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UNH TRANSFER STUDY

by

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Industrial Engineering Operation
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UNH TRANSFER STUDY**DECLASSIFIED**INTRODUCTION

The transfer of uranyl nitrate hexahydrate solution from the Purex Plant in 200-East Area to the UO₃ Plant in 200-West Area is presently being accomplished with the use of two specially built trailer trucks. This system has been used since the startup of the Purex Plant. Because the production rate of Purex has increased significantly since then, it seems appropriate to ask: "Is trucking the optimum method under the present and predicted rates of production?"

At the request of Purex Operation, a study has been made of the UNH hauling system, and of some possible alternatives. The purpose of this study was to compare the various advantages and disadvantages of the present and alternate systems, to make recommendations, and to provide a basis for possible management action.

SUMMARY

The present system, as it has been operated historically, would be able to handle the output if Purex is operated up to 4.0 capacity factor. Full two-shift, five-day week operation would be required. The out-of-pocket cost of operating the present system for 1962 is estimated to be \$40,800. Estimated cost for FY 1968 is \$54,000. (Reference: Pages 4 through 7, page 27.)

Minor modifications would increase the capacity of the present system and permit more economical operation. Using the same basic equipment and the same crew size as is presently used, the 4.0 capacity factor rate could be achieved by operating five day-shifts and two swing-shifts per week. As an alternate, the addition of another driver to the crew would allow the same rate to be achieved by operating five day-shifts per week, with one swing-shift every two weeks. The potential savings for either proposed method over the present system is \$12,000/year, and the cost of modification would be approximately \$3,000. The chief differences between the proposed methods and present operation are that the truck driver would use Purex as his base of operation, the Purex loadout rate would be increased to 100 gallons per minute, and the reliability of the probe-operated shut-off system would be improved. (Reference: Pages 8 through 15, page 27.)

The addition of a third truck to the present system will lower operating costs by achieving a better utilization of manpower. The estimated investment of \$45,000 would pay off in about three years. The annual reduction in operating cost over the present system as operated is approximately \$20,000. The savings accumulated as a result of buying a third truck would not equal the savings resulting from modification of the present system, as previously discussed, until FY 1973. (Reference: Pages 15 through 18; 27 and 29.)

The hauling of UNH in railroad tank cars has two distinct advantages over all trucking systems: An existing service facility is used, and danger

of spillage on the project roads is eliminated. The investment of \$65,000 would pay off in approximately three years, with an annual reduction of operating costs of \$27,000. (Reference: Pages 18 through 20, pages 27 and 28,)

The pumping of UNH from Purex Plant directly to the UO₃ Plant has the advantage of safety to even a greater degree than the railroad. Operation of such a system one shift per day, five days per week can adequately handle an output at 4.0 capacity factor. A two-line system, one for pumping UNH to UO₃ Plant, and the other for returning recovered nitric acid from the UO₃ Plant to Purex provides even greater safety, flexibility, and economy. The combined system, with an estimated project cost of \$167,000, offers an average annual cost reduction over the present system of approximately \$52,000 per year, and a pay-off period of about four years. The potential long term savings are \$425,000 by the end of FY 1975. (Reference: Pages 21 through 24, pages 27, 28, and 29.)

It is recommended that the changes in the present system, as detailed in Section 2, be implemented immediately as a short range improvement.

If future production rates according to the forecast can be reasonably assumed through FY 1969, and two of the existing unused east-west cross-country lines can be released for use with UNH and acid, it is recommended that the scoping for the UNH-acid pipelines be completed and that project action be considered.

If the pipelines cannot be built due to funding difficulties or other management decisions, the scoping for hauling by rail is recommended, since the system is attractive from both safety and economic standpoints.

DISCUSSION

1. Analysis of Present System as Historically Operated

1A. Capacity

Records* covering the period March 30, 1962 to February 1, 1963 furnished information on which the following table is based:

	Day Shift			Swing Shift		
	From Purex to:			From Purex to:		
	UO ₃	Redox	Total	UO ₃	Redox	Total
Total No. Loads Hauled	740	80	820	112	8	120
No. of Shifts**	171	20	186	28	3	31
Av. No. Loads Hauled/Shift	4.33	4.00	4.41	4.00	2.66	3.88

* UNH Driver's Log, Monitoring and Fission Products Log (Purex Operation), and official accountability records.

** The number of shifts when any hauling was done to indicated destination.

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Frequency Distribution of No. of Loads Hauled/Shift

Maximum number of loads hauled/shift using two trucks = 7
 Maximum number of loads hauled/shift using one truck = 3
 Number of days of truck maintenance over period of study (one truck out of service) = 15.75
 Average capacity factor of Purex over period of study = 2.1

Maximum Continuous Rate of System:

Day Shift

$$5 \text{ days/wk} \times 4.41 \text{ loads/day av.} \times 2860 \text{ gal/load av.} \times \frac{4\#U}{\text{gal}} \times \frac{1 \text{ ton}}{2000\#} = 126 \text{ tons/wk}$$

$$\frac{126 \text{ tons/wk}}{7 \text{ days/wk}} \times \frac{1 \text{ CF}^*}{8.33} = 2.16 \text{ CF}$$

Swing Shift

$$5 \text{ days/wk} \times 3.88 \text{ loads/day av.} \times 2860 \text{ gal/load av.} \times \frac{4\#U}{\text{gal}} \times \frac{1 \text{ ton}}{2000\#} = 110.9 \text{ tons/wk}$$

$$\frac{110.9 \text{ tons/wk}}{7 \text{ days/wk}} \times \frac{1}{8.33} = 1.90 \text{ CF}$$

$$1.90 \text{ CF} + 2.16 \text{ CF} = 4.06 \text{ CF}$$

The data and calculations above indicate that the present system, based on actual performance over a 10-month period, could sustain a Purex capacity factor of 4.0. The average loads per day for day

* A capacity factor of 1 indicates a process rate of 8.33 tons U/day.

shift and swing shift are realistic in that they reflect the capacity that has actually been achieved, with all delays such as truck maintenance, overfills, and road delays combined.

1B. Operating Cost

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The present and alternate systems are costed on the basis of Chemical Processing Department "out-of-pocket dollars". "Out-of-pocket dollars" in this report is defined as cost incurred by components of the Chemical Processing Department directly as a result of operation of the UNH transfer system, and includes such items as direct operating labor, maintenance labor and material, and equipment rental. Supervisory and administrative overhead are not included. This definition was chosen because these dollars are the dollars that could be saved by change in equipment, method, or operation, and could be used for a project pay-off.

In order to estimate the labor used for loadout at Purex, the three tasks that the two operators handle were analysed by observation and determination of work content under present rates of production. The unloading of the recovered acid averages about 133 man-minutes/day, the UNH loadout averages 208 man-minutes/day, and silica gel regeneration averages 45 man-minutes/day. The nonproductive time was allocated by proportion among the three tasks, and the following results were obtained:

Acid Unloading	-	34.5% of the day
UNH Loading	-	54.0% of the day
Silica Gel	-	11.5% of the day

From this data, it was assumed that one of the two men's time could properly be charged to UNH. The cost/year for such a man is \$8,520,* based on wages, isolation, employee benefits, bus expense, and laundry expense.

For second-shift loadout on overtime, the cost was found to be \$51.55/second shift worked.

Under normal operation, one trailer is filled on graveyard shift by two shift operators. The cost/filling on this shift was found to be \$18.10.

The basic costs for the truck driver, the one operator required at UO_3 , and the operator used occasionally at Redox are the same.

Each truck and trailer combination are rented at a flat rate of \$2,400/year. This figure includes operating and maintenance expenses.

* Basic cost information was supplied by financial specialists.

* The cost at the zero capacity factor rate is used in this study as a basis for plotting Graph I, page 26. The use of Graph I is explained in Section 6.

2. Analysis of Potential Modifications of Present System

2A. Determination of the Elemental Times for the Transfer Operation

The following table was constructed from information gained from monitoring the present operation for a day:

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Truck No.	Movement	Time	Purex Loading Time (min)	Trip Time (min)		Truck No. 2		UO ₃ Turnaround Time (min)
				Truck No. 1		Loaded	Unloaded	
2	Lv. Purex	8:25 a.m.				15		
	Arv. UO ₃	8:40						6
1	Lv. UO ₃	8:46		14				
	Arv. Purex	9:00	39					
1	Lv. Purex	9:39				16		7
	Arv. UO ₃	9:55						
2	Lv. UO ₃	10:02					14	
	Arv. Purex	10:16	39					
2	Lv. Purex	10:55				17		
	Arv. UO ₃	11:12						5
1	Lv. UO ₃	11:17		19				
	Arv. Purex	11:36						
	Lunch		1 hr. 3 min.*					
1	Lv. Purex	12:39 p.m.				15		
	Arv. UO ₃	12:54						5
2	Lv. UO ₃	12:59					13	
	Arv. Purex	1:12	35					
2	Lv. Purex	1:47				13		
	Arv. UO ₃	2:00						5
1	Lv. UO ₃	2:05		14				
	Arv. Purex	2:19	34					
1	Lv. Purex	2:53				16		
	Arv. UO ₃	3:09						7
2	Lv. UO ₃	3:16					16	
	Arv. Purex	3:32						
Summary			147	47	47	45	43	35
Average			36.8	15.6	15.6	15.0	14.3	5.8
Range			5	1	5	4	3	2

* Loading time and driver's lunch time.

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Purex Loading Time:

The two loadings that took place in the morning each took 39 minutes. Due to inaccurate results from the flow meter at 100 gallons per minute, the flow rate has been cut to approximately 85 gallons per minute. At this rate, the pumping time is about 34 minutes, which leaves about five minutes total for connecting and disconnecting. On the last load, the full cycle of connect, pump, and disconnect was 34 minutes. For this loading, the weekly probe test was made. Since the flow meter was not used for cutoff, the full 100 gallons per minute flow rate was used. The 34 minute value will be used, since it is assumed that the flow meter will be repaired to record correctly at 100 gpm.

Trip Times:

The trip times seemed natural, so the average of 15.1 minutes will be used.

UO₃ Turnaround Time:

It is felt that the 5.8 minute average could be cut to about four minutes if the gate could be unlocked when the driver is ready to pull out. A mirror system and a remote controlled gate might be feasible, since a guard must now make a special trip to open the gate. Possibly, the U Plant guard could close his gates, lock the guard house, walk down and let the truck out. Also, the truck might be able to swing around UO₃ Plant if a steam line were raised and a road were laid. The empty truck might also be backed through the presently manned gate. It is judged that while some reduction in turnaround time might be accomplished, the gains would not justify the expense or inconvenience. For this reason, the turnaround time of 5.8 minutes will be accepted.

Lunch Time:

The one hour and three minutes time between arrival of the truck at Purex and the leaving of the next loaded truck seems fairly representative historically. Approximately 20 to 25 minutes of this is used in obtaining and using transportation to and from the 2101-M Building where the driver eats his lunch. He must call and get a ride, wash up, eat, and get a ride back to Purex. If the driver ate at the Purex lunchroom he could be off the job for only about 40 minutes (30 minutes eating, 10 minutes travel and wash up).

Starting and Quitting Time:

Historically, the driver has seldom left Purex with the first load at or before 8:15 a.m. and has seldom returned to Purex with the last empty at or after 3:30 p.m. The approximate average time for leaving Purex is 8:25 a.m. and the last empty is returned, on the average, at approximately 3:06 p.m. To

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determine quantitatively just how the extra time in the morning and evening is spent is difficult, but certain segments of the time can be isolated. On the day that the operation was monitored, the driver checked in at the 2101-M Building with the foreman. He then changed, obtained a ride to Purex, boarded the truck, allowed the engine to warm for a minute or so, and pulled out. The time was 8:25 a.m. At 3:32 p.m., after the last empty was returned in the afternoon, the driver called to have somebody pick him up, returned to 2101-M, changed, and washed up. By this time it was after 4:00. At no time during the day did the driver seem to have excess time. Effectively, his day on the truck starts at about 8:25 and can end as late as 3:30 but not much later.

If the driver reported to Purex in the morning, he could pull out with the first load at about 8:00 a.m. If he returned at 3:50, he would have ample time to change and wash up at Purex before boarding the bus to the gate. This arrangement would make the driver available for about 45 minutes more than he is now and make the hauling of one more load per day a possibility.

2B. Capacity, Using One Driver

Purex Load Time = 34 min. Trip Time = 15.1 min.
UO₃ Turnaround Time = 5.8 min.
Driver's lunch allowance: 40 min. (he eats while the truck is
being loaded)
Operators' lunch allowance: 45 min. (they eat immediately
after loading)

The table on the next page shows that seven loads on a shift would be possible, if the following assumptions are made:

- (1) The driver reports to, eats lunch at, and leaves from Purex.
- (2) There is no equipment trouble.
- (3) Road delays are negligible.
- (4) Neither truck requires routine servicing.
- (5) Trailer is loaded on graveyard shift.
- (6) Accidental overfilling, with the resulting spillage and cleanup, does not occur.
- (7) All personnel are available for the assigned work for the whole day.

For any given day, seven loads per day can be achieved, if all assumptions hold. Assumptions (1) and (5) are a matter of management policy. Assumption (6) depends on the frequency occurrence of overfilling at Purex. At the present time, there are two automatic shutoff systems that can prevent overfilling.

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Time of Activity Completion	(Min.) Activity Time	Activity
8:00	--	Driver ready at Purex
8:15	15.1	Drive load to UO3
8:21	5.8	Turnaround
8:36	15.1	Drive empty to Purex
9:10	34.0	Load trailer
9:25	15.1	Drive load to UO3
9:31	5.8	Turnaround
9:46	15.1	Drive empty to Purex
10:20	34.0	Load trailer
10:35	15.1	Drive load to UO3
10:41	5.8	Turnaround
10:56	15.1	Drive empty to Purex
11:30	34.0	Load trailer
11:45	15.1	Drive load to UO3
11:50	5.8	Turnaround
12:06	15.1	Drive empty to Purex
12:15	9.0	None (Wait for Purex operators to finish eating.)
12:49	34.0	Load trailer
1:04	15.1	Drive load to UO3
1:10	5.8	Turnaround
1:25	15.1	Drive empty to Purex
1:59	34.0	Load trailer
2:14	15.1	Drive load to UO3
2:20	5.8	Turnaround
2:35	15.1	Drive empty to Purex
3:09	34.0	Load trailer
3:24	15.1	Drive load to UO3
3:30	5.8	Turnaround
3:45	15.1	Drive empty to Purex

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In the first, a magnetic flow meter and integrator determine the cumulative flow. When the quantity reaches a predetermined amount, the flow is shut off. In the second, a set of probes is mounted in the top of the tank. When the liquid level in the tank reaches the probes, the electrical resistance between the probes drops. The resistance change is sensed by a device, which in turn shuts off the flow. In spite of the two systems, overflows have occurred approximately once per month, historically. An overflow not only slows the hauling, but results in the loss of some valuable UNH solution. Because of the low level radioactivity of the solution, decontamination of the trailer and loadout pad are sometimes necessary.

Spills occur because neither shutoff system is foolproof. The flow measuring system uses the quantity of solution pumped as the criterion for shutoff. If an unusually large heel is in the tank at the start of filling, the tank can overflow before the flow measuring system has reached the shutoff point. The probe system strikes directly at the heart of the problem (liquid level), but is somewhat unreliable at the present time. The sensing leads are plugged into a receptacle that is located inside the inlet dome on the tank. The receptacle appears to be badly corroded and good contact reliability between the plug and the receptacle is questionable. A solution to the problem would be to mount a weatherproof receptacle outside the dome, away from acid fumes. In addition, a shorting button could be incorporated into the receptacle. After the operator makes the inlet hose connection and plugs in the sensing lead, he could check the circuit by pressing the button. A signal horn connected to the circuit would then indicate the integrity of the connection. The installation of such a check would virtually eliminate all overflows and spills.

Assumption (7) alludes to the fact that the UNH transfer system requires the presence of three groups of people to function. The Purex operators, the driver, and UO_3 operator must be available when their specific function is to be performed, if maximum efficiency and minimum cost of the system is to be achieved. In addition, the scheduling of the hauling days can affect efficiency. If four loads of UNH are hauled to UO_3 plant, and then the transfer system is shut down because either UO_3 is full or Purex is empty, the day's production loss of two loads is due to scheduling, not to any failing in the transfer system. It should be remembered that hauling a load on swing shift costs very nearly one and three-quarters times as much as hauling that same load on days.

Truck maintenance has the effect of decreasing the ideal transfer rate approximately 5.8%* and will be taken into account in the calculation below. Road delays (Assumption 3), such as burials, occur occasionally, and the trucks require fuel and oil every other day (Assumption 4).

* Based on historical data.

It will, therefore, be assumed that seven loads per day can be obtained two days out of five, and six loads per day can be obtained the other three.

Calculation for average loads per day, including allowance for truck maintenance:

Average loads/day	= 6.40
Less 5.8% of 6.4	= <u>.37</u>

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Corrected Average loads/day = 6.03 $\approx$ 6.0

The system will deliver 6.0 loads per shift on the average. Since 8.15 loads/day must be delivered for 4.0 CF operation, a swing shift will have to be run part of the time. If the system is operated for one five-day week on day shift, $(8.15 - 6.0)(5) = 10.75$ loads will have to be hauled on swing shift. Two swing shifts per week will take care of this. Therefore, 4.0 operation can be sustained with normal day shift operation five days/week plus operating two swing shifts/week.

2C. Capacity, Using Two Drivers

The present system could be modified by adding one more driver. In this mode of operation, the same equipment would be used, with a driver assigned to each truck. From the following table it can be seen that eight loads per day can be achieved with forty minutes to spare for truck fueling and some road delay.

<u>Time of</u> <u>Activity Completion</u>	<u>Activity Time (min)</u>	<u>Activity</u>
8:00 a.m.	--	One driver ready at Purex, the other ready at UO ₃
8:15	15.1*	Drive load to UO ₃ , drive empty to Purex
8:55	40.0	Load, empty
9:10	15.1	Drive load to UO ₃ , drive empty to Purex
9:50	40.0	Load, empty
10:05	15.1	Drive load to UO ₃ , drive empty to Purex
10:45	40.0	Load, empty
11:00	15.1	Drive load to UO ₃ , drive empty to Purex
11:40	40.0	Load, empty
11:56	15.1	Drive load to UO ₃ , drive empty to Purex
12:36 p.m.	40.0	Load, empty. Drivers eat.
1:21	45.0	Drive load to UO ₃ , drive empty to Purex. Operators eat.
2:01	40.0	Load, empty
2:16	15.1	Drive load to UO ₃ , drive empty to Purex
2:56	40.0	Load, empty
3:11	15.1	Drive load to UO ₃ , drive empty to Purex
3:51	40.0	Load, empty. (Can be done on swing shift or graveyard shift, if necessary.)

* The digit to the right of the decimal point denotes the number of tenths of minutes.

The nature of the system gives more than adequate rest and delay allowance for the operating personnel. The same time measures were used that were used for the one-driver operation, with one exception. An allowance of 40 minutes is made for unloading at UO_3 because the pumping rate at UO_3 is approximately eighty-five gallons per minute. The same assumptions as to driver and operator availability and negligible spill delay hold.

The 8 load/day rate does not take truck maintenance into account, and must be corrected. It is estimated that the ideal rate will be reduced by about 7.7%* due to the truck maintenance.

Average loads/day	= 8.0
Less 7.7% of 8.0	= <u>.6</u>

Corrected average loads/day = 7.4

Since 8.15 loads/day must be delivered for 4.0 CF operation, a swing shift will be needed occasionally. If the system is operated for four five-day weeks on day shift, $(8.15 - 7.4)(20) = 15.0$ loads will have to be hauled on swing shift. Two swing shifts every four weeks will just about handle the excess.

2D. Operating Cost, Using One Driver

Because this system uses the same equipment and personnel as the historically operated system, the basic cost factors are the same. The principal calculations are as follows:

<u>At 0 CF</u>	<u>At 2.94 CF (full one-shift operation)</u>
\$30,360 (Same as historical operation)	\$30,360 (total at 0 CF)
	3,330 (Purex maintenance)
	<u>3,250</u> (graveyard loadout)
	\$36,940 (total)

At 4.0 CF

Overtime expense:

The yearly cost of a full second shift on overtime equals \$40,040. Since the second shift will be required only two days out of five, the yearly cost will be $(2/5 \times \$40,040) = \$16,016$.

\$30,360	(total at 0 CF)
4,540	(Purex maintenance)
3,250	(graveyard loadout)
<u>16,016</u>	(overtime labor)
\$54,166	(total)

The results are plotted on Graph I, page 26.

* Based on historical data.

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2E. Operating Cost, Using Two Drivers

The cost of operation for this system is based on the same factors as the present system, with the exception that one more driver has been added. The principal calculations follow:

<u>At 0 CF</u>	<u>At 3.62 CF (full one-shift operation)</u>
\$30,360 (total for present system)	\$38,880 (total at 0 CF)
8,520 (one driver)	4,080 (Purex maintenance)
<u>\$38,880 (total)</u>	<u>3,250 (graveyard loadout)</u>
	<u>\$46,210 (total)</u>

At 4.0 CF

Overtime expense:

The yearly cost of a full second shift on overtime is \$54,000. Since the second shift will be required one day in every ten, the yearly cost will be $(1/10 \times \$54,000) = \$5,400$.

\$38,880 (total at 0 CF)
4,540 (Purex maintenance)
3,250 (graveyard loadout)
<u>5,400 (overtime labor)</u>
<u>\$52,070 (total)</u>

The results are plotted on Graph I, page 26.

2F. Estimated Cost of Modifying Present System

- a. Modify trailer probe system to provide contact checkout and higher reliability.

\$1,500

- b. Repair or adjust magnetic flow meter to accurately record at a flow rate of 100 gpm.

1,500

Total \$3,000

3. Analysis of Three-Truck Operation

If a third truck was added to the present system, the hauling operation could operate much as it does now. The same number of men would be used and the rest of the equipment would be the same. The advantage of the system is that the driver would not have to wait while the truck is loaded at Purex.

3A. Capacity

Using the activity times developed in Section 2, the following table was constructed.

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<u>Time of</u> <u>Activity Completion</u>	<u>Activity Time</u>	<u>Activity</u>
8:00	--	Driver ready at Purex
8:06	5.8	Change trucks at Purex
8:21	15.1	Drive load to UO ₃
8:27	5.8	Change trucks at UO ₃
8:42	15.1	Drive empty to Purex
8:48	5.8	Change trucks at Purex
9:03	15.1	Drive load to UO ₃
9:07	4.0	Wait for UO ₃ unload
9:18	11.0	Driver hourly break
9:24	5.8	Change trucks at UO ₃
9:39	15.1	Drive empty to Purex
9:44	5.8	Change trucks
10:00	15.1	Drive load to UO ₃
10:15	15.0	Wait for UO ₃ unload and driver break
10:20	5.8	Change trucks
10:35	15.1	Drive empty to Purex
10:41	5.8	Change trucks
10:56	15.1	Drive load to UO ₃
11:11	15.0	Wait for UO ₃ unload and driver break
11:17	5.8	Change trucks
11:32	15.1	Drive empty to Purex
12:12	40.0	Driver and Operators eat
12:18	5.8	Change trucks
12:33	15.1	Drive load to UO ₃
12:37	4.0	Wait for UO ₃ unload
12:43	5.8	Change trucks
12:58	15.1	Drive empty to Purex
1:04	5.8	Change trucks
1:19	15.1	Drive load to UO ₃
1:23	4.0	Wait for unload
1:29	5.8	Change trucks
1:44	15.1	Drive empty to Purex
1:50	5.8	Change trucks
2:05	15.1	Drive load to UO ₃
2:20	15.0	Wait for UO ₃ unload and driver break
2:26	5.8	Change trucks
2:41	15.1	Drive empty to Purex
2:46	5.8	Change trucks
3:02	15.1	Drive load to UO ₃
3:17	15.0	Wait for UO ₃ unload and driver break
3:22	5.8	Change trucks
3:37	<u>15.1</u>	Drive empty to Purex

457.4

Using standard rest and delay allowances, it was found that eight loads per shift can be hauled, leaving allowance for the fueling of one truck.

The eight load/day rate does not take truck maintenance into account, and must be corrected. It is estimated that the ideal rate will be reduced by about 2.1%*.

Average loads/day	= 8.0
Less 2.1% of 8.0	= <u>.17</u>

Corrected average loads/day = 7.83

Since 8.15 loads/day must be delivered for 4.0 CF, operating a swing shift would be needed occasionally. If the system is operated for five five-day weeks on day shift, $(8.15 - 7.83)(25) = 8$ loads will have to be hauled on swing shift. One swing shift every five weeks will handle the excess.

3B. Operating Cost

The cost of operation for this system is based on the same factors as the present system, with the exception that another truck rental of approximately twenty-four hundred dollars per year is incurred. The principal calculations are as follows:

<u>At 0 CF</u>	<u>At 3.84 CF</u> (full one-shift operation)
\$ 8,520 (cost/man)	
x 3 (men)	\$32,760 (total at 0 CF)
<u>\$25,560</u> (total labor)	4,350 (Purex maintenance)
7,200 (rent - 3 trucks)	<u>3,250</u> (graveyard loadout)
<u>\$32,760</u>	<u>\$40,360</u>

At 4.0 CF

The yearly cost of a full second shift on overtime is \$40,040. Since the second shift will be required one day in every 25, the yearly cost will be $(1/25 \times \$40,040) = \$1,600$.

\$32,760	(total at 0 CF)
4,540	(Purex maintenance)
3,250	(graveyard loadout)
<u>1,600</u>	(overtime labor)
<u>\$42,150</u>	(total)

The results are plotted on Graph I, page 26.

* Based on historical data.

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3C. Estimated Cost of Obtaining a Three-Truck System

1 - stainless trailer with loadout pump	\$25,000
1 - heavy duty Western Tractor	<u>20,000</u>
	\$45,000 Total

A coated carbon steel trailer could save \$5,000.

4. Analysis of Railroad Hauling

UNH could be transferred from Purex to UO₃ Plant by loading it into acid resistant cars and shipping it to U Plant via the Hanford railroad. Here, it would be unloaded and pumped to UO₃ Plant. A similar system is presently being operated for the transfer of UO₃ recovered nitric acid to Purex.

At Purex, a loadout spot would be constructed on one of the two chemical service sidings. The existing UNH loadout pumps could be connected to service the new spot. A capstan type car puller would be installed so that each car could be brought to the spot for loading, without the use of a locomotive.

At U Plant, a loadin spot would be built on an existing siding, and a car puller would be provided. There is an excellent chance that the loadout pump could be connected to existing piping systems that would carry the solution to the 221-U canyon. Here, a jumper connection could be installed that would allow the UNH to flow to the 224-U Building. A specific route was not plotted, but a study of some of the U Plant and T Plant drawings indicates the existence of several lines between the 221 Building and the 224 Building in these plants. Also, there appear to be lines between the storage tanks at U Plant and the canyon itself.

The cars could be lined with stainless steel, or could be plastic coated. The use of the three present acid tank cars for both acid and UNH service was studied, and it was determined that both services could not be carried out with the existing three cars. UNH will require approximately forty-eight thousand gallons of tank car capacity assuming a two-day turnaround. This is more than twice the capacity that is available with the acid cars. In addition, a one-day turnaround would preclude dual use of the cars, since there would not be enough time to load, haul and unload UNH, then load, haul and unload acid, all within 24 hours. Also, it appears that none of the acid tank cars can be removed from that service without incurring significantly greater operating expense, and a capital expenditure for more acid storage capacity at Purex. It has been found that there are no stainless lined cars available from other government installations, but that there are carbon steel cars available. There appears to be a good possibility that used carbon steel cars could be sandblasted and coated with an acid-resistant plastic lining. As an example, "Pfaudlon 301", a coating that can be sprayed, is recommended by the manufacturer for service with nitric acid mixtures up to a temperature of 210 F.

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4A. Capacity

At capacity factor 4.0, approximately 23,300 gallons of UNH must be moved five days per week. Six 8,000-gallon cars will be needed for a two-day turnaround. Loading or unloading three cars will take approximately six hours:

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<u>Time of</u> <u>Activity Completion</u>	<u>Activity Time</u>	<u>Activity</u>
8:00	--	Operator ready at Purex or UO ₃
8:10	10 min.	Hook up first car
9:30	80	Fill first car
9:40	10	Unhook first car
9:50	10	Move cars
10:00	10	Hook up second car
11:20	80	Fill second car
11:30	10	Unhook second car
11:40	10	Move cars
11:50	10	Hook up third car
12:35	45	Operator eats lunch
1:55	80	Pump third car
2:05	10	Unhook third car

The loadout operator at Purex and the loadin operator at UO₃ will each have three 80-minute periods of nonproductive time per day, while the cars are being pumped. Some of this time can be utilized by hooking up and loading or unloading the recovered acid cars. One man at each end can handle both the acid and the UNH systems from an available time standpoint and also from a work content standpoint, if the loading spots and car pullers are arranged for one-man operation.

4B. Operating Cost, UNH Haul

Because two men will be required for the operation of both the UNH and the acid system, it will be assumed that one man is charged to UNH. The Hanford Railroad hauling rate is thirty-five dollars per round trip per car. Pump and loadout maintenance can be estimated by using the Purex historical cost of \$2,382/yr at approximately a capacity factor of 2.1 and scaling it up to 4.0. The utilization of pumps, loadout hoses, and flow meters is reasonably comparable for the two systems.

<u>0 CF</u>	<u>4.0 CF</u>
\$8,520 (one operator)	\$ 8,520 (one operator)
	4,540 (maintenance)
\$8,520	27,300 (railroad hauling charges)
	\$40,360 (total)

The results are plotted on Graph I, page 26.

4C. Estimated Cost of Obtaining a Railroad Hauling System for UNH

System Using Coated Carbon Steel Cars

Cost of coating six carbon steel cars for acid service	\$30,000
Receiving pump and pad	4,000
Two jumpers	3,000
Two car pullers	4,000
Loadout pad	2,000
	<u>\$43,000</u>
Allowance for project expense (1/2 x 43,000)*	<u>21,500</u>

TOTAL \$64,500

System Using Stainless Steel Lined Cars

Six stainless steel lined cars	\$240,000
Others as above	13,000
	<u>\$253,000</u>
Allowance for project expense (1/2 x 13,000)	<u>6,500</u>

TOTAL \$259,500

4D. Operating Cost, Nitric Acid Haul

The cost of hauling the recovered acid via railroad from the UO₃ Plant to the Purex Plant by the present method is needed for comparison purposes, since the transfer of nitric acid by pipeline is considered in the next section.

From Section 1, at 2.0 CF, unloading recovered acid took one-third of productive time at Purex. Since there are two men assigned, two-thirds of a man will be allocated to acid unloading at Purex. At UO₃, men are sent over specifically to pump acid, so one-third will be allocated there. If capacity was increased to 4.0, two-thirds of a man's time will still be able to handle the job at Purex, but two-thirds man will be needed at UO₃.

CF = 0

\$10,800 (1-1/3 men)

\$10,800 Total

CF = 4.0

\$10,800

16,400 (468 carloads @ \$35 each)

\$27,200 Total

* The expense listed for individual items does not cover design, administration, and construction overhead expense for the project. The allowance for project expense is a rough estimate of this type of expense, and is based on one-half of the expense of the items which must be in part engineered, constructed, or installed at Hanford.

5. Analysis of Pipeline Transfer

Characteristics of UNH produced and concentrated at the Purex Plant:
(60% UNH by weight)

Viscosity = 2.9 Centipoises @ 25 C
Specific Gravity = 1.62 @ 25 C
Concentration of UNH = 1.92 Molar
Concentration of nitric acid = 0.26 Molar (maximum)
Freezing point of solution at above concentrations = approx. 0 C

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The above data was taken from Purex Tech Manual.

5A. Existing Portion of Pipeline

There are six 3-1/2 inch diameter stainless steel, concrete encased, buried pipelines between the 241-UX-154 diversion box at U Plant and the 241-ER-151 diversion box near B Plant. These were installed at the time that U Plant was converted to the TBP process for extraction of uranium metal from the bismuth phosphate process wastes. They were used mainly for transferring the metal feed solution from the East Area Tank Farms to U Plant, and the waste stream from the TBP process back to these same farms. Because of the high value of the metal feed solution and the extreme radioactivity of both the feed and the TBP waste, the lines were placed in a concrete encasement six feet below grade, with sampling wells. These wells can be sampled to determine if any of the lines are leaking. The six-foot depth insures against temperatures at or near 0 C.

Approximate length = 19,600 feet
Approximate elevations = 241-UX-154 702 feet
High point 753 feet
241-ER-151 698 feet
Purex Plant 708 feet

5B. Proposed Section of Pipeline

An overground line could be constructed between the Purex Plant and 241-ER-151 diversion box, a distance of approximately 6,500 feet. The hookup at the diversion box can be accomplished by digging down and connecting to one of the existing stubs.

The proposed specifications are:

Pipe material: 4" diameter normal impact unplasticised polyvinyl chloride schedule 80 solvent joined pipe sections.

Recommended maximum working pressure: 225 psi @ 75 F
130 psi @ 140 F

Recommended working pressure is 20 percent of burst pressure.
Hence, the above specifications have a safety factor of 5-to-1.

Note: The specifications given are for an economical grade PVC pipe. Higher pressures and higher temperatures can be handled by other plastic pipe, or plastic or glass lined steel pipes, but at a higher first cost.

The pipeline would be field assembled, wound with soil heating cable and lagged with weatherproof insulation. The heating cable would be thermostatically controlled to keep the line at about 40 F or higher. The cable would draw approximately 75 kilowatts, when the power was on. Power could be fed at the Purex end, and at the point where the line crosses Baltimore Street. The line would be mounted on supports approximately two feet above ground and five feet apart. Road and rail crossings would be accomplished by raising the line to a sufficient height at these points.

Operating conditions for the line would be:

- One shift operation, five days a week
- Flow rate - 60 gal/min (4.6 CF based on 7.5 hr pumping time per shift)
- Pressure at Purex (pumping) end - 130 psi (based on classical pipe flow calculations, with allowance for static head due to high point in pipeline)
- Maximum temperature - 140 F (UNH is presently stored at 140 F at Purex, for the silica gel process. The temperature of the storage tanks used for loadout could be held at a minimum of 40 F. The use of a lower temperature would not only assure a greater safety factor on the line and lessen thermal shock, but would be easier to pump, because of the lower vapor pressure.)
- Line holdup - 8500 gal. (17 tons U)

The pump would be a single-stage, direct-connected centrifugal of approximately eight horsepower, to be located either outdoors, or inside the existing 203A pumphouse.

Naturally, the integrity of such a line is an important concern. The concept of using an overhead pipeline to transport UNH is acceptable, since there is a two-inch diameter schedule 40 stainless overhead line between Redox and UO₃ Plant. This heated, insulated, one-half mile line carries 60 percent UNH and is successfully operating now. It is believed that no serious operating difficulties or leaks have occurred.

Unplasticised polyvinyl chloride pipe is widely used in the chemical process industry. It has high resistance to many acids, bases, salts, and organics. It is recommended for service with 10 percent and 68 percent nitric acid up to 140 F. The PVC pipe apparently meets and exceeds industry standards for the conditions on the proposed line, and is included in Guide No. DG-110-M, Volume 1 of the Hanford Atomic Products Operation Guides.

Of course, there is always some possibility that the line would develop a leak. The proposed operation calls for walking the above-ground part and sampling the wells once per week. In addition,

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volumetric or magnetic flow meters could be installed at each end. The two signals could be compared by a device at Purex, and the difference in flow rate recorded on a chart. After startup, it is reasonable to expect that the flow at each end would be very near equal, and in fact, should average out the same. A significant loss of solution in the line would be detected by a more or less steady difference in the two flow signals. If the difference was integrated over time, an alarm could be sounded, and the pump shut off automatically. This system could also serve for accountability purposes, and remove the need for that function being performed in the C-1 tank at UO₃ Plant.

The connection from the East-West line to the UO₃ Plant can be made with jumpers in the 221-U canyon. In the event that this is not desirable, a short overhead line can be built between 241-UX-154 diversion box and UO₃ Plant, for a small percent increase in project cost.

The pipeline can be built and operated with the greatest efficiency if a second line is built at the same time for recovered nitric service. The nitric acid could be pumped from the existing storage facilities in front of U Plant. It would flow to 241-WR diversion vault, through another of the East-West pipelines, and through a two-inch diameter PVC pipe that would run along side the four-inch diameter UNH line. The main advantage is that significant savings in operation can be achieved, since two operators could operate both systems.

5C. Operating Cost of UNH Pipeline

<u>0 CF</u>		<u>4.0 CF</u>	
\$ 4,260	(1/2 man at Purex)	\$10,670	(min. total
4,260	(1/2 man at UO ₃)		0 CF)
1,700	(1/5 man walk line)	1,070	(Purex maint)
\$10,220		\$11,740	(min. total)
450	(power cost)	4,260	(1/2 man con-
\$10,670	(min. total)		tingency)
4,260	(1/2 man contingency at UO ₃)	\$16,000	(max. total)
\$14,930	(max. total)		
		\$13,870	(average total)
\$12,800	(average total)		

5D. Operating Cost of Nitric Acid Pipeline

<u>0 CF</u>		<u>4.0 CF</u>	
\$4,260	(1/2 man at Purex)	\$8,520	(total at 0 CF)
4,260	(1/2 man at UO ₃)	1,070	(maintenance)
\$8,520	(total)	\$9,590	(total)

5E. Estimated Project Cost for UNH Pipeline

Single Plastic Line:

4" Sch. 80 PVC pipe, with support, cable & insulation	\$ 74,000
Pump	3,300
Five jumpers	7,500
Tie-in at diversion box	500
Power supply for heating line	10,000
	<u>\$ 95,300</u>
Allowance for Project expense (1/2 x \$95,000)	47,650
TOTAL	<u>\$142,950</u>

Single Stainless Steel Line:

4" Sch. 40 S.S. pipe, with support, cable & insulation	171,600
Others as above	21,300
	<u>\$192,900</u>
Allowance for Project expense (1/2 x \$192,900)	96,450
TOTAL	<u>\$289,350</u>

5F. Estimated Project Cost for UNH and Acid Pipelines

One UNH Line and One Acid Line, Both Plastic:

4" Sch. 80 PVC pipe with support, cable & insulation and 2" Sch. 40 PVC pipe	\$ 83,000
Two Pumps	6,600
Five UNH jumpers	7,500
Two acid jumpers	3,000
Tie-in at diversion box	1,000
Power supply	10,000
	<u>\$111,100</u>
Allowance for Project expense (1/2 x \$111,100)	55,550
TOTAL	<u>\$166,650</u>

6. Economic Comparison of the Present System and Alternates

Graphs I, II, III, and IV are included in this report to give the reader an understanding of the methods that were used to convert primary data and estimates into a comparison of the various alternatives with the present system on an economic basis.

Graph I, "Cost vs. Rate of Production for UNH Hauling", shows a comparison of the estimates of yearly cost of the alternatives at different instantaneous rates of Purex production. The cost is given in Chemical Processing Department out-of-pocket dollars. The assumption is made that spare time of personnel during periods of low production is not utilized. This assumption, while not necessarily accurate, shows the maximum cost of an operation when shut down or almost shut down, if there is no other truly productive work for the personnel to do.

Graph II, "Estimated Yearly Annual Costs for the Various Ways of Hauling UNH and Acid", is a comparison of estimated operating costs for

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alternatives for the UNH and nitric acid transfer systems, taken separately. This graph is based on Graph I, and the production estimates for Purex for FY 1964 through FY 1968. The assumption is made that Purex is either running at 4.0 or shut down. It is expected that, as in the past, Purex will have several "runs" in a year, and will be shut down in between. Notice that the costs are given as a range, rather than single value. For instance, it is expected that the present system, operated historically, will cost between thirty-five and fifty thousand dollars to run in FY 1964. The upper and lower limits represent the extremes in utilization of the personnel during shut-down periods when no UNH hauling is being done. The high value assumes that no utilization was accomplished, while the low value assumes that full normal utilization was the case. It is expected that the actual value would fall some place within these two extremes.

Graph III, "Estimated Annual Costs for Acid Haul and UNH Combined," was constructed by combining the acid haul costs and the UNH haul costs. The purpose of this was to see how the alternatives would compare when viewed together. The advantage of the dual pipeline can clearly be seen here.

Graph IV, "Cash Flow, UNH and Acid Transfer Combined," is a prediction of how the alternatives compare, not only from a yearly cost standpoint but from a first cost standpoint as well. In each case, the savings that the alternative offered over the present system was computed from Graph III, assuming that 50 percent of normal utilization of the men's time was achieved during shutdown. The graph assumes that money would be neither saved nor lost if the present system is operated historically, so the present system is the zero dollar line. The other alternatives all cost something to implement, and will save something in return. Since forecasts were only available through FY 1968, the savings lines are merely extended on the assumption that production will remain at or near the FY 1968 level through FY 1975.

GRAPH I
COST VS. RATE OF PRODUCTION FOR UNR HAULING

EUGENE DIETZEN CO.
MADE IN U. S. A.

NO. 340 EUGENE DIETZEN GRAPH PAPER
10 X 10 PER INCH

DOLLARS (X 1000)

80
70
60
50
40
30
20
10
0

CAPACITY FACTOR

1 2 3 4

2 TRUCKS, 1 DRIVER (HISTORICAL)

2 TRUCKS, 1 DRIVER (MODIFIED)

2 TRUCKS, 2 DRIVERS

RAILROAD
3 TRUCKS, 1 DRIVER

PIPELINE

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ESTIMATED YEARLY ANNUAL COSTS FOR THE VARIOUS WAYS OF HAULING UNII AND ACID

GRAPH II

GRAPH I
ESTIMATED ANNUAL COSTS FOR ACID AND
UNH HAUL COMBINED

EUGENE DIETZGEN CO.
MADE IN U. S. A.

NO. 340 10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH

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GRAPH IV
CASH FLOW - UNH AND ACID TRANSFER
COMBINED

EUGENE DIETZEN CO.
MADE IN U. S. A.

NO. 340 110 DIETZEN GRAPH PAPER
10 X 10 PER INCH

DOLLARS (X100,000)

+5

+4

+3

+2

+1

0

-1

-2

(1) UNH AND ACID PIPELINES

(2) ONE PIPELINE

(3) R.R. HAULS COATED C/S CARS

(4) PRESENT SYSTEM (MODIFIED - 1 DRIVER)

(5) PRESENT SYSTEM (MODIFIED - 2 DRIVERS)

(6) THREE TRUCK OPERATION

(7) PRESENT SYSTEM (HISTORICAL)

ACCUMULATED SAVINGS

'64 '65 '66 '67 '68 '69 '70 '71 '72 '73 '74 '75

FISCAL YEAR

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**DATE
FILMED**

11 / 9 / 93

END