Disposal of Potentially Neutron Activated PCB Capacitors at Argonne National Laboratory through the Authorized Release Process

J.J. Cheng, S. Y. Chen, N. Brachmann, S. Butala, F. Brumwell,
A. Bindokas, A. Gabel, and P. Neeson

Disposal of Potentially Neutron Activated PCB Capacitors at Argonne National Laboratory through the Authorized Release Process - 11064

J.-J. Cheng*, S. Y. Chen*, N. Brachmann*, S. Butala*, F. Brumwell*,
A. Bindokas**, A. Gabel***, and P. Neeson***

*Argonne National Laboratory, Argonne, IL 60439
** U. S. Department of Energy, Office of Science, Chicago Office, Argonne, IL 60439
*** U. S. Department of Energy, Office of Science, Argonne Site Office, Argonne, IL 60439

ABSTRACT

Several hundred capacitors located in Buildings 361 and 391 at Argonne National Laboratory were given high priority for disposal to facilitate decontamination and decommissioning of the Intense Pulsed Neutron Source (IPNS) facility. These capacitors contained polychlorinated biphenyl (PCB) oil that must be treated and disposed of as hazardous waste under the Toxic Substance Control Act (TSCA). However, they had been located in radiological control areas where the potential for neutron activation existed; therefore, direct release of these capacitors to a commercial facility for PCB treatment and landfill disposal was not allowable unless authorized release had been approved.

This paper discusses the efforts undertaken by Argonne to meet the requirements in DOE Order 5400.5 for authorized release, including (1) performing radiological characterization of the capacitors, (2) procuring a potential vendor for accepting the PCB capacitors, (3) ensuring release to the vendor meet relevant federal or state regulatory requirements, (4) conducting dose assessments to analyze potential radiation exposures associated with the release, and (5) proposing authorized release limits consistent with the ALARA principle to DOE for approval. The DOE Argonne Site Office reviewed Argonne's request and approved the proposal in February, 2010. In May, 2010, the last batch of the PCB capacitors was shipped to Clean Harbors' facility in Deer Park, Texas.The capacitors were incinerated to destroy the PCB oils. Metal slag removed from the furnace was disposed to a Resource Conservation and Recovery Act (RCRA) Subtitle C landfill. It was estimated that the authorized release of PCB capacitors resulted in a cost saving of $950,000 over the mixed waste disposal option.

INTRODUCTION

The IPNS at Argonne National Laboratory began operations in 1981, ceased operations in December 2007, and was formally shut down in September 2008. PCB capacitors located in Buildings 361 and 391 had the potential of being activated by neutrons because they were located in radiological controlled areas when the IPNS operated [1]. To facilitate the decontamination and decommissioning (D&D) of the IPNS facility, these PCB capacitors required removal, treatment, and disposal. As a result, their disposal became a priority issue for the IPNS D&D team.

Thecapacitors located in Buildings 361 and 391 contained PCB oils, and thus required disposal within one year under the TSCA regulation unless an extension was granted by EPA. However, there was no available disposal path for these large capacitors historically located in radiological controlled areas. The low-level waste disposal facility owned by EnergySolutionswhich was identified as a potential destination forthese capacitors had not yet been approved by EPA for shredding and treating the large capacitors, although it was in the process of modifying its permit with EPA.As such, there was no feasible disposition alternative other than the authorized release from radiological control.Furthermore, preliminary characterization data found no loose contamination on the exterior surface of the capacitors, and the radioactivity levels measured were either below or just slightly above the detection limits. Because of the low activity, lack of a radiological treatment and disposal pathway, regulatory requirements for disposal, and the potential for significant cost savings, Argonne decided to evaluate and pursue the authorized release option.

WASTE STREAM CHARACTERIZATION

Characterization of the PCB capacitors began in March 2009 and continued through September 2009. A total of 344 large capacitors, each weighing 57 kg (126 lb), had been located in Building 391 outside the 450-MeV rapid cycling synchrotron (RCS) proton accelerator shield in a radiation area. Radiological evaluation made by analyzing the small parts associated with three capacitors that were closest to the beam line and had the highest potential for neutron activation revealed three isotopes - Mn-54, Co-57, and Co-60, known to be activation products. The average concentrations measured in March, 2009 were adjusted for radioactive decay to obtain the average concentrations in September, 2009. They were 0.00037, 0.00041, and 0.0084 Bq/g (0.010, 0.011, and 0.226 pCi/g) for Mn-54, Co-57, and Co-60, respectively[1]. It was noted that the existence of Co-60 was unique for the brass nuts and was not found in the steel bulk of the capacitors, due to the unique metallic composition of brass metal. The small parts that would be shipped along with the capacitors for disposal would constitute only 0.25% of the weight of the capacitors. Assuming that radionuclides distributed evenly throughout the small parts with the measured concentrations, the total activity contained in the small parts that would be shipped off-site for disposal was estimated to be about 447 Bq (12.08 nCi).

In addition to the small parts, two large capacitors that had sat on the floor closest to the two dominant neutron sources for the entire period of time that the RCS was operated were retrieved for gamma spectroscopy characterization. The measurements, conducted on July 16, 2009, identified two activation products - Na-22 and Mn-54, in the bulk of the capacitors. Adjusted for radioactive decay, the average concentrations for Na-22 and Mn-54 would be 0.0014 and 0.0021 Bq/g (0.038 and 0.057 pCi/g), respectively, on September 30, 2009. Assuming, conservatively, that all other capacitors have the same radioactivity levels as the two retrieved ones, a total radioactivity of 69,190 Bq (1.87 µCi) was estimated for the Mn-54 and Na-22 combined in the bulk of the capacitors. The PCB oils were sampled, characterized via gamma spectroscopy, and confirmed to be not activated.

A total of 72 PCB capacitors were located on the floor in Building 361 adjacent to the 50-MeV linac. The potential for neutron activation was much lower for these capacitors because of the lower energy of the proton beam in this stage of the accelerator system. This was verified by the gamma spectroscopy analysis results, which showed no measurable radioactivity in the hardware removed from these capacitors. To estimate the total radioactivity, the lowest limit of detection (LLD), 0.0022 Bq/g (0.06 pCi/g), was assumed as the bulk concentration; this resulted in an estimate of total activity of 5,624 Bq (152 nCi) for Mn-54 and Na-22, respectively.

Table 1 summarizes the measured radioactivity concentrations in each type of capacitor. In addition to the concentrations, the total activities of these capacitors that were considered for authorized release are listed. The sums of the total activities were used for comparison with the exemption limits established by the State of Texas. The concentrations formed the basis of the ALARA dose assessment detailed later in this paper.

PROCUREMENT OF A POTENTIAL VENDOR FOR WASTE DISPOSAL

Clean Harbors, which is permitted by the EPA for handling hazardous wastes, owns an incinerator and landfill near Deer Park, Texas. In March 2009, it accepted and treated the PCB dielectric fluid waste from Portsmouth Gaseous Diffusion Plant after the waste was approved for authorized release by DOE [2].

Clean Harbors was contacted and indicated willingness to accept, treat, and dispose of the PCB capacitors, subject to DOE approval for authorized release, if the radioactivity concentrations and total inventory in the PCB capacitors met the State of Texas exemption limits. Argonne provided a report to Clean Harbors that documented the evaluation of induced radioactivity in the PCB capacitors and the radiological characterization results [1], which was then submitted by Clean Harbors to State of Texas to obtain approval for accepting and treating the PCB capacitors.

Under the authorized release alternative, the PCB capacitors would be shipped by trucks from Argonne to Deer Park, Texas, where they would be shredded and incinerated to destroy the PCB oils, then metal slag removed from the furnace would be disposed to a RCRA Subtitle C landfill owned by Clean Harbors. The approval by the State of Texas was granted in November 2009. Table 4 compares the radioactivity inventory in the PCB capacitors with the State of Texas exemption limits.

Table 1. Summary of Radioactivity Concentrations and Total Inventory in PCB Capacitors

Capacitor Location/Type	Total Weight (kg)	Activity Concentration in Bq/g (pCi/g)[a]				Total Activity in Bq(nCi)			
		Mn-54	Na-22	Co-57	Co-60	Mn-54	Na-22	Co-57	Co-60
Building 391 (small parts)	49	0.00037 (0.01)	ND[b]	0.00041 (0.011)	0.0084 (0.226)	18.13 (0.49)	ND[b]	19.98 (0.54)	0.41 (11.04)
Building 391 (bulk)	19,677	0.0021 (0.057)	0.0014 (0.038)	ND[b]	ND[b]	41,477 (1,121)	27,676 (748)	ND[b]	ND[b]
Building 361	3,145	0.0022 (0.06)	0.0022 (0.06)	ND[b]	ND[b]	5,624 (152)	5,624 (152)	ND[b]	ND[b]
Sum	22,871					47,138 (1,274)	33,300 (900)	19.98 (0.54)	0.41 (11.04)

[a] Activity concentrations are estimates based on measurement data, with adjustment for radioactive decay to September 30, 2009.

[b] ND = not detected.

DOSE ASSESSMENT AND ALARA ANALYSIS

An ALARA analysis was conducted to evaluate the two disposition alternatives (the authorized release alternative and the mixed waste disposition alternative) considered for the PCB capacitors. The analysis results support the selection of the authorized release option.

For the ALARA analysis, potential human radiation exposures associated with the release of the PCB capacitors were evaluated; then a dose constraint of 0.01 mSv/yr (1 mrem/yr), which is a small fraction of the primary dose limit of 0.25 mSv/yr (25 mrem/yr), was selected to derive authorized release limits. The derived authorized release limits were approved by DOE and were used as release criteria for comparison with radiological survey data measured before the actual shipment of the PCB capacitors. The evaluation of a comprehensive list of receptors and the selection of a small fraction of the primary dose limit as the dose constraint were consistent with the DOE ALARA process for protection of the public and environment [3].

Although the dose assessments discussed in the following sections were conducted to evaluate the authorized release alternative, the potential dose to workers and the general public associated with the mixed waste disposition alternative would not be significantly different. For both alternatives, the PCB capacitors would be shipped from Argonne to the designated facility where they would be shredded and treated to destroy the PCB content, and the solid residue from the treatment would then be disposed of at an on-site disposal facility. The waste treatment methods employed by EnergySolutions and Clean Harbors to destroy the PCB content may not be the same; however, it was expected that rigorous emission control technologies would be implemented at both facilities to minimize potential releases to the environment. Both disposal facilities would incorporate engineered designs to minimize leaching; institutional control and deed restriction would also be in place to prevent future intrusion. Therefore, the dose estimates presented in the following sections were considered to be conservative for both disposal options.

Handling of Uncertainty

Since there could be uncertainties involved in the dose assessment, the strategy for mitigating such uncertainties was added conservatism (i.e., toward maximizing the potential doses) whenever such uncertaintiesarose.

Source Term

Two shipments would be required to transport the PCB capacitors to the incinerator at Deer Park, Texas. The first shipment would contain 14 wire baskets and weighedabout 13,620 kg (30,000 lb). The second shipment would contain 11 wire baskets and weighed about12,400 kg (27,300 lb).

For the dose assessment, two shipments, each loaded with 15,000 kg (33,040 lb) of capacitors, were assumed. The radioactivity concentrations in the capacitors were assumed to be 0.00041, 0.0022, 0.0022, and 0.0084 Bq/g (0.011, 0.06, 0.06, and 0.226 pCi/g) for Co-57, Mn-54, Na-22, and Co-60, respectively, which were the maximal averaged concentrations obtained from the characterization efforts (see Table 1). Note that Co-57 and Co-60 were not observed in the bulk of the capacitors. They existed only in the small parts of the B.391 capacitors, and constituted a small fraction of the total weight of the capacitors. Furthermore, only the capacitors closest to the dominant proton beam loss points and judged to have the highest activation were characterized. Even so, the radioactivity levels in some of the characterized capacitors were below the lowest detection limits. Therefore, the assumptions used to determine the source term for dose assessments were very conservative; they overestimated the total activity of Co-57 and Co-60 by at least two orders of magnitude.

Exposure Scenarios

All activities involved in handling, transport, treatment, and disposal of the PCB capacitors would be outside of the radiological control areas and thus the potentially exposed personnel were assumed to be nonoccupational (or nonbadged) personnel. These included workers surveying the capacitors prior to the shipment, workers loading and securing the waste packages to a truck for shipment, truck drivers transporting the waste packages from Argonne to the incineration facility owned by Clean Harbors (at Deer Park, Texas), workers receiving and placing the capacitors in storage at the incineration facility, workers handling the capacitors for shredding and incineration, and workers handling and disposing the incineration residue at the landfill.

Members of the general public who would have the potential of incurring radiation exposures were the drivers of vehicles that shared the road with the waste trucks when they were en route to the treatment and disposal facility (on-link population); the passengers at stops when the waste trucks were parked for maintenance, refueling, food, and rest (stop population); as well as residents living on each side of the transportation route (off-link population). People who lived close to the incineration facility could also incur radiation exposure to the flue gas and dust particles released during the incineration of the PCB capacitors. Because of the much longer exposure distance and shorter exposure time for the general public, their individual dose was expected to be much lower than that for the individual worker; however, the general public populations would be much larger than the worker population.

In addition to radiation exposures incurred before and during the disposition of the PCB capacitors, potential exposure after the disposition of the PCB capacitors was also analyzed. The analysis involved the consideration of a future farmer who unknowingly intrudes the landfill and sets up living above the waste disposal area. It was conservatively assumed that the landfill would be closed immediately after the disposition, followed by an institutional control period of 30 years, a common practice for RCRA landfills. After 30 years, a farmer was assumed to build a house, dig a well, plant crops, and raise livestock to live a subsistence life above the landfill area. The consideration of a subsistence farmer was very conservative in that it would encompass the most exposure pathways and the longest exposure duration. In reality, it is very unlikely that such a scenario would occur; nevertheless, the estimate of the corresponding exposure would provide the upper limit that bounds the exposures associated with any other scenario that would be more likely to occur after the disposition of the PCB capacitors.

Exposure Pathways

The radiation exposures of workers were analyzed for the external radiation and inhalation pathways. Exposures for the ingestion pathway were not analyzed. They were considered to be very small compared with exposures from the other two pathways, either because there was no removable contamination on the exterior surface of the capacitors or because workers would handle the shredded capacitors or the incineration residue with equipment and would not touch them directly. In reality, the workers would probably wear protective gloves while handling the shredded capacitors or incineration residue; thereby the possibility of ingestion exposure would be greatly reduced. Inhalation exposures of workers were considered to result from dispersion of sawdust generated by shredding the capacitors and from release of airborne particles entrapped in the flue gas during incineration.

Exposures of the general public were analyzed for the external radiation pathway during transport of the PCB capacitors. During waste treatment, radiation exposure of the general public living close to the incineration facility was considered to result from release of the flue gas, through air submersion, inhalation, and external radiation to the particles entrapped in the flue gas and subsequently deposited to the ground surface at downwind locations. After disposal of the incineration residue, the general public could incur radiation exposure as a result of (1) leaching of radionuclides from the disposal area to the underlying groundwater and (2) exhumation of the buried incineration residue by digging a well or building a foundation directly into the disposal area. A resident farmer scenario was assumed to evaluate the potential radiation exposures from both mechanisms. The farmer was assumed to unknowingly intrude the landfill after its closure and set up living above the disposal area. The cover material shielding the buried residue was assumed to be removed, exposing the underlying residue to the ground surface; at the same time, precipitation and irrigation water flowed through the waste area, causing radionuclides in the residue to leach to groundwater. Radiation exposure pathways considered for the farmer scenario included external radiation, inhalation and direct ingestion of dust particles, ingestion of groundwater, ingestion of crops grown in the disposal area and irrigated with the groundwater, and ingestion of meat and milk produced by livestock fed with the groundwater and fodder grown in the disposal area.

Use of Computer Codes

The radiation doses incurred by workers were calculated with the TSD-DOSE model [4], which was designed specifically to consider radiation exposures resulting from transportation, storage, treatment, and disposal of wastes containing radioactive materials. The RADTRAN model [5,6], which performs detailed analyses of radiation exposures of the general public along the transportation route, was used to assess population radiation exposure from shipping the PCB capacitors from Argonne to the incineration facility. Routing information for the shipment was obtained with TRAGIS [7], which is a routing analysis tool with an extensive database of highways, railways, and waterways, as well as traffic load and population density. Information generated by TRAGIS was entered into RADTRAN for the calculation of collective radiation exposure resulting from waste transportation. The radiation dose incurred by the farmer intruding the landfill was calculated with the RESRAD code, version 6.21 [8], which is a multiple exposure pathways model for analyzing radiation exposure resulting from residual soil contamination.

Values of input parameters used to run the computer codes were developed considering the waste inventory and the nature of specific worker activities. They were purposely selected to yield conservative dose results and are detailed in Cheng and Chen 2009 [9], which was prepared to support the request for authorized release of the PCB capacitors.

Dose Results for Workers

Table 2 lists the estimated worker doses associated with the PCB capacitors loaded in one truck shipment from Argonne to Deer Park, Texas. Although some activities might be conducted by one worker, two primary workers were assumed for each type of activity to obtain more conservative estimates of collective exposure. The average exposure distance for each type of activity was either the default value in TSD-DOSE or determined on the basis of empirical experience. The exposure durations were also intentionally chosen to be more conservative to yield higher radiation dose results.

Assuming all the activities involved in disposition of the PCB capacitors would occur within one year, then according to the estimated dose results, the incineration worker would receive the highest radiation exposure, about 4.3×10^{-5}mSv/yr (0.0043 mrem/yr) from handling a truckload of capacitors. The radiation dose received by the truck drivers was estimated to be a little lower, 3.2×10^{-5}mSv/yr(0.0032 mrem/yr). Radiation exposures received by the surveying workers, riggers, receiving workers, and landfill workers were all lower than 1.0×10^{-5}mSv/yr(0.001 mrem/yr) per shipment of PCB capacitors. Because two shipments would be required for the entire inventory of PCB capacitors, the maximum worker dose would be 8.6×10^{-5}mSv/yr(0.0086 mrem/yr), which is less than 1% of the 0.01 mSv/yr (1mrem/yr) dose constraint selected as a reference for deriving the authorized release limits.

Dose Results for the General Public

Table 3 lists the estimated radiation doses to the general public resulting from one shipment of the PCB capacitors from Argonne to Deer Park, Texas. Potential exposures could result during the shipment, during the incineration treatment, and after disposal of the incineration residue.

During shipment of the PCB capacitors, the maximal individual dose would be incurred by a person who happened to be at the same stop where the waste truck was parked for rest, refueling, or maintenance. The estimated individual dose was 3.18×10^{-11}mSv/yr(3.18×10^{-9} mrem/yr). Compared with the maximum worker dose, the maximum public dose was six orders of magnitude lower because of the much greater distance to the waste packages and the much shorter duration of exposure. The collective dose for the stop population was estimated to be 3.75×10^{-8} person-Sv/yr(3.75×10^{-6} person-rem/yr), based on the assumptions of 25 persons at each stop, an average distance of 10 m to the waste truck, and a total stop time of 18 hours. The collective dose estimated for the on-link population was 1.63×10^{-8} person-Sv/yr(1.63×10^{-6} person-rem/yr), based on the assumption that one-way traffic counts in rural, suburban, and urban areas were 470, 780, and 2,800 vehicles/hr, respectively, and two people were in each vehicle sharing the same route. For the off-link population that lived within800m on each side of the transportation route, the estimated collective dose was 2.52×10^{-9} person-Sv/yr(2.52×10^{-7} person-rem/yr). This estimate was based on the assumption that the average population densities along the transportation route were 14.2, 301.7, and 2338.4 people/km^2 for the rural, suburban, and urban section, respectively. These population densities were estimated by TRAGIS, which also estimated the total

TABLE 2. Potential Radiation Exposures of Workers Resulting from Shipping, Treating, and Disposing of the PCB Capacitors — Results Associated with the Capacitors in One Shipment

Worker Category	Worker Activity	No. of Workers Involved in Each Type of Activity	Average Exposure Distance (m)	Exposure Duration per Shipment (hr)	Individual Dose from the Specific Activity (mSv)	Individual Dose of Each Worker, (mSv)	Collective Worker Exposure, (person-Sv)
Inspector	Survey waste packages prior to shipment	2	0.15	4	2.90E-05	2.90E-06	1.74E-07
Rigger	Load/secure waste packages for shipment	2	0.6	3	5.10E-06	5.10E-06	
Driver	Transport waste packages to Deer Park, Texas	2	0.6 – 2.1	45	3.20E-05	3.20E-05	
Receiving worker	Unload waste packages and put them into storage	2	0.6	3	2.80E-06	4.60E-06	
	Move waste packages to the shredding area	2	0.9	2	1.80E-06		
Incineration worker	Shred capacitors	2	0.9	30	2.80E-05	4.31E-05	
	Incinerate shredded capacitors	2	0.9	10	9.40E-06		
	Collect incineration residue and prepare for disposal	2	0.6	0.75	5.70E-06		
Landfill worker	Unload, mix, and dispose of the residues	2	1.5 - 3	1.25	1.30E-06	1.30E-06	

TABLE 3. Potential Radiation Exposures of the General Public from Shipping, Treating, and Disposing of the PCB Capacitors — Results Associated with the Capacitors in One Shipment

Receptor Category	Maximum Individual Dose (mSv)	Collective Population Dose (person-Sv)
In transit, on-link population	3.18E-11	1.63E-08
In transit, off-link population		2.52E-09
In transit, stop population		3.75E-08
Off-site population of the incineration facility	3.40E-08	1.70E-06
Intruder to the landfill	1.07E-04	Not applicable

mileage traveled in each area (1272.3 km in rural area, 574.4 km in suburban area, and 49.9 km in urban area).

During the incineration process, 3% of the radionuclides in the capacitors were assumed to escape with the flue gas. This would result in a maximal individual dose of 3.4×10^{-8}mSv/yr(3.4×10^{-6}mrem/yr) among the general public that lived within a 80-km (50-mile) radius of the incineration facility. The collective exposure of the population was estimated to be 1.7×10^{-6} person-Sv/yr(1.7×10^{-4} person-rem/yr), based on an urban population density.

Of the radionuclides in the PCB capacitors, 100% were assumed to remain in the residue after incineration. According to Clean Harbors, the weight reduction after incineration was about 20:1 [10]. Given an average density of 1.5 g/cm^3[10] for the incinearation residue, the residue volume for one truckload of the PCB capacitors would be less than 0.5 m^3. For estimating the potential radiation exposure of an intruder, the residue was assumed to be mixed with other wastes and buried in the landfill within a volume of 25 m^3 (5 m × 5 m × 1 m for length, width, and height, respectively). Then 30 years after the disposal of the PCB capacitors, a farmer was assumed to intrude the landfill and set up living above the disposal area. The potential radiation dose of the farmer, estimated with RESRAD, was a peak dose of about 1.1×10^{-4}mSv/yr(0.011 mrem/yr), primarily from external radiation. Because of the short half-lives of the radionuclides of concern, the radioactivity would decay away before reaching the groundwater table. As a result, there would be no groundwater contamination problem caused by disposition of the PCB capacitors.

PROPOSAL OF AUTHORIZED RELEASE LIMITS

On the basis of the dose assessment results presented in Tables 2 and 3, the maximal individual dose associated with releasing the PCB capacitors at Argonne National Laboratory to the Clean Harbors facility located at Deer Park, Texas, was estimated to be 2.2×10^{-4}mSv/yr($2 \times 1.1 \times 10^{-4}$mSv/yr to account for two shipments)(0.022mrem/yr) for a future farmer intruding the landfill area after closure of the disposal facility. This dose estimate was obtained by assuming homogeneous distribution of radionuclides throughout the PCB capacitors with a concentration of the maximal averaged level measured for each radionuclide. Although intrusion to the landfill by a farmer would be very unlikely, the selection of the intruder scenario as the critical scenario for developing the authorized release limits was a conservative approach and was consistent with the ALARA principle to reduce potential radiation exposure.

To target a small fraction of 0.01 mSv/yr (1 mrem/yr, the reference dose constraint selected for authorized release) for the critical scenario, authorized release limits of 0.021 Bq/g (0.6 pCi/g) for Mn-54, 0.021 Bq/g (0.6 pCi/g) for Na-22, 0.0037 Bq/g (0.1 pCi/g) for Co-57, and 0.084 Bq/g (2.3 pCi/g) for Co-60 (each was 10 times of the concentration assumed for the individual radionuclide in the dose assessment) wereselected and proposed to DOE. If the concentrations of radionuclides in the PCB capacitors were at the proposed authorized release limits, a radiation dose ofabout 0.0022 mSv/yr(0.22mrem/yr)would be incurred by the intruder identified as the maximally exposed individual from the dose assessment. The collective population doses corresponding to the proposed authorized release limits would be far below the DOE objective of 0.1 person-Sv/yr(10 person-rem/yr) for collective exposure.

DEMONSTRATION OF COMPLIANCE

The proposed authorized release limits would result in potential radiation exposures much lower than the primary dose limit of 0.25 mSv/yr(25 mrem/yr) for a DOE source or practice. Table 4 compares the proposed authorized release limits with the State of Texas exemption levels [11], the American National

Standards Institute (ANSI)/Health Physics Society (HPS) screening levels, and the International Atomic Energy Agency (IAEA) screening standards for clearance of non-real properties from radiological control. Both the proposed authorized release limits and the estimated total radioactivity in the PCB capacitors are much lower than the respective State of Texas exemption levels. The proposed authorized release limits are also lower than the screening levels developed by ANSI/HPS and screening standards developed by IAEA, which were calculated on the basis of a dose limit of 0.01 mSv/yr (1 mrem/yr).

A cost-benefit analysis was conducted to compare the two disposition alternatives. The total cost for the mixed waste disposition alternative was estimated to be $1,009,000 based on quotes from the existing contract between Argonne and EnergySolutions. The cost with the authorized release alternative was estimated to be $57,000 based on quotes by Clean Harbors. Therefore, the savings of the authorized release alternative would be about $950,000 over the mixed waste disposition alternative.

Table 4. Comparison of the Derived Authorized Release Limits, Exemption Levels Prescribed by State of Texas, and National andInternational Standards for Clearance of Non-real Properties

Radionuclide	Authorized Release Limit, Bq/g (pCi/g)	Estimated Total Radioactivity[a], Bq (nCi)	State of Texas Exemption Level[b]		ANSI/HPS Screening Level[c], Bq/g (pCi/g)	IAEA Clearance Level[d], Bq/g(pCi/g)
			Total Radioactivity, Bq (nCi)	Concentration, Bq/g (pCi/g)		
Mn-54	0.021 (0.6)	4.71E+04 (1.27E+03)	3.70E+05 (1.00E+04)	37 (1,000)	1.11 (30)	0.1 (2.7)
Na-22	0.021 (0.6)	3.33E+04 (9.00E+02)	3.70E+05 (1.00E+04)	Not available	1.11 (30)	0.1 (2.7)
Co-57	0.0041 (0.1)	2.00E+01 (5.4E-01)	3.70E+06 (1.00E+05)	185 (5,000)	Not available	1 (27)
Co-60	0.084 (2.3)	4.10E-01 (1.10E+01)	3.70E+04 (1.00E+03)	18.5 (500)	1.11 (30)	0.1 (2.7)

[a] The total radioactivity in the PCB capacitors was estimated based on the characterization data [1] listed in Table 1.
[b] [11] Texas Administrative Code, Title 25 Part 1, Chapter 289, Subchapter F, Rule § 289.251. Available at http://info.sos.state.tx.us/fids/25_0289_0251-13.html.
[c] Information extracted from ANSI/HPS [12].
[d] Information extracted from IAEA Safety Guide No. RS-G-1.7 [13].

Clearance of the PCB capacitorsfrom radiological control to off-site commercial incineration and disposal would not result in groundwater contamination at the off-site location. As demonstrated in the dose assessment with RESRAD for the future intruder scenario, there would be no radiation dose associated with the use of groundwater. The radionuclides identified for the PCB capacitors all have short half-lives (2.6, 0.86, 0.74, and 5.27 years for Na-22, Mn-54, Co-57, and Co-60, respectively); therefore, even if the radionuclides leach out from the waste disposal area, their radioactivity would decay away before they reach the groundwater table.

Release of the PCB capacitors for commercial incineration and disposal at an off-site facility would not result in remediation requirement in the future at the off-site location. The radionuclides of concern are all short-lived (with half-life less than 5.27 years) and would substantiallydecay (by at least 100 times) during the institutional control period (estimated to be 30 years or more). This is verified by the dose assessment results with the RESRAD code. In the RESRAD analysis, a future intruder was assumed to exhume and expose to the ground surface the buried incineration residues through construction activities. The potential peak dose estimated for the intruder, by considering all possible exposure pathways associated with subsistence living, was 2.2×10^{-4}mSv/yr (0.022mrem/yr), which is less than 0.1% of the 0.25 mSv/yr (25 mrem/yr) dose limit set by DOE for deriving cleanup guidelines for radioactively contaminated sites.

Argonne would maintain appropriate records of the cleared materials consistent with the requirements of DOE Order 5400.5 and other applicable DOE directives. Copies of the authorized release limits report [9] and the PCB capacitors characterization report [1] would be made publicly available, and survey results of the capacitors would be reported consistently with DOE guidance [14,15].

CONCLUSIONS

Authorized release was pursued by Argonne National Laboratory for the disposition of several hundred large PCB capacitors that were located in radiological control areas and had no secured path for disposal. In the process, Argonne followed DOE requirements for authorized release, including (1) characterizing the radioactivity content of the capacitors, (2) procuring a vendor that was permitted to treat and dispose of the capacitors under the State of Texas exemption limits provision, (3) conducting a comprehensive dose assessment to demonstrate that potential human radiation exposures associated with release of the capacitors would be far below the primary dose limit for the protection of the general public, (4) demonstrating that the release would be in compliance with the requirements of the disposal facility and would not result in groundwater contamination or remediation requirement for the disposal site in the future, (5) proposing authorized release limits consistent with the ALARA principle, and maintaining appropriate record keeping and survey protocols for the review of clearance of the PCB capacitors.

The request for authorized release was granted in February 2010 and the last batch of capacitors was shipped out to Clean Harbors in May 2010. The implementation of authorized release saved Argonne about $950,000 compared with the cost associated with the mixed waste disposal option that would require Argonne to send the capacitors to a licensed low-level waste disposal facility.

When dealing with disposition of non-real properties that contain levels of radioactivity near or slightly above the background levels, authorized release should be included in the consideration as a viable option.

ACKNOWLEDGEMENT

Argonne National Laboratory's work was supported by the U.S. Department of Energy, Assistant Secretary for Environmental Management, Office of Science and Technology, under contract DE-AC02-06CH11357.

REFERENCES

1. Butala,S., and F. Brumwell, 2009, *An Evaluation of Induced Radioactivity in PCB Capacitors at the Argonne Intense Pulsed Neutron Source*, JMLT-137-W-T011, ESQ and AES Divisions, Argonne National Laboratory, Argonne, IL.

2. DOE, 2008, *Authorized Limits for Disposal of PCB Dielectric Fluid from Process Buildings X-330 & X-333 at the Portsmouth Gaseous Diffusion Plant, Portsmouth, Ohio*, DOE Portsmouth/Paducah Project Office, Lexington, Kentucky, Sept.

3. DOE, 1997, *Applying the ALARA Process for Radiation Protection of the Public and Environmental Compliance with 10 CFR Part 834 and DOE 5400.5 ALARA Program Requirements*, Draft DOE ALARA Standard, April.

4. Pfingston, M., J. Arnish, D. LePoire, and S.-Y. Chen, 1998, *TSD-DOSE: A Radiological Dose Assessment Model for Treatment, Storage, and Disposal Facilities*, ANL/EAD/LD 4 (Revision 1), Sept. 1998.

5. Weiner, R.F., et al., 2006, *RadCat 2.2 User Guide*, SAND2006-1965, Sandia National Laboratories, Albuquerque, N.M., April.

6. Neuhauser, K.S., et al, 2000, *RADTRAN 5 Technical Manual*, SAND2000-1256, Sandia National Laboratories, Albuquerque, N.M., May.

7. Johnson, P.E., and R.D. Michelhaugh, 2000, *Transportation Routing Analysis Geographic Information system (WebTRAGIS) User's Manual*, ORNL/TM-2000/86, prepared by Oak Ridge National Laboratory, Oak Ridge, Tenn., for U.S. Department of Energy, National Transportation Program, Albuquerque, N.M., April.

8. Yu, C., et al., 2001, *Users Manual for RESRAD Version 6*, ANL/EAD-4, Argonne National Laboratory, Argonne, Ill., July.

9. Cheng, J.-J. and S.Y. Chen, 2010, *Authorized Limits for Disposal of PCB Capacitors from Buildings 361 and 391 at Argonne National Laboratory, Argonne, Illinois*, ANL/EVS/RP-65867, Argonne National Laboratory, Argonne, Ill., January.

10. Brachmann N.M. 2009, "ANL_CapsProj question list 102009_cost information needed.doc," attachment to e-mail with subject "FW: Responses to ANL questions" from N.M. Brachmann N.M. to J.A. Jacoboski, F.R. Brumwell, and S. Butala, and cc: to W.S. Heffron and J. Cheng, Oct. 27, 2009.

11. Texas Department of State Health Services 2009, Texas Administration Code, Title 25, Part I, Chapter 289, Subchapter F, Rule §289.251, Exemptions, General Licenses, and General License Acknowledgements.

12. ANSI/HPS (American National Standards Institute/Health Physics Society), 1999, *American National Standard - Surface and Volume Radioactivity Standards for Clearance*, ANSI/HPS N13.12-1999, approved Aug. 31.

13. IAEA (International Atomic Energy Agency), 2004, *Application of the Concepts of Exclusion, Exemption and Clearance, Safety Standards Series, Study Guide No. RS-G-1.7*, Vienna, Austria.

14. DOE, 1997, *Environmental Implementation Guide for Radiological Survey Procedures*, Draft Report for Comment, Office of Environmental Guidance, February.

15. DOE, 1991, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*, DOE/EH-0173T, January.