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Preliminary Tank Characterization Report for Single-Shell Tank 241-T-204: Best-Basis Inventory

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U.S. Department of Energy Contract DE-AC06-96RL13200

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Abstract: An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities. As part of this effort, an evaluation of available information for single-shell tank 241-T-204 was performed, and a best-basis inventory was established. This work follows the methodology that was established by the standard inventory task.

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**PRELIMINARY TANK
CHARACTERIZATION REPORT
FOR SINGLE-SHELL TANK
241-T-204:
BEST-BASIS INVENTORY**

August 1997

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Richland, Washington

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**PRELIMINARY TANK CHARACTERIZATION REPORT
FOR SINGLE-SHELL TANK 241-T-204:
BEST-BASIS INVENTORY**

This document is a preliminary Tank Characterization Report (TCR). It only contains the current best-basis inventory (Appendix D) for single-shell tank 241-T-204. No TCRs have been previously issued for this tank, and current core sample analyses are not available. The best-basis inventory, therefore, is based on an engineering assessment of waste type, process flowsheet data, early sample data, and/or other available information.

The *Standard Inventories of Chemicals and Radionuclides in Hanford Site Tank Wastes* (Kupfer et al. 1997) describes standard methodology used to derive the tank-by-tank best-basis inventories. This preliminary TCR will be updated using this same methodology when additional data on tank contents become available.

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APPENDIX D

**EVALUATION TO ESTABLISH BEST-BASIS
INVENTORY FOR SINGLE-SHELL
TANK 241-T-204**

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APPENDIX D**EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR
SINGLE-SHELL TANK 241-T-204**

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of available information for single-shell tank 241-T-204 was performed, and a best-basis inventory was established. This work, detailed in the following sections, follows the methodology that was established by the standard inventory task.

D1.0 CHEMICAL INFORMATION SOURCES

There is no Tank Characterization Report (TCR) for this tank. The information provided in Section 4 and Appendix A of Field et al. (1997) provides characterization results for tank 241-B-204 which contains the same type of waste as tank 241-T-204.

D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

The engineering assessment-based inventories listed in Table D2-1 were calculated by multiplying the inventories for tank 241-B-204 (Table 4-2 of Field et al. 1997) by the ratio of the waste volume in tank 241-T-204 to the waste volume in tank 241-B-204 (0.76). (The chemical species are reported without charge designation per the best-basis inventory convention). Tank 241-T-204 is reported to contain 144 kL (38 kgal) of waste and tank 241-B-204 is reported to contain 189 kL (50 kgal) (Hanlon 1997). The Hanford Defined Waste (HDW) model (Agnew et al. 1997a) inventory also is derived using this same waste volume and is also given in Table D2-1.

Table D2-1. Engineering Assessment- and Hanford Defined Waste-Based Inventory Estimates for Tank 241-T-204 Nonradioactive Components

Analyte	Engineering ^a inv. estimate (kg)	HDW ^b inv. estimate (kg)	Analyte	Engineering ^a inv. estimate (kg)	HDW ^b inv. estimate (kg)
Al	10.9	0	Ni	39.1	12.0
Bi	8,130	1,670	NO ₂	122	21.2
Ca	51.1	1,410	NO ₃	8,970	10,900
Ce	9.35	NR	OH	NR	2,690
Cl	118	121	oxalate	286	13,400
Cr	543	45.2	P as PO ₄	1,200	1,150
Cu	3.71	NR	Si	179	0
F	1,200	2,760	SO ₄	111	36.9
Fe	638	2,910	Sr	65.4	0
K	980	1,150	TIC as CO ₃	NR	2,110
La	1,740	67.5	Zn	8.97	NR
Mg	13.9	NR	H ₂ O (wt%)	77.1	68.6
Mn	2,480	35.8	density (g/mL)	1.19	1.21
Na	4,470	14,000			

HDW = Hanford Defined Waste

NR = Not reported

^a Table 4-2 from Field et al. (1997) multiplied by 0.76

^b Agnew et al. (1997a).

D3.0 COMPONENT INVENTORY EVALUATION

The following evaluation provides a best-basis inventory estimate for chemical and radionuclide components in tank 241-T-204.

D3.1 CONTRIBUTING WASTE TYPES

The following abbreviations were used to designate waste types:

224 = LaF₃ final plutonium decontamination and concentration waste from the BiPO₄ process

1C = First decontamination cycle BiPO₄ waste, operational 1944 to 1956.

Agnew et al. (1997b) first shows waste in the 200 series tanks in 1952 for the B and T Tank Farms and in 1956 for the U Tank Farm. However, Borsheim (1994) reports that originally the 224 wastes were routed to the 6.1 m (20 ft) diameter concrete settling tank (241-361) and overflowed from there to a dry well. The dry well was replaced with a crib by June 1945.

Cell drainage (5 to 6 waste) was also routed to the 241-361 tank. High activity cell drainage was supposed to be routed to tanks 241-B-107 and 241-T-107 in the 1C waste cascades. Borsheim (1994) also notes that the 200 series tanks were each provided with two inlet lines, were not cascaded, and had no overflow lines. Experiments (as of November 1944) indicated that the 224 wastes should contain 3 percent solids by volume.

Borsheim (1994) notes that the "Hanford Works Monthly Reports" show a plan to provide a separate crib for the B Plant cell drainage. The cell drainage was then being disposed to tank 241-B-201 along with the 224 waste. Tank 241-B-201 and the T tanks were in service as sludge settling tanks for 224-B and T wastes, respectively. The remaining 200 series tanks (202, 203, 204) were being excavated and piped in series to increase settling capacity.

Borsheim (1994) reports that by July 1950, tank 241-B-204, which had been in service since November 1948, was filled to a depth of 6.1 m (20 ft) with sludge. The tank overflowed to tank 241-B-203 which had received 10.2 cm (4 in.) of sludge by that time. This suggests that tanks 241-B-201 and 241-T-201 received 224 waste before the other B-200 and T-200 series tanks, and that when the other B-200 series tanks received waste, it overflowed from tank 241-B-204 to tank 241-B-203 and then to tank 241-B-202. The T-200 series tanks received 224 waste in a similar fashion.

The waste volumes in tanks 241-B-204, 241-B-203, and 241-B-202 are 189 kL (50 kgal), 193 kL (51 kgal), and 102 kL (27 kgal), respectively (Hanlon 1997). Tank 241-B-201 contains 110 kL (29 kgal) and is piped separately from the other B-200 tanks, indicating that it received waste independent of the other three B-200 series tanks. The T-200 series tank waste volumes show the same trends.

Expected Types of Solids in the Waste

Hill et al. (1995):	224
Agnew et al (1997a):	224

D3.2 EVALUATION OF FLOWSHEET INFORMATION

Technical flowsheet information (Kupfer et al. 1997) for 224 streams is shown in Table D3-1. The comparative HDW model defined waste streams are also shown in this table.

Table D3-1. Technical Flowsheet and HDW Defined Waste Streams.

Analyte	Flowsheet 224 ^a (M) (Place)	Flowsheet 224 ^a (M) (Schneider)	HDW 224 ^b (M)
Bi	0.00595	0.00565	0.006
C ₂ O ₄	0.0458	0.0147	0.046
Cr	0.00362	0.00327	0.0068
F	0.272	0.295	0.27
K	0.223	0.218	0.231
La	0.00376	0.00353	0.0038
Mn	0.00514	0.00601	0.0051
Na	1.62	1.60	1.60
NO ₃	1.06	0.684	1.38
PO ₄	0.0322	0.0321	0.038
SO ₄	0.00140	0.00364	0.003
NH ₄	NR	0.0067	NR

HDW = Hanford Defined Waste

NR = Not Reported

^a Appendix C of Kupfer et al. (1997), Bismuth Phosphate Process Flowsheet

^b Agnew et al. (1997a).

D3.3 ASSUMPTIONS FOR RECONCILING WASTE INVENTORIES

Reference inventories in tank 241-T-204 were estimated using an engineering assessment that is based on the results of a sampling event from tank 241-B-204 which has a nearly identical history and the contains the same waste type. The inventories were then compared with the HDW model inventories. The assumptions and observations for the engineering assessment were based on best technical judgement pertaining to input information that can significantly influence tank inventories. This includes: (1) correct predictions of contributing waste types, and correct relative proportions of the waste types, (2) accurate predictions of flowsheet conditions, fuel processed, and waste volumes,

(3) accurate predictions of partitioning of components, and (4) accurate predictions of physical parameters such as density, percent solids, etc. By using this evaluation, the assumptions can be modified as necessary to provide a basis for identifying potential errors and/or missing information that could influence the sample- and model-based inventories. Following are the simplified assumptions and observations used for the evaluation.

- Tank waste mass is calculated using the measured density and the tank volume listed in Hanlon (1997). Both engineering assessment-based and model-based inventories are derived using this volume. As a result, inventory comparisons are made on the same volume basis.
- Only the 224 waste stream contributed to solids formation. It is assumed that tanks with the same waste type will have the same concentrations of individual analytes.
- Bulk component (chemical species) information is sufficient for comparing the computed data sets. This information can be obtained from technical flowsheets (see Table D3-1).

D3.4 BASIS FOR CALCULATIONS USED IN THIS ENGINEERING EVALUATION

Because analytical data from a sampling event does not exist for tank 241-T-204, a comparison of sample data to flowsheet derived data cannot be done. A review of waste transfer transaction records (Agnew et al. 1997b) confirms that the waste in this tank is from the 224 process. Hill et al. (1995) and Anderson (1990) agree with the designation of the waste in tank 241-T-204 as 224 waste.

The best-basis evaluation for tank 241-B-204 (Field et al. 1997) includes a comparison of the sample data to flowsheet predictions for 224 waste and shows reasonably good agreement between most sample data and flowsheet predictions. Since tanks 241-B-204 and 241-T-204 received the same waste, in the same time period, and are located in the same position in their respective cascades it is appropriate to use the tank 241-B-204 sample results to estimate the inventories for tank 241-T-204.

The inventories for tank 241-T-204 were estimated using the inventories for tank 241-B-204 and adjusting them by a factor equal to the ratio of the volumes of waste (0.76) in the two tanks. Estimated component inventories from this engineering evaluation are compared with the HDW-estimated based inventories in Table D3-2. Observations regarding these inventories are noted by component in the following text.

Table D3-2. Comparison of Selected Component Inventory Estimates for Tank 241-T-204.

Component	This evaluation (kg)	HDW estimated ^a (kg)
Bi	8,130	1,670
K	980	1,150
La	1,740	67.5
NO ₃	8,970	10,900
Mn	2,480	35.8
SO ₄	111	36.9
Cr	543	45.2
PO ₄	1,200	1,150
F	1,200	2,760
Na	4,470	14,000
H ₂ O %	77.1	68.6

HDW = Hanford Defined Waste

^a Agnew et al. (1997a).

Bismuth. The Agnew et al. (1997a) estimate is about five times lower than the sample. This appears to be caused by the assumption in the HDW that bismuth is partially soluble.

Nitrate. The HDW estimate is higher than the engineering assessment results. The HDW estimated inventory is derived from the HDW model defined 224 waste stream, in which the nitrate concentration is about 30 percent higher than the Place flowsheet (Appendix C of Kupfer et al. 1997).

Sulfate. The HDW estimated inventory is smaller than the engineering assessment-based inventory. Schneider's waste stream estimate is about three times higher for sulfate than is Place's (Kupfer et al. 1997).

Chromium. The HDW-estimated inventory is lower than the sample-based inventory. The data for tank 241-B-204 suggests that about 40 percent of the Cr precipitated; the HDW model assumes a much smaller percent.

Phosphate. The engineering assessment phosphate value is close to the HDW value.

Fluoride. The engineering assessment is based on water soluble fluoride only. The assessment value is about two times lower than the HDW value. Until a sample is analyzed by a methodology that measures total fluoride, these differences cannot be reconciled.

Sodium. The HDW value is approximately three times the value from this evaluation.

Potassium. The HDW and sampling values for potassium agree fairly well.

Lanthanum. Based on the tank 241-B-204 data lanthanum appears to partition between the phases in the tank. The lanthanum inventory predicted by the HDW model is much lower than the inventory from the engineering evaluation.

Manganese. The value from the engineering evaluation is much larger than that predicted by the HDW model (Agnew et al. 1997a). The HDW model treats manganese as highly soluble for the B and T-200 series tanks, and predicts much less manganese in the waste.

Total Hydroxide. Once the best basis inventories were determined, the hydroxide inventory was calculated by performing a charge balance with the valences of other analytes. In some cases this approach requires that other analyte (e.g., sodium or nitrate) inventories be adjusted to achieve the charge balance. During such adjustments the number of significant figures is not increased. This charge balance approach was consistent with that used by Agnew et al. (1997a). The calculated total hydroxide inventories based on engineering assessments and HDW model estimates were 3,220 kg and 2,690 kg, respectively.

Comments On Other Analytes

Strontium. The HDW model assumes there is no strontium in the 224 waste. However, engineering results indicate that tank 241-T-204 contains 65.4 kg of strontium.

D4.0 DEFINE THE BEST-BASIS AND ESTABLISH COMPONENT INVENTORIES

Information about chemical, radiological, and/or physical properties is used to perform safety analyses, engineering evaluations, and risk assessment associated with waste management activities and to address regulatory issues. These activities include overseeing tank farm operations and identifying, monitoring, and resolving safety issues associated with these operations and with the tank wastes. Disposal activities include designing equipment, processes, and facilities for retrieving wastes, and processing them into a form suitable for long-term storage/disposal.

Chemical and radiological inventory information are generally derived using three approaches: (1) component inventories are estimated using the results of sample analyses, (2) component inventories are predicted using the HDW model based on process knowledge and historical information, or (3) a tank-specific process estimate is made based on process flowsheets, reactor fuel data, essential material usage, and other operating data. The information derived from these different approaches is often inconsistent.

As part of this effort, an evaluation of available chemical information for tank 241-T-204 was performed, including the following:

- Data from two 1995 core samples of tank 241-B-204 (Field et al. 1997).
- An inventory estimate generated by the HDW model (Agnew et al. 1997a).

The calculations based on flowsheet information and factors determined from the bismuth analytical data from tank 241-B-204 have been compared to analytical data and the HDW model. These calculations compare well with the analytical data and, in some cases, with the HDW model. Given current resources, the best source of inventory data appears to be the analytical data which was obtained during the 1995 core sampling and analysis event from tank 241-B-204. One analyte, for which the analytical data is suspect is fluoride. Only the water soluble forms of fluoride are reported in the analytical data, because water insoluble fluoride was not measured. Tables D4-1 and D4-2 present the best-basis inventory estimates for the nonradioactive and radioactive waste components, respectively. The inventory values reported in Tables D4-1 and D4-2 are subject to change. Refer to the Tank Characterization Database (TCD) for the most current inventory values.

Best-basis tank inventory values are derived for 46 key radionuclides (as defined in Section 3.1 of Kupfer et al. 1997), all decayed to a common report date of January 1, 1994. Often, waste sample analyses have only reported ^{90}Sr , ^{137}Cs , $^{239/240}\text{Pu}$, and total uranium (or total beta and total alpha), while other key radionuclides such as ^{60}Co , ^{99}Tc , ^{129}I , ^{154}Eu , ^{155}Eu , and ^{241}Am , etc., have been infrequently reported. For this reason it has been necessary to derive most of the 46 key radionuclides by computer models. These models estimate radionuclide activity in batches of reactor fuel, account for the split of radionuclides to various separations plant waste streams, and track their movement with tank waste

transactions. (These computer models are described in Kupfer et al. 1997, Section 6.1 and in Watrous and Wootan 1997.) Model generated values for radionuclides in any of 177 tanks are reported in the HDW Rev. 4 model results (Agnew et al. 1997a). The best-basis value for any one analyte may be either a model result or a sample or engineering assessment-based result if available. (No attempt has been made to ratio or normalize model results for all 46 radionuclides when values for measured radionuclides disagree with the model.) For a discussion of typical error between model derived values and sample derived values, see Kupfer et al. 1997, Section 6.1.10. The radionuclide inventories shown in Table D4-2 are based on engineering assessments and Agnew et al. (1997a) HDW model estimates for tank 241-B-204.

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-T-204 (Effective May 31, 1997). (2 Sheets)

Analyte	Total inventory (kg)	Basis (S, M, E, or C) ¹	Comment
Al	10.9	E	
Bi	8,130	E	
Ca	51.1	E	
Cl	118	E	
TIC as CO ₃	2,100	M	
Cr	543	E	
F	1,200	E	Only the water soluble forms of fluoride are reported in the analytical data.
Fe	638	E	
Hg	0	M	
K	980	E	
La	1,740	E	
Mn	2,480	E	
Na	4,470	E	
Ni	39.1	E	
NO ₂	122	E	
NO ₃	8,970	E	
OH _{TOTAL}	3,220	C	Based on charge balance
Pb	0	M	
P as PO ₄	1,200	E	

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-T-204 (Effective May 31, 1997). (2 Sheets)

Analyte	Total inventory (kg)	Basis (S, M, E, or C) ¹	Comment
Si	179	E	
S as SO ₄	111	E	
Sr	65.4	E	
TOC	3,670	M	
U _{TOTAL}	11.0	M	
Zr	0	M	

¹S = Sample-based

M = Hanford Defined Waste model-based, Agnew et al. (1997a)

E = Engineering assessment-based

C = Calculated by charge balance; includes oxides as hydroxides, not including CO₃, NO₂, NO₃, PO₄, SO₄, and SiO₃.

Table D4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-T-204, Decayed to January 1, 1994, (Effective May 31, 1997). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E) ¹	Comment
³ H	7.64 E-04	M	
¹⁴ C	2.37 E-04	M	
⁵⁹ Ni	6.73 E-05	M	
⁶⁰ Co	7.60 E-05	M	
⁶³ Ni	0.00621	M	
⁷⁹ Se	5.00 E-05	M	
⁹⁰ Sr	24.7	M	
⁹⁰ Y	24.7	M	
^{93m} Nb	1.96 E-04	M	
⁹³ Zr	2.37 E-04	M	
⁹⁹ Tc	0.00164	M	
¹⁰⁶ Ru	5.70 E-11	M	
^{113m} Cd	6.64 E-04	M	
¹²⁵ Sb	8.77 E-05	M	
¹²⁶ Sn	7.53 E-05	M	
¹²⁹ I	3.10 E-06	M	
¹³⁴ Cs	3.78 E-06	M	
^{137m} Ba	26.5	M	
¹³⁷ Cs	28.1	M	
¹⁵¹ Sm	0.189	M	
¹⁵² Eu	2.47 E-04	M	
¹⁵⁴ Eu	0.00122	M	
¹⁵⁵ Eu	0.0223	M	
²²⁶ Ra	1.12 E-08	M	
²²⁷ Ac	5.89 E-08	M	
²²⁸ Ra	7.17 E-13	M	
²²⁹ Th	1.39 E-10	M	
²³¹ Pa	1.36 E-07	M	
²³² Th	6.27 E-14	M	
²³² U	7.27 E-08	M	
²³³ U	3.32 E-09	M	

Table D4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-T-204, Decayed to January 1, 1994, (Effective May 31, 1997). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E) ¹	Comment
²³⁴ U	0.00363	M	
²³⁵ U	1.61 E-04	M	
²³⁶ U	3.16 E-05	M	
²³⁷ Np	1.02 E-05	M	
²³⁸ Pu	4.35 E-04	M	
²³⁸ U	0.00368	M	
²³⁹ Pu	0.063	M	
²⁴⁰ Pu	0.00553	M	
²⁴¹ Am	5.15 E-04	M	
²⁴¹ Pu	0.0183	M	
²⁴² Cm	5.03 E-06	M	
²⁴² Pu	8.45 E-08	M	
²⁴³ Am	4.19 E-09	M	
²⁴³ Cm	1.08 E-07	M	
²⁴⁴ Cm	1.06 E-07	M	

¹S = Sample-based

M = Hanford Defined Waste model-based, Agnew et al. (1997a)

E = Engineering assessment-based.

D5.0 APPENDIX D REFERENCES

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