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OCTOBER 1970

PLANT INSTRUMENTATION PROGRAM

SECOND QUARTERLY REPORT

JULY-SEPTEMBER 1970

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BREEDER REACTOR DEVELOPMENT OPERATION • GENERAL ELECTRIC COMPANY
SUNNYVALE, CALIFORNIA

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July-September 1970

compiled by:

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D. M. Bishop* and E. A. Aitken†

ABSTRACT

Technical efforts associated with the Plant Instrumentation Program were directed toward the evaluation and qualification of nuclear assay instrumentation in time for their application to upcoming fuel fabrication programs. The evaluation of assay instrument techniques on prepared fuel rod, scrap, and waste standards is in the final stages. Approximately 600 individual assay tests were performed with calorimeter, gamma (sodium iodide and germanium–lithium) and neutron (gross and coincident) instrumentation techniques. Plans were formulated for the application of selected instrumentation to fuel fabrication programs, including the nondestructive nuclear assay of input, process, and product output materials.

I. INTRODUCTION

The General Electric Company has entered into a contract with the United States Atomic Energy Commission, Contract Number AT(30–1)–68, to support technical activities associated with the Plant Instrumentation Program. The program is sponsored by the Office of Safeguards and Materials Management and administration is provided by the Brookhaven office. The definition of program technical objectives as well as provisions for necessary equipment and technical direction are administered through the Brookhaven National Laboratory Technical Support Organization.

The Plant Instrumentation Program is an integrated experimental program directed toward the demonstration and evaluation of nondestructive techniques for the assay of special nuclear materials under actual fuel fabrication and processing plant conditions. Over—all program objectives were formulated to result ultimately in the development of a technological basis for a complex system of analytical instruments intended to increase assurance that high strategic value materials are not missing or diverted from intended use. At the same time, said equipment will provide in-plant inventory verification after events that might render past measurements doubtful or invalid.

Pursuant to these objectives, the initial phase of the Plant Instrumentation Program consists of the installation of suitable instrumentation in private plants engaged in processing special nuclear materials of high strategic value. Existing guidelines provide for instrument testing and evaluation under the following typical in-plant situations:

- Task A — Passive Assay of Plutonium Fuels
- Task B — Active Assay of Highly Enriched Uranium Scrap
- Task C — Calorimetric Determination of Plutonium in Scrap

Technical efforts were initiated by the General Electric Company in mid–April 1970, in the areas of Tasks A and C. The existing work scope includes: (a) the assembly of prototypical rod, scrap, and waste discard fuel standards; (b) the evaluation of supplied and General Electric Company assay equipment and techniques using these standard fuel specimens; (c) the demonstration of the utility of selected assay equipment as a materials balance tool during routine fuel rod fabrication campaigns.

This is the second in a series of quarterly progress reports written in partial fulfillment of Contract Number AT(30–1)–68. The reporting period is July–September 1970. The previous quarterly report in this series was GEAP-12114–1 for the reporting period April–June 1970.

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II. SUMMARY

Work effort continued on the evaluation of supplied and General Electric Company nondestructive nuclear assay instrumentation and techniques under actual fuel fabrication operating conditions. Gamma (sodium iodide and germanium—lithium), gross neutron, coincident neutron, and calorimetric (macro and micro) equipment systems are being tested. Fuel rod, scrap, and waste discard standards have been prepared and instrument calibration methods developed for each assay technique to assure time-independent analyses.

Approximately 500 individual tests were performed on mixed oxide fuel rod, scrap, and waste discard standards with gamma and neutron interrogation techniques. Approximately 100 calorimetric tests of plutonia feed materials and individual product fuel pellets were completed. The latter data will subsequently be compared with chemical analytical assay data on the same pellets.

The evaluation of initial nondestructive gamma and neutron assay techniques on typical fuel rod, scrap, and waste discard standards showed correlation to chemical analytical assay results for Plutonium—239 and Plutonium—241 analyses on the order of 1 to 2%. Relative standard errors of 0.025% were observed for the calorimetric inspection of 1 kg feed material lots.

Tentative plans were formalized for the application of selected nuclear assay techniques to fuel rod fabrication programs in support of the Atomic Energy Commission — Brookhaven National Laboratory sponsored Integrated Safeguards Experiment Program (ISE). Major categories are outlined as follows:

<u>Material</u>	<u>Assay Technique</u>
1. Plutonia Feed (powder)	Calorimetry Neutron (gross and coincident)
2. Process Pellets	Calorimetry Neutron (gross and coincident)
3. Product Fuel Rods	Gamma (sodium iodide and germanium—lithium)
4. Process Waste Scrap	Neutron (gross and coincident)
5. Absolute Filters	Neutron (gross and coincident) Gamma (germanium—lithium)

III. TASK A — PASSIVE ASSAY OF PLUTONIUM FUELS

A. TASK A1 — QUALIFICATION TESTING

1. Supply of Test Equipment

a. GAMMA SODIUM IODIDE TESTING

(1) *Fuel Rod Standards.* The counting instrumentation used for fuel rod standard testing consisted of a General Electric Company 2— by 2—inch sodium iodide detector, with a 0.020—inch—thick lead cover shield, and a double, single—channel analyzer. This equipment was installed in the Plutonium Fuels Laboratory adjacent to the fuel fabrication equipment.

Four distinct spectral regions were evaluated during a two-part test sequence:

<u>Channel</u>	<u>Spectral Region, MeV</u>	<u>Major Contributing Isotope</u>
A	0.20 to 0.30	Plutonium-239 Uranium-237 Americium-241 Uranium-238 daughter
B	0.30 to 0.50	Plutonium-239 Uranium-237 Americium-241 Uranium-238 daughter
C	0.50 to 0.75	Americium-241 Uranium-238 daughter
D	0.75 to 1.20	Americium-241 Uranium-238 daughter

Initial, single-channel gating was accomplished remotely through a cable tie-in with counting room multichannel analyzer instrumentation.

(2) *Fuel Scrap and Waste Discard Standards.* The counting equipment used for fuel scrap and waste discard testing consisted of a 2- by 2-inch sodium iodide detector with a 0.040-inch-thick lead cover shield. General Electric Company double, single-channel analyzer instrumentation was coupled with two additional single-channel analyzers supplied by Brookhaven National Laboratory Technical Support Organization to facilitate testing.

Four distinct spectral regions were simultaneously evaluated:

<u>Channel</u>	<u>Spectral Region, MeV</u>	<u>Major Contributing Isotope</u>
A	0.20 to 0.30	Plutonium-239 Uranium-237 Americium-241 Uranium-238 daughter
B	0.30 to 0.50	Plutonium-239 Uranium-237 Americium-241 Uranium-238 daughter
C	0.50 to 0.85	Americium-241 Uranium-238
D	0.85 to 1.20	Uranium-238

Initial, single-channel analyzer gating was accomplished remotely by using counting room multichannel analyzer instrumentation.

It should be noted that spectral regions C and D were modified from original rod scan channel gating to minimize drift problems by moving to the spectral valley beyond the 0.75-MeV composite photopeak. Thus, Americium-241 contributions to channel D were eliminated.

b. GAMMA GERMANIUM (LITHIUM) TESTING

(1) *Fuel Rod Standards.* A Brookhaven National Laboratory Technical Support Organization supplied 50-cc germanium (lithium) detector with an efficiency of 6.9%, resolution of 2.56 keV (Cobalt-60 full-width, half-maximum) and peak-to-Compton ratio of 20:1 was used for fuel rod standard testing. Single-channel analyzer gating was selected as follows:

<u>Channel</u>	<u>Spectral Region, MeV</u>
A	0.202 to 0.212
B	0.212 to 0.230
C	0.408 to 0.418
D	0.419 to 0.438

Thus, the 0.208-MeV Uranium-237 and 0.414 MeV Plutonium-239 photopeaks and background regions adjacent to each peak were simultaneously monitored. Single-channel analysis equipment supplied by General Electric Company and Brookhaven National Laboratory was used. Initial, single-channel analyzer gating was accomplished remotely by using counting room multichannel analyzer instrumentation.

c. GROSS AND COINCIDENT NEUTRON TESTING

Gross and coincident neutron counting equipment was supplied by the Brookhaven National Laboratory and installed in the Plutonium Fuels Laboratory. Operating instructions for the neutron counting equipment were provided by Brookhaven National Laboratory Technical Support Organization personnel. Preliminary neutron testing revealed instrumentation stability problems subsequently attributed to the system pre-amplifier and logic circuitry. Replacement components modified at Brookhaven National Laboratory operated satisfactorily.

Plutonium Fuels Laboratory neutron background levels were determined to be statistically significant. Background levels on the order of 20,000 gross counts, 160 real and accidental counts, and 150 accident counts per 5-minute test run were observed at a gate length of 2 by 64. A shielding system consisting of 0.026-inch-thick cadmium sheet, a 2-inch-thick layer of $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10 \text{H}_2\text{O}$ (borax), and 4 inches of polyethylene was constructed to surround the neutron coincident well counter and thereby decrease the relative background levels. As a result, neutron backgrounds were decreased to 5000 gross counts, 10 real and accidental counts, and 5 accident counts per 5-minute test run.

d. MISCELLANEOUS

Arrangements were finalized with the Lawrence Radiation Laboratory for a mutual-benefit, no-cost, loan agreement so that fuel standards prepared as part of the Plant Instrumentation Program could be evaluated at the Lawrence Radiation Laboratory.

2. Equipment Calibration

a. GAMMA SODIUM IODIDE TESTING

(1) *Fuel Rod Standards.* Day-to-day test instrument calibration was maintained by using the 0.511-MeV peak of a Sodium-22 source as a standard reference point. The calibration sequence is outlined as follows:

1. Calibration was verified by monitoring the ratio of counts observed in Channel A (0.20 to 0.30 MeV) to those observed in Channel B (0.30 to 0.50 MeV) for the Sodium-22 source.
2. Allowable ratio variations were determined by (a) defining as insignificant an instrument gain drift resulting in a 1% decrease in the count rate on a production fuel rod; (b) relating this decreased count rate from a characteristic plutonium peak-to-channel movement as observed on a multichannel analyzer (Appendix A, Figure A-1); and (c) finally, translating this peak channel drift back to the Sodium-22 source to establish allowable Channel A:B ratio-limits (Appendix A, Figure A-2).
3. A 100-second count time was selected for calibration verification tests after experimentally determining that the statistical significance gained by a 400-second count time did not compensate for the resulting test delays. A summary of 100- and 400-second calibration data for the Sodium-22 source is shown in Appendix A, Table A-1. The application of this calibration technique to routine testing resulted in the performance of a calibration test with the Sodium-22 source before and after each rod standard test run. The test data were considered valid only if each calibration check fell within prescribed Channel A and B ratio limits.

(2) *Fuel Scrap and Waste Discard Standards.* Routine test instrument calibration was verified in a manner similar to that previously described for rod standard testing. The Sodium-22 source, however, was counted in the static position for 200 seconds before and after every two tests. The effect of static versus rotating calibration tests were evaluated and determined to be insignificant. Sodium iodide scrap test calibration experiment data and results are summarized in Appendix A, Table A-2.

b. GAMMA GERMANIUM (LITHIUM) TESTING

(1) *Fuel Rod Standards.* Routine test instrument calibration was verified by changing single-channel analyzer D to 0.419 to 0.511 MeV to include the 0.511-MeV peak from a Sodium-22 calibration source. The calibration consisted of a 200-second static qualification test. Allowable gross count variations were determined by (a) defining as insignificant a 2% decrease in the net count rate on a production fuel rod; (b) relating this decreased count rate from a characteristic plutonium peak-to-channel movement as observed on a multichannel analyzer (Appendix A, Figure A-3), and (c) finally, translating this peak channel movement back to the Sodium-22 source to establish allowable gross count limits (Appendix A, Figure A-4). The application of this calibration technique to routine testing resulted in the performance of a calibration test before and after each rod standard test run. The test data were considered valid only if each calibration check fell within the prescribed channel D net count limits.

c. GROSS AND COINCIDENT NEUTRON TESTING

(1) *Fuel Rod Standards.* Routine test instrument calibration was maintained by intermittent test runs with fuel rod standard PIP-4 as a reference. No corrections for gain change or drift were required during the fuel standards evaluation test period.

Plutonium-238 and Plutonium-242 spontaneous neutron contribution to the net count test results were determined to be statistically significant (on the order of 4%). To compensate for this bias, the calculation of Plutonium-240 equivalent weights for the 32 fuel rod, scrap, and waste discard standards under evaluation were completed. Factors of 3.23 for the Plutonium-238 and 1.60 for the Plutonium-242 were multiplied by the isotopic weight fraction to determine the neutron equivalent Plutonium-240 mass numbers for each sample. Further, Uranium-238 contribution to the net count test results were determined empirically to be on the order of 10 to 15 net counts per 100 grams of urania per 5-minute test run.

3. Preparation of Fuel Standards

The collection and assembly of appropriate (Pu,U)O₂ fuel standards from previously categorized fuels selected from existing inventories were described in GEAP-12114-1. A summary of the fuel rod, scrap and waste discard standard configurations is presented in Table 1.

TABLE 1. Fuel Standard Designations

A. Encapsulated Fuel Rods

Mixed Oxide Weight (gm)	Thermal Fuel				Fast Fuel		Urania
	90% Fissile Pu % Pu/Pu+U				90% Fissile Pu % Pu/Pu+U-235		Natural Urania Feed Material % U-235
	1.632	2.563	5.493	9.160	2.540	24.716	0.74
160	PIP-1	PIP-2	PIP-3	PIP-4	PIP-5	PIP-6	PIP-7

(6 in. active fuel column)

B. Fuel Scrap*

	2.563	5.493	9.160	2.540	24.716	0.74
50	PIP-8	PIP-11	PIP-14	PIP-17	PIP-20	—
100	PIP-9	PIP-12	PIP-15	PIP-18	PIP-21	PIP-33
500	PIP-10	PIP-13	PIP-16	PIP-19	PIP-22	—

C. Fuel Waste Discards*

Mixed Oxide Weight (gm)	Thermal Fuel			Fast Fuel			
	Point Source	90% Fissile Fuel 5.493% Pu/Pu+U		80% Fissile Pu 2.540% Pu/Pu+U		90% Fissile Pu 24.716% Pu	
		1/2 Radius	Full Radius	Point Source	Point Source	1/2 Radius	Full Radius
1	PIP-23	PIP-25	PIP-27	PIP-29	PIP-30	PIP-31	PIP-32
10	PIP-24	PIP-26	PIP-28	—	—	—	—

*Fuel materials contained in standard one-gallon paint cans.

It should be noted that rod standard chemical analytical assay analyses were corrected for Plutonium-241 decay to the approximate date of nondestructive assay inspection. The decay scheme used is presented in Table 2. The resultant chemical analytical assay data for Plutonium-239, Plutonium-241, Uranium-238, and Americium-241 is given in Table 3.

TABLE 2. Decay Scheme Plutonium-241 ($t_{1/2} = 13$ years)

<u>Months Decay</u>	<u>Decay Factor</u>	<u>Months Decay</u>	<u>Decay Factor</u>
0*	1.000	10	1.045
1	1.0045	11	1.050
2	1.009	12	1.055
3	1.013	13	1.0595
4	1.018	14	1.064
5	1.0225	15	1.069
6	1.027	16	1.074
7**	1.032	17	1.0785
8	1.031	18	1.083
9	1.041	19	1.088

*Original chemical analysis date — 1/70

**Nondestructive assay date — 7/70

B. TASK A2 — PERFORMANCE TESTING**1. Gamma Sodium Iodide Testing****a. FUEL ROD STANDARDS**

(1) *Test Methods.* Approximately 60 tests were completed on fuel rod standards, including five thermal fuel rods, one urania fuel rod and one Americium-241 source rod. Fuel rod standard testing was accomplished in a sequential order rather than in serial order to be more representative of actual fuel fabrication plant operating conditions. The test sequence conducted is outlined as follows:

1. Calibration checks — Sodium-22 source (static);
2. Rod standard test scan — spectral channels B and C (dynamic);
3. Calibration checks — Sodium-22 source (static);
4. Rod standard test scan — spectral channels A and D (dynamic);
5. Calibration check - Sodium-22 source (static).

A rod scan test consisted of a 1000-second dynamic scan with the rod passed through a lead-shielded, collet-slit assembly at approximately 1/2 inch/minute. Calibration verifications were accomplished by placing an encapsulated Sodium-22 source in a fixed position in the collet assembly.

(2) *Data Analysis.* A ratio method, data stripping technique was developed to analyze gamma sodium iodide counting data. The technique is based on the ratio comparison of each of the four spectral channels (channel A, B, C, and D) for known prototypical fuel rod geometry urania, plutonia, and americium standard sources. This technique results in quantitative Plutonium-239, Plutonium-241, Americium-241 and Uranium-238 analyses independent of plutonia fuel isotopic enrichment. A description of the data stripping technique is presented in Appendix B, Table B-1.

(3) *Test Results.* Test data resulting from four sequential test runs per rod along with all calibration and background data are presented in Appendix B, Table B-2. The computer program developed to facilitate the ratio method test data analysis is shown in Appendix B, Table B-3. A urania feed material fuel rod (PIP-7) and an Americium-241 source were utilized to establish the necessary constants required for test data stripping. PIP-2 and PIP-5 were selected as mixed oxide fuel rod calibration standards.

TABLE 3. Fuel Rod Standards Analytical Chemistry Assay Results **

Fuel Group	Rod	Mixed Oxide	SS Factor (U+Pu)	Metal Assay		SS Weight (gm) (U+Pu)	Plutonium (gm)				Uranium (gm)		Americium (gm)*
		Net Weight (gm)		Pu, %	U, %		Total	Pu-239	Pu-241		U-235	U-238	Am-241 at 7/70
									at 1/70	at 7/70			
2	1	156.89	0.8815	1.632	98.368	138.30	2.257	1.96	0.056	0.0545	1.01	134.87	0.00914
2	2	164.82	0.8816	2.563	97.437	145.31	3.724	3.23	0.093	0.0906	1.05	140.36	0.0152
2	3	159.68	0.8818	5.493	94.507	140.81	7.735	6.72	0.194	0.189	0.98	131.92	0.0317
2	4	163.31	0.8818	9.160	90.840	144.01	13.190	11.47	0.331	0.322	0.97	129.68	0.0540
3	5	159.01	0.8815	2.540	97.460	140.17	3.510	2.68	0.178	0.174	1.01	135.19	0.0268
4	6	37.46	0.8818	24.716	75.284	33.03	—	7.40	0.03	—	22.66	1.97	—
5	7	181.00	0.8809	0.0	100.00	159.44	—	—	—	—	1.18	158.06	—

*Vendor analysis:

90% 2443 ppm Am-241/PuO₂ at 7/8/69

80% 5103 ppm Am-241 at 11/5/69

**Analysis performed November—December 1969

The result of intermediate test data stripping was the differentiation of the gross count data into specific isotopic contributions per channel. A summary of these data for each run on the five rod standards tested is presented in Appendix B, Table B-4. It should be noted the net count per gram constants utilized for subsequent analysis were determined by the major isotopic contribution per channel as follows:

<u>Channel</u>	<u>Isotope</u>
A	Plutonium-241
B	Plutonium-239
C	Americium-241
D	Uranium-238

Isotopic net count contributions per channel are translated into mass units (grams) of the isotope and are compared to the results of chemical analytical analysis (Appendix B, Table B-5).

A summary comparison of mean rod standard test results with known chemical analytical assay values is presented in Table 4. Average deviations from known assay values are outlined as follows:

<u>Isotope</u>	<u>Average Deviation from Chemical Analytical Value (%)</u>
Plutonium-239	1.67
Plutonium-241	2.16
Americium-241	13.32
Uranium-238	14.05
Uranium-235	22.43

TABLE 4. Gamma Sodium Iodide Testing Rod Data Summary

Plutonium-239				Plutonium-241		
Sample	Chemical Analytical Assay Value	Test	% Dev. from Std.	Chemical Analytical Assay Value	Test	% Dev. from Std.
PIP-1	1.96	2.01	2.55	0.054	0.057	5.56
PIP-2	3.23	3.23	0.00	0.090	0.091	1.11
PIP-3	6.72	6.69	0.45	0.187	0.189	1.07
PIP-4	11.47	10.98	4.27	0.319	0.313	1.88
PIP-5	2.68	2.71	1.12	0.172	0.174	1.16
			$\bar{x} = 1.67$			2.16

Americium-241 (gm)				Uranium-238 (gm)			Uranium-235 (gm)		
Sample	Chemical Analytical Assay Value	Test	% Dev. from Std.	Chemical Analytical Assay Value	Test	% Dev. from Std.	Chemical Analytical Assay Value	Test	% Dev. from Std.
PIP-1	0.009	0.012	33.33	134.87	123.475	8.45	1.010	0.923	8.61
PIP-2	0.015	0.016	6.67	140.360	140.375	0.01	1.050	1.045	0.48
PIP-3	0.032	0.034	6.25	131.920	152.275	15.43	0.980	1.135	15.82
PIP-4	0.054	0.057	5.56	129.680	174.525	34.58	1.010	1.303	29.01
PIP-5	0.027	0.023	14.81	135.190	149.775	10.79	1.010	1.118	10.69
			$\bar{x} = 13.32$			14.05			22.43

Uranium-238 and Americium-241 results deviated from analytical assay data by as much as 35%. This variance in analyses results is partially explained by the original spectral region channel selection for channel D (0.75 to 1.20 MeV). Americium-241 contributions to that channel were assumed to be statistically insignificant. The variations in test results make the validity of this assumption questionable. Further, Plutonium-239 contributions to channel C (0.50 to 0.75 MeV), previously considered negligible, appear also to be statistically significant and should be accounted for in subsequent testing. A proposed method for this correction is the iterative adjustment of the data stripping equations by using empirical data to optimize results. Subsequent efforts will be handled in this manner. The use of pure isotopic sources is an alternative method for making these corrections.

(4) *Serial Ordering Experiment.* As an aside from sequential order rod testing, five fuel rod standards tests were accomplished in serial order to compare process capability in the short-to-long-term sequential rod test data. No significant variation between the ordering methods was observed. A summary of gamma sodium iodide serial test data and results for rod standard PIP-1 is given in Appendix B, Tables B-6 and B-7.

(5) *Position Experiment.* A rod positioning experiment was conducted to determine the statistical significance of fuel column position within the cladding material. Testing was accomplished in a similar manner to that used for routine rod testing. Test results showed no significant bias attributed to fuel column position within the cladding. Rod position experiment test data are presented in Appendix B, Table B-8.

b. FUEL SCRAP AND WASTE DISCARD STANDARDS

(1) *Test Method.* Approximately 200 tests were completed on fuel scrap standards including nineteen thermal fuel, six fast fuel, and one uranium fuel standard. Routine standard testing was accomplished by rotating the 1-gallon sample container. No attempt was made to maintain concentric or reproducible sample position within the sample container. The specimen was rotated at 8 rpm. No attempt was made to maintain concentric or reproducible sample position within the sample container. The sample container was located within a lead-shielded cave (15-5/8 inches from the sodium iodide detector to the can circumference). The test sequence used involved counting each fuel specimen five times, in serial order for 400 seconds.

Test data for the 25 fuel scrap and waste standards are presented in Appendix C, Table C-1. Further analysis of these data is progressing on a low priority basis.

(2) *Position Experiment.* A test was completed to evaluate possible measurement errors resulting from variations in source positioning within the 1-gallon scrap standard container. Center and peripheral container loadings were tested by placing known sources first high, then middle, then low along the vertical axis. The purpose of this experiment was to determine the sensitivity of the measurement method to various locations of a fixed quantity of source material within a standard 1-gallon can specimen holder. PIP fuel standards 8 and 16 were measured and compared to a Sodium-22 standard source. Test results are outlined as follows:

1. The Sodium-22 standard operated as a point source and produced essentially the same count regardless of position within the can. Neither position nor run differences were significant factors at the 95% confidence level.
2. Fuel scrap standards PIP-8 produced significantly variable results. Positions C, D, and B were statistically related. Positions B, D, A, and F were also statistically related but were significantly different from the set C, D, and B. Position E was entirely unique.
3. Fuel scrap standards PIP-16 showed all six positions to be statistically different from one another at the 95% confidence level.

Sodium iodide scrap test position experiment test data are presented in Appendix C, Table C-2. A summary of source location and statistical data evaluation methods is given in Appendix C, Table C-3.

2. Gamma Germanium (Lithium) Testing

a. TEST METHODS

Approximately 50 tests were performed on six (Pu,U)O₂ fuel rod standards and one urania fuel rod standard. Routine rod standard testing was accomplished in a sequential order. A typical test sequence is outlined as follows:

1. Calibration check — Sodium-22 source (static);
2. Rod standard test scan — spectral channels A, B, C, and D (dynamic);
3. Calibration check — Sodium-22 source (static).

A rod scan test consisted of a 1000-second dynamic scan with the rod passed through a lead-shielded, collet-slit assembly at approximately 1/2-inch/minute. Calibration verifications were accomplished by placing an encapsulated Sodium-22 source in a fixed position in the collet assembly.

b. TEST RESULTS

Test data result from five test runs per standard rod along with all calibration and background data are presented in Appendix D, Table D-1. It should be noted that a faulty instrument setting resulted in incorrect gating of spectral region D. Data from that channel was multiplied by a correction factor of 0.205 (based on rod specimen PIP-3 as a standard) to compensate for this error. The computer program utilized for test data stripping is presented in Appendix D, Table D-2, and final germanium (lithium) test results are in Appendix D, Table D-3. Germanium (lithium) test result accuracies are presented in Table 5; a summary of these data follows:

Isotope	Mean Deviation from Chemical Analytical Value (%)
Plutonium-239	2.53
Plutonium-241	1.47

TABLE 5. Gamma Germanium (Lithium) Rod Scan Test Results Data Summary

Sample	Plutonium-239			Plutonium-241		
	Chemical Analytical Assay Value	Test	% Dev. From Std.	Chemical Analytical Assay Value	Test	% Dev. From Std.
PIP-1	1.96	2.01	2.55	0.054	0.056	3.70
PIP-2	3.23	3.23	0.00	0.090	0.090	0.00
PIP-3	6.72	6.72	0.00	0.187	0.187	0.00
PIP-4	11.47	10.43	8.98	0.319	0.311	2.51
PIP-5	2.68	2.65	1.12	0.172	0.170	1.16
			$\bar{x} = 2.53$			1.47

3. Gross and Coincident Neutron Counting

Approximately 200 tests were recently completed on 32 fuel rod, scrap, and waste standards. Operating stability of the Brookhaven National Laboratory Technical Support Organization instrumentation was excellent.

The analysis of rod, scrap, and waste fuel standard test data is in progress. Preliminary rod counting test results are presented in Table 6 to allow comparison with gamma sodium iodide and germanium (lithium) rod standard test results. A summary of these data follows:

Gross Neutron Testing

<u>Isotope</u>	<u>Mean Deviation from Chemical Analytical Value (%)</u>
Plutonium-239	2.70
Plutonium-241	3.04

Coincident Neutron Testing

<u>Isotope</u>	<u>Mean Deviation from Chemical Analytical Value (%)</u>
Plutonium-239	1.33
Plutonium-241	3.78

The analysis of fuel scrap and waste discard standard test data is in progress.

TABLE 6. Neutron Counting Rod Scan Test Results Data Summary

Plutonium-239						Plutonium-241					
		Gross Neutron		Coincident Neutron				Gross Neutron		Coincident Neutron	
Sample	Chemical Analytical Assay Value	% Dev. Test from Std.	% Dev. Test from Std.	Sample	Chemical Analytical Assay Value	% Dev. Test from Std.	% Dev. Test from Std.	Sample	Chemical Analytical Assay Value	% Dev. Test from Std.	% Dev. Test from Std.
PIP-1	1.96	1.92	2.04	PIP-1	0.054	0.055	1.81	PIP-1	0.054	0.059	9.26
PIP-2	3.23	3.12	3.41	PIP-2	0.090	0.090	0.00	PIP-2	0.090	0.092	2.22
PIP-3	6.72	6.64	1.19	PIP-3	0.187	0.192	2.67	PIP-3	0.187	0.194	3.74
PIP-4	11.47	11.46	0.87	PIP-4	0.319	0.331	3.76	PIP-4	0.319	0.331	3.76
PIP-5	2.68	2.50	5.97	PIP-5	0.172	0.160	6.98	PIP-5	0.172	0.172	0.00
		x̄ = 2.70		1.33		3.04				3.78	

4. Miscellaneous

a. SEFOR ROD 876

Assistance was provided to Brookhaven National Laboratory Technical Support Organization personnel for the pellet by pellet gamma scan inspection of (Pu,U)O₂ fuel pellets removed from SEFOR fuel rod 876.

IV. TASK C – CALORIMETRIC DETERMINATION OF PLUTONIUM IN SCRAP

A. TASK C1 – QUALIFICATION TESTING

1. Supply of Test Equipment

Checkout and calibration of the two calorimeters received from the Mound Laboratory were completed. These calorimeters were used to measure the heat outputs of PuO₂ powders and mixed oxide fuel pellets. One calorimeter compatible with standard size feed material containers has been used to determine the heat outputs of the received PuO₂ powder in the watt range. The second calorimeter has been used to measure heat outputs on individual mixed oxide fuel pellet material in the milliwatt range.

2. Equipment Calibration

Twenty-three test runs were made on Mound-supplied standards to determine operating performance. A test plan to measure the energy output from feed material to be used in the forthcoming Integrated Safeguards Experiment (ISE) fabrication campaigns was implemented. In addition, two scrap samples were measured to determine the detectability limits of the large calorimeter (128). Assessment of this calorimeter data indicates the following accuracy of measurement.

- 5 milliwatts (approximately 2 grams Pu) to within 5%;
- 35 milliwatts (approximately 14 grams Pu) to within 1%;
- 2 watts (approximately 800 grams Pu) to within 0.2%.

B. TASK C2 – PERFORMANCE TESTING

1. Feed Material (PuO₂ Powder)

The heat outputs from the feed material for ISE campaigns one and two have been measured. These feed material batches were identified as A0122 and A0146, respectively. A summary of the calculation constants and the isotopic data used for data analysis are presented in Appendix E, Table E-1.

All seven A0122 cans were calorimetered. Several runs were made on cans A and D to determine the precision of the method. Test results are presented in Table 7A. Duplicate test runs were performed on each of the four cans of A0146; test results are presented in Table 7B.

The output data from the calorimeter are in terms of watts. These data are absolute measurements, that is, the heat from the sample is measured and compared to a known, measured amount of electrical heat. As repetitive runs are made, the wattage output increases as a result of the decay of Plutonium-241 and buildup of Americium-241. The wattage values for each isotope used to calculate the plutonium content are listed below. Several factors are used in this calculation: (a) isotopic abundance of plutonium on a given day; (b) americium concentration on a given day; (c) heat outputs per gram of isotope; and (d) half-life data for the isotopes. The last two items for the isotopes are known to a great degree of certainty. However, the first two have to be determined analytically. In calculating the grams of plutonium, the vendors' analytical results have been used. In A0122, the grams of plutonium determined by calorimetry versus chemical assay give close agreement. However, in A0146, the agreement between the calorimeter values and the chemical assay are not so good — the calorimeter values being approximately 14% high. Also, although the wattages generally increase because of the increased Americium-241, the plutonium values decrease. Both the large

TABLE 7. ISE Campaigns — Calorimetric Inspection — Feed Material

A. A0122 Test Results

<u>Sample Can</u>	<u>Date Analyzed</u>	<u>Calorimeter Wattage</u>	<u>Calorimeter** Pu, gm</u>	<u>Chemical* Assay, Pu, gm</u>	<u>Difference, %</u>
A	7/31/70	1.718000	486.50	487.46	-0.19
A	8/11/70	1.719435	486.64	487.46	-0.17
A	8/21/70	1.721044	486.45	487.46	-0.21
A	8/26/70	1.722616	486.58	487.46	-0.18
A	8/31/70	1.722531	486.30	487.46	-0.24
A	9/ 3/70	1.723511	486.42	487.46	-0.21
B	7/21/70	2.068589	586.56	581.58	+0.86
C	8/ 5/70	2.894039	819.33	823.87	-0.55
D	7/29/70	3.456342	979.24	973.52	+0.59
D	8/ 4/70	3.457878	979.08	973.52	+0.57
D	8/10/70	3.459859	979.03	973.52	+0.56
D	8/12/70	3.462494	979.06	973.52	+0.57
D	8/20/70	3.464772	979.40	973.52	+0.60
D	8/24/70	3.465533	979.29	973.52	+0.59
D	8/28/70	3.466933	979.08	973.52	+0.57
D	9/ 1/70	3.468854	979.22	973.52	+0.58
D	9/ 3/70	3.469366	979.15	973.52	+0.58
E	7/24/70	3.499556	991.86	984.92	+0.70
F	7/30/70	3.603188	1020.74	1019.74	+0.10
F	8/14/70	3.609739	1021.02	1019.74	+0.12
G	8/ 6/70	3.593811	1017.35	1020.62	-0.32
G	8/18/70	3.597854	1017.36	1020.62	-0.32

Sample Can A

 $\sigma = \pm 0.122$ 95% confidence level for individual results = ± 0.316

Relative standard error — 0.025%

Sample Can D

 $\sigma = \pm 0.123$ 95% confidence level for individual results = ± 0.278

Relative standard error — 0.013%

B. A0146 Test Results

A	9/11/70	0.068965	14.76	12.9	+14.4
A	9/17/70	0.068815	14.72	12.9	+14.1
B	9/15/70	4.187611	895.96	788.7	+13.6
B	9/21/70	4.189144	895.54	788.7	+13.5
C	9/22/70	4.493089	960.39	845.6	+13.6
C	9/29/70	4.496009	960.06	845.6	+13.5
D	9/24/70	4.27731349	913.99	804.8	+13.6
D	10/6/70	4.28251106	913.69	804.8	+13.5

*Chemical assay includes only vendor analyses.

disagreement between the two methods in determining total plutonium content and the "decrease" in the amount of plutonium on duplicate runs point to inaccuracies in the determination of the isotopic abundances. As such, the vendor-supplied isotopic and americium values are being verified at our laboratory and by an independent source.

2. Process Samples

Several calorimetric samples were taken from two mixed oxide fuel blends prepared as part of ISE Campaign 1. The two blends, identified as M0095 and M0098, were physically mixed to be 4.00 and 3.92% Pu/Pu+U (nominal). Test data from both blends are given in Table 8. The average Pu/Pu+U value from each blend is essentially the same as the target composition. However, the range in each series of samples is uncomfortably high. The observed range was 0.44% for M0095 and 0.51% for M0098 fuel pellets.

TABLE 8. Process Sample Calorimetry — Test Results

Fuel Batch	Sample	Date Analyzed	Weight (gm)	Calorimetry Wattage	$\frac{\text{Pu}}{\text{Pu+U}} \times 100$
A. M0095	1	1/ 1/70	10.1119	0.00136439	4.22
	2	9/ 1/70	9.9649	0.00125413	3.95
	3	9/ 2/70	10.4303	0.00126080	3.78
	4	9/ 2/70	11.0001	0.00146709	4.18
	5	9/ 3/70	11.0340	0.00142577	4.05
	6	9/ 4/70	11.1678	0.00149469	4.19
	7	9/ 4/70	10.6191	0.00136787	4.04
	8	9/ 8/70	9.9389	0.00128607	4.03
	9	9/ 9/70	10.4071	0.00128016	3.82
	10	9/ 9/70	9.6761	0.00126506	4.08
	11	9/10/70	10.7616	0.00135794	3.92
B. M0098	1	9/14/70	11.2083	0.00137675	3.84
	2	9/15/70	12.1192	0.00157373	4.07
	3	9/15/70	11.4298	0.00144547	3.96
	4	9/16/70	10.5216	0.00125590	3.73
	5	9/17/70	10.8707	0.00147689	4.22
	6	9/18/70	10.9575	0.00140395	4.01
	7	9/21/70	11.5136	0.00151589	4.12
	8	9/22/70	12.1803	0.00158617	4.07
	9	9/24/70	12.0470	0.00147539	3.83
	10	9/25/70	11.9164	0.0014676	3.85
	11	9/29/70	11.1310	0.00139285	3.91
	12	9/28/70	11.6469	0.00141266	3.79
	13	9/30/70	12.3381	0.00146469	3.71
	14		11.1283	0.00132520	3.83

M0095 — average $4.02 \sigma \pm 0.14$

M0098 — average $3.92 \sigma \pm 0.15$

Several factors could account for the large variations in results. The first and probably most important anomaly involved a localized fragmentation of insulator material in the microcalorimeter detector bridge area and resulted in an increased sensitivity to environment temperature variations. A second problem could be sensitivity of the calorimeter in the low milliwatt range. However, Mound has stated that repeatability should be at least $\pm 1\%$ in this wattage region. Evaluation of this problem is continuing.

As a further means of minimizing environmental variations the differential method of calorimetry (rather than the replacement method) will be evaluated. In the replacement method, the sample heat is measured and followed by a measurement of a known amount of electrical heat. The sample wattage calculation is based on the amount of electrical heat measured. These are two separate measurements between which environmental change may occur and cause inaccuracies. In the differential method, the sample heat output is simultaneously measured against a known standard sample. The standard is placed in one side of the calorimeter and the sample in the other. With this method, only one measurement is required. Environmental changes will affect both standard and sample to the same degree and thus be cancelled. An additional advantage is this method requires only one measurement for each sample and reduces the test time by one-half. Evaluation of the differential method is in progress.

3. Miscellaneous

The calorimetric inspection of fuel scrap specimen plutonium nitrate feed material solution was deferred to provide maximum available test time for current fuel fabrication campaign commitments (ISE campaigns 1 and 2). However, both sample areas remain as future technical objectives.

CONTRIBUTORS

The following General Electric Company personnel contributed to the work performed on the Plant Instrumentation Program during the quarter ending September 30, 1970:

Task A — Passive Assay of Plutonium Fuel
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APPENDIX A

EQUIPMENT CALIBRATION

TABLE A-1. Gamma Sodium Iodide Rod Test Calibration
Count Time Experiment - Sodium-22 SourceCounting
Time

		100 Sec.			400 Sec.			
Item No.	Test No.	Channel		Ratio A/B	Test No.	Channel		Ratio A/B
		A	B			A	B	
1	I33A	27332	43779	.624	I33B	113348	170682	.664
2	I33C	28183	42387	.665	I33D	113264	170372	.665
3	I33E	28511	42987	.663	I33F	113357	169754	.668
4	I33G	28129	42808	.657	I33H	112560	171096	.658
5	I33I	27995	42828	.654	I34A	111746	171655	.651
6	I34B	28177	43028	.655	I34C	111560	172611	.646
7	I34D	27261	44062	.619	I34E	111637	171653	.650
8	I34F	27907	42867	.651	I34G	111614	173133	.645
9	I34H	27705	43244	.641	I34I	111089	172591	.644
$\bar{X}$ =		27911.1	43110				112286	171505
S_X =		412.237	517.95				964.385	1134.22
$2S_X\%$ =		2.95%	2.4				1.72	1.32

TABLE A-2. Gamma Sodium Iodide Scrap Testing
Calibration Equipment Test Data

200 Second Counts

A. Static

<u>Test No.</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>
III47F	13172	18893	17798	4655
G	13264	18373	18018	4577
H	13292	18876	17884	4700
I	13454	18518	17764	4642
III48A	13280	18881	17907	4587
B	13247	18730	17654	4685
C	13134	18713	18152	4632
D	12922	18631	17999	4667
E	13184	18621	18144	4699
F	13354	18544	17887	4689
n	= 10	10	10	10
$\bar{x}_{net}$	= 12729.3	18063.0	17181.7	4262.3
S_x	= 142.6	174.0	160.7	44.1

B. Rotating

III48G	12783	18185	17483	4443
H	12943	18516	17228	4557
I	12843	18318	17649	4568
A	12687	18344	17430	4475
B	12677	18233	17651	4506
C	12645	17879	17601	4407
D	12641	18373	17584	4526
E	12760	18215	17666	4473
F	12920	18247	17402	4389
G	12734	18273	17909	4499
n	= 10	10	10	10
$\bar{x}_{net}$	= 12262.3	17643.3	16821.3	4093.3
S_x	= 108.9	164.17	185.4	59.3

C. Background

501	615	739	391
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FIGURE A-1. Gamma Sodium Iodide Testing - (PuU) O_2 Rod Calibration Curve
Test Number I17A, Rod Number PIP-4

FIGURE A-2. Gamma Sodium Iodide Testing – Sodium-22 Calibration Curve
Test Number I15A

FIGURE A-3. Gamma Germanium (Lithium) Testing - (Pu, U) O_2 Rod Calibration Curve
Test Number IV.8A, Rod Number PIP-4

FIGURE A-4. Gamma Germanium (Lithium) Rod Testing – Sodium-22 Calibration Curve
Test Number IV 10A

APPENDIX B

GAMMA SODIUM IODIDE ROD
STANDARD - TEST RESULTS

TABLE B-1. Gamma Sodium Iodide Testing Ratio Analysis Data Stripping Method

1. Definitions:

A_i = the 0.180 to 0.294 MeV spectral region

B_i = the 0.294 to 0.500 MeV spectral region

C_i = the 0.500 to 0.750 MeV spectral region

D_i = the 0.750 to 1.20 MeV spectral region

2. Symbols:

a. 1 = Americium-241

7 = Uranium-237

8 = Uranium-238

9 = Plutonium-239

b. A = the integral count rate in region A_i

B = the integral count rate in region B_i

C = the integral count rate in region C_i

D = the integral count rate in region D_i

c. b_s = the background in region(s)

d. A1 = net count contribution in region A_i resulting from Americium-241

A7 = net count contribution in region A_i resulting from Uranium-237

A8 = net count contribution in region A_i resulting from Uranium-238

A9 = net count contribution in region A_i resulting from Plutonium-239

Similar isotopic spectral region contributions hold for spectral regions B_i , C_i and D_i .

3. Assumptions:

a. $A = A8 + A1 + A9 + A7 + b_A$

b. $B = B8 + B1 + B9 + B7 + b_B$

c. $C = C8 + C1 + b_C$

d. $D = D8 + D1 + b_D$

4. Ratio Analysis Method:

- a. By experimentally determining gross count and background count levels in channels A_i , B_i , C_i and D_i resulting from a urania fuel rod standard (PIP-7), the following Uranium-238 ratios were defined:

$$(1) \quad \frac{C8}{D8} = Z$$

$$(2) \quad \frac{B8}{D8} = Y$$

$$(3) \quad \frac{A8}{D8} = X$$

- b. By experimentally determining gross count and background count levels in channels A_i , B_i , C_i , and D_i and also those resulting from an Am-241 source rod standard, the following Am-241 ratios were defined:

$$(1) \quad \frac{B1}{C1} = v$$

$$(2) \quad \frac{A1}{C1} = u$$

$$(3) \quad \frac{D1}{C1} = w1$$

- c. Define:

G_{19} = grams of Plutonium-239 in standard rod number 1 (PIP-2)

G_{17} = grams of Plutonium-241 in standard rod number 1 (PIP-2)

G_{18} = grams of Uranium-238 in standard rod number 1 (PIP-2)

G_{11} = grams of Americium-241 in standard rod number 1 (PIP-2)

G_{29} = grams of Plutonium-239 in standard rod number 2 (PIP-5)

G_{27} = grams of Plutonium-241 in standard rod number 2 (PIP-5)

G_{28} = grams of Uranium-238 in standard rod number 2 (PIP-5)

G_{21} = grams of Americium-241 in standard rod number 2 (PIP-5)

- d. Scan the standard fuel rods (PIP-2 and 5) to determine gross counts in regions A_i , B_i , C_i and D_i .

- e. Restating equations (3a . . . 3d):

$$C8 = C - C1 - b_C$$

$$D8 = D - D1 - b_D$$

$$\therefore \frac{C8}{D8} = \frac{C - C1 - b_C}{D - D1 - b_D} = Z$$

and,

$$\frac{D1}{C1} = \frac{D - D8 - b_D}{C - C8 - b_C} = w1$$

Further:

$$C1 = [C - b_C - Z(D - b_D)] / [1 - w1(Z)]$$

$$C8 = [D - b_D - w1(C - b_C)] / \left(\frac{1}{Z} - w1 \right)$$

$$D1 = [C - b_C - Z(D - b_D)] / \left(\frac{1}{w1} - Z \right)$$

$$D8 = [D - b_D - w1(C - b_C)] / [1 - w1(Z)]$$

f. Define: (counts/gram ratios)

$$(1) \quad R1 = D8/G_{i8}$$

$$R2 = C1/G_{11}$$

$$P1 = C8/G_{18}$$

$$P2 = D1/G_{11}$$

$$(2) \quad K = B8 + B1 + b_B$$

$$L = A8 + A1 + b_A$$

g. Therefore:

$$\begin{aligned} K_n &= \left(\frac{B8}{D8} \right) D_n 8 + \left(\frac{B1}{C1} \right) C_n 1 + b_{nB} \\ &= Y(G_n 8) R1 + v(G_n 1) R2 + b_{nB} \end{aligned}$$

and,

$$\begin{aligned} L_n &= \left(\frac{A8}{D8} \right) D_n 8 + \left(\frac{A1}{C1} \right) C_n 1 + b_{nA} \\ &= x(G_n 8) R1 + u(G_n 1) R2 + b_{nA} \end{aligned}$$

where n = the standard rod number (n = 1 for PIP-2 and 2 for PIP-5)

h. Define:

$$R3 = \frac{B9}{G9} = \frac{G_1^7(K_2 - B_2) - G_2^7(G_1 - B_1)}{G_1^9(G_2^7) - G_2^9(G_1^7)}$$

$$R4 = \frac{A7}{G7} = \frac{G_1^9(L_2 - A_2) - G_2^9(L_1 - A_1)}{G_1^7(G_2^9) - G_2^7(G_1^9)}$$

$$R5 = \frac{A9}{G9} = \frac{G_1^7(L_2 - A_2) - G_2^7(L_1 - A_1)}{G_1^9(G_2^7) - G_2^9(G_1^7)}$$

$$R6 = \frac{B7}{G7} = \frac{G_1^9(K_2 - B_2) - G_2^9(K_1 - B_1)}{G_1^7(G_2^9) - G_2^7(G_1^9)}$$

5. Basic Relationships:

a. $C_n = P_1 G_n^8 + R_2 G_n^1 + b_C$

b. $D_n = R_1 G_n^8 + P_2 G_n^1 + b_D$

c. $A_n = R_5 G_n^9 + R_4 G_n^7 + L$

d. $B_n = R_3 G_n^9 + R_6 G_n^7 + K$

6. Results:

Solving for:

$$\begin{aligned} G_n^9 &= \text{the grams of Plutonium-239 in rod (n)} \\ &= [R4(B_n - K_n) - R6(A_n - L_n)] / (R_3 R_4 - R_5 R_6) \end{aligned}$$

$$\begin{aligned} G_n^7 &= \text{the grams of Uranium-237 in rod (n)} \\ &= [R3(A_n - L_n) - R5(B_n - K_n)] / (R_3 R_4 - R_5 R_6) \end{aligned}$$

$$\begin{aligned} G_n^8 &= \text{the grams of Uranium-238 in rod (n)} \\ &= [D_n - Q_n - w1(C_n - N_n - C9)] / [1 - w1(Z)] [R1] \end{aligned}$$

$$G_n^1 = \text{the grams of Americium-241 in rod (n)}$$

$$G_n^1 = [C_n - N_n - C9 - Z(D_n - Q_n)] / [1 - w1(Z)] [R2]$$

where:

$$N_n = b_n C_i$$

$$Q_n = b_n D_i$$

$$P_n = b_n A_i$$

$$M_n = b_n B_i$$

$C_9 = 0$ The contribution of Plutonium-239
in region C_i was assumed to be zero.

Therefore, by experimentally counting the unknown rods to determine the gross count and background counts in spectral regions A_i , B_i , C_i and D_i , quantitative Plutonium-239, Plutonium-241, Americium-241 and Uranium-238 analysis should be possible.

TABLE B-2. PIP Gamma Sodium Iodide Rod Specimen Test Data Sequential Order

	Testing			Calibration	Channel		Calibration	Calibration	Channel		Calibration
Sample	Run	No.	Date	C ₁	B	C	C ₂	C ₃	A	D	C ₄
PIP-1	1	I 22A	6/26/70	0.579	43,293	13,746	0.575	-	38,470	9,957	0.576
		Background			2,919	2,321			2,745	2,278	
	2	I 24A	6/26/70	0.574	42,940	13,659	0.569	-	38,282	9,778	0.556
		Background			2,919	2,395			2,745	2,379	
	3	I 43A	7/7/70	0.575	43,795	13,610	0.555	0.588	35,806	9,596	0.558
		Background			1,763	1,750			1,269	2,100	
	4	I 46C	7/8/70	0.583	41,623	12,992	0.568	0.583	35,534	9,770	0.568
		Background			1,765	1,760			1,219	2,227	
		$\bar{x}$	=		40,571.25	11,445.25			35,028.50	7,529.25	
		S	=		990.56	282.44			697.45	105.13	
		2S ^x	=		1,981.12	564.87			1,394.90	210.26	
	2S ^x %	=		4.883	4.935			3.982	2.792		
PIP-2	1	I 20A	6/25/70	0.562	61,406	14,831	0.577	-	53,896	10,193	0.593
		Background			2,782	1,887			2,596	2,144	
	2	I 44A	7/7/70	0.589	61,832	15,672	0.556	0.577	54,228	10,951	0.566
		Background			1,763	1,750			1,269	2,100	
	3	I 47C	7/8/70	0.569	59,493	14,853	0.572	0.582	52,120	10,763	0.569
					1,717	1,747			1,291	2,035	
	4	I 50A	7/8/70	0.580	59,916	15,283	0.568	0.561	53,726	10,795	0.576
					1,717	1,747			1,291	2,035	
		$\bar{x}$	=		58,667.00	13,377.00			51,880.75	8,597.00	
		S	=		986.86	435.84			976.62	365.13	
		2S ^x	=		1,973.72	871.67			1,953.25	730.25	
	2S ^x %	=		3.364	6.516			3.764	8.494		

Sample	Testing			Calibration	Channel		Calibration	Calibration	Channel		Calibration
	Run	No.	Date	C ₁	B	C	C ₂	C ₃	A	D	C ₄
PIP-3	1	I 19A	6/25/70	0.588	112,763	19,148	0.578	-	97,583	10,969	0.568
		Background			2,782	1,887			2,596	2,144	
	2	I 44B	7/7/70	0.574	109,363	19,282	0.584	0.579	103,401	11,980	0.566
		Background			1,765	1,763			1,269	2,100	
	3	I 48B	7/8/70	0.572	110,967	19,447	0.578	-	101,084	11,858	0.552
		Background			1,717	1,747			1,291	2,035	
	4	I 52A	7/9/70	0.569	114,838	20,394	0.574	-	104,689	12,243	0.560
		Background			1,753	1,637			1,265	2,100	
	$\bar{x}$	=			109,978.50	17,809.25			100,084.00	9,667.75	
	S	=			2,290.40	652.48			3,710.97	576.07	
	2S ^x	=			4,580.81	1,304.95			7,241.94	1,152.14	
	2S ^x %	=			4.165	7.327			7.415	11.917	
PIP-4	1	I 21B	6/25/70	0.564	179,326	25,888	0.557	0.594	167,983	13,678	0.580
		Background			2,782	1,887			2,596	2,144	
	2	I 45A	7/8/70	0.571	179,036	25,666	0.568	-	160,265	13,547	0.574
		Background			1,765	1,763			1,291	2,227	
	3	I 49A	7/8/70	0.561	174,847	25,789	0.569	0.556	160,205	13,521	0.571
		Background			1,717	1,747			1,291	2,035	
	4	I 54B	7/9/70	0.576	172,889	25,494	0.579	0.591	161,290	13,560	0.576
		Background			1,753	1,637			1,265	2,100	
	$\bar{x}$	=			174,520.25	23,950.75			160,825.00	11,450.00	
	S	=			2,879.45	26.01			3,075.12	68.07	
	2S ^x	=			5,758.89	52.03			6,150.25	136.15	
	2S ^x %	=			3.299	0.217			3.824	1.189	

Sample	Testing			Calibration	Channel		Calibration	Calibration	Channel		Calibration
	Run	No.	Date	C ₁	B	C	C ₂	C ₃	A	D	C ₄
PIP-5	1	I 20B	6/25/70	0.593	63,164	16,686	0.555	0.573	85,500	10,998	0.580
		Background			2,782	1,887			2,596	2,144	
	2	I 46A	7/8/70	0.584	63,612	17,156	0.585	-	83,213	11,235	0.583
		Background			1,765	1,763			1,219	2,227	
	3	I 49B	7/8/70	0.575	63,691	18,013	0.572	0.582	88,103	11,909	0.562
		Background			1,717	1,747			1,291	2,035	
	4	I 58A	7/10/70	0.573	62,777	17,265	0.592	-	81,248	11,561	0.560
		Background			2,011	1,750			1,265	2,100	
	$\bar{x}$	=			61,242.25	15,493.25			82,923.25	9,299.25	
	S	=			776.05	598.37			2,860.56	458.36	
PIP-7	1	I 41B	7/7/70	0.569	27,705	23,604	0.596	-	18,516	19,639	0.560
		Background			1,881	1,750			1,326	2,100	
	2	I 51B	7/9/70	0.581	26,548	22,578	0.562	-	17,766	18,248	0.569
		Background			1,753	1,637			1,265	2,100	
	3	I 53B	7/9/70	0.587	26,738	22,239	0.598	0.571	18,189	18,355	0.591
		Background			1,753	1,637			1,265	2,100	
	4	I 58A	7/10/70	0.579	27,142	22,471	0.573	0.560	18,277	18,842	0.568
		Background			2,011	1,750			1,358	2,100	
	5	I 59B	7/10/70	0.576	27,235	22,355	0.556	0.568	17,965	18,509	0.560
		Background			2,011	1,750			1,358	2,100	
	$\bar{x}$	=			25,191.80	20,944.60			16,828.20	16,618.60	
	S	=			380.62	521.72			265.09	557.53	
	2S	=			761.23	1,043.44			536.17	1,115.05	
	2S _{x%}	=			3.021	4.981			3.186	6.709	

Sample	Run	Testing		Calibration	Channel		Calibration	Calibration	Channel		Calibration
		No.	Date	C_1	B	C	C_2	C_3	A	D	C_4
Am-241 Source	1	I 42A	7/7/70	0.567	17,183	9,257	0.582	0.582	9,457	2,813	0.547
		Background			1,881	1,750			1,326	2,100	
	2	I 51A	7/9/70	0.562	17,288	9,588	0.562	0.560	9,385	2,886	0.583
		Background			1,753	1,637			1,265	2,100	
	3	I 52B	7/9/70	0.583	17,238	9,782	0.559	0.583	9,007	2,941	0.587
		Background			1,753	1,637			1,265	2,100	
	4	I 54C	7/10/70	0.575	17,066	10,112	0.559	0.576	9,472	3,049	0.562
		Background			2,011	1,750			1,358	2,100	
	5	I 58D	7/10/70		18,354	10,048	0.578	0.578	9,637	2,996	0.576
		Background			2,011	1,250			1,358	2,100	
	$\bar{x}$	=			15,544.00	8,052.60			8,077.20	837	
	S	=			480.65	340.75			194.35	91.08	
	$2S_x$	=			961.30	681.50			388.70	182.16	
	$2S_x\%$	=			6.184	8.463			4.812	21.76	

TABLE B-3. Gamma Sodium Iodide Rod Scan Data Stripping Computer Program

```

100 FILES UAMDTA; STNDDTA; RODDTA
120 FOR I = 1 TO 6
140 READ A$(I)
160 NEXT I
180 READ W
200 PRINT USING 220
220: U ROD      A/D      B/D      C/D
240 PRINT
260 FOR J = 1 TO 10
280 READ #1, B1, Q2, C1, Q3, A1, Q1, D1, Q4
300 IF J > 5 THEN 760
320 LET D = D1 - Q4
340 LET Z(J) = (C1-Q3)/D
360 LET Y(J) = (B1-Q2)/D
380 LET X(J) = (A1-Q1)/D
400 PRINT USING 420, J, X(J), Y(J), Z(J)
420: ###      ##.#### ##.#### ##.####
440 LET Z = Z(J) + Z
460 LET Y = Y(J) + Y
480 LET X = X(J) + X
500 IF J < 5 THEN 920
520 LET Z = Z/J
540 LET Y = Y/J
560 LET X = X/J
580 PRINT
600 PRINT USING 620, X, Y, Z
620: AVERAGE ##.#### ##.#### ##.####
640 PRINT
660 PRINT
680 PRINT USING 700
700: AM ROD      A/C      B/C      D/C
720 PRINT
740 GOTO 920
760 LET C = C1 - Q3
780 LET V(J) = (B1-Q2)/C
800 LET U(J) = (A1-Q1)/C
820 LET W(J) = (D1-Q4)/C
840 PRINT USING 420, J-5, U(J), V(J), W(J)
860 LET V = V(J) + V
880 LET U = U(J) + U
900 LET W1 = W(J) + W1
920 NEXT J
940 LET V = V/(J-5)
960 LET U = U/(J-5)
980 LET W1 = W1/(J-5)
1000 PRINT
1020 PRINT USING 620, U, V, W1
1040 PRINT
1060 PRINT
1080 LET J1 = 1
1100 READ G(9,1), G(7,1), G(8,1), G(1,1), G(9,2), G(7,2), G(8,2), G(1,2)

```



```

1120 FOR J = 1 TO 2
1140 PRINT "FOR CALIBRATION ROD";J
1160 PRINT
1180 PRINT USING 1200
1200: COUNT NO. NET COUNTS B NET COUNTS C NET COUNTS A NET COUNTS D
1220 PRINT
1240 READ C1,D1,B1,A1,A3,B3,C3,D3,N
1260 FOR I = J1 TO J1 + 3
1280 LET N = N+1
1300 READ #2,B(I),M(I),C(I),N(I),A(I),P(I),D(I),Q(I)
1320 PRINT USING 1340,N,B(I)-M(I),C(I)-N(I),A(I)-P(I),D(I)-Q(I)
1340:      ###          #####          #####          #####          #####
1360 LET A3 = A(I) - P(I) + A3
1380 LET B3 = B(I) - M(I) + B3
1400 LET C3 = C(I) - N(I) + C3
1420 LET D3 = D(I) - Q(I) + D3
1440 LET C1 = M(I) + C1
1460 LET D1 = P(I) + D1
1480 LET B1 = B(I) + B1
1500 LET A1 = A(I) + A1
1520 NEXT I
1540 PRINT
1560 PRINT USING 1580,B3/4,C3/4,A3/4,D3/4
1580: AVERAGE      #####          #####          #####          #####
1600 LET M(J) = C1/4
1620 LET P(J) = D1/4
1640 LET H(J) = B1/4
1660 LET S(J) = A1/4
1680 LET Q(J) = C3/4
1700 LET T(J) = D3/4
1720 PRINT
1740 PRINT
1760 LET J1 = J1 + 4
1780 NEXT J
1800 PRINT
1820 PRINT
1830 LET C9 = 0
1840 LET R1 = (T(1)-(Q(1)-C9)*W1)/((1-W1*Z)*G(8,1))
1860 LET R2 = (Q(1)-C9-T(1)*Z)/((1-W1*Z)*G(1,1))
1880 LET P1 = (T(1)-(Q(1)-C9)*W1)/(((1/Z)-W1)*G(8,1))
1900 LET P2 = (Q(1)-C9-T(1)*Z)/(((1/W1)-Z)*G(1,1))
1920 FOR I = 1 TO 2
1940 GOSUB 2800
1960 NEXT I
1980 LET R3 = G(7,1)*(K(2)-H(2))-G(7,2)*(K(1)-H(1))
2000 LET R7 = G(9,1)*G(7,2)-G(9,2)*G(7,1)
2020 LET R3 = R3/R7
2040 LET R4 = G(9,1)*(L(2)-S(2))-G(9,2)*(L(1)-S(1))
2060 LET R8 = G(7,1)*G(9,2)-G(7,2)*G(9,1)
2080 LET R4 = R4/R8
2100 LET R5 = G(7,1)*(L(2)-S(2))-G(7,2)*(L(1)-S(1))
2120 LET R5 = R5/R7
2140 LET R6 = G(9,1)*(K(2)-H(2))-G(9,2)*(K(1)-H(1))

```

```

2160 LET R6 = R6/R8
2180 PRINT "D COUNTS/GRAM U-238 = "; R1
2200 PRINT "C COUNTS/GRAM AM-241 = "; R2
2220 PRINT "C COUNTS/GRAM U-238 = "; P1
2240 PRINT "D COUNTS/GRAM AM-241 = "; P2
2260 PRINT "B COUNTS/GRAM PU-239 = "; R3
2280 PRINT "A COUNTS/GRAM PU-241 = "; R4
2300 PRINT "A COUNTS/GRAM PU-239 = "; R5
2320 PRINT "B COUNTS/GRAM PU-241 = "; R6
2340 PRINT
2360 PRINT " -----"
2380 PRINT
2400 LET I = 1
2420 FOR J = 1 TO 20
2440 READ #3, R(I), B(I), M(I), C(I), N(I), A(I), P(I), D(I), Q(I)
2460 GO SUB 2760
2480 LET G(9, I) = (R4*(B(I)-K(I))-R6*(A(I)-L(I)))/(R3*R4-R6*R5)
2500 LET G(7, I) = (R3*(A(I)-L(I))-R5*(B(I)-K(I)))/(R3*R4-R6*R5)
2520 GO SUB 2860
2540 PRINT USING 2560
2560:      GRAMS PU-239   GRAMS PU-241   GRAMS AM-241   GRAMS U-238   GRAMS B
2580 PRINT
2600 PRINT USING 2620, G(9, I), G(7, I), G(1, I), G(8, I), G(8, I)/134
2620:      ###.##      #.###      #.####      ####.##      ###
2640 PRINT
2660 PRINT " -----"
2680 PRINT
2700 PRINT
2720 NEXT J
2740 GOTO 3420
2760 LET G(8, I) = (D(I)-Q(I)-W1*(C(I)-N(I)-C9))/((1-W1*Z)*R1)
2780 LET G(1, I) = (C(I)-N(I)-C9-Z*(D(I)-Q(I)))/((1-W1*Z)*R2)
2800 LET K(I) = Y*R1*G(8, I)+V*R2*G(1, I)+M(I)
2820 LET L(I) = X*R1*G(8, I)+U*R2*G(1, I)+P(I)
2840 RETURN
2860 PRINT "ROD NUMBER   "; R(I)
2880 PRINT
2900 PRINT USING 2920
2920:      COUNTS A      COUNTS B      COUNTS C      COUNTS D
2940 PRINT
2960 LET M1 = L(I)-P(I)-X*R1*G(8, I)
2980 LET M2 = K(I)-M(I)-Y*R1*G(8, I)
3000 LET M3 = L(I)-P(I)-U*R2*G(1, I)
3020 LET M4 = K(I)-M(I)-V*R2*G(1, I)
3040 LET M5 = P2*G(1, I)
3060 LET M6 = R5*G(9, I)
3080 LET M7 = R3*G(9, I)
3100 LET M8 = R4*G(7, I)
3120 LET M9 = R6*G(7, I)
3140 LET M0 = R2*G(1, I)
3160 PRINT USING 3260, A$(1), M6, M7, C9, W
3180 PRINT USING 3260, A$(2), M8, M9, W, W
3200 PRINT USING 3260, A$(3), M1, M2, M0, M5

```

```

3220 PRINT USING 3260,A$(4),M3,M4,P1*G(8,I),R1*G(8,I)
3240 PRINT USING 3260,A$(5),P(I),M(I),N(I),Q(I)
3260:"      "      #####          #####          #####          #####
3280 PRINT
3300 LET T8 = M7 + M9 + M2 + M4 + M(I)
3320 LET T9 = M6 + M8 + M1 + M3 + P(I)
3340PRINT USING 3260,A$(6),T9,T8,C9+M0+P1*G(8,I)+N(I),M5+R1*G(8,I)+Q(I)
3360 PRINT
3380 PRINT
3400 RETURN
3420 STOP
4900 DATA PU-239,PU-241,AM-241,U-238,BKGD,TOTAL,0
5000 DATA 3.23,.0906,140.36,.0152,2.68,.174,135.19,.0268
5100 DATA 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
9999 END

```

TABLE B-4. Gamma Sodium Iodine Rod Scan Isotopic Channel Contribution Results

A. CALIBRATION DATA

U ROD	A/D	B/D	C/D
1	.9801	1.4724	1.2460
2	1.0219	1.5355	1.2968
3	1.0412	1.5371	1.2674
4	1.0106	1.5011	1.2377
5	1.0121	1.5372	1.2557
AVERAGE	1.0132	1.5166	1.2607

AM ROD	A/C	B/C	D/C
1	1.0831	2.0384	.0950
2	1.0213	1.9538	.0989
3	.9505	1.9012	.1033
4	.9703	1.8004	.1135
5	.9977	1.9695	.1080
AVERAGE	1.0046	1.9327	.1037

FOR CALIBRATION STD 1 (Fuel Rod Specimen PIP-2)

COUNT NO.	NET COUNTS B	NET COUNTS C	NET COUNTS A	NET COUNTS D
1	58624	12944	51300	8049
2	60069	13922	52959	8851
3	57776	13106	50829	8728
4	58199	13536	52435	8760
AVERAGE	58667	13377	51880	8597

FOR CALIBRATION STD 2 (Fuel Rod Specimen PIP-5)

COUNT NO.	NET COUNTS B	NET COUNTS C	NET COUNTS A	NET COUNTS D
1	60382	14799	82904	8854
2	61847	15393	81994	9008
3	61974	16266	86812	9874
4	60766	15515	79983	9461
AVERAGE	61242	15493	82923	9299

D COUNTS/GRAM U-238 = 59.0918
 C COUNTS/GRAM AM-241 = 192129.
 C COUNTS/GRAM U-238 = 74.4988
 D COUNTS/GRAM AM-241 = 19925.8
 B COUNTS/GRAM PU-239 = 10926.8
 A COUNTS/GRAM PU-241 = 364442.
 A COUNTS/GRAM PU-239 = 2329.81
 B COUNTS/GRAM PU-241 = 56846.7

B. FUEL ROD SPECIMEN PIP-1

ROD NUMBER 1

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	4584	21499	0	0
PU-241	21453	3346	0	0
AM-241	2237	4304	2227	230
U-238	7262	10871	9036	7168
BKGD	2745	2919	2395	2379
TOTAL	38281	42939	13658	9777

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
2.00	.059	.010	126.43	.94

ROD NUMBER 1

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	4652	21822	0	0
PU-241	21437	3343	0	0
AM-241	2015	3877	2006	208
U-238	7569	11330	9418	7470
BKGD	2745	2919	2321	2278
TOTAL	38419	43292	13745	9956

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
1.97	.059	.012	121.30	.91

ROD NUMBER 1

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	4836	22682	0	0
PU-241	19612	3059	0	0
AM-241	2784	5357	2772	287
U-238	7303	10932	9087	7208
BKGD	1269	1763	1750	2100
TOTAL	35805	43794	13609	9595

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
2.08	.054	.014	121.99	.91

ROD NUMBER 1

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	4636	21746	0	0
PU-241	20256	3159	0	0
AM-241	1987	3822	1977	205
U-238	7434	11128	9251	7337
BKGD	1219	1765	1763	2227
TOTAL	35533	41622	12991	9769

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
1.99	.056	.010	124.18	.93

C. FUEL ROD SPECIMEN PIP-2

ROD NUMBER 2

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	7593	35611	0	0
PU-241	32658	5094	0	0
AM-241	3231	6217	3217	333
U-238	7816	11701	9726	7715
BKGD	2596	2782	1887	2144
TOTAL	53895	61405	14830	10192

GRAMS PU-239 GRAMS PU-241 GRAMS AM-241 GRAMS U-238 GRAMS U-235
 3.26 .090 .017 130.57 .97

ROD NUMBER 2

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	7628	35775	0	0
PU-241	33504	5226	0	0
AM-241	3193	6143	3178	329
U-238	8633	12923	10743	8521
BKGD	1269	1763	1750	2100
TOTAL	54227	61831	15671	10950

GRAMS PU-239 GRAMS PU-241 GRAMS AM-241 GRAMS U-238 GRAMS U-235
 3.27 .092 .017 144.20 1.08

ROD NUMBER 2

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	7506	35206	0	0
PU-241	32303	5038	0	0
AM-241	2429	4674	2418	250
U-238	8588	12856	10687	8477
BKGD	1291	1717	1747	2035
TOTAL	52119	59492	14852	10762

GRAMS PU-239 GRAMS PU-241 GRAMS AM-241 GRAMS U-238 GRAMS U-235
 3.22 .089 .013 143.46 1.07

ROD NUMBER 2

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	7373	34581	0	0
PU-241	33607	5242	0	0
AM-241	2880	5540	2866	297
U-238	8573	12834	10669	8462
BKGD	1291	1717	1747	2035
TOTAL	53725	59915	15282	10794

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
3.16	.092	.015	143.21	1.07

D. FUEL ROD SPECIMEN PIP-3

ROD NUMBER 3

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	15799	74099	0	0
PU-241	63897	9966	0	0
AM-241	7090	13640	7057	731
U-238	8199	12274	10203	8093
BKGD	2596	2782	1887	2144
TOTAL	97582	112762	19147	10968

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
6.78	.175	.037	136.96	1.02

ROD NUMBER 3

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	15156	71084	0	0
PU-241	71725	11188	0	0
AM-241	5851	11256	5824	604
U-238	9397	14068	11694	9275
BKGD	1269	1765	1763	2100
TOTAL	103400	109362	19281	11979

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
6.51	.197	.030	156.97	1.17

ROD NUMBER 3

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	15513	72759	0	0
PU-241	68826	10735	0	0
AM-241	6143	11819	6115	634
U-238	9309	13936	11584	9188
BKGD	1291	1717	1747	2035
TOTAL	101083	110966	19446	11857

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
6.66	.189	.032	155.50	1.16

ROD NUMBER 3

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	15867	74418	0	0
PU-241	71102	11090	0	0
AM-241	6898	13272	6867	712
U-238	9554	14303	11889	9430
BKGD	1265	1753	1637	2100
TOTAL	104688	114837	20393	12242

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
6.81	.195	.036	159.60	1.19

E. FUEL ROD SPECIMEN PIP-4

ROD NUMBER 4

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	25867	121317	0	0
PU-241	118044	18412	0	0
AM-241	10932	21032	10882	1128
U-238	10542	15781	13118	10405
BKGD	2596	2782	1887	2144
TOTAL	167983	179326	25887	13677

GRAMS PU-239 GRAMS PU-241 GRAMS AM-241 GRAMS U-238 GRAMS U-235

11.10

.324

.057

176.09

1.31

ROD NUMBER 4

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	25309	118700	0	0
PU-241	112073	17481	0	0
AM-241	11049	21258	10999	1140
U-238	10481	15690	13042	10345
BKGD	1291	1717	1747	2035
TOTAL	160204	174846	25788	13520

GRAMS PU-239 GRAMS PU-241 GRAMS AM-241 GRAMS U-238 GRAMS U-235

10.86

.308

.057

175.07

1.31

ROD NUMBER 4

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	26238	123059	0	0
PU-241	111371	17372	0	0
AM-241	11131	21414	11080	1149
U-238	10304	15425	12822	10170
BKGD	1219	1765	1763	2227
TOTAL	160264	179035	25665	13546

GRAMS PU-239 GRAMS PU-241 GRAMS AM-241 GRAMS U-238 GRAMS U-235

11.26

.306

.058

172.12

1.28

ROD NUMBER 4

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	24902	116791	0	0
PU-241	113775	17746	0	0
AM-241	10874	20919	10824	1122
U-238	10473	15678	13032	10337
BKGD	1265	1753	1637	2100
TOTAL	161289	172888	25493	13559

GRAMS PU-239 GRAMS PU-241 GRAMS AM-241 GRAMS U-238 GRAMS U-235

10.69

.312

.056

174.94

1.31

F. FUEL ROD SPECIMEN PIP-5

ROD NUMBER 5

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	6303	29564	0	0
PU-241	63866	9962	0	0
AM-241	4202	8085	4183	433
U-238	8530	12770	10615	8420
BKGD	2596	2782	1887	2144
TOTAL	85499	63163	16685	10997

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
2.71	.175	.022	142.49	1.06

ROD NUMBER 5

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	6139	28794	0	0
PU-241	66718	10406	0	0
AM-241	4411	8487	4391	455
U-238	9542	14284	11874	9418
BKGD	1291	1717	1747	2035
TOTAL	88102	63690	18012	11908

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
2.64	.183	.023	159.39	1.19

ROD NUMBER 5

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	6327	29675	0	0
PU-241	60357	9414	0	0
AM-241	4145	7975	4126	427
U-238	9151	13699	11388	9033
BKGD	1265	2011	1750	2100
TOTAL	81247	62776	17264	11560

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
2.72	.166	.021	152.86	1.14

ROD NUMBER 5

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	6446	30232	0	0
PU-241	62244	9709	0	0
AM-241	4664	8974	4643	481
U-238	8638	12931	10749	8526
BKGD	1219	1765	1763	2227
TOTAL	83212	63611	17155	11234

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
2.77	.171	.024	144.29	1.08

TABLE B-5. Gamma Sodium Iodine Rod Scan Isotopic Mass Results.

A. FUEL ROD SPECIMEN - PIP-1

ROD NUMBER =	1	GRAMS PU-239 =	1.960*	
COUNT NUMBER	1	GRAMS MEASURED =	2.000	PCT DIFFERENCE = 2.0
COUNT NUMBER	2	GRAMS MEASURED =	1.970	PCT DIFFERENCE = .5
COUNT NUMBER	3	GRAMS MEASURED =	2.080	PCT DIFFERENCE = 6.1
COUNT NUMBER	4	GRAMS MEASURED =	1.990	PCT DIFFERENCE = 1.5
MEAN		1- SIGMA	2- SIGMA	2- SIGMA PERCENT
2.01		4.83046E-02	9.66092E-02	4.81

ROD NUMBER =	1	GRAMS PU-241 =	.055*	
COUNT NUMBER	1	GRAMS MEASURED =	.059	PCT DIFFERENCE = 8.3
COUNT NUMBER	2	GRAMS MEASURED =	.059	PCT DIFFERENCE = 8.3
COUNT NUMBER	3	GRAMS MEASURED =	.054	PCT DIFFERENCE = -.9
COUNT NUMBER	4	GRAMS MEASURED =	.056	PCT DIFFERENCE = 2.8
MEAN		1- SIGMA	2- SIGMA	2- SIGMA PERCENT
.057		2.44949E-03	4.89898E-03	8.59

ROD NUMBER =	1	GRAMS AM-241 =	.009*	
COUNT NUMBER	1	GRAMS MEASURED =	.010	PCT DIFFERENCE = 9.4
COUNT NUMBER	2	GRAMS MEASURED =	.012	PCT DIFFERENCE = 31.3
COUNT NUMBER	3	GRAMS MEASURED =	.014	PCT DIFFERENCE = 53.2
COUNT NUMBER	4	GRAMS MEASURED =	.010	PCT DIFFERENCE = 9.4
MEAN		1- SIGMA	2- SIGMA	2- SIGMA PERCENT
.0115		1.91485E-03	3.82971E-03	33.3

* Chemical Analytical Value

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-----
ROD NUMBER = 1      GRAMS U-238      = 134.870*
COUNT NUMBER 1      GRAMS MEASURED = 126.400      PCT DIFFERENCE = -6.3
COUNT NUMBER 2      GRAMS MEASURED = 121.300      PCT DIFFERENCE = -10.1
COUNT NUMBER 3      GRAMS MEASURED = 122.000      PCT DIFFERENCE = -9.5
COUNT NUMBER 4      GRAMS MEASURED = 124.200      PCT DIFFERENCE = -7.9
MEAN                1- SIGMA          2- SIGMA          2- SIGMA PERCENT
123.475             2.3085             4.617             3.74
-----

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ROD NUMBER = 1      GRAMS U-235      = 1.010*
COUNT NUMBER 1      GRAMS MEASURED = .940      PCT DIFFERENCE = -6.9
COUNT NUMBER 2      GRAMS MEASURED = .910      PCT DIFFERENCE = -9.9
COUNT NUMBER 3      GRAMS MEASURED = .910      PCT DIFFERENCE = -9.9
COUNT NUMBER 4      GRAMS MEASURED = .930      PCT DIFFERENCE = -7.9
MEAN                1- SIGMA          2- SIGMA          2- SIGMA PERCENT
.9225               .015             .03              3.25
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 B. FUEL ROD SPECIMEN - PIP-2

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ROD NUMBER = 2      GRAMS PU-239      = 3.230*
COUNT NUMBER 1      GRAMS MEASURED = 3.260      PCT DIFFERENCE = .9
COUNT NUMBER 2      GRAMS MEASURED = 3.270      PCT DIFFERENCE = 1.2
COUNT NUMBER 3      GRAMS MEASURED = 3.220      PCT DIFFERENCE = -.3
COUNT NUMBER 4      GRAMS MEASURED = 3.160      PCT DIFFERENCE = -2.2
MEAN                1- SIGMA          2- SIGMA          2- SIGMA PERCENT
3.2275             4.99166E-02      9.98332E-02      3.09
-----

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* Chemical Analytical Value

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-----
ROD NUMBER = 2      GRAMS PU-241      =      .091*
COUNT NUMBER 1      GRAMS MEASURED =      .090      PCT DIFFERENCE =      -0.7
COUNT NUMBER 2      GRAMS MEASURED =      .092      PCT DIFFERENCE =      1.5
COUNT NUMBER 3      GRAMS MEASURED =      .089      PCT DIFFERENCE =     -1.8
COUNT NUMBER 4      GRAMS MEASURED =      .092      PCT DIFFERENCE =      1.5

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MEAN          1-SIGMA          2-SIGMA          2-SIGMA PERCENT
.09075        .0015           .003           3.31

```

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-----
ROD NUMBER = 2      GRAMS AM-241      =      .015*
COUNT NUMBER 1      GRAMS MEASURED =      .017      PCT DIFFERENCE =     11.8
COUNT NUMBER 2      GRAMS MEASURED =      .017      PCT DIFFERENCE =     11.8
COUNT NUMBER 3      GRAMS MEASURED =      .013      PCT DIFFERENCE =    -14.5
COUNT NUMBER 4      GRAMS MEASURED =      .015      PCT DIFFERENCE =     -1.3

```

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MEAN          1-SIGMA          2-SIGMA          2-SIGMA PERCENT
.0155         1.91485E-03      3.82971E-03      24.71

```

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ROD NUMBER = 2      GRAMS U-238      = 140.360*
COUNT NUMBER 1      GRAMS MEASURED = 130.600      PCT DIFFERENCE =     -7.0
COUNT NUMBER 2      GRAMS MEASURED = 144.200      PCT DIFFERENCE =      2.7
COUNT NUMBER 3      GRAMS MEASURED = 143.500      PCT DIFFERENCE =      2.2
COUNT NUMBER 4      GRAMS MEASURED = 143.200      PCT DIFFERENCE =      2.0

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MEAN          1-SIGMA          2-SIGMA          2-SIGMA PERCENT
140.375        6.53012          13.0602          9.3

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-----
ROD NUMBER = 2      GRAMS U-235      =      1.050*
COUNT NUMBER 1      GRAMS MEASURED =      .970      PCT DIFFERENCE =     -7.6

```

* Chemical Analytical Value

COUNT NUMBER	2	GRAMS MEASURED =	1.080	PCT DIFFERENCE =	2.9
COUNT NUMBER	3	GRAMS MEASURED =	1.070	PCT DIFFERENCE =	1.9
COUNT NUMBER	4	GRAMS MEASURED =	1.070	PCT DIFFERENCE =	1.9
MEAN		1-SIGMA	2-SIGMA	2-SIGMA PERCENT	
	1.0475	5.18813E-02	.103763	9.91	

C. FUEL ROD SPECIMEN - PIP-3

ROD NUMBER =	3	GRAMS PU-239 =	6.720*		
COUNT NUMBER	1	GRAMS MEASURED =	6.780	PCT DIFFERENCE =	.9
COUNT NUMBER	2	GRAMS MEASURED =	6.510	PCT DIFFERENCE =	-3.1
COUNT NUMBER	3	GRAMS MEASURED =	6.660	PCT DIFFERENCE =	-.9
COUNT NUMBER	4	GRAMS MEASURED =	6.810	PCT DIFFERENCE =	1.3
MEAN		1-SIGMA	2-SIGMA	2-SIGMA PERCENT	
	6.69	.136382	.272764	4.08	

ROD NUMBER =	3	GRAMS PU-241 =	.189*		
COUNT NUMBER	1	GRAMS MEASURED =	.175	PCT DIFFERENCE =	-7.4
COUNT NUMBER	2	GRAMS MEASURED =	.197	PCT DIFFERENCE =	4.2
COUNT NUMBER	3	GRAMS MEASURED =	.189	PCT DIFFERENCE =	.0
COUNT NUMBER	4	GRAMS MEASURED =	.195	PCT DIFFERENCE =	3.2
MEAN		1-SIGMA	2-SIGMA	2-SIGMA PERCENT	
	.189	9.93311E-03	1.98662E-02	10.51	

ROD NUMBER =	3	GRAMS AM-241 =	.032*		
COUNT NUMBER	1	GRAMS MEASURED =	.037	PCT DIFFERENCE =	16.7
COUNT NUMBER	2	GRAMS MEASURED =	.030	PCT DIFFERENCE =	-5.4

* Chemical Analytical Value

COUNT NUMBER 3 GRAMS MEASURED = .032 PCT DIFFERENCE = .9

COUNT NUMBER 4 GRAMS MEASURED = .036 PCT DIFFERENCE = 13.6

MEAN 1-SIGMA 2-SIGMA 2-SIGMA PERCENT

.03375 3.30404E-03 6.60808E-03 19.58

ROD NUMBER = 3 GRAMS U-238 = 131.920*

COUNT NUMBER 1 GRAMS MEASURED = 137.000 PCT DIFFERENCE = 3.9

COUNT NUMBER 2 GRAMS MEASURED = 157.000 PCT DIFFERENCE = 19.0

COUNT NUMBER 3 GRAMS MEASURED = 155.500 PCT DIFFERENCE = 17.9

COUNT NUMBER 4 GRAMS MEASURED = 159.600 PCT DIFFERENCE = 21.0

MEAN 1-SIGMA 2-SIGMA 2-SIGMA PERCENT

152.275 10.3232 20.6465 13.56

ROD NUMBER = 3 GRAMS U-235 = .980*

COUNT NUMBER 1 GRAMS MEASURED = 1.020 PCT DIFFERENCE = 4.1

COUNT NUMBER 2 GRAMS MEASURED = 1.170 PCT DIFFERENCE = 19.4

COUNT NUMBER 3 GRAMS MEASURED = 1.160 PCT DIFFERENCE = 18.4

COUNT NUMBER 4 GRAMS MEASURED = 1.190 PCT DIFFERENCE = 21.4

MEAN 1-SIGMA 2-SIGMA 2-SIGMA PERCENT

1.135 7.76745E-02 .155349 13.69

D. FUEL ROD SPECIMEN - PIP-4

ROD NUMBER = 4 GRAMS PU-239 = 11.470*

COUNT NUMBER 1 GRAMS MEASURED = 11.100 PCT DIFFERENCE = -3.2

COUNT NUMBER 2 GRAMS MEASURED = 11.260 PCT DIFFERENCE = -1.8

COUNT NUMBER 3 GRAMS MEASURED = 10.860 PCT DIFFERENCE = -5.3

* Chemical Analytical Value

COUNT NUMBER 4 GRAMS MEASURED = 10.690 PCT DIFFERENCE = -6.8

MEAN	1- SIGMA	2- SIGMA	2- SIGMA PERCENT
10.9775	.252504	.505008	4.6

ROD NUMBER = 4 GRAMS PU-241 = .322*

COUNT NUMBER 1 GRAMS MEASURED = .324 PCT DIFFERENCE = .6

COUNT NUMBER 2 GRAMS MEASURED = .306 PCT DIFFERENCE = -5.0

COUNT NUMBER 3 GRAMS MEASURED = .308 PCT DIFFERENCE = -4.3

COUNT NUMBER 4 GRAMS MEASURED = .312 PCT DIFFERENCE = -3.1

MEAN	1- SIGMA	2- SIGMA	2- SIGMA PERCENT
.3125	8.06226E-03	1.61245E-02	5.16

ROD NUMBER = 4 GRAMS AM-241 = .054*

COUNT NUMBER 1 GRAMS MEASURED = .057 PCT DIFFERENCE = 5.6

COUNT NUMBER 2 GRAMS MEASURED = .058 PCT DIFFERENCE = 7.4

COUNT NUMBER 3 GRAMS MEASURED = .057 PCT DIFFERENCE = 5.6

COUNT NUMBER 4 GRAMS MEASURED = .056 PCT DIFFERENCE = 3.7

MEAN	1- SIGMA	2- SIGMA	2- SIGMA PERCENT
.057	8.16497E-04	1.63299E-03	2.86

ROD NUMBER = 4 GRAMS U-238 = 129.680*

COUNT NUMBER 1 GRAMS MEASURED = 176.100 PCT DIFFERENCE = 35.8

COUNT NUMBER 2 GRAMS MEASURED = 172.000 PCT DIFFERENCE = 32.6

COUNT NUMBER 3 GRAMS MEASURED = 175.000 PCT DIFFERENCE = 34.9

COUNT NUMBER 4 GRAMS MEASURED = 175.000 PCT DIFFERENCE = 34.9

MEAN	1- SIGMA	2- SIGMA	2- SIGMA PERCENT
174.525	1.76139	3.52278	2.02

* Chemical Analytical Value

ROD NUMBER =	4	GRAMS U-235	=	1.010*	
COUNT NUMBER	1	GRAMS MEASURED	=	1.310	PCT DIFFERENCE = 29.7
COUNT NUMBER	2	GRAMS MEASURED	=	1.280	PCT DIFFERENCE = 26.7
COUNT NUMBER	3	GRAMS MEASURED	=	1.310	PCT DIFFERENCE = 29.7
COUNT NUMBER	4	GRAMS MEASURED	=	1.310	PCT DIFFERENCE = 29.7
MEAN		1-SIGMA		2-SIGMA	2-SIGMA PERCENT
1.3025		.015		.03	2.3

E. FUEL ROD SPECIMEN - PIP-5

ROD NUMBER =	5	GRAMS PU-239	=	2.680*	
COUNT NUMBER	1	GRAMS MEASURED	=	2.710	PCT DIFFERENCE = 1.1
COUNT NUMBER	2	GRAMS MEASURED	=	2.770	PCT DIFFERENCE = 3.4
COUNT NUMBER	3	GRAMS MEASURED	=	2.640	PCT DIFFERENCE = -1.5
COUNT NUMBER	4	GRAMS MEASURED	=	2.720	PCT DIFFERENCE = 1.5
MEAN		1-SIGMA		2-SIGMA	2-SIGMA PERCENT
2.71		5.35413E-02		.107083	3.95

ROD NUMBER =	5	GRAMS PU-241	=	.174*	
COUNT NUMBER	1	GRAMS MEASURED	=	.175	PCT DIFFERENCE = .6
COUNT NUMBER	2	GRAMS MEASURED	=	.171	PCT DIFFERENCE = -1.7
COUNT NUMBER	3	GRAMS MEASURED	=	.183	PCT DIFFERENCE = 5.2
COUNT NUMBER	4	GRAMS MEASURED	=	.166	PCT DIFFERENCE = -4.6
MEAN		1-SIGMA		2-SIGMA	2-SIGMA PERCENT
.17375		7.18215E-03		1.43643E-02	8.27

* Chemical Analytical Value

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-----
ROD NUMBER = 5    GRAMS AM-241    =    .027*
COUNT NUMBER 1    GRAMS MEASURED =    .022    PCT DIFFERENCE = -17.9
COUNT NUMBER 2    GRAMS MEASURED =    .024    PCT DIFFERENCE = -10.4
COUNT NUMBER 3    GRAMS MEASURED =    .023    PCT DIFFERENCE = -14.2
COUNT NUMBER 4    GRAMS MEASURED =    .021    PCT DIFFERENCE = -21.6
MEAN              1-SIGMA          2-SIGMA          2-SIGMA PERCENT
    .0225          1.29099E-03    2.58199E-03    11.48
-----

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ROD NUMBER = 5    GRAMS U-238    = 135.190*
COUNT NUMBER 1    GRAMS MEASURED = 142.500    PCT DIFFERENCE = 5.4
COUNT NUMBER 2    GRAMS MEASURED = 144.300    PCT DIFFERENCE = 6.7
COUNT NUMBER 3    GRAMS MEASURED = 159.400    PCT DIFFERENCE = 17.9
COUNT NUMBER 4    GRAMS MEASURED = 152.900    PCT DIFFERENCE = 13.1
MEAN              1-SIGMA          2-SIGMA          2-SIGMA PERCENT
    149.775        7.85934        15.7187        10.49
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ROD NUMBER = 5    GRAMS U-235    =    1.010*
COUNT NUMBER 1    GRAMS MEASURED =    1.060    PCT DIFFERENCE = 5.0
COUNT NUMBER 2    GRAMS MEASURED =    1.080    PCT DIFFERENCE = 6.9
COUNT NUMBER 3    GRAMS MEASURED =    1.190    PCT DIFFERENCE = 17.8
COUNT NUMBER 4    GRAMS MEASURED =    1.140    PCT DIFFERENCE = 12.9
MEAN              1-SIGMA          2-SIGMA          2-SIGMA PERCENT
    1.1175        5.90903E-02    .118181        10.58
-----

```

* Chemical Analytical Value

TABLE B-6. Gamma Sodium Iodide Testing Serial Ordering Experiment - Rod Number PIP-1 Test Data

Serial Scan

Channel Calibration Data		<u>Calibration</u> <u>C₁</u>	<u>Channel</u> <u>B</u> <u>C</u>		<u>Calibration</u> <u>C₂</u> <u>C₃</u>	<u>Channel</u> <u>A</u> <u>D</u>		<u>Calibration</u> <u>C₄</u>
Test Data								
<u>Number</u>	<u>Date</u>							
I22A	6/26/70	0.579	43,293	13,746	0.575	38,470	9,957	0.576
I22B	6/26/70	0.576	42,998	13,589	0.562	37,845	9,927	0.583
I22C	6/26/70	0.583	43,251	13,503	0.572	38,567	10,008	0.581
I22D	6/26/70	0.581	43,671	13,634	0.574 0.566	38,075	9,742	0.556
I22E	6/26/70	0.574	42,940	13,659	0.569	38,282	9,778	0.556
			<hr/>			<hr/>		
		$\bar{X}$	43,231	13,626		38,248	9,882	
		S_X	250	90		277	116	

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TABLE B-7. Gamma Sodium Iodide Testing Serial Ordering Experiment Test Results

A. TEST RESULTS

1. Calibration Constants

D COUNTS/GRAM U-238 = 59.0918
 C COUNTS/GRAM AM-241 = 192129.
 C COUNTS/GRAM U-238 = 74.4988
 D COUNTS/GRAM AM-241 = 19925.8
 B COUNTS/GRAM PU-239 = 10926.8
 A COUNTS/GRAM PU-241 = 364442.
 A COUNTS/GRAM PU-239 = 2329.81
 B COUNTS/GRAM PU-241 = 56846.7

2. Channel Contributions

ROD NUMBER 1 (Run 1)

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	4651	21814	0	0
PU-241	21489	3351	0	0
AM-241	2015	3877	2006	208
U-238	7569	11330	9418	7470
BKGD	2745	2919	2321	2278
TOTAL	38469	43292	13745	9956

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
2.00	.059	.0104	126.43	.944

ROD NUMBER 1 (Run 2)

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	4666	21883	0	0
PU-241	21003	3276	0	0
AM-241	1877	3612	1869	193
U-238	7553	11306	9398	7455
BKGD	2745	2919	2321	2278
TOTAL	37844	42997	13588	9926

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
2.00	.058	.0097	126.16	.942

ROD NUMBER 1 (Run 3)

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	4750	22281	0	0
PU-241	21752	3393	0	0
AM-241	1660	3194	1652	171
U-238	7658	11463	9529	7558
BKGD	2745	2919	2321	2278
TOTAL	38566	43250	13502	10007

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
2.04	.060	.0086	127.91	.955

ROD NUMBER 1 (Run 4)

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	4754	22299	0	0
PU-241	21091	3289	0	0
AM-241	2260	4349	2250	233
U-238	7223	10813	8988	7129
BKGD	2745	2919	2395	2379
TOTAL	38074	43670	13633	9741

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
2.04	.058	.0117	120.65	.900

ROD NUMBER 1 (Run 5)

	COUNTS A	COUNTS B	COUNTS C	COUNTS D
PU-239	4584	21499	0	0
PU-241	21453	3346	0	0
AM-241	2237	4304	2227	230
U-238	7262	10871	9036	7168
BKGD	2745	2919	2395	2379
TOTAL	38281	42939	13658	9777

GRAMS PU-239	GRAMS PU-241	GRAMS AM-241	GRAMS U-238	GRAMS U-235
1.97	.059	.0116	121.30	.905

3. Final Results

ROD NUMBER =	1	GRAMS PU-239	=	1.960*	
COUNT NUMBER	1	GRAMS MEASURED	=	2.000	PCT DIFFERENCE = 2.0
COUNT NUMBER	2	GRAMS MEASURED	=	2.000	PCT DIFFERENCE = 2.0
COUNT NUMBER	3	GRAMS MEASURED	=	2.040	PCT DIFFERENCE = 4.1
COUNT NUMBER	4	GRAMS MEASURED	=	2.040	PCT DIFFERENCE = 4.1
COUNT NUMBER	5	GRAMS MEASURED	=	1.970	PCT DIFFERENCE = 0.5

MEAN	1- SIGMA	2- SIGMA	2- SIGMA PERCENT
2.01	.03	.06	2.99

ROD NUMBER =	1	GRAMS PU-241	=	.055*	
COUNT NUMBER	1	GRAMS MEASURED	=	.059	PCT DIFFERENCE = 8.3
COUNT NUMBER	2	GRAMS MEASURED	=	.058	PCT DIFFERENCE = 6.4
COUNT NUMBER	3	GRAMS MEASURED	=	.060	PCT DIFFERENCE = 10.1
COUNT NUMBER	4	GRAMS MEASURED	=	.058	PCT DIFFERENCE = 6.4
COUNT NUMBER	5	GRAMS MEASURED	=	.059	PCT DIFFERENCE = 8.3

MEAN	1- SIGMA	2- SIGMA	2- SIGMA PERCENT
.0588	8.36660E-04	1.67332E-03	2.85

ROD NUMBER =	1	GRAMS AM-241	=	.009*	
COUNT NUMBER	1	GRAMS MEASURED	=	.010	PCT DIFFERENCE = 13.8
COUNT NUMBER	2	GRAMS MEASURED	=	.010	PCT DIFFERENCE = 6.1
COUNT NUMBER	3	GRAMS MEASURED	=	.009	PCT DIFFERENCE = 5.9
COUNT NUMBER	4	GRAMS MEASURED	=	.012	PCT DIFFERENCE = 28.0
COUNT NUMBER	5	GRAMS MEASURED	=	.012	PCT DIFFERENCE = 26.9

MEAN	1- SIGMA	2- SIGMA	2- SIGMA PERCENT
.0104	1.30958E-03	2.61916E-03	25.18

* Chemical analytical assay value

ROD NUMBER =	1	GRAMS U-238	=	134.870*	
COUNT NUMBER	1	GRAMS MEASURED	=	126.430	PCT DIFFERENCE = -6.3
COUNT NUMBER	2	GRAMS MEASURED	=	126.160	PCT DIFFERENCE = -6.5
COUNT NUMBER	3	GRAMS MEASURED	=	127.910	PCT DIFFERENCE = -5.2
COUNT NUMBER	4	GRAMS MEASURED	=	120.650	PCT DIFFERENCE = -10.5
COUNT NUMBER	5	GRAMS MEASURED	=	121.300	PCT DIFFERENCE = -10.1
MEAN	1-SIGMA	2-SIGMA	2-SIGMA PERCENT		
124.49	3.28522	6.57043	5.28		

ROD NUMBER =	1	GRAMS U-235	=	1.010*	
COUNT NUMBER	1	GRAMS MEASURED	=	.944	PCT DIFFERENCE = -6.5
COUNT NUMBER	2	GRAMS MEASURED	=	.942	PCT DIFFERENCE = -6.7
COUNT NUMBER	3	GRAMS MEASURED	=	.955	PCT DIFFERENCE = -5.4
COUNT NUMBER	4	GRAMS MEASURED	=	.900	PCT DIFFERENCE = -10.9
COUNT NUMBER	5	GRAMS MEASURED	=	.905	PCT DIFFERENCE = -10.4
MEAN	1-SIGMA	2-SIGMA	2-SIGMA PERCENT		
.9292	2.49339E-02	4.98678E-02	5.37		

* Chemical analytical assay value

TABLE B-8. Sodium Iodide Rod Test Calibration Position Experiment
(Fuel Rod Number PIP-4 — 1000 Second Counting Time)

Item No.	Test No.	Orientation	Channel			
			A	B	C	D
1.	I63E	0°	175031	192225	27081	14869
2.	I65D		175001	191869	26944	14920
			$\bar{x} = 175016$	192047	27013	14895
3.	I63B	90°	174153	188764	26807	14307
4.	I65F		174620	191699	27115	14868
			$\bar{x} = 174387$	190232	26962	14588
5.	I63E	180°	173390	189771	26919	14513
6.	I66B		173966	190439	26931	14895
			$\bar{x} = 173676$	19104	26925	14704
7.	I65D	270°	175361	191488	26885	15018
8.	I66D		173564	191221	26877	15045
			$\bar{x} = 174463$	191355	26881	15032
			$n = 8$	8	8	8
			$\bar{x} = 172778$	188827	25010	12377
			$S_x = 733.5$	1184.5	113.7	259.9
			$2S_x \% = 0.85\%$	1.25%	0.91%	4.20%
<u>Background</u>						
1.	I63A		1586	2041	1932	2374
2.	I64A		1556	2127	2007	2522
3.	I64F		1585	2098	1862	2287
4.	I66A		1660	2155	1960	2449
5.	I66F		1652	2121	1913	2505
			$\bar{x} = 1608$	2108	1935	2427

APPENDIX C

GAMMA SODIUM IODIDE
FUEL SCRAP AND WASTE-DISCARD STANDARD TESTING

TABLE C-1. Gamma Sodium Iodide Testing Fuel Scrap Standards Test Data

A. Test Data		Testing		Calibration	Channel				Calibration
Sample	Run	Number	Date	C ₁	A	B	C	D	C ₂
8	1	III 7D	8/7/70	0.696	9,811	9,778	2,777	1,239	0.709
		BG*			1,094	1,366	1,594	926	
	2	III 12H	8/10/70	0.704	8,652	8,707	2,810	1,208	0.713
		BG			1,132	1,438	1,584	916	
	3	III 17B	8/10/70	0.706	9,996	10,110	2,831	1,244	0.713
		BG			1,132	1,438	1,584	916	
	4	III 21B	8/11/70	0.692	9,213	8,956	2,867	1,208	0.685
		BG			1,124	1,418	1,602	912	
	5	III 27B	8/11/70	0.699	9,071	8,974	2,712	1,132	0.707
		BG			1,124	1,418	1,602	912	
$\bar{x} =$					8,227.4	7,889.4	1,206.2	289.8	
1 sigma =					557.486	613.414	61.8603	41.5716	
2 sigma % =					13.55	15.55	10.26	28.69	
9	1	III 7A	8/7/70	0.709	14,735	14,694	3,711	1,451	0.696
		BG			1,094	1,366	1,594	926	
	2	III 10E	8/7/70	0.704	16,386	16,546	3,891	1,495	0.692
		BG			1,094	1,366	1,594	926	
	3	III 13D	8/10/70	0.713	13,994	14,268	3,764	1,463	0.706
		BG			1,132	1,438	1,584	916	
	4	III 21C	8/11/70	0.692	15,413	15,467	3,718	1,465	0.685
		BG			1,124	1,418	1,602	912	
	5	III 27D	8/11/70	0.707	13,980	14,092	3,556	1,387	0.716
		BG			1,124	1,418	1,602	912	
$\bar{x}$					13,789	13,612.2	2,132.8	533.8	
1 sigma =					1,032.69	1,027.33	124.188	36.4586	
2 sigma % =					14.98	15.09	11.65	13.66	

* Background

10	1	III 7G BG	8/7/70	0.709	38,664 1,094	39,934 1,366	8,991 1,594	2,890 926	0.691
	2	III 13C BG	8/10/70	0.713	39,077 1,132	40,351 1,438	9,078 1,584	2,939 916	0.706
	3	III 14E BG	8/10/70	0.688	38,870 1,132	40,368 1,438	9,155 1,584	2,857 916	0.692
	4	III 21E BG	8/11/70	0.685	38,556 1,124	39,850 1,418	8,788 1,602	2,833 912	0.692
	5	III 27E BG	8/11/70	0.707	38,951 1,124	40,337 1,418	8,769 1,602	2,823 912	0.716
				$\bar{x} =$	37,702.4	38,832.4	7,363	1,952	
				1 sigma =	203.895	347.502	181.195	44.5758	
				2 sigma % =	1.08	1.79	4.92	4.57	

11	1	III 7E BG	8/7/70	0.695	19,811 1,094	20,644 1,366	3,393 1,594	1,314 926	0.709
	2	III 14D BG	8/11/70	0.688	19,716 1,132	19,165 1,438	3,596 1,584	1,297 916	0.692
	3	III 20H BG	8/11/70	0.707	17,946 1,124	17,607 1,418	3,209 1,602	1,244 912	0.692
	4	III 27A BG	8/11/70	0.696	16,947 1,124	16,449 1,418	3,110 1,602	1,242 912	0.707
	5	III 30H BG	8/12/70	0.700	17,762 1,124	17,434 1,400	3,150 1,538	1,206 886	0.698
				$\bar{x} =$	17,316.8	16,851.8	1,707.6	350.2	
				1 sigma =	1,275.09	1,664.02	200.071	31.7364	
				2 sigma % =	14.73	19.75	23.43	18.12	

Sample	Testing			Calibration	Channel				Calibration
	Run	Number	Date	C ₁	A	B	C	D	C ₂
12	1	III 13G	8/10/70	0.706	28,136	27,548	4,518	1,571	0.714
		BG			1,132	1,438	1,584	916	
	2	III 17E	8/10/70	0.713	31,609	30,906	4,789	1,509	0.721
		BG			1,132	1,438	1,584	916	
	3	III 20I	8/11/70	0.707	27,828	27,266	4,560	1,511	0.692
		BG			1,124	1,418	1,602	912	
	4	III 31D	8/12/70	0.709	29,974	28,970	4,483	1,414	0.697
		BG			1,124	1,400	1,538	886	
	5	III 33E	8/13/70	0.698	28,470	28,078	4,306	1,464	0.714
		BG			1,078	1,326	1,488	886	
				$\bar{x} =$	28,085.4	27,537.6	2,972	590.6	
				1 sigma =	1,570.26	1,272.67	141.752	45.5555	
				2 sigma % =	11.18	9.24	9.54	15.43	
13	1	III 12D	8/10/70	0.727	78,970	79,350	11,573	3,224	0.718
		BG			1,132	1,438	1,584	916	
	2	III 17C	8/10/70	0.706	77,176	78,123	11,771	3,186	0.713
		BG			1,132	1,438	1,584	916	
	3	III 21F	8/11/70	0.685	76,671	77,508	11,562	3,051	0.692
		BG			1,124	1,418	1,602	912	
	4	III 27H	8/11/70	0.716	76,086	76,887	11,609	3,095	0.724
		BG			1,124	1,418	1,602	912	
	5	III 30I	8/12/70	0.700	75,834	76,800	11,291	3,090	0.698
		BG			1,124	1,400	1,538	886	
				$\bar{x} =$	75,820.2	76,311.2	9,979.2	2,220.8	
				1 sigma =	1,241.5	1,035.71	154.584	67.8727	
				2 sigma % =	3.27	2.71	3.1	6.11	

14	1	III 5D BG	8/7/70	0.705	30,659 1,094	29,070 1,366	3,638 1,594	1,293 926	0.709	
	2	III 10F BG	8/7/70	0.704	28,656 1,094	26,886 1,366	3,766 1,594	1,315 926	0.692	
	3	III 12E BG	8/10/70	0.727	29,804 1,132	28,141 1,438	3,933 1,584	1,293 916	0.718	
	4	III 21H BG	8/11/70	0.692	31,577 1,124	30,239 1,418	3,896 1,602	1,293 912	0.701	
	5	III 26D BG	8/11/70	0.716	27,957 1,124	26,680 1,418	3,634 1,002	1,284 912	0.718	
					$\bar{x} =$	28.617	26,802	2,178.2	377.2	
					1 sigma =	1,463.58	1,492.89	143.183	8.43801	
					2 sigma % =	10.23	11.14	13.15	4.47	

15	1	III 14I BG	8/10/70	0.692	51,415 1,132	49,105 1,438	5,830 1,584	1,653 916	0.688	
	2	III 17H BG	8/10/70	0.721	47,673 1,132	46,089 1,438	5,582 1,584	1,568 916	0.711	
	3	III 21I BG	8/11/70	0.692	45,810 1,124	43,740 1,418	5,229 1,602	1,575 912	0.701	
	4	III 29E BG	8/12/70	0.709	49,800 1,124	47,561 1,400	5,493 1,538	1,561 886	0.690	
	5	III 31B BG	8/12/70	0.698	53,135 1,124	50,247 1,400	5,529 1,538	1,594 886	0.707	
					$\bar{x} =$	48,439.4	45,929.6	3,987.4	687	
					1 sigma =	2,911.32	2,560.9	230.869	34.97	
					2 sigma % =	12.02	11.15	11.58	10.17	

Sample	Run	Testing		Calibration	Channel				Calibration	
		Number	Date	C ₁	A	B	C	D	C ₂	
16	1	III 5E BG	8/7/70	0.705	126,538 1,094	125,451 1,366	14,713 1,594	3,267 926	0.709	
	2	III 10H BG	8/7/70	0.692	126,309 1,094	124,886 1,366	14,550 1,594	3,349 926	0.691	
	3	III 17F BG	8/10/70	0.713	127,225 1,132	126,368 1,438	14,751 1,584	3,350 916	0.721	
	4	III 17I BG	8/10/70	0.721	127,175 1,132	125,864 1,438	14,836 1,584	3,492 916	0.711	
	5	III 23A BG	8/11/70	0.696	125,375 1,124	124,622 1,418	14,570 1,602	3,296 912	0.685	
				$\bar{x} =$	125,409	124,033	13,092.4	2,431.6		
				1 sigma =	749.939	691.467	128.282	88.6076		
				2 sigma % =	1.2	1.11	1.96	7.29		
	17	1	III 4A BG	8/7/70	0.707	15,297 1,094	10,846 1,366	3,117 1,594	1,210 926	0.686
		2	III 18B BG	8/10/70	0.711	13,688 1,132	9,762 1,438	3,148 1,584	1,322 916	0.717
3		III 22D BG	8/11/70	0.701	13,658 1,124	9,699 1,418	3,070 1,602	1,238 912	0.707	
4		III 31C BG	8/12/70	0.698	13,437 1,124	9,695 1,400	2,926 1,538	1,219 886	0.707	
5		III 34A BG	8/13/70	0.691	14,581 1,078	9,814 1,326	3,004 1,488	1,142 886	0.692	
				$\bar{x} =$	13,021.8	8,573.6	1,491.8	321		
				1 sigma =	803.757	513.425	67.2919	56.9825		
				2 sigma % =	12.34	11.98	9.02	35.5		

18	1	III 15B BG	8/10/70	0.688	22,282 1,132	15,608 1,438	4,482 1,584	1,540 916	0.697
	2	III 18C BG	8/10/70	0.711	21,413 1,132	15,153 1,438	4,208 1,584	1,522 916	0.717
	3	III 22F BG	8/11/70	0.707	21,802 1,124	15,652 1,418	4,312 1,602	1,421 912	0.696
	4	III 33F BG	8/13/70	0.698	21,062 1,078	15,059 1,326	4,085 1,488	1,367 886	0.714
	5	III 34E EG	8/13/70	0.695	24,480 1,028	17,502 1,326	4,184 1,488	1,417 886	0.691
				$\bar{x} =$	21,099	14,405.6	2,705	550.2	
				1 sigma =	1,359.78	1,013.4	117.877	62.0782	
				2 sigma % =	12.89	14.14	8.72	22.57	

19	1	III 8D EG	8/7/70	0.697	60,496 1,094	44,986 1,366	10,522 1,594	3,059 926	0.687
	2	III 14B EG	8/10/70	0.714	59,581 1,132	44,450 1,438	10,892 1,584	3,078 916	0.688
	3	III 29G EG	8/12/70	0.707	59,188 1,124	44,145 1,400	10,597 1,538	3,062 886	0.709
	4	III 30F EG	8/12/70	0.690	59,421 1,124	44,432 1,400	10,469 1,538	2,869 886	0.700
	5	III 33H BG	8/13/70	0.714	59,466 1,078	44,199 1,326	10,423 1,488	3,024 886	0.695
				$\bar{x} =$	58,520	43,056.4	9,032.2	2,118	
				1 sigma =	514.309	335.715	163.807	77.7001	
				2 sigma % =	1.76	1.56	3.63	7.34	

Sample	Testing			Calibration	Channel				Calibration
	Run	Number	Date	C ₁	A	B	C	D	C ₂
20	1	III 23C BG	8/11/70	0.685	42,748 1,124	55,888 1,418	3,560 1,602	1,095 912	0.688
	2	III 28H BG	8/12/70	0.712	42,286 1,124	55,470 1,400	3,453 1,538	1,023 886	0.707
	3	III 30B BG	8/12/70	0.698	41,146 1,124	54,826 1,400	3,483 1,538	1,046 886	0.690
	4	III 35C BG	8/13/70	0.692	41,620 1,078	55,433 1,326	3,274 1,488	1,029 886	0.705
	5	III 36D BG	8/13/70	0.701	43,737 1,078	56,393 1,326	3,353 1,488	976 886	0.691
					$\bar{x} =$				
					1 sigma =				
					2 sigma % =				
					41,201.8	54,218	1,893.8	142.6	
					1,016.19	604.792	70.0764	34.3991	
					4.93	2.23	7.4	48.25	
21	1	III 22C BG	8/11/70	0.701	73,418 1,124	97,942 1,418	5,352 1,602	1,133 912	0.707
	2	III 22I BG	8/11/70	0.696	74,067 1,124	96,824 1,418	5,447 1,602	1,216 912	0.685
	3	III 26C BG	8/11/70	0.716	79,104 1,124	104,237 1,418	5,201 1,602	1,221 912	0.718
	4	III 28G BG	8/12/70	0.712	81,530 1,124	105,887 1,400	5,259 1,538	1,168 886	0.707
	5	III 36E BG	8/13/70	0.701	78,567 1,078	102,495 1,326	5,066 1,488	1,142 886	0.691
					76,222.4	100,081	3,698.6	274.4	
					3,477.88	3,956.04	110.726	36.4733	
					9.13	7.91	5.99	26.58	

22 Not Tested

23	1	III 9G BG	8/7/70	0.706	1,503 1,094	1,623 1,366	1,661 1,594	859 926	0.698
	2	III 15D BG	8/10/70	0.697	1,573 1,132	1,688 1,438	1,540 1,584	835 916	0.700
	3	III 18I BG	8/10/70	0.703	1,511 1,132	1,728 1,438	1,608 1,584	911 916	0.721
	4	III 24E BG	8/11/70	0.710	1,507 1,124	1,677 1,418	1,594 1,602	861 912	0.710
	5	III 35D BG	8/13/70	0.692	1,551 1,078	1,653 1,326	1,513 1,488	866 886	0.705

$\bar{x} =$ 417 276.6 12.8 -44.8
 1 sigma = 39.9249 32.0983 41.4451 31.7836
 2 sigma % = 19.15 23.21 647.58 -141.89

24	1	III 9H BG	8/7/70	0.706	3,617 1,094	3,177 1,366	1,897 1,594	932 926	0.698
	2	III 15I BG	8/10/70	0.700	3,599 1,132	3,353 1,438	1,803 1,584	928	0.706
	3	III 20C BG	8/10/70	0.717	3,557 1,132	3,224 1,438	1,920 1,584	1,021 916	0.716
	4	III 23G BG	8/11/70	0.688	3,636 1,124	3,200 1,418	1,810 1,602	989 912	0.710
	5	III 37B BG	8/13/70	0.709	3,511 1,078	3,277 1,326	1,756 1,488	924 886	0.690

2,472 1,849 266.8 47.6
 44.5982 78.5207 54.4123 42.5711
 3.61 8.49 40.79 178.87

Sample	Testing			Calibration	Channel				Calibration
	Run	Number	Date	C ₁	A	B	C	D	C ₂
25	1	III 8E	8/7/70	0.697	1,830	1,698	1,612	925	0.687
		BG			1,094	1,366	1,594	926	
	2	III 16E	8/10/70	0.705	1,734	1,805	1,624	968	0.714
		BG			1,132	1,438	1,584	916	
	3	III 19I	8/10/70	0.716	1,791	1,771	1,693	966	0.717
		BG			1,132	1,438	1,584	916	
	4	III 24F	8/11/70	0.710	1,792	1,643	1,607	940	0.710
		BG			1,124	1,400	1,538	886	
	5	III 36H	8/13/70	0.691	1,775	1,704	1,605	846	0.709
		BG			1,078	1,326	1,488	886	
	$\bar{x} =$				672.4	327	57.8	17.8	
	1 sigma =				49.5106	60.5516	51.9971	38.7453	
	2 sigma % =				14.73	37.03	179.92	435.34	
26	1	III 8A	8/7/70	0.691	5,816	3,813	1,836	928	0.697
		BG			1,094	1,366	1,594	926	
	2	III 15E	8/10/70	0.697	5,802	3,688	1,786	942	0.700
		BG			1,132	1,438	1,584	916	
	3	III 18H	8/10/70	0.703	5,828	3,871	1,945	951	0.721
		BG			1,132	1,438	1,584	916	
	4	III 25B	8/11/70	0.710	5,736	3,853	1,814	1,007	0.710
		BG			1,124	1,418	1,602	912	
	5	III 33B	8/13/70	0.706	5,724	3,777	1,758	922	0.698
		BG			1,078	1,326	1,488	886	
	$\bar{x} =$				4,669.2	2,403.2	257.4	38.8	
	1 sigma =				42.7691	85.9837	63.7558	34.2739	
	2 sigma % =				1.83	7.16	49.54	176.67	

27	1	III 9D BG	8/7/70	0.686	1,949 1,094	1,767 1,366	1,549 1,594	936 926	0.706
	2	III 16C BG	8/10/70	0.706	1,914 1,132	1,750 1,438	1,650 1,584	895 916	0.705
	3	III 20B BG	8/10/70	0.717	1,942 1,132	1,754 1,438	1,687 1,584	908 916	0.716
	4	III 29H BG	8/12/70	0.690	1,904 1,124	1,714 1,400	1,518 1,538	894 886	0.698
	5	III 37C BG	8/13/70	0.709	1,940 1,078	1,704 1,326	1,497 1,488	875 886	0.690

$\bar{x}$ =	817.8	344.2	22.6	-4.4
1 sigma =	39.0794	42.1687	61.068	13.1643
2 sigma % =	9.56	24.5	540.42	-598.38

28	1	III 16F BG	8/10/70	0.705	7,198 1,132	3,947 1,438	1,840 1,584	997 916	0.714
	2	III 19H BG	8/10/70	0.716	7,096 1,132	3,997 1,438	1,829 1,584	994 916	0.717
	3	III 24I BG	8/11/70	0.710	7,079 1,124	3,958 1,478	1,851 1,502	936 912	0.710
	4	III 30A BG	8/11/70	0.698	7,102 1,124	4,019 1,418	1,785 1,602	926 912	0.690
	5	III 35F BG	8/13/70	0.705	7,453 1,078	3,985 1,326	1,761 1,488	956 886	0.678

$\bar{x}$ =	6,067.3	2,573.6	241.2	53.4
1 sigma =	177.438	58.222	34.252	31.8559
2 sigma % =	5.85	4.52	28.4	119.31

Sample	Testing			Calibration	Channel				Calibration
	Run	Number	Date	C ₁	A	B	C	D	C ₂
29	1	III 8B	8/7/70	0.691	2,295	1,805	1,599	938	0.697
		BG			1,094	1,366	1,594	926	
	2	III 11F	8/10/70	0.709	2,248	1,817	1,507	864	0.716
		BG			1,132	1,438	1,584	916	
	3	III 19C	8/10/70	0.721	2,357	1,855	1,686	912	0.704
		BG			1,132	1,438	1,584	916	
	4	III 25H	8/11/70	0.714	2,241	1,924	1,553	865	0.716
		BG			1,124	1,418	1,602	912	
	5	III 35A	8/13/70	0.691	2,341	1,819	1,555	874	0.692
		BG			1,078	1,326	1,488	886	
$\bar{x} =$					1,180.4	446.8	9.6	-20.6	
1 sigma =					63.2835	52.8791	75.4771	27.8173	
2 sigma % =					10.72	23.67	1,572.44	-270.07	
30	1	III 12A	8/10/70	0.716	4,372	4,266	1,654	926	0.727
		BG			1,132	1,438	1,584	916	
	2	III 16I	8/10/70	0.714	4,305	4,418	1,730	917	0.706
		BG			1,132	1,438	1,584	916	
	3	III 19B	8/10/70	0.721	4,403	4,379	1,660	936	0.704
		BG			1,132	1,438	1,584	916	
	4	III 25C	8/11/70	0.710	4,382	4,369	1,551	909	0.710
		BG			1,124	1,418	1,602	912	
	5	III 34C	8/13/70	0.695	4,668	4,293	1,616	846	0.691
		BG			1,028	1,326	1,488	886	
$\bar{x} =$					3,006.4	2,933.4	73.8	-2.4	
1 sigma =					162.964	60.7808	77.0467	22.8101	
2 sigma % =					9.86	4.14	208.8	-1,900.84	

31	1	III 7B BG	8/7/70	0.709	6,457 1,094	5,127 1,366	1,712 1,594	960 926	0.696
	2	III 16B BG	8/10/70	0.706	6,440 1,132	5,057 1,438	1,607 1,584	889 916	0.705
	3	III 19E BG	8/10/70	0.704	6,641 1,132	5,023 1,438	1,689 1,584	968 916	0.716
	4	III 24H BG	8/11/70	0.710	6,493 1,124	4,847 1,418	1,608 1,602	880 912	0.710
	5	III 33C BG	8/13/70	0.706	6,247 1,078	4,757 1,326	1,576 1,488	886 886	0.698

$\bar{x} =$ 5,343.6 3,565 68 5.4
1 sigma = 122.608 139.807 50.3438 36.9703
2 sigma % = 4.59 7.84 148.07 1,369.27

32	1	III 12A BG	8/10/70	0.716	6,957 1,132	5,050 1,438	1,676 1,584	902 916	0.727
	2	III 16H BG	8/10/70	0.714	6,736 1,132	5,165 1,438	1,679 1,584	908 916	0.706
	3	III 19F BG	8/10/70	0.704	6,815 1,132	4,924 1,438	1,740 1,584	898 916	0.716
	4	III 26A BG	8/11/70	0.714	6,746 1,124	5,054 1,418	1,620 1,602	834 912	0.716
	5	III 34A BG	8/13/70	0.714	6,545 1,078	4,958 1,326	1,641 1,488	852 886	0.695

$\bar{x} =$ 5,640.2 3,618.6 102.8 -30.4
1 sigma = 130.022 86.3991 56.3888 28.2984
2 sigma % = 4.61 4.78 109.71 -186.17

Sample	Testing			Calibration	Channel				Calibration
	Run	Number	Date	C ₁	A	B	C	D	C ₂
33 (U-STD)	1	III 7H BG	8/7/70	0.709	4,391 1,094	4,728 1,366	3,618 1,594	1,624 926	0.691
	2	III 15H BG	8/10/70	0.700	4,460 1,132	4,697 1,438	3,610 1,584	1,492 916	0.706
	3	III 30E BG	8/12/70	0.690	4,210 1,124	4,563 1,400	3,510 1,538	1,480 886	0.700
	4	III 31I BG	8/12/70	0.697	4,168 1,124	4,545 1,400	3,439 1,538	1,548 886	0.698
	5	III 33A BG	8/13/70	0.706	4,132 1,078	4,559 1,326	3,432 1,488	1,522 886	0.698
					$\bar{x} =$	$\bar{x} =$	$\bar{x} =$	$\bar{x} =$	
					1 sigma =	1 sigma =	1 sigma =	1 sigma =	
					2 sigma % =	2 sigma % =	2 sigma % =	2 sigma % =	
34 (Am-241)	1	III 44F	8/14/70	0.705	1,351	1,855	1,648	799	
	2	III 44G	8/14/70		1,306	1,802	1,553	790	
	3	III 45A	8/14/70		1,356	1,801	1,604	800	
	4	III 45B	8/14/70		1,338	1,858	1,621	769	
	5	III 45C	8/14/70		1,314	1,783	1,674	793	
	6	III 45D	8/14/70		1,345	1,836	1,575	778	
	7	III 45E	8/14/70		1,371	1,876	1,655	806	
	8	III 45F	8/14/70		1,384	1,782	1,626	878	
	9	III 45G	8/14/70		1,340	1,773	1,667	795	
	10	III 45H	8/14/70		1,384	1,880	1,630	788	0.706
					$\bar{x} =$	$\bar{x} =$	$\bar{x} =$	$\bar{x} =$	
					1 sigma =	1 sigma =	1 sigma =	1 sigma =	
					2 sigma % =	2 sigma % =	2 sigma % =	2 sigma % =	

B. Background Data

200 Seconds

1	III 5B	8/7/70	0.707	523	680	787	473	0.705
2	III 8G		0.687	550	665	773	433	0.707
3	III 11A		0.692	568	704	832	483	0.691
			$\bar{x} =$	547	683	797	463	
			1 sigma =	22.6	19.7	30.8	26.5	
1	III 11G	8/10/70	0.709	604	684	789	439	0.716
2	III 13I		0.706	541	714	800	472	0.688
3	III 15A		0.688	545	686	814	444	0.697
4	III 18F		0.717	556	760	791	493	0.703
5	III 20E		0.716	582	749	764	442	
			$\bar{x} =$	566	719	792	450	
			1 sigma =	26.7	35.1	18.3	23.6	
1	III 20F	8/11/70		571	746	816	443	0.707
2	III 22A		0.692	570	688	825	477	0.701
3	III 23D		0.685	534	672	838	450	0.688
4	III 24C		0.705	579	714	762	459	0.710
5	III 27G		0.716	554	725	762	451	0.724
			$\bar{x} =$	562	709	801	456	
			1 sigma =	17.9	29.4	36.1	13.0	
1	III 28E	8/12/70	0.708	536	703	800	466	0.712
2	III 30C		0.696	588	696	737	420	0.690
			$\bar{x} =$	562	700	769	443	
			1 sigma =	36.8	4.9	44.5	32.5	

Testing			Calibration	Channel				Calibration
Run	Number	Date	C ₁	A	B	C	D	C ₂
1	III 32C	8/13/70		515	653	751	443	0.690
2	III 34G		0.691	528	653	710	435	0.692
3	III 37D		0.709	566	687	725	438	0.690
4	III 39G		0.700	525	647	722	459	0.703
5	III 43A		0.706	559	677	764	443	0.707
			$\bar{x} =$	539	663	744	443	
			1 sigma =	22.5	17.5	27.6	9.3	
1	III 44A	8/14/70		511	654	687	408	0.675
2	III 44E		0.705	526	639	651	415	0.706
3	III 46A		0.706	509	624	699	417	
			$\bar{x} =$	515	639	679	413	
			1 sigma =	9.3	15.0	25.0	4.7	
1	III 47B	8/17/70	0.669	496	595	705	406	0.696
2	III 47E		0.704	507	681	764	352	0.697
3	III 51I		0.705	500	570	749	416	0.714
			$\bar{x} =$	501	615	739	391	
			1 sigma =	5.6	58.2	30.7	34.4	

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TABLE C-2. Gamma Sodium Iodide Scrap Standard Testing
Position Experiment Test Results

8/17/70 - Sodium-22 Source - 200 Seconds

Position	Test No.	Channel			
		A	B	C	D
a	III 50F	12,580	18,721	18,224	4,557
	III 50G	12,729	18,497	17,969	4,631
	III 50H	12,838	18,385	18,042	4,754
b	III 51C	12,641	18,235	18,063	4,555
	III 51D	12,350	18,381	17,488	4,617
	III 51E	12,441	18,448	17,501	4,531
c	III 50C	12,884	18,229	18,042	4,725
	III 50D	12,981	18,592	18,231	4,635
	III 50E	13,032	18,325	18,207	4,709
d	III 51F	12,726	18,249	17,431	4,490
	III 51G	12,813	18,188	17,899	4,603
	III 51H	12,902	18,393	17,282	4,637
e	III 49I	13,407	18,321	18,085	4,651
	III 50A	13,153	18,538	18,080	4,671
	III 50B	13,323	18,453	18,271	4,701
f	III 50I	13,370	18,218	17,329	4,642
	III 51A	13,380	18,680	17,642	4,481
	III 51B	13,495	18,651	17,355	4,497
Background		501	615	739	391
	$\bar{x} =$	12,445.9	17,801.9	17,102.2	4,224.9
	$S_x =$	346.706	167.959	355.037	82.466
	$2S_x\% =$	5.57	1.89	4.15	3.9

8/13/70 - Sample 8 - 200 Seconds

a	III 40A	8,317	8,603	2,690	1,101
	III 40B	8,495	8,635	2,656	1,112
b	III 42C	8,216	8,537	2,674	1,166
	III 42D	8,199	8,516	2,595	1,158
c	III 39A	8,227	8,213	2,594	1,153
	III 39C	8,321	8,523	2,717	1,174
d	III 41E	8,409	8,454	2,681	1,167
	III 41F	8,472	8,466	2,665	1,257

TABLE C-2. (Continued)

Position	Test No.	Channel			
		A	B	C	D
e	III 38C	9,313	9,322	2,785	1,128
	III 38D	8,983	9,034	2,712	1,109
f	III 40F	8,620	8,626	2,752	1,233
	III 41A	8,393	8,650	2,747	1,219
Background		539	663	744	443
	$\bar{x} =$	7,958.18	7,968.58	1,945	721.75
	$s_x =$	335.804	287.319	58.5258	50.1745
	$2s_{x\%} =$	8.44	7.21	6.02	13.9
8/13/70 - Sample 16 - 200 Seconds					
a	III 39D	132,529	138,823	15,854	3,512
	III 39E	132,740	138,266	15,794	3,489
b	III 41G	141,204	146,163	16,553	3,532
	III 42B	140,833	145,793	16,329	3,589
c	III 38F	138,339	143,449	16,123	3,495
	III 38G	138,282	142,893	16,145	3,613
d	III 41B	131,869	136,640	15,648	3,527
	III 41C	132,770	136,681	15,632	3,471
e	III 42F	140,026	142,557	16,449	3,553
	III 42G	139,494	142,617	16,237	3,510
f	III 40D	133,292	134,769	15,432	3,397
	III 40E	134,112	134,526	15,477	3,439
Background		539	663	744	443
	$\bar{x} =$	135,752	139,602	15,228.8	3,067.58
	$s_x =$	3,687.71	4,130.27	383.559	89.9006
	$2s_{x\%} =$	5.43	5.93	5.04	3.91

TABLE C-3. Gamma Sodium Iodide Scrap Testing-Position Experiment

A. Position within Can. B. Analysis of Variance (Duncan Range Analysis Method)

1. Sodium-22 Source

<u>Source</u>	<u>df</u>	<u>SS</u>	<u>MS</u>	<u>F</u>
Position	5	146554.444	29310.888	1.130
Runs	2	73854.111	36927.055	1.424
Error	10	259165.223	25916.522	
Total	17	479573.778		

$$F(2,10)_{0.9} = 2.92$$

$$F(5,10)_{0.9} = 2.52$$

Not Significant

2. (PIP 8) Fuel Scrap Standard

<u>Source</u>	<u>df</u>	<u>SS</u>	<u>MS</u>	<u>F</u>
Position	5	817460.5	163492.1	9.0**
Runs	1	396.8	396.8	0.0
Error	5	90217.7	18043.5	
Total	11	90807.5		

$$F(5,5)_{0.95} = 5.05$$

$$F(5,5)_{0.99} = 11.0$$

** Position Effect is Significant at 95% Level.

3. (PIP 16) Fuel Scrap Standard

<u>Source</u>	<u>df</u>	<u>SS</u>	<u>MS</u>	<u>F</u>
Position	5	187967470.75	37593494.15	987***
Runs	1	220052.083	220052.083	5.783*
Error	5	190255.417	38051.083	
Total	11	188377778.25		

$$F(5,5)_{0.99} = 11$$

$$F(1,5)_{0.90} = 4.06$$

$$F(1,5)_{0.95} = 6.61$$

*** Highly Significant

* Significant

APPENDIX D

GAMMA GERMANIUM (LITHIUM) TESTING

TABLE D-1. Gamma Germanium (Lithium) Rod Standard

A. Test Data (1000 seconds)

Rod Number	Testing			Calibration	Channel				Calibration
	Run	Number	Date	<u>C₁</u>	A	B	C	D	<u>C₂</u>
1	1	IV 12C	8/27/70	36,597	76,182	21,461	12,029	21,149	32,312
	2	IV 16G	8/28/70	37,760	74,931	19,270	11,665	20,064	37,991
	3	IV 18G	8/28/70	30,969	76,476	21,268	12,223	21,139	34,407
	4	IV 19G	8/28/70	33,793	74,451	21,124	12,430	22,380	32,994
	5	IV 22G	8/31/70	36,794	77,054	19,469	12,458	19,923	38,347
2	1	IV 12E	8/27/70	32,312	117,606	28,719	17,860	25,155	36,403
	2	IV 17D	8/28/70	32,105	116,947	26,820	17,686	24,053	39,065
	3	IV 20A	8/28/70	32,994	112,925	30,001	17,923	25,315	36,273
	4	IV 23A	8/31/70	38,347	120,046	27,069	17,573	25,950	30,575
	5	IV 28B	9/1/70	32,103	116,807	27,670	17,661	23,685	30,989
3	1	IV 13C	8/27/70	34,968	238,726	48,213	33,417	35,134	33,537
	2	IV 18C	8/28/70	33,347	229,538	49,742	33,769	35,854	33,855
	3	IV 19C	8/28/70	35,709	232,247	48,828	33,619	34,604	37,728
	4	IV 20C	8/28/70	36,273	233,966	49,169	33,362	35,504	32,398
	5	IV 23F	8/31/70	35,918	237,068	47,322	33,555	34,136	34,123

TABLE D-1. (Continued)

Rod Number	Testing			Calibration	Channel				Calibration
	Run	Number	Date	C ₁	A	B	C	D	C ₂
4	1	IV 13E	8/27/70	33,537	387,728	74,626	51,450	48,844	33,160
	2	IV 16E	8/28/70	32,649	390,648	74,262	50,913	48,850	37,760
	3	IV 19E	8/28/70	37,728	383,753	74,677	51,040	49,349	33,793
	4	IV 20E	8/28/70	32,398	379,719	73,685	50,930	48,400	37,523
	5	IV 23H	8/31/70	34,123	376,287	75,099	49,864	46,818	40,087
5	1	IV 13G	8/27/70	33,160	203,904	32,116	16,256	28,305	38,313
	2	IV 15H	8/28/70	34,519	202,185	30,573	15,859	26,737	30,646
	3	IV 20G	8/28/70	37,523	200,134	32,870	16,010	28,462	34,993
	4	IV 24B	8/31/70	40,087	197,053	32,113	16,020	27,370	31,645
	5	IV 29A	9/1/70	33,443	200,789	31,904	16,155	27,465	35,695
6	1	IV 29C	9/1/70	35,695	243,512	61,497	51,989	26,121	34,432
	2	IV 29F	9/1/70	34,432	239,955	60,382	51,009	26,323	30,744
7	1	IV 18E	8/28/70	33,855	10,007	8,294	2,899	16,478	30,969
	2	IV 29H	9/1/70	30,744	9,864	8,083	2,772	16,215	38,518

TABLE D-1. (Continued)

B. Background Data (200 seconds)

Date	Run	Test Number	Channel			
			A	B	C	D
8/27/70	1	IV 11B	1348	902	163	776
	2	IV 11D	1392	910	188	935
	3	IV 12B	1373	753	198	868
		n =	3	3	3	3
		$\bar{x}$ =	1371	855	183	860
		S_x	22.1	88.4	18.0	79.8
8/28/70	1	IV 15A	897	583	203	839
	2	IV 15D	847	550	153	700
	3	IV 17I	852	612	270	814
	4	IV 18A	944	671	193	724
	5	IV 19B	909	548	259	888
	6	IV 21A	906	623	210	957
		n =	6	6	6	6
		$\bar{x}$ =	893	598	215	820
		S_x =	37.0	47.3	43.5	97.4
8/31/70	1	IV 21C	800	548	296	823
	2	IV 22D	833	595	294	916
	3	IV 23C	867	586	221	1132
	4	IV 24D	867	582	189	720
		n =	4	4	4	4
		$\bar{x}$ =	842	578	250	898
		S_x =	32.1	20.5	53.6	175.5
9/1/70*	1		4217	2947	925	3489
	2		4365	2800	900	3495

*1000 Second Counts

TABLE D-2. Gamma Germanium (Lithium) Rod Specimen - Computer Data Stripping Program

```

100 PRINT
120 FOR K = 1 TO 6
140 READ Y(K),Z(K)
160 NEXT K
180 LET X = 0
200 PRINT
210 IF X = 0 THEN 260
220 PRINT "X = ";X
240 PRINT
260 FOR I = 1 TO 6
280 IF I <> 1 THEN 350
300 PRINT "STND ROD"
320 PRINT
340 GOTO 400
350 IF X = 0 THEN 400
360 PRINT "FOR ROD # ";I-1,"GMS 241 = ";Y(I),"GMS 239 = ";Z(I)
380 PRINT
400 IF X > 0 THEN 440
420 READ R(I)
440 LET S1 = 0
460 LET S9 = 0
480 LET R1 = 0
500 LET R9 = 0
520 IF I = 1 THEN 600
530 IF X = 0 THEN 600
540 PRINT USING 560
560:GMS-PU-241 PCT DIFE GMS PU-239 PCT DIFE NET CTS: 241 239
580 PRINT
600 FOR J = 1 TO 5
620 IF X > 0 THEN 680
640 READ A(I,J),B(I,J),C(I,J),D(I,J)
680 LET U(I,J) = A(I,J) - B(I,J)
700 LET S1 = U(I,J) + S1
720 LET P(I,J) = C(I,J) - X*D(I,J)
740 LET S9 = P(I,J) + S9
760 IF I > 1 THEN 920
780 IF J < 5 THEN 1160
800 LET C1 = S1/(5*Y(1))
820 LET C9 = S9/(5*Z(1))
840 PRINT "CTS/GM PU-241 = ";C1
860 PRINT "CTS/GM PU-239 = ";C9
880 PRINT
900 GOTO 1160
920 LET G1 = U(I,J)/C1
940 LET G9 = P(I,J)/C9
960 LET P1 = (Y(I)-G1)*100/Y(1)
980 LET P9 = (Z(I)-G9)*100/Z(1)
1000 LET R1 = ABS(P1) + R1
1020 LET R9 = ABS(P9) + R9
1030 IF X = 0 THEN 1160
1040 PRINT USING#1060,G1,P1,G9,P9,U(I,J),P(I,J)

```

88

```

10 DIM C(300)
12 READ A$(1),A$(2),A$(3),A$(4),A$(5)
14 DATA PU-239,PU-241,AM-241,U-238,U-235
15 LET I = 1
16 READ X
18 IF X = 1.01E-20 THEN 9999
20 LET N = 0
30 LET S1 = 0
40 LET D = 0
42 READ Y
43 PRINT "-----"
44 PRINT
45 PRINT USING 50,X,A$(I),Y
50: ROD NUMBER = ## GRAMS " " =####.###
60 PRINT
70 FOR J = 1 TO 4
80 READ C(J)
85 LET M(J) = INT(1E3*(C(J)-Y)/Y + .5)/10
90 PRINT USING 95,J,C(J),M(J)
95: COUNT NUMBER ## GRAMS MEASURED =####.### PCT DIFFERENCE =####.#
99 PRINT
100 LET N = N + 1
110 LET S1 = C(J) + S1
120 NEXT J
130 LET A = S1/N
140 FOR K = 1 TO N
150 LET D = (C(K) - A)*2 + D
160 NEXT K
170 LET S = SQR(D/(N-1))
175 PRINT "MEAN","1-SIGMA","2-SIGMA","2-SIGMA PERCENT"
177 PRINT
180 PRINT A,S,2*S,INT(2E4*S/A + .5)/100
185 PRINT
200 LET I = I + 1
210 IF I = 6 THEN 15
220 GOTO 20
5000 DATA 2,3.23,3.26,3.27,3.22,3.16,.0906,.090,.092,.089,.092
5100 DATA .0152,.017,.017,.013,.015,140.36,130.6,144.2,143.5,143.2
5200 DATA 1.05,.97,1.08,1.07,1.07,5,2.68,2.71,2.77,2.64,2.72,.174,.175
5300 DATA .171,.183,.166,.0268,.022,.024,.023,.021,135.19,142.5,144.3
5400 DATA 159.4,152.9,1.01,1.06,1.08,1.19,1.14,1,1.96,2.0,1.97,2.08
5500 DATA 1.99,.0545,.059,.059,.054,.056,.00914,.01,.012,.014,.01,134.87
5600 DATA 126.4,121.3,122,124.2,1.01,.94,.91,.91,.93,3,6.72,6.78,6.51
5700 DATA 6.66,6.81,.189,.175,.197,.189,.195,.0317,.037,.03,.032
5800 DATA .036,131.92,137,157,155.5,159.6,.98,1.02,1.17,1.16,1.19,4
5900 DATA 11.47,11.1,11.26,10.86,10.69,.322,.324,.306,.308,.312,.054
6000 DATA .057,.058,.057,.056,129.68,176.1,172,175,175,1.01,1.31,1.28
6100 DATA 1.31,1.31
9997 DATA 1.01E-20
9999 END

```

TABLE D-3. Gamma Germanium (Lithium) Rod Specimen - Test Results

A. Calibration

X = .205 PIP-3

STND ROD

CTS/GM PU-241 = 992803.

CTS/GM PU-239 = 3922.6

B. Fuel Rod Specimen PIP-1

FOR ROD # 1 GMS 241 = .054*

GMS 239 = 1.96*

GMS PU-241 PCT DIFF GMS PU-239 PCT DIFF NET CTS: 241 239

.055	2.1	1.961	.1	54721	7693
.056	3.8	1.925	-1.8	55661	7551
.056	3.0	2.011	2.6	55208	7889
.054	- .5	1.999	2.0	53327	7842
.058	7.4	2.135	8.9	57585	8373

AV PCT 3.4 3.1

$\bar{x} = 0.0558$	2.0062	$\bar{x} =$	55,300	7,870
$S_x = 0.00148$	0.07953	$S_x =$	1548.2	311.1
		$2S_x \% =$	5.59	7.90

C. Fuel Rod Specimen PIP-2

FOR ROD # 2 GMS 241 = .0898*

GMS 239 = 3.23*

GMS PU-241 PCT DIFF GMS PU-239 PCT DIFF NET CTS: 241 239

.090	.3	3.238	.3	88887	12703
.091	1.1	3.252	.7	90127	12755
.084	-7.0	3.246	.5	82924	12733
.094	4.3	3.124	-3.3	92977	12253
.090	.0	3.265	1.1	89137	12805

AV PCT 2.5 1.2

$\bar{x} = 0.0898$	3.2250	$\bar{x} =$	88,810	12,650
$S_x = 0.00363$	0.05731	$S_x =$	3669.3	224.9
		$2S_x \% =$	8.26	3.55

* Chemical analytical assay value

D. Fuel Rod Specimen PIP-3

FOR ROD # 3 GMS 241 = .187*

GMS 239 = 6.72*

GMS PU-241 PCT DIFF GMS PU-239 PCT DIFF NET CTS: 241 239

.192	2.6	6.683	-.6	190513	26214
.181	-3.2	6.735	.2	179796	26418
.185	-1.2	6.762	.6	183419	26525
.186	-.5	6.650	-1.0	184797	26083
.191	2.2	6.770	.7	189746	26557

AV PCT 1.9

.6

$$\bar{x} = 0.1870$$

$$S_x = 0.00452$$

$$6.7200$$

$$0.05186$$

$$\bar{x} =$$

$$S_x =$$

$$2S_x\% =$$

$$185,654$$

$$4483.3$$

$$4.83$$

$$26,359.4$$

$$204.6$$

$$1.55$$

E. Fuel Rod Specimen PIP-4

FOR ROD # 4 GMS 241 = .319*

GMS 239 = 11.47*

GMS PU-241 PCT DIFF GMS PU-239 PCT DIFF NET CTS: 241 239

.315	-1.1	10.564	-7.9	313102	41436
.319	-.1	10.426	-9.1	316386	40898
.311	-2.4	10.433	-9.0	309076	40923
.308	-3.4	10.454	-8.9	306034	41008
.303	-4.9	10.265	-10.5	301188	40266

AV PCT 2.4

9.1

$$\bar{x} = 0.3112$$

$$S_x = 0.00618$$

$$10.4284$$

$$0.10697$$

$$\bar{x} =$$

$$S_x =$$

$$2S_x\% =$$

$$309,157$$

$$5938.9$$

$$3.84$$

$$40,906$$

$$418.7$$

$$1.02$$

* Chemical analytical assay value

F. Fuel Rod Specimen PIP-5

FOR ROD # 5 GMS 241 = .172*

GMS 239 = 2.66*

GMS PU-241 PCT DIFF GMS PU-239 PCT DIFF NET CTS: 241 239

.173	.6	2.665	- .6	171788	10453
.173	.5	2.646	- 1.3	171612	10377
.168	- 2.0	2.594	- 3.2	167264	10175
.166	- 3.4	2.654	- 1.0	164940	10409
.170	- 1.1	2.683	.1	168835	10524

AV PCT 1.5

1.2

 $\bar{x} = 0.1700$
 $s_x = 0.00308$
 $\bar{x} = 2.6484$
 $s_x = 0.03343$
 $\bar{x} = 168,898$
 $s_x = 2917.7$
 $2s_x \% = 3.45$
 $\bar{x} = 10,388$
 $s_x = 131.0$
 $2s_x \% = 2.52$

* Chemical analytical assay value

APPENDIX E

FEED AND PROCESS MATERIALS INSPECTION
DATA SUMMARY

TABLE E-1. Calorimeter Feed Material Inspection Calculation Data

A. Isotopic Analysis (Vendor)

<u>Isotope</u>	A0122 ¹	A0146 ²
	<u>Weight Percent</u>	<u>Weight Percent</u>
Pu-238	0.104%	0.135%
Pu-239	86.919%	75.625%
Pu-240	10.162%	18.533%
Pu-241	2.532%	4.567%
Pu-242	0.283%	1.140%
Am-241	0.278%	0.812%

1. The chemical/isotopic analyses were made on 7/8/69.
2. The chemical/isotopic analyses were made on 8/18/70.

B. Wattage and Half-Life Data (Mound)

<u>Isotope</u>	<u>Watts/gm</u>	<u>λ/Day</u>
Pu-238	0.566420 ¹	2.1614×10^{-5}
Pu-239	0.001924 ¹	7.860×10^{-8}
Pu-240	0.007089 ¹	2.903×10^{-7}
Pu-241	0.003348 ¹	1.2981×10^{-4}
Pu-242	0.0001146 ¹	4.3859×10^{-6}
Am-241	0.11450 ²	10^{-6}

1. Mound Laboratory.
2. Journal of Inorganic and Nuclear Chemistry, Vol. 29, pp. 2659.

C. Calculations Methods

1. Correction for decay of Pu-241 to Am-241
 $\% \text{ decay Pu-241} = \% \text{ buildup Am-241}$
 $\% \text{ decay Pu-241} = (\% \text{ Pu-241})e^{-\lambda T}$
 $\% \text{ Pu-241} = \text{isotopic abundance at time of chemical assay (day 1)}$
 $\lambda = 1.2981 \times 10^{-4}$
 $T = \text{elapsed time in days from time of chemical assay}$
 $\% \text{ Pu-241} - \% \text{ decay Pu-241} = \text{Pu-241 at time of calorimetry}$
 $\% \text{ Am-241 (day 1)} + \% \text{ decay Pu-241} = \text{Am-241 at time of calorimetry}$
2. Total Plutonium, grams

$$\frac{\text{wattage via calorimeter}}{\Sigma (\text{isotopic abundance}) (\text{watts/gm/isotope})} * \times \frac{100 **}{\Sigma \% \text{ isotopes}} = \text{Pu grams}$$

- * Isotopes include Pu-238, Pu-239, Pu-240, Pu-242 and corrected values for Pu-241 and Am-241.
- ** % isotopes is greater than 100 because of the presence of americium

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