



FE17758

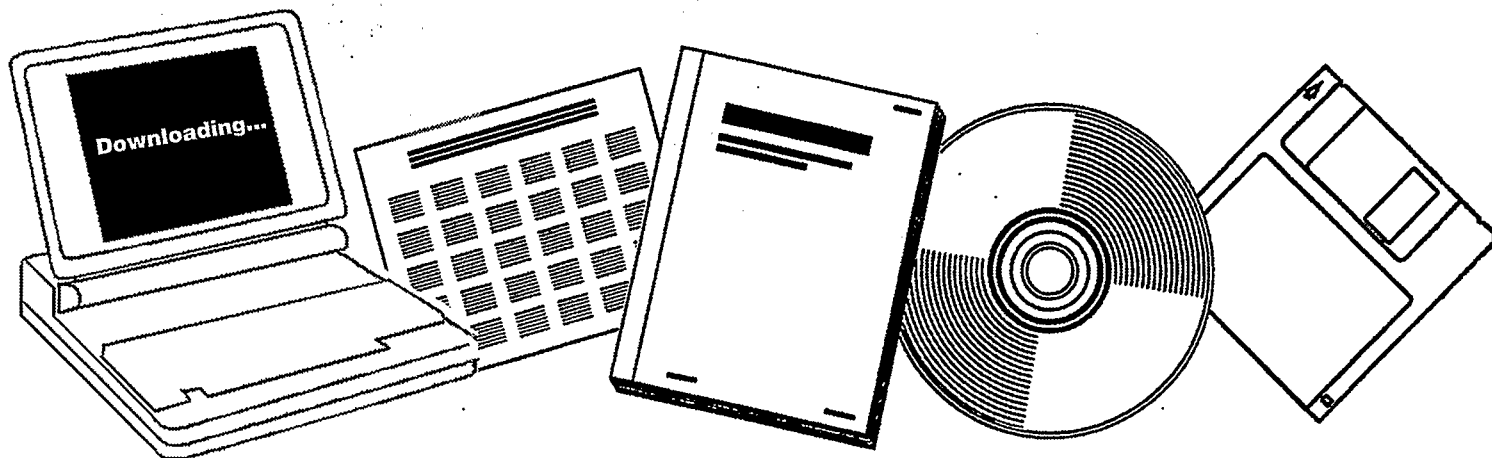
**NTIS**

One Source. One Search. One Solution.

**OIL/GAS COMPLEX CONCEPTUAL DESIGN/ECONOMIC  
ANALYSIS: OIL AND SNG PRODUCTION. R AND D  
REPORT NO. 114, INTERIM REPORT NO. 4**

PARSONS (RALPH M.) CO., PASADENA, CALIF

MAR 1977



U.S. Department of Commerce  
**National Technical Information Service**

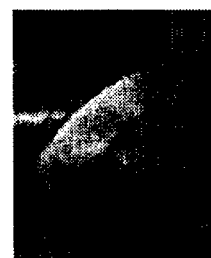
**One Source. One Search. One Solution.**

# NTIS



## **Providing Permanent, Easy Access to U.S. Government Information**

National Technical Information Service is the nation's largest repository and disseminator of government-initiated scientific, technical, engineering, and related business information. The NTIS collection includes almost 3,000,000 information products in a variety of formats: electronic download, online access, CD-ROM, magnetic tape, diskette, multimedia, microfiche and paper.



### **Search the NTIS Database from 1990 forward**

NTIS has upgraded its bibliographic database system and has made all entries since 1990 searchable on [www.ntis.gov](http://www.ntis.gov). You now have access to information on more than 600,000 government research information products from this web site.

### **Link to Full Text Documents at Government Web Sites**

Because many Government agencies have their most recent reports available on their own web site, we have added links directly to these reports. When available, you will see a link on the right side of the bibliographic screen.

### **Download Publications (1997 - Present)**

NTIS can now provides the full text of reports as downloadable PDF files. This means that when an agency stops maintaining a report on the web, NTIS will offer a downloadable version. There is a nominal fee for each download for most publications.

For more information visit our website:

**[www.ntis.gov](http://www.ntis.gov)**



U.S. DEPARTMENT OF COMMERCE  
Technology Administration  
National Technical Information Service  
Springfield, VA 22161

OIL/GAS COMPLEX  
CONCEPTUAL DESIGN/ECONOMIC ANALYSIS

OIL AND SNG PRODUCTION

R & D REPORT NO. 114 - INTERIM REPORT NO. 4

*Prepared by*  
The Ralph M. Parsons Company  
100 West Walnut Street  
Pasadena, California 91124

*Authors*  
J. B. O'Hara, G. H. Hervey, S. M. Fass,  
N. E. Jentz, H.W. Klumpe, B. I. Loran, E. A. Mills, R.V. Teeple

Date Published: March 1977

*Prepared for*  
MAJOR FACILITY/PROJECT MANAGEMENT DIVISION  
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION  
WASHINGTON, D. C. 20545

*Under the Direction of*  
David Garrett, Chief, Process Systems Branch  
Neal P. Cochran, Senior Technical Advisor  
Contract No. E(49-18)-1775

## CONTENTS

SECTION 1	INTRODUCTION . . . . .	1-1
SECTION 2	SUMMARY . . . . .	2-1
SECTION 3	DESIGN PARAMETERS . . . . .	3-1
SECTION 4	SUMMARY FACILITY DESCRIPTION . . . . .	4-1
SECTION 5	PLANT UNIT DESCRIPTIONS. . . . .	5-1
SECTION 6	PROCESS FLOW DIAGRAMS . . . . .	6-1
SECTION 7	MATERIAL BALANCE . . . . .	7-1
SECTION 8	PRODUCTS: PROJECTED MARKETABILITY AND CHARACTERISTICS . . . . .	8-1
SECTION 9	ENERGY BALANCE . . . . .	9-1
SECTION 10	UTILITIES . . . . .	10-1
SECTION 11	ENVIRONMENTAL FACTORS . . . . .	11-1
SECTION 12	STARTUP PROCEDURE . . . . .	12-1
SECTION 13	MAJOR EQUIPMENT SUMMARY. . . . .	13-1
SECTION 14	ECONOMICS . . . . .	14-1
SECTION 15	EXPERIMENTAL DATA BASE FOR KEY CONVERSION PROCESSES. . . . .	15-1
SECTION 16	PREDESIGN STUDIES . . . . .	16-1
SECTION 17	PROJECTED PLANT PERFORMANCE. . . . .	17-1
SECTION 18	POTENTIAL IMPROVEMENTS . . . . .	18-1
SECTION 19	LITERATURE CITED . . . . .	19-1
APPENDIX		
A	BASIC SITE DESIGN CRITERIA . . . . .	A-1

## CONTENTS (Contd)

### FIGURES

4-1	Oil/Gas Plant Block Flow Diagram. . . . .	4-3
4-2	Conceptual Overall Plot Plan. . . . .	4-5
4-3	Artist's Concept. . . . .	4-6
4-4	Model of Conceptual Oil/Gas Plant Design. . . . .	4-7
5-1	Sketch of Mine and Working Plan . . . . .	5-31
5-2	High-Pressure Gasifier Conceptual Design. . . . .	5-32
5-3	Fuel Gas Gasifier Conceptual Sketch . . . . .	5-33
7-1	Overall Material Balance for Complex. . . . .	7-2
9-1	Energy Balance. . . . .	9-2
11-1	Block Flow Diagram, Air Pollution Abatement, Oil/Gas Plant . . . . .	11-15
11-2	Block Flow Diagram, Water Treatment and Supply, Oil/Gas Plant . . . . .	11-17
11-3	Block Flow Diagram, Highlighting Units Requiring Environmental Pollution Abatement (Heavy Frames), Oil/Gas Plant . . . . .	11-19
14-1	Project Schedule. . . . .	14-13
14-2	Fund Drawdown Schedule. . . . .	14-15
14-3	Cumulative Fund Drawdown. . . . .	14-16
14-4	Sensitivity of Required Selling Price to DCF. . . . .	14-17
14-5	Sensitivity Analysis of DCF 65% Debt at 9% Interest . . . . .	14-18
15-1	Dissolver Product True Boiling-Point Curve. . . . .	15-4
15-2	Dissolver Product Specific Gravity vs. Boiling Point. . . . .	15-5
16-1	SNG and LPG Production Schematic Diagram. . . . .	16-6
16-2	SNG Production (No LPG Product) Schematic Diagram . . . . .	16-7
16-3	H <sub>2</sub> Dissolver Feed . . . . .	16-9
16-4	SRC Process Sour Vis-a-Vis Sweet Shift, Process Configuration . . . . .	16-11
16-5	Preliminary Block Flow Diagram Filter Cake Drying . . . . .	16-13

### TABLES

10-1	Utilities Balance . . . . .	10-3
11-1	Effluents Emitted to the Air. . . . .	11-21
11-2	Comparison of Gaseous Emissions with Illinois and New Mexico Source Emission Standards. . . . .	11-22
11-3	Sulfur Balance (TPD). . . . .	11-23
11-4	Comparison of Aqueous Effluents with Federal Petroleum Refinery Standards. . . . .	11-23
11-5	Aqueous Effluent Standards, State of Illinois . . . . .	11-24
11-6	Mean Analytical Values for 82 Coals from the Illinois Basin. . . . .	11-25

## CONTENTS (Contd)

### TABLES (Contd)

11-7	Affinity of Elements for Pure Coal and for Mineral Matter, as Determined from Float-Sink Data. . . . .	11-26
11-8	Environmental Pollution Abatement Costs (\$000). . . . .	11-27
13-1	Major Equipment Summary Unit 9 - Coal Mine. . . . .	13-3
13-2	Major Equipment Summary Unit 10 - Coal Preparation. . . . .	13-5
13-3	Major Equipment Summary Unit 11 - Coal Storage, Crushing, and Drying. . . . .	13-11
13-4	Major Equipment Summary Unit 12 - Coal Slurrying and Dissolving. . . . .	13-19
13-5	Major Equipment Summary Unit 13 - Filtration and Filter Cake Drying. . . . .	13-27
13-6	Major Equipment Summary Unit 14 - Product Distillation. . . . .	13-32
13-7	Major Equipment Summary Unit 16 - Naphtha Hydrotreater. . . . .	13-37
13-8	Major Equipment Summary Unit 17 - Dissolver Acid Gas Removal. . . . .	13-40
13-9	Major Equipment Summary Unit 18 - SNG and LNG Production. . . . .	13-44
13-10	Major Equipment Summary Unit 19 - Methanation. . . . .	13-52
13-11	Major Equipment Summary Unit 20 - Process Gasifier. . . . .	13-53
13-12	Major Equipment Summary Unit 21 - Shift Conversion. . . . .	13-56
13-13	Major Equipment Summary Unit 24 - Fuel Gas Gasifier. . . . .	13-59
13-14	Major Equipment Summary Unit 26 - Sour Water Treating. . . . .	13-63
13-15	Major Equipment Summary Unit 29 - Product Tankage. . . . .	13-67
13-16	Major Equipment Summary Unit 30 - Plant Air and Instrument Nitrogen. . . . .	13-70
13-17	Equipment List Unit 31 - Raw Water Treating. . . . .	13-71
13-18	Major Equipment Summary Unit 32 - Steam and Power Generation. . . . .	13-75
13-19	Major Equipment Summary Unit 34 - Effluent Water Treatment. . . . .	13-79
13-20	Major Equipment Summary Unit 35 - General Facilities. . . . .	13-82
14-1	Estimated Fixed Capital Investment. . . . .	14-19
14-2	Major Equipment Costs by Unit. . . . .	14-21
14-3	Total Capital Requirements (\$ Million). . . . .	14-23
14-4	Estimated Fixed Capital Investment by Cost Center (\$ Million). . . . .	14-24
14-5	Catalyst and Chemicals Cost Summary. . . . .	14-25
14-6	Startup Costs (\$ Million). . . . .	14-27
14-7	Estimate of Working Capital Requirements (\$ Million). . . . .	14-28
14-8	Coal Mine Operating Costs and Equipment Replacement Schedule. . . . .	14-29
14-9	Annual Operating Cost Summary (\$ Million/yr). . . . .	14-30
14-10	Manpower Summary. . . . .	14-31
14-11	Annual Maintenance Cost Summary (\$ Million). . . . .	14-32
14-12	Coal Mine Operating Labor and Supervision Costs. . . . .	14-34
14-13	Coal Mine Maintenance Costs - Labor and Supervision. . . . .	14-36
14-14	Coal Preparation Labor Costs. . . . .	14-37

## CONTENTS (Contd)

### TABLES (Contd)

14-15	Process Plant Labor Costs . . . . .	11-58
14-16	Offsites Chemical Requirements/Costs. . . . .	11-59
14-17	Offsite Operating Labor Costs . . . . .	11-10
14-18	Offsites Maintenance Labor Costs. . . . .	14-12
14-19	Contribution of Cost Centers to Required Revenue. . . . .	11-15
14-20	Cash Flow Computer Output 100% Equity . . . . .	14-11
14-21	Cash Flow Computer Output 65% Debit/35% Equity. . . . .	11-17
14-22	Cash Flow Computer Output 0% DCF. . . . .	14-50
14-23	Evaluation of Effect of Possible Product Market Values on Profitability. . . . .	14-53
15-1	Design Dissolver Balance. . . . .	15-6
16-1	Additional SNG Production EUAC at 12% DCF . . . . .	16-15
16-2	Syngas vs. Hydrogen as Dissolver Feed Case A (LPG+SNG) EUAC at 12% DCF . . . . .	16-16
16-3	Alternate H <sub>2</sub> S Removal Processes EUAC to Achieve a 12% DCF After Tax Return on Investment. . . . .	16-17
16-4	Comparison of Sweet and Sour Shift Economics Savings in EUAC With 12% DCF . . . . .	16-18
16-5	Filter Cake Washing, Material and Utility Balance . . . . .	16-19
16-6	Filter Cake Solvent Recovery, Economic Evaluation EUAC at 12% DCF. . . . .	16-20

### FLOW DIAGRAMS (Section 6)

R-10-FS-1	10	Coal Preparation
R-11-FS-1	11	Coal Grinding and Drying
R-12-FS-1	12	Coal Slurrying and Dissolving
R-13-FS-1	13	Filtration and Filter Cake Drying
R-14-FS-1	14	Product Distillation
R-16/19-FS-1	16,19	Naphtha Hydrotreater, Methanation
R-17-FS-1	17	Dissolver Acid Gas Removal
R-18-FS-1 and 2	18	SNG and LPG Production
R-20/21/22-FS-1	20, 21, 22	Process Gasifier, Shift Conversion, Gasifier Acid Gas Removal
R-24-FS-1	24	Fuel Gas Gasifier
B-25-FS-1	25	Fuel Gas Sulfur Removal
R-26-FS-1	26	Sour Water Treating
B-27-FS-1 and 2	27	Sulfur Plant
R-31-FS-1	31	Raw Water Treating
R-32-FS-1	32	Power Generation
R-34-FS-1	34	Effluent Water Treatment

## ABBREVIATIONS

ABS	absolute
atm	atmosphere
av	average
bb1	barrel
BCR	Bituminous Coal Research, Inc.
BCY	bank cubic yard
BFW	boiler feedwater
bhp	brake horsepower
BOD	biological oxygen demand
bp	boiling point
BPD	barrel per day
BPCD	barrel per calendar day
BPSD	barrel per stream day
Btu	British thermal unit
Btu/hr	Btu per hour
CA	corrosion allowance
Chan.	channel
CI	cast iron
COD	chemical oxygen demand
CS	carbon steel (material)
CS	centistokes (viscosity)
DCF	discounted cash flow
DE	diatomaceous earth
DTPH	dry ton per hour
eff	efficiency



ABBREVIATIONS (Contd)

EP	end point
EUAC	equivalent uniform annual cost
FOE	fuel oil equivalent
gpm	gallon per minute
Gr	grade
HC	hot condensate
Hdr	header
Hg	mercury
HHV	higher heating value
HP	high pressure
hp	horsepower
IBP	initial boiling point
ID	inside diameter
K.O.	knockout
kV	kilovolt (1,000 volt)
kW	kilowatt (1,000 watt)
lb/hr	pound per hour
LP	low pressure
LPG	liquefied petroleum gas
LT	Long ton (2,240 lb)
M	thousand
MAF	moisture and ash free (coal)
MF	moisture free (coal)
MM	million
MM SCFD	million standard cubic foot per day

ABBREVIATIONS (Contd)

mo	moly
MW	megawatt
MWe	megawatt electricity
OCR	Office of Coal Research
O/G	Oil/Gas
PF	power factor
P&M	Pittsburgh & Midway Coal Mining Company
ppm	part per million
psia	pound per square inch absolute
psig	pound per square inch gauge
RAR	required annual revenue
R&D	research and development
ROM	run-of-mine (raw coal from mine, unbroken and not cleaned)
SA	ASME quality material
scf	standard cubic foot
scfd	standard cubic foot per day
scfh	standard cubic foot per hour
SH	shell
SLTC	steel lathe turnings catalyst
SNG	substitute natural gas
sp gr and S.G.	specific gravity
SRC	solvent refined coal
SS	stainless steel
SSF	Saybolt

### ABBREVIATIONS (Contd)

stp	standard temperature and pressure
T	tubes
TPD	ton per day (2,000 lb/ton)
TPH	ton per hour (2,000 lb/ton)
TPSD	ton per stream day
TPY	ton per year (2,000 lb/ton)
TT	tangent to tangent
TWR	tube wall reactor
USAEDH	U.S. Army Engineer Division, Huntsville
wt	weight
wt %	weight percent