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HW-76361

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CP-NUCLEAR MATERIALS TRANSFER MEASUREMENT STATISTICS

HANFORD ATOMIC ENERGY PLANT

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CP - NUCLEAR MATERIALS

TRANSFER MEASUREMENT STATISTICS

GE-AEC BUSINESS RECORD

Compiled by

Nuclear Materials Measurements
Nuclear Materials Operation
L. H. Steves

December, 1963

Classification Cancelled and Changed To

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RLD-CG-4, 3-17-94

By DK Hanson, 4-17-94

Verified By J E Sawely 4/8/94

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101. OBJECTIVE

It is the purpose of this document to provide, in one well-referenced manual, a measure of the degree of reliability that may be placed on routine nuclear material transfer measurements within the Chemical Processing Department, and the relative effects of each measurement uncertainty on the various nuclear material balances. Although statistical techniques were used as a tool in analyzing the data, the results have been presented in a form that should require a bare minimum of statistical training to comprehend. Revisions and corrections will be provided as needed.

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102. SCOPE AND LIMITATIONS

The scope of this report includes all routine transfer measurements to, from, and between CPD material balance areas. No effort has been made to include transfers which do not occur at least on a monthly basis. All nominal average quantities, both individual and monthly, are included only to give the reader a feel for the magnitude of the quantities involved and should not be interpreted in any way as standard values or norms.

Although this study has been by no means exhaustive, considerable plant data has gone into most of the error analyses contained in this report. It is felt that most of the stated uncertainties are reasonable reflections of the capabilities of the various measurements as taken under normal operating conditions. It should be remembered that gross human errors are not included in the error limits as stated in this report. Such errors have been rejected from the data on the grounds of being nonrepresentative of normal operating conditions. In all cases error estimates have been on the liberal side, particularly at those points at which an overestimate of the error has little effect on any material balance.

The analyses contained in this report are strictly applicable only for the "nominal average" values as given, and proper adjustment must be made for deviations from these values. In particular, attention must be given to nonroutine transfers for which a generalized evaluation, as is presented in this report, is not applicable.

CP - NUCLEAR MATERIALSTRANSFER MEASUREMENT STATISTICS103. ORGANIZATION OF THE REPORT

1. Section 100: Introduction. This section contains the usual introduction comments and explanations of the document's format.
2. Section 200: Summaries by Material Balance Area. This section contains a summary sheet of all routine receipt and removal points for each pertinent CPD material balance area. The 95% confidence limit errors are included for each point for nominal average transfers and months, tabulated in such a manner as to allow easy comparability. The abbreviations FE, RE, and TE refer to the fixed random and total errors, respectively. In the last column is referenced the page in Section 300 in which the particular measurement point is evaluated. The total receipt, total removal, and total transfer errors are also given for each material balance area for nominal average months.
3. Section 300: Analyses of Individual Measurement Points. This section contains a page for each measurement point listed in Section 200. All pages in Section 200 in which the particular point is referenced are listed at the top of the page. Following this, the method of calculating each nuclear materials transfer is given as a word equation. Each component appearing on the right hand side of the equation is listed in the table along with a brief explanation of how each measurement component is determined. In the next two columns are listed the nominal average values and the number of times each measurement component is performed per month. The fixed, random, and total 95% confidence limit errors per determination are listed twice for each measurement component. The upper set of errors is given in the same units as the nominal average values, while the lower set is expressed as a percentage effect of the upper error on the nuclear materials quantity. In most cases, the percentage effect is merely the upper error divided by the nominal average value. The source of error estimates for each measurement component is footnoted in the last column.

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104. DEFINITIONS

Nominal Average Values (Nom. Av.)

Individual transfer or monthly quantities provided as a basis for calculation and to give the reader a feel for the magnitude of the quantities involved. They should not be interpreted in any way as standard values or norms.

Fixed Error (FE)

That portion of the deviation of a measurement value from its true value which is consistently directional over a period of time. For the purposes of this report, the fixed errors as given are the 95% confidence limits (2σ) on that portion of the total error which is directional for one month or more. As such, the fixed error includes uncertainties which may be random over a long enough period of time; consequently, care must be exercised in extrapolating the data to longer periods of time. Component fixed errors are accumulated as follows:

$$FE = \sqrt{\sum (FE_i)^2}$$

where: FE is the fixed error per transfer (or per month) in per cent
FE_i is the fixed error of component i in per cent

Random Error (RE)

That portion of the deviation of a measurement value from its true value which is truly random in nature and is a result of the fact that no observation of physical quantities can be made exact. Random errors as given in this report are the 95% confidence limits (2σ). Component random errors are accumulated as follows:

$$RE = \sqrt{\sum \frac{(RE_i)^2}{n_i}}$$

where: RE is the random error per transfer (or per month) in per cent
RE_i is the random error of component i in per cent
n_i is the number of times component i is performed per transfer
(or per month)

Total Error (TE)

Total deviation of a measurement value from its true value, given in this report as the 95% confidence limits (2σ). It is computed from the fixed and random errors as follows:

$$TE = \sqrt{(FE)^2 + (RE)^2}$$

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105. EXTRAPOLATION TECHNIQUES

This subsection provides generalized methods by which the Section 200 Material Balance Summaries may be extrapolated to yield transfer measurement uncertainties for periods of time in which the "nominal average" monthly values do not hold. It must be remembered, however, that provision must be made for nonroutine transfers in arriving at total transfer uncertainty, and that provision must be made for beginning and ending inventoried in arriving at total material balance uncertainty.

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105. EXTRAPOLATION TECHNIQUES

105.1 Time Periods of Approximately One Month

Extrapolation of the Material Balance Summary uncertainties for one-month periods in which the nominal average values do not hold is relatively simple. As an illustration, consider a plutonium material balance area which has receipt and removal points as listed on page 105.3. Take a one-month period in which this material balance area has 66 dissolver charges for a total of 450 kg Pu and loads out 58 L-9 batches for a total of 500 kg Pu.

- a. Rough Approximation. A fast, easy estimate of the total transfer measurement uncertainty may be obtained by multiplying the total transfer total error percentage by the average of the receipt and removal total weights. From page 105.3, this percentage is 3.1% and the average of the receipt and removal totals is 475 kg. Consequently, for the example:

$$TE = 3.1\% \times 475 \text{ kg} = \underline{14,700 \text{ g}}$$

- b. Detailed Analysis. A considerably more accurate method than the above is the use of the per transfer uncertainties from the left-hand side of the Material Balance Summary sheets. The number of times each significant transfer is performed must be either known or estimated by dividing the total weight transferred by the per transfer nominal average. For each significant transfer point, the Fixed Error is multiplied by the number of transfers and the Random Error is multiplied by the square root of the number of transfers. All errors, both FE and RE, are combined by summation of the squares to obtain the square of the total transfer error. An examination of page 105.3 reveals that there are only two significant routine transfers for the example. Therefore, the total transfer error may be estimated as follows:

Fuel Element Pu:

$$\begin{array}{ll} FE = 30 \times 66 = 1980 \text{ g} & FE^2 = 3.9 \times 10^6 \\ RE = 1200 \times \sqrt{66} = 9750 \text{ g} & RE^2 = 95.0 \times 10^6 \end{array}$$

L-9 Pu Loadout:

$$\begin{array}{ll} FE = 60 \times 58 = 3480 \text{ g} & FE^2 = 12.1 \times 10^6 \\ RE = 150 \times \sqrt{58} = 1140 \text{ g} & RE^2 = 1.3 \times 10^6 \\ & TE^2 = 112.3 \times 10^6 \\ & TE = \underline{10,600 \text{ g}} \end{array}$$

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TRANSFER MEASUREMENT STATISTICS

105. EXTRAPOLATION TECHNIQUES

105.2 Time Periods Greater Than One Month

Extrapolation of the Material Balance Summary uncertainties to time periods of greater than a month is not as direct as for monthly uncertainties due to the long-term random nature of most of the fixed errors. However, with sufficient care fairly accurate estimates of the limits of uncertainty can be drawn from the Section 200 sheets. As an illustration, consider a three-month period in which the material balance area as depicted on page 105.3 has 140 dissolver charges for a total of 820 kg Pu and loads out 100 L-9 batches for a total of 860 kg Pu.

- a. Rough Approximation. A rough estimate of the total transfer measurement uncertainty may be obtained from the total transfer error percentages, if the assumption is valid that the Fixed Error is truly fixed over the time period in question. If this is the case, then the Random Error percentage should be divided by the square root of the number of months in the time period. This resulting error is then combined with the Fixed Error percentage by summation of the squares to obtain the square of the total transfer error percentage. This percentage error is then multiplied by the average of the receipt and removal total weights. Using the values from page 105.3 and the example above, the total transfer error may be estimated as follows:

$$\begin{array}{lll} \text{FE}\% = & 0.9\% & \text{FE}\%^2 = 0.81 \\ \text{RE}\% = 2.9\% \div \sqrt{3} = & 1.7\% & \text{RE}\%^2 = 2.80 \end{array}$$

$$\begin{array}{ll} \text{TE}\%^2 = & 3.61 \\ \text{TE}\% = & 1.9\% \end{array}$$

$$\text{TE} = 1.9\% \times \frac{820 \text{ kg} + 860 \text{ kg}}{2} = \underline{16,000 \text{ g}}$$

- b. Detailed Analysis. A more accurate method than the above is the use of the per transfer uncertainties as described in part b on page 105.1. The assumption is still made, however, that the Fixed Error is truly fixed over the time period in question. For the example:

Fuel Element Pu:

$$\begin{array}{ll} \text{FE} = 30 \times 140 = & 4,200 \\ \text{RE} = 1200 \times \sqrt{140} = & 14,200 \end{array}$$

$$\begin{array}{ll} \text{FE}^2 = & 17.6 \times 10^6 \\ \text{RE}^2 = & 201.6 \times 10^6 \end{array}$$

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105. EXTRAPOLATION TECHNIQUES

105.2 Time Periods Greater Than One Month (continued)

L-9 Pu Loadout:

$$\begin{aligned} FE &= 60 \times 100 = 6,000 \\ RE &= 150 \times \sqrt{100} = 1,500 \end{aligned}$$

$$\begin{aligned} FE^2 &= 36.0 \times 10^6 \\ RE^2 &= 2.2 \times 10^6 \end{aligned}$$

$$\begin{aligned} TE^2 &= 257.4 \times 10^6 \\ TE &= \underline{16,000} \text{ g} \end{aligned}$$

- c. Detailed Analysis Allowing for Randomness of Fixed Error. In order to obtain the best estimate of the transfer measurement uncertainty, the preceding method must be modified slightly to account for the long-term randomness of most fixed errors. Application of this refinement requires a thorough understanding of the measurements and in all cases results in lower error limits than the preceding method. In the example given, fuel element plutonium measurement has a fixed error which is set by the normalization and should not be adjusted for long-term randomness. However, the L-9 loadout measurement's fixed error is due mainly to the analytical bias correction which is applied monthly. Although any error in the bias correction is fixed on a monthly basis (see page 104), it will behave randomly over time periods of two months or greater. Consequently, the fixed error for the L-9 measurement as calculated in part b above should be divided by the square root of the number of months. The adjusted calculation follows:

Fuel Element Pu:

$$\begin{aligned} FE &= 30 \times 140 = 4,200 \\ RE &= 1200 \times \sqrt{140} = 14,200 \end{aligned}$$

$$\begin{aligned} FE^2 &= 17.6 \times 10^6 \\ RE^2 &= 201.6 \times 10^6 \end{aligned}$$

L-9 Pu Loadout:

$$\begin{aligned} FE &= 60 \times 100 \div \sqrt{3} = 3,460 \\ RE &= 150 \times \sqrt{100} = 1,500 \end{aligned}$$

$$\begin{aligned} FE^2 &= 12.0 \times 10^6 \\ RE^2 &= 2.2 \times 10^6 \end{aligned}$$

$$\begin{aligned} TE^2 &= 233.4 \times 10^6 \\ TE &= \underline{15,300} \text{ g} \end{aligned}$$

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MATERIAL BALANCE SUMMARY

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OPERATION Example					MATERIAL BALANCE AREA Example Plutonium					
MEASUREMENT POINT	PER TRANSFER, g Pu				TRANSFERS PER MONTH	PER MONTH, g Pu				REFERENCE
	NOM AV	FE	RE	TE		NOM AV	FE	RE	TE	
<u>RECEIPT POINT</u>										
Fuel Element Pu	6,000	30	1,200	1,200	50	300,000	1,500	8,800	8,900	307.2
			Total Receipts			300,000	1,500	8,800	8,900	
<u>REMOVAL POINT</u>										
L-9 Pu Loadout	8,800	60	150	160	34	300,000	2,100	900	2,300	306.1
D-2 Coat Waste	--	--	--	--	--	600	70	20	70	306.4
V-1 Misc. Waste	21	2	9	9	16	340	31	34	50	306.5
			Total Removals			300,000	2,100	900	2,300	
			Total Transfers				2,600 0.9%	8,800 2.9%	9,200 3.1%	

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TRANSFER MEASUREMENT STATISTICS

201. PUREX OPERATION MATERIAL BALANCE AREAS

201.1 Plutonium In-Process

201.2 Uranium Total

201.3 Uranium In-Process

201.4 UNH Storage

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TRANSFER MEASUREMENT STATISTICS
MATERIAL BALANCE SUMMARY

OPERATION Purex					MATERIAL BALANCE AREA Plutonium In-Process					
MEASUREMENT POINT	PER TRANSFER, g Pu				TRANSFERS PER MONTH	PER MONTH, g Pu				REFERENCE
	NOM AV	FE	RE	TE		NOM AV	FE	RE	TE	
RECEIPT POINT										
Fuel Element Pu	6,000	30	1,200	1,200	50	300,000	1,500	8,800	8,900	305.2
			Total Receipts			300,000	1,500	8,800	8,900	

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CP - NUCLEAR MATERIALS

TRANSFER MEASUREMENT STATISTICS

MATERIAL BALANCE SUMMARY

OPERATION Purex					MATERIAL BALANCE AREA Over-all Uranium					
MEASUREMENT POINT	PER TRANSFER, lb U				TRANSFERS PER MONTH	PER MONTH, lb U				REFERENCE
	NOM AV	FE	RE	TE		NOM AV	FE	RE	TE	
<u>RECEIPT POINT</u>										
Fuel Element U	20,000	9	17	20	50	1,000,000	430	110	440	305.1
UO ₂ Recovered Acid	540	10	44	46	16	8,600	165	180	240	301.3
		Total Receipts				1,000,000	460	210	500	
<u>REMOVAL POINT</u>										
C-1 UNH	11,000	26	54	60	90	1,000,000	2,400	1,000	2,600	303.1
D-2 Coat Waste	--	--	--	--	--	2,100	230	--	230	301.4
F-15 Salt Waste	17	2	11	12	16	270	32	46	60	301.5
F-18 Utility Waste	23	3	15	15	24	560	70	70	100	301.6
G-8 Org. Wash Waste	5	1	3	3	50	250	30	20	35	301.7
R-8 Org. Wash Waste	3	--	2	2	10	30	4	6	7	301.8
		Total Removals				1,000,000	2,400	1,000	2,600	
		Total Transfers					2,500	1,000	2,700	
							0.25%	0.1%	0.3%	

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TRANSFER MEASUREMENT STATISTICS
MATERIAL BALANCE SUMMARY

OPERATION Purex					MATERIAL BALANCE AREA Uranium In-Process					
MEASUREMENT POINT	PER TRANSFER. lb U				TRANSFER PER MONTH	PER MONTH. lb U				REFERENCE
	NOM AV	FE	RE	TE		NOM AV	FE	RE	TE	
RECEIPT POINT										
Fuel Element U	20,000	9	17	20	50	1,000,000	430	110	440	305.1
UO ₂ Recovered Acid	540	10	44	46	16	8,600	165	180	240	301.3
Total Receipts						1,000,000	460	210	500	

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TRANSFER MEASUREMENT STATISTICS
MATERIAL BALANCE SUMMARY

OPERATION Purex					MATERIAL BALANCE AREA UNH Storage					
MEASUREMENT POINT	PER TRANSFER. lb U				TRANSFERS PER MONTH	PER MONTH. lb U				REFERENCE
	NOM AV	FE	RE	TE		NOM AV	FE	RE	TE	
<u>RECEIPT POINT</u>										
K-6 UNH	15,500	90	370	380	65	1,000,000	6,000	3,000	7,000	301.2
		Total Receipts				1,000,000	6,000	3,000	7,000	

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TRANSFER MEASUREMENT STATISTICS

202. REDOX OPERATION MATERIAL BALANCE AREAS

202.1 Plutonium In-Process

202.2 Uranium Total

202.3 Uranium In-Process

202.4 UNH Storage

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MATERIAL BALANCE SUMMARY

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OPERATION Redox					MATERIAL BALANCE AREA Plutonium In-Process					
MEASUREMENT POINT	PER TRANSFER, g Pu				TRANSFER PER MONTH	PER MONTH, g Pu				REFERENCE
	NOM AV	FE	RE	TE		NOM AV	FE	RE	TE	
RECEIPT POINT										
Fuel Element Pu	5,000	40	780	800	19	90,000	720	3,100	3,200	305.2
		Total Receipts				90,000	720	3,100	3,200	

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TRANSFER MEASUREMENT STATISTICS
MATERIAL BALANCE SUMMARY

OPERATION Redox					MATERIAL BALANCE AREA Uranium Total					
MEASUREMENT POINT	PER TRANSFER, lb U				TRANSFERS PER MONTH	PER MONTH, lb U				REFERENCE
	NOM AV	FE	RE	TE		NOM AV	FE	RE	TE	
<u>RECEIPT POINT</u>										
Fuel Element	16,000	11	10	15	19	300,000	200	45	210	305.1
		Total Receipts				300,000	200	45	210	
<u>REMOVAL POINT</u>										
X-36 UNH	10,000	60	100	120	46	300,000	1,800	540	1,900	303.2
H-10 Coat Waste	28	3	16	16	19	530	58	70	90	302.3
D-7/D-9 Salt Waste	2	--	1	1	64	160	32	10	34	302.4
D-2 Org. Wash Waste	--	--	--	--	--	5	1	2	2	302.5
		Total Removals				300,000	1,800	550	1,890	
		Total Transfers					1,810 0.6%	550 0.2%	1,890 0.6%	

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TRANSFER MEASUREMENT STATISTICS
MATERIAL BALANCE SUMMARY

OPERATION Redox					MATERIAL BALANCE AREA Uranium In-Process					
MEASUREMENT POINT	PER TRANSFER. lb U				TRANSFERS PER MONTH	PER MONTH, lb U				REFERENCE
	NOM AV	FE	RE	TE		NOM AV	FE	RE	TE	
<u>RECEIPT POINT</u>										
Fuel Element U	16,000	11	10	15	12	300,000	200	45	210	305.1
		Total Receipts				300,000	200	45	210	
<u>REMOVAL POINT</u>										
E-12 UNH	6,500	37	64	73	46	300,000	1,710	430	1,760	302.2
H-10 Coat Waste	28	3	16	16	19	530	58	70	90	302.3
D-7/D-9 Salt Waste	2	--	1	1	64	160	32	10	34	302.4
D-2 Org. Wash Waste	--	--	--	--	--	5	1	2	2	302.5
		Total Removals				300,000	1,710	440	1,760	
		Total Transfers					1,720	440	1,770	
							0.6%	0.1%	0.6%	

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MATERIAL BALANCE SUMMARY

OPERATION Redox					MATERIAL BALANCE AREA UNH Storage					
MEASUREMENT POINT	PER TRANSFER, lb U				TRANSFERS PER MONTH	PER MONTH, lb U				REFERENCE
	NOM AV	FE	RE	TE		NOM AV	FE	RE	TE	
<u>RECEIPT POINT</u>										
E-12 UNH	6,500	37	64	73	46	300,000	1,710	430	1,760	302.2
		Total Receipts				300,000	1,710	430	1,760	
<u>REMOVAL POINT</u>										
E-36 UNH	10,000	60	100	120	30	300,000	1,800	540	1,900	303.2
		Total Removals				300,000	1,800	540	1,900	
		Total Transfers					2,480 0.8%	690 0.2%	2,590 0.8%	

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TRANSFER MEASUREMENT STATISTICS

203. URANIUM OXIDE OPERATION MATERIAL BALANCE AREAS

203.1 Depleted Uranium In-Process

203.2 Enriched Uranium In-Process

203.3 Total Uranium In-Process

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MATERIAL BALANCE SUMMARY

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OPERATION					MATERIAL BALANCE AREA					
Uranium Oxide					Depleted Uranium In-Process					
MEASUREMENT POINT	PER TRANSFER, lb U				TRANSFERS PER MONTH	PER MONTH, lb U				REFERENCE
	NOM AV	FE	RE	TE		NOM AV	FE	RE	TE	
RECEIPT POINT										
C-1 UNH Receiver	11,000	26	54	60	90	1,000,000	2,400	1,000	2,600	303.1
UO ₃ Container Heels	80	8	11	15	11	880	90	35	100	303.4
Enriched U Down-grade	2,000	40	2,600	2,600	1	2,000	40	2,600	2,600	303.5
Total Receipts						1,000,000	2,400	2,800	3,700	

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TRANSFER MEASUREMENT STATISTICS

MATERIAL BALANCE SUMMARY

OPERATION Uranium Oxide					MATERIAL BALANCE AREA Enriched Uranium In-Process					
MEASUREMENT POINT	PER TRANSFER, 1b U				TRANSFERS PER MONTH	PER MONTH, 1b U				REFERENCE
	NOM AV	FE	RE	TE		NOM AV	FE	RE	TE	
RECEIPT POINT										
X-36 UNH Receiver	10,000	60	100	120	30	300,000	1,800	540	1,900	303.2
UO ₃ Container Heels	80	8	11	14	3	240	24	18	30	303.4
Total Receipts						300,000	1,800	540	1,900	

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MATERIAL BALANCE SUMMARY

OPERATION Uranium Oxide					MATERIAL BALANCE AREA Total Uranium In-Process					
MEASUREMENT POINT	PER TRANSFER, 1b U				TRANSFERS PER MONTH	PER MONTH, 1b U				REFERENCE
	NOM AV	FE	RE	TE		NOM AV	FE	RE	TE	
RECEIPT POINT										
C-1 UNH Receiver	11,000	26	54	60	90	1,000,000	2,400	1,000	2,600	303.1
X-36 UNH Receiver	10,000	60	100	120	30	300,000	1,800	540	1,900	303.2
UO ₃ Container Heels	80	8	11	14	13	1,100	90	40	100	303.4
Total Receipts						1,300,000	3,000	1,100	3,200	

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TRANSFER MEASUREMENT STATISTICS

204. WEAPONS MANUFACTURING OPERATION MATERIAL BALANCE AREAS

(This subsection and 304 have been combined into the "Weapons Data Appendix to CP - Nuclear Materials Transfer Measurement Statistics", HW-76361 APP.)

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TRANSFER MEASUREMENT STATISTICS

205. CHEMICAL PROCESSING DEPARTMENT MATERIAL BALANCE AREAS

- 205.1 Over-all Plutonium
- 205.2 Depleted Uranium
- 205.3 Enriched Uranium
- 205.4 Total Uranium

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TRANSFER MEASUREMENT STATISTICS
 MATERIAL BALANCE SUMMARY

OPERATION HAPO					MATERIAL BALANCE AREA Over-all Plutonium					
MEASUREMENT POINT	PER TRANSFER. g Pu				TRANSFER PER MONTH	PER MONTH. g Pu				REFERENCE
	NOM AV	FE	RE	TE		NOM AV	FE	RE	TE	
<u>RECEIPT POINT</u>										
Fuel Element Pu										
Purex	6,000	30	1,200	1,200	50	300,000	1,500	8,800	8,900	305.2
Redox	5,000	40	780	800	19	90,000	720	3,100	3,200	305.2
			Total Receipts			390,000	1,700	9,300	9,500	
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TRANSFER MEASUREMENT STATISTICS
MATERIAL BALANCE SUMMARY

OPERATION CPD					MATERIAL BALANCE AREA Depleted Uranium					
MEASUREMENT POINT	PER TRANSFER, 1b U				TRANSFER PER MONTH	PER MONTH, 1b U				REFERENCE
	NOM AV	FE	RE	TE		NOM AV	FE	RE	TE	
<u>RECEIPT POINT</u>										
Fuel Element U	20,000	9	17	20	50	1,000,000	430	110	440	305.1
UO ₃ Container Heels	80	8	11	14	11	880	90	35	100	303.4
Enr. U Downgrade	--	--	--	--	--	2,000	40	2,600	2,600	303.5
		Total Receipts				1,000,000	440	2,600	2,600	
<u>REMOVAL POINT</u>										
UO ₃ Powder Loadout	99,000	60	120	130	11	1,000,000	600	400	700	303.31
Purex Waste										
D-2	--	--	--	--	--	2,100	230	--	230	301.4
F-15/F-16	17	2	11	12	16	270	32	46	60	301.5
F-18	23	3	15	15	24	560	70	70	100	301.6
G-8	5	1	3	3	50	250	30	20	35	301.7
R-8	3	--	2	2	10	30	4	6	7	301.8
UO ₂ Waste										
Swamp	--	--	--	--	--	15	8	8	11	303.7
C-5	--	--	--	--	--	36	7	18	19	303.6
		Total Removals				1,000,000	650	400	750	
		Total Transfers					800	2,600	2,700	
							0.1%	0.3%	0.3%	

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TRANSFER MEASUREMENT STATISTICS

MATERIAL BALANCE SUMMARY

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OPERATION Chemical Processing Department					MATERIAL BALANCE AREA Enriched Uranium					
MEASUREMENT POINT	PER TRANSFER. 1b U				TRANSFER PER MONTH	PER MONTH. 1b U				REFERENCE
	NOM AV	FE	RE	TE		NOM AV	FE	RE	TE	
<u>RECEIPT POINT</u>										
Fuel Element U	16,000	11	10	15	19	300,000	200	45	210	305.1
UO ₃ Container Heels	80	8	11	14	3	240	24	18	30	303.4
Total Receipts						300,000	200	50	210	
<u>REMOVAL POINT</u>										
UO ₃ Powder Loadout	99,000	60	120	130	3	300,000	180	210	280	303.32
Enriched U Downgrade	--	--	--	--	1	2,000	40	2,600	2,600	303.5
Redox Waste										
H-10	28	3	16	16	19	530	58	70	90	302.3
D-7/D-9	2	--	1	1	64	160	32	10	34	302.4
D-2	--	--	--	--	100	5	1	2	2	302.5
UO ₂ Waste										
C-5	--	--	--	--	1	9	2	13	13	303.6
Swamp	--	--	--	--	1	3	2	4	4	303.7
Total Removals						300,000	200	2,600	2,600	
Total Transfers							280	2,600	2,600	
							0.1%	0.9%	0.9%	

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TRANSFER MEASUREMENT STATISTICS
MATERIAL BALANCE SUMMARY

OPERATION Chemical Processing Department					MATERIAL BALANCE AREA Total Uranium					
MEASUREMENT POINT	PER TRANSFER, 1b U				TRANSFER PER MONTH	PER MONTH, 1b U				REFERENCE
	NOM AV	FE	RE	TE		NOM AV	FE	RE	TE	
RECEIPT POINT										
Fuel Element U										
Depleted	20,000	9	17	20	50	1,000,000	430	110	440	305.1
Enriched	16,000	11	10	15	19	300,000	200	45	210	305.1
UO ₃ Container Heels	80	8	11	14	30	1,100	90	40	100	303.4
		Total Receipts				1,300,000	480	120	500	

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TRANSFER MEASUREMENT STATISTICS

301. PUREX PLANT MEASUREMENTS

- 301.1 L-9 Plutonium Loadout
- 301.2 K-6 UNH Loadout
- 301.3 UO₂ - Recovered Acid, Tanks 13-14
- 301.4 D-2 Coating Waste
- 301.5 F-15/F-16 Salt Waste
- 301.6 F-18 Utility Waste
- 301.7 G-8 Organic Wash Waste
- 301.8 R-8 Organic Wash Waste

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BUILDING Purex	MEASUREMENT POINT L-9 Pu Loadout	MATERIAL BALANCE REFERENCES 201.1, 204.1, 204.2
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TRANSFER QUANTITY CALCULATIONS

Plutonium, g = (Pu analysis, lb/gal) $\frac{(\text{Net weight, kg})(119.83 \text{ g-gal/lb-liter})}{\text{Sp. Gr., kg/liter}}$

MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% CL ERROR			NOTES
			FIXED	RANDOM	TOTAL	
Pu analysis, PuX-3a, bias corrected monthly	2.16 lb/gal	34	0.014 0.7%	0.034 1.6%	0.037 1.7%	1
Specific gravity, DZ-1a, bias corrected monthly	1.52	34	0.001 0.1%	0.008 0.5%	0.008 0.5%	1
Net weight, Toledo Scale, Model 2481	10.4 kg	170	--	20 g 0.2%	20 g 0.2%	2
Sampling, bottle	--	34	--	--	--	3
Pu, per PR can	1,770 g	170	12 g 0.7%	30 g 1.7%	32 g 1.8%	
Pu, per batch (5 cans)	8,800 g	34	60 g 0.7%	150 g 1.7%	160 g 1.8%	
Pu, per month	300,000 g		2,100 g 0.7%	900 g 0.3%	2,300 g 0.8%	

NOTES

1. Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory.
2. Based on analysis of scale check weight results, FY-1963. Bias correction determined and applied on an individual can basis.
3. Based on data supporting HW-62174, "SS Materials Sampling Within the CPD," by D. W. Hoba, September 21, 1959.

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BUILDING	MEASUREMENT POINT	MATERIAL BALANCE REFERENCES				
Purex	K-6 UNH Loadout	201.3, 201.4				
TRANSFER QUANTITY CALCULATIONS						
Uranium, lb = $\frac{(\text{Mano. Diff., in.})(\text{Tank slope, gal/in.})}{(\text{Sp. Gr.})}$ (U analysis, lb/gal)						
MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% CL ERROR			NOTES
			FIXED	RANDOM	TOTAL	
Tank slope, cumulative regression model	48 gal/in.	--	0.18 0.38%	--	0.18 0.38%	1
Manometer difference, Trimount, #3 oil	130 in.	65	0.3 in 0.2%	3 in 2.1%	3 in 2.1%	1,2
Specific Gravity, DZ-1a, bias corrected monthly	1.65	65	0.0005 0.03%	0.0056 0.34%	0.0056 0.34%	3
Uranium analysis, UX-2a, bias corrected monthly	4.1 lb/gal.	65	0.017 0.42%	0.046 1.1%	0.05 1.2%	3
Sampling, Purex C-Type	--	65	--	--	--	4
Uranium, per batch (3,800 gal)	15,500 lb	65	90 lb 0.6%	370 lb 2.4%	380 lb 2.5%	
Uranium, per month	1,000,000 lb		6,000 lb 0.6%	3,000 lb 0.3%	7,000 lb 0.7%	
NOTES 1. Based on letter, D. W. Hoba to File, December 20, 1960, titled "Purex K-6 UNH Tank". 2. Fixed error based on possible manometer oil variations. 3. Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory. 4. None detectable HW-62174 HW-56341						

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TRANSFER MEASUREMENT STATISTICS

BUILDING Purex	MEASUREMENT POINT U00 - Recovered Acid, Tanks 13-14	MATERIAL BALANCE REFERENCES 201.2, 201.3, 203.1, 203.3
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TRANSFER QUANTITY CALCULATIONS

Dep. U, lb = (Uranium analysis, lb/gal) $\frac{(\text{Mano. difference, in.})(\text{Tank slope, gal/in.})}{(\text{Sp. Gr.})}$

MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% C L ERROR			NOTE
			FIXED	RANDOM	TOTAL	
U analysis, UX-4a	0.078 lb/gal	16	0.001 1.6%	0.006 8.0%	0.006 8.2%	1
Manometer difference, 2 parallel Tri- mount Type 22-24 mercury manometers	90 in.	16	--	2 in. 2.0%	2 in. 2.0%	2
Tank slope, calibrated May, 1959	97.44 gal/in.	--	1.07 1.1%	--	1.07 1.1%	3
Specific Gravity, DZ-1a	1.3	16	0.0003 0.02%	0.003 0.2%	0.003 0.2%	1
Sampling, line circulated and sampled into 100 ml bottle	--	16	--	--	--	4
Depleted Uranium per batch (6,700 gal)	540 lb	16	10 lb 1.9%	44 lb 8.2%	46 lb 8.5%	
Depleted Uranium per month	8,600 lb	--	165 lb 1.9%	180 lb 2.1%	240 lb 2.8%	

NOTES

1. Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory.
2. Based on vendor's reliability statements and readability error.
3. Based on error associated with difference between actual calibration and line of best fit.
4. Sampling error assumed negligible, due to homogeneity of stream and high analytical uncertainty.

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TRANSFER MEASUREMENT STATISTICS

BUILDING Purex	MEASUREMENT POINT D-2 Coating Waste	MATERIAL BALANCE REFERENCES 201.1, 201.2, 201.3, 205.2, 205.4
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TRANSFER QUANTITY CALCULATIONS

$U, lb = (Factor, \% \text{ of input})(U \text{ input, lb } U)$

$Pu, g = (Factor, \% \text{ of input})(Pu \text{ input, g } Pu)$

MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% C L ERROR			NOTE
			FIXED	RANDOM	TOTAL	
Factor, % of input based on 38 batches	0.21%	--	0.02% 11%	--	0.02% 11%	1,2,
U input	1,000,000 lb	--	--	--	--	4
Pu input	300,000 g	--	1,500 g 0.5%	8,900 g 2.9%	8.900 g 3%	5
Uranium, per month	2,100 lb	--	230 lb 11%	--	230 lb 11%	
Plutonium, per month	600 g	--	70 g 11%	20 g 3%	70 g 11%	

NOTES

1. HW-71321, "Cesium-137 as an Index of the Nuclear Materials Content of Coating Waste", by R. A. Schneider, October 11, 1961.
2. HW-73504, "Analysis of Cesium-137 in Coating Waste", by J. Mishima, May 3, 1962.
3. Based on Purex assay data, 4th Quarter, FY-1963.
4. Error negligible, see 305.1.
5. See 305.2.

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TRANSFER MEASUREMENT STATISTICS

BUILDING Purex	MEASUREMENT POINT F-15/F-16 Salt Waste	MATERIAL BALANCE REFERENCES 201.1, 201.2, 201.3, 205.2, 205.4
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TRANSFER QUANTITY CALCULATIONS

$U, lb = (U \text{ analysis, lb/gal})(\text{Volume transferred, gal})$

$Pu, g = (Pu \text{ analysis, cpm/gal})(ICF, g/cpm)(\text{Volume transferred, gal})$

MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% C L ERROR			NOTES
			FIXED	RANDOM	TOTAL	
U analysis, UF-1c	7×10^{-3} lb/gal	16	0.8×10^{-3} 12%	4×10^{-3} 60%	4×10^{-3} 61%	1
Pu analysis, PuA-20a	7×10^8 cpm/gal	16	0.6×10^8 9%	2×10^8 28%	2×10^8 29%	1
ICF, calculated monthly from L-9 data	1.24×10^{-11} g/cpm	1	0.02×10^{-11} 1.6%	0.01×10^{-11} 0.7%	0.02×10^{-11} 1.7%	2
Wt. factor difference, Foxboro trans- mitter and recorder	45 in.	16	--	1 in. 2%	1 in. 2%	3
Tank calibration, water increment, August, 1961	70 gal/in.	--	0.7 1%	--	0.7 1%	4
Sp. Gr., Republic transmitter and Foxboro recorder	1.3	16	0.02 1.5%	0.02 1.5%	0.03 2%	3
Sampling, Purex A-type	--	16	--	30%	30%	5
Uranium, per batch (2,400 gal)	17 lb	16	2 lb 12%	11 lb 67%	12 lb 68%	
Plutonium, per batch (2,400 gal)	21 g		2 g 9%	9 g 41%	9 g 42%	
Uranium, per month	270 lb		32 lb 12%	46 lb 17%	60 lb 21%	
Plutonium, per month	340 g		31 g 9%	34 g 10%	50 g 14%	

NOTES

1. Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory.
2. Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory for L-9 PuX-3a and PuA-6b-1.
3. Based on vendor's reliability statements and readability error.
4. Based on error associated with difference between actual calibration and line of best fit.
5. Estimated from duplicate sample results and standards and referee results as compiled by CPD/Separations Chemistry Laboratory.

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TRANSFER MEASUREMENT STATISTICS

BUILDING	MEASUREMENT POINT	MATERIAL BALANCE REFERENCES				
Purex	F-18 Utility Waste	201.1, 201.2, 201.3, 205.2, 205.4				
TRANSFER QUANTITY CALCULATIONS						
U, lb = (U analysis, lb/gal)(Volume transferred, gal)						
Pu, g = (Pu analysis, cpm/gal)(ICF, g/cpm)(Volume transferred, gal)						
MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% C L ERROR			NOTE
			FIXED	RANDOM	TOTAL	
U analysis, UF-1c	7x10 ⁻³ lb/gal	24	0.8x10 ⁻³ 12%	4x10 ⁻³ 60%	4x10 ⁻³ 61%	1
Pu analysis, PuA-20a	3x10 ⁸ cpm/gal	24	0.3x10 ⁸ 9%	1x10 ⁸ 28%	1x10 ⁸ 29%	1
ICF, calculated monthly from L-9 data	1.24x10 ⁻¹¹ g/cpm	1	0.02x10 ⁻¹¹ 1.6%	0.01x10 ⁻¹¹ 0.7%	0.02x10 ⁻¹¹ 1.7%	2
Wt. factor difference, Foxboro trans- mitter and recorder	50 in.	24	--	1 in. 2%	1 in. 2%	3
Tank calibration, water increment, July, 1957	70 gal/in.	--	0.7 1%	--	0.7 1%	4
Sp. Gr., Republic transmitter and Foxboro recorder	1.1	24	0.02 1.5%	0.02 1.5%	0.02 2%	3
Sampling, Purex A-type	--	24	--	25%	25%	5
Uranium, per batch (3,200 gal)	23 lb	24	3 lb 12%	15 lb 65%	15 lb 66%	
Plutonium, per batch (3,200 gal)	1.2 g		1 g 9%	5 g 38%	5 g 39%	
Uranium, per month	560 lb		70 lb 12%	70 lb 13%	100 lb 18%	
Plutonium, per month	290 g		26 g 9%	23 g 8%	35 g 12%	

NOTES

- Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory.
- Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory for L-9 PuX-3a and PuA-6b-1.
- Based on vendor's reliability statements and readability error.
- Based on error associated with difference between actual calibration and line of best fit.
- Estimated from duplicate sample results and standards and referee results as compiled by CPD/Separations Chemistry Laboratory.

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TRANSFER MEASUREMENT STATISTICS

BUILDING	MEASUREMENT POINT	MATERIAL BALANCE REFERENCES
Purex	G-8 Organic Wash Waste	201.1, 201.2, 201.3, 205.2, 205.4

TRANSFER QUANTITY CALCULATIONS

U, lb = (U analysis, lb/gal) $\frac{(\text{Wt. factor difference, in.})(\text{Tank calibration})}{(\text{Sp. Gr.})}$

Pu, g = Factor, g Pu

MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% CL ERROR			NOTE
			FIXED	RANDOM	TOTAL	
U analysis, UF-1c	1.5×10^{-3} lb/gal	50	0.2×10^{-3} 12%	0.9×10^{-3} 60%	0.9×10^{-3} 61%	1
Wt. factor difference, Foxboro transmitter and recorder	50 in.	50	--	1 in. 2%	1 in. 2%	2
Tank calibration, water increment, July, 1957	70 gal/in.	--	0.7 1%	--	0.7 1%	3
Sp. Gr., Republic transmitter and Foxboro recorder	1.01	50	0.015 1.5%	0.015 1.5%	0.02 2%	2
Sampling, Purex A-type	--	50	--	--	--	4
Pu factor	2 g	50	1 g 56%	5 g 250%	5 g 256%	5
Uranium, per batch (3,500 gal)	5 lb	50	1 lb 12%	3 lb 60%	3 lb 62%	
Plutonium, per batch (3,500 gal)	2 g		1 g 56%	5 g 250%	5 g 256%	
Uranium, per month	250 lb		30 lb 12%	20 lb 8%	35 lb 14%	
Plutonium, per month	100 g		56 g 56%	35 g 35%	66 g 66%	

NOTES

1. Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory.
2. Based on vendor's reliability statements and readability error.
3. Based on error associated with difference between actual calibration and line of best fit.
4. Sampling error not discernable due to large analytical uncertainties.
5. Factor based on analyses of 20 batches per quarter, selected at random.

TRANSFER MEASUREMENT STATISTICS

BUILDING Purex	MEASUREMENT POINT R-8 Organic Wash Waste	MATERIAL BALANCE REFERENCES 201.1, 201.2, 201.3, 205.2, 205.4
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TRANSFER QUANTITY CALCULATIONS

$U, lb = (U \text{ analysis, lb/gal})(\text{Volume transferred, gal})$

$Pu, g = (Pu \text{ analysis, cpm/gal})(ICF, g/cpm)(\text{Volume transferred, gal})$

MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% C L ERROR			NOTE:
			FIXED	RANDOM	TOTAL	
U analysis, UF-1c	1×10^{-3} lb/gal	10	0.1×10^{-3} 12%	0.6×10^{-3} 60%	0.6×10^{-3} 61%	1
Pu analysis, PuA-6b	3×10^6 cpm/gal	10	0.1×10^6 4%	1×10^6 30%	1×10^6 30%	1
ICF, calculated monthly	1.24×10^{-11} g/cpm	1	0.02×10^{-11} 1.6%	0.01×10^{-11} 0.7%	0.02×10^{-11} 1.7%	2
Wt. factor difference, Foxboro trans- mitter and recorder	35 in.	10	--	0.7 in. 2%	0.7 in. 2%	3
Sp. Gr., Republic transmitter and Foxboro recorder	1.00	10	0.015 1.5%	0.015 1.5%	0.02 2%	3
Tank calibration, water increment, July, 1957	70 gal/in.	--	0.7 1%	--	0.7 1%	4
Sampling, Purex C-type	--	--	--	--	--	5
Uranium, per batch (2,400 gal)	3 lb	10	0.4 lb 12%	2 lb 60%	2 lb 61%	
Plutonium, per batch (2,400 gal)	<0.1 g		<0.01 g 5%	<0.03 g 30%	<0.03 g 30%	
Uranium, per month	30 lb		4 lb 12%	6 lb 19%	7 lb 22%	
Plutonium, per month	<1 g		<0.1 g 5%	<0.1 g 9%	<0.1 g 10%	

NOTES

1. Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory.
2. Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory for L-9 PuX-3a and PuA-6b-1.
3. Based on vendor's reliability statements and readability error.
4. Based on error associated with difference between actual calibration and line of best fit.
5. Sampling error not discernable due to large analytical uncertainties.

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TRANSFER MEASUREMENT STATISTICS

302. REDOX PLANT MEASUREMENTS

302.1 L-6 Plutonium Loadout

302.2 E-12 UNH Loadout

302.3 H-10 Coating Waste

302.4 D-7/D-9 Salt Waste

302.5 D-2 Organic Wash Waste

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BUILDING	MEASUREMENT POINT	MATERIAL BALANCE REFERENCES				
Redox	L-6 Pu Loadout	202.1, 204.1, 204.2				
TRANSFER QUANTITY CALCULATIONS						
Plutonium, g = (Pu analysis, g/gal) $\frac{(\text{Net weight, kg})(0.2642 \text{ gal/liter})}{\text{Sp. Gr., kg/liter}}$						
MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% C L ERROR			NOTES
			FIXED	RANDOM	TOTAL	
Pu analysis, PuX-3a, bias corrected monthly	980 g/gal	17	6 g/gal 0.6%	9 g/gal 0.9%	11 g/gal 1.1%	1
Sp. Gr., DZ-1a, bias corrected monthly	1.55 kg/l	17	0.003 0.2%	0.01 0.6%	0.01 0.6%	1
Net Weight, Toledo Scale Model 2431	10 kg	60	60 g 0.6%	50 g 0.5%	77 g 0.8%	2
Sampling, bottle	--	17	--	1.0%	1.0%	3
Pu, per PR can	1,600 g	60	14 g 0.9%	25 g 1.6%	29 g 1.8%	
Pu, per batch (3 or 4 cans)	5,200 g	17	50 g 0.9%	80 g 1.5%	90 g 1.7%	
Pu, per month	90,000 g	--	810 g 0.9%	350 g 0.4%	880 g 1.0%	
NOTES 1. Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory. 2. Based on analysis of scale check weight results, FY 1963. 3. Based on data supporting HW-62174: "SS Materials Sampling Within the Chemical Processing Department" by D. W. Hoba, September 21, 1959.						

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BUILDING	MEASUREMENT POINT	MATERIAL BALANCE REFERENCES				
Redox	E-12 UNH Loadout	202.3, 202.4				
TRANSFER QUANTITY CALCULATIONS						
Uranium, lb= $\frac{(\text{Mano. Diff., in.})(\text{Tank slope, gal/in.})}{(\text{Sp. Gr.})}$ (U analysis, lb/gal)						
MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% CL ERROR			NOTES
			FIXED	RANDOM	TOTAL	
Tank slope, cumulative regression model	23.132 gal/in.	--	0.097 0.42%	--	0.097 0.42%	1
Manometer difference, King Model AS-76	114 in.	46	0.3 in. 0.3%	0.8 in. 0.67%	0.8 in. 0.73%	1,2
Specific Gravity, DW-1a	1.64	46	0.0005 0.03%	0.0009 0.05%	0.001 0.06%	3
Uranium analysis, UX-2a, bias corrected monthly	4.0 lb/gal	46	0.009 0.23%	0.02 0.50%	0.02 0.55%	3
Sampling	--	46	--	0.5%	0.5%	4
Uranium, per batch (1,600 gal)	6,500 lb	46	37 lb 0.57%	64 lb 0.98%	73 lb 1.12%	
Uranium, per month	300,000 lb	--	1,710 lb 0.57%	430 lb 0.14%	1,760 lb 0.59%	
NOTES 1. Based on letter, D. W. Hoba to J. R. Cartmell, et al., April 17, 1962, titled "Calibration Report - Redox E-12 UNH Tank". 2. Fixed error based on possible manometer oil variations. 3. Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory. 4. Based on letter, D. W. Hoba to P. H. Parker, July 10, 1958, titled "E-12 Sampling Plan-Preliminary Findings", and on supporting data.						

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BUILDING Redox	MEASUREMENT POINT H-10 Coating Waste	MATERIAL BALANCE REFERENCES 202.1, 202.2, 202.3, 205.3, 205.4				
TRANSFER QUANTITY CALCULATIONS						
$U, lb = (Factor, \mu c Cs-137)(Factor, lb U/\mu c Cs-137)$ $Pu, g = (Factor, \mu c Cs-137)(Factor, g Pu/\mu c Cs-137)$						
MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% CL ERROR			NOTES
			FIXED	RANDOM	TOTAL	
Factor, μc Cs-137 per batch based on 42 batches	4.21×10^7 μc Cs-137	19	0.35×10^7 8%	2.27×10^7 54%	2.30×10^7 55%	1
Factor, g Pu/ μc Cs-137	1.893×10^{-7} g/ μc	19	0.1×10^{-7} 5%	0.2×10^{-7} 10%	0.2×10^{-7} 11%	2
Factor, lb U/ μc Cs-137	5.667×10^{-7} lb/ μc	19	0.5×10^{-7} 7%	1.0×10^{-7} 15%	1.1×10^{-7} 17%	2
U Factor (per batch)	28 lb	19	3 lb 11%	16 lb 56%	16 lb 57%	
Pu Factor (per batch)	8 g		1 g 9%	4 g 55%	4 g 56%	
U, per month	530 lb	--	58 lb 11%	70 lb 13%	90 lb 17%	
Pu, per month	150 g		14 g 9%	19 g 13%	24 g 16%	
NOTES 1. Based on letter, HW-78915, C. J. Shortess to C. B. Foster, September 11, 1963, titled "Product Losses to Redox H-10 Coating Waste". 2. HW-71321: "Cesium-137 as an Index of the Nuclear Materials Content of Coating Waste" by R. A. Schneider, October 11, 1961.						

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BUILDING	MEASUREMENT POINT	MATERIAL BALANCE REFERENCES				
Redox	D-7/D-9 Salt Waste	202.1, 202.2, 202.3, 205.3, 205.4				
TRANSFER QUANTITY CALCULATIONS						
$U, lb = (U \text{ analysis, lb/gal}) \frac{(\text{Manometer difference})(\text{Tank calibration})}{(\text{Sp. Gr.})}$ $Pu, g = (Pu \text{ analysis, cpm/gal})(ICF, g/cpm) \frac{(\text{Manometer difference})(\text{Tank calibration})}{(\text{Sp. Gr.})}$						
MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% CL ERROR			NOTES
			FIXED	RANDOM	TOTAL	
U analysis, UF-1b	1.5×10^{-3} lb/gal	64	0.3×10^{-3} 20%	0.7×10^{-3} 46%	0.8×10^{-3} 50%	1
Pu analysis, PuA-20a	1.7×10^8 cpm/gal	64	0.1×10^8 3%	0.3×10^8 17%	0.3×10^8 17%	1
ICF- calculated monthly from L-6 data	1.23×10^{-11} g/cpm	1	0.01×10^{-11} 1.0%	0.01×10^{-11} 0.8%	0.02×10^{-11} 1.3%	2
Manometer difference, Trimount 22-70 (D7), 50-W (D9)	100 in.	64	2 in. 2%	2 in. 2%	3 in. 3%	3
Tank calibration, meter pump	23 gal/in.	--	0.5 2%	--	0.5 2%	4
Specific gravity, DZ-1a	1.35	64	<0.01 <1%	<0.01 <1%	<0.01 <1%	1
Sampling, doorstep	--	64	--	--	--	5
Uranium, per batch (1,700 gal)	2.5 lb	64	0.5 lb 20%	1.2 lb 46%	1.2 lb 50%	
Plutonium, per batch (1,700 gal)	3.5 g		0.1 g 4%	0.6 g 17%	0.6 g 17%	
Uranium, per month	160 lb		32 lb 20%	10 lb 6%	34 lb 21%	
Plutonium, per month	220 g		9 g 4%	5 g 2%	10 g 5%	
<p>NOTES</p> <ol style="list-style-type: none"> Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory. Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory for L-6 PuX-3a and PuA-6b-1. Based on vendor's reliability statements and readability error. Error is an estimate based on the analysis of similar type calibrations. HW-62174, "SS Materials Sampling Within the CPD", by D. W. Hoba, September 21, 1959. 						

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BUILDING	MEASUREMENT POINT	MATERIAL BALANCE REFERENCES				
Redox	D-2 Organic Wash Waste	202.1, 202.2, 202.3, 205.3, 205.4				
TRANSFER QUANTITY CALCULATIONS						
$U, lb = (U \text{ analysis, lb/gal})(\text{Volume transferred, gal})$ $Pu, g = (Pu \text{ analysis, cpm/gal})(ICF, g/cpm)(\text{Volume transferred, gal})$						
MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% CL ERROR			NOTES
			FIXED	RANDOM	TOTAL	
U analysis, UF-1c	6×10^{-6} lb/gal	2	1×10^{-6} 20%	3×10^{-6} 46%	3×10^{-6} 50%	1
Pu analysis, PuA-20t	1×10^5 cpm/gal	2	0.1×10^5 10%	0.3×10^5 30%	0.3×10^5 32%	2
ICF, calculated monthly from L-6 data	1.23×10^{-11} g/cpm	1	0.01×10^{-11} 1.0%	0.01×10^{-11} 0.8%	0.01×10^{-11} 1.3%	3
Volume trans., amount det. by adding value from calib. table to value obtained from continuous flow into tank	8000 gal	100	800 gal 10%	4000 gal 50%	4000 gal 50%	4
Sampling and Compositing	--	100/1	--	10%	10%	5
Uranium, per month	5 lb		1 lb 25%	2 lb 34%	2 lb 42%	
Plutonium, per month	1 g		0.1 g 14%	0.2 g 24%	0.3 g 28%	
NOTES <ol style="list-style-type: none"> Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory for UF-1b and on duplicate analysis data. Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory for PuA-20a and on duplicate analysis data. Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory for L-6 PuX-3a and PuA-6b-1. Error estimated from maximum variance of continuous flow into tank. Based on U analyses as run on each batch. 						

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303. UO₃ PLANT MEASUREMENTS

- 303.1 C-1 UNH Receiver
- 303.2 X-36 UNH Receiver
- 303.3 UO₃ Powder Loadout
- 303.4 UO₃ Container Heels
- 303.5 Enriched Uranium Downgrade
- 303.6 C-5 Waste
- 303.7 Swamp Waste

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BUILDING 224-U	MEASUREMENT POINT C-1 UNH Receiver	MATERIAL BALANCE REFERENCES 201.2, 201.4, 203.1, 203.3
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TRANSFER QUANTITY CALCULATIONS

Dep. Uranium, lb = $\frac{(\text{Tank slope, gal/in.})(\text{Mano. difference, in.})}{(\text{Sp. Gr.})}$ (U analysis, lb/gal)

MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% CL ERROR			NOTE
			FIXED	RANDOM	TOTAL	
Tank slope, cumulative regression model	38.61 gal/in.	--	0.066 0.17%	-- --	0.066 0.17%	1
Manometer difference, Meriam Prec. Mano. 30FE35	120 in.	90	0.12 in. 0.1%	0.26 in. 0.21%	0.28 in. 0.23%	1, 2
Uranium analysis, UD-1a, bias corrected monthly	4.0 lb/gal	20	0.006 0.14%	0.017 0.43%	0.018 0.45%	3, 4
Specific Gravity, DW-1a, bias corrected monthly	1.6	20	0.0005 0.03%	0.0016 0.10%	0.0017 0.10%	3
Sampling and Compositing	--	20	--	--	--	5
Dep. Uranium per batch (2,900 gal)	11,000 lb	90	26 lb 0.24%	54 lb 0.49%	60 lb 0.55%	
Dep. Uranium per month	1,000,000 lb	--	2400 lb 0.24%	1000 lb 0.10%	2600 lb 0.26%	

NOTES

1. Based on letter, C. G. Hough to J. J. Courtney, February 17, 1960, titled "Calibration of C-1 Vessel (January 27, 1960)".
2. Manometer scale and range checked monthly with Wallace-Tierman Precision Pressure Gauge ($\pm 0.1\%$). Zero checked weekly.
3. Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory.
4. See also letter, J. H. Campbell and C. W. Pollock to J. W. Jordan and A. D. Waligura February 23, 1962, titled "Uranium Analysis by Specific Gravity".
5. HW-62174: "SS Materials Sampling Within the CPD" by D. W. Hoba, September 21, 1959.

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TRANSFER MEASUREMENT STATISTICS

BUILDING 224-U	MEASUREMENT POINT X-36 UNH Receiver	MATERIAL BALANCE REFERENCES 202.2, 202.4, 203.2, 203.3
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TRANSFER QUANTITY CALCULATIONS

Enr. Uranium, lb = $\frac{(\text{Tank slope, gal/in.})(\text{Mano. difference, in.})}{(\text{Sp. Gr.})}$ (U analysis, lb/gal)

MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% C L ERROR			NOTES
			FIXED	RANDOM	TOTAL	
Tank slope (cumulative regression model)	38.45 gal/in.	--	0.23 0.6%	--	0.23 0.6%	1
Mano. difference, Meriam Type W Mano. Model M-100	110 in	30	0.1 in. 0.1%	1 in. 0.9%	1 in. 0.9%	1,2
Uranium analysis, UD-1a, bias corrected monthly	3.8 lb/gal	30	0.005 0.14%	0.015 0.4%	0.016 0.4%	3,4
Specific Gravity, DW-1a, bias corrected monthly	1.6	30	0.0005 0.03%	0.0016 0.1%	0.0017 0.1%	3
Sampling	--	30	--	--	--	5
Enr. Uranium per batch (2,600 gal)	10,000 lb	30	60 lb 0.6%	100 lb 1.0%	120 lb 1.2%	
Enr. Uranium, per month	300,000 lb	--	1,800 lb 0.6%	540 lb 0.2%	1,900 lb 0.6%	

NOTES

1. Based on calibration data taken in July, 1960.
2. Manometer scale and range checked monthly with Wallace-Tiernan Precision Pressure Gauge ($\pm 0.1\%$). Zero checked weekly.
3. Based on standards and referee results as compiled by CPD/Separations Chemistry Laboratory.
4. See also letter, J. H. Campbell and C. W. Pollock to J. W. Jordan and A. D. Waligura, February 23, 1962, titled "Uranium Analysis by Specific Gravity".
5. HW-62174: "SS Materials Sampling Within the CPD" by D. W. Hoba, September 21, 1959.

TRANSFER MEASUREMENT STATISTICS

BUILDING	MEASUREMENT POINT	MATERIAL BALANCE REFERENCES				
224-U	UO ₃ Container Heels	203.1, 203.2, 203.3, 205.2, 205.3, 205.4				
TRANSFER QUANTITY CALCULATIONS						
Uranium, lb = (Container wt., lb - Tare weight, lb)(Average U analysis, wt. % U)						
MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% C L ERROR			NOTES
			FIXED	RANDOM	TOTAL	
Container wt., weighed by shipper	2,000 lb	110 30	1 lb 10%	3 lb 30%	3 lb 30%	1
Tare weight, historical tares as maintained by CKY	2,000 lb	110 30	--	3 lb 30%	3 lb 30%	2
Average U analysis for prior months	82% U	- -	1% U 1%	2% U 2%	2% U 2%	3
Uranium, per hopper (10 lb net weight)	8 lb	110 30	1 lb 10%	3 lb 40%	3 lb 40%	
Uranium, per carload	80 lb	11 3	8 lb 10%	11 lb 13%	14 lb 17%	
Enriched Uranium, per month	240 lb		24 lb 10%	18 lb 8%	30 lb 13%	
Depleted Uranium, per month	880 lb		90 lb 10%	35 lb 4%	100 lb 11%	
Total Uranium, per month	1 100 lb		90 lb 8%	40 lb 4%	100 lb 9%	
NOTES 1. Based on shipper-receiver gross weight data for depleted uranium cars 778 through 810, assuming equal variances at both sites. 2. Historical tares, determined for each hopper when new, are abridged only when actual tares indicate error. Random error in historical tares assumed to be equivalent to gross weight random error. 3. Maximum error in actual U content from average. Definitely insignificant.						

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BUILDING 224-U	MEASUREMENT POINT Enriched U Downgrade	MATERIAL BALANCE REFERENCES 203.1, 203.2, 205.2, 205.3				
TRANSFER QUANTITY CALCULATIONS						
Uranium Downgraded, = 1b	$\left[\begin{array}{ccc} \text{(U in} & \text{(U in} & \text{(U in} \\ \text{acid to} & \text{+ acid} & \text{- acid} \\ \text{Purex,1b)} & \text{EI,1b)} & \text{BI,1b)} \end{array} \right]$	$\frac{\text{(Enr. U throughput, 1b)}}{\text{(Enr. U + Dep. U throughput, 1b)}}$				
MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% C L ERROR			NOTES
			FIXED	RANDOM	TOTAL	
U in acid to Purex	10,000 1b U	1	200 1b 2%	200 1b 2%	300 1b 3%	1
U in acid inventories (Tanks 306,307, and 308)	10,000 1b U	2	200 1b 2%	1,000 1b 10%	1,000 1b 10%	2
Throughput ratio, enriched to total	0.20%	1	--	--	--	3
Correlation, uranium carry-over with powder throughput	(0.8% of throughput)	1	--	130%	130%	4
Enriched Uranium downgraded per month	2,000 1b		40 1b 2%	2,600 1b 130%	2,600 1b 130%	
Enriched Uranium downgraded per year	20,000 1b		400 1b 2%	8,000 1b 40%	8,000 1b 40%	
NOTES						
1. See 301.3.						
2. Estimated from data obtained for 301.3						
3. Error in throughput ratio negligible.						
4. Based on analysis of FY-1963 data as presented in letter, L. H. Steves to C. J. Shortess, Jr., August 22, 1963, titled, "Limits of Uncertainty - UO ₂ Enriched Uranium Downgrade".						

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TRANSFER MEASUREMENT STATISTICS

BUILDING	MEASUREMENT POINT	MATERIAL BALANCE REFERENCES				
224-U	C-5 Waste	203.1, 203.2, 203.3, 205.2, 205.3				
TRANSFER QUANTITY CALCULATIONS		205.4				
Total U, lb = (U analysis, lb/gal)(Integrator reading)(Volume factor, gal) Dep. U, lb = (Total U, lb)(Dep. U Throughput ratio) Enr. U, lb = (Total U, lb)(Enr. U Throughput ratio)						
MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% C L ERROR			NOTES
			FIXED	RANDOM	TOTAL	
Uranium analysis, UF-1c	1.5×10^{-4} lb/gal	1	0.3×10^{-4} 20%	0.7×10^{-4} 46%	0.8×10^{-4} 50%	1
Integrator reading	500	1	--	--	--	2
Integrator factor, meter-pump determined pump actuator limit	590 gal	--	10 gal 2%	--	10 gal 2%	3
Sampling and Compositing, automatic continuous sampler	--	--	--	--	--	4
Dep. U Throughput Ratio Correlation	0.8	1	--	0.18 23%	0.18 23%	5
Enr. U Throughput Ratio Correlation	0.2	1	--	0.26 130%	0.26 130%	5
Total Uranium per month	45 lb	--	9 lb 20%	20 lb 46%	22 lb 50%	
Depleted Uranium per month	36 lb	--	7 lb 20%	18 lb 51%	19 lb 55%	
Enriched Uranium per month	9 lb	--	2 lb 20%	13 lb 140%	13 lb 140%	
NOTES 1. Based on standards and referee results for Redox D-9 (UF-1b) as compiled by CPD/Separations Chemistry Laboratory. 2. Actual count of C-5 batches. 3. Based on error associated with meter pump calibrations. 4. Sampling error assumed negligible, based on nature of sampler. 5. Error in throughput ratio negligible. Error in correlation assumed to be same as error in enriched uranium downgrade (303.5).						

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BUILDING 224-U	MEASUREMENT POINT Swamp Waste	MATERIAL BALANCE REFERENCES 203.1, 203.2, 203.3, 205.2, 205.3, 205.4				
TRANSFER QUANTITY CALCULATIONS						
<p>Total Uranium, lb = (Uranium analysis, lb/gal)(Volume, gal)</p> <p>Dep. U, lb = (Total U, lb)(Dep. U Throughput ratio)</p> <p>Enr. U, lb = (Total U, lb)(Enr. U Throughput ratio)</p>						
MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% CL ERROR			NOTES
			FIXED	RANDOM	TOTAL	
Uranium analysis, UF-1c	7×10^{-7} lb/gal	1	1.4×10^{-7} 20%	3.2×10^{-7} 46%	3.5×10^{-7} 50%	1
Volume, constant factor based on prior performance	2.6×10^7 gal	--	1.3×10^7 50%	--	1.3×10^7 50%	2
Sampling and Compositing, automatic continuous sampler	--	--	--	--	--	3
Dep. U Throughput Ratio Correlation	0.8	1	--	0.18 23%	0.18 23%	4
Enr. U Throughput Ratio Correlation	0.2	1	--	0.26 130%	0.26 130%	4
Total Uranium per month	18 lb	--	10 lb 54%	8 lb 46%	13 lb 71%	
Depleted Uranium per month	15 lb	--	8 lb 54%	8 lb 51%	11 lb 75%	
Enriched Uranium per month	3 lb	--	2 lb 54%	4 lb 140%	4 lb 150%	
<p>NOTES</p> <p>1. Based on standards and referee results for Redox D-9 (UF-1b) as compiled by CPD/ Separations Chemistry Laboratory.</p> <p>2. Error estimated from prior data.</p> <p>3. Sampling error assumed negligible, based on nature of sampler.</p> <p>4. Error in throughput ratio negligible. Error in correlation assumed to be same as error in enriched uranium downgrade (303.5).</p>						

TRANSFER MEASUREMENT STATISTICS

BUILDING	MEASUREMENT POINT	MATERIAL BALANCE REFERENCES				
224-U	UO ₃ Powder Loadout - Depleted Uranium	203.1, 203.3, 205.2, 205.4				
TRANSFER QUANTITY CALCULATIONS						
Uranium, lb = (Gross weight, lb - Tare weight, lb)(Uranium analysis, wt. % U)						
U ₂₃₅ , lb = Uranium, lb x % U ₂₃₅						
MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95 % C L ERROR			NOTES
			FIXED	RANDOM	TOTAL	
Gross weight, Toledo Model 2271 FE Scale with Model 631 Print-Weight mechanism	14,000 lb	108	<1 lb <0.01%	6 lb 0.06%	6 lb 0.06%	1
Tare weight, historical tares as maintained by CKY	2,000 lb	108	--	3 lb 0.03%	3 lb 0.03%	2
Uranium analysis, gravimetric UG-1b	82%	11	0.05% U 0.06%	0.06% U 0.07%	0.08% U 0.09%	1
U ₂₃₅ , estimated from reactor date and blending in reprocessing facilities	0.64%	11	0.04%	0.50%	0.50%	1
Sampling and Compositing, composite of 10 samples, each taken from top of full hopper	--	11	--	0.09%	0.09%	1
Uranium, per hopper	9,900 lb	108	6 lb 0.06%	13 lb 0.13%	14 lb 0.14%	
Uranium, per carload shipment	99,000 lb	11	60 lb 0.06%	120 lb 0.12%	130 lb 0.13%	
U ₂₃₅ , per carload	630 lb	11	0.4 lb 0.07%	3 lb 0.52%	3 lb 0.52%	
Uranium, per month	1,000,000 lb		600 lb 0.06%	360 lb 0.04%	700 lb 0.07%	
U-235, per month	6,400 lb		4 lb 0.07%	10 lb 0.16%	11 lb 0.17%	
NOTES:						
1. Based on shipper-receiver data for depleted uranium cars 761 through 828, assuming equal variance at both sides. HWN-3162 - Personal Notebook - L. F. Wirfs.						
2. Historical tares, determined for each hopper when new, are abridged only when actual tares indicate error. Random error in historical tares assumed to be equivalent to the gross weight random error for five repetitive weight determinations.						

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BUILDING	MEASUREMENT POINT	MATERIAL BALANCE REFERENCES				
224-U	UO ₃ Powder Loadout - Enriched Uranium	203.2, 203.3, 205.3, 205.4				
TRANSFER QUANTITY CALCULATIONS						
Uranium, lb = (Gross weight, lb - Tare weight, lb)(Uranium analysis, wt. % U)						
U ₂₃₅ , lb = Uranium, lb x % U ₂₃₅						
MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% CL ERROR			NOTES
			FIXED	RANDOM	TOTAL	
Gross weight, Toledo Model 2271 FE Scale with Model 631 Print-Weight mechanism	14,000 lb	30	<1 lb <0.01%	6 lb 0.06%	6 lb 0.06%	1
Tare weight, historical tares as maintained by CKY	2,000 lb	30	--	3 lb 0.03%	3 lb 0.03%	2
Uranium analysis, gravimetric UG-1b	82%	3	0.05% U 0.06%	0.06% U 0.07%	0.08% U 0.09%	1
U ₂₃₅ , estimated from reactor data and blending in reprocessing facilities	0.85%	3	0.04%	0.50%	0.50%	1
Sampling and Compositing, composite of 10 samples, each taken from top of full hopper	--	3	--	0.09%	0.09%	1
Uranium, per hopper	9,900 lb	30	6 lb 0.06%	13 lb 0.13%	14 lb 0.14%	
Uranium, per carload shipment	99,000 lb	3	60 lb 0.06%	120 lb 0.12%	130 lb 0.13%	
U ₂₃₅ , per carload	840 lb	3	0.6 lb 0.07%	4 lb 0.52%	4 lb 0.52%	
Uranium, per month	300,000 lb		180 lb 0.06%	210 lb 0.07%	280 lb 0.09%	
U ₂₃₅ , per month	2,500 lb		2 lb 0.06%	8 lb 0.30%	8 lb 0.31%	
NOTES						
1. Based on shipper-receiver data for depleted uranium cars 761 through 828, assuming equal variance at both sides. HWN-3162 - Personal Notebook - L. F. Wirfs.						
2. Historical tares, determined for each hopper when new, are abridged only when actual tares indicate error. Random error in historical tares assumed to be equivalent to the gross weight random error for five repetitive weight determinations.						

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TRANSFER MEASUREMENT STATISTICS

304. Z-PLANT MEASUREMENTS

(This subsection and 204 have been combined into the "Weapons Data Appendix to CP - Nuclear Materials Transfer Measurement Statistics", HW-76361 APP.)

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CP - NUCLEAR MATERIALS

TRANSFER MEASUREMENT STATISTICS

305. REACTOR MEASUREMENTS

305.1 Fuel Element Uranium

305.2 Fuel Element Plutonium

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TRANSFER MEASUREMENT STATISTICS

BUILDING	MEASUREMENT POINT	MATERIAL BALANCE REFERENCES				
Reactors	Fuel Element Uranium	201.2, 201.3, 202.2, 202.3, 205.2, 205.3, 205.4				
TRANSFER QUANTITY CALCULATIONS						
Uranium, lb = (Factor weight) - (Burnout)						
MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% C L ERROR			NOTES
			FIXED	RANDOM	TOTAL	
<u>Depleted U</u>						
Factor weight, 10 factors currently in use	7.31 lb	140,000	0.003 lb 0.043%	0.32 lb 4.4%	.32 lb 4.4%	1,2
Burnout	.01 lb	140,000	.00017 lb .0023%	.002 lb .027%	.002 lb .027%	3
Depleted U, per dissolver charge (2,800 elements)	20,000 lb	50	9 lb 0.043%	17 lb .083%	20 lb .093%	
Depleted U per month	1,000,000 lb	--	430 lb 0.043%	110 lb 0.011%	440 lb 0.044%	
<u>Enriched U</u>						
Factor weight, 4 factors currently in use	5.31 lb	56,000	0.004 lb 0.067%	0.18 lb 3.5%	0.18 lb 3.5%	1,2
Burnout	.009 lb	56,000	.00025 lb .0047%	.001 lb .019%	.001 lb .009%	3
Enriched U, per dissolver charge (3,000 elements)	16,000 lb	19	11 lb 0.067%	10 lb .064%	15 lb .092%	
Enriched U, per month	300,000 lb	--	200 lb 0.067%	45 lb 0.015%	210 lb 0.069%	
NOTES 1. Factor weights are determined from average weights of statistical samples (~1.0%) of each shipment. 2. Random error is determined from variance of samples weighed. Fixed error is set by rounding factor weights to closest .01 lb. 3. Burnout error is estimated to be similar to that used for plutonium generation (See 305.2).						

TRANSFER MEASUREMENT STATISTICS

BUILDING	MEASUREMENT POINT	MATERIAL BALANCE REFERENCES				
Reactors	Fuel Element Plutonium	201.1, 202.1, 205.1				
TRANSFER QUANTITY CALCULATIONS						
Plutonium, g = f (normalized prediction, exposure)						
MEASUREMENT	NOMINAL AVERAGE VALUE	NO. PER MONTH	95% C.L. ERROR			NOTES
			FIXED	RANDOM	TOTAL	
<u>Purex Pu</u>						
Normalized prediction	0.85 g/MWD	--	0.50%	0.85% (yearly basis)	0.98%	1,2
Exposure	640 MWD	--				
Purex Pu per dissolver charge	6,000 g	50	30 g 0.50%	1,200 g 20%	1,200 g 20%	
Purex Pu per month	800,000 g	--	1,500 g 0.50%	8,800 g 2.94%	8,900 g 2.98%	2
<u>Redox Pu</u>						
Normalized prediction	0.70 g/MWD	--	0.80%	1.32% (yearly basis)	1.54%	1,2
Exposure	850 MWD	--				
Redox Pu per dissolver charge	5,000 g	19	40 g 0.80%	780 g 15%	800 g 16%	
Redox Pu per month	90,000 g	--	720 g 0.8%	3,100 g 3.4%	3,200 g 3.5%	2
NOTES						
<p>1. Fixed error based on difference between IPD prediction and Purex-Redox output purposely fixed by the normalization.</p> <p>2. Random error is calculated from average monthly variance estimates between IPD-CPD values. Since the error estimate is a function of amount of material (or time), the annual error was obtained by dividing by $\sqrt{12}$.</p>						

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