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ECONOMIC ANALYSIS OF 10-INCH AND 12-INCH
FUEL ELEMENT PRODUCTION FOR THREE SEPARATE
CONDITIONS.

F. W. Grubb

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ECONOMIC ANALYSIS OF 10-INCH AND
12-INCH FUEL ELEMENT PRODUCTION
FOR THREE SEPARATE CONDITIONS

Author: F. W. Grubb

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ECONOMIC ANALYSIS OF 10-INCH AND 12-INCH FUEL ELEMENT
PRODUCTION FOR THREE SEPARATE CONDITIONS

Ref: (1) Letter Astley to Mobley 5-23-62
(2) HW-73865 - WN Mobley 5-31-62
(3) Production Quantity Basis - D. - Snyder 1-24-63

INTRODUCTION

Three conditions representing various quantities of 10-inch and/or 12-inch fuel elements were presented by the Industrial Engineering Group, IPD, as a basis for initial estimates of economic incentive to partially convert the Production Fuels Section ALSi process to longer fuel elements for FY 1964..

An earlier study (Ref. 1) pertained to 10-inch instead of 6-inch enriched fuels. The comparatively larger quantities of the 4" longer fuel for full E-N loading showed a larger payout than for the requirements shown in this study. Since the estimates have been prepared without the benefit of any process development or equipment design, the validity of the results of this study rest directly with the assumptions. These assumptions are itemized in some detail to explain the basis from which payout was calculated. At best, the study can be used as a preliminary estimate, subject to changes as more detailed analysis are made.

The basic fuel requirements in condensed form are as follows:

<u>Present Forecast (FY 1964)</u>	<u>Pieces</u>	<u>Tons</u>
6" E	484,031	1,280.0
8" N	<u>1,614,452</u>	<u>5,984.0</u>
Total	2,098,483	7,264.0

<u>Condition I</u>	<u>Pieces</u>	<u>Tons</u>
6" E	98,326	261.9
10" E	224,235	1,018.1
8" N	<u>1,614,452</u>	<u>5,984.0</u>
Total	1,937,013	7,264.0
	(161,470)	

<u>Condition II</u>		
6" E	484,031	1,280.0
8" N	244,252	915.5
10" N	<u>1,102,478</u>	<u>5,063.5</u>
Total	1,830,763	7,264.0
	(267,720)	

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<u>Condition III</u>	<u>Pieces</u>	<u>Tons</u>
6" E	98,326	261.9
10" E	224,235	1,018.1
8" N	249,328	934.4
12" N	953,192	5,049.6
Total	1,525,081 (578,081)	7,264.0

Summary

The table below summarizes tentative findings based on a lengthy set of assumptions. Payout is expressed as a dollar comparison to present condition (FY 1964) noted in the requirements.

<u>Condition</u>	<u>I</u>	<u>II</u>	<u>III</u>
Component Parts	\$137,910	\$120,600	\$354,600
Labor	116,160	135,000	187,500
Annual Sub Total	\$254,070	\$255,600	\$542,100
Equipment			
Conversion Cost	\$459,500	\$521,000	\$638,000
*Payout Period (in years)	1.65	2.04	1.18

*This measure excludes National Lead Company equipment conversion costs and savings which will not be available for several weeks.

Conclusion

An adequate incentive exists to begin a serious process development and evaluation program for longer, heavier fuel elements. Assuming a successful development and radiation program, which may require a year, approximately 15 months would be required to complete a project for equipment to meet the conditions. Beneficial use could be expected in one year. PERT techniques as planned by Facilities Engineering would be used to compress time and minimize disturbance in the process during installation.

When National Lead Company analysis is complete, results should be included in this report. Lead time at their location may have an effect on scheduling here.

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ASSUMPTIONS

I. Yield and Canning Line Efficiency

	6 & 8"		10"		12"	
	<u>Yield(%)</u>	<u>Eff.(%)</u>	<u>Yield(%)</u>	<u>Eff(%)</u>	<u>Yield(%)</u>	<u>Eff.(%)</u>
Non-Projection	91	95	88	94	86	92
Projection	85	95	82	94	80	92
Self Support	83	95	80	94	78	92

A. Yield and Efficiency Basis

1. CY-1963 Production Section Goal yields are used as a comparison basis since at least 15 months will be required to obtain the first quantity output of longer fuel elements from the 313 Buildings.
2. No loss of bond quality for 10" and 12" pieces is assumed as a basic condition of the study. Since no longer pieces have been assembled, this assumption is open to speculation. However, there is evidence to suggest that 8" fuel element bonds are as good as or better than 6" fuel bonds in spite of furnace temperature gradients. A deterioration in bond quality would make the program to produce longer fuel elements highly questionable.
3. Yields for 10" and 12" fuel elements represent an estimate of stable conditions prevailing following shake down of equipment and process. The yields (as expressed) represent opinions within the Fuels Engineering and Quality Control subsections and present a challenge to good manufacturing performance on a well developed process. In general, marred surfaces, assembly rejects and thin wall rejects are expected to be somewhat higher, but confined in total within the limits shown.
4. A 45-second canning cycle is assumed for both 10 and 12 inch elements. Furnace heat calculations have been made for the 10 and 12 inch pieces. If additional heat is needed for satisfactory processing of the 12 inch fuel, higher rated coils can be obtained.

The heaviest weight of the 10 inch piece is 9.63 pounds and the 12 inch fuel element will not exceed 11.10 pounds. The heaviest 8" core is 7.75 pounds. The assumption is made that employees can physically handle and assemble the longer elements without undue exertion or safety problems. See appendix for actual lengths and weights. Time did not allow a nuclear safety review for 10 inch enriched fuel during this study. Certainly such a study should be one of the first tasks in any further analysis.

5. Production yield is calculated on a fuel element, not a weight, basis. Scrap returns to National Lead Company are reported in tons, and the length of the fuel core will not affect the total weight returned, barring some unforeseen fuel core quality problem.
6. A slightly lower canning line efficiency is shown for the longer, heavier elements. Even with well designed equipment the heavier element will present an equipment durability problem in the assembly process.

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7. Critical problems such as pulsing a longer spire and agitating the heavier mass of the longer fuel are presumed solvable with a process development program. The same assumption applied to warp, and other important characteristics of a longer core, such as grain size variation.
8. There has been no irradiation experience to date. Production of more than test quantities could not proceed without satisfactory irradiation results.
9. Alternate processes are being developed in the Production Fuels Section. These efforts should include serious consideration of fabricating longer fuel.

II. Component Prices

- A. The latest quotations of approximately ~~\$0.92~~^{.8} per set was used in computing 8-inch and 6-inch component costs.
- B. Manufacturing vendor liaison contacts have resulted in estimated 10% adder for 10-inch and 15% adder for 12-inch component sets. This reflects quantity orders after experience is gained following initial tooling and development expense.

III. Equipment

- A. The detailed equipment assumptions are included in the appendix together with an itemized list of equipment alteration and cost.
- B. In Condition I, the equivalent of only one canning line of 10-inch fuel elements is required. However, it is not practical to schedule with only one canning line operating due to finishing requirements and product mix. Consequently, a conversion of two lines is shown. It is possible that this equipment estimate could be reduced somewhat by a more detailed analysis.
- C. All equipment estimates include a 20% contingency in addition to general overhead and engineering allowances. This is believed adequate to take care of any detail which may have been missed.
- D. The possibility of producing required quantities, for Condition I, in the 306 Pilot Plant was considered undesirable due to interference with other process development activity.
- E. Additional models in the conditions presented will introduce scheduling complexity into the plant. Equipment which will handle 12" can be readily adopted to 10-inch and 8-inch although a detailed shift schedule was not produced due to the time available. Equipment and line capacities will handle up to 3 full canning lines per shift of 10- or 12-inch fuel elements operating at 100% capacity.

Jan. 28, 1963

F. W. Grubb
F. W. Grubb, Specialist
Facilities Planning

APPENDIX

TABLE I

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FY-1964

LONGER FUEL ELEMENTS STUDY

Quantity Basis

Condi- tion	Metal type	B		D		F		DR		H		C		KE		KW		Total	
		Pcs	Tons	Pcs	Tons	Pcs	Tons	Pcs	Tons	Pcs	Tons	Pcs	Tons	Pcs	Tons	Pcs	Tons	Pcs	Tons
Present	EN 6"	32,615	87	19,869	53	22,868	61	44,611	119	142,830	381	66,919	177	75,240	196	79,079	206	484,031	1,280.0
	N 8"	175,570	654	182,282	679	172,081	641	157,852	588	40,268	150	178,581	692	342,112	1247	365,706	1333	1,614,452	5,988.0
#1																		2,098,483	7,204.0
	EN 6"	16,870	45	7,497	20	11,321	30.2	10,404	28	32,615	87	19,539	51.7					98,326	261.9
	EN 10"	9,153	42	7,191	33	6,712	30.8	19,838	91	64,066	294	27,543	125.3	43,750	196	45,982	206	224,235	1,018.1
	N 8"	175,570	654	182,282	679	172,081	641	157,852	588	40,268	150	178,581	692	342,112	1247	365,706	1333	1,614,452	5,988.0
#2																		1,927,013	7,204.0
																		(161,470)	
	EN 6"	32,615	87	19,869	53	22,868	61	44,611	119	142,830	381	66,919	177	75,240	196	79,079	206	484,031	1,280.0
	N 8"	63,624	237	66,309	247	62,550	233	13,733	51.1			38,038	117.4					244,254	915.1
#3																		1,102,478	5,068.5
	N 10"	90,065	417	93,305	432	88,121	408	115,949	536.9	32,397	150	133,106	544.6	275,275	1247	294,260	1333	1,830,703	7,204.0
																		(267,720)	
	EN 6"	16,870	45	7,497	20	11,321	30.2	10,404	28	32,615	87	19,539	51.7					98,326	261.9
#3	EN 10"	9,153	42	7,191	33	6,712	30.8	19,838	91	64,066	294	27,543	125.3	43,750	196	45,982	206	224,235	1,018.1
	N 8"	63,624	237	66,309	247	62,550	233	13,733	51.1	5,074	18.9	38,038	147.4					249,328	921.1
	N 12"	78,163	417	80,975	432	76,476	408	100,627	536.9	24,574	131.1	98,126	544.6	238,888	1247	255,363	1333	953,192	5,068.5
																		1,525,081	7,204.0
#3																		(573,462)	

I. REQUIREMENTS:

Table I (above)

All K requirements are considered to be projection.

II. PHYSICAL PROPERTIES:

TABLE II (next page)

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TABLE II

PHYSICAL PROPERTIES BASIS - FUEL ELEMENTS

<u>METAL</u>	<u>NOMINAL LENGTH</u>	<u>TYPE</u>	<u>ACTUAL LENGTH*</u>	<u>WEIGHT</u>	<u>Pcs/Atom</u>	
Enriched	6"	O III E	6.053"	5.36#	373	
		C III E	6.053"	5.29#	378	
		K IV E	6.053"	5.21#	384	
		K V E	6.000	5.87#		
	10"	O	10.413"	9.18#	218	
		C	10.413"	9.10#	220	
		K	10.413"	8.96# 10.19#		
	Natural	8"	O III N	8.378"	7.45#	262
			C V N	8.378"	7.75#	258
K IV N			8.378"	7.29#	274	
K V N			8.325	7.85#		
10"		O	10.413"	9.26#	200	
		C	10.413"	9.65#	207	
		KVN	10.413"	9.06#	221	
		KVN	10.413	9.82#		
12"		O	12.00	10.67#	187	
		C	12.00	11.10#	182	
	KIVN	12.00	10.44#	192		
	KVN	12.00	11.32#			

* Uranium only

III. SAMPLE CALCULATION - (Present Conditions for Enriched)

Yield and Efficiency Assumptions, see page 3.

Present condition - 6" enriched requirement - 484,031 pieces.

A. Canning Lines Required:

$$\frac{484,031 \text{ acceptable pieces}}{1,088 \times 85\% \text{ yield} \times 95\% \text{ eff.} \times 252 \text{ days/year}} = 2.19 \text{ canning lines/year on one shift}$$

B. Component Costs

$$\frac{484,031}{.85} = 569,440 \text{ component sets at } \$0.92 \text{ each} = \$523,885$$

C. Labor Costs

Labor costs are based on total canning lines required. Personnel requirements were based on HW-73414, "Direct and Indirect Labor Requirements for Various Methods of ALSi Shop Operation". Employee expense is calculated the average salary of those added plus 10% continuity of service, or \$28 per day total.

All overtime was based on 5-line shifts of 93 employees at an expense of \$3,989/shift.

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- D. In Condition I, 8.62 canning lines are required. Since 0.62 canning lines per year require 33 overtime shifts (five lines), it is cheaper to man 9 lines. On 9 full canning lines, 90,000 too many pieces would be produced. The difference between 8 and 9 lines is 12 employees who could devote 38% of their time to other work such as "N" metal. This is equivalent to \$32,000. Another approach would be to run 9 lines part of the year and 8 lines part of the year. Total labor savings is approximately the same in either case.

IV. LABOR AND MATERIALS

TABLE III

	Reactor Requirements			Canning Lines Req'd	Personnel Incremental	Labor costs Incremental (\$)	Components required	Component costs (\$)	Component costs to present condition	Total Increment. Labor & Material to Present Case
	Old Reactors		'K' Reactor							
	Regular	Project.	Self-Suppt.							
Present Condition										
6" E		484,031		2.19	199 (5-4)		569,440		\$	\$
8" N	906,634		707,818	7.10	--		996,310			
Total				9.29		63,000 (OT)	2,418,540	2,225,000	--	+ 63,000
Condition I					(5-4) (3) at Proj. weld					
6" E		98,326		0.44		(21,170)	115,677	106,422		
10" E		134,503	89,732	1.08		(32,000)	164,028	165,996		
8" N	906,643		707,809	7.10			112,165	113,510		
Total				8.62	(3)	(53,170)	996,310	916,605		
Condition II					(5-4)		852,780	784,557		
6" E		484,031		2.19	(3) Proj. weld	(21,168)	115,677	106,422		
8" N	244,254			1.03		(50,820) available labor	164,028	165,996		
10" N	531,943		570,535	5.16			112,165	113,510		
Total				8.38	(3)	(71,988)	273,986	252,061		
Condition III					5-2 from 5-A4 is (22) (3) Proj. weld		533,650	564,602		
6" E		98,326		0.44		155,200	115,677	106,422		
10" E		134,503	89,732	1.08		(41,884) OT	164,028	165,996		
8" N	249,328			1.05			112,165	113,510		
10" N	458,941		494,251	4.63			273,986	252,061		
				7.20	(25)	124,514	631,070	667,693		
							1,830,596	1,870,284	354,644	(542,158)