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Marshall Laboratory
July 2, 1951

MEMORANDUM REPORT NO. M-363

POLYMER K BASE - MANUFACTURING COSTS

Re: D. N. Staicopoulos' letter 5/24/51 to G. E. Lewis

We have made a high spot estimate of the cost of manufacturing at Philadelphia a Polymer K suspension of the following composition:

Polymer K	100,000	lbs./yr.
Toluene	400,000	"
H-555	48,750	"
Total	548,750	"

Cost estimates have been made for three production scales ranging from 100,000-300,000 lbs./yr. Polymer K content. Mill cost plus 25% net return (50% Federal tax and 7.9% A.O.E.) varies from $3.05 to $2.40/lb. Polymer K at 100,000 and 300,000 lbs./yr. (total Polymer K) production scales respectively. A summary of the results of the estimate is given on the following page:

TABLE I

POLYMER K AT PHILADELPHIA

SUMMARY OF COST CALCULATIONS

BASIS: 5-DAY WEEK - 1-SHIFT DAY

Production lbs./yr. Polymer K Content	Scale gal./yr. ≠	Investment		Mill Cost ≠ 25% Net Return, ¢/lb. Polymer K	
		New Plant	Total Incl. New Plant & Working Capital	*	**
100,000 (549,000 lb. product)	64,000	$112,000 = $1.12/annual lb.	$206,000	¢3.05	¢3.51
200,000 (1,098,000 lb. product)	128,000	$170,000 = .85/annual lb.	325,000	2.59	2.95
300,000 (1,647,000 lb. product)	256,000	$216,000 = .72/annual lb.	426,000	2.40	2.72

≠ approximate

* 25% net return: 54.3% gross return incl. 50% Federal tax and 7.9% A.O.E.

** 25% net return: 76.6% gross return incl. 64.6% Federal tax and 7.9% A.O.E.

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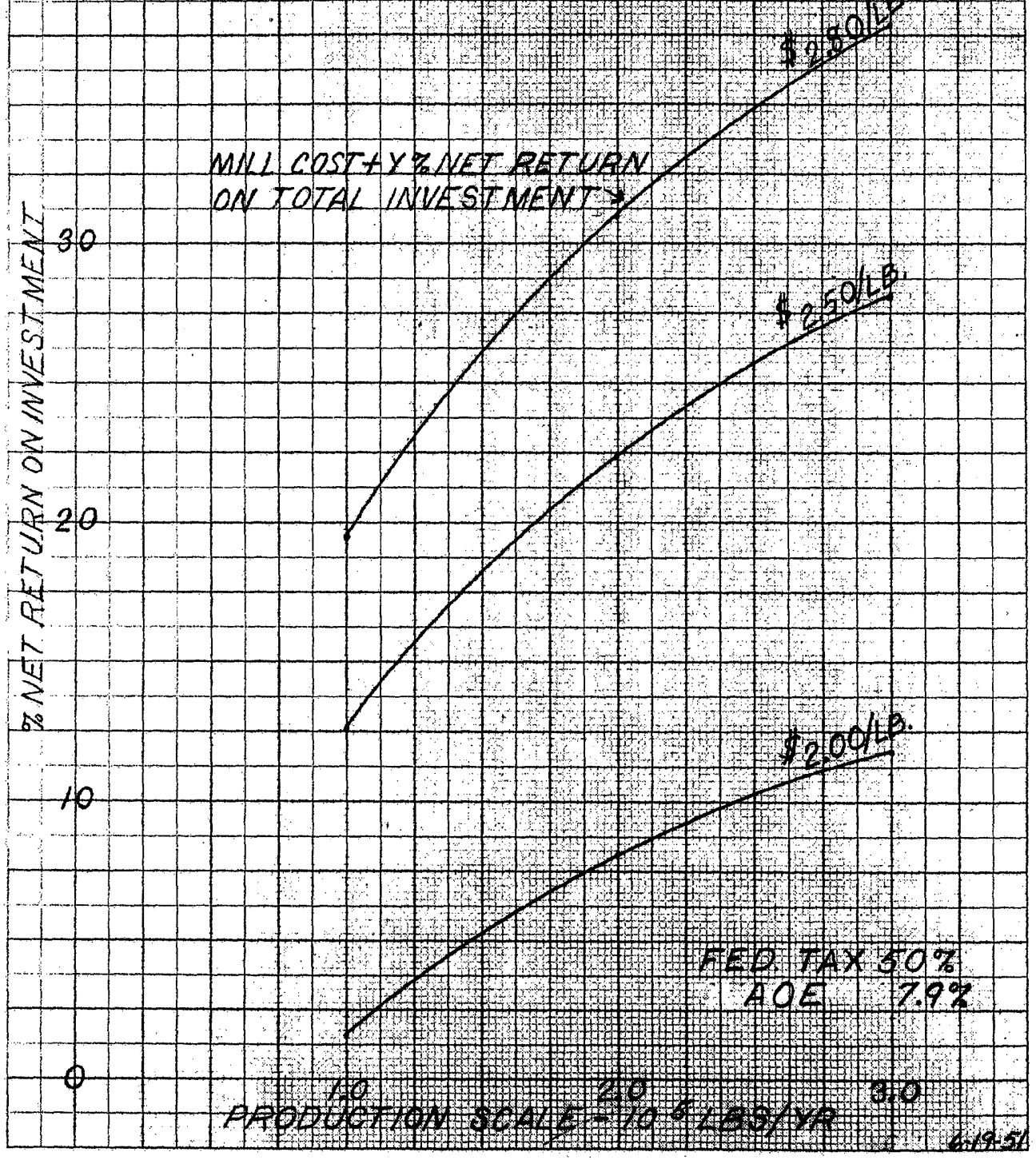

The attached graph shows the manner in which return on investment varies with production level at certain assumed values of mill cost plus Y% return per pound Polymer K content. The steep slope of the curves demonstrates the natural disadvantages accruing from low capacity outputs.

In the appendix are given:

Process Flow Diagram - assumed process

Table II Unit Cost Analysis

Table III Equipment List and Total Direct Plant Investment

Table IV Capital Cost Summary

We recommend:

1. Process development aimed at flushing Polymer K into a single solvent and avoiding the use of two solvents such as both toluene and butanol.

2. Determination of maximum permissible sodium chloride residue in Polymer K, which should dictate the necessary scope of experimental work on leaching out the chloride with water. Thus, it may prove possible to eliminate the W & P mixer here assumed necessary for leaching.

3. Investigation to determine if nickel sulfate may be substituted for nickelous chloride. If satisfactory, this would reduce nickel salt cost per pound of Polymer K about 15%.

The equipment in this estimate was designed for one-shift operation because of the low production scale assumed. Smaller equipment required for the same production in three shifts would not represent substantially smaller investment because we would have arrived at the point of rapidly increasing unit investments due to small equipment size. For this reason, one-shift operation was chosen, but operating the equipment of this estimate on a three-shift basis would triple productive capacity. Such operation would change production of the smallest plant from 100,000 lbs./yr. Polymer K to 300,000 lbs./yr. The mill cost plus 25% net return on investment would become $2.14/lb. instead of $3.08/lb.

Not included in this estimate is the appreciable sum of money that may prove necessary for research and process development.

MARSHALL LABORATORY

George B Crane

GEORGE B. CRANE

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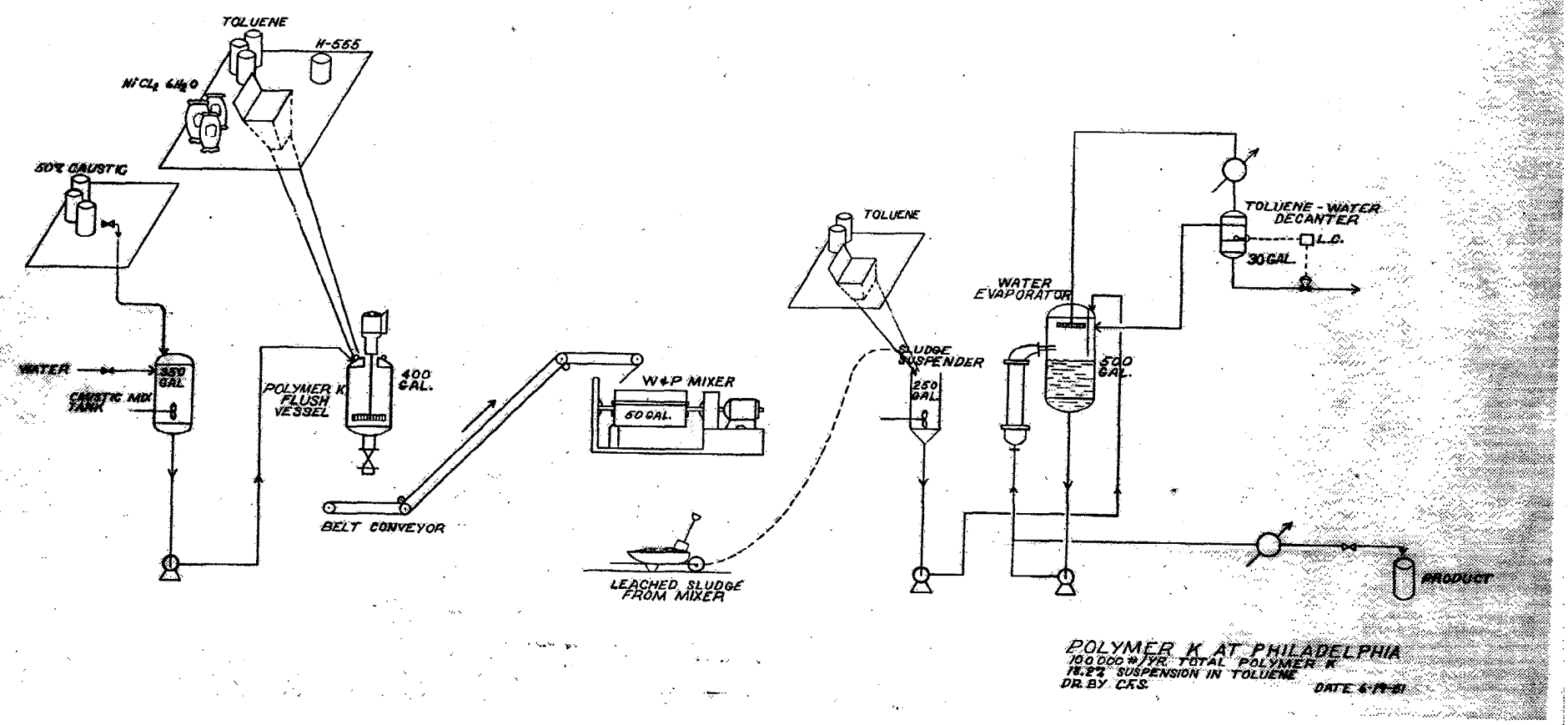

A P P E N D I X

A unit cost breakdown is given in Table II for the three production levels considered in this estimate. Return on investment is given for the "arbitrary" tax rate set by the treasurer and for the Company's "forecast effective overall" tax rate.

Table III gives an equipment cost summary and derivation of direct plant investment (new money) for a plant (design basis) of 100,000 lbs./yr. Polymer K (dry basis) capacity.

Table IV is a capital cost summary showing allocation of investments and derivation of working capital for the 100,000 lbs./yr. Polymer K plant.

PROCESS DESCRIPTION

The assumed process is based on the writer's observation of some laboratory preparations with material balance indicated by D. N. Staicopoulos. Refer to the process flow diagram.

1. A suitable amount of nickelous chloride solution is made up in the Monel flush vessel which is provided with a removable two-speed turbine-type agitator. Caustic solution is added, leaving a slight excess of nickelous chloride. The mixture is agitated at the low speed.

Some H-555 is added with high speed agitation, and the mix thickens somewhat. The function of the H-555 is to place organophilic groups around the Polymer K to enable the latter to be flushed into toluene.

Toluene is added and the high-speed agitator employed to flush the Polymer K into the toluene. For this, considerable shearing action seems necessary, which this type agitation usually provides. The Polymer K and toluene will form a pasty mass which is very hydrophobic. Should distribution to the agitator prove difficult, high and low speed stirring may be alternated, and the agitator may be moved up and down.

The separated water is drained out thru a large valve in the bottom of the flush vessel. The vessel cover is removable and the Polymer K-toluene mass is manually poked out thru the bottom onto a traveling belt.

2. A suitable traveling belt (which may be covered) conveys the Polymer K paste a short distance to a W & P type sigma mixer.

3. The function of the mixer is to knead the Polymer K-toluene paste with water to leach out sodium chloride. Water is decanted by tilting the mixer. The process is short and may be repeated as many times as required for adequate salt removal.

4. The Polymer K-toluene paste is manually removed from the mixer and put into the sludge suspender where it is mixed up with toluene to form a suspension containing a little water.

Though not assumed in this estimate, it may prove desirable to add some butanol as a deflocculating agent. This would increase the fluidity by breaking up the gel structure while maintaining the desired degree of suspension. However, as pointed out in the recommendations, it will be desirable from a process (and cost) standpoint to avoid use of this solvent if possible.

5. The water is removed by distilling overhead with toluene where it separates as a layer. Forced circulation is employed in the calandria and drying of Polymer K and/or fouling of the calandria tubes is minimized by maintaining a back pressure in the tubes so that flashing occurs only in the free vessel space and not in the tubes. This back pressure is a matter of design and can be obtained by a suitable nozzle restriction on the calandria outlet as shown. The evaporator contents are boiled down to the toluene concentration desired in the product, when it only remains to pump the product out thru a suitable cooler into drums for storage.

ASSUMPTION AND COST BASES

1. An adjusted Construction Cost Index of 600 was assumed.

2. The following material prices were used:

$NiCl_2 \cdot 6H_2O$	$0.35/lb.
Toluene	0.0497/lb.
H-555	0.4973/lb.
50% Caustic	2.75/100 lbs.

3. A five-day week, one-shift day was assumed, with the following labor rates:

Operator	$2.00/hr.
Helper	1.67
Laborer	1.54

4. Polymer K was assumed to be $Ni(OH)_2 \cdot 1/4H_2O$. The following losses were assumed:

$NiCl_2 \cdot 6H_2O$	0.5%
Toluene	5.0

Material balance was according to reference letter with 110 c.c. of H-555 substituted for 65 c.c.

5. There is an existing W & P type mixer, 50-gallon capacity in the "Dulux" Dept., bldg. 176. It is idle most of the time. We have assumed reinstallation and use of this mixer in another location.

6. Use of existing building and storage space has been assumed. Building #73 investment has been prorated by floor area to arrive at approximate building investment allocation.

7. We have assumed that the product will be used as a raw material within the Finishes Division, and none sold outside.

8. Semi-detailed design was made for capacity of 100,000 lbs./yr. Polymer K. Investments at other capacities were arrived at by factoring.

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TABLE II

UNIT COST ANALYSIS

POLYMER K AT PHILADELPHIA

18.2% SUSPENSION IN TOLUENE AND H-555

BASIS: ¢/LB. POLYMER K

Production level - lbs. Polymer K/yr.			100,000	200,000	300,000
$NiCl_2.6H_2O$	2.41 lbs./lb.	at 35.00¢/lb.	84.4¢/lb.	84.4¢/lb.	84.4¢/lb.
Toluene	4.18	" " 4.97¢/lb.	20.8	20.8	20.8
H-555	.487	" " 49.73¢/lb.	24.2	24.2	24.2
50% caustic	1.60	" " 2.75¢/lb.	4.4	4.4	4.4
Total Materials			133.8	133.8	133.8
Utilities			0.6	0.45	0.37
Labor			9.24	4.75	3.16
Salaries			3.4	1.75	1.17
Maintenance					
materials			4.1	3.1	2.64
labor			4.3	3.25	2.76
Overhead			3.4	2.0	2.36
Taxes - Insurance			10.3	7.8	6.6
Depreciation			8.6	6.5	5.5
Process control			15.0	7.5	5.0
Mill Cost			192.74	171	163.5
25% net return on total plant investment			92.8	70.2	59.7
" " " " working capital			19.2	17.8	17.3
Mill cost plus 25% net return *			305 ¢/lb.	259 ¢/lb.	240 ¢/lb.
25% net return on total plant investment			130.8	99.0	84.4
" " " " working capital			27.2	25.2	24.4
Mill cost plus 25% net return **			351 ¢/lb.	295 ¢/lb.	272 ¢/lb.

* 25% net return: 54.3% gross return incl. 50% Fed. tax and 7.9% A.O.E.

** " " " 76.6%. " " " 64.6% " " " " "

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TABLE III

EQUIPMENT LIST AND TOTAL DIRECT PLANT INVESTMENT

CONSTRUCTION COST INDEX = 600
POLYMER K AT PHILADELPHIA

100,000 LBS. POLYMER K/YR. AS 18.2% SUSPENSION IN H-47 & H-555

	Installed Cost +
Caustic mix tank, 350 gal. stl. stress relieved,	$ 900
Side entering agitator	800
Pumpout pump	1,200
Polymer K flushing vessel 400 gal. monel,	
7-1/2 HP two-speed turbine agitator	4,000
Freight	150
Installation	500
Belt conveyor 20' long with side leaves 24" wide	2,000
Reinstallation of existing 50-gal. W & P type mixer *	2,500
Mix tank Polymer K-toluene 250 gals. S/S clad	1,400
pumpout pump S/S	1,800
side entering agitator, S/S propeller	1,000
Water evaporator 500 gal. S/S clad	8,700
entrainment separator, baffle & nozzles	1,300
reboiler S/S tubes 40 sq. ft.	3,100
circulation pump S/S	1,600
overhead condenser, 51 sq. ft. Brown fintube	500
toluene-water decanter 30 gal., S/S	800
Product bottoms cooler 51 sq. ft. Brown fintube S/S	600
Drum stacker (storage)	5,000
Total apparatus & equipment	$37,850
Instrumentation 8% A & E	3,000
Piping 40% "	15,000
Outside lines 5% "	1,900
Elec. installations 8% "	3,000
Sub-total plant	$60,750

Field distributives	25% STP	$15,150
Engineering	20% "	12,100
Undeveloped design	40% "	24,000
Total Direct Plant Investment		$112,000

+ unless otherwise noted

* mixer itself under existing equipt. (q.v.)

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TABLE IV

CAPITAL COST SUMMARY

POLYMER K AT PHILADELPHIA

100,000 LBS./YR. AS POLYMER K

I.	Plant investment	
	Direct Plant	$112,000
	Existing facilities used directly	19,384
	Allocated facilities-process building	15,400
	" storage "	1,000
	" " tankage	1,500
	" electrical	600
	" service	21,000
	Permanent investment	$171,000
II.	Working capital	
	Raw materials 1.1 mo.	12,300
	Cash 1.5 mo. (mill cost - deprec.)	23,000
	Total working capital	$35,300
	Total Investment	$206,300

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