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SYSTEMS, SCIENCE AND SOFTWARE

SSS-R-77-3021
Revision 0

AN ECONOMIC MODEL OF PIPELINE TRANSPORTATION SYSTEMS

by

William F. Banks

MASTER

Technical Report - Task 1
Contract EY-76-C-03-1171

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
SAN FRANCISCO OPERATIONS OFFICE
1333 BROADWAY
OAKLAND, CA 94612

July 29, 1977

P. O. BOX 1620, LA JOLLA, CALIFORNIA 92038, TELEPHONE (714) 453-0060

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ABSTRACT

The objective of the work reported here was to develop a model which could be used to assess the economic effects of energy-conservative technological innovations upon the pipeline industry. The model is a dynamic simulator which accepts inputs of two classes: the physical description (design parameters, fluid properties, and financial structure) of the system to be studied, and the postulated market (throughput and price) projection. The model consists of time independent submodels: the fluidics model which simulates the physical behavior of the system, and the financial model which operates upon the output of the fluidics model to calculate the economics outputs. Any of a number of existing fluidics models can be used in addition to that which was developed as a part of this study. The financial model, known as the Systems, Science and Software (S^3) Financial Projection Model, contains user options whereby pipeline-peculiar characteristics can be removed and/or modified, so that the model can be applied to virtually any kind of business enterprise. The several dozen outputs are of two classes: the energetics and the economics. The energetics outputs of primary interest are the energy intensity (EI), also called unit energy consumption, and the total energy consumed. The primary economics outputs are the long-run average cost (LAC), profit, cash flow, and return on investment (RoI).

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1.0 INTRODUCTION

1.1 Objectives

1.1.1 Purpose of the Project

The work reported here is a part of a project which is being carried out by the team of Systems, Science and Software (S^3) of San Diego, and Pipe Line Technologists, Inc. (Pipetech) of Houston, under Contract E(04-03)-1171, "Energy Study of Pipeline Transportation Systems." The primary objectives of the project are to assess the susceptibility of the oil, gas, and other pipeline industries to technological innovations and to identify the associated research, development, and demonstration (R,D,&D) requirements. The project final report will be published in October 1977 as S^3 report SSS-R-77-3020, "An Energy Study of Pipeline Transportation Systems." That final report will be in summary form, combining the results from the seven task reports listed in Table 1.1-1. As will be noted from the table, this present report is one of those task reports.

1.1.2 Purpose of this Report

This report summarizes the work under Subtask 1.3, whose objective was to develop a pipeline economic model (PEM) which could be used to assess the economic effects of the technological innovations referred to above. That is, given an innovation which would appear to result in energy savings, the model should enable one to estimate the amount of energy that could be saved in practice, its effect upon the long-run average cost (LAC) of operating the pipeline, and its financial effects upon the pipeline owner. As will be seen, the model that was developed calculates the first two of these effects and in addition, several dozen of the financial effects.

The largest portion of the work under this subtask was previously reported in SSS-R-77-3069, "S^3 Financial Projection Model - Preliminary User's Manual and System Overview"(1) and in the

Table 1.1-1

Project Reports

SSS-R-77-	Title	Associated Task
3020	An Energy Study of Pipeline Transportation Systems	All
3021	An Economic Model of Pipeline Transportation Systems	1 (partial)
3022	Summary Survey of Energy Consumption in the Pipeline Industry	1 (partial)
3023	Slurry Pipelines - Economic and Political Issues - A Review	2.1
3024	Federal Regulation of the Pipeline Industry	2.2
3025	Potential Efficiency Improvements in Pipeline Transportation Systems	3
3026	Recommendations for Energy-conservative Research and Development in Pipeline Transportation	4 (partial)
3027	Opportunities for Future Energy Conservation in the Pipeline Industry	4 (partial)
3069	S^3 Financial Projection Model - Preliminary User's Manual and System Overview	1 (partial)

"User's Manual for Program LIQPL," not previously published, which is appended hereto as Appendix 1. The reader who wishes to understand in detail the equations and rules contained in the model, the options available to the user, etc., will find it necessary to consult those reports. This present report is intended to place those earlier reports into the context of the program.

1.2 Technical Approach

It had originally been intended to devise a model of each of the five types (crude, products, gas, slurry, and water) of pipeline industries as a whole. That is, the hope had been to develop a model of the entire crude oil pipeline industry, one for the products industry, and so on. However, no way was found to effect this approach. The National Petroleum Council Task Force (2) also reached this conclusion earlier. As reported in a Rand Corporation report,(3) "The NPC Group found no valid way to correlate distance, volume, and cost using historical information on transmission costs."

While the failure of that prestigious group to develop an industry-wide LAC model does not necessarily mean that the task is inherently impossible, it means that the initial failure under this program is the second one of record. At that juncture, prudence seemed to dictate another approach, and after due deliberation the simulation route was chosen. The final result was an economic model of a pipeline which is a dynamic simulator. The advantages and limitations of that approach are discussed in later sections. More importantly, as is discussed in Section 5.0 below, an industry-wide model would be of only limited usefulness for the purposes of this study.

2.0 SUMMARY

2.1 General Description of the PEM

The PEM simulates the operational dynamics of a pipeline, in a quasi-steady-state approximation. Inputs are of two general classes: the system to be simulated and the postulated market projection. The system to be simulated is in turn characterized by two structures: the physical structure and the financial structure. Table 2.1-1 lists some examples of the parameters whereby these inputs are specified.

The outputs of the PEM are of two kinds: the energetics and the economics. These latter are available in a number of report formats, and the user may call any, all, or none of them. The major output report formats appearing in Tables 2.1-1 through 2.1-6 are taken from Ref. 1, which the reader may consult for further detail. There is some duplication of commonly requested output variables among the reports, so that for many studies, only one or two reports need be called because these variables are available through two or more reports.

2.2 PEM Submodels

The PEM consists of two major submodels: the fluidics (physical) model and the financial model. The fluidics model is referred to hereafter under the generic name PEP (Pipeline Energy Program), while the financial model is referred to as JFM, the code name by which it is recognized by the S^3 UNIVAC 1108 computer executive system.

2.2.1 Fluidics Models

The fluidics model accepts as input the physical description of the system, e.g., segment lengths, diameters, elevation profile, bend index, pump characteristics, and fluid properties. Also input is the market projection which the investigator postulates for the simulation, specified as a projection of throughput and product mix. The model calculates the

Table 2.1-1

Inputs to the PEM

Description of System to be Simulated

- Physical description

  *Segment length, diameter, elevation profile, bend index, etc.

  *Pump characteristics

  *Fluid properties

- Financial structure

  *Debt-equity structure and policy

  *Finance terms, e.g., interest rate, payback

  *Regulatory constraints (FPC, ICC, etc.)

  *Depreciation mode

  *Dividend/reinvestment policy

  *Postulated escalation

Market Projection

  *Postulated throughput profile

  *Postulated product mix profile

Table 2.1-2, p.1

PEM Outputs - Report 10

Consolidated Statement of Income
Profit and Loss Projection

	Variable Name
Revenues	
Net sales and operation revenues	SREV
Sales - Product A	REVA
Sales - Product B	REVB
Miscellaneous revenues	MREV
Total revenues	TREV
Costs and Expenses	
Cost of goods sold	COST
Operation and maintenance expenses	OMEX
General and administrative expenses	GAEX
Selling expenses	SEX
Segregated expenses - Type A	SEXA
Segregated expenses - Type B	SEXB
Segregated expenses - Type C	SEXC
Miscellaneous expenses	MEX
Taxes, other than federal income	TOFIT
Direct labor costs	DLABOR
Direct materials costs	DMATR
Overhead	OVERH
Costs, excluding depreciation and interest	PEX
Gross operating income	GOINC
Interest expenses	INTEX
Financial depreciation	FDEP
Amortization of financial expenses	FDCIA
Total expenses	TOTEX
Other Income	
Investment income,net	IINC
Net income before taxes	INCBT

Table 2.1-2, p.2

	Variable Name
Income Taxes	
Tax depreciation	FITDEP
Taxable income	FITINC
Unused tax losses	FITUTL
Tax loss carry-forward	FITLCF
Tax loss applied this year	FITTLA
Investment tax credit	FITITC
Unused investment tax credits	UTCR
Tax credits carried forward	TCRCF
Tax credits applied this year	TCRA
Current income tax	FITCUR
Deferred income tax	FITDEF
Total income tax	FITTOT
Net income (book profit)	NET

Table 2.1-3

PEM Outputs - Report 20

Changes in Financial Position and Cash Flow Projection

	Variable Name
Sources of Funds	
Net income (book profit)	NET
Financial depreciation	FDEP
Amortization of financial expenses	FDCIA
Deferred income taxes	FITDEF
Provided by operations	TSOFOP
Short-term borrowing	STD
Long-term borrowing	LTD
Net additions to equity	ADEQ
Miscellaneous sources of funds	MSOF
Total sources of funds	TSOF
Application of Funds	
Additions to plant and equipment	CAPO
Short-term debt retirement	STDRET
Long-term debt retirement	LTDRET
Financial and debt expense	FDCIX
Miscellaneous application of funds	MAOF
Subtotal	TAOF1
Cash dividends paid	DIVP
Net increase in investments	ADINVM
Total application of funds	TAOF
Increase in working capital	ADWC
Total disposition of funds	TDOF
Cash benefits less investment costs	CASHO
Net cash generated during the period	CASHG
Cumulative net cash generated	CUMCG

Table 2.1-4, p.1

PEM Outputs - Report 30

Balance Sheet Projection

	Variable Name
Assets	
Current Assets	
Cash	CASH
Accounts receivable - Net	RECEIV
Inventory	GOODS
Prepaid expenses and other current assets	PREPEX
Total current assets	CURAS
Property, Plant and Equipment	
At original cost	CAPEO
Less - accumulated depreciation	CAPED
- net property and equipment	CAPEN
Investments	INVM
Goodwill and other assets	OTHERA
Deferred Charges	
Unamortized financial and debt expenses	DEFFDX
Unamortized construction interest	CAPCI
Other deferred charges	DEFC
Total deferred charges	DEF
Total assets	TOTALA

Table 2.1-4, p.2

Balance Sheet Projection (cont'd)

	Variable Name
Liabilities and Shareholders Equity	
Current Liabilities	
Accounts payable	PAYABS
Accrued expenses	ACCES
Accrued taxes	ACCTAX
Notes payable	NOTESP
Total current liabilities	CURLS
Short-term unpaid balance	STDBAL
Long-term unpaid balance	LTDBAL
Total debt balance	DBAL
Deferred income taxes	DBAL
Deferred credits	DEFCR
Total liabilities	TOTALL
Shareholders Equity	
Capital stock at par value	STOCK
Capital surplus	STKSUR
Total paid-in capital	CAPPD
Retained earnings	RETE
Total equity capital	EQUITY
Total liabilities and equity	TOTALE
New working capital	WORKC

Table 2.1-5, p.1

PEM Output - Report 38

	Variable Name
Activity	
Annual throughput	THRUP
" " - MM barrels	THRUP
" " - MM barrel-miles	THRUP
" " - MMMMCF-miles	THRUP
" " - MM gallon-miles	THRUP
Nominal tariff	VAR8
Transportation revenues	SREV
Nominal actual total revenues	TREV
Revenue reduction	REVA
Total revenues	TREV
Tariff constraint factor	TARF
Leverage	
Long-term (funded) debt to equity (%)	LTDEQ
" " " capital (%)	LTDCAP
" " " assets (%)	LTDASS
Profitability	
Operating income (ICC rules)	OPINC
" " (FPC rules)	OPINC
Operating income	OPINC
Annual ICC rate base	RBASE
" FPC " "	RBASE
Rate of return on rate base (%)	ROIR
" " paid-in capital (%)	ROIC
" " total equity (%)	ROIE
" " total capital (%)	ROIT

Table 2.1-5, p.2

	Variable Name
Energy Consumption	
Annual energy use in MM KW-HR	ENERGU
" " " gas (MMCF)	ENERGU
" " " oil (BBL)	ENERGU
Annual energy costs	ENERGC
Discounted value of energy used (@ ...)	PVEC(NT)
Unit cost of energy ($)	UCOSTE
Unit cost of energy ($/MMCF)	UCOSTE
Annual energy wasted (KW-HR(M))	ENERGW
Annual energy wasted ($)	ENERGS
Present value of energy wasted	PVPS
Discounted value of energy wasted (@...)	PVPS(NT)
Other Measures	
Segregated expenses - Type A	SEXA
Present value of above item	VV
Discounted net cash flow (@...)	SUM1
Total annual unit costs	UCOSTS
Present value of average unit costs	PVCOST
Discounted average (annual) unit costs/ long-run average costs (@...)	LAC
Net income (book profit)	NET
Present value of book profits	PVBK
Discounted value of book profits (@...)	PVBK(NT)
Net cash generated during the period	ASHG
Present value of net cash generated	PVCASH
Discounted net cash flow (@...)	DNCG
Discount factor (@...)	PVF
Internal Rate of Return	
DCF-ROI of $___ (from year ___ over ___(year)	DROIA(M), DROIY1(M), DROINY(M)

Table 2.1-5, p.3

Other Line Items	Variable Name
Operations and maintenance expense	OMEX
Interest expenses	INTEX
Total expenses	TOTEX
Unused tax loss	FITUTL
Unused investment tax credits	UTCR
Long-term borrowing	LTD
Net additions to equity	ADEQ
Additions to plant and equipment	CAPO
Long-term debt retirement	LTDRET
Plant and equipment (at original cost)	CAPEO
Net property and equipment	CAPEN
Total debt balance	DBAL
Total equity capital	EQUITY

Table 2.1-6

PEM Output - Report 40

Capital Investment and Financial Performance Measures

	Variable Name
Liquidity	
Quick ratio	RATIOQ
Current Ratio	RATIOC
Inventory to capital ratio	RATIOI
Working capital	WORKC
Leverage	
Long-term debt to equity	LTDEQ
Long-term debt to capital	LTDCAR
Long-term debt to assets	LTDASS
Activity	
Annual unit sales	USALES
Unit price	UPRICE
Total revenues	TREV
Profitability	
Net income (book profit)	NET
Net margin - return on revenue	NETM
Gross operating margin	GROSSM
Rate of return on paid-in capital (%)	ROIC
" " total equity (%)	ROIE
" " total capital (%)	ROIT

required pressure profile, selects the pumps, and calculates the energy consumed in useful work to overcome flow resistance and the energy wasted in throttling.

It is of course necessary to have several fluidics models if all types of pipelines are to be treated. Single-phase or gas flow, two-phase flow, non-Newtonian flow, with or without heating and/or cooling, must all be accounted for as the situation may require. A file is created in the computer system for the output of the fluidics model. When JFM is run, it accesses the fluidics output file. Thus, there is no direct interaction between the two submodels, and accordingly no restraint upon what analytic program is used for the fluidics model. Any characterization of the fluidic behavior can be used, so long as its output is constituted in the appropriate file format for access by JFM. For the gas pipeline simulations, a proprietary Pipetech code is used and the output is formatted manually and stored in the S^3 computer. This code is available at a moderate royalty for use by other organizations. For the liquid cases, several variations are available on the S^3 computer of a basic pipeline fluidics model which was developed under this contract by Dr. Mary Baker of S^3 and Mr. Wayne Baker of Pipetech. The Pipetech version of this code is known as LIQPL, and its user's manual is Appendix A of this report. The version which is in the S^3 computer is called pipeline energy program (PEP).

Figure 2.2.1-1 presents an example input to PEP. It is seen to specify the parameters which characterize the physical structure and fluid properties of the system. Figure 2.2.1-2 presents an example of the output file which PEP creates for use by JFM. Additionally, PEP prints the pressure profile and pump selections for each year of the throughput projection. Examples of this complete output can be found in Appendix A.

2.2.2 The Financial Model

The financial model is the S^3 financial projection model, developed by Dr. Joseph Masso of S^3 and referred

ERDA PRODUCTS PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1,3,6,10, AND 14.

STEADY STATE FLOW EQUATION = HAZEN WILLIAMS
HAZEN WILLIAMS C FACTOR = 150.
FIRST YEAR OF OPERATION = 1
LIFE OF PIPELIN, IN YEARS = 20

AVERAGE PUMP DRIVER EFFICIENCY = 1.00

ESCALATOR FACTORS.

STARTING AT YEAR	THRUPUT ESC FAC	POWER RATE ESC FAC
1	1.015	1.060
3	1.463	1.059
4	1.040	1.056
5	1.040	1.030
9	1.030	1.030
20	1.000	1.030

INITIAL SHIPMENT/DELIVERY DATA.

STATION	MILEPOST	SHP/DEL RATE,BPH
RS-1	.00	6175.
DF-4	686.00	-1660.
DF-5	891.00	-4515.

PIPE SCHEDULE.

MILE-POST	PIPE ID INCHES	MAX OPER PRESSURE PSI
.00	23.376	975.
686.00	19.500	936.
784.00	17.500	1040.
891.00	17.500	1040.

HYDRAULIC PROPERTIES OF LIQUID.

LIQUID	PERCENT OF	SPECIFIC GRAVITY	VISCOSITY CS	MINIMUM PRESSURE

Fig. 2.2.1-1, sheet 1

LINEFILL PSI

GASO	.700	.730	.770	50.
AVGAS	.050	.700	.750	50.
KEROSE	.050	.800	3.100	50.
NO2 FU	.200	.860	5.520	50.

PUMP CURVE DATA.
NAME PUMP CURVE = SML-13

CAPACITY GPM	HEAD BPH	EFF	
0.	0.	168.	.00
4000.	5714.	146.	.69
6000.	8571.	127.	.82
7000.	10000.	115.	.83
7500.	10714.	107.	.82
8000.	11429.	100.	.79

PUMP CURVE DATA.
NAME PUMP CURVE = SML-14

CAPACITY GPM	HEAD BPH	EFF	
0.	0.	201.	.00
4000.	5714.	181.	.67
6000.	8571.	162.	.82
7000.	10000.	150.	.84
8000.	11429.	135.	.84
9200.	13143.	111.	.79

PUMP CURVE DATA.
NAME PUMP CURVE = SML-15

CAPACITY GPM	HEAD BPH	EFF	
0.	0.	238.	.00
4000.	5714.	213.	.65
6000.	8571.	194.	.81
8000.	11429.	167.	.85
10000.	14286.	125.	.80
10700.	15286.	111.	.73

PUMP CURVE DATA.
NAME PUMP CURVE = SML-16

CAPACITY GPM	HEAD BPH	EFF	
0.	0.	277.	.00
4000.	5714.	253.	.61

Fig. 2.2.1-1, sheet 2

6000.	8572.	236.	.79
8000.	11429.	210.	.87
10000.	14286.	171.	.86
11200.	16000.	137.	.79

PUMP CURVE DATA.
NAME PUMP CURVE = SML-17

CAPACITY GPM	BPH	HEAD	EFF
0.	0.	300.	.00
4000.	5714.	274.	.59
6000.	8572.	255.	.77
8000.	11429.	230.	.86
10000.	14286.	195.	.87
11800.	16857.	143.	.79

PUMP CURVE DATA.
NAME PUMP CURVE = LGE-23

CAPACITY GPM	BPH	HEAD	EFF
0.	0.	1100.	.00
2000.	2857.	1120.	.35
4000.	5714.	1110.	.65
6000.	8571.	1062.	.79
8000.	11429.	982.	.85
9370.	13386.	902.	.84

PUMP CURVE DATA.
NAME PUMP CURVE = LG-23A

CAPACITY GPM	BPH	HEAD	EFF
0.	0.	1202.	.00
4000.	5714.	1211.	.67
6000.	8571.	1164.	.81
8000.	11429.	1092.	.86
10000.	14286.	988.	.85
10600.	15143.	949.	.84

PUMP CURVE DATA.
NAME PUMP CURVE = LGE-24

CAPACITY GPM	BPH	HEAD	EFF
0.	0.	1304.	.00
3000.	4286.	1324.	.55
5000.	7143.	1293.	.74
7000.	10000.	1235.	.85

Fig. 2.2.1-1, sheet 3

9000.	12857.	1153.	.87
11400.	16286.	995.	.84

PUMP CURVE DATA.
NAME PUMP CURVE = LGE-26

CAPACITY GPM	HEAD BPH	EFF	
0.	0.	1460.	.00
4000.	5714.	1460.	.62
6000.	8572.	1432.	.78
8000.	11429.	1361.	.87
10000.	14286.	1257.	.88
12000.	17143.	1100.	.86

PUMP CURVE DATA.
NAME PUMP CURVE = LGE-27

CAPACITY GPM	HEAD BPH	EFF	
0.	0.	1580.	.00
4000.	5714.	1580.	.58
6000.	8572.	1541.	.77
8000.	11429.	1474.	.86
10000.	14286.	1372.	.88
12000.	17143.	1240.	.87

PUMP STA DATA.

PUMP STA	MILE-POST	PUMP NAME	QUAN-TITY	FIRST YR POWER RATE	PERCENT OF TIME PUMPING	YEAR STA COMES ON LINE
PS-1	.00	SML-17	2	.02500	.35	1
PS-1	.00	LGE-23	2	.02500	.35	1
PS-1	.00	LGE-24	2	.02500	.35	1
PS-2	62.36	SML-17	2	.02500	.61	8
PS-2	62.36	LGE-24	2	.02500	.61	8
PS-3	124.73	SML-13	1	.02500	1.00	3
PS-3	124.73	SML-17	2	.02500	1.00	3
PS-3	124.73	LGE-23	1	.02500	1.00	3
PS-3	124.73	LG-23A	1	.02500	1.00	3
PS-3	124.73	LGE-24	2	.02500	1.00	3
PS-4	187.09	SML-16	1	.02500	1.00	8
PS-4	187.09	SML-17	2	.02500	1.00	8
PS-4	187.09	LGE-24	2	.02500	1.00	8
PS-5	249.45	SML-16	2	.02500	1.00	1
PS-5	249.45	SML-17	2	.02500	1.00	1
PS-5	249.45	LGE-23	1	.02500	1.00	1
PS-5	249.45	LG-23A	1	.02500	1.00	1
PS-5	249.45	LGE-24	2	.02500	1.00	1

Fig. 2.2.1-1, sheet 4

PS-6	311.82	SML-17	2	.02500	1.00	8
PS-6	311.82	LGE-24	2	.02500	1.00	8
PS-7	374.18	SML-17	2	.02500	1.00	3
PS-7	374.18	LGE-23	1	.02500	1.00	3
PS-7	374.18	LG-23A	1	.02500	1.00	3
PS-7	374.18	LGE-24	2	.02500	1.00	3
PS-8	436.55	SML-17	2	.02500	1.00	8
PS-8	436.55	LGE-24	2	.02500	1.00	8
PS-9	498.91	SML-17	2	.02500	1.00	1
PS-9	498.91	LGE-23	1	.02500	1.00	1
PS-9	498.91	LG-23A	1	.02500	1.00	1
PS-9	498.91	LGE-24	2	.02500	1.00	1
PS-10	561.27	SML-17	2	.02500	1.00	8
PS-10	561.27	LGE-24	2	.02500	1.00	8
PS-11	623.64	SML-17	2	.02500	1.00	3
PS-11	623.64	LGE-23	1	.02500	1.00	3
PS-11	623.64	LG-23A	1	.02500	1.00	3
PS-11	623.64	LGE-24	2	.02500	1.00	3
PS-12	686.00	SML-17	2	.02500	1.00	10
PS-12	686.00	LGE-24	2	.02500	1.00	10
PS-13	718.67	SML-17	2	.02500	1.00	1
PS-13	718.67	LGE-23	1	.02500	1.00	1
PS-13	718.67	LG-23A	1	.02500	1.00	1
PS-13	718.67	LGE-24	2	.02500	1.00	1
PS-14	751.33	SML-17	2	.02500	1.00	14
PS-14	751.33	LGE-24	2	.02500	1.00	14
PS-15	784.00	SML-17	2	.02500	1.00	1
PS-15	784.00	LGE-23	1	.02500	1.00	1
PS-15	784.00	LGE-24	2	.02500	1.00	1
PS-16	811.00	SML-17	2	.02500	1.00	10
PS-16	811.00	LGE-24	2	.02500	1.00	10
PS-17	837.00	SML-17	2	.02500	1.00	3
PS-17	837.00	LGE-23	1	.02500	1.00	3
PS-17	837.00	LG-23A	1	.02500	1.00	3
PS-17	837.00	LGE-24	2	.02500	1.00	3
PS-18	864.00	SML-17	2	.02500	1.00	8
PS-18	864.00	LGE-23	1	.02500	1.00	8
PS-18	864.00	LGE-24	2	.02500	1.00	8

TARIFF= .001140 DOLLARS IN YEAR 1

TARIFF ESCALATION RATES

YEAR	RATE
1	1.0500
2	1.0500
3	1.0500
4	1.0500
5	1.0500
6	1.0500
7	1.0500
8	1.0500
9	1.0500
10	1.0500
11	1.0500

Fig. 2.2.1-1, sheet 5

12	1.0500
13	1.0500
14	1.0500
15	1.0500
16	1.0500
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18	1.0500
19	1.0500
20	1.0500

Fig. 2.2.1-1, sheet 6

SYSTEMS, SCIENCE AND SOFTWARE
JFM FINANCIAL PROJECTION MODEL
PIPELINE TRANSPORTATION SYSTEMS ENERGY CONSERVATION STUDY

DATE JANUARY 27, 1977 15:15:51 #6 111976
RUN ID THE LIQUID PETROLEUM PRODUCTS REFERENCE SYSTEM
BASELINE CASE

JFM REPORT NO. 8 TRANSPORTATION REVENUE, THROUGHPUT, AND ENERGY COSTS MODEL (PEP) PROJECTION

•••••• PEP OUTPUT FILE •PEPOUT• READ FROM UNIT 8 PMODE = 1 THRUPM = 1 ENERGM = 0 NYPEP = 20

IDPEP =REFERENCE SYSTEM 06/24/76 13:23:24

YEAR	ENERGY USED THOUSAND KILOWATT-HRS	COST OF ENERGY THOUS. $/YR.	ENERGY WASTED THOUSAND KILOWATT-HRS	COST WASTED ENG. THOUS. $/YR.	THROUGHPUT MILLION BARREL•MILES/YR	REVENUE THOUS. $/YR.	SEG. EXPENSES THOUS. $/YR.
2	24459.642	611.491	.000	.000	22607.907	25773.014	.000
3	48898.810	1320.268	.000	.000	45894.055	54935.183	.000
4	129641.862	3706.850	.000	.000	67143.010	84388.689	.000
5	145439.601	4391.440	.000	.000	69828.729	92152.446	.000
6	156608.459	4870.528	.000	.000	72621.875	100630.467	.000
7	176312.361	5647.820	.000	.000	75526.755	109880.476	.000
8	191498.391	6318.303	6.730	.222	78547.821	119998.209	.000
9	215982.172	7339.905	3.923	.133	81689.727	131038.031	.000
10	233036.197	8157.050	364.675	12.765	84140.426	141717.639	.000
11	250366.588	9026.582	.000	.000	86664.633	153267.617	.000
12	269231.836	9997.942	167.151	6.207	89264.570	165758.926	.000
13	293514.160	11238.132	21.762	.832	91942.510	179268.279	.000
14	321793.691	12677.582	636.126	25.061	94700.783	193878.639	.000
15	341304.961	13849.639	21.740	.882	97541.812	209679.758	.000
16	373707.945	15619.438	149.693	6.257	100468.062	226768.648	.000
17	411998.066	17736.400	545.531	23.485	103482.101	245250.281	.000
18	447678.566	19850.609	151.285	6.708	106586.562	265238.172	.000
19	494375.156	22122.113	79.754	3.642	109784.165	286855.094	.000
20	530802.773	24969.804	27.725	1.304	113077.681	310233.758	.000
21	530802.773	25718.899	27.725	1.343	113077.681	325745.441	.000

Fig. 2.2.1-2

to as JFM, which accepts as input the output of the fluidics model and the financial characterization of the system.[1] The JFM output is the set of financial results which was described earlier and displayed in Tables 2.1.2 through 2.1.6.

In the development of JFM, care was taken to construct a general business model, i.e., one which is not pipeline-peculiar. This objective was accomplished by building in options which allow the user to remove the regulatory constraints. These options are described in Section 14 of the user's manual.[1] The defaults for these options, ICC=F, FPC=F, etc., enable the program to simulate any business venture.

The principal limitation upon its applicability is then probably in the number of product lines which it can reflect. Net sales and operating revenues (SREV) and two product revenue streams (REVA and REVB) are accepted, along with miscellaneous revenue (MREV) and a net investment income (IINC). Twelve categories of segregated expenses are accepted, but multiple streams, e.g., cost of goods sold (COST) for separate product lines, are not accepted. The modifications necessary to separately accept complete sets of expense and revenue streams for separate product lines could easily be made, but since they are not of interest for the present purpose, these capabilities were not included.

2.3 The Reference Systems

A simulator can serve a useful purpose only it if is mated with a simulatee. Stated equivalently, a model only has value as it reveals something about its prototype. For this study the prototype (simulatee) is a pipeline which is termed a reference system. Five reference systems were designed: crude oil, petroleum products, natural gas, coal-water slurry, and water. These designs are not hypothetical; they were developed by Pipetech by modifying an actual pipeline system design which had been built and operated. A schematic arrangement of the petroleum products reference system, as it was originally conceived (the system was later modified) is shown in Fig. 2.3-1. This diagram is for illustrative purposes only; since all of the current reference system designs are now on magnetic tape in the S^3 computer facility, schematics are unnecessary.

2.4 Example Use of the Model

Figures 2.4-1, sheets 1-6, and 2.4-2, sheets 1-6, show an example pair of simulations that were run during the course of this study as a part of the work described in Report 3025 (see Table 1.1-1 above), Section 7.0, of this series. The purpose of this particular investigation was to assess the worth of a hypothetical technological innovation which would reduce viscosity in a liquid pipeline by a factor of five. Previous study of the literature (discussed in Report 3025, Section 7.2) had shown that reductions of this order may be reasonably anticipated from a well conducted R,D&D program.

The baseline for the investigation is presented in Fig. 2.4-1. Sheet 1 includes the principal outputs of the fluidics submodel which was discussed in Section 2.2.1 above. Note that the fourth column tabulates the energy wasted in throttling, as discussed in detail in Report 3025, Section 4.3.6.1, Duty Cycles in Products Pipelines. Sheets 2 through 6 present one of the output formats, output Report 38, which is produced by the report generator in the model. This format presents 31 output variables, most of them having a separate value for each year over the life of the project, along with the lifetime total and average for each variable. For this viscosity reduction study, the principal output values of interest are in lines 13-16, under the heading Energy Consumption. In particular, the total energy used (sheet 4, line 13) is 5.58×10^{12} kw-hr, and its cost over the 20-year life (sheet 4, line 14) is $225 million. Sheet 5 presents the internal return on investment (RoI or DCF), and sheet 6 shows a number of additional variables. (In addition to this Report 38 format, a number of other output formats are available, some of which are described in Section 3.6 below.

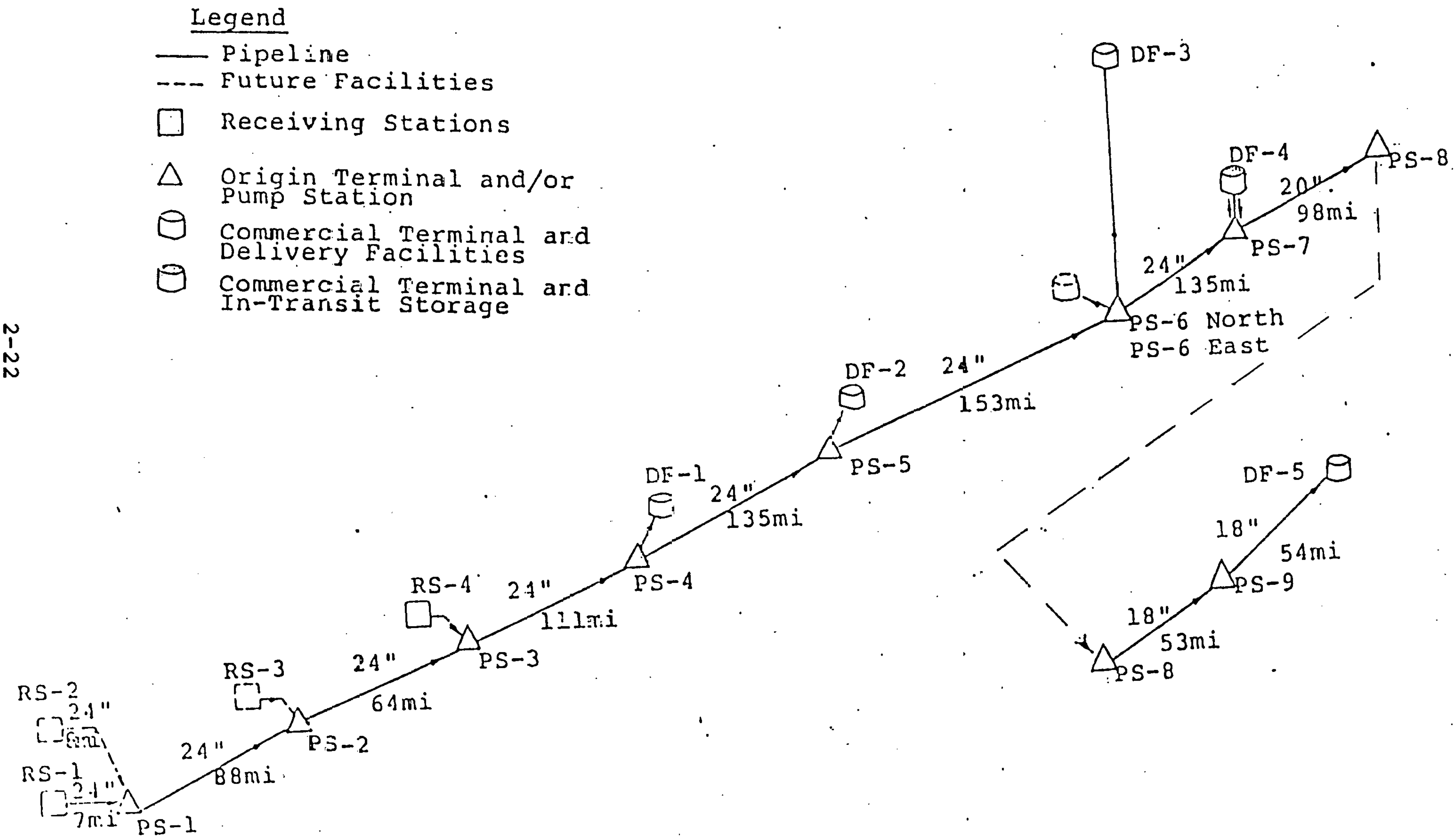

Fig. 2.3-1 - The original reference system - petroleum products

•••• PRODUCTS PIPELINE BASELINE CASE(BASE1) LINKED WITH •PROD1 DATE 012777 PAGE 9

SYSTEMS, SCIENCE AND SOFTWARE
JFM FINANCIAL PROJECTION MODEL
PIPELINE TRANSPORTATION SYSTEMS ENERGY CONSERVATION STUDY

DATE JANUARY 27, 1977 15:15:51 #6 111976
RUN ID THE LIQUID PETROLEUM PRODUCTS REFERENCE SYSTEM
BASELINE CASE

JFM REPORT NO. 8 TRANSPORTATION REVENUE, THROUGHPUT, AND ENERGY COSTS MODEL (PEP) PROJECTION

•••••• PEP OUTPUT FILE •PEPOUT• READ FROM UNIT 8 PMODE = 1 THRUPM = 1 ENERGM = 0 NYPEP = 20

IOPEP =REFERENCE SYSTEM 06/24/76 13:23:24

YEAR	ENERGY USED THOUSAND KILOWATT-HRS	COST OF ENERGY THOUS. $/YR.	ENERGY WASTED THOUSAND KILOWATT-HRS	COST WASTED ENG. THOUS. $/YR.	THROUGHPUT MILLION BARREL•MILES/YR	REVENUE THOUS. $/YR.	SEG. EXPENSES THOUS. $/YR.
2	24459.642	611.491	.000	.000	22607.907	25773.014	.000
3	48898.810	1320.268	.000	.000	45894.055	54935.183	.000
4	129641.862	3706.850	.000	.000	67143.010	84388.689	.000
5	145439.801	4391.440	.000	.000	69828.729	92152.446	.000
6	156608.459	4870.528	.000	.000	72621.875	100630.467	.000
7	176312.361	5647.820	.000	.000	75526.755	109888.476	.000
8	191498.391	6318.303	6.730	.222	78547.821	119998.209	.000
9	215982.172	7339.905	3.923	.133	81689.727	131038.031	.000
10	233036.197	8157.050	364.675	12.765	84140.426	141717.639	.000
11	250366.588	9026.582	.000	.000	86664.633	153267.617	.000
12	269231.836	9997.942	167.151	6.207	89264.570	165758.926	.000
13	293814.160	11238.132	21.762	.832	91942.510	179268.279	.000
14	321793.891	12677.582	636.126	25.061	94700.783	193878.639	.000
15	341304.961	13049.639	21.740	.882	97541.812	209679.758	.000
16	373707.945	15619.438	149.693	6.257	100468.062	226768.648	.000
17	411998.066	17736.400	545.531	23.485	103482.101	245250.281	.000
18	447678.566	19850.609	151.285	6.708	106586.562	265238.172	.000
19	484375.156	22122.113	79.754	3.642	109784.165	286855.094	.000
20	530802.773	24969.804	27.725	1.304	113077.681	310233.758	.000
21	530802.773	25718.899	27.725	1.343	113077.681	325745.441	.000

Fig. 2.4-1, sheet 1

SYSTEMS, SCIENCE AND SOFTWARE
LAC PROJECTION MODEL
PIPELINE TRANSPORTATION SYSTEMS ENERGY CONSERVATION STUDY

DATE JANUARY 27, 1977 15:15:51 #6 111976
RUN ID THE LIQUID PETROLEUM PRODUCTS REFERENCE SYSTEM
BASELINE CASE

P38 REPORT NO. 38 CAPITAL INVESTMENT PLANNING AND ENERGY CONSERVATION IMPACT PROJECTION (DOLLARS IN THOUSANDS)

TIME PERIOD	1976	1977	1978	1979	1980	1981	1982	1983
ACTIVITY								
ANNUAL THROUGHPUT (MM BARREL-MILES)	.000	22607.907	45894.055	67143.010	69828.729	72621.875	75526.755	78547.821
NOMINAL TARIFF (UNIT TRANSP. CHARGE)	.000	1.140	1.197	1.257	1.320	1.386	1.455	1.528
ACTUAL TARIFF	.000	1.140	1.197	1.115	1.057	1.030	1.009	.958
NOMINAL TRANSPORTATION REVENUES	.000	25773.014	54935.183	84388.689	92152.446	100630.467	109888.476	119998.209
ACTUAL TOTAL REVENUES	.000	25773.014	54935.183	74851.489	73808.483	74780.360	76208.908	75243.863
LEVERAGE								
LONG-TERM (FUNDED) DEBT TO CAPITAL %	93.088	93.355	93.515	91.130	87.066	83.885	79.755	74.138
LONG-TERM (FUNDED) DEBT TO ASSETS %	90.000	88.614	86.072	81.236	75.491	70.761	65.621	59.735
PROFITABILITY								
OPERATING INCOME (ICC RULES)	.000	4417.958	10887.245	27670.617	27331.541	26533.424	25767.195	25170.192
ANNUAL ICC RATE BASE	.000	282503.030	282740.168	276706.172	273315.414	265144.727	257425.039	251619.947
RATE OF RETURN ON RATE-BASE (%)	.000	1.554	3.851	10.000	10.000	10.007	10.010	10.003
RATE OF RETURN ON PAID-IN CAPITAL(%)	.000	-2.759	4.683	69.386	73.037	74.418	75.561	76.850
RATE OF RETURN ON TOTAL CAPITAL (%)	.000	-.236	.474	7.414	8.132	8.780	9.415	10.011
ENERGY CONSUMPTION								
ANNUAL ENERGY USAGE IN MM KW-HRS	.000	24459.642	48898.810	129641.862	145439.801	156608.459	176312.361	191498.391
ANNUAL ENERGY COSTS	.000	611.491	1320.268	3706.850	4391.440	4870.528	5647.820	6318.303
PRESENT VALUE OF ENERGY USED	.000	555.901	1091.130	2785.011	2999.412	3024.215	3188.047	3242.288
UNIT COST OF ENERGY ($)	.000	.025	.027	.029	.030	.031	.032	.033
ANNUAL ENERGY WASTED IN KW-HRS (M)	.000	.000	.000	.000	.000	.000	.000	6.730
ANNUAL ENERGY WASTED COST ($)	.000	.000	.000	.000	.000	.000	.000	.222
PRESENT VALUE OF ENERGY WASTED	.000	.000	.000	.000	.000	.000	.000	.114
OTHER MEASURES								
TOTAL ANNUAL UNIT COSTS	.000	.995	.960	.703	.666	.628	.593	.560
PRESENT VALUE OF AVERAGE UNIT COSTS	.000	.859	.793	.528	.455	.390	.335	.287
NET INCOME (BOOK PROFIT)	-9372.500	-779.376	1323.043	19601.735	23633.042	21023.212	21346.328	21710.488
PRESENT VALUE OF BOOK PROFITS	-9372.500	-708.524	1093.424	14727.073	14092.646	13053.761	12049.446	11140.913
NET CASH GENERATED DURING THE PERIOD	.000	8592.868	17956.146	14249.607	11267.836	15250.941	14033.713	11522.237
PRESENT VALUE OF NET CASH GENERATED	.000	7811.717	14839.790	10705.941	7696.084	9469.635	7921.665	5912.730
DISCOUNT FACTOR (@10.000 %) =	1.000	.909	.826	.751	.683	.621	.564	.513

Fig. 2.4-1, sheet 2

•••• PRODUCTS PIPELINE BASELINE CASE(BASE1) LINKED WITH •PROD1 DATE 012777 PAGE 13

SYSTEMS, SCIENCE AND SOFTWARE
LAC PROJECTION MODEL
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DATE JANUARY 27, 1977 15:15:51 #6 111976
RUN ID THE LIQUID PETROLEUM PRODUCTS REFERENCE SYSTEM
BASELINE CASE

P38 REPORT NO. 38 CAPITAL INVESTMENT PLANNING AND ENERGY CONSERVATION IMPACT PROJECTION (DOLLARS IN THOUSANDS)

TIME PERIOD	1984	1985	1986	1987	1988	1989	1990	1991
ACTIVITY								
ANNUAL THROUGHPUT (MM BARREL-MILES)	81689.727	84140.426	86664.633	89264.570	91942.510	94700.783	97541.812	100468.062
NOMINAL TARIFF (UNIT TRANSP. CHARGE)	1.604	1.684	1.769	1.857	1.950	2.047	2.150	2.257
ACTUAL TARIFF	1.034	1.056	1.022	1.024	.980	.946	.916	.891
NOMINAL TRANSPORTATION REVENUES	131038.031	141717.639	153267.617	165758.926	179268.279	193878.639	209679.758	226768.648
ACTUAL TOTAL REVENUES	84477.415	88844.299	88555.166	91410.311	90062.736	89575.643	89302.502	89471.592
LEVERAGE								
LONG-TERM (FUNDED) DEBT TO CAPITAL %	69.118	61.872	53.425	44.960	37.223	26.771	18.792	7.281
LONG-TERM (FUNDED) DEBT TO ASSETS %	54.986	48.477	41.371	34.575	28.584	20.493	14.380	5.547
PROFITABILITY								
OPERATING INCOME (ICC RULES)	25187.003	24607.067	24210.833	23398.619	23067.618	22616.031	22412.323	21931.233
ANNUAL ICC RATE BASE	251642.461	245941.521	241950.270	233804.590	230458.281	226032.957	223976.248	219144.680
RATE OF RETURN ON RATE BASE (%)	10.009	10.005	10.007	10.008	10.009	10.006	10.007	10.008
RATE OF RETURN ON PAID-IN CAPITAL(%)	79.862	80.232	81.119	85.095	83.907	82.140	81.281	79.361
RATE OF RETURN ON TOTAL CAPITAL (%)	10.558	11.032	11.482	12.554	12.596	12.628	12.640	12.687
ENERGY CONSUMPTION								
ANNUAL ENERGY USAGE IN MM KW-HRS	215982.172	233036.197	250366.588	269231.836	293814.160	321793.891	341304.961	373707.945
ANNUAL ENERGY COSTS	7339.905	8157.050	9026.582	9997.942	11238.132	12677.582	13849.639	15619.438
PRESENT VALUE OF ENERGY USED	3424.120	3459.386	3480.138	3504.218	3580.815	3672.244	3647.043	3739.170
UNIT COST OF ENERGY ($)	.034	.035	.036	.037	.038	.039	.041	.042
ANNUAL ENERGY WASTED IN KW-HRS (M)	3.923	364.675	.000	167.151	21.762	636.126	21.740	149.693
ANNUAL ENERGY WASTED COST ($)	.133	12.765	.000	6.207	.832	25.061	.882	6.257
PRESENT VALUE OF ENERGY WASTED	.062	5.414	.000	2.176	.265	7.259	.232	1.498
OTHER MEASURES								
TOTAL ANNUAL UNIT COSTS	.545	.524	.503	.487	.476	.465	.459	.453
PRESENT VALUE OF AVERAGE UNIT COSTS	.254	.222	.194	.171	.152	.135	.121	.108
NET INCOME (BOOK PROFIT)	22561.358	22665.778	22916.230	24039.602	23703.886	23204.928	22962.107	22419.840
PRESENT VALUE OF BOOK PROFITS	10525.040	9612.503	8835.199	8425.734	7552.789	6721.641	6046.641	5367.132
NET CASH GENERATED DURING THE PERIOD	12659.744	10361.658	8256.508	11599.988	10960.405	6777.918	10006.182	6088.269
PRESENT VALUE OF NET CASH GENERATED	5905.864	4394.354	3183.241	4065.725	3492.323	1963.322	2634.941	1457.483
DISCOUNT FACTOR (@10.000 %) =	.467	.424	.386	.350	.319	.290	.263	.239

Fig. 2.4-1, sheet 3

SYSTEMS, SCIENCE AND SOFTWARE
LAC PROJECTION MODEL
PIPELINE TRANSPORTATION SYSTEMS ENERGY CONSERVATION STUDY

DATE JANUARY 27, 1977 15:15:51 #6 111976
RUN ID THE LIQUID PETROLEUM PRODUCTS REFERENCE SYSTEM
BASELINE CASE

P38 REPORT NO. 38 CAPITAL INVESTMENT PLANNING AND ENERGY CONSERVATION IMPACT PROJECTION (DOLLARS IN THOUSANDS)

TIME PERIOD	1992	1993	1994	1995	1956	TOTAL	AVERAGE
ACTIVITY							
ANNUAL THROUGHPUT (MM BARREL-MILES)	103482.101	106586.562	109784.165	113077.681	113077.681	1704590.797	85229.539
NOMINAL TARIFF (UNIT TRANSP. CHARGE)	2.370	2.488	2.613	2.744	2.881	37.695	1.885
ACTUAL TARIFF	.851	.823	.810	.801	.798	17.764	.888
NOMINAL TRANSPORTATION REVENUES	245250.281	265238.172	286855.094	310233.758	325745.441	3422466.656	171123.332
ACTUAL TOTAL REVENUES	88100.143	87729.949	88872.961	90593.301	90258.336	1612855.578	80642.778
LEVERAGE							
LONG-TERM (FUNDED) DEBT TO CAPITAL %	6.375	5.711	5.038	4.356	3.664	55.342	55.342
LONG-TERM (FUNDED) DEBT TO ASSETS %	4.848	4.333	3.813	3.288	2.758	45.201	45.201
PROFITABILITY							
OPERATING INCOME (ICC RULES)	21006.722	20071.436	19145.752	18220.140	17294.173	430947.094	21547.354
ANNUAL ICC RATE BASE	209875.338	200605.99[illegible]	191336.654	182067.312	172797.971	4719088.437	235954.422
RATE OF RETURN ON RATE BASE (%)	10.009	10.005	10.006	10.007	10.008	9.132	9.132
RATE OF RETURN ON PAID-IN CAPITAL(%)	74.847	70.431	67.154	63.876	60.600	63.234	63.234
RATE OF RETURN ON TOTAL CAPITAL (%)	12.082	11.458	10.996	10.534	10.065	8.470	8.470
ENERGY CONSUMPTION							
ANNUAL ENERGY USAGE IN MM KW-HRS	411998.066	447678.566	484375.156	530802.773	530802.773	5577754.250	278887.711
ANNUAL ENERGY COSTS	17736.400	19850.60[illegible]	22122.113	24969.804	25713.899	225170.787	11258.539
PRESENT VALUE OF ENERGY USED	3859.950	3927.337	3978.857	4082.763	3822.951	65065.001	.000
DISCOUNTED VALUE OF ENERGY USED (@ 10.00 %) =		55065.001					
UNIT COST OF ENERGY ($)	.043	.044	.046	.047	.048	.738	.037
ANNUAL ENERGY WASTED IN KW-HRS (M)	545.531	151.285	79.759	27.725	27.725	2203.819	110.191
ANNUAL ENERGY WASTED COST ($)	23.485	6.706	3.642	1.304	1.343	88.843	4.442
PRESENT VALUE OF ENERGY WASTED	5.111	1.327	.655	.213	.200	24.526	1.226
DISCOUNTED VALUE OF ENERGY WASTED (@ 10.00 %) =		24.526					
OTHER MEASURES							
TOTAL ANNUAL UNIT COSTS	.443	.450	.464	.482	.495	11.298	.565
PRESENT VALUE OF AVERAGE UNIT COSTS	.096	.089	.083	.079	.074	5.424	.271
DISCOUNTED AVERAGE (ANNUAL) UNIT COSTS (LONG-RUN AVERAGE COSTS) (@ 10.00 %) =		.271					
NET INCOME (BOOK PROFIT)	21144.641	19896.938	18971.255	18045.642	17115.675	375137.840	17863.707
PRESENT VALUE OF BOOK PROFITS	4601.690	3936.504	3412.147	2950.607	2544.731	136608.590	6830.429
DISCOUNTED VALUE OF BOOK PROFITS (@ 10.00 %) =		136608.590					
NET CASH GENERATED DURING THE PERIOD	28535.784	27456.037	26530.353	25604.740	24678.774	302389.715	15119.486
PRESENT VALUE OF NET CASH GENERATED	6210.218	5432.031	4771.718	4186.580	3668.343	115723.697	5786.185
DISCOUNTED NET CASH FLOW (@ 10.00 %) =		115723.697					
DISCOUNT FACTOR (@10.000 %) =	.218	.198	.180	.164	.149	.000	.000

•••••• INT[illegible]L RATE OF RETURN ••••••

Fig. 2.4-1, sheet 4

```
DCF - ROI  OF  $  28250.300  (FROM YEAR  1  OVER 10 YEARS) =  43.99 %
DCF - ROI  OF  $  28250.300  (FROM YEAR  1  OVER 15 YEARS) =  44.76 %
DCF - ROI  OF  $  28250.300  (FROM YEAR  1  OVER 20 YEARS) =  45.07 %
```


Fig. 2.4-1, sheet 5

TIME PERIOD	1976	1977	1978	1979	1980	1981	1982	1983
OTHER LINE ITEMS								
OPERATION AND MAINTENANCE EXPENSES	.000	623.000	1304.000	1600.000	1613.000	1759.000	1838.000	1921.00n
INTEREST EXPENSES	.000	12712.635	26145.810	26097.774	24093.948	22090.122	20086.296	18082.470
TOTAL EXPENSES	.000	21355.056	44047.938	47180.873	46476.942	45574.427	44799.893	43990.078
UNUSED TAX LOSS	.000	.000	.000	.000	.000	.000	.000	.000
UNUSED INVESTMENT TAX CREDITS	11162.776	.000	.000	.000	.000	.000	.000	.000
LONG-TERM BORROWING	254252.699	.000	7205.400	.000	.000	.000	.000	.000
NET ADDITIONS TO EQUITY	28250.300	.000	.000	.000	.000	.000	.000	.000
ADDITIONS TO PLANT & EQUIPMENT	255607.000	.000	8006.000	1955.000	4652.000	.000	451.000	2378.000
LONG-TERM DEBT RETIREMENT	.000	.000	480.360	20038.260	20038.260	20038.260	20038.260	20038.260
PLANT & EQUIPMENT (@ ORIGINAL COST)	255607.000	255607.000	263613.000	265568.000	270220.000	270220.000	270671.000	273049.000
NET PROPERTY & EQUIPMENT	255607.000	252056.904	252962.711	247595.129	244870.238	237364.129	230309.016	225168.379
TOTAL DEBT BALANCE	254252.699	254252.699	260977.738	240939.480	220901.221	200862.963	180824.705	160786.445
TOTAL EQUITY CAPITAL	18877.800	18098.424	18098.424	23450.552	32815.758	38588.029	45900.644	56088.895

TIME PERIOD	1984	1985	1986	1987	1988	1989	1990	1991
OTHER LINE ITEMS								
OPERATION AND MAINTENANCE EXPENSES	2045.000	2142.000	2279.000	2444.000	2545.000	2752.000	2940.000	3163.000
INTEREST EXPENSES	16823.034	14769.583	12716.131	10662.679	9090.367	7004.839	5540.671	3413.719
TOTAL EXPENSES	44497.299	44067.743	43634.906	43437.508	43724.165	44048.587	44769.087	45495.712
UNUSED TAX LOSS	.000	.000	.000	.000	.000	.000	.000	.000
UNUSED INVESTMENT TAX CREDITS	.000	.000	.000	.000	.000	.000	.000	.000
LONG-TERM BORROWING	7443.900	.000	.000	.000	4811.400	.000	6213.600	.000
NET ADDITIONS TO EQUITY	.000	.000	.000	.000	.000	.000	.000	.000
ADDITIONS TO PLANT & EQUIPMENT	8271.000	2775.000	4561.000	532.000	5346.000	4414.000	6904.000	4319.000
LONG-TERM DEBT RETIREMENT	20534.520	20534.520	20534.520	20534.520	20855.279	20855.279	21269.519	21269.519
PLANT & EQUIPMENT (@ ORIGINAL COST)	281320.000	284095.000	288656.000	289188.000	294534.000	298948.000	305852.000	310171.000
NET PROPERTY & EQUIPMENT	225854.684	220815.242	217484.715	209998.492	207311.492	203543.992	202143.883	197966.996
TOTAL DEBT BALANCE	147695.826	127161.310	106626.791	86092.271	70048.392	49193.112	34137.192	12867.673
TOTAL EQUITY CAPITAL	65990.509	78294.629	92954.352	105393.966	118137.447	134564.457	147520.383	163851.953

TIME PERIOD	1992	1993	1994	1995	1996	TOTAL	AVERAGE
OTHER LINE ITEMS							
OPERATION AND MAINTENANCE EXPENSES	3361.000	3503.000	3652.000	3766.000	3883.000	49038.000	2451.900
INTEREST EXPENSES	1286.767	1115.604	992.478	869.352	746.226	234340.488	11717.024
TOTAL EXPENSES	45810.860	47936.073	50930.452	54502.017	56019.985	902288.578	45114.429
UNUSED TAX LOSS	.000	.000	.000	.000	.000	.000	.000
UNUSED INVESTMENT TAX CREDITS	.000	.000	.000	.000	.000	11162.776	558.139
LONG-TERM BORROWING	.000	.000	.000	.000	.000	279926.992	13329.857
NET ADDITIONS TO EQUITY	.000	.000	.000	.000	.000	28250.300	1345.252
ADDITIONS TO PLANT & EQUIPMENT	.000	.000	.000	.000	.000	310171.000	14770.048
LONG-TERM DEBT RETIREMENT	1711.632	1231.260	1231.260	1231.260	1231.260	273695.988	13033.142
PLANT & EQUIPMENT (@ ORIGINAL COST)	310171.000	310171.000	310171.000	310171.000	310171.000	6028174.000	287055.902
NET PROPERTY & EQUIPMENT	189351.137	180735.273	172119.414	163503.555	154887.695	4491649.812	213888.086
TOTAL DEBT BALANCE	11156.041	9924.781	8693.521	7462.261	6231.001	2451087.906	116718.472
TOTAL EQUITY CAPITAL	163851.953	163851.953	163851.953	163851.953	163851.953	1977885.969	94185.046

****** AND THAT'S THE WAY IT WILL BE **** THIS IS THE S-CUBED FINANCIAL PROJECTION MODEL *JFM* VERSION #6 111976

Fig. 2.4-1, sheet 6

SYSTEMS, SCIENCE AND SOFTWARE
JFM FINANCIAL PROJECTION MODEL
PIPELINE TRANSPORTATION SYSTEMS   ENERGY CONSERVATION STUDY

DATE   JANUARY 27, 1977   15:16:10   #6   111976
RUN ID   THE LIQUID PETROLEUM PRODUCTS REFERENCE SYSTEM
BASELINE CASE

JFM REPORT NO. 8   TRANSPORTATION REVENUE, THROUGHPUT, AND ENERGY COSTS MODEL (PEP) PROJECTION

•••••• PEP OUTPUT FILE •PEPOUT• READ FROM UNIT 8   PMODE = 1   THRUPM = 1   ENERGM = 0   NYPEP = 20

IOPEP •VISCOSITY DIVIDED BY 5.   01/27/77 13:27:54

YEAR	ENERGY USED THOUSAND KILOWATT-HRS	COST OF ENERGY THOUS. $/YR.	ENERGY WASTED THOUSAND KILOWATT-HRS	COST WASTED ENG. THOUS. $/YR.	THROUGHPUT MILLION BARREL•MILES/YR	REVENUE THOUS. $/YR.	SEG. EXPENSES THOUS. $/YR.
2	17972.732	449.318	.000	.000	22607.907	25773.C14	.000
3	37889.585	1023.019	.000	.000	45894.055	54935.183	.000
4	100700.902	2879.341	.000	.000	67143.010	84388.689	.000
5	111664.309	3371.615	.000	.000	69828.729	92152.446	.000
6	124121.066	3860.169	.000	.000	72621.875	100630.467	.000
7	135371.734	4336.367	.000	.000	75526.755	109888.476	.000
8	154337.863	5092.227	.000	.000	78547.821	119998.209	.000
9	168232.037	5717.171	.000	.000	81689.727	131038.031	.000
10	185806.506	6503.852	.000	.000	84140.426	141717.639	.000
11	197485.158	7120.023	.000	.000	86664.633	153267.617	.000
12	211307.082	7846.902	.000	.000	89264.570	165758.926	.000
13	229178.729	8765.884	.000	.000	91942.510	179268.279	.000
14	249230.361	9818.826	.000	.000	94700.783	193878.639	.000
15	272350.344	11051.565	.000	.000	97541.812	209679.758	.000
16	290961.219	12160.969	.000	.000	100468.062	226768.648	.000
17	321556.160	13842.902	.000	.000	103482.101	245250.281	.000
18	349546.426	15481.574	.000	.000	106586.562	265238.172	.000
19	385553.066	17608.765	.000	.000	109784.165	286855.094	.000
20	419244.125	19721.909	197.663	9.298	113077.681	310233.758	.000
21	419244.125	20313.566	197.663	9.577	113077.681	325745.441	.000

Fig. 2.4-2, sheet 1

SYSTEMS, SCIENCE AND SOFTWARE
LAC PROJECTION MODEL
PIPELINE TRANSPORTATION SYSTEMS   ENERGY CONSERVATION STUDY

DATE   JANUARY 27, 1977   15:16:10   #6   111976
RUN ID   THE LIQUID PETROLEUM PRODUCTS REFERENCE SYSTEM
BASELINE CASE

P38 REPORT NO. 38   CAPITAL INVESTMENT PLANNING AND ENERGY CONSERVATION IMPACT PROJECTION (DOLLARS IN THOUSANDS)

TIME PERIOD	1976	1977	1978	1979	1980	1981	1982	1983
ACTIVITY								
ANNUAL THROUGHPUT (MM BARREL-MILES)	.000	22607.907	45894.055	67143.010	69828.729	72621.875	75526.755	78547.821
NOMINAL TARIFF (UNIT TRANSP. CHARGE)	.000	1.140	1.197	1.257	1.320	1.386	1.455	1.528
ACTUAL TARIFF	.000	1.140	1.197	1.102	1.042	1.018	.992	.942
NOMINAL TRANSPORTATION REVENUES	.000	25773.014	54935.183	84388.689	92152.446	100630.467	109888.476	119998.209
ACTUAL TOTAL REVENUES	.000	25773.014	54935.183	74023.980	72788.659	73923.979	74898.737	74018.087
LEVERAGE								
LONG-TERM (FUNDED) DEBT TO CAPITAL %	93.083	93.299	93.461	91.074	87.010	83.828	79.698	74.082
LONG-TERM (FUNDED) DEBT TO ASSETS %	90.000	88.564	86.026	81.191	75.449	70.720	65.583	59.699
PROFITABILITY								
OPERATING INCOME (ICC RULES)	.000	4580.131	11184.494	27670.617	27331.541	26534.052	25768.156	25170.416
ANNUAL ICC RATE BASE	.000	282503.000	282740.168	276706.172	273315.914	265144.727	257425.039	251619.947
RATE OF RETURN ON RATE BASE (%)	.000	1.621	3.956	10.000	10.000	10.007	10.010	10.003
RATE OF RETURN ON PAID-IN CAPITAL(%)	.000	-2.185	5.735	69.386	73.037	74.420	75.565	76.851
RATE OF RETURN ON TOTAL CAPITAL (%)	.000	-.226	.580	7.409	8.127	8.774	9.409	10.003
ENERGY CONSUMPTION								
ANNUAL ENERGY USAGE IN MM KW-HRS	.000	17972.732	37869.585	100700.902	111664.309	124121.066	135371.734	154337.863
ANNUAL ENERGY COSTS	.000	449.318	1023.019	2879.341	3371.615	3860.169	4336.367	5092.227
PRESENT VALUE OF ENERGY USED	.000	408.471	845.470	2163.291	2302.859	2396.861	2447.766	2613.118
UNIT COST OF ENERGY ($)	.000	.025	.027	.029	.030	.031	.032	.033
ANNUAL ENERGY WASTED IN KW-HRS (M)	.000	.000	.000	.000	.000	.000	.000	.000
ANNUAL ENERGY WASTED COST ($)	.000	.000	.000	.000	.000	.000	.000	.000
PRESENT VALUE OF ENERGY WASTED	.000	.000	.000	.000	.000	.000	.000	.000
OTHER MEASURES								
TOTAL ANNUAL UNIT COSTS	.000	.937	.953	.690	.651	.614	.576	.544
PRESENT VALUE OF AVERAGE UNIT COSTS	.000	.852	.788	.519	.445	.381	.325	.279
NET INCOME (BOOK PROFIT)	-9372.500	-617.204	1620.292	19601.735	20633.042	21023.840	21347.289	21710.712
PRESENT VALUE OF BOOK PROFITS	-9372.500	-561.094	1339.084	14727.073	14092.646	13054.151	12049.989	11141.028
NET CASH GENERATED DURING THE PERIOD	.000	8755.051	18253.395	14249.607	11267.836	15251.569	14034.674	11522.461
PRESENT VALUE OF NET CASH GENERATED	.000	7959.146	15085.450	10705.941	7696.084	9470.025	7922.208	5912.845
DISCOUNT FACTOR (@10.000 %) =	1.000	.909	.826	.751	.683	.621	.564	.513

Fig. 2.4-2, sheet 2

SYSTEMS, SCIENCE AND SOFTWARE
LAC PROJECTION MODEL
PIPELINE TRANSPORTATION SYSTEMS ENERGY CONSERVATION STUDY

DATE JANUARY 27, 1977 15:16:10 #6 111976
RUN ID THE LIQUID PETROLEUM PRODUCTS REFERENCE SYSTEM
BASELINE CASE

P38 REPORT NO. 38 CAPITAL INVESTMENT PLANNING AND ENERGY CONSERVATION IMPACT PROJECTION (DOLLARS IN THOUSANDS)

TIME PERIOD	1984	1985	1986	1987	1988	1989	1990	1991
ACTIVITY								
ANNUAL THROUGHPUT (MM BARREL-MILES)	81689.727	84140.426	86664.633	89264.570	91942.510	94700.783	97541.812	100468.062
NOMINAL TARIFF (UNIT TRANSP. CHARGE)	1.604	1.684	1.769	1.857	1.950	2.047	2.150	2.257
ACTUAL TARIFF	1.014	1.036	1.000	1.000	.953	.916	.807	.856
NOMINAL TRANSPORTATION REVENUES	131038.031	141717.639	153267.617	165758.926	179268.279	193878.639	209679.758	226768.648
ACTUAL TOTAL REVENUES	82856.267	87191.908	86649.539	89260.322	87591.695	86717.584	86505.111	86013.967
LEVERAGE								
LONG-TERM (FUNDED) DEBT TO CAPITAL %	69.066	61.843	53.382	44.922	37.191	26.747	18.775	7.275
LONG-TERM (FUNDED) DEBT TO ASSETS %	54.953	48.447	41.345	34.553	28.565	20.479	14.370	5.543
PROFITABILITY								
OPERATING INCOME (ICC RULES)	25187.795	24607.471	24211.299	23399.145	23068.221	22616.380	22412.665	21931.655
ANNUAL ICC RATE BASE	251642.461	245941.521	241950.270	233804.590	230458.281	226032.957	223976.248	219144.680
RATE OF RETURN ON RATE BASE (%)	10.009	10.005	10.007	10.008	10.010	10.006	10.007	10.008
RATE OF RETURN ON PAID-IN CAPITAL(%)	79.865	80.233	81.120	85.097	83.909	82.142	81.282	79.363
RATE OF RETURN ON TOTAL CAPITAL (%)	10.551	11.023	11.473	12.544	12.585	12.617	12.629	12.675
ENERGY CONSUMPTION								
ANNUAL ENERGY USAGE IN MM KW-HRS	168232.037	185806.506	197485.158	211307.082	229178.729	249230.361	272350.344	290961.219
ANNUAL ENERGY COSTS	5717.171	6503.852	7120.023	7846.902	8765.884	9818.826	11051.565	12160.969
PRESENT VALUE OF ENERGY USED	2667.103	2758.268	2745.077	2750.292	2793.081	2844.164	2910.223	2911.240
UNIT COST OF ENERGY ($)	.034	.035	.036	.037	.038	.039	.041	.042
ANNUAL ENERGY WASTED IN KW-HRS (M)	.000	.000	.000	.000	.000	.000	.000	.000
ANNUAL ENERGY WASTED COST ($)	.000	.000	.000	.000	.000	.000	.000	.000
PRESENT VALUE OF ENERGY WASTED	.000	.000	.000	.000	.000	.000	.000	.000
OTHER MEASURES								
TOTAL ANNUAL UNIT COSTS	.525	.504	.481	.463	.449	.435	.430	.418
PRESENT VALUE OF AVERAGE UNIT COSTS	.245	.214	.186	.162	.143	.126	.113	.100
NET INCOME (BOOK PROFIT)	22562.150	22666.182	22916.696	24040.127	23704.490	23205.276	22962.449	22420.262
PRESENT VALUE OF BOOK PROFITS	10525.410	9612.674	8835.379	8425.918	7552.981	6721.742	6046.731	5367.233
NET CASH GENERATED DURING THE PERIOD	12660.536	10362.062	8256.974	11600.513	10961.008	6778.267	10006.523	6088.691
PRESENT VALUE OF NET CASH GENERATED	5906.234	4394.526	3183.421	4065.909	3492.515	1963.423	2635.031	1457.584
DISCOUNT FACTOR (@10.000 %) =	.467	.424	.386	.350	.319	.290	.263	.239

Fig. 2.4-2, sheet 3

SYSTEMS, SCIENCE AND SOFTWARE
LAC PROJECTION MODEL
PIPELINE TRANSPORTATION SYSTEMS   ENERGY CONSERVATION STUDY

DATE   JANUARY 27, 1977   15:16:10   #6   111976
RUN ID   THE LIQUID PETROLEUM PRODUCTS REFERENCE SYSTEM
BASELINE CASE

P38 REPORT NO. 38   CAPITAL INVESTMENT PLANNING AND ENERGY CONSERVATION IMPACT PROJECTION (DOLLARS IN THOUSANDS)

TIME PERIOD	1992	1993	1994	1995	1996	TOTAL	AVERAGE
ACTIVITY							
ANNUAL THROUGHPUT (MM BARREL-MILES)	103482.101	106586.562	109784.165	113077.681	113077.681	1704590.797	85229.539
NOMINAL TARIFF (UNIT TRANSP. CHARGE)	2.370	2.488	2.613	2.744	2.881	37.695	1.885
ACTUAL TARIFF	.814	.782	.768	.755	.750	17.240	.862
NOMINAL TRANSPORTATION REVENUES	245250.281	265238.172	286855.094	310233.758	325745.441	3422466.656	171123.332
ACTUAL TOTAL REVENUES	84207.596	83361.445	84360.164	85346.047	84853.664	1565276.891	78263.844
LEVERAGE							
LONG-TERM (FUNDED) DEBT TO CAPITAL %	6.369	5.706	5.034	4.352	3.660	55.302	55.302
LONG-TERM (FUNDED) DEBT TO ASSETS %	4.845	4.330	3.810	3.286	2.756	45.174	45.174
PROFITABILITY							
OPERATING INCOME (ICC RULES)	21007.198	20071.701	19146.028	18220.460	17294.503	431413.906	21570.695
ANNUAL ICC RATE BASE	209875.336	200605.996	191336.654	182067.312	172797.971	4719088.437	235954.422
RATE OF RETURN ON RATE BASE (%)	10.009	10.006	10.006	10.008	10.009	9.142	9.142
RATE OF RETURN ON PAID-IN CAPITAL(%)	74.849	70.432	67.155	63.879	60.601	63.312	63.312
RATE OF RETURN ON TOTAL CAPITAL (%)	12.071	11.439	10.985	10.524	10.056	8.474	8.474
ENERGY CONSUMPTION							
ANNUAL ENERGY USAGE IN MM KW-HRS	321556.160	349146.426	385553.066	419244.125	419244.125	4381353.437	219067.672
ANNUAL ENERGY COSTS	13842.902	15481.574	17608.765	19721.909	20313.566	176965.961	8848.298
PRESENT VALUE OF ENERGY USED	3012.619	3062.947	3167.091	3224.690	3019.492	51044.112	.000
DISCOUNTED VALUE OF ENERGY USED (@ 10.00 %) =		51044.112					
UNIT COST OF ENERGY ($)	.043	.044	.046	.047	.048	.738	.037
ANNUAL ENERGY WASTED IN KW-HRS (M)	.000	.000	.000	197.663	197.663	395.325	19.766
ANNUAL ENERGY WASTED COST ($)	.000	.000	.000	9.298	9.577	18.876	.944
PRESENT VALUE OF ENERGY WASTED	.000	.000	.000	1.520	1.424	2.944	.147
DISCOUNTED VALUE OF ENERGY WASTED (@ 10.00 %) =		2.944					
OTHER MEASURES							
TOTAL ANNUAL UNIT COSTS	.405	.409	.423	.436	.448	10.791	.540
PRESENT VALUE OF AVERAGE UNIT COSTS	.088	.081	.076	.071	.067	5.260	.263
DISCOUNTED AVERAGE (ANNUAL) UNIT COSTS (LONG-RUN AVERAGE COSTS) (@ 10.00 %) =		.263					
NET INCOME (BOOK PROFIT)	21145.117	19897.204	18971.530	18045.963	17120.006	375604.641	17885.935
PRESENT VALUE OF BOOK PROFITS	4601.794	3936.556	3412.197	2950.659	2544.780	137004.424	6850.221
DISCOUNTED VALUE OF BOOK PROFITS (@ 10.00 %) =		137004.424					
NET CASH GENERATED DURING THE PERIOD	28536.260	27456.302	26530.629	25605.061	24679.104	302856.520	15142.826
PRESENT VALUE OF NET CASH GENERATED	6210.322	5432.083	4771.767	4186.633	3668.392	116119.530	5805.977
DISCOUNTED NET CASH FLOW (@ 10.00 %) =		116119.530					
DISCOUNT FACTOR (@10.000 %) =	.213	.198	.180	.164	.149	.000	.000

****** INTERNAL RATE OF RETURN ******

Fig. 2.4-2, sheet 4

```
DCF - ROI  OF  $   28250.300  (FROM YEAR  1  OVER 10 YEARS) =  44.41 %
DCF - ROI  OF  $   28250.300  (FROM YEAR  1  OVER 15 YEARS) =  45.17 %
DCF - ROI  OF  $   28250.300  (FROM YEAR  1  OVER 20 YEARS) =  45.47 %
```


Fig. 2.4-2, sheet 5

TIME PERIOD	1976	1977	1978	1979	1980	1981	1982	1983
OTHER LINE ITEMS								
OPERATION AND MAINTENANCE EXPENSES	.000	623.000	1304.000	1500.000	1613.000	1759.000	1838.000	1921.000
INTEREST EXPENSES	.000	12712.635	26145.810	26097.774	24093.948	22090.122	20086.296	18082.470
TOTAL EXPENSES	.000	21192.884	43750.689	46353.364	45457.118	44564.068	43488.440	42764.002
UNUSED TAX LOSS	.000	.000	.000	.000	.000	.000	.000	.000
UNUSED INVESTMENT TAX CREDITS	11009.031	.000	.000	.000	.000	.000	.000	.000
LONG-TERM BORROWING	254252.699	.000	7205.400	.000	.000	.000	.000	.000
NET ADDITIONS TO EQUITY	28250.300	.000	.000	.000	.000	.000	.000	.000
ADDITIONS TO PLANT & EQUIPMENT	255607.000	.000	8006.000	1955.000	4652.000	.000	451.000	2378.000
LONG-TERM DEBT RETIREMENT	.000	.000	480.360	20038.260	20038.260	20038.260	20038.260	20038.260
PLANT & EQUIPMENT (@ ORIGINAL COST)	255607.000	255607.000	263613.000	265568.000	270220.000	270220.000	270671.000	273049.000
NET PROPERTY & EQUIPMENT	255607.000	252056.904	252962.711	247595.129	244870.238	237364.129	230309.016	225168.379
TOTAL DEBT BALANCE	254252.699	254252.699	260977.738	240939.480	220901.221	200862.963	180824.705	160786.445
TOTAL EQUITY CAPITAL	18877.800	18260.596	18260.596	23612.724	32977.930	38750.201	46062.816	56251.067

TIME PERIOD	1984	1985	1986	1987	1988	1989	1990	1991
OTHER LINE ITEMS								
OPERATION AND MAINTENANCE EXPENSES	2045.000	2142.000	2279.000	2444.000	2545.000	2752.000	2940.000	3163.000
INTEREST EXPENSES	16823.034	14769.583	12716.131	10662.679	9090.367	7004.839	5540.671	3413.719
TOTAL EXPENSES	42874.566	42414.544	41728.348	41286.469	41251.917	41189.832	41961.013	42037.243
UNUSED TAX LOSS	.000	.000	.000	.000	.000	.000	.000	.000
UNUSED INVESTMENT TAX CREDITS	.000	.000	.000	.000	.000	.000	.000	.000
LONG-TERM BORROWING	7443.900	.000	.000	.000	4811.400	.000	6213.600	.000
NET ADDITIONS TO EQUITY	.000	.000	.000	.000	.000	.000	.000	.000
ADDITIONS TO PLANT & EQUIPMENT	8271.000	2775.000	4561.000	532.000	5346.000	4414.000	6904.000	4319.000
LONG-TERM DEBT RETIREMENT	20534.520	20534.520	20534.520	20534.520	20855.279	20855.279	21269.519	21269.519
PLANT & EQUIPMENT (@ ORIGINAL COST)	281320.000	284095.000	288656.000	289188.000	294534.000	298948.000	305852.000	310171.000
NET PROPERTY & EQUIPMENT	225854.684	220815.242	217484.715	209996.492	207311.492	203543.992	202143.883	197966.996
TOTAL DEBT BALANCE	147695.826	127161.310	106626.791	86092.271	70048.392	49193.112	34137.192	12867.673
TOTAL EQUITY CAPITAL	66152.681	78456.802	93116.523	105556.138	119299.619	134726.629	147682.555	164014.125

TIME PERIOD	1992	1993	1994	1995	1996	TOTAL	AVERAGE
OTHER LINE ITEMS							
OPERATION AND MAINTENANCE EXPENSES	3361.000	3503.000	3652.000	3766.000	3888.000	49038.000	2451.900
INTEREST EXPENSES	1286.767	1115.604	992.478	869.352	746.226	234340.488	11717.024
TOTAL EXPENSES	41917.362	43567.039	46917.104	49254.121	50613.653	854083.734	42704.187
UNUSED TAX LOSS	.000	.000	.000	.000	.000	.000	.000
UNUSED INVESTMENT TAX CREDITS	.000	.000	.000	.000	.000	11009.031	550.452
LONG-TERM BORROWING	.000	.000	.000	.000	.000	279926.992	13329.857
NET ADDITIONS TO EQUITY	.000	.000	.000	.000	.000	28250.300	1345.252
ADDITIONS TO PLANT & EQUIPMENT	.000	.000	.000	.000	.000	310171.000	14770.048
LONG-TERM DEBT RETIREMENT	1711.632	1231.260	1231.260	1231.260	1231.260	273695.988	13033.142
PLANT & EQUIPMENT (@ ORIGINAL COST)	310171.000	310171.000	310171.000	310171.000	310171.000	6028174.000	287055.902
NET PROPERTY & EQUIPMENT	189351.137	180735.273	172119.414	163503.555	154887.695	4491649.812	213888.086
TOTAL DEBT BALANCE	11156.041	9924.781	8693.521	7462.261	6231.001	2451087.906	116718.472
TOTAL EQUITY CAPITAL	164014.125	164014.125	164014.125	164014.125	164014.125	1981129.406	94339.495

****** AND THAT'S THE WAY IT WILL BE **** THIS IS THE S-CUBED FINANCIAL PROJECTION MODEL *JFM* VERSION #6 111976

Fig. 2.4-2, sheet 6

Figure 2.4-2 presents the results for the comparative case in which viscosity is reduced by five. Sheet 10, line 13, reveals that the enrgy consumption has decreased by 1.2×10^{12} kw-hr to 4.38×10^{12}. The total cost of the energy consumed is \$177 million, a decrease of \$48 million. Thus, if an additive could be developed which would realize the postulated viscosity reduction, and if capital costs were not significantly affected, the operator of this particular pipeline could afford to spend up to \$2.4 million/year to make use of this innovation. During the course of this project, many such studies were conducted using the PEM.

3.0 MAJOR DEPENDENT (OUTPUT) VARIABLES

The many economic, accounting, and engineering variables which are calculated and printed as output by the model, Tables 2.1-2 through 2.1-6 of the preceding section, are all necessary for analyses of one kind or another, although it is seldom necessary to call them all in a single run, as was in fact the case with the viscosity variation study which was presented in Section 2.4 preceding. However, for summary purposes, there are six major results (dependent variables) by which most situations of interest can be characterized. They are the two energetics variables:

(1) Energy intensity (EI), also called unit energy consumption, and

(2) Total energy consumed by the system;

and the four summary economics variables:

(1) Long-run average cost (LAC),
(2) Profit,
(3) Cash flow, and
(4) Return on investment (RoI).

To show how these variables are presented in the various model output formats, example printouts are presented in Figs. 3.0-1 through 3.0-4 of four of the major formats:

(1) Output report 10 - Consolidated statement of income;
(2) Output report 20 - Consolidated statement of changes in financial condition;
(3) Output report 30 - Consolidated statement financial position;
(4) Output report 38 - Capital investment planning and energy conservation impact projection.

SYSTEMS, SCIENCE AND SOFTWARE
JFM FINANCIAL PROJECTION MODEL
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BASELINE CASE

JFM REPORT NO. 10 CONSOLIDATED STATEMENT OF INCOME •••• PROFIT AND LOSS PROJECTION ••••

TIME PERIOD	1976	1977	1978	1979	1980	1981	1982	1983
REVENUES								
NET SALES AND OPERATION REVENUES	.000	37991.023	42228.454	46942.505	51842.370	57340.993	63306.632	69786.962
SALES - PRODUCT A	.000	-1200.617	-2640.108	-5104.355	-6796.504	-11886.421	-16824.961	-19444.809
TOTAL REVENUE	.000	36790.406	39588.346	41838.150	45045.866	45454.572	46481.671	50342.153
COST AND EXPENSES								
OPERATION AND MAINTENANCE EXPENSES	.000	6242.000	6567.000	7159.000	7722.000	8078.000	8558.000	9606.000
SEGREGATED EXPENSES - TYPE C	.000	2213.897	2989.640	3543.570	4896.529	5708.731	6741.059	8373.357
COSTS, EXCL DEPREC & INTEREST	.000	8455.897	9556.640	10702.570	12618.529	13786.731	15299.059	17979.357
GROSS OPERATING INCOME	.000	28334.508	30031.707	31135.580	32427.337	31667.842	31182.612	32362.796
INTEREST EXPENSES	.000	10432.672	10280.112	10280.112	9708.995	9137.877	8566.760	8276.683
FINANCIAL DEPRECIATION	.000	5645.083	5819.778	5819.778	6290.361	6290.361	6290.361	6392.722
AMORTIZATION OF FINANCIAL EXPENSES	.000	333.139	333.139	333.139	333.139	333.139	333.139	333.139
TOTAL EXPENSES	.000	24886.791	25989.668	27135.598	28951.023	29548.107	30489.318	32981.901
INVESTMENT INCOME, NET	.000	.000	.000	.000	.000	.000	.000	.000
NET INCOME BEFORE TAXES	.000	11903.615	13598.678	14702.552	16094.843	15906.465	15992.353	17360.252
INCOME TAXES								
TAX DEPRECIATION	.000	10077.682	10437.128	10257.625	11634.530	11346.172	11089.029	11180.716
TAXABLE INCOME	-10226.000	7824.155	9314.467	10597.844	11083.812	11183.792	11531.824	12905.398
UNUSED TAX LOSS	.000	.000	.000	.000	.000	.000	.000	.000
TAX LOSS CARRYFORWARD	.000	-10226.000	-2401.845	.000	.000	.000	.000	.000
TAX LOSS APPLIED THIS YEAR	.000	-7824.155	-2401.845	.000	.000	.000	.000	.000
INVESTMENT TAX CREDIT	20394.300	557.000	.000	1598.700	.000	.000	368.500	2370.500
UNUSED INVESTMENT TAX CREDITS	4340.477	.000	.000	.000	.000	.000	.000	.000
TAX CREDITS CARRIED FORWARD	.000	20394.300	20951.299	19223.144	18172.383	15401.430	12605.482	10091.026
TAX CREDITS APPLIED THIS YEAR	.000	.000	1728.156	2649.461	2770.953	2795.948	2882.956	3226.349
CURRENT INCOME TAX	.000	.000	1728.156	2649.461	2770.953	2795.948	2882.956	3226.349
DEFERRED INCOME TAX	5113.000	2039.730	2142.106	2052.354	2505.515	2361.336	2230.264	2227.427
TOTAL INCOME TAX	5113.000	2039.730	3870.261	4701.815	5276.468	5157.284	5113.220	5453.777
NET INCOME (BOOK PROFIT)	-5113.000	9863.885	9728.417	10000.737	10818.375	10749.181	10879.132	11906.476

Fig. 3.0-1, sheet 1

SYSTEMS, SCIENCE AND SOFTWARE
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BASELINE CASE

JFM REPORT NO. 10 CONSOLIDATED STATEMENT OF INCOME **** PROFIT AND LOSS PROJECTION ****

TIME PERIOD	1984	1985	1986	1987	1988	1989	1990	1991
REVENUES								
NET SALES AND OPERATION REVENUES	75999.933	83385.776	91214.742	99812.914	108691.813	118674.064	128929.953	139709.234
SALES - PRODUCT A	-23281.405	-28039.467	-30462.272	-36962.949	-38354.364	-46292.970	-44231.328	-48266.189
TOTAL REVENUE	52718.528	55346.311	60752.471	62849.965	70337.430	72381.095	84698.626	91443.047
COST AND EXPENSES								
OPERATION AND MAINTENANCE EXPENSES	10052.000	11545.000	12084.000	12653.000	13409.000	16038.000	16986.000	17793.000
SEGREGATED EXPENSES - TYPE C	8924.424	10322.299	11664.140	14302.946	16861.721	19739.403	25606.156	29842.332
COSTS, EXCL DEPREC & INTEREST	18976.424	21867.299	23748.140	26955.946	30270.721	35777.402	42592.156	47635.332
GROSS OPERATING INCOME	33742.104	33479.012	37004.331	35894.019	40066.709	36603.692	42106.470	43807.716
INTEREST EXPENSES	9390.446	8819.328	10660.118	9979.783	9299.448	8824.890	12097.853	11658.256
FINANCIAL DEPRECIATION	7051.194	7051.194	7303.750	7401.028	7834.139	7834.139	9154.972	9247.333
AMORTIZATION OF FINANCIAL EXPENSES	333.139	333.139	333.139	333.139	333.139	333.139	333.139	333.139
TOTAL EXPENSES	35751.203	38070.959	42045.146	44669.895	47737.446	52769.570	64178.120	68874.059
INVESTMENT INCOME, NET	.000	.000	.000	.000	.000	.000	.000	.000
NET INCOME BEFORE TAXES	16967.326	17275.351	18707.325	18180.070	22599.984	19611.525	20520.507	22568.988
INCOME TAXES								
TAX DEPRECIATION	13088.614	12668.066	13112.296	13007.959	14012.198	13559.150	17486.147	17035.689
TAXABLE INCOME	11263.045	11991.618	13231.918	12906.278	16755.064	14219.653	12522.471	15113.771
UNUSED TAX LOSS	.000	.000	.000	.000	.000	.000	.000	.000
TAX LOSS CARRYFORWARD	.000	.000	.000	.000	.000	.000	.000	.000
TAX LOSS APPLIED THIS YEAR	.000	.000	.000	.000	.000	.000	.000	.000
INVESTMENT TAX CREDIT	.000	909.200	344.500	1511.100	.000	4755.000	332.500	392.100
UNUSED INVESTMENT TAX CREDITS	.000	.000	.000	.000	.000	.000	.000	.000
TAX CREDITS CARRIED FORWARD	4894.700	2078.939	.000	.000	.000	.000	1200.087	.000
TAX CREDITS APPLIED THIS YEAR	2815.761	2988.139	344.500	1511.100	.000	3554.913	1532.587	392.100
CURRENT INCOME TAX	2815.761	3007.671	6271.459	4942.039	8377.532	3554.913	4728.649	7164.786
DEFERRED INCOME TAX	2852.140	2641.866	2737.704	2636.896	2922.460	2695.936	3999.018	3727.609
TOTAL INCOME TAX	5667.902	5649.537	9009.163	7578.935	11299.992	6250.849	8727.667	10892.394
NET INCOME (BOOK PROFIT)	11299.424	11625.814	9698.163	10601.135	11299.992	13360.676	11792.840	11676.594

Fig. 3.0-1, sheet 2

SYSTEMS, SCIENCE AND SOFTWARE
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JFM REPORT NO. 10 CONSOLIDATED STATEMENT OF INCOME **** PROFIT AND LOSS PROJECTION ****

TIME PERIOD	1992	1993	1994	1995	1996	1997	1998	1999
REVENUES								
NET SALES AND OPERATION REVENUES	146690.373	154024.891	161726.135	169812.439	178303.061	187218.213	196579.121	206408.076
SALES - PRODUCT A	-52537.012	-58218.304	-64121.679	-70201.245	-76628.393	-83314.925	-90847.661	-98689.039
TOTAL REVENUE	94153.361	95806.588	97604.461	99611.195	101674.668	103903.289	105731.461	107719.037
COST AND EXPENSES								
OPERATION AND MAINTENANCE EXPENSES	18639.000	19526.000	20458.000	21418.000	22446.000	23568.300	24746.715	25984.050
SEGREGATED EXPENSES - TYPE C	31469.182	33042.641	34694.773	36429.511	38250.986	40163.536	42171.712	44280.297
COSTS, EXCL DEPREC & INTEREST	50108.182	52568.641	55152.773	57847.511	60696.986	63731.835	66918.426	70264.347
GROSS OPERATING INCOME	44045.180	43237.947	42451.688	41763.685	40977.682	40171.454	38813.035	37454.690
INTEREST EXPENSES	10824.134	9762.892	8680.784	7598.675	6516.567	5434.459	4923.467	4412.476
FINANCIAL DEPRECIATION	9356.250	9356.250	9356.250	9356.250	9356.250	9356.250	9356.250	9356.250
AMORTIZATION OF FINANCIAL EXPENSES	333.139	333.139	333.139	234.972	234.972	234.972	234.972	234.972
TOTAL EXPENSES	70621.704	72020.921	73522.944	75037.407	76804.773	78757.515	81433.113	84268.043
INVESTMENT INCOME, NET	.000	.000	.000	.000	.000	.000	.000	.000
NET INCOME BEFORE TAXES	23531.657	23785.667	24081.517	24573.788	24869.895	25145.774	24298.348	23450.994
INCOME TAXES								
TAX DEPRECIATION	16729.436	16094.570	15517.419	15003.411	14604.795	14242.417	13939.319	4645.258
TAXABLE INCOME	16491.209	17380.485	18253.486	19161.599	19856.322	20494.580	19950.251	28396.958
UNUSED TAX LOSS	.000	.000	.000	.000	.000	.000	.000	.000
TAX LOSS CARRYFORWARD	.000	.000	.000	.000	.000	.000	.000	.000
TAX LOSS APPLIED THIS YEAR	.000	.000	.000	.000	.000	.000	.000	.000
INVESTMENT TAX CREDIT	.000	.000	.000	.000	.000	.000	.000	.000
UNUSED INVESTMENT TAX CREDITS	.000	.000	.000	.000	.000	.000	.000	.000
TAX CREDITS CARRIED FORWARD	.000	.000	.000	.000	.000	.000	.000	.000
TAX CREDITS APPLIED THIS YEAR	.000	.000	.000	.000	.000	.000	.000	.000
CURRENT INCOME TAX	8245.805	8690.243	9126.743	9580.800	9928.161	10247.290	9975.125	14198.479
DEFERRED INCOME TAX	3520.024	3202.591	2914.015	2706.094	2506.786	2325.597	2174.048	-2472.982
TOTAL INCOME TAX	11765.829	11892.833	12040.758	12286.894	12434.947	12572.887	12149.174	11725.497
NET INCOME (BOOK PROFIT)	11765.829	11892.833	12040.758	12286.894	12434.947	12572.887	12149.174	11725.497

Fig. 3.0-1, sheet 3

SYSTEMS, SCIENCE AND SOFTWARE
JFM FINANCIAL PROJECTION MODEL
PIPELINE TRANSPORTATION SYSTEMS ENERGY CONSERVATION STUDY

DATE OCTOBER 7, 1976 17:05:45 #5 090176

RUN ID THE NATURAL GAS REFERENCE SYSTEM
BASELINE CASE

JFM REPORT NO. 10 CONSOLIDATED STATEMENT OF INCOME •••• PROFIT AND LOSS PROJECTION ••••

TIME PERIOD	2000	2001	2002	2003	2004	2005	TOTAL	AVERAGE
REVENUES								
NET SALES AND OPERATION REVENUES	216728.479	227564.898	238943.141	250890.295	263434.809	276606.547	4090787.625	141061.641
SALES - PRODUCT A	-106854.488	-115360.212	-124238.396	-133477.689	-143126.562	-153282.682	**********	-59678.860
TOTAL REVENUE	109873.990	112204.687	114704.746	117412.605	120308.246	123323.867	2360100.687	81382.782
COST AND EXPENSES								
OPERATION AND MAINTENANCE EXPENSES	27283.252	28647.415	30079.785	31583.774	33162.963	34821.111	526856.344	18167.460
SEGREGATED EXPENSES - TYPE C	46994.312	48819.027	51259.978	53822.977	56514.125	59339.831	788483.070	27189.071
COSTS, EXCL DEPREC & INTEREST	73777.563	77466.441	81339.763	85406.751	89677.088	94160.941	1315339.391	45356.530
GROSS OPERATING INCOME	36096.427	34738.246	33364.983	32005.854	30631.158	29162.926	1044761.328	36026.252
INTEREST EXPENSES	3901.485	3390.494	2879.502	2368.511	1873.134	1471.360	221451.252	7636.250
FINANCIAL DEPRECIATION	9356.250	9356.250	9356.250	9356.250	9356.250	9356.250	236433.664	8152.885
AMORTIZATION OF FINANCIAL EXPENSES	234.972	234.972	234.972	234.972	234.972	234.972	8581.194	295.903
TOTAL EXPENSES	87270.269	90448.155	93810.485	97366.482	101141.441	105223.521	1781805.484	61441.568
INVESTMENT INCOME, NET	.000	.000	.000	.000	.000	.000	.000	.000
NET INCOME BEFORE TAXES	22603.722	21756.532	20894.261	20046.123	19166.805	18100.346	578295.234	19941.215
INCOME TAXES								
TAX DEPRECIATION	4271.696	4093.416	3529.286	3516.792	3516.792	3399.377	323091.953	10769.732
TAXABLE INCOME	27923.248	27254.338	26956.197	26120.552	25241.234	24292.191	489992.133	16333.071
UNUSED TAX LOSS	.000	.000	.000	.000	.000	.000	.000	.000
TAX LOSS CARRYFORWARD	.000	.000	.000	.000	.000	.000	.000	.000
TAX LOSS APPLIED THIS YEAR	.000	.000	.000	.000	.000	.000	-10226.000	-340.867
INVESTMENT TAX CREDIT	.000	.000	.000	.000	.000	.000	33533.397	1117.780
UNUSED INVESTMENT TAX CREDITS	.000	.000	.000	.000	.000	.000	4340.477	144.683
TAX CREDITS CARRIED FORWARD	.000	.000	.000	.000	.000	.000	.000	.000
TAX CREDITS APPLIED THIS YEAR	.000	.000	.000	.000	.000	.000	29192.922	973.097
CURRENT INCOME TAX	13961.624	13627.169	13478.098	13060.276	12620.617	12146.095	215803.145	7193.438
DEFERRED INCOME TAX	-2659.763	-2748.903	-3030.968	-3037.215	-3037.215	-3095.922	44151.550	1471.718
TOTAL INCOME TAX	11301.861	10878.266	10447.130	10023.062	9583.402	9050.173	259954.695	8665.156
NET INCOME (BOOK PROFIT)	11301.861	10878.266	10447.130	10023.062	9583.402	9050.173	318340.535	10611.351

Fig. 3.0-1, sheet 4

SYSTEMS, SCIENCE AND SOFTWARE
JFM FINANCIAL PROJECTION MODEL
PIPELINE TRANSPORTATION SYSTEMS ENERGY CONSERVATION STUDY

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RUN ID THE NATURAL GAS REFERENCE SYSTEM
BASELINE CASE

JFM REPORT NO. 20 CONSOLIDATED STATEMENT OF CHANGES IN FINANCIAL POSITION •••• CASH FLOW PROJECTION ••••

TIME PERIOD	1976	1977	1978	1979	1980	1981	1982	1983
SOURCES OF FUNDS								
NET INCOME (BOOK PROFIT)	-5113.000	9863.885	9728.417	10000.737	10818.375	10749.181	10879.132	11906.476
FINANCIAL DEPRECIATION	.000	5665.083	5819.778	5819.778	6290.361	6290.361	6290.361	6392.722
AMORTIZATION OF FINANCIAL EXPENSES	.000	333.139	333.139	333.139	333.139	333.139	333.139	333.139
DEFERRED INCOME TAX	5113.000	2039.730	2142.106	2052.359	2505.515	2361.336	2230.264	2227.427
PROVIDED BY OPERATIONS	.000	17901.837	18023.439	18206.008	19947.389	19734.016	19732.896	20859.763
SHORT-TERM BORROWING	1907.000	.000	.000	.000	.000	.000	.000	.000
LONG-TERM BORROWING	128501.400	.000	.000	.000	.000	.000	3513.000	21061.000
NET ADDITIONS TO EQUITY	85667.600	.000	.000	.000	.000	.000	.000	.000
MISCELLANEOUS SOURCES OF FUNDS	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL SOURCES OF FUNDS	216076.000	17901.837	18023.439	18206.008	19947.389	19734.016	23245.896	41920.763
APPLICATION OF FUNDS								
ADDITIONS TO PLANT & EQUIPMENT	203943.000	5569.000	.000	16941.000	.000	.000	3685.000	23705.000
SHORT-TERM DEBT RETIREMENT	.000	1907.000	.000	.000	.000	.000	.000	.000
LONG-TERM DEBT RETIREMENT	.000	.000	.000	7138.967	7138.967	7138.967	7138.967	7138.967
FINANCIAL AND DEBT EXPENSE	10226.000	.000	.000	.000	.000	.000	.000	.000
MISCELLANEOUS APPLICATION OF FUNDS	.000	.000	.000	.000	.000	.000	.000	.000
SUBTOTAL	214169.000	7476.000	.000	24079.967	7138.967	7138.967	10823.967	30843.967
CASH DIVIDENDS PAID	.000	.000	.000	.000	.000	.000	.000	.000
NET INCREASE IN INVESTMENTS	.000	10425.837	18023.439	-5873.959	12808.423	12595.050	12421.929	11076.797
TOTAL APPLICATION OF FUNDS	214169.000	17901.837	18023.439	18206.008	19947.389	19734.016	23245.896	41920.763
INCREASE IN WORKING CAPITAL	1907.000	.000	.000	.000	.000	.000	.000	.000
TOTAL DISPOSITION OF FUNDS	216076.000	17901.837	18023.439	18206.008	19947.389	19734.016	23245.896	41920.763
CASH BENEFITS LESS INVESTMENT COSTS	-216076.000	12332.837	18023.439	1265.008	19947.389	19734.016	16047.896	-2845.237
NET CASH GENERATED DURING THE PERIOD	.000	10425.837	18023.439	-5873.959	12808.423	12595.050	12421.929	11076.797
CUMULATIVE NET CASH GENERATED	.000	10425.837	28449.276	22575.317	35383.739	47978.789	60400.718	71477.515

Fig. 3.0-2, sheet 1

SYSTEMS, SCIENCE AND SOFTWARE
JFM FINANCIAL PROJECTION MODEL
PIPELINE TRANSPORTATION SYSTEMS ENERGY CONSERVATION STUDY

DATE OCTOBER 7, 1976 17:05:45 #5 090176
RUN ID THE NATURAL GAS REFERENCE SYSTEM
BASELINE CASE

JFM REPORT NO. 20 CONSOLIDATED STATEMENT OF CHANGES IN FINANCIAL POSITION **** CASH FLOW PROJECTION ****

TIME PERIOD	1984	1985	1986	1987	1988	1989	1990	1991
SOURCES OF FUNDS								
NET INCOME (BOOK PROFIT)	11299.424	11625.814	9698.163	10601.135	11299.992	13360.676	11792.840	11676.594
FINANCIAL DEPRECIATION	7051.194	7051.194	7303.750	7401.028	7834.139	7834.139	9154.972	9247.333
AMORTIZATION OF FINANCIAL EXPENSES	333.139	333.139	333.139	333.139	333.139	333.139	333.139	333.139
DEFERRED INCOME TAX	2852.140	2641.866	2737.704	2636.896	2922.460	2695.936	3999.018	3727.609
PROVIDED BY OPERATIONS	21535.897	21652.013	20072.754	20972.198	22389.729	24223.889	25279.969	24984.675
SHORT-TERM BORROWING	.000	.000	.000	.000	.000	.000	.000	.000
LONG-TERM BORROWING	.000	30344.000	.000	.000	4258.000	51102.000	4695.000	.000
NET ADDITIONS TO EQUITY	.000	.000	.000	.000	.000	.000	.000	.000
MISCELLANEOUS SOURCES OF FUNDS	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL SOURCES OF FUNDS	21535.897	51996.013	20072.754	20972.198	26647.729	75325.889	29974.969	24984.675
APPLICATION OF FUNDS								
ADDITIONS TO PLANT & EQUIPMENT	.000	9092.000	3502.000	15592.000	.000	47550.000	3325.000	3921.000
SHORT-TERM DEBT RETIREMENT	.000	.000	.000	.000	.000	.000	.000	.000
LONG-TERM DEBT RETIREMENT	7138.967	7334.133	8504.189	8504.189	10189.967	10189.967	10189.967	10426.522
FINANCIAL AND DEBT EXPENSE	.000	.000	.000	.000	.000	.000	.000	.000
MISCELLANEOUS APPLICATION OF FUNDS	.000	.000	.000	.000	.000	.000	.000	.000
SUBTOTAL	7138.967	16426.133	12006.189	24096.189	10189.967	57739.966	13514.967	14347.522
CASH DIVIDENDS PAID	.000	.000	.000	.000	.000	.000	.000	.000
NET INCREASE IN INVESTMENTS	14396.931	35569.880	8066.566	-3123.991	16457.763	17585.923	16460.002	10637.153
TOTAL APPLICATION OF FUNDS	21535.897	51996.013	20072.754	20972.198	26647.729	75325.889	29974.969	24984.675
INCREASE IN WORKING CAPITAL	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL DISPOSITION OF FUNDS	21535.897	51996.013	20072.754	20972.198	26647.729	75325.889	29974.969	24984.675
CASH BENEFITS LESS INVESTMENT COSTS	21535.897	12560.013	16570.754	5380.198	22389.729	-23326.111	21954.969	21063.675
NET CASH GENERATED DURING THE PERIOD	14396.931	35569.880	8066.566	-3123.991	16457.763	17585.923	16460.002	10637.153
CUMULATIVE NET CASH GENERATED	85874.445	121444.325	129510.891	126386.899	142844.662	160430.584	176890.586	187527.738

Fig. 3.0-2, sheet 2

SYSTEMS, SCIENCE AND SOFTWARE
JFM FINANCIAL PROJECTION MODEL
PIPELINE TRANSPORTATION SYSTEMS ENERGY CONSERVATION STUDY

DATE OCTOBER 7, 1976 17:05:45 #5 090176
RUN ID THE NATURAL GAS REFERENCE SYSTEM
BASELINE CASE

JFM REPORT NO. 20 CONSOLIDATED STATEMENT OF CHANGES IN FINANCIAL POSITION **** CASH FLOW PROJECTION ****

TIME PERIOD	1992	1993	1994	1995	1996	1997	1998	1999
SOURCES OF FUNDS								
NET INCOME (BOOK PROFIT)	11765.829	11892.833	12040.758	12286.894	12434.947	12572.887	12149.174	11725.497
FINANCIAL DEPRECIATION	9356.250	9356.250	9356.250	9356.250	9356.250	9356.250	9356.250	9356.250
AMORTIZATION OF FINANCIAL EXPENSES	333.139	333.139	333.139	234.972	234.972	234.972	234.972	234.972
DEFERRED INCOME TAX	3520.024	3202.591	2914.015	2706.094	2506.786	2325.597	2174.048	-2472.982
PROVIDED BY OPERATIONS	24975.241	24784.812	24644.162	24584.210	24532.955	24489.706	23914.444	18843.737
SHORT-TERM BORROWING	.000	.000	.000	.000	.000	.000	.000	.000
LONG-TERM BORROWING	.000	.000	.000	.000	.000	.000	.000	.000
NET ADDITIONS TO EQUITY	.000	.000	.000	.000	.000	.000	.000	.000
MISCELLANEOUS SOURCES OF FUNDS	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL SOURCES OF FUNDS	24975.241	24784.812	24644.162	24584.210	24532.955	24489.706	23914.444	18843.737
APPLICATION OF FUNDS								
ADDITIONS TO PLANT & EQUIPMENT	.000	.000	.000	.000	.000	.000	.000	.000
SHORT-TERM DEBT RETIREMENT	.000	.000	.000	.000	.000	.000	.000	.000
LONG-TERM DEBT RETIREMENT	13265.522	13526.355	13526.355	13526.355	13526.355	6387.399	6387.389	6387.389
FINANCIAL AND DEBT EXPENSE	.000	.000	.000	.000	.000	.000	.000	.000
MISCELLANEOUS APPLICATION OF FUNDS	.000	.000	.000	.000	.000	.000	.000	.000
SUBTOTAL	13265.522	13526.355	13526.355	13526.355	13526.355	6387.399	6387.389	6387.389
CASH DIVIDENDS PAID	.000	.000	.000	.000	.000	.000	.000	.000
NET INCREASE IN INVESTMENTS	11709.719	11258.457	11117.806	11057.855	11006.600	18102.308	17527.055	12456.348
TOTAL APPLICATION OF FUNDS	24975.241	24784.812	24644.162	24584.210	24532.955	24489.706	23914.444	18843.737
INCREASE IN WORKING CAPITAL	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL DISPOSITION OF FUNDS	24975.241	24784.812	24644.162	24584.210	24532.955	24489.706	23914.444	18843.737
CASH BENEFITS LESS INVESTMENT COSTS	24975.241	24784.312	24644.162	24584.210	24532.955	24489.706	23914.444	18843.737
NET CASH GENERATED DURING THE PERIOD	11709.719	11258.457	11117.806	11057.855	11006.600	18102.308	17527.055	12456.348
CUMULATIVE NET CASH GENERATED	199237.457	210495.914	221613.719	232671.572	243678.172	261780.479	279307.531	291763.879

Fig. 3.0-2, sheet 3

SYSTEMS, SCIENCE AND SOFTWARE

JFM FINANCIAL PROJECTION MODEL

PIPELINE TRANSPORTATION SYSTEMS ENERGY CONSERVATION STUDY

DATE OCTOBER 7, 1976 17:05:45 #5 090176

RUN ID THE NATURAL GAS REFERENCE SYSTEM
BASELINE CASE

JFM REPORT NO. 20 CONSOLIDATED STATEMENT OF CHANGES IN FINANCIAL POSITION **** CASH FLOW PROJECTION ****

TIME PERIOD	2000	2001	2002	2003	2004	2005	TOTAL	AVERAGE
SOURCES OF FUNDS								
NET INCOME (BOOK PROFIT)	11301.861	10870.266	10447.130	10023.062	9583.402	9050.173	318340.535	10611.351
FINANCIAL DEPRECIATION	9356.250	9356.250	9356.250	9356.250	9356.250	9356.250	236433.664	8152.885
AMORTIZATION OF FINANCIAL EXPENSES	234.972	234.972	234.972	234.972	234.972	234.972	8581.194	295.903
DEFERRED INCOME TAX	-2659.763	-2748.903	-3030.968	-3037.215	-3037.215	-3095.922	44151.550	1471.718
PROVIDED BY OPERATIONS	18233.320	17720.585	17007.384	16577.069	16137.409	15545.472	607506.922	20250.231
SHORT-TERM BORROWING	.000	.000	.000	.000	.000	.000	1907.000	63.567
LONG-TERM BORROWING	.000	.000	.000	.000	.000	.000	243474.400	8115.813
NET ADDITIONS TO EQUITY	.000	.000	.000	.000	.000	.000	85667.600	2855.587
MISCELLANEOUS SOURCES OF FUNDS	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL SOURCES OF FUNDS	18233.320	17720.585	17007.384	16577.069	16137.409	15545.472	938555.883	31285.196
APPLICATION OF FUNDS								
ADDITIONS TO PLANT & EQUIPMENT	.000	.000	.000	.000	.000	.000	336825.000	11227.500
SHORT-TERM DEBT RETIREMENT	.000	.000	.000	.000	.000	.000	1907.000	63.567
LONG-TERM DEBT RETIREMENT	6387.389	6387.389	6387.389	6192.222	5022.167	5022.167	230104.559	7670.152
FINANCIAL AND DEBT EXPENSE	.000	.000	.000	.000	.000	.000	10226.000	340.867
MISCELLANEOUS APPLICATION OF FUNDS	.000	.000	.000	.000	.000	.000	.000	.000
SUBTOTAL	6387.389	6387.389	6387.389	6192.222	5022.167	5022.167	579062.492	19302.083
CASH DIVIDENDS PAID	.000	.000	.000	.000	.000	.000	.000	.000
NET INCREASE IN INVESTMENTS	11845.931	11333.196	10619.996	10384.846	11115.242	10523.306	357586.383	11919.546
TOTAL APPLICATION OF FUNDS	18233.320	17720.585	17007.384	16577.069	16137.409	15545.472	936648.883	31221.629
INCREASE IN WORKING CAPITAL	.000	.000	.000	.000	.000	.000	1907.000	63.567
TOTAL DISPOSITION OF FUNDS	18233.320	17720.585	17007.384	16577.069	16137.409	15545.472	938555.883	31285.196
CASH BENEFITS LESS INVESTMENT COSTS	18233.320	17720.585	17007.384	16577.069	16137.409	15545.472	258548.961	8618.299
NET CASH GENERATED DURING THE PERIOD	11845.931	11333.196	10619.996	10384.846	11115.242	10523.306	357586.383	11919.546
CUMULATIVE NET CASH GENERATED	303609.809	314943.004	325562.996	335947.840	347063.078	357586.383	5332862.937	177762.098

Fig. 3.0-2, sheet 4

SYSTEMS, SCIENCE AND SOFTWARE
JFM FINANCIAL PROJECTION MODEL
PIPELINE TRANSPORTATION SYSTEMS ENERGY CONSERVATION STUDY

DATE OCTOBER 7, 1976 17:06:45 #5 090176
RUN ID THE NATURAL GAS REFERENCE SYSTEM
BASELINE CASE

JFM REPORT NO. 30 CONSOLIDATED STATEMENT OF FINANCIAL POSITION •••• BALANCE SHEET PROJECTION ••••

TIME PERIOD	1976	1977	1978	1979	1980	1981	1982	1983
ASSETS								
CURRENT ASSETS								
CASH	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000
TOTAL CURRENT ASSETS	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000
PROPERTY, PLANT AND EQUIPMENT								
@ ORIGINAL COST	203743.000	209512.000	209512.000	226453.000	226453.000	226453.000	230138.000	253843.000
LESS - ACCUMULATED DEPRECIATION	.000	5665.083	11484.861	17304.639	23595.000	29885.360	36175.721	42568.443
NET PROPERTY & EQUIP.	203743.000	203846.918	198027.141	209148.361	202858.002	196567.641	193962.279	211274.559
INVESTMENTS	.000	10425.837	28449.276	22575.317	35383.739	47978.789	60400.718	71477.515
DEFERRED CHARGES								
UNAMORTIZED FIN. & DEBT EXPENSES	1767.000	1668.833	1570.667	1472.500	1374.333	1276.167	1178.000	1079.833
UNAMORTIZED CONSTRUCTION INTEREST	8459.000	8224.028	7989.056	7754.083	7519.111	7284.139	7049.167	6814.195
OTHER DEFERRED CHARGES	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL DEFERRED CHARGES	10226.000	9892.861	9559.722	9226.583	8893.445	8560.306	8227.167	7894.028
TOTAL ASSETS	216076.000	226072.613	237943.137	242857.260	249042.184	255013.734	264497.160	292553.098
LIABILITIES AND SHAREHOLDERS EQUITY								
CURRENT LIABILITIES								
TOTAL CURRENT LIABILITIES	.000	.000	.000	.000	.000	.000	.000	.000
SHORT-DEBT UNPAID BALANCE	1907.000	.000	.000	.000	.000	.000	.000	.000
LONG-DEBT UNPAID BALANCE	128501.400	128501.400	128501.400	121362.435	114223.469	107084.503	103458.537	117380.571
TOTAL DEBT BALANCE	130408.400	128501.400	128501.400	121362.435	114223.469	107084.503	103458.537	117380.571
DEFERED FEDERAL INCOME TAXES	5113.000	7152.730	9294.835	11347.189	13852.704	16214.041	18444.305	20671.732
STOCKHOLDERS EQUITY								
TOTAL PAID-IN CAPITAL	85667.600	85667.600	85667.600	85667.600	85667.600	85667.600	85667.600	85667.600
RETAINED EARNINGS	-5113.000	4750.885	14479.302	24480.039	35298.414	46047.594	56926.726	68833.201
TOTAL EQUITY CAPITAL	80554.600	90418.484	100146.901	110147.639	120966.013	131715.193	142594.324	154500.801
TOTAL LIABILITIES & EQUITY	216076.000	226072.613	237943.135	242857.262	249042.186	255013.736	264497.164	292553.102
NET WORKING CAPITAL	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	17.000

Fig. 3.0-3, sheet 1

SYSTEMS, SCIENCE AND SOFTWARE
JFM FINANCIAL PROJECTION MODEL
PIPELINE TRANSPORTATION SYSTEMS ENERGY CONSERVATION STUDY

DATE OCTOBER 7, 1976 17:05:45 #5 090176
RUN ID THE NATURAL GAS REFERENCE SYSTEM
BASELINE CASE

JFM REPORT NO. 30 CONSOLIDATED STATEMENT OF FINANCIAL POSITION **** BALANCE SHEET PROJECTION ****

TIME PERIOD	1984	1985	1986	1987	1988	1989	1990	1991
ASSETS								
CURRENT ASSETS								
CASH	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000
TOTAL CURRENT ASSETS	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000
PROPERTY, PLANT AND EQUIPMENT								
@ ORIGINAL COST	253843.000	262935.000	266437.000	282029.000	282029.000	329579.000	332904.000	336825.000
LESS - ACCUMULATED DEPRECIATION	49619.637	56670.831	63974.580	71375.607	79209.746	87043.885	96198.856	105446.189
NET PROPERTY & EQUIP.	204223.363	206264.172	202462.422	210653.395	202819.254	242535.117	236705.145	231378.812
INVESTMENTS	85874.445	121444.325	129510.891	126386.899	142844.662	160430.584	176890.586	187527.738
DEFERRED CHARGES								
UNAMORTIZED FIN. & DEBT EXPENSES	981.667	883.500	785.333	687.167	589.000	490.833	392.667	294.500
UNAMORTIZED CONSTRUCTION INTEREST	6579.223	6344.250	6109.278	5874.306	5639.334	5404.362	5169.390	4934.417
OTHER DEFERRED CHARGES	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL DEFERRED CHARGES	7560.889	7227.751	6894.612	6561.473	6228.334	5895.195	5562.056	5228.918
TOTAL ASSETS	299565.695	336843.246	340774.922	345508.766	353799.246	410767.891	421064.785	426042.465
LIABILITIES AND SHAREHOLDERS EQUITY								
CURRENT LIABILITIES								
TOTAL CURRENT LIABILITIES	.000	.000	.000	.000	.000	.000	.000	.000
SHORT-DEBT UNPAID BALANCE	.000	.000	.000	.000	.000	.000	.000	.000
LONG-DEBT UNPAID BALANCE	110241.605	133251.473	124747.284	116243.097	110311.130	151223.164	145728.197	135301.676
TOTAL DEBT BALANCE	110241.605	133251.473	124747.284	116243.097	110311.130	151223.164	145728.197	135301.676
DEFERED FEDERAL INCOME TAXES	23523.872	26165.739	28903.442	31540.338	34462.798	37158.734	41157.751	44885.360
STOCKHOLDERS EQUITY								
TOTAL PAID-IN CAPITAL	85667.600	85667.600	85667.600	85667.600	85667.600	85667.600	85667.600	85667.600
RETAINED EARNINGS	80132.625	91758.438	101456.601	112057.735	123357.728	136718.402	148511.242	160187.836
TOTAL EQUITY CAPITAL	165800.225	177426.037	187124.199	197725.334	209025.326	222386.002	234178.842	245855.436
TOTAL LIABILITIES & EQUITY	299565.699	336843.246	340774.922	345508.766	353799.254	410767.898	421064.789	426042.469
NET WORKING CAPITAL	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000

Fig. 3.0-3, sheet 2

SYSTEMS, SCIENCE AND SOFTWARE
JFM FINANCIAL PROJECTION MODEL
PIPELINE TRANSPORTATION SYSTEMS ENERGY CONSERVATION STUDY

DATE OCTOBER 7, 1976 17:05:45 #5 090176
RUN ID THE NATURAL GAS REFERENCE SYSTEM
BASELINE CASE

JFM REPORT NO. 30 CONSOLIDATED STATEMENT OF FINANCIAL POSITION **** BALANCE SHEET PROJECTION ****

TIME PERIOD	1992	1993	1994	1995	1996	1997	1998	1999
ASSETS								
CURRENT ASSETS								
CASH	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000
TOTAL CURRENT ASSETS	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000
PROPERTY, PLANT AND EQUIPMENT								
@ ORIGINAL COST	336825.000	336825.000	336825.000	336825.000	336825.000	336825.000	336825.000	336825.000
LESS - ACCUMULATED DEPRECIATION	114802.438	124158.687	133514.936	142871.184	152227.432	161583.680	170939.928	180296.176
NET PROPERTY & EQUIP.	222022.562	212666.312	203310.066	193953.816	184597.570	175241.320	165885.074	156528.824
INVESTMENTS	199237.457	210495.914	221613.719	232671.572	243678.172	261780.479	279307.531	291763.879
DEFERRED CHARGES								
UNAMORTIZED FIN. & DEBT EXPENSES	196.333	98.167	.000	.000	.000	.000	.000	.000
UNAMORTIZED CONSTRUCTION INTEREST	4699.445	4464.473	4229.501	3994.529	3759.557	3524.584	3289.612	3054.640
OTHER DEFERRED CHARGES	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL DEFERRED CHARGES	4895.779	4562.640	4229.501	3994.529	3759.557	3524.585	3289.612	3054.640
TOTAL ASSETS	428062.797	429631.863	431060.285	432526.914	433942.297	442453.379	450389.215	453254.340
LIABILITIES AND SHAREHOLDERS EQUITY								
CURRENT LIABILITIES								
TOTAL CURRENT LIABILITIES	.000	.000	.000	.000	.000	.000	.000	.000
SHORT-DEBT UNPAID BALANCE	.000	.000	.000	.000	.000	.000	.000	.000
LONG-DEBT UNPAID BALANCE	122036.155	108509.799	94983.444	81457.090	67930.734	61543.335	55155.947	48768.558
TOTAL DEBT BALANCE	122036.155	108509.799	94983.444	81457.090	67930.734	61543.335	55155.947	48768.558
DEFERED FEDERAL INCOME TAXES	48405.184	51607.975	54521.990	57228.084	59734.870	62060.467	64234.516	61761.534
STOCKHOLDERS EQUITY								
TOTAL PAID-IN CAPITAL	85667.600	85667.600	85667.600	85667.600	85667.600	85667.600	85667.600	85667.600
RETAINED EARNINGS	171953.664	183846.496	195887.259	208174.146	220609.094	233181.980	245331.154	257056.650
TOTAL EQUITY CAPITAL	257621.264	269514.094	281554.852	293841.746	306276.691	318849.578	330998.754	342724.250
TOTAL LIABILITIES & EQUITY	428062.801	429631.867	431060.285	432526.918	433942.293	442453.379	450389.215	453254.340
NET WORKING CAPITAL	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000

Fig. 3.0-3, sheet 3

SYSTEMS, SCIENCE AND SOFTWARE
JFM FINANCIAL PROJECTION MODEL
PIPELINE TRANSPORTATION SYSTEMS ENERGY CONSERVATION STUDY

DATE OCTOBER 7, 1976 17105145 #5 090176
RUN ID THE NATURAL GAS REFERENCE SYSTEM
BASELINE CASE

JFM REPORT NO. 30 CONSOLIDATED STATEMENT OF FINANCIAL POSITION **** BALANCE SHEET PROJECTION ****

TIME PERIOD	2000	2001	2002	2003	2004	2005	TOTAL	AVERAGE
ASSETS								
CURRENT ASSETS								
CASH	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	57210.000	1907.000
TOTAL CURRENT ASSETS	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	57210.000	1907.000
PROPERTY, PLANT AND EQUIPMENT								
@ ORIGINAL COST	336825.000	336825.000	336825.000	336825.000	336825.000	336825.000	8848438.000	294947.930
LESS - ACCUMULATED DEPRECIATION	189652.424	199008.672	208364.920	217721.168	227077.416	236433.664	3234871.031	107829.034
NET PROPERTY & EQUIP.	147172.578	137816.328	128460.082	119103.832	109747.586	100391.336	5613566.562	187118.885
INVESTMENTS	303609.809	314943.004	325562.996	335947.840	347063.078	357586.383	5332862.937	177762.098
DEFERRED CHARGES								
UNAMORTIZED FIN. & DEBT EXPENSES	.000	.000	.000	.000	.000	.000	16786.500	559.550
UNAMORTIZED CONSTRUCTION INTEREST	2819.668	2584.696	2349.723	2114.751	1879.779	1644.807	151557.092	5051.903
OTHER DEFERRED CHARGES	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL DEFERRED CHARGES	2819.668	2584.696	2349.724	2114.751	1879.779	1644.807	168343.588	5611.453
TOTAL ASSETS	455509.051	457251.027	458279.801	459073.422	460597.441	461529.523	**********	372399.422

****

LIABILITIES AND SHAREHOLDERS EQUITY	2000	2001	2002	2003	2004	2005	TOTAL	AVERAGE
CURRENT LIABILITIES								
TOTAL CURRENT LIABILITIES	.000	.000	.000	.000	.000	.000	.000	.000
SHORT-DEBT UNPAID BALANCE	.000	.000	.000	.000	.000	.000	1907.000	63.567
LONG-DEBT UNPAID BALANCE	42381.169	35993.781	29606.392	23414.170	18392.002	13369.836	2779603.437	92653.447
TOTAL DEBT BALANCE	42381.169	35993.781	29606.392	23414.170	18392.002	13369.836	2781510.437	92717.014
DEFERED FEDERAL INCOME TAXES	59101.771	56352.869	53321.901	50284.687	47247.472	44151.550	1139903.578	37996.786

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STOCKHOLDERS EQUITY	2000	2001	2002	2003	2004	2005	TOTAL	AVERAGE
TOTAL PAID-IN CAPITAL	85667.600	85667.600	85667.600	85667.600	85667.600	85667.600	2570027.844	85667.595
RETAINED EARNINGS	268358.508	279236.773	289683.902	299706.961	309290.363	318340.535	4680541.000	156018.033
TOTAL EQUITY CAPITAL	354026.105	364904.371	375351.500	385374.559	394957.961	404008.133	7250568.812	241685.627
TOTAL LIABILITIES & EQUITY	455509.043	457251.020	458279.789	459073.414	460597.434	461529.516	**********	372399.426

****

	2000	2001	2002	2003	2004	2005	TOTAL	AVERAGE
NET WORKING CAPITAL	1907.000	1907.000	1907.000	1907.000	1907.000	1907.000	57210.000	1907.000

Fig. 3.0-3, sheet 4

SYSTEMS, SCIENCE AND SOFTWARE
LAC PROJECTION MODEL
PIPELINE TRANSPORTATION SYSTEMS ENERGY CONSERVATION STUDY

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BASELINE CASE

P38 REPORT NO. 38 CAPITAL INVESTMENT PLANNING AND ENERGY CONSERVATION IMPACT PROJECTION (DOLLARS IN THOUSANDS)

TIME PERIOD	1976	1977	1978	1979	1980	1981	1982	1983
ACTIVITY								
ANNUAL THROUGHPUT	.000	57.562	60.936	64.512	67.854	71.477	75.155	78.903
MEASURED IN MILLION MMCSF - MILES								
TARIFF - UNIT TRANSPORTATION CHARGE	.000	660.000	693.000	727.650	764.032	802.234	842.346	884.463
TRANSPORTATION REVENUES	.000	37991.023	42228.454	46942.505	51842.370	57340.993	63306.632	69786.962
REVENUE REDUCTION	.000	-1200.617	-2640.108	-5104.355	-6796.504	-11886.421	-16824.961	-19444.809
TOTAL REVENUE	.000	36790.406	39588.346	41838.150	45045.866	45454.572	46481.671	50342.153
TARIFF CONSTRAINT FACTOR	.000	.968	.937	.891	.869	.793	.734	.721
LEVERAGE								
LONG-TERM (FUNDED) DEBT TO EQUITY(%)	159.521	142.119	128.313	110.182	94.426	81.300	72.554	75.974
LONG-TERM (FUNDED) DEBT TO CAPITAL %	61.467	58.698	56.200	52.422	48.567	44.843	42.047	43.173
LONG-TERM (FUNDED) DEBT TO ASSETS %	59.470	56.841	54.005	49.973	45.865	41.992	39.115	40.123
PROFITABILITY								
OPERATING INCOME (FPC RULES)	.000	20629.696	20341.667	20613.988	20860.508	20220.197	19779.031	20516.297
ANNUAL FPC RATE BASE	206345.000	206296.959	203339.029	205987.750	208905.182	202114.822	197666.961	205020.418
RATE OF RETURN ON RATE BASE (%)	.000	10.000	10.004	10.007	10.010	10.004	10.006	10.007
RATE OF RETURN ON PAID-IN CAPITAL(%)	.000	11.514	11.356	11.674	12.628	12.548	12.699	13.698
RATE OF RETURN ON TOTAL EQUITY (%)	.000	10.909	9.714	9.079	8.943	8.161	7.629	7.706
RATE OF RETURN ON TOTAL CAPITAL (%)	.000	4.506	4.255	4.320	4.600	4.501	4.421	4.379
ENERGY CONSUMPTION								
ANNUAL ENERGY USAGE OF GAS (MMCSF)	.000	1559.083	2005.124	2263.467	2978.737	3307.456	3719.575	4400.231
ANNUAL ENERGY COSTS	.000	2213.897	2989.640	3543.570	4896.529	5708.731	6741.059	8373.357
PRESENT VALUE OF ENERGY USED	.000	2012.634	2470.777	2662.337	3344.395	3544.673	3805.152	4296.856
UNIT COST OF ENERGY ($)	.000	1.420	1.491	1.566	1.644	1.726	1.812	1.903
ANNUAL ENERGY WASTED IN GAS (MMCSF)	.000	.000	.000	.000	.000	.000	.000	.000
ANNUAL ENERGY WASTED COST ($)	.000	.000	.000	.000	.000	.000	.000	.000
PRESENT VALUE OF ENERGY WASTED	.000	.000	.000	.000	.000	.000	.000	.000
OTHER MEASURES								
ANNUAL UNIT COSTS (TOTAL)	.000	432.346	426.510	420.626	426.669	413.395	405.685	418.005
PRESENT VALUE OF AVERAGE UNIT COSTS	.000	393.042	352.487	316.022	291.421	256.686	228.999	214.502
NET INCOME (BOOK PROFIT)	-5113.000	9863.885	9728.417	10000.737	10818.375	10749.181	10879.132	11906.476
PRESENT VALUE OF BOOK PROFITS	-5113.000	8967.168	8040.014	7513.702	7389.095	6674.396	6140.987	6109.905

Fig. 3.0-4, sheet 1

NET CASH GENERATED DURING THE PERIOD	.000	10425.837	18023.439	-5873.959	12808.423	12595.050	12421.929	11076.797
PRESENT VALUE OF NET CASH GENERATED	.000	9478.033	14895.404	-4413.192	8748.325	7820.535	7011.856	5684.148
DISCOUNT FACTOR (@10.000 %) =	1.000	.909	.826	.751	.683	.621	.564	.513

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Fig. 3.0-4, sheet 2

SYSTEMS, SCIENCE AND SOFTWARE
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TIME PERIOD	1984	1985	1986	1987	1988	1989	1990	1991
ACTIVITY								
ANNUAL THROUGHPUT	81.836	85.513	89.088	92.843	96.288	100.124	103.597	106.913
MEASURED IN MILLION MMCSF - MILES								
TARIFF - UNIT TRANSPORTATION CHARGE	928.686	975.121	1023.877	1075.070	1128.824	1185.265	1244.528	1306.755
TRANSPORTATION REVENUES	75999.933	83385.776	91214.742	99812.914	108691.813	118674.064	128929.953	139709.234
REVENUE REDUCTION	-23281.405	-28039.467	-30462.272	-36962.949	-38354.384	-46292.970	-44231.328	-48266.189
TOTAL REVENUE	52718.528	55346.311	60752.471	62849.965	70337.430	72381.095	84698.626	91443.047
TARIFF CONSTRAINT FACTOR	.694	.664	.666	.630	.647	.610	.657	.655
LEVERAGE								
LONG-TERM (FUNDED) DEBT TO EQUITY(%)	6[illegible].491	75.103	66.665	58.790	52.774	68.000	62.229	55.033
LONG-TERM (FUNDED) DEBT TO CAPITAL %	37.937	42.891	40.000	37.024	34.544	40.476	38.359	35.498
LONG-TERM (FUNDED) DEBT TO ASSETS %	3[illegible].800	39.559	36.607	33.644	31.179	36.815	34.609	31.758
PROFITABILITY								
OPERATING INCOME (FPC RULES)	21021.009	20778.281	20691.419	20914.056	20932.578	22518.705	24223.832	23667.989
ANNUAL FPC RATE BASE	210150.763	207645.766	206765.299	208959.906	209138.326	225079.184	242022.133	236443.979
RATE OF RETURN ON RATE BASE (%)	10.004	10.007	10.007	10.009	10.009	10.005	10.009	10.010
RATE OF RETURN ON PAIDIN CAPITAL(%)	13.190	13.571	11.321	12.375	13.191	15.596	13.766	13.630
RATE OF RETURN ON TOTAL EQUITY (%)	[illegible].915	6.552	5.183	5.362	5.406	6.008	5.036	4.749
RATE OF RETURN ON TOTAL CAPITAL (%)	4.093	3.742	3.110	3.376	3.539	3.576	3.104	3.063
ENERGY CONSUMPTION								
ANNUAL ENERGY USAGE OF GAS (MMCSF)	446[illegible].495	4920.097	5294.936	6183.640	6942.746	7740.591	9563.023	10614.371
ANNUAL ENERGY COSTS	8924.424	10322.299	11664.140	14302.946	16661.721	19739.403	25606.156	29842.332
PRESENT VALUE OF ENERGY USED	4163.310	4377.662	4497.031	5013.096	5372.664	5717.802	6742.902	7144.017
UNIT COST OF ENERGY ($)	1.998	2.098	2.203	2.313	2.429	2.550	2.678	2.812
ANNUAL ENERGY WASTED IN GAS (MMCSF)	.000	.000	.000	.000	.000	.000	.000	.000
ANNUAL ENERGY WASTED COST ($)	.000	.000	.000	.000	.000	.000	.000	.000
PRESENT VALUE OF ENERGY WASTED	.000	.000	.000	.000	.000	.000	.000	.000
OTHER MEASURES								
ANNUAL UNIT COSTS (TOTAL)	434.864	445.205	471.953	481.133	495.779	527.040	619.495	644.206
PRESENT VALUE OF AVERAGE UNIT COSTS	203.800	188.810	181.958	168.639	167.971	152.665	163.132	154.218
NET INCOME (BOOK PROFIT)	11295.424	11625.814	9698.163	10601.135	11299.992	13360.676	11792.840	11676.594
PRESENT VALUE OF BOOK PROFITS	5271.265	4930.480	3739.062	3715.633	3600.526	3870.112	3105.424	2795.284

Fig. 3.0-4, sheet 3

NET CASH GENERATED DURING THE PERIOD	14396.931	35569.880	8066.566	-3123.991	16457.763	17585.923	16460.002	10637.153
PRESENT VALUE OF NET CASH GENERATED	6716.275	15085.102	3110.010	-1094.940	5243.951	5094.016	4334.433	2546.450
DISCOUNT FACTOR (@10.000 %) =	.467	.424	.386	.350	.319	.290	.263	.239

Fig. 3.0-4, sheet 4

SYSTEMS, SCIENCE AND SOFTWARE
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P38 REPORT NO. 38 CAPITAL INVESTMENT PLANNING AND ENERGY CONSERVATION IMPACT PROJECTION (DOLLARS IN THOUSANDS)

TIME PERIOD	1992	1993	1994	1995	1996	1997	1998	1999
ACTIVITY								
ANNUAL THROUGHPUT	106.910	106.910	106.910	106.910	106.910	106.910	106.910	106.910
MEASURED IN MILLION MMCSF - MILES								
TARIFF - UNIT TRANSPORTATION CHARGE	1372.092	1448.697	1512.732	1588.368	1667.787	1751.176	1838.735	1930.672
TRANSPORTATION REVENUES	146690.373	154024.891	161726.135	169812.439	178303.061	187218.213	196579.121	206408.076
REVENUE REDUCTION	-52537.012	-58218.304	-64121.674	-70201.245	-76628.393	-83314.925	-90847.661	-98689.039
TOTAL REVENUE	94153.361	95806.588	97604.461	99611.195	101674.668	103903.289	105731.461	107719.037
TARIFF CONSTRAINT FACTOR	.542	.622	.604	.587	.570	.555	.538	.522
LEVERAGE								
LONG-TERM (FUNDED) DEBT TO EQUITY(%)	47.370	40.261	33.735	27.721	22.180	19.302	16.663	14.230
LONG-TERM (FUNDED) DEBT TO CAPITAL %	32.144	28.704	25.225	21.705	18.153	16.179	14.283	12.457
LONG-TERM (FUNDED) DEBT TO ASSETS %	28.509	25.256	22.035	18.833	15.654	13.910	12.246	10.760
PROFITABILITY								
OPERATING INCOME (FPC RULES)	22923.101	21988.865	21054.681	20120.542	19186.487	18242.318	17307.613	16372.945
ANNUAL FPC RATE BASE	229102.089	219746.439	210390.189	201033.943	191677.693	182321.447	172965.197	163608.951
RATE OF RETURN ON RATE BASE (%)	10.005	10.006	10.007	10.009	10.010	10.006	10.006	10.007
RATE OF RETURN ON PAID-IN CAPITAL(%)	13.734	13.883	14.055	14.343	14.515	14.676	14.182	13.687
RATE OF RETURN ON TOTAL EQUITY (%)	4.567	4.413	4.277	4.181	4.060	3.943	3.670	3.421
RATE OF RETURN ON TOTAL CAPITAL (%)	3.099	3.146	3.196	3.274	3.323	3.305	3.146	2.995
ENERGY CONSUMPTION								
ANNUAL ENERGY USAGE OF GAS (MMCSF)	10660.011	10660.011	10660.011	10660.011	10660.011	10660.011	10660.011	10660.011
ANNUAL ENERGY COSTS	31469.182	33042.641	34694.773	36429.511	38250.986	40163.536	42171.712	44280.297
PRESENT VALUE OF ENERGY USED	6848.615	6537.311	6240.160	5956.517	5685.766	5427.322	5180.626	4945.143
UNIT COST OF ENERGY ($)	2.952	3.100	3.255	3.417	3.568	3.768	3.956	4.154
ANNUAL ENERGY WASTED IN GAS (MMCSF)	.000	.000	.000	.000	.000	.000	.000	.000
ANNUAL ENERGY WASTED COST ($)	.000	.000	.000	.000	.000	.000	.000	.000
PRESENT VALUE OF ENERGY WASTED	.000	.000	.000	.000	.000	.000	.000	.000
OTHER MEASURES								
ANNUAL UNIT COSTS (TOTAL)	660.572	673.659	687.709	701.875	718.406	736.671	761.698	788.215
PRESENT VALUE OF AVERAGE UNIT COSTS	143.760	133.280	123.690	114.762	106.786	99.547	93.572	88.026
NET INCOME (BOOK PROFIT)	11765.829	11892.833	12040.758	12286.894	12434.947	12572.887	12149.174	11725.497
PRESENT VALUE OF BOOK PROFITS	2560.587	2352.934	2165.636	2009.006	1848.376	1698.982	1492.477	1309.482

Fig. 3.0-4, sheet 5

NET CASH GENERATED DURING THE PERIOD	11709.719	11258.457	11117.806	11057.855	11006.600	18102.308	17527.055	12456.348
PRESENT VALUE OF NET CASH GENERATED	2548.376	2227.426	1999.635	1808.048	1636.061	2446.175	2153.128	1391.102
DISCOUNT FACTOR (@10.000 %) =	.218	.198	.180	.164	.149	.135	.123	.112

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Fig. 3.0-4, sheet 6

SYSTEMS, SCIENCE AND SOFTWARE
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TIME PERIOD	2000	2001	2002	2003	2004	2005	TOTAL	AVERAGE
ACTIVITY								
ANNUAL THROUGHPUT	106.910	106.910	106.910	106.910	106.910	106.910	2729.341	94.115
MEASURED IN MILLION MMCSF - MILES								
TARIFF - UNIT TRANSPORTATION CHARGE	2027.205	2128.566	2234.994	2346.743	2464.081	2587.285	41132.981	1418.379
TRANSPORTATION REVENUES	216728.479	227564.898	238943.141	250890.295	263434.809	276606.547	4090787.625	141061.641
REVENUE REDUCTION	-106854.488	-115360.212	-124238.396	-133477.689	-143126.562	-153282.682	**********	-59678.860
TOTAL REVENUE	109873.990	112204.687	114704.746	117412.605	120308.246	123323.867	2360100.687	81382.782
TARIFF CONSTRAINT FACTOR	.507	.493	.480	.468	.457	.446	.577	.577
LEVERAGE								
LONG-TERM (FUNDED) DEBT TO EQUITY(%)	11.971	9.864	7.888	6.076	4.657	3.309	38.336	38.336
LONG-TERM (FUNDED) DEBT TO CAPITAL %	10.691	8.978	7.311	5.728	4.449	3.203	27.712	27.712
LONG-TERM (FUNDED) DEBT TO ASSETS %	9.304	7.072	6.460	5.100	3.993	2.897	24.880	24.880
PROFITABILITY								
OPERATING INCOME (FPC RULES)	15438.318	14503.732	13561.605	12626.545	11691.508	10756.505	553485.969	19085.723
ANNUAL FPC RATE BASE	154252.701	144896.455	135540.205	126183.958	116827.708	107471.462	5737402.437	197841.463
RATE OF RETURN ON RATE BASE (%)	10.038	10.010	10.006	10.006	10.007	10.009	9.647	9.647
RATE OF RETURN ON PAID-IN CAPITAL(%)	13.193	12.698	12.195	11.700	11.187	10.564	12.387	12.387
RATE OF RETURN ON TOTAL EQUITY (%)	3.192	2.981	2.783	2.601	2.426	2.240	4.391	4.391
RATE OF RETURN ON TOTAL CAPITAL (%)	2.851	2.713	2.580	2.452	2.318	2.168	3.174	3.174
ENERGY CONSUMPTION								
ANNUAL ENERGY USAGE OF GAS (MMCSF)	10660.011	10660.011	10660.011	10660.011	10660.011	10660.011	225199.711	7765.507
ANNUAL ENERGY COSTS	46494.312	48819.027	51259.978	53822.977	56514.125	59339.831	788483.070	27189.071
PRESENT VALUE OF ENERGY USED	4720.363	4505.801	4300.992	4105.493	3918.879	3740.746	137279.033	.000
DISCOUNTED VALUE OF ENERGY USED (@ 10.00 %) =	137279.033							
UNIT COST OF ENERGY (%)	4.362	4.580	4.809	5.049	5.302	5.567	88.498	3.052
ANNUAL ENERGY WASTED IN GAS (MMCSF)	.000	.000	.000	.000	.000	.000	.000	.000
ANNUAL ENERGY WASTED COST (%)	.000	.000	.000	.000	.000	.000	.000	.000
PRESENT VALUE OF ENERGY WASTED	.000	.000	.000	.000	.000	.000	.000	.000
DISCOUNTED VALUE OF ENERGY WASTED (@ 10.00 %) =	.000							
OTHER MEASURES								
ANNUAL UNIT COSTS (TOTAL)	816.297	846.022	877.472	910.733	946.043	984.225	18174.506	626.707
PRESENT VALUE OF AVERAGE UNIT COSTS	82.875	78.084	73.625	69.469	65.602	62.045	4759.470	164.120
DISCOUNTED AVERAGE (ANNUAL) UNIT COSTS (LONG RUN AVERAGE COSTS) (@ 10.00 %) =	164.120							

Fig. 3.0-4, sheet 7

NET INCOME (BOOK PROFIT)	11301.861	10878.266	10447.130	10023.062	9583.402	9050.173	318340.535	10611.351
PRESENT VALUE OF BOOK PROFITS	1147.428	1004.021	876.571	764.536	664.545	570.518	97215.141	3352.246

DISCOUNTED VALUE OF BOOK PROFITS (@ 10.00 %) = 97215.141

NET CASH GENERATED DURING THE PERIOD	11845.931	11333.196	10619.996	10384.846	11115.242	10523.306	357586.383	11919.546
PRESENT VALUE OF NET CASH GENERATED	1202.665	1046.009	891.076	792.132	770.768	663.383	111836.381	3856.427

DISCOUNTED NET CASH FLOW (@ 10.00 %) = 111836.381

DISCOUNT FACTOR (@10.000 %) =	.102	.092	.084	.076	.069	.063	.000	.000

****** INTERNAL RATE OF RETURN ******

DCF - ROI OF $ .000 (FROM YEAR 1 OVER 10 YEARS) = 7.17 %

DCF - ROI OF $ .000 (FROM YEAR 1 OVER 15 YEARS) = 10.85 %

DCF - ROI OF $ .000 (FROM YEAR 1 OVER 20 YEARS) = 12.30 %

DCF - ROI OF $ .000 (FROM YEAR 1 OVER 29 YEARS) = 13.34 %

****** AND THAT'S THE WAY IT WILL BE **** THIS IS THE S-CUBED FINANCIAL PROJECTION MODEL *JFM* VERSION #5 090176

TICKER = 10.5598(SEC)

GBRKPT PRINTS

Fig. 3.0-4, sheet 8

This run was performed to compare the economics of pipeline operation under continued growth conditions with nongrowth conditions. The throughput (market) projection over the first 15 years was the growth pattern that was used in the other gas system studies, e.g., regulatory effects, bottoming cycle effects, etc. Then, throughput was held constant for 14 years at the value reached in the fifteenth year, without further capital additions to the system. Thus, the run shows a 15-year growth period immediately followed by 15 years of no growth. No highly significant conclusions emerged. However, it was mildly surprising to see that the last 14 years of operation, without any additional capital investment, only raise the RoI from 10.85% to 13.34% (Fig. 3.0-4, sheet 8). The basic reason of course is the regulatory policy. Over the same 14 years, the rate base depreciated from $236 million (Fig. 3.0-4, sheet 3, line 11) in 1991 to $107 million in 2005, forcing book profit from $11.7 to $9.1 million (Fig. 3.0-1, sheets 2 and 4, bottom line).

As noted above, the purpose of displaying this run at this time is to show a complete set of output formats for the model, and also to show how the six major summary variables are embedded in the format.

3.1 Energetics Summary Variables

The energy intensity (EI) of pipeline systems is discussed in Report 3022 of this series (see Table 1.1-1 above). It is defined in Section 1.2 of that report as the quantity that is calculated from any of the formulae,

$$I_E = \frac{E}{QxD} = \frac{P}{FxD} = \frac{\frac{dE}{dt}}{\left(\frac{dQ}{dt}\right)D}$$

where

$I_E \triangleq$ energy intensity (EI) ,

$E \triangleq$ energy consumed

$Q \triangleq$ quantity of commodity transported

$D \triangleq$ distance transported

$P \triangleq$ power,

and $F \triangleq$ commodity flow.

The second and third formulae yield an instantaneous value for I_E, while the first yields an average over whatever time period E and Q have been integrated. In this study, only annual averages are considered, so the line is considered to be in quasi-steady state operation. It is, of course, recognized that system transients do in fact adversely affect energy consumption, as is discussed in Report 3025, Section 4.4.6.2 of this series, in connection with duty cycles.

The energy intensity is found from Report 38 by dividing the energy consumed (first line under Energy Consumption) by the throughput (first line under Activity). The other important energetics summary variable is just the first of those two values, i.e., the line entitled "Annual Energy Usage in MM Kw-Hr."

3.2 Economics Summary Variables

The LAC is displayed in output Report 38, third line under the heading "other measures." It is the present (discounted) value of the total average unit cost over the life of the project.

The profit appears in two forms in Report 38: as the annual net income under Other Measures, and as its present value immediately thereafter. Profit also appears in Report 20 (Fig. 3.0-2, line 1) and in Report 10 (Fig. 3.0-1, bottom line).

The cash flow appears in Report 38, third line from the bottom, followed by its present value. It is also found in Report 20, second line from the bottom.

The internal RoI appears as the bottom line of Report 38. This financial index of merit, also often called the DCF, is defined as the annual discount which makes the lifetime present value of the stream of cash returned to the investor equal to that of the investor's cash out-of-pocket stream. In the terminology of Report 20, Fig. 3.2-2, it is the discount rate which makes the present value of the net cash generated, line 23, equal to that of the additions of equity, line 8. It is the break-even interest rate at which the investor's out-of-pocket payments could be borrowed and be exactly repaid by the cash payments returned to the investor. The internal RoI is generally considered a better index of mert than another that is often used, i.e., the payback period, and therefore only the RoI is calculated in the model. It would of course be easy to modify the model to make the payback calculation if it were specifically desired for a particular study.

4.0 METHODOLOGY OF APPLICATION OF THE MODEL

The principal, i.e., defining, characteristic of a simulator (model) is that it responds to an input in a similar way to that in which the actual physical system (simulatee or prototype) would respond to that input. The degree of similarity between the two responses of course reflects the degree of perfection with which the model represents the prototype. That is, the model merely completes the second half of the scenario, "if input $\underline{I}$ is applied, under conditions $\underline{C}$, then output $\underline{O}$ results." It remains for the investigator to generalize the cause-effect relationships between the $\underline{I}$ and $\underline{C}$ combination on one hand and $\underline{O}$ on the other. Thus, the conclusions that are likely to be drawn from any group of simulations of course depend heavily upon the selection of input situations for study. The investigator must exercise care to ask the questions of the model which are pertinent to the issue under investigation. Two areas of precaution which then arise, even with well posed questions, will be discussed below.

4.1 Superposition of Effects

Generally, the approach taken is to postulate a series of cases under which basic inputs and conditions are held constant, only one or a few of these being changed between simulation runs. In using this method, it is necessary to recognize and allow for the fact that such results are not directly summable unless the model is linear. And useful simulators are almost never linear because linear systems are amenable to mathematical generalization and analysis without the necessity of simulation.

The principle of superposition may be explained as follows. If the system S is linear, and it is subjected to the collection of inputs $\underline{I}_1$ under conditions $\underline{C}_1$, yielding output $\underline{O}_1$, and again to $\underline{I}_2$ under $\underline{C}_2$, yielding $\underline{O}_2$, and again to $\underline{I}_1 + \underline{I}_2$ under $\underline{C}_1 + \underline{C}_2$, the result in this combined case is $\underline{O}_1 + \underline{O}_2$. Thus, if a set of simulation cases is run on a nonlinear model in which inputs and/or conditions are varied only one at a time, then it cannot be assumed that the additive combination of those outputs is the same output that would be obtained if all the input/condition changes were applied at once.

There is of course nothing in all this that is pipeline-peculiar. It is a basic principle that is well known among system theorists and simulation analysts. It is only mentioned here for the benefit of the generalist reader who may not previously have encountered this limitation.

4.2 Closed Loop Operation

The simplest way of exercising the model is to simply specify the input $\underline{I}$ and condition $\underline{C}$ in advance, let the model run, and see what output $\underline{O}$ results. However, this open-loop mode is often not sufficiently representative of the situation of interest. That is, the $\underline{I}$ and $\underline{C}$ in later phases of the exercise are likely to be influenced by the output $\underline{O}$ of earlier phases, and it becomes necessary to close the loop by providing a model of the exterior environment which reflects this influence. These relationships are illustrated in Fig. 4.2-1.

The PEM contains an example of the environmental simulator in the subroutine which applies the regulatory limit upon profit and forces the price of service down accordingly. Another environmental influence which might be important is the effect of market demand upon price. That is, the demand may fall with quantity sufficiently to drive the price below the level at which maximum regulatory profit may be realized. To account for this effect would require a market supply-demand simulator as part of the environment simulator. The strength of influence of this supply-demand simulator depends upon the elasticity of the market.

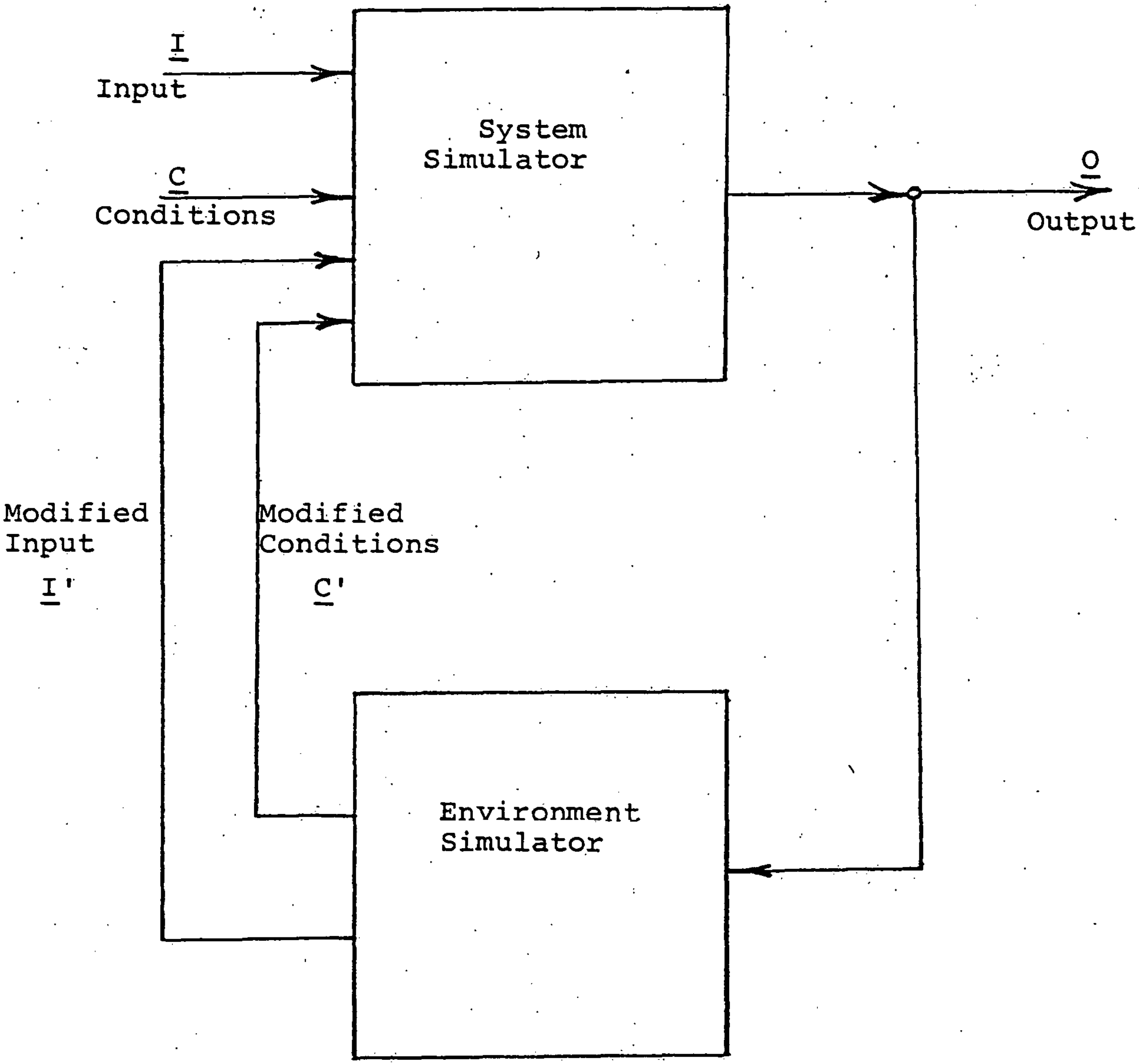


Fig. 4.2-1 - Closed-loop operation of the system simulator

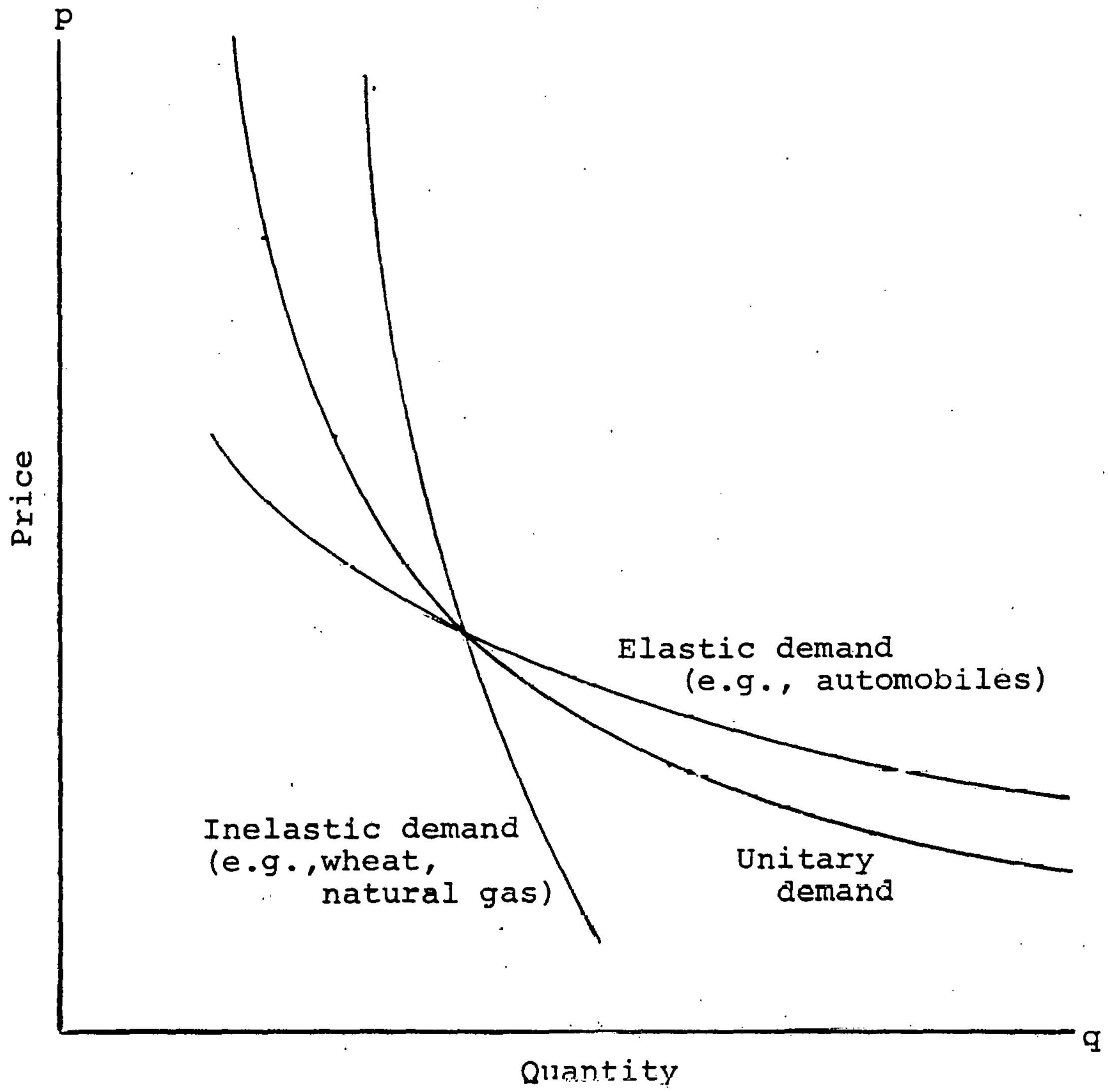


Fig. 4.2-2 - Examples of demand functions

Economists characterize the demand for a commodity by the following definitions involving the quantity q which is offered at price p:

Demand is <u>elastic</u> if $\left|\frac{\delta q}{q}\right| > \left|\frac{\delta p}{p}\right|$

Demand is <u>inelastic</u> if $\left|\frac{\delta q}{q}\right| < \left|\frac{\delta p}{p}\right|$

At <u>unitary</u> elasticity, $\left|\frac{\delta q}{q}\right| = \left|\frac{\delta p}{p}\right|$

Examples of elastic and inelastic demand functions are shown in Fig. 4.2-2. The coefficient of elasticity is defined by

$$E_d \triangleq \frac{\delta q/q}{\delta p/p} \Rightarrow -\frac{dq}{dp}\left(\frac{p}{q}\right) \quad \begin{array}{l} < 1, \text{ inelastic} \\ = 1, \text{ unitary} \\ > 1, \text{ elastic} \end{array}$$

To account for inflation, one may separate p into components

$$\delta p \triangleq (\delta p)_{\text{inflation}} + (\delta p)_{\text{real value}}, \text{ and}$$

use only $(\delta p)_{rv}$ and p_{rv}.

It is of interest to calculate the deflated (real value) coefficient of elasticity which was implicit in the simulation runs presented in Section 3.0 above. This implicit coefficient is that above which the postulated throughput would not be absorbed by the market. In other words, if the demand were sufficiently elastic, the operator could not realize the full 10% return allowed by regulation. The regulatory environment simulator would not operate and it would be necessary to provide a market environment simulator.

Table 4.2-1 presents this calculation for two randomly selected intervals, 1977-78 and 1982-83. It is seen that the values E_d are 2.08 and 1.48 respectively. These values are well into the elastic range, whereas the demand for natural gas is known to be very inelastic. It is therefore concluded that the regulatory environment simulator is adequate. In any future studies, however, and in particular in simulating any unregulated situations, the elasticity of the market must be recognized.

Table 4.2-1

	Q	P_{rv}	ΔP	$\lvert\Delta P/P\rvert$	ΔQ	$\lvert\Delta Q/Q\rvert$	E_d
1977	57.562	638.88	-20.46	0.0320	3.374	0.05862	1.83
1978	60.936	618.42					
1982	75.155	484.44	- 8.59	0.01773	3.748	0.04987	2.82
1983	78.903	475.85					

5.0 INDUSTRYWIDE INFERENCES

The ideal model for use in this study would be that which, for a postulated energy-conservative technological innovation in pipeline operation, would yield the following resulting outputs:

(1) Change in total energy consumption
(2) Change in industry-average unit energy consumption (energy intensity)
(3) Change in industry-average long-run average cost of pipeline operation.

The impracticalities of realizing this ideal model have been discussed in Section 1.2 above. It is also well to recognize the limited usefulness such a model would possess. Since it would yield no information about the individual companies, or even classes of companies, within the industry, it could not guide the demonstration and commercialization programs that would seek to exploit the innovations which show promising potential. And it is unnecessary to develop any model at all to identify the promising innovations.

As was seen in Report 3025 of this series (see Table 1.1-1 above), there are two key factors which determine the promise of any potential innovation:

(1) The energetics and economics of its application under favorable conditions.

(2) The degree and extent of conditions across the industry which are favorable to introduction of the innovation.

As was done in Report 3025, factor (1) can be assessed with a few simple calculations which establish the upside potential. Factor (2) requires study of the operations the individual companies, or of representative classes of companies, within the industry, which is precisely the use for which the PEM was designed.

The critical term employed in the foregoing statement is "representative." In principle, the PEM could be used to simulate every company in the industry to estimate the effects of the postulated innovation. In practice, it is necessary to confine the investigation to one or a few representative pipeline systems, so that the question of how representative those systems are assumes importance.

The justification for the representativeness of the reference systems described in Section 2.3 above rests upon two bases: the systems were developed by modification of real systems, and those real systems were chosen by experienced pipeline engineers because they were believed to be representative. This latter judgement has not been substantiated by quantitative estimation of statistical correlation, since such a characterization is beyond the needs of this present study, whose principal objective is to identify the promising innovations. However, in planning and executing the demonstration program for each specific innovation, this characterization should be performed, recognizing and emphasizing the system parameters that are important in the application of that innovation. For example, it is easy to see that these factors of importance will be different in the case of bottoming engine installation on gas pipelines, where the innovation involves primarily capital investment, than in the case of viscosity-reducing additives in a liquid pipeline, where the innovation introduces operational complexity as opposed to capital investment. In assessing the potential industrywide impact of these innovations, the factors which determine the representativeness of the reference systems will be different. From the example study presented earlier in Section 2.4, it has been seen that the model is sufficiently sophisticated, and the reference system is sufficiently representative, for the purposes of the present study, i.e., to develop R&D recommendations. However, in both cases, it may well be advisable or necessary to develop additional reference systems and/or to conduct simulation studies on the particular system on which the demonstration is planned.

6.0 REFERENCES

1. Masso, J. M., "S^3 Financial Projection Model - Preliminary User's Manual and System Overview," Systems, Science and Software report SSS-R-77-3069, November 1976.

2. National Petroleum Council, Comm. on U.S. Energy Outlook, Gas Subcommittee, Gas Transportation Task Group, Washington, D.C., 1973.

3. "The Long-run Marginal Costs of Energy," The Rand Corp., Santa Monica, NTIS PB-252504, February 1975.

Appendix A

USERS' MANUAL

FOR

PROGRAM LIQPL

PIPE LINE TECHNOLOGISTS, INC.
Houston, Texas

June 1976

CONTENTS

GENERAL DESCRIPTION
OF PROGRAM LIQPL

GENERAL DESCRIPTION

LIQPL is a digital computer program that can model a steady state liquid pipeline for a given set of shipment and delivery rates. It can simulate any number of changes in the pipe diameter, shipment/delivery stations, and pump stations, but does not model branches or loops.

The program computes the hydraulic profile in both head in feet and pressure in psi, the brake horsepower requirements for each pump station, the power cost per year for each pump station, and the total power cost per year. When pump curve data is entered, LIQPL selects the most economical combination of pumps for each pump station. LIQPL will iterate over the life of the pipeline, escalating the shipment rates and the power rates as specified by the user and printing results for each year of operation.

Practically any type of pipeline can be modeled, including products, crude oil, water and coal slurry lines. For friction drop calculations, the user chooses between the Hazen Williams Formula, the Darcy Weisbach Formula, and an algorithm for computing pressure drop in slurry pipelines based on the Durand Correlation.

When modeling a products pipeline, the user can enter the percentage of each product in the pipeline. LIQPL will compute the linefill based on the given percentage of each product being located between each two pump stations. The hydraulic gradients are computed based on this linefill and the average brake horsepower requirements are computed based on each product being in the pumps the given percentage of the time.

The user has the option of entering pump curves in tabular form or specifying the average pump efficiency. If pump curves are entered, a smooth curve interpolation involving a second order polynomial equation is used to find values between the given points.

In performing the hydraulic calculations, LIQPL first computes the hydraulic gradient by starting at the downstream end and working upstream. It uses the minimum pressure at the terminal end, and at each pump station suction. (The year in which each pump station comes on line can be specified by the user.) This gradient gives the minimum discharge head at each pump station that will move the given throughputs.

In the next step, LIQPL examines every possible combination of pumps for each pump station and finds the combination that equals or exceeds the minimum required head and uses the least power. In this way the optimum combination of pumps are selected for each pump station. The hydraulic gradient is then recalculated based on the new discharge heads.

Throttling will be simulated where necessary to keep from exceeding the maximum operating pressure of the pipe. In the case of a products pipeline, throttling may possibly occur only when certain products are in the pumps.

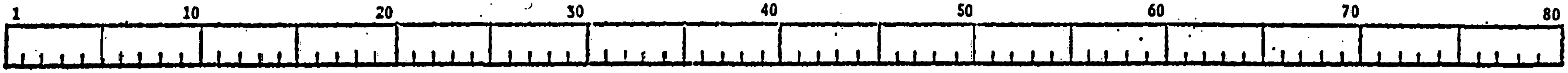
Brake horsepower requirements will be computed using throughputs, heads put up by the pumps, density of the liquid(s), and the efficiencies from the pump curves. If pump curves are not entered, the brake horsepower will be computed using the given or the default average pump efficiency and the hydraulic profile based on the minimum allowable suction pressure at each pump station.

Flags are printed when 1) throttling occurs, 2) it is impossible to pump the given throughput with the given pump stations, and 3) the given pump curves are insufficient to pump the given throughput.

INPUT FOR

PROGRAM LIQPL

TITLE CARD



Program will iterate and read data for additional runs until it reads "end" for the title.

OUTPUT OPTION, AVERAGE PUMP EFFICIENCY, AND AVERAGE DRIVER EFFICIENCY.

IOUT = Output format option. (Integer.)
IOUT=0, print power cost data only.
IOUT=1, print hydraulic data plus power cost data.
IOUT=2, print total power cost only.

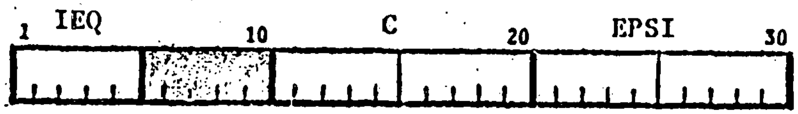
PEFF = Average pump efficiency. (Real.) PEFF will be used in calculating horsepower if no pump curves are entered. Default value is 0.80. This variable will not be used if pump curves are read.

DEFF = Average driver efficiency (Real.) DEFF will be used in calculating power cost. Default value is 1.00. An alternate procedure is to combine driver efficiency with EPC below.

LIFE OF PIPELIN DATA. YEAR ONE, TOTAL NO. OF YEARS.

IYRI = First year of operation. (Integer)
NOYR = Total number of years to be studied. (Integer)

FLOW EQUATION DATA.



IEQ = Term used to select the method used to compute friction loss.
IEQ = 0, subroutine slurry will be used.
IEQ = 1, Hazen Williams formula will be used.
IEQ = 2, Darcy Weisbach formula will be used.

C = Pipe roughness factor for the Hazen Williams Eq. (Real). Default value is 150.

EPSI = Roughness of pipe for use with Moody diagram in inches. (Real). Default value is 0.0018.

SLURRY PIPELINE DATA. OMIT THESE CARDS IF PIPELINE IS NOT A SLURRY PIPELINE, I.E., IF IEQ IS NOT EQUAL TO ZERO.

1–10	11–20	21–30	31–40	41–50
VOLFRC	WTFRC	GVS	SIZFLG	SOLSIZ

VOLFRC = VOLUME FRACTION of solids present. (Real.)

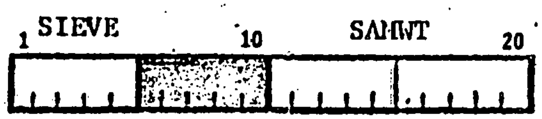
WTFRC = Weight fraction of solids present. (Real.) Either VOLFRC or WTFRC must be specified. The one not specified is computed.

GVS = The solids specific gravity with respect to water. (Real.)

SIZFLG = A flag determining the size distribution of the solids. (Integer.)
SIZFLG = 1, use one size only, SOLSIZ.
SIZFLG = 2, use the previous size distribution.
SIZFLG = 3, read another size distribution.

SOLSIZ = The average solids diameter, inches. (Real.) Required only if SIZFLG = 1.

ADDITIONAL SLURRY PIPELINE DATA. OMIT IF IEQ IS NOT EQUAL ZERO. OTHERWISE END DATA WITH A 999 CARD.



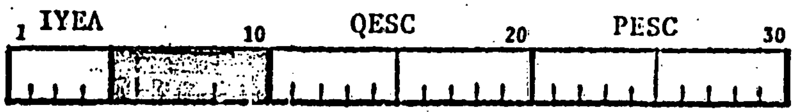
SIEVE = An array of sieve designations corresponding to the ISO standard sieve sizes as shown in Perry's Handbook table 21.12 (Fifth Ed.) numbering from top to bottom (i.e. 1=107.6 mm, 6=53.8 mm, etc.). (Integer array.)

SAMWT = An array of sample weights which were found on the corresponding sieve screens. (Real array.)

NOTE: The average size for a sample is the mean of the screen size on which the sample is found and the size of the next larger screen. The size of the largest sample is taken to be 120 percent of its screen size. The screen size of the sample which passed through the last (smallest) screen should be the same as the smallest screen. The average size of the sample is taken to be 80 percent of its screen size.

End this data with a card with 999 starting in column one.

ESCALATOR FACTORS FOR THROUGHPUTS AND POWER RATES. END DATA WITH A CARD WITH 999 STARTING IN COLUMN ONE.



IYEA = The year in which the corresponding escalator factors begin. (Integer array.)

QESC = Throughput escalator factor. (Real array.) If this field is blank, the value given on the previous card will be used.

PESC = Power rate escalator factor. (Real array.) If this field is blank, the value given on the previous card will be used.

End this data with a card containing 999 starting in column one.

NODE DATA. END NODE DATA WITH A CARD WITH 999 IN THE FIRST 3 COLUMNS.

1 NAME	IYEAR 10	ITYP	20	XMP	30	RATE	40	PMAX	50	PID	60	PRAT	70	PERO

NAME = Name of node. (Alphanumeric array.)

IYEAR = Year in which a pump station comes on line. It is only necessary to enter this data for nodes representing pump station suctions. Default value is first year of operation. (Integer array.)

ITYP = Node type. (Integer array.)
ITYP = 1, Batch interface. Refer to the following page for more information.
ITYP = 2, shipment/delivery station.
ITYP = 3, P.S. suction.
ITYP = 4, P.S. discharge.
ITYP = 5, diameter change.

*XMP = Milepost of node. (Real array.)

RATE = Shipment/delivery rate. Minus sign designates delivery. Enter this data only if ITYP = 2. (Real array.)

*PMAX = Maximum operating pressure. (Real array.)

*PID = Inside pipe diameter. (Real array.)

*PRAT = Power rate during the first year of operation. (Real array.)

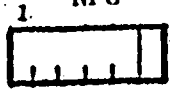
*PERO = Percent of time pump station is in operation. (Real array.)

End this data with a 999 card.

* Default value is the last value entered in this field.

PUMP CURVE DATA. READ IN 6 POINTS FOR EACH CURVE. LAST CARD IS TO BE 999 CARD.

ONE OF THESE CARDS FOR EACH PUMP CURVE:



THREE OF THESE CARDS FOR EACH PUMP CURVE:

NPC = Name of pump curve. (Alphanumeric array.)

QPC = Capacity of pump in Barrels per Hour. (Real array.)

HPC = Corresponding head put up by pump, in feet. (Real array.)

EPC = Corresponding efficiency of pump. (Real array.)

End this data with a card with 999 starting in column one.

PUMP CURVES AVAILABLE AT EACH PUMP STATION. START WITH FIRST P.S. AND WORK DOWNSTREAM. END DATA WITH A CARD CONTAINING 99 STARTING IN COLUMN 1. END P.C. AVAILABLE DATA WITH A CARD CONTAINING 999 STARTING IN COLUMN 1.

NAPC = Name of pump curve. This must be identical to one of the values of "NPC" on preceeding page. (Alphanumeric array.)

NUPC = Number of pump curves with the specified name available at this pump station. (Integer array.)

ALL = Device for assigning all pump stations the same pumps. (Real.) If "ALL" is not equal to zero, all pump stations will be assigned the same pump curves as the first pump station. Use any card in this set to designate the value of "ALL".

End this data with a 999 card.

LIQUID PROPERTIES. LAST CARD IS TO BE 999 CARD.

NOTE: If a products pipeline is being modeled, the decimal volume fraction of each product may be entered, and the program will compute the linefill based on the given percentage of each product being located between each two pump stations. Average horsepowers are then calculated based on each product being in the pumps the given fraction of the time.

1 NPRO 10	PERC 20	SGPR 30	VISP 40	PMIN 50

NPRO = Name of liquid. (Alphanumeric array.)

PERC = Corresponding decimal fraction of total linefill. (Real array.)

SGPR = Specific gravity of liquid. (Real array.)

VISP = Viscosity in centistokes. (Real array.)

PMIN = Minimum allowable pressure. (Real array.)

End this data with a card with 999 starting in column one.

GROUND PROFILE DATA. END THIS DATA WITH A CARD WITH 999 STARTING IN COLUMN 1.

1 XM7 10	ELE7 20	XM7 30	ELE7 40	XM7 50	ELE7 60	XM7 70	ELE7 80

XM7 = Milepost of point in ground profile. (Real array.)

ELE7 = Corresponding ground elevation. (Real array.)

End this data with a 999 card.

This is the end of the input data. The program will iterate and attempt to read a new set of data unless a card with "END" starting in column one is placed at this point.

EXAMPLE RUN

FOR

PROGRAM LIQPL

```
LISTING OF INPUT DATA FOR SAMPLE CRUCE OIL PIPELINE.

SAMPLE CRUDE OIL PIPLLINE.  PUMP STATICNS COME ON LINE IN YEARS 1, 8, ANC 12.
    1
    1   20
    2
    1      1.056     1.080
    3                1.059
    4                1.056
    5                1.030
    8      1.118     1.030
   12      1.118     1.03
   13      1.1049
   16      1.000
999
24 IN          5     0.                  975.     23.376    .025      1.00
RS-1           2               3000.
PS-1           3
PS-1           4
PS-2    12     3     95.
PS-2           4
PS-3     8     3     192.
PS-3           4
PS-4    12     3     287.
PS-4           4
PS-5           3     386.
PS-5           4
PS-6    12     3     486.
PS-6           4
PS-7     8     3     586.
PS-7           4
0 IN           5     686.
DF-5           2
999
CRUDE    1.00       .874      17.00      50.
999
PC-16
0.       1285.      0.        4286.      1261.    .72
5714.    1239.      .81       7143.      1190.    .85
8571.    1130.      .87       9857.      1060.    .85
PC-15
0.       1150.      0.        4286.      1080.    .74
5714.    1050.      .82       7143.      1010.    .86
8571.    940.       .87       9857.      870.     .85
PC-14
0.       945.       0.        4286.      918.     .75
5714.    881.       .83       7143.      840.     .86
8571.    762.       .86       9857.      690.     .84
PC-13
0.       750.       0.        4286.      720.     .76
5714.    690.       .84       7143.      640.     .86
8571.    555.       .83       9857.      460.     .80
999
PC-16          3
PC-15          3
PC-14          3
PC-13          3     1.
999
0.       80.        88.       175.       152.     110.      264.      225.
422.     190.       551.      140.       686.     80.       784.      25.
891.     10.
999
```

SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

STEADY STATE FLOW EQUATION = DARCY WEISBACH
PIPE ROUGHNESS FACTOR, INCHES = .00180
FIRST YEAR OF OPERATION = 1
LIFE OF PIPELIN, IN YEARS = 20
AVERAGE PUMP DRIVER EFFICIENCY = 1.00

ESCALATOR FACTORS.

STARTING AT YEAR	THRUPUT ESC FAC	POWER RATE ESC FAC
1	1.056	1.080
3	1.056	1.059
4	1.056	1.056
5	1.056	1.030
8	1.118	1.030
12	1.118	1.030
13	1.105	1.030
16	1.000	1.030

INITIAL SHIPMENT/DELIVERY DATA.

STATION	MILEPOST	SHP/DEL RATE,BPH
RS-1	0.00	3000.
DF-5	686.00	-3000.

PIPE SCHEDULE.

MILE-POST	PIPE ID INCHES	MAX OPER PRESSURE PSI
0.00	23.376	575.
686.00	23.376	575.

HYDRAULIC PROPERTIES OF LIQUID.

LIQUID	PERCENT OF LINEFILL	SPECIFIC GRAVITY	VISCOSITY CS	MINIMUM PRESSURE PSI
CRUDE	1.000	.874	17.000	50.

PUMP CURVE DATA.
NAME PUMP CURVE = PC-16

CAPACI GPM	BPH	HEAD	EFF
0.	0.	1265.	0.00

4000.	[illegible]	1239.	.81
5000.	[illegible]	1190.	.85
6000.	8571.	1130.	.87
6900.	9857.	1060.	.85

PUMP CURVE DATA.
NAME PUMP CURVE = PC-15

CAPACITY GPM	BPH	HEAD	EFF
0.	0.	1150.	0.00
3000.	4286.	1080.	.74
4000.	5714.	1050.	.82
5000.	7143.	1010.	.86
6000.	8571.	940.	.87
6900.	9857.	870.	.85

PUMP CURVE DATA.
NAME PUMP CURVE = PC-14

CAPACITY GPM	BPH	HEAD	EFF
0.	0.	945.	0.00
3000.	4286.	918.	.75
4000.	5714.	881.	.83
5000.	7143.	840.	.86
6000.	8571.	762.	.86
6900.	9857.	690.	.84

PUMP CURVE DATA.
NAME PUMP CURVE = PC-13

CAPACITY GPM	BPH	HEAD	EFF
0.	0.	750.	0.00
3000.	4286.	720.	.76
4000.	5714.	690.	.84
5000.	7143.	640.	.86
6000.	8571.	555.	.83
6900.	9857.	460.	.80

PUMP STA DATA.

PUMP STA	MILE-POST	PUMP NAME	QUAN-TITY	FIRST YR POWER RATE	PERCENT OF TIME PUMPING	YEAR STA COMES ON LINE
PS-1	0.00	PC-16	3	.02500	1.00	1
PS-1	0.00	PC-15	3	.02500	1.00	1
PS-1	0.00	PC-14	3	.02500	1.00	1
PS-1	0.00	PC-13	3	.02500	1.00	1
PS-2	95.00	PC-16	3	.02500	1.00	12
PS-2	95.00	PC-15	3	.02500	1.00	12
PS-2	95.00	PC-14	3	.02500	1.00	12
PS-2	95.00	PC-13	3	.02500	1.00	12
PS-3	192.00	PC-16	3	.02500	1.00	8
PS-3	192.00	PC-15	3	.02500	1.00	8
PS-3	192.00	PC-14	3	.02500	1.00	8
PS-3	192.00	PC-13	3	.02500	1.00	8
PS-4	287.00	PC-16	3	.02500	1.00	12

PS-4	2[illegible]30	PC-13	3	.02500	1.00	12
PS-5	386.00	PC-16	3	.02500	1.00	1
PS-5	386.00	PC-15	3	.02500	1.00	1
PS-5	386.00	PC-14	3	.02500	1.00	1
PS-5	386.00	PC-13	3	.02500	1.00	1
PS-6	486.00	PC-16	3	.02500	1.00	12
PS-6	486.00	PC-15	3	.02500	1.00	12
PS-6	486.00	PC-14	3	.02500	1.00	12
PS-6	486.00	PC-13	3	.02500	1.00	12
PS-7	586.00	PC-16	3	.02500	1.00	8
PS-7	586.00	PC-15	3	.02500	1.00	8
PS-7	586.00	PC-14	3	.02500	1.00	8
PS-7	586.00	PC-13	3	.02500	1.00	8

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SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

YEAR - 1

PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	HEAD IN FT ELEVATION DN	PRESS PSI	WEIGHTED AVERAGE BHP	LIQ	LINEFILL VOLUME BBLS
24 IN	DIA CH	0.00	80.	-.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	3000.	3000.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	-.	3000.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	-.	3000.	1689.	1689.	609.	1114.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	-.	3000.	511.	511.	119.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	-.	3000.	1250.	1250.	398.	557.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	3000.	335.	335.	96.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	-.	3000.	335.	335.	96.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-3000.	0.	335.	335.	96.	0.	CRUDE	1922686.

YEAR - 1

POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUAN-TITY	THRUPUT BPH	BRAKE HORSE-POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	0	3000.	1114.	.02500	1.00	181992.
PS-1	PC-15	0	3000.	1114.	.02500	1.00	181992.
PS-1	PC-14	0	3000.	1114.	.02500	1.00	181992.
PS-1	PC-13	2	3000.	1114.	.02500	1.00	181992.
PS-5	PC-16	0	3000.	557.	.02500	1.00	90996.
PS-5	PC-15	0	3000.	557.	.02500	1.00	90996.
PS-5	PC-14	0	3000.	557.	.02500	1.00	90996.
PS-5	PC-13	1	3000.	557.	.02500	1.00	90996.

							272988.

SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

YEAR - 2
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	HEAD IN FT ELEVATION DN	PRESS PSI	WEIGHTED AVERAGE BHP	LIQ	LINEFILL VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	3168.	3168.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	3168.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	3168.	1685.	1685.	607.	1131.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	3168.	392.	392.	73.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	3168.	1329.	1329.	428.	730.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	3168.	324.	324.	92.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	3168.	324.	324.	92.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-3168.	0.	324.	324.	92.	0.	CRUDE	1922686.

YEAR - 2
POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUAN-TITY	THRUPUT BPH	BRAKE HORSE-POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	0	3168.	1131.	.02700	1.00	199509.
PS-1	PC-15	0	3168.	1131.	.02700	1.00	199509.
PS-1	PC-14	0	3168.	1131.	.02700	1.00	199509.
PS-1	PC-13	2	3168.	1131.	.02700	1.00	199509.
PS-5	PC-16	0	3168.	730.	.02700	1.00	128723.
PS-5	PC-15	0	3168.	730.	.02700	1.00	128723.
PS-5	PC-14	1	3168.	730.	.02700	1.00	128723.
PS-5	PC-13	0	3168.	730.	.02700	1.00	128723.

							328232.

SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

YEAR - 3
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	DN	PRESS PSI	WEIGHTED AVERAGE BHP	LINEFILL LIQ	VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	3345.	3345.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	3345.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	3345.	1881.	1881.	682.	1315.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	3345.	461.	461.	99.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	3345.	1395.	1395.	453.	742.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	3345.	291.	291.	80.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	3345.	291.	291.	80.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-3345.	0.	291.	291.	80.	0.	CRUDE	1922686.

YEAR - 3
POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUAN-TITY	THRUPUT BPH	BRAKE HORSE-POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	0	3345.	1315.	.02859	1.00	245655.
PS-1	PC-15	0	3345.	1315.	.02859	1.00	245655.
PS-1	PC-14	1	3345.	1315.	.02859	1.00	245655.
PS-1	PC-13	1	3345.	1315.	.02859	1.00	245655.
PS-5	PC-16	0	3345.	742.	.02859	1.00	138538.
PS-5	PC-15	0	3345.	742.	.02859	1.00	138538.
PS-5	PC-14	1	3345.	742.	.02859	1.00	138538.
PS-5	PC-13	0	3345.	742.	.02859	1.00	138538.

							384194.

SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 6, AND 12.

YEAR - 4
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	DN	PRESS PSI	WEIGHTED AVERAGE EHP	LIQ	LINEFILL VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	3533.	3533.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	3533.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	3533.	2038.	2038.	741.	1479.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	3533.	478.	478.	106.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	3533.	1572.	1572.	520.	899.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	3533.	359.	359.	106.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	3533.	359.	359.	106.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-3533.	0.	359.	359.	106.	0.	CRUDE	1922686.

YEAR - 4
POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUAN-TITY	THRUPUT BPH	BRAKE HORSE-POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	0	3533.	1479.	.03019	1.00	291683.
PS-1	PC-15	1	3533.	1479.	.03019	1.00	291683.
PS-1	PC-14	0	3533.	1479.	.03019	1.00	291683.
PS-1	PC-13	1	3533.	1479.	.03019	1.00	291683.
PS-5	PC-16	0	3533.	899.	.03019	1.00	177259.
PS-5	PC-15	1	3533.	899.	.03019	1.00	177259.
PS-5	PC-14	0	3533.	899.	.03019	1.00	177259.
PS-5	PC-13	0	3533.	899.	.03019	1.00	177259.

							468942.

SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

YEAR - 5
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	HEAD IN FT ELEVATION DN	PRESS PSI	WEIGHTED AVERAGE BHP	LINEFILL LIQ	LINEFILL VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	3731.	3731.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	3731.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	3731.	2069.	2069.	753.	1537.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	3731.	355.	355.	59.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	3731.	1622.	1622.	539.	1098.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	3731.	290.	290.	79.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	3731.	290.	290.	79.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-3731.	0.	290.	290.	79.	0.	CRUDE	1922686.

YEAR - 5
POWER COST DATA.

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PUMP STA	PUMP CURVE NAME	QUANTITY	THRUPUT BPH	BRAKE HORSE-POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	0	3731.	1537.	.03110	1.00	312270.
PS-1	PC-15	0	3731.	1537.	.03110	1.00	312270.
PS-1	PC-14	2	3731.	1537.	.03110	1.00	312270.
PS-1	PC-13	0	3731.	1537.	.03110	1.00	312270.
PS-5	PC-16	1	3731.	1098.	.03110	1.00	223144.
PS-5	PC-15	0	3731.	1098.	.03110	1.00	223144.
PS-5	PC-14	0	3731.	1098.	.03110	1.00	223144.
PS-5	PC-13	0	3731.	1098.	.03110	1.00	223144.

							535413.

SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

YEAR - 6

PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	DN	PRESS PSI	WEIGHTED AVERAGE BHP	LINEFILL LIQ	VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	3939.	3939.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	3939.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	3939.	2224.	2224.	811.	1716.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	3939.	340.	340.	54.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	3939.	1791.	1791.	6[illegible]3.	1214.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	3939.	327.	327.	93.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	3939.	327.	327.	93.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-3939.	0.	327.	327.	93.	0.	CRUDE	1922686.

YEAR - 6

POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUAN-TITY	THRUPUT BPH	BRAKE HORSE-POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	0	3939.	1716.	.03203	1.00	359137.
PS-1	PC-15	1	3939.	1716.	.03203	1.00	359137.
PS-1	PC-14	1	3939.	1716.	.03203	1.00	359137.
PS-1	PC-13	0	3939.	1716.	.03203	1.00	359137.
PS-5	PC-16	0	3939.	1214.	.03203	1.00	253934.
PS-5	PC-15	0	3939.	1214.	.03203	1.00	253934.
PS-5	PC-14	0	3939.	1214.	.03203	1.00	253934.
PS-5	PC-13	2	3939.	1214.	.03203	1.00	253934.

							613071.

SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

YEAR - 7
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	DN	PRESS PSI	WEIGHTED AVERAGE EHP	LIQ	LINEFILL VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	4160.	4160.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	4160.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	4160.	2577.	2577.	945.	2038.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	4160.	506.	506.	117.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	4160.	1951.	1951.	663.	1239.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	4160.	341.	341.	99.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	4160.	341.	341.	99.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-4160.	0.	341.	341.	99.	0.	CRUDE	1922686.

YEAR - 7
POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUAN-TITY	THRUPUT BPH	BRAKE HORSE-POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	0	4160.	2038.	.03299	1.00	439159.
PS-1	PC-15	0	4160.	2038.	.03299	1.00	439159.
PS-1	PC-14	1	4160.	2038.	.03299	1.00	439159.
PS-1	PC-13	2	4160.	2038.	.03299	1.00	439159.
PS-5	PC-16	0	4160.	1239.	.03299	1.00	267024.
PS-5	PC-15	0	4160.	1239.	.03299	1.00	267024.
PS-5	PC-14	0	4160.	1239.	.03299	1.00	267024.
PS-5	PC-13	2	4160.	1239.	.03299	1.00	267024.

							706183.

SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

YEAR - 8
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	HEAD IN FT ELEVATION DN	PRESS PSI	WEIGHTED AVERAGE BHP	LIQ	LINEFILL VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	4651.	4651.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	4651.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	4651.	1639.	1639.	590.	1299.	CRUDE	1922686.
PS-3	PS SUC	192.00	151.	0.	4651.	388.	388.	90.	0.	CRUDE	1922686.
PS-3	PS DIS	192.00	151.	0.	4651.	1644.	1644.	565.	1202.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	4651.	381.	381.	69.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	4651.	1637.	1637.	545.	1202.	CRUDE	1922686.
PS-7	PS SUC	586.00	124.	0.	4651.	335.	335.	80.	0.	CRUDE	1922686.
PS-7	PS DIS	586.00	124.	0.	4651.	1048.	1048.	350.	649.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	4651.	397.	397.	120.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	4651.	397.	397.	120.	0.	CRUDE	1922686.
DE-5	SH/DEL	686.00	80.	-4651.	0.	397.	397.	120.	0.	CRUDE	1922686.

YEAR - 8
POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUAN-TITY	THRUPUT BPH	BRAKE HORSE-POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	0	4651.	1299.	.03398	1.00	288346.
PS-1	PC-15	0	4651.	1299.	.03398	1.00	288346.
PS-1	PC-14	0	4651.	1299.	.03398	1.00	288346.
PS-1	PC-13	2	4651.	1299.	.03398	1.00	288346.
PS-3	PC-16	1	4651.	1202.	.03398	1.00	266926.
PS-3	PC-15	0	4651.	1202.	.03398	1.00	266926.
PS-3	PC-14	0	4651.	1202.	.03398	1.00	266926.
PS-3	PC-13	0	4651.	1202.	.03398	1.00	266926.
PS-5	PC-16	1	4651.	1202.	.03398	1.00	266926.
PS-5	PC-15	0	4651.	1202.	.03398	1.00	266926.
PS-5	PC-14	0	4651.	1202.	.03398	1.00	266926.
PS-5	PC-13	0	4651.	1202.	.03398	1.00	266926.
PS-7	PC-16	0	4651.	649.	.03398	1.00	144173.
PS-7	PC-15	0	4651.	649.	.03398	1.00	144173.
PS-7	PC-14	0	4651.	649.	.03398	1.00	144173.
PS-7	PC-13	1	4651.	649.	.03398	1.00	144173.

							966371.

SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

YEAR - 9
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	HEAD IN FT ELEVATION DN	PRESS PSI	WEIGHTED AVERAGE BHP	LIQ	LINEFILL VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	5200.	5200.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	5200.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	5200.	1810.	1810.	655.	1572.	CRUDE	1922686.
PS-3	PS SUC	192.00	151.	0.	5200.	291.	291.	53.	0.	CRUDE	1922686.
PS-3	PS DIS	192.00	151.	0.	5200.	1889.	1889.	658.	1572.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	5200.	355.	355.	59.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	5200.	1953.	1953.	664.	1572.	CRUDE	1922686.
PS-7	PS SUC	586.00	124.	0.	5200.	371.	371.	93.	0.	CRUDE	1922686.
PS-7	PS DIS	586.00	124.	0.	5200.	1073.	1073.	359.	686.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	5200.	282.	282.	76.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	5200.	282.	282.	76.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-5200.	0.	282.	282.	76.	0.	CRUDE	1922686.

YEAR - 9
POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUAN-TITY	THRUPUT BPH	BRAKE HORSE-POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	0	5200.	1572.	.03500	1.00	359436.
PS-1	PC-15	0	5200.	1572.	.03500	1.00	359436.
PS-1	PC-14	1	5200.	1572.	.03500	1.00	359436.
PS-1	PC-13	1	5200.	1572.	.03500	1.00	359436.
PS-3	PC-16	0	5200.	1572.	.03500	1.00	359436.
PS-3	PC-15	0	5200.	1572.	.03500	1.00	359436.
PS-3	PC-14	1	5200.	1572.	.03500	1.00	359436.
PS-3	PC-13	1	5200.	1572.	.03500	1.00	359436.
PS-5	PC-16	0	5200.	1572.	.03500	1.00	359436.
PS-5	PC-15	0	5200.	1572.	.03500	1.00	359436.
PS-5	PC-14	1	5200.	1572.	.03500	1.00	359436.
PS-5	PC-13	1	5200.	1572.	.03500	1.00	359436.
PS-7	PC-16	0	5200.	686.	.03500	1.00	156921.
PS-7	PC-15	0	5200.	686.	.03500	1.00	156921.
PS-7	PC-14	0	5200.	686.	.03500	1.00	156921.
PS-7	PC-13	1	5200.	686.	.03500	1.00	156921.

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SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

YEAR - 10
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	DN	PRESS PSI	WEIGHTED AVERAGE BHP	LINEFILL LIQ	VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	5813.	5813.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	5813.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	5813.	2138.	2138.	779.	2085.	CRUDE	1922686.
PS-3	PS SUC	192.00	151.	0.	5813.	292.	292.	53.	0.	CRUDE	1922686.
PS-3	PS DIS	192.00	151.	0.	5813.	2218.	2218.	782.	2085.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	5813.	353.	353.	59.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	5813.	2279.	2279.	788.	2085.	CRUDE	1922686.
PS-7	PS SUC	586.00	124.	0.	5813.	357.	357.	68.	0.	CRUDE	1922686.
PS-7	PS DIS	586.00	124.	0.	5813.	1235.	1235.	420.	946.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	5813.	274.	274.	73.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	5813.	274.	274.	73.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-5813.	0.	274.	274.	73.	0.	CRUDE	1922686.

YEAR - 10
POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUAN-TITY	THRUPUT BPH	BRAKE HORSE-POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	0	5813.	2085.	.03605	1.00	491133.
PS-1	PC-15	1	5813.	2085.	.03605	1.00	491133.
PS-1	PC-14	1	5813.	2085.	.03605	1.00	491133.
PS-1	PC-13	0	5813.	2085.	.03605	1.00	491133.
PS-3	PC-16	0	5813.	2085.	.03605	1.00	491133.
PS-3	PC-15	1	5813.	2085.	.03605	1.00	491133.
PS-3	PC-14	1	5813.	2085.	.03605	1.00	491133.
PS-3	PC-13	0	5813.	2085.	.03605	1.00	491133.
PS-5	PC-16	0	5813.	2085.	.03605	1.00	491133.
PS-5	PC-15	1	5813.	2085.	.03605	1.00	491133.
PS-5	PC-14	1	5813.	2085.	.03605	1.00	491133.
PS-5	PC-13	0	5813.	2085.	.03605	1.00	491133.
PS-7	PC-16	0	5813.	946.	.03605	1.00	222690.
PS-7	PC-15	0	5813.	946.	.03605	1.00	222690.
PS-7	PC-14	1	5813.	946.	.03605	1.00	222690.
PS-7	PC-13	0	5813.	946.	.03605	1.00	222690.

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SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

YEAR - 11
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	DN	PRESS PSI	WEIGHTED AVERAGE BHP	LIQ	LINEFILL VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	6499.	6499.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	6459.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	6499.	2571.	2571.	943.	2770.	CRUDE	1922686.
PS-3	PS SUC	192.00	151.	0.	6499.	327.	327.	66.	0.	CRUDE	1922686.
PS-3	PS DIS	192.00	151.	0.	6499.	2686.	2686.	959.	2770.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	6499.	418.	418.	83.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	6499.	2607.	2607.	912.	2565.	CRUDE	1922686.
PS-7	PS SUC	586.00	124.	0.	6499.	269.	269.	55.	0.	CRUDE	1922686.
PS-7	PS DIS	586.00	124.	0.	6499.	1484.	1484.	515.	1455.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	6499.	315.	315.	89.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	6499.	315.	315.	89.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-6499.	0.	315.	315.	89.	0.	CRUDE	1922686.

YEAR - 11
POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUAN-TITY	THRUPUT BPH	BRAKE HORSE-POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	0	6499.	2770.	.03714	1.00	672003.
PS-1	PC-15	1	6499.	2770.	.03714	1.00	672003.
PS-1	PC-14	0	6499.	2770.	.03714	1.00	672003.
PS-1	PC-13	2	6499.	2770.	.03714	1.00	672003.
PS-3	PC-16	0	6499.	2770.	.03714	1.00	672003.
PS-3	PC-15	1	6499.	2770.	.03714	1.00	672003.
PS-3	PC-14	0	6499.	2770.	.03714	1.00	672003.
PS-3	PC-13	2	6499.	2770.	.03714	1.00	672003.
PS-5	PC-16	0	6499.	2565.	.03714	1.00	622103.
PS-5	PC-15	0	6499.	2565.	.03714	1.00	622103.
PS-5	PC-14	1	6499.	2565.	.03714	1.00	622103.
PS-5	PC-13	2	6499.	2565.	.03714	1.00	622103.
PS-7	PC-16	1	6499.	1455.	.03714	1.00	352977.
PS-7	PC-15	0	6499.	1455.	.03714	1.00	352977.
PS-7	PC-14	0	6499.	1455.	.03714	1.00	352977.
PS-7	PC-13	0	6499.	1455.	.03714	1.00	352977.

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SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

YEAR - 12
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	DN	PRESS PSI	WEIGHTED AVERAGE BHP	LIQ	LINEFILL VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	SH/DEL	0.00	80.	7266.	7266.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	7266.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	7266.	1681.	1681.	606.	1916.	CRUDE	1922686.
PS-2	PS SUC	95.00	168.	0.	7266.	329.	329.	61.	0.	CRUDE	1922686.
PS-2	PS DIS	95.00	168.	0.	7266.	1798.	1798.	617.	1916.	CRUDE	1922686.
PS-3	PS SUC	192.00	151.	0.	7266.	418.	418.	101.	0.	CRUDE	1922686.
PS-3	PS DIS	192.00	151.	0.	7266.	1887.	1887.	657.	1916.	CRUDE	1922686.
PS-4	PS SUC	287.00	220.	0.	7266.	535.	535.	119.	0.	CRUDE	1922686.
PS-4	PS DIS	287.00	220.	0.	7266.	1803.	1803.	599.	1656.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	7266.	395.	395.	75.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	7266.	1864.	1864.	630.	1916.	CRUDE	1922686.
PS-6	PS SUC	486.00	165.	0.	7266.	441.	441.	104.	0.	CRUDE	1922686.
PS-6	PS DIS	486.00	165.	0.	7266.	1709.	1709.	584.	1656.	CRUDE	1922686.
PS-7	PS SUC	586.00	124.	0.	7266.	287.	287.	61.	0.	CRUDE	1922686.
PS-7	PS DIS	586.00	124.	0.	7266.	1755.	1755.	617.	1916.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	7266.	333.	333.	96.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	7266.	333.	333.	96.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-7266.	0.	333.	333.	96.	0.	CRUDE	1922686.

YEAR - 12
POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUAN-TITY	THRUPUT BPH	BRAKE HORSE-POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	0	7266.	1916.	.03825	1.00	478578.
PS-1	PC-15	0	7266.	1916.	.03825	1.00	478578.
PS-1	PC-14	1	7266.	1916.	.03825	1.00	478578.
PS-1	PC-13	1	7266.	1916.	.03825	1.00	478578.
PS-2	PC-16	0	7266.	1916.	.03825	1.00	478578.
PS-2	PC-15	0	7266.	1916.	.03825	1.00	478578.
PS-2	PC-14	1	7266.	1916.	.03825	1.00	478578.
PS-2	PC-13	1	7266.	1916.	.03825	1.00	478578.
PS-3	PC-16	0	7266.	1916.	.03825	1.00	478578.
PS-3	PC-15	0	7266.	1916.	.03825	1.00	478578.
PS-3	PC-14	1	7266.	1916.	.03825	1.00	478578.
PS-3	PC-13	1	7266.	1916.	.03825	1.00	478578.
PS-4	PC-16	0	7265.	1655.	.03825	1.00	413622.
PS-4	PC-15	0	7266.	1655.	.03825	1.00	413622.
PS-4	PC-14	0	7266.	1656.	.03825	1.00	413622.
PS-4	PC-13	2	7266.	1656.	.03825	1.00	413622.
PS-5	PC [illegible]	0	7266.	1916.	.03825	1.00	478578.
PS-5	PC [illegible]	0	7266.	1916.	.03825	1.00	478578.
PS-5	PC-[illegible]	1	7266.	1916.	.03825	1.00	478578.
P[illegible] 5	PC-13	1	7266.	1916.	.[illegible]825	1.00	478578.

PS-6	P[illegible]	0	7266.	1656.	.03825	1.00	413622.
PS-6	P[illegible]	2	7266.	1656.	.03825	1.00	413622.
PS-7	PC-16	0	7266.	1916.	.03825	1.00	478578.
PS-7	PC-15	0	7266.	1916.	.03825	1.00	478578.
PS-7	PC-14	1	7266.	1916.	.03825	1.00	478578.
PS-7	PC-13	1	7266.	1916.	.03825	1.00	478578.
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SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

YEAR - 13
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	HEAD IN FT ELEVATION DN	PRESS PSI	WEIGHTED AVERAGE BHP	LIQ	LINEFILL VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	8029.	8029.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	8029.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	8029.	1958.	1958.	711.	2528.	CRUDE	1922686.
PS-2	PS SUC	95.00	168.	0.	8029.	346.	346.	67.	0.	CRUDE	1922686.
PS-2	PS DIS	95.00	168.	0.	8029.	1938.	1938.	670.	2285.	CRUDE	1922686.
PS-3	PS SUC	192.00	151.	0.	8029.	292.	292.	53.	0.	CRUDE	1922686.
PS-3	PS DIS	192.00	151.	0.	8029.	2038.	2038.	714.	2528.	CRUDE	1922686.
PS-4	PS SUC	287.00	220.	0.	8029.	426.	426.	78.	0.	CRUDE	1922686.
PS-4	PS DIS	287.00	220.	0.	8029.	2018.	2018.	680.	2285.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	8029.	338.	338.	53.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	8029.	2083.	2083.	714.	2528.	CRUDE	1922686.
PS-6	PS SUC	486.00	165.	0.	8029.	387.	387.	84.	0.	CRUDE	1922686.
PS-6	PS DIS	486.00	165.	0.	8029.	1979.	1979.	686.	2285.	CRUDE	1922686.
PS-7	PS SUC	586.00	124.	0.	8029.	282.	282.	50.	0.	CRUDE	1922686.
PS-7	PS DIS	586.00	124.	0.	8029.	2028.	2028.	720.	2528.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	8029.	331.	331.	95.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	8029.	331.	331.	95.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-8029.	0.	331.	331.	95.	0.	CRUDE	1922686.

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YEAR - 13
POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUAN-TITY	THRUPUT BPH	BRAKE HORSE-POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	1	8029.	2528.	.03940	1.00	650488.
PS-1	PC-15	0	8029.	2528.	.03940	1.00	650488.
PS-1	PC-14	0	8029.	2528.	.03940	1.00	650488.
PS-1	PC-13	1	8029.	2528.	.03940	1.00	650488.
PS-2	PC-16	0	8029.	2285.	.03940	1.00	588114.
PS-2	PC-15	0	8029.	2285.	.03940	1.00	588114.
PS-2	PC-14	2	8029.	2285.	.03940	1.00	588114.
PS-2	PC-13	0	8029.	2285.	.03940	1.00	588114.
PS-3	PC-16	1	8029.	2528.	.03940	1.00	650488.
PS-3	PC-15	0	8029.	2528.	.03940	1.00	650489.
PS-3	PC-14	0	8029.	2528.	.03940	1.00	650483.
PS-3	PC-13	1	8029.	2528.	.03940	1.00	650483.
PS-4	PC-16	0	8029.	2285.	.03940	1.00	588113.
PS-4	PC-15	0	8029.	2285.	.03940	1.00	588114.
PS-4	PC-14	2	8029.	2285.	.03940	1.00	588114.
PS-4	PC-13	0	8029.	2285.	.03940	1.00	588114.
PS-5	P[illegible]	1	8029.	2528.	.03940	1.00	650488.
PS-5	P[illegible]	0	8029.	2528.	.03940	1.00	650488.
PS-5	PC-14	0	8029.	2528.	.03940	1.00	650488.
P[illegible]-5	PC-13	1	8029	2528.	[illegible]3940	1.01	650488.

PS-6	P(	2	8029.	2285.	.03940	1.00	588114.
PS-6	P(	0	8029.	2285.	.03940	1.00	588114.
PS-7	PC-16	1	8029.	2528.	.03940	1.00	650488.
PS-7	PC-15	0	8029.	2528.	.03940	1.00	650488.
PS-7	PC-14	0	8029.	2528.	.03940	1.00	650488.
PS-7	PC-13	1	8029.	2528.	.03940	1.00	650488.

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SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

YEAR - 14
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	DN	PRESS PSI	WEIGHTED AVERAGE BHP	LINEFILL LIQ	VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	8871.	8871.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	8871.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	8871.	2251.	2251.	822.	3217.	CRUDE	1922686.
PS-2	PS SUC	95.00	168.	0.	8871.	328.	328.	61.	0.	CRUDE	1922686.
PS-2	PS DIS	95.00	168.	0.	8871.	2367.	2367.	832.	3217.	CRUDE	1922686.
PS-3	PS SUC	192.00	151.	0.	8871.	404.	404.	96.	0.	CRUDE	1922686.
PS-3	PS DIS	192.00	151.	0.	8871.	2443.	2443.	867.	3217.	CRUDE	1922686.
PS-4	PS SUC	287.00	220.	0.	8871.	520.	520.	113.	0.	CRUDE	1922686.
PS-4	PS DIS	287.00	220.	0.	8871.	2368.	2368.	813.	2918.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	8871.	364.	364.	63.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	8871.	2403.	2403.	835.	3217.	CRUDE	1922686.
PS-6	PS SUC	486.00	165.	0.	8871.	379.	379.	81.	0.	CRUDE	1922686.
PS-6	PS DIS	486.00	165.	0.	8871.	2418.	2418.	853.	3217.	CRUDE	1922686.
PS-7	PS SUC	586.00	124.	0.	8871.	394.	394.	102.	0.	CRUDE	1922686.
PS-7	PS DIS	586.00	124.	0.	8871.	2242.	2242.	801.	2918.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	8871.	218.	218.	52.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	8871.	218.	218.	52.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-8871.	0.	218.	218.	52.	0.	CRUDE	1922686.

YEAR - 14
POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUANTITY	THRUPUT BPH	BRAKE HORSE-POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	1	8871.	3217.	.04058	1.00	852779.
PS-1	PC-15	1	8871.	3217.	.04058	1.00	852779.
PS-1	PC-14	0	8871.	3217.	.04058	1.00	852779.
PS-1	PC-13	0	8871.	3217.	.04058	1.00	852779.
PS-2	PC-16	1	8871.	3217.	.04058	1.00	852779.
PS-2	PC-15	1	8871.	3217.	.04058	1.00	852779.
PS-2	PC-14	0	8871.	3217.	.04058	1.00	852779.
PS-2	PC-13	0	8871.	3217.	.04058	1.00	852779.
PS-3	PC-16	1	8871.	3217.	.04058	1.00	852779.
PS-3	PC-15	1	8871.	3217.	.04058	1.00	852779.
PS-3	PC-14	0	8871.	3217.	.04058	1.00	852779.
PS-3	PC-13	0	8871.	3217.	.04058	1.00	852779.
PS-4	PC-16	0	8871.	2918.	.04058	1.00	773348.
PS-4	PC-15	2	8871.	2918.	.04058	1.00	773348.
PS-4	PC-14	0	8871.	2918.	.04058	1.00	773348.
PS-4	PC-13	0	8871.	2918.	.04058	1.00	773348.
PS-5	PC-[illegible]	1	8871.	3217.	.04058	1.00	852779.
PS-5	PC-[illegible]	1	8871.	3217.	.04058	1.00	852779.
PS-5	PC-[illegible]	0	8871.	3217.	.04058	1.00	852779.
PS[illegible]	PC-13	0	8871.	3217.	.0[illegible]058	1.00	852779.

PS-6		0	8871.	3217.	.04058	1.00	852779.
PS-6	PC-13	0	8871.	3217.	.04058	1.00	852779.
PS-7	PC-16	0	8871.	2918.	.04058	1.00	773348.
PS-7	PC-15	2	8871.	2918.	.04058	1.00	773348.
PS-7	PC-14	0	8871.	2918.	.04058	1.00	773348.
PS-7	PC-13	0	8871.	2918.	.04058	1.00	773348.

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SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

YEAR - 15
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	HEAD IN FT ELEVATION DN	PRESS PSI	WEIGHTED AVERAGE BHP	LIQ	LINEFILL VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	9801.	9801.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	9801.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	9801.	2613.	2613.	959.	4353.	CRUDE	1922686.
PS-2	PS SUC	95.00	168.	0.	9801.	317.	317.	56.	0.	CRUDE	1922686.
PS-2	PS DIS	95.00	168.	0.	9801.	2632.	2632.	933.	4266.	CRUDE	1922686.
PS-3	PS SUC	192.00	151.	0.	9801.	288.	288.	52.	0.	CRUDE	1922686.
PS-3	PS DIS	192.00	151.	0.	9801.	2689.	2589.	960.	4353.	CRUDE	1922686.
PS-4	PS SUC	287.00	220.	0.	9801.	393.	393.	65.	0.	CRUDE	1922686.
PS-4	PS DIS	287.00	220.	0.	9801.	2794.	2794.	974.	4353.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	9801.	401.	401.	77.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	9801.	2716.	2716.	953.	4266.	CRUDE	1922686.
PS-6	PS SUC	486.00	165.	0.	9801.	300.	300.	51.	0.	CRUDE	1922686.
PS-6	PS DIS	486.00	165.	0.	9801.	2701.	2701.	959.	4353.	CRUDE	1922686.
PS-7	PS SUC	586.00	124.	0.	9801.	284.	284.	60.	0.	CRUDE	1922686.
PS-7	PS DIS	586.00	124.	0.	9801.	2685.	2685.	969.	4353.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	9801.	268.	268.	71.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	9801.	268.	268.	71.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-9801.	0.	268.	268.	71.	0.	CRUDE	1922686.

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YEAR - 15
POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUAN-TITY	THRUPUT BPH	BRAKE HORSE-POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	1	9801.	4353.	.04180	1.00	1188308.
PS-1	PC-15	1	9801.	4353.	.04180	1.00	1188308.
PS-1	PC-14	0	9801.	4353.	.04180	1.00	1188308.
PS-1	PC-13	1	9801.	4353.	.04180	1.00	1188308.
PS-2	PC-16	0	9801.	4265.	.04180	1.00	1164705.
PS-2	PC-15	0	9501.	4266.	.04180	1.00	1164705.
PS-2	PC-14	2	9801.	4266.	.04180	1.00	1164705.
PS-2	PC-13	2	9801.	4266.	.04180	1.00	1164705.
PS-3	PC-16	1	9801.	4353.	.04180	1.00	1188308.
PS-3	PC-15	1	9801.	4353.	.04180	1.00	1188308.
PS-3	PC-14	0	9801.	4353.	.04180	1.00	1188308.
PS-3	PC-13	1	9801.	4353.	.04180	1.00	1188308.
PS-4	PC-16	1	9801.	4353.	.04180	1.00	1188308.
PS-4	PC-15	1	9801.	4353.	.04180	1.00	1188308.
PS-4	PC-14	0	9801.	4353.	.04180	1.00	1188308.
PS-4	PC-13	1	9801.	4353.	.04180	1.00	1188308.
PS-5	PC-16	0	9801.	4266.	.04180	1.00	1164705.
PS-5	P[illegible]	0	9801.	4266.	.04180	1.00	1164705.
PS-5	P[illegible]	2	9801.	4266.	.04180	1.00	1164705.
PS-5	PC-13	2	9801.	4266.	.04180	1.00	1164705.
[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PS-6		0	9801.	4353.	.04180	1.00	1188306.
PS-6	3	1	9801.	4353.	.04180	1.00	1188308.
PS-7	PC-16	1	9801.	4353.	.04180	1.00	1188308.
PS-7	PC-15	1	9801.	4353.	.04180	1.00	1188308.
PS-7	PC-14	0	9801.	4353.	.04180	1.00	1188306.
PS-7	PC-13	1	9801.	4353.	.04180	1.00	1188308.

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SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

YEAR - 16
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	HEAD IN FT ELEVATION DN	PRESS PSI	WEIGHTED AVERAGE BHP	LIQ	LINEFILL VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	9801.	9801.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	9801.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	9801.	2613.	2613.	959.	4353.	CRUDE	1922686.
PS-2	PS SUC	95.00	168.	0.	9801.	317.	317.	56.	0.	CRUDE	1922686.
PS-2	PS DIS	95.00	168.	0.	9801.	2632.	2632.	933.	4266.	CRUDE	1922686.
PS-3	PS SUC	192.00	151.	0.	9801.	288.	288.	52.	0.	CRUDE	1922686.
PS-3	PS DIS	192.00	151.	0.	9801.	2689.	2689.	960.	4353.	CRUDE	1922686.
PS-4	PS SUC	287.00	220.	0.	9801.	393.	393.	65.	0.	CRUDE	1922686.
PS-4	PS DIS	287.00	220.	0.	9801.	2794.	2794.	974.	4353.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	9801.	401.	401.	77.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	9801.	2716.	2716.	953.	4266.	CRUDE	1922686.
PS-6	PS SUC	486.00	165.	0.	9801.	300.	300.	51.	0.	CRUDE	1922686.
PS-6	PS DIS	486.00	165.	0.	9801.	2701.	2701.	959.	4353.	CRUDE	1922686.
PS-7	PS SUC	586.00	124.	0.	9801.	284.	284.	60.	0.	CRUDE	1922686.
PS-7	PS DIS	586.00	124.	0.	9801.	2685.	2685.	969.	4353.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	9801.	268.	268.	71.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	9801.	268.	268.	71.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-9801.	0.	268.	268.	71.	0.	CRUDE	1922686.

YEAR - 16
POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUANTITY	THRUPUT BPH	BRAKE HORSEPOWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	1	9801.	4353.	.04305	1.00	1223957.
PS-1	PC-15	1	9801.	4353.	.04305	1.00	1223957.
PS-1	PC-14	0	9801.	4353.	.04305	1.00	1223957.
PS-1	PC-13	1	9801.	4353.	.04305	1.00	1223957.
PS-2	PC-16	0	9801.	4266.	.04305	1.00	1199646.
PS-2	PC-15	0	9801.	4266.	.04305	1.00	1199646.
PS-2	PC-14	2	9801.	4266.	.04305	1.00	1199646.
PS-2	PC-13	2	9801.	4266.	.04305	1.00	1199646.
PS-3	PC-16	1	9801.	4353.	.04305	1.00	1223957.
PS-3	PC-15	1	9801.	4353.	.04305	1.00	1223957.
PS-3	PC-14	0	9801.	4353.	.04305	1.00	1223957.
PS-3	PC-13	1	9801.	4353.	.04305	1.00	1223957.
PS-4	PC-16	1	9801.	4353.	.04305	1.00	1223957.
PS-4	PC-15	1	9801.	4353.	.04305	1.00	1223957.
PS-4	PC-14	0	9801.	4353.	.04305	1.00	1223957.
PS-4	PC-13	1	9801.	4353.	.04305	1.00	1223957.
PS-5	PC-16	0	9801.	4266.	.04305	1.00	1199646.
PS-5	P[illegible]5	0	9801.	4266.	.04305	1.00	1199646.
PS-5	P[illegible]4	2	9801.	4266.	.04305	1.00	1199646.
PS-5	PC-13	2	9801.	4266.	.04305	1.00	1199646.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PS-6	PC-15	1	9801.	4353.	.04305	1.00	1223957.
PS-6	|	0	9801.	4353.	.04305	1.00	1223957.
PS-6	|	1	9801.	4353.	.04305	1.00	1223957.
PS-7	PC-16	1	9801.	4353.	.04305	1.00	1223957.
PS-7	PC-15	1	9801.	4353.	.04305	1.00	1223957.
PS-7	PC-14	0	9801.	4353.	.04305	1.00	1223957.
PS-7	PC-13	1	9801.	4353.	.04305	1.00	1223957.

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SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

YEAR - 17
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	HEAD IN FT ELEVATION DN	PRESS PSI	WEIGHTED AVERAGE BHP	LINEFILL LIQ	LINEFILL VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	9801.	9801.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	9801.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	9801.	2613.	2613.	959.	4353.	CRUDE	1922686.
PS-2	PS SUC	95.00	168.	0.	9801.	317.	317.	56.	0.	CRUDE	1922686.
PS-2	PS DIS	95.00	168.	0.	9801.	2632.	2632.	933.	4266.	CRUDE	1922686.
PS-3	PS SUC	192.00	151.	0.	9801.	288.	288.	52.	0.	CRUDE	1922686.
PS-3	PS DIS	192.00	151.	0.	9801.	2689.	2689.	960.	4353.	CRUDE	1922686.
PS-4	PS SUC	287.00	220.	0.	9801.	393.	393.	65.	0.	CRUDE	1922686.
PS-4	PS DIS	287.00	220.	0.	9801.	2794.	2794.	974.	4353.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	9801.	401.	401.	77.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	9801.	2716.	2716.	953.	4266.	CRUDE	1922686.
PS-6	PS SUC	486.00	165.	0.	9801.	300.	300.	51.	0.	CRUDE	1922686.
PS-6	PS DIS	486.00	165.	0.	9801.	2701.	2701.	959.	4353.	CRUDE	1922686.
PS-7	PS SUC	586.00	124.	0.	9801.	284.	284.	60.	0.	CRUDE	1922686.
PS-7	PS DIS	586.00	124.	0.	9801.	2685.	2685.	969.	4353.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	9801.	268.	268.	71.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	9801.	268.	268.	71.	0.	CRUDE	1922686.
DE-5	SH/DEL	686.00	80.	-9801.	0.	268.	268.	71.	0.	CRUDE	1922686.

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YEAR - 17
POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUAN-TITY	THRUPUT BPH	BRAKE HORSE-POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	1	9801.	4353.	.04434	1.00	1260676.
PS-1	PC-15	1	9801.	4353.	.04434	1.00	1260676.
PS-1	PC-14	0	9801.	4353.	.04434	1.00	1260676.
PS-1	PC-13	1	9801.	4353.	.04434	1.00	1260676.
PS-2	PC-16	0	9801.	4266.	.04434	1.00	1235635.
PS-2	PC-15	0	9801.	4266.	.04434	1.00	1235635.
PS-2	PC-14	2	9801.	4266.	.04434	1.00	1235635.
PS-2	PC-13	2	9801.	4266.	.04434	1.00	1235635.
PS-3	PC-16	1	9801.	4353.	.04434	1.00	1260676.
PS-3	PC-15	1	9801.	4353.	.04434	1.00	1260676.
PS-3	PC-14	0	9801.	4353.	.04434	1.00	1260676.
PS-3	PC-13	1	9801.	4353.	.04434	1.00	1260676.
PS-4	PC-16	1	9801.	4353.	.04434	1.00	1260676.
PS-4	PC-15	1	9801.	4353.	.04434	1.00	1260676.
PS-4	PC-14	0	9801.	4353.	.04434	1.00	1260676.
PS-4	PC-13	1	9801.	4353.	.04434	1.00	1260676.
PS-5	PC-16	0	9801.	4266.	.04434	1.00	1235635.
PS-5	PC-15	0	9801.	4266.	.04434	1.00	1235635.
PS-5	[illegible]4	2	9801.	4266.	.04434	1.00	1235635.
PS-5	[illegible]3	2	9801.	4266.	.04434	1.00	1235635.
[illegible]-6	PC-1[illegible]	1	98[illegible]	4353.	[illegible]4434	1.00	1260[illegible]76.

[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PS-6	PC-1[illegible]	1	980[illegible].	4353.	.04434	1.0[illegible]	1260676.
PS-6		0	9801.	4353.	.04434	1.00	1260676.
PS-6		1	9801.	4353.	.04434	1.00	1260676.
PS-7	PC-16	1	9801.	4353.	.04434	1.00	1260676.
PS-7	PC-15	1	9801.	4353.	.04434	1.00	1260676.
PS-7	PC-14	0	9801.	4353.	.04434	1.00	1260676.
PS-7	PC-13	1	9801.	4353.	.04434	1.00	1260676.

							8774649.

SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 6, AND 12.

YEAR - 18
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	HEAD IN FT ELEVATION DN	PRESS PSI	WEIGHTED AVERAGE BHP	LIQ	LINEFILL VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	9801.	9801.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	9801.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	9801.	2613.	2613.	959.	4353.	CRUDE	1922686.
PS-2	PS SUC	95.00	168.	0.	9801.	317.	317.	56.	0.	CRUDE	1922686.
PS-2	PS DIS	95.00	168.	0.	9801.	2632.	2632.	933.	4266.	CRUDE	1922686.
PS-3	PS SUC	192.00	151.	0.	9801.	288.	288.	52.	0.	CRUDE	1922686.
PS-3	PS DIS	192.00	151.	0.	9801.	2689.	2689.	960.	4353.	CRUDE	1922686.
PS-4	PS SUC	287.00	220.	0.	9801.	393.	393.	65.	0.	CRUDE	1922686.
PS-4	PS DIS	287.00	220.	0.	9801.	2794.	2794.	974.	4353.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	9801.	401.	401.	77.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	9801.	2716.	2716.	953.	4266.	CRUDE	1922686.
PS-6	PS SUC	486.00	165.	0.	9801.	300.	300.	51.	0.	CRUDE	1922686.
PS-6	PS DIS	486.00	165.	0.	9801.	2701.	2701.	959.	4353.	CRUDE	1922686.
PS-7	PS SUC	586.00	124.	0.	9801.	284.	284.	60.	0.	CRUDE	1922686.
PS-7	PS DIS	586.00	124.	0.	9801.	2685.	2685.	969.	4353.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	9801.	268.	268.	71.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	9801.	268.	268.	71.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-9801.	0.	268.	268.	71.	0.	CRUDE	1922686.

8.42

YEAR - 18
POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUAN-TITY	THRUPUT BPH	BRAKE HORSE-POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	1	9801.	4353.	.04567	1.00	1298496.
PS-1	PC-15	1	9801.	4353.	.04567	1.00	1298496.
PS-1	PC-14	0	9801.	4353.	.04567	1.00	1298496.
PS-1	PC-13	1	9801.	4353.	.04567	1.00	1298496.
PS-2	PC-16	0	9801.	4266.	.04567	1.00	1272704.
PS-2	PC-15	0	9801.	4266.	.04567	1.00	1272704.
PS-2	PC-14	2	9801.	4266.	.04567	1.00	1272704.
PS-2	PC-13	2	9801.	4266.	.04567	1.00	1272704.
PS-3	PC-16	1	9801.	4353.	.04567	1.00	1298496.
PS-3	PC-15	1	9801.	4353.	.04567	1.00	1298496.
PS-3	PC-14	0	9801.	4353.	.04567	1.00	1298496.
PS-3	PC-13	1	9801.	4353.	.04567	1.00	1298496.
PS-4	PC-16	1	9801.	4353.	.04567	1.00	1298496.
PS-4	PC-15	1	9801.	4353.	.04567	1.00	1298496.
PS-4	PC-14	0	9801.	4353.	.04567	1.00	1298496.
PS-4	PC-13	1	9801.	4353.	.04567	1.00	1298496.
PS-5	PC-16	0	9801.	4266.	.04567	1.00	1272704.
PS-5	P[illegible]	0	9801.	4266.	.04567	1.00	1272704.
PS-5	P[illegible]	2	9801.	4266.	.04567	1.00	1272704.
PS-5	P[illegible]	2	9801.	4266.	.04567	1.00	1272704.
[illegible]-6	PC-16	1	9801[illegible]	4353.	.[illegible]567	1.00	1298496.

Pipe Line Technologists, I[illegible].
a Kane[illegible] company

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
.S-6	PC-15	1	9801.	4353.	.04567	1.00	1298496.
PS-6		0	9801.	4353.	.04567	1.00	1298496.
PS-6		1	9801.	4353.	.04567	1.00	1298496.
PS-7	PC-16	1	9801.	4353.	.04567	1.00	1298496.
PS-7	PC-15	1	9801.	4353.	.04567	1.00	1298496.
PS-7	PC-14	0	9801.	4353.	.04567	1.00	1298496.
PS-7	PC-13	1	9801.	4353.	.04567	1.00	1298496.

							9037889.

SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 6, AND 12.

YEAR - 19
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	DN	PRESS PSI	WEIGHTED AVERAGE BHP	LIQ	LINEFILL VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	9801.	9801.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	9801.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	9801.	2613.	2613.	959.	4353.	CRUDE	1922686.
PS-2	PS SUC	95.00	168.	0.	9801.	317.	317.	56.	0.	CRUDE	1922686.
PS-2	PS DIS	95.00	168.	0.	9801.	2632.	2632.	933.	4266.	CRUDE	1922686.
PS-3	PS SUC	192.00	151.	0.	9801.	288.	288.	52.	0.	CRUDE	1922686.
PS-3	PS DIS	192.00	151.	0.	9801.	2689.	2689.	960.	4353.	CRUDE	1922686.
PS-4	PS SUC	287.00	220.	0.	9801.	393.	393.	65.	0.	CRUDE	1922686.
PS-4	PS DIS	287.00	220.	0.	9801.	2794.	2794.	974.	4353.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	9801.	401.	401.	77.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	9801.	2716.	2716.	953.	4266.	CRUDE	1922686.
PS-6	PS SUC	486.00	165.	0.	9801.	300.	300.	51.	0.	CRUDE	1922686.
PS-6	PS DIS	486.00	165.	0.	9801.	2701.	2701.	959.	4353.	CRUDE	1922686.
PS-7	PS SUC	586.00	124.	0.	9801.	284.	284.	60.	0.	CRUDE	1922686.
PS-7	PS DIS	586.00	124.	0.	9801.	2685.	2685.	969.	4353.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	9801.	268.	268.	71.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	9801.	268.	268.	71.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-9801.	0.	268.	268.	71.	0.	CRUDE	1922686.

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YEAR - 19
POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUANTITY	THRUPUT BPH	BRAKE HORSEPOWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	1	9801.	4353.	.04704	1.00	1337451.
PS-1	PC-15	1	9801.	4353.	.04704	1.00	1337451.
PS-1	PC-14	0	9801.	4353.	.04704	1.00	1337451.
PS-1	PC-13	1	9801.	4353.	.04704	1.00	1337451.
PS-2	PC-16	0	9801.	4266.	.04704	1.00	1310885.
PS-2	PC-15	0	9801.	4266.	.04704	1.00	1310885.
PS-2	PC-14	2	9801.	4266.	.04704	1.00	1310885.
PS-2	PC-13	2	9801.	4266.	.04704	1.00	1310885.
PS-3	PC-16	1	9801.	4353.	.04704	1.00	1337451.
PS-3	PC-15	1	9801.	4353.	.04704	1.00	1337451.
PS-3	PC-14	0	9801.	4353.	.04704	1.00	1337451.
PS-3	PC-13	1	9801.	4353.	.04704	1.00	1337451.
PS-4	PC-16	1	9801.	4353.	.04704	1.00	1337451.
PS-4	PC-15	1	9801.	4353.	.04704	1.00	1337451.
PS-4	PC-14	0	9801.	4353.	.04704	1.00	1337451.
PS-4	PC-13	1	9801.	4353.	.04704	1.00	1337451.
PS-5	PC-16	0	9801.	4266.	.04704	1.00	1310885.
PS-5	P[illegible]	0	9801.	4266.	.04704	1.00	1310885.
PS-5	P[illegible]	2	9801.	4266.	.04704	1.00	1310885.
PS-5	P[illegible]	2	9801.	4266.	.04704	1.00	1310885.
[illegible]-6	PC-16	1	9801[illegible]	4353.	.[illegible]704	1.00	1337451.

Pipe Line Technologists, I[illegible]
a Kaneb company

.S-6	PC-15	1	9801.	4353.	.04704	1.00	1337451.
PS-6		0	9801.	4353.	.04704	1.00	1337451.
PS-6		1	9801.	4353.	.04704	1.00	1337451.
PS-7	PC-16	1	9801.	4353.	.04704	1.00	1337451.
PS-7	PC-15	1	9801.	4353.	.04704	1.00	1337451.
PS-7	PC-14	0	9801.	4353.	.04704	1.00	1337451.
PS-7	PC-13	1	9801.	4353.	.04704	1.00	1337451.

							9309025.

SAMPLE CRUDE OIL PIPELINE. PUMP STATIONS COME ON LINE IN YEARS 1, 8, AND 12.

YEAR - 20
PRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.

NODE NAME	NODE TYPE	MILE POST	GROUND ELEV FEET	SHP/DEL RATE BPH	P/L RATE BPH	HEAD IN FT ELEVATION UP	DN	PRESS PSI	WEIGHTED AVERAGE BHP	LINEFILL LIQ	VOLUME BBLS
24 IN	DIA CH	0.00	80.	0.	0.	212.	212.	50.	0.	CRUDE	1922686.
RS-1	SH/DEL	0.00	80.	9801.	9801.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS SUC	0.00	80.	0.	9801.	212.	212.	50.	0.	CRUDE	1922686.
PS-1	PS DIS	0.00	80.	0.	9801.	2613.	2613.	959.	4353.	CRUDE	1922686.
PS-2	PS SUC	95.00	168.	0.	9801.	317.	317.	56.	0.	CRUDE	1922686.
PS-2	PS DIS	95.00	168.	0.	9801.	2632.	2632.	933.	4266.	CRUDE	1922686.
PS-3	PS SUC	192.00	151.	0.	9801.	268.	268.	52.	0.	CRUDE	1922686.
PS-3	PS DIS	192.00	151.	0.	9801.	2689.	2689.	960.	4353.	CRUDE	1922686.
PS-4	PS SUC	287.00	220.	0.	9801.	393.	393.	65.	0.	CRUDE	1922686.
PS-4	PS DIS	287.00	220.	0.	9801.	2794.	2794.	974.	4353.	CRUDE	1922686.
PS-5	PS SUC	386.00	198.	0.	9801.	401.	401.	77.	0.	CRUDE	1922686.
PS-5	PS DIS	386.00	198.	0.	9801.	2716.	2716.	953.	4266.	CRUDE	1922686.
PS-6	PS SUC	486.00	165.	0.	9801.	300.	300.	51.	0.	CRUDE	1922686.
PS-6	PS DIS	486.00	165.	0.	9801.	2701.	2701.	959.	4353.	CRUDE	1922686.
PS-7	PS SUC	586.00	124.	0.	9801.	284.	284.	60.	0.	CRUDE	1922686.
PS-7	PS DIS	586.00	124.	0.	9801.	2685.	2685.	969.	4353.	CRUDE	1922686.
INTF	INTERF	686.00	80.	0.	9801.	268.	268.	71.	0.	CRUDE	1922686.
0 IN	DIA CH	686.00	80.	0.	9801.	268.	268.	71.	0.	CRUDE	1922686.
DF-5	SH/DEL	686.00	80.	-9801.	0.	268.	268.	71.	0.	CRUDE	1922686.

YEAR - 20
POWER COST DATA.

PUMP STA	PUMP CURVE NAME	QUAN- TITY	THRUPUT BPH	BRAKE HORSE- POWER	POWER RATE $/KWHR	PERCENT OF TIME PUMPING	POWER COST $/YR
PS-1	PC-16	1	9801.	4353.	.04845	1.00	1377574.
PS-1	PC-15	1	9801.	4353.	.04845	1.00	1377574.
PS-1	PC-14	0	9801.	4353.	.04845	1.00	1377574.
PS-1	PC-13	1	9801.	4353.	.04845	1.00	1377574.
PS-2	PC-16	0	9801.	4266.	.04845	1.00	1350212.
PS-2	PC-15	0	9801.	4266.	.04845	1.00	1350212.
PS-2	PC-14	2	9801.	4266.	.04845	1.00	1350212.
PS-2	PC-13	2	9801.	4266.	.04845	1.00	1350212.
PS-3	PC-16	1	9801.	4353.	.04845	1.00	1377574.
PS-3	PC-15	1	9801.	4353.	.04845	1.00	1377574.
PS-3	PC-14	0	9801.	4353.	.04845	1.00	1377574.
PS-3	PC-13	1	9801.	4353.	.04845	1.00	1377574.
PS-4	PC-16	1	9801.	4353.	.04845	1.00	1377574.
PS-4	PC-15	1	9801.	4353.	.04845	1.00	1377574.
PS-4	PC-14	0	9801.	4353.	.04845	1.00	1377574.
PS-4	PC-13	1	9801.	4353.	.04845	1.00	1377574.
PS-5	PC-16	0	9801.	4266.	.04845	1.00	1350212.
PS-5	P[illegible]	0	9801.	4266.	.04845	1.00	1350212.
PS-5	P[illegible]	2	9801.	4266.	.04845	1.00	1350212.
PS-5	P[illegible]	2	9801.	4266.	.04845	1.00	1350212.
[illegible]-6	PC-16	1	9801	4353.	.[illegible]845	1.00	1377574.

[illegible]-6	PC-15	1	9801.	4353.	.0[illegible]845	1.00	1377574.
PS-6	P[illegible]	0	9801.	4353.	.04845	1.00	1377574.
PS-6	P[illegible]	1	9801.	4353.	.04845	1.00	1377574.
PS-7	PC-1[illegible]	1	9801.	4353.	.04845	1.00	1377574.
PS-7	PC-15	1	9801.	4353.	.04845	1.00	1377574.
PS-7	PC-14	0	9801.	4353.	.04845	1.00	1377574.
PS-7	PC-13	1	9801.	4353.	.04845	1.00	1377574.

							9568296.

LISTING OF

PROGRAM LIQPL

```
      PROGRAM LIQPL ( INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
C***********************************************************************
C
C     LIQPL SIMULATES A STEADY STATE LIQUID
C     PIPELINE WITH ANY NUMBER OF INJECTION/DELIVERY STATIONS, DIAMETER
C     CHANGES, AND PUMP STATIONS.
C
C     THE PIPELINE MAY BE FILLED WITH ANY NUMBER OF LIQUIDS WITH
C     DIFFERENT HYDRAULIC PROPERTIES.  THE USER SPECIFIES THE PERCENTAGE
C     OF EACH LIQUID MAKING UP THE LINEFILL, AND THE PROGRAM COMPUTES
C     THE LINEFILL BY PLACING THE GIVEN PERCENTAGE OF EACH LIQUID BETWEEN
C     EACH TWO PUMP STATIONS.
C
C     ANY NUMBER OF PUMP CURVES CAN BE ENTERED AS DATA AND THE QUANTITY
C     OF EACH CURVE AT EACH PUMP STATION SPECIFIED.  THE PROGRAM THEN
C     COMPUTES THE OPTIMUM COMBINATION OF PUMPS FOR EACH PUMP STATION
C     BASED ON THE GIVEN THROUGHPUTS.
C
C     FRICTION LOSSES ARE CALCULATED BASED ON THE LINEFILL.  THE USER
C     CHOOSES BETWEEN THE HAZEN WILLIAMS, THE DARCY WEISBACH FORMULAS
C     AND SUBROUTINE SLURRY
C     FOR FRICTION LOSS CALCULATION.  THE BRAKE HORSEPOWER REQUIRED AT
C     EACH PUMP STATION IS CALCULATED BASED ON EACH GIVEN LIQUID BEING
C     IN THE PUMPS FOR THE GIVEN PERCENTAGE OF THE TIME.
C
C     SEE SUBROUTINE SLURRY FOR DESCRIPTION OF FRICTION LOSS CALCULATIONS
C     IN SLURRY PIPELINES.
C
C
C     SYMBOL                DEFINITION
C
C     I           NODE NUMBER
C     C           PIPE ROUGHNESS FACTOR FOR THE HAZEN WILLIAMS EQ.
C                     DEFAULT VALUE = 150.
C     XMP(I)      MILEPOST OF NODE NUMBER I.
C     ITYP(I)     NODE TYPE.  1 = BATCH INTERFACE
C                             2 = SHIPMENT/DELIVERY STATION
C                             3 = P.S. SUCTION
C                             4 = P.S. DISCHARGE
C                             5 = DIAMETER CHANGE
C     H(I)        HEAD IN FEET ABOVE SEA LEVEL
C     HUP(I)      HEAD AT AN INTERFACE BASED ON DENSITY OF UPSTREAM PRODUCT
C     P(I)        PRESSURE IN PSI
C     Q(I)        FLOW RATE OUT OF NODE IN BPH
C     NAME(I)     NAME OF NODE
C     RATE(I)     SHIPMENT OR DELIVERY RATE.  NEG. NO. IS DELIVERY.
C     PMAX(I)     MAXIMUM ALLOWABLE PRESSURE
C     SG(I)       SPECIFIC GRAVITY OF LIQUID
C     VIS(I)      VISCOSITY OF LIQUID
C     PMIN(I)     MINIMUM ALLOWABLE PRESSURE IN PSI
C     BHP(I)      BRAKE HORSEPOWER AT NODE I
C     EL(I)       GROUND ELEVATION IN FEET
C     PID(I)      PIPE INSIDE DIAMETER IN INCHES
C     EPSI        ROUGHNESS OF PIPE FOR USE WITH MOODY DIAGRAM IN INCHES
C                     DEFAULT VALUE IS 0.0018
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C   IPRO(I)     PRODUCT NAME
C   NUMI        TOTAL NUMBER OF NODES
C   NOL1        NUMBER OF BATCH INTERFACES
C   NOL2        NUMBER OF SHIPMENT/DELIVERY STATIONS
C   NOL3        NUMBER OF P.S. SUCTIONS
C   NOL4        NUMBER OF P.S. DISCHARGES
C   NOL5        NUMBER OF DIAMETER CHANGES
C   NOL6        NUMBER OF POINTS IN GROUND PROFILE
C   XM1(I1)     MILEPOST OF BATCH INTERFACE
C   XM2(I2)     MILEPOST OF SHIPMENT/DELIVERY STATION
C   XM3(I3)     MILEPOST OF P.S. SUCTIONS
C   XM4(I4)     MILEPOST OF P.S. DISCHARGES
C   XM5(I5)     MILEPOST OF DIAMETER CHANGES
C   XM6(I6)     MILEPOST OF POINTS IN GROUND PROFILE
C   ELEV(I6)    ELEVATION OF GROUND IN FEET
C   IEQ         TERM USED TO SELECT THE FLOW EQ.
C                    IF IEQ = 0, SUBROUTINE SLURRY WILL BE USED.
C                    IF IEQ = 1, HAZEN WILLIAMS FORMULA WILL BE USED.
C                    IF IEQ = 2, DARCY WEISBACH FORMULA WILL BE USED.
C   PRAT(I)   POWER RATE IN DOLLARS PER KILOWATT HOURS.
C   POW(I)    POWER IN KILOWATT HOURS.
C   PCOS(I)   POWER COST IN DOLLARS.
C   IYR1      FIRST YEAR OF PIPELINE OPERATION.
C   NOYR      NUMBER OF YEARS OF PIPELINE OPERATION TO BE STUDIED.
C   PERO      PERCENT OF TIME PIPELINE IS OPERATING, IN DECIMALS.
C   QESC(IY)  THROUGHPUT ESCALATOR FACTOR.
C   PESC(IY)  POWER RATE ESCALATOR FACTOR.
C   IYEA(IY)  YEAR THAT THE GIVEN ESCALATOR FACTORS START.
C   NPRO(IPR) NAME OF PRODUCT
C   PERC(IPR) PERCENT OF LINEFILL.
C   SGPR(IPR) SPECIFIC GRAVITY OF PRODUCT.
C   VISP(IPR) VISCOSITY OF PRODUCT IN CENTISTOKES.
C   NPC(IPC)  NAME OF PUMP CURVE
C   QPC(IPC)  CAPACITY OF PUMP
C   HPC(IPC)  HEAD OF PUMP
C   EPC(IPC)  EFFICIENCY OF PUMP
C   NOPC      TOTAL NUMBER OF PUMP CURVES IN PIPELINE.
C   NOPU(I3)  NUMBER OF PUMPS AT PUMP STATION.
C   NAPC(I3)  NAME OF PUMP CURVE AT PUMP STATION.
C   NUPC(IPU,I3)  NUMBER OF SPECIFIC PUMP CURVE AT PUMP STATION.
C   XM7(I7)   MILEPOST OF POINT IN GROUND PROFILE.
C   ELE7(I7)  ELEVATION OF POINT IN GROUND PROFILE.
C   NOL7      NUMBER OF POINTS IN GROUND PROFILE
C   JTYPE(I)  NAME OF NODE TYPE.
C   PID5(I5)  INSIDE DIAMETER OF PIPE, INCHES.  POINT ON PIPE SCHEDULE
C   PMX5(I5)  MAX ALLOWABLE PRESSURE OF PIPE.
C   VOLM(I3)  VOLUME BETWEEN TWO PUMP STATIONS, BBLS.
C   VOL1(I1)  VOLUME OF A SPECIFIC BATCH, BBLS.
C   SG1(I1)   SPECIFIC GRAVITY OF A SPECIFIC BATCH.
C   VIS1(I1)  VISCOSITY OF A SPECIFIC BATCH IN CS.
C   PMN1(I1)  MINIMUM ALLOWABLE PRESSURE OF A SPECIFIC BATCH, PSI
C   NPR1(I1)  NAME OF PRODUCT IN A SPECIFIC BATCH.
C   NAPR(I)   NAME OF PRODUCT AT NODE.
C   VO(I)     VOLUME OF BATCH AT NODE.
C   TPC       TOTAL POWER COST FOR ONE YEAR.
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C   IYEAR(I)  THE YEAR IN WHICH A PUMP STATION COMES ON LINE.
C   IOUT      OUTPUT FORMAT OPTION.
C                IF IOUT=0, PRINT POWER COST DATA ONLY.
C                IF IOUT=1, PRINT LONG OUTPUT.
C                IF IOUT=2, PRINT TOTAL POWER COST ONLY.
C*************************************************************************
C
C   BLANK COMMON
      INTEGER SIZFLG,SIEVE
C
C                                   NAME,QUAN.  POINTS     GROUND
C           NODES       PRODUCTS    PUMP CURV   PUMP CURV  PROFILE
C
C
      COMMON NAME(200) , NPRO(10) , NPC(25)    , QPC(6,25) ,  XM7(100),
     1      ITYP(200) , PERC(10) , NAPC(6,30), HPC(6,25) , ELE7(100),
     2       XMP(200) , SGPR(10) , NUPC(6,30), EPC(6,25) ,
     3      RATE(200) , VISP(10) ,
     4      PMAX(200) ,  PMN(10) ,
     5       PID(200)
C           NODES       NODES        PIPE       PUMP       BATCH
C                                    DIAM       STA        INTERF
C
      COMMON PMIN(200) , NPC1(200) ,  XM5(5)   ,  XM3(30) ,  XM1(100) ,
     1        VIS(200) , NPC2(200) , PID5(5)   , PMN3(30) ,  SG1(100) ,
     2         SG(200) , NPC3(200) ,             PMX4(30) , VIS1(100) ,
     3          Q(200) , NPC4(200) ,             NOPU(30) , PMN1(100) ,
     4         EL(200) , NPC5(200) ,                        NPR1(100) ,
     5          P(200) , NPC6(200)
      COMMON    H(200) ,  BHP(200) ,
     1        HUP(200) , HPCH(200) ,
     2       PCOS(200) ,  POW(200) ,
     3       PRAT(200) ,  PERO(200),
     4     IYEAR(200)
      COMMON NOL1,NOL2,NOL3,NOL4,NOL5,NOL6,NOL7,NOPC,NOPR,NUMI,
     1  IEQ,EPSI,IW,C,IPMX, PEFF,IYR ,DEFF
      COMMON/SLURR/SIEVE(25) , SAMWT(25) ,VOLFRC,WTFRC,GVS,SIZFLG,SOLSIZ
     1  ,GVL,SIZE(25),CV(25),CD(25),NSAMPL,WTSUM,CVT,GVSLR,VISC,FLOW,
     2  PROD,VEL,DELPS,DELPW,DIFF,HPM,DIA,RUF
      DIMENSION VOLM(30),JTYP(200),NAPR(200),VOL1(100),VO(200),
     1  PR3(30), FE3(30), PMX5(5),IYEA(50),GESC(50),PESC(50)
C*************************************************************************
C
C   SET MISC. COUNTERS TO ZERO.
C
   99 NUMI = 0
      NOPR = 0
      NOPC = 0
      NOL3 = 0
      NOL7 = 0
      IPMX = 0
      KONT = 0
      EVERY = 0.
      IYPR = 1
      JEND = 3HEND
```

```
      I999 = 3H999
      I99  = 2H99
      DO 7 IPC=1,25
      DO 6 IPT=1,6
      GPC(IPT,IPC) = 0.
      HPC(IPT,IPC) = 0.
      EPC(IPT,IPC) = 0.
    6 CONTINUE
    7 CONTINUE
      DO 9 I3=1,30
      DO 8 IPU=1,6
      NAPC(IPU,I3) = 6H
      NUPC(IPU,I3) = 0
    8 CONTINUE
    9 CONTINUE
C***********************************************************************
C
C     ASSIGN LOGICAL UNIT NUMBER FOR READ AND WRITE STATEMENTS.
C
      IR = 5
      IW = 6
C***********************************************************************
C
C     READ INPUT DATA.
C
C
C     TITLE
C     PROGRAM WILL ITERATE AND READ DATA FOR ADDITIONAL RUNS UNTIL
C     IT READS END FOR THE TITLE.
C
      READ(IR,200) IT1,IT2,IT3,IT4,IT5,IT6,IT7,IT8,IT9,IT10,IT11,
     1    IT12,IT13,IT14,IT15,IT16,IT17,IT18,IT19,IT20
      IF(IT1.EQ.JEND)GO TO 9999
C
C     OUTPUT OPTION. IOUT=1 GIVES THE LONG OUTPUT.
C     PUMP EFFICIENCY.  PEFF WILL BE USED IN CALCULATING HORSEPOWER IF NO
C     PUMP CURVES ARE READ IN.  THIS VARIABLE WILL NOT BE USED IF PUMP CURVES
C     ARE READ IN.
C     DRIVER EFFICIENCY.  DEFF WILL BE USED IN CALCULATING POWER COST.
C     DEFAULT VALUE IS 1.00.  AN ALTERNATE PROCEDURE IS TO COMBINE DRIVER
C     EFFICIENCY WITH EPC NEAR STATMENT 50 BELOW.
C
      READ(IR,210)IOUT,PEFF ,DEFF
      IF(PEFF.LE.0.)PEFF=.80
      IF(DEFF.LE.0.)DEFF=1.00
C
C     LIFE OF PIPELIN DATA.  YEAR ONE, TOTAL NO. OF YEARS.
C
      READ(IR,260) IYR1,NOYR
      IEND = IYR1 + NOYR - 1
      IYR = IYR1
C
C     FLOW EQUATION DATA.
C
      READ(IR,210)IEQ, C, EPSI
```

```
      IF(C.LE.0.)C=150.
      IF(EPSI.LE.0.)EPSI=.0018
C
C     SLURRY PIPELINE DATA.  OMIT THESE CARDS IF PIPELINE IS NOT A
C     SLURRY PIPELINE, I.E., IF IEQ IS NOT EQUAL TO ZERO.
C
      IF(IEQ.NE.0) GO TO 2
      READ(IR,280) VOLFRC,WTFRC,GVS,SIZFLG,SOLSIZ
C
C     ADDITIONAL SLURRY PIPELINE DATA.  OMIT IF IEQ IS NOT EQUAL ZERO.
C     OTHERWISE END DATA WITH A 999 CARD.
C
      NSAMPL = 0
      DO  1 IS=1,900
      READ(IR,290) SIEVE(IS),SAMWT(IS)
      IF(SIEVE(IS).EQ.99900)GO TO 2
    1 NSAMPL= NSAMPL+ 1
C
C     ESCALATOR FACTORS FOR THROUGHPUTS AND POWER RATES.
C     END DATA WITH A CARD WITH 999 STARTING IN COLUMN ONE.
C
    2 DO 3 IY=1,900
      READ(IR,270) IYEA(IY), QESC(IY), PESC(IY)
      IF(IYEA(IY).EQ.9990)GO TO 4
      NOIY = IY
      IF(IY.EQ.1)GO TO 3
      IF(QESC(IY).LE.0.)QESC(IY) = QESC(IY-1)
      IF(PESC(IY).LE.0.)PESC(IY) = PESC(IY-1)
    3 CONTINUE
C
C     NODE DATA.  END NODE DATA WITH A CARD WITH 999 IN THE FIRST 3 COLUMNS.
C     XMP, PMAX, AND PID WILL EACH BE SET TO PREVIOUSLY ENTERED VALUE
C     IF LEFT BLANK.
C
    4 RA = 0.
      DO 10 I=1,900
      READ(IR,215)  NAME(I),IYEAR(I),ITYP(I),XMP(I),RATE(I),PMAX(I),
     1  PID(I), PRAT(I), PERO(I)
      IF(I.EQ.1)GO TO 5
      IF(ITYP(I).EQ.4)IYEAR(I)=IYEAR(I-1)
      IF(XMP(I).LE.0.)XMP(I)=XMP(I-1)
      IF(PMAX(I).LE.0.)PMAX(I)=PMAX(I-1)
      IF(PID(I).LE.0.)PID(I)=PID(I-1)
      IF(PRAT(I).LE.0.)PRAT(I)=PRAT(I-1)
      IF(PERO(I).LE.0.)PERO(I)=PERO(I-1)
    5 IF(NAME(I).EQ.1999)GO TO 20
      RA = RA + RATE(I)
   10 NUMI = NUMI + 1
   20 RATE(NUMI) =-RA
C
C     LIQUID PROPERTIES.  LAST CARD IS TO BE 999 CARD.
C
      DO 30 IPR=1,900
      READ(IR,230)  NPRO(IPR),PERC(IPR),SGPR(IPR),VISP(IPR),PMN(IPR)
      IF (NPRO(IPR).EQ.1999)GO TO 40
```

```
      C
      C   NOTE - IF THIS IS A SLURRY PIPELINE, SET GVL= SPECIFIC GRAVITY
      C   OF THE LIQUID AND SGPR(IPR)=SPECIFIC GRAVITY OF THE SLURRY.
      C
            IF(IFQ.GT.0)GO TO 30
            GVL = SGPR(IPR)
            SGPR(IPR) = VOLFRC*GVS + (1.0-VOLFRC)*GVL
         30 NOPR = NOPR + 1
      C
      C   PUMP CURVE DATA.  READ IN 6 POINTS FOR EACH CURVE.  LAST CARD IS
      C   TO BE 999 CARD.
      C
         40 DO 50 IPC=1,900
            READ(IR,220)NPC(IPC)
            IF(NPC(IPC).EQ.I999)GO TO 60
            READ(IR,250) ( QPC(IPT,IPC), HPC(IPT,IPC),EPC(IPT,IPC),IPT=1,6)
         50 NOPC = NOPC + 1
      C
      C   PUMP CURVES AVAILABLE AT EACH PUMP STATION.  START WITH FIRST P.S.
      C   AND WORK DOWNSTREAM.  END DATA FOR EACH P.S. WITH A CARD CONTAINING
      C   99 STARTING IN  COLUMN 1.  END P.C. AVAILABLE DATA WITH A CARD
      C   CONTAINING 999 STARTING IN COLUMN 1.
      C
         60 DO 80  I3=1,900
            NOPU(I3) = 0
            DO 70 IPU=1,100
            IF(NOPU(I3).GT.6)WRITE(IW,75)
            IF(NOPU(I3).GT.6)GO TO 9999
      C
      C   NOTE.  IF ALL IS NOT EQUAL TO ZERO, ALL PUMP STATIONS WILL BE
      C   ASSIGNED THE SAME PUMP CURVES AS THE FIRST PUMP STATION.  USE THE
      C   LAST CARD IN THIS SET TO DESIGNATE THE VALUE OF ALL.
      C
            READ(IR,220)  NAPC(IPU,I3),NUPC(IPU,I3)   ,ALL
            IF(ALL.GT.0.)EVERY=ALL
            IF(NAPC(IPU,I3).EQ.I99)GO TO 80
            IF(NAPC(IPU,I3).EQ.I999)GO TO 9B
         70 NOPU(I3) = NOPU(I3) + 1
         80 CONTINUE
         75 FORMAT (////,1X,46HINPUT ERROR *** NO MORE THAN SIX (6) DIFFERENT,
           145H PUMP CURVES MAY BE USED AT ANY PUMP STATION.)
      C
      C   GROUND PROFILE DATA.  END THIS DATA WITH A CARD WITH 999 STARTING
      C   IN COLUMN 1.
      C
         90 DO 100 I7=1,900,4
            READ(IR,240) XM7(I7),ELE7(I7),XM7(I7+1),ELE7(I7+1),XM7(I7+2),
           1     ELE7(I7+2),XM7(I7+3),ELE7(I7+3)
            IF(XM7(I7).EQ.999.)GO TO 110
        100 NOL7 = NOL7 + 4
        110 CONTINUE
            IF(XM7(NOL7).GT.0.)GO TO 120
            NOL7 = NOL7 - 1
            GO TO 110
        120 CONTINUE
```

```
  200 FORMAT (20A4)
  210 FORMAT ( I5,5X,2F10.0)
  215 FORMAT ( A6,I4,I5,5X,6F10.0)
  220 FORMAT ( A6,4X,I5,5X,6F10.0)
  230 FORMAT ( A6,4X,4F10.0)
  240 FORMAT ( F10.7, 7F10.0)
  250 FORMAT ( 6F10.0)
  260 FORMAT ( I4,1X,I5,10X,2F10.0 )
  270 FORMAT ( I4,6X,2F10.0)
  280 FORMAT ( 3F10.0,I5,5X,F10.0)
  290 FORMAT(I5,5X,F10.0)
C*********************************************************************
C
C   CALCULATE MISCELLANEOUS VALUES FOR EACH NODE TYPE.
C
      I2 = 0
      I3 = 0
      I4 = 0
      I5 = 0
      DO 350 I=1,NUMI
      IF(ITYP(I).EQ.2)GO TO 310
      IF(ITYP(I).EQ.3)GO TO 320
      IF(ITYP(I).EQ.4)GO TO 330
      IF(ITYP(I).EQ.5)GO TO 340
      WRITE(IW,300)
  300 FORMAT(1X,51HINPUT ERROR *** ILLEGAL VALUE FOR NODE TYPE NUMBER.)
      GO TO 999
C
C     NODE TYPE 2, SHIPMENT/DELIVERY STATION.
C
  310 I2 = I2 +1
      NOL2 = I2
      JTYP(I) = 6HSH/DEL
      GO TO 350
C
C   NODE TYPE 3, PUMP STATION SUCTION.
C
  320 I3 = I3 + 1
      NOL3 = I3
      IF(EVERY.LE.0.)GO TO 326
      NOPU(I3) = NOPU(1)
      N = NOPU(1)
      DO 325 IPU=1,N
      NAPC(IPU,I3) = NAPC(IPU,1)
      NUPC(IPU,I3) = NUPC(IPU,1)
  325 CONTINUE
  326 JTYP(I) = 6HPS SUC
      XM3(I3) = XMP(I)
      PR3(I3) = PRAT(I)
      PE3(I3) = PESC(I)
      IF(IYEAR(I).LE.0)IYEAR(I)=IYR1
      GO TO 350
C
C   NODE TYPE 4, PUMP STATION DISCHARGE
C
```

```
  330 I4 = I4 + 1
      NOL4 = I4
      JTYP(I) = 6HPS DIS
      PMX4(I4) = PMAX(I)
      IF(IYEAR(I).LE.0)IYEAR(I)=IYE1
      GO TO 350
C
C   NODE TYPE 5, DIAMETER CHANGE
C
  340 I5 = I5 + 1
      NOL5 = I5
      JTYP(I) = 6HDIA CH
      XM5(I5) = XMP(I)
      PID5(I5) = PID(I)
      PMX5(I5) = PMAX(I)
  350 CONTINUE
C*************************************************************************
C
C   CALCULATE THE LINEFILL FROM THE GIVEN PEECENTAGE CF EACH LIQUID.
C
C   FIND THE VOLUMES BETWEEN PUMP STATIONS.
C
      IF(NOPR.NE.1)GO TO 450
      NOL1 =1
      VOL1(1) = VOLU(NOL5,XM5,XMP,NUMI,XMP,1,PID5)
      NPR1(1) = NPRO(1)
      XM1(1) = XMP(NUMI)
      SG1(1) = SGPR(1)
      VIS1(1) = VISP(1)
      PMN1(1) = PMN(1)
      GO TO 495
  450 N = NOL3 - 1
      DO 460 I3=1,N
      I31 = I3 +1
      XM3(I31)= XM3(I31)
      XM3(I3) = XM3(I3)
  460 VOLM(I3) = VOLU(NOL5,XM5,XM3,I31,XM3,I3,PID5)
      XMP(NUMI) = XMP(NUMI)
      XM3(NOL3) = XM3(NOL3)
      VOLM(NOL3)=VOLU(NOL5,XM5,XMP,NUMI,XM3,NOL3,PID5)
C
C  FIND THE MILEPOSTS OF BATCH INTERFACES BASED ON THE GIVEN
C  PERCENTAGE OF EACH LIQUID  BETWEEN EACH TWO PLEP STATICNS.
C
      I1 = 0
      DO 490 I3=1,NOL3
      DO 480 IPR=1,NOPR
      IF(I3.NE.1)GO TO 470
      IF(IPR.NE.1)GO TO 470
      I1 = I1 + 1
      VOL = VOLM(1)*PERC(1)
      VOL1(1) = VOL
      NPR1(1) = NPRO(1)
      XM1(1) = DIST(VOL,XM3,1,NOL5,XM5,PID5)
      SG1(1) = SGPR(1)
```

```
      VIS1(1) = VISP(1)
      PMN1(1) = PMN(1)
      GO TO 480
  470 I1 = I1 + 1
      VOL = VOLM(I3)*PERC(IPE)
      I11 = I1 - 1
      XM1(I1) = XM1(I1-1) + DIST(VOL,XM1,I11,NOL5,XM5,PID5)
      SG1(I1) = SGPR(IPR)
      VIS1(I1) = VISP(IPR)
      PMN1(I1) = PMN(IPR)
      VOL1(I1) = VOL
      NPR1(I1) = NPRO(IPR)
      NOL1 = I1
  480 CONTINUE
  490 CONTINUE
C
C    FIND THE LIQUID PROPERTIES AT EACH NODE.
C
  495 DO 520 I=1,NUMI
      DO 500 I1=1,NOL1
      IF(XMP(I).LT.XM1(I1))GO TO 510
      IF(I1.EQ.NOL1)GO TO 510
  500 CONTINUE
  510 SG(I) = SG1(I1)
      VIS(I) = VIS1(I1)
      NAPR(I) = NPR1(I1)
        VO(I) = VOL1(I1)
      PMIN(I) = PMN1(I1)
  520 CONTINUE
C***********************************************************************
C
C    CALCULATE LINE FLOW RATES FROM SHIPMENT/DELIVERY DATA.
C
      SUM = 0.
      DO 600 I=1,NUMI
      SUM = SUM + RATE(I)
  600 Q(I) = SUM
C***********************************************************************
C
C    MAKE EACH BATCH INTERFACE A NODE.
C
      I1 = 1
      DO 730 I=1,900
      II = I
      XM1(I1) = XM1(I1)
      XMP(I) = XMP(I)
      IF(XM1(I1).GT.XMP(I))GO TO 730
      NUMI = NUMI + 1
      K2 = -1
  700 K2 = K2 + 1
      N = NUMI - I - K2
      IF(N.EQ.0)GO TO 710
      NUMK2 = NUMI - K2
      XMP(NUMI-K2) = XMP(NUMI-K2-1)
      NAME(NUMI-K2) = NAME(NUMI-K2-1)
```

```
      ITYP(NUMI-K2) = ITYP(NUMI-K2-1)
      RATE(NUMI-K2) = RATE(NUMI-K2-1)
      PID(NUMI-K2) = PID(NUMI-K2-1)
      PMAX(NUMI-K2) = PMAX(NUMI-K2-1)
      Q(NUMI-K2) = Q(NUMI-K2-1)
        SG(NUMI-K2) =    SG(NUMI-K2-1)
       VIS(NUMI-K2) =  VIS(NUMI-K2-1)
      PMIN(NUMI-K2) = PMIN(NUMI-K2-1)
      JTYP(NUMI-K2) = JTYP(NUMI-K2-1)
      NAPR(NUMI-K2) = NAPR(NUMI-K2-1)
        VO(NUMI-K2) = VO(NUMI-K2-1)
      PRAT(NUMI-K2) = PRAT(NUMI-K2-1)
      PERO(NUMI-K2) = PERO(NUMI-K2-1)
      IYEAR(NUMI-K2) = IYEAR(NUMI-K2-1)
      GO TO 700
  710 XMP(I) = XM1(I1)
      I1 = I
      NAME(I) = 4HINTF
      ITYP(I) = 1
      RATE(I) = 0.
      PID(I) = PID(I-1)
      PMAX(I) = PMAX(I-1)
      Q(I) = Q(I-1)
      PRAT(I) = PRAT(I-1)
      PERO(I) = PERO(I-1)
      SG(I) = SG1(I1)
      VIS(I) = VIS1(I1)
      PMIN(I) = PMN1(I1)
      JTYP(I) = 6HINTERF
      NAPR(I) = NPR1(I1)
        VO(I) = VOL1(I1)
      IYEAR(I) = 0
      I1 = I1 + 1
      IF(I1.GT.NOL1)GO TO 740
  730 CONTINUE
  740 CONTINUE
C***********************************************************************
C
C   INTERPOLATE GROUND PROFILE TO FIND ELEVATION AT EACH NODE.
C
      DO 620 I=1,NUMI
      DO 610 I7=2,NOL7
      IF(XM7(I7).LT.XMP(I))GO TO 610
      EL(I) = ELE7(I7-1) + (XMP(I)-XM7(I7-1))/(XM7(I7)
     1        -XM7(I7-1))*(ELE7(I7)-ELE7(I7-1))
      GO TO 620
  610 CONTINUE
  620 CONTINUE
      GO TO 680
C***********************************************************************
C
C   COMPUTE NEW VALUES OF THRUPUTS , Q(I), AND POWER RATE, PRAT(I),
C   FOR THE NEXT YEARS RUN.
C
  630 IYR  = IYR  + 1
```

```
      IF(IYR .GT.IEND) GO TO 999
      DO 640 IY=1,NOIY
      IF(IYEA(IY).EQ.IYR )GO TO 660
  640 CONTINUE
      IY = IYPR
  660 DO 670 I=1,NUMI
      Q(I) = Q(I)*QESC(IY)
      RATE(I) = RATE(I) * QESC(IY)
  670 PRAT(I) = PRAT(I)*PESC(IY)
      IYPR = IY
C*************************************************************************
C
C   CALCULATE THE REQUIRED HYDRAULIC GRADIENT BASED ON THE MINIMUM
C   SUCTION PRESSURE AT EACH PUMP STATION AND THE GIVEN THROUGHPUT
C   USING SUBROUTINE GRAD.
C
  680 CALL GRAD
C*************************************************************************
C
C   CALCULATE THE BRAKE HORSEPOWER REQUIRED AT EACH PUMP STATION
C   AND RECALCULATE THE HYDRAULIC GRADIENT USING SUBROUTINE HORSE.
C
      IF(NOPU(1).EQ.0)GO TO 685
      CALL HORSE
C*************************************************************************
C
C   COMPUTE TOTAL POWER COST.
C
  685 TPC = 0.
      DO 690 I=1,NUMI
  690 TPC = TPC + PCOS(I)
C*************************************************************************
C
C   PROGRAM OUTPUT.
C
      IF(KONT.GT.0)GO TO 1100
      KONT = 1
      WRITE(IW,900) IT1,IT2,IT3,IT4,IT5,IT6,IT7,IT8,IT9,IT10,IT11,
     1      IT12,IT13,IT14,IT15,IT16,IT17,IT18,IT19,IT20
  900 FORMAT(1H1,////,1X,20A4, )
      IF(IEQ.NE.1)GO TO 910
      N1 = 6HHAZEN
      N2 = 6HWILLIA
      N3 = 6HMS
      WRITE(IW,932) N1,N2,N3,C
  932 FORMAT (//,1X,29HSTEADY STATE FLOW EQUATION = , 3A6,/,
     1  1X,26HHAZEN WILLIAMS C FACTOR = ,F4.0)
      GO TO 920
  910 N1 = 6HDARCY
      N2 = 6HWEISBA
      N3 = 6HCH
      WRITE(IW,930) N1,N2,N3,EPSI
  930 FORMAT (//,1X,29HSTEADY STATE FLOW EQUATION = , 3A6,/,
     1  1X,32HPIPE ROUGHNESS FACTOR, INCHES = ,F6.5)
  920 WRITE(IW,935) IYR1 ,NOYR
```

```
  935 FORMAT (     1X,26HFIRST YEAR OF OPERATION = ,I4,/,1X,
     1 28HLIFE OF PIPELIN, IN YEARS = ,I2)
      IF(NOPC.EQ.0)WRITE(IW,925)PEFF
  925 FORMAT ( 1X,26HAVERAGE PUMP EFFICIENCY = ,F4.2, )
      WRITE(IW,926) DEFF
  926 FORMAT ( 1X,33HAVERAGE PUMP DRIVER EFFICIENCY = ,F4.2, )
C
C   SLURRY DATA.
C
      IF(IEG.GT.0)GO TO 9353
      WRITE(IW,906)  GVL, GVS, GVSLR,
     1VISC , VOLFRC, WTFRC, FLOW, PROD, VEL ,DIA
      IF(SIZFLG.LT.2)GO TO 9351
      WRITE (IW,902) NSAMPL
      WRITE (IW,903)(SIZE(K), SAMWT(K), CV(K), CD(K),K=1,NSAMPL)
      WRITE (IW,904) WTSUM, CVT
      GO TO 9352
 9351 WRITE (IW,901) SOLSIZ
 9352 WRITE(IW,905) DELPS,DELPW,DIFF
  906 FORMAT (//,1X,21HSLURRY PIPELINE DATA. ,//,
     X  1X,32H LIQUID GRAVITY WRT WATER      = ,F9.3/
     X  1X,32H SOLIDS GRAVITY WRT WATER      = ,F9.3/
     X  1X,32H SLURRY GRAVITY WRT WATER      = ,F9.3/
     X  1X,32H LIQUID VISCOSITY, CP.         = ,F9.3/
     X  1X,32H VOLUME FRACTION SOLIDS        = ,F9.4/
     X  1X,32H WEIGHT FRACTION SOLIDS        = ,F9.4/
     X  1X,32H FLOW RATE, GPM                = ,F9.2/
     X  1X,32H SOLIDS PRODUCTION RATE, T/HR  = ,F9.1/
     X  1X,32H SLURRY VELOCITY, FT/SEC       = ,F9.4/
     X  1X,32H PIPE INSIDE DIAMETER, IN.     = ,F9.3)
  901 FORMAT( 2X,30HAVERAGE SOLIDS DIAMETER,IN.  =,F10.4)
  902 FORMAT(1H0, 1X,19H*** SOLIDS DATA FOR,I3,12H SAMPLES ***/
     X 1H0,1X,48HSAMPLE AVG  FRACTION  OF  SLURRY VOLUME      DRAG/
     X 2X,52H DIAMETER   TOTAL SOLIDS     FRACTION    COEFFICIENT/1H )
  903 FORMAT(2X,F9.6,4X,F8.4,8X,F8.4,6X,F8.4)
  904 FORMAT(15X,8H--------,8X,8H--------/15X,F8.4,8X,F8.4)
  905 FORMAT(1H0,5X,22HTOTAL PRESSURE DROP  =, F8.2,9H PSI/MILE/
     X 6X,22HLIQUID PRESSURE DROP =, F8.2,9H PSI/MILE/
     X 6X,22HPERCENT INCREASE     =,F9.4)
C
C
 9353 WRITE(IW,936)
  936 FORMAT (//,1X,18HESCALATOR FACTORS.,//,1X,6HSTARTING,2X,
     1  7HTHRUPUT,2X,10HPOWER RATE,/,1X, 7HAT YEAR,3X, 7HESC FAC,2X,
     2  7HESC FAC,/)
      DO 938 IYE=1,NOIY
      WRITE(IW,937) IYEA(IYE), GESC(IYE), PESC(IYE)
  937 FORMAT (1X,I4,6X,F5.3,4X,F5.3)
  938 CONTINUE
      WRITE(IW,939)
  939 FORMAT(//,1X,31HINITIAL SHIPMENT/DELIVERY DATA.,//,1X,
     1  7HSTATION,2X,6HMILEPOST,2X,7HSHP/DEL,/,20X,8HRATE,BPH,/)
      DO 942 I=1,NUMI
      IF(ITYP(I).NE.2)GO TO 942
      WRITE(IW,941) NAME(I), XMP(I), RATE(I)
```

```
  941 FORMAT(1X,A6,3X,F7.2,3X,F7.0)
  942 CONTINUE
      WRITE (IW,940)
  940 FORMAT (//,1X,14HPIPE SCHEDULE.,//,1X,5HMILE-,4X,4HPIPE,4X,
     1  8HMAX OPER,/,1X,4HPOST,6X,2HID,5X,8HPRESSURE,/,10X,6HINCHES,
     2  4X,3HPSI,/)
      DO 960 I5 = 1,NOL5
      WRITE(IW,950) XM5(I5),PID5(I5),PMX5(I5)
  950 FORMAT (1X,F7.2, F8.3,F8.0)
  960 CONTINUE
      WRITE (IW,970)
  970 FORMAT (//,1X,31HHYDRAULIC PROPERTIES OF LIQUID.,//,1X,
     1  6HLIQUID,3X,7HPERCENT,2X,8HSPECIFIC,2X,9HVISCOSITY,2X,
     2  7HMINIMUM,/,12X,2HOF,5X,7HGRAVITY,6X,2HCS,6X,8HPRESSURE,/,
     3 10X,8HLINEFILL,24X,3HPSI,/)
      DO 990 IPR=1,NOPR
      WRITE(IW,980) NPRO(IPR),PERC(IPR),SGPR(IPR),VISP(IPR),PMN(IPR)
  980 FORMAT (1X,A6,F8.3,F9.3,F11.3,F11.0)
  990 CONTINUE
      IF(NOPC.EQ.0)GO TO 1045
      DO 1040 IPC = 1,NOPC
      WRITE (IW,1000) NPC(IPC)
 1000 FORMAT(//,1X,16HPUMP CURVE DATA.,/ ,1X,18HNAME PUMP CURVE = ,A6)
      WRITE(IW,1010)
 1010 FORMAT ( /,4X, 8HCAPACITY,6X, 4HHEAD, 3X, 3HEFF,/, 2X 3HGPM,6X,
     1  3HBPH)
      DO 1030 IPT = 1,6
      GPM = .7 * GPC(IPT,IPC)
      WRITE(IW,1020) GPM,GPC(IPT,IPC),HPC(IPT,IPC),EPC(IPT,IPC)
 1020 FORMAT (1X, 3F7.0,F6.2)
 1030 CONTINUE
 1040 CONTINUE
 1045 WRITE(IW,1050)
 1050 FORMAT(//,1X,15HPUMP STA DATA. ,//,1X,4HPUMP,4X,5HMILE-,3X,
     1  4HPUMP,3X,5HQUAN-,4X,8HFIRST YR,4X,7HPERCENT,3X,8HYEAR STA,
     2  /,1X,3HSTA,5X,4HPOST,4X,4HNAME,3X,4HTITY,5X,10HPOWER RATE,
     3  2X,7HOF TIME, 3X,8HCOMES ON,/,45X,7HPUMPING,3X,4HLINE,/)
      I3 = 0
      DO 1080 I=1,NUMI
      IF(ITYP(I).NE.3)GO TO 1080
      I3 = I3 + 1
      N = NOPU(I3)
      DO 1070 IPU = 1,N
      WRITE(IW,1060) NAME(I), XM3(I3) , NAPC(IPU,I3), NUPC(IPU,I3),
     1  PRAT(I), PERO(I),IYEAR(I)
 1060 FORMAT(1X,A6,F9.2 ,2X,A6,2X,I2,4X,F7.5,7X,F4.2,6X,I4)
 1070 CONTINUE
 1080 CONTINUE
 1100 WRITE(IW,900) IT1,IT2,IT3,IT4,IT5,IT6,IT7,IT8,IT9,IT10,IT11,
     1       IT12,IT13,IT14,IT15,IT16,IT17,IT18,IT19,IT20
      WRITE(IW,1230) IYR
      IF(IOUT-1)   1235,1104,1290
 1104 WRITE(IW,1105)
 1105 FORMAT(   1X,45HPRESSURE GRADIENT, HORSEPOWER, LINEFILL, ETC.)
      WRITE(IW,1110)
```

```
1110 FORMAT (       /,2X,4HNODE,3X,4HNODE,4X,4HMILE,3X,6HGROUND,3X,
    1  7HSHP/DEL,2X,3HP/L,3X,10HHEAD IN FT,3X,5HPRESS,2X,8HWEIGHTED,
    2  3X,8HLINEFILL,/,2X,4HNAME,3X,4HTYPE,4X,4HPOST,4X,4HELEV,6X,
    3  4HRATE,3X,4HRATE,2X,9HELEVATION,5X,3HPSI,3X,7HAVERAGE,2X,
    4  3HLIQ,4X,6HVOLUME,/,25X,4HFEET,6X,
    5  3HBPH,4X,3HBPH,4X,2HUP,4X,2HDN,13X,3HEHP,12X,4HBBLS,/)
     DO 1140 I=1,NUMI
     IF(IYEAR(I).GT.IYR)GO TO 1140
1120 WRITE(IW,1130)  NAME(I),JTYP(I),XMP(I),EL(I),RATE(I),Q(I),HUP(I),
    1  H(I),P(I),BHP(I),NAPR(I),VD(I)
1130 FORMAT (1X,A6,1X,A6,F9.2, F7.0,1X,3F7.0,F6.0,F7.0,3X,F6.0,
    1  2X, A6, F9.0)
1140 CONTINUE
     WRITE(IW,1230) IYR
1230 FORMAT (//,1X,7HYEAR - ,I4)
1235 WRITE(IW,1240)
1240 FORMAT (1X,16HPOWER COST DATA.,//,2X,4HPUMP,
    1  3X,4HPUMP,3X,5HQUAN-,2X,7HTHRUPUT,2X,5HBRAKE,3X, 5HPOWER,4X,
    2  7HPERCENT,4X,5HPOWER,/,2X,3HSTA,4X,5HCURVE,2X,4HTITY,3X,
    3  3HBPH,6X,6HHORSE-,2X,4HRATE,5X,7HOF TIME,4X,4HCOST,/,9X,
    4  4HNAME,19X,5HPOWER,3X,6H$/KWHR,3X,7HPUMPING,4X,4H$/YR,/)
     I3 = 0
     DO 1270 I=1,NUMI
     IF(ITYP(I).NE.4)GO TO 1270
     I3 = I3 + 1
     IF(IYEAR(I).GT.IYR)GO TO 1270
     N = NOPU(I3)
     DO 1260 IPU=1,N
     IF(IPU.EQ.1)NNPC=NPC1(I)
     IF(IPU.EQ.2)NNPC=NPC2(I)
     IF(IPU.EQ.3)NNPC=NPC3(I)
     IF(IPU.EQ.4)NNPC=NPC4(I)
     IF(IPU.EQ.5)NNPC=NPC5(I)
     IF(IPU.EQ.6)NNPC=NPC6(I)
     WRITE(IW,1250) NAME(I),NAPC(IPU,I3),NNPC,Q(I),BHP(I),PRAT(I),
    1  PERO(I),PCOS(I)
1250 FORMAT (1X,A6,2X,A6,2X,I3,2X,F7.0,2X,F6.0,2X,F7.5,4X,F4.2,3X,F8.0)
1260 CONTINUE
1270 CONTINUE
     WRITE(IW,1280) TPC
1280 FORMAT (56X,9H---------,/,56X,F9.0/////)
     GO TO 630
1290 IF(KONT.GT.1)GO TO 1310
     KONT = 2
     WRITE(IW,1300)
1300 FORMAT (//,1X,12HPOWER COSTS.,//,1X,4HYEAR,2X,10HPOWER COST,/,
    1  7X,10HIN DOLLARS,/)
1310 WRITE(IW,1320) IYR , TPC
1320 FORMAT (1X,I4,F12.2)
     GO TO 630
C
 999 GO TO 99
9999 CONTINUE
     END
```

```
      SUBROUTINE GRAD
C*******************************************************************
C
C   THIS SUBROUTINE COMPUTES THE REQUIRED HYDRAULIC GRADIENT BASED ON THE
C   MINIMUM SUCTION PRESSURE AT EACH PUMP STATION AND THE GIVEN THROUGHPUTS.
      INTEGER SIZFLG,SIEVE
C   BLANK COMMON
C
C                                       NAME,QUAN.  POINTS      GROUND
C              NODES        PRODUCTS   PUMP CURV   PUMP CURV   PROFILE
C
      COMMON NAME(200) , NPRO(10) , NPC(25)    , OPC(6,25) ,  XM7(100),
     1        ITYP(200) , PERC(10) , NAPC(6,30), HPC(6,25) , ELE7(100),
     2         XMP(200) , SGPR(10) , NUPC(6,30), EPC(6,25) ,
     3        RATE(200) , VISP(10) ,
     4        PMAX(200) ,  PMN(10) ,
     5         PIO(200)
C
C              NODES         NODES        PIPE         PUMP        BATCH
C                                         DIAM         STA         INTERF
C
      COMMON PMIN(200) , NPC1(200) ,  XM5(5)   ,  XM3(30) ,  XM1(100) ,
     1         VIS(200) , NPC2(200) , PID5(5)  , PMN3(30) ,  SG1(100) ,
     2          SG(200) , NPC3(200) ,            PMX4(30) , VIS1(100) ,
     3           Q(200) , NPC4(200) ,            NOPU(30) , PMN1(100) ,
     4          EL(200) , NPC5(200) ,                       NPR1(100) ,
     5           P(200) , NPC6(200)
      COMMON      H(200) ,  BHP(200) ,
     1         HUP(200) , HPCH(200) ,
     2        PCOS(200) ,  POW(200) ,
     3        PRAT(200) ,  PERO(200),
     4       IYEAR(200)
      COMMON NOL1,NOL2,NOL3,NOL4,NOL5,NOL6,NOL7,NOPC,NOPR,NUMI,
     1  IEQ,EPSI,IW,C,IPMX, PEFF,IYR ,DEFF
      COMMON/SLURR/SIEVE(25) , SAMWT(25) ,VOLFRC,WTFRC,GVS,SIZFLG,SOLSIZ
     1  ,GVL,SIZE(25),CV(25),CD(25),NSAMPL,WTSUM,CVT,GVSLR,VISC,FLOW,
     2  PROD,VEL,DELPS,DELPW,DIFF,HPM,DIA,RUF
      DIMENSION PPR(10),BHPP(10)
C
C$    STORES(I,P,H,HUP,R,F,REL,A,B,C,HPM,EFFA,PPR,DELP,BHPP,IPMX,
C$   1  DELH,BHP,POW,PCOS)
      I = NUMI + 1
   10 I = I - 1
      IF(I.EQ.0) GO TO 999
      BHP(I) = 0.
      PCOS(I) = 0.
      IF (I.EQ.NUMI) GO TO 20
      IF (ITYP(I).NE.3) GO TO 25
      IF(IYR.GE.IYEAR(I))GO TO 20
      IF(IYEAR(I).LE.0)GO TO 20
      P(I) = P(I+1)
      H(I) = H(I+1)
      HUP(I) = HUP(I+1)
      GO TO 10
C
```

```
C     TERMINAL END OF LINE OR PUMP STATION SUCTION
C
   20 P(I) = PMIN(I)
      H(I) = P(I)/(.433*SG(I-1)) + EL(I)
      HUP(I) = H(I)
      GO TO 10
C
C     IEQ TELLS WHICH FLOW EQUATION TO USE FOR PREDICTING FRICTION DROP.
C         IEQ=0, SLURRY PIPELINE.  USE SUBROUTINE SLURRY.
C         IEQ=1, PRODUCTS OR WATER PIPELINE. USE HAZEN WILLIAMS FORMULA.
C         IEQ=2, CRUDE OIL PIPELINE. USE DARCY WEISBACH EQUATION.
C
   25 IF(ITYP(I)-1)27,26,27
   26 K = I + 1
      GO TO 28
   27 K = I
   28 IF (IEQ - 1) 82,30,35
C
C     USE HAZEN WILLIAMS EQUATION
C     TO CALCULATE HEAD LOSS PER MILE. (THIS EQUATION SHOULD BE USED FOR
C     PRODUCT PIPELINES.)
C
   30 C1 = C*((.75/VIS(K))**.08)/(SG(K)**.54)
      IF(VIS(K).EQ.1.00.AND.SG(K).EQ.1.00)C1=C
      CONST = 12355./(.433*SG(K))
      HPM = CONST*((Q(I)/C1)**1.852)/(PID(I)**4.87)
      GO TO 85
C
C     USE THE DARCY WEISBACH EQUATION TO CALCULATE HEAD LOSS PER MILE (THIS
C     EQUATION SHOULD BE USED FOR CRUDE OIL PIPELINES.)
C
C
C     COMPUTE THE REYNOLDS NUMBER.
C
   35 R = 1739.33*Q(I)/(PID(I)*VIS(K))
      IF(R-0.)37,37,38
   37 HPM = 0.
      GO TO 85
   38 IF (R-2000.) 40,40,50
C
C     CALCULATE THE MOODY FRICTION FACTOR.
C
C     LAMINAR FLOW.
C
   40 F = 64./R
      GO TO 80
   50 IF (R-3000.) 60,60,70
C
C     TRANSITION FLOW.
C
   60 F = .000104*(R**.753)
      GO TO 80
C
C     TURBULENT FLOW. (USE THE DON J. WOOD EQUATION TO CALCULATE THE FRICTION
C     FACTOR, F.)
```

```
      C
       70 REL = EPSI/PID(I)
          A = .094*(REL**.225) + .53* REL
          B = 88.*(REL**.44)
          C = 1.62*(REL**.134)
          F = A + B * (R**(-C))
      C
      C   DARCY WEISBACH EQUATION.
      C
       80 HPM = 80.5536*F*Q(I)*Q(I)/PID(I)**5
          GO TO 85
      C
      C   USE SUBROUTINE SLURRY TO PREDICT THE HEAD LOSS PER MILE FOR
      C   A SLURRY PIPELINE.
      C
       82 VISC = VIS(I)
          DIA = PID(I)
          RUF = EPSI
          FLOW = Q(I) * .7
          CALL SLURRY
      C
      C   COMPUTE THE HEADS AND PRESSURE AT EACH NODE.
      C
       85 H(I) = HUP(I + 1) + (XMP(I + 1) - XMP(I))*HPM
      C
      C   CALCULATE PRESSURE USING THE HEAD AND GROUND ELEVATION.
      C
          P(I) = (H(I) - EL(I))*.433*SG(K)
      C
      C   TEST TO SEE IF LINE PRESSURE EXCEEDS PMAX.  USE THE DENSITY OF
      C   EACH OF THE GIVEN LIQUIDS IN THE TEST.
      C
          DO 87 IPR=1,NOPR
          PPR(IPR) = P(I)*SGPR(IPR)/SG(K)
          DELP = PPR(IPR) - PMIN(I)
          IF(IYEAR(I).GT.IYR)DELP=0.
          PHPP(IPR) = .000408*Q(I)*DELP/PEFF
          IF(PMAX(I).GE.PPR(IPR))GO TO 87
          IPMX = 1
          WRITE(IW,86) NAME(I),IYR,NPRO(IPR)
       86 FORMAT (1X,29HWARNING *** PMAX EXCEEDED AT ,A6,9H IN YEAR ,I4,
         1  4H IF ,A6, 16H IS IN THE PIPE.)
       87 CONTINUE
      C
      C   TEST TO SEE IF PRESSURE IS LESS THAN PMIN.
      C
       88 IF (PMIN(I) - P(I)) 110,110,90
      C
      C   PRESSURE LESS THAN PMIN. CORRECT THE HYDRAULIC GRADIENT, WORKING DOWNSTREAM
      C   TO NEXT PS SUCTION.
      C
       90 DELH = PMIN(I)/(.433*SG(K)) + EL(I) - H(I)
          DO 100 J = I,NUMI
          H(J) = H(J) + DELH
          P(J) = (H(J) - EL(J))*.433*SG(K)
```

```
      C
      C   IF NODE TYPE IS PS SUCTION, GO TO 110.
      C
            IF(ITYP(J).EQ.3) GO TO 110
        100 CONTINUE
      C
      C   CALCULATE THE HEAD ON UPSTREAM SIDE OF BATCH INTERFACE. THE PRESSURES
      C   ON EACH SIDE OF BATCH INTERFACE WILL BE EQUAL.
      C
        110 IF(ITYP(I) - 1) 130,120,130
        120 HUP(I) = P(I)/(.433*SG(I)) + EL(I)
            GO TO  140
        130 HUP (I) = H(I)
      C
      C   CALCULATE WEIGHTED BHP.
      C
        140 IF(ITYP(I).NE.4)GO TO 10
            BHP(I) = 0.
            DO 150 IPR=1,NOPR
            BHP(I) = BHP(I) + BHPP(IPR)*PERC(IPR)
        150 CONTINUE
      C   COMPUTE POWER IN KILOWATT HOURS FOR ONE YEARS OPERATION.
            POW(I) = 6532. * BHP(I) * PERO(I) / OEFF
      C   COMPUTE POWER COST FOR ONE YEARS OPERATION.
            PCOS(I) = POW(I) * PRAT(I)
            GO TO 10
        999 CONTINUE
            RETURN
            END
```

```
      SUBROUTINE HORSE
C*************************************************************************
C
C     THIS SUBROUTINE DETERMINES WHICH PUMPS ARE TO BE ON LINE AT EACH PUMP
C     STATION, DETERMINES IF THROTLING IS REQUIRED AND HOW MUCH, CALCULATES
C     THE BRAKE HORSEPOWER REQUIRED AT EACH PUMP STATION, AND RECALCULATES THE
C     HYDRAULIC GRADIENT.
C
C     BLANK COMMON
C
C                                    NAME,QUAN.  POINTS      GROUND
C              NODES       PRODUCTS  PUMP CURV   PUMP CURV   PROFILE
C
      COMMON NAME(200) , NPRO(10) , NPC(25)    , QPC(6,25) ,  XM7(100),
     1       ITYP(200) , PERC(10) , NAPC(6,30), HPC(6,25) , ELE7(100),
     2        XMP(200) , SGPR(10) , NUPC(6,30), EPC(6,25) ,
     3       RATE(200) , VISP(10) ,
     4       PMAX(200) ,  PMN(10) ,
     5        PID(200)
C
C              NODES       NODES       PIPE        PUMP        BATCH
C                                      DIAM        STA         INTERF
C
      COMMON PMIN(200) , NPC1(200) ,  XM5(5)    ,  XM3(30) ,  XM1(100) ,
     1        VIS(200) , NPC2(200) , PID5(5)    , PMA3(30) ,  SG1(100) ,
     2         SG(200) , NPC3(200) ,               PMX4(30) , VIS1(100) ,
     3          Q(200) , NPC4(200) ,               NOPU(30) , PMN1(100) ,
     4         EL(200) , NPC5(200) ,                          NPR1(100) ,
     5          P(200) , NPC6(200)
      COMMON     H(200) ,  BHP(200) ,
     1        HUP(200) , HPCH(200) ,
     2       PCOS(200) ,  POW(200) ,
     3       PRAT(200) ,  PERO(200),
     4       IYEAR(200)
      COMMON NOL1,NOL2,NOL3,NOL4,NOL5,NOL6,NOL7,NOPC,NOPR,NUMI,
     1 IEQ,EPSI,IW,C,IPMX, PEFF,IYR ,DEFF
      DIMENSION HD(200) , PUMH(6) , EFF(6),PPR(10),        BHPP(10)
C$    STORES (HD,I,DHLD,BHP,NPC1,NPC2,NPC3,HUP,P,H,ISTA,PUMH,EFF,N,
C$   1      QP,KKKK,COLO,N1,N2,N3,HEAD,DELH,COST,HH,NPCT,EFFA,PPR,HPR,
C$   2    DELP,BHPP,PCHO,HPR,HPCH,,BHPC)
C
C     SET ARRAY HD EQUAL TO ARRAY H.  ASSIGN MISC. VALUES.
C
      DO 10 I=1,NUMI
   10 HD(I) = H(I)
      I = 0
      DHLD = 0.
   20 I = I + 1
      IF (I.GT.NUMI) GO TO 999
      BHP(I) = 0.
      POW(I) = 0.
      PCOS(I) = 0.
C
C     SET NUMBER OF PUMP CURVES AT NODE vIv TO ZERO.
C
```

```
      NPC1(I) = 0
      NPC2(I) = 0
      NPC3(I) = 0
      NPC4(I) = 0
      NPC5(I) = 0
      NPC6(I) = 0
C
C   FIND THE NODE TYPE.
C
      IF(ITYP(I).EQ.2) GO TO 30
      IF (ITYP(I).EQ.3) GO TO 40
      IF (ITYP(I).EQ.4) GO TO 50
      IF (ITYP(I).EQ.5) GO TO 30
C
C   BATCH INTERFACE
C
      HUP(I) = (HD(I) - EL(I))*.433*SG(I+1)/(.433*SG(I)) + EL(I) + DHLO
      P(I) = .433*SG(I)*(HUP(I)-EL(I))
      H(I) = P(I)/(.433*SG(I+1)) + EL(I)
      DHLO = H(I) - HD(I)
      GO TO 20
C
C   SHIPMENT/DELIVERY STATION OR DIAMETER CHANGE.
C
   30 H(I) = HD(I) + DHLO
      HUP(I) = H(I)
      P(I) = .433*SG(I)*(H(I)-EL(I))
      GO TO 20
C
C   PUMP STATION SUCTION
C
   40 H(I) = HD(I) + DHLO
      HUP(I) = H(I)
      P(I) = .433*SG(I)*(H(I)-EL(I))
C
C   IF H(I) IS GREATER THAN OR EQUAL TO HD(I+1) - BYPASS THIS STATION.
C
   48 IF (H(I).LT.HD(I+1)) GO TO 20
      I = I + 1
      DHLO = H(I-1) - HD(I)
      EHP(I) = 0.
      H(I) = H(I-1)
      HUP(I) = H(I)
      P(I) = P(I-1)
      GO TO 20
C
C   PUMP STATION DISCHARGE.
C
C   FIND ISTA, PUMP STA NUMBER.
C
   50 ISTA = 0
      IF(IYR.GE.IYEAR(I))GO TO 55
      IF(IYEAR(I).LE.0)GO TO 55
      P(I) = P(I-1)
      H(I) = H(I-1)
```

```
      HUP(I) = H(I-1)
      GO TO 20
   55 DO 60 J = 1,NUM1
      IF(ITYP(J).EQ.4) ISTA = ISTA + 1
      IF (J.EQ.I) GO TO 70
   60 CONTINUE
C
C  FIND THE HEAD PUT UP BY EACH PUMP.
C
   70 DO 80 IPU = 1,6
      PUMH(IPU) = 0.
   80 EFF(IPU) = .0001
      N = NOPU(ISTA)
      QP = Q(I)
      IF(QP.EQ.0.)GO TO 30
      DO 140 IPU = 1,N
      DO 90 IPC = 1,NOPC
      IF(NAPC(IPU,ISTA).EQ.NPC(IPC)) GO TO 100
   90 CONTINUE
      WRITE(IW,95)
   95 FORMAT (1X,47HINPUT ERROR *** NAMES OF PUMPS AT PUMP STATION ,
     1 40HDO NOT MATCH NAMES OF GIVEN PUMP CURVES.)
  100 DO 110 IP = 1,6
      IF (QP - QPC(IP,IPC)) 120,110,110
  110 CONTINUE
  120 IP = IP - 1
      PUMH(IPU) = CURV(QP,IPC,IP,HPC,QPC)
      EFF(IPU) = CURV(QP,IPC,IP,EPC,QPC)
      IF(EFF(IPU).EQ.0.)EFF(IPU)=.0001
  140 CONTINUE
C
C  FIND OPTIMUM COMBINATION OF PUMPS.
C
      KKKK = 0
      COLD = 999999.
      N1 = NUPC(1,ISTA) + 1
      N2 = NUPC(2,ISTA) + 1
      N3 = NUPC(3,ISTA) + 1
      N4 = NUPC(4,ISTA) + 1
      N5 = NUPC(5,ISTA) + 1
      N6 = NUPC(6,ISTA) + 1
      DO 220 MUL6 = 1,N6
      DO 210 MUL5 = 1,N5
      DO 200 MUL4 = 1,N4
      DO 190 MUL3 = 1,N3
      DO 180 MUL2 = 1,N2
      DO 170 MUL1 = 1,N1
      HEAD = PUMH(1)*(MUL1-1) + PUMH(2)*(MUL2-1) + PUMH(3)*(MUL3-1)
     1+ PUMH(4)*(MUL4-1) + PUMH(5)*(MUL5-1) + PUMH(6)*(MUL6-1)
      DELH = HEAD - (H(I) - H(I-1))
      IF (DELH) 170,150,150
C
C  FIND LOWEST RELATIVE COST OF EACH PUMP COMBINATION THAT GIVES A POSITIVE
C  VALUE OF DELH.
C
```

```
      150 KKKK = 1
          COST = PUMH(1)*(MUL1-1)/EFF(1) + PUMH(2)*(MUL2-1)/EFF(2)
         1+ PUMH(3)*(MUL3-1)/EFF(3) + PUMH(4)*(MUL4-1)/EFF(4)
         2+ PUMH(5)*(MUL5-1)/EFF(5) + PUMH(6)*(MUL6-1)/EFF(6)
          IF (COST-COLO) 160,170,170
      160 COLO = COST
          DHLO = DELH
          NPC1(I) = MUL1 - 1
          NPC2(I) = MUL2 - 1
          NPC3(I) = MUL3 - 1
          NPC4(I) = MUL4 - 1
          NPC5(I) = MUL5 - 1
          NPC6(I) = MUL6 - 1
      170 CONTINUE
      180 CONTINUE
      190 CONTINUE
      200 CONTINUE
      210 CONTINUE
      220 CONTINUE
C
C     SET THE DISCHARGE HEAD EQUAL TO THE SUM OF PUMP HEADS PLUS SUCTION HEAD.
C
          IF (KKKK) 270,230,270
      230 HH = H(I) - H(I-1)
          WRITE(IW,240) NAME(I) , HH , Q(I)
      240 FORMAT (1X, 19HWARNING - PUMPS AT , A6, 15HNOT CAPABLE OF ,
         117HREQUIRED HEAD OF ,F6.0, 7H FT AT ,F6.0, 5H BPH.)
          DHLO = 0.
          GO TO 280
      270 H(I) = HD(I) + DHLO
          HUP(I) = H(I)
      280 P(I) = .433*SG(I)*(H(I)-EL(I))
C
C     CALCULATE THE BRAKE HORSEPOWER REQUIRED TO DRIVE THE PUMPS.
C
          NPCT = NPC1(I) + NPC2(I) + NPC3(I) + NPC4(I) + NPC5(I) + NPC6(I)
          IF (NPCT) 290,290,300
      290 EFFA = PEFF
          GO TO 310
      300 EFFA = (EFF(1)*NPC1(I) + EFF(2)*NPC2(I) + EFF(3)*NPC3(I) + EFF(4)*
         1NPC4(I) + EFF(5)*NPC5(I) + EFF(6)*NPC6(I))/NPCT
      310 BHP(I) = .000408*Q(I)*(P(I)-P(I-1))/EFFA
C     COMPUTE POWER IN KILOWATT HOURS FOR ONE YEARS OPERATION.
          POW(I) = 6532. * BHP(I) * PERO(I) / DEFF
C     COMPUTE POWER COST FOR ONE YEARS OPERATION.
          PCOS(I) = POW(I) * PRAT(I)
C
C     CALCULATE THE DISCHARGE PRESSURE WITH EACH OF THE PRODUCTS IN THE
C     PUMPS.  SEE IF THROTTELING IS NECESSARY WITH ANY OF THE PRODUCTS.
C     CALCULATE WEIGHTED AVERAGE BRAKE HORSEPOWER REQUIREMENTS AND HEAD.
C
          DO 313 IPR=1,NOPR
          PPR(IPR) = .433*SGPR(IPR)*(H(I)-EL(I))
          DELP = (H(I)-H(I-1))*.433*SGPR(IPR)
          BHPP(IPR) = .000408*Q(I)*DELP/EFFA
```

```
C
C     CHECK TO SEE IF PMAX IS EXCEEDED.
C
      IF(PMX4(ISTA)-PPR(IPR))311,313,313
  311 PCHO = PPR(IPR) - PMX4(ISTA)
      BHPC = .000408*Q(I)*PCHO/EFFA
      WRITE(IW,312) IYR, PCHO,BHPC,NAME(I),NPRO(IPR)
  312 FORMAT (1X,15HNOTE.  IN YEAR ,I4,2H, ,F4.0,17H PSI PRESSURE OR ,
     1 F5.0,30H HORSEPOWER ARE THROTTELED AT ,A6,6H WHEN ,A6,
     2 17H IS IN THE PUMPS.)
  313 CONTINUE
      BHP(I) = 0.
      DO 314 IPR = 1,NOPR
      BHP(I) = BHP(I) + BHPP(IPR)*PERC(IPR)
  314 CONTINUE
C     COMPUTE POWER IN KILOWATT HOURS FOR ONE YEARS OPERATION.
      POW(I) = 6532. * BHP(I) * PERO(I) / DEFF
C     COMPUTE POWER COST FOR ONE YEARS OPERATION.
      PCOS(I) = POW(I) * PRAT(I)
C
C     CHECK TO SEE IF MAXIMUM ALLOWABLE DISCHARGE PRESSURE IS EXCEEDED.
C
      IF (PMX4(ISTA) - P(I)) 320,330,330
  320 PCHO = P(I) - PMX4(ISTA)
      GO TO 340
  330 PCHO = 0.
      HPCH(I) = 0.
      GO TO 20
C
C     CALCULATE HORSEPOWER CHOKED.
C
  340 HPCH(I) = .00408*Q(I)*PCHO/EFFA
      H(I) = PMX4(ISTA)/(.433*SG(I)) + EL(I)
      HUP(I) = H(I)
      DHLO = H(I) - HD(I)
      P(I) = PMX4(ISTA)
      GO TO 20
  999 RETURN
      END
```

```
      FUNCTION DIST (VOL,MP1,IL1,NOL4,MP4,PID)                          DIST
C**********************************************************************
C                                                                       DIST
C   THIS FUNCTION CALCULATES THE DISTANCE ADVANCED BY AN INTERFACE AS   DIST
C   A GIVEN VOLUME MOVES PAST A POINT.                                  DIST
C                                                                       DIST
      REAL MP1(100),MP4(5),M1,M4
      DIMENSION PID(5)
      DIST = 0.                                                         DIST
      M1 = MP1(IL1)                                                     DIST
      DO 10 IDIA = 2,NOL4                                               DIST
      M4 = MP4(IDIA)                                                    DIST
      IF(M1-M4)20,10,10                                                 DIST
   10 CONTINUE                                                          DIST
   20 V4 = (M4-M1)*(PID(IDIA-1)**2)*5.1291309                           DIST
      IF(VOL-V4)40,40,30                                                DIST
   30 VOL = VOL - V4                                                    DIST
      DIST = DIST + (M4-M1)                                             DIST
      M1 = M4                                                           DIST
      IDIA = IDIA + 1                                                   DIST
      M4 = MP4(IDIA)                                                    DIST
      IF(IDIA - NOL4)20,20,50                                           DIST
   40 DIST = DIST + VOL/(5.1291309*(PID(IDIA-1))**2)                    DIST
   50 RETURN                                                            DIST
      END
```

```
      FUNCTION VOLU  (NOL4,MP4, MP2,IL2,MP1,IL1,PID)
C*********************************************************************
C                                                                       VOLUM
C   THIS FUNCTION CALCULATES THE VOLUME OF PRODUCTS BETWEEN A DOWNSTREAM VOLUM
C   MILEPOST, MP2(IL2), AND AN UPSTREAM MILEPOST, MP1(IL1).             VOLUM
C                                                                       VOLUM
      REAL MP1(100),MP2(100),MP4(5)
      DIMENSION PID(5)
      VOLUM = 0.                                                        VOLUM
      K1 = 0                                                            VOLUM
      MP1(IL1) = MP1(IL1)
      MP2(IL2) = MP2(IL2)
C                                                                       VOLUM
C   FIND THE DIAMETER CHANGE JUST DOWNSTREAM FROM MP2.                  VOLUM
C                                                                       VOLUM
      DO 10 IDIA = 2,NOL4                                               VOLUM
      IF(MP4(IDIA) - MP2(IL2))10,20,20                                  VOLUM
   10 CONTINUE                                                          VOLUM
      IDIA1 = IDIA
      IDIA = IDIA -1                                                    VOLUM
      PID1 = PID(IDIA)
C                                                                       VOLUM
C   CALCULATE THE VOLUME BETWEEN MP2(IL2) AND MP1(IL1).                 VOLUM
C                                                                       VOLUM
   20 IDIA = IDIA - 1                                                   VOLUM
      IF(MP4(IDIA)-MP1(IL1))75,75,25                                    VOLUM
   25 K1 = K1 + 1                                                       VOLUM
      IF(IDIA-K1+1)26,80                                                VOLUM
   26 IF(MP4(IDIA-K1+1)-MP1(IL1)) 70,30,30                              VOLUM
   30 IF(K1 -1) 50,40                                                   VOLUM
   40 UPMP = MP2(IL2)                                                   VOLUM
      GO TO 60                                                          VOLUM
   50 UPMP = MP4(IDIA-K1+2)                                             VOLUM
   60 VOLUM = VOLUM + (UPMP - MP4(IDIA-K1+1))*(PID(IDIA-K1+1)**2)       VOLUM
     1         *5.1291309                                               VOLUM
      VM = VOLUM
      MP41 = MP4(IDIA-K1+1)
      PID1 = PID(IDIA-K1+1)
      GO TO 25                                                          VOLUM
   70 VOLUM = VOLUM + (MP4(IDIA-K1+2)-MP1(IL1))*(PID(IDIA-K1+1)**2)     VOLUM
     1* 5.1291309                                                       VOLUM
      MPX4 = MP4(IDIA-K1+2)
      MP1(IL1) = MP1(IL1)
      MP2(IL2) = MP2(IL2)
      VM = VOLUM
      GO TO 80                                                          VOLUM
   75 VOLUM = (MP2(IL2)-MP1(IL1))*(PID(IDIA)**2)*5.1291309              VOLUM
   80 CONTINUE
      VOLU = VOLUM
      RETURN
      END
```

```
      FUNCTION CURV (QKNOWN,IPC,IP,HPC,QPC)
C*********************************************************************
C                                                                      CURVE
C  THIS FUNCTION INTERPOLATES BETWEEN GIVEN POINTS ON A SMOOTH CURVE.  CURVE
C  IT USES THE THREE NEAREST KNOWN POINTS TO DETERMINE THE COEFFICIENTS CURVE
C  A, B, AND C, OF A SECOND ORDER POLYNOMINAL EQUATION.  THIS EQUATION CURVE
C  IS THEN USED TO MAKE THE INTERPOLATION.  Y = A(X)(X) + B(X) + C     CURVE
C                                                                      CURVE
      DIMENSION HPC(6,25),QPC(6,25)
C                                                                      CURVE
C  SELECT WHICH WHICH THREE KNOWN POINTS TO USE.                       CURVE
C                                                                      CURVE
      IW = 6
      IF(IP.EQ.8)GO TO 40
      IF( (IP.GT.6).OR.(IP.LT.1) )GO TO 50
      IF(QKNOWN - QPC(6,IPC))6,40,3
    3 CURVE = .0001
      GO TO 70
    6 IF(IP-1)50,20,10
   10 IP1 = IP - 1                                                     CURVE
      IP2 = IP                                                         CURVE
      IP3 = IP + 1                                                     CURVE
      GO TO 30                                                         CURVE
   20 IP1 = IP                                                         CURVE
      IP2 = IP + 1                                                     CURVE
      IP3 = IP + 2                                                     CURVE
C                                                                      CURVE
C  CALCULATE THE COEFFICIENTS.                                         CURVE
C                                                                      CURVE
   30 A = ((HPC(IP1,IPC)-HPC(IP2,IPC))/(QPC(IP1,IPC)-QPC(IP2,IPC))     CURVE
     1     -(HPC(IP1,IPC)-HPC(IP3,IPC))/(QPC(IP1,IPC)-QPC(IP3,IPC)))   CURVE
     2     /(QPC(IP2,IPC)-QPC(IP3,IPC))                                CURVE
      B = (HPC(IP1,IPC)-HPC(IP2,IPC))/(QPC(IP1,IPC)-QPC(IP2,IPC))      CURVE
     1     -A*(QPC(IP1,IPC)+QPC(IP2,IPC))
      C = HPC(IP1,IPC)-A*QPC(IP1,IPC)*QPC(IP1,IPC)-B*QPC(IF1,IPC)      CURVE
C                                                                      CURVE
C  CALCULATE THE UNKNOWN VARIABLE.                                     CURVE
C                                                                      CURVE
      CURVE = A*QKNOWN*QKNOWN + B*QKNOWN + C                           CURVE
      GO TO 7)
   40 CURVE = HPC(IPC,6)
      GO TO 70
   50 WRITE(IW,60)IP
   60 FORMAT (/,1X,38HERROR FLAG FROM FUNCTION CURVE.  IP = ,I3,
     1 30H,  INDEX FOR HPC, QPC, OR EPC ,/,1X,18HHAS BEEN EXCEECED.)
   70 CONTINUE
      CURV = CURVE
      RETURN
      END
```

```
      SUBROUTINE SLURRY
C*************************************************************************
C     THIS SUBROUTINE COMPUTES THE PRESSURE DROP EXPECTED IN A SLURRY
C     PIPELINE ACCORDING TO THE DURAND CORRELATION AS IMPLEMENTED
C     BY WASP ET AL AT BECHTEL, INC. THE FOLLOWING DATA ARE REQUIRED
C   SLURRY DATA.
C       1. VOLFRC OR WTFRC, THE VOLUME OR WEIGHT FRACTION SOLIDS
C            PRESENT. THE ONE NOT SPECIFIED IS COMPUTED.
C       2. GVS, THE SOLIDS SPECIFIC GRAVITY WRT WATER.
C       3. GVL, THE LIQUID SPECIFIC GRAVITY WRT WATER.
C       4. LNGTH, THE PIPE LENGTH IN MILES.
C       5. DIA, THE PIPE INSIDE DIAMETER IN INCHES.
C       6. RUF, PIPE ABSOLUTE ROUGHNESS, INCHES. DEFAULT=0.00018
C       7. FLOW, THE SLURRY FLOW RATE, GPM.
C       8. VEL, THE SLURRY VELOCITY, FT/SEC.
C       9. PROD, THE SOLIDS PRODUCTION RATE DESIRED, T/HR.
C     NOTE: ONLY ONE OF 7.,8., AND 9. NEED BE SPECIFIED AS THE OTHERS ARE
C            THEN SET.
C      10. SOLSIZ, THE AVERAGE SOLIDS DIAMETER, INCHES.
C      11. SIZFLG, A FLAG DETERMINING THE SIZE DISTRIBUTION OF THE SOLIDS
C            =1 IF USE ONE SIZE ONLY, SOLSIZ.
C            =2 IF USE THE PREVIOUS SIZE DISTRIBUTION.
C            =3 IF READ ANOTHER SOLIDS SIZE DISTRIBUTION
C            FROM NAMELIST SIZING.
C      12. VISCL, VISCOSITY OF LIQUID, CP.
C   ADDITIONAL SLURRY DATA.
C       1. NSAMPL, THE NUMBER OF GRADES TAKEN.
C       2. SIEVE, AN ARRAY OF NSAMPL INTEGER SIEVE DESIGNATIONS
C            CORRESPONDING TO THE IOS STANDARD SIEVE SIZES AS SHOWN IN
C            PERRY<S TABLE 21.12 (FIFTH ED.) NUMBERING FROM TOP TO
C            BOTTOM (I.E. 1=107.6 MM, 6=53.8 MM, ETC.)
C       3. SAMWT, AN ARRAY WITH NSAMPL ENTRIES CORRESPONDING TO THE
C            WEIGHT OF THE SAMPLE FOUND ON THE CORRESPONDING SIEVE SCREEN.
C     NOTE: THE AVERAGE SIZE FOR A SAMPLE IS THE MEAN OF THE SCREEN
C            SIZE ON WHICH THE SAMPLE IS FOUND AND THE SCREEN SIZE OF THE
C            NEXT LARGER SAMPLE. THE SIZE OF THE LARGEST SAMPLE IS TAKEN
C            TO BE 120= OF ITS SCREEN SIZE.
C            THE SCREEN SIZE OF THE SAMPLE WHICH PASSED THROUGH THE LAST
C            SCREEN SHOULD BE THE SAME AS THAT PREVIOUS TO IT. THE AVERAGE
C            SIZE OF THIS SAMPLE IS 80 PER CENT OF THE SMALLEST SCREEN SIZE.
C
C     THE PRESSURE DROP IS THEN COMPUTED TO THAT EXPECTED
C     IF ONLY THE LIQUID CARRIER FLUID WERE FLOWING AT THE SLURRY RATE.
C
C     THE DEFINITION OF OTHER VARIABLES USED IN THIS PROGRAM ARE AS
C     FOLLOWS:
C
C       CV  AN ARRAY REPRESENTING THE CONTRIBUTION OF THE ITH
C             SAMPLE OF A SOLID TO THE VOLUME OF THE SLURRY.
C       CD  AN ARRAY CONTAINING THE DRAG COEFFICIENT OF THE ITH
C             SAMPLE OF THE SOLIDS.
C       EOD THE RELATIVE ROUGHNESS OF THE PIPE.
C       F   THE MOODY FRICTION FACTOR OF THE SLURRY USED TO
C             COMPUTE THE SLURRY PRESSURE DROP.
C       FW    THE MOODY FRICTION FACTOR FOUND IF THE LIQUID
```

```
      C          FLOWED IN THE PIPE AT THE SLURRY VELOCITY WITHOUT
      C          ANY SOLIDS PRESENT.
      C     DELP THE OVERALL PRESSURE DROP OF THE SLURRY FLOWING.
      C     DELPW THE PRESSURE DROP TO BE EXPECTED WITH NO SOLIDS
      C          PRESENT IN THE PIPE.
      C     DIFF  THE PERCENT DIFFERENCE BETWEEN DELP AND DELPW.
      C     GVSLR THE SLURRY SPECIFIC GRAVITY.
            INTEGER SIZFLG, SIEVE
            REAL LNGTH
            COMMON/SLURR/SIEVE(25) , SAMWT(25) ,VOLFRC,WTFRC,GVS,SIZFLG,SOLSIZ
           1  ,GVL,SIZE(25),CV(25),CD(25),NSAMPL,WTSUM,CVT,GVSLR,VISC,FLOW,
           2  PROD,VEL,DELPS,DELPW,DIFF,HPM,DIA,RUF
            DIMENSION           SIEVE(25), SAMWT(25), SIZE(25),
           1          CV(25), CD(25)
      C$    STORES(VOLFRC,WTFRC,GVS,GVL,LNGTH,DIA,RUF,FLOW,SOLSIZ,SIZFLG,
      C$   1  VISCL,NSAMPL,SIEVE,SAMWT,GVSLR,AREA,VEL,PROD,WTSUM,CVT,CV,CD,
      C$   2  SUM,CORR,FOD,PF,FW,DELPW,F,DELP,DIFF)
            LNGTH = 1.
            VISCL = VISC
      C
      C
      C     COMPUTE THE WEIGHT OR VOLUME FRACTION SOLIDS
      C     ALONG WITH OTHER SLURRY PROPERTIES.
      C
            IF(VOLFRC.LE.0.0) VOLFRC = WTFRC*GVL/(GVS + WTFRC*(GVL-GVS))
            WTFRC = 1.0/(1.0+(1.0-VOLFRC)*GVL/GVS/VOLFRC)
      C
            GVSLR = VOLFRC*GVS + (1.0-VOLFRC)*GVL
            AREA = 3.14159*DIA*DIA/144.0/4.0
            IF(FLOW.GT.0.0) GO TO 12
            IF(VEL.GT.0.0) GO TO 13
            FLOW = PROD*2000./60./WTFRC/GVSLR/62.47*7.481
            VEL = FLOW/7.481/60./AREA
            GO TO 14
         12 VEL = FLOW/7.481/60./AREA
            PROD = FLOW*60.*WTFRC*GVSLR*62.4/2000./7.481
            GO TO 14
         13 FLOW = VEL * 7.481 * 60. * AREA
            PROD = FLOW*60.*WTFRC*GVSLR*62.4/2000./7.481
         14 CONTINUE
      C
      C     COMPUTE THE SIZE DISTRIBUTION.
      C
            IF (SIZFLG-2) 23,22,21
      C
      C     READ NEW SIZE DISTRIBUTION.
      C
         21 WTSUM = SCRCON(NSAMPL, SIEVE, SAMWT, SIZE)
         22 CONTINUE
      C
      C     USE THE LAST SIZE DISTRIBUTION ( OR NEW SIZES
      C     JUST READ AND CONVERTED)
      C
            CVT = 0.0
      C
```

```
      C     COMPUTE THE VOLUME FRACTIONS AND DRAG COEFFICIENTS FOR EACH SAMPLE.
      C
            DO 20 I = 1,NSAMPL
            CV(I) = VOLFRC * SAMWT(I)
            CVT = CVT + CV(I)
            CD(I) = DRGCOF(SIZE(I),GVS,GVL,VISCL)
         20 CONTINUE
            GO TO 24
      C
      C     ONE SIZE ONLY.
      C
         23 NSAMPL = 1
            CD(1) = DRGCOF(SOLSIZ,GVS,GVL,VISCL)
            CV(1) = VOLFRC
         24 CONTINUE
      C
      C     COMPUTE THE TOTAL FRICTION FACTOR CORRECTION BY SUMMING THE
      C     CONTRIBUTIONS OF EACH SOLID.
      C
            SUM = 0.0
            DO 25 I = 1,NSAMPL
         25 SUM = SUM + CV(I)/CD(I)**0.75
            CORR = 82.0*SUM*(32.2/VEL/VEL*DIA/12.*(GVSLR-GVL)/GVL)**1.5
      C
      C     COMPUTE LIQUID FRICTION FACTOR AND PRESSURE DROP.
      C
            EOD = RUF/DIA
            RE = GVL*62.4*VEL*DIA*1488./12./VISCL
            FW = AMOODY(RE,EOD)
            DELPW = FW*VEL*VEL*GVL*62.4*LNGTH*5280./DIA/32.2/24.
      C
      C     COMPUTE SLURRY FRICTION FACTOR AND PRESSURE DROP AND COMPARE
      C     THAT TO THE LIQUID DROP.
      C
            F = FW*(1.0 + CORR)
            DELPS = DELPW * F/FW*GVSLR/GVL
            HPM = DELPS/(.433*GVSLR)
            DIFF = (DELPS-DELPW)/DELPW*100.0
        999 CONTINUE
      C
            RETURN
            END
```

```
      FUNCTION DRGCOF(D,GVS,GVL,VISC)
C
C     THIS FUNCTION COMPUTES THE DRAG COEFFICIENT OF A SPHERICAL
C     SOLID PARTICLE WITH DIAMETER D AND SPECIFIC GRAVITY GVS,
C     FALLING THROUGH A LIQUID WITH SPECIFIC GRAVITY GVL
C     AND VISCOSITY VISC CP.
C
      DIMENSION A(5)
      DATA A /-1.381,1.045,-5.324E-2,2.819E-4,1.142E-4/
C$    STORES(D,GVS,GVL,VISC,CONST,CDRE2,X,SUM,C,RE)
      D=D
      GVS=GVS
      GVL=GVL
      VISC=VISC
      CONST = 4.0*32.2*62.4*62.4*1488.*1488./3.0/1728.
      CDRE2 = CONST * (GVS-GVL) *GVL *D*D*D /VISC /VISC
      IF(CDRE2.GT.7.2) GO TO 1
      DRGCOF = 24. * 24. / CDRE2
      RETURN
    1 CONTINUE
      X = 1.0
      SUM = A(1)
      C = ALOG10(CDRE2)
      DO 10 I=2,5
      X = X*C
   10 SUM = SUM + X*A(I)
      RE = 10.0**SUM
      DRGCOF = CDRE2 /RE/RE
      RETURN
      END
```

```
      FUNCTION SCRCON(N,ISIV,WTS,SZ)
C
C     THIS FUNCTION CONVERTS INFORMATION TO AVERAGE
C     PARTICLES DIAMETERS ACCORDING TO THE IOS STANDARD SCREEN SIZES.
C     THE SAMPLE WEIGHTS ARE NORMALIZED TO WEIGHT FRACTION AND THE
C     TOTAL WEIGHT FRACTION IS RETURNED (SHOULD ALWAYS BE 1.0)
C
      REAL MESH (52)
      DIMENSION ISIV(N),WTS(N),SZ(N)
      DATA CONV/25.4/,MESH/107.6,101.6,90.5,76.1,64.0,53.8,50.8,
     X45.3,38.1,32.0,26.9,25.4,22.6,19.0,16.0,13.5,12.7,11.2,9.51,
     X8.00,6.73,6.35,5.66,4.76,4.00,3.36,2.83,2.38,2.00,1.68,1.41,
     X1.19 ,1.00,
     X0.841,0.707,0.595,0.500,0.420,0.354,0.297,0.250,0.210,0.177,
     X0.149,0.125,0.105,0.088,0.074,0.063,0.053,0.044,0.037/
      J = ISIV(1)
      SZ(1) = MESH(J) * 1.2 / CONV
      NM1 = N - 1
      SUM = WTS(1)
      DO 10 I = 2,NM1
      JJ = ISIV(I)
      SZ(I) = (MESH(J) + MESH(JJ))/2.0/CONV
      J = JJ
   10 SUM = SUM + WTS(I)
      SUM = SUM + WTS(N)
      SCRCON = 0.0
      J = ISIV(N)
      SZ(N) = MESH(J) * 0.8/CONV
      DO 20 I=1,N
      WTS(I) = WTS(I)/SUM
   20 SCRCON = SCRCON + WTS(I)
      RETURN
      END
```

```
      FUNCTION AMOODY (RE,AK)
C
C     THIS FUNCTION COMPUTES THE MOODY FRICTION FACTOR FOR A
C     FLUID FLOWING IN A PIPE GIVEN THE REYNOLDS NUMBER AND
C     THE RELATIVE ROUGHNESS OF THE PIPE, AK.
C
      DATA S2/1.14142136/
      F=16.0/RE
      FRCFAC = 1.0
      IF(RE.LT.2100.0) GO TO 101
      F = 4.0*ALOG10(0.5/AK) + 3.48
      FRCFAC = 2.0
      IF (AK*RE/F/S2.GE.70.0) GO TO 102
      DO 50 I=1,10
      F = 3.48-4.0*ALOG10(2.0*AK*(1.0+9.35*F/2.0/AK/RE))
   50 CONTINUE
      FRCFAC = 3.0
      A = AK*RE/F/S2
      IF (A.GT.3.0.AND.A.LT.70.0) GO TO 102
      DO 100 I=1,10
  100 F = 4.0*ALOG10(RE/F)-0.4
      FRCFAC = 4.0
  102 F = 1.0/F/F
  101 AMOODY = 4.0*F
      RETURN
      END
```