CALORIMETRY EXCHANGE PROGRAM
ANNUAL DATA REPORT
FOR CY93

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CALORIMETRY EXCHANGE PROGRAM

ANNUAL DATA REPORT

FOR CY93

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The Calorimetry Sample Exchange Program

The goals of the Calorimetry Sample Exchange Program are:

1. Discuss measurement differences
2. Review and improve analytical measurements and methods
3. Discuss new measurement capabilities
4. Provide data to DOE on measurement capabilities to evaluate shipper-receiver differences
5. Provide characterized or standard materials as necessary for exchange participants
6. Provide a measurement control program for plutonium analysis

A sample of PuO_2 powder is available at each participating site for NDA measurement, including either or both calorimetry and high-resolution gamma-ray spectroscopy, the elements which are typically combined to provide a calorimetric assay of plutonium. The facilities measure the sample as frequently and to the level of precision which they desire, and then submit the data to the Exchange for analysis. The data report includes summary tables for each measurement and charts showing the performance of each laboratory. Comparisons are made to the accepted values for the exchange sample and to data previously reported by that laboratory. This information is presented, in the form of quarterly and annual reports, intended for use by Exchange participants in measurement control programs, or to indicate when bias corrections may be appropriate. No attempt, however, has been made to standardize methods or frequency of data collection, calibration, or operating procedures. Direct comparisons between laboratories may, therefore, be misleading since data have not been collected to the same precision or for the same time periods.

A meeting of the participants of the Calorimetry Exchange is held annually at EG&G Mound Applied Technologies. The purposes of this meeting are to discuss measurement differences, problems, and new measurement capabilities, and to determine the additional activities needed to fulfill the goals of the Exchange.

SUMMARY TABLE

% DIFFERENCE FROM ACCEPTED VALUES FOR THE CALORIMETRY EXCHANGE SAMPLE

	LIVERMORE	LOS ALAMOS	MOUND	HANFORD	ROCKY CSL	FLATS AL	SAVANNAH RIVER
POWER	0.65	0.16	0.05	-0.04	*	0.24	*
P-EFF	-0.19	0.19	0.16	0.05	*	0.10	*
238/239 Pu	-1.66	5.71	4.88	3.07	*	9.56	*
240/239 Pu	-0.24	0.26	0.08	0.92	*	0.69	*
241/239 Pu	-0.50	0.46	-0.92	0.01	*	0.40	*
Am/239 Pu	-1.48	0.65	0.49	-1.05	*	-0.12	*
% 238 Pu	-1.64	5.65	4.90	3.02	*	9.54	*
% 239 Pu	0.02	-0.06	0.03	-0.05	*	-0.01	*
% 240 Pu	-0.22	0.19	0.10	0.87	*	0.68	*
% 241 Pu	-0.49	0.33	-0.90	-0.03	*	0.38	*
% 241 Am	-1.47	0.58	0.52	-1.10	*	-0.13	*

RESULTS OF ANALYSIS OF POWER DATA 1993

REPORTING LABORATORY

	CSL	LLNL	LANL	MOUND	WHO	RFP	SRS
an Error (mW)	****	6.470	1.543	0.508	-0.439	2.409	****
. Dev. (mW)	****	10.071	2.221	1.606	2.799	2.012	****
c. in Mean (mW)	****	1.067	0.280	0.336	0.324	0.606	****
an Error (%)	****	0.65%	0.16%	0.05%	-0.04%	0.24%	****
. Dev. (%)	****	1.01%	0.22%	0.16%	0.28%	0.20%	****
c. in Mean (%)	****	0.11%	0.03%	0.03%	0.03%	0.06%	****
DIFFERENCE FROM LAST YEAR							
f. in Mean Error (mW)	****	8.097	0.929	0.993	0.395	1.154	****
f. in Std. Dev. (mW)	****	-2.840	0.699	-0.167	0.417	0.791	****
f. in Mean Error (%)	****	0.81%	0.10%	0.10%	0.04%	0.11%	****
f. in Std. Dev. (%)	****	-0.29%	0.07%	-0.02%	0.04%	0.08%	****
mber of Data Points	0	22	29	64	77	117	0

LAWRENCE LIVERMORE POWER DATA 1993

All standard deviation and uncertainty limits are at two-sigma.

LOS ALAMOS
POWER DATA 1993

EG&G MOUND POWER DATA 1993

All standard deviation and uncertainty limits are at two-sigma.

WESTINGHOUSE HANFORD POWER DATA 1993

EG&G ROCKY FLATS - ANALYTICAL LAB. POWER DATA 1993

All standard deviation and uncertainty limits are at two-sigma.

RESULTS OF ANALYSIS OF P-EFFECTIVE DATA 1993

	REPORTING LABORATORY						
	CSL	LLNL	LANL	MOUND	WHO	RFP	SRS
Mean Error (mW/g)	****	-0.0047	0.0048	0.0039	0.0013	0.0025	****
Std. Dev. (mW/g)	****	0.0030	0.0049	0.0057	0.0044	0.0177	****
% in Mean (mW/g)	****	0.0003	0.0013	0.0007	0.0002	0.0016	****
Mean Error (%)	****	-0.19%	0.19%	0.16%	0.05%	0.10%	****
Std. Dev. (%)	****	0.12%	0.20%	0.23%	0.18%	0.71%	****
% in Mean (%)	****	0.01%	0.05%	0.03%	0.01%	0.06%	****
DIFFERENCE FROM LAST YEAR							
% in Mean Error (mW/g)	****	0.0018	0.0049	-0.0009	0.0000	-0.0051	****
% in Std. Dev. (mW/g)	****	0.0012	-0.0010	-0.0008	-0.0001	0.0047	****
% in Mean Error (%)	****	0.07%	0.19%	-0.03%	0.00%	-0.21%	****
% in Std. Dev. (%)	****	0.05%	-0.04%	-0.03%	0.00%	0.19%	****
Number of Data Points	0	83	44	66	132	65	0

LAWRENCE LIVERMORE
P-EFFECTIVE 1993

LOS ALAMOS
P-EFFECTIVE 1993

EG&G MOUND

P-EFFECTIVE 1993

All standard deviation and uncertainty limits are at two-sigma.

WESTINGHOUSE HANFORD
P-EFFECTIVE 1993

EG&G ROCKY FLATS – ANALYTICAL LAB. P-EFFECTIVE 1993

All standard deviation and uncertainty limits are at two-sigma.

RESULTS OF ANALYSIS OF 238-Pu/239-Pu DATA 1993

	REPORTING LABORATORY						
	CSL	LLNL	LANL	MOUND	WHO	RFP	
Mean Error (ppm)	****	-2	6	5	3	9	****
Std. Dev. (ppm)	****	4.57	6.79	6.88	5.13	20.21	****
% in Mean (ppm)	****	0.42	1.03	0.81	0.34	2.30	****
Mean Error (%)	****	-1.66%	5.71%	4.88%	3.07%	9.56%	****
Std. Dev. (%)	****	4.69%	6.96%	7.06%	5.25%	20.74%	****
% in Mean (%)	****	0.44%	1.01%	0.79%	0.34%	2.24%	****
DIFFERENCE FROM LAST YEAR							
% in Mean Error (ppm)	****	0	-1	0	0	-7	****
% in Std. Dev. (ppm)	****	1.86	-0.66	0.90	-0.65	0.93	****
% in Mean Error (%)	****	0.68%	-1.29%	0.02%	0.09%	-7.08%	****
% in Std. Dev. (%)	****	1.93%	-0.61%	0.98%	-0.62%	1.10%	****
Number of Data Points	0	83	44	66	132	65	0

LAWRENCE LIVERMORE
238-PU/239-PU 1993

LOS ALAMOS
238-PU/239-PU 1993

EG&G MOUND
238-PU/239-PU 1993

All standard deviation and uncertainty limits are at two-sigma.

WESTINGHOUSE HANFORD
238-PU/239-PU 1993

EG&G ROCKY FLATS - ANALYTICAL LAB.
238-PU/239-PU 1993

All standard deviation and uncertainty limits are at two-sigma.

RESULTS OF ANALYSIS OF 240-Pu/239-Pu DATA 1993

	REPORTING LABORATORY						
	CSL	LLNL	LANL	MOUND	WHO	RFP	SRS
Mean Error (ppm)	****	-148	159	48	570	432	****
Std. Dev. (ppm)	****	271.52	1105.58	857.22	411.82	1740.29	****
% in Mean (ppm)	****	32.86	170.77	114.52	29.92	228.93	****
Mean Error (%)	****	-0.24%	0.26%	0.08%	0.92%	0.69%	****
Std. Dev. (%)	****	0.44%	1.78%	1.38%	0.66%	2.80%	****
% in Mean (%)	****	0.05%	0.27%	0.18%	0.05%	0.36%	****
DIFFERENCE FROM LAST YEAR							
% in Mean Error (ppm)	****	26	60	-113	-30	493	****
% in Std. Dev. (ppm)	****	70.82	21.10	-563.19	-46.69	385.19	****
% in Mean Error (%)	****	0.04%	0.10%	-0.18%	-0.05%	0.79%	****
% in Std. Dev. (%)	****	0.12%	0.04%	-0.91%	-0.08%	0.62%	****
Number of Data Points	0	83	44	66	132	65	0

LAWRENCE LIVERMORE
240-PU/239-PU 1993

LOS ALAMOS
240-PU/239-PU 1993

EG&G MOUND 240-PU/239-PU 1993

All standard deviation and uncertainty limits are at two-sigma.

WESTINGHOUSE HANFORD
240-PU/239-PU 1993

EG&G ROCKY FLATS - ANALYTICAL LAB.
240-PU/239-PU 1993

All standard deviation and uncertainty limits are at two-sigma.

RESULTS OF ANALYSIS OF 241-Pu/239-Pu DATA 1993

	REPORTING LABORATORY						
	CSL	LLNL	LANL	MOUND	WHO	RFP	SRS
Mean Error (ppm)	****	-10	9	-19	0	8	****
Std. Dev. (ppm)	****	13.05	6.33	12.47	9.78	17.53	****
% in Mean (ppm)	****	0.81	0.34	1.75	0.68	2.49	****
Mean Error (%)	****	-0.50%	0.46%	-0.92%	0.01%	0.40%	****
Std. Dev. (%)	****	0.66%	0.32%	0.62%	0.49%	0.89%	****
% in Mean (%)	****	0.04%	0.02%	0.09%	0.03%	0.13%	****
DIFFERENCE FROM LAST YEAR							
% in Mean Error (ppm)	****	3	5	-11	5	3	****
% in Std. Dev. (ppm)	****	5.12	0.46	3.10	-0.54	0.06	****
% in Mean Error (%)	****	0.10%	0.28%	-0.51%	0.24%	0.15%	****
% in Std. Dev. (%)	****	0.28%	0.04%	0.16%	0.00%	0.04%	****
Number of Data Points	0	83	44	66	132	65	0

LAWRENCE LIVERMORE
241-PU/239-PU 1993

LOS ALAMOS
241-PU/239-PU 1993

EG&G MOUND
241-PU/239-PU 1993

All standard deviation and uncertainty limits are at two-sigma.

WESTINGHOUSE HANFORD
241-PU/239-PU 1993

EG&G ROCKY FLATS - ANALYTICAL LAB.
241-PU/239-PU 1993

All standard deviation and uncertainty limits are at two-sigma.

RESULTS OF ANALYSIS OF 241-Am/239-Pu DATA 1993

	REPORTING LABORATORY						
	CSL	LLNL	LANL	MOUND	WHO	RFP	SRS
Mean Error (ppm)	****	-29	13	10	-21	-2	****
Std. Dev. (ppm)	****	7.84	25.91	7.47	9.96	17.29	****
% in Mean (ppm)	****	0.82	2.15	2.00	0.66	2.88	****
Mean Error (%)	****	-1.48%	0.65%	0.49%	-1.05%	-0.12%	****
Std. Dev. (%)	****	0.40%	1.31%	0.38%	0.50%	0.87%	****
% in Mean (%)	****	0.04%	0.11%	0.10%	0.03%	0.14%	****
DIFFERENCE FROM LAST YEAR							
% in Mean Error (ppm)	****	0	38	-3	0	5	****
% in Std. Dev. (ppm)	****	3.74	7.22	-7.11	1.41	-8.77	****
% in Mean Error (%)	****	0.08%	2.00%	-0.19%	0.09%	0.24%	****
% in Std. Dev. (%)	****	0.17%	0.31%	-0.39%	0.04%	-0.50%	****
Number of Data Points	0	83	44	66	132	65	0

LAWRENCE LIVERMORE
241-AM/239-PU 1993

All standard deviation and uncertainty limits are at two-sigma.

LOS ALAMOS
241-AM/239-PU 1993

EG&G MOUND
241-AM/239-PU 1993

All standard deviation and uncertainty limits are at two-sigma.

WESTINGHOUSE HANFORD
241-AM/239-PU 1993.

EG&G ROCKY FLATS - ANALYTICAL LAB.
241-AM/239-PU 1993

All standard deviation and uncertainty limits are at two-sigma.

RESULTS OF ANALYSIS OF PERCENT 238-Pu DATA

193

	REPORTING LABORATORY						SRS
	CSL	LLNL	LANL	MOUND	WHO	RFP	
Mean Error (weight %)	****	-0.0001%	0.0005%	0.0004%	0.0003%	0.0009%	****
Std. Dev. (weight %)	****	0.0004%	0.0006%	0.0006%	0.0005%	0.0019%	****
% in Mean (weight %)	****	0.0000%	0.0001%	0.0001%	0.0000%	0.0002%	****
Mean Error (%)	****	-1.64%	5.65%	4.90%	3.02%	9.54%	****
Std. Dev. (%)	****	4.69%	7.03%	7.04%	5.23%	20.70%	****
% in Mean (%)	****	0.44%	1.01%	0.79%	0.34%	2.24%	****
DIFFERENCE FROM LAST YEAR							
% in Mean Error (wt. %)	****	0.0001%	-0.0001%	0.0000%	0.0000%	-0.0006%	****
% in Std. Dev. (wt. %)	****	0.0001%	-0.0001%	0.0000%	0.0000%	0.0001%	****
% in Mean Error (%)	****	0.69%	-1.32%	0.03%	0.10%	-7.13%	****
% in Std. Dev. (%)	****	1.93%	-0.52%	0.92%	-0.62%	1.09%	****
Number of Data Points	0	83	44	66	132	65	0

LAWRENCE LIVERMORE
PERCENT 238-PU 1993

LOS ALAMOS
PERCENT 238-Pu 1993

EG&G MOUND PERCENT 238-Pu 1993

All standard deviation and uncertainty limits are at two-sigma.

WESTINGHOUSE HANFORD
PERCENT 238-PU 1993

EG&G ROCKY FLATS - ANALYTICAL LAB.
PERCENT 238-PU 1993

All standard deviation and uncertainty limits are at two-sigma.

RESULTS OF ANALYSIS OF PERCENT 239-Pu DATA

93

	REPORTING LABORATORY						
	CSL	LLNL	LANL	MOUND	WHO	RFP	SRS
Mean Error (weight %)	****	0.0142%	-0.0602%	0.0244%	-0.0443%	-0.0121%	****
Dev. (weight %)	****	0.0245%	0.1829%	0.0764%	0.0381%	0.1543%	****
Mean in Mean (weight %)	****	0.0030%	0.0151%	0.0131%	0.0027%	0.0262%	****
Mean Error (%)	****	0.02%	-0.06%	0.03%	-0.05%	-0.01%	****
Dev. (%)	****	0.03%	0.19%	0.08%	0.04%	0.16%	****
Mean in Mean (%)	****	0.00%	0.02%	0.01%	0.00%	0.03%	****
REFERENCE FROM LAST YEAR							
Mean in Mean Error (wt. %)	****	-0.3966%	-0.4374%	0.0108%	0.0025%	-0.0431%	****
Mean in Std. Dev. (wt. %)	****	0.0067%	0.0735%	-0.0490%	-0.0034%	0.0342%	****
Mean in Mean Error (%)	****	-0.42%	-0.46%	0.02%	0.00%	-0.04%	****
Mean in Std. Dev. (%)	****	0.01%	0.07%	-0.05%	0.00%	0.03%	****
Number of Data Points	0	83	44	66	132	65	0

LAWRENCE LIVERMORE
PERCENT 239-Pu 1993

Measured/Accepted

LOS ALAMOS
PERCENT 239-PU 1993

EG&G MOUND
PERCENT 239-PU 1993

All standard deviation and uncertainty limits are at two-sigma.

WESTINGHOUSE HANFORD
PERCENT 239-PU 1993

EG&G ROCKY FLATS - ANALYTICAL LAB.
PERCENT 239-PU 1993

RESULTS OF ANALYSIS OF PERCENT 240-Pu DATA

93

	REPORTING LABORATORY						
	CSL	LLNL	LANL	MOUND	WHO	RFP	SRS
n Error (weight %)	****	-0.0130%	0.0111%	0.0059%	0.0509%	0.0397%	****
Dev. (weight %)	****	0.0241%	0.1013%	0.0761%	0.0365%	0.1543%	****
, in Mean (weight %)	****	0.0029%	0.0151%	0.0108%	0.0027%	0.0216%	****
n Error (%)	****	-0.22%	0.19%	0.10%	0.87%	0.68%	****
Dev. (%)	****	0.41%	1.73%	1.30%	0.62%	2.63%	****
, in Mean (%)	****	0.05%	0.26%	0.18%	0.04%	0.36%	****
REFERENCE FROM LAST YEAR							
, in Mean Error (wt. %)	****	0.0024%	0.0029%	-0.0099%	-0.0027%	0.0436%	****
, in Std. Dev. (wt. %)	****	0.0063%	0.0053%	-0.0499%	-0.0042%	0.0340%	****
, in Mean Error (%)	****	0.04%	0.05%	-0.17%	-0.05%	0.75%	****
, in Std. Dev. (%)	****	0.11%	0.09%	-0.85%	-0.07%	0.58%	****
Number of Data Points	0	83	44	66	132	65	0

LAWRENCE LIVERMORE
PERCENT 240-PU 1993

All standard deviation and uncertainty limits are at two-sigma.

LOS ALAMOS
PERCENT 240-PU 1993

EG&G MOUND
PERCENT 240-PU 1993

All standard deviation and uncertainty limits are at two-sigma.

WESTINGHOUSE HANFORD
PERCENT 240-PU 1993

EG&G ROCKY FLATS - ANALYTICAL LAB.
PERCENT 240-PU 1993

RESULTS OF ANALYSIS OF PERCENT 241-Pu DATA

1993

	REPORTING LABORATORY						
	CSL	LLNL	LANL	MOUND	WHO	RFP	SRS
Mean Error (weight %)	****	-0.0009%	0.0006%	-0.0017%	-0.0001%	0.0007%	****
Std. Dev. (weight %)	****	0.0012%	0.0004%	0.0012%	0.0009%	0.0017%	****
Change in Mean (weight %)	****	0.0001%	0.0000%	0.0002%	0.0001%	0.0002%	****
Mean Error (%)	****	-0.49%	0.33%	-0.90%	-0.03%	0.38%	****
Std. Dev. (%)	****	0.65%	0.22%	0.60%	0.49%	0.90%	****
Change in Mean (%)	****	0.04%	0.02%	0.09%	0.03%	0.13%	****
REFERENCE FROM LAST YEAR							
Change in Mean Error (wt. %)	****	0.0003%	0.0003%	-0.0009%	0.0005%	0.0002%	****
Change in Std. Dev. (wt. %)	****	0.0005%	-0.0002%	0.0002%	-0.0001%	0.0000%	****
Change in Mean Error (%)	****	0.09%	0.17%	-0.51%	0.25%	0.10%	****
Change in Std. Dev. (%)	****	0.28%	-0.09%	0.11%	0.00%	0.02%	****
Number of Data Points	0	83	44	66	132	65	0

LAWRENCE LIVERMORE PERCENT 241-PU 1993

All standard deviation and uncertainty limits are at two-sigma.

LOS ALAMOS
PERCENT 241-PU 1993

EG&G MOUND
PERCENT 241-Pu 1993

All standard deviation and uncertainty limits are at two-sigma.

WESTINGHOUSE HANFORD
PERCENT 241-Pu 1993

EG&G ROCKY FLATS - ANALYTICAL LAB.
PERCENT 241-Pu 1993

All standard deviation and uncertainty limits are at two-sigma.

RESULTS OF ANALYSIS OF PERCENT 241-Am DATA

93

	REPORTING LABORATORY						
	CSL	LLNL	LANL	MOUND	WHO	RFP	SRS
n Error (weight %)	****	-0.0028%	0.0011%	0.0010%	-0.0021%	-0.0003%	****
Dev. (weight %)	****	0.0007%	0.0025%	0.0008%	0.0009%	0.0017%	****
in Mean (weight %)	****	0.0001%	0.0002%	0.0002%	0.0001%	0.0003%	****
n Error (%)	****	-1.47%	0.58%	0.52%	-1.10%	-0.13%	****
Dev. (%)	****	0.39%	1.31%	0.41%	0.49%	0.88%	****
in Mean (%)	****	0.04%	0.11%	0.10%	0.03%	0.15%	****
REFERENCE FROM LAST YEAR							
in Mean Error (wt. %)	****	-0.0001%	0.0035%	-0.0002%	0.0000%	0.0003%	****
in Std. Dev. (wt. %)	****	0.0003%	0.0007%	-0.0006%	0.0001%	-0.0008%	****
in Mean Error (%)	****	0.07%	1.95%	-0.17%	0.09%	0.19%	****
in Std. Dev. (%)	****	0.16%	0.31%	-0.35%	0.05%	-0.52%	****
iber of Data Points	0	83	44	66	132	65	0

LAWRENCE LIVERMORE PERCENT 241-AM 1993

All standard deviation and uncertainty limits are at two-sigma.

LOS ALAMOS
PERCENT 241-AM 1993

EG&G MOUND
PERCENT 241-AM 1993

All standard deviation and uncertainty limits are at two-sigma.

Measured/Accepted

WESTINGHOUSE HANFORD
PERCENT 241-AM 1993

EG&G ROCKY FLATS - ANALYTICAL LAB.
PERCENT 241-AM 1993

All standard deviation and uncertainty limits are at two-sigma.

CALORIMETRY EXCHANGE SAMPLE ON 01/01/89

Isotope	PPM Isotope / 239-Pu	% Isotope / Pu	% Uncertainty *
238-Pu	101	0.00944	0.6
239-Pu	1,000,000	93.8676	0.003
240-Pu	62,168	5.8600	0.06
241-Pu	2471	0.2338	0.57
242-Pu	306	0.0291	5.0
241-Am	1509	0.1429	0.4

Power = 0.9759 Watts +/- 0.07%

P-effective = 2.450 mW/g +/- 0.05%

* Uncertainties shown for Pu isotopes are one standard deviation, as found using the data reported by four labs which made the reference measurements on the sample in 1982.

CONSTANTS

Isotope	Decay Constant (day)**	Specific Power (W/g)
238-Pu	2.1630E-05	0.56757
239-Pu	7.8684E-08	1.9288E-03
240-Pu	2.8912E-07	7.0824E-03
241-Pu	1.3227E-04	3.4120E-03
242-Pu	5.0432E-09	1.1590E-04
241-Am	4.3768E-06	0.11420

** Reference: ANSI 15.22-1987 (Plutonium Bearing Solids - Calibration Techniques for Calorimetric Assay), page 22 (Table 4)

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