APPENDIX B:

ISSUES ASSOCIATED WITH DUF_6 CYLINDER CONTAMINATION

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This appendix discusses issues associated with possible contamination of the depleted uranium hexafluoride (DUF_6) within the cylinders and on the cylinders themselves. Section B.1 addresses possible contamination of the DUF_6 with transuranic (TRU) isotopes and technetium-99 (Tc-99). Section B.2 addresses the existence of polychlorinated biphenyls (PCBs) used in the paint on some portion of the cylinder inventory. References are provided in Section B.3.

B.1 POSSIBLE TRANSURANIC CONTAMINATION

B.1.1 Summary

This section addresses the concerns and impacts associated with potential contamination of DUF_6 cylinders with TRU isotopes (these isotopes have an atomic number greater than that of uranium-92 [U-92]) and Tc-99. The extent of contamination is discussed, and potential radiological, chemical, and waste management impacts are evaluated. The results indicate that a small but unknown number of DUF_6 cylinders in the U.S. Department of Energy's (DOE's) inventory are likely to contain relatively high concentrations of TRU and Tc-99 in a small volume inside the cylinders. The TRU and Tc-99 concentrations in a great majority of the cylinders and in the bulk of the small number of contaminated cylinders are expected to be relatively low. The impacts associated with such low concentrations are also expected to be negligibly low (less than 10%) compared with the impacts that would be associated with DUF_6 in the cylinders. In addition, both the concentrations and impacts associated with TRU and Tc-99 in the conversion facility at either the Paducah, Kentucky, or Portsmouth, Ohio, site and in the conversion products are estimated to be negligibly small. However, under certain circumstances, the doses resulting from the high concentrations of TRU and Tc-99 in a small number of emptied cylinders could be relatively high. In addition, depending on how the emptied cylinders are processed and dispositioned, there may be some transuranic waste (TRUW) issues at either conversion site. However, under the proposed action and by using the cylinder disposition strategy proposed by the conversion contractor, Uranium Disposition Services, LLC (UDS), no TRUW is expected to be generated at either the Paducah or Portsmouth site.

B.1.2 Background

At about the time the final programmatic environmental impact statement (PEIS) for DUF_6 was published in April 1999 (DOE 1999), and while DOE was preparing a request for proposals (RFP) to acquire the services of a private firm to design, construct, and operate two plants at Paducah and Portsmouth to convert DOE's inventory of DUF_6 to a more stable

chemical form (DOE 2000a), concern was raised that some portion of DOE's DUF_6 inventory might be contaminated with TRU and Tc. This concern arose because in the period before 1985, some reprocessed uranium from defense production sites was fed into the diffusion cascades in the form of UF_6. The reprocessed uranium was obtained from the fuel that had been irradiated in the production reactors (reactors used by the government to produce nuclear materials for weapons). This irradiation produced a large number of radionuclides that initially had not been present in the fresh fuel. These radionuclides were either TRU or fission products (radionuclides created from the fissioning of uranium atoms). When the used fuel was reprocessed to separate the wanted nuclear materials and the uranium to be used again, a small fraction of the TRU elements and a fission product, Tc-99, ended up in the uranium stream. It was thought that when the reprocessed uranium was converted to UF_6 and fed to the diffusion cascades for reenrichment, part of the contaminants in the uranium might have transferred into the tails cylinders (cylinders containing the DUF_6). The principal isotopes of concern were two TRU isotopes, plutonium-239 (Pu-239) and neptunium-237 (Np-237), and Tc-99.

DOE wanted to determine the extent of contamination in the cylinders so that potential responders to the RFP could properly factor it into their proposals. To resolve this uncertainty, DOE commissioned Oak Ridge National Laboratory (ORNL) to develop a strategy for characterizing TRU and Tc contamination in the tails cylinders (Hightower et al. 2000). The draft strategy developed by ORNL was peer reviewed by a team of scientists and engineers from Lawrence Livermore National Laboratory and Argonne National Laboratory (Brumburgh et al. 2000). The peer review team found that available data and process knowledge was sufficient to establish bounding concentrations of contaminants in the tails cylinders and that additional sampling of the cylinders would not be cost-effective. The ORNL team also concluded that additional characterization of the cylinders would not be likely to result in lower bids by prospective vendors, and that direct sampling of many older cylinders might not be practical. However, during the period December 1999 through August 2000, additional measurements were taken on 14 selected full DUF_6 cylinders and heels cylinders (i.e., empty cylinders containing about 10 to 23 kg (22 to 50 lb) of residual DUF_6, uranium decay products, and, in some cases, TRU and Tc) stored at the Paducah and Portsmouth Gaseous Diffusion Plants. The results of these measurements were included in the final ORNL strategy document (Hightower et al. 2000).

B.1.3 Extent of Transuranic and Technetium Contamination in the DUF_6 Cylinders

Both the ORNL team and the peer review team reviewed the previous characterization studies conducted on the tails cylinders. The ORNL team also interviewed some staff members who worked at the Portsmouth and Paducah Gaseous Diffusion Plant sites when the recycled uranium was being fed to the cascades. On the basis of those reviews and the characterization performed in the period December 1999 to August 2000, it was concluded that the level of contamination in the tails cylinders is very limited. The peer review team stated that the only plausible pathway for the TRU and Tc to get into the DUF_6 cylinders was by way of the heels from prior use of the cylinders to store reactor return feed. It was discovered during the investigations that some cylinders that were used to store reprocessed UF_6 were emptied into the cascades for reenriching the UF_6. The same cylinders were later filled with DUF_6 without first

being cleaned. The TRU contamination in the feed cylinders consisted mainly of nonvolatile fluorides. Therefore, they were concentrated in the heels of the feed cylinders. Any TRU isotopes that were carried into the cascades were thought to have plated out and been captured in the cascades; thus, they never made it into the tails cylinders. Similarly, nonvolatile compounds of Tc stayed in the heels, while the volatile components, because of their low molecular weight compared with UF_6, moved up the cascades and either were released in the purge stream or stayed with the enriched product.

The number of reprocessed uranium feed cylinders that were later used to store DUF_6 was not known, but it was estimated to be in the hundreds (Hightower et al. 2000). This number represents only a portion of the total of approximately 60,000 DUF_6 cylinders that are used to store DOE's inventory of DUF_6 at the three storage sites — Portsmouth, Paducah, and East Tennessee Technology Park.

It is believed that when the cylinders with contaminated heels were filled with DUF_6, the liquid DUF_6 entering the cylinder stirred the heels and caused some fraction of the contamination to be mixed with the DUF_6. It is also possible that a small fraction of the TRU that had been captured in the cascades may have revolatized during the cascade improvement projects and was carried into some DUF_6 cylinders. Therefore, TRU and Tc could be found both in the heels and in the bulk of a small, but unknown, number of DUF_6 cylinders in the DOE inventory. To provide guidance to prospective responders to the RFP, the ORNL study listed bounding concentrations of TRU and Tc in the cylinders in the bulk DUF_6 and in the heels. It also gave an estimated maximum quantity that could exist in the entire cylinder inventory. This information was included in the final RFP issued in October 2000 (DOE 2000a) and is reproduced here in Tables B-1 and B-2. The quantities listed were used in this environmental impact statement (EIS) to estimate the impacts associated with TRU and Tc contamination.

TABLE B-1 Bounding Concentrations of Dispersed Transuranic and Tc-99 Contamination in the DUF_6 Full and Heels Cylinders

Contaminant[a]	Concentration in Full Cylinders (ppb)[b]	Concentration in Heels Cylinders (ppb)[b]
Pu-238	0.00012	5
Pu-239	0.043	1,600
Np-237	5.2	54,000
Tc-99	15.9	5,700,000
Am-241	0.0013	0.57

[a] Am = americium, Np = neptunium, Pu = plutonium, and Tc = technetium.

[b] Equivalent to grams of contaminant per billion grams of uranium.

B.1.4 Extent of Transuranic and Technetium Contamination in the Conversion Facility

It is expected that when cylinders with TRU and Tc contamination would be fed into the conversion facility, the TRU and the Tc contamination, which would principally exist in the form of nonvolatile fluorides, would remain in the heels of the emptied cylinders (Brumburgh et al.

2000; Hightower et al. 2000). Although a small fraction of TRU might be carried out of the cylinders with the gaseous UF_6 as particulates, it is expected that it would instead be captured in the filters through which the UF_6 would pass before it entered the conversion equipment. Therefore, the only places at the entire conversion facility where TRU contamination could be of concern would be in some full cylinders before they were emptied, in some heels cylinders after they were emptied, and in the filters at the front end of the facility.

TABLE B-2 Maximum Total Quantities of Transuranics and Technetium in the DUF_6 Inventory

Radionuclide	Maximum Quantity (g)
Pu	24
Np	17,800
Tc	804,000

It is also expected that most of the Tc that existed in the cylinders would remain in the heels or be captured in the filters. However, because of the existence of some volatile technetium fluoride compounds, and for the purposes of analyses in this EIS, it was assumed that all of the Tc would volatilize with UF_6 and be carried into the conversion process equipment. Any Tc compounds transferred into the reaction chambers would be oxidized in the reaction chambers along with the DUF_6. For this EIS, it was also assumed that the Tc in the form of oxides would partition into the triuranium octaoxide (U_3O_8) and hydrogen fluoride (HF) products in the same ratio as the uranium.

Under the proposed action, it is assumed that after the emptied cylinders were removed from the autoclaves, a stabilizing agent would be introduced in the cylinders to neutralize residual fluoride in the heels. The cylinders would then be moved out to the aging yard and stored for at least 4 months to allow short-lived daughter products of uranium to decay. Then the cylinders would be transported to the cylinder disposition facility on site, where they would be compacted and dissected. Finally, the sectioned cylinder parts with heels in them would be transported to the Envirocare of Utah, Inc., facility for disposal. The emptied cylinders would be surveyed by using nondestructive assay (NDA) techniques to determine the presence of a significant quantity of TRU isotopes. If TRU isotopes were detected, samples would be taken and analyzed. Cylinders that exceeded the disposal site limits at the Envirocare of Utah facility would be treated to immobilize the heel (e.g., with grout) within the cylinder, compacted, and sectioned; then the cylinder/heel waste stream would be sent to the Nevada Test Site (NTS) and disposed of as low-level radioactive waste (LLW).

Because of a recent design change, UDS is now planning to fill the emptied cylinders with the depleted U_3O_8 product, transport the filled cylinders to the Envirocare of Utah disposal facility, and dispose of them there. Previously, the depleted U_3O_8 product was to have been poured into 11,340-kg (25,000-lb) capacity bulk bags, transported to the same disposal facility, and disposed of there. The cylinders were to be treated and disposed of as a separate waste stream, as discussed above. This EIS considers both options.

A small quantity of nonvolatile TRU contamination, which might be entrained in the gaseous DUF_6 during the cylinder emptying operations and carried out of the cylinders, would be captured in the filters that would be used between the cylinders and the conversion equipment.

These filters would be monitored and changed out periodically to prevent buildup of TRU, and they would be disposed of as LLW.

Under the proposed action, there would not be any TRUW (radioactive waste that contains transuranic radionuclides with half-lives greater than 20 years and in concentrations greater than 100 nCi/g) generated at the conversion plant at either the Paducah or Portsmouth site. However, to provide a conservative estimate of the impacts associated with the management of TRU- and Tc-contaminated heels materials, this EIS also considers the option of washing the emptied cylinders, removing the heels from the emptied cylinders, and disposing of the solids from the washing solution as waste. Under this option, it is shown that some of the waste thus generated might possibly be classified as TRUW.

B.1.5 Impact Areas

TRU contamination of DUF_6 is of concern with regard to its potential impact on the health and safety of the workers and the public primarily because the radiological toxicity of TRU radionuclides is higher than that of uranium isotopes. If the TRU was concentrated in waste materials generated during the conversion process, potential generation of TRUW would also be of concern.

As discussed above, TRU and Tc could occur in some full and heels cylinders. They could also be collected in the filters used in the front end of the conversion plant process. TRU and Tc would be health and safety concerns primarily if they were released to the environment in forms that could be taken internally by workers and the general public through inhalation, ingestion, or dermal absorption. The primary pathway of exposure is inhalation of particulates in air. The chemical toxicity of both the TRU and Tc is not much different than that of uranium, but because the concentrations of TRU and Tc are much less than that of uranium, their chemical impacts compared with those of uranium would be negligibly small.

During normal operations, the DUF_6 and any contaminants in it would be contained in the cylinders or the process equipment to prevent any measurable internal contamination of the workers or the public. However, if an accident caused the DUF_6 to be released to the atmosphere, the potential would arise for internal exposures. As discussed above, the TRU contaminants would be present in some of the cylinders and in the filters, but they would not enter the conversion process areas. Tc-99 could also be present in the same locations and could transfer into the process areas and conversion products. The highest concentration of the contaminants would be in the heels of some of the emptied cylinders. Therefore, potential impacts of any TRU and Tc contamination would be the greatest in cases involving accidents during storage, transportation, or handling of the cylinders, and during the management of wastes associated with the cleaning and disposition of empty cylinders.

Relative contributions of TRU and Tc to radiological doses under accident conditions are discussed below and in the main text of this EIS. Also discussed is the potential quantity of TRUW that could be generated at a conversion plant if the empty cylinders were to be washed and the heels separated.

In 1999 and 2000, a team of experts from DOE conducted a study on the historical generation and flow of recycled uranium (through reprocessing and reusing) in the DOE complex. The team report provided evaluation guidelines for the health and safety impacts associated with the contaminants found in the recycled uranium (DOE 2000b). In particular, Appendix A of the report provided the technical basis for identifying the relative radiological health hazards of the constituents. For each constituent and for a range of uranium enrichments, the appendix listed the concentrations of TRU radionulides in the reprocessed uranium that would result in a 10% increase in the dose received by an individual over and above the dose the individual would receive from the uranium alone. The concentrations that corresponded to the depleted uranium (0.2% U-235) are reproduced in Table B-3 for three different clearance classes, D, W, and Y. The clearance class indicates the speed by which the radionuclides taken internally by an individual would leave the body through biological mechanisms. Depending on the chemical from of the radionuclide, it could be on the order of days (D class), weeks (W class), or years (Y class). Among the chemical forms of uranium that are of concern in this EIS, UF_6 and uranyl fluoride (UO_2F_2) are considered to be D class, whereas the oxides and uranium tetrafluoride (UF_4) are considered to be W class.

A comparison of the concentrations given in Tables B-1 and B-3 shows that the concentrations of all the constituents in full cylinders (Column 2 in Table B-1) are less than the concentrations given in Table B-3. This indicates that each constituent would contribute less than 10% to dose. By applying the sum of fractions rule, it can be shown that the contribution to dose

TABLE B-3 Concentrations of Transuranic Constituents and Tc-99 in Depleted Uranium That Would Result in 10% Contribution to Dose

	ppb U[a]			pCi/g[b]		
	Clearance Class			Clearance Class		
Contaminant	D	W	Y	D	W	Y
Pu-238	0.0115	0.0227	0.804	201	395	14,000
Pu-239	2.17	4.34	193	133	266	11,900
Np-237	189	379	5,630	133	266	3,950
Am-241	0.0387	0.0775	1.15	133	266	3,950
Tc-99	NL[c]	NL	NL	NL	NL	NL

[a] ppb U = parts per billion of uranium.

[b] pCi/g = picocuries of constituent per gram of total uranium.

[c] NL = no limit.

Source: DOE (2000b).

by all the constituents combined would also be less than 10% even under the most restrictive clearance class (D class). According to this rule, if the sum of the concentration of each constituent from Table B-1 divided by the concentration of the same constituent from Table B-3 is less than 1, then the sum of contributions to dose from all the constituents would be expected to be less than 10%. Under the D class, this sum would be 0.00012/0.0115 (Pu-238) + 0.043/2.17 (Pu-239) + 5.2/189 (Np-237) + 0.0013/0.0387 (Am-241) + 0 (Tc-99) = 0.091. For the W and Y classes, the same sum of ratios would be 0.046 and 0.0024, respectively.

Thus, on the basis of the above analysis, it can be concluded that as long as the TRU and Tc-99 existed in uranium streams at concentrations equal to or less than those shown in Column 2 of Table B-1, their contribution to dose would be less than 10% of the dose due to uranium alone. In fact, because the sum of ratios is considerably below 1.0, the contribution would be much less than 10%. Given the uncertainties associated with the estimation of doses, this type of contribution to dose would be considered negligible. The analyses performed for this EIS (see Section B.1.6.1 below) also demonstrate the fact that when the TRU and Tc-99 concentrations are at or below the levels shown in Table B-1, Column 2, for full cylinders, their contribution to dose is negligibly small. However, as discussed below, doses that can be attributed to TRU and Tc-99 found in the heels of some of the cylinders under accident conditions can be relatively high compared to uranium doses.

B.1.6 Conservative Estimates of Impacts

B.1.6.1 Cylinder Accidents

The TRU and Tc contaminants in the cylinders could become available for human uptake as a result of accidents involving the release of some portion of the contents of a cylinder. Such accidents could occur during storage, handling, or transportation of cylinders. A spectrum of cylinder accidents was analyzed for the DUF_6 PEIS (Policastro et al. 1997). The resulting impacts were estimated on the basis of projected release quantities of DUF_6. For purposes of this analysis, it is assumed that in accidents involving full cylinders, TRU and Tc would exist at their maximum concentrations, as listed in Table B-1. It is also assumed that these contaminants would be released and transported through environmental media at the same relative concentration as that present in the cylinder (i.e., it is assumed that the mass concentration of TRU divided by the mass concentration of total uranium isotopes would remain constant). When DUF_6 is released to the environment, it interacts with moisture in the air and converts to depleted UO_2F_2, which is solid at atmospheric conditions. Therefore, the assumption that depleted UO_2F_2 particles and particulate forms of TRU and Tc travel in tandem is considered to be reasonable.

The possibility of an accident involving heels cylinders with the highest TRU concentrations as shown in Table B-1 is also considered. Table B-4 shows the pertinent radiological data for the radionuclides under consideration. Table B-5 shows the relative doses (relative to uranium, assuming that the uranium is 0.25% U-235, with the remaining being U-238) for the TRU isotopes and Tc-99. The data show that when TRU isotopes are present at

TABLE B-4 Radiological Parameters for Uranium, Transuranic, and Technetium Isotopes

	Dose Conversion Factor			Nuclide Constants	
Radionuclide	Inhalation (mrem/pCi)	Ingestion (mrem/pCi)	External Surface ([mrem/yr]/[pCi/cm^2])	Half-Life (yr)	Atomic Mass
U-238	0.118	2.69×10^{-4}	3.25×10^{-2}	4.47×10^{9}	238
U-235	0.123	2.67×10^{-4}	0.194	7.04×10^{8}	235
Pu-238	0.392	3.2×10^{-3}	9.79×10^{-4}	87.74	238
Pu-239	0.429	3.54×10^{-3}	4.29×10^{-4}	2.41×10^{4}	239
Np-237	0.54	4.44×10^{-3}	0.261	2.14×10^{6}	237
Tc-99	8.33×10^{-6}	1.46×10^{-6}	9.11×10^{-5}	2.13×10^{5}	99
Am-241	0.444	3.64×10^{-3}	3.21×10^{-2}	432.2	241

TABLE B-5 Relative Contributions of Transuranic and Technetium Isotopes to Dose

	Bounding Concentration in ppb (U)[a]		TRU Contribution[b]	
Radionuclide	Tails	Heels	Inhalation Dose (conservative heels concentration)	Inhalation Dose (realistic tails concentration)
Pu-238	1.2×10^{-4}	5	0.835	2.00×10^{-5}
Pu-239	4.3×10^{-2}	1.6×10^{3}	1.06	2.85×10^{-5}
Np-237	5.2	5.4×10^{4}	0.511	4.92×10^{-5}
Tc-99	15.9	5.7×10^{6}	2.00×10^{-2}	5.59×10^{-8}
Am-241	1.3×10^{-3}	0.57	2.16×10^{-2}	4.93×10^{-5}
Total			2.45	1.47×10^{-4}

[a] Equivalent to grams of contaminant per billion grams of uranium.

[b] Relative to uranium; e.g., the dose from Pu-238 would be 0.835 times the dose from uranium for a conservative heels concentration.

the maximum bulk concentrations, the TRU and Tc add only about 0.015% to the dose calculated on the basis of DUF_6 alone. However, when they are present in maximum heels concentrations, the dose can be increased by about a factor of 4 (2.45 + 1 for uranium) over what it would be for DUF_6 alone.

In the accident analyses performed for the DUF_6 PEIS, accidents involving both full cylinders and heels were considered. However, it was found that the releases and, consequently, the impacts from the accidents involving full cylinders were considerably higher than those

involving only the heels cylinders. In fact, in the source document for the PEIS, the Engineering Analysis Report (Dubrin et al. 1997, Section 7, p. 7-5), an accident involving two heels cylinders was described. The estimated amount of DUF_6 leaving each cylinder was 7 kg (15 lb), for a total release of about 14 kg (31 lb) of DUF_6. A similar accident was also postulated for full cylinders. In that case, it was estimated that about 1,500 kg (3,306 lb) of DUF_6 would be released from the cylinders. As expected, the estimated impacts from the accident involving the full cylinders were considerably greater than the estimated impacts from the heels cylinder accident; therefore, only the impacts for the full cylinder accident were discussed in the PEIS.

Dose contributions from potential TRU and Tc contaminants were not considered in the PEIS. If such contributions were added, the dose from a heels cylinder accident would increase by a factor of about 4, which would be equivalent to about 60 kg (132 lb) of DUF_6 being released (the dose is directly proportional to the quantity of DUF_6 released from the cylinders), whereas the dose from the full cylinder accident would remain the same, with about 1,500 kg (3,307 lb) of DUF_6 being released. Because the doses from the full cylinder accident were much greater and because the frequencies of the two accidents were considered to be about the same (they were both considered to belong to the extremely unlikely category, with a frequency range of 10^{-4} to 10^{-6} per year), the full cylinder accident was discussed in the PEIS, but the heels cylinder accident was not. As the analyses above show, even after including the contributions from TRU and Tc, the full cylinder accident would still produce a much greater dose than the heels cylinder accident and, therefore, would still be bounding for the group of accidents belonging to the extremely unlikely frequency category.

The relative contributions of Tc-99 to dose from exposure to bulk DUF_6 in the cylinders and to heels material with maximum contaminant concentrations (Table B-1) are 0.000006% and 0.2%, respectively (Table B-5). Similar to TRU contaminants, most of Tc-99 would be expected to remain in the heels or be captured in the filters when the cylinders were emptied. However, if it did transfer into the conversion equipment, there it would be expected to (a) convert to technetium oxide during the conversion of DUF_6 to U_3O_8 and (b) partition into the uranium and HF products at about the same ratio as the uranium. As a result, the relative concentration of Tc-99 in both products (relative to uranium) would be about the same as in the bulk DUF_6; namely, 15.9 ppb. Its relative contribution to dose (relative to uranium) would be about 0.000006%. Given such a low contribution and the low doses that would result from exposure to U_3O_8 (see Section 5.2.3) and HF product (see Section 5.2.6), the radiological impacts of Tc-99 in the conversion products can be considered to be negligible.

B.1.6.2 Waste Management

As mentioned previously, no TRUW would be generated at either conversion facility in Paducah or Portsmouth under the proposed action. The empty cylinders would be refilled with the depleted U_3O_8 product and disposed of. The impacts associated with management of LLW, including transportation to a disposal facility, are discussed in Sections 5.2.3 and 5.2.5 of this EIS. The option of disposing of the emptied cylinders as a separate LLW stream is also discussed. This section provides a conservative estimate of waste management impacts associated with the heels material in emptied cylinders, under the assumption that they are

cleansed by washing the cylinders with water and treating the wash solution to generate solid U_3O_8 and a small quantity of solid CaF_2. Such an option was discussed in the Engineering Analysis Report (Dubrin et al. 1997, Section 6.3) and in the PEIS. Under the approach considered, no liquid radioactive waste would be generated.

Table B-6 shows that if the heels in the emptied cylinders contained TRU and Tc at the maximum concentrations shown in Table B-1, and if the heels material was separated and declared waste, it would be classified as TRUW because the concentration of TRU radionuclides would exceed 100 nCi/g. If the heels were left in the form of DUF_6, the calculated TRU activity concentration would be about 150 nCi/g. If the heels were converted to U_3O_8 and dried and the TRU were also converted to oxides, the TRU activity concentration would be about 190 nCi/g (Table B-7).

Table B-2 indicates that there is a maximum of 24 g (0.85 oz.) of Pu and 17.8 kg (3.97 lb) of Np in the DUF_6 inventory. If this amount of TRU was distributed uniformly in the heels of as many cylinders as possible and if the concentration of TRU in the converted U_3O_8 heels material was 100 nCi/g, there would be approximately 240 drums of converted U_3O_8 (each drum containing 627 kg [1,382 lb] of U_3O_8) that could be classified as TRUW (see Table B-8). The total number of drums of converted U_3O_8 heels material would be about 820 (61,422 cylinders $\times$ 8 kg [18 lb] heels U_3O_8 per cylinder/627 kg [1,382 lb] per drum $\times$ 1.023, where the factor 1.023 accounts for the presence of granulating binder, water, etc., in the final product). That would mean that about 30% of the heels-generated U_3O_8 would be classified as TRUW; the remainder (about 580 drums) would be classified as LLW. In actuality, the amount of waste that would fall under the definition of TRUW would be considerably less than 30%. The assumptions made in deriving the above TRUW quantities are highly conservative. These assumptions include the following:

1. The quantity of heels material in an emptied cylinder was assumed to be 10 kg (22 lb). This amount is actually likely to be greater than 10 kg (22 lb). In fact, it could be greater than 20 kg (44 lb) per cylinder, in which case none of the heels material would be classified as TRUW.

2. It is very unlikely that TRU would be distributed uniformly at a concentration just high enough to make the waste TRUW. Some might be present at concentrations greater than 100 nCi/g, with the result that the volume and the number of drums of TRUW would be less.

Filters used to process the DUF_6 leaving the cylinders would be monitored and replaced before the concentration of TRU reached the stage where the filters would have to be managed as TRUW. Therefore, no TRUW is assumed to be generated from the filters. However, an estimate was made of the amount of LLW that could be generated. The following assumptions were used in the estimation:

1. The filters are metallic, cylindrical in shape (6-in. [5-cm] diameter and 15-in. [38-cm] height), and weigh about 38 kg (84 lb);

TABLE B-6 Estimated Maximum Transuranic Radioactivity Concentration in Heels

Contaminant	Concentration (ppb) (U)[a]	Quantity of DUF_6 in Heel (kg)	Quantity of U in Heel (kg)	Quantity of Contaminant in Heel (g)	Specific Activity (Ci/g)	Radioactivity in Heel	
						in Ci	in nCi
Pu-238	5	10	6.8	3.38×10^{-5}	1.71×10^{1}	5.79×10^{-4}	5.79×10^{5}
Pu-239	1,600	10	6.8	1.08×10^{-2}	6.22×10^{-2}	6.72×10^{-4}	6.72×10^{5}
Np-237	54,000	10	6.8	3.65×10^{-1}	7.05×10^{-4}	2.57×10^{-4}	2.57×10^{5}
Am-241	0.57	10	6.8	3.85×10^{-6}	3.43	1.32×10^{-5}	1.32×10^{4}
Total				3.76×10^{-1}		1.52×10^{-3}	1.52×10^{6}

[a] Equivalent to grams of contaminant per billion grams of uranium.

TABLE B-7 Estimated Maximum Transuranic Activity Concentration in Converted Heels Material

Final Form	Quantity in Heel (g)	Total TRU Activity Concentration (nCi/g)
$^{238}PuO_2$	3.8×10^{-5}	72.6
$^{239}PuO_2$	1.2×10^{-2}	84.3
$^{237}NpO_2$	4.1×10^{-1}	32.3
$^{241}AmO_2$	4.4×10^{-6}	1.66
U_3O_8	8.0×10^{3}	0
Total	8.0×10^{3}	191

TABLE B-8 Estimated Maximum Number of Drums Containing Potential Transuranic Waste

Contaminant	Maximum Quantity (g)	Isotope-Averaged Specific Activity (Ci/g)	Maximum Activity (Ci)	Total Quantity in One Drum (g)	TRUW Concentration Limit (nCi/g)	Radioactivity in One Drum (nCi)	No. of Drums
Pu	24	1.15×10^{-1}	2.77	627,273	100	62,727,273	44
Np	17,800	7.05×10^{-4}	12.5	627,273	100	62,727,273	200
Total			15.3	627,273	100	62,727,273	244

2. About 10% of the TRU in the cylinders is entrained during emptying of the cylinders by sublimation and captured in the filters;

3. Filters are replaced when the activity concentration reaches 50 nCi/g; and

4. Filters are macroencapsulated and placed in 55-gal drums for disposal.

On the basis of the above assumptions, it is estimated that on average, 1 drum of LLW would be generated per year of operation, and overall there would be about 26 drums generated over the lifetime of the conversion campaign at both plants combined (Folga 2002).

B.1.6.3 Transportation

Transportation impacts estimated for the PEIS and this EIS include the impacts of transporting all wastes and all products of the conversion process as LLW, low-level mixed waste (LLMW), or nonradioactive/nonhazardous waste (see Section 5.2.5). Under the proposed action, no TRUW would be generated at either the Paducah or Portsmouth site. However, as discussed in Section B.1.6.2, there could be up to 244 drums of TRUW generated over the lifetime of the conversion campaign at both conversion facilities combined, if the heels cylinders were to be washed and the heels materials disposed of as waste. Under these conditions, the TRUW would need to be shipped from the conversion facilities to a disposal site authorized to receive such waste. The total number of truck shipments required would be 6 (assuming 14 drums per TRUPACT-II container and 3 containers per truck) from both conversion plants combined. This number is much less than the approximately 6,000 to 36,000 truck shipments of LLW from the two facilities.

On a single-shipment basis, the impacts associated with incident-free transportation of a TRUW shipment and with a LLW shipment of U_3O_8 drums would be comparable, because the external exposure rate in the vicinity of the truck would be about the same. However, the accident risks would be larger for the TRU shipments if the same amount of material spilled to the environment. The factor of increase in doses would be similar to what was estimated for heels cylinder accidents, namely a factor of 4. However, the TRUW would be shipped in drums placed in TRUPACT-II containers. TRUPACT-II containers are much stronger than the drums themselves. As a result, the probability of material being released to the environment from TRUW shipments as a result of an accident is much smaller than the probability associated with LLW shipments. (LLW drums are generally shipped “as is,” without additional protection.) The overall relative risk of shipping the U_3O_8 generated during cylinder washing in the cylinder treatment facility (if one is constructed) to a disposal facility would be about the same, irrespective of whether it was classified as TRUW or LLW.

B.2 ISSUES ASSOCIATED WITH POLYCHLORINATED BIPHENYLS IN CYLINDER PAINT

B.2.1 Background

B.2.1.1 PCBs in Cylinder Paint

The three-site cylinder inventory contains cylinders of diverse ages, with cylinders having been generated from the early 1950s to the present time. The paints applied to the cylinders had various compositions and included some PCBs. Up until 1977, when the manufacture and use of PCBs in the United States was generally discontinued, certain paints contained up to 10% by weight PCBs. The PCBs were added to the paints to act as a fungicide and to increase durability and flexibility.

Records of the PCB concentrations in the paints used were not kept, so it is currently unknown how many cylinders are coated with paint containing PCBs. However, paint chips from a representative sample of cylinders at the ETTP site have been analyzed for PCBs. The results indicate that up to 50% of the cylinders at ETTP may have coatings on them containing PCBs. Because the Portsmouth and Paducah inventories contain a large number of cylinders produced before 1978, it is reasonable to assume that a significant number of cylinders at those sites also contain PCBs.

The PCBs in dried paint generally have a low environmental mobility, but as the paint ages and chips off the cylinders, there is a potential for transport and subsequent exposure to the PCBs. There is also a potential for the volatilization of the PCBs if the cylinders are heated enough during processing.

B.2.1.2 PCB Use, Contamination, and Distribution at ETTP, Portsmouth, and Paducah

PCB use was very prevalent and widespread in the United States prior to 1978. As a result, PCBs are often detected in locations with no known source of contamination. Because of their tendency to bioaccumulate, PCBs are also widespread in fish and other biota.

For each of the three storage sites, the PCBs in cylinder paints constitute an extremely small proportion of the PCBs that were previously and are currently at the sites. For example, although the Paducah site has been working for several years to dispose of PCB-containing equipment, the site still had about 870 liquid PCB-containing items (mostly capacitors) in service at the end of 2001 (DOE 2002a). The Portsmouth and ETTP sites also still have a large number of liquid PCB-containing items in service.

The three current DUF_6 cylinder storage sites are suspected to have had spills of PCB liquids during past operations, prior to the identification of the health and environmental hazards

of PCBs. Each of the three sites has an existing program for managing PCB-contaminated waste under the Toxic Substances Control Act (TSCA). In addition, the environmental monitoring program at each site includes monitoring of PCB concentrations in soil, sediment, groundwater, surface water, and biota on and in the vicinity of the sites (results are presented in Sections 3.1 and 3.2). Soil, water, sediment, and biota samples obtained from on and near each of the sites since the early 1990s have periodically contained detectable levels of PCBs. Background samples have also had detectable levels of PCBs.

B.2.1.3 Regulation of PCBs

Processing, use, storage, transportation, and disposal of cylinders with applied dried paint that contains PCBs are subject to the federal TSCA regulations applicable to PCBs and PCB items. These federal regulations are located in Title 40, Part 761 of the *Code of Federal Regulations* (40 CFR Part 761), "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," and are implemented by the U.S. Environmental Protection Agency (EPA). 40 CFR Part 761 requires that after PCB items have been designated for disposal, they be packaged and marked in compliance with applicable U.S. Department of Transportation (DOT) hazardous materials regulations (HMRs), which are located in 49 CFR Parts 171 through 180. If DOT HMRs do not apply to a PCB waste, then 40 CFR Part 761 identifies applicable packaging and marking requirements.

B.2.2 Potential Impacts from PCBs in Cylinder Paint

The remainder of this appendix discusses the potential impacts associated with PCBs in cylinder paint during storage, transport, processing, and disposal of the cylinders. The presence of PCBs in the coatings of some cylinders is not expected to result in health and safety risks to workers or the public, as detailed in the sections that follow.

B.2.2.1 Storage

During cylinder storage, the risk to cylinder handlers from dermal contact with the PCBs on cylinders is negligible. The PCBs are bound in a matrix from which dermal absorption is insignificant (Fowler 1999). Because the PCBs are bound in the paint, the potential for them to volatilize under ambient conditions and be inhaled by the workers or the general public would be negligible. In addition, in the case of a cylinder accident involving a fire, the impacts associated with PCBs released from the paint on the cylinders would be negligibly small when compared with the impacts associated with the DUF_6 released from the cylinders.

Cylinder paint chips deposited on the cylinder yard soils can be carried to surface water via runoff. All three sites monitor their surface water discharges for PCBs and also conduct some downstream surface water and sediment monitoring. In general, PCBs have been below detection limits. However, PCBs have occasionally been detected (see Affected Environment in Sections 3.1 and 3.2 of the EIS).

At the Paducah site, effluent at Kentucky Pollutant Discharge Elimination System (KPDES) outfall 017 (which receives runoff from the cylinder yards) contained a maximum of 0.415 µg/L PCBs in 2001 samples; this was not a KPDES permit violation (DOE 2002a). PCBs were not detected in 2002 samples (DOE 2003b). At the Portsmouth site in 2001, seven samples from five different sampling locations that receive runoff from the cylinder yards were obtained throughout the year (DOE 2002b); no PCBs were detected in these samples. PCBs are also monitored in outfalls, sediment, and surface water at and near the ETTP site. Several outfalls at the site (S14, S20, and 113) have contained PCBs at levels of up to 6 µg/L (DOE 2000c, 2001, 2003a). The PCBs in samples from ETTP outfalls are likely attributable to past releases of liquid PCB oils at the plant. The primary source of PCBs in environmental samples is past releases of liquid PCBs. Movement of nonliquid PCBs from the cylinder yards via paint chips in runoff is likely a very minor contributor to environmental releases of PCBs from the sites.

B.2.2.2 Transportation

Transport of cylinders from the ETTP site to either Portsmouth or Paducah would occur under the action alternatives addressed in this EIS. Under the proposed action, to the extent practicable, emptied cylinders at the conversion facilities would be refilled with uranium oxide product, welded shut, and shipped to the designated disposal facility. As a precautionary measure, cylinders with loose paint chips may be bagged for transport to avoid loss of potentially PCB-containing material.

B.2.2.3 Cylinder Processing

Potential impacts during cylinder processing might occur if PCBs volatilized during autoclaving to remove the DUF_6 from the cylinders or if PCBs were released and/or transformed during the cutting and welding process.

During autoclaving, desorption of pure-phase PCBs from the paint matrix would be unlikely, given that the PCBs are bound into the paint structure. PCBs by their very nature are not highly volatile, and losses from PCBs bound in the paint matrix would also be unlikely. However, initial experiments conducted at the University of British Columbia have indicated that some lower chlorinated PCBs may volatize from PCB-containing paints at 70°C (Gill et al. 1997). Because the DUF_6 autoclaves would operate at approximately 95°C, testing should be conducted either prior to or during the conversion facility startup operations to determine if the air vented from the autoclaves should be monitored or if any alternative measures would need to be taken to ensure that worker exposures to PCBs above allowable Occupational Safety and Health Administration (OSHA) limits do not occur.

Before the emptied cylinders were refilled with depleted uranium oxide product, a solvent would be applied to a small area on each cylinder to remove the paint before cut/weld operations occurred (McCoy 2004). Any paint removed from the surface would be managed as Resource Conservation and Recovery Act (RCRA) hazardous waste, TSCA hazardous waste, or LLMW, as appropriate. Removing the paint before welding would reduce or eliminate the

potential for the volatilization of PCBs or for the generation of other toxic chemicals during welding operations. The quantity of waste generated by this operation would be negligibly small when compared with the quantities generated by other operations at either the Paducah or Portsmouth sites.

B.2.2.4 Disposal

The proposed action alternatives of this EIS assume that the cylinders (either filled with depleted uranium oxide or empty) would be disposed of at Envirocare of Utah, located in Utah, or at NTS, located in Nevada. The waste acceptance criteria for both facilities indicate that they have units permitted to receive LLW containing PCBs.

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