RADIOLOGICAL RISK ASSESSMENT FOR THE REMOTE–HANDLED TRANSURANIC WASTE STORAGE OPTIONS AT ARGONNE NATIONAL LABORATORY – EAST *

Jing-Jy Cheng, Halil Avci, Daniel Hecker, William Bray,
Terri Bray, and Christopher Grandy
Argonne National Laboratory
9700 S. Cass Ave., Argonne, IL 60439

Submitted to WM'02 Conference, February 24-28, 2002, Tucson, AZ

* Work supported by the U.S. Department of Energy, Assistant Secretary for Environmental Management, under contract W-31-109-Eng-38.

WM’02 Conference, February 24-28, 2002, Tucson, AZ

RADIOLOGICAL RISK ASSESSMENT FOR THE REMOTE–HANDLED TRANSURANIC WASTE STORAGE OPTIONS AT ARGONNE NATIONAL LABORATORY – EAST *

Jing-Jy Cheng, Halil Avci, Daniel Hecker, William Bray,
Terri Bray, and Christopher Grandy
Argonne National Laboratory
9700 S. Cass Ave., Argonne, IL 60439

ABSTRACT

Interim storage of the remote-handled transuranic (RH/TRU) waste is needed at Argonne National Laboratory – East (ANL–E). Two on-site facilities, the northwest (NW) vaults in the 317 Area and the converted spent nuclear fuel pool in Building 331, were identified as potential storage locations through previous studies. To assist the decision making process of selecting a storage location, radiological risk assessments were conducted to analyze potential radiation exposures that would be associated with storage of the RH/TRU waste in these two facilities. Three drum storage scenarios (one for the 317 Area and two for Building 331) considering different drum handling procedures and stacking patterns were developed. Time-motion information on worker activities that would occur in the procedures was collected and recorded in spreadsheets. Using the time-motion information, potential external doses were estimated for the involved workers for each step in the procedures. The sum of the potential external doses over all the activity steps gave the total collective dose for each scenario. The results show that during the storage phase, storing waste drums in half-liners in Building 331 would result in the lowest collective radiation exposure; however, it would also require the most human resources. When retrieving waste drums for off-site shipment was considered, storing waste drums in the 317 Area would be the most favorable option because it would require the least amount of human resources and would also result in the lowest collective radiation exposure.

INTRODUCTION

An amount of remote-handled transuranic (RH/TRU) waste equivalent to that contained in thirty 30-gal drums was generated from past research activities conducted at the Alpha Gamma Hot Cell Facility (AGHCF) at Argonne National Laboratory – East (ANL–E). In the past, this waste was shipped off-site for storage and eventual disposal. However, that option was closed several years ago and the possibility for off-site disposal is not likely for the next few years. The accumulated RH/TRU waste took up space in the research facility and began hindering the operation of on-going projects. It became apparent that removing the RH/TRU waste from the research facility to an on-site interim storage facility was needed and would be consistent with the ALARA principle.

Two on-site storage facilities were identified: the northwest vaults in the 317 Area and the converted spent nuclear fuel pool in Building 331, former location of the experimental boiling water reactor at ANL–E. The northwest vaults in the 317 Area are spacious and allow direct lifting of the RH/TRU waste drums from a shipping cask loaded on the transportation vehicle to

* Work supported by the U.S. Department of Energy, Assistant Secretary for Environmental Management, under contract W-31-109-Eng-38.

the vault area. However, remote lift equipment is not installed in the area, so workers would be exposed to the high level of radiation coming from the waste containers. Building 331, on the other hand, has limited overhead clearance to conduct drum transfers. Lifting the waste drums from or into a shipping cask sitting on the transportation vehicle is impossible inside the building. Additionally, the high cost of a shipping cask stresses the need to minimize shipping cask handling, thereby minimizing potential cask damage. Remote lift equipment was previously installed in Building 331 so that radiation exposures to workers during drum lifting activities would be reduced. Arrangement of waste drums in the storage area and its impact on future drum retrieval for off-site shipment was another issue for consideration.

To conduct risk assessments, three storage scenarios involving different drum-handling procedures and stacking patterns were developed; two scenarios involved the use of Building 331 and one scenario involved the use of the 317 Area. Potential radiological doses associated with the three scenarios were calculated and compared. The following sections discuss the baseline assumptions used, the methodology employed, and the drum handling procedures assumed in the risk assessments. After that, the calculated dose results are presented and discussed.

Baseline Assumptions

An amount of RH/TRU waste equivalent to that contained in thirty 30-gal drums was initially stored at the AGHCF. The waste would be shipped to an on-site storage facility as soon as a storage location was chosen. In the future, ten 30-gal drums are expected to be generated each year. On the basis of the stacking pattern and the size of the fuel pool, it was estimated that a total of sixty 30-gal drums could be stored in Building 331. Although the NW vault in Area 317 could accommodate more than 60 drums, for comparison purposes, it was assumed that a total of 60 drums could be stored at that facility as well in the risk assessment. On the basis of this assumption, the risk assessment analyzed radiation exposures associated with handling 30 drums in the current year (2001). For the years 2002, 2003, and 2004, radiation exposures resulting from handling 10 drums per year were analyzed. For the year 2005, all the drums in storage were assumed to be retrieved and shipped off-site.

Risk Assessment Methodology

Radiation exposures for drum handling activities were analyzed by considering the external radiation that would be incurred by involved workers. The RH/TRU waste would be sealed inside 30-gal drums, which then would be enclosed in 55-gal shielded casks for transportation. Therefore, under normal operational conditions, the waste would not be released outside the containers and be inhaled or ingested by the involved workers. In an accident, however, the waste could be released from the containers to the surrounding environment. The Safety Analysis Report (SAR) prepared for the AGHCF and each proposed storage facility (1, 2, 3) analyze a wide range of hypothetical accidents that could happen to the materials handled and processed in each facility, including the RH/TRU waste considered in this risk assessment. The accident scenarios hypothesized and the approach used for the hazard analyses in these SARs encompassed the accident conditions considered likely within the scope of this assessment. Therefore, the conclusions of the SARs are considered to be applicable to the RH/TRU waste. The conclusions indicate that on the basis of the current designs of the AGHCF, Building 331, and Area 317, no unacceptable risks would result from natural or man-made accidents involving RH/TRU waste within the facilities.

Potential external radiation that could be received by the workers was estimated by using time-motion information on each activity that would be involved in handling waste. The time-motion information on each step included the number of workers required, duration of the activity, frequency of operation each year, radiation sources involved, and distances between the radiation sources and the workers. The time-motion information allowed estimates to be made of the radiation doses pertinent to each activity. When summed together, the doses yield an estimate of the collective dose for the entire handling procedure. Spreadsheets containing the time-motion information were developed to facilitate dose calculations. They were designed specifically for the waste handling procedure at each facility. The waste handling procedure for AGHCF was developed by the staff of the AGHCF. The procedures for placing waste into the two storage facilities and for removing the waste for off-site shipment were developed by Argonne Waste Management Operations (WMO) staff who are experienced in handling waste drums and who would be involved in the handling of RH/TRU waste in the future.

AGHCF staff have recorded data on the RH/TRU waste stored in the facility. The data included radionuclide inventories in the waste, total mass and volume, and radiation dose rates at the surfaces of the waste containers. The average of the measured dose rates was used as the basis for estimating the dose rates for each handling activity. The dose rates for each handling activity were calculated by multiplying the basic dose rate by appropriate adjustment factors. The factors were obtained by running the MicroShield computer code (4) to account for the influence of source geometry, shielding material, shielding thickness, and exposure distance. When an activity involved a few miscellaneous steps and radiation sources were difficult to define, past registered radiation exposures received by workers conducting the same type of activity were used to develop the dose rate for that activity. (An example is the setting up activity that is done for each drum removal campaign at AGHCF.)

A consistent methodology was used to calculate the radiation exposures of involved workers handling RH/TRU waste at each facility. Since the values of the exposure parameters used to estimate the dose rates have a certain degree of uncertainty, the collective doses calculated by using these parameters have a certain degree of uncertainty as well. However, using a consistent methodology should allow for meaningful comparisons among the options analyzed. In practice, all the involved workers would be required to wear dosimeters; and radiation exposures would be kept ALARA (as low as reasonably achievable).

The risks associated with transporting waste among on-site facilities were not calculated mainly because of two reasons. First, because of the locations of the two storage facilities, the transportation risks would be about the same no matter which one was used. Second, because of the use of shielded casks and because of the large distances between the on-site workers (including the drivers) and the casks, the doses received by the workers during transportation would be relatively small when compared with the doses received by the workers at the facilities themselves. The facility doses include the activities for unloading the waste from the conveyer vehicles at the storage facilities. The transportation accidents are considered in *the On-Site Radioactive Waste Transportation Safety Assessment* (5). The analyses indicate that the radiation dose associated with the bounding accident, which involves a vehicle catching fire and the fire spreading to the waste containers, would be less than 5 rem at a distance of 100 m (the closest distance to the site boundary).

Drum Handling Procedures and Assumptions

Table I contains time-motion information on drum packaging and loading activities at AGHCF for year 2001. It is presented to demonstrate the format of the spreadsheets that were developed for dose calculation. It is assumed that one campaign to remove RH/TRU waste drums would be conducted each year (2001, 2002, 2003, and 2004). Two 7-gal cans containing RH/TRU waste would be placed in a pouch inside a 30-gal drum, which would be placed inside a 55-gal shielded cask to reduce radiation exposure. After placement, the pouch would be sealed, the drum would be covered, and the shielded cask would be closed. The loaded shielded cask would then be moved to a loading dock for transport to a storage facility. During the operation, some activities would be done remotely through a shielding window. Three workers would be involved in each drum removal campaign.

In addition to the use of 55-gal shielded casks for on-site transport of the RH/TRU waste, other types of containers would be used for storage and off-site shipment of the waste. One of these other containers considered is a full-cask liner that can hold ten 30-gal drums in two layers. For storage of waste, the full-liner would be placed in the storage area, and 30-gal drums of waste (inside 55-gal shielded casks) would be unloaded directly from a truck to the liner. For off-site shipment, the full-liner containing waste would be lifted from the storage area and be placed inside an 8-120 shipping cask on the back of a transport vehicle. The use of the full-liners would reduce the number of lifting activities required for off-site shipment, thereby reducing radiation exposure of workers engaged in these activities. The full-cask liner would be used in Area 317.

The second type of container that could be used for RH/TRU waste is a half-cask liner. The function of a half-cask liner is the same as that of a full-cask liner except that it can only hold up to five 30-gal drums in one layer. It could be used in Building 331 for drum storage and off-site shipment activities. The half-cask liner can fit into a 7-100 shielded cask, as well as into an 8-120 shipping cask. Inside Building 331, the 7-100 shielded cask would be placed on the floor and would be used to temporarily hold a half-liner before it reaches its full capacity of five 30-gal drums. In this way, radiation exposure from the 30-gal drums could be reduced.

The 8-120 shipping casks would always be used for off-site shipment. The shipping cask has lead shielding and can hold ten 30-gal drums directly or ten 30-gal drums inside one full-cask liner or two half-cask liners. Because of the high cost of the 8-120 shipping cask, it is always left at the back of the transport vehicle without being unloaded to the ground so that potential damage to the cask caused by loading and unloading can be avoided.

A spreadsheet similar to Table I containing time-motion information on drum emplacement and retrieval activities at the NW vault of Area 317 was developed. For drum emplacement, it is assumed that three drums would be shipped each trip. Upon the arrival of waste drums, the rain cover and the shielding concrete of the vault would be removed. Then the drums would be transferred from the back of the truck to the full-cask liner already placed inside the vault area. When it is time to retrieve the drums for off-site shipment, the full-cask liners, each containing 10 waste drums, would be lifted from the vault area and placed directly into an 8-120 shipping cask loaded on the back of a truck. For each off-site shipment, it is assumed that a truck would carry 10 waste drums. Ten persons would be involved in the activities, including mechanics, riggers, crane operators, truck drivers, a waste specialist, and health physicists.

Two storage scenarios involving two drum handling procedures were considered for Building 331. The first scenario assumes the 55-gal shielded casks containing waste drums would be loaded onto a trailer connected to a truck at the AGHCF and be shipped to Building 331. The

Table I. RH/TRU Waste Drums Handling Activities at the AGHCF in Year 2001

Activity	Number of Workers Involved[a]	Time per Operation (min)	Operations Per Year	Exposure Distance (ft)	Dose Rate (mrem/h)	Collective Time (person-hrs)	Collective Dose (person-rem)
Year 2001							
Prepare cask for drum loading	2	150	1	0-4	50	5.00	0.250
	1	150	1		1	2.50	0.003
In the Clean Transfer Area (CTA), attach the inner pouch of the empty drum to the outside of the drop chute and position the funnel into the inside of the drum	3	20	30	0	25	30.00	0.750
Transport two loaded and inventoried waste cans from their shielded holding area to CTA	2	5	30	0	1	5.00	0.005
	1	5	30		1	2.50	0.003
Inspect the waste cans, measure the gamma activity outside the waste cans, and verify the waste cans	1	10	30	0	1	5.00	0.005
	2	10	30		1	10.00	0.010
Drop the waste cans into the drum. Enter the CTA to check and ensure that the dropping was properly done	2	5	30	0	1	5.00	0.005
	1	1	30	2	6.12	0.50	0.003
	1	4	30		1	2.00	0.002
Lift funnel and close the shield cask covers to their stops	2	5	30	0	1	5.00	0.005
	1	5	30		1	2.50	0.003
Perform radiation survey of the CTA and the slit between the gates of the cask	1	2	30	0	6.12	1.00	0.006
	2	2	30		1	2.00	0.002
Remove the wrinkles in the inner pouch, pull it up, seal the inner pouch, and inspect the seal	1	5	30	0-2	6.12	2.50	0.015
	2	5	30		1	5.00	0.005
Swing the cask for shipping outside	2	2	30	0-2	6.12	2.00	0.012
	1	2	30		1	1.00	0.001
Punch down the inner pouch, pull up the outer pouch, close the double-gated cask, vacuum the outer pouch, and seal the outer pouch	1	5	30	0-2	6.12	2.50	0.015
	2	5	30		1	5.00	0.005
Attach the drum lifting fixture to the drum	1	2	30	0	1	1.00	0.001
	2	2	30		1	2.00	0.002
Lift the drum from the cask, take gamma reading, and place the drum in a carrier cask temporarily	1	5	30	0	1	2.50	0.003
	2	5	30		1	5.00	0.005
Enter the CTA. Prepare the double-gated cask for drum loading	1	2	30	0-2	6.12	1.00	0.006
	2	2	30		1	2.00	0.002
Lift the drum out of the carrier cask and return it to the double-gated cask	1	2	30	0	1	1.00	0.001
	1	2	30		1	1.00	0.001
Place the drum cover on the drum, close the drum closure ring, start the closure bolt, and spot-weld the tamper seal across the locking ring lugs. Make a single weld to lock the nut to the bolt	1	10	30	0-2	152.5	5.00	0.763
	2	10	30		1	10.00	0.010
Weigh and smear the top, side, and bottom of the drums for gamma readings	1	5	30	0	1	2.50	0.003
	2	5	30		1	5.00	0.005
Move the drum back to the shielded carrier cask and put the shield cover in place over the drum	1	5	30	0	1	2.50	0.003
	2	5	30		1	5.00	0.005
Remove the shielded carrier cask from the CTA	1	2	30	0-6	2.01	1.00	0.002
		2	30		1	2.00	0.002
Survey the cask	1	2	30	0-6	2.01	1.00	0.002
	2	2	30		1	2.00	0.002
Move the cask by motor-truck to the E-wing loading dock for shipping to WM facilities	1	5	30	0-6	2.01	2.50	0.005
	2	5	30		1	5.00	0.005
Total person-hours						**155.00**	
Total collective dose for year 2001							**1.931**

trailer would then be brought into Building 331, and the 30-gal drums inside the 55-gal shielded casks would be lifted and placed in storage positions inside the fuel pool. To retrieve waste drums, a trailer connected to a truck would be used again. The waste drums would be retrieved from the fuel pool and loaded into the 55-gal shielded casks on the trailer. Then the truck would move the trailer to Area 317, where the 30-gal drums inside the 55-gallon shielded casks on the trailer would be transferred to an 8-120 shipping cask loaded on another truck.

The second storage scenario for Building 331 involves the use of a trailer as well. However, it also involves the use of a 7-100 shielded cask and half-cask liners. Before the arrival of waste drums, an empty 7-100 cask would be brought inside Building 331 and a half-liner would be placed inside the 7-100 cask. When the waste drums arrived at the facility on a trailer, they would be transferred to the half-liner. When the half-liner was full (holding five 30-gal drums), the concrete shielding block of the fuel pool would be removed, and the half-liner would be lifted and placed in a storage position inside the fuel pool. To retrieve the drums for off-site disposal, the half-liner would be lifted and placed inside the 7-100 cask that had been put on a trailer. The trailer would then be moved outside the building, and the half-liner inside the 7-100 cask would be transferred to an empty 8-120 shipping cask loaded on another truck.

For the two Building 331 scenarios, it is assumed that the trailer would carry three waste drums in each shipment. Building 331 has the equipment to allow lifting activities to be conducted remotely. Therefore, the workers could reduce their radiation exposure during lifting by staying inside the control room. Twelve persons would be involved in the drum emplacement activities, and 16 persons would be involved in the retrieval and off-site shipment activities. These persons would include a foreman, mechanics, riggers, a crane operator, drivers, health physicists, and a waste specialist.

Results and Discussions

Table II summarizes the calculation results of the risk assessment. Packaging the RH/TRU waste would result in much higher radiation exposures than would unloading the drums and placing them in storage positions. According to the estimates, the radiation exposures for packaging the RH/TRU waste would be about 1.93 person-rem for 30 drums in year 2001 and about 0.81 person-rem for 10 drums in each of the following year (2002, 2003, and 2004).

For drum storage activities, the half-liner scenario considered for Building 331 would require the most human resources (668 person-hours for year 2001 and 249 person-hours for each subsequent year). However, it would also result in the lowest radiation exposures, 0.65 person-rem for 2001 and 0.22 person-rem for 2002, 2003, and 2004. The lower exposures would occur because the drum lifting would be controlled remotely, inside the control room, and because the shielding concrete of the fuel pool would not be removed as frequently as it would be under the other two storage scenarios. Storage in Area 317 would require the least amount of human resources, but the radiation exposures would be higher than those associated with the half-liner scenario for Building 331. For storing the waste drums without liners in the fuel pool area of Building 331, the required person-hours estimated would be slightly fewer than those estimated for the half-liner scenario, but the estimated radiation exposures would be twice as high.

From the point of view of preparing the waste for off-site shipment, storing the waste drums in Area 317 would require less human resources (187 person-hours) and would result in lower radiation exposures (0.35 person-rem) than would the two storage scenarios for Building 331. Storing the waste drums without liners in Building 331 would again require the most estimated human resources and result in the highest radiation exposures among the three options considered.

Table II. Summary of the Risk Assessment Results for the RH/TRU Waste Handling Activities

	Location and Storage Scenarios			
	AGHCF	**317 Vault**	**B. 331 Drum Scenario**	**B. 331 Half-Liner Scenario**
Year 2001				
Number of drums handled	30	30	30	30
Total person-hours required	155.00	500.00	626.00	668.00
Total collective dose (person-rem)	1.93	0.97	1.30	0.65
Years 2002, 2003, and 2004				
Number of drums handled per year	10	10	10	10
Total person-hours required	56.67	181.67	226.67	248.67
Total collective dose (person-rem)	0.81	0.33	0.45	0.22
Year 2005 (shipping drums off-site)				
Number of drums handled	N/A	60	60	60
Total person-hours required	N/A	187.00	2294.00	696.00
Total collective dose (person-rem)	N/A	0.35	2.35	1.16

N/A = not applicable.

The time-motion table methodology was demonstrated to be useful in comparing radiation exposures of involved workers associated with radioactive waste handling activities. The results of this risk assessment provided valuable input into the decision-making process to select an interim storage location for the RH/TRU waste at ANL–E.

REFERENCES

1. Pan, D., et al., *Safety Analysis Report for Building 331, Radioactive Waste Storage Facility, Rev. 3*, Plant Facilities and Services, Waste Management Operations, Argonne National Laboratory, Argonne, Ill. (2000).

2. Pan, D., et al., *Safety Analysis Report for Facility 317B, Waste Management Operations Facility, Rev. 2*, Plant Facilities and Services, Waste Management Operations, Argonne National Laboratory, Argonne, Ill. (2000).

3. Argonne National Laboratory, *Alpha-Gamma Hot Cell Facility (AGHCF) Safety Analysis Report*, IPS-221-00-00, Energy Technology Division, Argonne, Ill. (1998).

4. Negin, C.A., and G. Worku, *MicroShield, Version 4, User's Manual*, Grove 92-2, Grove Engineering, Inc., Rockville, Md. (1992).

5. Page, R., *Argonne National Laboratory-East On-Site Radioactive Waste Transportation Safety Assessment, Rev. 0*, Reactor Engineering Division, Argonne National Laboratory, Argonne, Ill. (1998).