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MOBIL RESEARCH AND DEVELOPMENT CORPORATION

RESEARCH DEPARTMENT

TECHNICAL MEMORANDUM NO. 67-36

REHABILITATION OF RETORT NO. 3
ENGINEERING, CONSTRUCTION, AND COSTS

ANVIL POINTS OIL SHALE RESEARCH CENTER

Rifle, Colorado

October 20, 1967

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The primary object of the Anvil Points Oil Shale Research Center TECHNICAL 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 TECHNICAL 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 TECHNICAL MEMORANDA have not been edited in detail.

(1)Mobil Research and Development Corporation, Project Manager

Continental Oil Company
Humble Oil and Refining Company
Pan American Petroleum Corporation
Phillips Petroleum Company
Sinclair Research, Inc.

REHABILITATION OF RETORT NO. 3
ENGINEERING, CONSTRUCTION, AND COSTS

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REHABILITATION OF RETORT NO. 3
ENGINEERING, CONSTRUCTION, AND COSTS

I. INTRODUCTION

During January of 1966, a comprehensive study was initiated to finalize the programs, needs, and costs for a Stage II Research Program at Anvil Points. Stage I and its Extension Program were scheduled for completion during April 1966. Preparation for the Stage II Program was completed February 28, 1966. (References 1, 2 and 3).

An agreement was reached March 31, 1966 between the Participating Parties for further experimentation - in Mining, Retorting and Crushing, which authorized Stage II.

One of the principal efforts early in Stage II was the rehabilitation of Retort No. 3 and supporting facilities. This memorandum will discuss the Engineering Design, Construction, and Costs of this work.

Since the Stage II Program was funded for only 18 months duration, it was necessary to construct experimental facilities in the quickest time possible. The Vietnam War was also being escalated during the summer of 1966, complicating material procurement procedures. The cooperation of various contractors and suppliers in preplanning work and arranging contractual details before the formal signing of the Stage II Research Program, and at no cost to the project, shortened the engineering and construction period to a minimum.

II. SUMMARY

Retort No. 3, the shale crushing plant, and supporting ground level utilities were completely modified for the Stage II Retorting Program to process shale at a flow rate of 500 tons per stream day. The design and construction of this work was contracted to the F. C. Torkelson Company of Salt Lake City, Utah, on a cost plus percentage fee basis.

The design, purchasing,and construction effort were projected for completion in a six month period. Costs of this work were estimated to be $725,000.

Construction was actually completed in seven months at a cost of $920,000.

Coordination between the design and construction effort was satisfactory. However, material deliveries lagged construction schedules because of the general business conditions resulting from the intensified effort in Vietnam during mid and late 1966. Retort No. 3 was ready for startup testing November 15, 1966.

III. DISCUSSION

A. Design Criteria

1. General Design Conditions

Retort No. 3 was extensively revised for Stage II studies. The general philosophy guiding its design was directed toward proving scaleup and commercialization potentials. Basically, a modular design concept was used in the development of the retort. Retort No. 3 and its internals were to serve as prototypes; larger unit internals being multiples of the Retort No. 3 distribution and drawoff device modules.

Scaleup of processing conditions, air, gas and shale handling equipment and systems developed during Stage I were to be proven in this retort. Purchased materials and equipment were to be of commercial potential. Other material handling equipment or systems designed and fabricated for Retort No. 3 were also to be of commercial potential.

Finally, the retort and all supporting facilities and utilities were to be fully integrated to provide a complete processing plant.

2. Process Design Conditions (Reference 1)

a. Shale rate - 500 tons per day based on a shale rate of 700 lbs/(hr)(ft^2).

b. Air rate - 6500 SCF/T maximum at 700 lbs/(hr)(ft^2) shale rate.

c. Recycle rate - 14,000 SCF/T maximum at 700 lbs/(hr)(ft^2) shale rate.

d. Shale size range - 1/4 to 1 inch, 1 to 2 1/2 inch and 1/4 to 2 1/2 inch.

e. Bed Heights - 5 to 15 feet above air distributor, variable.
6 to 7 feet below air distributor, variable.

f. Distributors - Air - Single level, riser type, across 6 foot span.
Recycle - Single level, perforated pipe type, across 6 foot span.

3. Retort Design Conditions (Reference 1)

The cross-section of the retort was to be sized to serve as a pilot plant prototype, being a module of a commercial size rectangular retort element.

a. The cross-sectional dimensions selected were 6 feet by 10 feet, which permitted use of the existing shell.

    1. The 6 foot dimension was considered to be approximately one-half of a practical maximum span of a commercial retort.

    2. The 10 foot dimension was considered to be large enough to represent a repeating module and produce any operational difficulties which might occur in a larger unit.

b. The retort walls were straight and vertical with no taper or liner.

c. The retort walls were lined with brick suitable for commercial application.

d. Raw Shale Inlet - anti-segregation system was designed.

e. Spent Shale Outlet - multipipe single level drawoff system was designed.

    1. Calming height needs were incorporated in design.

It is the judgment of the Mechanical Engineering Group that data developed on shale flow, air and gas distributors, and unit operability with the rectangular retort is also adaptable to a circular cross-sectional retort.

4. Supporting Facilities (Reference 1)

All supporting facilities and utilities were upgraded to support the retort design capacity. Specific design modifications included:

a. Crushing plant was revised and upgraded to be operative 16 hours per day - 7 days a week. Crushing, screening, and conveying equipment was designed to produce 30 tons per hour of the three shale fractions specified.

b. Crushed shale storage capacity was designed for two days' retorting to allow for major crusher plant repairs.

c. Process instrumentation developed flow measuring and/or rate control systems with a 1% accuracy or better for air, recycle gas, vent gas, raw shale and liquid product.

d. Mist recovery equipment was designed to remove 99.5% or more of the product formed as mist.

e. Liquid product treating equipment was designed to deliver oil with less than 1.0% water.

B. Cost Estimate

A conceptual flow diagram (Reference 4) and retort configuration (Reference 5) were developed for Stage II retorting. From these and the design criteria, cost estimates were prepared. (Reference 1).

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

Much of the existing crushing equipment was satisfactory. However, little of the existing retorting equipment was utilized for Stage II. Such equipment that was used required extensive renovation and repair.

Costs were included to contract the services of a reputable engineering firm for engineering and drafting. Rehabilitation of retorting, plant, and crushing facilities was planned to be contracted to an outside contractor and executed under the direction of the engineering firm.

Table 1 is a summary of the cost estimate prepared for Retort No. 3 rehabilitation. (Reference 1).

C. Contractural Arrangements

1. Type of Contract

After reviewing the scope of the work of rehabilitating the retort, the use of an engineer-constructor contractural arrangement was judged to be the best method of completing the job within the desired time schedule. A six month design and construction period was allotted in the Stage II Program.

In addition, the six months' schedule precluded using normal procedures of completing designs and specifications, obtaining construction bids, and then awarding

TABLE 1

COST ESTIMATE
RETORT NO. 3 REHABILITATION
FEBRUARY 1966

Retort-Crusher-Plant Facilities		Design Cost (Includes Fee)	Material Cost	Construction Cost
1.	Crusher Plant Storage Bins Shale Handling	$25,000.00	$87,000.00	$39,600.00
2.	Retort No. 3, Battery Limits	62,000.00	228,000.00	145,000.00
3.	Liquid Product Treating and Tankage	5,000.00	18,300.00	9,800.00
4.	Plant Facilities	5,000.00	16,200.00	9,100.00
5.	Equipment Rental	___	24,000.00	___
6.	Contingency	---	34,000.00	17,000.00
		$ 97,000.00	407,500.00	220,500.00

Total Cost $725,000.00

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a construction contract. The work of both design and construction was awarded on a cost plus percentage fee basis.

2. Award of Contract

Three engineering firms in the local area were selected to bid this job. To work with a firm further in distance than Denver or Salt Lake City was unwarranted for a job of this nature and scope.

These firms were:

F.C. Torkelson Company, Salt Lake City, Utah
Stearns-Roger, Denver, Colorado
Ken R. White Company, Denver, Colorado

Bid invitations were initiated for the engineering and construction, and bid proposals were received March 23, 1966. After a careful analysis of the three bid proposals, the F. C. Torkelson Company was the apparent low bidder and awarded the contract. Their bid had a $19,000 advantage over the second low bidder, Stearns-Roger (Table 2).

Stage II of the Research Program had not been authorized at that time. However, the F. C. Torkelson Company was willing to continue contractural negotiations to facilitate the start of work when Stage II was authorized.

A contract was written and submitted to the Office of General Counsel, Mobil Oil Corporation (previously Socony Mobil Oil Company) for review and approval. This contract was approved by the Law Counselors of The F. C. Torkelson Company, Mobil Oil Corporation and the Colorado School of Mines Research Foundation, Inc. All parties cooperated to the fullest in generating this contract in three weeks time. The contract was signed April 11, 1966.

3. Terms of Payment

Costs paid to The F. C. Torkelson Company as Prime Contractor were:

a. Engineering and Design Costs

1. Direct payroll of engineering, engineering construction supervision, and office personnel.

2. Payroll overhead costs equal to 15.45% of the above.

TABLE 2

BID ANALYSIS
DESIGN AND CONSTRUCTION
REVISE RETORT NO. 3 AND SUPPORTING FACILITIES

	Anvil Points Estimate*	TORKELSON Unit Cost	TORKELSON Extended Cost	STEARNS-ROGER Unit Cost	STEARNS-ROGER Extended Cost	KEN R. WHITE Unit Cost	KEN R. WHITE Extended Cost
Design Engineering							
Purchasing & Clerical	1,500 Hr	3.50/Hr	5,250	3.50/Hr	5,250	3.50/Hr*	5,250
Engineering - Project	2,000 Hr	6.17/Hr	12,300	6.40/Hr	12,800	6.40/Hr*	12,800
Engineering - Design	800 Hr	3.81/Hr	3,050	4.09/Hr	3,250	4.09/Hr*	3,250
Draftsmen - Senior	2,220 Hr	3.60/Hr	7,950	4.47/Hr	9,900	4.47/Hr*	9,900
Draftsmen - Junior	1,060	2.66/Hr	2,800	2.83/Hr	3,000	2.83/Hr*	3,000
Payroll Burden		15.45%	4,850	13.2%	4,500	15%	5,100
Overhead Burden		50%	18,200	100%	38,500	100%	39,100
Supplies	*	At Cost	2,000	At Cost	2,000	At Cost	2,000
Other Costs	*	At Cost	1,000	At Cost	1,000	At Cost	1,000
Travel - Expenses	*	At Cost	4,000	At Cost	4,000	At Cost	4,000
Purchase Equipment	*	At Cost	317,000	Cost + 1%	320,000	At Cost	317,000
Construction Labor							
Payroll	*	At Cost	150,000	At Cost	150,000	At Cost	150,000
Payroll Burden	*	9%*	13,500	9%*	13,500	9%*	13,500
Overhead		10%	15,000	--	--	--	--
Construction Supervision							
Payroll (Two Included)	20 Wk	350/Wk	7,000	415/Wk	8,300	415/Wk*	8,300
Payroll Burden		9%*	600	13.2%*	1,100	13.2%*	1,100
Overhead Burden		10%	700	--	--	--	--
Living Expenses (Two Included)	20 Wk	70/Wk	1,400	100/Wk	2,000	100/Wk*	2,000
Field Engineering							
Payroll (One Included)	20 Wk	260/Wk	5,200	200/Wk	4,000	200/Wk*	4,000
Payroll Burden		15.45%	800	13.2%	500	13.2%	500
Overhead Burden		50%	3,000	--	--	--	--
Living Expenses	20 Wk	60/Wk	1,200	40/Wk	800	40/Wk	800
Construction Tools-Equipment							
Small $250 Limit		In Fee	--	3% Labor*	4,500	3% Labor	4,500
Large		100% AED	15,000	100% AED	15,000	100% AED	15,000
Field Expenses							
Transportation	*	At Cost	500	At Cost	500	At Cost	500
Other	*	At Cost	500	At Cost	500	At Cost	500
Total Cost			592,800		604,900		603,100
Fee		7%	41,500	8%	48,400	9%	54,300
Contingency			51,000		51,000		51,000
GRAND TOTAL			685,300		704,300		708,400

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3. Overheads equal to 50% of the sum of the first two items.

4. Office materials and expenses, engineering subcontracts and travel expenses at cost.

b. Construction and Subcontract Costs

1. Union labor costs including subsistance, travel allowance, and fringe benefits.

2. Contractors, superintendance, accounting and clerical costs.

3. Construction subcontractor overhead costs equal to 10% of the direct labor costs (Items b.-1. and b.-2. above).

4. Equipment rental on items having a unit cost in excess of $250.00 at cost.

c. Purchased Materials

1. Materials and equipment at cost less discount.

d. Fee

1. Seven percent of the total of all costs.

Incorporated in the contract was a provision for retention of 10% of the billed costs until final acceptance of the job.

D. Engineering and Construction

1. Project Administration and Cost Control

a. F. C. Torkelson Company

The F. C. Torkelson Company, located in Salt Lake City, Utah, is a medium sized engineering service organization with a staff of approximately 140 people. Their experience includes engineering and architectural designs for mining complexes, processing plants, material handling systems and heavy industrial equipment.

The Torkelson technical staff includes Mechanical, Electrical, Civil and Mining Engineers. When a significant portion of the design work requires unusual chemical or instrumentation know-how, consultants in the Salt Lake City area are hired to supply these services. For the Retort No. 3 rehabilitation, an instrumentation consultant was retained.

Torkelson has engineered many industrial jobs with construction costs ranging from $100,000 to $8,000,000.

Torkelson does not, as a rule, enter into contracts to supply both engineering and construction services. However, for this work, Torkelson was the Prime Contractor. They in turn subcontracted the construction to Colorado MACCO, Inc., of Grand Junction, Colorado.

b. Project Organization

The F. C. Torkelson Company used the Project Group approach to the management and organization of their work. Their bid proposal states:

"A member of the Torkelson's Operations Management Group is assigned as Project Director on every project, serving as administrative consultant to insure suitability of basic scheduling and cost estimates, assignment of qualified personnel, and assurance of fulfillment of the Company's contractural obligations to the complete satisfaction of the Client.

A Project Engineer is selected on the basis of experience on projects of a similar nature and magnitude and assigned to the project, for its full duration, to be responsible for coordination, scheduling, production, and expediting of the work. Additional Permanent Project Personnel are assigned as the size and scope of the project dictates. The Project Engineer can call upon the various departments for specialized assistance at any time.

As the work progresses Design Engineers, Designers, Draftsmen, Support, and Office Service personnel are assigned to the Project Staff as required."

The following outline indicates the Project Organization which Torkelson proposed for the work.

Project Director - Client Coordination and Liaison.

Project Engineer - Project Supervision.

Chief Project Draftsman - Drafting Supervision*

Engineering Department Heads and Group Engineers - Assigned permanently or as consultants to the project, as required, to provide and direct Engineering Design.

Design Engineers, Designers, and Draftsmen - As required.

Engineering Support and Office Service Personnel - As required.

Procurement Personnel.

Field Engineer and Construction Supervisor.

Monthly Audit of time and materials accounts by a C.P.A.

*Utilized only to the extent that the scope or magnitude of the work would warrant supervision over and above that given by the Project Engineer.

Mr. H. J. Woestemeyer of the Torkelson staff served jointly as Project Director and Project Engineer. He is Vice-President of Operations at Torkelson. Earlier in his professional career, Mr. Woestemeyer was employed at Anvil Points with the Bureau of Mines as Chief of the Plant Engineering Section.

c. Cost Control

(1) Cost Estimates

The Torkelson Company was requested to prepare a cost estimate of the work early during the design phase of rehabilitating Retort No. 3. This estimate was to serve as an independent cost appraisal of the work.

Torkelson prepared a preliminary estimate during May 1966. A firm cost estimate was later prepared by Torkelson during September 1966 when the design work and a good portion of the construction effort was completed. The May 1966 estimate was used for cost control and comparative purposes.

Torkelson's May 1966 estimate of the project cost closely approximated the Anvil Points' estimate. The September 1966 estimate indicated that only a slight overrun would occur.

These cost estimates and the final job costs are shown on Table 3. The cost of the completed work was $920,000.00 in comparison with early cost estimates of $725,000.00.

An analysis of the increased cost of the work is discussed later in the memorandum.

(2) Monthly Evaluation of Costs

An accounting and monthly billing procedure was established with Torkelson acceptable to the Mobil Oil Corporation, Paulsboro Laboratory, Accounting Department. The monthly billing was also itemized to afford a comparison of engineering, materials, and construction costs with the May 1966 estimated costs. Tables 4, 5 and 6 exemplify this feature of monthly billing.

In addition to these costs, the amount of committed but unbilled material costs was reviewed monthly to assess overall commitments.

The most difficult cost to assess was that for uncompleted construction. Repeated meetings with Torkelson's engineering and construction supervisors to develop estimates of work during the last months of construction failed to produce realistic evaluations of remaining costs.

2. Design Engineering

Torkelson's Engineers were on site the week of April 11, 1966 to inspect existing facilities - electricals, mechanicals, instruments, and plant utilities. The process was reviewed in detail with their staff, all intermediates of existing drawings transmitted and the project initiated.

a. Design

Torkelson's key project personnel had been chosen prior to the signing of the contract. Design work began immediately in early April 1966.

TABLE 3

RETORT NO. 3 - COST PROJECTIONS AND FINAL COSTS

PROJECT CONSTRUCTION BUDGET - $725,000

	Stage II Scoping Study Feb. 28, 1966 Estimate	Torkelson Co. May 1966 Estimate	Torkelson's Sept. 9, 1966 Estimate	Final Cost of Rehabilitation
1. Engineering & Construction Supervision	47,000	74,000	103,000	120,590.82
2. Materials - Equipment	373,500	346,000	356,000	405,634.58
3. Construction & Construction Supervision	203,500	222,000	241,000	334,625.92
4. Contingency	51,000*	38,000	--	--
5. Fee	50,000	45,000	49,000	60,084.42
Total	$725,000	$725,000	$749,000	$920,935.74

*Contingency - $34,000 Materials
Split $17,000 Construction

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TABLE 4

TYPICAL EXAMPLE MONTHLY BILLING - ENGINEERING

Colorado School of Mines
Research Foundation, Inc.

Period Covered - August 1, to September 1, 1966	Current Month	Cost To Date	Estimated Total Cost
I. Engineering			
1. Crusher Plant	$ 282.93	$ 6,671.02	$ 3,408.00
2. Storage Bins	12.36	1,648.46	4,052.00
3. Shale Handling	3,166.13	9,035.05	4,591.00
4. Retort No. 3			
a. Instrumentation	4,042.79	8,539.38	3,408.00
b. Piping, Compressors and Recovery Equipment	1,659.83	9,502.13	6,816.00
c. Retort Revisions & Internals	2,852.76	10,272.07	8,716.00
d. Spent Shale Handling	4,876.18	12,418.35	8,336.00
5. Liquid Product Treating & Tankage	1,363.14	1,736.87	4,052.00
6. Plant Utilities	64.00	2,420.24	4,052.00
7. Equipment Rental	-	-	-
8. Demolition	-	39.98	-
9a. General Expense	2,419.72	10,223.20	8,760.00
9b. Engineering General Expense	1,127.72	3,834.30	4,000.00
10. Purchasing and Clerk	4,092.24	9,467.24	6,250.00
11. Field Construction Superintendent	1,964.43	6,238.72	7,600.00
12a. Construction Supervision	-	-	-
12b. Construction General Expense	-	-	-
TOTALS	$ 28,734.23	$ 92,047.01	$ 74,041.00

TABLE 5

TYPICAL EXAMPLE MONTHLY BILLING - CONSTRUCTION

Colorado School of Mines
Research Foundation, Inc.

Period Covered - July 28, to September 1, 1966	Current Month	Cost To Date	Estimated Total Cost
II. Construction			
1. Crusher Plant	$ 3,357.18	$ 10,458.12	$ 18,829.00
2. Storage Bins	6.434.16	13,955.93	22,150.00
3. Shale Handling	5,991.31	16,467.74	6,850.00
4. Retort No. 3			
a. Instrumentation	362.41	362.41	26,800.00
b. Piping, Compressors and Recovery Equipment	1,990.07	2,328.81	36,740.00
c. Retort Revisions & Internals	15,564.86	36,736.55	34,221.00
d. Spent Shale Handling	7,703.72	7,881.15	19.666.00
5. Liquid Product Treating & Tankage	3,841.28	7,351.65	11,000.00
6. Plant Utilities	2,678.45	3,084.44	6,110.00
7. Equipment Rental	5,956.19	10,646.17	11,320.00
8. Demolition	939.53	9,718.30	12,000.00
9a. General Expense	659.16	1,683.02	-
9b. Engineering General Expense	-	-	-
10. Purchasing and Clerk	1,782.88	4,175.60	5,248.00
11. Field Construction Superintendent	-	-	-
12a. Construction Supervision	1,237.50	3,613.50	8,694.00
12b. Construction General Expense	14,591.67	33,118.11	1,990.00
TOTALS	$ 73,092.37	$ 161,581.50	$ 221,618.00

F. C. TORKELSON CO.
ENGINEERS

TABLE 6

TYPICAL EXAMPLE MONTHLY BILLING - PROCUREMENT

Colorado School of Mines
Research Foundation, Inc.

Period Covered -	Current Month	Cost To Date	Estimated Total Cost
III. Procurement			
1. Crusher Plant	$ 6,836.31	$ 12,817.27	$ 17,529.00
2. Storage Bins	500.03	2,930.06	27,033.00
3. Shale Handling	10,320.89	12,729.19	19,200.00
4. Retort No. 3			
a. Instrumentation	8,147.10	8,605.68	55,000.00
b. Piping, Compressors and Recovery Equipment	11,059.36	15,859.60	122,408.00
c. Retort Revisions & Internals	8,009.50	15,055.03	40,320.00
d. Spent Shale Handling	5,482.15	6,856.89	40,067.00
5. Liquid Product Treating & Tankage	472.37	824.21	8,741.00
6. Plant Utilities	8,436.49	9,272.87	10,800.00
7. Equipment Rental	-	-	-
8. Demolition	-	299.42	-
9a. General Expense	1,072.40	4,059.08	5,100.00
9b. Engineering General Expense	-	-	-
10. Purchasing and Clerk	-	-	-
11. Field Construction Superintendent	-	-	-
12a. Construction Supervision	-	-	-
12b. Construction General Expense	-	-	-
TOTALS	$ 60,336.60	$ 89,309.30	$ 346,198.00

Most of the design work was completed by the middle of August. Torkelson had as many as 30 design engineers and draftsmen working on this project at one time.

Final drawings were updated to reflect installed conditions.

At the completion of the design and construction effort, all drawings were copied and reduced in size to form an 8 1/2 by 14 inch booklet. Two booklets were distributed to each of the Participating Companies.

b. Material Procurement

A concerted effort was initiated to purchase all the long delivery equipment as early as possible. Necessarily, this was done prior to completion of most designs. Items in this category included the electrostatic precipitator, star feeders, line burner, instrumentation, motor control centers, conveyors, and liquid product measuring equipment.

Next, all items that were needed during the early construction stage were ordered. By mid August, 95% of the materials for the work had been ordered.

A close liaison was also maintained between the job site and Torkelson's purchasing agent to expedite material delivery.

3. Project Scheduling

Engineering, material specifications and procurement, and construction were to be completed in a six month period. A planning system was needed. Torkelson was authorized to prepare a detailed schedule to properly coordinate plans.

A PERT diagram was developed. Over 200 events were programmed. Many more events could have been included but the detail presented was felt to be sufficient for control of this work. This information was committed to an IBM 7044 computer. Printouts from the computer were used to schedule and review the work and material deliveries.

The PERT network was revised and updated monthly during the first four months (during the design, material procurement, and early construction phase). Construction was completed using the final PERT as a guide.

However, many suppliers did not meet their committed delivery schedules and construction plans had to be revised to be consistent with available materials.

The use of the PERT network did assist measurably throughout the project. It was used not only at Torkelson's office but also at the construction site to check current and scheduled work, and manpower and material needs.

The cost of developing and maintaining the PERT was approximately $1200.00.

4. <u>Construction</u>

Construction work was subcontracted by the Torkelson Company to Colorado MACCO of Grand Junction, Colorado. Colorado MACCO is a local industrial contractor with a good reputation in the Grand Junction area. Colorado MACCO has completed several installations at the American Gilsonite and Union Carbide Plants in this area.

Colorado MACCO maintains a small staff of well qualified men and hires additional manpower as needed.

All work at Anvil Points rehabilitating Retort No. 3 was performed with manpower supplied by various national trade unions. Manpower was drawn from Colorado and all bordering states. At times, as many as 70 men were employed by the contractor at the site.

Rehabilitation of Retort No. 3 began during May 1966 with the demolition of most equipment on the Retort No. 3 structure. Work was closed out at the end of October 1966.

As much work as possible was prefabricated in shops in Grand Junction and Salt Lake City. Locally, the Grand Junction Steel Fabrication Company facilities were utilized. Their shop is well equipped for carbon steel fabrication and they compete for work nationally.

The first two weeks of November 1966 were spent completing instrumentation installation and equipment testing. The Colorado School of Mines Research Foundation personnel and manufacturers representatives were used for this work. Late delivery of much of the instrumentation from Fischer & Porter Co. delayed its installation until this period.

5. Actual Project Costs

The final cost of the job was $920,000.00. This represented a budget overexpenditure of approximately $195,000.00. Table 2 reviews estimates prepared at various times for this job and final job costs.

A careful analysis was made of the overall job costs, design criteria, design engineering, materials purchased, construction procedures, and construction problems to determine not only where the extra funds were spent but why they were needed. A summary of the $195,000.00 overexpenditure is shown on Table 7.

Basically, extra costs were encountered because of:

a. Changes in plans due to the unsatisfactory condition found with existing equipment when it was dismantled.

    During the rehabilitation of the crusher plant, detailed inspections were made of crushing plant equipment. The motor control center, crusher wiring, and apron feeder were deemed unreliable for sustained operations. Since changes or extensive revisions made at a later date would be at the expense of Retort No. 3 operating time, these items were replaced.

    Other field decisions involved upgrading conveyor, wiring, and product systems which were found defective or unreliable upon disassembly

b. Process changes requiring additional engineering and construction.

    Process changes were not extensive. They included additional flow calibrating equipment a pressurized gas sampling system, the addition of zero speed switches on all conveying equipment, and spare instruments and equipment. This equipment proved to be necessary and useful in operation.

c. Delays in equipment delivery which extended construction time and interrupted construction continuity.

    Throughout the construction period, delays in receipt of purchased equipment were experienced. Rotary feeders, instruments,

TABLE 7

RETORT NO. 3 - COST ESTIMATE

ANALYSIS OF BUDGET OVER-EXPENDITURE

Budget - $725,000
Estimated Final Cost - $920,000

1.	Field decisions necessitating additional engineering, construction, and equipment when detailed inspections showed existing equipment to be unsatisfactory for reliable and sustained operation. Estimated added cost	$ 67,000
2.	Process changes necessitating additional engineering, construction, and equipment. Estimated added cost	33,000
3.	Unusual delays in equipment delivery have resulted in extending the construction time one month and interrupting the continuity of the work effort. This condition resulted in additional overhead and construction costs. Estimated added cost	30,000
4.	Low cost estimate of (a) planned electrical work for $23,000 and (b) planned engineering cost for $27,000. Total added cost	$ 50,000
5.	Added fee due to higher job cost	15,000
	Total - Estimated added cost	$195,000

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some electrical components, motor valves, the line burner, and many other components did not arrive when scheduled. The net effect was that the continuity of work was interrupted, and construction time was extended one month over the six month period planned. As a result, extra costs were sustained, both in additional overheads and construction.

d. Low estimates of the planned electrical work and engineering design.

A review of estimated costs of planned work revealed that the estimates of electrical work and engineering were low. In addition the productivity level of the electrical workmen was exceptionally low. Since this job was of short duration, no additional traveling electricians in a four state area were available as replacements.

6. Contractor Performance

a. F. C. Torkelson Company, Engineers, Salt Lake City, Utah

Torkelson did a good engineering job and maintained a high productivity level. Their staff was small and it was recognized at the time the contract was signed that they were light in process experience. However, the job did move rapidly. Design, material procurement, and construction schedules were tight, with no room for delays. Torkelson was most energetic in their handling of the job in general and expended a considerable effort to overcome material delays.

The contractural arrangements presented no problems either with the School of Mines Research Foundation or between the prime and subcontractors.

Torkelson's field supervision and coordination between field and office effort was satisfactory.

One area of frustration, however, was the lack of good estimates near the end of the job for cost control purposes. Not enough time was spent to properly judge remaining work. This, in part, may have been due to the concerted effort to bring the job to completion as early as possible.

b. Colorado MACCO, Grand Junction, Colorado

Colorado MACCO, the construction contractor, performed well. Their foremen were particularly effective in getting the work accomplished properly. The quality of their general construction work was very good. Very few problems were created by faulty workmanship.

Productivity levels of the workmen were satisfactory. Coordinating within MACCO organization also appeared satisfactory.

c. Midwest Electric, Grand Junction, Colorado

Midwest was the electrical subcontractor. They operate in a manner similar to MACCO in that they maintain a skeleton crew and hire electrical travelers as jobs develop.

The productivity of the electrical workers was, in general, poor.

The quality of the work was satisfactory except for one or two instances where sloppy workmanship could be related to an individual electrician.

Electrical help in this area is limited and any construction will depend upon travelers.

7. Supplier Performance

Suppliers performed fairly well in meeting the delivery schedule requirements of this job. Notable exceptions were Fischer & Porter, the Fuller Company, and General Electric.

The purchasing agent at Torkelson coordinated material needs very closely with their construction superintendent. General delays of two weeks were not uncommon, however. While short delays of that nature could not be considered severe or unusual due to material shortages created by the Vietnam War, they impaired the construction effort.

a. Fischer & Porter Co.

Late delivery of instrumentation from the Fischer & Porter Co. seriously delayed construction, startup, and testing. Fischer & Porter missed their promised delivery by two months. All efforts by the Participating Parties to improve or even maintain an amended late schedule were to no avail.

Prior to the award of the contract for instrumentation, the three low bidders were contacted to review delivery promises. Current delivery schedules, shop backlogs, and priority delivery commitments were discussed to assure placing the order with the company most likely to meet its delivery schedule.

After placing the order with Fischer & Porter, continual checks of delivery schedules were maintained. As late as August 10, they reported no disruption of the schedule. When the first units did not arrive on schedule early in September, short delays were projected. These delays finally developed into a two month delay in delivery.

b. The Fuller Company

Delivery of the Fuller Company star type rotary feeders was delayed due to a strike of several months duration. Finally the star feeders were removed from Retort No. 2 and installed on Retort No. 3 for startup and testing.

c. General Electric Company

The spent shale slusher motor, ordered from the General Electric Company, did not arrive until the spring of 1967. However, the supplier did install a used motor for the interim period.

d. United Precision, Salt Lake City, Utah

The stainless steel air headers, manifolds, and risers were fabricated by United Precision in Salt Lake City. United Precision has excellent shop facilities and specializes in fabrication of shapes of metals other than carbon steel. The quality of their work was very good. No such facilities are available in Grand Junction.

e. Koppers Company

The Koppers Company cooperated fully to deliver the electrostatic precipitator when scheduled. Koppers also installed and tested the precipitator when requested. The service performance of the unit was excellent.

f. General Equipment Suppliers

A considerable effort was required to bring much of the new equipment to a reliable operating condition. Test work of this nature is normal to construction work. However, an abnormal amount of new equipment, all furnished by nationally known suppliers, either failed to function properly initially or failed in service early during operations.

Several specific examples include

(1) The motor control center for the crusher plant was housed and wired into a non dust-proof housing. A dustproof housing had been ordered. I-T-E Circuit Breaker Company supplied this equipment.

(2) The top star feeder casing fell apart New Years Eve, 1966 - a defective casing. Fuller Company supplied this equipment.

(3) The spent shale controller had to be completely revised at Anvil Points. This control system was supplied by The Louis Allis Co.

(4) Shale weighing timing equipment was highly erratic. Two units (one spare) were continuously in rotation for servicing. This unit was supplied by Merrick.

(5) The problems with the secondary roll crusher furnished by Allis-Chalmers were too numerous to recount. The unit was structurally underdesigned.

(6) The temperature controller for the line burner was finally replaced. Factory servicing could not solve the problem. This unit was supplied by Minneapolis Honeywell.

A three month period was required to overcome most of these problems. During this time, retort testing was performed.

IV. REFERENCES

1. "Scoping Study for Stage II," Special Memorandum; February 28, 1966.

2. "Monthly Progress Memorandum," Anvil Points Oil Shale Research Center, February 21, 1966, Pages 10 and 11.

3. "Monthly Progress Memorandum," Anvil Points Oil Shale Research Center, March 28, 1966.

4. "Process Flow Diagram for Retort No. 3," Drawing RB 93-0, February 25, 1966.

5. "Conceptual Retort Section, Retort No. 3," Drawing RB 96-0, February 25, 1966.