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SOCONY MOBIL OIL COMPANY, INC.

RESEARCH DEPARTMENT

SPECIAL MEMORANDUM

SCOPING STUDY FOR STAGE II
1. CONSTRUCTION AND OPERATING COSTS
2. MANPOWER REQUIREMENTS

ANVIL POINTS OIL SHALE RESEARCH CENTER

Rifle, Colorado

February 28, 1966

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NOTICE

The primary object of the Anvil Points Oil Shale Research Center SPECIAL MEMORANDUM is to advise authorized personnel employed by the Participating Parties[1] that various activities are in progress or that certain significant data have been obtained within the Research Center

These SPECIAL MEMORANDA have been prepared to provide rapid, on-the-spot reporting of research currently in progress at Anvil Points. The conclusions drawn by project personnel are tentative and may be subject to change as work progresses. The SPECIAL MEMORANDA have not been edited in detail.

[1] Socony Mobil Oil Company, Inc., Project Manager

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I. PURPOSE AND DESCRIPTION OF SCOPING STUDY

The Technical Advisory Committee, at its January 17, 1966 meeting, requested that the entire Stage II program be scoped for costing. Four alternate cases have been developed involving different retorting and mining programs. An additional option which can be included with any of the cases above involves a cooperative crushing study with Allis Chalmers and Nordberg.

This study differs from the May 1965 Scoping Study in that all Stage II needs have been incorporated - rehabilitation of the mine, Retort No. 3 and the crushing plant revisions, all programs for Retorts No. 1, No. 2 and No. 3 and the mechanical models group, mining studies, analytical, and plant facilities. Manpower for the four cases has also been developed.

A modified PERT diagram showing hiring and construction for mining and retorting has been diagramed for one case. In developing both rehabilitation and program costs, discussions were held with all Research Center staff engineers to:

1. Discuss and review goals, methods, and systems proposed for Retort No. 3.

2. Discuss and review goals and methods to accomplish mining needs.

3. Discuss, develop, and review meaningful retorting programs.

4. Discuss, develop, and review meaningful programs for the mechanical models and analytical groups.

5. Discuss, develop, and review needed plant facilities to support all Stage II programs.

A. Definition of Program Proposals Case A1, A2, B1, B2

In defining the programs, retorting programs have been designated by A and B and mining programs 1 and 2. The same letter or number will define the same respective program for any case.

The four cases proposed for Stage II programing are:

A1 Retorting program operating one retort at a time and mining to develop shale for retorting.

A2 Retorting program operating one retort at a time and a full mining research program.

B1 Retorting program operating Retort No. 3 and either Retorts No. 1 or No. 2 at the same time with mining to develop shale for retorting.

B2 Retorting program operating Retort No. 3 and either Retorts No. 1 or No. 2 at the same time with a full mining research program.

In addition to the above, two additive programs - a shale crushing study to be carried out in cooperation with Allis Chalmers and Nordberg and the cost of revising Retort No. 1 for pressure operation - have been estimated. Both involve out of pocket money only and may be added to any of the four proposals.

II. BUDGET SUMMARY - COSTS AND MANPOWER

The estimated costs and manpower requirements for Stage II are computed on the basis of the four alternative cases.

The Cost Summary (Table 1) summarizes the estimated total gross costs for each case broken down by major headings. Gross costs are shown in more detail on Table 2. The estimated salvage is deducted from each case to reflect the net expense. The salvage is shown in detail on Table 3. The optional crushing study, which is not included in the computation of the gross program expense, is added to reflect the net cost including this option. The Salaries, Benefits and Allowance caption includes only the basic costs without allowance for contingencies. The summary of costs by function (Table 1) is intended to show the approximate cost incurred by recapping the gross program expense into groups by function. Salary and wages for the Research Foundation have been estimated based on the February 1966 wage structure. No attempt has been made to estimate the basis of settlement for the current round of labor negotiations between the Research Foundation and OCAW.

Table 2 is a breakdown in detail of gross expense by specific accounts for each case along with the budget estimated October 28, 1965 as a comparison. This table indicates the estimated date for the expiration of $3,000,000 for each case.

Table 3 itemizes the potential salvage value of equipment at the end of Stage II for each of the four cases.

The present imprest fund of $200,000 advanced by the Participating Parties to the Research Foundation will be inadequate for Stage II. Table 4 details the needs for each case during the six month rehabilitation and the twelve month operating period on Retort No. 3.

The estimated manpower requirements are listed on Table 5 by each department and further totaled by the administrative and program needs. The manpower grand total for each case is divided according to requirements from the Participating Parties and the Research Foundation. A list of incremental manpower needs by specific job headings is detailed for each case. Table 6 presents the schedule of manpower requirements according to the dates when each major function will increase its staff according to Stage II needs for each case.

TABLE 1

STAGE II PROGRAM ESTIMATED COST SUMMARY, M$

	CASE A1 Retort No. 3 Without Mining Program	CASE A2 Retort No. 3 With Mining Program	CASE B1 Retort No. 3 Plus No. 1 or No. 2 Without Mining Program	CASE B2 Retort No. 3 Plus No. 1 or No. 2 With Mining Program
Salaries, Benefits and Allowances:				
Participating Parties	$ 734	$ 734	$ 846	$ 846
Research Foundation	1,227 *	1,330 *	1,548 *	1,644 *
Total	1,961	2,064	2,394	2,490
Equipment, Materials and Supplies	621	696	783	863
Improving Plant Facilities	50	50	50	50
Mining Research Equipment	0	220	0	220
Rehabilitate Mine	89	89	89	89
Rehabilitate Retort No. 3	725	725	725	725
All Other Net Expenses	554	556	559	563
Gross Program Expense	$4,000	$4,400	$4,600	$5,000
Less: Estimated Salvage	70	130	70	130
Net Program Expense	$3,930	$4,270	$4,530	$4,870
Optional Study Not Included in Stage II Cost Summary:				
Crushing Study	60	60	60	60
Net Program Expense With Crushing Study	$3,990	$4,330	$4,590	$4,930

ESTIMATED SUMMARY OF COSTS BY FUNCTIONS, M$

Administration	$1,640	$1,640	$1,788	$1,805
Pilot Plant and Mechanical Models	1,600	1,600	2,000	2,000
Mining	620	1,020	637	1,020
Analytical	140	140	175	175
Gross Program Expense	$4,000	$4,400	$4,600	$5,000

* Assumes present wage rates.

TABLE 3

ANALYSIS OF SALVAGE AS APPLIED TO STAGE II PROGRAM

	CASE A1	CASE A2	CASE B1	CASE B2
	Retort No. 3 Without Mining Program	Retort No. 3 With Mining Program	Retort No. 3 Plus No. 1 or No. 2 Without Mining Program	Retort No. 3 Plus No. 1 or No. 2 With Mining Program
Office Equipment	$ 2,000	$ 2,000	$ 2,000	$ 2,000
Vehicles	4,000	4,000	4,000	4,000
Mining Equipment	25,000	25,000	25,000	25,000
Mining Research Equipment	--	58,000	--	58,000
Instruments	9,000	9,000	9,000	9,000
Process Equipment	30,000	32,000	30,000	32,000
Total Salvage	$ 70,000	$130,000	$ 70,000	$130,000

TABLE 4

IMPREST FUND REQUIREMENTS FOR STAGE II

The present imprest fund of $200,000 advanced by the Participating Parties to the Research Foundation will be inadequate for Stage II. Due to unusually high costs during the rehabilitation part of Stage II the advance must be substantially increased for six months and then will be reduced for the twelve months operating period on Retort No. 3. The following are the requirements for each case:

	April 1966 - Oct. 1966	Nov. 1966 - Oct. 1967
Case A1	$500,000	$300,000
Case A2	$500,000	$300,000
Case B1	$500,000	$330,000
Case B2	$500,000	$350,000

As per the Research Contract and the Research Agreement this fund will be returned to the Participating Parties at the completion of Stage II.

TABLE 2

ESTIMATED STAGE II GROSS PROGRAM COSTS

	Budget Estimated 10/28/65	CASE A1 Retort No. 3 Without Mining Program	CASE A2 Retort No. 3 With Mining Program	CASE B1 Retort No. 3 Plus No. 1 or No. 2 Without Mining Program	CASE B2 Retort No. 3 Plus No. 1 or No. 2 With Mining Program
Salaries, Benefits & Allowances					
Participating Parties	$ 706,000	$ 734,000	$ 734,000	$ 846,000	$ 846,000
Research Foundation	1,358,000	1,227,000	1,330,000	1,548,000	1,644,000
Total	$2,064,000	$1,961,000	$2,064,000	$2,394,000	$2,490,000
Equipment, Maintenance Materials & Supplies					
Mechanical Models and Retort	312,800	224,000	224,000	302,000	319,000
Warehouse Replenishment and Miscellaneous	84,600	120,600	120,600	138,600	138,600
Mining	239,400	143,100	218,100	155,100	218,100
Road Maintenance	20,000				
Analytical	12,600	18,000	18,000	22,000	22,000
Storage Bin	5,000	--	--	--	--
Stationery Supplies	10,800	10,800	10,800	10,800	10,800
Housing	4,500	4,500	4 500	4,500	4,500
Analytical + Retort + Mechanical Model Special Equipment	--	100,000	100,000	150,000	150,000
Miscellaneous Equipment	10,000	--	--	--	--
	$ 699,700	$ 621,000	$ 696,000	$ 783,000	$ 863,000
Improving Plant Facilities	--	50,000	50,000	50,000	50,000
Mining Research Equipment	228,500	--	220,000	--	220,000
Rehabilitate Mine	66,000	89,000	89,000	89,000	89,000
Rehabilitate Retort No. 3	609,000	725,000	725,000	725,000	725,000
All Other Net Expenses					
Employee Expense	26,500	77,500	77,500	77,500	77,500
Consultants, Auditors and Attorneys	5,400	11,400	11,400	11,400	11,400
Project Manager Expense	10,600	10,600	10,600	10,600	10,600
Other Participating Party Expense	1,200	1,200	1,200	1,200	1,200
Contractors Fee	90,000	90,000	90,000	90,000	90,000
Rents on Leased Equipment	58,000	109,800	111,800	109,800	112,700
Subcontracts	54,000	54,000	54,000	54,000	54,000
Freight and Postage	19,800	19,800	19,800	21,900	23,000
Utilities	179,300	190,300	190,300	190,300	190,300
Insurance and Operating Taxes	17,400	14,400	14,400	14,400	14,400
Personnel Procurement	5,100	5,100	5,100	8,000	8,000
Labor Relations and Negotiations	900	5,000	5,000	5,000	5,000
Other Miscellaneous Expenses	2,700	3,000	3,000	3,000	3,000
Less: Income	(38,100)	(38,100)	(38,100)	(38,100)	(38,100)

	$ 432,800	$ 554,000	$ 556,000	$ 559,000	$ 563,000
GROSS PROGRAM EXPENSE	$4,100,000	$4,000,000	$4,400,000	$4,600,000	$5,000,000
Estimated Date of $3,000,000 Expenditure	May 1, 1967	May 1, 1967	Mar. 1, 1967	Mar. 1, 1967	Feb. 1, 1967

TABLE 5

STAGE II MANPOWER REQUIREMENTS

Existing 3/9/66	CASE A1 Retort No. 3 Without Mining Program	CASE A2 Retort No. 3 With Mining Program	CASE B1 Retort No. 3 Plus No. 1 or No. 2 Without Mining Program	CASE B2 Retort No. 3 Plus No. 1 or No. 2 With Mining Program
2	6	6	6	6
5	7	7	8	8
5	5	5	6	6
5	5	5	5	5
6	6	6	8	8
7	9	9	11	11
10	15	15	18	18
15	19	19	24	24
55	72	72	86	86
8	9	9	10	10
11	24	32	25	32
27	37	37	52	52
8	9	9	12	12
54	79	87	99	106
109	151	159	185	192
21	24	24	28	28
88	127	135	157	164
109	151	159	185	192

Incremental Manpower Needs

	CASE A1	CASE A2	CASE B1	CASE B2
I. Participating Parties				
Secretary	1	1	1	1
Economic Analyst	1	1	1	1
Mechanical Engineer	0	0	1	1
Retort Engineers	2	2	5	5
Consultant	-1	-1	-1	-1
Sub-Total	3	3	7	7
II. Research Foundation				
Operations Foremen	4	4	4	4
Accounts Payable Clerk	0	0	1	1
Steno Clerk	1	1	1	1
Payroll Clerk	1	1	1	1
Warehouse Supply Clerk	0	0	1	1
Draftsman	0	0	1	1
Instrument Specialist	0	0	1	1
Electricians	2	2	3	3
Machinists	0	0	1	1
Pipefitter-Welders	0	0	4	4
Garage Mechanics	4	4	4	4
Oiler	0	0	1	1
Mine Foreman	1	1	1	1
Engineering Assistant	1	1	1	1
Miners	1	5	2	5
Shovel Operators	4	4	4	4
Truck Drivers	0	3	0	3
Mine Laborers	1	2	1	2
Mine Mechanics	4	4	4	4
Dozer/Loader Operator	1	1	1	1
Crusher Operators	2	2	2	2
Heavy Equipment Operator	2	2	2	2
Crusher Helpers	3	3	3	3
Retort Operators	0	0	4	4
Retort Helpers	0	0	8	8
Bench Scale Technician	1	1	1	1
Laboratory Technician	1	1	4	4
Utility & Housing Foreman	1	1	1	1
Filter Plant Operator	0	0	1	1
Carpenter	1	1	1	1
Janitor	1	1	1	1
Labor Pool	2	2	4	4
	39	47	69	76
Grand Total	42	50	76	83

ESTIMATED

Manpower Requirements

Administration and Support
- Management
- Personnel & Accounting
- Purchasing
- Safety
- Engineering
- Electrical
- Utilities & Housing
- Mechanical
  - Sub-Total

Program
- Management and Support
- Mining
- Crushing & Retorting
- Analytical
  - Sub-Total

Grand Total

Participating Parties
Research Foundation

TABLE 6

SCHEDULE OF STAGE II MANPOWER REQUIREMENTS

	Existing 3/9/66	April 1966	July 1966	Sept. 1966	Oct. 1966 to Oct. 1967
CASE A1 Retort No. 3 Without Mining Program					
Administration and Support	63	65	65	65	81
Pilot Plant and Mechanical Models	27	29	29	30	37
Mining	11	14	14	14	24
Analytical	8	8	9	9	9
	109	116	117	118	151
CASE A2 Retort No. 3 With Mining Program					
Administration and Support	63	65	65	65	81
Pilot Plant and Mechanical Models	27	29	29	30	37
Mining	11	18	18	18	32
Analytical	8	8	9	9	9
	109	120	121	122	159
CASE B1 Retort No. 3 Plus No. 1 or No. 2 Without Mining Program					
Administration and Support	63	67	67	67	96
Pilot Plant and Mechanical Models	27	29	29	33	52
Mining	11	14	14	14	25
Analytical	8	8	9	12	12
	109	118	119	126	185
CASE B2 Retort No. 3 Plus No. 1 or No. 2 With Mining Program					
Administration and Support	63	67	67	68	96
Pilot Plant and Mechanical Models	27	29	29	33	52
Mining	11	18	18	18	32
Analytical	8	8	9	12	12
	109	122	123	131	192

III. REHABILITATION COST

A. Retort No. 3

1. Criteria

Retort No. 3 will be extensively revised for Stage II studies. This retort will incorporate all features found of commercial potential in the Stage I program. The crushing plant, shale feed, anti-segregation, spent shale drawoff, distributor configuration, gas disengagers, shale mass flow, shale size range, air and recycle gas rates, bed heights, spent shale handling and disposal, mist recovery units, and process automation are included.

The following ground rules were established for the scoping study regarding retorting, crushing, and plant facilities:

a. Retort will be nominally designed for 500 T/D of shale based on a 700 lbs/(hr)(ft^2) shale rate.

b. Anti-segregation devices will be employed for raw shale.

c. Multi-pipe single level drawoff will be used for spent shale from the bottom of the retort.

d. Distributors - single level air inlet, bayonet type, with a six foot span.

e. Shale size range: 1/4 to 1 inch, 1 to 3 inch, and 1/4 to 3 inch.

f. Air rates - 6,500 SCF/Ton maximum at 700 lbs/(hr)(ft^2).

g. Recycle - 14,000 SCF/Ton maximum at 700 lbs/(hr)(ft^2).

h. Bed Heights - 13 feet above air distributor
6 feet below air distributor.

i. Spent Shale Disposal - spread type and water spray.

j. Mist Recovery Equipment
   1. One rough-cut unit such as a multiclone or cyclone and an
   2. Electrostatic precipitator for cleanup.

k. Process Instrumentation.
   1. Raw shale weight and rate measuring and spent shale rate measuring - both with integrators.
   2. Liquid product metering.
   3. Test meter for gas streams.
   4. Temperature, pressure, flow recorders and indicators, and controls as required.

l. Crushing - Crushing plant to be rehabilitated for 16 hour/day - 7 day/week operation. Must produce 30 ton/hour of any shale size to be studied.

m. Plant facilities - Plant facilities, utilities to be upgraded to meet retorting and staff needs.

A conceptual retort drawing has been prepared. This drawing is not final and is being used for estimating purposes only. One Process Flow Diagram is also included. It is of a conceptual nature and for cost estimating purposes only.

The proposed cross-sectional area of the retort will be 6 feet by 10 feet, which is the same as the Bureau of Mines Retort No. 3. This cross-section is considered adequate as a pilot-plant prototype of a commercial-size rectangular retort; the six foot dimension is considered to be approximately one half of a practical maximum span of a commercial rectangular retort, and the ten foot dimension is large enough to produce any operational difficulties which might occur in a large size unit. Data developed on shale flow, air and gas distributors, and operability are also adaptable to a circular retort configuration. Using the existing retort shell offers a considerable cost and time advantage in this program.

2. Cost Estimate

A conceptual flow diagram and retort configuration have been developed for Stage II retorting. From these and the criteria established in the previous section, cost estimates have been prepared.

The retorting program established the supporting facilities of crushing and plant utilities.

Much of the existing crushing and retorting equipment will be utilized for Stage II. Much of this equipment will require extensive renovation and repair. Some existing equipment is undersized for Stage II needs and will be removed or demolished. New equipment will be purchased where needed.

It will be necessary to hire the services of a reputable engineering firm for engineering and drafting. Construction of retorting, plant, and crushing facilities will be by an outside contractor under the direction of the engineering firm. Most of the mining rehabilitation needs will be furnished by Research Foundation personnel.

Timing for construction will require awarding the engineering and construction contract on a cost-plus basis with possibly a fixed fee.

A contingency fee has been incorporated and is standard in all construction cost estimates.

Table 7 is a summary of costs for Retort No. 3 rehabilitation.

TABLE 7

SUMMARY OF COSTS - RETORT NO. 3 REHABILITATION

Retort-Crusher-Plant Facilities	Contractors Fee Engr. Draft. Lead Time Wks.	Contractors Fee Engr. Draft. Cost $	Purchases Lead Time Wks.	Purchases Cost $	Construction Lead Time Wks.	Construction Cost $
1. Crusher Plant Storage Bins Shale Handling			16	$ 87,000	4	$ 39,600
2. Retort No. 3, Battery Limits			16	228,000	6	145,000
3. Liquid Product Treating and Tankage			8	18,300	3	9,800
4. Plant Facilities			8	16,200	3	9,100
5. Equipment Rental			--	24,000	--	--
6. Contingency	--		--	34,000	--	17,000
	8	$ 97,000	16	$407,500	16	$220,500

Total Cost - $725,000

3. Cost Comparison of Present Retort Rehabilitation Cost With May 1965 Estimate

Rehabilitation Retort No. 3 of May 1965 Scoping Report	$609,000
Rehabilitation Retort No. 3 of February 1966 Scoping Report	$725,000

At the conclusion of the scoping and costing of Retort No. 3 rehabilitation as now defined a comparison was made with the May 1965 proposal.

Basic differences appeared, in general, centering on upgrading and adding to the crushing, shale handling and weighing equipment, additional oil product treating and measuring systems, additional seals at the top of the retort, and replacement of instruments and equipment cannibalized from Retort No. 3 during the past year.

A summary of these differences including design costs is listed in Table 8.

TABLE 8

INCREMENTAL COST INCREASES PRESENT RETORT OVER MAY 24, 1965
SCOPING ESTIMATE

		Total Differential Cost
Raw Shale Crushing and Handling		
1.	New Flextooth Crusher	$ 9,000
2.	New Fines Screener	8,000
3.	Trainer Idlers	7,500
4.	Dust Control - Crusher Plant Plus Pollution Control	25,000
5.	Complete New Belting	11,000
6.	500 Ton Bin Conveyor System	7,500
7.	Back Up Shale Weighing System	10,000
		$ 78,000
Retort - Controls		
1.	Double Rotary Seals - Top of Retort	$ 12,000
2.	Instrumentation - Equipment used on Retorts No. 1 and No. 2	7,500
3.	Instrument Air Compressor	4,500
		$ 24,000
Spent Shale - Liquid Product		
1.	Spent Shale Sampler	$ 22,000
2.	Liquid Treating	20,000
		$ 42,000
All Other Changes		Minus-$ 28,000
Total Incremental Cost - Feb. 1966 Over May 1965		$116,000
Original Estimate, May 24, 1965		$609,000
Final Estimate, February 22, 1966		$725,000

The following information is supplied in support of the addition of these items to the retort rehabilitation.

1. All crushers were inspected by their respective manufacturers. The secondary Flextooth crusher was judged to be in poor shape considering the duty to be imposed for Stage II. A new unit was recommended.

2. Considerable problems have been experienced with proper tracking of conveyor belting. Trainer idlers will be installed on all conveyors.

3. The conveyor belting in the crushing plant has worn badly during the past year and requires replacement.

4. Due to the pending air pollution control laws in Colorado, health inspection recommendations and general dust level within the crushing plant, a complete dust collection system has been added to the estimate.

5. The 500 ton shale storage bin was recently put into service. A new conveying system will be needed for Stage II shale rates.

6. A backup raw shale weighing system has been added to the originally proposed raw shale rate control and totalizing system.

7. Double seals will be installed at the top of the retort to provide more precise retorting data.

8. The spent shale sampling system and its structure has been cannibalized during the last year for the large shale flow model.

9. Last year, a considerable effort was spent to ascertain the best method of handling and measuring liquid product. Water content in the product stream requires special handling. As a result of these studies additional funds have been added to the rehabilitation for suitable equipment.

4. Discussion of Equipment and Facilities

(a) Crusher Plant and Storage Bins

All crushers, screeners, conveyors, elevators, and ventilation will be repaired for full time operation. A new fines screener will be added to screen out minus 1/4 inch particles. Control and electrical systems will be upgraded where required. A new Flextooth Secondary Crusher will be installed to replace the worn out existing unit. A new crusher plant ventilation and dust control system will be installed. New belts and trainer idlers will be installed on all conveyors.

The 100 ton storage bins will be revised to include anti-segregation and uniform shale drawoff devices. Both the 500 ton and 100 ton bins will have new drawoff feeder systems. Shale feed to the retort will be flow controlled and rate measured by a new system.

Materials	$ 87,000
Construction	$ 39,600

(b) Retorting-Piping-Instrumentation

All gas piping will be replaced with pipes of larger sizes. Where possible, Victaulic type fittings will be used. New line burner, control valves, rebricking of the top of the retort, air and recycle gas distributors, structural changes, mist recovery equipment, blower, double rotary gas seals at the top and bottom of the unit, instrument air compressor, and insulation are included. The Bureau of Mines recycle blowers will be used to supply air. A large Spencer blower located at the Socony Mobil Oil Company Paulsboro Laboratory has been reserved for the recycle duty for the retort. This unit has been inspected and found to be in excellent condition.

An electrostatic precipitator plus one rough-cut recovery unit will form the recovery train. The precipitator will cost approximately $75,000 installed. No air cooled condenser is included in the estimate.

New shale rate controllers and spent shale gravimetric and sampling systems will be incorporated. At the top of the retort, an anti-segregation

inlet section will be designed. The drawoff system will incorporate results of the experimental work of the Mechanical Models Group. Spent shale will be slushed over the cliff with suitable conveyors to vary the point of dumping.

Much of the present instrumentation will be used. However, additional recorders and controllers will be required. New thermocouples will be purchased. The unit will be automated to the fullest extent with controls suitable for commercial application.

Material	$228,000
Construction	$145,000

(c) Liquid Product Treating and Tankage

Liquid product will be heated to 200° F and treated for removal of water and sludge materials. After cooling, the liquid product will be accurately metered, sampled, and pumped to existing storage tanks. Separated water and sludge will be accurately sampled, metered, and collected in day tanks before discharge.

Existing product tankage will be cleaned and reconditioned.

Material	$ 18,300
Construction	$ 9,800

(d) Plant Utilities

All systems such as water, steam, heating, lighting, plant air, drainage, etc. will be rehabilitated and improved where required. A new transformer will be required for the recycle blower.

Material	$ 16,200
Construction	$ 9,100

(e) Rental of Construction Equipment

Budgeted For	$ 24,000

(f) Contingency

This item includes funds for retort, crushing, liquid product handling and plant facilities.

Material	$ 34,000
Construction	$ 17,000

(g) Design Engineering

Present plans are to have a competent engineering firm provide both design engineering and construction for the retort and crushing plant rehabilitation. This contract will be awarded on a cost-plus basis or a cost plus fixed fee basis. As the work involves a considerable amount of revision and inspection of systems during rehabilitation, many field decisions will be made. One firm responsible for both design and construction would provide the closest coordination of such matters.

Three large engineering firms were contacted and inspected in the Denver - Salt Lake City area. Our needs were reviewed in detail with each.

(1) Torkelson Co. - Salt Lake City
(2) Stearns-Roger - Denver
(3) Ken R. White - Denver

All companies have a staff in excess of 200 draftsmen, designers, and engineers. They are all capable and willing to assume both the engineering and construction responsibilities for this job.

Several other national firms will also be contacted to review their interest in this work. Proposals will be requested from at least three and possibly five firms.

Engineering Fees	$ 97,000

B. Mine

1. Discussion of Equipment and Facilities

All capacity calculations are based upon the assumption that the crusher feed rate will average 560 tons per day, seven days per week, throughout the 12 month period of Retort No. 3 operation. Basic mining rehabilitation is the same for either Mining Program - 1 or 2. All work is planned using Research Foundation personnel.

Total Rehabilitation Cost	$ 89,000

(a) Water Supply

Rehabilitation of the water supply system from the reservoirs on top of the mesa is complete, and the system is operating satisfactorily.

(b) Mine Ventilation

In order to provide adequate ventilation through the mine to conform with State regulations, it will be necessary to purchase a 200,000 cfm fan to install in Adit No. 2. Three additional portable 25,000 cfm fans will also have to be obtained to create circulation at the working faces.

Purchase of main fan 200,000 cfm	$ 6,000
Purchase of three portable fans	6,000
	$12,000

(c) Mine Service Facilities

The mine buildings will be rehabilitated. It is necessary to provide a change room, maintenance shop, stockroom and an office, all of which have to be heated, furnished and provided with tools. Rehabilitation of the change room is necessary for the number of men who will be employed at the mine. The shop will be used for preventive maintenance work and minor repairs. Routine supplies will be kept at the mine, this will save a considerable amount of transportation time.

Estimated cost of rehabilitating the change room and office building	$20,000

(d) Electrical Power and Lights

For supply of power to the main ventilation fan and to the portable fans it will be necessary to purchase a portable stepdown transformer 2,300 V/440 V with 150 KVA capacity.

Additional miners' lamps are required for the larger working force, a re-charging panel would be purchased with the lamps.

Estimated cost of transformer, switch gear and cable	$15,000
Purchase of Miners' lamps and charger	2,000
	$17,000

(e) Transportation

Equipment will be needed to transport the men to and from work, and for use by the staff between plant and mine offices. It is proposed to overhaul the Anvil Points bus to carry the men up the mine road. A station wagon for the staff would also be used as a service truck for carrying supplies and parts.

Estimated cost of overhauling bus	$ 2,000
Purchase of station wagon	4,000
	$ 6,000

(f) Road Maintenance

Prior to starting the haulage of shale for Retort No. 3 in November 1966, it will be necessary to resurface the road again with crushed gravel. For continuous haulage the road must be maintained in safe operating condition.

This spring it will also be necessary to crib a section of road where there is excessive bank erosion. The section of road involved is narrow and further erosion will endanger road stability during truck haulage operations.

Estimated cost of resurfacing road	$15,000
Estimated cost of installing cribbing	10,000
	$25,000

(g) Mine Equipment

(1) Roof Bolting

The hydraulic scaling rig can be modified to mount a roof bolter on the aerial platform. It is intended to purchase a rotary percussion drill for this purpose which will improve the efficiency of this operation and reduce manpower requirements.

Estimated cost of purchasing and installing rotary percussion roof bolter	$ 7,000

(2) Face Drilling Equipment

For the purpose of producing the ore required for Stage II retorting, the existing jumbo and percussion drills are quite adequate. Further equipment will be necessary for drilling and blasting research and this is included in the Stage II Mining Research Option.

A basic weakness of the present jumbo is that it is difficult and time consuming to level up with the existing manual jacks. It is proposed to install hydraulic jacks on the unit.

Estimated cost of installing hydraulic jacks	$ 2,000

(3) Loading and Hauling Equipment

The most economical method of hauling the shale required for Retort No. 3 to the crusher plant, is to rent a 40 ton rear dump truck. One 40 ton truck operated around the clock can haul the 560 tons per day feed rate: 40 tons per trip X 17 trips per day X 85 per cent availability = 575 tons per day.

To load this high profile truck it will be necessary to rent a larger front end loader. One company has submitted a very reasonable quotation on a Koehring Scooper which has the dumping height to load a 40 ton truck.

Rental cost of 40 ton truck	$ 2,025/mon
Rental cost of Koehring Scooper	3,500/mon

IV. PROGRAMS

A. Retorting

1. Case A, Retorts No. 1, 2, and 3

The broad objective of Retort Program "a" is to:

(a) Provide demonstrated retort design data for scaling up the conventional Gas-Combustion Retort to at least a commercial prototype.

(b) Provide a minimum exploration into process modifications which promise better understanding of the process and possible yield improvement.

The method of achieving this is to develop process variable relationships, air distributor designs and other hardware features on Retort No. 2; then demonstrate the results on Retort No. 3. In addition, minimum one to two week explorations of potential modifications to the basic process, such as use of external heating and the addition of a soaking zone, would be carried out on Retorts No. 1 and No. 2 as time permits. The estimated operating time on each retort is summarized below:

	Estimated Operating Time, Months		
Retort No.	During Constr. of Retort No. 3	After Constr. of Retort No. 3	Total
1	1	1	2
2	4 1/2	2	6 1/2
3	--	6	6

A more detailed summary of the specific objectives follows:

STAGE II RETORTING PROGRAM - SUMMARY - CASE A

Broad Objectives

1. Demonstrate yields and operability with commercial size retort equipment designed from scale-up of Stage I results.

2. Carry out minimum exploratory studies aimed at developing an understanding of the mechanisms by which the Gas-Combustion process consumes 15 to 20 per cent of the potential yield; and at developing leads which promise at least a five per cent improvement over the conventional Gas-Combustion REtort.

Specific Objectives

A. Retort No. 3

1. Demonstrate commercial retort designs for processing 1/4 to 1 inch, 1 to 3 inch, and 1/4 to 3 inch oil shale using a 60 ft^2 retort designed from the Stage I technology.

2. Carry out corrosion - erosion studies to establish material requirements for a commercial retorting plant.

Estimated Operating Time - 180 Days

B. Retorts No. 1 and No. 2

1. Carry out a process variable study in Retort No. 2 to establish the effect on yield of:

   a. Shale size
   b. Shale rate
   c. Air rate
   d. Recycle rate
   e. Bed height

Estimated Operating Time - 120 Days

2. Establish operating conditions for processing rich shale.

Estimated Operating Time - 30 Days

3. Carry out minimum exploratory studies to determine if there is reasonable potential for:

   a. Obtaining a 5 to 10 per cent yield improvement from the full effect of external heating.

Estimated Operating Time - 12 Days

   b. Obtaining a 5 to 10 per cent yield improvement and the potential of operating at 700 lbs/(hr)(ft^2) from the use of a retorting soaking zone.

Estimated Operating Time - 15 Days

   c. Obtaining a 5 to 10 per cent yield improvement by using nucleating agents.

Estimated Operating Time 12 Days

4. Develop a better understanding of where the Gas Combustion process consumes 15 to 20 per cent of the potential yield.

   a. Evaluate more thoroughly the effect of of oil refluxing.

Estimated Operating Time - 20 Days

   b. Evaluate startup procedures.

Estimated Operating Time - 10 Days

   c. Evaluate the effect of operating conditions on bed density using radiation-scintillator techniques.

5. Carry out mist evaluation studies to determine the effect of process variables on mist and the effect of mist on the process.

Estimated Duration of Study - 120 Days

C. Bench Scale Studies

Carry out bench scale studies to increase our fundamental knowledge using a fixed bed of oil shale to determine the effect of:

1. Time-Temperature

2. Sweep Gas

3. Bitumen decomposition and coke generation during retorting.

4. Other miscellaneous studies such as effect of gas composition on retorting, effect of nucleating agents, and water-fines removal from raw shale oil.

2. Case B, Retorts No. 1, 2, and 3

The broad objective of Retort Program "B" is to:

(a) Provide demonstrated retort design data for scaling up the conventional Gas-Combustion Retort to at least a commercial prototype.

(b) Provide sufficient understanding of the process fundamentals to provide reasonable extrapolation of operating conditions and designs.

(c) Provide sufficient evaluation of potential process modifications to ascertain the economic incentive of testing on a Retort No. 3 scale; and to assure that the conventional Gas-Combustion Retort will not be obsolete in yield achievement before a reasonable return is realized.

The method of achieving this is to develop process variable relationships and a better understanding of the process on Retorts No. 1 and No. 2, then demonstrate the results on Retort No. 3. Retorts No. 1 or No. 2 would be operated simultaneously with Retort No. 3 in this option. This will provide about nine months for additional operation of Retorts No. 1 or No. 2 than Program "A" does to develop process understanding and to evaluate potential process modifications. This additional time will permit more reliable consideration of variations in the commercial design of the conventional Gas-Combustion Retort and of modifying the process to obtain higher yields. The estimated operating time on each retort is summarized below:

	Estimated Operating Time, Months		
Retort No.	During Constr. of Retort No. 3	After Constr. of Retort No. 3	Total
1	1	2	3
2	4 1/2	8	12 1/2
3	--	6	6

A more detailed summary of the specific objectives follows:

STAGE II RETORTING PROGRAM - SUMMARY - CASE B

Broad Objectives

1. Demonstrate yields and operability with commercial size retort equipment designed from scale-up of Stage I results.

2. Carry out studies to determine the mechanisms whereby the Gas-Combustion process consumes 15 to 20 per cent of the potential yield and to increase fundamental knowledge of the process.

3. Carry out studies to determine the commercial feasibility of obtaining 10 to 15 per cent higher yield via modification of the conventional Gas-Combustion Retort.

Specific Objectives

A. Retort No. 3

1. Demonstrate commercial retort designs for processing 1/4 to 1 inch, 1 to 3 inch, and 1/4 to 3 inch oil shale using a 60 ft^2 retort designed from the Stage I technology.

2. Carry out corrosion - erosion studies to establish material requirements for a commercial retorting plant.

Estimated Operating Time - 180 Days

B. Retorts No. 1 and No. 2

1. Carry out a process variable study in Retort No. 2 to establish the effect on yield of:

   a. Shale size
   b. Shale rate
   c. Air rate
   d. Recycle rate
   e. Bed height

Estimated Operating Time - 120 Days

2. Establish operating conditions for processing rich shale.

Estimated Operating Time - 30 Days

3. Carry out studies to determine if there is a reasonable potential for:

   a. Obtaining a 5 to 10 per cent yield improvement from the full effect of external heating.

Estimated Operating Time - 45 Days

b. Obtaining a 5 to 10 per cent yield improvement and the potential of operating at 700 lbs/(hr)(ft^2) from the use of a retorting soaking zone and/or dust removal design.

Estimated Operating Time - 90 Days

c. Obtaining a 5 to 10 per cent yield improvement by using nucleating agents.

Estimated Operating Time - 45 Days

4. Develop a better understanding of where the Gas-Combustion process consumes 15 to 20 per cent of the potential yield.

a. Evaluate more thoroughly the effect of oil refluxing.

Estimated Operating Time - 30 Days

b. Evaluate startup procedures.

Estimated Operating Time - 30 Days

c. Evaluate the effect of operating conditions on bed density using radiation scintillator techniques.

5. Carry out mist evaluation studies to determine the effect of process variables on mist and the effect of mist on the process.

Estimated Duration of Study - 120 Days

C. Bench Scale Studies

Carry out bench scale studies to increase our fundamental knowledge using a fixed bed of oil shale to determine the effect of:

1. Time-Temperature

2. Sweep Gas

3. Bitumen decomposition and coke generation during retorting.

4. Other miscellaneous studies such as effect of gas composition on retorting, effect of nucleating agents, and water-fines removal from raw shale oil.

(a) Incremental Facilities and Manpower Needs

Incremental facilities to operate two retorts simultaneously were reviewed. Included in this review were:

1. Mining
2. Crushing Plant - Shale Supply
3. Shale Handling and Storage
4. Plant Utilities and Facility Requirements
5. Staff Needs
    a. Mining
    b. Crushing and Shale Handling
    c. Retorting
    d. Analytical
    e. Shop Support
    f. Engineeering Support
    g. Office Staff Support

Discussion

(1) Mining

Mining and shale hauling capabilities will not change existing manpower or equipment needs if the mining option is exercised. One extra miner will be required if it is not exercised. One and a half extra trips per day for one 40 ton truck will be required. Operating costs (powder, etc.) will be proportional to mining needs. Mining is now scheduled for a two shift, five day operation; hauling three shifts per day.

(2) Crushing Plant - Shale Supply

This will be planned on an overtime basis. One extra shift per week when Retort No. 3 is operating on a very high mass (600) would be required. Retort No. 3 shale supply is planned for a two shift seven day operation.

(3) Shale Handling and Storage

The existing shale storage bins are reserved for Retort No. 3 operation. One additional bin with at least 300 tons storage is recommended.

A bucket elevator is required to load the bin. Shale would feed to this elevator on conveyors from the existing storage area. From the new bin, shale would be loaded for transport to the 60 ton bins by a vibratory feeder followed by a conveyor.

(4) Plant Utilities and Facilities

The existing 750 KVA plant substation will not handle both Retort No. 2 and Retort No. 3. A new 14,400/440 volts, 300 KVA transformer for Retort No. 3 is recommended. No additional changes would be required in the existing plant system.

Since two retorts would be operating at one time additional funds will be required for normal expenses. This includes analytical laboratory equipment and supplies, storehouse materials, equipment needs due to an accelerated program, office supplies for an increased clerical staff.

No additional trucking would be needed.

(5) Manpower

A considerable incremental manpower requirement would develop from this type operation. Estimated needs are:

> 34 incremental men if the mining research program is not exercised and 33 men if the mining research program is exercised.

B. Mechanical Models

Initially, the efforts will be directed toward assisting in the rehabilitation of Retort No. 3 and the associated shale storage facilities. This includes assisting in the design of the shale feed and shale drawoff assemblies and the design of internals for the 100 ton storage bins to improve flow and reduce size segregation. Conical inserts hold the most promise for use in these particular bins and some model work will be required to guide the sizing and positioning of the inserts. This work will also aid in evaluating the use of inserts as a means of obtaining uniform flow in a large vessel.

Upon completion of design and fabrication, the major assemblies will be evaluated either in place or external to the retort. This includes testing of screw conveyors and other moving devices. It is anticipated that additional model work will be required to supplement the retorting work as the overall program progresses.

It is proposed that the mist impaction studies be continued into Stage II. The variables include: mist size, gas velocity, mist loading, shale size, bed depth, and fines injection. Some basic studies dealing with mist formation and the flow characteristics of mist-laden gas in empty pipes, in bends, etc. appear to be worthwhile.

In a new effort, it is planned to study the handling of spent shale with respect to minimizing dust and smoke pollution.

C. Mining

1. Program 1 (For Cases A1 and B1)

The mining budget is based upon mining and hauling to the crusher, 560 tons per day of 28 gallon per ton oil shale. Production will be taken from four 60 feet wide rooms in the top 40 feet of the Mahogany Ledge. Drilling, blasting and roof bolting would be accomplished with existing equipment after some minor modifications. A Koehring Scooper and a 40 ton truck would be rented to load and haul the shale. This budget covers the cost of producing shale for Retort No. 3, no provision has been made for any mining research.

2. Program 2 (For Cases A2 and B2)

The mining option includes research which will be oriented principally toward the study of pillar strength and stability and also toward improvement in drilling and blasting techniques.

It is proposed to mine out an area leaving 73 feet high pillars 40 feet square giving a recovery factor of 80 per cent. The extra mining involves the removal of an additional 200,000 tons of oil shale mainly from a 33 feet high lower bench. It is proposed to dispose of this additional tonnage at the dumping point near Adit No. 4. This will be done using two 20 ton trucks on two shifts. The mined out area thus created would simulate quite closely that of a commercial operation. In the center of the area two pillars 73 feet high by 40 feet square would be fully instrumented to measure stresses and deformations in the rock. In order to instrument the pillar site as soon as possible and thereby obtain complete information, an instrument tunnel is proposed; the tunnel would be driven below the area where the two center pillars would later be formed. Two pillars will give more reliable data than one. The information thus gained will be valuable in correctly designing mine pillars in oil shale and in determining the best type of instrumentation to monitor the stability of such pillars. Other instruments will be installed to measure rock measurements and stress changes in the roof while using various configurations of rock bolt patterns. Large savings can be made by determining the minimum number of rock bolts necessary to safely support a given roof span.

Drilling and blasting research would be performed using a rotary drill. For this purpose it is proposed

to purchase a rotary drill jumbo which would enable us to find the best operating conditions of thrust, rotation and bit type; the best design of jumbo for a commercial operation and last, but not least, would permit us to develop a drilling pattern for breaking a 30 foot round. The ability to break a round this deep would result in a substantial reduction of mining costs. Further research would be performed using a down hole rotary drill which would permit a study of bench rounds to determine the optimum blasting pattern. The cost of mining from benches is likely to be much less than that of mining from headings. These costs would be developed.

It is proposed to conduct a series of size - classification analyses on run of mine shale. This information would provide reliable data for the design of a commercial oil shale crushing plant.

D. Analytical Laboratory

The primary task of the Analytical Section is to supply rapid and accurate analytical data for retorting, crushing, and mining studies. Concurrently, it will improve existing methods of analysis and sampling, and develop additional methods as needed. Additionally, the section will do laboratory research with the aim of solving specific problems related to oil shale and shale oil, such as the study of the cause of shale "clinkering", the composition of retort gases at various positions in the retort, the distribution of bitumen and kerogen at different levels in the retort, etc.

E. Cooperative Crushing Research Study

Crushing is an important factor in the recovery of oil from shale. It will represent approximately 20 per cent of the cost of producing shale oil. The total investment for crushing facility of a 50,000 barrel per day has been estimated at $15,000,000. Crushers alone will cost several million dollars.

In addition, crushing affects mining and retorting costs through fines production and retort feed size distribution. Finally, operating costs, maintenance and power consumption are important and will be determined by the crushers initially installed.

Thus, research work aimed at improving selection of crushing equipment has a potential savings of several million dollars for each company. With this in mind, crushing technology has been reviewed with two manufacturers, Allis Chalmers and Nordberg, who possess the specialized skills, equipment and experience needed to define crusher research requirements.

Allis Chalmers and Nordberg have prepared proposals for additional crushing research which should provide the information needed to define commercial equipment and its performance. The research proposals will provide the information listed as requirements on Table 9.

Allis Chalmers currently favors and plans to do additional research work on the single roll crusher. Nordberg favors and plans additional work on the gyratory crusher for the primary crushing stage.

Large scale test of several hundred tons on commercial equipment will be run if facilities are available. The cost for both Allis Chalmers and Nordberg research programs is $60,000.

Research Cost Breakdown

Allis Chalmers	$36,000
Nordberg	17,000
Technical Manpower	7,000
	$60,000

TABLE 9

CRUSHING TECHNOLOGY REQUIREMENTS

I. Proposal Preparation
- A. By March 1, 1966
- B. Present contract committments on results

II. Research Program
- A. Raw Shale Requirements
  1. Size
  2. Amount
  3. Character
     - Representative
     - Richness
- B. Cost
- C. Completion Date

III. Program Goals

A. Equipment
1. No. of Stages
2. Type of Crushers
   a. Primary, Secondary
   b. Advantages, Disadvantages
   c. Feasability of Portable
3. Capacity
4. Size Opening
5. Cost - Crusher, Accessories
6. Delivery
7. Head Room, Room Size

B. Maintenance
1. Service Factor
2. Parts Delivery
3. Maintenance Manning
4. Maintenance Material
5. Measurement of Abrasion
6. Equipment for Servicing
7. Spares - Considerations and Factors Involved
8. Length of Downtimes

C. Product
1. Size Distribution
2. Fines - 1/4" minus
3. Effect of Richness
   a. Power
   b. Fines
4. Effect of Feed Size, Shape
   a. Fines
   b. Number of Stages

D. Economics
1. Two Stages Versus Three
2. Recirculation
3. Effect of Maximum Size, 2, 3, 4 Inch
   a. Define Maximum Size
   b. Fines
   c. Cost

E. Other Factors
1. [illegible]er
2. Dust Control
3. Power Accessories
4. Centralized Lubrication
5. Vibration, Sound

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V. PLANT FACILITIES

Plant facilities needed to support Stage II were reviewed with Research Foundation. Additional equipment for the instrument shop, upgrading of the power distribution to the Retort No. 1 and No. 2 building, housing needs, water plant and storage needs, garage equipment, welding equipment, road resurfacing, and retort engineer office revisions are included.

Equipment Cost	$ 50,000

VI. PRESSURIZED RETORTING - CONSTRUCTION COSTS

A cost has been developed to construct a pressured retort equivalent in size to Retort No. 1. Basically it is designed for 60 PSIG operation, for a 1,100 lbs/(hr)(ft^2) shale mass flow, 16,000 SCF/Ton recycle, 5,500 SCF/Ton air. No preheat at pressure is provided. The unit would be started in the normal manner and pressured after startup.

The recovery system will exclude the precipitator, be at operating pressure, and have the most efficient mechanical system found to date.

Lock hoppers will be employed. A new retort body will be fabricated and the conveyor feeding the retort will be raised. A considerable amount of new structuring is included.

Since the recycle blower will be sized for 60 PSIG operation at the recycle and mass flow stated, its flow is limited at lower pressures.

Plant air for combustion will be used from existing service piping.

All construction will be by Research Foundation personnel.

Equipment Cost	$ 55,000
Plus - Estimated Construction Labor	550 Man Days

(No estimate of program time or manpower for this option has been developed because of the uncertainties involved.)