

APPENDIX B:

**ESTIMATION OF IMPACTS ASSOCIATED WITH TRANSURANIC
AND TECHNETIUM CONTAMINATION IN THE DUF₆ CYLINDERS**

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B.1 SUMMARY

This appendix addresses the concerns and impacts associated with potential contamination of depleted uranium hexafluoride (DUF₆) cylinders with transuranic (TRU) isotopes (these isotopes have an atomic number greater than that of uranium-92 [U-92]) and technetium-99 (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 DUF₆ 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 DUF₆ 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.2 BACKGROUND

At about the time the final programmatic environmental impact statement (PEIS) for DUF₆ 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 DUF₆ to a more stable chemical form (DOE 2000a), concern was raised that some portion of DOE's DUF₆ 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 UF₆. 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 UF₆ 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 DUF₆). 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 DUF₆ cylinders and heels cylinders (i.e., empty cylinders containing about 10 to 23 kg (22 to 50 lb) of residual DUF₆, 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.3 EXTENT OF TRANSURANIC AND TECHNETIUM CONTAMINATION IN THE DUF₆ 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 DUF₆ 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 UF₆ were emptied into the cascades for reenriching the UF₆. The same cylinders were later filled with DUF₆ 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 UF₆, 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 DUF₆ 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 DUF₆ cylinders that are used to store DOE's inventory of DUF₆ 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 DUF₆, the liquid DUF₆ entering the cylinder stirred the heels and caused some fraction of the contamination to be mixed with the DUF₆. It is also possible that a small fraction of the TRU that had been captured in the cascades may have revolatilized during the cascade improvement projects and was carried into some DUF₆ cylinders. Therefore, TRU and Tc could be found both in the heels and in the bulk of a small, but unknown, number of DUF₆ 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 DUF₆ 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 DUF₆ 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.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. Although a small fraction of TRU might be carried out of the cylinders with the gaseous UF₆ as particulates, it is expected that it would instead be captured in the filters through which the UF₆ 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.

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 UF₆ 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 DUF₆. For this EIS, it was also assumed that the Tc in the form of oxides would partition into the triuranium octaoxide (U₃O₈) and hydrogen fluoride (HF) products in the same ratio as the uranium.

TABLE B-2 Maximum Total Quantities of Transuranics and Technetium in the DUF₆ Inventory

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

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 U₃O₈ product, transport the filled cylinders to the Envirocare of Utah disposal facility, and dispose of them there. Previously, the depleted U₃O₈ 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 DUF₆ 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.5 IMPACT AREAS

TRU contamination of DUF₆ 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 DUF₆ 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 DUF₆ 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 radionuclides 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 form 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, UF₆ and uranyl fluoride (UO₂F₂) are considered to be D class, whereas the oxides and uranium tetrafluoride (UF₄) 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 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.

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

Contaminant	ppb U ^a			pCi/g ^b		
	Clearance Class			Clearance Class		
	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).

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.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.6 CONSERVATIVE ESTIMATES OF IMPACTS

B.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 DUF₆ PEIS (Policastro et al. 1997). The resulting impacts were estimated on the basis of projected release quantities of DUF₆. 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 DUF₆ is released to the environment, it interacts with moisture in the air and converts to depleted UO₂F₂, which is solid at atmospheric conditions. Therefore, the assumption that depleted UO₂F₂ 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 the maximum bulk concentrations, the TRU and Tc add only about 0.015% to the dose calculated on the basis of DUF₆ 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 DUF₆ alone.

In the accident analyses performed for the DUF₆ 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

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

Radionuclide	Dose Conversion Factor			Nuclide Constants	
	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

Radionuclide	Bounding Concentration in ppb (U) ^a		TRU Contribution ^b	
	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.

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 DUF₆ leaving each cylinder was 7 kg (15 lb), for a total release of about 14 kg (31 lb) of DUF₆. A similar accident was also postulated for full cylinders. In that case, it was estimated that about 1,500 kg (3,306 lb) of DUF₆ 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 DUF₆ being released (the dose is directly proportional to the quantity of DUF₆ 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 DUF₆ 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 DUF₆ 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 DUF₆ to U₃O₈ 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 DUF₆; 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 U₃O₈ (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.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 U₃O₈ product and disposed of. The impacts associated with management of LLW, including transportation to a disposal facility, are discussed in Sections 5.2.2 and 5.2.3 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 U₃O₈ and a small quantity of solid CaF₂. 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 DUF₆, the calculated TRU activity

concentration would be about 150 nCi/g. If the heels were converted to U₃O₈ 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 DUF₆ 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 U₃O₈ heels material was 100 nCi/g, there would be approximately 240 drums of converted U₃O₈ (each drum containing 627 kg [1,382 lb] of U₃O₈) that could be classified as TRUW (see Table B-8). The total number of drums of converted U₃O₈ heels material would be about 820 (61,422 cylinders × 8 kg [18 lb] heels U₃O₈ per cylinder/627 kg [1,382 lb] per drum × 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 U₃O₈ 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 DUF₆ 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);
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.

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 ₃ O 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

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.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.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 U₃O₈ 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 U₃O₈ 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.7 REFERENCES

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