[redacted]

DECLASSIFIED
WITH DELETIONS

[redacted] PRODUCTION [redacted] STOCKPILE
QU[redacted] INFOR[redacted]

RECORD CENTER FILE [redacted]

REFERENCE COPY RECEIVED SEP 23 1980 UNC NUCLEAR INDUSTRIES DOCUMENT CONTROL CENTER	NOTEBOOK NUMBER: UNI-N-80 DEL DATE OF ISSUE: ~~9-23-80~~ — SERIES AND COPY: ~~#2A~~ TITLE (INDICATE SUBJECT CONTENT): RPR PROGRAM PERSONAL NOTES
AUTHOR (S) - DEPARTMENT AND SECTION: ~~T.J. Trapp~~ A.M. Nolan, Advanced Technology	
PERIOD COVERED (INCLUSIVE - MONTH, DAY, YEAR) FROM 2/22/82 TO	REVIEW[redacted]ASSIFICATION ON 4-5-[redacted] BY [redacted] CLASSIFICATION IS U[redacted]GED
IF CONTINUED FROM ANOTHER NOTEBOOK, GIVE NOTEBOOK NUMBER: N/A	
IF CONTINUED IN ANOTHER NOTEBOOK, GIVE NOTEBOOK NUMBER	

ROUTE TO	P. R. NO.	LOCATION	ROUTE DATE	SIGNATURE & DATE
~~T.J. Trapp~~	~~61923~~	~~Fed B~~	~~9-23-80~~	
~~A.M. NOLAN~~	~~55316~~	~~FED.~~	~~2-23-82~~	
~~UNI Record~~				

RECORD COPY

JD Watrous 11/30/98
APPROVED FOR PUBLIC RELEASE

[redacted] RESTRICTED DATA
THIS DOCU[redacted]AINS RESTRICTED DATA AS DEFINED IN [redacted] ENERGY ACT OF 1954. UNAUTHORIZED [redacted] SUBJECT TO ADMINISTRATIVE AND CRIMIN[redacted]CTIONS.

DECLASSIFIED With DELETIONS

1st REVIEW-DATE	11-30-98
AUTHORITY	AOC ADC (ADD)
NAME	R.M. Itzen
ORG	PNNL
2nd REVIEW-DATE	11/30/98
NAME	JD Watrous
ORG	PNNL ADD

PD Omaw 12-11-98
PM Eick 12-15-98

RLO-CG-5, REV 1 (E.O.UP)
10-16-95

[redacted] FOR DECLASSIFICATION
ON [redacted]
BY [redacted] PNNL-ADD
CLASSIFICATION IS UN[redacted]GED

[redacted]

DECLASSIFIED
WITH DELETIONS

[redacted] DECLASSIFIED

This document consists of ~~52~~ pages, No. ~~1~~ of ~~1~~ copies, Series ~~A~~

Copy-1 - J.J. Trapp UNI Record

DEL

RD

RESTRICTED DATA

THIS [redacted] CONTAINS RESTRICTED DATA AS DEFINED IN [redacted] IC ENERGY ACT OF 1954. UNAUTHORIZED [redacted] RE SUBJECT TO ADMINISTRATIVE AND CRI[redacted]CTIONS.

CLASSIFIER: [signature] DATE [redacted]

TITLE: [handwritten]

RULES FOR RECORDING IDEAS AND EXPERIMENTS

1. ORIGINAL RECORDS ARE TO BE IN INK.
2. NOTEBOOK PAGES ARE TO BE USED CONSECUTIVELY. IF FOR ANY REASON A PAGE IS SKIPPED, IT SHOULD BE RULED OUT. IF THE ENTRIES ON A GIVEN SUBJECT DO NOT COMPLETELY FILL A PAGE, THE REMAINDER OF THE PAGE SHOULD BE RULED OUT. IF THE ENTRIES ON A GIVEN SUBJECT EXTEND OVER SEVERAL PAGES WHICH ARE NOT CONSECUTIVE, PROPER CROSS REFERENCES SHOULD BE INSERTED.
3. THE NOTEBOOK IS TO BE PRESERVED INTACT. IN NO CASE SHOULD ANY PAGE OR PART OF A PAGE BE REMOVED.
4. NO ERASURES ARE TO OCCUR IN THE RECORD. ANY CORRECTIONS OR CHANGES SHOULD BE MADE BY CANCELLATION, LEAVING THE ORIGINAL ENTRY LEGIBLE.
5. ALL ENTRIES SHOULD BE DATED, INCLUDING THE YEAR. IF A GIVEN ENTRY EXTENDS OVER MORE THAN ONE PAGE, THE DATE SHOULD APPEAR ON EACH PAGE.
6. THE PERSON MAKING EACH ENTRY SHOULD SIGN HIS NAME AT THE END THEREOF.
7. ANY ENTRY RELATING TO A NEW IDEA, CONTAINING A PROPOSAL FOR A FUTURE EXPERIMENT, OR CONTAINING A COMPLETED EXPERIMENT, SHOULD RECEIVE PARTICULAR ATTENTION. IT SHOULD BE SUCH AS TO BE UNDERSTANDABLE TO OTHERS AND NOT A MERE REMINDER TO THE MAKER. IT SHOULD BE READ OVER BY A TECHNICALLY QUALIFIED PERSON WHO DID NOT CONTRIBUTE NOVEL IDEAS IN CONNECTION WITH THE WORK INVOLVED AND DATED AND SIGNED BY HIM AS A WITNESS ON EACH PAGE OF THE ENTRY, AFTER MAKING SURE THAT HE UNDERSTANDS IT. (IF FURTHER DETAILS ARE NECESSARY TO COMPLETE THE WITNESS' UNDERSTANDING; PROPER ADDITIONAL ENTRIES SHOULD BE MADE BEFORE HE SIGNS.)
8. CLASSIFIED INFORMATION SHALL BE MADE ONLY IN THE PROPER NOTEBOOKS PROVIDED FOR THAT PURPOSE.

I CERTIFY THAT I HAVE EXAMINED THIS NOTEBOOK AS OF THE DATE SET FORTH BELOW, AND THAT IT CONTAINS NO PROBABLY PATENTABLE IDEAS OR INVENTIONS MADE OR CONCEIVED IN THE COURSE OF MY EMPLOYMENT BY UNC NUCLEAR INDUSTRIES, FOR WHICH A PATENT DISCLOSURE REPORT HAS NOT BEEN FILED.

DATE ______ SIGNATURE ______

BD-5000-303 (12-79) DOE- Richland, WA

DECLASSIFIED

[redacted]

[redacted] DECLASSIFIED

UNI-N-801

DEL

2/22/82

Hanford Production Data, 1944 – 19~~45~~ 71

(1944) B-reactor 1st critical in Sept. 1944

all production data for 1944 is in <u>code</u> – I can't tell how many slugs were discharged.

obviously, however, 1944 production was small.

(1945) Production data through August is in code – however, comparisons with Sept – Dec data provide a key to the code.

Production data is shown as "Product 49" (Pu-239) delivered to Area Engineer", for 2 enrichments: over and under 205 MWD/english ton. The production figures are in <u>milligrams</u>.

Month	Over 205	Under 205
J	60,250	
F	171,750	152,000
M	159,500	239,500
A	715,800	635,800
M	5,282,700	5,362,700
J	7,222,000	7,222,000
J	6,072,000	6,072,000
A	8,490,000	8,490,000
S	10,123,000	4,013,000
O	11,537,000	5,941,000
N	16,032,000	2,741,000
D	481,000	18,616,000
	47,779,000 ? not consistent with data?	49,879,000

(boxed Under 205 values, Feb–Aug:) data suspect – "over 205" may be the whole story – concerns about 205 arose in August or so.

year's totals from report.

D, F, B <u>reactors only</u>

[redacted] DECLASSIFIED

 [redacted]

DEL

2/22/82

DECLASSIFIED

B, D, F reactors

1946

Month	Over 205	under 205
J	7,705,000	11,760,960
F	~~9~~ 9,155,000	8,025,000
M	4,806,200	5,930,000
A	160,000	17,787,000
M	0	16,812,000
J	800,000	16,374,000
J	3,143,000	8,007,000
A	0	17,826,000
S	0	9,943,000
O	0	9,108,000
N	0	8,638,000
D	0	15,244,000

over + under 220

Jul-D : 71.9

B, D, F reactors

J-J 56.670

Jul-D 52.044

1947

J	0	9,150,000	
F	0	8,637,000	
M	0	9,611,000	
A	0	8,624,000	
M	0	9,281,000	
J	0	11,367,000	
J	0	~~11,367,000~~	7,698,000
A	0	9,935,000	
S	0	12,150,000	
O	—	—	no shipments
N	0	19,536,000	
D	0	2,725,000	

Inventory at monthend {
6,133,000
13,993,000
2,618,000
9,855,000

DECLASSIFIED

[redacted]

(1948) Product figures now in kg

these production figures are for Pu out put from processing + shipped

new format

Month	Over 220	under 220	month-end inventory
J	–	9.129	11.041
F	–	11.2	11.2
M		14.4	7.1
A		8.5	8.6

(Start over:)
kg Pu thru final chem processing

Month	
April	10.0
May	10.8
J	10.9
J	14.7
A	13.0
S	10.8
O	11.9
N	13.6
D	17.5

J-J 64.0

J-D 81.5

these are total pu, not just pu-239

B, D, F (B down part of year)

(1949)

	Pu(kg)	T(cm3)
J	19.3	
F	13.4	25.0
M	22.6	166.1
A	14.2	488.1
M	12.3	280.5
J	11.8	0
J	8.7	0
A	11.5	0
S	13.8	0
O	14.7	1 234.65
N	19.2	2 768.52
D	20.4	4161.

Tritium production started – quantities given in cm^3

	P	T
J-J	93.6	0.3 gm
J-D	88.3	2.2 gm

(O–D) ~~no units given~~ cm^3

H reactor added

4 UNI-N-80-DEL
2/22/82

[redacted] DECLASSIFIED

DEL

(1950) Now give Pu production in MWD discharged as well   B, D, F, H

Month	MWD Pu discharged	Pu thru Chem. Proc. (kg)		Tritium extracted produced (cm3)		MWDOT discharged
J	19,355	20.6		8831		
F	22,810	18.04		8927		
M	22,294	~~A~~ 24.1		10,657		
A	20,421	20.7	J-J 122.6	11,263	J-J 56,243	15.1gm
M	22,260	18.7		6,575		
J	38,704	21.5		9995		
J	39,821	24.4		16,504		
A	33,426	34.4		18,734	J-D 92409	24.9gm
S	48,830	29.3	J-D 188.5	7171.1		15
O	30,342	32.2		4331.		0
DR added N	~~45,741~~ 34,036	32.6		5585		54
D	32,320	35.6		40,084.2		38

(1951) → B, D, DR, F, H

Month	MWD Pu discharged	Pu thru Chem. Proc. (kg)		Tritium produced (cm3)		MWDOT discharged
J	~~46,464~~ 27,277	28.7		5,842.3		27
F	33,882	32.3		2,058.		128
M	33,953	38.2		5,843.		493
A	35,186	37.7		7,444.	135,192	1069
M	33,392	39.5	207.6	73,653.	(36.6 gm)	790
J	38,603	31.2		41,152		8,439
J	40,882	28.0		79,702		3093
A	50,025	29.1	231.6	77,759	462,643	6271
S	65,926	36.2		23,855	(124.4 gm)	14,516
O	55,869	43.7		105,303.2		0
N	~~62~~ 48,065	48.2		54,078		0
D	60,603	46.4		121,946		—

DECLASSIFIED [redacted]

 DEL

[redacted]

UNI-N-80-5 DE
2/22/82

(B, D, DR, F, H) — C-reactor added in Nov.
tritium production apparently closed

(1952)

Month	MWD Discharged Pu	MWD Discharged T	Pu thru chem proc. (kg)		T extracted (cm³)	
J	~~[illegible]~~ 61,581	—	42.3		300,504	
F	50,665	—	35.5		437,099	
M	73,184	—	53.9		226,133	200 gm
A	80,649	—	56.9	278.7	—	
M	56,799	—	52.7		—	
J	81,376	—	37.4		—	
J	64,585		48.3			
A	82,298		72.0			
S	76,044		~~68.3~~ 60.8	350.0		
O	79,069		45.1			
N	60,778		66.3			
D	74,116		57.5			

(1953) (B, C, D, DR, F, H)

Month	MWD	Pu thru chem proc. (kg)		T produced (cm³)	
J	78,797	61.6			
F	52,646	38.3			
M	70,885	81.6	385.1		
A	95,133	74.9		40,482	333,645
M	100,374	64.7		102,883	(89.95[illegible])
J	104,627	64.0		190,281	
J	72,141	90.0		218,200	

(new format)

Month	Pu discharged, kg		T, cm³ (cal.) produced		MWD Pu	Conversion, MWD/kg
~~Aug~~ July	62.8		218,200	369.2 gm		
Aug	60.7		250,700		(69,728 MWD Pu)	1150
S	99	474.5	251,701		114,272	1154
O	70		219.1 liters		80,098	1144
N	90		204.2 = 55 gms		103,826	1154
D	92		61.0 grams		105,820	1150

[redacted]

6 UNI-N° 80-DEL [redacted]
2/22/82

DECLASSIFIED WITH DELETIONS

DEL

(B, C, D, DR, F, H)

	Month	kg Pu discharged (low g/t)	kg Pu discharged (high g/t)	gms of T produced	T discharged	MWD Pu Discharged (low MWDs)		MWD Pu Discharged (high MWDs)	Conversion MWD/kgPu
(1954)	J	81		65		93,218			1151
	F	98		70		112,316			1146
	M	79		89		89,661			1135
	A	18	107	122	81	141,670			1133
	M	16	126	111	9	17,188	1074	146,579	1163
	J	4	138	92	165	3,784	946	162,523	1178
	J	29	58	85	132	30,717	1059	67,926	1171
	A	32.5	51.5	100	1	34,220	1053	60,550	1176
	S	36.3	7.3	91	0	38,728	1067	8,449	1157
	O	49.33	51.96	65 + 7	—	52,803	1070	61,109	1176
	N	24.66	70.87	<50 + 7	—	26,449	1073	84,807	1197
	D	58	50	30 + 7	—	61,849	1066	61,133	1223

Bracket totals (1954): kg Pu J–J: 667; T produced J–J: 549; kg Pu J–D: 519.5; T produced J–D: 442.

KE + KW added in May

	Month	kg Pu discharged (low g/t)	kg Pu discharged (high g/t)	gms of T produced	T discharged	MWD Pu Discharged (low MWDs)		MWD Pu Discharged (high MWDs)	Conversion MWD/kgPu
(1955)	J	44	63	32+8	—	47,111	1071	76,400	1213
	F	43	106	18 + –	—	46,475	1083	130,982	1236
	M	36	73	18+7	—	38,981	1083	91,401	1252
	A	68	38	– + 6	—	74,284	1092	47,101	1240
	M	78	39	– + 8	—	87,480	1122	48,802	1251
	J	81	40	8	–	88,199	1089	50,693	1267
	J	106	25	6	–	114,943	1084	30,224	1209
	A	93	62	8	–	100,496	1081	78,160	1261
	S	46.9	75.7	4		50,819	1084	95,211	1258
	O	58.9	27.1	4		63,740	1082	34,033	1256
	N	61.8	36.9	6		66,961	1084	45,833	1242
	D	18.1	49.8	12		19,548	1080	59,936	1204

Bracket totals (1955): kg Pu J–J: 709.0; T produced J–J: 105; kg Pu J–D: 661.2; T produced J–D: 40.

DECLASSIFIED WITH DELETIONS

[redacted]

 DEL

[redacted]

UNI-N-80-DEW 7
2/22/82

(1956) B, C, D, DR, F, H, KE, KW

Month	kg Pu discharged low g/t	kg Pu discharged high g/t		gm T produced	
J	56.6	105.3	1104.5	10	39
F	21.1	177.8		7	
M	56.2	132.6		7	
A	63.7	124.8		6	
M	57.0	153.7		5	
J	28.9	124.8		4	
J	36.4	178.4	1434.8	7.6	41.6
A	40	179		8	
S	13	277		7	
O	0	258		7	
N	0	229		6	
D	0	224		6	

(1957)

Month	low g/t	high g/t		gm T produced		gm T discharged	
J	0	248	1414	5	31		
F	0	197		5			
M	0	250		7			
A	–	213		5			
M		238		4			
J		268		5			
J		292	1576	5		4	15.9
A		242		7		0.5 [illegible]	
S		249		7		1	
O		231		7		4	
N		284		10.6		5.1	
D		278		8.7		~~4.0~~ 1.3	

[redacted]

8 UNI-N-80-DEL
2/22/82

[redacted]

DECLASSIFIED

DEL

(all but N)

Year	Month	Kg Pu discharged		gms T discharged	
1958	J	278		4.3	
	F	230		2.8	
	M	340	1526	5.8	12.9
	A	212		0	
	M	314		0	
	J	152		0	
	J	373		17.8	
	A	306		0.5	
	S	319	1758	3.8	28.5
	O	208		4.2	
	N	269		0.4	
	D	283		1.8	
1959	J	286		2.1 ← "Mint"	
	F	231		2.0	
	M	436	1787	0	191.8
	A	291		26.7	
	M	296		161.0	
	J	247		0	
	J	355		1.1	
	A	380		5.4	
	S	300	2258	3.9	20.2
	O	419		9.8	
	N	264		0	
	D	540		0	
1960	J	~~360~~ 358		~~[illegible]~~ 0.9	
	F	347		0	140.3
	M	298	2058	3.3	
	A	371		49.1	
	M	263		84.0	
	J	421		3.0	
	J	366		242.1	
	A	338		0	
	S	419	2207	0	242.1
	O	380		0	
	N	338		[redacted]	
	D	366		0	

DECLASSIFIED

[redacted]

UNI-N-80-DEL 9
2/22/82

1961	J	427	2311	0	0
	F	438		0	
	M	328		0	
	A	440		0	
	M	443		0	← "Mint"
	J	235		0	← "Tritium"
	J	333	2036	0	293.4
	A	274		0	
	S	474		0	
	O	325		0	
	N	320		293.4	
	D	310		–	
1962	J	414	2180	134.1	356.3
	F	350		212.8	
	M	342		0	
	A	377		4.3	
	M	313		4.7	
	J	384		0.4	
	J	342	1956	0	41.7
	A	227		0	
	S	417		0	
	O	379		0.7	
	N	281		37.7	
	D	310		3.3	
1963	J	780	2500	855	1462.0
	F	358		0	
	M	240		96	
	A	421		100	
	M	291		272	
	J	410		139	
	J	384	2171	13	433
	A	337		61	
	S	384		341	
	O	206		0	
	N	413		0	
	D	447		18	

Still all but N

[redacted]

10 UNI-N-80-DEL
2/22/82

[redacted]

DEL

Year	Month	Half-year total			Half-year total	Notes
1964	J	1406	384	1067	1468	
	F		324	1		
	M		346	0		
	A		689	371		
	M		291	21		
	J		426	8		
	J	2523	502	247	850	
	A		204	0		
	S		469	230		DR went away somewhere in here
	O		~~88~~ 430	3		
	N		~~450~~ 304	131		← 1st from N
	D		~~304~~ 614	~~131~~ 239		
1965	J	2084	274	90	794	
	F		425	0		
	M		197	0		← last discharge from H
	A		420	509		
	M		378	2		← last discharge from F
	J		390	193		
	J	2036	255	0	2	
	A		350	2		
	S		280	0		
	O		352	0		
	N		406	0		
	D		~~4~~ 393	0		B, C, D, KE, KW, N
1966	J	1797	283	0	0	
	F		427	0		
	M		218	0		
	A		217	0		
	M		375	0		
	J		277	0		
	J	1350	208	0	0	
	A		3	0		
	S		255	0		
	O		322	0		
	N		382	0		
	D		~~382~~ 180	0		B, C, D, KE, KW, N

[redacted]

[redacted]

DECLASSIFIED

UNI-N-80-DEL 11
2/22/80

DEL

(def.) (non def.)(Pu) — all but N — N: Pu d, nmd, T

1967

	def.	non def.	all but N	N: d	N: nmd	N: T
J	444		0			
F	493		4	25	128	0
M	271	120	0	7	129	0
A	141	0	0	1	109	0
M	362	0	0	23	60	85
J	73	125	35	32	0	234
J	142	2	0	0	0	1
A	40	236	182	0	0	0
S						
O						
N						
D						

all reactors but N: defense Pu; non-defense Pu material; T (all reactors)

N reactor

1967

	defense Pu	non-defense Pu	T (all reactors but N)	N: d	N: nmd	N: T
J	444		0			
F	493		0	5	128	–
M	271	120	0	7	129	–
A	141	0	0	1	109	* 759
M	362	0	0	23	60	85
J	73	125	0	32	0	234
Jan–Jun totals	1784	245	0	68	426	1078
J	165	47	35	0	0	0
A	142	2	0	0	0	1
S	40	236	182	0	0	0
O	258	25	0	73	35	284
N	20	167	0	22	11	81
D	80	91	0	0	0	1
Jul–Dec totals	705	568	217	95	46	367

1968

	defense Pu	non-defense Pu	T (all reactors but N)	N: d	N: nmd	N: T	
J	251	69	0	–	–	6	B, C, KE, KW, N
F	107	182	0	1	73	585	
M	133	56	0	55	0	378	
A	111	176	0	48	3	343	
M	7	90	0	49	0	346	C, KE, KW, N
J	312	207	0	46	1	344	
Jan–Jun totals	921	780	0	199	77	2022	
J	0	39	0	0	0	0	
A	100	102	0	28	21	314	
S	20	150	0	0	0	0	
O	76	110	0	0	0	0	
N	50	177	0	0	33	0	
D	0	157	0	0	0	0	
Jul–Dec totals	246	735	0	28	54	314	314

S[redacted]

DECLASSIFIED

12 UNI-N-80-DEL [redacted]
2/22/80

DEL

1969

Month	Def	Other non-def	T	N			Notes
J	21	91	0	0	109	0	
F	0	194	0	0	5	0	
M	72	117	0	5	108	135	135
A	56	197	0	0	1	0	C KE KW N
M	6	144	0	5	117	0	KE KW N
J	1	111	0	0	1	0	
Subtotal	156	854	0	10	341	135	
J	133	14	0	6	63	0	KE KW N
A	77	5	0	0	0	0	
S	122	18	0	0	0	0	KE KW N
O	131	77	0	0	0	0	
N	74	5	0	0	127	0	KE KW N
D	47	76	0	0	19	0	
Subtotal	584	195	0	6	209	0	

1970

Month	Def	Other non-def	T	N			Notes
J	104	0	0	0	127	0	KE KW N
F	205	0	0	0	1	0	
M	0	3	0	2	116	0	KE N
A	60	0	0	0	0	0	
M	121	0	0	4	57	0	KE N
J	0	0	0	1	120	0	KE N
Subtotal	490	3	0	7	421	0	
J	200	0	0	0	0	0	KE N
A	0	0	0	0	0	0	KE N
S	0	78	0	0	2	0	
O	43	23	0	0	0	0	KE N
N	75	0	0	0	0	0	
D	63	20	0	2	97	0	KE N
Subtotal	381	121	0	2	99	0	

1971

Month	Def	Other non-def	T	N			Notes
J	92	0	0	0	0	0	
F	0	0	90	0	0	0	KE N
M	0	0	0	0	0	0	
A	0	0	0	0	0	0	
M	0	0	0	0	0	0	
J	0	0	0	0	0	0	
Subtotal	92						
J	0	0	0	0	0	0	
A	0	0	0	1	1	0	
S	0	0	0	0	0	0	
O	0	0	0	0	128	0	N only
N				0	0	0	
D				0	133	0	
Subtotal					262		

[redacted]

Anne M. Nolan

DECLASSIFIED [redacted]

UNI-N80 DEL 13
2/23/82

Analysis of Hanford production data

Working backwards:

Pu in kg, T in gms

[illegible]	low-pressure reactors: Def. Pu	Non-Def Pu	T	N: Def. Pu	Non-Def. Pu	T
1971	92	0	90	1	262	0
1970	871	124	0	9	520	0
1969	740	1049	0	16	550	135
1968	1167	1515	0	227	131	2336
1967	1552 + 493 unspec. Pu	813	217	163	472	1445

plus 444 kg Pu from all reactors

all reactors, discharge quantities

	Pu (kg)	T (gm)
1966	3147	0
1965	4120	796
1964	4983	2318
1963	4671	1895
1962	4136	398
1961	4347	293
1960	4265	382
1959	4045	212
1958	3284	41
1957	2990	76

DECLASSIFIED

[redacted]

14 UNI-N-80-DEL
2/23/82

[redacted]

DECLASSIFIED

DEL

	Pu, kg low g/t	Pu, kg high g/t	T produced, gms → not discharged
1956	375	2164	81
1955	735	636	145
1954	268 +258 kg unspec. Pu	661	991

	Pu discharged, kg	T produced, ~~gms~~ liters
1953 July-Dec	475	1144.1 + 61 gms
	Pu discharged, MWD	
1953 Jan-June	574,603	~~554.8~~ 333.6

Conversion:
204.2 l = 55 gm.
(Nov 1953 data)

	Pu discharged, ~~kg~~ MWD	T extracted, l.
1952	779,563	963.7
1951	523,663	598.6
1950	364,619	148.7

	kg Pu thru final Chem processing	T extracted, l.
~~[illegible]~~ 1949	169.6	9.1
1948 Apr-Dec.	113.2	0

	Product 49 (kg) over spec	Product 49 (kg) under spec		
1948 Jan-Apr.	0	43.2		spec = 220
1947	0	108.7		
1946	25.8	145.5		
1945	~~56.5~~ 47.8	50.0	[redacted]	Spec = 205

no decipherable data for 1944.

DECLASSIFIED

[redacted]

DECLASSIFIED

UNI-N-80-DEL 15
2/23/82

Conversion of MWD Pu to kg Pu is available by using data obtained during 1953 -1955.

Use 1953 data, since Pu is "mixed" → ~ 1150 MWD/kgPu

Conversion of liters of T to gms - Nov 1953 data point → 3.71 l/gm

Final Table of Production by Year:

Year	Pu, kg	T, gm	~~[illegible]~~
1945	~~[illegible]~~ 97.8	0	"Product 49" delivered to Area Engineer"
1946	171.3	0	
1947	108.7	0	
1948	43.2 / 113.2	0	Pu (total) thru final Chem processing
1949	169.6	2.5[illegible]	T extracted (1949–1956)
1950	317	40	Plutonium discharged ↓
1951	455	161	
1952	678	260	
1953	975	~~149~~ ~~518~~ 459	
1954	929	~~369~~ 991	
1955	1371	~~991~~ 145	
1956	2539	~~145~~ 81	
1957	2990	76	Tritium discharged ↓
1958	3284	41	
1959	4045	212	
1960	4265	382	
1961	4347	293	
1962	4136	398	
1963	4671	1895	
1964	4983	2318	
1965	4120	796	
1966	3147	0	
1967	3937	1662	
1968	3040	2336	
1969	2355	135	
1970	1524	0	
1971	355	90	

DECLASSIFIED

Anne M Nolan

[redacted]

16 UNI-N-80-DEL
2/23/82

[redacted]

DECLASSIFIED

DEL

Reactor Operating History

Reactor	1st Discharge	last discharge	
✓ B	late 1944	early 1968	Feb
C	Nov 1952	April 1969 ✓	
✓ D	1945	1967	June
✓ DR	Nov 1950	late 1964	Dec
✓ F	1945	June 1965 ✓	
✓ H	Oct 1949	April 1965 ✓	
KE	May 1955	~~Feb~~ Jan 1971	
KW	May 1955	Feb 1970 ✓	
N	Nov 1964		

Could obtain more exact dates from other sources.

Anne M Nolan

DECLASSIFIED

[redacted]

DECLASSIFIED [redacted]

UNI-N-80-DEL 17
2/23/82 DEL

Data Obtained from Jim Ostic : N Reactor Pu production

FY	kg Pu
1972	414.4
73	672.8
74	607.2
75	556.5
76	429.0
77	560.5
78	558.7
79	543.8
80	412.5
81	196.4

from memo, JKO to TMH 1/11/82

Anne M. Nolan
2/24/82

Defense vs. Non-Defense Pu by year

Year	Def.	Non-Def.
1968	1394	1646
1969	756	1599
1970	880	644
1971	93	262

Anne M. Nolan

DECLASSIFIED

[redacted]

18 UNI-N-80-DEL [redacted] DECLASSIFIED DEL

2/26/82

Weapons Material Production in Commercial LWR

- Similar RPR concept, but constrained to existing PWR design - must be backfittable into existing pressure vessels, etc.

- Andy Prichard did some work along these lines in June-July 1981. The current work will be to refine his work + to make a design adapted to a particular PWR.

- Will look at Pu + T production both.

- Analysis will include:
    - production rates
    - safety issues
    - resource requirements

Safety issues to include:
- moderator + fuel temperature coefficients
- shutdown margins
- stuck rod accident
- refueling scenarios
- criticality concerns

Parameters to vary:
- pin size
- pitch
- enrichment
- Li-6 loading (T mode)
- Gd loading (T mode)

Tools:
- LEOPARD
- WIMS
- KENO
- 2DB

Will look at pin cell, assembly, + 1/4-core models.

DECLASSIFIED

Anne M. Nolan

[redacted]

DECLASSIFIED [redacted]

UNI-N-80 19 DEL

[redacted] 3/4/82 ①

2020 Briefing

2 major resources - RPR + AMPS

11/30/81 - directive to all 4 sites to do studies

Roser → Gilbert → Cochran → Jicha

(DIRECTIVE)

Major Planning Options

High + Low Demand Cases (Stockpile memo)

All production in gov't facil or use of commercial facil.

Opt. 1 Gov't facil. only

Opt. 2 DOE + comm. Faci

5 sub options as in UNI-I-41

} high + low demand for each

Concentrate on far-term (beyond 2000)
Consider all sources of material

PNL - technology assessment of impacts on society

impact on near-term production

DECLASSIFIED

54-3000-323 (2-58)
AEC-GE RICHLAND, WASH

[redacted]

SEC[redacted]

20 UNI-N-80-DEL [redacted] DECLASSIFIED DEL

[redacted] 3/4/82 ②

results so far:

- Early comm. to RPR required to assure T supply
- SIS key to low cost prod. of Pu - need risk assessment
- T demand can be met w/ ref. case (Case II) for all times
- Pu demand can be met w/ ref case, except for possible near term shortfall → make up by AMPS
- Long term waste mgmt is critical issue
- initial studies can be done as 3 cases at all sites
- need to do issues study early to establish constraints

T demand curve - peaks in 1990 high + low split after 2000

Pu demand peaks in 1885 & ~1993 - high + low very diff. (after 2000)

ISSUES

- demand
- Licensing + reg. exemptions
- changes to fed. statutes
- mat. prod. in licensed power reactors
- use of LWR or other Pu as feed to SLS
- technical assessment of SIS + AIS
- need for duality in production
- waste repos. locations
- site specific issues: inst., envir., social, political
- avail. of partially completed reactors

54-3000-323 (2-58) AEC-RL RICHLAND, WASH [redacted]

DECLASSIFIED [redacted]

DECLASSIFIED [redacted] SECRET

DEL

SE[redacted] 3/4/82 (3)

– power production + transmission

Matrix of cases → get copies of WRM's vugraphs

Case 1 – all DOE prod. highest cost

Case 2 – DOE T, SIS Pu

Case 3 – LWR T + Pu lowest cost

3 Cases included all options from directive

Case I is reference case & provides a common basis for comparison.

Case 1 needs 5 RPRs 2 for T, 3 for Pu

Case 2 need 2, for T production only

Case 3 – no RPRs

Key issue development done – letter sent to DOE HQ

DECLASSIFIED

Anne M. Nolan

[redacted]

[redacted]

22 UNI-N-80 TT1822
4/7/80 DEL Handwritten entries are recently corrected #s. DEL

[redacted]

DECLASSIFIED
WITH DELETIONS

[redacted]

TABLE 1

Anne M Nolan

[redacted]

DECLASSIFIED
WITH DELETIONS

[redacted]

UNI-N-80-DEL 23

DECLASSIFIED

[redacted]

N-Reactor ~~[illegible]~~ Pu Prod.

	Year	Defense Pu	Non-Defense Pu	Total
Calendar	1967	163	472	635 *
	1968	227	131	358
	1969	16	550	566
	1970	9	520	529
	1971	1	262	263
Fiscal	1972	–	414 ~~[illegible]~~	
	1973	–	673	
	1974	–	607	
	1975	–	556	
	1976	–	429	
	1977	–	560	
	1978	–	559	
	1979	–	544	
	1980	–	412	
	1981	–	196	

* Jan data unavailable

This is merely a summary of data on pages 11–15.

DECLASSIFIED

Anne M. Nolan

11/20/84

[redacted]

JKO/ 10/22/81

Co Product Experimental Results**

	← ISO-1012	Key #			→	← ARH-613 (Base-45.7 T)	→ (Spike-12 T)
	Chitwood	8203-1	8203-2	Average	8203-3	8304/8370-1	8304/8370-2
• Burnup* (MWD/T)	2085			2085			
• U-235 (w/o)	1.87	1.877	1.876	(1.869)	1.862	1.855	1.841
• Pu (g/T)	1060	895	1024	(1051)	1078	1092	1125
• 240 (w/o)	6.9	6.82	6.78	(6.88)	6.98	6.87	7.08
• 241 (w/o)	1.1	1.11	1.09	(1.11)	1.13	1.09	1.20
• 242 (w/o)	—	0.04	0.03		0.03	—	—

*Estimated

**ISO-1012 & ARH-613

[redacted]

[redacted]

10/81

RESULTS OF CoProduct BENCH MARKS

	BENCHMARKS	Recommended 238.2 235.4	3238.5 235.4	3238.5 235.2	3238.5 235.3	ACCURACY
PCTR RESULTS						
• DRY LATTICE (k_∞)	1.026 ± .007	1.0217	1.0357	1.0173	1.0116	−4.1 mk
• WET LATTICE (k_∞)	1.098 ± .005	1.0996	1.1087	1.0968	1.0932	+1.3 mk
EXPERIMENTAL RESULTS						
• Total Pu (g/ton)	1051	1127	1077	1089	1093	+ 7.2%
• Pu-241 (%)	1.11	1.06	1.19	1.22	1.23	− 4.5%
• Pu-240 (%)	6.88	6.83	7.06	7.13	7.17	− 0.7%
• U-235 (w/o)	1.87	1.87	1.87	1.864	1.864	—
• T (g/MWD)		.00432	.00427	.00432	.00434	

[redacted]

[redacted]

[redacted]

JKO [redacted]

10/81

BENCH MARK RESULTS

MARK - II FUEL

	DCODE*	WIMS	EXPERIMENTAL**	EXPERIMENTAL***
• BURNUP (MWD/T)	2085	2085	2085	
• U-235 (w/o)	1.85	1.87	1.87	1.816
• Pu (g/T)	1070	1078	1051	1047 ± 11 1031 ± 18
• ^{240}Pu (w/o)	6.05	7.06	6.88	6.655 ± .0122
• ^{241}Pu (w/o)	0.96	1.19	1.11	1.009
• ^{3}H PRODUCTION (g/MWD)		.00427		

* BASE FUEL

** ISO - 1012 w/ average of two higher burnup batches (2 samples)

*** ARH-998 51.1 TONS OF KEY # 8560 (4 samples)

Pages 24-26 were written by JK Ostic and were inserted in this book 11/20/84

Anne M. Nolan

[redacted]

DEL

Alan H. Rosinson's notes [redacted] ①

8-11-83

Estimates (by hand) of N-Reactor Np 237 production capability.

Assume current MK-IV fuel design with U238 replaced by U-236 in as many tubes as possible. EGGNIT calculations show that enrichment must be raised from 0.95 w/o to ~ 2.8 w/o.

N-Reactor U238 loading ≈ 365 kg/tube

Production of Pu ≈ 650/1000 = 0.65 kg/tube

In @ .95 w/o U235 → 3.4675 kg U235/tube

out @ .84 w/o " → 3.0660 kg U235/tube

CR_{ave} = 0.8095 { .4015 kg U235 burned per tube per ½ year; .325 kg Pu produced }

Assume a U236 → Np 237 design that is just as efficient. So, assume a conversion ratio = 0.80 for Np

DECLASSIFIED

[redacted]

28 UNI-N-80

DEL [redacted] DECLASSIFIED

[redacted] (2)

8-11-83

With same conversion ratio
each tube would produce $0.65\ \frac{\text{kg NP}}{\text{yr}}$.

Estimates of U236 total stockpile
range from 6 MT to 9 MT.

Using 9 MT → # tubes loaded

$= \frac{9000}{365} \approx 25$ tubes

$25 \times 0.65 = 16.25$ kg

+ 4.00 kg from U238 n,2n in other 975 tubes

20.25 kg/year

Inserted in book 11/20/83

Anne M. Nolan

54-3000-323 (2-58)
AEC-RL RICHLAND, WASH [redacted]

DECLASSIFIED [redacted]

[redacted]

AM Nolan's notes: 7/12/83 (1)

Talks with Buck Curtiss [illegible] indicate the desire for alternative fuel designs for N Reactor. Not only new designs, but other production modes as well should be looked into. The production of Np-237 is of current interest. Buck would like to have UNC able to present production concept by next April.

The problem with Np 237 is that you need to produce it from U236. [illegible] a quantity of this isotope exists in the defense production system, but only ~1500 kg. As an initially scoping "thought" experiment, one can consider replacing the U238 in Mark IA-IV fuel with U-236. The would require ~360 tons of U236 for 1 N Reactor core — therein lies the problem.

We can assume we can get U236 at whatever purity (up to 99%) we desire. SRL is going to be doing [illegible] PSP to get this.

[redacted]

[redacted] DECLASSIFIED

[redacted]

7/12/83 (2)

DEL

One source of Np-237 is the spent commercial fuel stored around the country. This is also a source of U236, if more Np237 is need. This requires reprocessing, however.

Alternative N fuel designs

We can use some of the ideas gained from the design work done on the revised RNR (UNI-2504). Some concepts to be considered:

- A Mark IV type design with U236 instead of U238 and a higher enrichment. – dimensions can be reoptimized.
- Combinations of production – coproduct or triproduct – depends on availability of U236
- Some Pu-238 will also be produced – a bonus if it's needed.

Current Problems

WIMS won't work with a high density ~~5~~ of U236 – we need new cross-sections developed for this. HEDL (Bob Schenter et al.) will be doing this, ~~B~~, and other nuclides as well. Also, they will update libraries for EGGNIT & BRT.

54-3000-323 (2-58)
AEC-RL RICHLAND, WASH

[redacted]T

[redacted] DECLASSIFIED

 [redacted]

[redacted]

7/12/83 ③

Np-237 needs to be added to some of these libraries. In the meantime, we can do scoping studies using EGGNIT + BRT to get enrichments right, etc.

Other areas / questions

- How much U236 do we have now? (~500 kg?)
- How much can we produce?
- How much Np 237 can we produce?
- In T mode situation (coproduct or other), explore use of boron injection into primary coolant or graphite cooling system for safety purposes.

Anne M. Nolan

11/20/84

54-3000-323 (2-58)
AEC-RL RICHLAND, WASH

[redacted]

[redacted]

[redacted]

[redacted] 8/83 (1)

U^{236} inventory (kg)

UNI-N-80 DEL

Location	Quantity (kg)
Paducah	567
NLO	995
RMI	83
Portsmouth	11
N basin	314
KE basin	939
KW basin	~~[illegible]~~ 24

} UNI-1800, Task III-2 p. 22

} DPSPU-81-9-1 Vol Add.

SRL - HEU

Np sep here ?

flowsheet - how done ?   routine • cleanup of solvent 0.2 kg/yr from N...

85% of what we get in tank.

how much Np in tanks is separable ?

Very low concentration

Not feasible - not much recoverable

140 kgs in all tanks

w/ PFMP → get FFTF Nep. - maybe equiv to N'

post 1990

?

[redacted]

54—3000—323 (2—58)
AEC RL RICHLAND, WASH

[redacted]

DECLASSIFIED [redacted] DEL 33

[redacted] 8/83

NP237 Production in LMFBR (FFTF)

20% U235 (no Pu) 160 MW/MTU 170 days (ORIGEN)

w/o U236	gm NP237/MTU
0	220
1	623
5	2218
10	4195
U238 only	75

total flux = 4.7×10^{15}

FFTF contain ~ 2.5 MTHM

DECLASSIFIED

54–3000–323 (2–58)
AEC-GE RICHLAND, WASH.

[redacted]

[redacted]

[redacted]

[redacted]

8/83

NP237 Production in LWR

3% U235   170 FPD   (3800 MWD/MTU)

w/o U236	gm NP237/MTU	
0	26.5	→ 13.3 is from U238 chain
1	299	
2	571	
5	1380	

(ORIGEN calculation)

thermal flux = 1.7×10^{13} (22 MW/MT)

Therm = 0.632
Res = 0.535
Fast = 3.93

[redacted]

[redacted]

[redacted] 8183

from WIMS MkIV run:

initial U^{236} conc. ~ .004 w/o → ~12%

at 3307 MWD/MTU, conc. of Np^{237} is:

inner 7.9 -7 } atoms/bn-cm ⇒ 3.1 -4 gm/cm³

outer 9.7 -7 ⇒ 3.8 -4 gm/cm³

	Area cm²	length, cm	fuel vol cm³	Np 237 gm
inner	6.164	742	4574	1.42
outer	13.223	742	9812	3.73
				5.15 gm/tube

x1000 tube ≈ 5.15 kg Np^{237}/core }
365 MTU/core } ⇒ (1.41-2 kg Np^{237}/MTU)

~~22 kg req. at Purex / .85 x 365 / 5.15~~

$$\Rightarrow \frac{(22\ kg/.85)}{1.41\text{-}2\ kg/MTU} \cong 1835\ MTU$$

⇓

gives 22 kg of Np^{237} out of Purex

[redacted]

[redacted] 8/83 (2)

wt% U236	kg U236 charged/MTU	gm Np237 at 173.1/MTU	$\frac{\text{gm Np237} - 26.5}{\text{kg U236}}$
0	0	26.5	0
1	10	299	27.3
2	20	571	27.2
5	50	1377	27.0

$\Longrightarrow$ ~ 27 gms of NP237 for each kg U236 charged

Assumptions: ^{236}U in fuel pin, 173 full power days, no decay (decay adds < 5%)
Commercial LWR environment

$\therefore$ Total U^{236} inventory = 9083 kg

$\Longrightarrow$ 245.2 kg of NP 237 is max. possible.

[illegible]

[redacted]

[redacted]

[redacted]

DEL

[redacted]

8/83 (3)

^{237}Np production in commercial LWR:

at 173 full power days, (= 3806 MWD/MTU) 26.5 gm of NP 237 is produced /MTU. For a 190 MTU core (RPR-LWR), this is ~5 kg of Np^{237}.

For the 72 operating commercial reactors, this gives ~360 kg of NP 237 per cycle.

From available low burnup spent fuel list in UNI-1950:

~500 MTU of fuel available. Burnup is < 13500 MWT/MTU

If it averaged ~5000 MWD/MTU (probably low), there's ~20 kg of Np 237 here.

54—3000—323 (2—58)
AEC-GE RICHLAND, WASH

[redacted]

[redacted]

[redacted]

DECLASSIFIED DEL

[redacted]

8/83

If you blended spent NR returns with depleted U (assume pure U-238) to get a Mark IV N Reactor composition, the following isotopics would result:

U235	0.95%	assuming no U236 enrichment penalty.
U236	0.13%	
U238	98.92%	

With U236 enr. penalty, the U235 fraction will need to increase. (Don't know how much) The U236 will increase proportionally.

For the Mark IA outers, the numbers are:

U235	1.25%
U236	0.17%
U238	98.58%

DECLASSIFIED

[redacted]

[redacted]

UNI-N-80 DEL

[redacted]

DECLASSIFIED
WITH DELETIONS

[redacted]

DPSPWD-81-4-1 VOL I ADD
UNI-N-80 ~ DEL

[redacted]A

[redacted]

SECRET

DECLASSIFIED

DEL

from Letter, J Eaves to H Toffer, 6/15/81

[redacted]

Mark IA analysis: 2134 MWD/T

8/83

~~other analysis:~~

~~test~~	isotope	wt % ①	②
	U 234	0,006	0.006
	235	0.736	0.565
	236	0.040	0.071
	238	99.217	99.358

NP237: ① 15.45 gm/Ton U ≅ 17 gm/MTU

② 34.6 gm/Ton U ≈ 38 gm/MTU

DECLASSIFIED

[redacted]

[redacted]

To: Joan Heaberlin Aug. 29, 1983

From: Anne Nolan

Subject: PRODUCTION OF NP-237 in N REACTOR

Alan Robinson and I have been investigating methods for producing Np-237 in N Reactor and the quantities that might be produced. Np-237 is produced by irradiating U-236 and, to a lesser extent, U-238.

We developed a preliminary fuel design concept for Np-237 production, based on the Mark IV fuel. We assumed that the U-238 in the Mark IV fuel is replaced by U-236. The U-235 enrichment would need to increase to about 2.8 % to compensate for the U-236 reactivity penalty.

We expect that the conversion ratio for Np-237 production would be similar to that for Pu-239 production, about 0.80. This implies that each N Reactor tube charged with the U-236 fuel could produce about 0.65 kg/yr.

54-3000-323 (2-58)
AEC-GE RICHLAND, WASH

[redacted]

[redacted]

I gathered data on the current national U-236 stockpile. The result are:

Location	Quantity (kg)
Hanford	1277 *
SRL	
Other	
Total	

* From UNI-1800, "Augmented Material Production Study", p. 22.

** From DPSPWD-81-9-1, Vol. 1 Addendum (FY83 Inventory).

If this entire inventory were available, it could be used to charge about 25 tubes. This would provide an annual production of about 16 kg of Np-237. In addition, about 4 kg/yr would be produced by (n, 2n) reactions in the U-238 in the rest of N Reactor, for a total of about 20 kg/yr.

[redacted]

[redacted]

[redacted]

AN EVALUATION OF THE MARK X TRITIUM MODE FUEL DESIGN

write-up by Fred Mollerus. Approx. 8/83

INTRODUCTION AND SUMMARY

The proposed Mark X fuel design contains several features which are unique and never used in other fuel designs that have operated in N-Reactor. These are:

1. The outer cylinder is a target element. This makes the outer target element very vulnerable to damage during charge-discharge. It also results in very little heat transfer into the outer flow annulus and the need for a device to achieve mixing of the flow channels to prevent a severe enthalpy unbalance.
2. A single fuel driver cylindrical element with heat transfer surfaces small ~~are~~ and heat fluxes higher than in fuel bundles operated to date.

The result is a high risk design to achieve the features of a burnable poison. Alternate designs to achieve burnable poison features which avoid these risks should be investigated before seriously considering the Mark X design.

DISCUSSION

Figure 1 shows the cross section of the Mark X - T mode fuel design. Table 1 gives the radii of the various cylinders in this design.

A unique feature of this design, compared to other designs used or considered for N-Reactor, is use of a target as the outer cylinder of the assembly. This presents several problems not here-to-fore existing in other fuel assembly designs.

1. The outer cylinder is more vulnerable to damage from scraping of the surface by a bowed process tube during the charging process and by impact from other discharging fuel assemblies

[redacted]

[redacted]

as they fall free into the "mine cart". Both could result in the loss of free tritium if the non-bounded outer cladding should be penetrated during discharge. Penetration of the outer clad during charging could expose the aluminum barrier to high temperature primary coolant, resulting in rapid corrosion of the aluminum and release of tritium into the primary coolant.

The problem of outer target damage by impact during refueling may be solved by designing the discharge system to prevent impact; i.e., do not allow assemblies to drop one on top of the other. A CANDU type of charge-discharge arrangement would solve this problem.

The problem of fuel assembly-process tube interference and the potential for cladding damage during charging is not readily solved in the N-Reactor tube geometry where tube distortion and charging forces are increasing. The LTHWR fuel assembly has a housing tube to protect the outer target tube. But, the LTHWR uses a much larger diameter tube.[1]

Fuel designs such as Mark X with an outer, unprotected target tube are vulnerable to damage and are inherently a high risk design. There appears to be no readily applicable solution to the problem.

2. The use of a target as the outer tube in the Mark X assembly results in very little heat flow into the outer flow annulus between the outer target tube and the process tube. The result is a severe enthalpy or energy pickup unbalance in the three flow annulii of the fuel assembly. This unbalance is shown below and is based on flow being approximately proportional to flow area, negligible heat generation in the target, and 3% heat into the outer channel from the graphite.

1. UNI-2000, Volume 12, Replacement Production Evaluation Program, Volume 12, Low Temperature Heavy Water Reactor, Replacment Reactor Concept Description, 4/30/81.

[redacted]

[redacted] DECLASSIFIED

Flow Channel	Flow Area Inch^2	Flow %	Heat Pickup %	Enthalpy Pickup/Flow
1 (inner)	0.565	22.3	45.2	2.03
2 (middle)	1.005	39.7	51.8	1.3
3 (outer)	0.961	38.0	3.0	0.08

The unbalance between the inner and middle flow channels can be eliminated by modifying the radii of the inner target rod and the inner tube. This approach cannot be used on the outer flow channel where the largest problem occurs, e.g. the outer flow channel has, in ~~preparative~~ proportion, a much larger flow area than heat pickup. This cannot, or should not, be corrected by reducing the gap across the outer channel or by putting any appreciable flow obstructions into the channel. The existing clearance is necessary for charging of assemblies into the distorted process tubes.

The flow vs. heat input, or enthalpy, unbalance noted above must be corrected to make the Mark X viable. The Mark II coproduct had an enthalpy unbalance of about 20%. This should be the objective of any new fuel design. The correction for Mark X or any other design using a target as the outer tube must be done by flow mixers at the end of some of the fuel elements that mix the streams leaving the three flow channels. Since flow mixing involves flow momentum change, flow mixing will result in additional riser-to-riser pressure drop that must be accommodated by less process tube flow or pressure drop in the fuel assembly.

The calculated heat flux for the inner surface of the driver is 888,000 Btu/ft^2-hr. This is 36% higher than the maximum heat flux of 651,000 Btu/hr-ft^2 obtained during the late 1960's co-product demonstration at 4000 Mwt and 13.4% higher than the maximum heat flux of 783,000 Btu/hr-ft^2 obtained under the 4800 Mwt-31 hour demonstration run.

The high heat flux is due to the smaller diameter of the driver. This higher heat flux does not appear to be a no-go situation but does need to be evaluated with the following concerns in mind.

DECLASSIFIED

[redacted]

[redacted]

[redacted] DECLASSIFIED [redacted]

DEL

1. Burn-out flux margins
2. Design of fuel supports to minimize hot spots.

The real concern is that the higher heat flux can result in a higher fuel failure rate.

The operating experience that fits closest to Mark X design is that of the Mark II co-product experience in 1963. Fuel failure, due to hot spots at fuel supports, were experienced when operation went from 6 to 5 cells.

A design of the Mark II with the high heat flux noted above will require considerable R and D, including prototype testing, since the problem of high heat flux hot spots cannot be solved only by analysis. The higher heat flux will also require considerable R and D to develop additional critical heat flux correlative data for the new operating region.

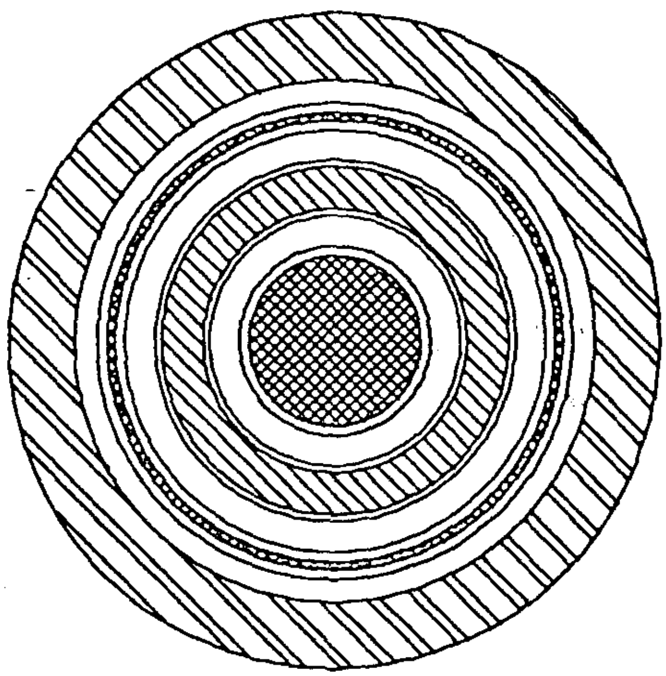
DECLASSIFIED

[redacted]

DEL

[redacted]

DECLASSIFIED [redacted]



N REACTOR T MODE

DECLASSIFIED [redacted]

FIGURE 1.

[redacted]

[redacted]T

DEL

[redacted]

Table 1

N REACTOR T MODE - "MARK X"

Dimensions	OR, CM
Target	1.121
Al	1.186
Zr	1.251 inner flow channel IR
H_2O	1.651 inner flow channel OR
Zr	1.740
Fuel	2.290
Zr	2.379 middle flow channel IR
H_2O	2.779 middle flow channel OR
Zr	2.844
Al	2.909
Target	3.009
Al	3.074
Zr	3.139 outer flow channel IR
H_2O	3.439 outer flow channel OR
Zr-pressure tube	4.318

Materials:

fuel = 93% enr U in Zr matrix

Target = $LiAlO_2$ or LiAl

[redacted]

[redacted]

DECLASSIFIED [redacted] 4/15/85 51

C Reactor information : questions to be answered:

* Operating mode / product
* Core design # of tubes, length, weight, fuel dimensions
* operating H_2O temperature
* typical exposures?
* power densities
* Graphite density & Temperature
* # z_R

RL-REA-2247 7/65 Historical Event - Reactors & Fuels Fabr.

C - 650 MW nominal

1954 - 55 did some U^{233} production + T prod.

1958 - 1740 MW set as power limit

1958 - irrad. depleted U for high Pu-240

1961 power limit = 2310 MW

1962 overbore fuel element: 631 MWD/T = 79% of goal

1965 has thoria blanket (fringe) 108 tubes

HW-74094 Vol 2 Hazards Summary Report (like SAR)
(May 1963) Process Control & Tech. Data - 6 Oldest Reactors

lattice pitch = 8 3/8", square equiv cell radius = 4.725"

Process Tube OD 1.764"
ID 1.633"

	natural (CIIN)	enr. (CIIIE)
OD clad	1.464	1.459
OD fuel	1.370	1.370
ID clad	0.375	0.375
ID fuel	0.481	0.488

DECLASSIFIED

p. 36 : ΔT coolant = 45°C

[redacted]

[redacted]

$2\overline{)2.310}$ = 1.155

11/15/85

Graphite ~~density~~ ~~[illegible]~~ 1.61 – 1.68
Al ρ = 2.70
U ρ = 18.9
} Cold

C Void fraction 2.51% (of active core)

Cold clean green k_∞ (wet) Nat = 1.034
Enr = 1.150 (.957)

2004 tubes (46 × 46, 28 missing each corner)

nat U charge 283" (52 slugs)
env. charg 217–226" (33–34 slugs)

181.5 ~~[illegible]~~ T nat U
37.9 ~~[illegible]~~ T env. U

18 w/o of core is enriched U (~~[illegible]~~ ~~18.0 w/o~~) (to support Overbore)

2310 MW = 49 kw/ft.

Avg. Fluxes		Therm	Res	Fast
	~~0 [illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~
	0 MWD/T	6.79+13	3.8+13	2.6+13
	400 " "	7.51+13	4.3+13	3.0+13
		E < .25 eV	.25 eV < E < .18 MeV	.18 MeV < E

Graphite temp (p. 161) 510° C – 700°C, depending on % He in reactor gas

---

HW 70219 Misc. Pu^{240} Conc. data for C Pile Overbore

(runs of Flex II Code)

@ 800 MWD/T

	% 240	% Power Gen	T_n °K
C II N	6.7	76	585
C II E	5.5	24	599

Pile avg 6.5

[redacted]

11/15/85

for last 6 mos of 1960, old reactors hit ~684 MWD/T exposure } Natural
→ 5.76% Pu^{240} }

823 MWD/T, 5.6% Pu^{240}) Enr.

Graphite temp = 425 °C ± 50 Nat
465 ± 50 °C Enr.

[redacted]

[redacted]

DEL

Pages 54-152
left blank

[redacted]