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**Prepared for the U.S. Department of Energy
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IPD PREDICTED VS CPD MEASUREMENT DIFFERENCES
TWELVE TWO-TON TEST BATCHES
MARCH 29, 1961

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IPD PREDICTED VS CPD MEASUREMENT DIFFERENCES

TWELVE TWO-TON TEST BATCHES

MARCH 29, 1961

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IPD PREDICTED VS CPD MEASUREMENT DIFFERENCES
TWELVE TWO-TON TEST BATCHES

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INTRODUCTION

This report summarizes the IPD predicted vs. CPD measured values from the twelve two-ton test batches in references 3, 5, and 7. Two sets of comparisons are provided:

1. CPD measured vs. IPD predicted based on techniques used since January 1, 1960.
2. CPD measured vs. IPD predicted based on techniques used prior to January 1, 1960.

The latter comparisons are shown primarily for historical purposes.

On January 1, 1960 a set of new SSA EDM programs was established for predicting plutonium formation rates from IPD reactor MWD measurements (Ref: 2 and 4). These SSA programs constituted a significant step forward in the science of reactor predictions, no longer was it necessary to estimate dependent functions or truncate mathematical expressions. However, unreconcilable differences occurred between techniques which by directive were alleviated by arbitrarily adjusting heats of fission on the new program to force agreement with the old. The net effect consisted of a plutonium conversion reduction for the six older reactors and essentially no change for the K-reactors.

OBJECTIVES

Now, with the long-awaited data available from the test batches, attainment of the two objectives (better IPD-CPD plutonium agreement and use of nuclear conversion constants at their best known values) appears feasible in the near future. Data evaluation is now in progress and results will be documented upon completion. The target date for integration of test and routine production data into the nuclear materials measurements system has been set as June 30, 1961.

SUMMARY

Eleven of the twelve batches were successfully analyzed; the twelfth batch (KW-12) was lost due to a sample vial failure. This loss is, however, considered of minor importance since agreement was achieved with the other batches.

Average differences between IPD predicted, (new program), and CPD measured are shown in the table below. A positive value indicates that the CPD measured value is less than the predicted.

IPD PREDICTED LESS CPD MEASURED AVERAGE PERCENT DIFFERENCES

	<u>H-REACTOR</u>		<u>KW-REACTOR</u>	
	<u>442.1 MWD/Ton</u>	<u>804.6 MWD/Ton</u>	<u>457.6 MWD/Ton</u>	<u>832.0 MWD/Ton</u>
Pu gm/U lbs	- 0.50%	- 0.39%	1.23%	2.23
Pu-239	- 0.25	- 0.62	- .03	- .14
Pu-240	5.5	7.1	1.6	0.11
Pu-241	28.	13.	2.7	17.
U-235 Burn Out*	10.	4.9	20.	10.
No. Batches	(3)	(3)	(3)	(3)

*NOTE: U-235 burn out is calculated as follows:

$$\frac{((0.7115\text{-Predicted Remain})-(0.7115\text{-Measured Remain})) \times 100}{(0.7115\text{-Measured Remain})}$$

Individual batch measurements, predictions (new program) and differences are presented on page 4-7. CPD measurements vs. predictions (old and new programs) are shown on page 8 in summary form.

Fuel elements (I&E), load patterns and exposure measurements of the test batches are considered representative of present conditions. The fact that small changes have subsequently been made in fuel element sizes or load patterns does not invalidate or lessen in any manner the value of these test batches. The test was constructed for the study of nuclear constants of a typical reactor load and not necessarily as a means for normalization of differences. Simple normalization could have been achieved by less rigorous methods.

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BATCH 1
H-REACTOR

437.49 MWD/TON

	<u>IPD</u> <u>Predicted</u>	<u>CPD</u> <u>Measured</u>	<u>+95%</u> <u>C.L.</u>	<u>IPD-CPD</u> <u>Differences</u>	
					<u>%</u>
Pu gm/MWD	0.8823	0.8864		-0.0041	
Pu gm/U lb	0.1930	0.1939	± 0.0016	-0.0009	-0.46
Pu-238 wt %		0.004			
Pu-239	95.43	95.66	± 0.08	-0.23	-0.24
Pu-240	4.31	4.11	± 0.06	0.20	4.9
Pu-241	0.26	0.22	± 0.04	0.04	18.0
Pu-242		0.01			
Np gm/U lb		0.00064			
U-235 Burn Out (0.7115-Remain)	0.0506	0.0365	± 0.002	0.0141	39.0

BATCH 2
H-REACTOR

443.56 MWD/TON

	<u>IPD</u> <u>Predicted</u>	<u>CPD</u> <u>Measured</u>	<u>+95%</u> <u>C.L.</u>	<u>IPD-CPD</u> <u>Differences</u>	
					<u>%</u>
Pu gm/MWD	0.8811	0.8928		-0.0117	
Pu gm/U lb	0.1954	0.1980	± 0.003	-0.0026	-1.31
Pu-238 wt %		0.006			
Pu-239	95.36	95.59	± 0.15	-0.23	-0.24
Pu-240	4.37	4.06	± 0.15	0.31	7.6
Pu-241	0.27	0.35	± 0.03	-0.08	-23.
Pu-242		< 0.01			
Np gm/U lb		0.00057			
U-235 Burn Out (0.7115-Remain)	0.0513	0.0610	± 0.002	-0.0097	-16.

BATCH 3
H-REACTOR

445.11 MWD/TON

	<u>IPD</u> <u>Predicted</u>	<u>CPD</u> <u>Measured</u>	<u>+95%</u> <u>C.L.</u>	<u>IPD-CPD</u> <u>Differences</u>	
					<u>%</u>
Pu gm/MWD	0.8811	0.8789		0.0022	
Pu gm/U lb	0.1961	0.1956	± 0.0009	0.0005	0.26
Pu-238 wt %		0.004			
Pu-239	95.35	95.60	± 0.37	-0.25	-0.26
Pu-240	4.38	4.21	± 0.35	0.17	4.0
Pu-241	0.27	0.19	± 0.06	0.08	42.
Pu-242		< 0.01			
Np gm/U lb		0.0008			
U-235 Burn Out (0.7115-Remain)	0.0264	0.0495	± 0.002	0.0231	-47.

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BATCH 4
H-REACTOR

796.85 MWD/TON

	<u>IPD</u>	<u>CPD</u>	<u>+95%</u>	<u>IPD-CPD</u>	
	<u>Predicted</u>	<u>Measured</u>	<u>C.L.</u>	<u>Differences</u>	<u>%</u>
Pu gm/MWD	0.8255	0.8275		-0.0020	
Pu gm/U lb	0.3289	0.3297	± 0.0058	-0.0008	-0.24
Pu-238 wt %		0.011			
Pu-239	92.05	92.80	± 0.20	-0.75	-0.81
Pu-240	7.21	6.54	± 0.20	0.67	10.
Pu-241	0.74	0.66	± 0.04	0.08	12.
Pu-242		< 0.01			
Np gm/U lb		0.00011			
U-235 Burn Out (0.7115-Remain)	0.0875	0.0834	± 0.001	0.0041	4.9

BATCH 5
H-REACTOR

802.28 MWD/TON

	<u>IPD</u>	<u>CPD</u>	<u>+95%</u>	<u>IPD-CPD</u>	
	<u>Predicted</u>	<u>Measured</u>	<u>C.L.</u>	<u>Differences</u>	<u>%</u>
Pu gm/MWD	0.8249	0.8244		0.0005	
Pu gm/U lb	0.3309	0.3307	± 0.006	0.0002	0.06
Pu-238 wt %		0.012			
Pu-239	92.00	92.35	± 0.21	-0.35	-0.38
Pu-240	7.25	6.97	± 0.20	0.28	4.0
Pu-241	0.75	0.68	± 0.06	0.07	10.
Pu-242		< 0.01			
Np gm/U lb		0.00012			
U-238 Burn Out (0.7115-Remain)	0.0880	0.0849		0.0031	3.7

BATCH 6
H-REACTOR

814.56 MWD/TON

	<u>IPD</u>	<u>CPD</u>	<u>+95%</u>	<u>IPD-CPD</u>	
	<u>Predicted</u>	<u>Measured</u>	<u>C.L.</u>	<u>Differences</u>	<u>%</u>
Pu gm/MWD	0.8230	0.8314		-0.0084	
Pu gm/U lb	0.3352	0.3386	± 0.0024	-0.0034	-1.00
Pu-238 wt %		0.010			
Pu-239	91.89	92.50	± 0.06	-0.61	-0.66
Pu-240	7.34	6.85	± 0.06	0.49	7.2
Pu-241	0.77	0.65	± 0.03	0.12	18.
Pu-242		< 0.01			
Np gm/U lb		0.00013			
U-238 Burn Out (0.7115-Remain)	0.0892	0.0840	± 0.001	0.0052	6.2

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BATCH 7
KW-REACTOR

456.55 MWD/TON

	<u>IPD</u> <u>Predicted</u>	<u>CPD</u> <u>Measured</u>	<u>+95%</u> <u>C.L.</u>	<u>IPD-CPD</u> <u>Differences</u>	
				<u>%</u>	
Pu gm/MWD	0.9576	0.9366		0.0210	
Pu gm/U lb	0.2186	0.2138	± 0.0016	0.0048	2.25
Pu-238 wt %		0.005			
Pu-239	95.46	95.80	± 0.13	-0.34	-0.35
Pu-240	4.24	4.00	± 0.11	0.24	6.0
Pu-241	0.30	0.20	± 0.02	0.10	50.0
Pu-242		<0.01			
Np gm/U lb		0.00072			
U-235 Burn Out (0.7115-Remain)	0.0553	0.0345	± 0.003	0.0208	60.

BATCH 8
KW-REACTOR

457.34 MWD/TON

	<u>IPD</u> <u>Predicted</u>	<u>CPD</u> <u>Measured</u>	<u>+95%</u> <u>C.L.</u>	<u>IPD-CPD</u> <u>Differences</u>	
				<u>%</u>	
Pu gm/MWD	0.9573	0.9437		0.0136	
Pu gm/U lb	0.2189	0.2158	± 0.0025	0.0031	1.44
Pu-238 wt %		0.005			
Pu-239	95.45	95.12	± 0.22	0.33	0.35
Pu-240	4.25	4.48	± 0.21	-0.23	-5.1
Pu-241	0.30	0.40	± 0.02	-0.10	-25.
Pu-242		<0.01			
Np gm/U lb		0.00074			
U-235 Burn Out (0.7115-Remain)	0.0554	0.0559	± 0.002	-0.0005	-0.89

BATCH 9
KW-REACTOR

458.90 MWD/TON

	<u>IPD</u> <u>Predicted</u>	<u>CPD</u> <u>Measured</u>	<u>+95%</u> <u>C.L.</u>	<u>IPD-CPD</u> <u>Differences</u>	
				<u>%</u>	
Pu gm/MWD	0.9571	0.9571		0.0	
Pu gm/U lb	0.2196	0.2196	± 0.0016	0.0	0.0
Pu-238 wt %		0.005			
Pu-239	95.44	95.54	± 0.35	-0.10	-0.10
Pu-240	4.26	4.10	± 0.35	0.16	3.9
Pu-241	0.30	0.36	± 0.04	-0.06	-17.
Pu-242		<0.01			
Np gm/U lb		0.00072			
U-235 Burn Out (0.7115-Remains)	0.0555	0.0551	± 0.001	0.0004	0.73

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BATCH 10
KW-REACTOR
830.01 MWD/TON

	IPD Predicted	CPD Measured	+95% C.L.	IPD-CPD Differences	
					%
Pu gm/MWD	0.8959	0.8819		0.0140	
Pu gm/U lb	0.3718	0.3660	±0.0021	0.0058	1.58
Pu-238 wt %		0.012			
Pu-239	92.13	92.04	±0.20	0.09	0.10
Pu-240	7.03	7.20	±0.20	-0.17	-2.4
Pu-241	0.84	0.76	±0.05	0.08	10.5
Pu-242		<0.01			
Np gm/U lb		0.00014			
U-235 Burn Out (0.7115-Remain)	0.0951	0.0879		0.0072	8.2

BATCH 11
KW-REACTOR
833.92 MWD/TON

	IPD Predicted	CPD Measured	+95% C.L.	IPD-CPD Differences	
					%
Pu gm/MWD	0.8953	0.8703		0.0250	
Pu gm/U lb	0.3733	0.3629	±0.0057	0.0104	2.87
Pu-238 wt %		0.013			
Pu-239	92.10	92.44	±0.15	-0.34	-0.37
Pu-240	7.06	6.88	±0.15	0.18	2.62
Pu-241	0.84	0.68	±0.05	0.16	24.
Pu-242		<0.01			
Np gm/U lb		0.00014			
U-235 Burn Out (0.7115-Remain)	0.0955	0.0854	±0.001	0.0101	12.

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Pu/U COMPARISON
VS IPD PREDICTED (OLD & NEW PROGRAMS) CPD MEASURED

Reactor	Batch	MWD/Ton	Pu gm/U lbs CPD Measurement	Old Program Pu gm/U lbs IPD Predicted	Percent Difference	New Program Pu gm/U lbs IPD Predicted	Percent Difference
H	1	437.49	0.1939	0.1998	3.04	0.1930	-0.46%
H	2	443.56	0.1980	0.2022	2.12	0.1954	-1.31
H	3	445.11	0.1956	0.2029	3.73	0.1961	0.26
H	4	796.85	0.3297	0.3370	2.21	0.3289	-0.24
H	5	802.28	0.3307	0.3387	2.42	0.3309	0.06
H	6	814.56	0.3386	0.3436	1.47	0.3352	-1.00
KW	7	456.55	0.2138	0.2194	2.62	0.2186	2.25
KW	8	457.34	0.2158	0.2197	1.81	0.2189	1.44
KW	9	458.90	0.2196	0.2205	0.41	0.2196	0.0
KW	10	830.01	0.3660	0.3689	0.79	0.3718	1.58
KW	11	833.92	0.3629	0.3705	2.09	0.3733	2.87

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