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TRANSFER MEASUREMENT STATISTIC DERIVED FROM
PUREX PROCESSING MEASUREMENTS' QUALITY CONTROL PROGRAM
SECOND HALF OF 1965

C. G. Hough
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TRANSFER MEASUREMENT STATISTIC DERIVED FROM
PUREX PROCESSING MEASUREMENTS' QUALITY CONTROL PROGRAM
SECOND HALF OF 1965

INTRODUCTION

This report gives an analysis of the audit data obtained during the last half of 1965 at eight transfer stations: L9 plutonium product, K6 uranium product, F15 salt waste, D5 dissolved feed, F18 utility waste, G8 organic wash waste, R8 organic wash waste, and U3 laboratory waste. Data obtained during the first half of 1965 for the transfer stations L9, K6, F15 and D5 were analyzed and discussed in an earlier report.⁽¹⁾

SUMMARY

The results are summarized for each transfer station in Table 1-8. In most cases results obtained during the second half of the year compared favorably to the first half.

The Purex quality control program can be improved in two ways. First, estimates of sampling error can be improved by analyzing one of the duplicate samples a second time (referee). This is discussed in more detail below under L9 Sampling Audit. Second, bias in manometer instruments and weight factor and specific gravity recorder instruments can be estimated and corrected by a relatively simple procedure. These potential sources of bias have not been monitored in the past and could cause significant bias (B-PID's) in uranium and plutonium material balance. A procedure is discussed below under K6 Tank Calibration.

(1) Hough, C. G. Transfer Measurement Statistics Derived from Purex Processing Measurements' Quality Control Program, BNWL-CC-315 (Secret), 11-23-65.

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Bias due to sampling is the only other significant source of error that is not well defined. Unfortunately, no relatively simple procedures for monitoring sampling bias have been developed over the years. The best insurance against this type of error is good agitation and circulation prior to sampling. An exception is the Gilmont samplers where additional precautions are needed. An example of the type of fluctuating bias that could be present at Gilmont sample stations is discussed below under F15 Sampling Audit.

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L9 Plutonium Product

Weighing Procedure Audit - PR Scales Calibration check is of little value from a statistical estimating viewpoint. Gross Weight Check data are useful and do provide variation estimates, however, it is considered unnecessary as long as Tare Weight Check (difference between can plus 10 kg check weight and tare weight) data are available.

Seven pairs of tare weight check data were obtained during the last half of 1965. This is considerably less than the four per month minimum recommended for this procedure. The bias between the observed average net weight and the standard 10 kilogram check weight was -1.8 grams. This compares with +2.4 grams during the first half of 1965 (18 data). Neither bias is significant at the 0.95 level. The scale random measurement precision (0.95 level) was estimated to be ± 25 grams or about 0.25 percent for a net weight of 10 kilograms. The scale precision for the first half of 1965 was erroneously reported⁽¹⁾ as ± 56 grams (0.95 level) when it should have been ± 36 grams. When data from the first and second half are combined the scale precision estimate is ± 31 grams which is the value given in Table 1.

Fixed error (0.95 level) of scale measurement was estimated by

$$FE = 31/\sqrt{4} = \pm 16 \text{ grams}$$

or about 0.15 percent for an average can loadout of 10.4 kilograms. This estimate assumes that the scale is tested by the tare weight check method four (4) times each month and a bias correction (or scale adjustment) is made once each month based on the average of the four tests. Actually the fixed error should be about ± 22 grams because the tare weight checks were made two times per month on the average during 1965 instead of the assumed four times.

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Analytical Control Audit -. Referee and Standards Program data covering the period 6-27-65 to 12-26-65 were analyzed and used to estimate random and fixed errors associated with the Pu assay (x-ray), radioassay (Pu A-6b) and specific gravity determinations. The results are given in Table 1 under the title "analytical." The random error estimates appear normal for these three analytical methods. The fixed error estimates compare favorable with estimates previously given in HW-76361. The respective fixed errors are based on the assumption that bias in each analytical method is checked by running known standards each month (5 for Pu by x-ray, 10 for PuA-6b and 15 for Sp. Gr.) and applying a monthly average bias correction.

Sampling Audit - Duplicate samples are taken and analyzed by the laboratory. Independence is ensured by selecting the second sample after the first has been delivered to the laboratory. The average range between the duplicate sample results is a measure of the combined effect of sampling and analytical variation. Data obtained during the last half of 1965 were analyzed and the results are given in Table 1 for each analytical method under the title "total."

Additional data is required to separate analytical variation from sampling variation. This is best accomplished by analyzing one of the duplicate samples a second time by a different analyst (referee). This is not currently done and as a result good estimates of sampling variation cannot be determined. Approximate estimates of sampling variation were obtained by using the Referee data discussed in the previous section and are listed in Table 1 under the title "Sampling." These estimates of sampling variation are not necessarily good estimates because analytical variation is based on an entirely different set of samples than the duplicate samples used to estimate "Total" variation. This is demonstrated by comparing sampling

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variation obtained for Pu A-6b during the first half of 1965⁽¹⁾ against the estimate obtained during the last half of 1965. It appears as though sampling variation improved from 2.8 percent to zero percent which is probably not true. It simply means that, during the last half of 1965, the combined analytical and sampling variation was relatively small for the set of duplicate samples and that analytical variation was relatively large for the set of referee samples. In other words the two sets of samples did not receive the same treatment with respect to analytical and sampling variation.

This problem can be avoided in the future by making sure that one of the duplicate samples is analyzed a second time (referee) by a different analyst.

Isotope Correction Factor (ICF)

The ICF is determined on each L9 plutonium product batch. A sample from each batch is analyzed for Pu by direct assay (Nominal value = 2.05 lb/gal) and by radioassay (nominal value = 7.6×10^{13} cpm/gal). The ratio of direct assay (Pu) to radioassay (AT) is multiplied by the conversion factor 453.59 g/lb to yield the ICF in units of g/cpm.

$$ICF = K \frac{Pu}{At}$$

A monthly ICF is determined by averaging the ICF values obtained on each batch within that month. Usually there are about 34 batches per month. This monthly ICF is used during the subsequent month to convert radioassay of waste streams to grams of plutonium.

The random error or precision of the monthly ICF is estimated as follows. In Table 1 it was shown that the standard deviation of the direct assay is 0.031 lb/gal and the standard deviation of a radioassay is 0.1165×10^{13} cpm/gal. Then the variance of an ICF ratio is

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$$\text{Var} \left(\frac{KX}{Y} \right) = \frac{K^2 \bar{X}^2}{\bar{Y}^2} \left[\frac{\sigma_x^2}{\bar{X}^2} + \frac{\sigma_y^2}{\bar{Y}^2} \right]$$

where K = constant to convert from lb to g, 453.59.

X = direct assay (Pu) in lb/gal

Y = radioassay (AT) in cpm/gal

σ_x = standard deviation of X

σ_y = standard deviation of Y

Substituting we obtain an estimate of $\text{Var}(KX/Y)$:

$$\begin{aligned} \text{Var} \left(\frac{KX}{Y} \right) &= \frac{(453.59)^2 (2.05)^2}{(7.6 \times 10^{13})^2} \left[\frac{(0.031)^2}{(2.05)^2} + \frac{(0.1165 \times 10^{13})^2}{(7.6 \times 10^{13})^2} \right] \\ &= 14970 \times 10^{-26} (0.0002287 + 0.0002350) \\ &= 14970 \times 10^{-26} (0.0004637) \\ &= 0.000694 \times 10^{-22} \end{aligned}$$

The standard deviation estimate is

$$\sqrt{\text{Var} \left(\frac{KX}{Y} \right)} = 0.0263 \times 10^{-11}$$

A typical ICF is 1.22×10^{-11} g/cpm and the standard deviation in percent units is $(0.0263 \times 10^{-11})(100)/(1.22 \times 10^{-11}) = 2.2$ percent. We are interested in computing the random error precision (0.95 level) of a monthly ICF which is approximately

$$\begin{aligned} \text{Precision of Monthly ICF} &= 2(\text{standard deviation})/\sqrt{\text{No. of batches}} \\ &= 2(0.0263 \times 10^{-11})/\sqrt{34} \\ &= 0.00904 \times 10^{-11} \end{aligned}$$

or about 0.75 in percent units. This is the value shown in Table 1 under random error (0.95 level)

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The direct assay and radioassay are known to be biased on the average. Analytical bias corrections are applied each month to correct for these biases. The bias corrections are determined by analyzing a known standard by direct assay and radioassay. The corrections are expressed in terms of percent recovery

$$\text{Percent recovery} = \frac{\text{observed value}}{\text{standard value}} \times 100$$

The recoveries are averaged to obtain the monthly average bias corrections. Typical average recoveries for the month of November 1965⁽²⁾ are 100.6 ± 0.8 percent for direct assay and 99.4 ± 3.4 percent for radioassay. The monthly average ICF is corrected by

$$\text{Corrected ICF} = (\text{Observed ICF}) \frac{(\text{Radioassay Recovery})}{(\text{Direct assay Recovery})}$$

$$= (1.22 \times 10^{-11}) \left(\frac{99.4}{100.6} \right) =$$

$$= 1.21 \times 10^{-11} \text{ g/cpm}$$

Based on many months of experience the standard deviation of a radioassay recovery is known to be about 1.8 percent and is about 0.92 percent for direct assay recovery (single determination). The standard deviation of the average monthly recoveries is $1.8/\sqrt{10} = 0.57$ percent and $0.92/\sqrt{5} = 0.41$ percent, respectively, where we assume the radioassay recovery is based on 10 standard determinations per month and the direct assay recovery is based on 5 standard determinations per month. These values (multiplied by two) were given in Table 1 as the fixed error associated with the radioassay and direct assay, respectively.

(2) C. W. Pollack, CPD Analytical Control Data Correction To Be Applied to Accountability Source Data - November 1965, 12-10-65, Unclassified.

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We now desire to compute the precision of the monthly bias correction used to correct the ICF factor. Let

$$\begin{aligned} B_y &= 99.4 \text{ percent} = \text{monthly average percent recovery of radioassay} \\ B_x &= 100.6 \text{ percent} = \text{monthly average percent recovery of direct assay} \\ B &= B_y/B_x = 99.4/100.6 = 0.988 = \text{ICF bias correction} \\ \sigma_{bx} &= 0.41 \text{ percent} = \text{standard deviation of average direct assay recovery} \\ \sigma_{by} &= 0.57 \text{ percent} = \text{standard deviation of average radioassay recovery.} \end{aligned}$$

Then the variance of B is given by

$$\text{Var}(B) = \text{Var}\left(\frac{B_y}{B_x}\right) = \frac{B_y^2}{B_x^2} \left[\frac{\sigma_{by}^2}{B_y^2} + \frac{\sigma_{bx}^2}{B_x^2} \right]$$

Substituting the above values we obtain an estimate of Var(B):

$$\begin{aligned} \text{Var}(B) &= \frac{(99.4)^2}{(100.6)^2} \left[\frac{(0.57)^2}{(99.4)^2} + \frac{(0.41)^2}{(100.6)^2} \right] \\ &= 0.97628 (0.00003288 + 0.00001661) \\ &= 0.97628 (0.00004949) \\ &= 0.4832 \times 10^{-4} \end{aligned}$$

The standard deviation estimate is

$$\sqrt{\text{Var } B} = 0.00695$$

and the 0.95 confidence limit for B is approximately

$$\begin{aligned} &0.988 \pm 2 (0.00695) \\ &0.988 \pm 0.0139 \end{aligned}$$

Thus, the fixed error associated with a corrected monthly ICF is $(0.0139)(100)/0.988 = 1.4$ percent and this value is given in Table 1.

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Propagation of Errors - Procedures used to compute overall batch variation were discussed in an earlier report.⁽¹⁾ Comparing the first half of 1965 to the second half of 1965 it appears as though batch random error increased from 1.6 percent to 3.1 percent. This may or may not reflect normal cycling of sampling and analytical error (Pu by X-ray). The estimates are based on 18 duplicate samples during the first half of 1965 and 14 duplicate samples during the last half of 1965. Statistically, the estimates are significantly different with 0.95 confidence.

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K6 Uranium Product

Analytical Control Audit - Referee and Standards Program data from the last half of 1965 were analyzed and used to estimate random and fixed errors for the uranium assay (x-ray) and specific gravity. The results are shown in Table 2. Random and fixed error estimates compare favorably with previous results. The respective fixed errors are based on the assumption that bias in each analytical method is checked by running known standards each month (10 for U by x-ray, 15 for Sp. Gr.) and applying a monthly average bias correction.

Sampling Audit - Thirteen duplicate samples were taken during the last half of 1965. The data were analyzed and the results are given in Table 2 for each analytical method under the title "Total." Approximate estimates of sampling error were obtained by observing the difference between the "total" estimates obtained on the duplicate samples and "analytical" estimates obtained from Referee samples. The sampling estimates compare favorably with the estimates obtained during the first half of 1965.

Tank Calibration - Volume error estimates do not change unless the tank is recalibrated. Fixed error due to the "manometer difference" does fluctuate. However, the present program does not provide data to measure this fluctuation. This can be accomplished by testing the service manometer at the average full and empty transfer levels (about 155" and 23" for K6) with a standard manometer at least once per week. For example, assume the service manometer readings corresponding to standard manometer pressures of 155.00" and 23.00" would be 155.32" and 23.06". The difference, $(155.32 - 23.06) - (155.00 - 23.00) = + 0.26"$ would be an estimate of bias in the net service manometer reading. However, it is only one estimate and we must repeat the test several times before we can be certain that the

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estimate is truly a bias as opposed to random variation. Suppose, at the end of the month we have four estimates, + 0.26, + 0.43, + 0.15, and +0.52. The average is 0.34 inches (about 16 gallons) and the standard deviation is 0.166. Confidence limits for the average (0.95 level) would be

$$+ 0.34 \pm (3.18)(0.166)/\sqrt{4}$$

$$+ 0.34 \pm 0.26 \text{ inches}$$

where 3.18 is Student's t factor for $n-1 = 3$ degrees of freedom. Since the confidence interval does not include zero we conclude the bias is significant. In percent units the bias would be $(0.34)(100)/132 = 0.26\%$. Thus all transfers made during the month could be corrected downward by this amount. The estimate of fixed error would be ± 0.26 inches or ± 0.20 in percent units. The bias could be eliminated by adjusting the service manometer (change oil, etc) but this is not absolutely necessary (unless gross errors are present) if monthly bias corrections were made. Needless to say, accuracy and reliability of the standard manometer is a prerequisite to this procedure and would probably require an instrument with quality comparable to the Wallace and Tierman FA 145 series.

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F15 Salt Waste

Analytical Control Audit - Referee and Standards Program data for the last half of 1965 were analyzed and used to estimate random and fixed errors for uranium (UF-1c) and plutonium (PuA-20a). Uranium in F-15 is not included in the Referee Program. The closest we can come to estimating analytical random error is to use referee data obtained on G-8 samples analyzed by the UF-1c method. Based on G-8 data, the estimate of analytical precision (0.95 level) is 1.1×10^{-3} lb U/gal or about 60 percent for an average F-15 concentration of 1.8×10^{-3} lb U/gal and this result is given in Table 3. Similarly, the Standards Program does not include a synthetic F-15 standard containing uranium that can be used to estimate analytical fixed error. We can approximate fixed error by using data from analyses of a simple uranium standard used for instrumental control of the UF-1c method. Based on this data analytical fixed error was estimated to be 17 percent and assumes that a bias correction is made each month based on the average of five determinations of the UF-1c uranium standard. This result is given in Table 3. However, no bias corrections are actually made. Thus, uranium in F-15 is probably biased low by 8-10 percent and this bias probably has a negligible effect on plant uranium accountability.

Referee data were available to estimate random error for plutonium in F-15 (seven data). The results are given in Table 3 under "analytical". Fixed error for plutonium in F15 can be estimated since the Standards Program includes a synthetic F-15 containing plutonium. The estimate in Table 3 assumes a bias correction is made each month based on the average of five assays of the F-15 standard. Actually, no correction is currently being made which is of no consequence in this case since the average recovery is about one percent high for plutonium in F-15.

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Specific gravity is determined by process instrumentation and the present program does not provide data that can be used to estimate random and fixed error of this measurement.

Sampling Audit - Data from 8 duplicate samples were obtained during the last half of 1965 and were used to estimate the combined effect of analytical and sampling variation for plutonium and uranium. The results are given in Table 3 under the title "total". Approximate estimates of sampling variation are also given under the title "sampling". These latter estimates are subject to the limitations of the Referee data discussed in the preceeding section and the fact that the referee samples are not the same as the duplicate samples.

The duplicate sample data were examined to see if a bias existed between the average of the first samples (original) and the average of the second samples (independent). For uranium, the average of the original samples was 5.4 percent higher than the average of the independent samples during the first half of 1965 and 35 percent lower than the average of the independent samples during the last half of 1965. No F-15 data were available that could be used to see if a similar bias existed between original and referee analyses. For plutonium, the average of the original samples was 31 percent lower than the average of the independent samples during the first half of 1965 and 18 percent higher than the average of the independent samples during the last half of 1965. Referee data from the last half of 1965 shows that the average of the original analyses was 13 percent higher than the average of the Referee analyses, in reasonable agreement with the 18 percent mentioned above. Individually, these biases are not significant. However, the shifts from +5.4 to -35 percent for uranium and -31 to 18 percent for plutonium are significant. These shifts indicate that sampling and possibly analytical bias is a factor, but there is no way of estimating the bias and associated fixed

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error because there is no known standard of comparison.

Tank Calibration - Volume random and fixed errors were discussed in an earlier report.⁽¹⁾ No data were available to estimate fixed error associated with the manometer difference.

Propagation of Error - Methods of computing batch variation were given in the previous report. Overall batch variation for both uranium and plutonium appear to have increased a slight amount compared to the first half of 1965. The increase is not statistically significant..

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D5 Dissolved Feed to Process

Analytical Control Audit - Referee and Standards Program data for the last half of 1965 were analyzed and used to estimate random and fixed variation for uranium (US-1a). Approximately 132 samples were refereed during a five month period yielding a precision estimate of 8.6 percent (0.95 level) and this result is shown in Table 4. Approximately 109 standard determinations were made during the same period yielding a fixed error estimate of 0.7% assuming that a monthly bias correction is made based on the average of 20 standard determinations.

Sampling Audit - Nine duplicate samples were analyzed for uranium (US-1a). The combined estimate of analytical and sampling random error was 28 percent (0.95 level) and this result is shown in Table 4. Approximate estimates of sampling variation were estimated using the duplicate sample data and the Referee data of the preceeding section. The resulting estimate 26.6% is given in Table 4. The combined estimate (28%) is significantly different than the estimate obtained during the first half of 1965 (11.5%) based on 12 duplicate samples. It was also noted that the average of the independent samples (second) was 12 percent higher than the average of the first samples which compares to 2.3 percent during the first half of 1965.

Tank Calibration - The D-5 tank was calibrated in September and again in November, 1965. The results and comparison to previous calibration data have been reported.⁽³⁾ The estimates shown in Table 4 were taken from this report.

No data were available to estimate random and fixed error associated with the specific gravity recorder. The estimates shown in Table 4 were taken from HW-76361.

(3) Letter, F. G. Kimble from L. F. Wirfs, D-5 Manometer Calibrations, February 9, 1966.

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F18 Utility Waste

Analytical Control Audit - Referee and Standards Program data for the last half of 1965 were analyzed and used to estimate random and fixed variation for uranium (UF-1c) and plutonium (PuA-20a). As with F15, referee data obtained on G-8 samples analyzed by the UF-1c method were used to give approximate estimates of analytical random error in Table 5. Also, data from the uranium standard used for instrument control of the UF-1c method was used to estimate analytical fixed error. Thus, the analytical estimates in Table 5 are identical to the F15 estimates in Table 3. For plutonium, nine referee data were available to estimate random error and the results are shown in Table 5. Fixed error is the same as given for F-15 in Table 3.

Sampling Audit - Data from 16 duplicate samples were obtained during the last half of 1965 and were used to estimate the combined effect of analytical and sampling variation for uranium and plutonium in F18. The results are given in Table 5 under the title "total". Approximate estimates of sampling variation are given under the title "sampling." The latter estimates are subject to the limitations discussed in previous sections.

No data were available to estimate variation associated with specific gravity. The estimates in Table 5 were taken directly from HW-76361.

Tank Calibration - The original 1955 WF-Recorder and standard manometer data were processed by the cumulative error model. The following table compares the two instruments at the time of calibration.

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SUMMARY OF F18 TANK CALIBRATION DATA (April 1955)

<u>Instrument Range (in.)</u>	<u>Intercept</u>	<u>Slope</u>	<u>No. of Increments</u>	<u>Manometer Variance (Random)</u>	<u>Slope Variance (Fixed)</u>
<u>Weight Factor Recorder</u>					
0.05 - 15.9	42	78.54	5	109.10	6.883
15.9 - 55.0	1287	87.075	<u>6</u>	<u>45.15</u>	<u>1.155</u>
			11	73.57	1.337
<u>Standard Manometer</u>					
0.5 - 28.2	42	44.94	6	5.58	0.201
28.2 - 97.4	1287	49.20	<u>7</u>	<u>22.1</u>	<u>0.319</u>
			13	14.59	0.150

The two curves are compared to the existing calibration table below

COMPARISON OF F18 CALIBRATION CURVES

	<u>Existing Table (1.50 scale)</u>	<u>Cumulative Error Model</u>	
		<u>Standard Manometer</u>	<u>W-F Recorder (1.81 scale)</u>
Initial Man. Rdg.	61.54	92.31	51
Final Man. Rdg.	1.21	1.81	1
+ by Sp. Gr. (1.1)	55.95	83.92	46.36
	1.09	1.64	0.91
Gallons Initial	3975	4028	3939
Gallons Final	<u>119</u>	<u>89</u>	<u>109</u>
Gallons Transferred	3856	3939	3830
% Difference		+ 2.1	-0.7
% Fixed error (0.95 CL)		1.7	2.7
% Random error (0.95 CL)		1.8	3.0
% Total error (0.95 CL)		2.4	4.0

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Comparison of the slope estimates (adjusted by 1.81 scale factor) indicates an approximate 2 percent bias between instruments at the time of calibration. The error estimates shown in Table 5 are based on the WF Recorder. Also shown is a 2 percent fixed error introduced by use of the meter pump.

Propagation of Error

The total error associated with an F18 batch is computed below using the data of table 5 (divided by two)

Uranium:

$$\begin{aligned}\% \text{ Total error (0.95 CL)} &= 2 \{ [(46.5)^2 + (0.75)^2 + (1.5)^2] \\ &\quad + [(8.5)^2 + (0.75)^2 + (1.35)^2 + (1.0)^2] \}^{1/2} \\ &= 2 \{ 2165.06 + 75.63 \}^{1/2} \\ &= 2(47.33) = 94.7\%\end{aligned}$$

Plutonium:

$$\begin{aligned}\% \text{ Total error (0.95 CL)} &= 2 \{ [(20)^2 + (0.75)^2 + (0.375)^2 + (1.5)^2] \\ &\quad + [(2.3)^2 + (0.75)^2 + (0.7)^2 + (1.35)^2 + (1.0)^2] \}^{1/2} \\ &= 2 \{ 402.95 + 9.165 \}^{1/2} \\ &= 2(20.3) = 40.6\%\end{aligned}$$

Most of the estimates in Table 5 compare favorably with HW-76361 except for sampling error which appears to be higher than previously estimated.

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G8 Organic Wash Waste

Analytical Control Audit - Nine referee data were available to estimate random error for uranium by UF-1c and the result (53%) is given in Table 6 under the title 'analytical.' Fixed error for uranium was estimated from UF-1c instrument control standard and is the same as was used for F15 and F18. Plutonium content is determined by computing a factor based on analysis of 20 batches selected at random each quarter. No attempt was made to estimate variation in this technique. The results given in Table 6 were taken directly from HW-76361.

Sampling Audit - Uranium data from 26 duplicate samples covering the period 3/65 to 12/65 were used to estimate the combined effect of analytical and sampling random error. The result (51%) is shown in Table 6 under 'total.' The fact that this estimate (51%) is less than the analytical estimate (53%) obtained above, indicates that sampling variation is negligible relative to analytical variation. This is not unreasonable since the sampling equipment at this station is the bayonet type.

No data were available to estimate variation associated with specific gravity. The estimates in Table 6 were taken directly from HW-76361.

Tank Calibration - In 1955, the G-8 was calibrated twice by the meter pump method. The results of applying the cumulative error model to the data are given below.

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SUMMARY OF G8 TANK CALIBRATION DATA (APRIL 1955)

<u>Instrument</u> <u>Range (in.)</u>	<u>Intercept</u>	<u>Slope</u>	<u>No. of</u> <u>Increments</u>	<u>Manometer</u> <u>Variance</u> <u>(Random)</u>	<u>Slope</u> <u>Variance</u> <u>(Fixed)</u>
<u>Weight Factor Recorder</u>					
1 0.5 - 65.4	34.9	72.28	13	54.307	0.8367
2 0.02- 65.2	<u>57.9</u>	<u>71.86</u>	<u>12</u>	<u>110.914</u>	<u>1.701</u>
Ave	46.4	72.07	25	81.48	1.253
<u>Standard Manometer</u>					
1 0.2 - 99.0	9.1	48.007	14	61.334	0.6208
2 0.1 - 109.0	<u>21.9</u>	<u>47.734</u>	<u>15</u>	<u>34.242</u>	<u>0.3144</u>
Ave	15.5	47.87	29	47.32	0.456

The two curves are compared to the existing calibration table below.

COMPARISON OF G8 CALIBRATION CURVES

	<u>Existing</u> <u>Table (1.50 scale)</u>	<u>Cumulative Error Model</u>	
		<u>Standard</u> <u>Manometer</u>	<u>W-F Recorder</u> <u>(1.50 scale)</u>
Initial Man. Rdg.	51	76.5	51
Final Man. Rdg.	1	1.5	1
+ by Sp. Gr. (1.01)	50.49	75.74	50.49
	0.99	1.48	0.99
Gallons Initial	3581	3641	3685
Gallons final	<u>106</u>	<u>86</u>	<u>118</u>
Gallons Transferred	3475	3555	3567
% Difference		+ 2.3	+ 2.6
% Fixed error (0.95 CL)		2.8	3.1
% Random error (0.95 CL)		3.3	3.6
% Total Error (0.95 CL)		4.4	4.7

The agreement between slope estimates was good at the time of calibration and the total error for the WF Recorder is about the same as the standard manometer.

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Propagation of Error - The total error associated with uranium in a G-8 batch is computed below using the data of table 6 (divided by two)

$$\begin{aligned}\% \text{ Total Error (0.95 CL)} &= 2 \{[(25.5)^2 + (0.75)^2 + (1.8)^2] \\ &\quad + [(8.5)^2 + (0.75)^2 + (\frac{1.55}{2})^2 + (1.0)^2]\}^{1/2} \\ &= 2 \{654.05 + 76.21\}^{1/2} \\ &= 2 (27) = 54\end{aligned}$$

which compares favorably with estimates given in HW-76361.

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R8 Organic Wash Waste

Analytical Control Audit - The G-8 referee data (9) were used to estimate random error for uranium by UF-1c. Fixed error for uranium was estimated from the UF-1c instrument control standard (also used for F15, F18 and G8). No data were available to estimate measurement error of plutonium content.

Sampling Audit - No duplicate sample data were available for plutonium content. Uranium data from five duplicate samples covering the period 3/65 to 6/65 were used to estimate the combined effect of analytical and sampling error. One of the duplicate pairs was eliminated as an "outlier." The remaining four pairs were used to obtain the estimate (184%) given in Table 7. An approximate estimate of sampling error was obtained by comparing the duplicate sample data to the Referee data of the previous section. These are not very good estimates since they are based on a small amount of data and because the Referee data was obtained on G-8 samples.

Tank Calibration - The R8 was calibrated twice during 1955 by the meter pump method. The results of applying the cumulative error model to the data are given below

SUMMARY OF R8 TANK CALIBRATION DATA (April 1955)

<u>Instrument</u> <u>Range (in.)</u>	<u>Intercept</u>	<u>Slope</u>	<u>No. of</u> <u>Increments</u>	<u>Manometer</u> <u>Variance</u> <u>(Random)</u>	<u>Slope</u> <u>Variance</u> <u>(Fixed)</u>
<u>Weight Factor Recorder</u>					
1 0.1 - 73.0	45.3	69.543	11	150.565	2.065
2 0 - 73.0	52.0	69.605	11	91.786	1.257
	48.6	69.574	22	121.175	1.661
<u>Standard Manometer</u>					
1 0.1 - 101.95	47.5	47.026	9	46.615	0.458
2 0 - 107.82	52.0	47.126	11	45.943	0.426
	49.7	47.076	20	46.279	0.442

The two curves are compared to the existing calibration table below.

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COMPARISON OF R8 CALIBRATION CURVES

	<u>Existing Table (1.50)</u>	<u>Standard Manometer</u>	<u>W-F Recorder (1.51 Scale)</u>
Initial Man. Rdg.	36.24	54.36	36
Final Man. Rdg.	1.01	1.51	1
+ By Sp. Gr. (1.01)	35.88	53.82	35.64
	1.0	1.49	0.99
Gallons Initial	2524	2583	2528
Gallons Final	<u>106</u>	<u>121</u>	<u>117</u>
Gallons Transferred	2418	2462	2411
% Difference		1.8	- 0.3
% Fixed Error (0.95 CL)		2.8	3.7
% Random Error (0.95 CL)		4.0	5.4
% Total Error (0.95 CL)		4.9	6.5

Comparison of the two slopes using the 1.51 scale factor indicates a bias of 2.1 percent between instruments. The total error is about the same for both instruments.

Propagation of Error - The total error associated with uranium in a G-8 batch is computed below using the data of Table 7 (divided by two).

$$\begin{aligned}
 \% \text{ Total error (0.95 CL)} &= 2 \{ [(92)^2 + (.75)^2 + (2.7)^2] + [(8.5)^2 + (0.75)^2 \\
 &\quad + \frac{(1.85)^2 + (1.0)^2}{2} \}^{1/2} \\
 &= 2 \{ 8471.8 + 75.5 \}^{1/2} \\
 &= 2 (92.45) \\
 &= 185
 \end{aligned}$$

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U3 Laboratory Waste

Analytical Control Audit - No Referee data were available for U3 samples.

The closest sample type is G8 (See Table 6) and these results are shown in Table 8 for uranium by UF-1c. Fixed error was estimated from Standards data obtained on the UF-1c instrument control standard. No comparable Referee or Standards data was available to estimate random or fixed error for plutonium by Pu A-6b.

Sampling Audit - Approximately 24 (excluding two outliers) and 33 (excluding 3 outliers) duplicate sample data were obtained between 2/65 and 12/65 for uranium (UF-1c) and plutonium (PU A-6b), respectively. The combined estimates of analytical and sampling error are 95% for uranium and 90% for plutonium and these results are shown in Table 8 under the title "Total." These numbers probably represent reasonably good estimates of random error. Estimates of analytical fixed error for plutonium were not made due to lack of Standards data. No attempt was made to estimate sampling error because of the lack of Referee data.

Tank Calibration - The original 1955 meter pump calibration data were processed with the cumulative error model. A summary of the calibration data is given below.

SUMMARY OF U3 CALIBRATION DATA (1955)

<u>Instrument Range (in.)</u>	<u>Intercept</u>	<u>Slope</u>	<u>No. of Increments</u>	<u>Manometer Variance (Random)</u>	<u>Slope Variance (Fixed)</u>
<u>Weight Factor Recorder (2.58 scale)</u>					
4 -67.9	171.6	118.537	12	275.939	4.318
<u>Standard Manometer</u>					
4-171.9	45	47.558	14	23.551	0.140

The bias between slope estimates, adjusted for the 2.58 scale factor, is 3.4 percent. A comparison of the computed curves with the existing table is given below.

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COMPARISON OF U3 CALIBRATION CURVES

	<u>Existing Table</u>	<u>Cumulative Error Model</u>	
		<u>WF Recorder (2.58 scale)</u>	<u>Standard Manometer</u>
Initial Man. Rdg.	56.76	55	141.9
Final Man. Rdg.	10.32	10	25.8
+ By Sp. Gr. (1.0)	56.76	55	141.9
	10.32	10	25.8
Gallons Initial	6786	6691	6793
Gallons Final	<u>1222</u>	<u>1357</u>	<u>1272</u>
Gallons Transferred	5564	5334	5521
% Difference		- 4.1	- 0.8
% Random Error (0.95 CL)		4.2	1.9
% Fixed Error (0.95 CL)		3.5	1.6
% Total Error (0.95 CL)		5.5	2.5

Propagation of Error - The total error associated with an U3 batch is computed below using the data of Table 8.

Uranium:

$$\begin{aligned}
 \% \text{ Total error (0.95 CL)} &= 2 \{ [(47.5)^2 + (0.75)^2 + (2.1)^2] + \\
 &\quad + [(8.5)^2 + (0.75)^2 + (1.75)^2 + (1.0)^2] \}^{1/2} \\
 &= 2 \{ 2261.2 + 76.9 \}^{1/2} \\
 &= 2(48.36) \\
 &= 96.7\%
 \end{aligned}$$

Plutonium:

$$\begin{aligned}
 \% \text{ Total error (0.95 CL)} &= 2 \{ [(45)^2 + (0.375)^2 + (0.75)^2 + (2.1)^2] \\
 &\quad + [(0.7)^2 + (0.75)^2 + (1.75)^2 + (1.0)^2] \}^{1/2} \\
 &= 2 \{ 2030.1 + 5.1 \}^{1/2} \\
 &= 2(45.12) \\
 &= 90.2\%
 \end{aligned}$$

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Total fixed error for plutonium is probably higher than indicated since no data were available to estimate fixed error due to analytical.

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TABLE 1

L9 Plutonium Product

<u>Measurement</u>	<u>Nominal Value</u>	<u>0.95 Confidence Level</u>			<u>Notes</u>
		<u>Random</u>	<u>Fixed</u>	<u>Total</u>	
<u>Pu, X-Ray</u>					
Analytical	2.05 lb/gal	0.041 2.0%	0.017 0.8%	0.044 2.2%	1
Sampling		0.047 2.3%	? ?	0.047 2.3%	2
Total		0.062 3.0%	0.017 0.8%	0.064 3.1%	3
<u>AT, PuA-6b</u>					
Analytical	7.58 ¹³ c/m/gal	0.233 ¹³ 3.1%	0.087 ¹³ 1.1	0.249 ¹³ 3.3%	1
Sampling		-0- -0-	? ?	-0- -0-	2
Total		0.233 ¹³ 3.1%	0.087 ¹³ 1.1	0.249 ¹³ 3.3%	3
<u>Specific Gravity</u>					
Analytical	1.50	0.0061 0.41%	0.0013 0.09%	0.0063 0.42%	1
Sampling		0.0073 0.49%	? ?	0.0073 0.49%	2
Total		0.0095 0.64%	0.0013 0.09%	0.0097 0.65%	3
ICF	1.24 x 10 ⁻¹¹ g/cpm	0.009x10 ⁻¹¹ 0.75%	0.017x10 ⁻¹¹ 1.4%	0.020x10 ⁻¹¹ 1.6%	5
<u>Net Weight</u>	10.4 kg	0.031 0.3%	0.016 0.15%	0.035 0.34%	4
Pu, batch	8500 grams	261 3.1%	70 0.8%	270 3.2%	

Calculation:

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

Notes:

- (1) Random and fixed error estimates obtained from recent Referee and Standard Program data.
- (2) Random error due to sampling is approximate only. No data available to estimate sampling fixed error.
- (3) Total random error for analytical and sampling combined was estimated from recent duplicate sample data.
- (4) Estimates based on recent Tare Weight Check data.
- (5) Estimates based on recent data. See text.

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TABLE 2

K6 Uranium Product

<u>Measurement</u>	<u>Average Value</u>	<u>0.95 Confidence Level</u>			<u>Notes</u>
		<u>Random</u>	<u>Fixed</u>	<u>Total</u>	
Tank Slope Estimate	3764 gals (48 gal/in)	-- --	43 gals 1.14%	65 gals 1.73%	5
Manometer Difference	3764 gals (155" to 23")	49 gals 1.30%	? ?		
<u>Specific Gravity</u>					
Analytical	1.66	0.0070 0.42%	0.0017 0.1%	0.0071 0.43%	1
Sampling		0.0109 0.66%	? ?	0.0109 0.66%	2
Total		0.0129 0.78%	0.0017 0.1%	0.0131 0.79%	3
<u>Uranium (x-ray)</u>					
Analytical	4.05 lb/gal	0.052 1.3%	0.015 0.37%	0.055 1.35%	1
Sampling		0.083 2.1%	? ?		2
Total		0.098 2.4%	0.015 0.37%	0.098 2.4%	3
Uranium, per batch	15,244 lb.	433 2.8%	116 0.76%	448 2.9%	6
<u>Calculation</u>					
Uranium, lb. = ($\frac{\text{Mano. diff., in.}}{\text{Sp. Gr.}}$) (Tank slope, gal/in)(U, lb/gal)					4

Notes:

- (1) Random and fixed error estimates obtained from recent Referee and Standards Program data.
- (2) Random error due to sampling is approximate only. No data available to estimate sampling fixed error.
- (3) Total random error for analytical and sampling combined was estimated from recent duplicate sample data.
- (4) This equation is not exact if the initial manometer reading occurs in a different slope region than the final manometer reading.
- (5) No data available to estimate manometer fixed error.
- (6) Fixed error due to tank slope estimate (1.14%) is reduced because tank was calibrated three times.

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TABLE 3

F15 Salt Waste

<u>Measurement</u>	<u>Nominal Value</u>	<u>0.95 Confidence Level</u>			<u>Notes</u>
		<u>Random</u>	<u>Fixed</u>	<u>Total</u>	
<u>U Analysis</u>					
Analytical	1.8x10 ⁻³	1.1x10 ⁻³	0.31x10 ⁻³	1.12x10 ⁻³	1
	lb/gal	60%	17%	62.4%	
Sampling		1.5x10 ⁻³	?	1.5x10 ⁻³	2
		82%	?	82%	
Total		1.8x10 ⁻³	0.31x10 ⁻³	1.84x10 ⁻³	3,8
		101%	17%	102.4%	
<u>Pu Analysis</u>					
Analytical	7.8x10 ⁸	2.5x10 ⁸	0.36x10 ⁸	2.52x10 ⁸	4
	c/m/gal	32%	4.6%	32.3%	
Sampling		7.4x10 ⁸	?	7.4x10 ⁸	2
		95%	?	95%	
Total		7.8x10 ⁸	0.36x10 ⁸	7.8x10 ⁸	3
		100%	4.6%	100.1%	
Sp. Gr. Recorder	1.3	0.02	0.02	0.027	5
		1.5%	1.5%	2.1%	
Weight Factor Recorder	2475 gals (45 to 0 in.)	245 gals 9.9%	? ?	245gals 9.9%	6
Tank Slope Estimate	2475 gals. (71.5 ga./in.)	-- --	173 gals 7.0%	173gals 7.0%	6
ICF	1.24x10 ⁻¹¹ g/cpm	0.009x10 ⁻¹¹ 0.75%	0.017x10 ⁻¹¹ 1.4%	0.020x10 ⁻¹¹ 1.6%	7
U, batch	5 lb	5.1 102%	0.9 18.5%	5.2 104%	8
Pu, batch	24 g	24.1 100.5%	2.1 8.7%	24.2 100.9%	8

Calculation:

$$U, lb = (U, lb/gal) \left(\frac{WF \text{ diff. in.}}{Sp. Gr.} \right) (\text{Tank slope, gal/in})$$

$$Pu, g = (Pu, cpm/gal)(ICF, g/cpm) \left(\frac{WF \text{ diff. in.}}{Sp. Gr.} \right) (\text{Tank slope, gal/in})$$

Notes:

- (1) Random error based on G-8 by UF-1c Referee data. Fixed error based on UF-1c instrument control standard.
- (2) Random error approximate only. No data available to estimate fixed error.
- (3) Combined analytical and sampling error estimated from recent duplicate sample data.
- (4) Random and Fixed error estimates based on recent Referee and Standards Program data.
- (5) No data available. Estimates from HW-76361.
- (6) Estimates based on cumulative error model, see BNWL-CC-315.
- (7) Based on recent L9 data. See L9 discussion.
- (8) When precision estimates are greater than 100% the lower limit should be interpreted as -100%, e.g., -100% to + 104% or 0 to + 5.2 lbs.

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TABLE 4

D5 Dissolved Feed to Process

<u>Measurement</u>	<u>Nominal Value</u>	<u>0.95 Confidence Level</u>			<u>Notes</u>
		<u>Random</u>	<u>Fixed</u>	<u>Total</u>	
<u>Uranium (US-1a)</u>					
Analytical	3.75	0.32	0.03	0.32	1
	lb/gal	8.6%	0.7%	8.6%	
Sampling		1.0	?	1.0	2
		26.6%	?	26.6%	
Total		1.05	0.03	1.05	3
		28%	0.7%	28%	
Sp. Gr. Recorder	1.6	0.024	0.024	0.032	4
		1.5%	1.5%	2%	
Tank Slope Estimate	4200 gal	--	25	25	5
	(47.7 gal/in)	--	0.6%	0.6%	
Manometer Difference	4200 gal	42	?	42	5
	(144 in)	1.0%	?	1.0%	
U, batch	15750 lb	4410	268	4426	
		28%	1.7%	28.1%	

Calculations:

$$U, lb = (U, lb/gal) \left(\frac{\text{Mano. Diff. in}}{\text{Sp. Gr}} \right) (\text{Tank slope, gal/in})$$

Notes:

- (1) Analytical random and fixed estimates based on recent Referee and Standards Program Data.
- (2) Random error approximate only. No data to estimate fixed error.
- (3) Combined analytical and sampling random error estimated from recent duplicate sample data.
- (4) No data available. Estimates from HW-76361
- (5) Based on recent tank calibration.

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TABLE 5
F-18 Utility Waste

Measurement	Nominal Value	0.95 Confidence Level			Notes
		Random	Fixed	Total	
<u>U Analysis</u>					
Analytical	6.9x10 ⁻³ lb/gal	4.1x10 ⁻³ 60%	1.2x10 ⁻³ 17%	4.3x10 ⁻³ 62.4%	1
Sampling		4.9x10 ⁻³ 71%	? ?	4.9x10 ⁻³ 71%	2
Total		6.4x10 ⁻³ 93%	1.2x10 ⁻³ 17%	6.5x10 ⁻³ 94.5%	3
<u>Pu Analysis</u>					
Analytical	4.9x10 ⁸ cpm/gal	0.5x10 ⁸ 11%	0.2x10 ⁸ 4.6%	0.6x10 ⁸ 11.9%	4
Sampling		1.9x10 ⁸ 38.6%	? ?	1.9x10 ⁸ 38.6%	2
Total		1.96x10 ⁸ 40%	0.2x10 ⁸ 4.6%	1.97x10 ⁸ 40.2%	3
Specific Gravity (Recorder)	1.1	0.02 1.5%	0.02 1.5%	0.02 2%	5
ICF	1.24x10 ⁻¹¹ g/cpm	0.009x10 ⁻¹¹ 0.75%	0.017x10 ⁻¹¹ 1.4%	0.02x10 ⁻¹¹ 1.6%	6
Weight Factor Recorder	3850 gals	115 3.0%	? 	115 3.0%	7
Tank Slope Estimate	3850 gals	-- --	104 2.7%	104 2.7%	7
Meter Pump Bias	3850 gals	-- --	77 2%	77 2%	
U, Batch	26 lbs	24 93.1%	4.5 17.4%	25 94.7%	
Pu, batch	23 grs	9.2 40.1%	1.4 6.1%	9.3 40.6%	

Calculation:

$$U, lb = (U, lb/gal) \left(\frac{WF \text{ diff., in}}{Sp.Gr.} \right) (Tank \text{ slope, gal/in})$$

$$Pu, g = (Pu, cpm/gal)(ICF, g/cpm) \left(\frac{WF \text{ diff., in}}{Sp.Gr.} \right) (Tank \text{ slope, gal/in})$$

Notes:

- (1) Random error based on G-8 by UF-1c Referee data. Fixed error based on UF-1c instrument control standard.
- (2) Random error approximate only. No data available to estimate fixed error.
- (3) Combined analytical and sampling error estimated from recent duplicate sample data.
- (4) Random and fixed error based on recent Referee and Standards Program Data.
- (5) No data. Estimates from HW-76361.
- (6) Based on recent L9 data. See discussion.
- (7) Estimates based on cumulative error model.

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TABLE 6

G8 Organic Wash Waste

<u>Measurement</u>	<u>Nominal Value</u>	<u>0.95 Confidence Level</u>			<u>Notes</u>
		<u>Random</u>	<u>Fixed</u>	<u>Total</u>	
<u>U, UF-1c</u>					
Analytical	2.7x10 ⁻³ lb/gal	1.43x10 ⁻³ 53%	0.5x10 ⁻³ 17%	1.9x10 ⁻³ 55.7%	1
Sampling		neg.	?		2
Total		1.38x10 ⁻³ 51%	0.5x10 ⁻³ 17%	1.45x10 ⁻³ 53.7%	3
<u>Pu. factor</u>	2g	5g 250%	1g 56%	5g 256%	4
Sp. Gr. Recorder	1.01	0.015 1.5%	0.015 1.5%	0.02 2%	4
WF Difference	3475 gals	125 3.6%	?	125 3.6%	5
Tank Slope Estimate	3475 gals	--	108 3.1%	108 3.1%	5
Meter Pump Bias	3475 gals	--	69 2%	69 2%	
U, batch	9 lb	4.6 51.2%	1.5 17.3%	4.9 54%	

Calculation:

$$U, lb = (U, lb/gal) \left(\frac{WF \text{ diff. in}}{Sp. Gr.} \right) (Tank \text{ slope, gal/in})$$

Notes:

- (1) Random error based on recent Referee data. Fixed error based on UF-1c instrument control standard.
- (2) Approximate only. No data to estimate fixed error.
- (3) Based on recent duplicate sample data.
- (4) No data. Taken from HW-76361.
- (5) Based on 1955 calibration (2) with meter pump.

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TABLE 7

R8 Organic Wash Waste

<u>Measurement</u>	<u>Nominal Value</u>	<u>0.95 Confidence Level</u>			<u>Notes</u>
		<u>Random</u>	<u>Fixed</u>	<u>Total</u>	
<u>U, UF-1c</u>					
Analytical	1.1x10 ⁻³	0.6x10 ⁻³	0.2x10 ⁻³	0.6x10 ⁻³	1
	lb/gal	53%	17%	55.7%	
Sampling		1.6x10 ⁻³	?	1.6x10 ⁻³	2
		150%	?	150%	
Total		2x10 ⁻³	0.2x10 ⁻³	2x10 ⁻³	3
		184%	17%	185%	
<u>Pu Analysis</u>					4
Sp. Gr. Recorder	1.01	0.015	0.015	0.02	5
		1.5%	1.5%	2%	
WF Difference	2400 gal	130	?	130	6
	(35 in)	5.4%	?	5.4%	
Slope Estimate	2400 gal	--	89	89	6
	(69.57 gal/in)	--	3.7%	3.7%	
Meter Pump bias	2400 gals	--	48	48	
		--	2%	2%	
U, batch	3 lb	5.5	0.5	5.6	
		184%	17.4%	185%	

Calculations:

$$U, lb = (U, lb/gal) \left(\frac{WF \text{ diff. in}}{Sp.Gr.} \right) (Tank \text{ slope, gal/in})$$

Notes:

- (1) Random error based on G-8 Referee data. Fixed error based on UF-1c instrument control standard.
- (2) Approximate only. No data to estimate fixed error.
- (3) Based on recent duplicate sample data (4).
- (4) No data.
- (5) No data. Taken from HW-76361
- (6) Based on 1955 calibrations (2) with meter pump.

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TABLE 8

U3 Laboratory Waste

<u>Measurement</u>	<u>Nominal Value</u>	<u>0.95 Confidence Level</u>			<u>Note</u>
		<u>Random</u>	<u>Fixed</u>	<u>Total</u>	
<u>U, UF-1c</u>					
Analytical	2.6×10^{-5} lb/gal	1.4×10^{-5} 53%	0.4×10^{-5} 17%	1.45×10^{-5} 55.7%	1
Sampling		not estimated			2
Total		2.5×10^{-5} 95%	0.4×10^{-5} 17%	2.5×10^{-5} 96.5%	3
<u>Pu, PuA-6b</u>					
Analytical	3.8×10^6	not estimated			2
Sampling	cpm/gal	not estimated			2
Total		3.4×10^6 90%	? ?	3.4×10^6 90%	3
ICF	1.2×10^{-11} g/cpm	0.009×10^{-11} 0.75%	0.017×10^{-11} 1.4%	0.020×10^{-11} 1.6%	4
Specific Gravity	1.0	0.015 1.5%	0.015 1.5%	0.02 2.0%	5
Weight Factor Recorder	5500 gal (45 in)	231 4.2%	? ?	231 4.2%	6
Tank Slope Estimate	5500 gal (118.5)	-- --	193 3.5%	193 3.5%	6
Meter Pump bias	5500 gal	-- --	110 2%	110 2%	
U, Batch	< 1 lb	0.95 95.1%	0.17 17.5%	1.0 96.7%	
Pu, Batch	< 1 gr.	0.9 90.1%	0.05 4.5%	0.9 90.2%	

Calculations:

$$U, lb = (U, lb/gal) \left(\frac{WF \text{ diff. in.}}{Sp.Gr.} \right) (\text{Tank slope, gal/in})$$

$$Pu, g = (Pu, cpm/gal)(ICF, g/cpm) \left(\frac{WF \text{ diff. in.}}{Sp.Gr.} \right) (\text{Tank slope, gal/in})$$

Notes:

- (1) Random error based on G8 by UF-1c Referee data. Fixed error based on UF-1c instrument control standard.
- (2) No data available.
- (3) Random error estimated from recent duplicate sample data.
- (4) Based on recent L9 data
- (5) No data. Estimates from HW-76361.
- (6) Estimates based on cumulative error model.

DATE

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7/01/94

END