

Hanford Tank Waste Information

1.0 Summary

This information demonstrates the wastes in the twelve Hanford Site tanks meet the definition of transuranic (TRU) waste as set forth in the Waste Isolation Pilot Plant (WIPP) Land Withdrawal Act of 1996, as amended. The wastes in these twelve (12) tanks are not high-level waste (HLW), and contain more than 100 nanocuries of alpha-emitting TRU isotopes per gram with half-lives greater than 20 years.

The Department's plan for these wastes is to remove these wastes from these tanks, dewater, package, certify, and then dispose of these TRU wastes at WIPP. Once dewatered and packaged, wastes from these twelve (12) tanks will meet all shipping and disposal requirements imposed by the WIPP. Waste from nine (9) of these twelve (12) tanks will be contact-handled TRU waste (i.e., container surface dose rate less than or equal to 200-mrem per hour), and waste from the other three (3) tanks will be remote-handled TRU waste (i.e., container surface dose rate greater than 200-mrem per hour). The fission product (i.e., Cs¹³⁷ and Sr⁹⁰) content of these wastes is consistent with the fission product content of other TRU wastes already stored or planned for storage in the WIPP.

The following sections provide a description of waste generation and management activities conducted at the Hanford Site to demonstrate how these wastes were generated and segregated and why these wastes are expected to meet the requirements for TRU waste, and thus, be eligible for disposal at WIPP.

2. Statutory Definitions

In evaluating the wastes contained in these twelve (12) tanks, the Department has applied the definition of TRU waste from the WIPP Land Withdrawal Act of 1996, as amended (LWA) and the definition of HLW from the Nuclear Waste Policy Act of 1982, as amended (NWPA).

The *WIPP Land Withdrawal Act (LWA) of 1992, P. L. No. 102-579, 106 Stat. 4777, as amended by the WIPP LWA Amendments of 1996, P. L. 104-201, 110 Stat. 2422*, defines TRU wastes as:

The term "transuranic waste" means waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years, except for:

- (A) high-level radioactive waste;*
- (B) waste that the Secretary has determined, with the concurrence of the Administrator, does not need the degree of isolation required by the disposal regulations; or*

(C) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with part 61 of title 10, Code of Federal Regulations.

The Nuclear Waste Policy Act of 1982 (42 U.S.C. 10101(12)), as amended defines HLW as:

(A) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and (B) other highly radioactive material that the Commission, consistent with existing law, determines by rule requires permanent isolation

Reprocessing is a chemical process by which spent nuclear fuel is dissolved and the isotopes of interest such as plutonium and uranium are separated from other spent fuel constituents, i.e., waste products. Key elements of reprocessing are that the separation of isotopes of interest (e.g., plutonium) and waste products from spent nuclear fuel. The term "spent nuclear fuel" means fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing. In the Bismuth Phosphate process, the plutonium recovery technology initially used at the Hanford Site during and immediately following the Manhattan Project, spent nuclear fuel was separated into its constituent elements during the Metal Dissolution process step described in more detail below.

3. Waste Generation Processes at the Hanford Site

The Hanford Site was created in 1943 to produce plutonium from spent nuclear fuel (SNF) as part of national defense activities. During the over 50 years of operations conducted at the Hanford Site, three chemical separation processes were used to recover plutonium from SNF¹:

- Bismuth Phosphate process (BPP): 1945 – 1956;
- Reduction-Oxidation (REDOX) process: 1951 – 1967; and
- Plutonium-Uranium Extraction (PUREX) process: 1956 – 1990.

All three of these chemical separation processes generated HLW, low-level waste, and TRU waste streams. The wastes from the REDOX process were not transferred to the tanks that are discussed in this paper. In general, the low-level waste streams generated from these chemical separation processes have been either disposed or mixed with HLW in the tank system. The HLW generated from reprocessing SNF in these chemical

¹ In addition to plutonium production activities, the Hanford Site processed HLW generated from the BPP to recover uranium using the Tri-Butyl Phosphate (TBP) process in the 221-U Plant from 1952 through 1957. Fission products (e.g., Tc⁹⁹, Cs¹³⁷, Sr⁹⁰, Pm¹⁴⁷, and Ce¹⁴⁴) were separated from some of the wastes generated from these chemical processes and shipped offsite for beneficial by-products use.

processes will be treated at the Hanford Site Waste Treatment and Immobilization Plant and disposed at the national SNF and HLW repository.

The contact-handled TRU waste stored in nine of the tanks at the Hanford Site originated from the BPP conducted from 1945 through 1956. The remote-handled TRU waste stored in two of the tanks (AW-103 and AW-105) at the Hanford Site originated from the PUREX process. The remote-handled TRU waste stored in one tank (SY-102) at the Hanford Site originated from a plutonium processing facility known as the Plutonium Finishing Plant (PFP).

The BPP, PUREX, and PFP processes and associated facilities are discussed in further detail in Sections 3.1, 3.2, and 3.3 to demonstrate that the twelve tank wastes intended for disposal at the WIPP are TRU waste.

3.1 Bismuth Phosphate Process

The BPP, the first production-scale SNF reprocessing process ever used, was deployed during the Manhattan Project (World War II) to separate plutonium (Pu) from SNF. An important feature of the BPP relative to waste designation is that it was a batch process, a feature that provides very sharp demarcation points between process steps which enables clear distinctions where SNF and HLW existed (or did not exist) within the process. This same feature allows clear distinctions where TRU waste was generated in the BPP process.

Figure 1 is a simplified diagram of the BPP process that is used to illustrate the batch processes and demarcation points between process steps. The BPP consisted of five batch process steps conducted in the 221-B and 221-T Plants and plutonium concentration step conducted in the 224-B and 224-T Buildings. The five BPP batch process steps conducted in the 221-B and 221-T Plants were:

- Coating Dissolution;
- Uranium Dissolution;
- Uranium Separation;
- First Decontamination Cycle for plutonium; and
- Second Decontamination Cycle for plutonium.

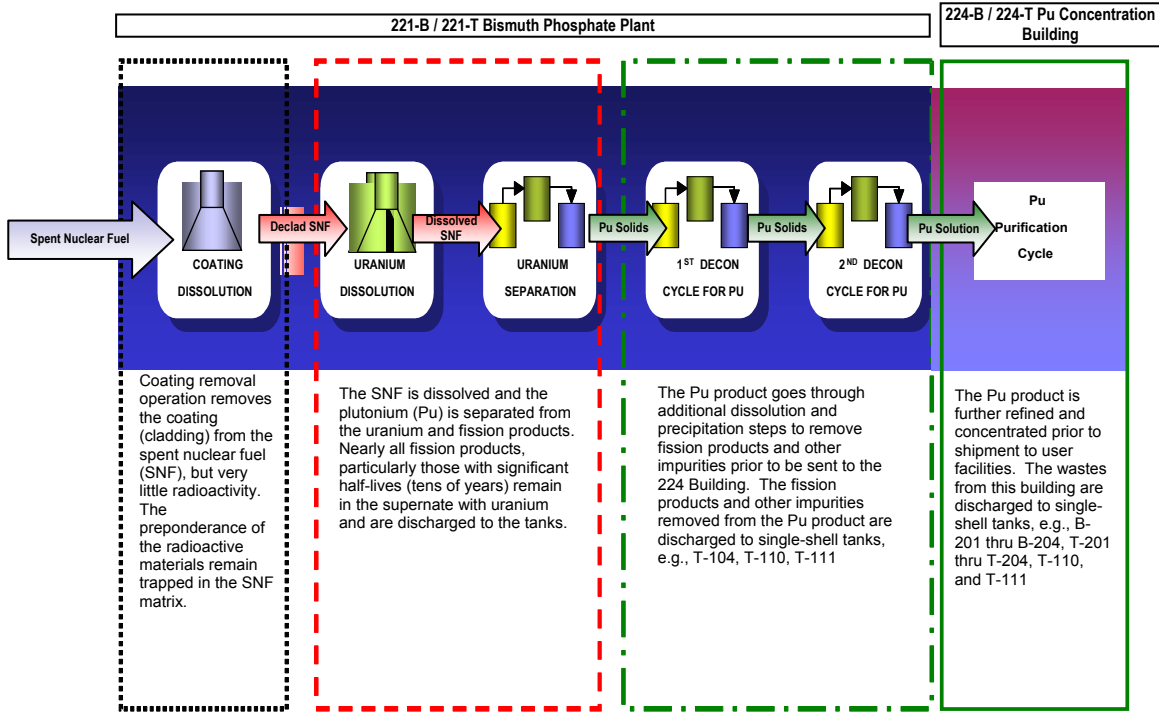


Figure 1. Simplified Bismuth Phosphate Process Diagram

The BPP achieved through liquid/solids separation via centrifugation and multiple water rinses of the centrifuge solids cake, thereby removing liquids and soluble materials from the cake. Each batch process step resulted in an extensive and selective separation of the process wastes from the process product streams that contained plutonium. As a result, out of the six distinct BPP process steps (coating dissolution, uranium [U] dissolution, uranium separation, first decontamination cycle, second decontamination cycle, and 224 building plutonium concentration), only two involved SNF reprocessing and generation of HLW: uranium dissolution and uranium separation.

The BPP also produced waste streams that are not HLW because those wastes do not meet the definition of HLW provided in the NWPA. The waste streams generated from the coating dissolution (designated as CW waste), first decontamination cycle (designated as 1C waste), second decontamination cycle (designated as 2C waste), and the plutonium concentration building (designated as 224 waste) are not HLW. These wastes were not produced during the reprocessing of SNF, as required for designation as HLW. Instead, these wastes were generated prior to dissolution of the SNF as is the case for CW waste or derived from processing plutonium solids as is the case for the 1C, 2C, and 224 waste types. The fact that these wastes are not HLW is confirmed by waste fission product concentrations that are orders of magnitude less than those the U.S. Nuclear Regulatory Commission requires to be disposed of in a geologic repository (see 10 CFR Part 61), as depicted in Figure 2.

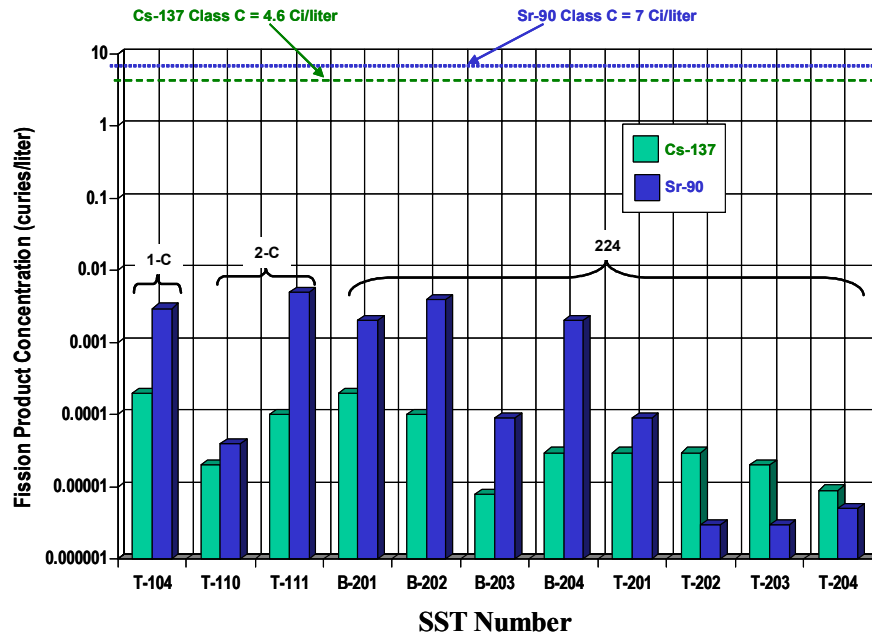


Figure 2. Cs¹³⁷ and Sr⁹⁰ Concentrations in 1C, 2C, and 224 Wastes from BPP²

Each of the BPP steps and the waste types generated are discussed in further detail in the following sections. The wastes types generated and the basis for designating these waste types is provided.

3.1.1 Coating Removal

Prior to actual reprocessing of the SNF, the aluminum coating of the SNF had to be removed to expose the uranium fuel. A boiling solution of sodium nitrate and sodium hydroxide was used to dissolve coating. While virtually all of the radioactive fission products remained within the intact spent fuel matrix, small amounts of radioactive materials at the surface of the fuel slugs entered the coating removal solutions. The coating removal step is considered a “head end” process and not part of SNF reprocessing since the SNF remained intact throughout the coating removal process. The coating removal wastes were subsequently combined with first cycle plutonium decontamination waste (discussed below) to use the excess sodium hydroxide in the coating removal wastes to neutralize acids in the first cycle decontamination wastes.

The coating removal process step did not create HLW because it only dissolved the aluminum coating leaving the SNF intact. The coating removal waste originated prior to the SNF being dissolved and reprocessed. The NAWPA defines HLW as “the highly radioactive material resulting from the reprocessing of spent nuclear fuel...”. Since SNF

² DOE/RL-2004-01, page 9: The Cs¹³⁷ and Sr⁹⁰ concentrations are decay corrected to January 1, 2001 and are based on analyses of waste samples obtained from the identified tanks.

was intact during the coating removal process, reprocessing had not occurred, and therefore, the coating removal waste is excluded from the HLW definition. This determination is consistent with the position established by the Atomic Energy Commission in 1969³ that cladding hulls (removed from spent fuel by mechanical rather than chemical means) are not HLW.

3.1.2 Uranium Dissolution and Uranium Separation

Following removal of the coating, the uranium fuel slugs were dissolved in nitric acid. Once dissolved, water and sulfuric acid were added to convert uranyl nitrate to uranyl sulfate. Next, bismuth nitrate and phosphoric acid were added and a bismuth phosphate carrier solid was formed that extracted plutonium from solution as precipitated solids. The uranyl sulfate remained in solution along with nearly all of the long-lived fission products such as cesium-137 (Cs^{137}) and strontium-90 (Sr^{90}). The plutonium solids were then separated from the uranium and fission products solution via centrifuging. The bismuth phosphate and plutonium solids were rinsed with water and re-centrifuged three times to remove any waste liquids and soluble fission products that may have been initially entrained in the solids. The bismuth and plutonium solids were transferred to the first plutonium decontamination cycle.

The uranium and fission products solution along with the water used to wash the plutonium solids were combined and discharged to specific underground storage tanks. This combined waste stream was known as metal waste (designated as MW).

Consistent with the NWPA definition, metal waste has been designated as HLW. HLW including all liquids produced directly in the reprocessing of SNF existed only within the uranium dissolution and uranium separation process steps. Acids introduced during uranium dissolution dissolved the SNF, placing the plutonium, the uranium, and all of the fission products in solution. The dissolved uranium fuel was then acted upon in the uranium separation step to separate plutonium as a solid. The uranium separation process step selectively precipitated the plutonium as a solid, leaving the uranium and fission products in solution as so-called metal waste.

The metal waste from uranium separations contained over 99.5% of the SNF constituent elements including >99.5% of the uranium, ~99% of the Cs^{137} , and ~90% of the Sr^{90} . The metal waste (liquid and solid wastes) produced during the uranium dissolution and uranium separation steps, therefore, fall squarely within the definition of HLW as set forth in the NWPA. The extensive liquid/solids separations and multiple rinses conducted during uranium separations ensured that any liquid wastes produced directly in reprocessing were discharged as liquid wastes and did not follow the plutonium solids into the first or second decontamination cycles or beyond.

³ In the Statement of Proposed Policy (34 FR 8712) for Appendix D, 10 CFR Part 50 "Policy Relating to the Siting of Fuel Reprocessing Plants and Related Waste Management Facilities," the Atomic Energy Commission (AEC) noted that the term high-level waste, as used in the proposed Appendix D, did not include all wastes originating from (spent nuclear fuel) reprocessing plant operations. Such wastes, later referred to as incidental wastes by the Nuclear Regulatory Commission (NRC) (52 FR 5993), included waste streams such as radioactive hulls from the irradiated fuel.

3.1.3 First and Second Decontamination Cycles

The plutonium precipitate from the uranium separation step, once triple rinsed, contained >99.5% of the plutonium, <0.5% of the uranium, and ~10% of the fission products. At least half of the fission products were short-lived isotopes that decayed to de minimis levels within one to two years. Because the SNF constituent elements were separated during uranium separations, no SNF was present in the subsequent plutonium decontamination cycles, and therefore, no HLW was generated from further processing of the plutonium solids. Accordingly, wastes from the first and second decontamination cycles and plutonium concentration process are not HLW based on the NWPA HLW definition.

In the first plutonium decontamination cycle, the plutonium solids were dissolved and oxidized to the +6 valence state via the addition of sodium bismuthate and sodium dichromate. Sodium bismuthate, phosphoric acid, zirconium nitrate, and cerium nitrate were added to precipitate bismuth phosphate and fission products (primarily strontium, cerium, and zirconium). The bismuth phosphate and fission product precipitate solids were centrifuged to separate them from the plutonium which remained in the liquid phase. The bismuth phosphate and fission product precipitate solids were dissolved in nitric acid and discharged to specific underground storage tanks as part of the first decontamination cycle waste.

Following separation, the plutonium in the liquid phase was reacted with bismuth subnitrate and phosphoric acid to produce a bismuth phosphate carrier and co-precipitate plutonium phosphate as solids. The bismuth phosphate carrier and plutonium phosphate solids were separated from the mother liquor by centrifugation. The plutonium phosphate solids were water washed and centrifuged three times. The mother liquor and wash water were combined and discharged to specific underground storage tanks as part of the first decontamination cycle waste.

The bismuth phosphate and plutonium phosphate solids were then dissolved in nitric acid, forming plutonium nitrate and bismuth nitrate in solution. This solution was then transferred to the second decontamination cycle where the first decontamination process steps (except for zirconium nitrate and cerium nitrate addition) were repeated to further purify the plutonium product. Waste solutions generated from the second decontamination cycle were discharged to specific underground storage tanks.

At the end of the second decontamination cycle, the washed plutonium solids were dissolved in nitric acid and transferred to the 224-B or 224-T Concentration Buildings for further processing.

3.1.4 224 Buildings

The plutonium solution from the 221-B (or 221-T) Plant was transferred to the 224-B (or 224-T) Concentration Building to remove the bismuth phosphate and residual fission products which were essentially all short half-life contaminants. The plutonium solution was received at 224 Concentration Building in a +4 valence state. It was first oxidized

with sodium bismuthate to a +6 valence state. Phosphoric acid was added to precipitate bismuth phosphate along with residual Zr⁹⁵ and Nb⁹⁵ fission products, which were then removed by centrifugation leaving the plutonium in solution. Hydrogen fluoride and lanthanum fluoride were added to precipitate remaining fission products leaving the plutonium in solution. Hydrogen fluoride and lanthanum salts were then added to create lanthanum fluoride and plutonium fluoride solids which were separated by centrifugation. The lanthanum fluoride and plutonium fluoride solids were reacted with potassium hydroxide to produce lanthanum hydroxide and plutonium hydroxide. The lanthanum hydroxide and plutonium hydroxide solids were reacted with nitric acid to produce the high purity plutonium nitrate/lanthanum nitrate product.

The waste solution generated from processing plutonium solutions in the 224 Concentration Buildings were discharged to specific underground storage tanks.

3.1.5 Tanks Receiving BPP Wastes

Originally, TRU wastes from the BPP were discharged to approximately fifty (50) of the 149 single-shell tanks (SSTs) at the Hanford Site. Figure 3 provides the gross gamma and gross beta concentrations of fission products measured in the waste received into some of these tanks from the BPP. Figure 3 clearly shows that the concentration of fission products in metal waste (i.e., HLW) was more than 100 times that of 1C waste, more than 1,000 to 100,000 times that of 2C and 224 wastes.

The U.S. Department of Energy, Office of River Protection (ORP) has identified nine (9) SSTs that contain contact-handled TRU waste generated from the BPP for inclusion in the Compliance Recertification Application (CRA) inventory. These tanks are designated as tanks B-201, B-202, B-203, B-204, T-111, T-201, T-202, T-203, and T-204. The waste types received into T-111 were second decontamination cycle waste and 224 Building plutonium concentration waste. 224 Building plutonium concentration waste was received in tanks B-201 through B-204, and T-201 through T-204. Tank B-201 through B-204 also received low-level waste water from an off-gas scrubber system and miscellaneous sources in the 221-B BPP Plant. Even though this low-level waste was added to these tanks, the analyses of waste samples from these tanks provides assurances that the waste contains greater than 100 nanocuries per gram of TRU elements. No other waste types have been added to these nine (9) SSTs.

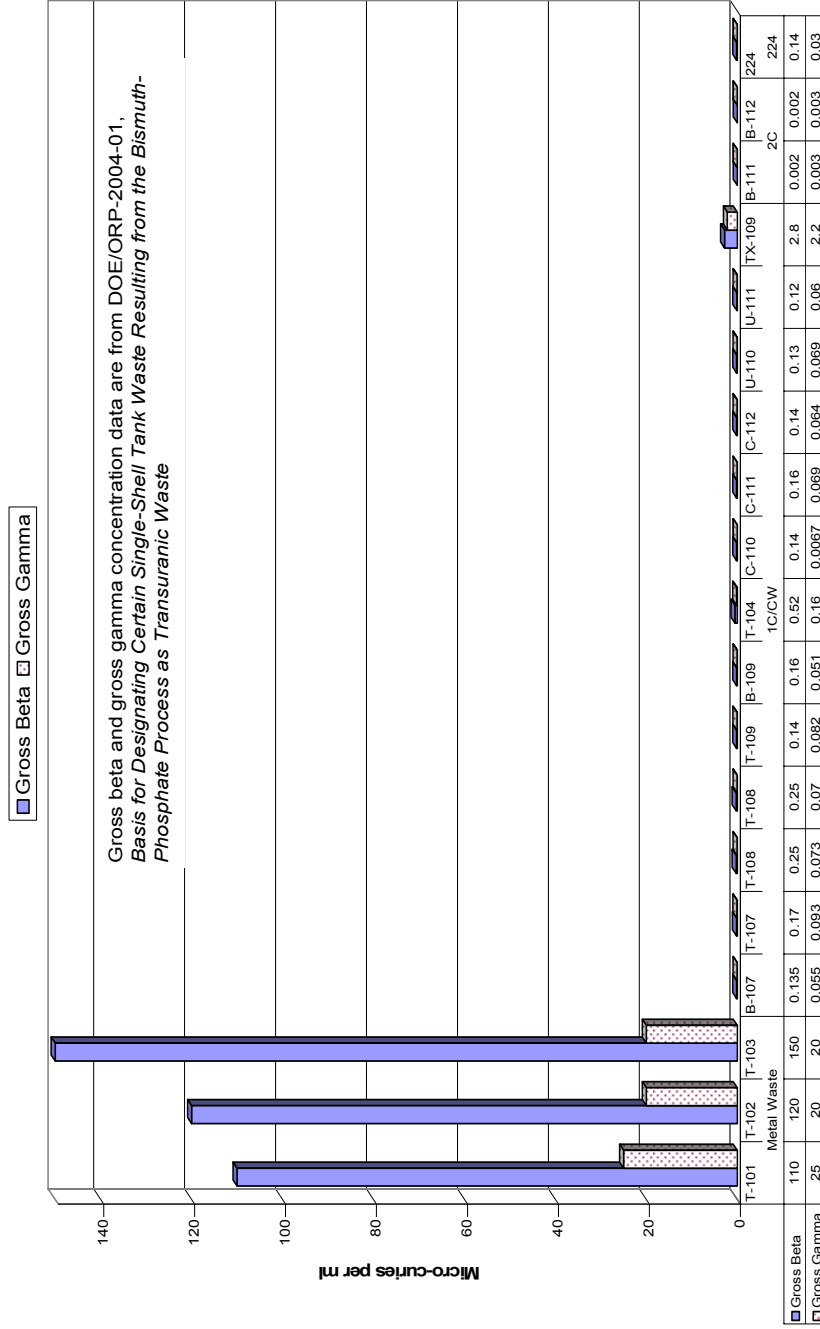


Figure 3. Fission Product Activity in Bismuth Phosphate Process Wastes (Late 1940's)

The fission product and TRU elements concentrations of the TRU solids stored in these nine (9) SSTs are listed in Table 1. The low fission product concentrations (see Table 1) in these wastes are consistent with a non-HLW designation. Moreover, the wastes in those nine (9) SSTs meet the definition of TRU waste set forth in the LWA and are, therefore, appropriate for disposal at WIPP. Specifically, these wastes are not HLW and these wastes contain more than 100 nanocuries of alpha-emitting TRU isotopes per gram of waste, with half-lives greater than 20 years.

Tank	Waste Volume (kgal)	Waste Types	TRU (nanocuries/gram)	Cs ¹³⁷ (curies/liter) ⁽¹⁾	Sr ⁹⁰ (curies/liter) ⁽¹⁾
Group I – Single-Shell Tanks Containing 224 Building Waste					
B-201 ⁽²⁾	30	224	824	0.0002	0.002
B-202 ⁽²⁾	29	224	214	0.0001	0.004
B-203 ⁽²⁾	51	224	297	0.000008	0.00009
B-204 ⁽²⁾	50	224	263	0.00003	0.0017
T-201 ⁽²⁾	29	224	754	0.00004	0.0001
T-202 ⁽²⁾	21	224	221	0.00003	0.000003
T-203 ⁽²⁾	37	224	295	0.00002	0.000003
T-204 ⁽²⁾	37	224	243	0.000009	0.000005
Group II – Single-Shell Tanks Containing 224 Building Waste and Second Decontamination Cycle Waste					
T-111 ⁽²⁾	447	224/2C/DW	182	0.0001	0.005
Key to Waste Type Designation					
Waste Type	Description				
2C	Second Plutonium Decontamination Cycle Waste from Bismuth Phosphate Plant				
224	224-B/T Plutonium Concentration Building Waste				
DW	Equipment decontamination waste from 221-T Plant				

Table 1. Candidate Contact-Handled Single-Shell Tanks TRU Waste Designation

Notes:

- (1) The concentrations of Cs¹³⁷ and Sr⁹⁰ are reported for these wastes as presently stored in these tanks. The treatment process will increase the concentration of radionuclides by removing free and bound water from these wastes. The Hanford Site maintains a Best Basis Inventory for all tank wastes, which is available at <http://twins.pnl.gov/twins.htm>. The Best Basis Inventories are re-evaluated on a quarterly basis when new information becomes available.
- (2) SST waste identified in CRA submittal.

3.2 PUREX Process

The PUREX process used a batch processing step to dissolve the cladding (or coating) on SNF, followed by a batch processing step to dissolve the uranium and then four continuous solvent extraction process steps to separate uranium and plutonium from fission products and other impurities, as depicted in Figure 4. The process steps conducted in the PUREX process are discussed in Sections 4.1 through 4.3 along with the waste types generated and the basis for designating these waste types.

An important feature of the PUREX process was the batch process steps to dissolve the cladding on the SNF and subsequently dissolve the SNF. This feature provides very sharp demarcation points between process steps which enable clear distinctions where SNF and HLW existed (or did not exist) within the process. This same feature allows clear distinctions where TRU waste was generated in the PUREX process. Specifically, the SNF was intact during the cladding removal process and no HLW existed during the batch dissolution of the cladding. Cladding waste, therefore, is not HLW. When the SNF was dissolved into its constituent elements (e.g., uranium, plutonium, fission products, and metal impurities), HLW was present. The HLW was separated from uranium and plutonium in the continuous solvent extraction process steps and discharged as HLW to specific underground storage tanks at the Hanford Site.

3.2.1 Coating Dissolution

The first step in the processing of SNF was to dissolve the coating or cladding that encased the SNF. The PUREX Plant processed both aluminum coated (1956 – 1973) and zirconium clad (1983 – 1990) SNFs. Two of the double-shell tanks (DSTs) identified in the CRA inventory update, tanks AW-103 and AW-105, received coating removal waste from dissolution of zirconium clad SNF. Therefore, only the zirconium clad SNF processing is discussed here.

The zirconium clad fuel, Zircaloy[®] (98.5% zirconium and 1.5% tin), was dissolved in a solution of ammonium fluoride and ammonium nitrate. The ammonium fluoride / ammonium nitrate solution also dissolved a small amount of the uranium, TRU elements, and other fission products that were associated with the SNF. The majority of the uranium and TRU elements that were dissolved during the coating dissolution were present as fluoride solids.

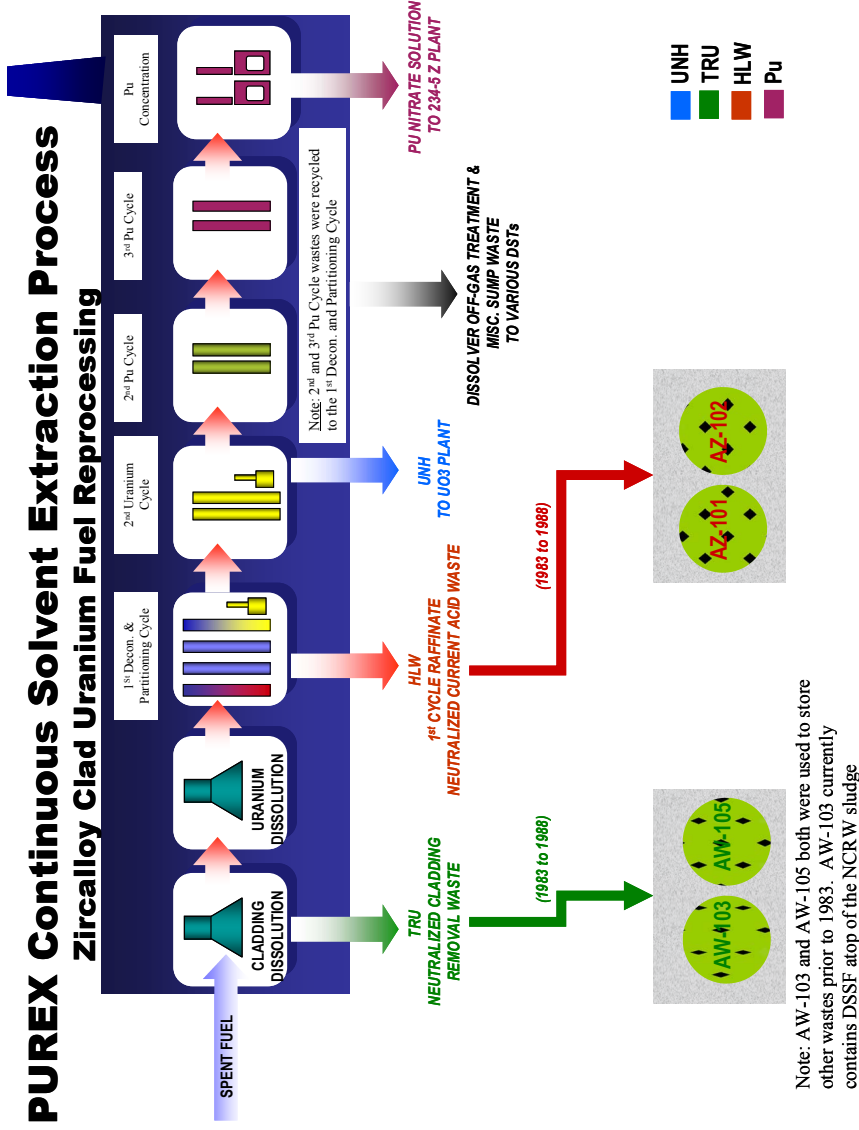


Figure 4. Simplified Diagram of PUREX Process

The cladding dissolution solution and entrained solids were removed from the dissolver vessel. The uranium fuel in the dissolver was rinsed with water and the rinse water combined with the cladding waste. The cladding waste was then processed through a centrifuge, where the solution was separated from the uranium and TRU fluoride solids and transferred to PUREX tank E-5. The uranium and TRU fluoride solids remained in the centrifuge bowl and were metathesized to hydroxide precipitates by addition of potassium hydroxide. The metathesis solution was separated from the uranium and plutonium hydroxide precipitates by centrifugation and washing. The metathesis and wash solutions were also collected in PUREX tank E-5. The cladding and metathesis wastes, plus wash solutions that were collected in PUREX Plant tank E-5, were neutralized with sodium hydroxide, and the slurry was transferred to the DSTs AW-103 and AW-105 to allow solids in the waste to precipitate as sludge. This zirconium cladding waste was designated as Neutralized Cladding Removal Waste (NCRW). The supernatant fraction of the NCRW has been periodically removed from tanks AW-103 and AW-105 to provide space for storage of the NCRW solids.

The cladding removal process step did not create HLW because it only dissolved the zirconium cladding, leaving the SNF intact. The cladding removal waste originated prior to the SNF being dissolved and reprocessed. The NWPA defines HLW as “*the highly radioactive material resulting from the reprocessing of spent nuclear fuel...*”. Since SNF was intact during the cladding removal process, reprocessing had not occurred, and therefore, the cladding removal waste is excluded from the HLW definition. This determination continues the position established by the Atomic Energy Commission in 1969⁴ that cladding hulls (removed from spent fuel by mechanical rather than chemical means) are not HLW.

3.2.2 Uranium Dissolution

After dissolving the coating/cladding on the SNF, the SNF was dissolved in nitric acid. The uranium nitrate solution contained essentially all of the plutonium and fission products along with metal impurities. The batch dissolution of the SNF did not create a liquid waste step that was discharged from the PUREX process.

3.2.3 Solvent Extraction

After dissolving the SNF, the uranium nitrate solution was processed through four continuous solvent extraction steps. The fission products and impurities were separated in a nitric acid solution from the uranium and plutonium in the first solvent extraction step; first Decontamination and Partitioning Cycle in Figure 4. The nitric acid solution containing the fission products and impurities was evaporated to volatilize nitric acid for

⁴ In the Statement of Proposed Policy (34 FR 8712) for Appendix D, 10 CFR Part 50 “Policy Relating to the Siting of Fuel Reprocessing Plants and Related Waste Management Facilities,” the Atomic Energy Commission (AEC) noted that the term high-level waste, as used in the proposed Appendix D, did not include all wastes originating from (spent nuclear fuel) reprocessing plant operations. Such wastes, later referred to as incidental wastes by the Nuclear Regulatory Commission (NRC) (52 FR 5993), included waste streams such as radioactive hulls from the irradiated fuel.

recovery and re-use in the PUREX Plant.

The concentrated, acidic fission product solution was reacted with sugar addition to drive off some of the nitric acid and neutralized by the addition of sodium hydroxide solution in PUREX tank F-16. The neutralized waste, designated as Neutralized Current Acid Waste (NCAW), was transferred from PUREX tank F-16 to underground storage tanks. The NCAW will be processed in the Waste Treatment and Immobilization Plant and shipped to the national SNF and HLW repository. The NCAW was not mixed with the NCRW generated during the cladding removal process step.

Consistent with the NWPA definition, NCAW has been designated as HLW. The NCAW is the *“the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations ...”*.

The three subsequent solvent extraction steps in the PUREX process separated uranium from plutonium (Second Uranium Cycle) and purified plutonium (Second and Third Plutonium Cycles). Waste streams generated from the Second Uranium Cycle, Second and Third Plutonium Cycles were internally recycled in the PUREX process and did not generate a waste solution requiring storage in the underground tanks.

Plutonium from the Third Plutonium Cycle was evaporated to concentrate the plutonium solution. The plutonium solutions generated at the PUREX Plant were transferred to the 234-5Z building (PFP) for processing into metallic form. Uranium solutions from the Second Uranium Cycle were transferred to the 224-U building (UO₃ Plant) for conversion to an oxide and transfer to offsite facilities for re-use in the manufacture of nuclear fuel.

3.3 Plutonium Finishing Plant (PFP)

The PFP was constructed in 1949 and operated until 1989 to convert plutonium nitrate solution and scrap plutonium into metal and other forms for nuclear weapons production. The PFP contained two main process steps consisting of (1) plutonium scrap dissolution and continuous solvent extraction step and (2) plutonium nitrate solution conversion to metal (or other solid forms). Waste from the latter of these process steps (plutonium nitrate solution conversion to metal) was returned to the plutonium scrap dissolution and continuous solvent extraction step for plutonium recovery.

In the plutonium scrap dissolution and continuous solvent extraction step, solid forms of plutonium were typically dissolved in nitric acid solution, yielding plutonium nitrate solution. The plutonium nitrate solution was fed to a continuous solvent extraction step that separated plutonium from americium-241 (Am²⁴¹) and other metal impurities. Am²⁴¹ is a TRU element with half-life greater than 20-years. The Am²⁴¹ and metal impurities, along with trace amounts of plutonium, were contained in a nitric acid solution that was mixed with a solution of iron and sodium hydroxide for safe storage. This waste stream was designated as PFP waste.

One of the underground storage tanks at the Hanford Site that received PFP waste was DST SY-102. After receipt in tank SY-102, the PFP waste formed separate sludge and supernatant phases. The supernate was periodically removed from tank SY-102, whereas the PFP sludge remains in this tank.

The PFP sludge in tank SY-102 is not HLW because it is not "...the highly radioactive waste material from the reprocessing of spent nuclear fuel, including liquid waste produced directly in the reprocessing and any solid materials derived from such liquid waste that contains fission products in sufficient concentrations...". The PFP received plutonium materials product and converted it to forms that were used to fabricate nuclear weapons or for other purposes. The PFP did not receive any SNF or HLW. Therefore, the waste from the PFP sludge is not HLW.

4. Waste Management Practices

The U.S. Department of Energy (DOE) has long had in place waste management rules that require the segregation of TRU waste from HLW to the extent practical (e.g., DOE Order 5820.2A, which was later superseded by DOE Order 435.1). Similarly, DOE's predecessor agencies required the segregation of wastes based on waste characteristics. The requirements were intended to facilitate both treatment and disposal activities.

In the Hanford Site tank farms, this segregation was achieved by establishing separate, dedicated storage tanks for each waste type (e.g., high-level, low level, and TRU wastes), restricting the transfer of wastes among tanks, and by subjecting tank wastes to specific administrative controls and decision-making processes. The administrative controls associated with segregating the TRU tank wastes remain in effect today.

These waste segregation controls allowed the storage of non-TRU waste supernatant solutions atop of the PFP sludge and NCRW sludge stored in DSTs SY-102 and AW-103. Some of these supernatant solutions precipitated salts and other solids. These will be removed from the PFP sludge and NCRW sludge, to the extent practical, before packaging these TRU sludges for disposal as TRU-mixed (TRUM). Washing these sludges will remove most of the soluble precipitated salts, Cs¹³⁷, and some of the Sr⁹⁰. Washing of the TRU sludges is discussed further in Section 6, TRU Tank Waste Treatment Plan.

Notwithstanding the physical segregation of waste by type, DOE and its contractors at the Hanford Site managed the TRU tank wastes under the stringent standards for HLW in order to preclude the need to construct and maintain a separate tank system for interim storage of TRU tank wastes. This also avoided the establishment of separate safety protocols for the management of different tanks, depending on whether the wastes were high-level, TRU, or low-level. Management efficiencies were achieved by applying the same safety standards to all tank wastes regardless of type.

Although DOE has managed all tank wastes under the standards for HLW, **DOE has not designated all tank wastes as HLW**. In fact, DOE has publicly stated in the "Tank

Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement” (DOE/EIS-0189), August 1996, page S-3:

“Tank wastes result from various processing activities and may be either high-level, transuranic, low-level or hazardous chemical wastes.”

“Waste must be managed, treated, stored, and disposed of differently according to the waste type, degree of risk posed to humans or the environment, and its source. Waste in the tank farm system includes the following waste types.

The most dangerous radioactive waste is **high-level waste**, a by-product of reprocessing spent nuclear fuel. This waste requires radiation shielding, special handling techniques, and when disposed of, special measures to isolate it from humans and the environment.

TRU waste is material contaminated with radioactive elements with atomic numbers greater than uranium. This waste does not require the same degree of isolation as high-level waste; however, it cannot be disposed of in a near-surface facility.

The least dangerous radioactive waste is **low-level waste**. It consists of all radioactive waste that is not high-level, TRU, spent nuclear fuel, or by-product material, and may be disposed of in a near-surface facility.

Low-activity waste consists of waste that remains following the process of separating as much of the radioactivity as is practicable from high-level waste. When solidified, low-activity waste may be disposed of as low-level waste in a near surface facility.

Hazardous or dangerous waste is ignitable, corrosive, reactive, toxic, persistent in the environment, exhibits dangerous waste characteristics, or appears on special EPA lists. The waste may cause or contribute to an increase in health hazards when improperly treated, stored, transported, disposed off, or otherwise managed.

Mixed waste is waste that is both hazardous or dangerous and radioactive.”

5. Decisions Regarding TRU Tank Wastes

In 1988, following the preparation of the Hanford Defense Waste Environmental Impact Statement, DOE issued a Record of Decision (ROD) (53 FR 12449, April 8, 1988, “Record of Decision, Hanford High-Level, TRU, and Tank Wastes”) on the proposed disposition of the tank wastes. DOE’s ROD announced its decision to retrieve and treat wastes contained in the DSTs. The ROD also announced that wastes contained in the SSTs, as well as buried TRU and other site wastes, would be further studied and their treatment and disposal would be the subject of future National Environmental Policy Act analyses and decisions. Consistent with this ROD, DOE initiated plans to construct the Hanford Waste Vitrification Plant, which would have had the capacity to complete waste treatment of DST wastes.

In the early 1990's, DOE determined that it needed to develop and implement a strategy to retrieve and treat the tank wastes in both the SST and DST systems. This strategic change required a significant increase in the total treatment capacity. The Hanford Waste Vitrification Plant was determined to be too small to support completion of the mission and was cancelled. A series of technical studies were undertaken in 1993 to establish a new path forward. A new plan emerged in 1995 to construct a much larger vitrification facility, with a pretreatment facility to separate low-activity tank wastes from high-activity tank wastes. The separate waste streams would then go to large vitrification facilities; one to immobilize the fraction of the wastes commonly called low-activity waste, and one to immobilize the high-activity waste fraction of the wastes, commonly called the HLW. This new treatment complex was to be constructed and begin operations in 1998, with the completion date of 2028 for the retrieval and treatment mission (approximately 30 years of operations).

During the planning timeframe of the early 1990's, DOE and its contractors conducted a series of additional studies to consider other waste treatment strategies. One particular study conducted in 1995 focused on identifying SSTs and DSTs containing TRU wastes. As an element of that study, the tank histories and inventories were reviewed to identify which of the tanks contained TRU wastes. TRU tank waste treatment strategies were developed using the definitions from the WIPP Land Withdrawal Act (LWA), the draft WIPP Waste Acceptance Criteria (WAC), and an earlier U.S. Nuclear Regulatory Commission proposed rulemaking associated with HLW definitions.

This same study identified an initial population of tanks that contain TRU wastes. The study also indicated that further characterization and development of tank process history would likely establish that additional tanks contained TRU wastes.

In 1995, the DOE determined that alternative tank waste disposal strategies should be evaluated based on the projected cost difference between estimated disposal costs for the HLW repository (assumed to be Yucca Mountain) and WIPP. Two follow-on technical studies were commissioned and issued.

The first was a decision document issued in 1996 recommending that the technical planning baseline be modified to include blending of the TRU tank wastes with HLW feeds for treatment and disposal of that blended material in the national HLW repository, rather than separately packaging it for disposal at the WIPP. The decision document was updated in 1996 to include an alternatives evaluation appendix. The second document, issued in 1996, established the technical feasibility of separately processing this TRU material for disposal in the WIPP.

In August 1996, DOE concurred with the recommendation that TRU tank waste should be processed with the HLW and authorized changes to the planning basis. As a consequence of this decision, the TRU tank waste streams were not included in the 1995 TRU Waste Baseline Inventory Report (TWBIR) for WIPP because DOE believed it had another cost-effective disposal pathway. Nevertheless, DOE specifically precluded any changes to the waste management procedures, thus requiring continued segregation of stored TRU wastes from HLWs.

Subsequent developments prompted a re-evaluation of the most appropriate and cost-effective pathway for the disposition of TRU tank wastes. The primary changes were:

- Historical knowledge of the sources and inventories of wastes in the tank farm has confirmed that the wastes in up to twenty tanks originated from the processing and purification operations of TRU elements.
- Based on its current capacity and processing schedule, the Waste Treatment and Immobilization Plant will not have the capability to process the tank wastes by the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) milestone of 2028. It is now clear that processing the TRU tank wastes in the Waste Treatment and Immobilization Plant would require two to three years of additional operation at ~\$400M per year.
- Significant tank waste characterization has been accomplished since 1996, and it is now apparent that the TRU wastes contained in nine of the tanks will be contact-handled when packaged for disposal at the WIPP.
- The WIPP has several years of operating experience with various types of TRU wastes, so the specifications for WIPP disposal are better known and understood.

6. TRU Tank Waste Treatment Plan

The contact-handled TRU tank wastes would be dewatered and mixed with additives (adsorbent such as sand and vermiculite are being considered) to yield a solid waste form meeting WIPP waste acceptance criteria. The DOE does not plan to conduct additional treatment to separate radionuclides from the contact-handled TRU waste stored in the nine (9) SSTs reported in the CRA 2004 inventory. Radionuclide separation from the remote-handled TRU wastes stored in the three DST may be desirable to optimize utilization of the WIPP by reducing the mass and radionuclide content of these remote-handled TRU tank wastes.

The DOE has evaluated washing the remote-handled TRU waste sludges stored in tanks AW-103, AW-105, and SY-102 to remove soluble fission products and salts. This would reduce the fission product content and radiation dose rate from these sludges as well as reduce the final disposal volume. The DOE has conducted testing with samples of these remote-handled TRU wastes to separate soluble salts and fission products such as Cs¹³⁷. These tests indicate that 95% of the soluble fission products can be separated from these remote-handled TRU wastes. However, the WIPP is currently not authorized to receive remote-handled TRU waste. In the future, DOE plans to treat and dispose of these wastes.

7. Further Compliance Measures

To prepare the Hanford Site TRU tank wastes for shipment to WIPP, the DOE will retrieve the wastes using a retrieval system in conjunction with a limited amount of water to facilitate recovery and to transfer wastes to the co-located waste treatment and

packaging system. The wastes will be retrieved from the waste tanks in a systematic and controlled fashion, utilizing the closed loop retrieval process which ensures the wastes and supporting Acceptable Knowledge remains unaffected, which ensures the acceptability of the wastes at the WIPP. The retrieval system will further homogenize the wastes as a function of the retrieval operations.

The WIPP waste acceptance and transportation protocols will be adhered to throughout the treatment and packaging operations. Wastes will be packaged in NRC-certified waste containers. Waste containers will be visually examined to confirm the acceptability of the wastes while providing independent validation that wastes are compliant with the waste stream profile and meet the WIPP requirements.

WIPP compliant waste characterization will be performed by trained professional staff performing to WIPP approved procedures, on certified equipment, and in compliance with the waste acceptance criteria. Independent review and certification of wastes to verify compliance with the WIPP Hazardous Waste Facility Permit requirements will be performed by an independent, trained, and certified waste certification team.

Waste loading and shipping operations will be performed in compliance with the WIPP Hazardous Waste Facility Permit, the Nuclear Regulatory Commission, and the U.S. Department of Transportation (DOT) transportation criteria. These operations will be performed by trained staff in accordance with approved procedures on certified equipment. Loading operations personnel, equipment, facilities, and processes will comply with the requirements and be independently certified to ensure WIPP compliance. Waste packages and their supporting characterization data will be submitted, independently reviewed, and authorized for shipment prior to the commencement of loading and shipping operations.

8. Conclusion

Although historically the Department has managed wastes within the Hanford Site tank farms as HLWs as a matter of operations management policy, the Department has also maintained that, depending on origin, process history, and radiological characteristics, the wastes in any specific tank may actually be HLW, TRU waste, low-level, or mixed waste. The Department planned to appropriately designate wastes into one of these categories once the wastes were ready for retrieval for treatment and disposal. The designation of the waste in question as TRU derives from the legal definitions of TRU waste and HLW, as well as waste origin, process history, and radiological characteristics.

The twelve (12) Hanford Site tanks identified in the CRA inventory contain TRU wastes. The Department has proposed additional treatment of the remote-handled TRU tank waste for removal of additional soluble fission products based on principles that have been tested. The processes that generated the wastes in these tanks clearly segregated the TRU waste from the HLW during processing. Controls established to maintain the segregation of TRU wastes from HLWs remain in effect today. As a result, the DOE maintains that it is now appropriate to package and dispose of the Hanford TRU tank wastes, discussed herein, at the WIPP.

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