK TASK DESCRIPTIONS AND DOSE ASSESSMENT

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Whole Body Gamma Dose per Radiation Zone per Year (man-rem) I	II	III	IV	V	VI
1.	1.		Receive transporter at RH dock									
		1.	Open door	2.0	RC WH	2		0.0005	0.0012			
		2.	Transfer cask transporter into building	2.0	RC WH	2		0.0005	0.0012			
		3.	Disconnect car mover	2.0	RC WH	2		0.0005	0.0012			
		4.	Remove prime mover to outside of building	2.0	RC WH	2		0.0005	0.0012			
		5.	Close door	2.0	RC WH	2		0.0005	0.0012			
	2.		Unload cask from transporter									
		1.	Inspect cask for contamination	10.0	RC WH	1 3	0.0008	0.0025	0.0062	0.0052	0.0072	
		2.	Attach cask lifting yoke	11.0	RC WH	3	0.0009	0.0027	0.0037	0.0052		
		3.	Lift and rotate cask to vertical and place on air mover	15.0	RC WH	3	0.0020	0.0025	0.0062			
	3.		Transfer cask to decontamination and preparation area	10.0	RC WH	1 2		0.0025 0.005				
	4.		Prepare cask for unloading									
		1.	Vent cask	14.0	RC WH	1 2		0.001 0.003	0.0031 0.005	0.0052 0.0083		
		2.	Remove cask head bolts	60.0	RC WH	2			0.0093	0.0156	0.1312	
		3.	Install cask head removal adapter and cask seal collar	20.0	RC WH	2			0.0031	0.0052	0.0437	

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Whole Body Gamma Dose per Radiation Zone per Year (man-rem) I	II	III	IV	V	VI
1.	5.		Transfer cask to unloading room									
		1.	Move cask to shield door and open door	7.0	RC WH	1 2		0.0017 0.001	0.0062			
		2.	Move cask to unloading room	5.0	RC WH	1 2		0.0012 0.0007	0.0043			
		3.	Set down air mover	2.0	RC WH	1 2		0.0005 0.0002	0.0018			
		4.	Inflate seal collar and close shield door	5.0	RC WH	1 2		0.0012 0.0007	0.0043			
2.	1.		Process waste canister through hot cell									
		1.	Remove hot cell shield plugs and cask head	15.0	RC WH	1 2	0.0012 0.0025					
		2.	Remove spacer and lay down	5.0	RC WH	1 2	0.0004 0.0008					
		3.	Remove canister and transfer to inspection station	12.0	RC WH	1 2	0.001 0.002					
		4.	Transfer drawer travel (2x3.0 min)	6.0	RC WH	1 2	0.0005 0.001					
		5.	Swipe canister and verify clean	84.0	RC WH	1 2	0.007 0.014					
		6.	Count swipes	20.0	RC WH	1 2	0.0016 0.0033					
		7.	Wait for crane	3.0	RC WH	1 2	0.0002 0.0005					
		8.	Open hot cell shield valve	15.0	RC WH	1 2	0.0012 0.0025					
		9.	Place canister in transfer cell shuttle car	7.0	RC WH	1 2	0.0005 0.0011					
		10.	Raise grapple and close hot cell shield valve	5.0	RC WH	1 2	0.0004 0.0008					

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Whole Body Gamma Dose per Radiation Zone per Year (man-rem) I	II	III	IV	V	VI
3.	1.		Load canister into facility cask									
		1.	Position canister under valve and engage telescoping port shield	8.0	RC WH	1 2	0.0006 0.0013					
		2.	Open loading room shield valve	1.5	RC WH	1 2	0.0001 0.0002					
		3.	Open cask valves	3.0	RC WH	1 2	0.0002 0.0005					
		4.	Lower grapple and pull canister into cask	5.0	RC WH	1 2	0.0004 0.0008					
		5.	Close bottom cask valve	1.5	RC WH	1 2	0.0001 0.0002					
		6.	Close loading room shield valve and retract telescoping shield	3.5	RC WH	1 2	0.0002 0.0005					
		7.	Release grapple from cylinder and retract to shield bell	1.0	RC WH	1 2	0.0000 0.0001					
		8.	Close top cask valve	1.5	RC WH	1 2	0.0001 0.0002					
		9.	Lift shield bell and grapple	1.5	RC WH	1 2	0.0001 0.0002					
		10.	Downend cask to horizontal position	7.5	RC WH	1 2	0.0006 0.0012					
		11.	Connect power cable	2.0	RC WH	1 2	0.0001	0.0005			0.0029	
	2.		Load facility cask car onto conveyance									
		1.	Open shaft room shield door	0.5	RC WH	1 1	0.0000 0.0000					
		2.	Open gate and lower pivoting rails	1.0	RC WH	1 1	0.0000 0.0000					
		3.	Run RH car into conveyance	2.0	RC WH	1 1	0.0001			0.0010	0.0014	
		4.	Disconnect power cable and retract	1.0	RC WH	1 1	0.0000				0.0014	
		5.	Raise pivoting rails up	0.5	RC WH	1 1	0.0000			0.0005		

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Whole Body Gamma Dose per Radiation Zone per Year (man-rem) I	II	III	IV	V	VI
3.	2.	6.	Close gate and close shaft room shield door	1.0	RC	1	0.0000					
					WH	1		0.0002				
	3.		Lower waste to repository level	5.5	(No Exposure)							
	4.		Unload cask from conveyance									
		1.	Open gate and lower pivoting rails	1.0	RC	1	0.0000					
					WH	2	0.0001					
		2.	Connect underground tractor and power cable to RH car	3.0	RC	1	0.0002					
					WH	2	0.0001	0.0005	0.0012			
		3.	Pull RH car out of conveyance	1.5	RC	1	0.0001					
					WH	2	0.0000	0.0002	0.0006			
		4.	Raise pivoting rails and close gate	1.0	RC	1	0.0000					
					WH	2	0.0001					
		5.	RH car tugged to unloading area	3.5	RC	1	0.0002					
					WH	2	0.0005					
	5.		Load cask onto transporter									
		1.	Pick up cask with forklift	3.0	RC	1	0.0002					
					WH	2		0.0005	0.0012	0.0020		
		2.	Set on transporter	5.0	RC	1	0.0004					
					WH	2		0.0007	0.0025	0.0031		
		3.	Transporter to emplacement area and RH car to shunt station	15.0	RC	1	0.0012					
					WH	2	0.0016	0.0025				
	6.		Waste emplacement									
		1.	Transport alignment fixture assembly to borehole location	10.0	RC							
					WH	4	0.0033					
		2.	Install alignment fixture assembly on sleeve	10.0	RC							
					WH	4	0.0033					
		3.	Hook up control console and power supply cabinets	5.0	RC							
					WH	4	0.0016					
		4.	Lower screw jacks on alignment fixture assembly	5.0	RC							
					WH	4	0.0016					
		5.	Transport waste transfer machine assembly to borehole location	5.0	RC							
					WH	4	0.0016					
		6.	Install waste transfer machine assembly on alignment fixture	10.0	RC							
					WH	4	0.0033					

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Whole Body Gamma Dose per Radiation Zone per Year (man-rem) I	II	III	IV	V	VI
3.	6.	7.	Install cables between the two assemblies	5.0	RC							
					WH	4	0.0016					
		8.	Align waste transfer machine assembly by operating rear screw jack	5.0	RC							
					WH	4	0.0016					
		9.	Retract staging platform	10.0	RC							
					WH	4	0.0033					
		10.	Install facility cask on waste transfer machine assembly	5.0	RC	1			0.0031			
					WH	4		0.0012	0.0062	0.0052		
		11.	Hook up air supply and cable connections to facility cask	5.0	RC	1	0.0004					
					WH	4		0.0012	0.0062	0.0052		
		12.	Check for alignment and make any adjustments as required	10.0	RC	1		0.0025				
					WH	4	0.0008	0.005	0.0062			
		13.	Extend staging platform to engage facility cask with sleeve	10.0	RC	1		0.0025				
					WH	4	0.0025	0.0012	0.0031			
		14.	Extend transfer carriage	15.0	RC	1		0.0037				
					WH	4	0.0033	0.005				
		15.	Install waste package in borehole	15.0	RC	1		0.0025	0.0031			
					WH	4		0.005	0.0125	0.0208		
		16.	Retract transfer mechanism	10.0	RC	1		0.0025				
					WH	4		0.0025	0.0125	0.0104		
		17.	Retract transfer carriage	15.0	RC	1		0.0037				
					WH	4		0.0037	0.0187	0.0156		
		18.	Move plug to emplacement area	15.0	RC							
					WH	2	0.0012	0.0037				
		19.	Install shield plug carriage with shield plug	5.0	RC	1	0.0004					
					WH	4	0.0004	0.0025	0.0031			
		20.	Install shield plug in borehole	10.0	RC	1		0.0025				
					WH	4		0.0025	0.0125	0.0104		
		21.	Retract transfer mechanism	10.0	RC	1		0.0025				
					WH	4		0.0025	0.0125	0.0104		
		22.	Extend transfer carriage	5.0	RC	1		0.0012				
					WH	4		0.0012	0.0062	0.0052		
		23.	Retract staging platform	10.0	RC	1		0.0025				
					WH	4		0.0025	0.0125	0.0104		

Task ID	Subtask ID	Step ID	Step Description	Total Time Required (minutes)	Job Group	Workers Per Job Group	Whole Body Gamma Dose per Radiation Zone per Year (man-rem) I	II	III	IV	V	VI
3.	6.	24.	Disconnect air supply and cable connections from facility cask	5.0	RC WH	 4		0.0012	0.0062	0.0052		
		25.	Unload facility cask from waste transfer machine assembly	5.0	RC WH	 4		0.0012	0.0062	0.0052		
		26.	Disconnect cables between alignment fixture and waste transfer machine	5.0	RC WH	 4		0.0012	0.0062	0.0052		
		27.	Remove waste transfer machine assembly from alignment fixture assembly	5.0	RC WH	1 4	0.0004	0.0012	0.0062	0.0052		
		28.	Disconnect alignment fixture assembly from sleeve	5.0	RC WH	1 4	0.0004	0.0012	0.0062	0.0052		
		29.	Transport alignment fixture to the next borehole location	5.0	RC WH	 4	0.0004	0.0025	0.0031			
	7.		Return cask to conveyance (reverse of 3.5)	23.0	RC WH	 2	0.0019	0.0028	0.0071			
	8.		Return cask to loading room (reverse of 3.4, 3.3,& 3.2)	19.5	RC WH	 2	0.0016	0.0048				

Radiation Zone Definitions

Zone ID	Dose Rate Range (mrem/hr)
I	DR < 0.1
II	0.1 < DR < 0.5
III	0.5 < DR < 1.0
IV	1.0 < DR < 1.5
V	1.5 < DR < 2.0
VI	DR > 2.0

RH TRU Waste Handling Dose Summaries

Radiation Control	0.08
Waste Handlers	0.72
Total Dose	0.80

Appendix E: Dose Rate Assessment Methodology

The dose rates external to the various waste configurations were determined by the methods presented in The Photon Shielding Manual by Anthony Foderaro (Reference 4). This manual allows the calculation of dose rates around most regular geometric shapes through the combined application of analytical solutions and empirically derived data. Of the twenty geometrical configurations or models described in the manual, only two models, the slab source (S10) and the cylindrical source (S20), were used in this evaluation. These two models were interactively programmed to facilitate the large number of calculations required.

The calculated dose rates were based on average source strengths derived for each of the two primary waste geometries, the standard 55-gallon drum and the remotely-handled (RH) waste canister. In the 55-gallon drum case, the drum was modeled as a right cylinder with a height of 34.81 in (88.42 cm), a radius of 11.75 in (29.85 cm), and a drum wall thickness of 0.0478 in (0.1214 cm). From Table 6.2-1 of the WIPP SAR, an average photon energy of 1.0 Mev was assumed. Using a photon source strength of 1.0E +6 photons/sec-cm^3, a dose rate of 6717 mrem/hr was calculated at 4 inches or 10.16 cm. Scaling this factor by the expected mean surface dose rate of approximately 6.0 mrem/hr (assumed measured at 4 inches), an average photon source strength of 8.93E +2 photons/sec-cm^3 was obtained. The mean surface dose rate was determined by weighting the dose rates reported by the shippers (Reference 9) by the volume fractions expected to be received from each shipper (Reference 10).

Similarly, the RH canister photon source strength was derived based on a calculated average surface dose rate of 30 rem/hr. This dose rate was again determined by weighting the dose rates reported by the shippers (Reference 11) by the expected volume fractions to be received from each shipper (Reference 10). The RH canister was modeled as a right cylinder with a waste height of 114.5 in (290.8 cm), a radius of 12.63 in (32.07 cm), and a canister wall thickness of 0.375 in (0.953 cm). Using a photon source strength of 1.0E +7 photons/sec-cm^3 at an average energy of 1.0 Mev, a surface dose rate of 18.6 rem/hr was calculated at the reference distance of 4 inches. Scaling the photon source strength by the 30 rem/hr average dose rate, a photon source strength of 1.61E +7 photons/sec-cm^3 was calculated.

Using these derived source strengths the dose rates were then calculated about the various waste configurations, containers, and casks. In the case of the six-packs and stacked configurations, the outermost drums (those nearest the dose rate location) were found to contribute the majority of the dose rate. The innermost drums were found to be effectively shielded by the outer drums and contribute very little to the dose rates around the various waste configurations. The dose rates calculated for the various waste configurations at varying distances are contained in Tables 1 and 2 in Section II.

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